IEC 61970-301

Edition 6.0 2016-12
REDLINE VERSION

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Energy management system application program interface (EMS-API) – Part 301: Common information model (CIM) base

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ICS 33.200

ISBN 978-2-8322-3763-2

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ENERGY MANAGEMENT SYSTEM APPLICATION PROGRAM INTERFACE (EMS-API) –

Part 301: Common information model (CIM) base

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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International Standard IEC 61970-301 has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

This sixth edition cancels and replaces the fifth edition, published in 2013. This sixth edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) new model for grounding including Petersen coils;
b) models for HVDC;
c) addition of Static Var Compensation models;
d) phase shift transformer updates - the section has been added;
e) short circuit calculations based on IEC 60909;
f) addition of non-linear shunt compensator;
g) addition of model for steady state calculation inputs, Steady State Hypothesis;
h) addition of base frequency model;
i) corrections of several smaller issues, e.g. issues found at ENTSO-E interoperability tests;
j) UML clean up;
k) new model for PowerElectronicUnits and their connection to the AC network added;
l) new section on relation between TapChanger.ltcFlag and TapChanger.TapChangerControl;
m) Annex A with custom extensions added.

The text of this standard is based on the following documents:

FDIS	Report on voting
57/1779/FDIS	57/1788/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61970 series, under the general title: *Energy management system application program interface (EMS-API)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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INTRODUCTION

This document is one of the IEC 61970 series which defines an application program interface (API) for an energy management system (EMS). IEC 61970 was originally based upon the work of the EPRI Control Center API (CCAPI) research project (RP-3654-1). The principle objectives of the EPRI CCAPI project were to:

- reduce the cost and time needed to add new applications to an EMS;
- protect the investment of existing applications or systems that are working effectively with an EMS.

The principal objective of the IEC 61970 series is to produce standards which facilitate the integration of EMS applications developed independently by different vendors, between entire EMS systems developed independently, or between an EMS system and other systems concerned with different aspects of power system operations, such as generation or distribution management systems (DMS). This is accomplished by defining application program interfaces to enable these applications or systems access to public data and exchange information independent of how such information is represented internally.

The Common Information Model (CIM) specifies the semantics for this API. The Component Interface Specifications (CIS), which are contained in other parts of the IEC 61970 series, specify the content of the messages exchanged.

The CIM is an abstract model that represents all the major objects in an electric utility enterprise typically needed to model the operational aspects of a utility. This model includes public classes and attributes for these objects, as well as the relationships between them.

~~The objects represented in the CIM are abstract in nature and may be used in a wide variety of applications. The use of the CIM goes far beyond its application in an EMS. This standard should be understood as a tool to enable integration in any domain where a common power system model is needed to facilitate interoperability and plug compatibility between applications and systems independent of any particular implementation.~~

This document defines the CIM Base set of packages which provide a logical view of the functional aspects of an Energy Management System including Supervisory Control and Data Acquisition (SCADA). Other functional areas are standardized in separate IEC documents that augment and reference this document. For example, IEC 61968-11 addresses distribution models and references this document. While there are multiple IEC standards dealing with different parts of the CIM, there is a single, unified information model comprising the CIM behind all these individual standards documents.

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning a computer-based implementation of an object-oriented power system model in a relational database. As such, it does not conflict with the development of any logical power system model including the Common Information Model (CIM), where implementation of the model is not defined.

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ENERGY MANAGEMENT SYSTEM APPLICATION PROGRAM INTERFACE (EMS-API) –

Part 301: Common information model (CIM) base

1 Scope

The common information model (CIM) is an abstract model that represents all the major objects in an electric utility enterprise typically involved in utility operations. By providing a standard way of representing power system resources as object classes and attributes, along with their relationships, the CIM facilitates the integration of ~~Energy Management System (EMS)~~ network applications developed independently by different vendors, between entire ~~EMS~~ systems running network applications developed independently, or between ~~an EMS~~ a system running network applications and other systems concerned with different aspects of power system operations, such as generation or distribution management. SCADA is modeled to the extent necessary to support power system simulation and inter-control centre communication. The CIM facilitates integration by defining a common language (i.e. semantics) based on the CIM to enable these applications or systems to access public data and exchange information independent of how such information is represented internally.

The object classes represented in the CIM are abstract in nature and may be used in a wide variety of applications. The use of the CIM goes far beyond its application in an EMS. This document should be understood as a tool to enable integration in any domain where a common power system model is needed to facilitate interoperability and plug compatibility between applications and systems independent of any particular implementation.

Due to the size of the complete CIM, the object classes contained in the CIM are grouped into a number of logical Packages, each of which represents a certain part of the overall power system being modeled. Collections of these Packages are progressed as separate International Standards. This document specifies a Base set of packages which provide a logical view of the functional aspects of Energy Management System (EMS) information within the electric utility enterprise that is shared between all applications. Other standards specify more specific parts of the model that are needed by only certain applications. Subclause 4.3 of this document provides the current grouping of packages into standards documents.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at www.electropedia.org)

~~IEC 60870-6 (all parts), *Telecontrol equipment and systems – Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations*~~

IEC 61850 (all parts), *Communication networks and systems for power utility automation*

~~IEC 61850-7-3:2010, *Communication networks and systems for power utility automation – Part 7-3: Basic communication structure – Common data classes*~~

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IEC 61850-7-4:2010, *Communication networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes*

IEC 61968 (all parts), *Application integration at electric utilities – System interfaces for distribution management*

IEC TS 61970-2, *Energy management system application program interface (EMS-API) – Part 2: Glossary*

~~IEC 62325 (all parts), *Framework for energy market communications*~~

Object Management Group: UML 2.0 Specification – http://www.omg.org

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61970-2, IEC 60050 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
energy management system
EMS
computer system comprising a software platform providing basic support services and a set of applications providing the functionality needed for the effective operation of electrical generation and transmission facilities so as to ~~ensure~~ assure adequate security of energy supply at minimum cost

3.1.2
application program interface
API
set of public functions provided by an executable application component for use by other executable application components

3.1.3
unified modeling language
UML
formal and comprehensive descriptive language with diagramming techniques used to represent software systems, from requirements analysis, through design and implementation, to documentation

Note 1 to entry: UML has evolved from a collection of methods contributed by different practitioners, into an International Standard (ISO/IEC 19505, published in 2012). The CIM relies on UML for defining the model, and automated tools generate the documentation, schemas, and other artifacts directly from the UML. A basic understanding of UML is necessary to understand the CIM.

3.1.4
profile
subset of ~~D~~CIM classes, associations and attributes needed to accomplish a specific type of interface

Note 1 to entry: This may be expressed in XSD, RDF, and/or OWL files. A profile can be tested between applications. A profile is necessary in order to "use" the ~~D~~CIM. Several profiles are defined in the IEC 61968 and IEC 62325 series.

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4 CIM specification

4.1 Overview

The CIM model is described in the Unified Modeling Language (UML) that is maintained as a UML file managed by a UML editing tool. The UML file exists in different formats:

- a tool proprietary format,
- a standardized xmi format.

The CIM model is described in Clause 6, which is a report generated from the UML file. The name of the UML file use to generate Clause 6 is:

- IEC 61970cim16v33_IEC 61968cim12v08_IEC 62325cim03v01a.

This file can be obtained from CIM users group.

4.2 CIM modeling notation

The CIM is defined using object-oriented modeling techniques. Specifically, the CIM specification uses the Unified Modeling Language (UML) notation, which defines the CIM as a group of packages.

Each package in the CIM contains one or more class diagrams showing graphically all the classes in that package and their relationships. Each class is then defined in text in terms of its attributes and relationships to other classes.

The UML notation is described in Object Management Group (OMG) documents and several published textbooks.

4.3 CIM packages

The CIM is partitioned into a set of packages. A package is a general purpose means of grouping related model elements. The packages have been chosen to make the model easier to design, understand and review. The common information model consists of the complete set of packages. Entities may have associations that cross many package boundaries. Each application will use information represented in several packages.

The comprehensive CIM is partitioned into groups of packages for convenience in managing and maintaining them. Packages included in IEC 61970-301 (this document) are contained within the IEC 61970 package. The IEC 61970 packages do not depend upon other outside packages. As shown in Figure 1, the IEC 61970 package and its subpackages are used as a core or base model for other CIM packages. The dashed lines indicate dependency relationships, with the arrowhead pointing from the dependent package to the package on which it has a dependency. Packages for the IEC 61968 series of standards describe additional parts of the CIM that deal with other logical views of utility operations including assets, locations, activities, consumers, documentation, work management, and metering. Packages for the IEC 62325 series of standards describe electric energy markets.

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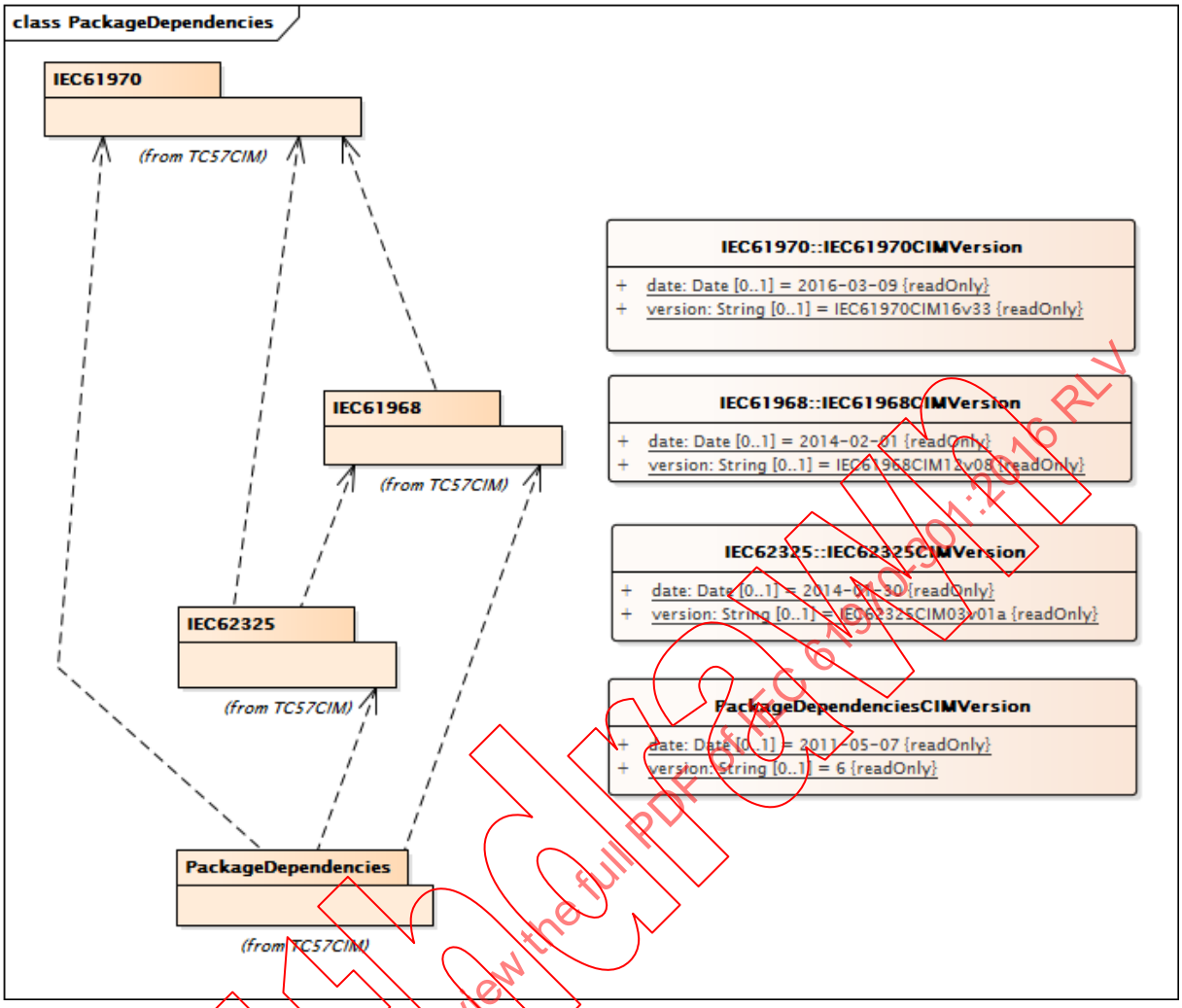


Figure 1 – Example ~~of~~ working group package dependencies

Note that the package boundaries do not imply application boundaries. An application may use CIM entities from several packages. It is also anticipated CIM packages outside of this document will have dependencies upon some of the packages described in this document, and particularly the Domain and Core packages, though other dependencies will also exist.

Figure 2 shows the packages defined for IEC 61970-301 CIM Base and their dependency relationships.

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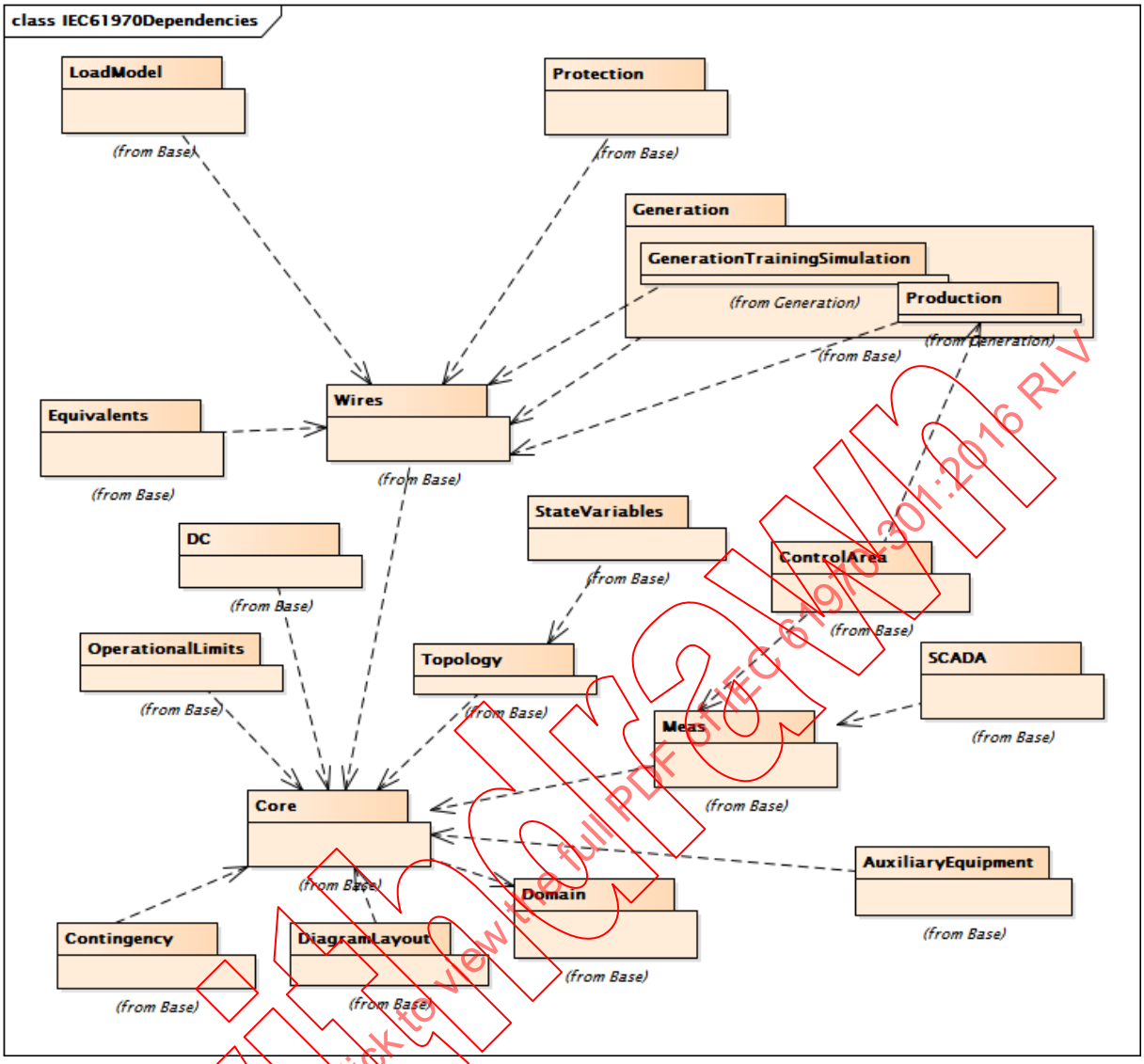


Figure 2 – CIM IEC 61970-301 package diagram

~~Clause 6 contains the specification for each of the CIM Base packages.~~

~~NOTE The contents of the CIM defined in this specification were auto-generated from the CIM UML electronic model release IEC61970CIM15v33, which is available through the CIM Users Group.~~

4.4 CIM classes and relationships

4.4.1 Classes

The class diagram(s) for each CIM package shows all the classes in the package and their relationships. Where relationships exist with classes in other packages, those classes may also be shown.

Classes and objects model what is in a power system that needs to be represented in a common way to power system applications. A class is a description of an object found in the real world, such as a power transformer, generator, or load that needs to be represented as part of the overall power system model in, for example, an EMS. Other types of objects include things such as schedules and measurements that EMS applications also need to process, analyze, and store. Such objects need a common representation to achieve the purposes of the EMS-API standard for plug-compatibility and interoperability. A particular object in a power system with a unique identity is modeled as an instance of the class to which it belongs.

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It should also be noted that the CIM is defined to facilitate data exchange. As defined in this document, CIM entities have no behavior. For a specific interface, a profile is defined consisting of subsets of CIM classes, attributes, and associations. A profile defines the message payload for an interface.

Classes have attributes that describe the characteristics of the objects. Each class in the CIM contains the attributes that describe and identify a specific instance of the class. Only the attributes that are of public interest to ~~EMS~~ network applications are included in the class descriptions.

Each attribute has a type, which identifies what kind of attribute it is. Typical attributes are of type Integer ~~(CIM class Integer)~~, Float ~~(CIM class Float)~~, Boolean ~~(CIM class Boolean)~~, String ~~(CIM class String)~~, Date ~~(CIM class Date)~~, and Decimal ~~(CIM class Decimal)~~, which are called primitive types. However, many additional types are defined as part of the CIM specification. For example, ShuntCompensator has a "maxU" attribute of type Voltage ~~(CIM class Voltage)~~. The definition of many shared types is contained in the Domain package ~~described in 6.3~~. The UML stereotypes of Primitive, enumeration, CIMDatatype, and Compound are added to classes used as types. The CIMDatatype stereotype is used with a specific CIM semantics for a ~~triple of attributes {value, unit, multiplier}~~ simple value with additional attributes describing the unit and multiplier of the value, e.g. unit, multiplier, denominatorUnit and denominatorMultiplier. This implies custom mapping to serialization artifacts such as RDFS, OWL, and XSD. Classes with these stereotypes do not participate in generalization or association relationships and are simply used as types for attributes. The enumeration stereotype is used to describe an attribute with an enumerated list of choices. The Compound stereotype is used to describe sets of related attributes that are commonly reused. Compound classes may consist of Primitive, enumeration, CIMDatatype or other Compound classes as long as the Compound classes do not recurse.

All CIM attributes are implicitly optional in the sense that profiles using the CIM may eliminate any attributes.

Relationships between classes reveal how they are structured in terms of each other. CIM classes are related in a variety of ways, as described in 4.4.2 to 4.4.4.

4.4.2 Generalization

A generalization is a relationship between a more general and a more specific class. The more specific class can contain only additional information. Generalization provides for the specific class to inherit attributes and relationships from all the more general classes above it.

Figure 3 is an example of generalization. In this example taken from the Wires package, a Breaker is a more specific type of ProtectedSwitch, which in turn is a more specific type of Switch, which is a more specific type of ConductingEquipment, etc. A PowerTransformer is another more specific type of ConductingEquipment. Note that PowerSystemResource inherits from class IdentifiedObject which is not on the diagram. Therefore, IdentifiedObject is shown in italic type in the upper right corner of class PowerSystemResource.

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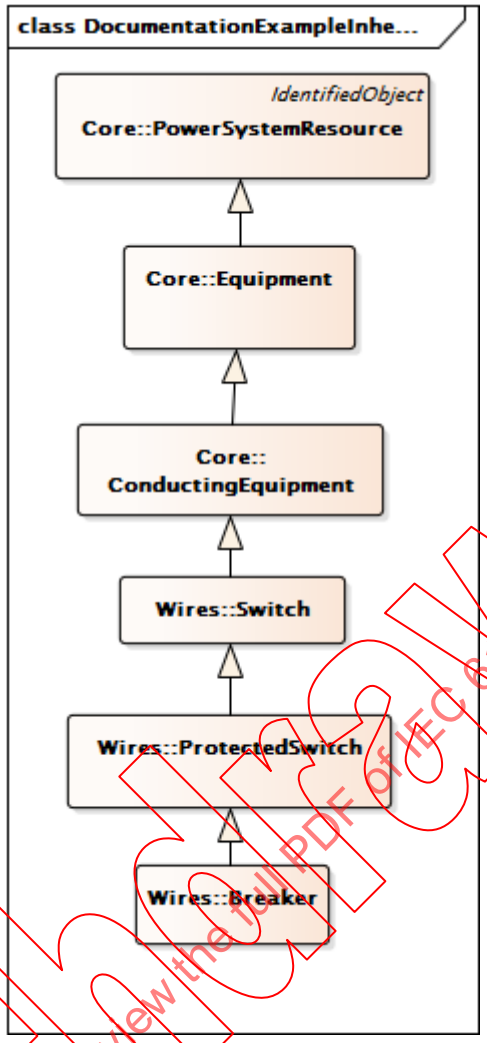


Figure 3 – Example of generalization

4.4.3 Simple association

An association is a conceptual connection between classes. Each association has two "association ends". The "association ends" were called "roles" prior to the UML 2.0 specification. Each association end describes the role the target class (i.e. the class the association end goes *to*) has in relation to the source class (i.e. the class the association end goes *from*). Association ends are usually given the name of the target class with or without a verb phrase. Each association end also has multiplicity/cardinality, which is an indication of how many objects may participate in the given relationship. In the CIM, associations are not named, only association ends are named. For example, as shown by Figure 4, in the CIM there is an association between ~~class~~ a BaseVoltage and ~~class~~ a VoltageLevel. Multiplicity is shown at both ends of the association. In this example, a VoltageLevel object may reference 1 BaseVoltage, and a BaseVoltage may be referenced by 0 or more VoltageLevel objects.

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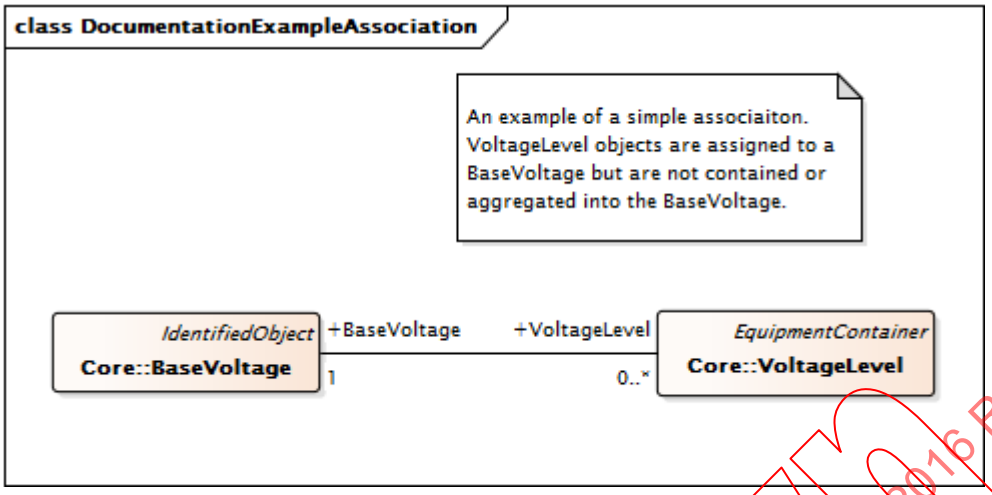


Figure 4 – Example of simple association

4.4.4 Aggregation

Aggregation is a special case of association. Aggregation indicates that the relationship between the classes is some sort of whole-part relationship, where the whole class "consists of" or "contains" the part class, and the part class is "part of" the whole class. The part class does not inherit from the whole class as in generalization. Figure 5 illustrates an aggregation between the EquipmentContainer class and the Equipment class, which is taken from the Core package. As shown, an Equipment can be a member of zero or one EquipmentContainer objects, but an EquipmentContainer object can contain any number of Equipment objects. In the context of using CIM as an information model, aggregation does not have a precise or formal interpretation beyond a simple association and is intended to visually assist in representing normal usage.

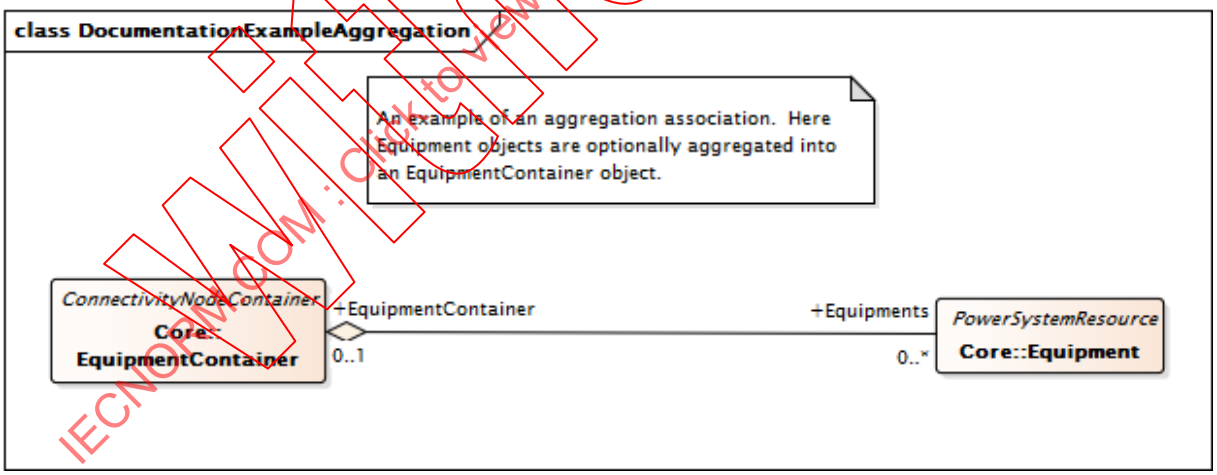


Figure 5 – Example of aggregation

4.5 CIM model concepts and examples

4.5.1 Concepts

~~The CIM classes, attributes, types, and relationships are specified in Clauses 5 and 6. Clause 6 comprises a complete description of the IEC 61970-301 CIM Base model.~~ To help understand how to interpret the CIM, some key model concepts used in the CIM are introduced and described in 4.5.2 to 4.5.14.

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4.5.2 Containment, equipment hierarchies and naming

4.5.2.1 Containment structure

Figure 6 shows the concept of equipment containers to form hierarchies in the CIM. Equipment containers represent ways of organizing and naming equipment typically found within a substation. As may be seen, there is some flexibility provided in which containers are used in a specific application of the CIM in order to accommodate different international practices as well as differences typically found between transmission and distribution substations. Bay, VoltageLevel, Substation, Line, and Plant are all types of EquipmentContainers. In general, a Bay is contained within a specific VoltageLevel, which in turn is contained within a Substation. Substations and Lines may be contained within SubGeographicRegions and GeographicRegions.

One containment hierarchy is used with the IdentifiedObject class to create hierarchical naming intended for human consumption. This hierarchy is specifically used to name equipment according to its function in the power system. This is the functional naming hierarchy. Other common identifications beside functional names are asset serial numbers. The functional name is different from a serial number in that it relates to the function of a particular equipment position or location in the power system. Regardless of what specific piece of physical equipment is placed at a location, the functional name is the same but the serial number varies depending on the physical equipment currently used.

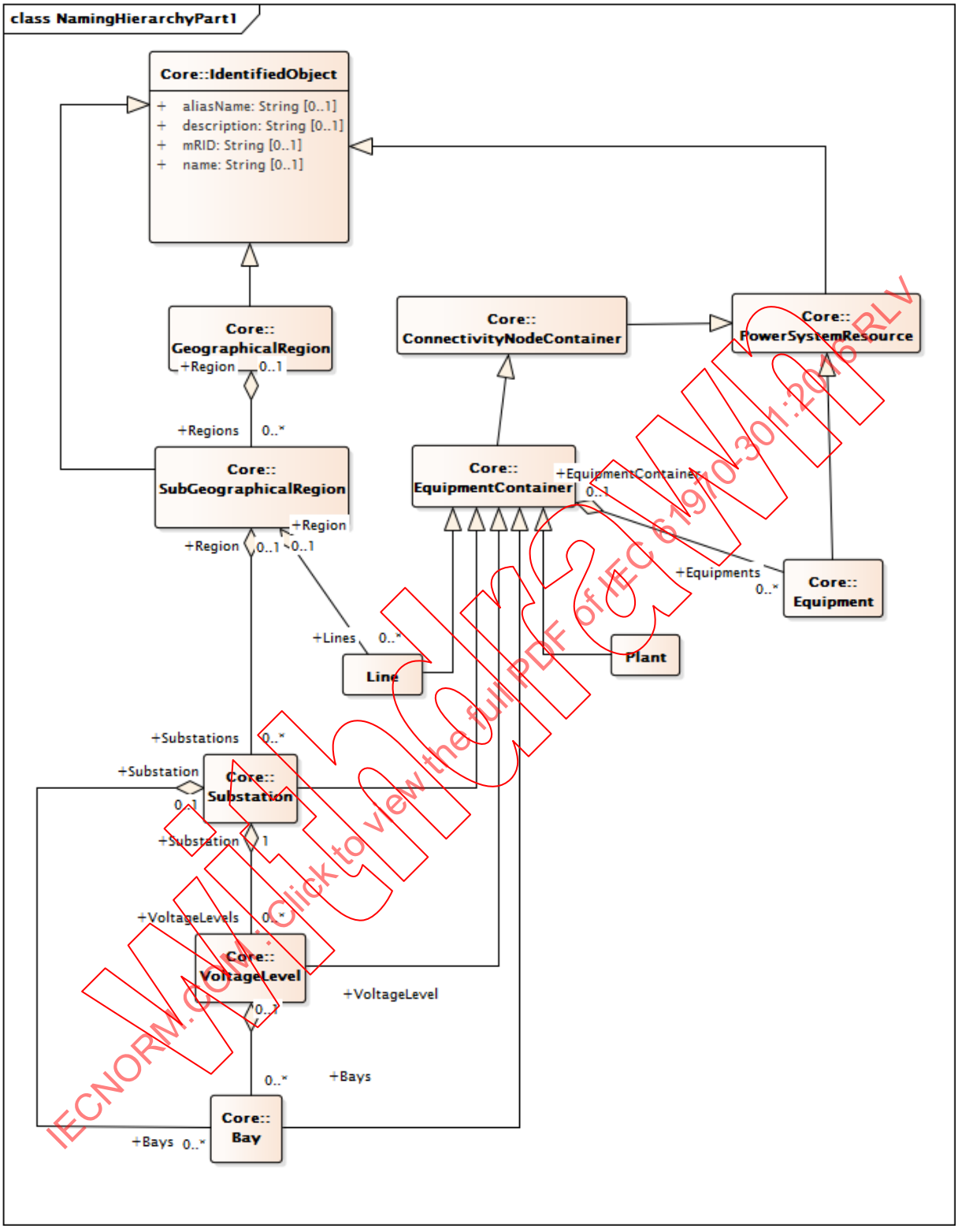
4.5.2.2 IdentifiedObject class

The IdentifiedObject class contained in the Core package is inherited by all PowerSystemResource and many other classes. This class has attributes and associations to be used for naming all CIM objects. The mRID attribute of the IdentifiedObject class provides a straight forward and rigorous means of identity for CIM objects.

The following are definitions and conventions for how to use the IdentifiedObject attributes when naming PowerSystemResource objects ~~(for more details, refer to documentation for IdentifiedObject and its attributes in Clause 6)~~:

- mRID (Master Resource ID): A globally unique machine-readable identifier for an object instance.
- name: The name is any free human readable and possibly non unique text naming the object.
- aliasName: This attribute is ~~deprecated and~~ an additional name but the Name classes of 4.5.3 provide a better alternative. The aliasName is free text human readable name of the object alternative to IdentifiedObject.name. It may be non unique and may not correlate to a naming hierarchy. The attribute aliasName is retained because of backwards compatibility between CIM releases. It is however recommended to replace aliasName with the Name class as aliasName is planned for retirement at a future time.

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Figure 6 – Equipment containers

The diagrams NamingHierarchyPart1 and NamingHierarchyPart2 in the Wires package show the functional naming hierarchy.

4.5.3 Names model

A flexible and extensible naming model is provided to specify alternate names for objects. A use cases where the names model is useful is when multiple applications or systems have

different names for the same object. The names model then enables exchange of these names.

Figure 7 shows the class diagram for alternate names and how they can be associated to a specific user defined name type. This model allows for specific definition of names within a particular domain and enforces no specific naming rules. The concepts of alias names, path names, and local names can all be accommodated by this model. The CIM models do not enforce or promote specific naming conventions, but allow for such naming conventions to be exchanged in a clear context.

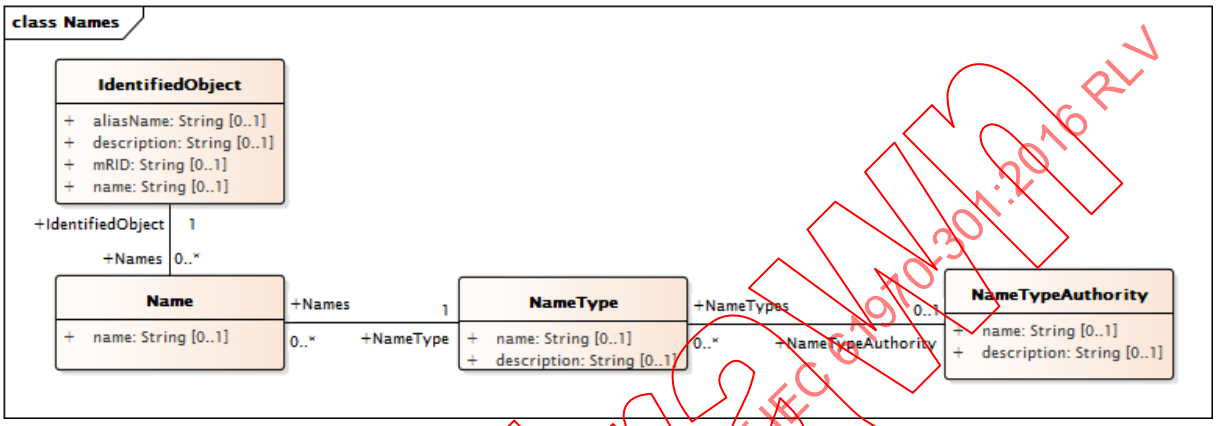


Figure 7 – Names

Table 1 – NameType class naming conventions

name	description
ICCP	Reserved for ICCP (TASE-2) names. Used to describe ICCP point names for the MeasurementValue class and ICCP source names for the MeasurementValueSource class.

Table 1 describes various name conventions for name types. The meanings of the columns in Table 1 are as follows:

name: The name attribute value.

description: The use of the name type.

Note that Table 1 is not an exhaustive list of values that can be used for the name attribute of the class Name.

4.5.4 Connectivity model

4.5.4.1 Connectivity description

Figure 8 shows the Topology class diagram which models connectivity between different types of ConductingEquipment. Also included is a portion of the Meas package class diagram dealing with measurements to illustrate how measurements are associated with conducting equipment.

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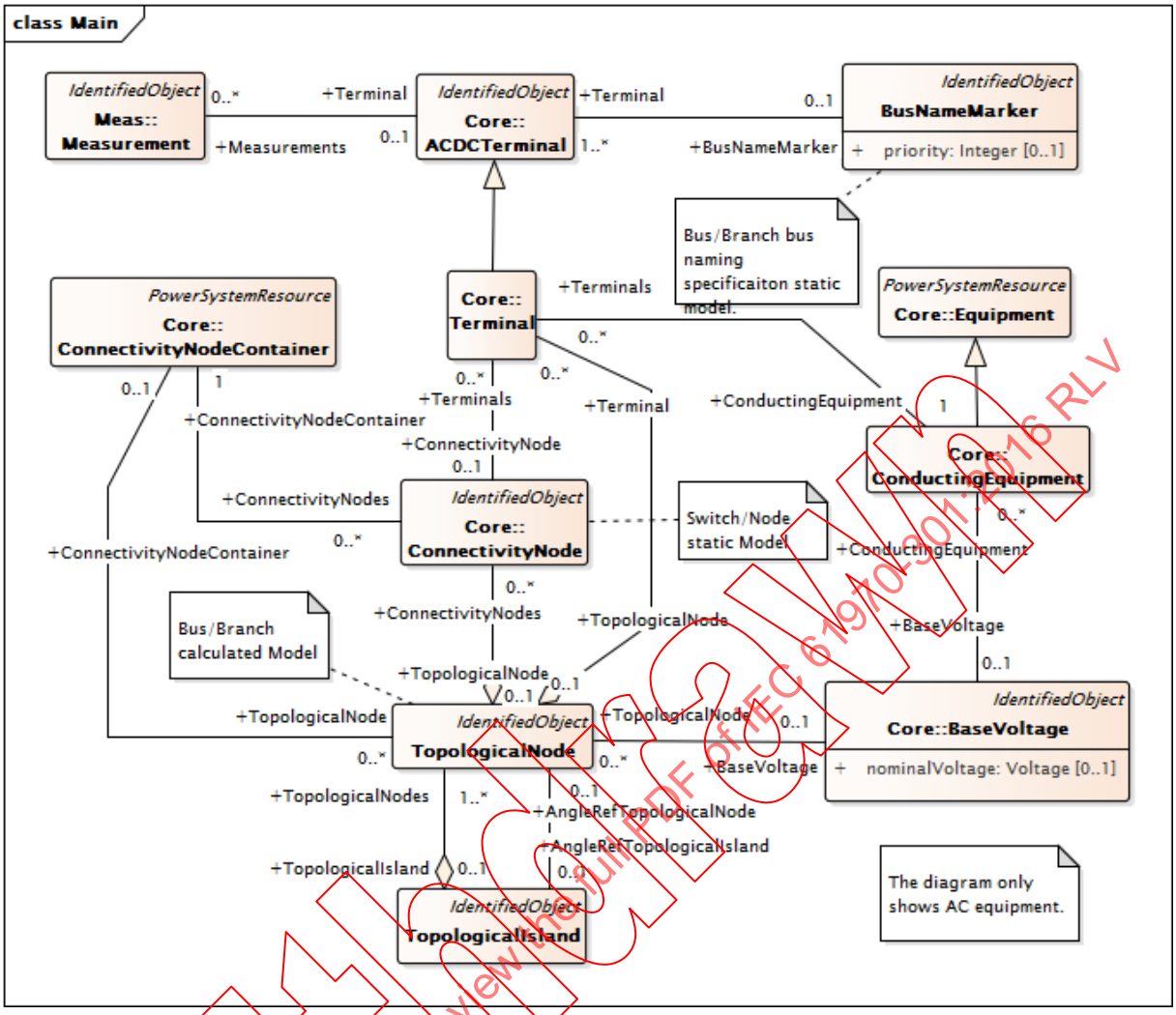


Figure 8 – Connectivity model

To model connectivity, Terminal and ConnectivityNode classes are defined. A Terminal belongs to one ConductingEquipment, although ConductingEquipment may have any number of Terminals. Each Terminal may be connected to a ConnectivityNode, which is a point where terminals of conducting equipment are connected together with zero impedance. A ConnectivityNode may have any number of terminals connected, and may be a member of a TopologicalNode (i.e. a bus), which is in turn a member of a TopologicalIsland. TopologicalNodes and TopologicalIslands are created as a result of a topology processor evaluating the "as built" ~~topology~~ connectivity and the actual Switch positions.

It is possible to exchange messages directly involving TopologicalNode and bypassing the ConnectivityNode details by using the TopologicalNode to Terminal association. This is often useful for exchanges involving bus/branch models which do not typically contain switch detail. When the TopologicalNode model is exchanged it is useful to also exchange the "connected" attribute on the Terminal class. This allows for the topological structure of the bus/branch model to be retained, yet indicate a terminal is not completely connected. Normally this disconnection is the result of one or more switches opening in the detailed model which is not represented in a bus/branch model exchange.

EquipmentContainers, which are a specialization of a ConnectivityNodeContainer, may contain zero or more ConnectivityNodes. The associations, ConductingEquipment–Terminal and Terminal–ConnectivityNode, capture the as-built ~~topology~~ connectivity of an actual power system network. For each Terminal connected to a ConnectivityNode, the associations of the other Terminal(s) connected to the same ConectivityNode identify the ConductingEqupment object(s) that are electrically connected. Similar connectivity at the "bus/branch" level of detail

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can be expressed using the TopologicalNode instead of the ConnectivityNode. The BusNameMarker class, which has an association to ConnectivityNode, is used to carry user bus names to be applied to TopologicalNodes. TopologicalNodes are created from ConnectivityNodes as a result of topology processing and various names might be applied depending upon which ConnectivityNode instances are present.

To model the analog values such as voltage and power, each Terminal has an association with a Measurement class from the Meas package. Although not shown in Figure 8, a Measurement object is associated with at least one MeasurementValue object. Each MeasurementValue object is an instance of a measurement from a specific source, for example, a telemetered measurement.

~~Clause 6 contains a complete description of each class in Figure 8 along with the definition of all the attributes and relationships supported in each class.~~

4.5.4.2 Connectivity and containment example

To illustrate how the connectivity model and containment model would appear as objects, a small example is presented in Figure 9. The example shows a transmission line with a T-junction spanning two substations and a substation having two voltage levels with a transformer between them. The transmission line consists of two different cables. One of the voltage levels is shown with a busbar section having a single busbar and two very simple switchgear bays connecting to the busbar.

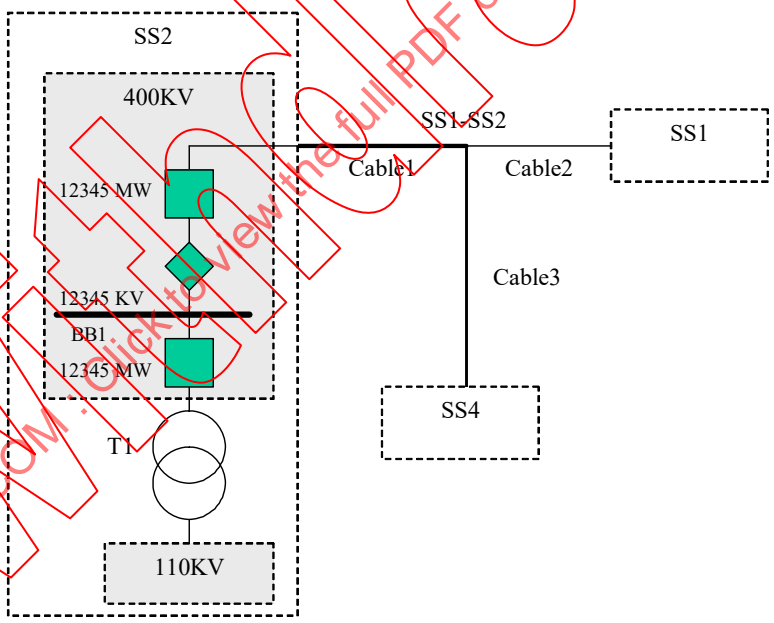


Figure 9 – Simple network example

Figure 10 shows how connectivity is modeled in the CIM as well as one way (but not necessarily the only way) containment is modeled for the diagram in Figure 9 The shaded square boxes represent EquipmentContainers, and the white square boxes represent ConductingEquipment. Darker shading indicates the EquipmentContainer is higher up in the containment hierarchy (i.e. Substation is highest, VoltageLevel next, etc.). White circles represent ConnectivityNodes, and black small circles represent Terminals. A Terminal belongs to a ConductingEquipment, and a ConnectivityNode belongs to an EquipmentContainer. This means that the borders (or contact points) between ConductingEquipment are their Terminals interconnected via ConnectivityNodes.

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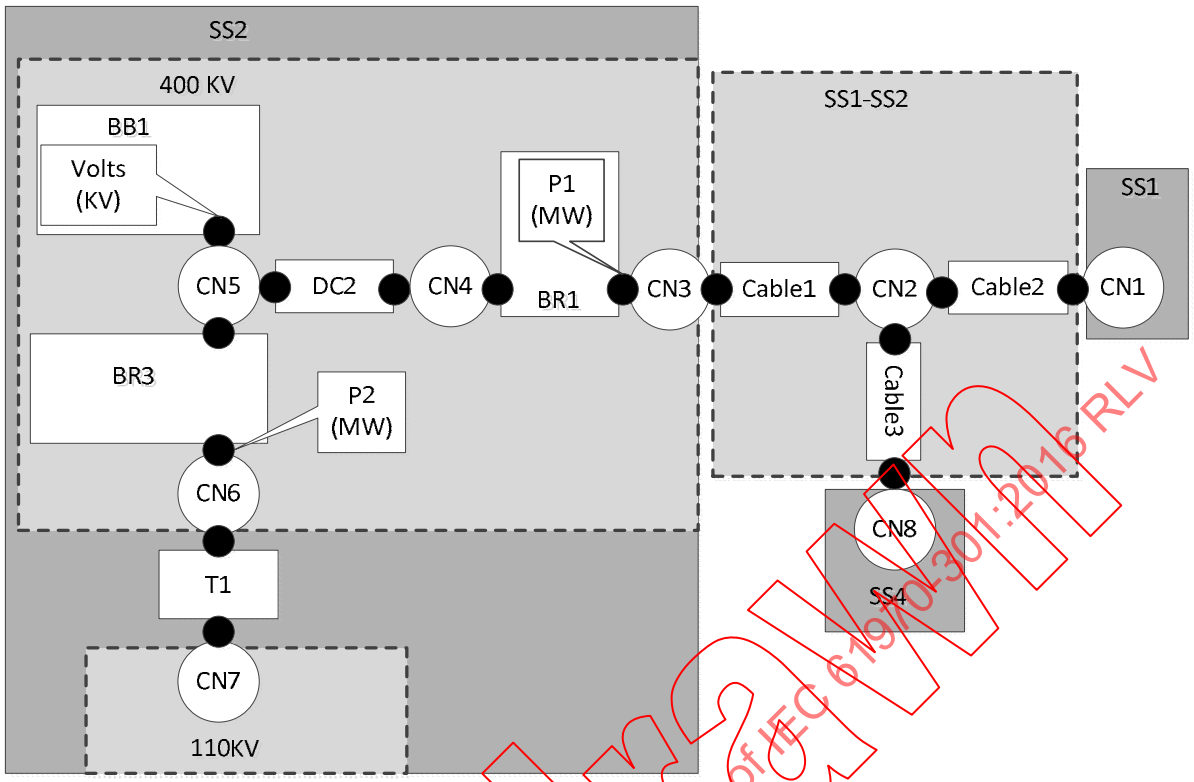


Figure 10 – Simple network connectivity modeled with CIM Topology

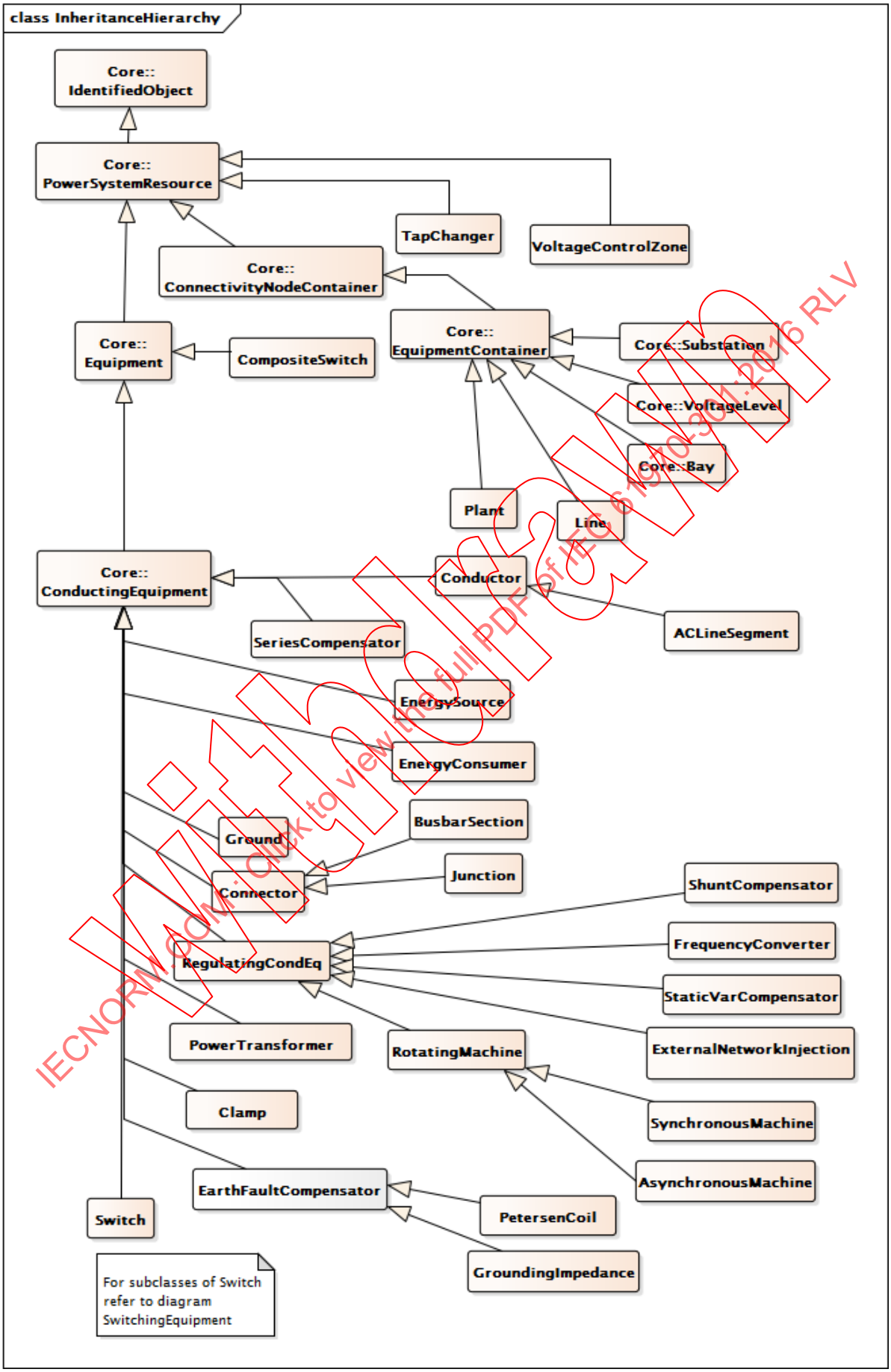
The Line SS1-SS2 contains three ACLineSegments (Cable1, Cable2, and Cable3) and associated ConnectivityNode (CN2) to model a T-junction, which provides a connection to SS4. This represents just one way that this configuration could be modeled. Each ACLineSegment has two Terminals. Cable1 is connected to CN3 and CN2 via these Terminals. CN3 is contained by the VoltageLevel 400 kV. The breaker BR1 has two terminals, one of which is connected to CN3.

Measurements are represented by square callouts where the arrow points to a Terminal. P1 is connected to the right Terminal belonging to Breaker BR1. Note that P1 is drawn inside the box representing BR1. This is because a Measurement may belong to a PowerSystemResource (PSR), as is the case with BR1. P2 is drawn inside the VoltageLevel 400 kV, which means it belongs to the 400 kV VoltageLevel instead of BR3.

4.5.5 Inheritance hierarchy

Figure 11 shows an overview of the inheritance hierarchy modeled in the CIM. This overview, which is included as one of the Wires package diagrams, spans several of the CIM packages.

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Figure 11 – Equipment inheritance hierarchy

4.5.6 Transformer model

Figure 13 shows a portion of the Wires package in a class diagram which models a PowerTransformer device.

The transformer model has been revised from previous versions to allow for use of the same instance model in both balanced and unbalanced models. Additionally the PowerTransformer itself is now a ConductingEquipment with potentially multiple terminals to more directly model transformers with one, two, three, or more terminals. As typical of ConductingEquipment, when in service, the PowerTransformer conducts power from one of its terminals to another.

As shown in Figure 12, the PowerTransformer is also able to optionally model tank details, which can be used to describe in detail the transformer internal winding phase connections and imbalances. In all cases a PowerTransformer models a group of physical devices acting together to transform power among terminals and in one physical location. Often for transmission systems three physical, single phase devices are represented by one PowerTransformer instance. If detail of the individual single phase devices were required, the TransformerTank objects should additionally be modeled.

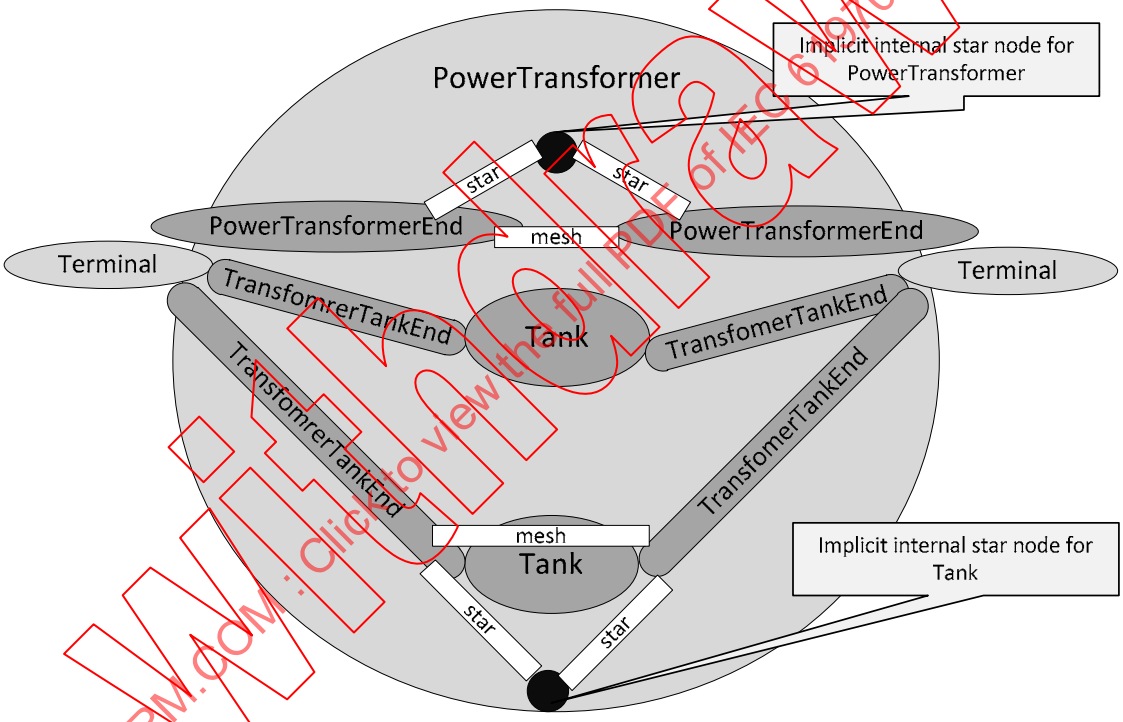


Figure 12 – Transformer and Tank model

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Both a PowerTransformer and a TransformerTank can have impedance described in either an assumed star connection with implied centre connection or with mesh impedance form by using the optional TransformerMeshImpedance class. The mesh form of impedance is required to accurately model transfromers with more than three terminals. If using the mesh impedance form, you would specify a TransformerMeshImpedance class for each possible terminal to terminal connection, thus one instance for two terminals, three for three terminals, and six for four terminals and so on. If using the star connection, the impedance parameters can be specified directly on the PowerTransformerEnd class, or alternatively shared among transformers using the TransformerStarImpedance class.

As shown in Figure 11, a PowerTransformer is a specialized class of ConductingEquipment, which is a specialized class of Equipment. This is shown by the use of the generalization-type of relationship, which uses an arrow to point to the general class. The ConductingEquipment is shown to be a specialized class of Equipment by use of the italic "*Equipment*" class name in the upper right corner. The inheritance permits the PowerTransformer to inherit attributes

from ConductingEquipment, Equipment, and all generalizations of Equipment that are not shown in Figure 11.

A PowerTransformer also has relationships to PowerTransformerEnd and TransformerTank which are modeled with association type relationships. As shown, a PowerTransformer may associate zero or more PowerTransformerEnds, but a PowerTransformerEnd may associate to only zero or one PowerTransformer. Simlarly, the PowerTransformer may associate to zero or more TransformerTank objects, but a TransformerTank may associate to only zero or one PowerTransformer object.

The PowerTransformerEnd specializes the TransformerEnd class which has other relationships as well:

- a generalization relationship with IdentifiedObject;
- two association relationships with the TransformerMeshImpedance class, such that a TransformerEnd object may be “From” 0, 1, or more TransformerMeshImpedance objects and “To” 0, 1, or more TransformerMeshImpedance objects;
- aggregation relationships with the PhaseTapChanger and RatioTapChanger classes, such that a TransformerWinding object may have 0 or 1 PhaseTapChanger objects and 0 or 1 RatioTapChanger objects associated with it.

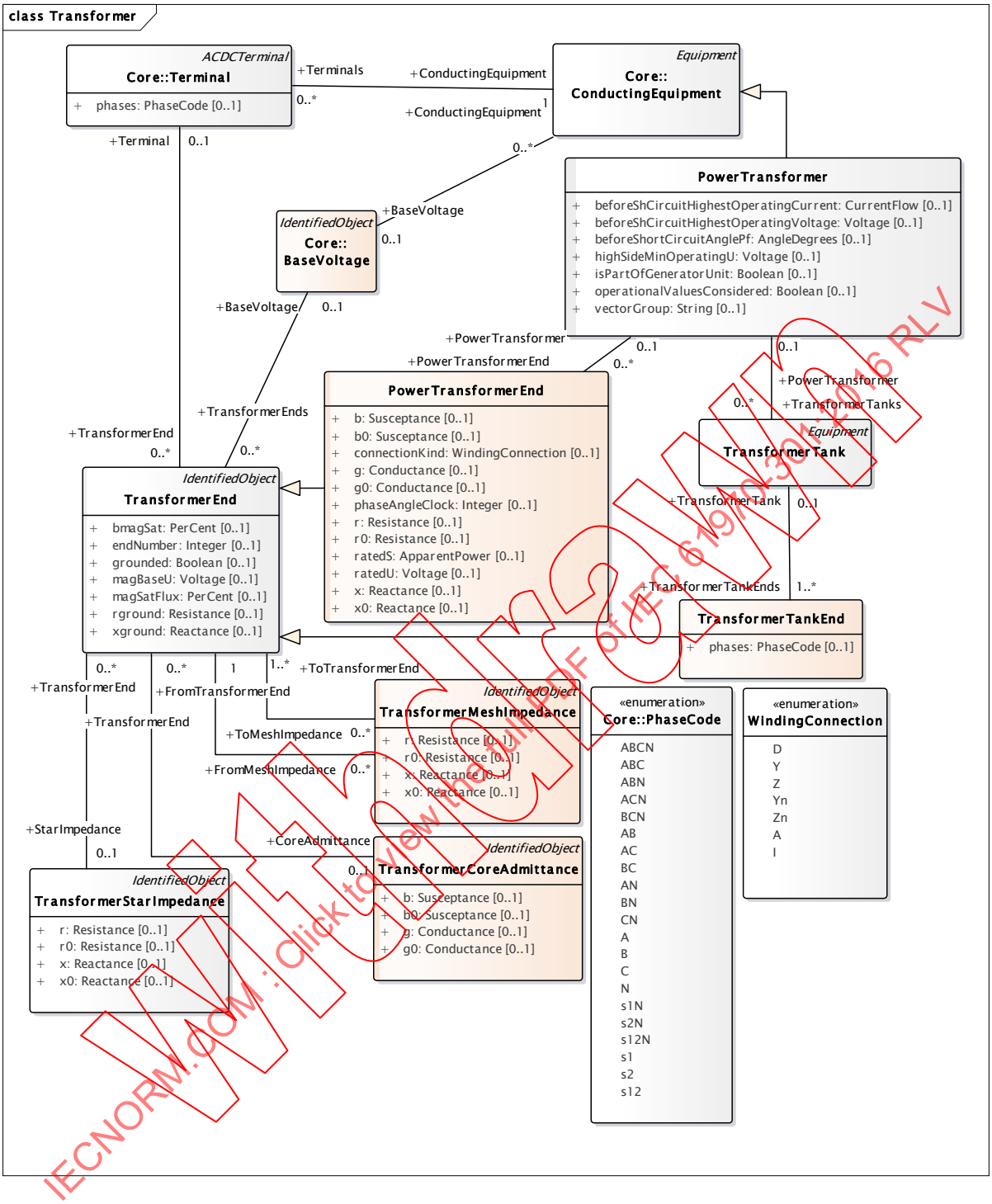
~~Clause 6 contains a complete description of each class in Figure 13 along with the definition of all the attributes and relationships supported in each class.~~

For a transmission network PowerTransfomer that has two or three ends, the equivalent pi-model impedances appear in the PowerTransformerEnd r, r0, x, x0, g, g0, b and b0 attributes. The following rules apply to such a PowerTransformer.

- The PowerTransformerEnd and its connected Terminal both have sequence numbers TransformerEnd.endNumber and ACDCTerminal.sequenceNumber. Those numbers may or may not be in synch.
- The TransformerEnd.endNumber 1 shall always be at the PowerTransformerEnd with the highest rated voltage (PowerTransformerEnd.ratedU).
- In case of a two terminal transformer with same rated voltage (PowerTransformerEnd.ratedU) on both sides, the system where the transformer is defined shall make sure that only one side has TransformerEnd.endNumber equal to 1.
- For a two terminal transformer the PowerTransformerEnd with the end number equal to 1 shall have values specified for r, r0, x, x0, g, g0, b and b0.
- For a two terminal transformer the PowerTransformerEnd with the end number different from 1, the values r, r0, x, x0, g, g0, b and b0 shall be zero.
- For a three terminal transformer each PowerTransformerEnd shall have r, r0, x and x0 values corresponding to that leg's equivalent impedance.
- For a three terminal transformer each PowerTransformerEnd shall have g, g0, b and b0 values corresponding the no load losses distributed on the three PowerTransformerEnds. The total no load loss shunt impedances may also be placed at one of the PowerTransformerEnds, preferably the end number 1, having the shunt values on end 1 is the preferred way.
- For a PowerTransformer with more than three terminals the PowerTransformerEnd impedance values cannot be used. Instead use the TransformerMeshImpedance or split the transformer into multiple PowerTransformers.

Figure 13 shows UML for the transformer model.

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Figure 13 – Transformer model

4.5.7 Transformer tap modeling

4.5.7.1 Generalized tap modeling

Multiple types of transformer tap models are supported by the CIM model. Depending on the physical construction, the effects of tap movement will be defined using either the RatioTapChanger class or the PhaseTapChanger class and its various specializations. The PhaseTapChanger can be specialized into a number of different types representing the physical construction and hence behavior. The attributes of TapChanger are applicable for all the RatioTapChanger specializations. Figure 14 shows the UML model for the transformer taps.

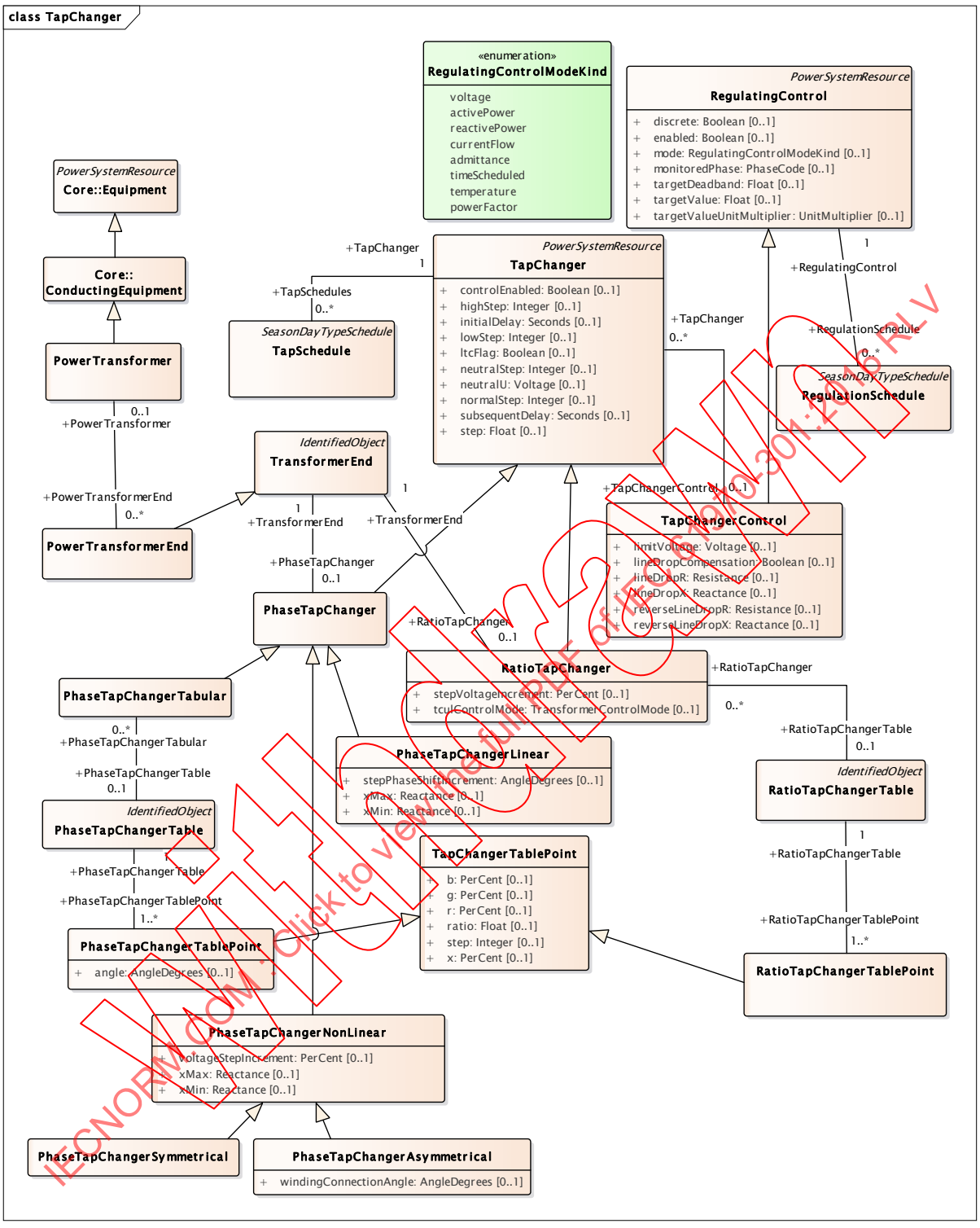


Figure 14 – Transformer tap model

Multiple tap changers can be combined within one power transformer, but it is expected that only one phase shifting and one ratio changing tap changer would be modeled on any given terminal. We document the ratio or phase shift change relative to the other terminal(s) assuming those terminals are at the nominal (1 PU) ratio and nominal (zero) phase angle shift. It is permitted to combine both a phase shifting and ratio tap changer on one terminal, though this practice is discouraged ~~if the asymmetrical transformer model is an appropriate representation~~ to avoid interpretation issues on the order of these tap changers. Tabular representation is preferred in such cases, as it conveys the explicit values of the resulting phases and angles.

Tabular representations for both ratio and phase shifting transformers can be used where the available CIM models do not appropriately reflect the physical behavior. The tabular models are optionall~~y added~~ to the other CIM tap models. ~~It is recommended to use the linear models when adding tabular models.~~ Tabular models may be used ~~on non-linear phase shifter or ratio tap changer devices~~ to describe the change in impedance through the tap range.

In 4.5.7.2 to 4.5.7.7 the various tap changer models are described in more detail.

4.5.7.2 Voltage ratio transformer modeling

The RatioTapChanger class is used to define a transformer tap that changes the voltage magnitude ratio without changing the phase angle across the transformer. A RatioTapChanger may be used in cases the where the transformer inherently introduces a fixed phase shift, such as from a wye-delta winding connection.

4.5.7.3 Voltage ratio transformer tabular modeling

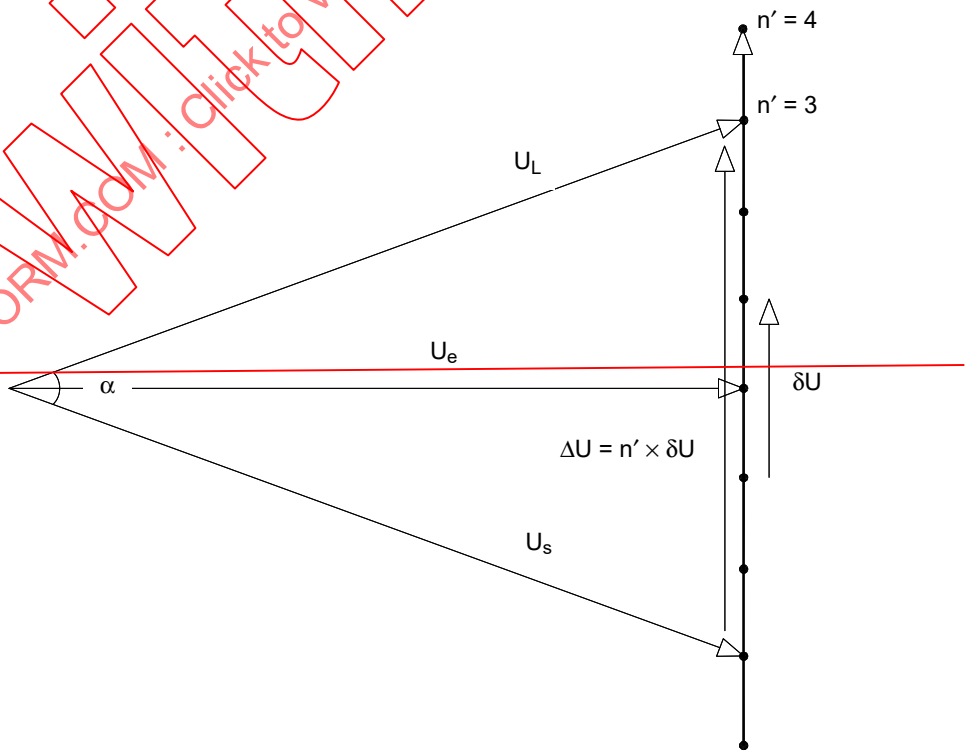
A RatioTapChangerTabular may be optionally associated to any RatioTapChanger and may represent~~s~~ a non-linear relationship between tap number, tap ratio, and impedances. ~~Normally,~~ If associated, the tabular ratio model takes precedence.

4.5.7.4 Linear phase shifter transformer modeling

A phase shifting transformer is linear if the phase shift increment per tap step is uniform and the voltage magnitude is constant over the full range of the tap changer. A linear phase shifter is modeled using the PhaseTapChangerLinear class.

4.5.7.5 Symmetrical and asymmetrical phase shifter modeling

~~A symmetrical phase shifter construction is modeled with a PhaseTapChangerSymmetrical class and changes to voltage magnitude and phase over the full range of tap steps for a symmetrical phase shifter are shown in Figure 15. A symmetrical phase shifter will change the phase angle across the transformer but will not change the voltage ratio.~~



~~Figure 15 – Symmetrical Phase Shifter~~

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~~The phase shift angle can be represented as:~~

$$\alpha = 2\arctan\frac{\Delta U}{2U_e} = 2\arctan\frac{n'\delta U}{2U_e}$$

~~$\rho = 1$~~

~~Where~~

~~α is the phase shift angle, local terminal relative to other nominal terminal;~~
~~n' is the current tap position;~~
~~ΔU is the quadrature voltage change;~~
~~U_e is the voltage at neutral tap;~~
~~δU is the voltage change per tap position;~~
~~ρ is the voltage magnitude transformation ratio, local terminal to other nominal terminal;~~
~~U_L is the local terminal voltage;~~
~~U_S is the system or other terminal voltage.~~

~~The sign of the $n'\delta U$ term is used to indicate the relative phase shift at the associated terminal. If $n'\delta U$ is positive, then the phase angle of the associated terminal is increased. If δU is negative then the phase angle of the associated terminal is decreased.~~

4.5.7.5.1 Symmetrical and asymmetrical phase shifter – common information

Subclause 4.5.7.5 describes Phase-Shifting Transformer (PST) modeling according to the type and technology of the equipment; and more specifically, equivalent series reactance of phase shifters in the positive sequence as a function of the phase shift angle. In these specific models, the resistances and the magnetizing currents are always neglected.

The phase shift transformers within 4.5.7.5 are mapped to CIM classes as described in Table 2.

Table 2 – Mapping of phase shift transformers to CIM classes

Phase shifter type	CIM class
General Case	cim:PhaseTapChangerTabular
Symmetrical phase shifters	cim:PhaseTapChangerSymmetrical or cim:PhaseTapChangerLinear
Asymmetrical phase shifter	cim:PhaseTapChangerAsymmetrical
In-phase transformer and symmetrical phase shifter	cim:PhaseTapChangerSymmetrical and cim:RatioTapChanger
In-phase transformer and asymmetrical phase shifter	cim:PhaseTapChangerAsymmetrical and cim:RatioTapChanger

It is highly recommended to use tabular data to exchange PST parameters (cim:PhaseTapChangerTabular) instead of having to recalculate the parameters per tap according to each model type.

The symbols used in formulas within 4.5.7.5 are mapped to CIM classes as described in Table 3.

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Table 3 – Mapping of symbols used in formulas to CIM attributes

Power Shifter Transformer attribute	CIM attribute
n	cim:PhaseTapChangerTablePoint.step
n_0	cim:TapChanger.neutralStep
δu	cim:PhaseTapChangerNonLinear.voltageStepIncrement
r	cim:TapChangerTablePoint.ratio
α	cim:PhaseTapChangerTablePoint.angle
$\delta\alpha$	cim:PhaseTapChangerLinear.stepPhaseShiftIncrement
$X(\alpha)$	cim:TapChangerTablePoint.x
$X(0)$	cim:PhaseTapChangerLinear.xMin or cim:PhaseTapChangerNonLinear.xMin
$X(\alpha_{max})$	cim:PhaseTapChangerLinear.xMax or cim:PhaseTapChangerNonLinear.xMax
θ	cim:PhaseTapChangerAsymmetrical.windingConnectionAngle

The impedance variation depending on tap position on a phase shift transformer is described in Table 4.

Table 4 – Impedance variations in a phase shift transformer

Equipment type	Equivalent series reactance as a function of the phase shift angle
Symmetrical phase shifters	$X(\alpha) = X(0) + \left(X(\alpha_{max}) - X(0)\right)\left(\frac{\sin(\alpha/2)}{\sin(\alpha_{max}/2)}\right)^2$
Asymmetrical phase shifter	$X(\alpha) = X(0) + \left(X(\alpha_{max}) - X(0)\right)\left(\frac{\tan\alpha}{\tan\alpha_{max}}\frac{\sin\theta - \tan\alpha_{max}\cos\theta}{\sin\theta - \tan\alpha\cos\theta}\right)^2$
In-phase transformer and symmetrical phase shifter	$X(r,\alpha) = X_r(r_{nom})\left(\frac{r}{r_{nom}}\right)^2 + X_\alpha(0) + \left(X_\alpha(\alpha_{max}) - X_\alpha(0)\right)\left(\frac{\sin(\alpha/2)}{\sin(\alpha_{max}/2)}\right)^2$
In-phase transformer and asymmetrical phase shifter	$X(r,\alpha) = X_r(r_{nom})\left(\frac{r}{r_{nom}}\right)^2 + X_\alpha(0)$ $+ \left(X_\alpha(\alpha^0_{max}) - X_\alpha(0)\right)\left(\frac{\tan\alpha}{\tan\alpha_{max}(r)}\frac{\sin\theta - \tan\alpha_{max}(r)\cos\theta}{\sin\theta - \tan\alpha\cos\theta}\right)^2$ with $\alpha_{max}(r) = A\tan\left(\frac{\sin\theta}{\frac{r}{r_{nom}\tan\alpha^0_{max}}\left(\sin\theta - \tan\alpha^0_{max}\cos\theta\right) + \cos\theta}\right)$ and $\alpha^0_{max} = \alpha_{max}(r_{nom})$

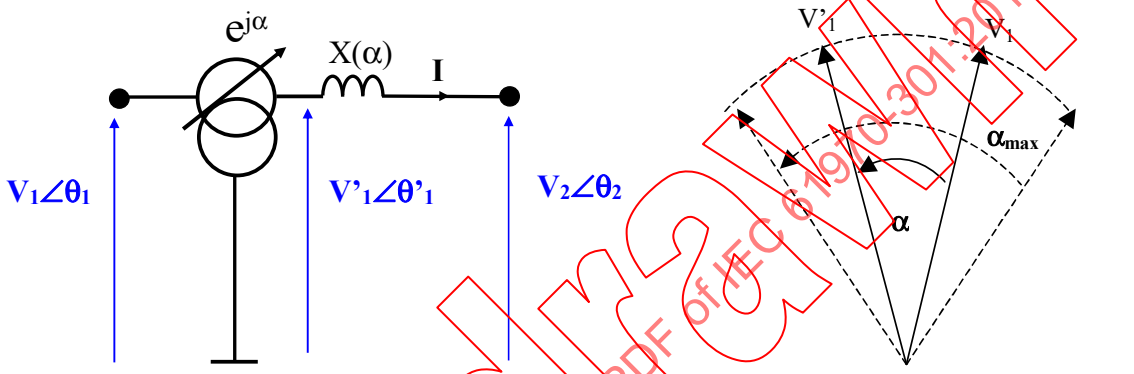
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Table 5 – Description of variables

Variable	Meaning
α_{max}	Maximal phase shift: the maximum angle value of the phase shifter angles table
r_{nom}	Nominal ratio of the in-phase transformer
α^0_{max}	Maximal phase shift when the in-phase transformer ratio is nominal

4.5.7.5.2 Symmetrical phase shifters

Phasor diagram and equations are shown in Figure 15.



$$V_2 = V_1 e^{j\alpha} - jX(\alpha)I \qquad V'_1 = V_1\left(1 + 2j\sin\frac{\alpha}{2}e^{j\frac{\alpha}{2}}\right) = e^{j\alpha}V_1$$

Figure 15 – Phasor diagram and equations

Expression of the angle and ratio per tap

Based on Figure 15:

$$\alpha = (n - n_0)\cdot\delta\alpha \quad \text{or} \quad \alpha = 2A\tan\left(\frac{(n - n_0)\cdot\delta u}{2}\right)$$

$$r = 1$$

Expression of the equivalent series reactance given the angle

Assuming the reactance of the regulating winding varies as the square of the number of turns, the equivalent reactance can be written as follows for non delta-hexagonal technologies.

$$X(\alpha) = X(0) + \left(X(\alpha_{max}) - X(0)\right)\left(\frac{\sin(\alpha/2)}{\sin(\alpha_{max}/2)}\right)^2$$

Parameters:

α_{max} maximal phase shift

$X(0)$ equivalent series reactance at zero phase shift $\alpha = 0$

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$X(\alpha_{max})$ equivalent series reactance at maximal phase shift $\alpha = \alpha_{max}$

Variable:

α current phase shift

The formula above is valid for single or double core symmetrical phase shifters except for the hexagonal technology.

For single core symmetrical phase shifters: $X(0) = 0$. An example of impedance variation is shown in Figure 16.

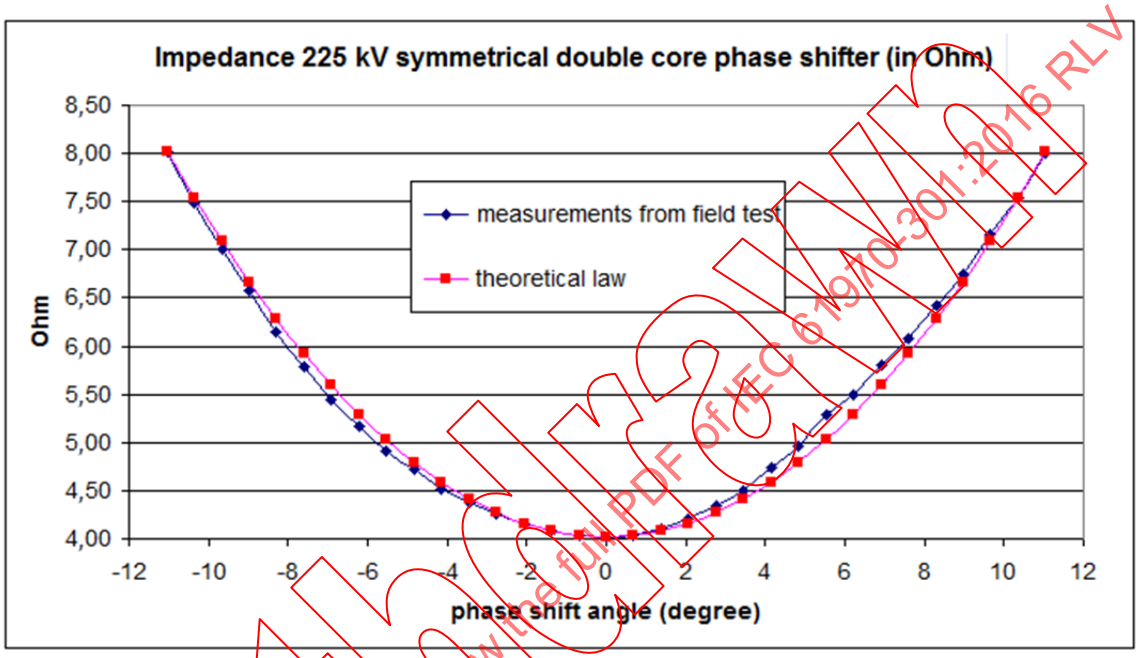
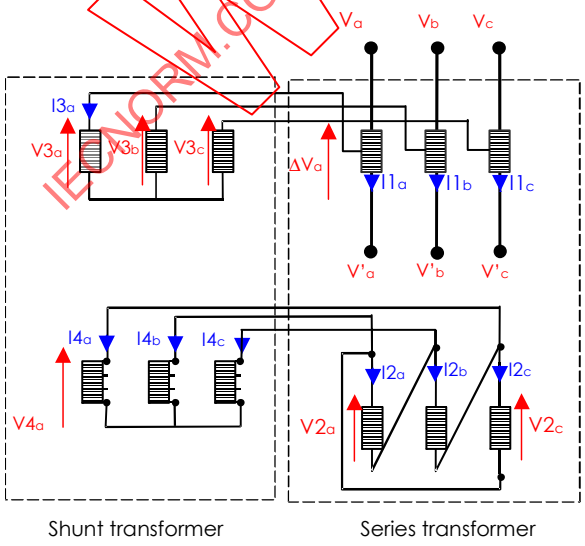


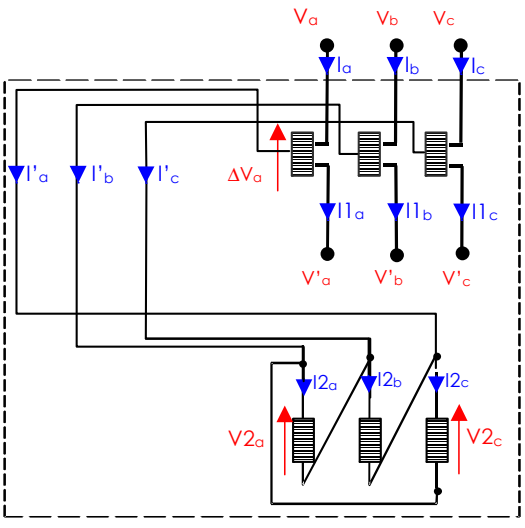
Figure 16 – Symmetrical phase shifter impedance variation

Three-phase core organization is shown in Figure 17.

Dual core:



Single core:



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Single core, delta hexagonal:

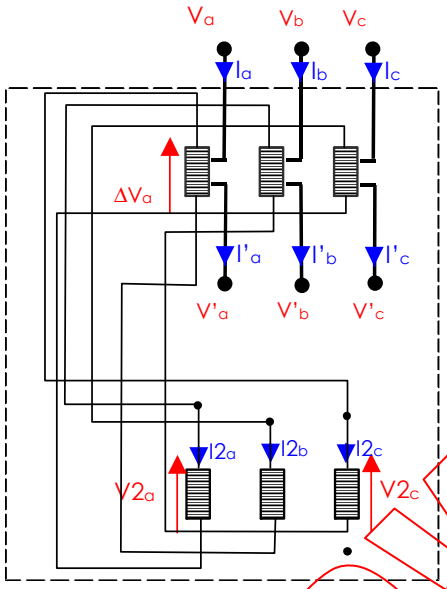
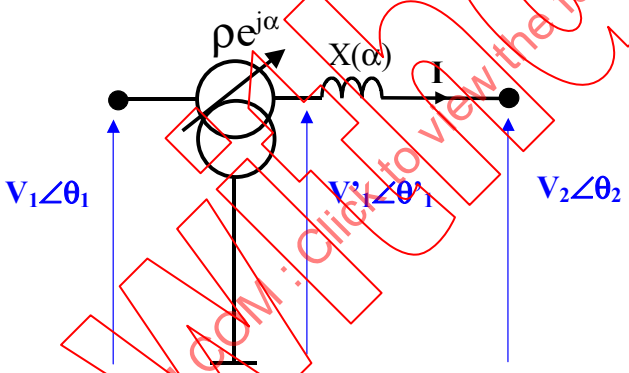
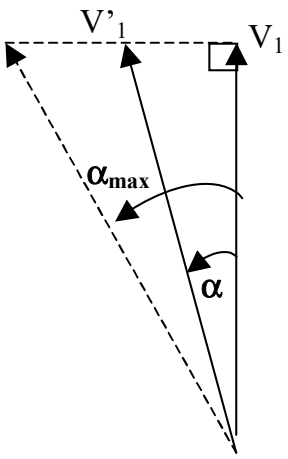


Figure 17 – Core organization

4.5.7.5.3 Quadrature booster

Phasor diagram and equations are shown in Figure 18.





$$V'_1 = V_1(1 + j\tan\alpha) = \rho e^{j\alpha} V_1 \qquad V_2 = V_1 \rho e^{j\alpha} - jX(\alpha)I$$

ρ and α vary with $\rho\cos\alpha$ = constant.

Figure 18 – Phasor diagram and equations

Expression of the angle and ratio per tap

Based on Figure 18:

$$\alpha = A\tan((n - n_0)\cdot\delta u)$$

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$$r = \frac{1}{\sqrt{((n - n_0) \cdot \delta u)^2 + 1}}$$

Expression of the equivalent series reactance given the angle

Assuming the reactance of the regulating winding varies as the square of the number of turns, the equivalent reactance of the quadrature booster can be written as follows.

$$X(\alpha) = X(0) + (X(\alpha_{max}) - X(0)) \left(\frac{\tan(\alpha)}{\tan(\alpha_{max})} \right)^2$$

Parameters:

α_{max} maximal phase shift

$X(0)$ equivalent series reactance at zero phase shift

$X(\alpha_{max})$ equivalent series reactance at maximal phase shift

Variable:

α current phase shift

For quadrature boosters with a single core: $X(0) = 0$

Three-phase core organization is shown in Figure 19.

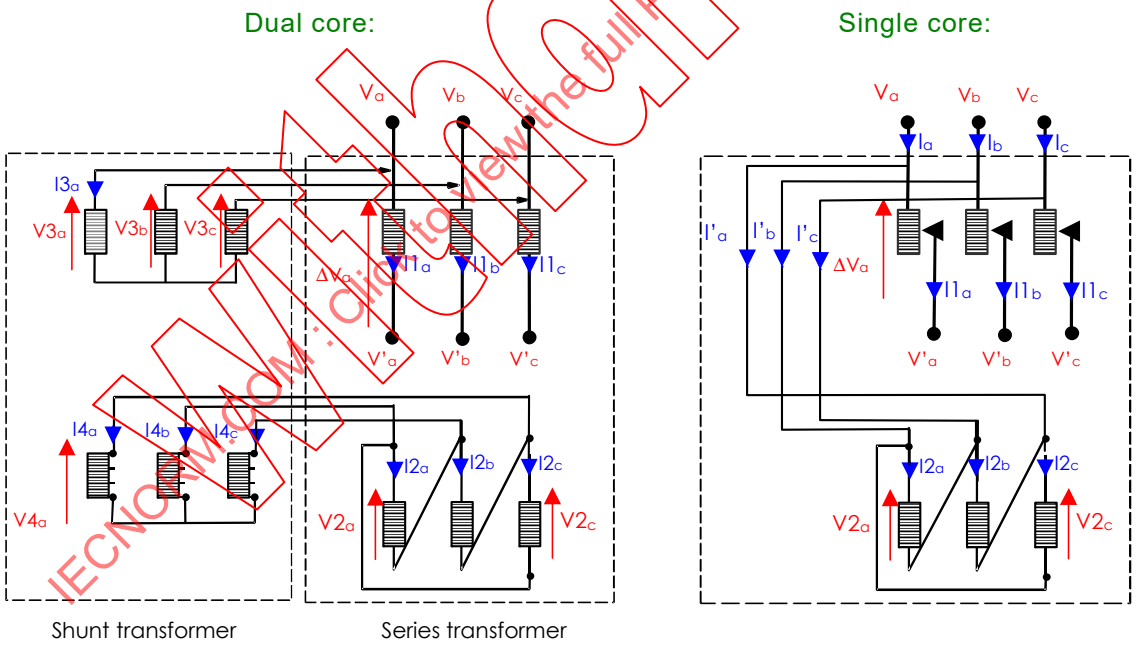


Figure 19 – Core organization

4.5.7.5.4 Asymmetrical phase shifter modeling

~~An asymmetrical phase shifter construction causes the voltage ratio to change as the phase shift changes. The changes to voltage magnitude and phase over the full range of tap steps for an asymmetrical phase shifter is shown in Figure 16 below.~~

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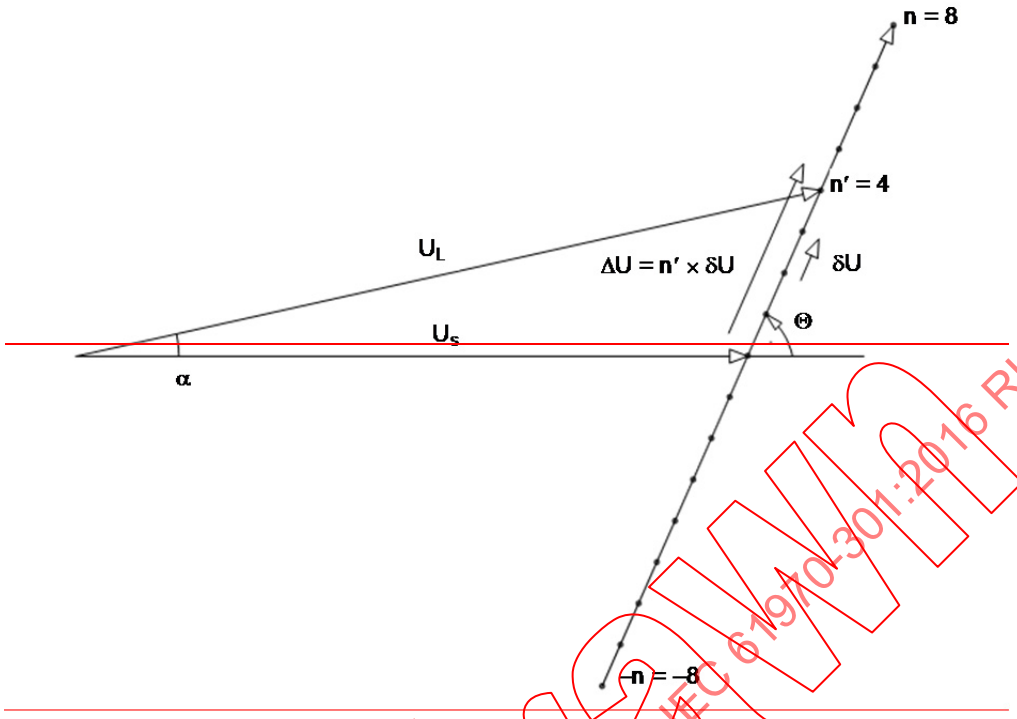


Figure 16 – Asymmetrical Phase Shifter

The phase shift angle can be represented as:

$$\alpha = \arctan\left(\frac{n'\delta U \sin\Theta}{Us + n'\delta U \cos\Theta}\right)$$

$$\rho = \frac{Us}{\sqrt{(n'\delta U \sin\Theta)^2 + (Us + n'\delta U \cos\Theta)^2}}$$

Where

α is the phase shift angle, local terminal relative to other nominal terminal;

n' is the current tap position;

δU is the voltage change per tap position;

Θ is the winding connection angle;

ρ is the voltage magnitude transformation ratio, local terminal to other nominal terminal;

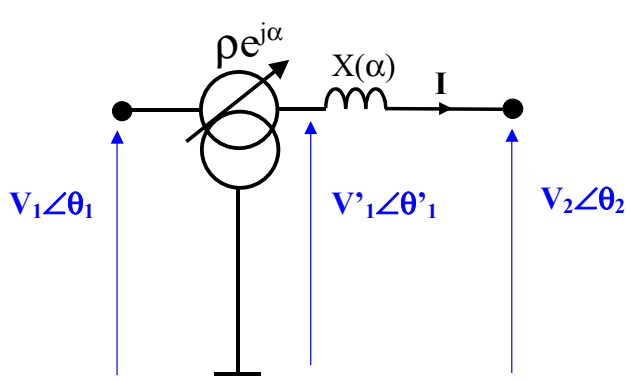
U_L is the local terminal voltage;

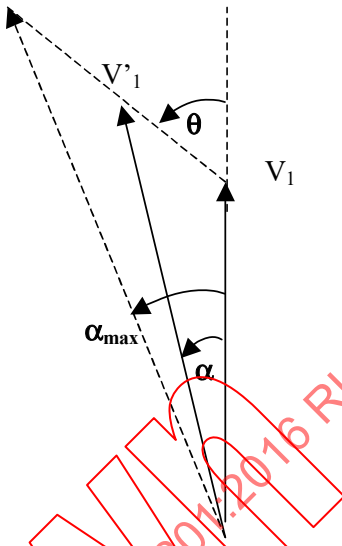
U_S is the system or other terminal voltage.

An asymmetrical phase shifter is modeled with the PhaseTapChangerAsymetrical class. The PhaseTapChanger.windingConnectionAngle shall be a multiple of 30 degrees: –90°, –60°, –30°, 30°, 60°, 90°, etc.). An asymmetrical phase shifter with a 90° winding connection angle is not the same as a symmetrical phase shifter.

Phasor diagram and equations are shown in Figure 20.

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$$V'_1 = V_1\left(1 + e^{j\theta}.\frac{\tan\alpha}{\sin\theta - \tan\alpha\cos\theta}\right) = \rho e^{j\alpha}V_1 \qquad V_2 = V_1.\rho e^{j\alpha} - jX(\alpha)I$$

θ is fixed, only α and ρ vary.

Figure 20 – Phasor diagram and equations

Expression of the angle and ratio per tap

Based on Figure 20:

$$\alpha = A\tan\left(\frac{(n-n_0)\cdot\delta u\cdot\sin\theta}{1+(n-n_0)\cdot\delta u\cdot\cos\theta}\right)$$

$$r = \frac{1}{\sqrt{((n-n_0)\cdot\delta u\cdot\sin\theta)^2 + (1+(n-n_0)\cdot\delta u\cdot\sin\theta)^2}}$$

Expression of the equivalent series reactance given the angle

Assuming the reactance of the regulating winding varies as the square of the number of turns, the equivalent reactance can be written as follows.

$$X(\alpha) = X(0) + (X(\alpha_{max}) - X(0))\left(\frac{\tan\alpha}{\tan\alpha_{max}}\frac{\sin\theta - \tan\alpha_{max}\cos\theta}{\sin\theta - \tan\alpha\cos\theta}\right)^2$$

Parameters:

α_{max}	maximal phase shift
$X(0)$	equivalent series reactance at zero phase shift
$X(\alpha_{max})$	equivalent series reactance at maximal phase shift
θ	boost voltage angle

Variable:

α	current phase shift

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Three-phase organizations are shown in Figure 21.

Dual core:

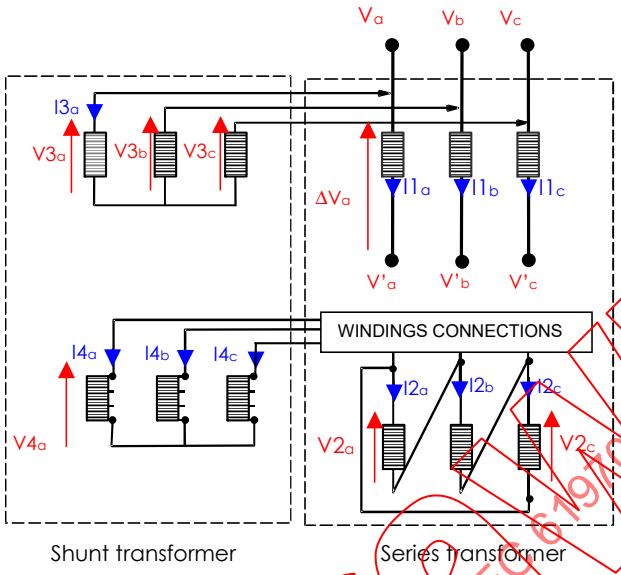
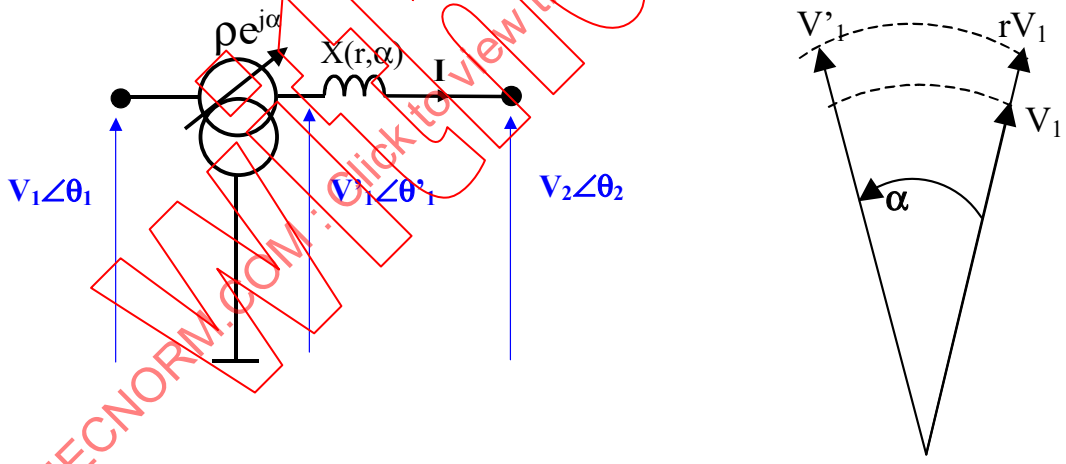


Figure 21 – Core organization

4.5.7.5.5 In-phase transformer and symmetrical phase shifter

Phasor diagram and equations are shown in Figure 22.



$$V_2 = \rho V_1 e^{j\alpha} - jX(\alpha)I.$$

$$V'_1 = rV_1\left(1 + 2j\sin\frac{\alpha}{2}e^{j\frac{\alpha}{2}}\right) = \rho e^{j\alpha}V_1$$

r and α vary, and $\rho = r$.

Figure 22 – Phasor diagram and equations

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Expression of the angle and ratio per tap

Same as 4.5.7.5.2 with the addition of the in-phase transformer ratio *r*.

Equivalent series reactance given the angle and the in-phase transformer ratio

Assumptions:

- The reactance of the regulating winding varies as the square of the number of turns.
- The equivalent reactance is the sum of the reactance of the in-phase transformer X_r and the reactance of the phase shifter part X_α.
- The phase shifting angle α does not depend on the in-phase ratio *r*.

The equivalent reactance can be written as follows:

$$X(r,\alpha) = X_r(r_{\text{nom}})\left(\frac{r}{r_{\text{nom}}}\right)^2 + X_\alpha(0) + \left(X_\alpha(\alpha_{\max}) - X_\alpha(0)\right)\left(\frac{\sin(\alpha/2)}{\sin(\alpha_{\max}/2)}\right)^2$$

Parameters:

r_{nom} nominal ratio of the in-phase transformer

$X_r(r_{\text{nom}})$ equivalent series reactance of the in-phase transformer at nominal in-phase ratio

$\alpha_{\max}$ maximal phase shift

$X_\alpha(0)$ equivalent series reactance of the phase shifter part at zero phase shift

$X_\alpha(\alpha_{\max})$ equivalent series reactance of the phase shifter part at maximal phase shift at nominal in-phase ratio (r_{nom})

Variables:

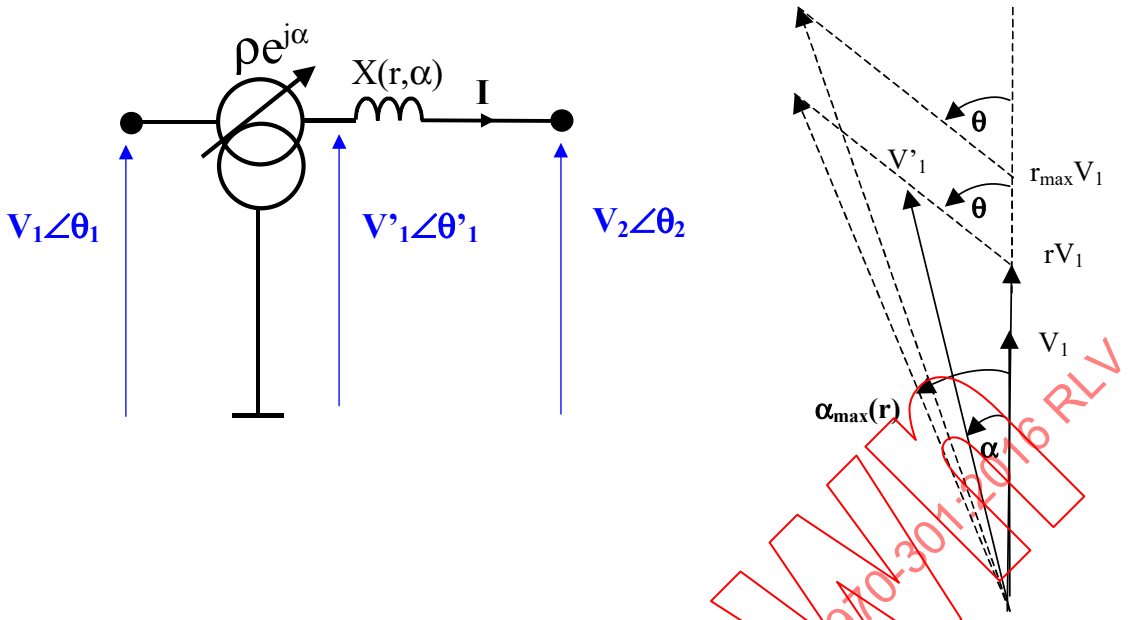
r current ratio of the in-phase transformer

α current phase shift

4.5.7.5.6 In-phase transformer and asymmetrical phase shifter

Phasor diagram and equations are shown in Figure 23.

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$$V'_1 = rV_1\left(1 + e^{j\theta}.\frac{\tan\alpha}{\sin\theta - \tan\alpha\cos\theta}\right) = \rho e^{j\alpha}V_1 \qquad V_2 = (V_1 - jX(\alpha)I)\rho e^{j\alpha}$$

θ is fixed, only r and α are variables, ρ varies as a consequence.

Figure 23 – Phasor diagrams and equations

Equivalent series reactance given the angle and the in-phase transformer ratio

Assumptions:

- The reactance of the regulating winding varies as the square of the number of turns.
- The equivalent reactance is the sum of the reactance of the in-phase transformer X_r and the reactance of the phase shifter part X_α.

The equivalent series reactance can be written as follows:

$$X(r,\alpha) = X_r(r_{nom})\left(\frac{r}{r_{nom}}\right)^2 + X_\alpha(0) + \left(X_\alpha(\alpha^0_{max}) - X_\alpha(0)\right)\left(\frac{\tan\alpha}{\tan\alpha_{max}(r)}\frac{\sin\theta - \tan\alpha_{max}(r)\cos\theta}{\sin\theta - \tan\alpha\cos\theta}\right)^2$$

with $\alpha_{max}(r) = A\tan\left(\frac{\sin\theta}{\frac{r}{r_{nom}\tan\alpha^0_{max}}\left(\sin\theta - \tan\alpha^0_{max}\cos\theta\right) + \cos\theta}\right)$ with $\alpha^0_{max} = \alpha_{max}(r_{nom})$

Parameters:

r_{nom}	nominal ratio of the in-phase transformer
$X_r(r_{nom})$	equivalent series reactance of the in-phase transformer at nominal in-phase ratio r_{nom}
θ	fixed boost voltage angle
$\alpha^0_{max} = \alpha_{max}(r_{nom})$	maximal phase shift for nominal in-phase ratio (r_{nom})
$X_\alpha(0)$	equivalent series reactance of the phase shifter part at zero phase shift

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$X_\alpha(\alpha^0_{max})$ equivalent series reactance of the phase shifter part at maximal phase shift at nominal in-phase ratio (r_{nom})

Variables:

r current ratio of the in-phase transformer

α current phase shift

For $\theta = \pi/2$ (quadrature booster): $\alpha_{max}(r) = A\tan\left(\frac{r_{nom}}{r}\tan\alpha^0_{max}\right)$

Three-phase organization is shown in Figure 24.

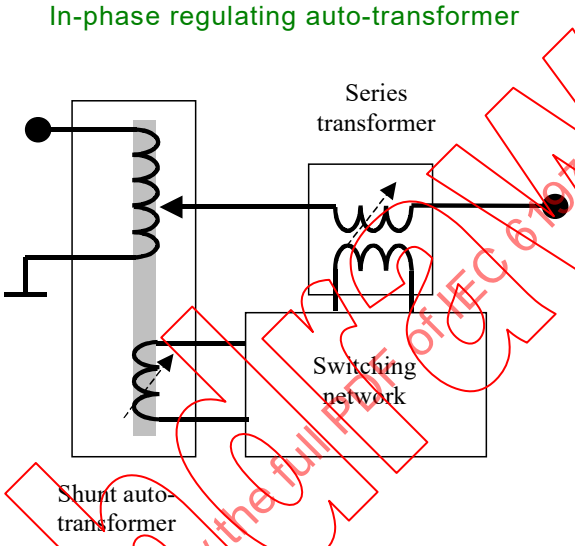


Figure 24 – Core organization

The phase shift regulation may be on the shunt or on the series transformer.

4.5.7.6 Phase shifter transformer tabular modeling

~~A PhaseTapChangerTabular may be optionally associated to any PhaseTapChanger and represents a non-linear relationship between tap number, phase shift, and impedances. A PhaseTapChangerTabular may be used to describe only the impedance change over the range of the tapchanger. Under these circumstances, the phase shift attribute is null or omitted. Normally, if associated, the tabular phase shifter model takes precedence.~~

A PhaseTapChangerTabular is an explicit tabular representation of the phase shift, ratio and impedance change over the range of the tap changer. The PhaseTapChangerTabular may be associated with PhaseTapChangerTable representing a non-linear relationship between tap number, phase shift, ratios and impedances.

4.5.7.7 Tap changer control

Control of tap changers in a power flow type of application is made using the TapChangerControl class and the TapChanger.ltcFlag. If a TapChanger has a TapChangerControl (referenced TapChanger.TapChangerControl), this means that the power flow application may control the tap changer. The TapChanger.ltcFlag provides information that the TapChanger has physical capability to move the tap under load. Also used in the IEC 60909 calculations to indicate if the tap can move on load.

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The meaning of the combinations for TapChanger.TapChangerControl and TapChanger.ltcFlag are described in Table 6.

Table 6 – Tap changer control options

TapChanger. ltcFlag	TapChanger. TapChangerControl	Description
False	Not present	A real and fixed tap that is not controlled and cannot be moved on load (manual tap change). Power flow cannot be set to change the tap for voltage control during the calculation.
True	Not present	A real and fixed tap that is not controlled but can be moved under load, e.g. manually. Power flow cannot be set to change the tap for voltage control during the calculation. Optimal power flow might have access to these taps and change in order to optimize. Also State Estimator may estimate the tap position to find a better solution for the system state.
True	Present	A real tap with a possibility to change taps automatically for voltage control/active power (load flow) enabled. Depending on the RegulatingControl.enabled and TapChanger.controlEnabled in SSH, the power flow shall or shall not participate in the regulation. In cases where the RegulatingControl is associated with more than one tap changer or other devices, the attribute TapChanger.controlEnabled can be set to false in order to set which of the taps are not enabled.
False	Present	An artificial tap changer can be used to simulate control behavior in power flow.

4.5.8 Phase wire modeling

The CIM models provide a means to specify equivalent single-line representation of balanced three phase networks or to additionally and optionally specify individual phase detail. In single phase networks there is a direct correspondence between Terminal objects and physical wire connections. In the single-line representation of balanced three phase networks we use one Terminal to represent the group of coordinating phase connections. Thus one Terminal can be used to specify one or more coordinated phase connections using the Terminal.phases attribute which is of enumeration type PhaseCode. PhaseCode has the possible phase connection combinations of ABC, ABCN, AB, BC, CA, A, B, C and so forth. The specification of phases at each terminal allows for modeling jumpers or switches that connect different phases. This phase connectivity specification is intended as a nominal or normal phase specification. The result of energization source is not reflected in this specification. This phase specification provides a means to locally connect like phases. Figure 25 show the phase wire data model.

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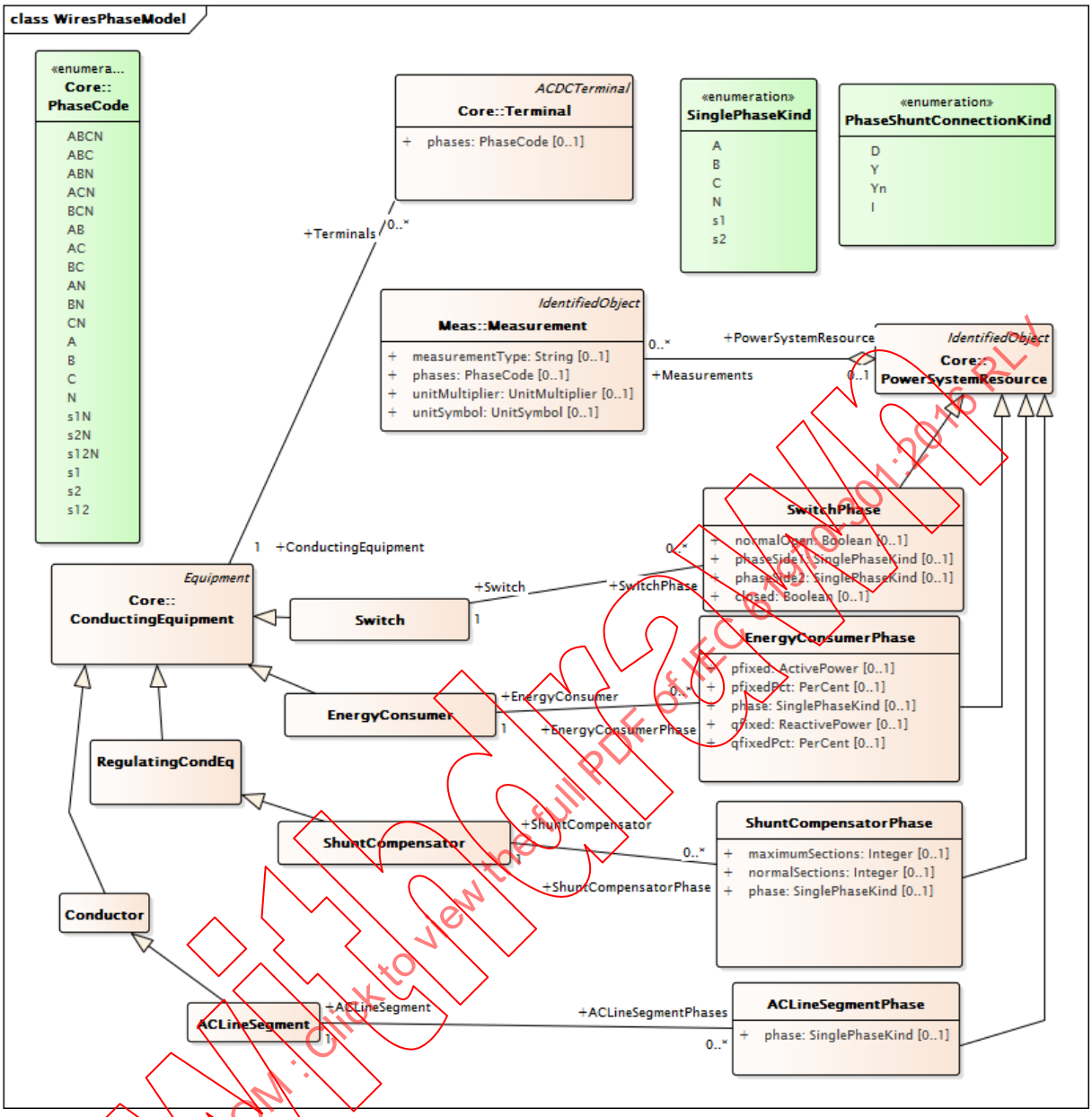


Figure 25 – Phase wire data model

Figure 26 provides an example for specifying phase connections. This example shows a ConnectivityNode instance on the left with A, B, and C phases implied. Note that ConnectivityNode does not specify its phase content but rather implicitly connects like phases of terminals associated to the ConnectivityNode. The example shows a two phase jumper connecting on the left (Terminal.sequenceNumber=1) phases A and C and on the right (Terminal.sequenceNumber=2) phases A and B, with the internals of the jumper model SwitchPhase objects which specify in detail how the phase connections route. The Terminal.phases attribute only specifies the external connection of a device. Continuing to the right, two line segments are connected. The upper line segment is a two phase line on phases A and B. The lower line segment is single phase on phase B. The dark lines indicate CIM associations while the lighter arrows indicate the represented electrical connections at the phase level.

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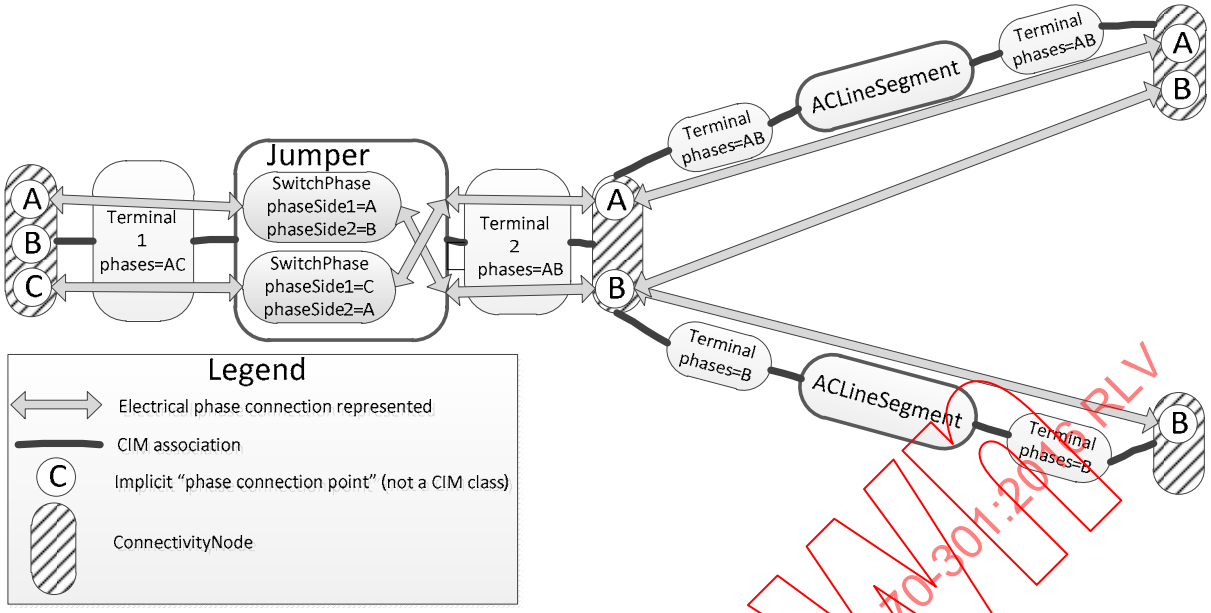


Figure 26 – Phase connectivity

As a clarification, the SwitchPhase attribute named phaseSide1 specifies any single phase (such as A, B, C, or N) and refers to the Terminal with sequenceNumber equal to 1. The SwitchPhase attribute named phaseSide2 refers to the Terminal with sequenceNumber equal to 2.

The switch model allows for cross phase connections to be modeled in general within the device. The transformer model also has explicit internal device modeling of phase connectivity. At this time all other ConductingEquipment branch specializations such as ACLineSegment assume like phases connect at both terminals. The CIM model is open for future extensions to introduce internal device phase connectivity.

4.5.9 Grounding devices modeling

4.5.9.1 Use case for modeling grounding devices.

These devices have significant impact on short circuit currents for unbalanced faults. The devices are switched around in operation with switches when transformer to line switching is reconfigured. Additionally Petersen coils are "tuned" to match the charging current expected from unbalanced faults. The impedance of Petersen coils can be "tuned" by adjusting a step position like a tap. This step position is telemetered sometimes. Sometimes a linear model is sufficient for relating step position to impedance value and sometimes a table is needed to reflect the non-linear relationship between step position and impedance.

4.5.9.2 Background and example

A Petersen coil is a grounding reactor, used in alternating-current power transmission systems, designed to limit the current flowing to ground at the location of a fault by setting up a reactive current to ground that balances the capacitive current to ground flowing from the lines. A design example is given in Figure 27.

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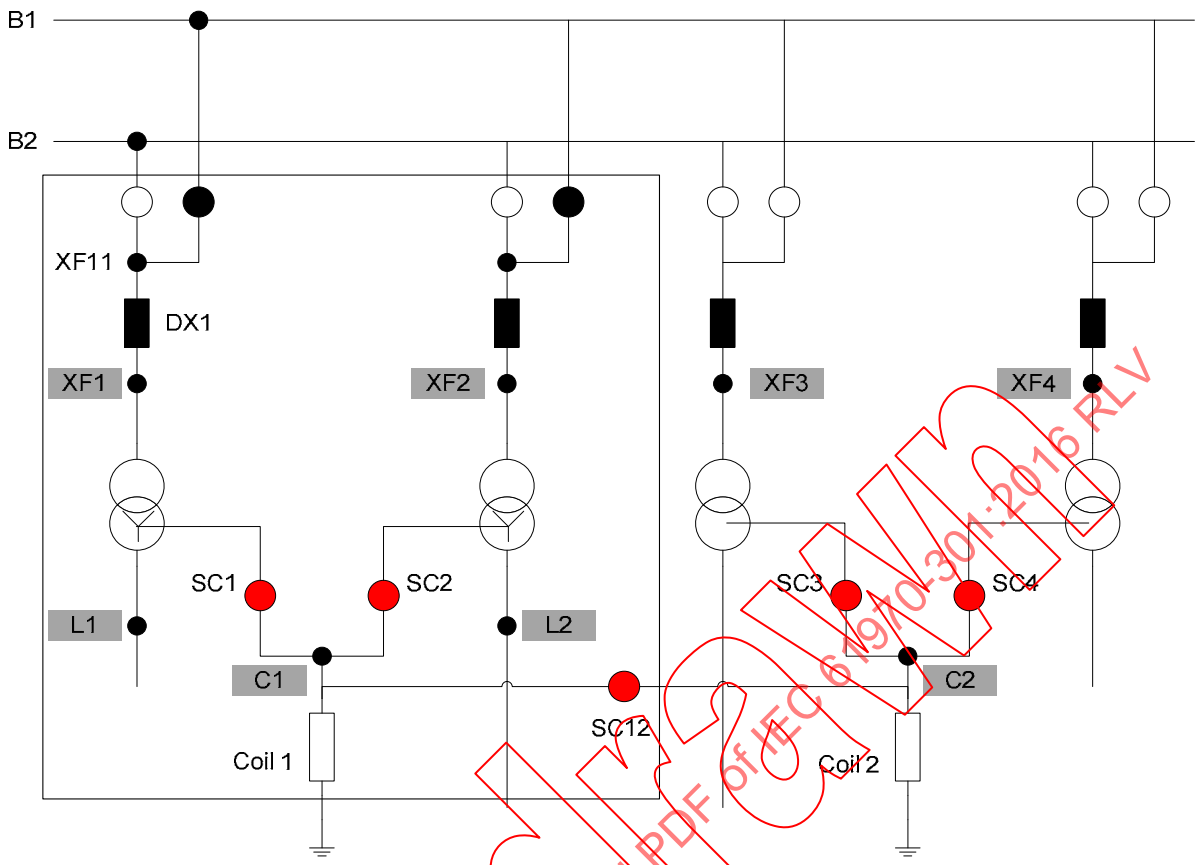


Figure 27 – Station including Petersen coils drawing example

In the example above, SC1, SC2, SC3, SC4 and SC12 are the ground circuit disconnectors. B1and B2 are busbar sections. XF1, XF2, XF3, XF4, C1, C2, L1 and L2 are connectivity nodes.

The grounding point in a transformer is the midpoint of the Y-connected windings and the ground circuit disconnectors are connected to these midpoints. In CIM the midpoint is described by the phasing attribute of the Terminal at the Y-connected windings. This means that ground circuit switches are connected to the connectivity node at the Terminal with the Y-connected windings. In Figure 27 this means SC1 is connected to L1 and SC2 is connected to L2 and that L1/L2 has the phases ABC as well as the N phase for the midpoint.

4.5.9.3 Model

The EarthFaultCompensator is a type of abstract conducting equipment intended to model grounding equipment. The EarthFaultCompensator is a specialization of ConductingEquipment because a short circuit requires proper connections and various switches may open or close to change the topology configuration. This is not the same thing as a branch like ACLineSegment, ShuntCompensator, or PowerTransformer; it does not regulate voltage and is never connected to Y or delta. A zig-zag grounding transformer is still a PowerTransformer, because of all the other complexities of the transformer. Two specializations are proposed to handle fixed impedance devices (GroundingImpedance) and adjustable (tunable) Petersen coil devices (PetersenCoil).

The EarthFaultCompensator could have either one or two terminals modeled. If the second terminal of an EarthFaultCompensator is omitted, it is assumed the terminal solidly connects to ground. If there is some kind of topology or local earth resistivity that is important to model on the ground side of the device, then a second terminal is added.

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A separate class for ground disconnector (GroundDisconnector) is included since these are typically physically very different from most other switches and often excluded from normal power flow analysis. For the data model refer to Figure 28.

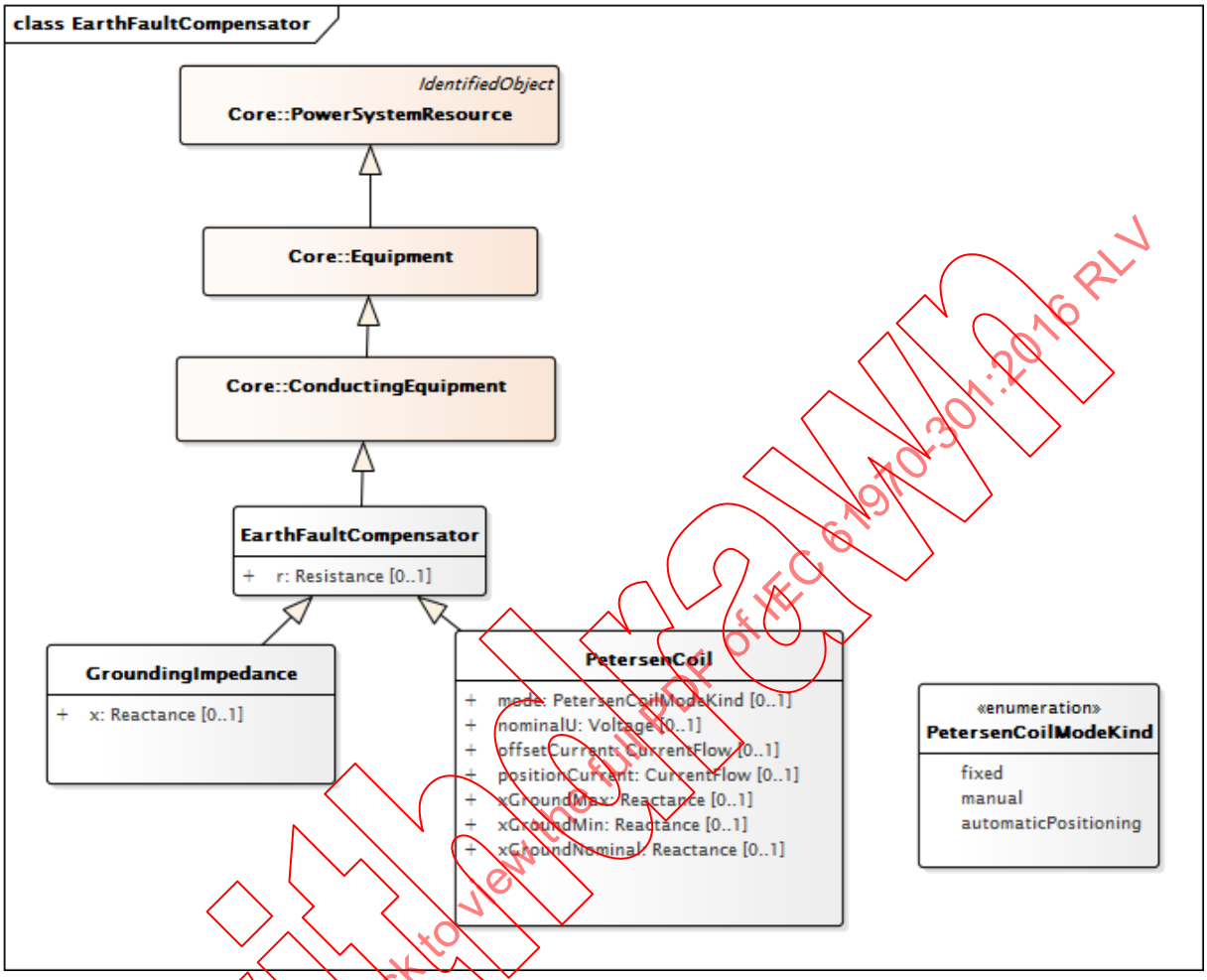


Figure 28 – Grounding device data model

4.5.9.4 CIM Instance model example

In Figure 29 the PetersenCoil is modeled as CIM objects with only one terminal and the grounding is implicit, which are a part of Figure 27.

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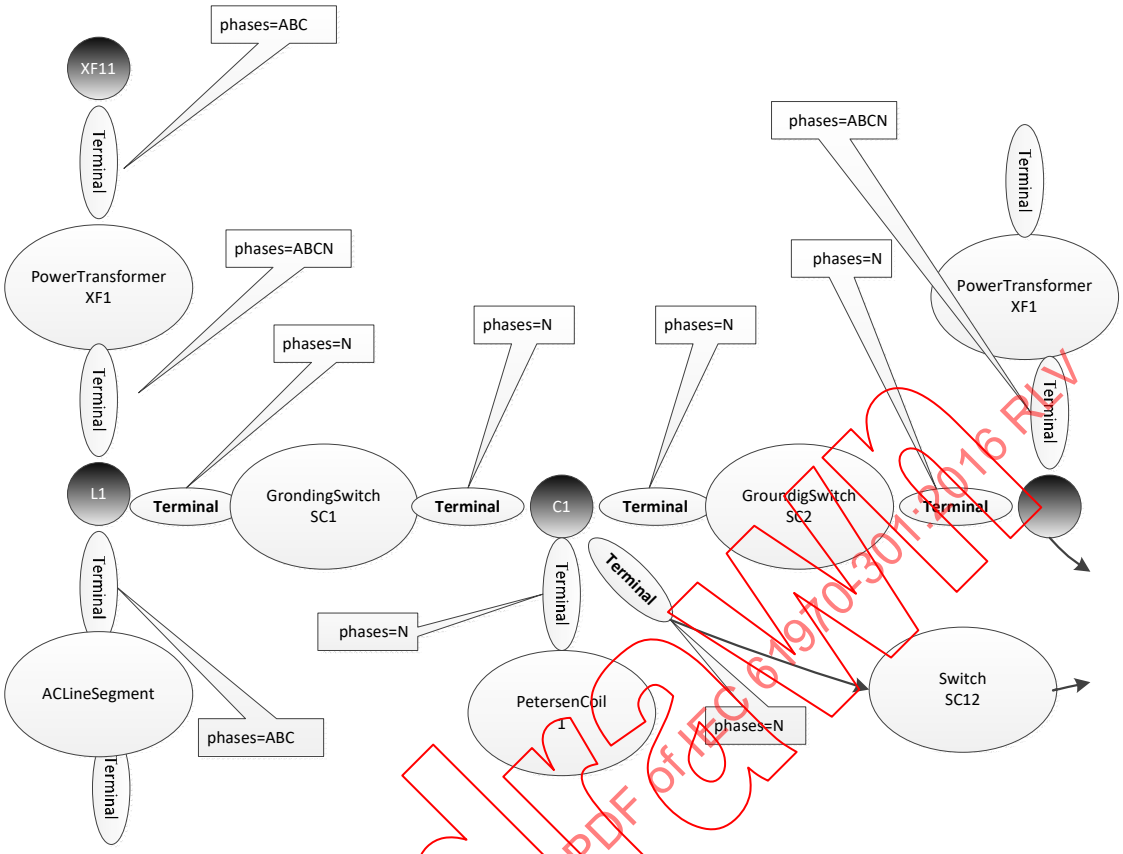


Figure 29 – Instance diagram objects with one terminal coil

Figure 29 shows how the switch SC1 has a Terminal with N phase and the transformer Terminal connected to L1 has the phases ABCN.

4.5.10 Cuts, clamps and jumpers model

The UML model for cuts and jumpers on a line segment and the additional connections are described in Figure 30. The Jumper class is a specialization of the more general Switch class and provides for phase crossings and phase connectivity as was illustrated in Figure 26. The jumpers therefore can connect terminals in the normal manner. The CIM classes Cut and Clamp provide a means to effectively add Terminals to an ACLineSegment at a specified distance down the line by associating new CIM objects to an ACLineSegment object, without other modification of ACLineSegment as-built model. Each Clamp instance introduces one new terminal connected at the specified distance down the line and without interruption of the line. Each Cut instance introduces two new terminals which are effectively the ends of the cut. By convention, each terminal of a cut is oriented toward the ACLineSegment terminal with the same sequenceNumber. If the cut is open, no flow passes through the ACLineSegment across the point of the cut, but flow can pass through either side of the ACLineSegment and through the appropriate cut terminal. Commonly, jumpers are connected to the ends of cuts, but they can also be connected to any type of conducting equipment in the normal manner using ConnectivityNode or TopologicalNode.

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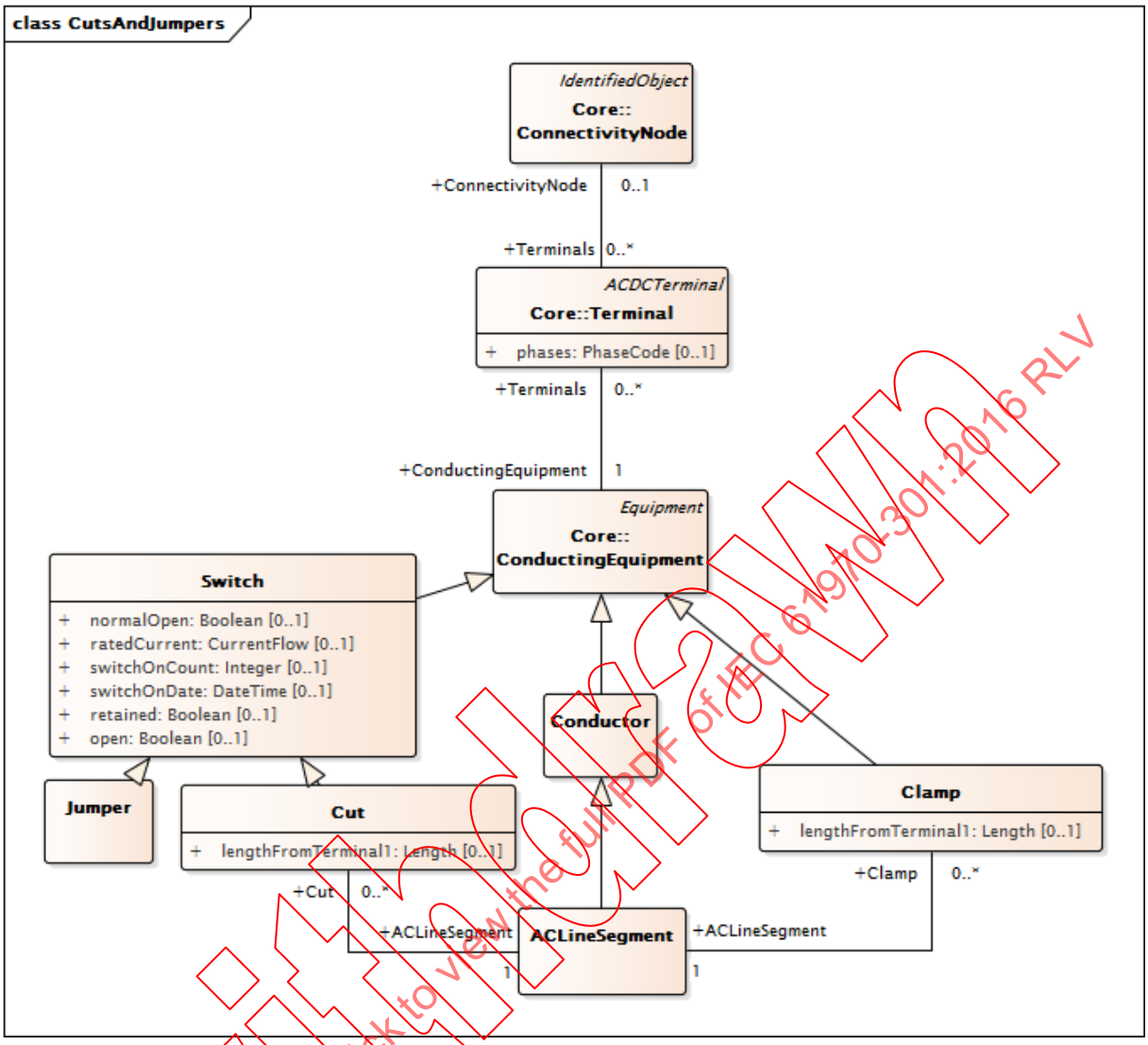


Figure 30 – Cuts, clamps, and jumpers UML model

An example of the addition of cuts and clamps to an existing CIM model is illustrated in Figure 31 and Figure 32. Figure 31 shows two physically parallel line segments named “FRED” and “LEROY”. In this example the system is energized from the right, the switch on the left is closed, and the loads named “ONE” and “TWO” are being supplied. Then the three faults are applied at the specified distances from Terminal 1 of the ~~line~~ respective line segments. In this example the phase detail is not specified for simplicity, but phase detail can follow the same approach outlined in 4.5.8.

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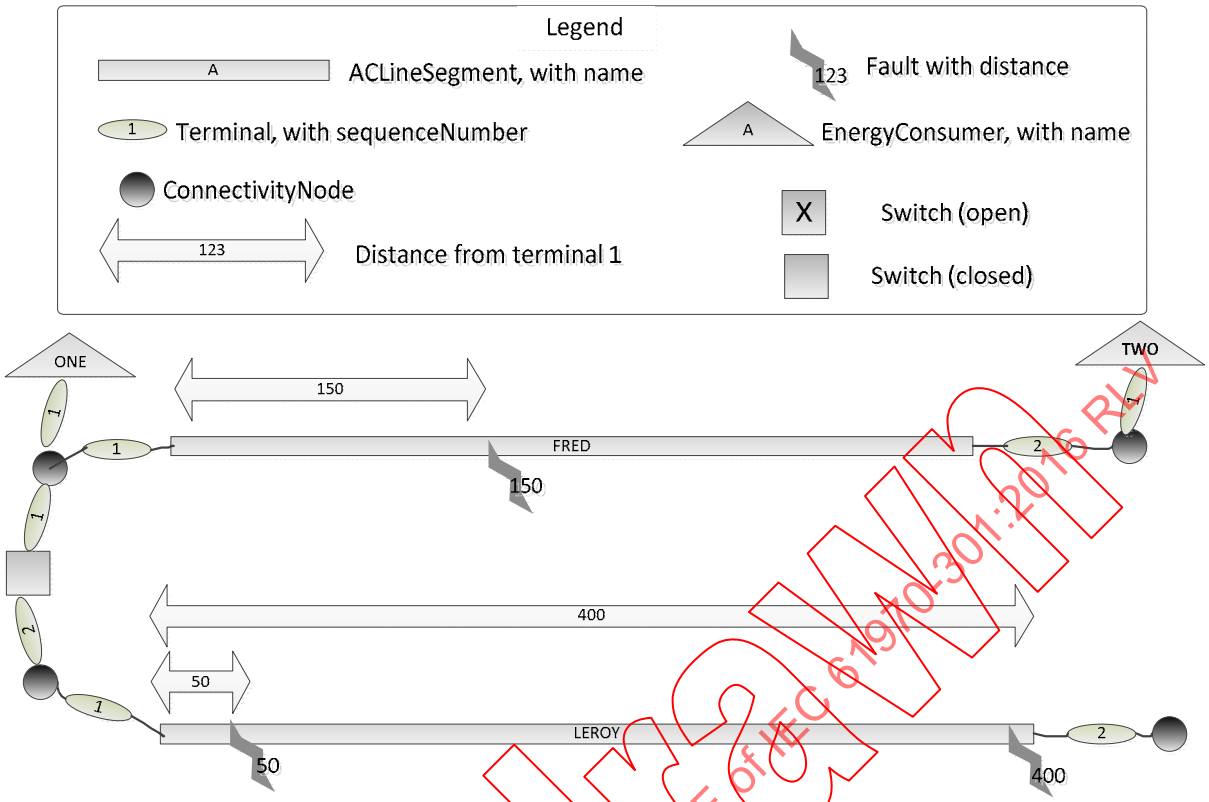


Figure 31 – Example before cuts and jumpers are applied

Figure 32 shows how the pure addition of Cut, ConnectivityNode, Jumper, Clamp and potentially other ConductingEquipment can represent model changes reflecting typical temporary work. These same models can also be used for permanent model changes. The example shows how cuts applied at the specified distances can isolate the faults, leaving the faulted ends of cuts dangling, while the unfaulted network is connected to supply the loads. This example also demonstrates how multiple cuts can be applied to one line segment. This example shows open cuts, but if a cut were closed, flow could continue through the ACLineSegment with part of the flow potentially redirected to the terminals of the cut, much like the case for a clamp.

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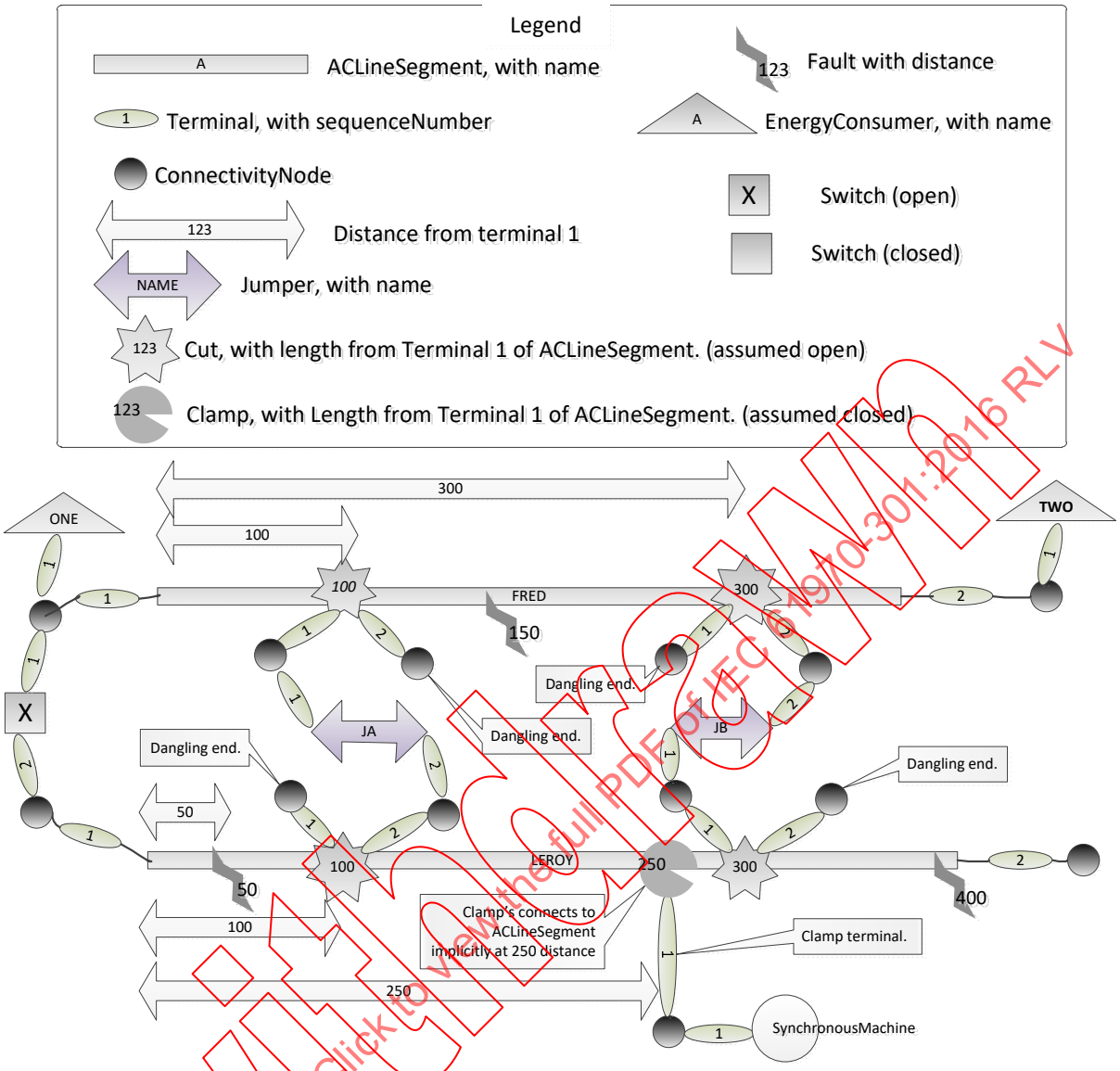


Figure 32 – Example after cuts and jumpers are applied

A cut provides two terminals, and although not shown in the example above, connections could be made to either or both terminals of the cut. An example case might involve introducing a cut and connecting both cut terminals with a jumper that crosses phases.

A jumper may be used without clamps or cuts in a situation where existing terminals are to be connected. Figure 33 shows an example of using a jumper without a cut or clamp. In this case a temporary jumper might be used to bypass a switch under maintenance.

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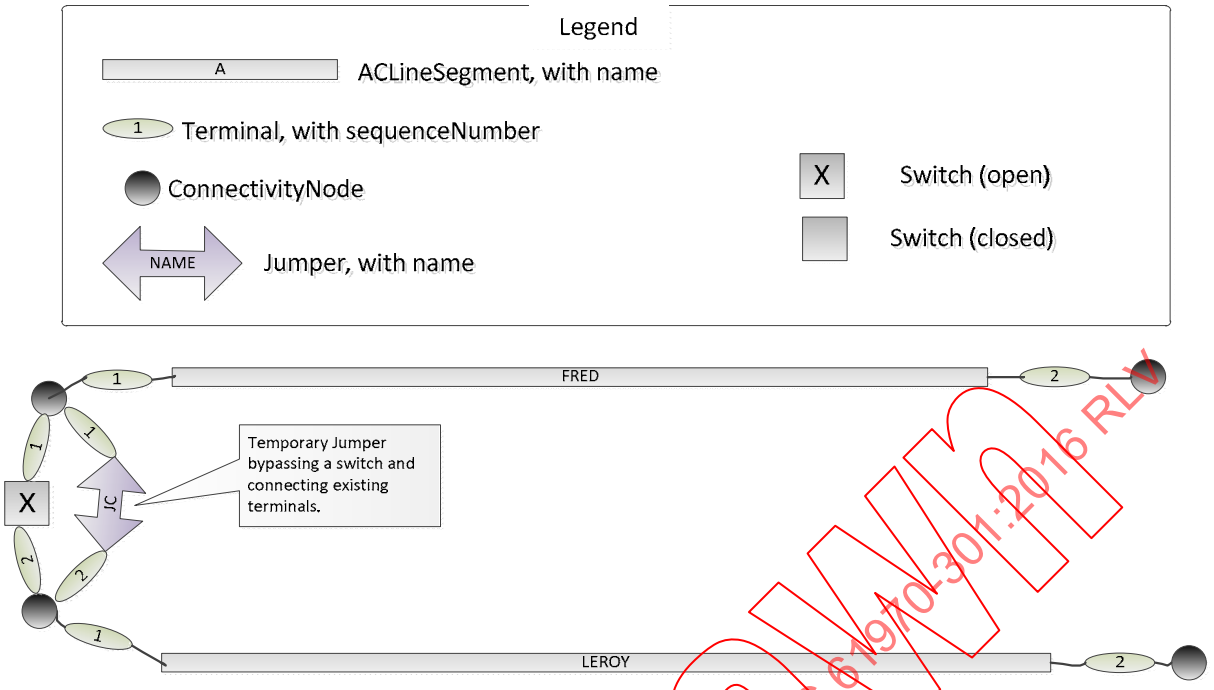


Figure 33 – Example of jumper without cut or clamp

4.5.11 Measurements and controls

4.5.11.1 Measurement overview

Measurements are used to represent the state variables that can be found in industrial processes. Each industrial process has its specific types of measurements. A power system typically has power flows, voltages, positions (e.g. breakers, isolators), fault indications (air pressure, oil pressure over temperature, etc.), counters (e.g. energy), etc.

The name "Measurement" would seem to indicate that all the state variables are measured. This is not always strictly the case as many measurements are calculated by SCADA or EMS/DMS functions, such as state estimator or power flow calculations. As a consequence, a measurement may have a number of alternate values (e.g. manually supplied, telemetered, state estimated, optimized etc.). This is supported by the Measurement and MeasurementValue models in the Meas package. The classes in the StateVariable package have been added to the CIM model specifically for the purpose of supporting exchange of values calculated by functions such as state estimator and power flow.

The measurement model now allows for optionally specifying the specific phases of a measurement.

4.5.11.2 Control overview

Controls are used to represent control variables. Power system control variables typically are set points, raise/lower commands, select before execute commands and on/off commands. The Meas package supports control variables with the Control model.

4.5.11.3 Use of measurement-related classes

A PowerSystemResource (PSR) may have zero to many measurements associated with it by containing one or more measurements. Each measurement may have one or more measurement values. Observing the following guidelines will enable applications to navigate and find the required measurement values in a consistent way (see Figure 34).

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a) Measurements of a PowerSystemResource are classified by the attribute measurementType. The values to be used for Measurement.measurementType are specified in Table 7.

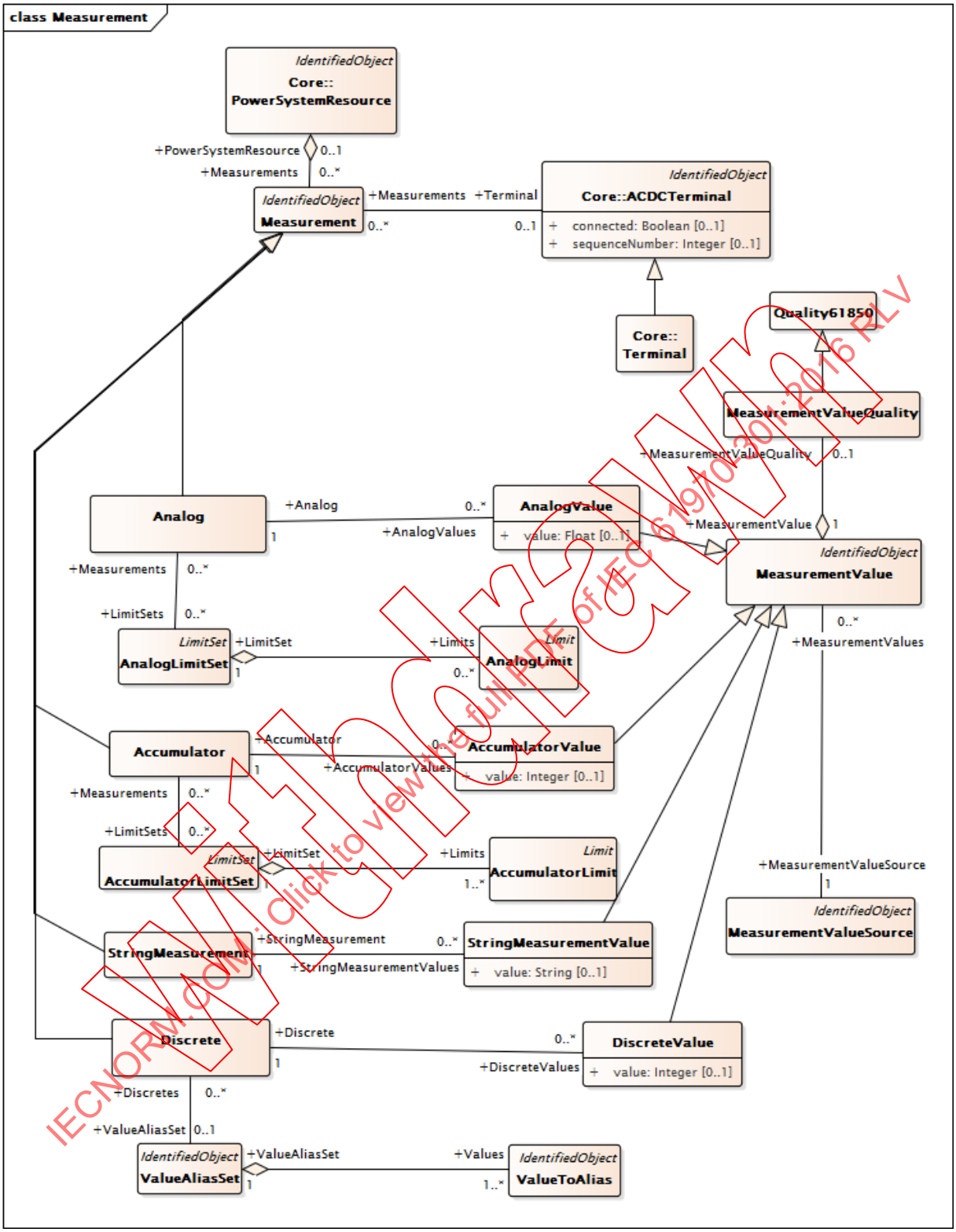
b) MeasurementValues of a Measurement are classified by MeasurementValueSource.

c) MeasurementValueSource inherits from IdentifiedObject. The values to be used for MeasurementValueSource.name are given in Table 8. This table provides a number of source names to be used where possible. However, the exact names to be used for specific applications are defined in related IEC 61970 Component Interface Specifications (CIS).

d) The tables may be extended for proprietary needs. The names added shall start with a unique name (e.g. the company name) and an underscore. Example: xyz_AverageTemperature.

e) The ValueAliasSet is used for discrete measurements and describes mappings from values to symbolic names, such as enumeration literals having specific integer values. Different communication protocols (e.g. for RTUs and for control centres such as ICCP or ELCOM) use different data encodings. A system may have a system wide mapping for all Discrete values or group the Discrete values and make a mapping per group. Creation of a single system wide mapping that covers existing communication protocols is outside the scope of this document.

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Figure 34 – Navigating from PSR to MeasurementValue

Table 7 – measurementType naming conventions

measurementType	61850 Name	description
Current	Amp	Current (rms) of a non-three phase circuit
ThreePhaseCurrent	AvAmps	Total current (rms) in a three phase circuit
PhaseCurrent	A	Measured phase current.
Frequency	Hz	Frequency
PowerFactor	PwrFact	Power factor not allocated to a phase
ThreePhasePowerFactor	TotPF	Average power factor in a three phase circuit
ThreePhaseApparentPower	TotVA	Total apparent power in a three phase circuit
ThreePhaseReactivePower	TotVAr	Total reactive power in a three phase circuit
ThreePhaseActivePower	TotW	Total real power in a three phase circuit.
ApparentPower	VoltAmp	Apparent power in a non-three phase circuit
ReactivePower	VoltAmpr	Reactive power in a non-three phase circuit
Voltage	Vol	Voltage (rms) not allocated to a phase
ActivePower	Watt	Real power in a non-three phase circuit
Pressure	Pres	Pressure
Temperature	Tmp	Temperature
Angle	Ang	Angle between voltage and current
ApparentEnergy	TotVAh	Apparent energy
ReactiveEnergy	TotVArh	Reactive energy
ActiveEnergy	TotWh	Real energy
Automatic	Auto	Automatic operation (not manual)
LocalOperation	Loc	Local operation (not remote)
SwitchPosition	Pos	Switch position [2bits= intermediate,open,closed,ignore]
TapPosition	TapPos	Tap position of power transformer or phaseshifter
Operation Count	OperCnt	Operation count – typically for switches
LineToNeutralVoltage		Line to neutral voltage.
LineToGroundVoltage		Line to ground voltage.

Table 7 describes various types of measurements also defined in IEC 61850. The meanings of the columns in Table 7 are as follows:

- measurementType (Measurement.measurementType) is the IEC 61970 measurement type name.
- 61850 Name is the name assigned to the data object in IEC 61850. IEC 61850-7-4:2010, data object name semantics).
- description is the description of the data.

It shall be noted that Table 7 is not an exhaustive list and that the mapping between measurements as defined in a control centre and a substation is non-trivial.

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Table 8 – MeasurementValueSource naming conventions

Name	description
SCADA	Telemetered values received from a local SCADA system
CCLink	Value received from a remote control centre via TASE.2 or other control centre protocol
Operator	Operator entered value (always manually maintained, PSR is not connected to an RTU)
Estimated	Value updated by a state estimator
PowerFlow	Value updated as result of a Powerflow
Forecasted	Value that is planned or forecasted.
Calculated	Calculated from other measurement values (e.g. a sum)
Allocated	Calculated by a load allocator

Following these conventions:

- each Measurement instance represents a technological quantity of a PowerSystemResource;
- each MeasurementValue of a Measurement represents a value for the technological quantity, as supplied from a single source;
- the source attribute in MeasurementValueQuality then indicates whether the source actually provided the current value, or whether it had been substituted or defaulted.

Note that a new MeasurementValue identity is not normally created for each exchange of a measured value. It is expected that the same MeasurementValue instance could exchange new values in subsequent messages. Therefore the identity of a MeasurementValue instance can be established a priori to exchange of measured values. The modeling of a time series of values is not explicitly expressed in the CIM model, though the model allows for systems to internally build such time series models through a series of measurement value exchanges.

4.5.11.4 Attachment of measurements

As mentioned in 4.5.11.3 and as shown in Figure 34, Measurements are contained by a PowerSystemResource. This is sufficient for Measurements that are not related to connectivity, e.g. temperature, weight, size.

To specify the location of a Measurement in the network, an association to Terminal is used. Examples include power flows, voltages, and currents. Voltages have no direction and can be attached wherever appropriate in relation to the sensor placement. Flows have direction and shall be attached such that the flow direction is evident from the placement.

Figure 35 shows two examples of the placement of Measurements.

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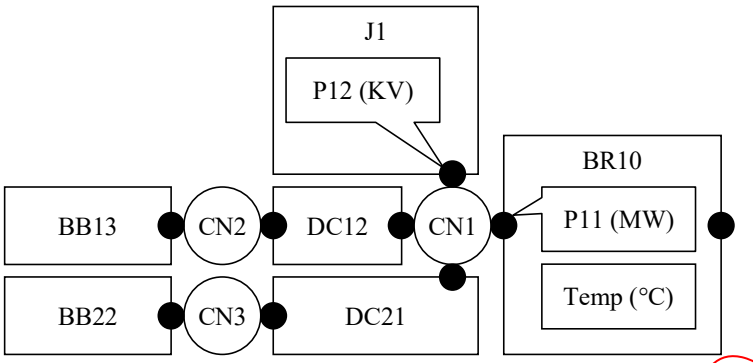


Figure 35 – Measurement placement

P12 is a voltage Measurement that measures the voltage at the Junction J1. P12 is topologically related to the ConnectivityNode CN1 via the Terminal in Junction J1. P11 is a Measurement that measures the flow through Breaker BR10 at the side connected to the ConnectivityNode CN1. P11 is topologically related to the ConnectivityNode CN1 via the left Terminal in Breaker BR10. Temp is a Measurement that measures the Breaker temperature. As a temperature is not related to connectivity, it has no relation to a Terminal – it just belongs to the Breaker BR10.

4.5.11.5 ICCP measurements

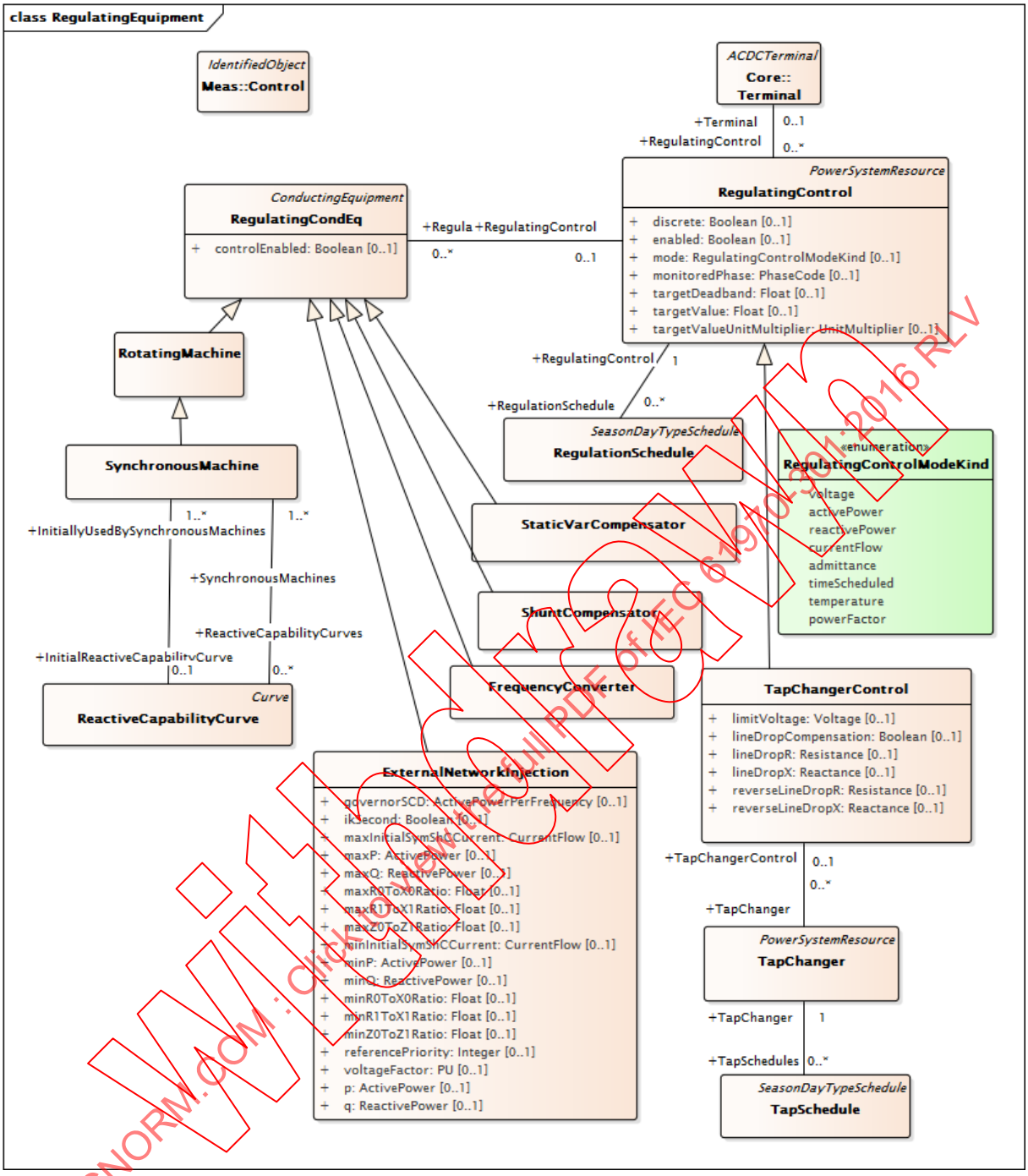
ICCP (known officially as IEC 60870-6 TASE.2) data sources are specified using the MeasurementValue classes (and its specializations) and the MeasurementValueSource class. The MeasurementValueSource class is used to define the control centre supplying the ICCP data. The MeasurementValueSource shall be associated with an instance of Name where the attribute Name.name holds the name of the supplying control centre. The instance of NameType associated with the control centre Name shall have the NameType.name attribute set to “ICCP”.

The MeasurementValue classes are used to specify the ICCP ID. The MeasurementValue shall be associated with an instance of Name where the attribute Name.name holds the ICCP ID. The instance of NameType associated with the ICCP ID Name shall have the NameType.name attribute set to “ICCP”. The MeasurementValue.name attribute holds the SCADA point name. Each MeasurementValue will be associated with one Measurement. Each MeasurementValue being supplied via ICCP shall also have an association to a MeasurementValueSource.

4.5.12 Regulating control models

Regulation control, such as automatic voltage control at generators or voltage tap control at transformers is modeled using the RegulatingControl class which provides the capability to model multiple instances of equipment participating in a regulation scheme. These regulation schemes may be physical or manually implemented in actual power system operation, but are reflected in the models used for power system analysis purposes. Figure 36 shows how RegulatingCondEq and TapChanger classes can participate in regulation.

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Figure 36 – Regulating control models

4.5.13 DC model for CIM

4.5.13.1 General

Control systems modeling HVDC stations typically have three levels of detail:

- simplified system model used in operations and planning;
- simplified system model supporting dynamic studies;
- detailed for transient studies of an HVDC station.

The purpose of this document is to outline the most minimal HVDC model possible for use in SCADA/EMS/planning power flow, short circuit calculations and dynamic studies. Transient studies are not covered.

4.5.13.2 HVDC basic design

4.5.13.2.1 General

The proposed model is based on the following documents:

- IEC 60633:1998+AMD1:2009, *Terminology for high-voltage direct current (HVDC) transmission*
- "VSC Transmission", CIGRÉ B4-37 April 2005
- IEC 62747, *Terminology for voltage-sourced converters (VSC) for high-voltage direct current (HVDC) systems*
- HVDC Transmission by Dennis A. Woodford, Manitoba HVDC Research Centre
- "ABB technical description of HVDC light technology"
- Flexible Power Transmission. Jos Arrillaga, Y. H. Liu, Neville R. Watson, 2007
- "Power System Stability Benefits with VSC DC-Transmission Systems", CIGRÉ B4-204, 2004

4.5.13.2.2 CSC Topology

A current source HVDC link is modeled as shown in Figure 37.

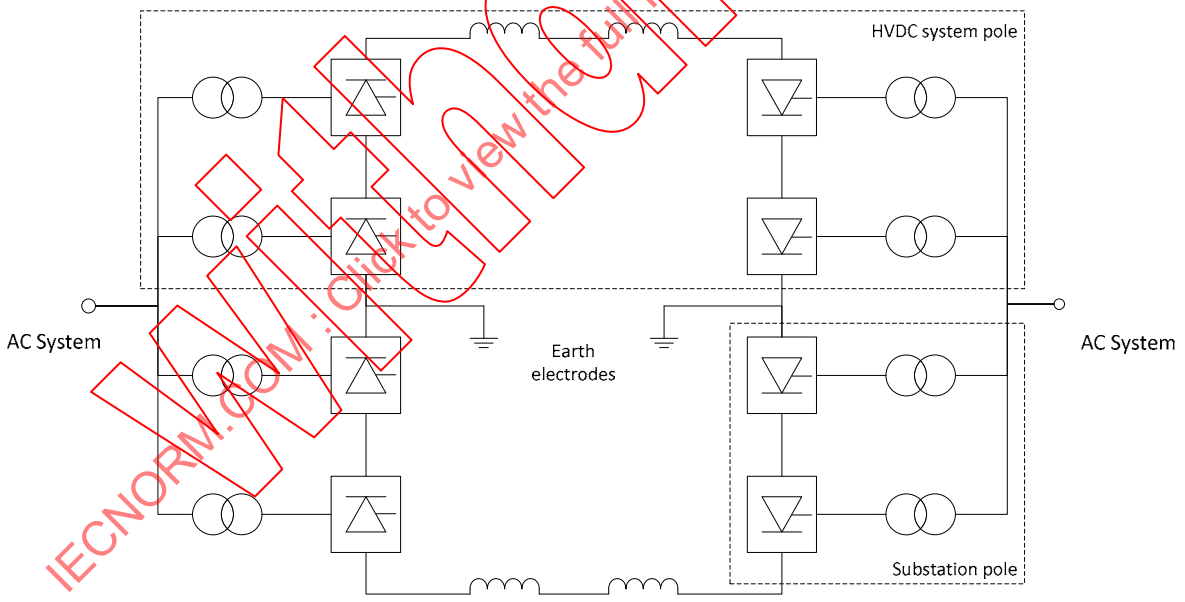


Figure 37 – HVDC bipolar link from IEC 60633

HVDC Bipolar link consists of two poles, one with positive polarity and another with negative polarity having both their natural points grounded. No current flows in the ground return because the current flowing in the poles is the same.

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4.5.13.2.3 VSC Topology

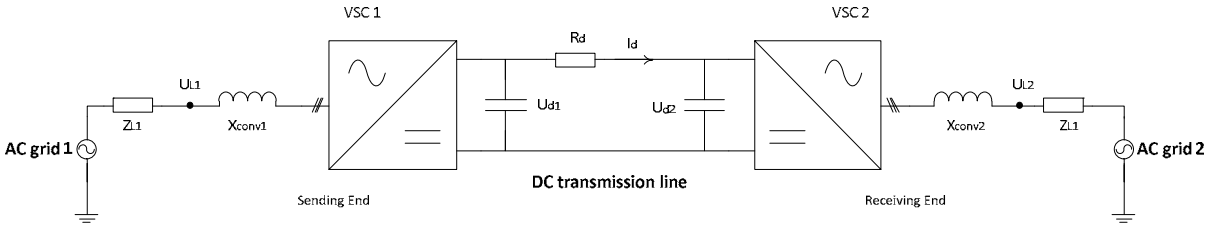


Figure 38 – A point-to-point VSC transmission scheme

The point-to-point VSC transmission scheme shown in Figure 38 consists of two VSCs interconnected on the DC side via a DC transmission line and connected to two different AC systems on the AC side. One of VSC characteristics is that the DC voltage polarity is always the same. Therefore, the direction of the power flow on the DC line is determined by the direction of the DC current.

The direction of a DC current is always from a higher DC voltage level to a lower DC voltage level. The DC voltage at the sending end of the DC line shall therefore be higher than DC voltage at the receiving end.

In line-commutated converter (LCC) HVDC, the DC line power flow can be controlled by holding the DC voltage at the receiving end converter (the inverter) at a constant value, and by letting the sending end converter (the rectifier) control the DC current. The same approach can be used in VSC transmission. However, one main difference is that in LCC HVDC the current direction is always the same; therefore, the power direction is changed by changing the DC voltage polarity.

4.5.13.3 HVDC power flow modeling

4.5.13.3.1 General

A power flow model derived from Figure 38 is shown in Figure 39.

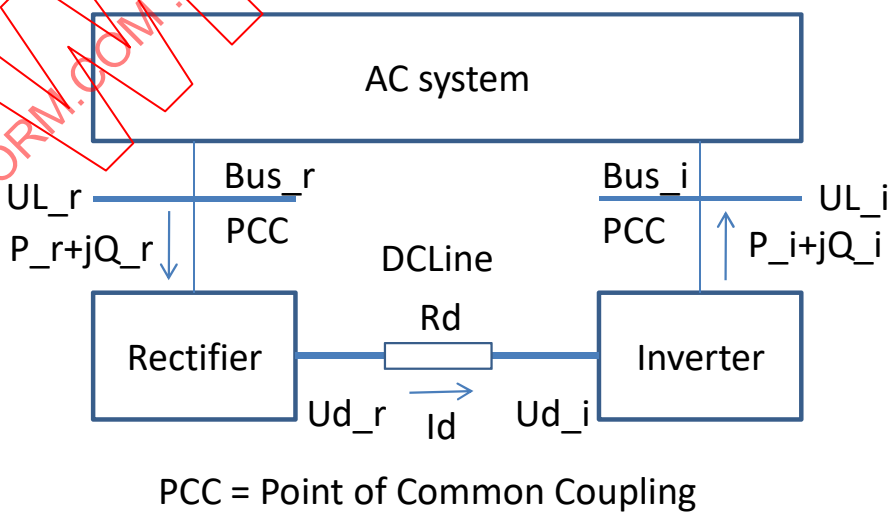


Figure 39 – HVDC power flow model

The AC side variables are as follows:

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- P is the AC side active power injection at the rectifier (index r) and inverter (index i).
- Q is the AC side reactive power injection at the rectifier (index r) and inverter (index i).
- U_L is the AC side voltage at the rectifier (index r) and inverter (index i).

The DC side variables are as follows:

- U_d is the DC voltage at the rectifier (index r) and inverter (index i).
- U_{dN} is the rated DC voltage.
- I_d is the DC line current.
- I_{dN} is rated DC line current.
- R_d is the DC line resistance.

The interface between the HVDC system and the AC system are the two busses Bus_r and Bus_i. The voltage at Bus_r is U_{L_r} and the voltage at Bus_i is U_{L_i}. Power injected into the Rectifier from the AC system is $P_r + jQ_r$ and power injected into the Inverter is $P_i + jQ_i$ .The busses Bus_r and Bus_i are from the AC system seen as PQ nodes for current source HVDC and PV nodes for voltage source HVDC. For PQ nodes the injections $P_r + jQ_r$ and $P_i + jQ_i$ and for PV nodes the active power injection and voltage P_r, UL_r and P_i, UL_i are computed from the HVDC link. Initial conditions for the HVDC link are given in two ways:

- P_r or P_i
- U_{d_r} or U_{d_i}

The relations between the variables are $I_d = P_r / U_{d_r} = P_i / U_{d_i}$.

The power flow is illustrated in Figure 40 and Figure 41.

4.5.13.3.2 Current Source Converter

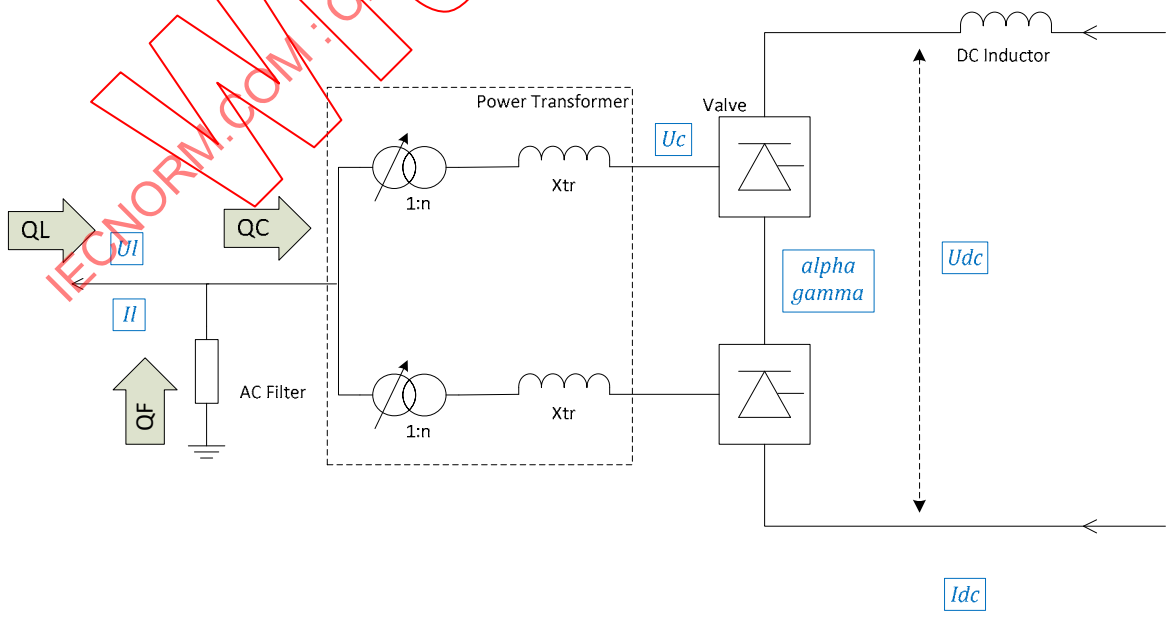


Figure 40 – Current Source Converter power flow

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In a current source converter the reactive power is not controlled. Instead it is determined by the bridge firing angle that impacts the power factor:

- α is the firing angle, typical value between 10° and 18°
- $U_d = U_{d0} \times \cos\alpha - \left(\frac{3}{\pi}\right)\left(\frac{X_{tr}}{2}\right) I_d$
- the rated direct voltage: $U_{d0} = \left(\left(3 \times \sqrt{2}\right)/\pi\right) \times U_C$
- $U_t = U_L \times tapratio$

The approximation of reactive power injection could be presented in the following way:

- $Q_L = Q_C - Q_F = \left(\frac{P}{2}\right) - Q_F \approx \frac{P}{2}$

4.5.13.3.3 Voltage Source Converter

The electrical components and their interconnections within a converter are shown in Figure 41. Figure 41 is the reference for the formulas in 4.5.13.3.3.

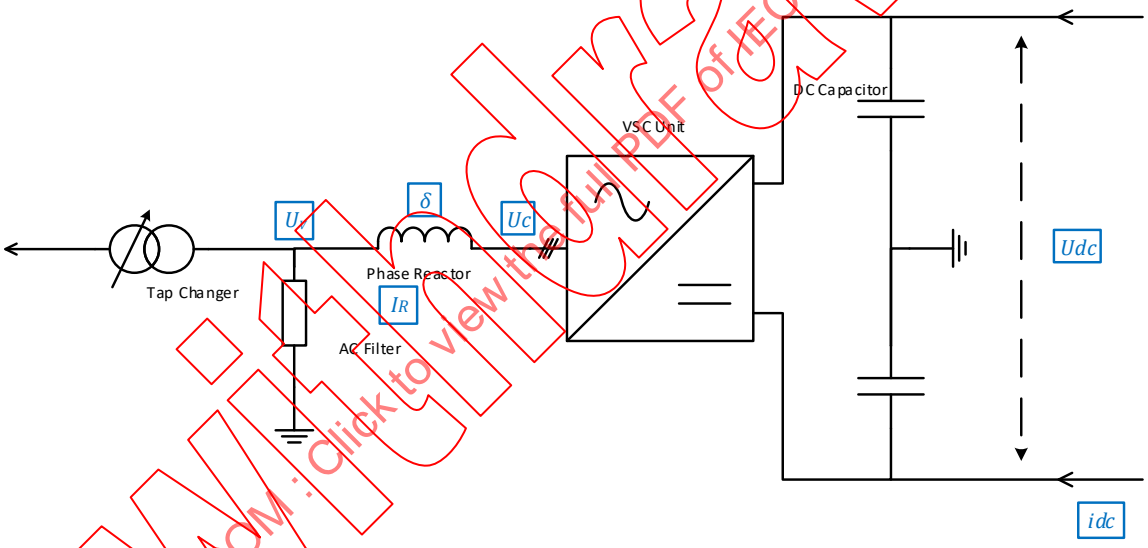


Figure 41 – Voltage Source Converter power flow

Additional parameters to those previously listed are as follows:

- U_{dc} is the voltage at the DC side of the VSC Unit.
- I_{dc} is the current at the DC side of the VSC Unit.
- U_C is the voltage at the AC side of the VSC Unit, also called converter voltage.
- U_V is the voltage at the filter bus.
- modulation index is the ratio between U_{dc} and U_C, this is a VSC parameter and has typical values between 0 and 1
- I_R is the current through the phase reactor.
- X_C is the phase reactor reactance.
- δ is the angle between the U_V and U_C voltages.

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The diagrams in Figure 42 show the voltage vectors and the resulting power flow cases.

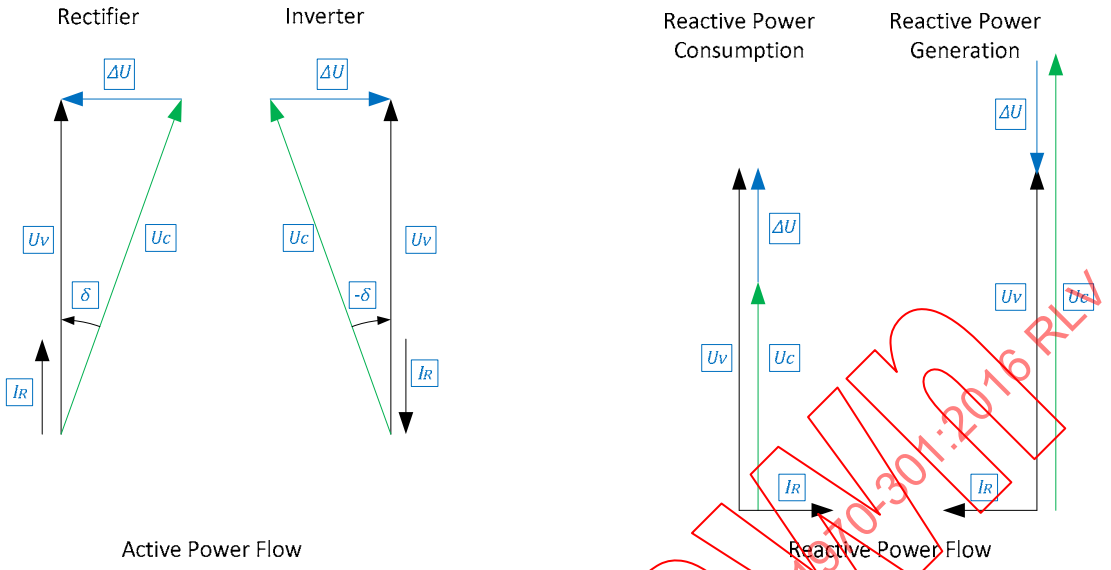


Figure 42 – Power flow cases

The behavior of the Rectifier and Inverter can be described by a set of formulas having the following parameters, some of which are shown in Figure 39 and Figure 41.

- U_{rated} is the converter rated AC voltage (one each for rectifier and inverter).
- S_{rated} is the converter rated AC power.
- R_C is the phase reactor resistance.
- number of converter bridges (one each for rectifier and inverter).
- I_{dmax} and I_{dmin} are the DC flow upper and lower limits.
- R_d is the DC line resistance.
- The active and reactive components (refer to Figure 42) are computed as $P = U_V \times U_C \times (\sin(\delta)/X_C)$.
- $Q = U_V \times (U_V - U_C) \times (\cos(\delta)/X_C)$.

The losses at a pole are described by the equation:

- $P(poleLoss) = idleLossFactor + switchLossFactor \times I_{dc} + resistiveLossFactor \times I_{dc} + resistiveLossFactor \times I_{dc}^2$

where

- $P_{dc} = P_{ac}$ for lossless operation;
- $P_{dc} = P_{ac} - P_{loss}$ for rectifier operation with losses;
- $P_{dc} = P_{ac} + P_{loss}$ for inverter operation with losses.

Figure 43 shows a diagram for a symmetric monopole Voltage Source Converter.

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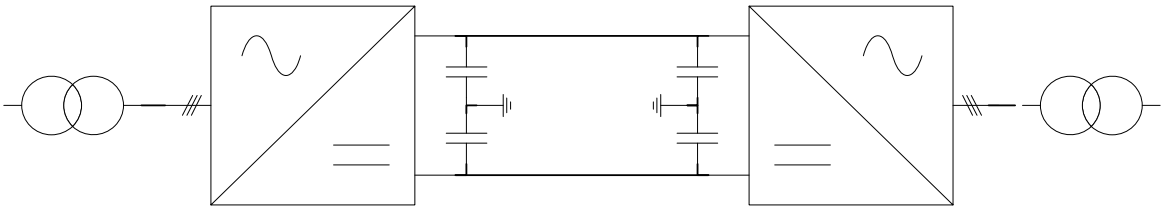


Figure 43 – VSC transmission with a symmetrical monopole illustrated with capacitive earthing on the DC side (IEC 62747)

By controlling the angle δ between the voltages U_V/U_C and voltage difference $U_V - U_C$, independent active and reactive power control is achieved.

Limitations of the VSC results in a *P-Q* curve. An example *P-Q* curve is shown in Figure 44.

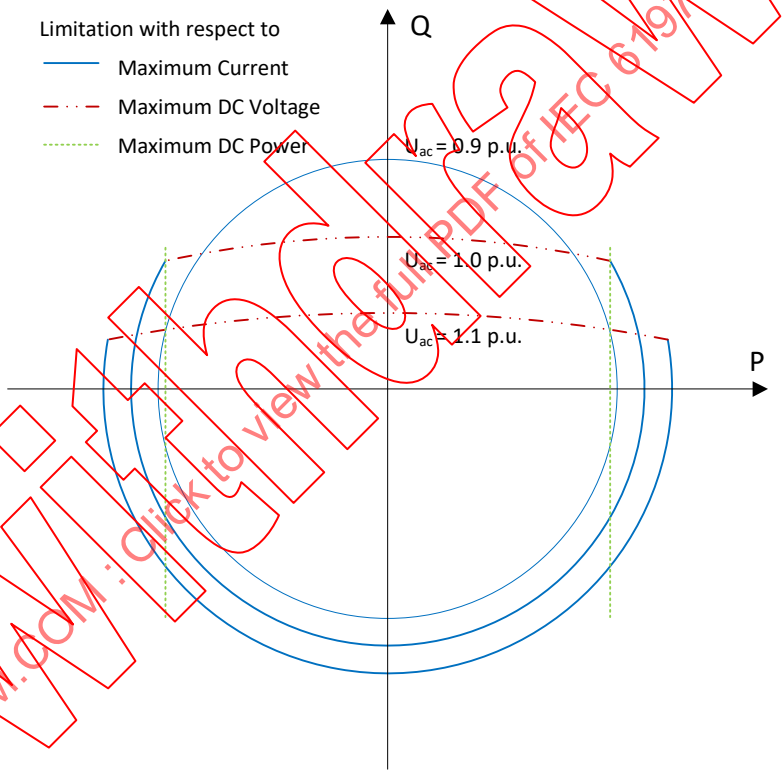


Figure 44 – VSC *P-Q* capability curve

It is also possible to use VSC in bipolar configurations as shown in Figure 45.

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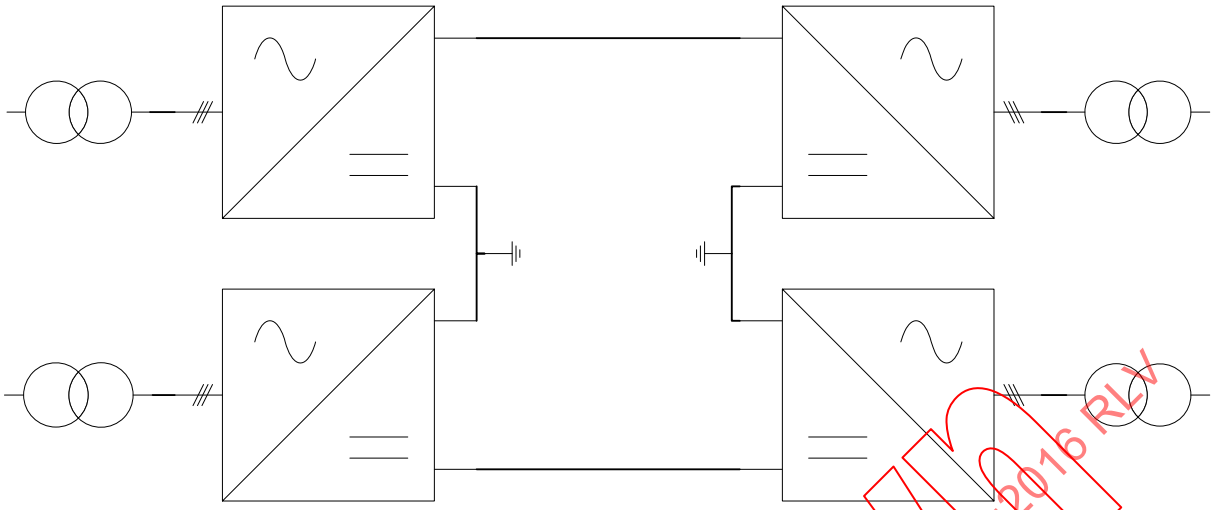


Figure 45 – Bipolar VSC transmission with earth return (IEC 62747)

In this configuration two high voltage DC cables are used for the positive (+DC) and negative (−DC) voltages. A medium voltage cable is used for the neutral.

4.5.13.4 Data model

4.5.13.4.1 General

A data model is created using the following assumptions.

- The DCConverterUnit in CIM is identical with IEC 60633 Substation Pole that is a container.
- The old CIM RectifierInverter is identical with the Converter.
- The IEC 60633 System Pole is not modeled in CIM. The reason is that the IEC 60633 System Pole is not relevant in DC grids. The bridges, filters and bridge units are not modeled explicitly in CIM and are considered part of the Converter.
- Using ConnectivityNode and Terminal for the connectivity also in DC grids enables DC and AC components to be connected together, which is an error. Attributes will also have different meanings in AC and DC grids, e.g. DCNode does not have phase angle or reactive power injection. Hence different artifacts are used to describe AC and DC grids.

Figure 46 shows an example with the modeled objects of a bipolar current source HVDC line.

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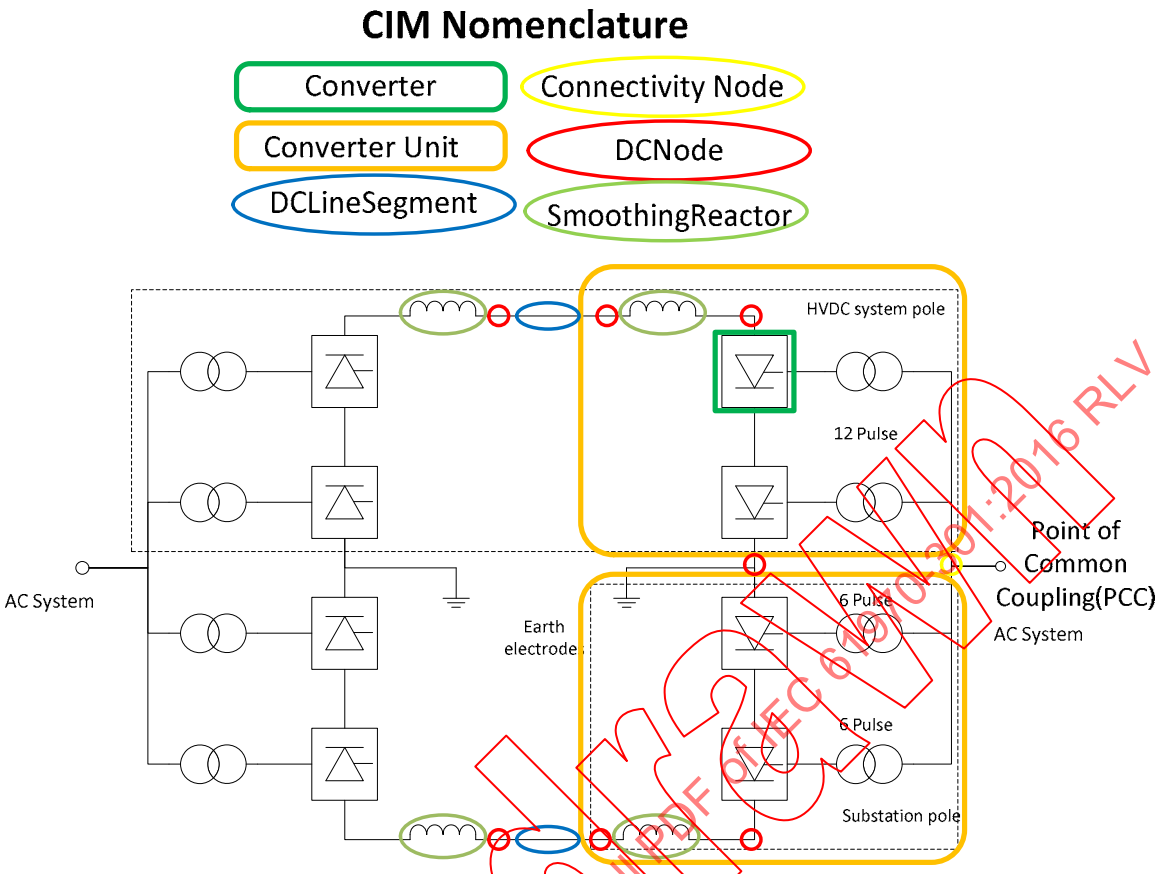


Figure 46 – Object instances for a bipolar current source HVDC line

The Converter Unit is the object bridging the AC and DC networks.

The corresponding diagram for VSC is shown in Figure 47.

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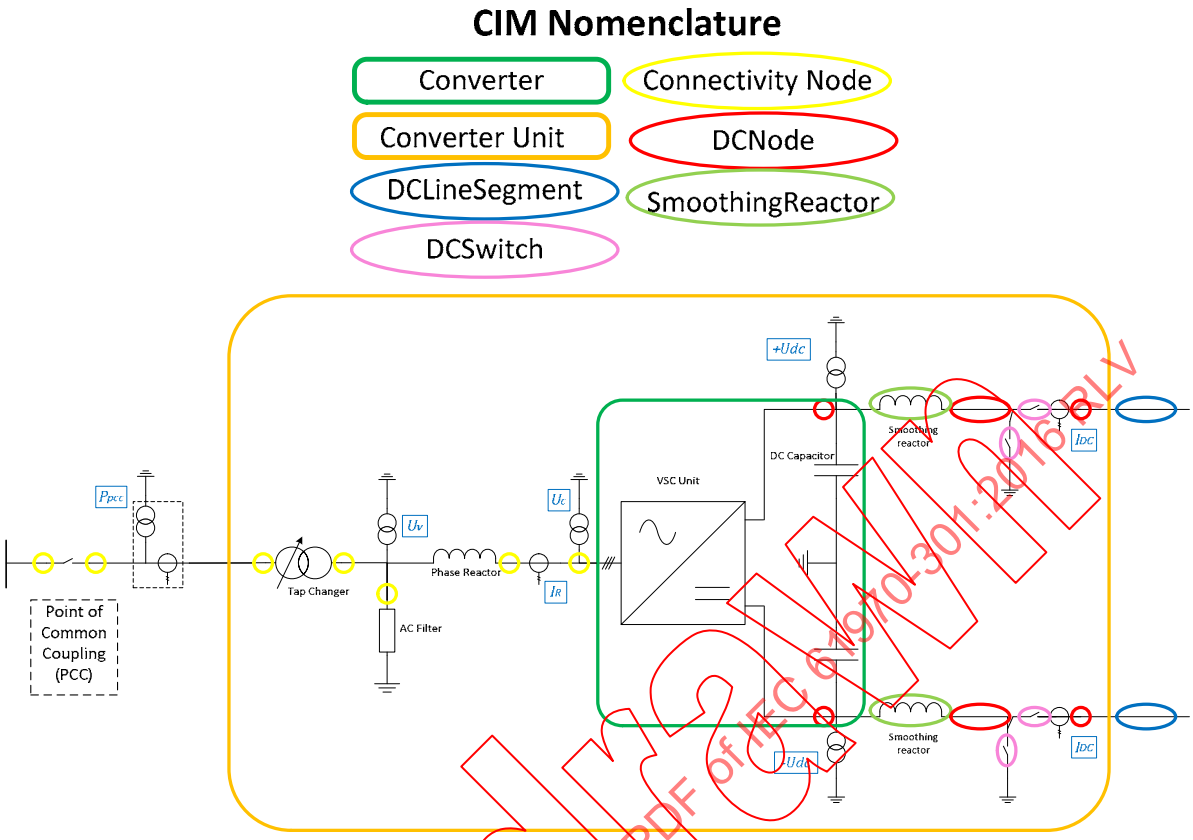


Figure 47 – Object instances for symmetric monopole VSC HVDC data model

As indicated in Figure 46 and Figure 47, an HVDC substation consists of

- one or more Converters;
- SmoothingReactors;
- DC switches for reconfiguration of the DC-lines;
- a Point of Common Coupling (PCC) that is the interface with the AC system.

A Converter consists of one or more sets of

- bridges;
- a PowerTransformer;
- an AC filter;
- a converter or phase reactor for VSC, in multi-level HVDC several Bridges exists in the converter arms. The Converter reactor is then part of the arms rather than a single reactor as shown in Figure 47;
- breakers and disconnectors.

HVDC Link can be operated in different ways:

- bipolar, refer to Figure 45;
- symmetrical monopole with capacitive earthing on the DC side – refer to Figure 43;
- asymmetrical monopole with ground return – this lower active power capacity and sustained operation is not allowed;
- asymmetrical monopole with metallic return – this lower active power capacity and sustained operation is allowed.

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A Converter with several Bridges may have the capability to reconfigure how Bridges are connected. A reconfiguration normally results in down rating of limits.

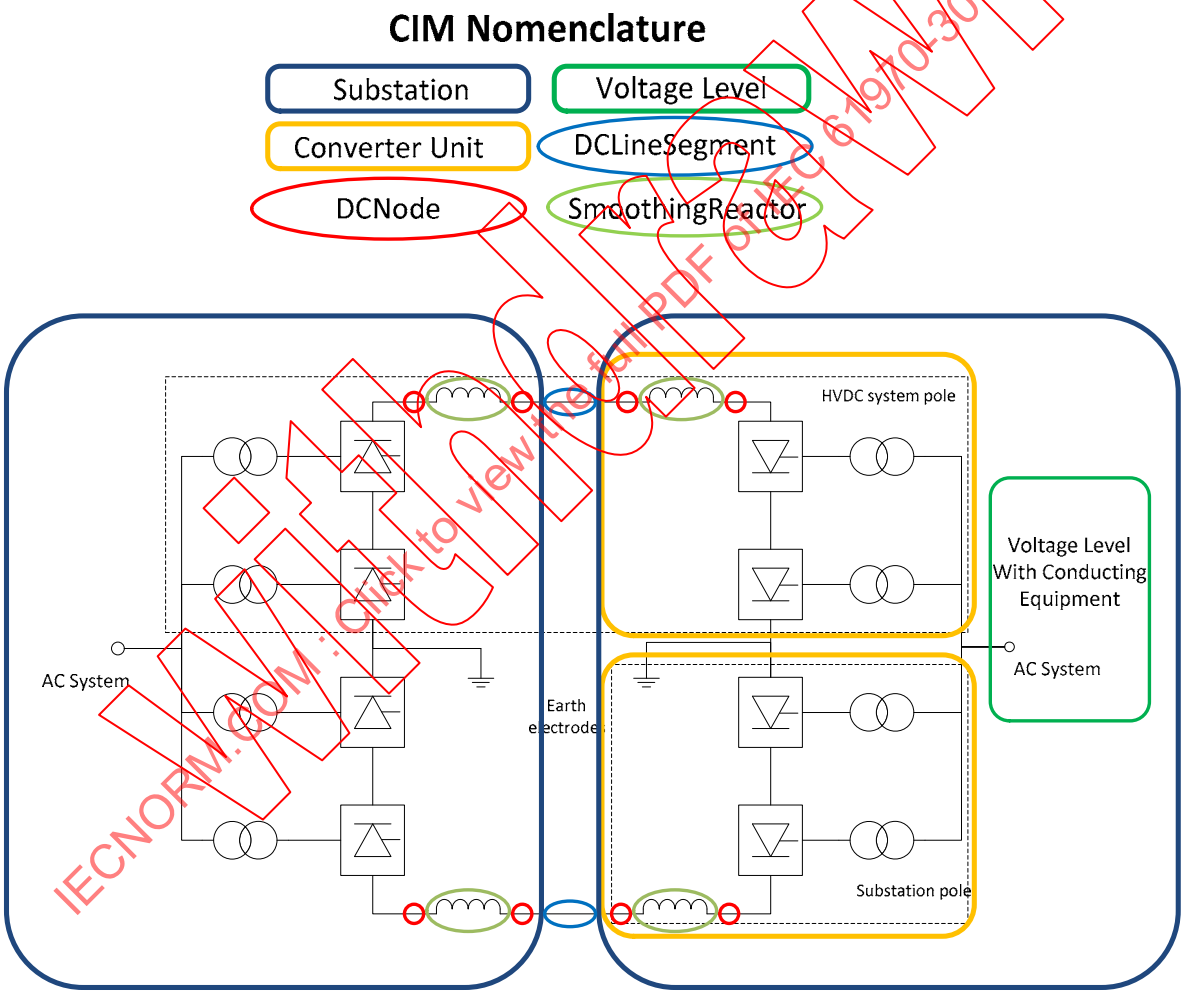
An HVDC substation sends operational status as SCADA signals to a superior SCADA. In bipolar operation mode, down rated Converter limits are typically sent to the superior SCADA.

The containment structures for two cases are shown in Figure 48 and Figure 49.

For the transformers note that

- they are not in a Substation but a DCConverterUnit;
- no VoltageLevels exist at the low and high voltage sides of a transformer.

Hence the containment rules for transformers in the AC network are replaced by rules specific to the DCConverterUnit.



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Figure 48 – Containment structure for a bipolar HVDC line

The two DCLineSegments are part of a Line. The reason is that the DCLineSegments typically are at the same tower or in the same cable channel.

The two substations are regular Substations mixing DC and AC equipment. The DCConverterUnit and Converters are at Substation level and connect to AC equipment in a VoltageLevel.

As Converters can operate at different voltages it does not make sense to have a BaseVoltage. Hence the flag BaseVoltage.isDC shall be removed.

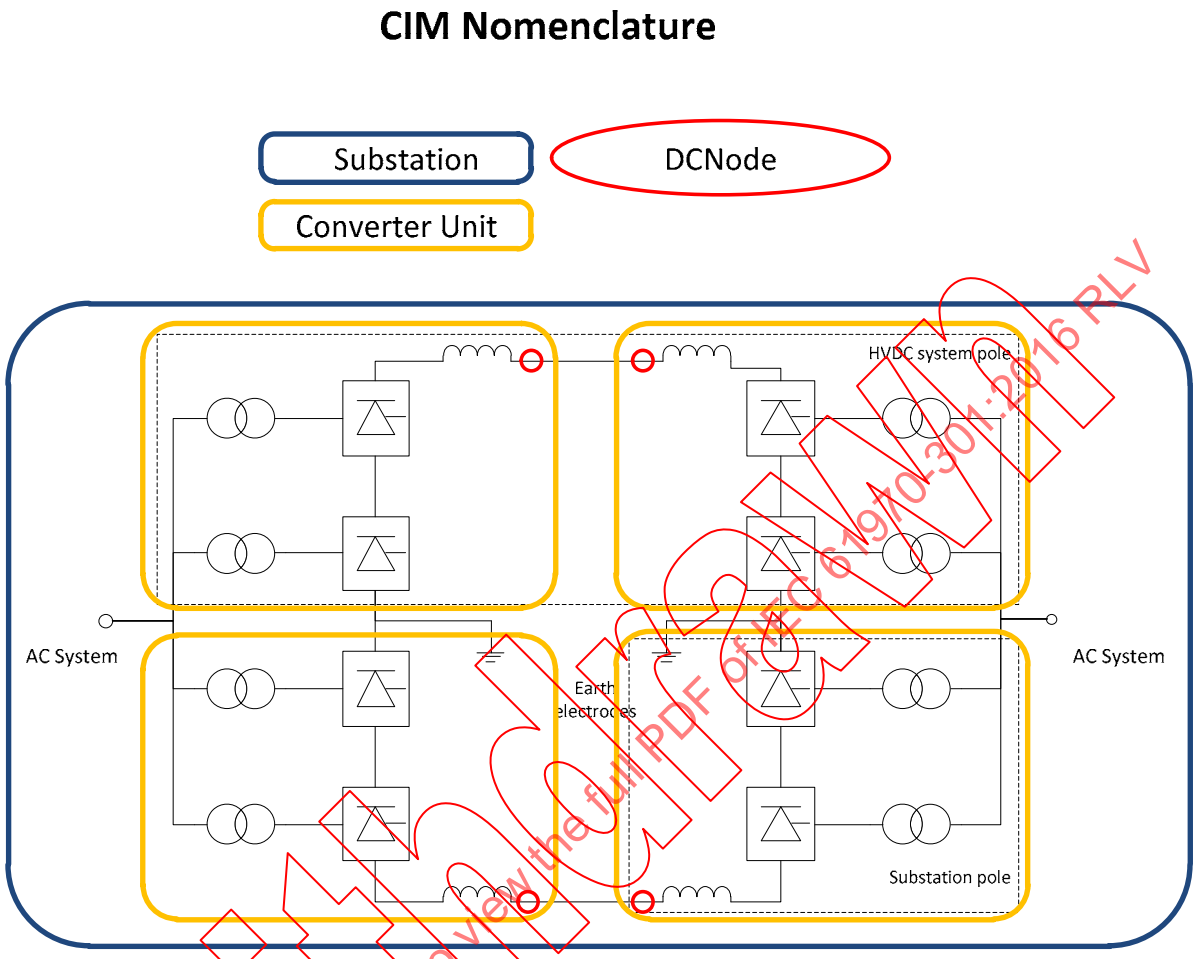


Figure 49 – Containment structure for a bipolar back-to-back HVDC station

4.5.13.4.2 DC grids

DC grids will have switches that are used to reconfigure the DCLines in the grid. To do this it is important that the switches are included in the model and are placed at the appropriate locations in the grid. Figure 47 shows a DCLine connected at a Converter with a simple switch arrangement. As the smoothing reactor belongs to the Substation rather than the DCLine it cannot be included in the DCLine inductance. For DCGrids the incoming DCLine connections with the Converters will have more switches and the information model needs to support this. DC grid topology processing will be required in the same way as AC grid topology processing is currently done.

4.5.13.5 Data model

4.5.13.5.1 Topology

The basic AC system connectivity is shown in Figure 50.

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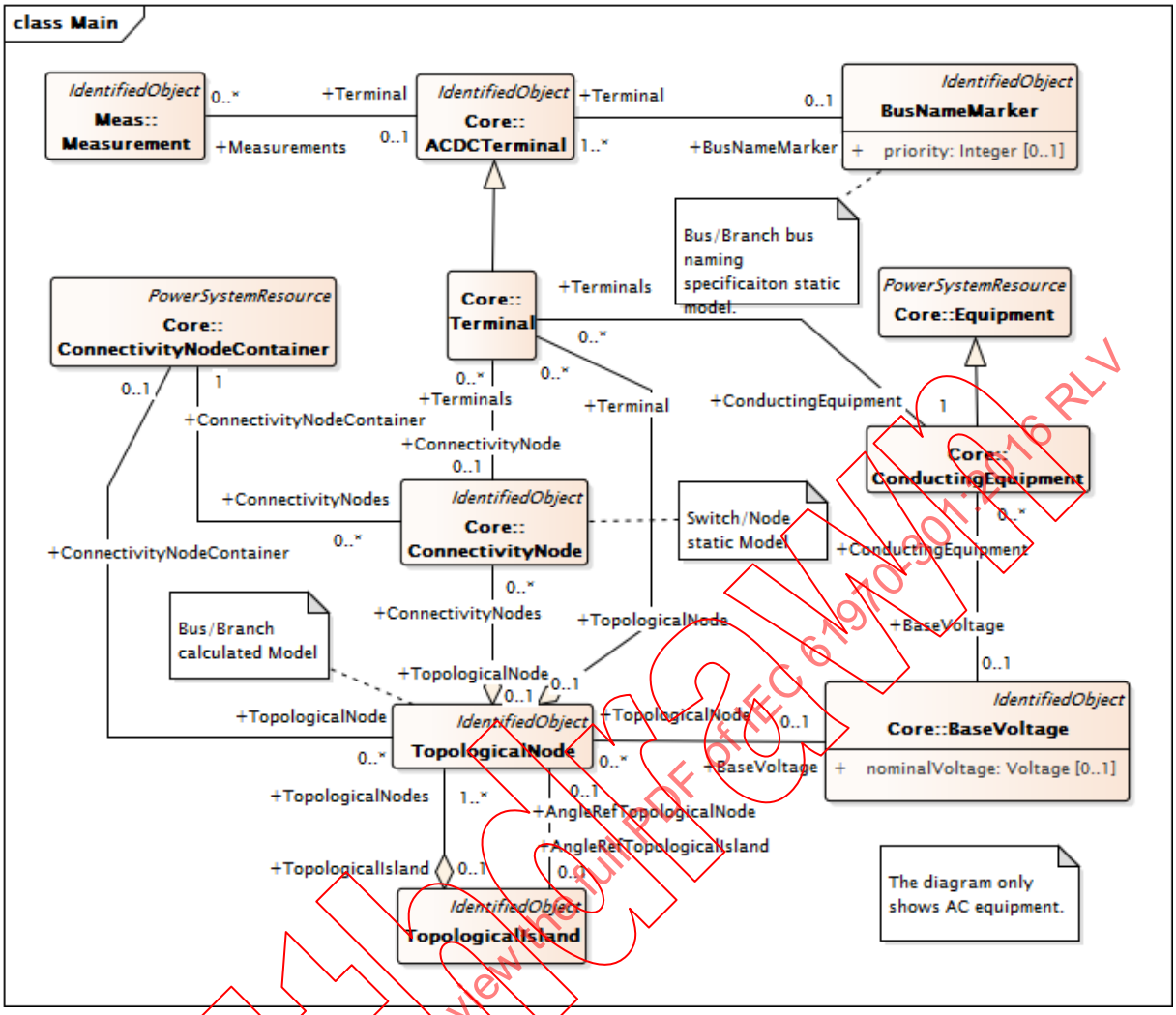


Figure 50 – The Basic topology in package Core

As shown in Figure 50, Terminal is used only for AC ConductingEquipment. A new class ACDCTerminal has been introduced to hold characteristics common between AC and DC.

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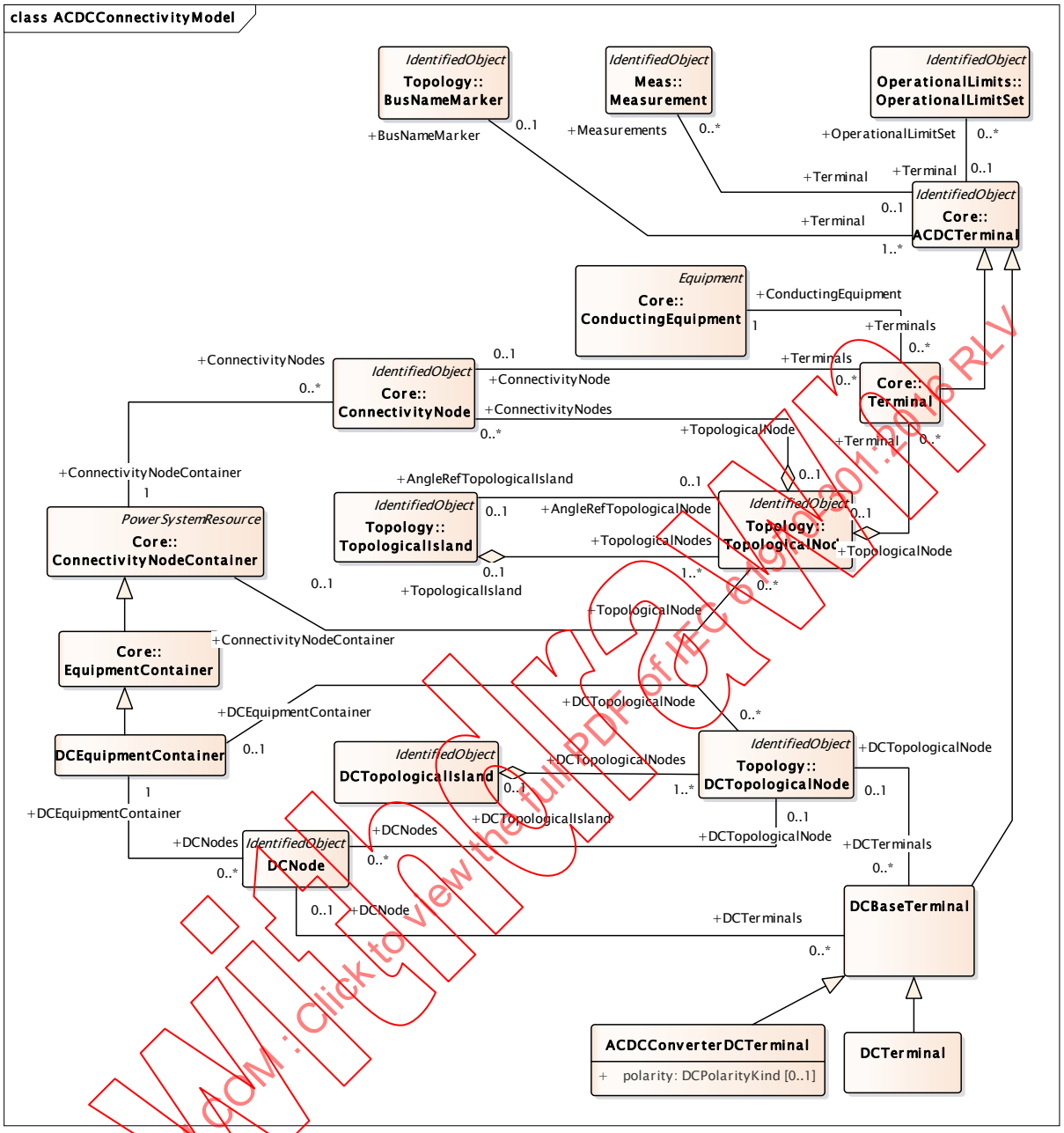


Figure 51 – DC and AC topology

As shown in Figure 51, the ConductingEquipment-Terminal-ConnectivityNode pattern from the AC network is repeated for the DC network with the classes DCConductingEquipment-DCTerminal-DCNode.

The association from Measurement to Terminal is moved from Terminal to ACDCTerminal. Hence DCTerminals may also have Measurements. The role “Measurement.Terminal” keeps its old name for backwards compatibility.

If more features will be common between DCTerminal and Terminal they are moved to ACDCTerminal.

DCNode and ConnectivityNode do not have a common ACDCNode base class as it does not seem to be needed.

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4.5.13.5.2 Containment

The containment structure for the DC model is shown in Figure 52.

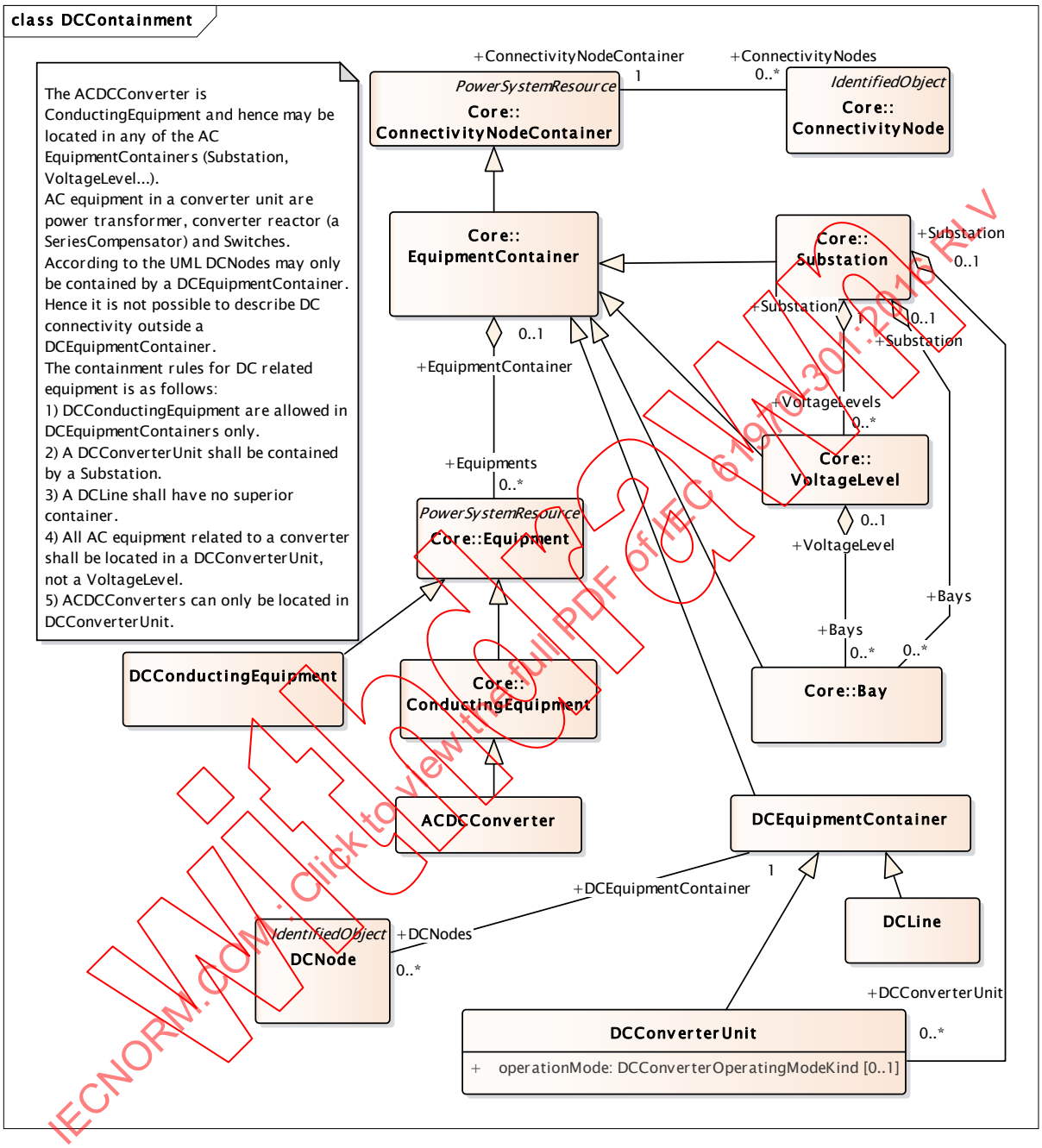


Figure 52 – HVDC Containment

As shown in Figure 52, DCConductingEquipment has the same features as Equipment, hence it can be placed in a Substation, Voltagelevel or Bay. However the DC topology requires DCNodes that only exist in a DCEquipmentContainer. Hence DCConductingEquipment will reside in DCConverterUnits or DCLines, subclasses to DCEquipmentContainer.

DCConverterUnits are part of Substation while DCLines are not. Hence DCLines can span between Substations.

DCConverterUnits can be mixed with AC equipment in a Substation. Hence both AC and DC equipment can coexist in Substations.

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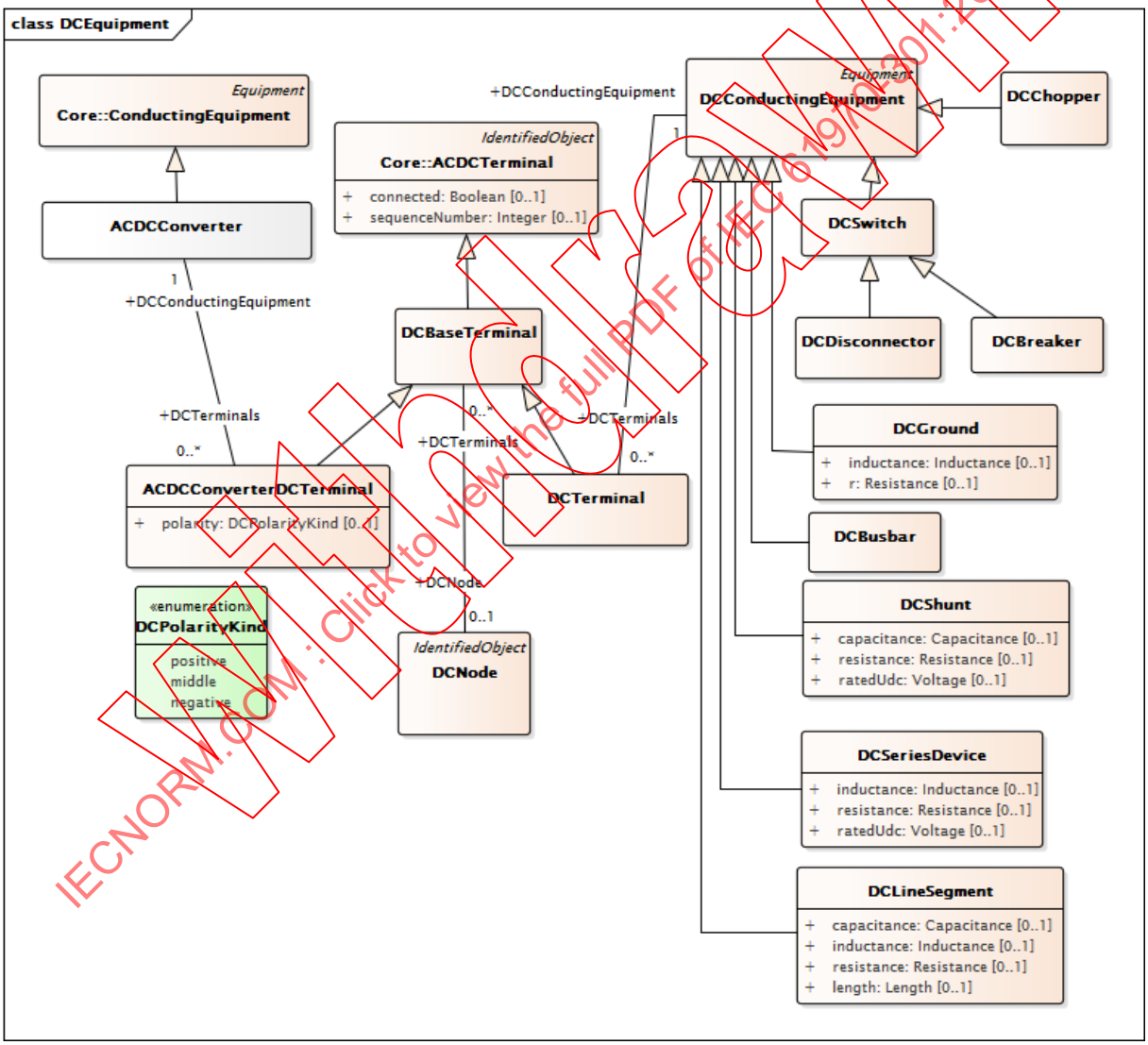
The back to back configuration in Figure 49 is solved by placing the DCLineSegment in the Substation instead of a DCLine.

The CIM containment model is open and which container classes shall contain what equipment needs to be specified in writing as follows.

- DCLineSegments are allowed in Substations (back to back configuration) and DCLines.
- All other DC equipment go into DCConverterUnit.
- AC equipment specific to a converter go into DCConverterUnit.

4.5.13.5.3 Equipment

The DC equipment model is shown in Figure 53.



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Figure 53 – Equipment model

In order for the ACDCTerminal to feature both ACDCConverter and DCConductingEquipment, two types of DC terminals have been implemented as shown in Figure 53: ACDCConverterDCTerminal and DCTerminal. ACDCConverterDCTerminal is associated with ACDCConverter. The DCTerminal is in association with DCConductingEquipment. In order to associate DCNode with DCTerminal and ACDCConverterDCTerminal, DCBaseTerminal is introduced which is inherited from ACDCTerminal.

As DCConductingEquipment in many cases will have different parameters compared with corresponding AC equipment, specific DC classes are needed anyway, e.g. the DCBreaker and DCBusbar.

The SvPowerFlows at the PCCTerminals hold the AC injections into the converter.

The DC line model is shown in Figure 54.

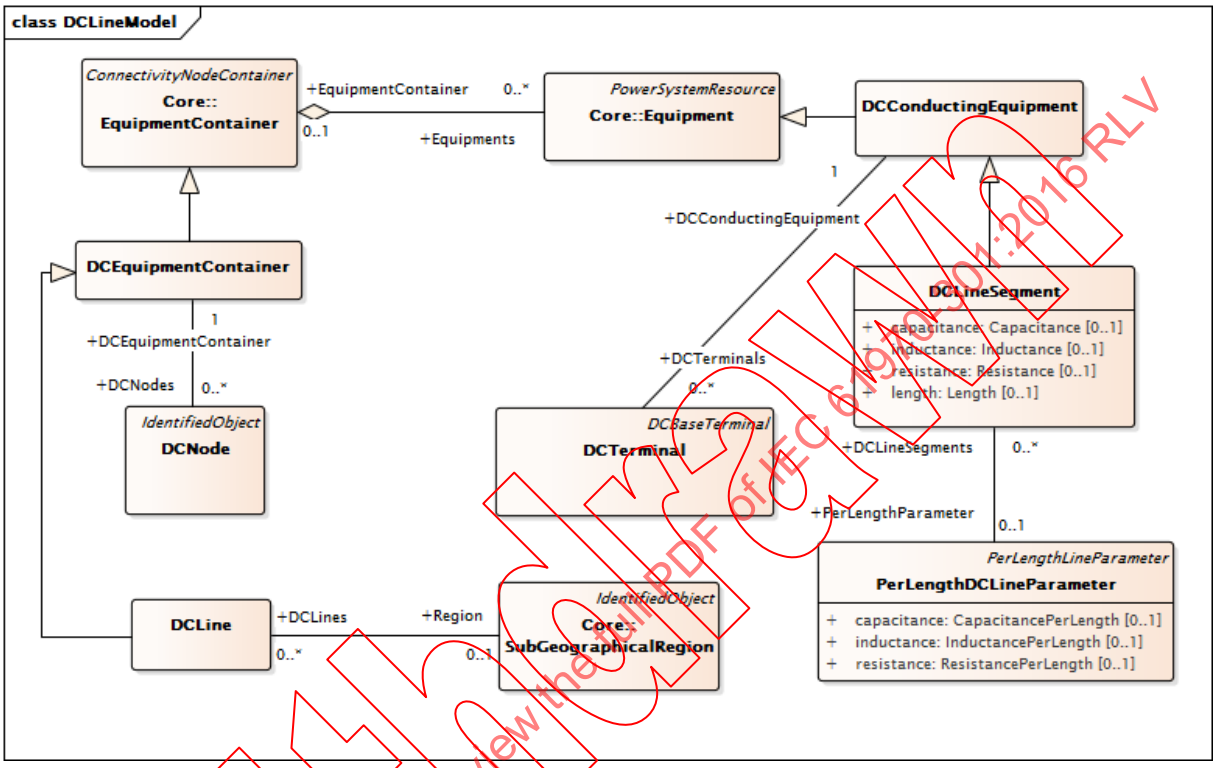


Figure 54 – HVDC line model

As shown in Figure 54, DCLineSegment is no longer a Conductor but DCConductingEquipment and does not connect to the AC network. It has its own attributes and per length class PerLengthDCLineParameter.

Every type of equipment in an HVDC grid will need its DC…class. Possible equipment types are

- DCSwitch,
- DCGround.

The method of specific DC… classes may result in duplication of attributes with the corresponding AC… classes.

4.5.13.6 Instance diagrams

Figure 58 show examples of DC equipment: a simple monopole, a simple bipolar and a detailed side of a monopole.

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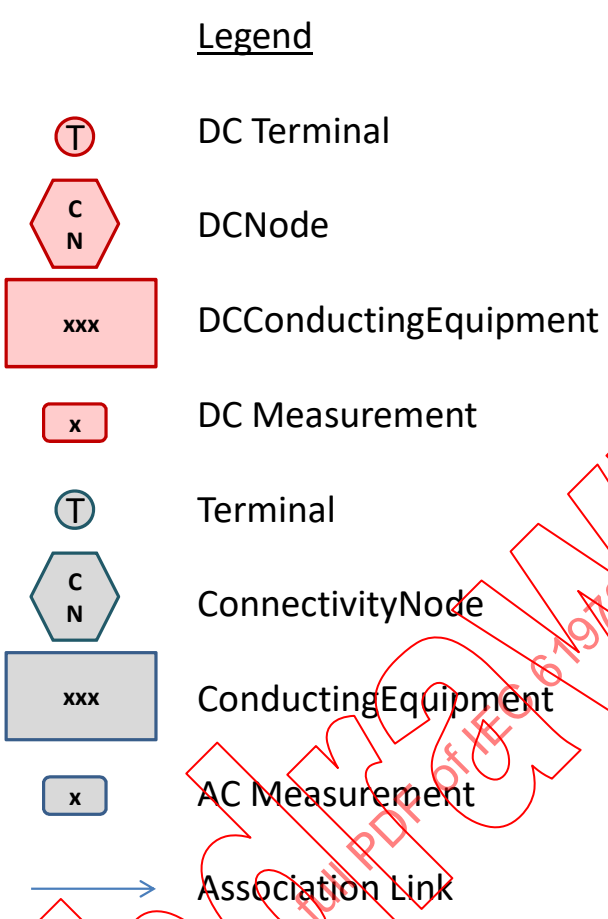
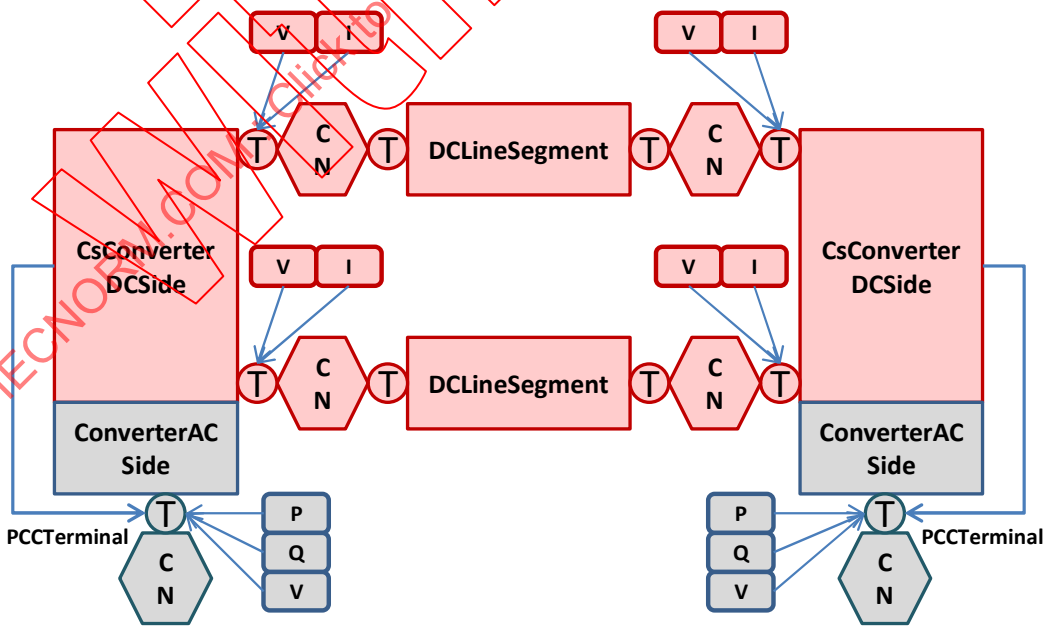


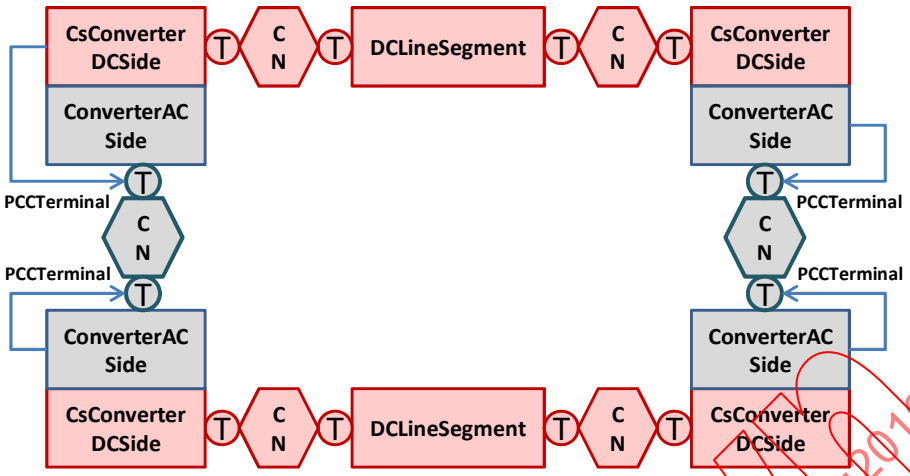
Figure 55 – Key for Figure 56, Figure 57 and Figure 58



Refer to Figure 55 for an explanation of the symbols.

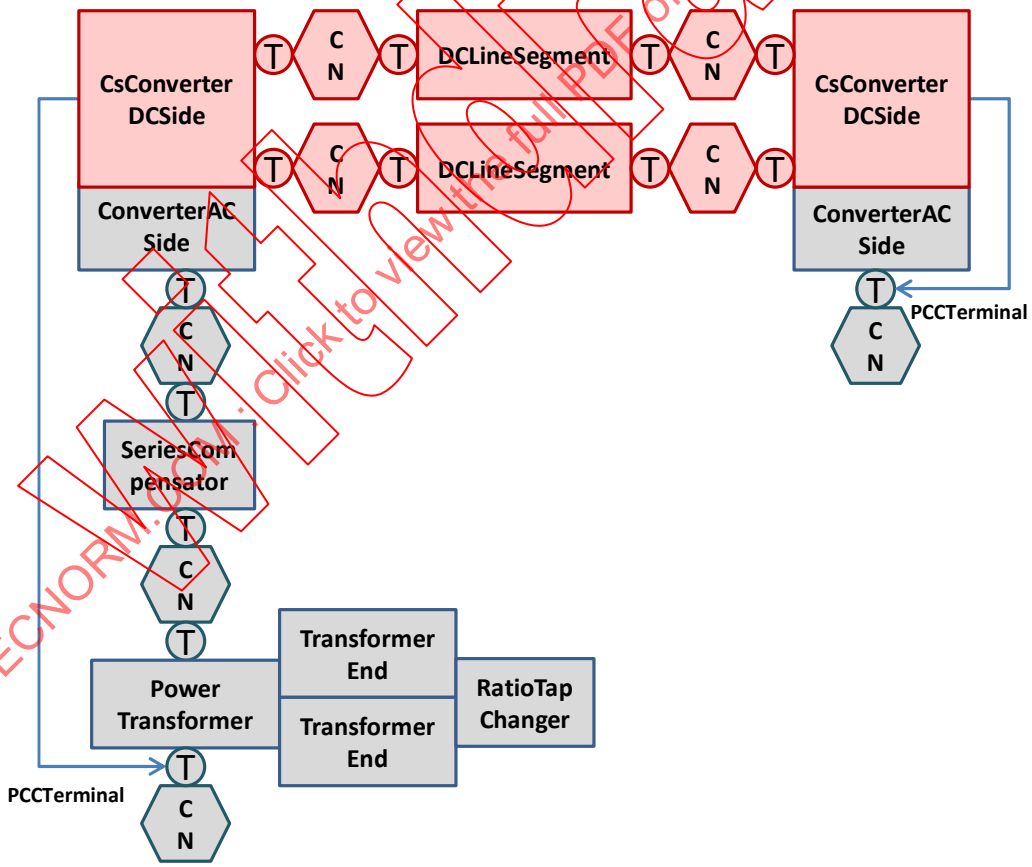
Figure 56 – Simple monopole with measurements

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Refer to Figure 55 for an explanation of the symbols.

Figure 57 – Simple bipolar



Refer to Figure 55 for an explanation of the symbols.

Figure 58 – Monopole one side with detailed model

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4.5.14 Static Var Compensator voltage regulation

4.5.14.1 Background

The Static Var Compensator (SVC) is a shunt device of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow and improve transient stability on power grids. The SVC can be operated in two different modes:

- voltage regulation mode (the voltage is regulated within limits as explained below);
- var control mode (the SVC susceptance is kept constant).

When the SVC is operated in voltage regulation mode, it implements the *V-I* characteristic shown in Figure 59.

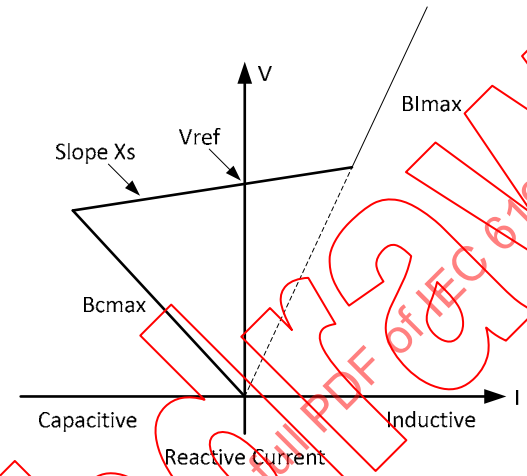


Figure 59 – *V-I* characteristic of SVC

As long as the SVC susceptance *B* stays within the maximum and minimum susceptance values imposed by the total reactive power of capacitor banks (Bc_{max}) and reactor banks (BI_{max}), the voltage is regulated at the reference voltage V_{ref} (also referred to as voltage set point). The voltage at which the SVC neither absorbs nor generates reactive power is the reference voltage (V_{ref}).

A voltage droop is normally used (usually between 1 % and 4 % at maximum reactive power output), and the *V-I* characteristic has the slope indicated in Figure 59. The *V-I* characteristic is described by the following three equations:

$$V = \begin{cases} V_{ref} + X_S \times I & \text{if SVC is in regulation mode} \quad (-Bc_{max} < B < BI_{max}) \\ -\dfrac{I}{Bc_{max}} & \text{if SVC is fully capacitive} \quad (B = Bc_{max}) \\ \dfrac{I}{BI_{max}} & \text{if SVC is fully inductive} \quad (B = BI_{max}) \end{cases}$$

where

V is the positive sequence voltage (pu) at regulated bus;

I is the reactive current ($I > 0$ indicates an inductive current);

X_S is the slope or droop reactance;

V_{ref} is the voltage reference (voltage set point);

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Bc_{max} is the maximum capacitive susceptance;

Bl_{max} is the maximum inductive susceptance.

The voltage set point is typically chosen such that under normal operating conditions the SVC delivers close to zero reactive power so that the full control range of the SVC is available.

The voltage set point of an SVC is fundamentally different from a target voltage. The reactive output of an SVC is proportional to the square of the difference between the regulated bus voltage and the voltage set point. If the SVC is generating or absorbing reactive power, then there will by definition be a difference between the regulated bus voltage and the voltage set point.

4.5.14.2 Current CIM Model

StaticVarCompensator is defined as a class in CIM with the following description:

A facility for providing variable and controllable shunt reactive power. The SVC typically consists of a stepdown transformer, filter, thyristor-controlled reactor, and thyristor-switched capacitor arms.

The SVC may operate in fixed MVar output mode or in voltage control mode. When in voltage control mode, the output of the SVC will be proportional to the deviation of voltage at the controlled bus from the voltage setpoint. The SVC characteristic slope defines the proportion. If the voltage at the controlled bus is equal to the voltage setpoint, the SVC MVar output is zero.

StaticVarCompensator has the following attributes:

capacitiveRating – Maximum available capacitive reactance.

inductiveRating – Maximum available inductive reactance.

q – Reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.

slope – The characteristics slope of an SVC defines how the reactive power output changes in proportion to the difference between the regulated bus voltage and the voltage setpoint.

sVCControlMode – SVC control mode. The values are

- reactivePower,
- voltage.

voltageSetPoint – The reactive power output of the SVC is proportional to the difference between the voltage at the regulated bus and the voltage setpoint. When the regulated bus voltage is equal to the voltage setpoint, the reactive power output is zero.

StaticVarCompensator inherits the following attributes from RegulatingCondEq:

controlEnabled – Specifies the regulation status of the equipment. True is regulating, false is not regulating.

StaticVarCompensator gets its regulated Terminal through the association to RegulatingControl inherited from RegulatingCondEq.

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4.5.14.3 Known issues

The physical characteristics of Static Var Compensators are handled with the attributes defined in CIM. However a few questions and issues remain.

a) None

Proposals

a) Consider changing StaticVarCompensator to inherit from ConductingEquipment rather than from RegulatingCondEq and adding a direct association from StaticVarCompensator to Terminal. The current model using RegulatingControl works for SVCs, but most of the attributes of RegulatingControl would be ignored.

4.6 Modeling guidelines

4.6.1 Modeling for change

Subclauses 4.6.2 to 4.6.5 provide guidelines on how to maintain and extend the CIM.

The CIM is meant to contain classes and attributes that will be exchanged over public interfaces between major applications. The goal is to keep, as much as possible, only the generic features from which a detailed implementation may be derived. In general, it is easier to change the value or domain of an attribute than to change a class definition. This makes the model more robust because it is able to support a broader class of requirements, and more stable because new requirements may be able to be handled without requiring changes to the model.

4.6.2 Process for amendments to the CIM

It may be desirable to amend the CIM to either revise the existing model or to extend the CIM to model additional elements of an electric utility power system. The recommended process for such amendments is as follows.

1) Prepare use case(s) and a request for change to describe the desired changes. This should include proposed changes to the appropriate class diagrams showing new/revised classes, attributes, and associations.
2) The use case(s) and request for change are then reviewed by the appropriate IEC Working Group to decide if the requested changes should be treated as revisions to the current CIM standard, or if they should be treated as private amendments, not requiring a change to the standard itself.
3) Proposed amendments accepted by the working group will be added to a list of outstanding issues, and, at the appropriate time, a new version of the CIM model will be prepared and an update made to the appropriate IEC CIM specification.

4.6.3 Changes to the CIM UML model

From a modeling perspective, when the CIM is extended, the approach is to start with the existing CIM UML model. The extensions may be added in any of several ways that are available in UML, but in all cases the approach is to inspect the current model and determine the best way to build off of the existing class diagrams. The extensions may take the form of any of the following, starting from the simplest to the most complex:

- adding additional attributes to existing classes;
- adding new classes that are specializations of existing classes;
- adding new classes via associations with existing classes.

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For the purpose of extending this standard, the main objective is to reuse the existing CIM to the maximum extent possible. From a packaging point of view, extensions should be made to existing packages where possible. If the extensions comprise a new domain of application, then consideration should be given to creating a new package for the additions, but still creating the necessary associations to the existing package, keeping in mind that even though a new package is being created, the CIM is still a single model.

For the purpose of creating non-standard changes to the information model, the standard CIM should be extended without modifying the standard CIM. Preferably, such extensions should be placed in new packages to both identify the changes as non-standard and to facilitate transferring changes to an updated version of the standard.

4.6.4 Changes to the CIM standards documents

From a documentation perspective, when the CIM is extended, a decision shall be made whether the changes constitute updates to existing CIM standards documents, or whether a new IEC 61970-3x is required. In either case, the extensions will then become part of the IEC standard CIM.

4.6.5 Deprecations

The CIM model may at times contain packages, classes, attributes, or associations that have been identifed as deprecated. These items will be noted in the documentation or with a UML stereotype of “deprecated”. A deprecated item is retained in the present version of the model, but is expected to be removed from future versions. An item that has not been deprecated is not guaranteed to be retained in future versions, but using an item marked as deprecated should be avoided if possible.

4.6.6 CIM profiles

An implementation of the CIM need not include all classes, attributes, or associations in the standard CIM specification to be compliant with the CIM standard. Profiles may be defined to specify which elements shall be included (i.e. mandatory elements) in a particular use of the CIM, as well as which are optional. These profiles are defined in the profile documents of IEC 61970 series, as well as in other IEC series that use and extend the base CIM specified in this document.

An example is the profile for exchanging power system models. This profile specifies how the CIM is to be used for exchanging power system models in XML, and also specifies the mandatory and optional classes, attributes, and associations to be supported for this use of the CIM. Profiles can be maintained using a variety of tools such as the open source CIMTool[1)].

4.7 Modeling tools

This CIM release was constructed using ~~Sparx Systems~~ Enterprise Architect ~~product~~[2)]. The entire CIM UML model exists as an Enterprise Architect project file and is viewable with that tool, including the class diagrams and descriptions of classes, attributes, types, and relationships. Viewing the CIM in this fashion provides a graphical navigation interface that

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1) Available at <http://www.CIMTool.org>. CIMTool is the trade name of a product supplied by the Free Software Foundation. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

2) Enterprise Architect is the trade name of a product supplied by Sparx Systems. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

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permits all CIM specification data to be viewed via point-and-click from the class diagram in each package. A free viewer is available through Sparx Systems.

Ideally, the CIM information model is independent of any specific UML tool, though experience has shown that exchanges between different tools are often less than perfect. Until tool interoperability is proven effective, future changes to the CIM specification, resulting in new versions of this standard, will be incorporated first into the Enterprise Architect project description to ensure a single source for the CIM model data.

Clause 6 of this document was auto-generated using the open source tool jCleanCim[3)], which uses the automation interfaces of Microsoft® Word[4)] and Enterprise Architect and the standard IEC format and styles.

4.8 User implementation conventions

4.8.1 Conventions beyond UML

Subclause 4.8.2 provides recommended user conventions when using the CIM in actual system implementations.

4.8.2 Number of terminals for ConductingEquipment objects

The following ConductingEquipment classes have two terminals: ACLineSegment, DCLineSegment, Switch and all its specializations (including Jumper, Fuse, Breaker, Disconnector, LoadBreakSwitch, and Cut), SeriesCompensator, and EquivalentBranch. The PowerTransformer class typically has two terminals, but may also have one or more terminals. For example a zig-zag connected grounding transformer may have one terminal. Three terminal transformers are commonly used in transmission systems and in special cases transformers may have four, five, or more terminals. All other ConductingEquipment leaf classes (notably also including Clamp and BusbarSection) have a single terminal.

4.9 CIM modeling examples

Power system models have been created from the CIM UML model in various ways. The first example is an RDF (Resource Description Framework) Schema version of the CIM, which uses XML (eXtensible Markup Language) to describe a power system network model. IEC 61970-501 and other profile standards in development are used to specify the model exchange format. RDF Schema versions of the CIM have been used to create XML model files of actual networks for purposes of interoperability testing. An RDF Schema version of the CIM is generated from the CIM UML model file using software tools based on the RDF Schema specification of the CIM.

It should be noted that an RDF schema version of the CIM is still metadata rather than an instantiation of an actual network. However, complete network model files with descriptions of all network elements and their electrical connectivity can be generated by system suppliers using proprietary export tools, and then imported by other systems via a similar import tool, which is used to populate a local network engineering tool database. Examples of such CIM

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3) Available at <http://cimug.ucaiug.org/MTEI/Shared%20Documents/jCleanCim>. JCleanCim is the trade name of a product supplied by the Free Software Foundation. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

4) Word is the trade name of a product supplied by Microsoft. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

XML models include the Siemens 100 bus model, the Alstom 60 bus model, and the ABB 40 bus model files[5] used for CIM XML interoperability testing.

5 Detailed model

5.1 Overview

The portion of the common information model (CIM) covered by IEC 61970-301 represents a comprehensive logical view of information exchanged among different systems in electrical utilities. This definition includes the public classes and attributes, as well as the relationships between them. ~~The following Subclauses describe how Clause 6 is structured. Clause 6 is automatically generated from the CIM model maintained with the tools described in 4.6.~~

5.2 Context

The CIM is partitioned into subpackages. Classes within the packages are listed in the order they are defined in the UML model. Native class attributes are listed first, followed by inherited attributes in order of depth of inheritance. Native associations are listed first for each class, followed by inherited associations in order of depth of inheritance, then alphabetically by association end name. The associations are described according to the role of each class participating in the association. The association ends are listed under the class at each end of an association.

Figure 60 shows the top level packages included in this document.

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5) Siemens100 bus model, Alstom 60 bus model, and ABB 40 model are the trade names of products supplied by Siemens, Alstom Grid, and ABB. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

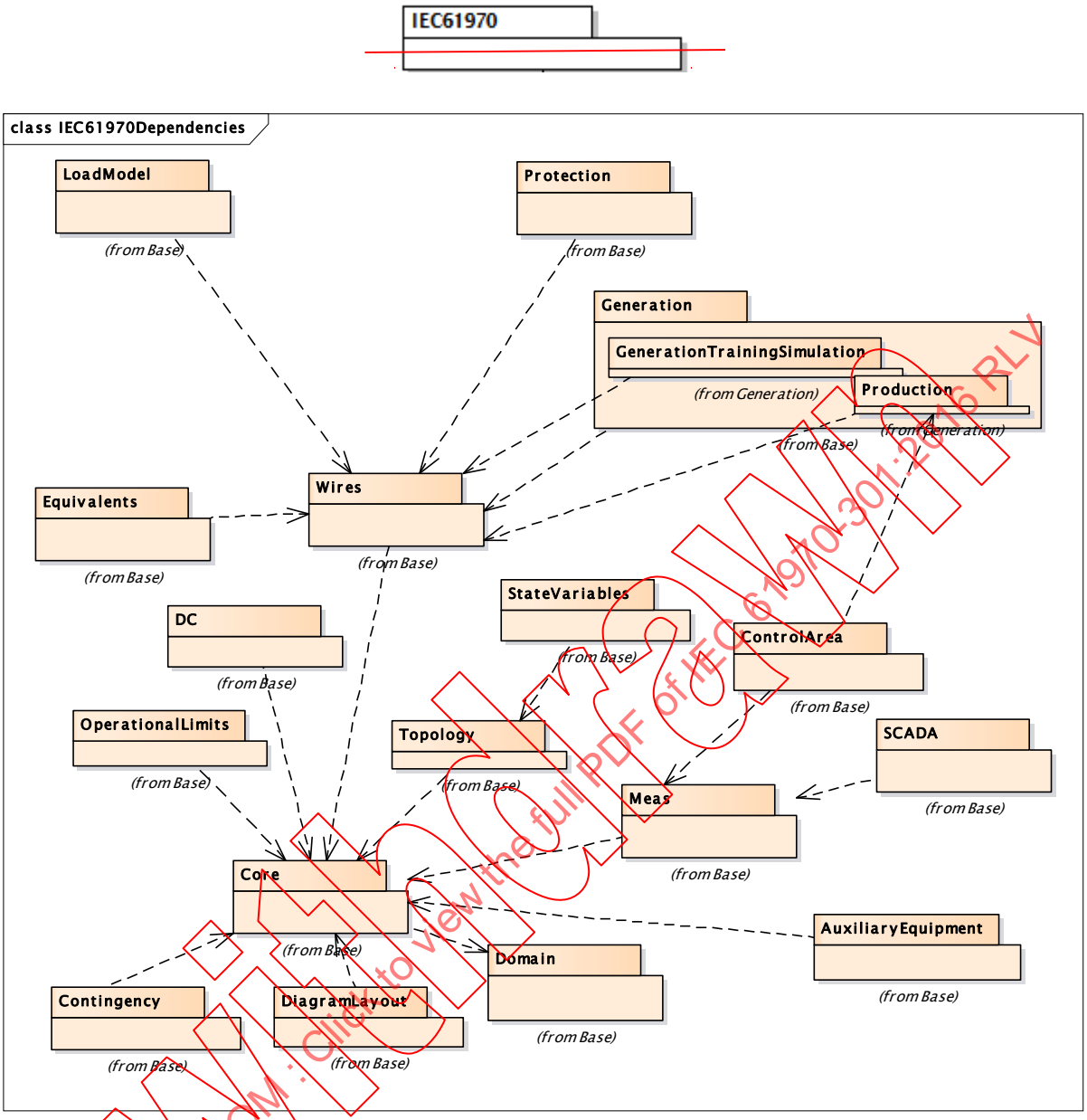


Figure 60 – CIM top level packages

For each package, the model information for each class is fully described. Attribute and association end information for native and inherited attributes is listed as in Table 9 and Table 10 for an example class named “Class1” in example package “Package1”. For any inherited attributes or association ends the “description” column will contain text indicating the attributes are inherited from a specific class. In this example we assume Class1 inherits from class IdentifiedObject. The description column for native attributes and association ends contains the actual description. For inherited attributes, the base class is noted in the description and the full attribute documentation is available in that base class as a native attribute.

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Table 9 – Attributes of Package1::Class1

name	type	description
native1	Float	A floating point native attribute of the class is described here.
native2	ActivePower	Documentation for another native attribute of type ActivePower.
name	String	Inherited from: IdentifiedObject

For cases where an attribute is a constant, Table 9 will add the phrase “(const)” to the name column. In such cases, the attribute normally has an initial value also which is preceded by an equal sign and appended to the attribute name.

Table 10 – Association ends of Package1::Class1 with other classes

[mult from]	[mult to] name	type	description
[0..*]	[0..1] Class2	Class2	The description of the association end to another class named “Class1”. Note it is typical, but not required, that the association end is the same as the referenced type. This association end may reference zero or one objects. The other end of the association may reference any number of Class1 instances.
[0..1]	[0..*] SecondClass2	Class2	The description of references to class named “Class2”. In this case any number of references may be made. The reverse reference may reference zero or one Class1 instances.
[1..1]	[0..*] Class3	Class3	References any number of Class3 instances. The reverse reference shall reference only one instance of Class1.
[0..*]	[0..*] Class4	Class4	A many to many association.
[0..1]	[0..*] DiagramObjects	DiagramObject	inherited from: IdentifiedObject
[1..1]	[0..*] Names	Name	inherited from: IdentifiedObject

In Table 10, the first column describes the multiplicity at this end of the association (i.e. how this class participates in association). Second column describes the other association end. Its multiplicity is included in brackets. The association end name is listed in plain text. The class at the other end of the association is in the third column. A multiplicity of zero indicates an optional association. A multiplicity of “*” indicates any number is allowed. For example, a multiplicity of [1..*] indicates a range from 1 to any larger number is allowed.

In the case that a class is an enumeration named “Enumeration1”, the attributes table is replaced by the literals documentation as shown in Table 11 since enumeration literals have no type. There are no inherited enumeration literals for an enumeration class.

Table 11 – Literals of Package1::Enumeration1

literal	description
native1	This is the first native enumeration value.
native2	This is the second native enumeration value.
native3	There are typically no inherited attributes for enumerations.

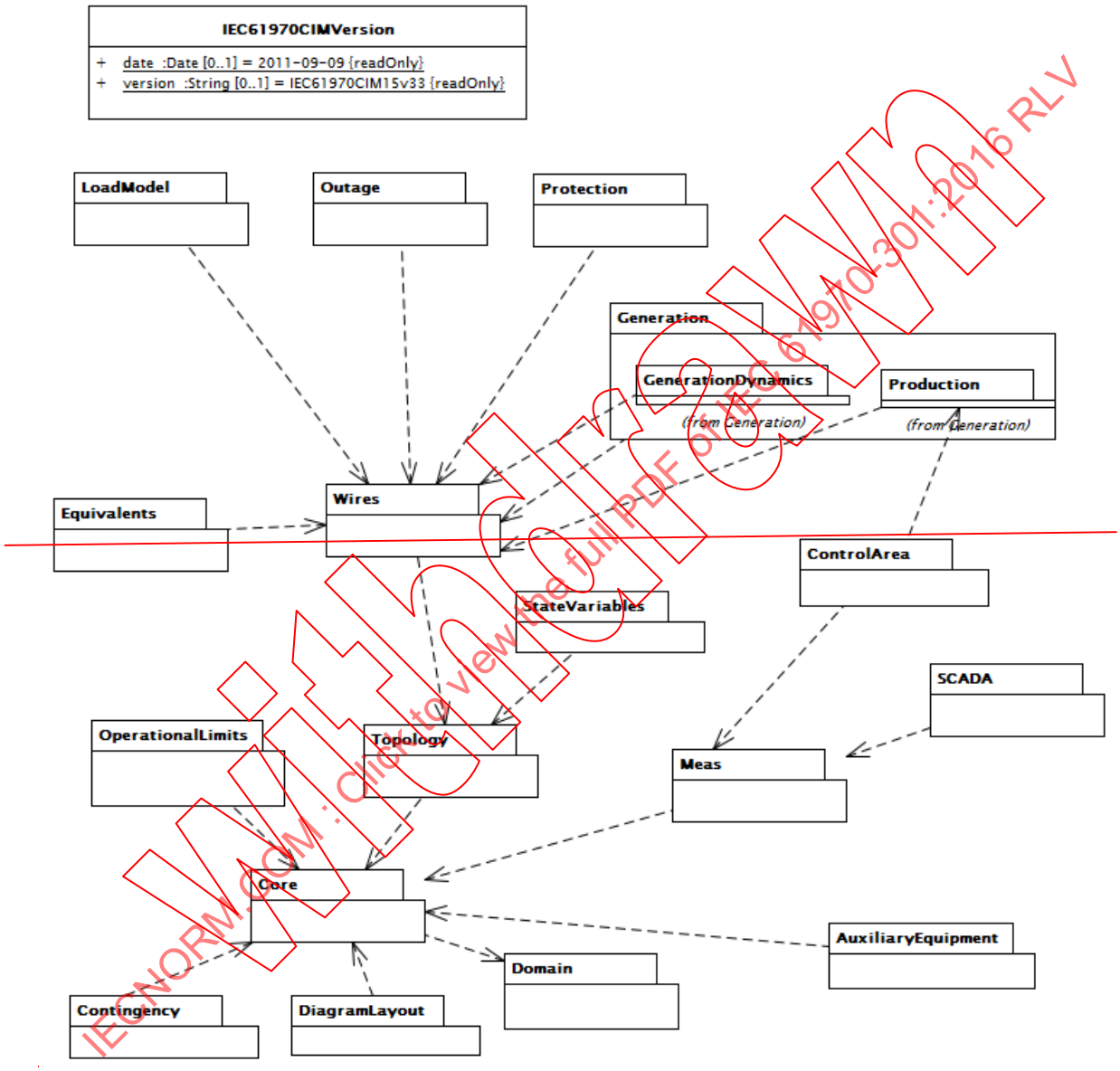
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6 ~~Top package IEC61970~~ Package Base

6.1 General

~~Top package for IEC 61970.~~

~~Figure 26 shows class diagram IEC61970Dependencies.~~



~~Figure 26 – Class diagram IEC61970::IEC61970Dependencies~~

~~This diagram shows all 61970 packages and their logical dependencies.~~

~~6.2 IEC61970CIMVersion root class~~

~~This is the IEC 61970 CIM version number assigned to this UML model.~~

~~Table 7 shows all attributes of IEC61970CIMVersion.~~

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~~Table 7 – Attributes of IEC61970::IEC61970CIMVersion~~

~~name~~	~~type~~	~~description~~
~~date=2011-09-09 (const)~~	~~Date~~	~~Form is YYYY-MM-DD for example for January 5, 2009 it is 2009-01-05.~~
~~version=IEC61970CIM15v33 (const)~~	~~String~~	~~Form is IEC61970CIMXXvYY where XX is the major CIM package version and the YY is the minor version. For example IEC61970CIM13v18.~~

Empty.

6.2 Package Faults

6.2.1 General

The package describes faults that may happen to conducting equipment, e.g. tree falling on a power line.

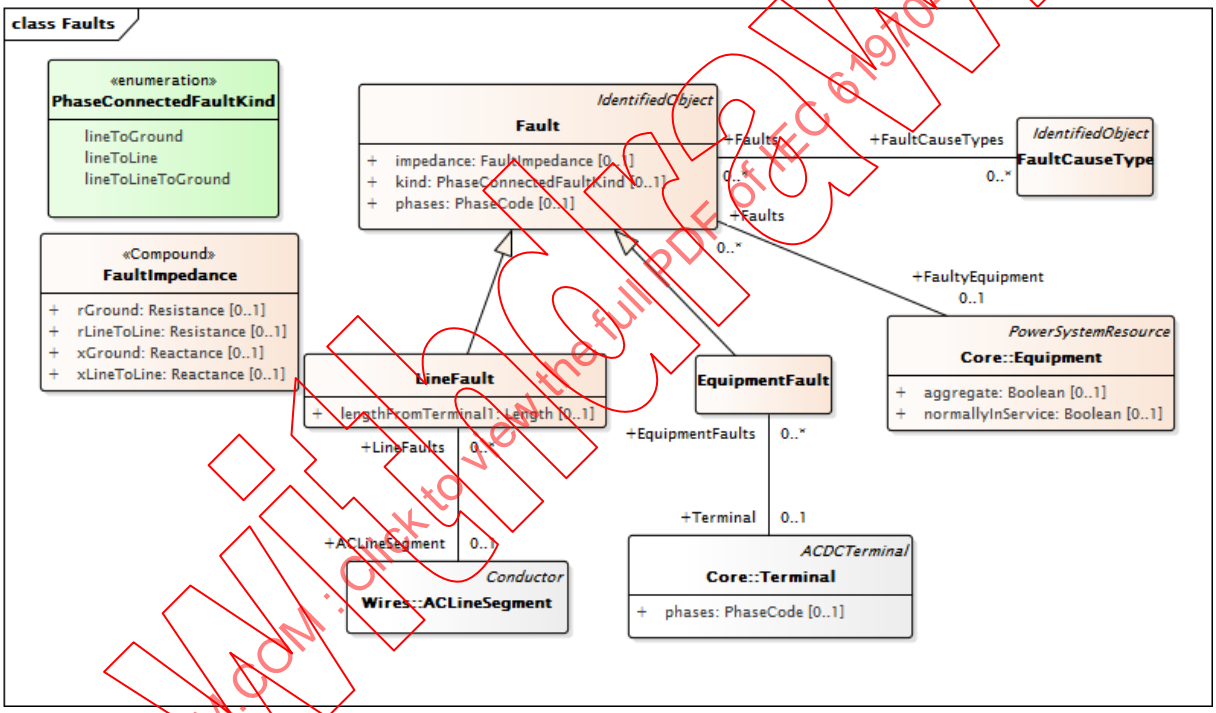


Figure 61 – Class diagram Faults::Faults

Figure 61: Classes used to model faults.

6.2.2 EquipmentFault

A fault applied at the terminal, external to the equipment. This class is not used to specify faults internal to the equipment.

Table 12 shows all attributes of EquipmentFault.

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Table 12 – Attributes of Faults::EquipmentFault

name	mult	type	description
impedance	0..1	FaultImpedance	inherited from: Fault
kind	0..1	PhaseConnectedFaultKind	inherited from: Fault
phases	0..1	PhaseCode	inherited from: Fault
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 13 shows all association ends of EquipmentFault with other classes.

Table 13 – Association ends of Faults::EquipmentFault with other classes

mult from	name	mult to	type	description
0..*	Terminal	0..1	Terminal	The terminal connecting to the bus to which the fault is applied.
0..*	FaultyEquipment	0..1	Equipment	inherited from: Fault
0..*	FaultCauseTypes	0..*	FaultCauseType	inherited from: Fault
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.2.3 Fault

Abnormal condition causing current flow through conducting equipment, such as caused by equipment failure or short circuits from objects not typically modeled (for example, a tree falling on a line).

Table 14 shows all attributes of Fault.

Table 14 – Attributes of Faults::Fault

name	mult	type	description
impedance	0..1	FaultImpedance	Fault impedance. Its usage is described by 'kind'.
kind	0..1	PhaseConnectedFaultKind	The kind of phase fault.
phases	0..1	PhaseCode	The phases participating in the fault. The fault connections into these phases are further specified by the type of fault.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 15 shows all association ends of Fault with other classes.

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Table 15 – Association ends of Faults::Fault with other classes

mult from	name	mult to	type	description
0..*	FaultyEquipment	0..1	Equipment	Equipment carrying this fault.
0..*	FaultCauseTypes	0..*	FaultCauseType	All types of fault cause.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.2.4 FaultCauseType

Type of cause of the fault.

Table 16 shows all attributes of FaultCauseType.

Table 16 – Attributes of Faults::FaultCauseType

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 17 shows all association ends of FaultCauseType with other classes.

Table 17 – Association ends of Faults::FaultCauseType with other classes

mult from	name	mult to	type	description
0..*	Faults	0..*	Fault	All faults with this cause type.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.2.5 FaultImpedance compound

Impedance description for the fault.

Table 18 shows all attributes of FaultImpedance.

Table 18 – Attributes of Faults::FaultImpedance

name	mult	type	description
rGround	0..1	Resistance	The resistance of the fault between phases and ground.
rLineToLine	0..1	Resistance	The resistance of the fault between phases.
xGround	0..1	Reactance	The reactance of the fault between phases and ground.
xLineToLine	0..1	Reactance	The reactance of the fault between phases.

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6.2.6 LineFault

A fault that occurs on an AC line segment at some point along the length.

Table 19 shows all attributes of LineFault.

Table 19 – Attributes of Faults::LineFault

name	mult	type	description
lengthFromTerminal1	0..1	Length	The length to the place where the fault is located starting from terminal with sequence number 1 of the faulted line segment.
impedance	0..1	FaultImpedance	inherited from: Fault
kind	0..1	PhaseConnectedFaultKind	inherited from: Fault
phases	0..1	PhaseCode	inherited from: Fault
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 20 shows all association ends of LineFault with other classes.

Table 20 – Association ends of Faults::LineFault with other classes

mult from	name	mult to	type	description
0..*	ACLineSegment	0..1	ACLineSegment	The line segment of this line fault.
0..*	FaultyEquipment	0..1	Equipment	inherited from: Fault
0..*	FaultCauseTypes	0..*	FaultCauseType	inherited from: Fault
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.2.7 PhaseConnectedFaultKind enumeration

The type of fault connection among phases.

Table 21 shows all literals of PhaseConnectedFaultKind.

Table 21 – Literals of Faults::PhaseConnectedFaultKind

literal	value	description
lineToGround		The fault connects the indicated phases to ground. The line to line fault impedance is not used and assumed infinite. The full ground impedance is connected between each phase specified in the fault and ground, but not between the phases.
lineToLine		The fault connects the specified phases together without a connection to ground. The ground impedance of this fault is ignored. The line to line impedance is connected between each of the phases specified in the fault. For example three times for a three phase fault, one time for a two phase fault. A single phase fault should not be specified.

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literal	value	description
lineToLineToGround		The fault connects the indicated phases to ground and to each other. The line to line impedance is connected between each of the phases specified in the fault in a full mesh. For example three times for a three phase fault, one time for a two phase fault. A single phase fault should not be specified. The full ground impedance is connected between each phase specified in the fault and ground.

6.3 Package DocIEC 61970

This package contains example documentation diagrams not intended to be documented in IEC 61970-301 with the rest of the normative packages. The diagrams within this package are individually included in the introductory text of the IEC 61970-301 document.

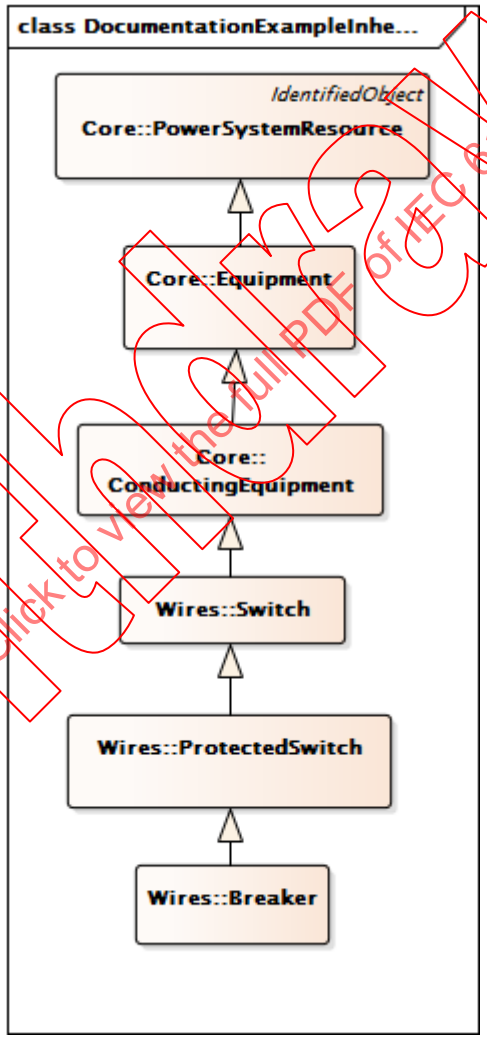


Figure 62 – Class diagram DocIEC 61970::DocumentationExampleInheritance

Figure 62: This shows an example of inheritance in UML. This diagram is only to support figures in the documentation.

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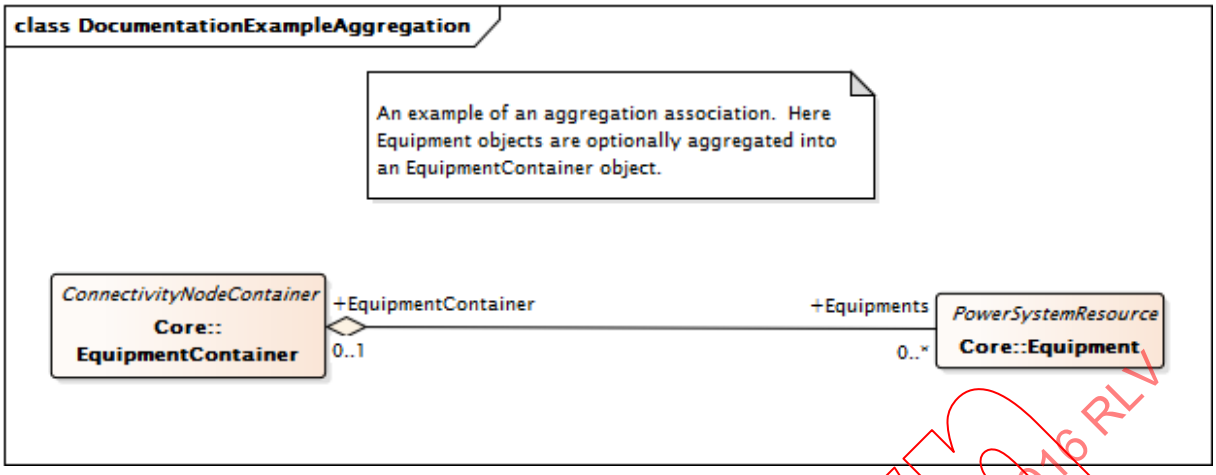


Figure 63 – Class diagram DocIEC 61970::DocumentationExampleAggregation

Figure 63: This shows an example of aggregation in UML. This diagram is only to support figures in the documentation.

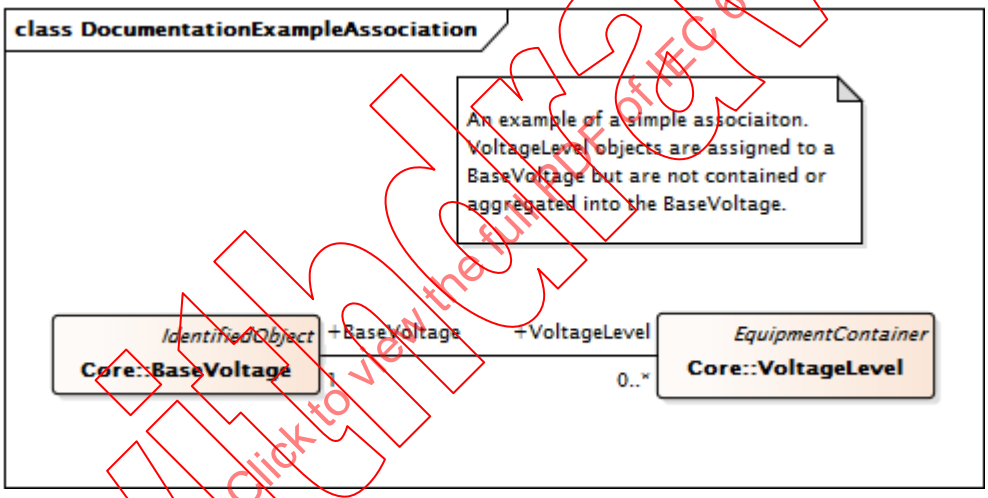


Figure 64 – Class diagram DocIEC 61970::DocumentationExampleAssociation

Figure 64: This diagram is an example used for documentation purposes. It shows how a simple association and an aggregation association are expressed in UML diagrams.

6.4 Package Domain

6.4.1 General

The domain package defines primitive datatypes that are used by classes in other packages. Stereotypes are used to describe the datatypes. The following stereotypes are defined:

<<enumeration>> A list of permissible constant values.

<<Primitive>> The most basic data types used to compose all other data types.

<<CIMDatatype>> A datatype that contains a value attribute, an optional unit of measure and a unit multiplier. The unit and multiplier may be specified as a static variable initialized to the allowed value.

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<<Compound>> A composite of Primitive, enumeration, CIMDatatype or other Compound classes, as long as the Compound classes do not recurse.

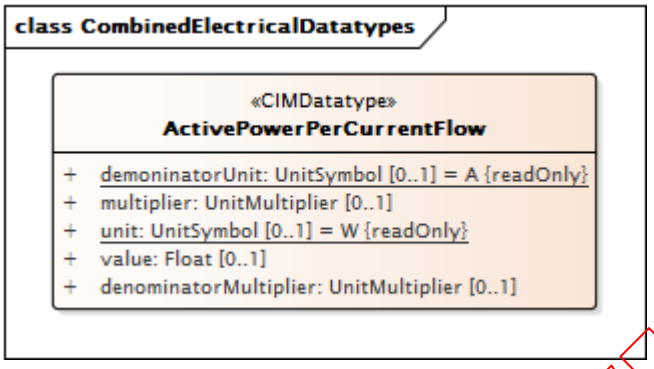


Figure 65 – Class diagram Domain::CombinedElectricalDatatypes

Figure 65: This diagram shows electrical datatypes that are combinations of other electrical datatypes.

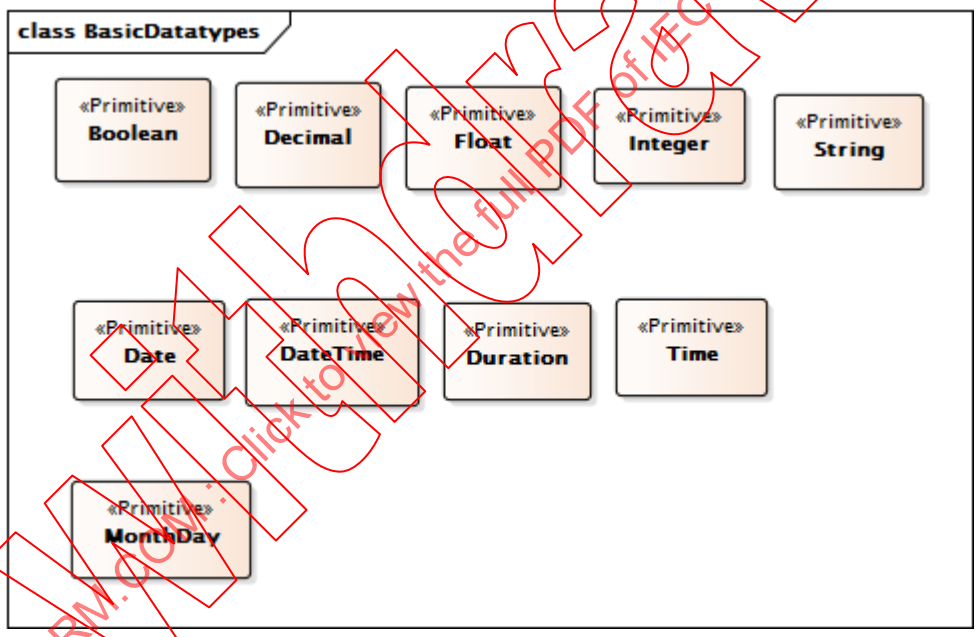
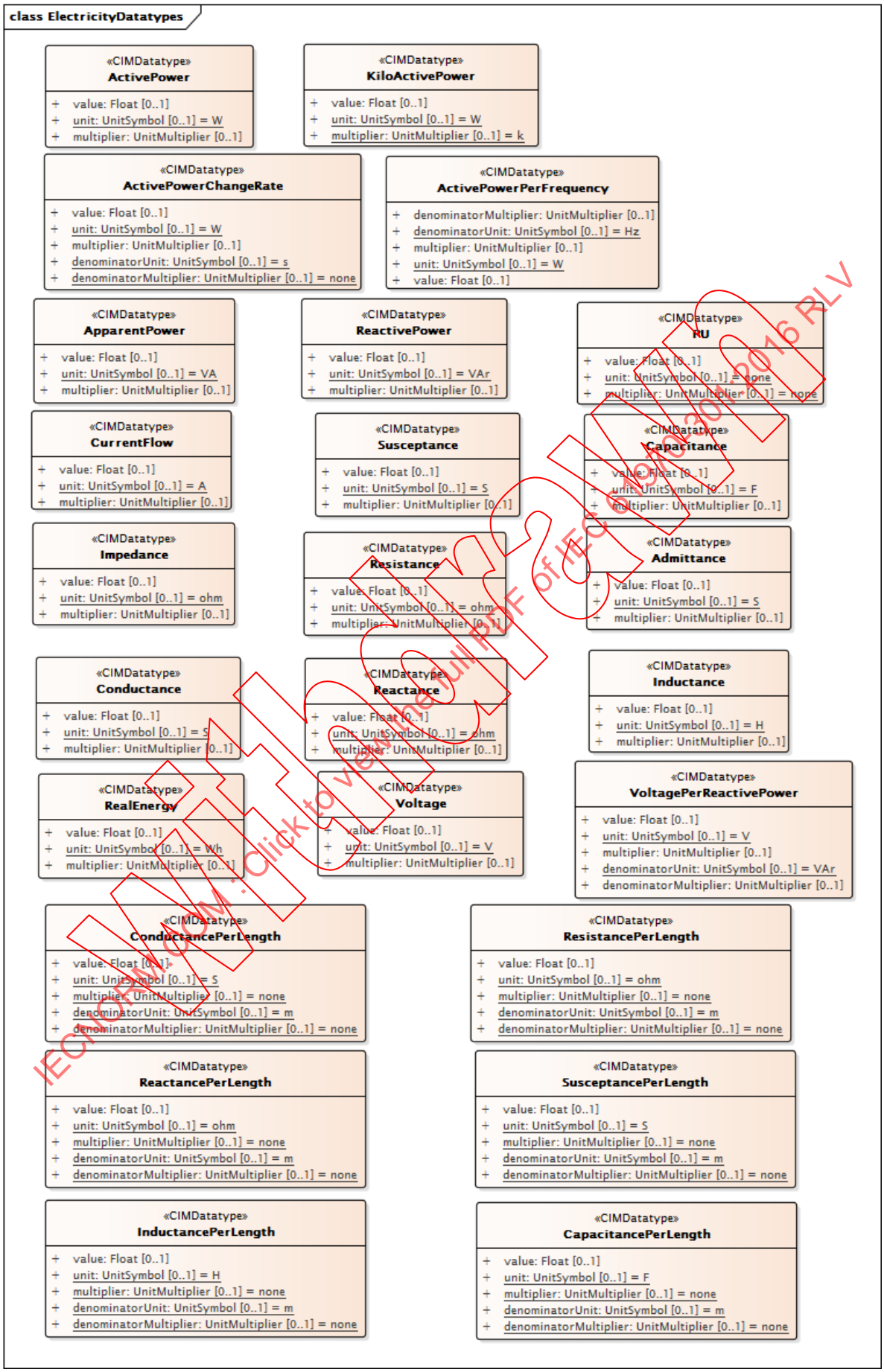


Figure 66 – Class diagram Domain::BasicDatatypes

Figure 66: This diagram shows basic datatypes that are the basis for all other datatypes.

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Figure 67 – Class diagram Domain::ElectricityDatatypes

Figure 67: This diagram shows electricity related data types.

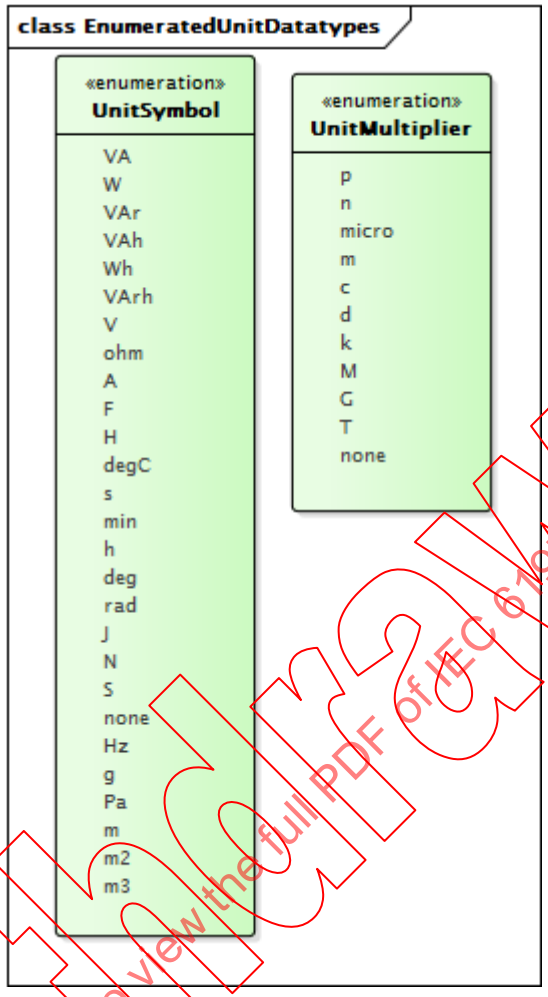
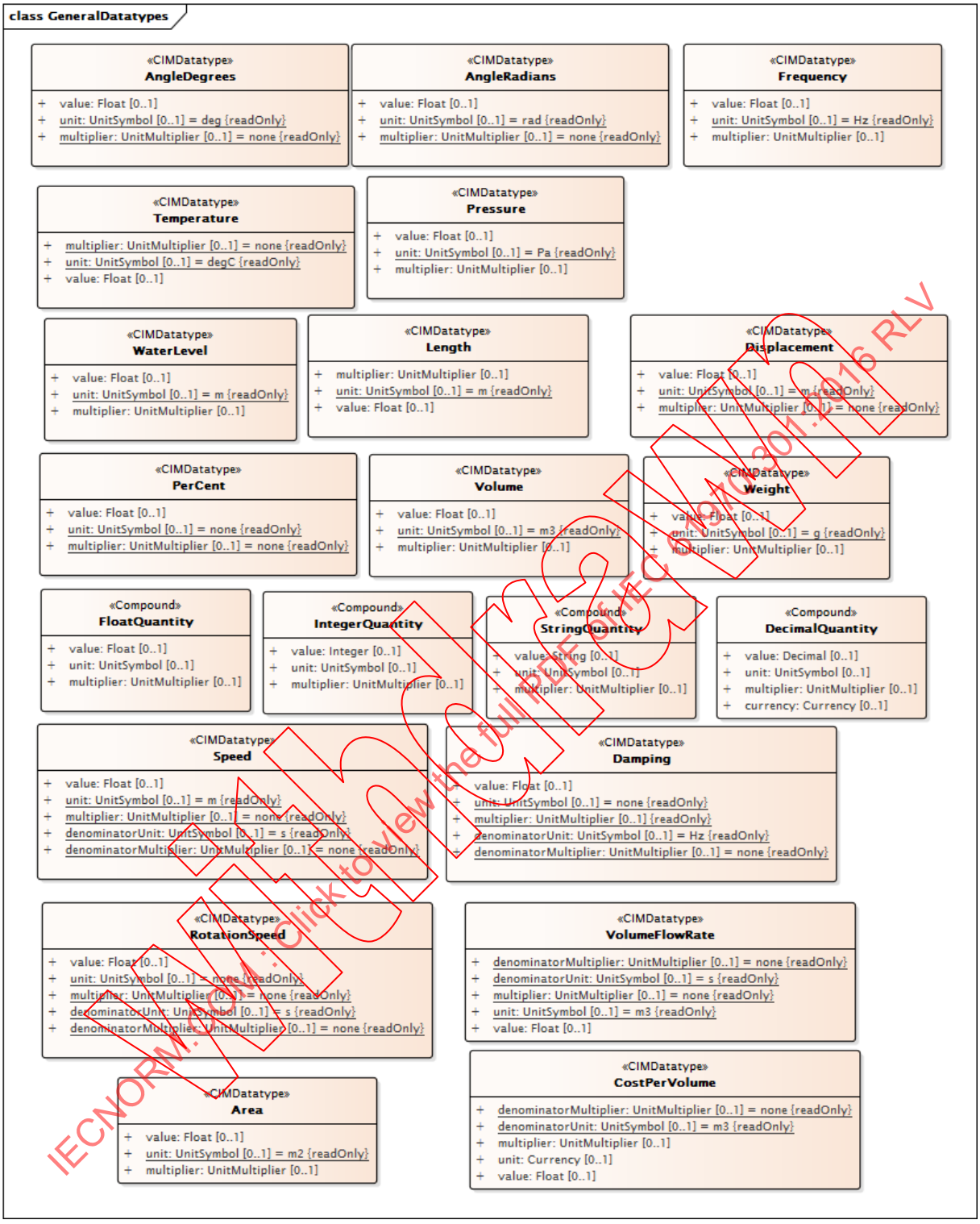


Figure 68 – Class diagram Domain::EnumeratedUnitDatatypes

Figure 68: This diagram shows enumerated data types related to the SI unit system.

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Figure 69 – Class diagram Domain::GeneralDatatypes

Figure 69: This diagram shows general data types.

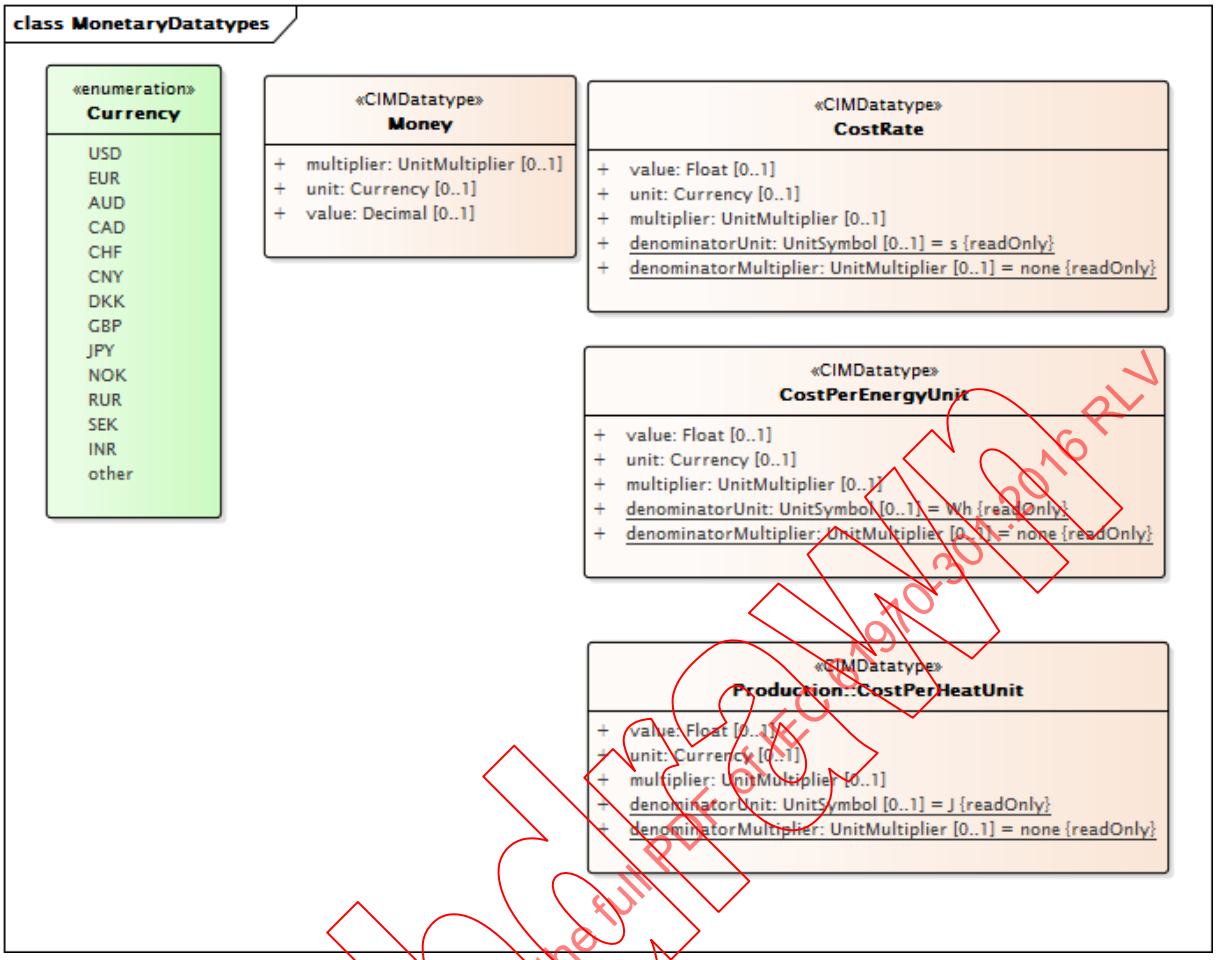


Figure 70 – Class diagram Domain::MonetaryDatatypes

Figure 70: This diagram shows monetary related data types.

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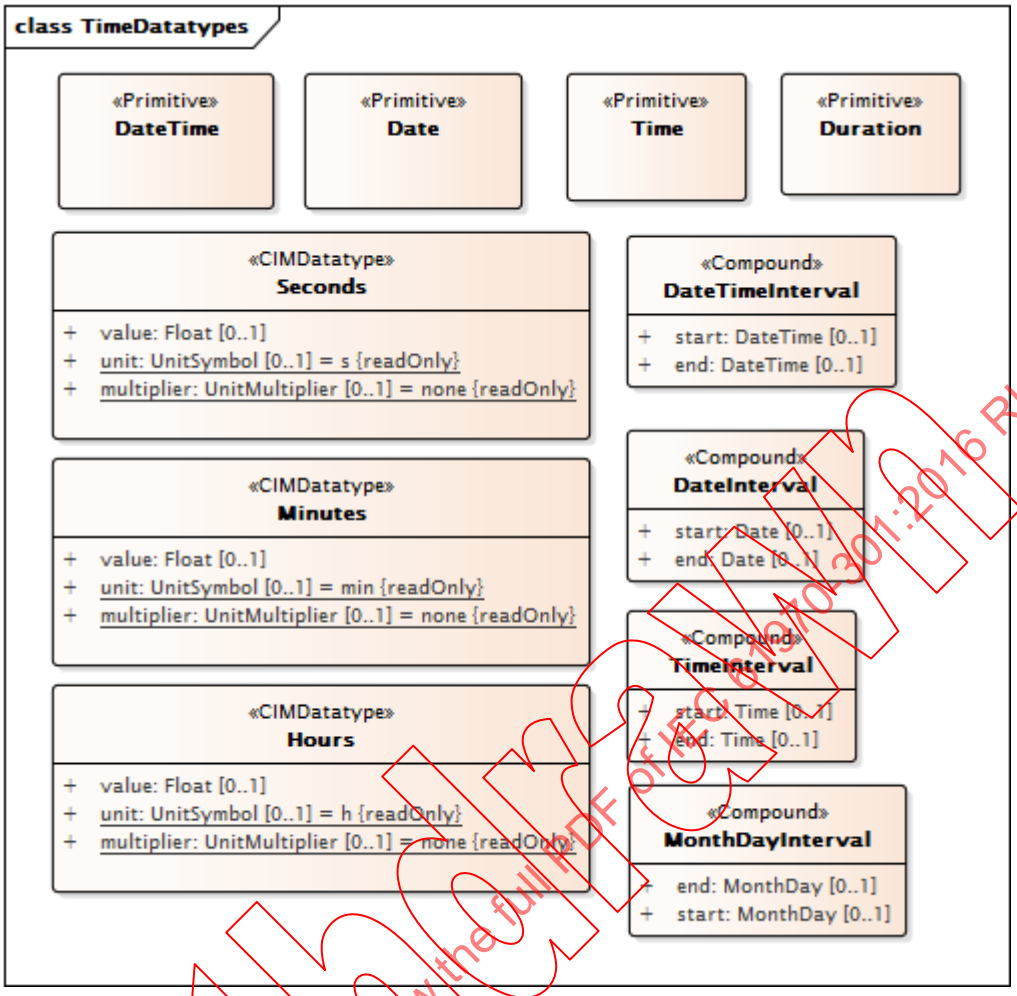


Figure 71 – Class diagram Domain::TimeDatatypes

Figure 71: This diagram shows time related data types.

6.4.2 ActivePower datatype

Product of RMS value of the voltage and the RMS value of the in-phase component of the current.

Table 22 shows all attributes of ActivePower.

Table 22 – Attributes of Domain::ActivePower

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=W)
multiplier	0..1	UnitMultiplier	

6.4.3 ActivePowerChangeRate datatype

Rate of change of active power per time.

Table 23 shows all attributes of ActivePowerChangeRate.

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Table 23 – Attributes of Domain::ActivePowerChangeRate

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=W)
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.4 ActivePowerPerCurrentFlow datatype

Table 24 shows all attributes of ActivePowerPerCurrentFlow.

Table 24 – Attributes of Domain::ActivePowerPerCurrentFlow

name	mult	type	description
denominatorUnit	0..1	UnitSymbol	(const=A)
multiplier	0..1	UnitMultiplier	
unit	0..1	UnitSymbol	(const=W)
value	0..1	Float	
denominatorMultiplier	0..1	UnitMultiplier	

6.4.5 ActivePowerPerFrequency datatype

Active power variation with frequency.

Table 25 shows all attributes of ActivePowerPerFrequency.

Table 25 – Attributes of Domain::ActivePowerPerFrequency

name	mult	type	description
denominatorMultiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=Hz)
multiplier	0..1	UnitMultiplier	
unit	0..1	UnitSymbol	(const=W)
value	0..1	Float	

6.4.6 Admittance datatype

Ratio of current to voltage.

Table 26 shows all attributes of Admittance.

Table 26 – Attributes of Domain::Admittance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	

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6.4.7 AngleDegrees datatype

Measurement of angle in degrees.

Table 27 shows all attributes of AngleDegrees.

Table 27 – Attributes of Domain::AngleDegrees

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=deg)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.8 AngleRadians datatype

Phase angle in radians.

Table 28 shows all attributes of AngleRadians.

Table 28 – Attributes of Domain::AngleRadians

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=rad)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.9 ApparentPower datatype

Product of the RMS value of the voltage and the RMS value of the current.

Table 29 shows all attributes of ApparentPower.

Table 29 – Attributes of Domain::ApparentPower

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=VA)
multiplier	0..1	UnitMultiplier	

6.4.10 Area datatype

Area.

Table 30 shows all attributes of Area.

Table 30 – Attributes of Domain::Area

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m2)
multiplier	0..1	UnitMultiplier	

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6.4.11 Boolean primitive

A type with the value space "true" and "false".

6.4.12 Capacitance datatype

Capacitive part of reactance (imaginary part of impedance), at rated frequency.

Table 31 shows all attributes of Capacitance.

Table 31 – Attributes of Domain::Capacitance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=F)
multiplier	0..1	UnitMultiplier	

6.4.13 CapacitancePerLength datatype

Capacitance per unit of length.

Table 32 shows all attributes of CapacitancePerLength.

Table 32 – Attributes of Domain::CapacitancePerLength

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=F)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.14 Conductance datatype

Factor by which voltage must be multiplied to give corresponding power lost from a circuit. Real part of admittance.

Table 33 shows all attributes of Conductance.

Table 33 – Attributes of Domain::Conductance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	

6.4.15 ConductancePerLength datatype

Real part of admittance per unit of length.

Table 34 shows all attributes of ConductancePerLength.

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Table 34 – Attributes of Domain::ConductancePerLength

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.16 CostPerEnergyUnit datatype

Cost, in units of currency, per quantity of electrical energy generated.

Table 35 shows all attributes of CostPerEnergyUnit.

Table 35 – Attributes of Domain::CostPerEnergyUnit

name	mult	type	description
value	0..1	Float	
unit	0..1	Currency	
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=Wh)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.17 CostPerVolume datatype

Cost per unit volume.

Table 36 shows all attributes of CostPerVolume.

Table 36 – Attributes of Domain::CostPerVolume

name	mult	type	description
denominatorMultiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m3)
multiplier	0..1	UnitMultiplier	
unit	0..1	Currency	
value	0..1	Float	

6.4.18 CostRate datatype

Cost, in units of currency, per elapsed time.

Table 37 shows all attributes of CostRate.

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Table 37 – Attributes of Domain::CostRate

name	mult	type	description
value	0..1	Float	
unit	0..1	Currency	
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.19 Currency enumeration

Monetary currencies. ~~Apologies for~~ This list is not ~~being~~ exhaustive.

Table 38 shows all literals of Currency.

Table 38 – Literals of Domain::Currency

literal	value	description
USD		US dollar
EUR		European euro
AUD		Australian dollar
CAD		Canadian dollar
CHF		Swiss franc
CNY		Chinese yuan renminbi
DKK		Danish crown
GBP		British pound
JPY		Japanese yen
NOK		Norwegian crown
RUR		Russian ruble
SEK		Swedish crown
INR		India rupees
other		Another type of currency.

6.4.20 CurrentFlow datatype

Electrical current with sign convention: positive flow is out of the conducting equipment into the connectivity node. Can be both AC and DC.

Table 39 shows all attributes of CurrentFlow.

Table 39 – Attributes of Domain::CurrentFlow

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=A)
multiplier	0..1	UnitMultiplier	

6.4.21 Damping datatype

Per-unit active power variation with frequency referenced on the system apparent power base. Typical values are in the range 1,0 to 2,0.

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Table 40 shows all attributes of Damping.

Table 40 – Attributes of Domain::Damping

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=Hz)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.22 Date primitive

Date ~~and time~~ as "yyyy-mm-dd", which conforms with ISO 8601. UTC time zone is specified as "yyyy-mm-ddZ". A local timezone relative UTC is specified as "yyyy-mm-dd(+/-)hh:mm".

6.4.23 DateInterval compound

Interval between two dates.

Table 41 shows all attributes of DateInterval.

Table 41 – Attributes of Domain::DateInterval

name	mult	type	description
start	0..1	Date	Start date of this interval.
end	0..1	Date	End date of this interval.

6.4.24 DateTime primitive

Date and time as "yyyy-mm-ddThh:mm:ss.sss", which conforms with ISO 8601. UTC time zone is specified as "yyyy-mm-ddThh:mm:ss.sssZ". A local timezone relative UTC is specified as "yyyy-mm-ddThh:mm:ss.sss-hh:mm". The second component (shown here as "ss.sss") could have any number of digits in its fractional part to allow any kind of precision beyond seconds.

6.4.25 DateTimeInterval compound

Interval between two date and time points.

Table 42 shows all attributes of DateTimeInterval.

Table 42 – Attributes of Domain::DateTimeInterval

name	mult	type	description
start	0..1	DateTime	Start date and time of this interval.
end	0..1	DateTime	End date and time of this interval.

6.4.26 Decimal primitive

Decimal is the base-10 notational system for representing real numbers.

6.4.27 DecimalQuantity compound

Table 43 shows all attributes of DecimalQuantity.

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Table 43 – Attributes of Domain::DecimalQuantity

name	mult	type	description
value	0..1	Decimal	
unit	0..1	UnitSymbol	
multiplier	0..1	UnitMultiplier	
currency	0..1	Currency	Quantity with decimal value and associated unit or currency information.

6.4.28 Displacement datatype

Unit of displacement relative to a reference position, hence can be negative.

Table 44 shows all attributes of Displacement.

Table 44 – Attributes of Domain::Displacement

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.29 Duration primitive

Duration as "PnYnMnDTnHnMnS" which conforms to ISO 8601, where nY expresses a number of years, nM a number of months, nD a number of days. The letter T separates the date expression from the time expression and, after it, nH identifies a number of hours, nM a number of minutes and nS a number of seconds. The number of seconds could be expressed as a decimal number, but all other numbers are integers.

6.4.30 Float primitive

A floating point number. The range is unspecified and not limited.

6.4.31 FloatQuantity ~~datatype~~ compound

Quantity with float value and associated unit information.

Table 45 shows all attributes of FloatQuantity.

Table 45 – Attributes of Domain::FloatQuantity

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	
multiplier	0..1	UnitMultiplier	

6.4.32 Frequency datatype

Cycles per second.

Table 46 shows all attributes of Frequency.

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Table 46 – Attributes of Domain::Frequency

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=Hz)
multiplier	0..1	UnitMultiplier	

6.4.33 Hours datatype

Time specified in hours.

Table 47 shows all attributes of Hours.

Table 47 – Attributes of Domain::Hours

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=h)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.34 Impedance datatype

Ratio of voltage to current.

Table 48 shows all attributes of Impedance.

Table 48 – Attributes of Domain::Impedance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	

6.4.35 Inductance datatype

Inductive part of reactance (imaginary part of impedance), at rated frequency.

Table 49 shows all attributes of Inductance.

Table 49 – Attributes of Domain::Inductance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=H)
multiplier	0..1	UnitMultiplier	

6.4.36 InductancePerLength datatype

Inductance per unit of length.

Table 50 shows all attributes of InductancePerLength.

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Table 50 – Attributes of Domain::InductancePerLength

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=H)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.37 Integer primitive

An integer number. The range is unspecified and not limited.

6.4.38 IntegerQuantity ~~datatype~~ compound

Quantity with integer value and associated unit information.

Table 51 shows all attributes of IntegerQuantity.

Table 51 – Attributes of Domain::IntegerQuantity

name	mult	type	description
value	0..1	Integer	
unit	0..1	UnitSymbol	
multiplier	0..1	UnitMultiplier	

6.4.39 KiloActivePower datatype

Active power in kilowatts.

Table 52 shows all attributes of KiloActivePower.

Table 52 – Attributes of Domain::KiloActivePower

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=W)
multiplier	0..1	UnitMultiplier	(const=k)

6.4.40 Length datatype

Unit of length. Never negative.

Table 53 shows all attributes of Length.

Table 53 – Attributes of Domain::Length

name	mult	type	description
multiplier	0..1	UnitMultiplier	
unit	0..1	UnitSymbol	(const=m)
value	0..1	Float	

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6.4.41 Minutes datatype

Time in minutes.

Table 54 shows all attributes of Minutes.

Table 54 – Attributes of Domain::Minutes

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=min)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.42 Money datatype

Amount of money.

Table 55 shows all attributes of Money.

Table 55 – Attributes of Domain::Money

name	mult	type	description
multiplier	0..1	UnitMultiplier	
unit	0..1	Currency	
value	0..1	Decimal	

6.4.43 MonthDay primitive

MonthDay format as "--mm-dd", which conforms with XSD data type gMonthDay.

6.4.44 MonthDayInterval compound

Interval between two times specified as month and day.

Table 56 shows all attributes of MonthDayInterval.

Table 56 – Attributes of Domain::MonthDayInterval

name	mult	type	description
end	0..1	MonthDay	End time of this interval.
start	0..1	MonthDay	Start time of this interval.

6.4.45 PU datatype

Per Unit – a positive or negative value referred to a defined base. Values typically range from −10 to +10.

Table 57 shows all attributes of PU.

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Table 57 – Attributes of Domain::PU

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.46 PerCent datatype

Percentage on a defined base. For example, specify as 100 to indicate the defined base.

Table 58 shows all attributes of PerCent.

Table 58 – Attributes of Domain::PerCent

name	mult	type	description
value	0..1	Float	Normally 0 to 100 on a defined base
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.47 Pressure datatype

Pressure in pascals.

Table 59 shows all attributes of Pressure.

Table 59 – Attributes of Domain::Pressure

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=Pa)
multiplier	0..1	UnitMultiplier	

6.4.48 Reactance datatype

Reactance (imaginary part of impedance), at rated frequency.

Table 60 shows all attributes of Reactance.

Table 60 – Attributes of Domain::Reactance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	

6.4.49 ReactancePerLength datatype

Reactance (imaginary part of impedance) per unit of length, at rated frequency.

Table 61 shows all attributes of ReactancePerLength.

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Table 61 – Attributes of Domain::ReactancePerLength

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.50 ReactivePower datatype

Product of RMS value of the voltage and the RMS value of the quadrature component of the current.

Table 62 shows all attributes of ReactivePower.

Table 62 – Attributes of Domain::ReactivePower

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=VAr)
multiplier	0..1	UnitMultiplier	

6.4.51 RealEnergy datatype

Real electrical energy.

Table 63 shows all attributes of RealEnergy.

Table 63 – Attributes of Domain::RealEnergy

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=Wh)
multiplier	0..1	UnitMultiplier	

6.4.52 Resistance datatype

Resistance (real part of impedance).

Table 64 shows all attributes of Resistance.

Table 64 – Attributes of Domain::Resistance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	

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6.4.53 ResistancePerLength datatype

Resistance (real part of impedance) per unit of length.

Table 65 shows all attributes of ResistancePerLength.

Table 65 – Attributes of Domain::ResistancePerLength

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.54 RotationSpeed datatype

Number of revolutions per second.

Table 66 shows all attributes of RotationSpeed.

Table 66 – Attributes of Domain::RotationSpeed

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.55 Seconds datatype

Time, in seconds.

Table 67 shows all attributes of Seconds.

Table 67 – Attributes of Domain::Seconds

name	mult	type	description
value	0..1	Float	Time, in seconds
unit	0..1	UnitSymbol	(const=s)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.56 Speed datatype

Distance per unit of time.

Table 68 shows all attributes of Speed.

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Table 68 – Attributes of Domain::Speed

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.57 String primitive

A string consisting of a sequence of ~~8 bit~~ characters. The character encoding is UTF-8. The string length is unspecified and unlimited.

6.4.58 StringQuantity ~~datatype~~ compound

Quantity with string value (when it is not important whether it is an integral or a floating point number) and associated unit information.

Table 69 shows all attributes of StringQuantity.

Table 69 – Attributes of Domain::StringQuantity

name	mult	type	description
value	0..1	String	
unit	0..1	UnitSymbol	
multiplier	0..1	UnitMultiplier	

6.4.59 Susceptance datatype

Imaginary part of admittance.

Table 70 shows all attributes of Susceptance.

Table 70 – Attributes of Domain::Susceptance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	

6.4.60 SusceptancePerLength datatype

Imaginary part of admittance per unit of length.

Table 71 shows all attributes of SusceptancePerLength.

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Table 71 – Attributes of Domain::SusceptancePerLength

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.61 Temperature datatype

Value of temperature in degrees Celsius.

Table 72 shows all attributes of Temperature.

Table 72 – Attributes of Domain::Temperature

name	mult	type	description
multiplier	0..1	UnitMultiplier	(const=none)
unit	0..1	UnitSymbol	(const=degC)
value	0..1	Float	

6.4.62 Time primitive

Time as "hh:mm:ss.sss", which conforms with ISO 8601. UTC time zone is specified as "hh:mm:ss.sssZ". A local timezone relative UTC is specified as "hh:mm:ss.sss±hh:mm". The second component (shown here as "ss.sss") could have any number of digits in its fractional part to allow any kind of precision beyond seconds.

6.4.63 TimeInterval compound

Interval between two times.

Table 73 shows all attributes of TimeInterval.

Table 73 – Attributes of Domain::TimeInterval

name	mult	type	description
start	0..1	Time	Start time of this interval.
end	0..1	Time	End time of this interval.

6.4.64 UnitMultiplier enumeration

The unit multipliers defined for the CIM.

Table 74 shows all literals of UnitMultiplier.

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Table 74 – Literals of Domain::UnitMultiplier

literal	value	description
p		Pico 10**-12.
n		Nano 10**-9.
micro		Micro 10**-6.
m		Milli 10**-3.
c		Centi 10**-2.
d		Deci 10**-1.
k		Kilo 10**3.
M		Mega 10**6.
G		Giga 10**9.
T		Tera 10**12.
none		No multiplier or equivalently multiply by 1.
** means "raised to power of".		

6.4.65 UnitSymbol enumeration

The units defined for usage in the CIM.

Table 75 shows all literals of UnitSymbol.

Table 75 – Literals of Domain::UnitSymbol

literal	value	description
VA		Apparent power in volt amperes.
W		Active power in watts.
VAr		Reactive power in volt amperes reactive.
VAh		Apparent energy in volt ampere hours.
Wh		Real energy in watt hours.
VArh		Reactive energy in volt ampere reactive hours.
V		Voltage in volts.
ohm		Resistance in ohms.
A		Current in amperes.
F		Capacitance in farads.
H		Inductance in henrys.
degC		Relative temperature in degrees Celsius. In the SI unit system the symbol is °C. Electric charge is measured in coulomb that has the unit symbol C. To distinguish degree Celsius from coulomb the symbol used in the UML is degC. The reason for not using °C is that the special character ° is difficult to manage in software.
s		Time in seconds.
min		Time in minutes.
h		Time in hours.
deg		Plane angle in degrees.
rad		Plane angle in radians.
J		Energy in joules.
N		Force in newtons.

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literal	value	description
S		Conductance in siemens.
none		Dimensionless quantity, e.g. count, per unit, etc.
Hz		Frequency in hertz.
g		Mass in grams.
Pa		Pressure in pascals (N/m2).
m		Length in metres.
m2		Area in square metres.
m3		Volume in cubic metres.

6.4.66 Voltage datatype

Electrical voltage, can be both AC and DC.

Table 76 shows all attributes of Voltage.

Table 76 – Attributes of Domain::Voltage

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=V)
multiplier	0..1	UnitMultiplier	

6.4.67 VoltagePerReactivePower datatype

Voltage variation with reactive power.

Table 77 shows all attributes of VoltagePerReactivePower.

Table 77 – Attributes of Domain::VoltagePerReactivePower

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=V)
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=VAr)
denominatorMultiplier	0..1	UnitMultiplier	

6.4.68 Volume datatype

Volume.

Table 78 shows all attributes of Volume.

Table 78 – Attributes of Domain::Volume

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m3)
multiplier	0..1	UnitMultiplier	

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6.4.69 VolumeFlowRate datatype

Volume per time.

Table 79 shows all attributes of VolumeFlowRate.

Table 79 – Attributes of Domain::VolumeFlowRate

name	mult	type	description
denominatorMultiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=s)
multiplier	0..1	UnitMultiplier	(const=none)
unit	0..1	UnitSymbol	(const=m3)
value	0..1	Float	

6.4.70 WaterLevel datatype

Reservoir water level referred to a given datum such as mean sea level.

Table 80 shows all attributes of WaterLevel.

Table 80 – Attributes of Domain::WaterLevel

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m)
multiplier	0..1	UnitMultiplier	

6.4.71 Weight datatype

The weight of an object.

Table 81 shows all attributes of Weight.

Table 81 – Attributes of Domain::Weight

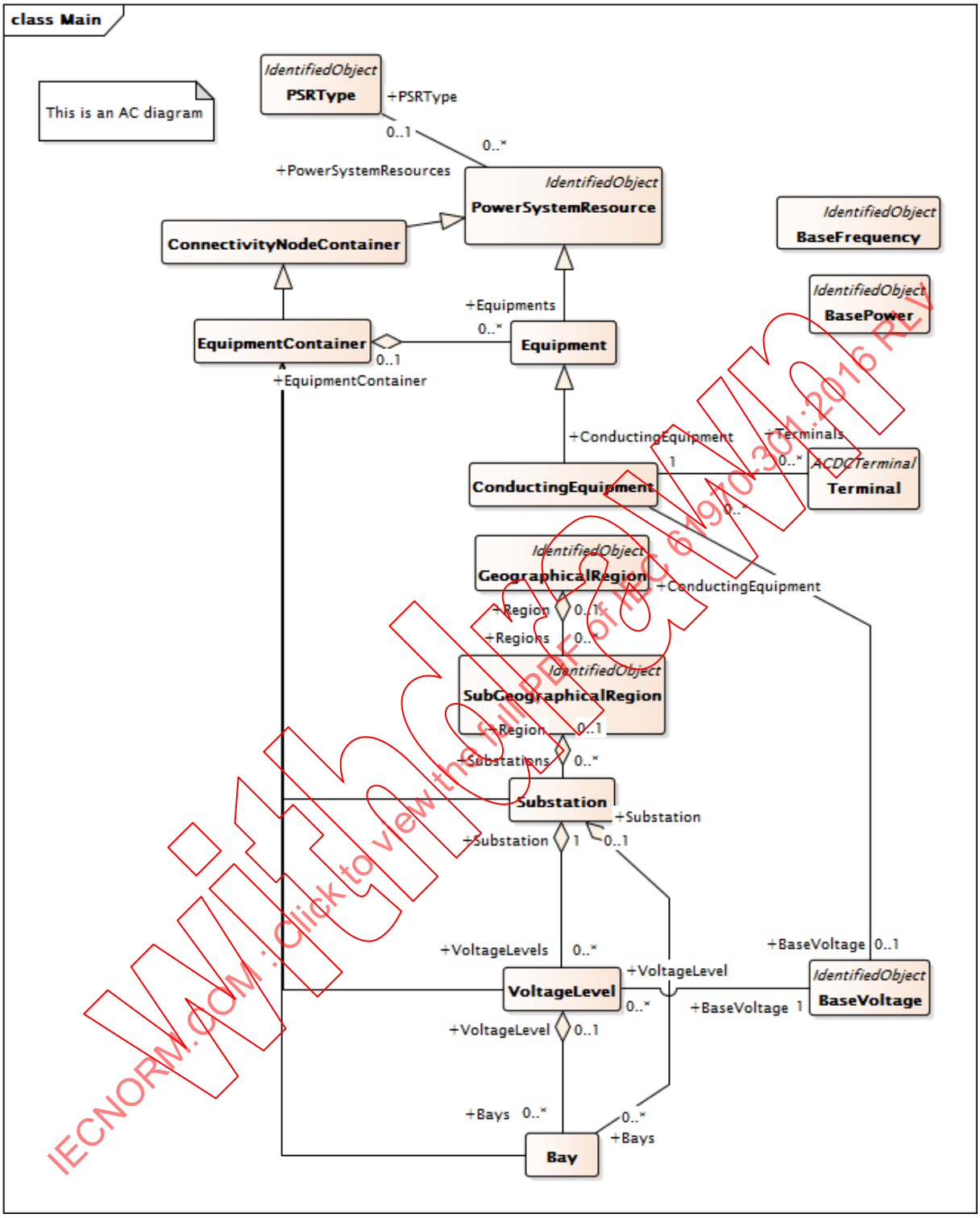
name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=g)
multiplier	0..1	UnitMultiplier	

6.5 Package Core

6.5.1 General

Contains the core PowerSystemResource and ConductingEquipment entities shared by all applications plus common collections of those entities. Not all applications require all the Core entities. This package does not depend on any other package except the Domain package, but most of the other packages have associations and generalizations that depend on it.

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Figure 72 – Class diagram Core::Main

Figure 72: This diagram shows the main classes needed for any application of the CIM for modeling transmission and generation systems.

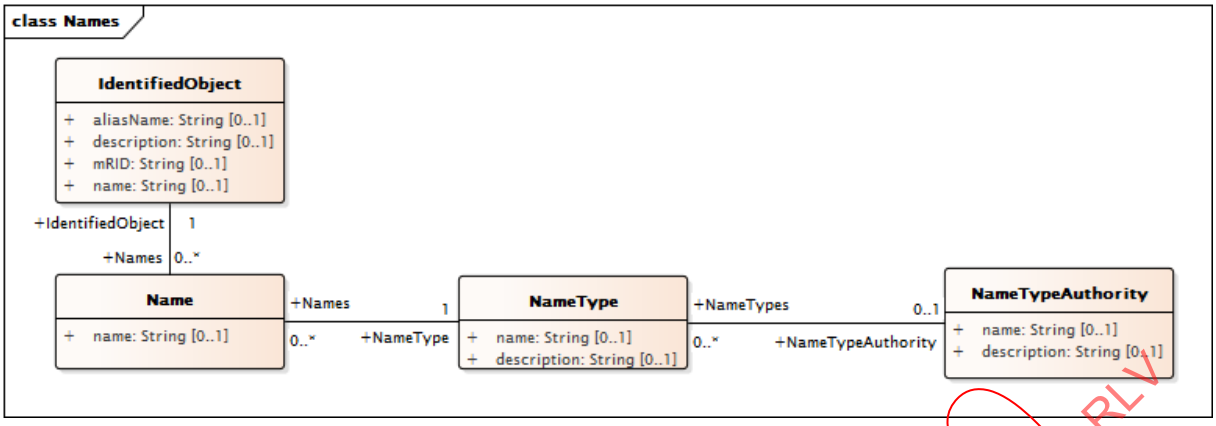
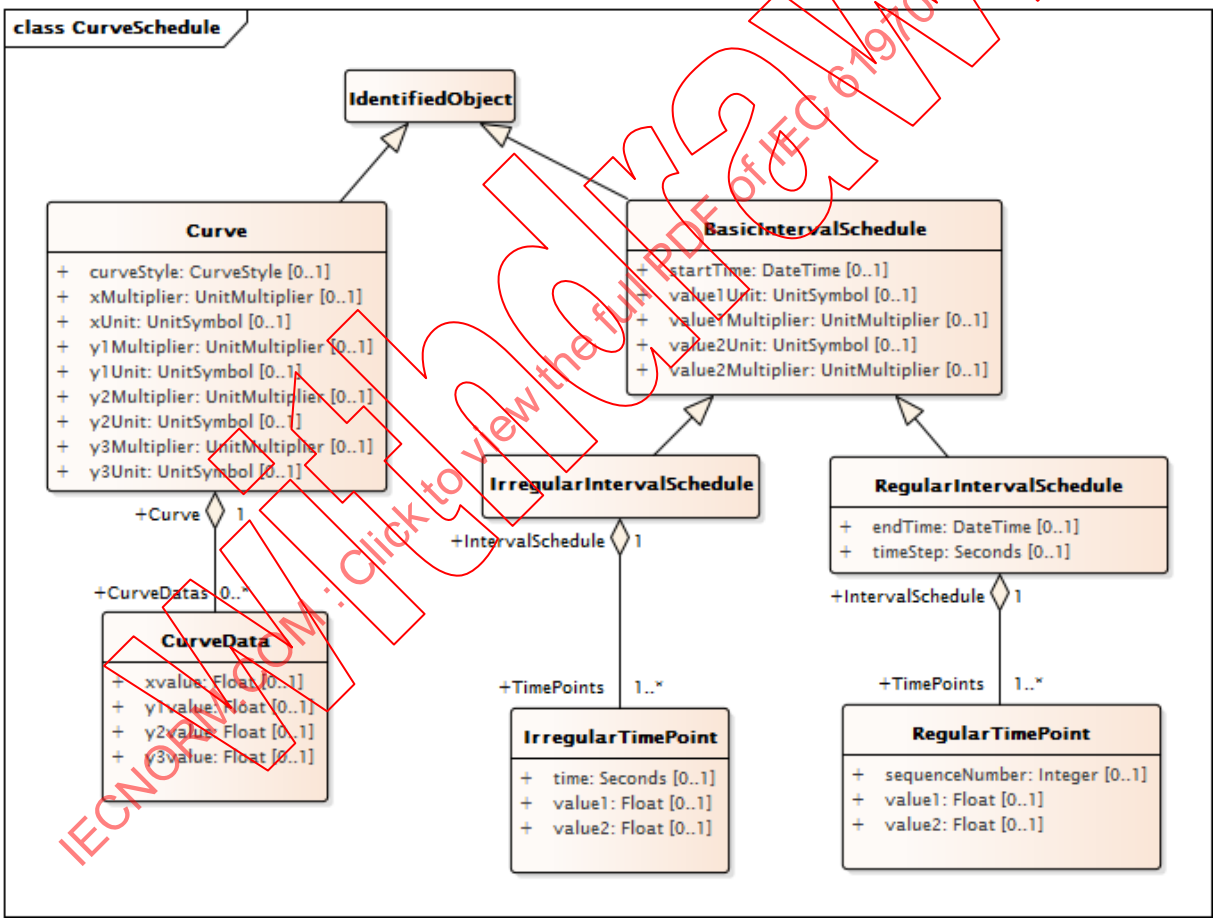


Figure 73 – Class diagram Core::Names

Figure 73: This diagram shows classes used to assign names to identified objects.



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Figure 74 – Class diagram Core::CurveSchedule

Figure 74: This diagram shows the common model for curves and time dependent schedules.



Figure 75 – Class diagram Core::Datatypes

Figure 75: This diagram shows the data types specific to the Core package.

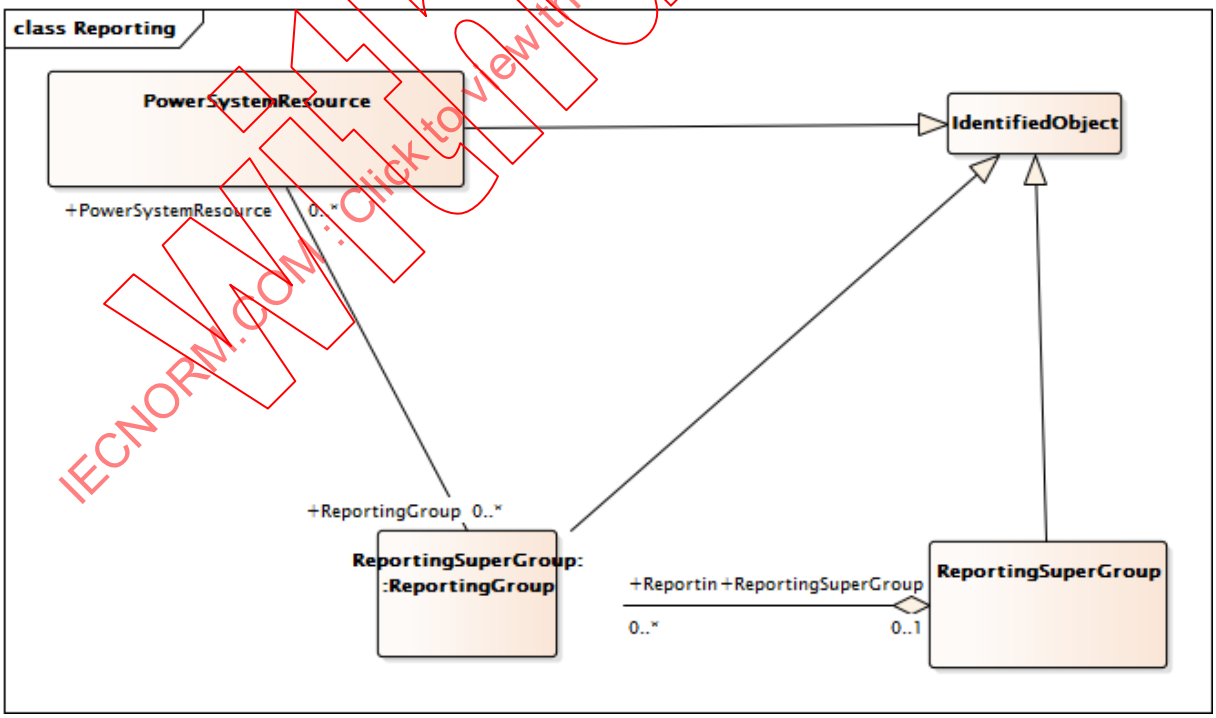


Figure 76 – Class diagram Core::Reporting

Figure 76: This diagram shows the common model for ad-hoc reporting.

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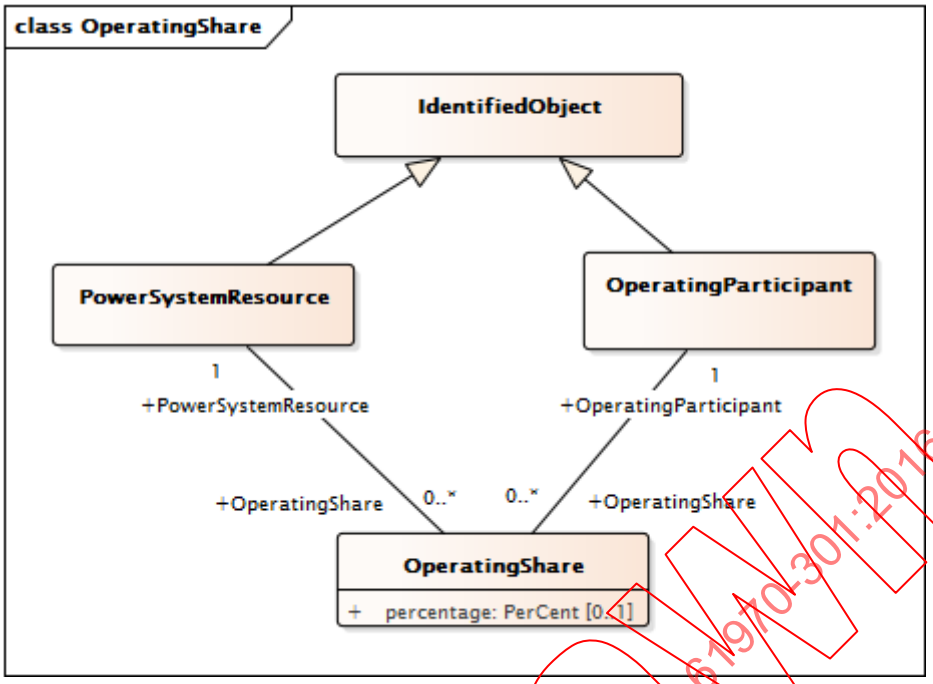


Figure 77 – Class diagram Core::OperatingShare

Figure 77: This diagram shows the common model for operating share.

6.5.2 ACDCTerminal

An electrical connection point (AC or DC) to a piece of conducting equipment. Terminals are connected at physical connection points called connectivity nodes.

Table 82 shows all attributes of ACDCTerminal.

Table 82 – Attributes of Core::ACDCTerminal

name	mult	type	description
connected	0..1	Boolean	The connected status is related to a bus-branch model and the topological node to terminal relation. True implies the terminal is connected to the related topological node and false implies it is not. In a bus-branch model, the connected status is used to tell if equipment is disconnected without having to change the connectivity described by the topological node to terminal relation. A valid case is that conducting equipment can be connected in one end and open in the other. In particular for an AC line segment, where the reactive line charging can be significant, this is a relevant case.
sequenceNumber	0..1	Integer	The orientation of the terminal connections for a multiple terminal conducting equipment. The sequence numbering starts with 1 and additional terminals should follow in increasing order. The first terminal is the "starting point" for a two terminal branch.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 83 shows all association ends of ACDCTerminal with other classes.

Table 83 – Association ends of Core::ACDCTerminal with other classes

mult from	name	mult to	type	description
1..*	BusNameMarker	0..1	BusNameMarker	The bus name marker used to name the bus (topological node).
0..1	OperationalLimitSet	0..*	OperationalLimitSet	The operational limit sets at the terminal.
0..1	Measurements	0..*	Measurement	Measurements associated with this terminal defining where the measurement is placed in the network topology. It may be used, for instance, to capture the sensor position, such as a voltage transformer (PT) at a busbar or a current transformer (CT) at the bar between a breaker and an isolator.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.3 BaseFrequency

The BaseFrequency class describes a base frequency for a power system network. In case of multiple power networks with different frequencies, e.g. 50 Hz or 60 Hz, each network will have it's own base frequency class. Hence it is assumed that power system objects having different base frequencies appear in separate documents where each document has a single base frequency instance.

Table 84 shows all attributes of BaseFrequency.

Table 84 – Attributes of Core::BaseFrequency

name	mult	type	description
frequency	0..1	Frequency	The base frequency.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 85 shows all association ends of BaseFrequency with other classes.

Table 85 – Association ends of Core::BaseFrequency with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.4 BasePower

The BasePower class defines the base power used in the per unit calculations.

Table 86 shows all attributes of BasePower.

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Table 86 – Attributes of Core::BasePower

name	mult	type	description
basePower	0..1	ApparentPower	Value used as base power.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 87 shows all association ends of BasePower with other classes.

Table 87 – Association ends of Core::BasePower with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.5 BaseVoltage

Defines a system base voltage which is referenced.

Table 88 shows all attributes of BaseVoltage.

Table 88 – Attributes of Core::BaseVoltage

name	mult	type	description
~~isDC~~		~~Boolean~~	~~If true, this is a direct current base voltage and items assigned to this base voltage are also associated with a direct current capabilities. False indicates alternating current.~~
nominalVoltage	0..1	Voltage	The power system resource's base voltage.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 89 shows all association ends of BaseVoltage with other classes.

Table 89 – Association ends of Core::BaseVoltage with other classes

mult from	name	mult to	type	description
0..1	ConductingEquipment	0..*	ConductingEquipment	All conducting equipment with this base voltage. Use only when there is no voltage level container used and only one base voltage applies. For example, not used for transformers.
1..1	VoltageLevel	0..*	VoltageLevel	The voltage levels having this base voltage.
0..1	TransformerEnds	0..*	TransformerEnd	Transformer ends at the base voltage. This is essential for PU calculation.
0..1	TopologicalNode	0..*	TopologicalNode	The topological nodes at the base voltage.

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mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.6 BasicIntervalSchedule

Schedule of values at points in time.

Table 90 shows all attributes of BasicIntervalSchedule.

Table 90 – Attributes of Core::BasicIntervalSchedule

name	mult	type	description
startTime	0..1	DateTime	The time for the first time point.
value1Unit	0..1	UnitSymbol	Value1 units of measure.
value1Multiplier	0..1	UnitMultiplier	Multiplier for value1.
value2Unit	0..1	UnitSymbol	Value2 units of measure.
value2Multiplier	0..1	UnitMultiplier	Multiplier for value2.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 91 shows all association ends of BasicIntervalSchedule with other classes.

Table 91 – Association ends of Core::BasicIntervalSchedule with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.7 Bay

A collection of power system resources (within a given substation) including conducting equipment, protection relays, measurements, and telemetry. A bay typically represents a physical grouping related to modularization of equipment.

Table 92 shows all attributes of Bay.

Table 92 – Attributes of Core::Bay

name	mult	type	description
bayEnergyMeasFlag	0..1	Boolean	Indicates the presence/absence of energy measurements.
bayPowerMeasFlag	0..1	Boolean	Indicates the presence/absence of active/reactive power measurements.
breakerConfiguration	0..1	BreakerConfiguration	Breaker configuration.
busBarConfiguration	0..1	BusbarConfiguration	Busbar configuration.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 93 shows all association ends of Bay with other classes.

Table 93 – Association ends of Core::Bay with other classes

mult from	name	mult to	type	description
0..*	Substation	0..1	Substation	Substation containing the bay.
0..*	VoltageLevel	0..1	VoltageLevel	The voltage level containing this bay.
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.8 BreakerConfiguration enumeration

Switching arrangement for bay.

Table 94 shows all literals of BreakerConfiguration.

Table 94 – Literals of Core::BreakerConfiguration

literal	value	description
singleBreaker		Single breaker.
breakerAndAHalf		Breaker and a half.
doubleBreaker		Double breaker.
noBreaker		No breaker.

6.5.9 BusbarConfiguration enumeration

Busbar layout for bay.

Table 95 shows all literals of BusbarConfiguration.

Table 95 – Literals of Core::BusbarConfiguration

literal	value	description
singleBus		Single bus.

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literal	value	description
doubleBus		Double bus.
mainWithTransfer		Main bus with transfer bus.
ringBus		Ring bus.

6.5.10 ConductingEquipment

The parts of the AC power system that are designed to carry current or that are conductively connected through terminals.

Table 96 shows all attributes of ConductingEquipment.

Table 96 – Attributes of Core::ConductingEquipment

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 97 shows all association ends of ConductingEquipment with other classes.

Table 97 – Association ends of Core::ConductingEquipment with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	Base voltage of this conducting equipment. Use only when there is no voltage level container used and only one base voltage applies. For example, not used for transformers.
1..1	SvStatus	0..1	SvStatus	The status state variable associated with this conducting equipment.
0..*	ProtectionEquipments	0..*	ProtectionEquipment	Protection equipment used to protect specific conducting equipment.
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~Clearance tags for authorized field work on this conducting equipment.~~
1..1	Terminals	0..*	Terminal	Conducting equipment have terminals that may be connected to other conducting equipment terminals via connectivity nodes or topological nodes.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~

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mult from	name	mult to	type	description
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.11 ConnectivityNode

Connectivity nodes are points where terminals of AC conducting equipment are connected together with zero impedance.

Table 98 shows all attributes of ConnectivityNode.

Table 98 – Attributes of Core::ConnectivityNode

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 99 shows all association ends of ConnectivityNode with other classes.

Table 99 – Association ends of Core::ConnectivityNode with other classes

mult from	name	mult to	type	description
0..*	TopologicalNode	0..1	TopologicalNode	The topological node to which this connectivity node is assigned. May depend on the current state of switches in the network.
0..*	ConnectivityNodeContainer	1..1	ConnectivityNodeContainer	Container of this connectivity node.
0..1	Terminals	0..*	Terminal	Terminals interconnected with zero impedance at a this connectivity node.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.12 ConnectivityNodeContainer

A base class for all objects that may contain connectivity nodes or topological nodes.

Table 100 shows all attributes of ConnectivityNodeContainer.

Table 100 – Attributes of Core::ConnectivityNodeContainer

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 101 shows all association ends of ConnectivityNodeContainer with other classes.

Table 101 – Association ends of Core::ConnectivityNodeContainer with other classes

mult from	name	mult to	type	description
1..1	ConnectivityNodes	0..*	ConnectivityNode	Connectivity nodes which belong to this connectivity node container.
0..1	TopologicalNode	0..*	TopologicalNode	The topological nodes which belong to this connectivity node container.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.13 Curve

A multi-purpose curve or functional relationship between an independent variable (X-axis) and dependent (Y-axis) variables.

Table 102 shows all attributes of Curve.

Table 102 – Attributes of Core::Curve

name	mult	type	description
curveStyle	0..1	CurveStyle	The style or shape of the curve.
xMultiplier	0..1	UnitMultiplier	Multiplier for X-axis.
xUnit	0..1	UnitSymbol	The X-axis units of measure.
y1Multiplier	0..1	UnitMultiplier	Multiplier for Y1-axis.
y1Unit	0..1	UnitSymbol	The Y1-axis units of measure.
y2Multiplier	0..1	UnitMultiplier	Multiplier for Y2-axis.
y2Unit	0..1	UnitSymbol	The Y2-axis units of measure.
y3Multiplier	0..1	UnitMultiplier	Multiplier for Y3-axis.
y3Unit	0..1	UnitSymbol	The Y3-axis units of measure.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 103 shows all association ends of Curve with other classes.

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Table 103 – Association ends of Core::Curve with other classes

mult from	name	mult to	type	description
1..1	CurveDatas	0..*	CurveData	The point data values that define this curve.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.14 CurveData root class

Multi-purpose data points for defining a curve. The use of this generic class is discouraged if a more specific class can be used to specify the X- and Y-axis values along with their specific data types.

Table 104 shows all attributes of CurveData.

Table 104 – Attributes of Core::CurveData

name	mult	type	description
xvalue	0..1	Float	The data value of the X-axis variable, depending on the X-axis units.
y1value	0..1	Float	The data value of the first Y-axis variable, depending on the Y-axis units.
y2value	0..1	Float	The data value of the second Y-axis variable (if present), depending on the Y-axis units.
y3value	0..1	Float	The data value of the third Y-axis variable (if present), depending on the Y-axis units.

Table 105 shows all association ends of CurveData with other classes.

Table 105 – Association ends of Core::CurveData with other classes

mult from	name	mult to	type	description
0..*	Curve	1..1	Curve	The curve of this curve data point.

6.5.15 CurveStyle enumeration

Style or shape of curve.

Table 106 shows all literals of CurveStyle.

Table 106 – Literals of Core::CurveStyle

literal	value	description
constantYValue		The Y-axis values are assumed constant until the next curve point and prior to the first curve point.
straightLineYValues		The Y-axis values are assumed to be a straight line between values. Also known as linear interpolation.
~~rampYValue~~		~~The Y-axis values are assumed to ramp between points.~~
~~formula~~		~~An unspecified formula is assumed to compute the Y-axis value between points.~~

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6.5.16 Equipment

The parts of a power system that are physical devices, electronic or mechanical.

Table 107 shows all attributes of Equipment.

Table 107 – Attributes of Core::Equipment

name	mult	type	description
aggregate	0..1	Boolean	The single instance of equipment represents multiple pieces of equipment that have been modeled together as an aggregate. Examples would be power transformers or synchronous machines operating in parallel modeled as a single aggregate power transformer or aggregate synchronous machine. This is not to be used to indicate equipment that is part of a group of interdependent equipment produced by a network production program.
normallyInService	0..1	Boolean	If true, the equipment is normally in service.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 108 shows all association ends of Equipment with other classes.

Table 108 – Association ends of Core::Equipment with other classes

mult from	name	mult to	type	description
0..1	Faults	0..*	Fault	All faults on this equipment.
0..1	OperationalLimitSet	0..*	OperationalLimitSet	The operational limit sets associated with this equipment.
1..1	ContingencyEquipment	0..*	ContingencyEquipment	The contingency equipments in which this equipment participates.
0..*	EquipmentContainer	0..1	EquipmentContainer	Container of this equipment.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.17 EquipmentContainer

A modeling construct to provide a root class for containing equipment.

Table 109 shows all attributes of EquipmentContainer.

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Table 109 – Attributes of Core::EquipmentContainer

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 110 shows all association ends of EquipmentContainer with other classes.

Table 110 – Association ends of Core::EquipmentContainer with other classes

mult from	name	mult to	type	description
0..1	Equipments	0..*	Equipment	Contained equipment.
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.18 GeographicalRegion

A geographical region of a power system network model.

Table 111 shows all attributes of GeographicalRegion.

Table 111 – Attributes of Core::GeographicalRegion

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 112 shows all association ends of GeographicalRegion with other classes.

Table 112 – Association ends of Core::GeographicalRegion with other classes

mult from	name	mult to	type	description
0..1	Regions	0..*	SubGeographicalRegion	All sub-geographical regions within this geographical region.

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mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.19 IdentifiedObject root class

This is a root class to provide common identification for all classes needing identification and naming attributes.

Table 113 shows all attributes of IdentifiedObject.

Table 113 – Attributes of Core::IdentifiedObject

name	mult	type	description
aliasName	0..1	String	The aliasName is free text human readable name of the object alternative to IdentifiedObject.name. It may be non unique and may not correlate to a naming hierarchy. The attribute aliasName is retained because of backwards compatibility between CIM relases. It is however recommended to replace aliasName with the Name class as aliasName is planned for retirement at a future time.
description	0..1	String	The description is a free human readable text describing or naming the object. It may be non unique and may not correlate to a naming hierarchy.
mRID	0..1	String	Master resource identifier issued by a model authority. The mRID is globally unique within an exchange context. Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended. For CIMXML data files in RDF syntax conforming to IEC 61970-552:2013, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object elements.
name	0..1	String	The name is any free human readable and possibly non unique text naming the object.

Table 114 shows all association ends of IdentifiedObject with other classes.

Table 114 – Association ends of Core::IdentifiedObject with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	The diagram objects that are associated with the domain object.
1..1	Names	0..*	Name	All names of this identified object.

6.5.20 IrregularIntervalSchedule

The schedule has time points where the time between them varies.

Table 115 shows all attributes of IrregularIntervalSchedule.

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Table 115 – Attributes of Core::IrregularIntervalSchedule

name	mult	type	description
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 116 shows all association ends of IrregularIntervalSchedule with other classes.

Table 116 – Association ends of Core::IrregularIntervalSchedule with other classes

mult from	name	mult to	type	description
1..1	TimePoints	1..*	IrregularTimePoint	The point data values that define a curve.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.21 IrregularTimePoint root class

TimePoints for a schedule where the time between the points varies.

Table 117 shows all attributes of IrregularTimePoint.

Table 117 – Attributes of Core::IrregularTimePoint

name	mult	type	description
time	0..1	Seconds	The time is relative to the schedule starting time.
value1	0..1	Float	The first value at the time. The meaning of the value is defined by the derived type of the associated schedule.
value2	0..1	Float	The second value at the time. The meaning of the value is defined by the derived type of the associated schedule.

Table 118 shows all association ends of IrregularTimePoint with other classes.

Table 118 – Association ends of Core::IrregularTimePoint with other classes

mult from	name	mult to	type	description
1..*	IntervalSchedule	1..1	IrregularIntervalSchedule	An IrregularTimePoint belongs to an IrregularIntervalSchedule.

6.5.22 Name root class

The Name class provides the means to define any number of human readable names for an object. A name is not to be used for defining inter-object relationships. For inter-object relationships instead use the object identification 'mRID'.

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Table 119 shows all attributes of Name.

Table 119 – Attributes of Core::Name

name	mult	type	description
name	0..1	String	Any free text that name the object.

Table 120 shows all association ends of Name with other classes.

Table 120 – Association ends of Core::Name with other classes

mult from	name	mult to	type	description
0..*	IdentifiedObject	1..1	IdentifiedObject	Identified object that this name designates.
0..*	NameType	1..1	NameType	Type of this name.

6.5.23 NameType root class

Type of name. Possible values for attribute 'name' are implementation dependent but standard profiles may specify types. An enterprise may have multiple IT systems each having its own local name for the same object, e.g. a planning system may have different names from an EMS. An object may also have different names within the same IT system, e.g. localName as defined in CIM version 14. The definition from CIM14 is:

The localName is a human readable name of the object. It is a free text name local to a node in a naming hierarchy similar to a file directory structure. A power system related naming hierarchy may be: Substation, VoltageLevel, Equipment etc. Children of the same parent in such a hierarchy have names that typically are unique among them.

Table 121 shows all attributes of NameType.

Table 121 – Attributes of Core::NameType

name	mult	type	description
name	0..1	String	Name of the name type.
description	0..1	String	Description of the name type.

Table 122 shows all association ends of NameType with other classes.

Table 122 – Association ends of Core::NameType with other classes

mult from	name	mult to	type	description
0..*	NameTypeAuthority	0..1	NameTypeAuthority	Authority responsible for managing names of this type.
1..1	Names	0..*	Name	All names of this type.

6.5.24 NameTypeAuthority root class

Authority responsible for creation and management of names of a given type; typically an organization or an enterprise system.

Table 123 shows all attributes of NameTypeAuthority.

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Table 123 – Attributes of Core::NameTypeAuthority

name	mult	type	description
name	0..1	String	Name of the name type authority.
description	0..1	String	Description of the name type authority.

Table 124 shows all association ends of NameTypeAuthority with other classes.

Table 124 – Association ends of Core::NameTypeAuthority with other classes

mult from	name	mult to	type	description
0..1	NameTypes	0..*	NameType	All name types managed by this authority.

6.5.25 OperatingParticipant

An operator of multiple power system resource objects. Note multiple operating participants may operate the same power system resource object. This can be used for modeling jointly owned units where each owner operates as a contractual share.

Table 125 shows all attributes of OperatingParticipant.

Table 125 – Attributes of Core::OperatingParticipant

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 126 shows all association ends of OperatingParticipant with other classes.

Table 126 – Association ends of Core::OperatingParticipant with other classes

mult from	name	mult to	type	description
1..1	OperatingShare	0..*	OperatingShare	The operating shares of this operating participant. An operating participant can be resused for any number of power system resources.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.26 OperatingShare root class

Specifies the operations contract relationship between a power system resource and a contract participant.

Table 127 shows all attributes of OperatingShare.

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Table 127 – Attributes of Core::OperatingShare

name	mult	type	description
percentage	0..1	PerCent	Percentage operational ownership between the pair (power system resource and operating participant) associated with this share. The total percentage ownership for a power system resource should add to 100 %.

Table 128 shows all association ends of OperatingShare with other classes.

Table 128 – Association ends of Core::OperatingShare with other classes

mult from	name	mult to	type	description
0..*	OperatingParticipant	1..1	OperatingParticipant	The operating participant having this share with the associated power system resource.
0..*	PowerSystemResource	1..1	PowerSystemResource	The power system resource to which the share applies.

6.5.27 PSRType

Classifying instances of the same class, e.g. overhead and underground ACLineSegments. This classification mechanism is intended to provide flexibility outside the scope of this standard, i.e. provide customization that is non standard.

Table 129 shows all attributes of PSRType.

Table 129 – Attributes of Core::PSRType

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 130 shows all association ends of PSRType with other classes.

Table 130 – Association ends of Core::PSRType with other classes

mult from	name	mult to	type	description
0..1	PowerSystemResources	0..*	PowerSystemResource	Power system resources classified with this power system resource type.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.28 PhaseCode enumeration

Enumeration of phase identifiers. Allows designation of phases for both transmission and distribution equipment, circuits and loads.

Residential and small commercial loads are often served from single-phase, or split-phase, secondary circuits. For the example of s12N, phases 1 and 2 refer to hot wires that are 180 degrees out of phase, while N refers to the neutral wire. Through single-phase transformer

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connections, these secondary circuits may be served from one or two of the primary phases A, B, and C. For three-phase loads, use the A, B, C phase codes instead of s12N.

Table 131 shows all literals of PhaseCode.

Table 131 – Literals of Core::PhaseCode

literal	value	description
ABCN		Phases A, B, C, and N.
ABC		Phases A, B, and C.
ABN		Phases A, B, and neutral.
ACN		Phases A, C and neutral.
BCN		Phases B, C, and neutral.
AB		Phases A and B.
AC		Phases A and C.
BC		Phases B and C.
AN		Phases A and neutral.
BN		Phases B and neutral.
CN		Phases C and neutral.
A		Phase A.
B		Phase B.
C		Phase C.
N		Neutral phase.
s1N		Secondary phase 1 and neutral.
s2N		Secondary phase 2 and neutral.
s12N		Secondary phases 1, 2, and neutral.
s1		Secondary phase 1.
s2		Secondary phase 2.
s12		Secondary phase 1 and 2.

6.5.29 PowerSystemResource

A power system resource can be an item of equipment such as a switch, an equipment container containing many individual items of equipment such as a substation, or an organizational entity such as sub-control area. Power system resources can have measurements associated.

Table 132 shows all attributes of PowerSystemResource.

Table 132 – Attributes of Core::PowerSystemResource

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 133 shows all association ends of PowerSystemResource with other classes.

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Table 133 – Association ends of Core::PowerSystemResource with other classes

mult from	name	mult to	type	description
0..*	PSRType	0..1	PSRType	Custom classification for this power system resource.
0..1	Controls	0..*	Control	The controller outputs used to actually govern a regulating device, e.g. the magnetization of a synchronous machine or capacitor bank breaker actuator.
0..1	Measurements	0..*	Measurement	The measurements associated with this power system resource.
1..1	OperatingShare	0..*	OperatingShare	The operating shares of this power system resource.
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~The lists to which this power system resource belongs.~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~A power system resource may have an outage schedule.~~
0..*	ReportingGroup	0..*	ReportingGroup	Reporting groups to which this power system resource belongs.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

~~**6.4.27 PsrList**~~

~~Arbitrary list of power system resources. Can be used for various purposes, including grouping for report generation.~~

~~Table 107 shows all attributes of PsrList.~~

~~**Table 107 – Attributes of Core::PsrList**~~

~~name~~	~~type~~	~~description~~
~~typePSRList~~	~~String~~	~~Type of power system resources in this list.~~
~~aliasName~~	~~String~~	~~inherited from: IdentifiedObject~~
~~mRID~~	~~String~~	~~inherited from: IdentifiedObject~~
~~name~~	~~String~~	~~inherited from: IdentifiedObject~~

~~Table 108 shows all association ends of PsrList with other classes.~~

~~**Table 108 – Association ends of Core::PsrList with other classes**~~

~~[mult from]~~	~~[mult to] name~~	~~type~~	~~description~~
~~[0..*]~~	~~[0..*] PowerSystemResources~~	~~PowerSystemResource~~	~~The power system resources in the list.~~
~~[0..1]~~	~~[0..*] DiagramObjects~~	~~DiagramObject~~	~~inherited from: IdentifiedObject~~
~~[1..1]~~	~~[0..*] Names~~	~~Name~~	~~inherited from: IdentifiedObject~~

6.5.30 RegularIntervalSchedule

The schedule has time points where the time between them is constant.

Table 134 shows all attributes of RegularIntervalSchedule.

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Table 134 – Attributes of Core::RegularIntervalSchedule

name	mult	type	description
endTime	0..1	DateTime	The time for the last time point.
timeStep	0..1	Seconds	The time between each pair of subsequent regular time points in sequence order.
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 135 shows all association ends of RegularIntervalSchedule with other classes.

Table 135 – Association ends of Core::RegularIntervalSchedule with other classes

mult from	name	mult to	type	description
1..1	TimePoints	1..*	RegularTimePoint	The regular interval time point data values that define this schedule.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.31 RegularTimePoint root class

Time point for a schedule where the time between the consecutive points is constant.

Table 136 shows all attributes of RegularTimePoint.

Table 136 – Attributes of Core::RegularTimePoint

name	mult	type	description
sequenceNumber	0..1	Integer	The position of the regular time point in the sequence. Note that time points don't have to be sequential, i.e. time points may be omitted. The actual time for a RegularTimePoint is computed by multiplying the associated regular interval schedule's time step with the regular time point sequence number and adding the associated schedule's start time.
value1	0..1	Float	The first value at the time. The meaning of the value is defined by the derived type of the associated schedule.
value2	0..1	Float	The second value at the time. The meaning of the value is defined by the derived type of the associated schedule.

Table 137 shows all association ends of RegularTimePoint with other classes.

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Table 137 – Association ends of Core::RegularTimePoint with other classes

mult from	name	mult to	type	description
1..*	IntervalSchedule	1..1	RegularIntervalSchedule	Regular interval schedule containing this time point.

~~6.4.31 ReportingGroup~~

~~A reporting group is used for various ad-hoc groupings used for reporting.~~

~~Table 115 shows all attributes of ReportingGroup.~~

~~Table 115 – Attributes of Core::ReportingGroup~~

~~name~~	~~type~~	~~description~~
~~aliasName~~	~~String~~	~~inherited from: IdentifiedObject~~
~~mRID~~	~~String~~	~~inherited from: IdentifiedObject~~
~~name~~	~~String~~	~~inherited from: IdentifiedObject~~

~~Table 116 shows all association ends of ReportingGroup with other classes.~~

~~Table 116 – Association ends of Core::ReportingGroup with other classes~~

~~[mult from]~~	~~[mult to] name~~	~~type~~	~~description~~
~~[0..*]~~	~~[0..*] PowerSystemResource~~	~~PowerSystemResource~~	~~Power system resources which belong to this reporting group.~~
~~[0..*]~~	~~[0..1] ReportingSuperGroup~~	~~ReportingSuperGroup~~	~~Reporting super group to which this reporting group belongs.~~
~~[0..1]~~	~~[0..*] BusNameMarker~~	~~BusNameMarker~~	~~The bus name markers that belong to this reporting group.~~
~~[0..1]~~	~~[0..*] TopologicalNode~~	~~TopologicalNode~~	~~The topological nodes that belong to the reporting group.~~
~~[0..1]~~	~~[0..*] DiagramObjects~~	~~DiagramObject~~	~~inherited from: IdentifiedObject~~
~~[1..1]~~	~~[0..*] Names~~	~~Name~~	~~inherited from: IdentifiedObject~~

6.5.32 ReportingSuperGroup

A reporting super group, groups reporting groups for a higher level report.

Table 138 shows all attributes of ReportingSuperGroup.

Table 138 – Attributes of Core::ReportingSuperGroup

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 139 shows all association ends of ReportingSuperGroup with other classes.

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Table 139 – Association ends of Core::ReportingSuperGroup with other classes

mult from	name	mult to	type	description
0..1	ReportingGroup	0..*	ReportingGroup	Reporting groups that are grouped under this super group.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.33 SubGeographicalRegion

A subset of a geographical region of a power system network model.

Table 140 shows all attributes of SubGeographicalRegion.

Table 140 – Attributes of Core::SubGeographicalRegion

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 141 shows all association ends of SubGeographicalRegion with other classes.

Table 141 – Association ends of Core::SubGeographicalRegion with other classes

mult from	name	mult to	type	description
0..1	Lines	0..*	Line	The lines within the sub-geographical region.
0..1	Substations	0..*	Substation	The substations in this sub-geographical region.
0..*	Region	0..1	GeographicalRegion	The geographical region which this sub-geographical region is within.
0..1	DCLines	0..*	DCLine	The DC lines in this sub-geographical region.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.34 Substation

A collection of equipment for purposes other than generation or utilization, through which electric energy in bulk is passed for the purposes of switching or modifying its characteristics.

Table 142 shows all attributes of Substation.

Table 142 – Attributes of Core::Substation

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 143 shows all association ends of Substation with other classes.

Table 143 – Association ends of Core::Substation with other classes

mult from	name	mult to	type	description
1..1	VoltageLevels	0..*	VoltageLevel	The voltage levels within this substation.
0..1	Bays	0..*	Bay	Bays contained in the substation.
0..*	Region	0..1	SubGeographicalRegion	The SubGeographicalRegion containing the substation.
0..1	DCConverterUnit	0..*	DCConverterUnit	The DC converter unit belonging of the substation.
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.35 Terminal

An AC electrical connection point to a piece of conducting equipment. Terminals are connected at physical connection points called connectivity nodes.

Table 144 shows all attributes of Terminal.

Table 144 – Attributes of Core::Terminal

name	mult	type	description
phases	0..1	PhaseCode	Represents the normal network phasing condition. If the attribute is missing three phases (ABC or ABCN) shall be assumed.
connected	0..1	Boolean	~~The connected status is related to a bus-branch model and the topological node to terminal relation. True implies the terminal is connected to the related topological node and false implies it is not.~~ ~~In a bus-branch model, the connected status is used to tell if equipment is disconnected without having to change the connectivity described by the topological node to terminal relation. A valid case is that conducting equipment can be connected in one end and open in the other. In particular for an AC line segment, where the reactive line charging can be significant, this is a relevant case.~~ inherited from: ACDCTerminal

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name	mult	type	description
sequenceNumber	0..1	Integer	inherited from: ACDCTerminal
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 145 shows all association ends of Terminal with other classes.

Table 145 – Association ends of Core::Terminal with other classes

mult from	name	mult to	type	description
0..*	ConductingEquipment	1..1	ConductingEquipment	The conducting equipment of the terminal. Conducting equipment have terminals that may be connected to other conducting equipment terminals via connectivity nodes or topological nodes.
0..*	ConnectivityNode	0..1	ConnectivityNode	The connectivity node to which this terminal connects with zero impedance.
0..*	TopologicalNode	0..1	TopologicalNode	The topological node associated with the terminal. This can be used as an alternative to the connectivity node path to topological node, thus making it unneccesary to model connectivity nodes in some cases. Note that the if connectivity nodes are in the model, this association would probably not be used as an input specification.
0..1	RegulatingControl	0..*	RegulatingControl	The controls regulating this terminal.
0..1	EquipmentFaults	0..*	EquipmentFault	The equipment faults at this terminal.
1..1	HasFirstMutualCoupling	0..*	MutualCoupling	Mutual couplings associated with the branch as the first branch.
0..1	TransformerEnd	0..*	TransformerEnd	All transformer ends connected at this terminal.
1..1	BranchGroupTerminal	0..*	BranchGroupTerminal	The directed branch group terminals for which this terminal is monitored.
1..1	SvPowerFlow	0..1	SvPowerFlow	The power flow state variable associated with the terminal.
1..1	AuxiliaryEquipment	0..*	AuxiliaryEquipment	The auxiliary equipment connected to the terminal.
1..1	HasSecondMutualCoupling	0..*	MutualCoupling	Mutual couplings with the branch associated as the first branch.
1..1	TieFlow	0..2	TieFlow	The control area tie flows to which this terminal associates.
0..1	ConverterDCSides	0..*	ACDCConverter	All converters' DC sides linked to this point of common coupling terminal.
1..1	RemoteInputSignal	0..*	RemoteInputSignal	Input signal coming from this terminal.
1..*	BusNameMarker	0..1	BusNameMarker	~~The bus name marker used to name the bus (topological node).~~ inherited from: ACDCTerminal
0..1	OperationalLimitSet	0..*	OperationalLimitSet	~~The operational limit sets that apply specifically to this terminal. Other operational limits sets may apply to this terminal through the association to equipment.~~ inherited from: ACDCTerminal

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mult from	name	mult to	type	description
0..1	Measurements	0..*	Measurement	~~Measurements associated with this terminal defining where the measurement is placed in the network topology. It may be used, for instance, to capture the sensor position, such as a voltage transformer (PT) at a busbar or a current transformer (CT) at the bar between a breaker and an isolator.~~ inherited from: ACDCTerminal
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.36 VoltageLevel

A collection of equipment at one common system voltage forming a switchgear. The equipment typically consist of breakers, busbars, instrumentation, control, regulation and protection devices as well as assemblies of all these.

Table 146 shows all attributes of VoltageLevel.

Table 146 – Attributes of Core::VoltageLevel

name	mult	type	description
highVoltageLimit	0..1	Voltage	The busbar's high voltage limit
lowVoltageLimit	0..1	Voltage	The busbar's low voltage limit
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 147 shows all association ends of VoltageLevel with other classes.

Table 147 – Association ends of Core::VoltageLevel with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	1..1	BaseVoltage	The base voltage used for all equipment within the voltage level.
0..1	Bays	0..*	Bay	The bays within this voltage level.
0..*	Substation	1..1	Substation	The substation of the voltage level.
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.6 Package DiagramLayout

6.6.1 General

This package describes diagram layout. This describes how objects are arranged in a coordinate system rather than how they are rendered.

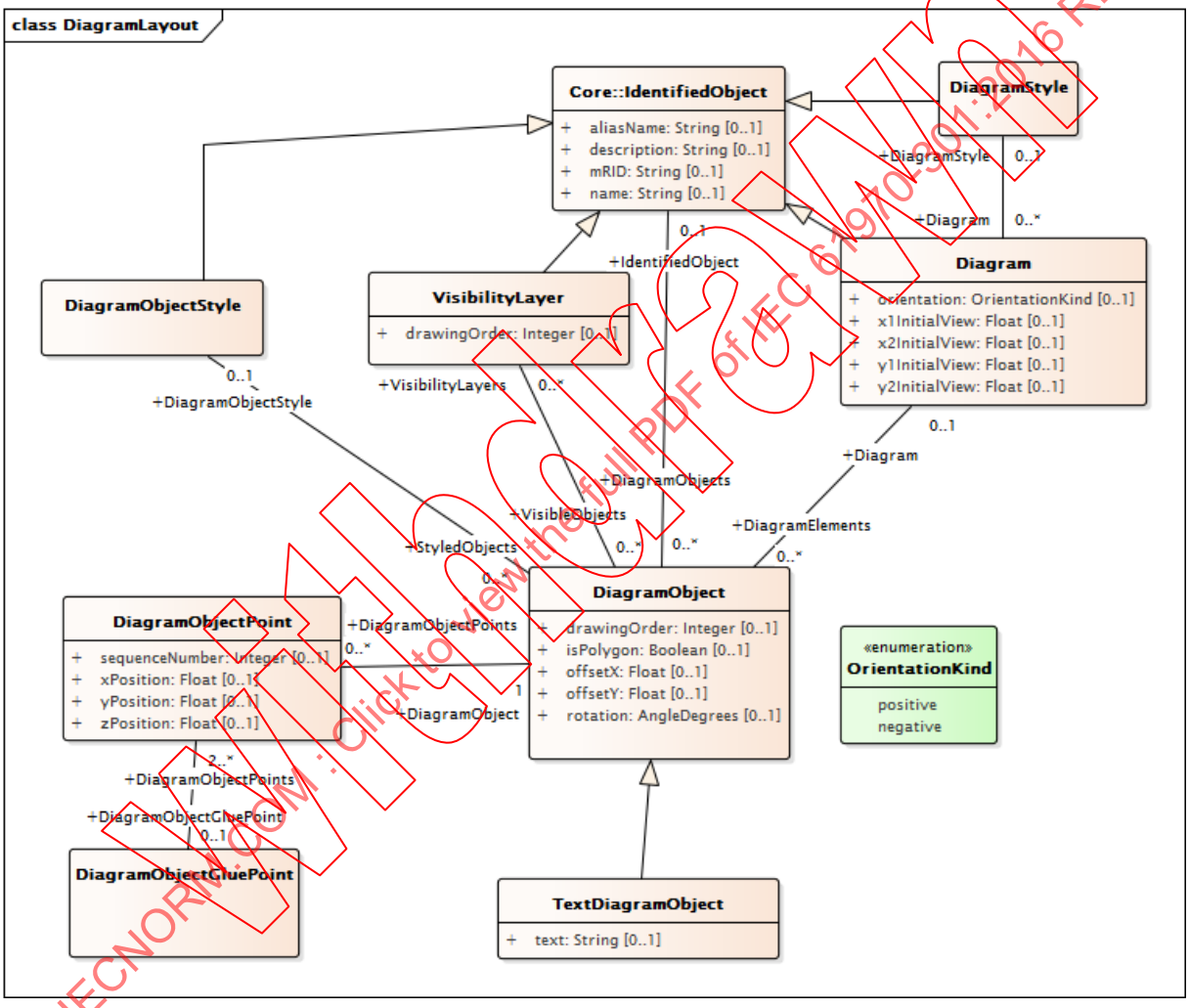


Figure 78 – Class diagram DiagramLayout::DiagramLayout

Figure 78: The diagram shows the diagram layout model.

6.6.2 DiagramStyle

The diagram style refers to a style used by the originating system for a diagram. A diagram style describes information such as schematic, geographic, bus-branch, etc.

Table 148 shows all attributes of DiagramStyle.

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Table 148 – Attributes of DiagramLayout::DiagramStyle

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 149 shows all association ends of DiagramStyle with other classes.

Table 149 – Association ends of DiagramLayout::DiagramStyle with other classes

mult from	name	mult to	type	description
0..1	Diagram	0..*	Diagram	A DiagramStyle can be used by many Diagrams.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.6.3 Diagram

The diagram being exchanged. The coordinate system is a standard Cartesian coordinate system and the orientation attribute defines the orientation.

Table 150 shows all attributes of Diagram.

Table 150 – Attributes of DiagramLayout::Diagram

name	mult	type	description
orientation	0..1	OrientationKind	Coordinate system orientation of the diagram.
x1InitialView	0..1	Float	X coordinate of the first corner of the initial view.
x2InitialView	0..1	Float	X coordinate of the second corner of the initial view.
y1InitialView	0..1	Float	Y coordinate of the first corner of the initial view.
y2InitialView	0..1	Float	Y coordinate of the second corner of the initial view.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 151 shows all association ends of Diagram with other classes.

Table 151 – Association ends of DiagramLayout::Diagram with other classes

mult from	name	mult to	type	description
0..*	DiagramStyle	0..1	DiagramStyle	A Diagram may have a DiagramStyle.
0..1	DiagramElements	0..*	DiagramObject	A diagram is made up of multiple diagram objects.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.6.4 DiagramObject

An object that defines one or more points in a given space. This object can be associated with anything that specializes IdentifiedObject. For single line diagrams such objects typically include such items as analog values, breakers, disconnectors, power transformers, and transmission lines.

Table 152 shows all attributes of DiagramObject.

Table 152 – Attributes of DiagramLayout::DiagramObject

name	mult	type	description
drawingOrder	0..1	Integer	The drawing order of this element. The higher the number, the later the element is drawn in sequence. This is used to ensure that elements that overlap are rendered in the correct order.
isPolygon	0..1	Boolean	Defines whether or not the diagram objects points define the boundaries of a polygon or the routing of a polyline. If this value is true then a receiving application should consider the first and last points to be connected.
offsetX	0..1	Float	The offset in the X direction. This is used for defining the offset from centre for rendering an icon (the default is that a single point specifies the centre of the icon). The offset is in per-unit with 0 indicating there is no offset from the horizontal centre of the icon. -0.5 indicates it is offset by 50 % to the left and 0.5 indicates an offset of 50 % to the right.
offsetY	0..1	Float	The offset in the Y direction. This is used for defining the offset from centre for rendering an icon (the default is that a single point specifies the centre of the icon). The offset is in per-unit with 0 indicating there is no offset from the vertical centre of the icon. The offset direction is dependent on the orientation of the diagram, with -0.5 and 0.5 indicating an offset of +/- 50 % on the vertical axis.
rotation	0..1	AngleDegrees	Sets the angle of rotation of the diagram object ~~in a clockwise direction from the normal~~. Zero degrees is pointing to the top of the diagram. Rotation is clockwise.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 153 shows all association ends of DiagramObject with other classes.

Table 153 – Association ends of DiagramLayout::DiagramObject with other classes

mult from	name	mult to	type	description
0..*	Diagram	0..1	Diagram	A diagram object is part of a diagram.
0..*	VisibilityLayers	0..*	VisibilityLayer	A diagram object can be part of multiple visibility layers.
1..1	DiagramObjectPoints	0..*	DiagramObjectPoint	A diagram object can have 0 or more points to reflect its layout position, routing (for polylines) or boundary (for polygons).

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mult from	name	mult to	type	description
0..*	DiagramObjectStyle	0..1	DiagramObjectStyle	A diagram object has a style associated that provides a reference for the style used in the originating system.
0..*	IdentifiedObject	0..1	IdentifiedObject	The domain object to which this diagram object is associated.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.6.5 DiagramObjectGluePoint root class

This is used for grouping diagram object points from different diagram objects that are considered to be glued together in a diagram even if they are not at the exact same coordinates.

Table 154 shows all association ends of DiagramObjectGluePoint with other classes.

Table 154 – Association ends of DiagramLayout::DiagramObjectGluePoint with other classes

mult from	name	mult to	type	description
0..1	DiagramObjectPoints	2..*	DiagramObjectPoint	A diagram object glue point is associated with 2 or more object points that are considered to be 'glued' together.

6.6.6 DiagramObjectPoint root class

A point in a given space defined by 3 coordinates and associated to a diagram object. The coordinates may be positive or negative as the origin does not have to be in the corner of a diagram.

Table 155 shows all attributes of DiagramObjectPoint.

Table 155 – Attributes of DiagramLayout::DiagramObjectPoint

name	mult	type	description
sequenceNumber	0..1	Integer	The sequence position of the point, used for defining the order of points for diagram objects acting as a polyline or polygon with more than one point.
xPosition	0..1	Float	The X coordinate of this point.
yPosition	0..1	Float	The Y coordinate of this point.
zPosition	0..1	Float	The Z coordinate of this point.

Table 156 shows all association ends of DiagramObjectPoint with other classes.

Table 156 – Association ends of DiagramLayout::DiagramObjectPoint with other classes

mult from	name	mult to	type	description
2..*	DiagramObjectGluePoint	0..1	DiagramObjectGluePoint	The 'glue' point to which this point is associated.
0..*	DiagramObject	1..1	DiagramObject	The diagram object with which the points are associated.

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6.6.7 DiagramObjectStyle

A reference to a style used by the originating system for a diagram object. A diagram object style describes information such as line thickness, shape such as circle or rectangle etc, and color.

Table 157 shows all attributes of DiagramObjectStyle.

Table 157 – Attributes of DiagramLayout::DiagramObjectStyle

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 158 shows all association ends of DiagramObjectStyle with other classes.

Table 158 – Association ends of DiagramLayout::DiagramObjectStyle with other classes

mult from	name	mult to	type	description
0..1	StyledObjects	0..*	DiagramObject	A style can be assigned to multiple diagram objects.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.6.8 OrientationKind enumeration

The orientation of the coordinate system with respect to top, left, and the coordinate number system.

Table 159 shows all literals of OrientationKind.

Table 159 – Literals of DiagramLayout::OrientationKind

literal	value	description
positive		For 2D diagrams, a positive orientation will result in X values increasing from left to right and Y values increasing from bottom to top. This is also known as a right hand orientation.
negative		For 2D diagrams, a negative orientation gives the left-hand orientation (favoured by computer graphics displays) with X values increasing from left to right and Y values increasing from top to bottom. This is also known as a left hand orientation.

6.6.9 TextDiagramObject

A diagram object for placing free-text or text derived from an associated domain object.

Table 160 shows all attributes of TextDiagramObject.

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Table 160 – Attributes of DiagramLayout::TextDiagramObject

name	mult	type	description
text	0..1	String	The text that is displayed by this text diagram object.
drawingOrder	0..1	Integer	inherited from: DiagramObject
isPolygon	0..1	Boolean	inherited from: DiagramObject
offsetX	0..1	Float	inherited from: DiagramObject
offsetY	0..1	Float	inherited from: DiagramObject
rotation	0..1	AngleDegrees	inherited from: DiagramObject
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 161 shows all association ends of TextDiagramObject with other classes.

Table 161 – Association ends of DiagramLayout::TextDiagramObject with other classes

mult from	name	mult to	type	description
0..*	Diagram	0..1	Diagram	inherited from: DiagramObject
0..*	VisibilityLayers	0..*	VisibilityLayer	inherited from: DiagramObject
1..1	DiagramObjectPoints	0..*	DiagramObjectPoint	inherited from: DiagramObject
0..*	DiagramObjectStyle	0..1	DiagramObjectStyle	inherited from: DiagramObject
0..*	IdentifiedObject	0..1	IdentifiedObject	inherited from: DiagramObject
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.6.10 VisibilityLayer

Layers are typically used for grouping diagram objects according to themes and scales. Themes are used to display or hide certain information (e.g. lakes, borders), while scales are used for hiding or displaying information depending on the current zoom level (hide text when it is too small to be read, or when it exceeds the screen size). This is also called de-cluttering.

CIM based graphics exchange will support an m:n relationship between diagram objects and layers. It will be the task of the importing system to convert an m:n case into an appropriate 1:n representation if the importing system does not support m:n.

Table 162 shows all attributes of VisibilityLayer.

Table 162 – Attributes of DiagramLayout::VisibilityLayer

name	mult	type	description
drawingOrder	0..1	Integer	The drawing order for this layer. The higher the number, the later the layer and the objects within it are rendered.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 163 shows all association ends of VisibilityLayer with other classes.

Table 163 – Association ends of DiagramLayout::VisibilityLayer with other classes

mult from	name	mult to	type	description
0..*	VisibleObjects	0..*	DiagramObject	A visibility layer can contain one or more diagram objects.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7 Package OperationalLimits

6.7.1 General

This package models a specification of limits associated with equipment and other operational entities.

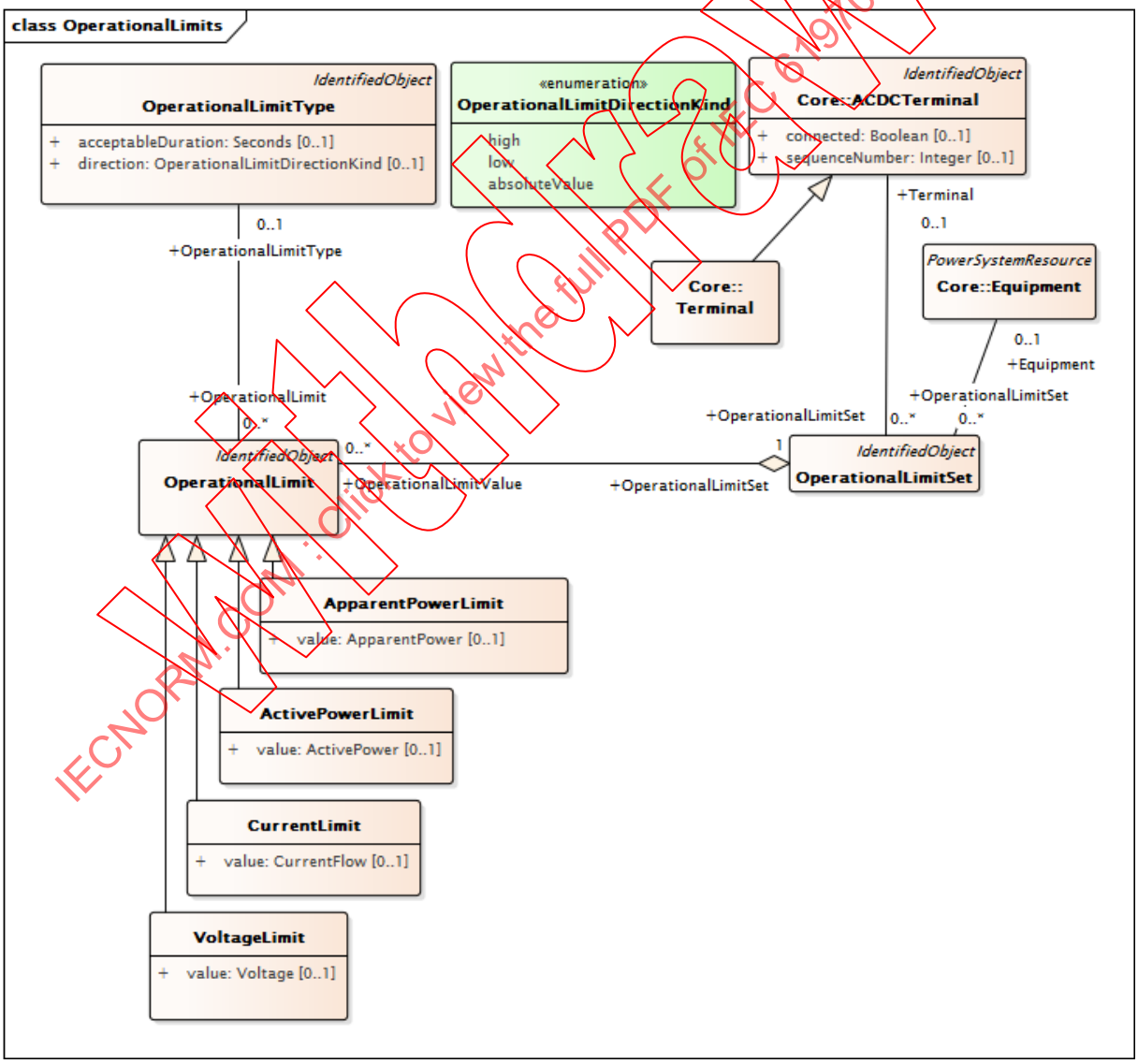


Figure 79 – Class diagram OperationalLimits::OperationalLimits

Figure 79: This diagram shows operational limits as they tie back into the core model.

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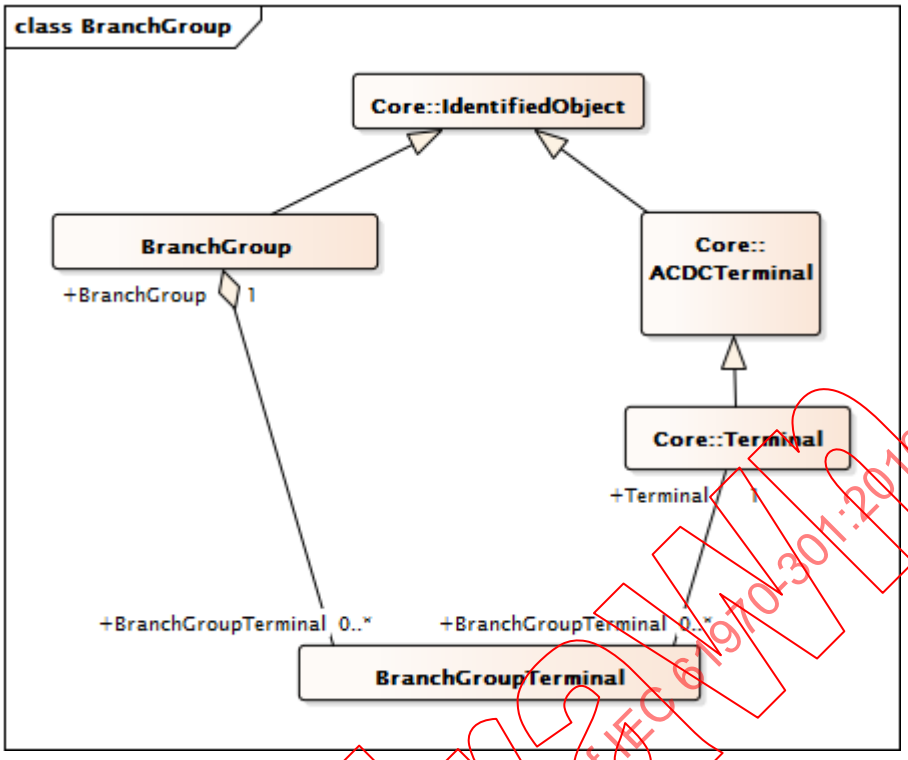


Figure 80 – Class diagram OperationalLimits::BranchGroup

Figure 80: This diagram shows the model for monitoring combined flows on groups of branches.

6.7.2 ActivePowerLimit

Limit on active power flow.

Table 164 shows all attributes of ActivePowerLimit.

Table 164 – Attributes of OperationalLimits::ActivePowerLimit

name	mult	type	description
value	0..1	ActivePower	Value of active power limit.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 165 shows all association ends of ActivePowerLimit with other classes.

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Table 165 – Association ends of OperationalLimits::ActivePowerLimit with other classes

mult from	name	mult to	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	inherited from: OperationalLimit
0..*	OperationalLimitType	0..1	OperationalLimitType	inherited from: OperationalLimit
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.3 ApparentPowerLimit

Apparent power limit.

Table 166 shows all attributes of ApparentPowerLimit.

Table 166 – Attributes of OperationalLimits::ApparentPowerLimit

name	mult	type	description
value	0..1	ApparentPower	The apparent power limit.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 167 shows all association ends of ApparentPowerLimit with other classes.

Table 167 – Association ends of OperationalLimits::ApparentPowerLimit with other classes

mult from	name	mult to	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	inherited from: OperationalLimit
0..*	OperationalLimitType	0..1	OperationalLimitType	inherited from: OperationalLimit
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.4 BranchGroup

A group of branch terminals whose directed flow summation is to be monitored. A branch group need not form a cutset of the network.

Table 168 shows all attributes of BranchGroup.

Table 168 – Attributes of OperationalLimits::BranchGroup

name	mult	type	description
maximumActivePower	0..1	ActivePower	The maximum active power flow.
maximumReactivePower	0..1	ReactivePower	The maximum reactive power flow.
minimumActivePower	0..1	ActivePower	The minimum active power flow.
minimumReactivePower	0..1	ReactivePower	The minimum reactive power flow.
monitorActivePower	0..1	Boolean	Monitor the active power flow.

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name	mult	type	description
monitorReactivePower	0..1	Boolean	Monitor the reactive power flow.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 169 shows all association ends of BranchGroup with other classes.

Table 169 – Association ends of OperationalLimits::BranchGroup with other classes

mult from	name	mult to	type	description
1..1	BranchGroupTerminal	0..*	BranchGroupTerminal	The directed branch group terminals to be summed.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.5 BranchGroupTerminal root class

A specific directed terminal flow for a branch group.

Table 170 shows all attributes of BranchGroupTerminal.

Table 170 – Attributes of OperationalLimits::BranchGroupTerminal

name	mult	type	description
positiveFlowIn	0..1	Boolean	The flow into the terminal is summed if set true. The flow out of the terminal is summed if set false.

Table 171 shows all association ends of BranchGroupTerminal with other classes.

Table 171 – Association ends of OperationalLimits::BranchGroupTerminal with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	The terminal to be summed.
0..*	BranchGroup	1..1	BranchGroup	The branch group to which the directed branch group terminals belong.

6.7.6 CurrentLimit

Operational limit on current.

Table 172 shows all attributes of CurrentLimit.

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Table 172 – Attributes of OperationalLimits::CurrentLimit

name	mult	type	description
value	0..1	CurrentFlow	Limit on current flow.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 173 shows all association ends of CurrentLimit with other classes.

Table 173 – Association ends of OperationalLimits::CurrentLimit with other classes

mult from	name	mult to	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	inherited from: OperationalLimit
0..*	OperationalLimitType	0..1	OperationalLimitType	inherited from: OperationalLimit
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.7 OperationalLimit

A value associated with a specific kind of limit.

The sub class value attribute shall be positive.

The sub class value attribute is inversely proportional to OperationalLimitType.acceptableDuration (acceptableDuration for short). A pair of value_x and acceptableDuration_x are related to each other as follows:

if value_1 > value_2 > value_3 > ..., then

acceptableDuration_1 < acceptableDuration_2 < acceptableDuration_3 < ...

A value_x with direction="high" shall be greater than a value_y with direction="low".

Table 174 shows all attributes of OperationalLimit.

Table 174 – Attributes of OperationalLimits::OperationalLimit

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 175 shows all association ends of OperationalLimit with other classes.

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Table 175 – Association ends of OperationalLimits::OperationalLimit with other classes

mult from	name	mult to	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	The limit set to which the limit values belong.
0..*	OperationalLimitType	0..1	OperationalLimitType	The limit type associated with this limit.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.8 OperationalLimitDirectionKind enumeration

The direction ~~of an operational limit~~ attribute describes the side of a limit that is a violation.

Table 176 shows all literals of OperationalLimitDirectionKind.

Table 176 – Literals of OperationalLimits::OperationalLimitDirectionKind

literal	value	description
high		~~The limit is a high limit.~~ High means that a monitored value above the limit value is a violation. If applied to a terminal flow, the positive direction is into the terminal.
low		~~The limit is a low limit.~~ Low means a monitored value below the limit is a violation. If applied to a terminal flow, the positive direction is into the terminal.
absoluteValue		~~If the absolute value of the monitored value is above the limit value, the limit is violated. In effect, the limit is both a high limit and its negative a low limit.~~ An absoluteValue limit means that a monitored absolute value above the limit value is a violation.

6.7.9 OperationalLimitSet

A set of limits associated with equipment. Sets of limits might apply to a specific temperature, or season for example. A set of limits may contain different severities of limit levels that would apply to the same equipment. The set may contain limits of different types such as apparent power and current limits or high and low voltage limits that are logically applied together as a set.

Table 177 shows all attributes of OperationalLimitSet.

Table 177 – Attributes of OperationalLimits::OperationalLimitSet

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 178 shows all association ends of OperationalLimitSet with other classes.

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Table 178 – Association ends of OperationalLimits::OperationalLimitSet with other classes

mult from	name	mult to	type	description
0..*	Terminal	0..1	ACDCTerminal	The terminal where the operational limit set apply.
0..*	Equipment	0..1	Equipment	The equipment to which the limit set applies.
1..1	OperationalLimitValue	0..*	OperationalLimit	Values of equipment limits.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.10 OperationalLimitType

The operational meaning of a category of limits.

Table 179 shows all attributes of OperationalLimitType.

Table 179 – Attributes of OperationalLimits::OperationalLimitType

name	mult	type	description
acceptableDuration	0..1	Seconds	The nominal acceptable duration of the limit. Limits are commonly expressed in terms of the ~~a~~ time limit for which the limit is normally acceptable. The actual acceptable duration of a specific limit may depend on other local factors such as temperature or wind speed.
direction	0..1	OperationalLimitDirectionKind	The direction of the limit.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 180 shows all association ends of OperationalLimitType with other classes.

Table 180 – Association ends of OperationalLimits::OperationalLimitType with other classes

mult from	name	mult to	type	description
0..1	OperationalLimit	0..*	OperationalLimit	The operational limits associated with this type of limit.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.11 VoltageLimit

Operational limit applied to voltage.

Table 181 shows all attributes of VoltageLimit.

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Table 181 – Attributes of OperationalLimits::VoltageLimit

name	mult	type	description
value	0..1	Voltage	Limit on voltage. High or low limit nature of the limit depends upon the properties of the operational limit type.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 182 shows all association ends of VoltageLimit with other classes.

Table 182 – Association ends of OperationalLimits::VoltageLimit with other classes

mult from	name	mult to	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	inherited from: OperationalLimit
0..*	OperationalLimitType	0..1	OperationalLimitType	inherited from: OperationalLimit
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

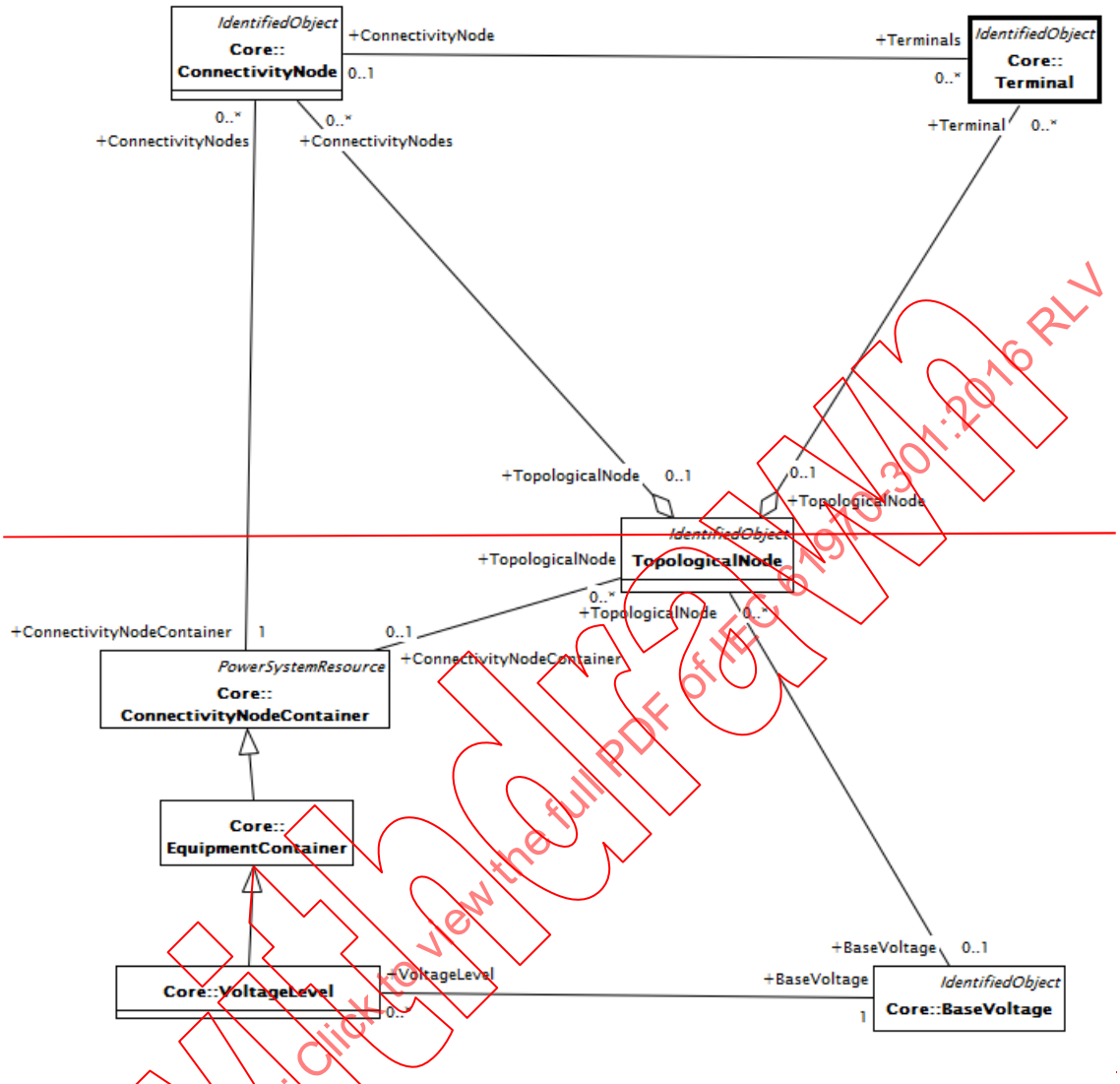
6.8 Package Topology

6.8.1 General

An extension to the Core Package that, in association with the Terminal class, models Connectivity, that is the physical definition of how equipment is connected together. In addition it models Topology, that is the logical definition of how equipment is connected via closed switches. The Topology definition is independent of the other electrical characteristics.

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~~Figure 42 shows class diagram TopologicalNodeTerminal.~~

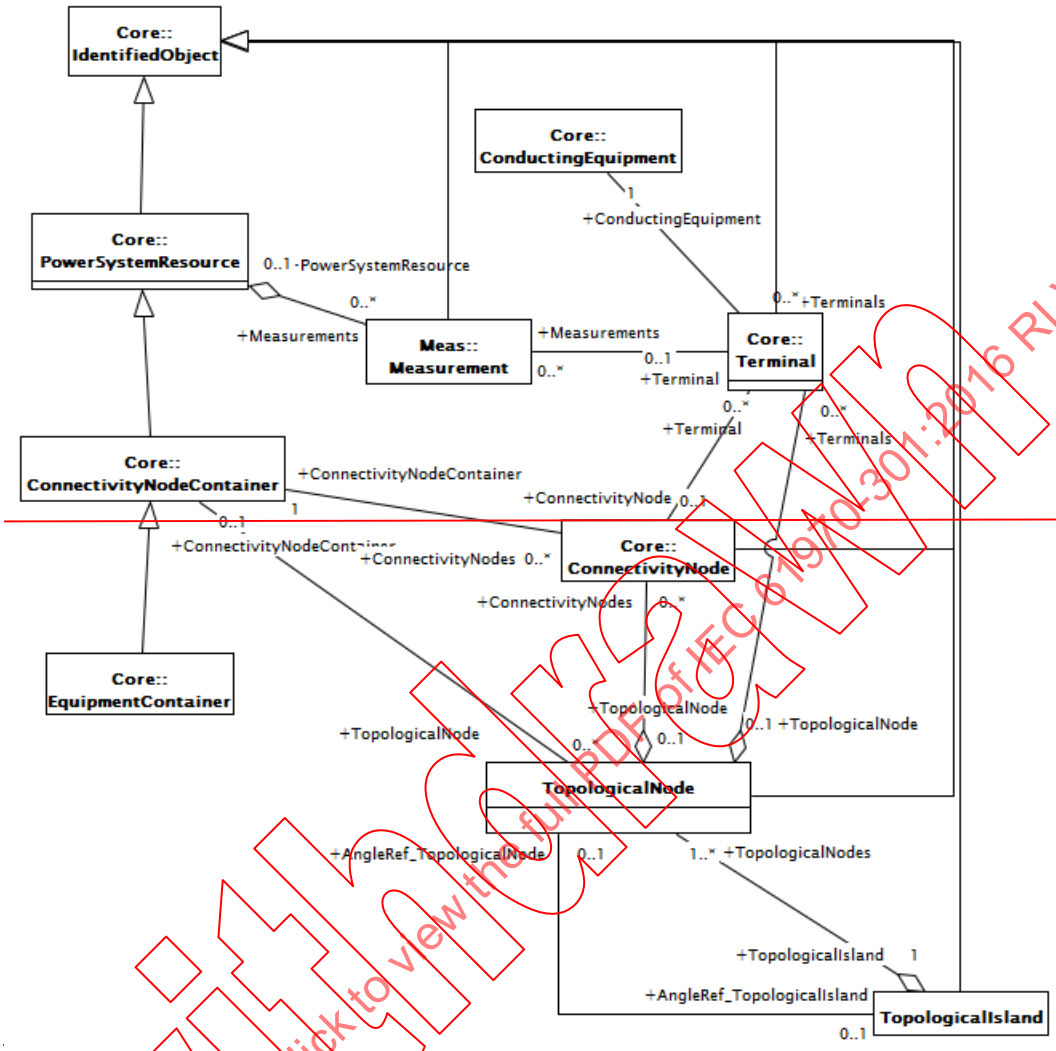


~~Figure 42 – Class diagram Topology::TopologicalNodeTerminal~~

~~Shows the relationships among topological nodes and terminals.~~

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~~Figure 43 shows class diagram TopologyMeasRelations.~~



~~Figure 43 – Class diagram Topology::TopologyMeasRelations~~

~~Shows the relationship of measurements to terminals and topology.~~

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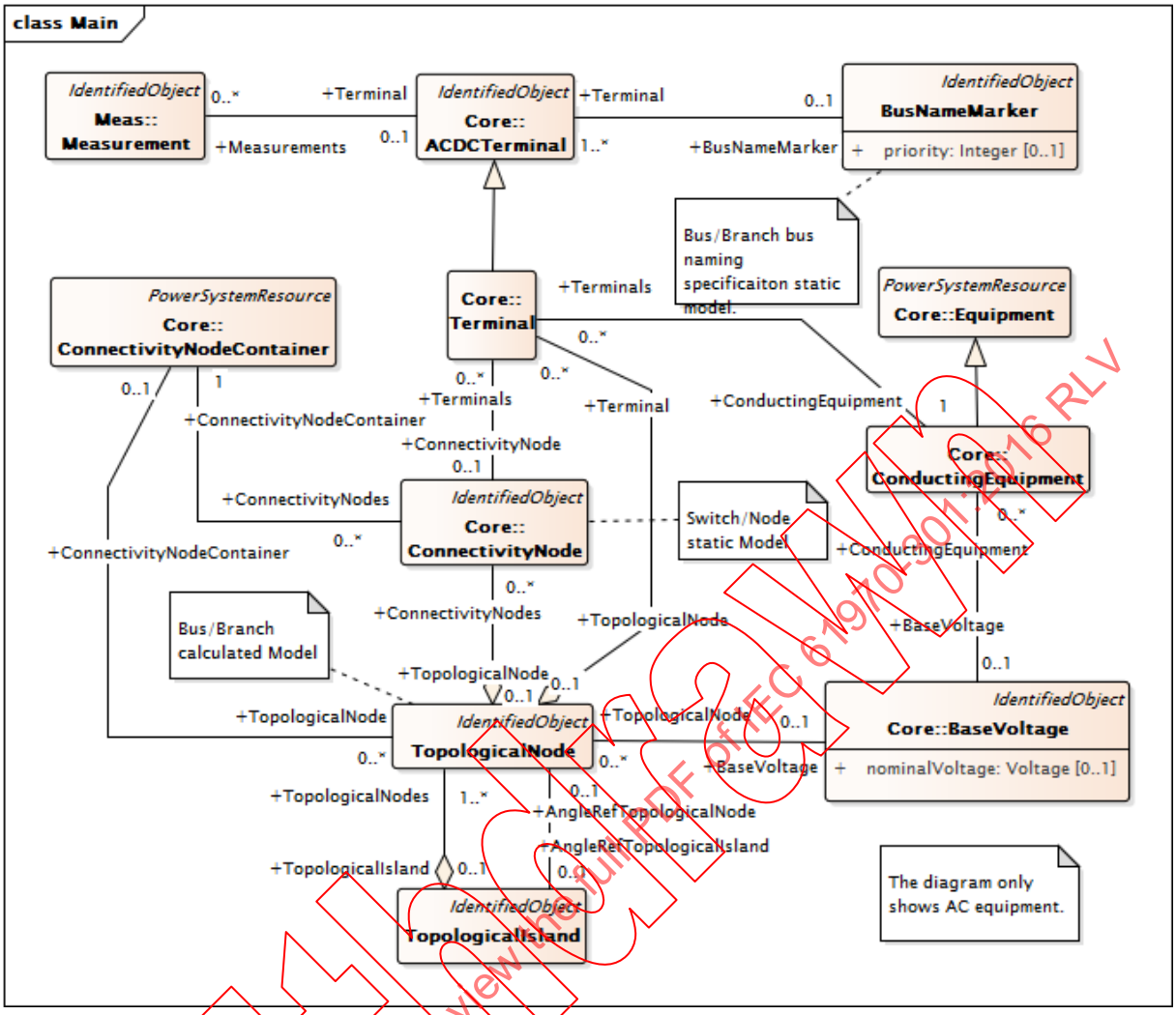


Figure 81 – Class diagram Topology::Main

Figure 81: This diagram shows all classes included in the Topology package as well as the key external classes that have associations with Topology classes.

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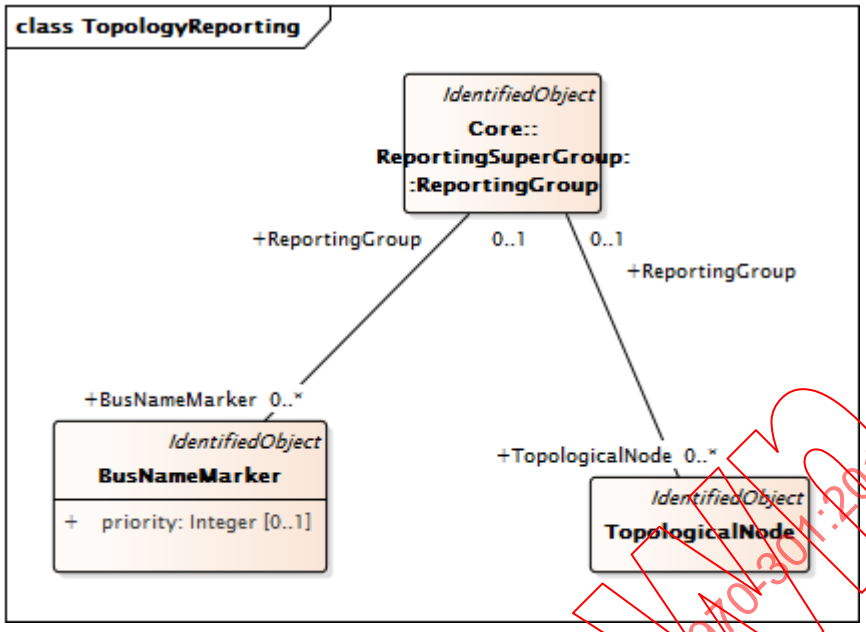


Figure 82 – Class diagram Topology::TopologyReporting

Figure 82: Shows topology reporting relationships.

6.8.2 BusNameMarker

Used to apply user standard names to topology buses. Typically used for "bus/branch" case generation. Associated with one or more ~~ConnectivityNodes~~ terminals that are normally ~~a part of~~ connected with the bus name. The associated ~~ConnectivityNodes~~ terminals are ~~to be~~ normally connected by non-retained switches. For a ring bus station configuration, all busbar ~~connectivity nodes~~ terminals in the ring are typically associated. For a breaker and a half scheme, both busbars would normally be associated. For a ring bus, all busbars would normally be associated. For a "straight" busbar configuration, normally only the main ~~connectivity node~~ terminal at the busbar would be associated.

Table 183 shows all attributes of BusNameMarker.

Table 183 – Attributes of Topology::BusNameMarker

name	mult	type	description
priority	0..1	Integer	Priority of bus name marker for use as topology bus name. Use 0 for don't care. Use 1 for highest priority. Use 2 as priority is less than 1 and so on.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 184 shows all association ends of BusNameMarker with other classes.

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Table 184 – Association ends of Topology::BusNameMarker with other classes

mult from	name	mult to	type	description
0..1	Terminal	1..*	ACDCTerminal	The terminals associated with this bus name marker.
0..*	ReportingGroup	0..1	ReportingGroup	The reporting group to which this bus name marker belongs.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.8.3 DCTopologicalNode

DC bus.

Table 185 shows all attributes of DCTopologicalNode.

Table 185 – Attributes of Topology::DCTopologicalNode

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 186 shows all association ends of DCTopologicalNode with other classes.

Table 186 – Association ends of Topology::DCTopologicalNode with other classes

mult from	name	mult to	type	description
1..*	DCTopologicalIsland	0..1	DCTopologicalIsland	A DC topological node belongs to a DC topological island.
0..1	DCTerminals	0..*	DCBaseTerminal	The DC base terminals associated with the DC topological node.
0..1	DCNodes	0..*	DCNode	The DC connectivity nodes combined together to form this DC topological node. May depend on the current state of switches in the network.
0..*	DCEquipmentContainer	0..1	DCEquipmentContainer	The connectivity node container to which the toplogical node belongs.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.8.4 TopologicalIsland

An electrically connected subset of the network. Topological islands can change as the current network state changes: e.g. due to

– disconnect switches or breakers changing state in a SCADA/EMS
– manual creation, change or deletion of topological nodes in a planning tool.

Table 187 shows all attributes of TopologicalIsland.

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Table 187 – Attributes of Topology::TopologicalIsland

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 188 shows all association ends of TopologicalIsland with other classes.

Table 188 – Association ends of Topology::TopologicalIsland with other classes

mult from	name	mult to	type	description
0..1	AngleRefTopologicalNode	0..1	TopologicalNode	The angle reference for the island. Normally there is one TopologicalNode that is selected as the angle reference for each island. Other reference schemes exist, so the association is typically optional.
0..1	TopologicalNodes	1..*	TopologicalNode	A topological node belongs to a topological island.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.8.5 TopologicalNode

For a detailed substation model a topological node is a set of connectivity nodes that, in the current network state, are connected together through any type of closed switches, including jumpers. Topological nodes change as the current network state changes (i.e. switches, breakers, etc. change state).

For a planning model, switch statuses are not used to form topological nodes. Instead they are manually created or deleted in a model builder tool. Topological nodes maintained this way are also called "busses".

Table 189 shows all attributes of TopologicalNode.

Table 189 – Attributes of Topology::TopologicalNode

name	mult	type	description
pInjection	0..1	ActivePower	The active power injected into the bus at this location in addition to injections from equipment. Positive sign means injection into the TopologicalNode (bus). Starting value for a steady state solution.
qInjection	0..1	ReactivePower	The reactive power injected into the bus at this location in addition to injections from equipment. Positive sign means injection into the TopologicalNode (bus). Starting value for a steady state solution.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 190 shows all association ends of TopologicalNode with other classes.

Table 190 – Association ends of Topology::TopologicalNode with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	The base voltage of the topologocial node.
0..*	ConnectivityNodeContainer	0..1	ConnectivityNodeContainer	The connectivity node container to which the toplogical node belongs.
0..*	ReportingGroup	0..1	ReportingGroup	The reporting group to which the topological node belongs.
1..*	TopologicalIsland	0..1	TopologicalIsland	A topological node belongs to a topological island.
0..1	ConnectivityNodes	0..*	ConnectivityNode	The connectivity nodes combined together to form this topological node. May depend on the current state of switches in the network.
0..1	Terminal	0..*	Terminal	The terminals associated with the topological node. This can be used as an alternative to the connectivity node path to terminal, thus making it unneccesary to model connectivity nodes in some cases. Note that if connectivity nodes are in the model, this association would probably not be used as an input specification.
0..1	AngleRefTopologicalIsland	0..1	TopologicalIsland	The island for which the node is an angle reference. Normally there is one angle reference node for each island.
1..1	SvInjection	0..1	SvInjection	The injection flows state variables associated with the topological node.
1..1	SvVoltage	0..1	SvVoltage	The state voltage associated with the topological node.
~~[1..1]~~	~~[0..1] SvShortCircuit~~		~~SvShortCircuit~~	~~The state variables for short circuit associated with the topological node.~~
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9 Package Wires

6.9.1 General

An extension to the Core and Topology package that models information on the electrical characteristics of Transmission and Distribution networks. This package is used by network applications such as State Estimation, Load Flow and Optimal Power Flow.

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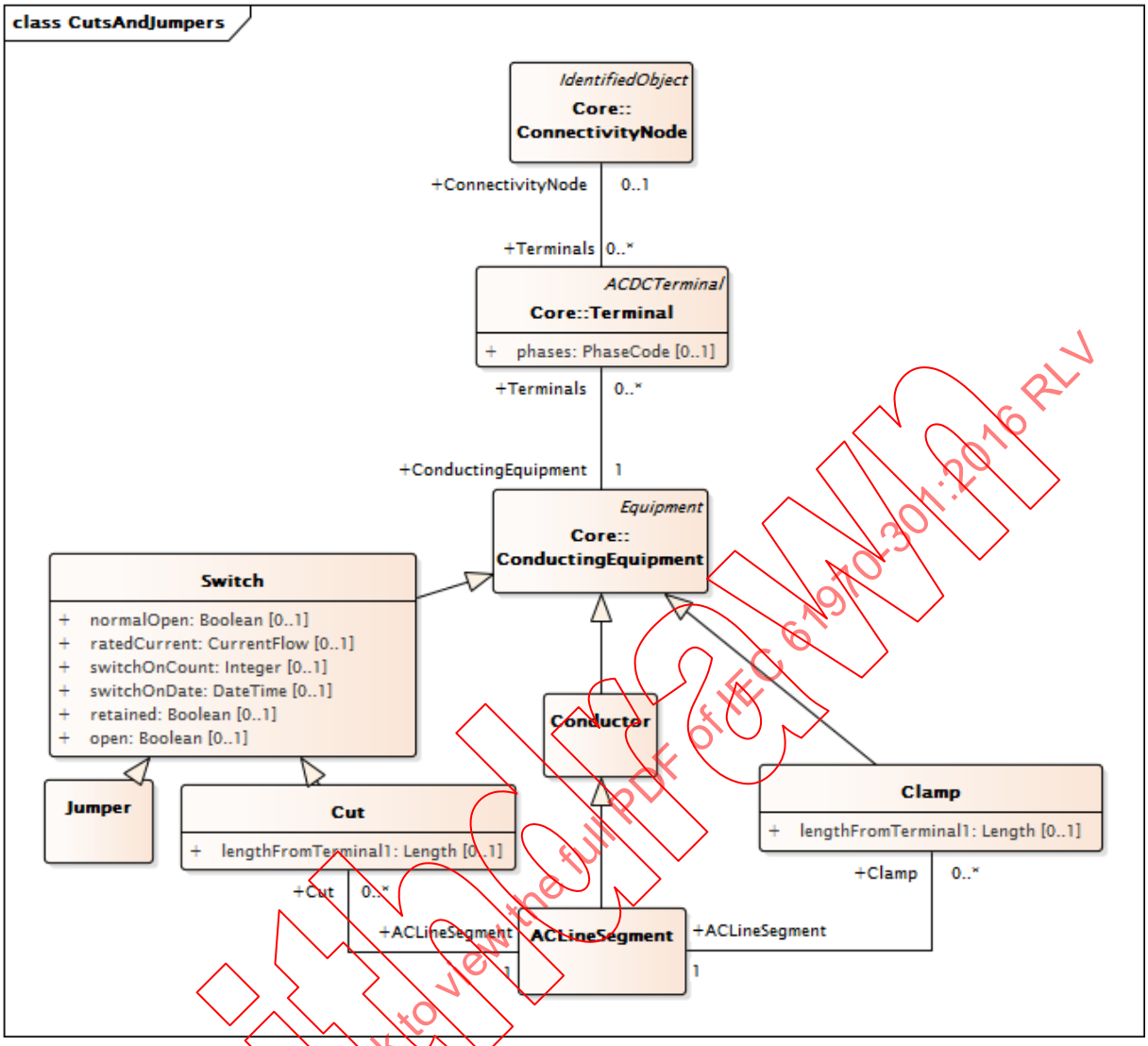


Figure 83 – Class diagram Wires::CutsAndJumpers

Figure 83: The diagram show the cuts and jumpers data model.

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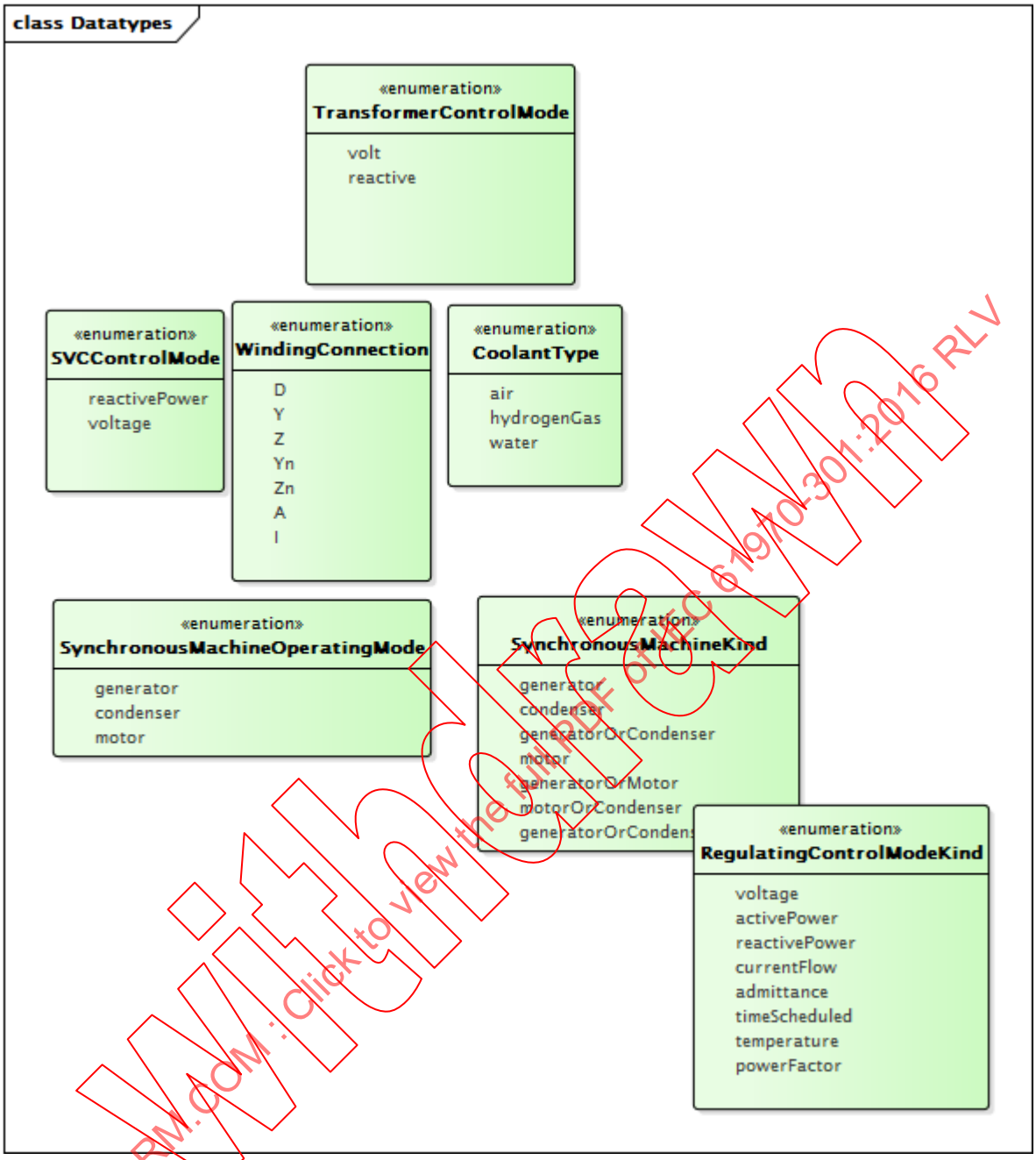


Figure 84 – Class diagram Wires::Datatypes

Figure 84: This diagram shows the data types specific to the Wires package.

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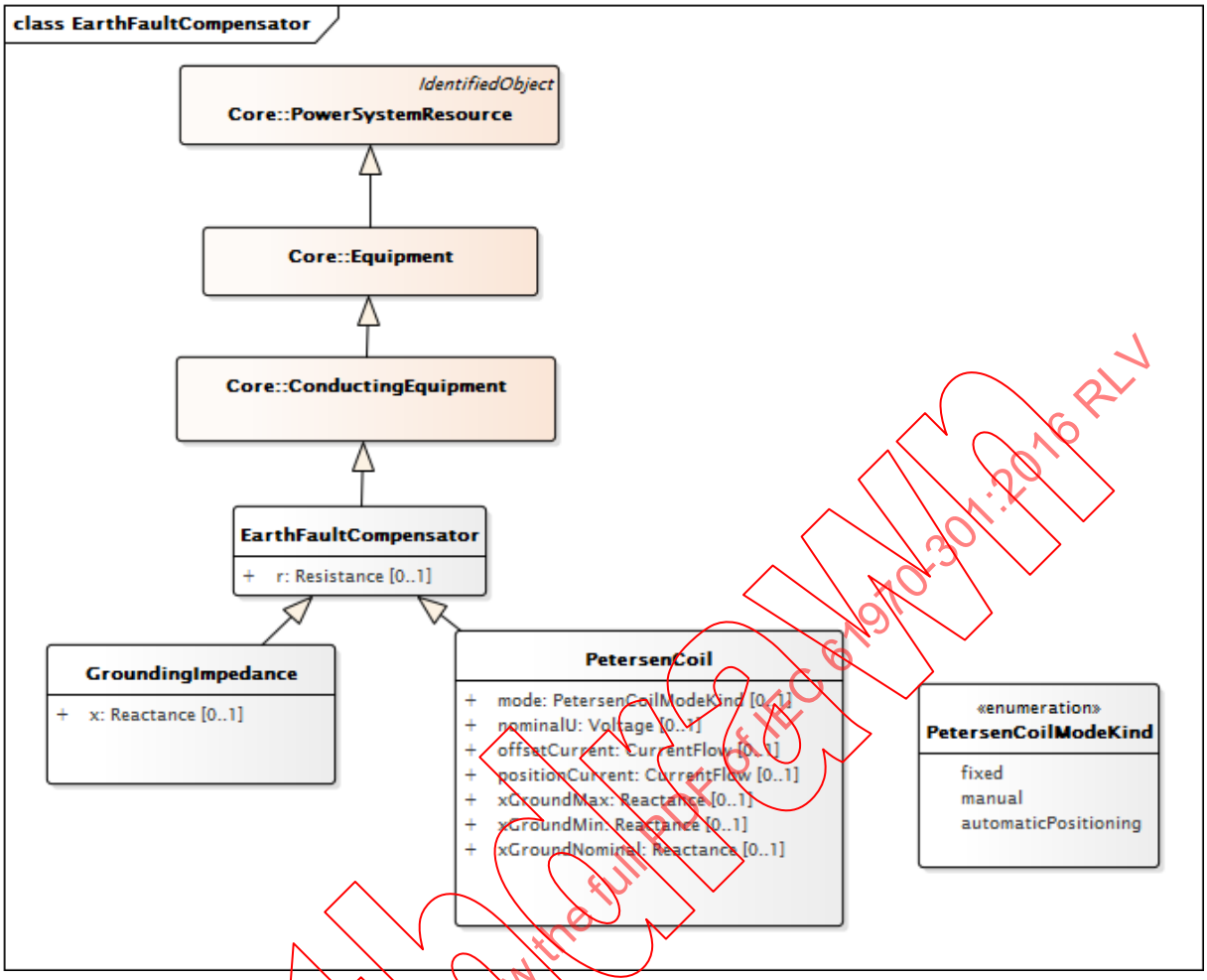
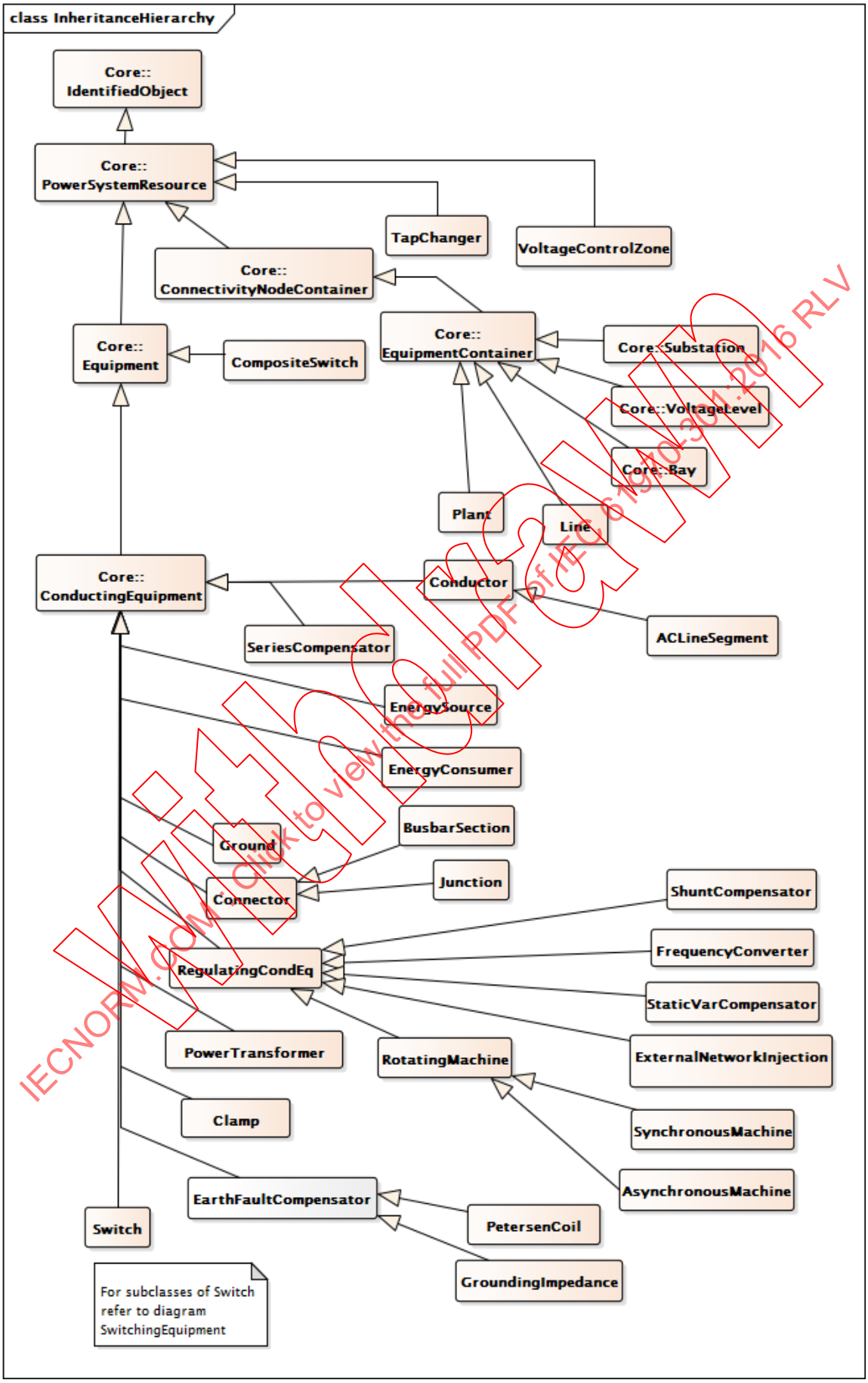


Figure 85 – Class diagram Wires::EarthFaultCompensator

Figure 85: Shows earth fault compensating devices.

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Figure 86 – Class diagram Wires::InheritanceHierarchy

Figure 86: This diagram describes inheritance between classes in and related to the Wires package.

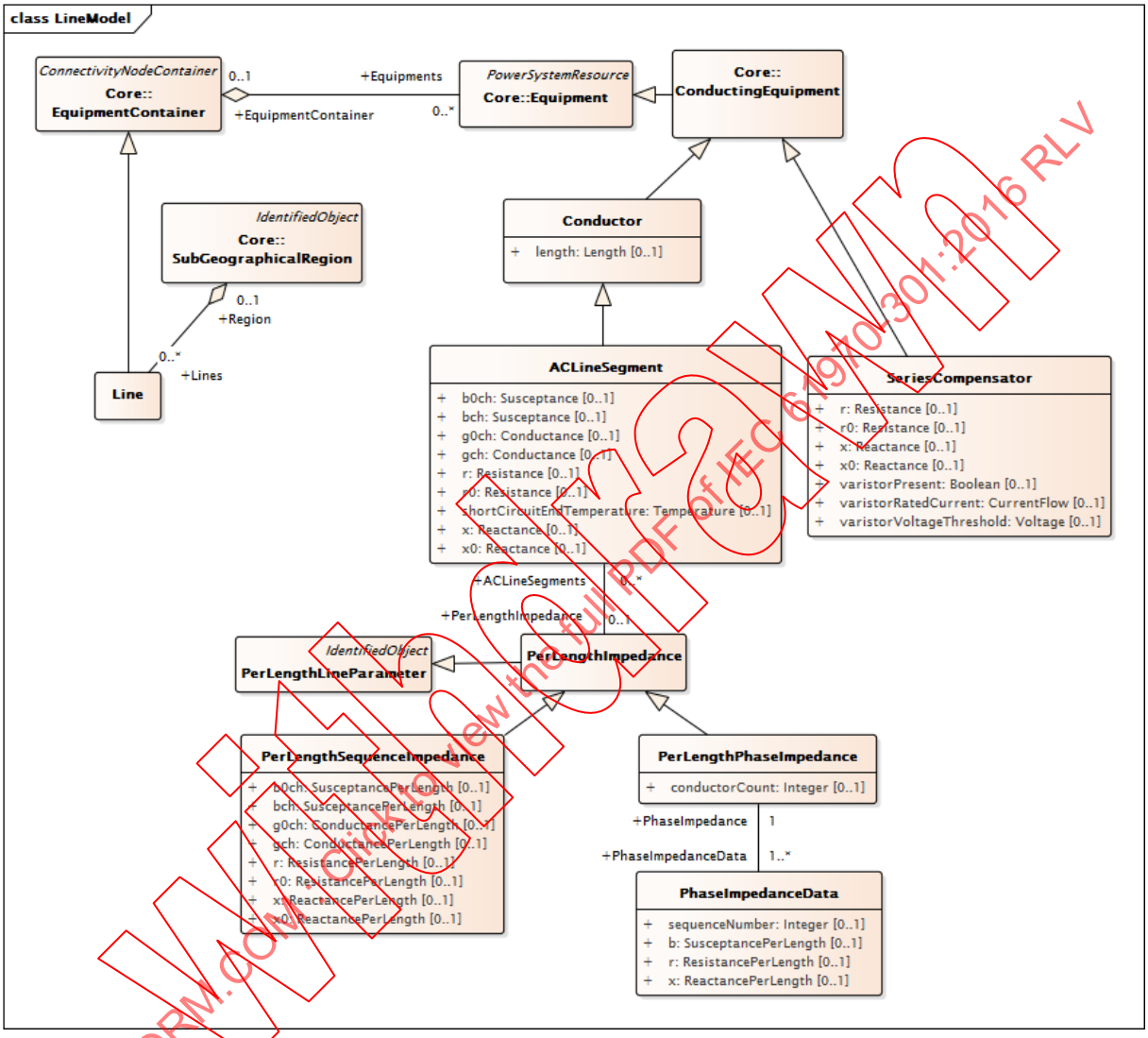


Figure 87 – Class diagram Wires::LineModel

Figure 87: This diagram shows all classes related to the transmission line model.

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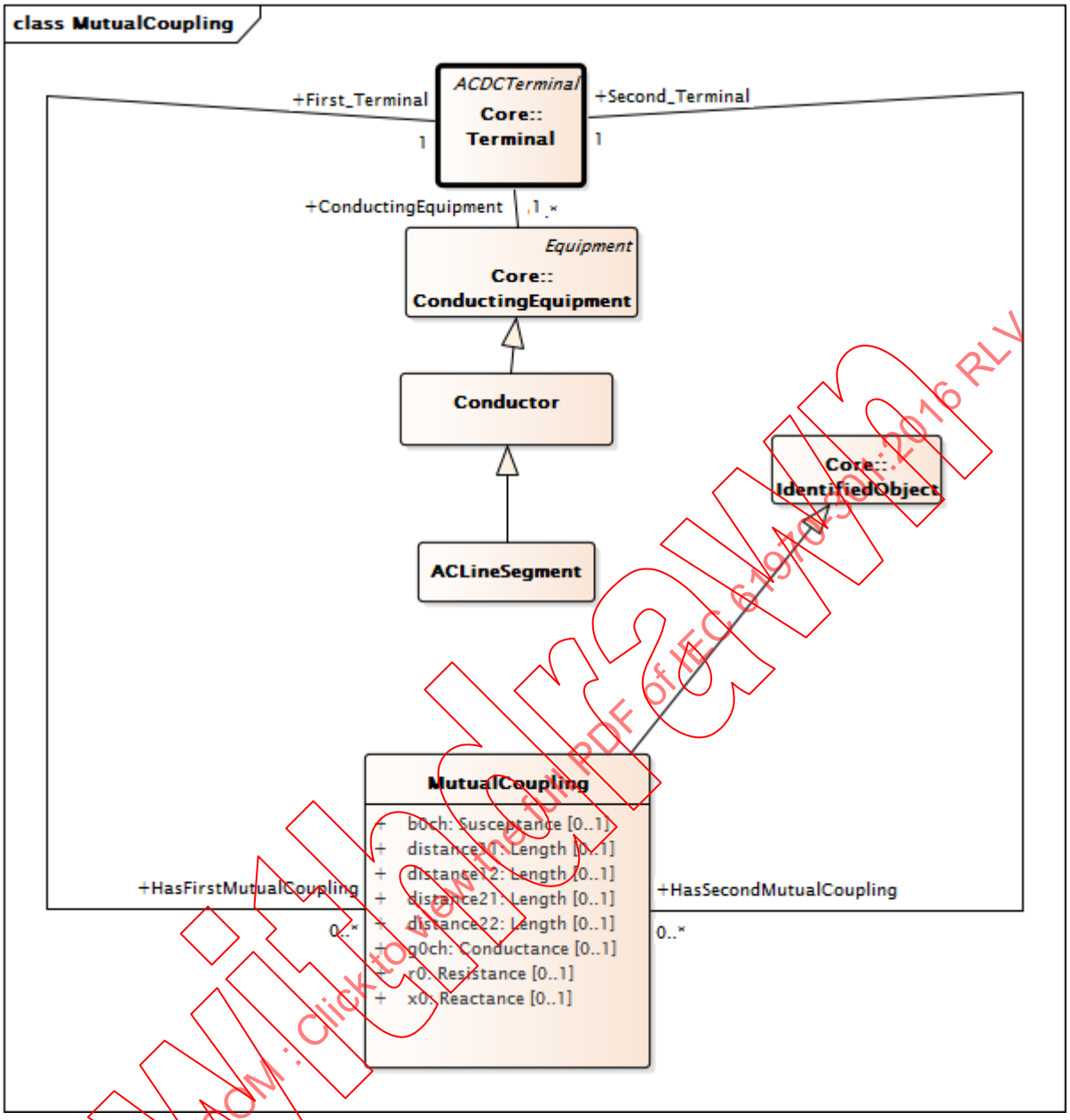


Figure 88 – Class diagram Wires::MutualCoupling

Figure 88: Shows mutual coupling models.

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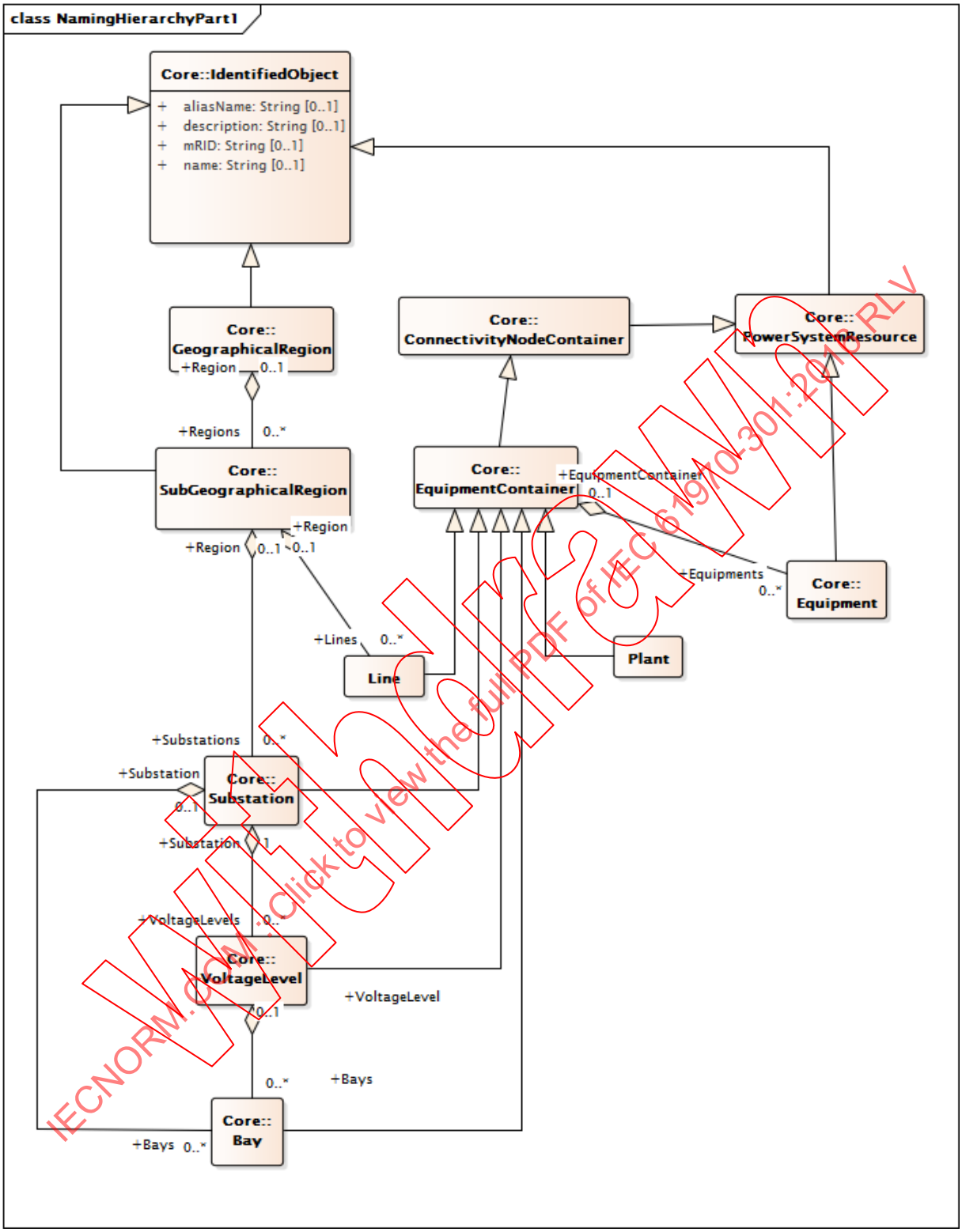
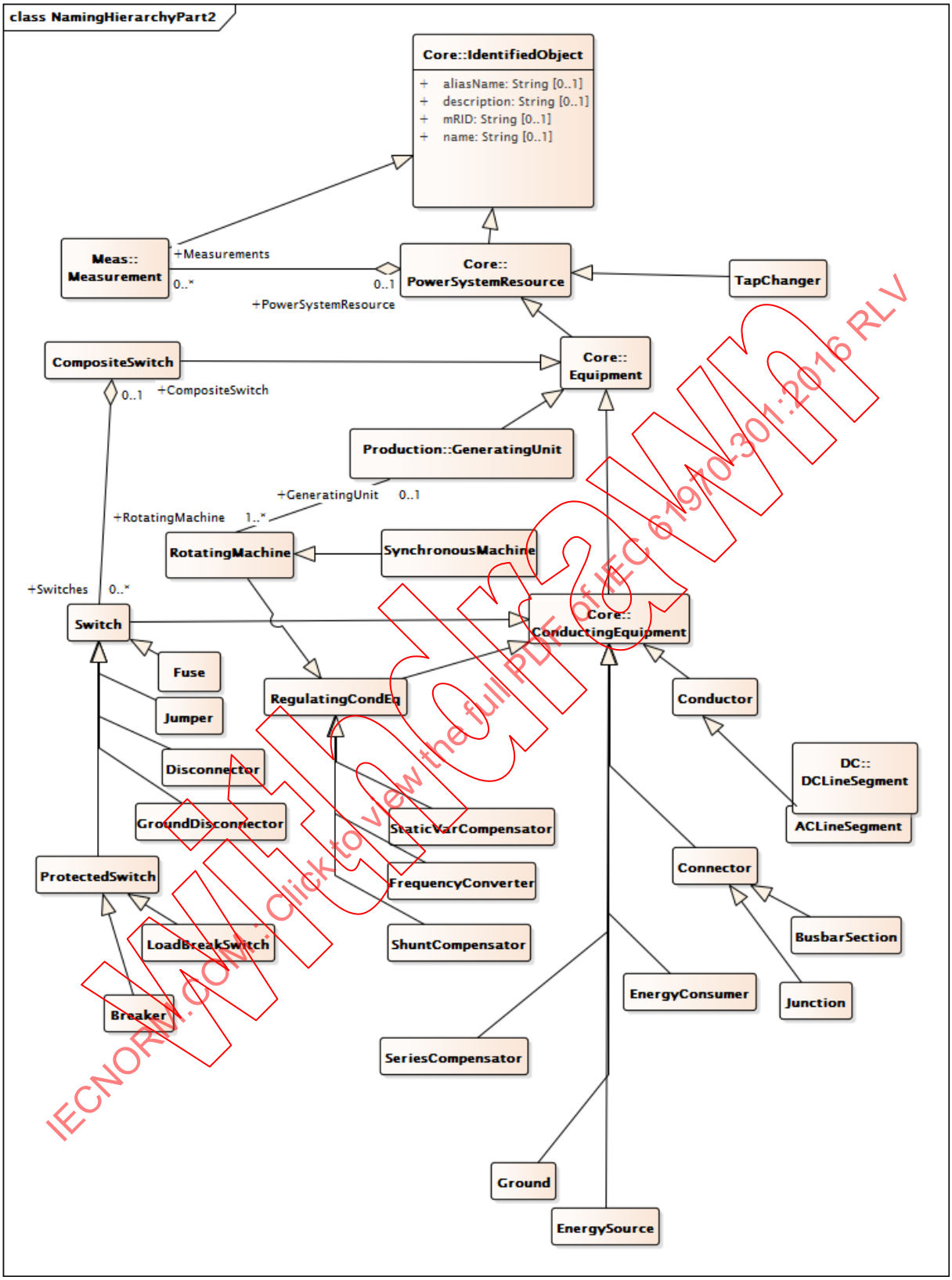


Figure 89 – Class diagram Wires::NamingHierarchyPart1

Figure 89: The diagram shows the upper part of the naming hierarchy. The hierarchy is a way to organize and name equipment. Hence it is tightly related to the IdentifiedObject and it's attributes. The Equipment class is further specialized into many subtypes that are all contained by subclasses of the EquipmentContainer.

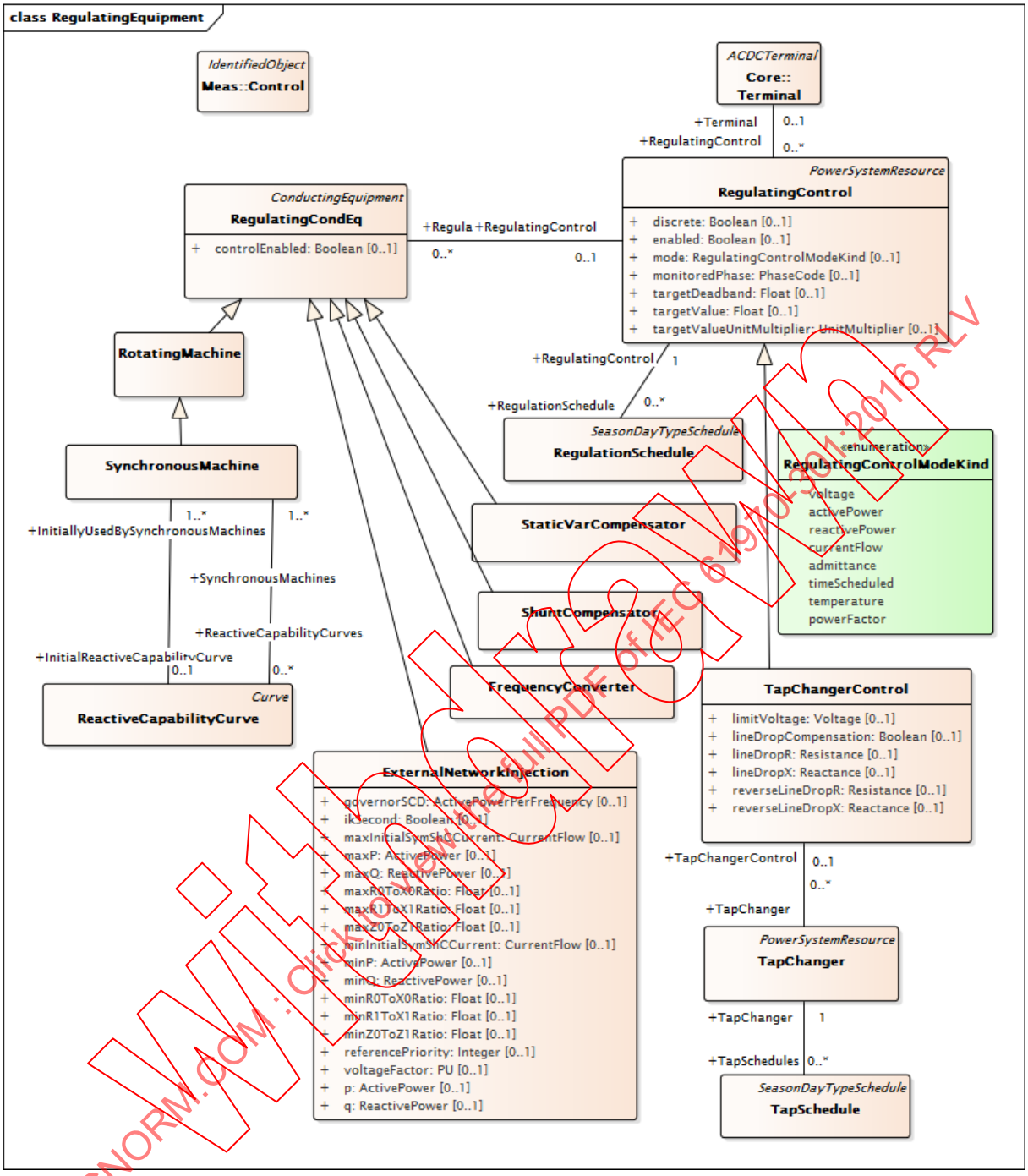
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Figure 90 – Class diagram Wires::NamingHierarchyPart2

Figure 90: The diagram shows the lower part of the naming hierarchy. It shows how the Equipment class is further specialized into many subtypes that are all contained by subclasses of the EquipmentContainer. For the subclasses of equipment container refer to Figure 89.



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Figure 91 – Class diagram Wires::RegulatingEquipment

Figure 91: The diagram shows all classes related to equipment regulation and reactive power compensation.

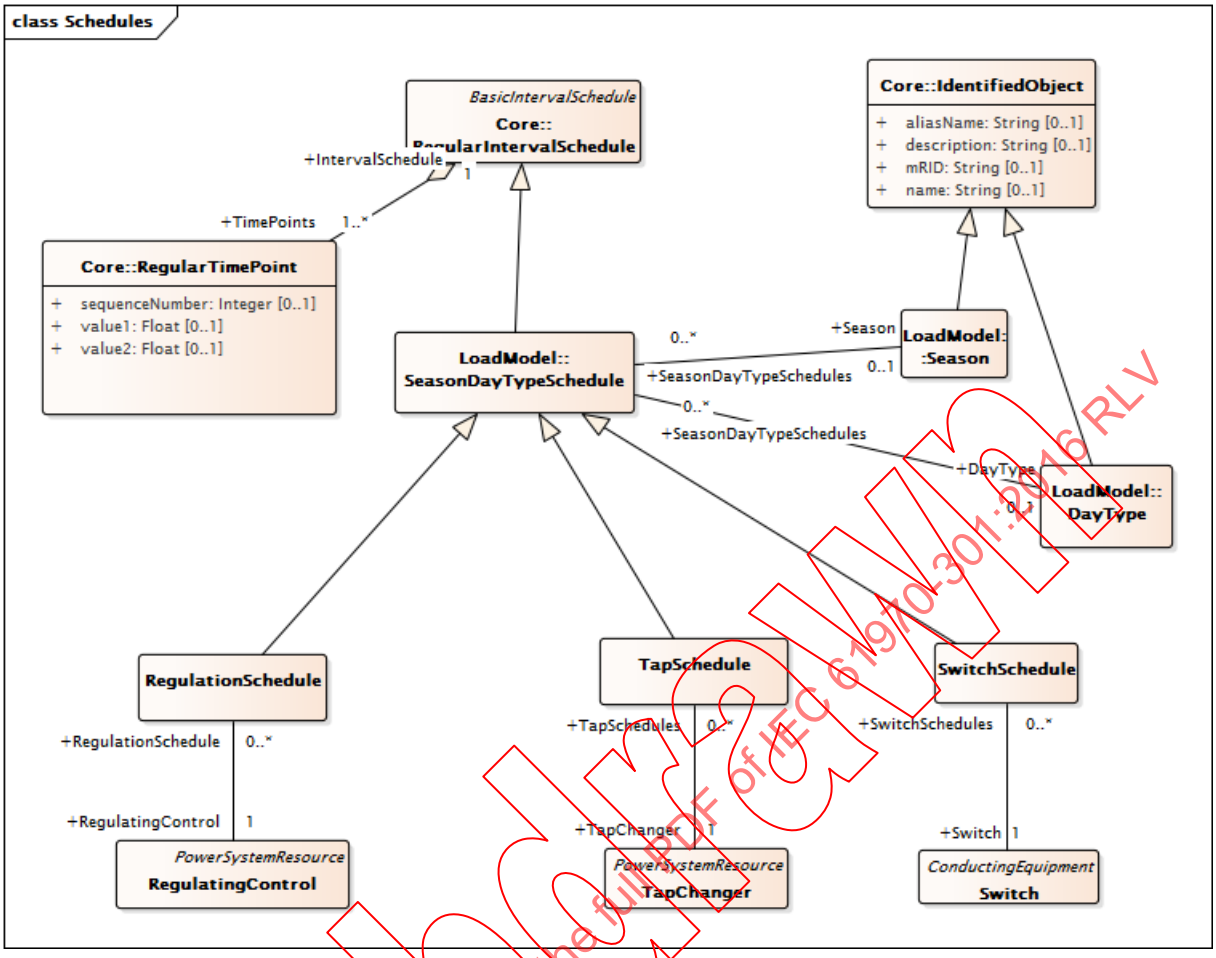


Figure 92 – Class diagram Wires::Schedules

Figure 92: Shows schedules of wires model.

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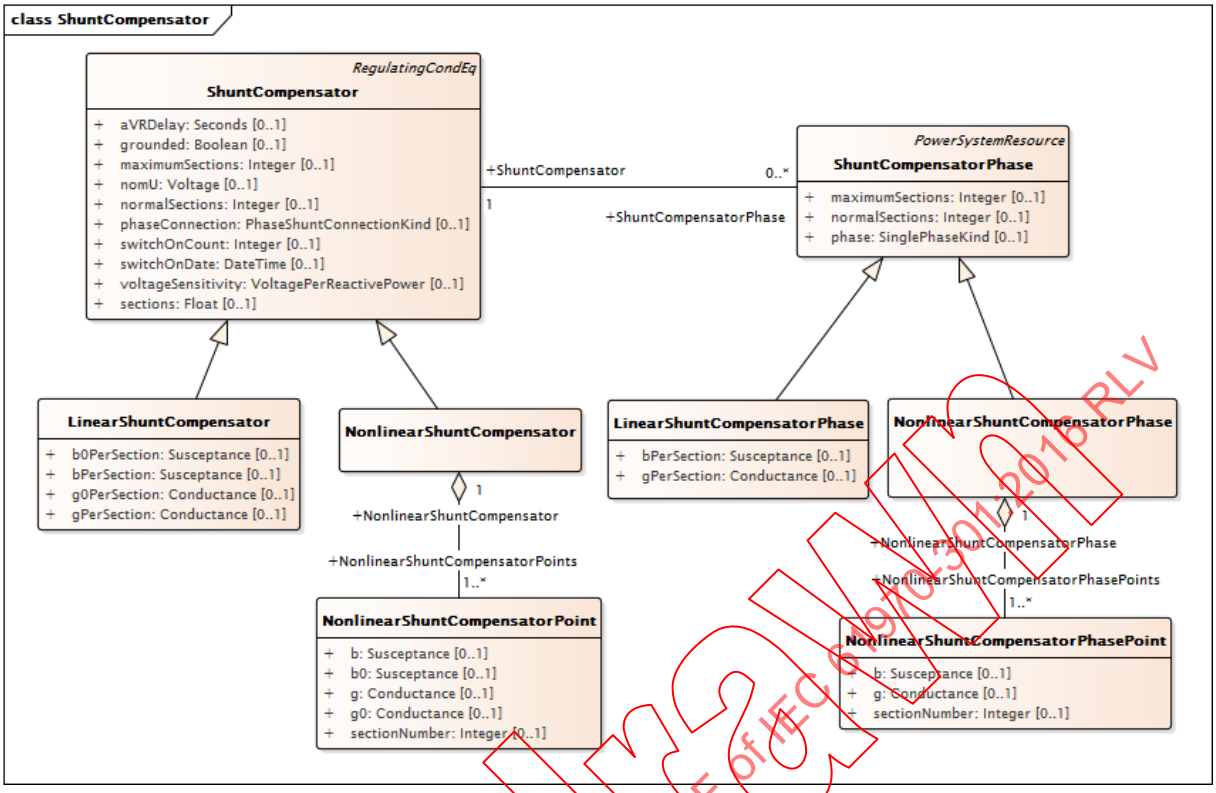


Figure 93 – Class diagram Wires::ShuntCompensator

Figure 93:.

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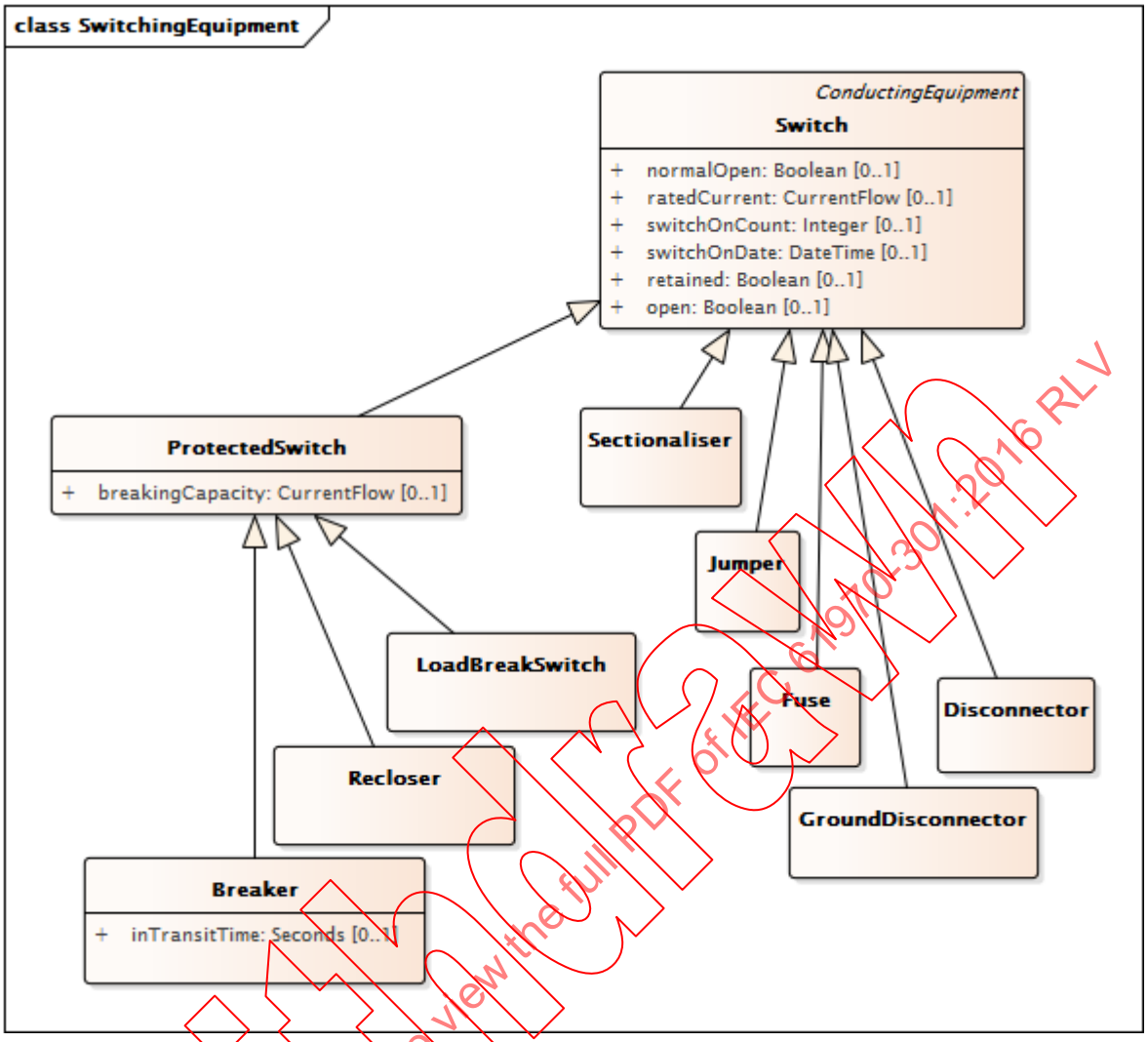


Figure 94 – Class diagram Wires::SwitchingEquipment

Figure 94: Shows switching equipment inheritance structure.

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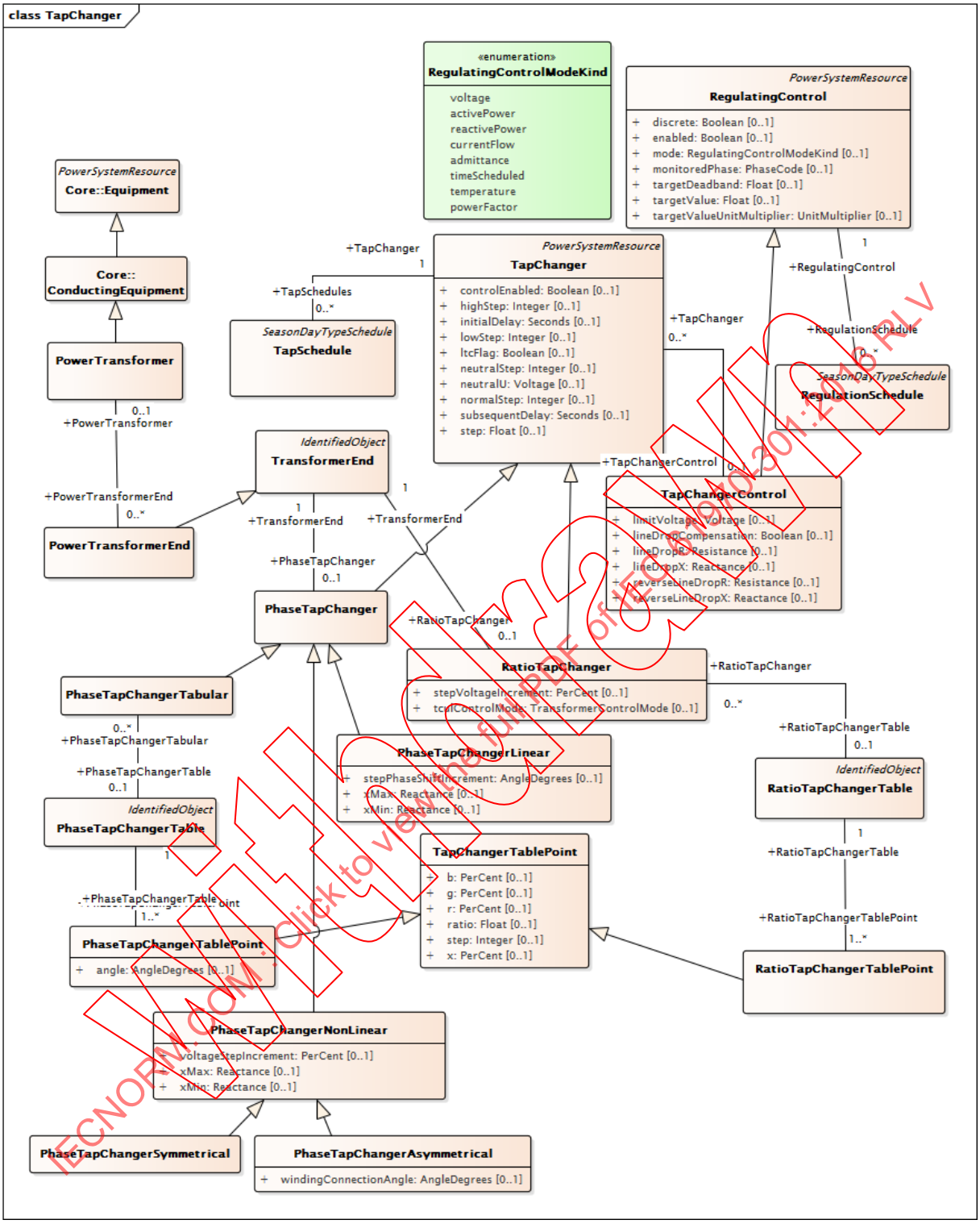


Figure 95 – Class diagram Wires::TapChanger

Figure 95: This diagram shows all classes related to the transformer tap model.

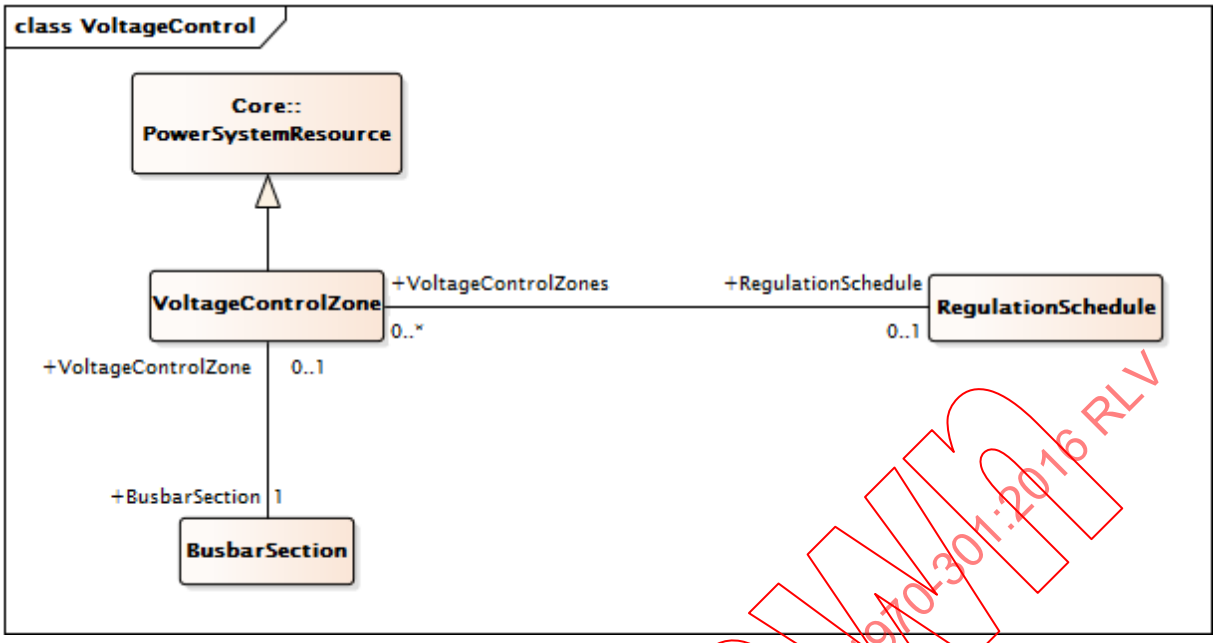


Figure 96 – Class diagram Wires::VoltageControl

Figure 96: This diagram shows all classes related to area voltage control.

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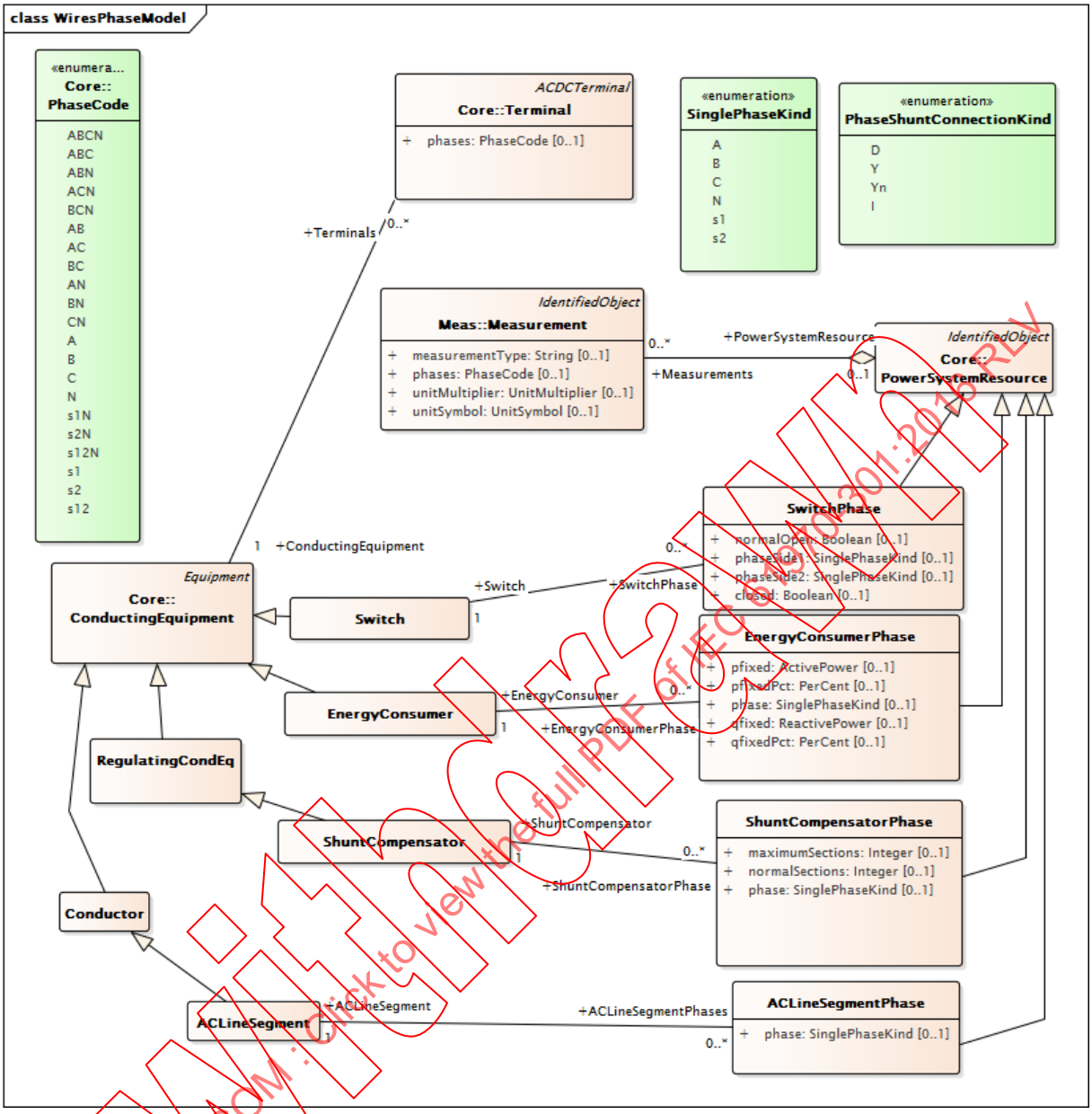
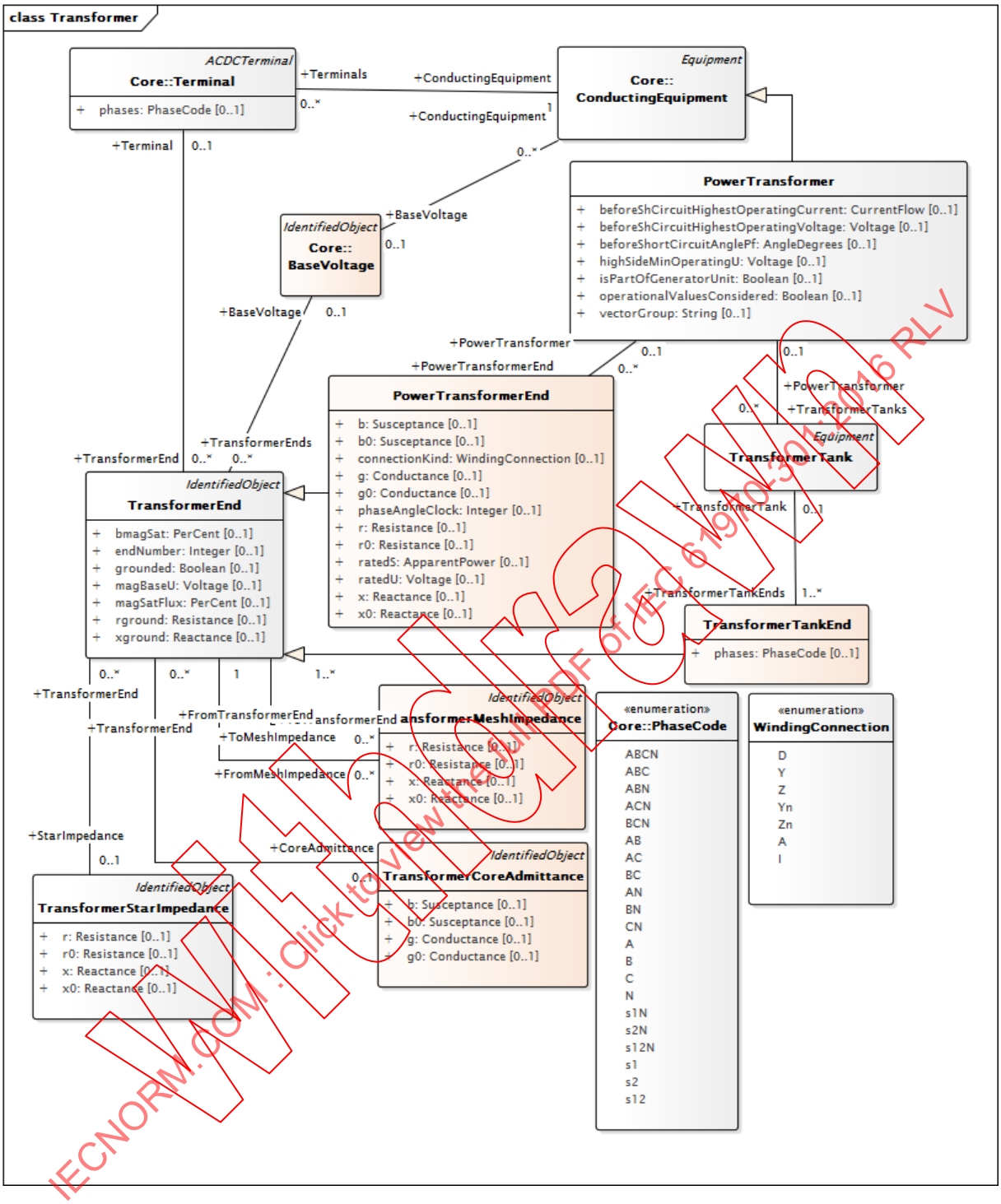


Figure 97 – Class diagram Wires::WiresPhaseModel

Figure 97: Show the phase connection detail when modeling devices down to the phase components within a conducting equipment.

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Figure 98 – Class diagram Wires::Transformer

Figure 98: This diagram shows classes related to the core transformer model, but does not show the tap changer details.

6.9.2 PerLengthSequenceImpedance

Sequence impedance and admittance parameters per unit length, for transposed lines of 1, 2, or 3 phases. For 1-phase lines, define x=x0=xself. For 2-phase lines, define x=xs-xm and x0=xs+xm.

Table 191 shows all attributes of PerLengthSequenceImpedance.

Table 191 – Attributes of Wires::PerLengthSequenceImpedance

name	mult	type	description
b0ch	0..1	SusceptancePerLength	Zero sequence shunt (charging) susceptance, per unit of length.
bch	0..1	SusceptancePerLength	Positive sequence shunt (charging) susceptance, per unit of length.
g0ch	0..1	ConductancePerLength	Zero sequence shunt (charging) conductance, per unit of length.
gch	0..1	ConductancePerLength	Positive sequence shunt (charging) conductance, per unit of length.
r	0..1	ResistancePerLength	Positive sequence series resistance, per unit of length.
r0	0..1	ResistancePerLength	Zero sequence series resistance, per unit of length.
x	0..1	ReactancePerLength	Positive sequence series reactance, per unit of length.
x0	0..1	ReactancePerLength	Zero sequence series reactance, per unit of length.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 192 shows all association ends of PerLengthSequenceImpedance with other classes.

Table 192 – Association ends of Wires::PerLengthSequenceImpedance with other classes

mult from	name	mult to	type	description
0..1	ACLineSegments	0..*	ACLineSegment	inherited from: PerLengthImpedance
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.3 PerLengthPhaseImpedance

Impedance and admittance parameters per unit length for n-wire unbalanced lines, in matrix form.

Table 193 shows all attributes of PerLengthPhaseImpedance.

Table 193 – Attributes of Wires::PerLengthPhaseImpedance

name	mult	type	description
conductorCount	0..1	Integer	Number of phase, neutral, and other wires retained. Constrains the number of matrix elements and the phase codes that can be used with this matrix.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 194 shows all association ends of PerLengthPhaseImpedance with other classes.

Table 194 – Association ends of Wires::PerLengthPhaseImpedance with other classes

mult from	name	mult to	type	description
1..1	PhaseImpedanceData	1..*	PhaseImpedanceData	All data that belong to this conductor phase impedance.
0..1	ACLineSegments	0..*	ACLineSegment	inherited from: PerLengthImpedance
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.4 ShuntCompensatorPhase

Single phase of a multi-phase shunt compensator when its attributes might be different per phase.

Table 195 shows all attributes of ShuntCompensatorPhase.

Table 195 – Attributes of Wires::ShuntCompensatorPhase

name	mult	type	description
~~bPerSection~~		~~Susceptance~~	~~Susceptance per section of the phase if shunt compensator is wye connected. Susceptance per section phase to phase if shunt compensator is delta connected.~~
~~gPerSection~~		~~Conductance~~	~~Conductance per section for this phase if shunt compensator is wye connected. Conductance per section phase to phase if shunt compensator is delta connected.~~
maximumSections	0..1	Integer	The maximum number of sections that may be switched in for this phase.
normalSections	0..1	Integer	For the capacitor phase, the normal number of sections switched in.
phase	0..1	SinglePhaseKind	Phase of this shunt compensator component. If the shunt compensator is wye connected, the connection is from the indicated phase to the central ground or neutral point. If the shunt compensator is delta connected, the phase indicates a shunt compensator connected from the indicated phase to the next logical non-neutral phase.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 196 shows all association ends of ShuntCompensatorPhase with other classes.

Table 196 – Association ends of Wires::ShuntCompensatorPhase with other classes

mult from	name	mult to	type	description
0..*	ShuntCompensator	1..1	ShuntCompensator	Shunt compensator of this shunt compensator phase.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.5 RatioTapChanger

A tap changer that changes the voltage ratio impacting the voltage magnitude but not the phase angle across the transformer.

Table 197 shows all attributes of RatioTapChanger.

Table 197 – Attributes of Wires::RatioTapChanger

name	mult	type	description
stepVoltageIncrement	0..1	PerCent	Tap step increment, in per cent of nominal voltage, per step position.
tculControlMode	0..1	TransformerControlMode	Specifies the regulation control mode (voltage or reactive) of the RatioTapChanger.
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger
~~regulationStatus~~		~~Boolean~~	~~inherited from: TapChanger~~
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 198 shows all association ends of RatioTapChanger with other classes.

Table 198 – Association ends of Wires::RatioTapChanger with other classes

mult from	name	mult to	type	description
0..*	RatioTapChanger~~Tabular~~ Table	0..1	RatioTapChanger~~Tabular~~ Table	The tap ratio table for this ratio tap changer.
0..1	TransformerEnd	1..1	TransformerEnd	Transformer end to which this ratio tap changer belongs.
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger

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mult from	name	mult to	type	description
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.6 BusbarSection

A conductor, or group of conductors, with negligible impedance, that serve to connect other conducting equipment within a single substation.

Voltage measurements are typically obtained from VoltageTransformers that are connected to busbar sections. A busbar section may have many physical terminals but for analysis is modeled with exactly one logical terminal.

Table 199 shows all attributes of BusbarSection.

Table 199 – Attributes of Wires::BusbarSection

name	mult	type	description
ipMax	0..1	CurrentFlow	Maximum allowable peak short-circuit current of busbar (Ipmax in IEC 60909-0). Mechanical limit of the busbar in the substation itself. Used for short circuit data exchange according to IEC 60909
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 200 shows all association ends of BusbarSection with other classes.

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Table 200 – Association ends of Wires::BusbarSection with other classes

mult from	name	mult to	type	description
1..1	VoltageControlZone	0..1	VoltageControlZone	A VoltageControlZone is controlled by a designated BusbarSection.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.7 SinglePhaseKind enumeration

Enumeration of single phase identifiers. Allows designation of single phases for both transmission and distribution equipment, circuits and loads.

Table 201 shows all literals of SinglePhaseKind.

Table 201 – Literals of Wires::SinglePhaseKind

literal	value	description
A		Phase A.
B		Phase B.
C		Phase C.
N		Neutral.
s1		Secondary phase 1.
s2		Secondary phase 2.

6.9.8 TransformerTank

An assembly of two or more coupled windings that transform electrical power between voltage levels. These windings are bound on a common core and place in the same tank. Transformer tank can be used to model both single-phase and 3-phase transformers.

Table 202 shows all attributes of TransformerTank.

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Table 202 – Attributes of Wires::TransformerTank

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 203 shows all association ends of TransformerTank with other classes.

Table 203 – Association ends of Wires::TransformerTank with other classes

mult from	name	mult to	type	description
0..*	PowerTransformer	0..1	PowerTransformer	Bank this transformer belongs to.
0..1	TransformerTankEnds	1..*	TransformerTankEnd	All windings of this transformer.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.9 Disconnector

A manually operated or motor operated mechanical switching device used for changing the connections in a circuit, or for isolating a circuit or equipment from a source of power. It is required to open or close circuits when negligible current is broken or made.

Table 204 shows all attributes of Disconnector.

Table 204 – Attributes of Wires::Disconnector

name	mult	type	description
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch

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name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 205 shows all association ends of Disconnector with other classes.

Table 205 – Association ends of Wires::Disconnector with other classes

mult from	name	mult to	type	description
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
~~[0..*]~~	~~[0..*] SwitchingOperations~~		~~SwitchingOperation~~	~~inherited from: Switch~~
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.10 Jumper

A short section of conductor with negligible impedance which can be manually removed and replaced if the circuit is de-energized. Note that zero-impedance branches can potentially be modeled by other equipment types.

Table 206 shows all attributes of Jumper.

Table 206 – Attributes of Wires::Jumper

name	mult	type	description
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 207 shows all association ends of Jumper with other classes.

Table 207 – Association ends of Wires::Jumper with other classes

mult from	name	mult to	type	description
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
~~[0..*]~~	~~[0..*] SwitchingOperations~~		~~SwitchingOperation~~	~~inherited from: Switch~~
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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~~6.8.73 TapChangerKind enumeration~~

~~Transformer tap changer type. Indicates the capabilities of the tap changer independent of the operating mode.~~

~~Table 298 shows all literals of TapChangerKind.~~

~~Table 298 – Literals of Wires::TapChangerKind~~

~~literal~~	~~description~~
~~fixed~~	~~Not capable of control. This is also indicated by no association of TapChanger to a RegulatingControl.~~
~~voltageControl~~	~~Capable of voltage control.~~
~~phaseControl~~	~~Capable of phase control.~~
~~voltageAndPhaseControl~~	~~Capable of voltage and phase control.~~

6.9.11 TapSchedule

A pre-established pattern over time for a tap step.

Table 208 shows all attributes of TapSchedule.

Table 208 – Attributes of Wires::TapSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 209 shows all association ends of TapSchedule with other classes.

Table 209 – Association ends of Wires::TapSchedule with other classes

mult from	name	mult to	type	description
0..*	TapChanger	1..1	TapChanger	A TapSchedule is associated with a TapChanger.
0..*	DayType	0..1	DayType	inherited from: SeasonDayTypeSchedule
0..*	Season	0..1	Season	inherited from: SeasonDayTypeSchedule
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.12 TransformerCoreAdmittance

The transformer core admittance. Used to specify the core admittance of a transformer in a manner that can be shared among power transformers.

Table 210 shows all attributes of TransformerCoreAdmittance.

Table 210 – Attributes of Wires::TransformerCoreAdmittance

name	mult	type	description
b	0..1	Susceptance	Magnetizing branch susceptance (B mag). The value can be positive or negative.
b0	0..1	Susceptance	Zero sequence magnetizing branch susceptance.
g	0..1	Conductance	Magnetizing branch conductance (G mag).
g0	0..1	Conductance	Zero sequence magnetizing branch conductance.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 211 shows all association ends of TransformerCoreAdmittance with other classes.

Table 211 – Association ends of Wires::TransformerCoreAdmittance with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	0..*	TransformerEnd	All transformer ends having this core admittance.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.13 SVCControlMode enumeration

Static VAr Compensator control mode.

Table 212 shows all literals of SVCControlMode.

Table 212 – Literals of Wires::SVCControlMode

literal	value	description
reactivePower		
voltage		
~~off~~		

6.9.14 EnergyConsumerPhase

A single phase of an energy consumer.

Table 213 shows all attributes of EnergyConsumerPhase.

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Table 213 – Attributes of Wires::EnergyConsumerPhase

name	mult	type	description
pfixed	0..1	ActivePower	Active power of the load that is a fixed quantity. Load sign convention is used, i.e. positive sign means flow out from a node.
pfixedPct	0..1	PerCent	Fixed active power as per cent of load group fixed active power. Load sign convention is used, i.e. positive sign means flow out from a node.
phase	0..1	SinglePhaseKind	Phase of this energy consumer component. If the energy consumer is wye connected, the connection is from the indicated phase to the central ground or neutral point. If the energy consumer is delta connected, the phase indicates an energy consumer connected from the indicated phase to the next logical non-neutral phase.
qfixed	0..1	ReactivePower	Reactive power of the load that is a fixed quantity. Load sign convention is used, i.e. positive sign means flow out from a node.
qfixedPct	0..1	PerCent	Fixed reactive power as per cent of load group fixed reactive power. Load sign convention is used, i.e. positive sign means flow out from a node.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 214 shows all association ends of EnergyConsumerPhase with other classes.

Table 214 – Association ends of Wires::EnergyConsumerPhase with other classes

mult from	name	mult to	type	description
0..*	EnergyConsumer	1..1	EnergyConsumer	The energy consumer to which this phase belongs.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.15 SynchronousMachineOperatingMode enumeration

Synchronous machine operating mode.

Table 215 shows all literals of SynchronousMachineOperatingMode.

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Table 215 – Literals of Wires::SynchronousMachineOperatingMode

literal	value	description
generator		
condenser		
motor		

6.9.16 TapChangerControl

Describes behavior specific to tap changers, e.g. how the voltage at the end of a line varies with the load level and compensation of the voltage drop by tap adjustment.

Table 216 shows all attributes of TapChangerControl.

Table 216 – Attributes of Wires::TapChangerControl

name	mult	type	description
limitVoltage	0..1	Voltage	Maximum allowed regulated voltage on the PT secondary, regardless of line drop compensation. Sometimes referred to as first-house protection.
lineDropCompensation	0..1	Boolean	If true, the line drop compensation is to be applied.
lineDropR	0..1	Resistance	Line drop compensator resistance setting for normal (forward) power flow.
lineDropX	0..1	Reactance	Line drop compensator reactance setting for normal (forward) power flow.
reverseLineDropR	0..1	Resistance	Line drop compensator resistance setting for reverse power flow.
reverseLineDropX	0..1	Reactance	Line drop compensator reactance setting for reverse power flow.
discrete	0..1	Boolean	inherited from: RegulatingControl
enabled	0..1	Boolean	inherited from: RegulatingControl
mode	0..1	RegulatingControlModeKind	inherited from: RegulatingControl
monitoredPhase	0..1	PhaseCode	inherited from: RegulatingControl
targetDeadband	0..1	Float	inherited from: RegulatingControl
~~targetRange~~		~~Float~~	~~inherited from: RegulatingControl~~
targetValue	0..1	Float	inherited from: RegulatingControl
targetValueUnitMultiplier	0..1	UnitMultiplier	inherited from: RegulatingControl
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 217 shows all association ends of TapChangerControl with other classes.

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Table 217 – Association ends of Wires::TapChangerControl with other classes

mult from	name	mult to	type	description
0..1	TapChanger	0..*	TapChanger	The tap changers that participate in this regulating tap control scheme.
0..*	Terminal	0..1	Terminal	inherited from: RegulatingControl
1..1	RegulationSchedule	0..*	RegulationSchedule	inherited from: RegulatingControl
0..1	RegulatingCondEq	0..*	RegulatingCondEq	inherited from: RegulatingControl
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.17 PhaseTapChangerTable

Describes a tabular curve for how the phase angle difference and impedance varies with the tap step.

Table 218 shows all attributes of PhaseTapChangerTable.

Table 218 – Attributes of Wires::PhaseTapChangerTable

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 219 shows all association ends of PhaseTapChangerTable with other classes.

Table 219 – Association ends of Wires::PhaseTapChangerTable with other classes

mult from	name	mult to	type	description
0..1	PhaseTapChangerTabular	0..*	PhaseTapChangerTabular	The phase tap changers to which this phase tap table applies.
1..1	PhaseTapChangerTablePoint	1..*	PhaseTapChangerTablePoint	The points of this table.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.18 TransformerStarImpedance

Transformer star impedance (Pi-model) that accurately reflects impedance for transformers with 2 or 3 windings. For transformers with 4 or more windings, ~~you must use~~ TransformerMeshImpedance class shall be used.

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For transmission networks use PowerTransformerEnd impedances (r, r0, x, x0, b, b0, g and g0).

Table 220 shows all attributes of TransformerStarImpedance.

Table 220 – Attributes of Wires::TransformerStarImpedance

name	mult	type	description
r	0..1	Resistance	Resistance of the transformer end.
r0	0..1	Resistance	Zero sequence series resistance of the transformer end.
x	0..1	Reactance	Positive sequence series reactance of the transformer end.
x0	0..1	Reactance	Zero sequence series reactance of the transformer end.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 221 shows all association ends of TransformerStarImpedance with other classes.

Table 221 – Association ends of Wires::TransformerStarImpedance with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	0..*	TransformerEnd	All transformer ends having this star impedance.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.19 Breaker

A mechanical switching device capable of making, carrying, and breaking currents under normal circuit conditions and also making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions e.g. those of short circuit.

Table 222 shows all attributes of Breaker.

Table 222 – Attributes of Wires::Breaker

name	mult	type	description
inTransitTime	0..1	Seconds	The transition time from open to close.
breakingCapacity	0..1	CurrentFlow	inherited from: ProtectedSwitch
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment

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name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 223 shows all association ends of Breaker with other classes.

Table 223 – Association ends of Wires::Breaker with other classes

mult from	name	mult to	type	description
0..*	OperatedByProtectionEquipment	0..*	ProtectionEquipment	inherited from: ProtectedSwitch
1..1	RecloseSequences	0..*	RecloseSequence	inherited from: ProtectedSwitch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
~~[0..*]~~	~~[0..*] SwitchingOperations~~		~~SwitchingOperation~~	~~inherited from: Switch~~
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.20 GroundDisconnector

A manually operated or motor operated mechanical switching device used for isolating a circuit or equipment from ground.

Table 224 shows all attributes of GroundDisconnector.

Table 224 – Attributes of Wires::GroundDisconnector

name	mult	type	description
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 225 shows all association ends of GroundDisconnector with other classes.

Table 225 – Association ends of Wires::GroundDisconnector with other classes

mult from	name	mult to	type	description
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
~~[0..*]~~	~~[0..*] SwitchingOperations~~		~~SwitchingOperation~~	~~inherited from: Switch~~
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.21 SwitchSchedule

A schedule of switch positions. If RegularTimePoint.value1 is 0, the switch is open. If 1, the switch is closed.

Table 226 shows all attributes of SwitchSchedule.

Table 226 – Attributes of Wires::SwitchSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 227 shows all association ends of SwitchSchedule with other classes.

Table 227 – Association ends of Wires::SwitchSchedule with other classes

mult from	name	mult to	type	description
0..*	Switch	1..1	Switch	A SwitchSchedule is associated with a Switch.
0..*	DayType	0..1	DayType	inherited from: SeasonDayTypeSchedule
0..*	Season	0..1	Season	inherited from: SeasonDayTypeSchedule
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.22 PowerTransformer

An electrical device consisting of two or more coupled windings, with or without a magnetic core, for introducing mutual coupling between electric circuits. Transformers can be used to control voltage and phase shift (active power flow).

A power transformer may be composed of separate transformer tanks that need not be identical.

A power transformer can be modeled with or without tanks and is intended for use in both balanced and unbalanced representations. A power transformer typically has two terminals, but may have one (grounding), three or more terminals.

The inherited association ConductingEquipment.BaseVoltage should not be used. The association from TransformerEnd to BaseVoltage should be used instead.

Table 228 shows all attributes of PowerTransformer.

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Table 228 – Attributes of Wires::PowerTransformer

name	mult	type	description
beforeShCircuitHighestOperatingCurrent	0..1	CurrentFlow	The highest operating current (Ib in the IEC 60909-0) before short circuit (depends on network configuration and relevant reliability philosophy). It is used for calculation of the impedance correction factor KT defined in IEC 60909-0.
beforeShCircuitHighestOperatingVoltage	0..1	Voltage	The highest operating voltage (Ub in the IEC 60909-0) before short circuit. It is used for calculation of the impedance correction factor KT defined in IEC 60909-0. This is worst case voltage on the low side winding (Section 3.7.1 in the standard). Used to define operating conditions.
beforeShortCircuitAnglePf	0..1	AngleDegrees	The angle of power factor before short circuit (phib in IEC 60909-0). It is used for calculation of the impedance correction factor KT defined in IEC 60909-0. This is the worst case power factor. Used to define operating conditions.
highSideMinOperatingU	0..1	Voltage	The minimum operating voltage (uQmin in the IEC 60909-0) at the high voltage side (Q side) of the unit transformer of the power station unit. A value well established from long-term operating experience of the system. It is used for calculation of the impedance correction factor KG defined in IEC 60909-0
isPartOfGeneratorUnit	0..1	Boolean	Indicates whether the machine is part of a power station unit. Used for short circuit data exchange according to IEC 60909
operationalValuesConsidered	0..1	Boolean	It is used to define if the data (other attributes related to short circuit data exchange) defines long term operational conditions or not. Used for short circuit data exchange according to IEC 60909.

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name	mult	type	description
vectorGroup	0..1	String	Vector group of the transformer for protective relaying, e.g. Dyn1. For unbalanced transformers, this may not be simply determined from the constituent winding connections and phase angle dispacements. The vectorGroup string consists of the following components in the order listed: high voltage winding connection, mid voltage winding connection (for three winding transformers), phase displacement clock number from 0 to 11, low voltage winding connection phase displacement clock number from 0 to 11. The winding connections are D (delta), Y (wye), YN (wye with neutral), Z (zigzag), ZN (zigzag with neutral), A (auto transformer). Upper case means the high voltage, lower case mid or low. The high voltage winding always has clock postion 0 and is not included in the vector group string. Some examples: YNy0 (two winding wye to wye with no phase displacement), YNd11 (two winding wye to delta with 330 degrees phase displacement), YNyn0d5 (three winding transformer wye with neutral high voltgage, wye with neutral mid voltgage and no phase displacement, delta low voltage with 150 degrees displacement). Phase displacement is defined as the angular difference between the phasors representing the voltages between the neutral point (real or imaginary) and the corresponding terminals of two windings, a positive sequence voltage system being applied to the high-voltage terminals, following each other in alphabetical sequence if they are lettered, or in numerical sequence if they are numbered: the phasors are assumed to rotate in a counter-clockwise sense.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 229 shows all association ends of PowerTransformer with other classes.

Table 229 – Association ends of Wires::PowerTransformer with other classes

mult from	name	mult to	type	description
0..1	PowerTransformerEnd	0..*	PowerTransformerEnd	The ends of this power transformer.
0..1	TransformerTanks	0..*	TransformerTank	All transformers that belong to this bank.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment

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mult from	name	mult to	type	description
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.23 PhaseTapChangerAsymmetrical

Describes the tap model for an asymmetrical phase shifting transformer in which the difference voltage vector adds to the primary side voltage. The angle between the primary side voltage and the difference voltage is named the winding connection angle. The phase shift depends on both the difference voltage magnitude and the winding connection angle.

Table 230 shows all attributes of PhaseTapChangerAsymmetrical.

Table 230 – Attributes of ~~Wires::~~PhaseTapChangerAsymmetrical

name	mult	type	description
windingConnectionAngle	0..1	AngleDegrees	The phase angle between the in-phase winding and the out-of-phase winding used for creating phase shift. The out-of-phase winding produces what is known as the difference voltage. Setting this angle to 90 degrees is not the same as a symmetrical transformer.
voltageStepIncrement	0..1	PerCent	inherited from: PhaseTapChangerNonLinear
xMax	0..1	Reactance	inherited from: PhaseTapChangerNonLinear
xMin	0..1	Reactance	inherited from: PhaseTapChangerNonLinear
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 231 shows all association ends of PhaseTapChangerAsymmetrical with other classes.

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Table 231 – Association ends of Wires::PhaseTapChangerAsymmetrical with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.24 Ground

~~A common point for connecting grounded conducting equipment such as shunt capacitors.~~ A point where the system is grounded used for connecting conducting equipment to ground. The power system model can have ~~more than one~~ any number of grounds.

Table 232 shows all attributes of Ground.

Table 232 – Attributes of Wires::Ground

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 233 shows all association ends of Ground with other classes.

Table 233 – Association ends of Wires::Ground with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment

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mult from	name	mult to	type	description
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.25 Line

Contains equipment beyond a substation belonging to a power transmission line.

Table 234 shows all attributes of Line.

Table 234 – Attributes of Wires::Line

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 235 shows all association ends of Line with other classes.

Table 235 – Association ends of Wires::Line with other classes

mult from	name	mult to	type	description
0..*	Region	0..1	SubGeographicalRegion	The sub-geographical region of the line.
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.26 PhaseTapChangerSymmetrical

Describes a symmetrical phase shifting transformer tap model in which the secondary side voltage magnitude is the same as at the primary side. The difference voltage magnitude is the base in an equal-sided triangle where the sides corresponds to the primary and secondary voltages. The phase angle difference corresponds to the top angle and can be expressed as twice the arctangent of half the total difference voltage.

Table 236 shows all attributes of PhaseTapChangerSymmetrical.

Table 236 – Attributes of Wires::PhaseTapChangerSymmetrical

name	mult	type	description
voltageStepIncrement	0..1	PerCent	inherited from: PhaseTapChangerNonLinear
xMax	0..1	Reactance	inherited from: PhaseTapChangerNonLinear
xMin	0..1	Reactance	inherited from: PhaseTapChangerNonLinear
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 237 shows all association ends of PhaseTapChangerSymmetrical with other classes.

Table 237 – Association ends of Wires::PhaseTapChangerSymmetrical with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.27 RegulationSchedule

A pre-established pattern over time for a controlled variable, e.g. busbar voltage.

Table 238 shows all attributes of RegulationSchedule.

Table 238 – Attributes of Wires::RegulationSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 239 shows all association ends of RegulationSchedule with other classes.

Table 239 – Association ends of Wires::RegulationSchedule with other classes

mult from	name	mult to	type	description
0..*	RegulatingControl	1..1	RegulatingControl	Regulating controls that have this Schedule.
0..1	VoltageControlZones	0..*	VoltageControlZone	A VoltageControlZone may have a voltage regulation schedule.
0..*	DayType	0..1	DayType	inherited from: SeasonDayTypeSchedule
0..*	Season	0..1	Season	inherited from: SeasonDayTypeSchedule
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.28 Fuse

An overcurrent protective device with a circuit opening fusible part that is heated and severed by the passage of overcurrent through it. A fuse is considered a switching device because it breaks current.

Table 240 shows all attributes of Fuse.

Table 240 – Attributes of Wires::Fuse

name	mult	type	description
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch

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name	mult	type	description
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 241 shows all association ends of Fuse with other classes.

Table 241 – Association ends of Wires::Fuse with other classes

mult from	name	mult to	type	description
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
~~[0..*]~~	~~[0..*] SwitchingOperations~~		~~SwitchingOperation~~	~~inherited from: Switch~~
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.29 TransformerMeshImpedance

Transformer mesh impedance (Delta-model) between transformer ends.

The typical case is that this class describes the impedance between two transformer ends pair-wise, i.e. the cardinalities at both tranformer end associations are 1. But in cases where two or more transformer ends are modeled the cardinalities are larger than 1.

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Table 242 shows all attributes of TransformerMeshImpedance.

Table 242 – Attributes of Wires::TransformerMeshImpedance

name	mult	type	description
r	0..1	Resistance	Resistance between the 'from' and the 'to' end, seen from the 'from' end.
r0	0..1	Resistance	Zero-sequence resistance between the 'from' and the 'to' end, seen from the 'from' end.
x	0..1	Reactance	Reactance between the 'from' and the 'to' end, seen from the 'from' end.
x0	0..1	Reactance	Zero-sequence reactance between the 'from' and the 'to' end, seen from the 'from' end.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 243 shows all association ends of TransformerMeshImpedance with other classes.

Table 243 – Association ends of Wires::TransformerMeshImpedance with other classes

mult from	name	mult to	type	description
0..*	ToTransformerEnd	1..*	TransformerEnd	All transformer ends this mesh impedance is connected to.
0..*	FromTransformerEnd	1..1	TransformerEnd	From end this mesh impedance is connected to. It determines the voltage reference.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.30 SwitchPhase

Single phase of a multi-phase switch when its attributes might be different per phase.

Table 244 shows all attributes of SwitchPhase.

Table 244 – Attributes of Wires::SwitchPhase

name	mult	type	description
normalOpen	0..1	Boolean	Used in cases when no Measurement for the status value is present. If the SwitchPhase has a status measurement the Discrete.normalValue is expected to match with this value.
phaseSide1	0..1	SinglePhaseKind	Phase of this SwitchPhase on the side with terminal sequence number equal to 1. Should be a phase contained in that terminal's phases attribute.
phaseSide2	0..1	SinglePhaseKind	Phase of this SwitchPhase on the side with terminal sequence number equal to 2. Should be a phase contained in that terminal's Terminal.phases attribute.
closed	0..1	Boolean	The attribute tells if the switch is considered closed when used as input to topology processing.

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name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 245 shows all association ends of SwitchPhase with other classes.

Table 245 – Association ends of Wires::SwitchPhase with other classes

mult from	name	mult to	type	description
0..*	Switch	1..1	Switch	The switch of the switch phase.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.31 PowerTransformerEnd

A PowerTransformerEnd is associated with each Terminal of a PowerTransformer.

The impedance values r, r0, x, and x0 of a PowerTransformerEnd represent a star equivalent as follows.

1) For a two Terminal PowerTransformer the high voltage (TransformerEnd.endNumber=1) PowerTransformerEnd has non zero values on r, r0, x, and x0 while the low voltage (TransformerEnd.endNumber=0) PowerTransformerEnd has zero values for r, r0, x, and x0.
2) For a three Terminal PowerTransformer the three PowerTransformerEnds represent a star equivalent with each leg in the star represented by r, r0, x, and x0 values.
3) For a three Terminal transformer each PowerTransformerEnd shall have g, g0, b and b0 values corresponding to the no load losses distributed on the three PowerTransformerEnds. The total no load loss shunt impedances may also be placed at one of the PowerTransformerEnds, preferably the end numbered 1, having the shunt values on end 1 is the preferred way.
4) For a PowerTransformer with more than three Terminals the PowerTransformerEnd impedance values cannot be used. Instead use the TransformerMeshImpedance or split the transformer into multiple PowerTransformers.

Table 246 shows all attributes of PowerTransformerEnd.

Table 246 – Attributes of Wires::PowerTransformerEnd

name	mult	type	description
b	0..1	Susceptance	Magnetizing branch susceptance (B mag). The value can be positive or negative.
b0	0..1	Susceptance	Zero sequence magnetizing branch susceptance.

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name	mult	type	description
connectionKind	0..1	WindingConnection	Kind of connection.
g	0..1	Conductance	Magnetizing branch conductance.
g0	0..1	Conductance	Zero sequence magnetizing branch conductance (star-model).
phaseAngleClock	0..1	Integer	Terminal voltage phase angle displacement where 360 degrees are represented with clock hours. The valid values are 0 to 11. For example, for the secondary side end of a transformer with vector group code of 'Dyn11', specify the connection kind as wye with neutral and specify the phase angle of the clock as 11. The clock value of the transformer end number specified as 1 is assumed to be zero. Note the transformer end number is not assumed to be the same as the terminal sequence number.
r	0..1	Resistance	Resistance (star-model) of the transformer end. The attribute shall be equal to or greater than zero for non-equivalent transformers.
r0	0..1	Resistance	Zero sequence series resistance (star-model) of the transformer end.
ratedS	0..1	ApparentPower	Normal apparent power rating. The attribute shall be a positive value. For a two-winding transformer the values for the high and low voltage sides shall be identical.
ratedU	0..1	Voltage	Rated voltage: phase-phase for three-phase windings, and either phase-phase or phase-neutral for single-phase windings. A high voltage side, as given by TransformerEnd.endNumber, shall have a ratedU that is greater than or equal to ratedU for the lower voltage sides.
x	0..1	Reactance	Positive sequence series reactance (star-model) of the transformer end.
x0	0..1	Reactance	Zero sequence series reactance of the transformer end.
bmagSat	0..1	PerCent	inherited from: TransformerEnd
endNumber	0..1	Integer	inherited from: TransformerEnd
grounded	0..1	Boolean	inherited from: TransformerEnd
magBaseU	0..1	Voltage	inherited from: TransformerEnd
magSatFlux	0..1	PerCent	inherited from: TransformerEnd
rground	0..1	Resistance	inherited from: TransformerEnd
xground	0..1	Reactance	inherited from: TransformerEnd
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 247 shows all association ends of PowerTransformerEnd with other classes.

Table 247 – Association ends of Wires::PowerTransformerEnd with other classes

mult from	name	mult to	type	description
0..*	PowerTransformer	0..1	PowerTransformer	The power transformer of this power transformer end.

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mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: TransformerEnd
0..*	Terminal	0..1	Terminal	inherited from: TransformerEnd
1..1	RatioTapChanger	0..1	RatioTapChanger	inherited from: TransformerEnd
0..*	StarImpedance	0..1	TransformerStarImpedance	inherited from: TransformerEnd
1..1	PhaseTapChanger	0..1	PhaseTapChanger	inherited from: TransformerEnd
0..*	CoreAdmittance	0..1	TransformerCoreAdmittance	inherited from: TransformerEnd
1..*	ToMeshImpedance	0..*	TransformerMeshImpedance	inherited from: TransformerEnd
1..1	FromMeshImpedance	0..*	TransformerMeshImpedance	inherited from: TransformerEnd
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.32 PetersenCoil

A tunable impedance device normally used to offset line charging during single line faults in an ungrounded section of network.

Table 248 shows all attributes of PetersenCoil.

Table 248 – Attributes of Wires::PetersenCoil

name	mult	type	description
mode	0..1	PetersenCoilModeKind	The mode of operation of the Petersen coil.
nominalU	0..1	Voltage	The nominal voltage for which the coil is designed.
offsetCurrent	0..1	CurrentFlow	The offset current that the Petersen coil controller is operating from the resonant point. This is normally a fixed amount for which the controller is configured and could be positive or negative. Typically 0 to 60 A depending on voltage and resonance conditions.
positionCurrent	0..1	CurrentFlow	The control current used to control the Petersen coil also known as the position current. Typically in the range of 20 mA to 200 mA.
xGroundMax	0..1	Reactance	The maximum reactance.
xGroundMin	0..1	Reactance	The minimum reactance.
xGroundNominal	0..1	Reactance	The nominal reactance. This is the operating point (normally over compensation) that is defined based on the resonance point in the healthy network condition. The impedance is calculated based on nominal voltage divided by position current.
r	0..1	Resistance	inherited from: EarthFaultCompensator
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 249 shows all association ends of PetersenCoil with other classes.

Table 249 – Association ends of Wires::PetersenCoil with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

~~6.8.50 RectifierInverter~~

~~Bi-directional AC-DC conversion equipment that can be used to control DC current, DC voltage, DC power flow, or firing angle.~~

~~Table 258 shows all attributes of RectifierInverter.~~

~~Table 258 – Attributes of Wires::RectifierInverter~~

~~name~~	~~type~~	~~description~~
~~bridges~~	~~Integer~~	~~Number of bridges~~
~~commutatingReactance~~	~~Reactance~~	~~Commutating reactance at AC bus frequency.~~
~~commutatingResistance~~	~~Resistance~~	~~Commutating resistance.~~
~~compoundResistance~~	~~Resistance~~	~~Compounding resistance.~~
~~frequency~~	~~Frequency~~	~~Frequency on the AC side.~~
~~maxP~~	~~ActivePower~~	~~The maximum active power on the DC side at which the fconverter should operate.~~
~~maxU~~	~~Voltage~~	~~The maximum voltage on the DC side at which the converter should operate.~~
~~minCompoundVoltage~~	~~Voltage~~	~~Minimum compounded DC voltage.~~
~~minP~~	~~ActivePower~~	~~The minimum active power on the DC side at which the converter should operate.~~
~~minU~~	~~Voltage~~	~~The minimum voltage on the DC side at which the converter should operate.~~
~~operatingMode~~	~~OperatingMode~~	~~Operating mode for the converter.~~
~~ratedU~~	~~Voltage~~	~~Rectifier/inverter primary base voltage.~~
~~aggregate~~	~~Boolean~~	~~inherited from: Equipment~~
~~normallyInService~~	~~Boolean~~	~~inherited from: Equipment~~

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name	type	description
aliasName	String	inherited from: IdentifiedObject
mRID	String	inherited from: IdentifiedObject
name	String	inherited from: IdentifiedObject

Table 259 shows all association ends of RectifierInverter with other classes.

Table 259 – Association ends of Wires::RectifierInverter with other classes

[mult from]	[mult to] name	type	description
[0..*]	[0..1] BaseVoltage	BaseVoltage	inherited from: ConductingEquipment
[1..1]	[0..*] Terminals	Terminal	inherited from: ConductingEquipment
[0..*]	[0..*] ProtectionEquipments	ProtectionEquipment	inherited from: ConductingEquipment
[1..1]	[0..*] ClearanceTags	ClearanceTag	inherited from: ConductingEquipment
[1..1]	[0..1] SvStatus	SvStatus	inherited from: ConductingEquipment
[0..*]	[0..1] EquipmentContainer	EquipmentContainer	inherited from: Equipment
[1..1]	[0..*] ContingencyEquipment	ContingencyEquipment	inherited from: Equipment
[0..1]	[0..*] OperationalLimitSet	OperationalLimitSet	inherited from: Equipment
[0..*]	[0..1] PSRType	PSRType	inherited from: PowerSystemResource
[0..1]	[0..*] Measurements	Measurement	inherited from: PowerSystemResource
[1..1]	[0..*] OperatingShare	OperatingShare	inherited from: PowerSystemResource
[0..*]	[0..*] PsrLists	PsrList	inherited from: PowerSystemResource
[1..1]	[0..1] OutageSchedule	OutageSchedule	inherited from: PowerSystemResource
[0..*]	[0..*] ReportingGroup	ReportingGroup	inherited from: PowerSystemResource
[0..1]	[0..*] DiagramObjects	DiagramObject	inherited from: IdentifiedObject
[1..1]	[0..*] Names	Name	inherited from: IdentifiedObject

6.9.33 RegulatingCondEq

A type of conducting equipment that can regulate a quantity (i.e. voltage or flow) at a specific point in the network.

Table 250 shows all attributes of RegulatingCondEq.

Table 250 – Attributes of Wires::RegulatingCondEq

name	mult	type	description
controlEnabled	0..1	Boolean	Specifies the regulation status of the equipment. True is regulating, false is not regulating.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 251 shows all association ends of RegulatingCondEq with other classes.

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Table 251 – Association ends of Wires::RegulatingCondEq with other classes

mult from	name	mult to	type	description
0..*	RegulatingControl	0..1	RegulatingControl	The regulating control scheme in which this equipment participates.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	~~[1..*]~~ Controls	0..*	Control	~~The controller outputs used to actually govern a regulating device, e.g. the magnetization of a synchronous machine or capacitor bank breaker actuator.~~ inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.34 PhaseTapChangerNonLinear

The non-linear phase tap changer describes the non-linear behavior of a phase tap changer. This is a base class for the symmetrical and asymmetrical phase tap changer models. The details of these models can be found in the IEC 61970-301 document.

Table 252 shows all attributes of PhaseTapChangerNonLinear.

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Table 252 – Attributes of Wires::PhaseTapChangerNonLinear

name	mult	type	description
voltageStepIncrement	0..1	PerCent	The voltage step increment on the out of phase winding specified in percent of nominal voltage of the transformer end.
xMax	0..1	Reactance	~~The reactance at the maximum tap step.~~ The reactance depends on the tap position according to a "u" shaped curve. The maximum reactance (xMax) appear at the low and high tap positions.
x~~Median~~Min	0..1	Reactance	~~The reactance at the mid tap step.~~ The reactance depend on the tap position according to a "u" shaped curve. The minimum reactance (xMin) appears at the mid tap position.
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger
~~regulationStatus~~		~~Boolean~~	~~inherited from: TapChanger~~
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 253 shows all association ends of PhaseTapChangerNonLinear with other classes.

Table 253 – Association ends of Wires::PhaseTapChangerNonLinear with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
~~[0..*]~~	~~[0..1] PhaseTapChangerTabular~~		~~PhaseTapChangerTabular~~	~~inherited from: PhaseTapChanger~~
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.35 SeriesCompensator

A Series Compensator is a series capacitor or reactor or an AC transmission line without charging susceptance. It is a two terminal device.

Table 254 shows all attributes of SeriesCompensator.

Table 254 – Attributes of Wires::SeriesCompensator

name	mult	type	description
r	0..1	Resistance	Positive sequence resistance.
r0	0..1	Resistance	Zero sequence resistance.
x	0..1	Reactance	Positive sequence reactance.
x0	0..1	Reactance	Zero sequence reactance.
varistorPresent	0..1	Boolean	Describe if a metal oxide varistor (mov) for over voltage protection is configured at the series compensator.
varistorRatedCurrent	0..1	CurrentFlow	The maximum current the varistor is designed to handle at specified duration.
varistorVoltageThreshold	0..1	Voltage	The DC voltage at which the varistor starts conducting.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 255 shows all association ends of SeriesCompensator with other classes.

Table 255 – Association ends of Wires::SeriesCompensator with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.36 PhaseShuntConnectionKind enumeration

The configuration of phase connections for a single terminal device such as a load or capacitor.

Table 256 shows all literals of PhaseShuntConnectionKind.

Table 256 – Literals of Wires::PhaseShuntConnectionKind

literal	value	description
D		Delta connection.
Y		Wye connection.
Yn		Wye, with neutral brought out for grounding.
I		Independent winding, for single-phase connections.

6.9.37 GroundingImpedance

A fixed impedance device used for grounding.

Table 257 shows all attributes of GroundingImpedance.

Table 257 – Attributes of Wires::GroundingImpedance

name	mult	type	description
x	0..1	Reactance	Reactance of device.
r	0..1	Resistance	inherited from: EarthFaultCompensator
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 258 shows all association ends of GroundingImpedance with other classes.

Table 258 – Association ends of Wires::GroundingImpedance with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment

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mult from	name	mult to	type	description
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.38 TransformerControlMode enumeration

Control modes for a transformer.

Table 259 shows all literals of TransformerControlMode.

Table 259 – Literals of Wires::TransformerControlMode

literal	value	description
volt		Voltage control
reactive		Reactive power flow control

6.9.39 RatioTapChangerTablePoint

Describes each tap step in the ratio tap changer tabular curve.

Table 260 shows all attributes of RatioTapChangerTablePoint.

Table 260 – Attributes of Wires::RatioTapChangerTablePoint

name	mult	type	description
b	0..1	PerCent	inherited from: TapChangerTablePoint
g	0..1	PerCent	inherited from: TapChangerTablePoint
r	0..1	PerCent	inherited from: TapChangerTablePoint
ratio	0..1	Float	inherited from: TapChangerTablePoint
step	0..1	Integer	inherited from: TapChangerTablePoint
x	0..1	PerCent	inherited from: TapChangerTablePoint

Table 261 shows all association ends of RatioTapChangerTablePoint with other classes.

Table 261 – Association ends of Wires::RatioTapChangerTablePoint with other classes

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mult from	name	mult to	type	description
1..*	RatioTapChangerTable	1..1	RatioTapChangerTable	Table of this point.

6.9.40 ACLineSegment

A wire or combination of wires, with consistent electrical characteristics, building a single electrical system, used to carry alternating current between points in the power system.

For symmetrical, transposed three phase lines, it is sufficient to use attributes of the line segment, which describe impedances and admittances for the entire length of the segment. Additionally impedances can be computed by using length and associated per length impedances.

The BaseVoltage at the two ends of ACLineSegments in a Line shall have the same BaseVoltage.nominalVoltage. However, boundary lines may have slightly different BaseVoltage.nominalVoltages and variation is allowed. Larger voltage difference in general requires use of an equivalent branch.

Table 262 shows all attributes of ACLineSegment.

Table 262 – Attributes of Wires::ACLineSegment

name	mult	type	description
b0ch	0..1	Susceptance	Zero sequence shunt (charging) susceptance, uniformly distributed, of the entire line section.
bch	0..1	Susceptance	Positive sequence shunt (charging) susceptance, uniformly distributed, of the entire line section. This value represents the full charging over the full length of the line.
g0ch	0..1	Conductance	Zero sequence shunt (charging) conductance, uniformly distributed, of the entire line section.
gch	0..1	Conductance	Positive sequence shunt (charging) conductance, uniformly distributed, of the entire line section.
r	0..1	Resistance	Positive sequence series resistance of the entire line section.
r0	0..1	Resistance	Zero sequence series resistance of the entire line section.
shortCircuitEndTemperature	0..1	Temperature	Maximum permitted temperature at the end of SC for the calculation of minimum short-circuit currents. Used for short circuit data exchange according to IEC 60909.
x	0..1	Reactance	Positive sequence series reactance of the entire line section.
x0	0..1	Reactance	Zero sequence series reactance of the entire line section.
length	0..1	Length	inherited from: Conductor
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 263 shows all association ends of ACLineSegment with other classes.

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Table 263 – Association ends of Wires::ACLineSegment with other classes

mult from	name	mult to	type	description
1..1	Clamp	0..*	Clamp	The clamps connected to the line segment.
0..1	LineFaults	0..*	LineFault	The line faults of the line segment.
0..*	PerLengthImpedance	0..1	PerLengthImpedance	Per-length impedance of this line segment.
1..1	Cut	0..*	Cut	Cuts applied to the line segment.
1..1	ACLineSegmentPhases	0..*	ACLineSegmentPhase	The line segment phases which belong to the line segment.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.41 Recloser

Pole-mounted fault interrupter with built-in phase and ground relays, current transformer (CT), and supplemental controls.

Table 264 shows all attributes of Recloser.

Table 264 – Attributes of Wires::Recloser

name	mult	type	description
breakingCapacity	0..1	CurrentFlow	inherited from: ProtectedSwitch
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment

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name	mult	type	description
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 265 shows all association ends of Recloser with other classes.

Table 265 – Association ends of Wires::Recloser with other classes

mult from	name	mult to	type	description
0..*	OperatedByProtectionEquipment	0..*	ProtectionEquipment	inherited from: ProtectedSwitch
1..1	RecloseSequences	0..*	RecloseSequence	inherited from: ProtectedSwitch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
~~[0..*]~~	~~[0..*] SwitchingOperations~~		~~SwitchingOpetation~~	~~inherited from: Switch~~
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.42 CompositeSwitch

A model of a set of individual Switches normally enclosed within the same cabinet and possibly with interlocks that restrict the combination of switch positions. These are typically found in medium voltage distribution networks.

A CompositeSwitch could represent a Ring-Main-Unit (RMU), or pad-mounted switchgear, with primitive internal devices such as an internal busbar plus 3 or 4 internal switches each of which may individually be open or closed. A CompositeSwitch and a set of contained

Switches can also be used to represent a multi-position switch, e.g. a switch that can connect a circuit to Ground, Open or Busbar.

Table 266 shows all attributes of CompositeSwitch.

Table 266 – Attributes of Wires::CompositeSwitch

name	mult	type	description
compositeSwitchType	0..1	String	An alphanumeric code that can be used as a reference to extra information such as the description of the interlocking scheme if any.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 267 shows all association ends of CompositeSwitch with other classes.

Table 267 – Association ends of Wires::CompositeSwitch with other classes

mult from	name	mult to	type	description
0..1	Switches	0..*	Switch	Switches contained in this Composite switch.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.43 TransformerEnd

A conducting connection point of a power transformer. It corresponds to a physical transformer winding terminal. In earlier CIM versions, the TransformerWinding class served a similar purpose, but this class is more flexible because it associates to terminal but is not a specialization of ConductingEquipment.

Table 268 shows all attributes of TransformerEnd.

Table 268 – Attributes of Wires::TransformerEnd

name	mult	type	description

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name	mult	type	description
bmagSat	0..1	PerCent	Core shunt magnetizing susceptance in the saturation region.
endNumber	0..1	Integer	Number for this transformer end, corresponding to the end's order in the power transformer vector group or phase angle clock number. Highest voltage winding should be 1. Each end within a power transformer should have a unique subsequent end number. Note the transformer end number need not match the terminal sequence number.
grounded	0..1	Boolean	(for Yn and Zn connections) True if the neutral is solidly grounded.
magBaseU	0..1	Voltage	The reference voltage at which the magnetizing saturation measurements were made.
magSatFlux	0..1	PerCent	Core magnetizing saturation curve knee flux level.
rground	0..1	Resistance	(for Yn and Zn connections) Resistance part of neutral impedance where 'grounded' is true.
xground	0..1	Reactance	(for Yn and Zn connections) Reactive part of neutral impedance where 'grounded' is true.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 269 shows all association ends of TransformerEnd with other classes.

Table 269 – Association ends of Wires::TransformerEnd with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	Base voltage of the transformer end. This is essential for PU calculation.
0..*	Terminal	0..1	Terminal	Terminal of the power transformer to which this transformer end belongs.
1..1	RatioTapChanger	0..1	RatioTapChanger	Ratio tap changer associated with this transformer end.
0..*	StarImpedance	0..1	TransformerStarImpedance	(accurate for 2- or 3-winding transformers only) Pi-model impedances of this transformer end. By convention, for a two winding transformer, the full values of the transformer should be entered on the high voltage end (endNumber=1).
1..1	PhaseTapChanger	0..1	PhaseTapChanger	Phase tap changer associated with this transformer end.
0..*	CoreAdmittance	0..1	TransformerCoreAdmittance	Core admittance of this transformer end, representing magnetizing current and core losses. The full values of the transformer should be supplied for one transformer end only.
1..*	ToMeshImpedance	0..*	TransformerMeshImpedance	All mesh impedances between this 'from' and other 'to' transformer ends.
1..1	FromMeshImpedance	0..*	TransformerMeshImpedance	All mesh impedances between this 'to' and other 'from' transformer ends.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.44 Sectionaliser

Automatic switch that will lock open to isolate a faulted section. It may, or may not, have load breaking capability. Its primary purpose is to provide fault sectionalising at locations where the fault current is either too high, or too low, for proper coordination of fuses.

Table 270 shows all attributes of Sectionaliser.

Table 270 – Attributes of Wires::Sectionaliser

name	mult	type	description
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 271 shows all association ends of Sectionaliser with other classes.

Table 271 – Association ends of Wires::Sectionaliser with other classes

mult from	name	mult to	type	description
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
~~[0..*]~~	~~[0..*] SwitchingOperations~~		~~SwitchingOperation~~	~~inherited from: Switch~~
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~

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mult from	name	mult to	type	description
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.45 VoltageControlZone

An area of the power system network which is defined for secondary voltage control purposes. A voltage control zone consists of a collection of substations with a designated busbar section whose voltage will be controlled.

Table 272 shows all attributes of VoltageControlZone.

Table 272 – Attributes of Wires::VoltageControlZone

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 273 shows all association ends of VoltageControlZone with other classes.

Table 273 – Association ends of Wires::VoltageControlZone with other classes

mult from	name	mult to	type	description
0..1	BusbarSection	1..1	BusbarSection	A VoltageControlZone is controlled by a designated BusbarSection.
0..*	RegulationSchedule	0..1	RegulationSchedule	A VoltageControlZone may have a voltage regulation schedule.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.46 EnergySource

A generic equivalent for an energy supplier on a transmission or distribution voltage level.

Table 274 shows all attributes of EnergySource.

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Table 274 – Attributes of Wires::EnergySource

name	mult	type	description
activePower	0..1	ActivePower	High voltage source ~~load~~ active injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
reactivePower	0..1	ReactivePower	High voltage source reactive injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
nominalVoltage	0..1	Voltage	Phase-to-phase nominal voltage.
r	0..1	Resistance	Positive sequence Thevenin resistance.
r0	0..1	Resistance	Zero sequence Thevenin resistance.
rn	0..1	Resistance	Negative sequence Thevenin resistance.
voltageAngle	0..1	AngleRadians	Phase angle of a phase open circuit.
voltageMagnitude	0..1	Voltage	Phase-to-phase open circuit voltage magnitude.
x	0..1	Reactance	Positive sequence Thevenin reactance.
x0	0..1	Reactance	Zero sequence Thevenin reactance.
xn	0..1	Reactance	Negative sequence Thevenin reactance.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 275 shows all association ends of EnergySource with other classes.

Table 275 – Association ends of Wires::EnergySource with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

~~6.8.67 SynchronousGeneratorType enumeration~~

~~Type of synchronous generator as used in dynamic simulation applications.~~

~~Table 289 shows all literals of SynchronousGeneratorType.~~

~~Table 289 – Literals of Wires::SynchronousGeneratorType~~

~~literal~~	~~description~~
~~roundRotor~~	~~Also known as genrou.~~
~~salientPole~~	~~Also known as gensal.~~
~~transient~~	~~Also known as gentra.~~
~~typeF~~	~~Also known as typeF.~~
~~typeJ~~	~~Also known as typeJ.~~

~~6.8.70 SynchronousMachineType enumeration~~

~~Synchronous machine type.~~

~~Table 293 shows all literals of SynchronousMachineType.~~

~~Table 293 – Literals of Wires::SynchronousMachineType~~

~~literal~~	~~description~~
~~generator~~	
~~condenser~~	
~~generator_or_condenser~~	

6.9.47 SynchronousMachine

An electromechanical device that operates with shaft rotating synchronously with the network. It is a single machine operating either as a generator or synchronous condenser or pump.

Table 276 shows all attributes of SynchronousMachine.

Table 276 – Attributes of Wires::SynchronousMachine

name	mult	type	description
aVRToManualLag	0..1	Seconds	Time delay required when switching from Automatic Voltage Regulation (AVR) to Manual for a lagging MVAr violation.
aVRToManualLead	0..1	Seconds	Time delay required when switching from Automatic Voltage Regulation (AVR) to Manual for a leading MVAr violation.
baseQ	0..1	ReactivePower	Default base reactive power value. This value represents the initial reactive power that can be used by any application function.

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name	mult	type	description
condenserP	0..1	ActivePower	Active power consumed when in condenser mode operation.
coolantCondition	0..1	Float	Temperature or pressure of coolant medium
coolantType	0..1	CoolantType	Method of cooling the machine.
earthing	0..1	Boolean	Indicates whether or not the generator is earthed. Used for short circuit data exchange according to IEC 60909
earthingStarPointR	0..1	Resistance	Generator star point earthing resistance (Re). Used for short circuit data exchange according to IEC 60909
earthingStarPointX	0..1	Reactance	Generator star point earthing reactance (Xe). Used for short circuit data exchange according to IEC 60909
ikk	0..1	CurrentFlow	Steady-state short-circuit current (in A for the profile) of generator with compound excitation during 3-phase short circuit. - Ikk=0: Generator with no compound excitation. - Ikk?0: Generator with compound excitation. Ikk is used to calculate the minimum steady-state short-circuit current for generators with compound excitation (Section 4.6.1.2 in the IEC 60909-0) Used only for single fed short circuit on a generator. (Section 4.3.4.2. in the IEC 60909-0)
manualToAVR	0..1	Seconds	Time delay required when switching from Manual to Automatic Voltage Regulation. This value is used in the accelerating power reference frame for powerflow solutions
maxQ	0..1	ReactivePower	Maximum reactive power limit. This is the maximum (nameplate) limit for the unit.
maxU	0..1	Voltage	Maximum voltage limit for the unit.
minQ	0..1	ReactivePower	Minimum reactive power limit for the unit.
minU	0..1	Voltage	Minimum voltage limit for the unit.
mu	0..1	Float	Factor to calculate the breaking current (Section 4.5.2.1 in the IEC 60909-0). Used only for single fed short circuit on a generator (Section 4.3.4.2. in the IEC 60909-0).
operatingMode	0..1	SynchronousMachineOperatingMode	Current mode of operation.
qPercent	0..1	PerCent	~~Percent~~ Part of the coordinated reactive control that comes from this machine. The attribute is used as a participation factor not necessarily summing up to 100% for the devices participating in the control.
r	0..1	Resistance	~~Positive sequence resistance of the synchronous machine.~~ Equivalent resistance (RG) of generator. RG is considered for the calculation of all currents, except for the calculation of the peak current ip. Used for short circuit data exchange according to IEC 60909
r0	0..1	Resistance	Zero sequence resistance of the synchronous machine.
r2	0..1	Resistance	Negative sequence resistance.
referencePriority	0..1	Integer	Priority of unit for use as powerflow voltage phase angle reference bus selection. 0 = don't care (default) 1 = highest priority. 2 is less than 1 and so on.

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name	mult	type	description
~~synchronousGeneratorType~~		~~SynchronousGeneratorType~~	~~Type of Synchronous Generator used in Dynamic simulation applications.~~
~~tpdo~~		~~Seconds~~	~~Direct axis transient rotor time constant, also known as T'do~~
~~tppdo~~		~~Seconds~~	~~Direct axis sub-transient rotor time constant, also known as T"do~~
~~tppqo~~		~~Seconds~~	~~Quadrature axis subtransient rotor time constant, also known as T"qo~~
~~tpqo~~		~~Seconds~~	~~Quadrature axis transient rotor time constant, also known as T'qo~~
satDirectSubtransX	0..1	PU	Direct-axis subtransient reactance saturated, also known as Xd"sat.
satDirectSyncX	0..1	PU	Direct-axes saturated synchronous reactance (xdsat); reciprocal of short-circuit ration. Used for short circuit data exchange, only for single fed short circuit on a generator. (Section 4.3.4.2. in the IEC 60909-0.
satDirectTransX	0..1	PU	Saturated Direct-axis transient reactance. The attribute is primarily used for short circuit calculations according to ANSI.
shortCircuitRotorType	0..1	ShortCircuitRotorKind	Type of rotor, used by short circuit applications, only for single fed short circuit according to IEC 60909.
type	0..1	SynchronousMachine~~Type~~Kind	Modes that this synchronous machine can operate in.
voltageRegulationRange	0..1	PerCent	Range of generator voltage regulation (PG in the IEC 60909-0) used for calculation of the impedance correction factor KG defined in IEC 60909-0 This attribute is used to describe the operating voltage of the generating unit.
~~x~~		~~Reactance~~	~~Positive sequence reactance of the synchronous machine.~~
x0	0..1	Reactance	Zero sequence reactance of the synchronous machine.
x2	0..1	Reactance	Negative sequence reactance.
~~xDirectSubtrans~~		~~Reactance~~	~~Direct-axis subtransient reactance, also known as X"d.~~
~~xDirectSync~~		~~Reactance~~	~~Direct-axis synchronous reactance. The quotient of a sustained value of that AC component of armature voltage that is produced by the total direct-axis flux due to direct-axis armature current and the value of the AC component of this current, the machine running at rated speed. (Xd)~~
~~xDirectTrans~~		~~Reactance~~	~~Direct-axis transient reactance, also known as X'd.~~
~~xQuadSubtrans~~		~~Reactance~~	~~Quadrature-axis subtransient reactance, also known as X"q.~~
~~xQuadSync~~		~~Reactance~~	~~Quadrature-axis synchronous reactance (Xq) , the ratio of the component of reactive armature voltage, due to the quadrature-axis component of armature current, to this component of current, under steady state conditions and at rated frequency.~~
~~xQuadTrans~~		~~Reactance~~	~~Quadrature-axis transient reactance, also known as X'q.~~
~~damping~~		~~Float~~	~~inherited from: RotatingMachine~~
~~inertia~~		~~Seconds~~	~~inherited from: RotatingMachine~~

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name	mult	type	description
~~ratedS~~		~~ApparentPower~~	~~inherited from: RotatingMachine~~
~~saturationFactor~~		~~Float~~	~~inherited from: RotatingMachine~~
~~saturationFactor120~~		~~Float~~	~~inherited from: RotatingMachine~~
~~statorLeakageReactance~~		~~Reactance~~	~~inherited from: RotatingMachine~~
~~statorResistance~~		~~Resistance~~	~~inherited from: RotatingMachine~~
ratedPowerFactor	0..1	Float	inherited from: RotatingMachine
p	0..1	ActivePower	inherited from: RotatingMachine
ratedS	0..1	ApparentPower	inherited from: RotatingMachine
q	0..1	ReactivePower	inherited from: RotatingMachine
ratedU	0..1	Voltage	inherited from: RotatingMachine
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 277 shows all association ends of SynchronousMachine with other classes.

Table 277 – Association ends of Wires::SynchronousMachine with other classes

mult from	name	mult to	type	description
0..*	PrimeMovers	0..*	PrimeMover	Prime movers that drive this SynchronousMachine.
1..*	InitialReactiveCapabilityCurve	0..1	ReactiveCapabilityCurve	The default reactive capability curve for use by a synchronous machine.
1..*	ReactiveCapabilityCurves	0..*	ReactiveCapabilityCurve	All available reactive capability curves for this synchronous machine.
1..1	SynchronousMachineDynamics	0..1	SynchronousMachineDynamics	Synchronous machine dynamics model used to describe dynamic behavior of this synchronous machine.
1..1	HydroPump	0..1	HydroPump	~~The synchronous machine drives the turbine which moves the water from a low elevation to a higher elevation. The direction of machine rotation for pumping may or may not be the same as for generating.~~ inherited from: RotatingMachine
1..*	GeneratingUnit	0..1	GeneratingUnit	~~A synchronous machine may operate as a generator and as such becomes a member of a generating unit.~~ inherited from: RotatingMachine
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment

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mult from	name	mult to	type	description
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	~~[1..*]~~ Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.48 RegulatingControlModeKind enumeration

The kind of regulation model. For example regulating voltage, reactive power, active power, etc.

Table 278 shows all literals of RegulatingControlModeKind.

Table 278 – Literals of Wires::RegulatingControlModeKind

literal	value	description
voltage		Voltage is specified.
activePower		Active power is specified.
reactivePower		Reactive power is specified.
currentFlow		Current flow is specified.
~~fixed~~		~~The regulation mode is fixed, and thus not regulating.~~
admittance		Admittance is specified.
timeScheduled		Control switches on/off by time of day. The times may change on the weekend, or in different seasons.
temperature		Control switches on/off based on the local temperature (i.e. a thermostat).
powerFactor		Power factor is specified.

6.9.49 Clamp

A Clamp is a galvanic connection at a line segment where other equipment is connected. A Clamp does not cut the line segment.

A Clamp is ConductingEquipment and has one Terminal with an associated ConnectivityNode. Any other ConductingEquipment can be connected to the Clamp ConnectivityNode.

Table 279 shows all attributes of Clamp.

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Table 279 – Attributes of Wires::Clamp

name	mult	type	description
lengthFromTerminal1	0..1	Length	The length to the place where the clamp is located starting from side one of the line segment, i.e. the line segment terminal with sequence number equal to 1.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 280 shows all association ends of Clamp with other classes.

Table 280 – Association ends of Wires::Clamp with other classes

mult from	name	mult to	type	description
0..*	ACLineSegment	1..1	ACLineSegment	The line segment to which the clamp is connected.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.50 TransformerTankEnd

Transformer tank end represents an individual winding for unbalanced models or for transformer tanks connected into a bank (and bank is modeled with the PowerTransformer).

Table 281 shows all attributes of TransformerTankEnd.

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Table 281 – Attributes of Wires::TransformerTankEnd

name	mult	type	description
phases	0..1	PhaseCode	Describes the phases carried by a conducting equipment.
bmagSat	0..1	PerCent	inherited from: TransformerEnd
endNumber	0..1	Integer	inherited from: TransformerEnd
grounded	0..1	Boolean	inherited from: TransformerEnd
magBaseU	0..1	Voltage	inherited from: TransformerEnd
magSatFlux	0..1	PerCent	inherited from: TransformerEnd
rground	0..1	Resistance	inherited from: TransformerEnd
xground	0..1	Reactance	inherited from: TransformerEnd
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 282 shows all association ends of TransformerTankEnd with other classes.

Table 282 – Association ends of Wires::TransformerTankEnd with other classes

mult from	name	mult to	type	description
1..*	TransformerTank	0..1	TransformerTank	Transformer this winding belongs to.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: TransformerEnd
0..*	Terminal	0..1	Terminal	inherited from: TransformerEnd
1..1	RatioTapChanger	0..1	RatioTapChanger	inherited from: TransformerEnd
0..*	StarImpedance	0..1	TransformerStarImpedance	inherited from: TransformerEnd
1..1	PhaseTapChanger	0..1	PhaseTapChanger	inherited from: TransformerEnd
0..*	CoreAdmittance	0..1	TransformerCoreAdmittance	inherited from: TransformerEnd
1..*	ToMeshImpedance	0..*	TransformerMeshImpedance	inherited from: TransformerEnd
1..1	FromMeshImpedance	0..*	TransformerMeshImpedance	inherited from: TransformerEnd
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.51 PhaseTapChanger

A transformer phase shifting tap model that controls the phase angle difference across the power transformer and potentially the active power flow through the power transformer. This phase tap model may also impact the voltage magnitude.

Table 283 shows all attributes of PhaseTapChanger.

Table 283 – Attributes of Wires::PhaseTapChanger

name	mult	type	description
controlEnabled	0..1	Boolean	inherited from: TapChanger

name	mult	type	description
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger
~~regulationStatus~~		~~Boolean~~	~~nherited from: TapChanger~~
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 284 shows all association ends of PhaseTapChanger with other classes.

Table 284 – Association ends of Wires::PhaseTapChanger with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	Transformer end to which this phase tap changer belongs.
~~[0..*]~~	~~[0..1] PhaseTapChangerTabular~~		~~PhaseTapChangerTabular~~	~~The phase tap changer table for this phase tap changer.~~
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.52 ACLineSegmentPhase

Represents a single wire of an alternating current line segment.

Table 285 shows all attributes of ACLineSegmentPhase.

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Table 285 – Attributes of Wires::ACLineSegmentPhase

name	mult	type	description
phase	0..1	SinglePhaseKind	The phase connection of the wire at both ends.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 286 shows all association ends of ACLineSegmentPhase with other classes.

Table 286 – Association ends of Wires::ACLineSegmentPhase with other classes

mult from	name	mult to	type	description
0..*	ACLineSegment	1..1	ACLineSegment	The line segment to which the phase belongs.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.53 RatioTapChangerTable

Describes a curve for how the voltage magnitude and impedance varies with the tap step.

Table 287 shows all attributes of RatioTapChangerTable.

Table 287 – Attributes of Wires::RatioTapChangerTable

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 288 shows all association ends of RatioTapChangerTable with other classes.

Table 288 – Association ends of Wires::RatioTapChangerTable with other classes

mult from	name	mult to	type	description
0..1	RatioTapChanger	0..*	RatioTapChanger	The ratio tap changer of this tap ratio table.
1..1	RatioTapChangerTablePoint	1..*	RatioTapChangerTablePoint	Points of this table.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject

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mult from	name	mult to	type	description
1..1	Names	0..*	Name	inherited from: IdentifiedObject

~~6.8.55 Resistor~~

~~Resistor, typically used in filter configurations or as earthing resistor for transformers. Used for electrical model of distribution networks.~~

~~Table 267 shows all attributes of Resistor.~~

~~Table 267 – Attributes of Wires::Resistor~~

name	type	description
aggregate	Boolean	inherited from: Equipment
normallyInService	Boolean	inherited from: Equipment
aliasName	String	inherited from: IdentifiedObject
mRID	String	inherited from: IdentifiedObject
name	String	inherited from: IdentifiedObject

~~Table 268 shows all association ends of Resistor with other classes.~~

~~Table 268 – Association ends of Wires::Resistor with other classes~~

[mult from]	[mult to] name	type	description
[0..*]	[0..1] BaseVoltage	BaseVoltage	inherited from: ConductingEquipment
[1..1]	[0..*] Terminals	Terminal	inherited from: ConductingEquipment
[0..*]	[0..*] ProtectionEquipments	ProtectionEquipment	inherited from: ConductingEquipment
[1..1]	[0..*] ClearanceTags	ClearanceTag	inherited from: ConductingEquipment
[1..1]	[0..1] SvStatus	SvStatus	inherited from: ConductingEquipment
[0..*]	[0..1] EquipmentContainer	EquipmentContainer	inherited from: Equipment
[1..1]	[0..*] ContingencyEquipment	ContingencyEquipment	inherited from: Equipment
[0..1]	[0..*] OperationalLimitSet	OperationalLimitSet	inherited from: Equipment
[0..*]	[0..1] PSRType	PSRType	inherited from: PowerSystemResource
[0..1]	[0..*] Measurements	Measurement	inherited from: PowerSystemResource
[1..1]	[0..*] OperatingShare	OperatingShare	inherited from: PowerSystemResource
[0..*]	[0..*] PsrLists	PsrList	inherited from: PowerSystemResource
[1..1]	[0..1] OutageSchedule	OutageSchedule	inherited from: PowerSystemResource
[0..*]	[0..*] ReportingGroup	ReportingGroup	inherited from: PowerSystemResource
[0..1]	[0..*] DiagramObjects	DiagramObject	inherited from: IdentifiedObject
[1..1]	[0..*] Names	Name	inherited from: IdentifiedObject

6.9.54 RotatingMachine

A rotating machine which may be used as a generator or motor.

Table 289 shows all attributes of RotatingMachine.

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Table 289 – Attributes of Wires::RotatingMachine

name	mult	type	description
~~damping~~		~~Float~~	~~Damping torque coefficient, a proportionality constant that, when multiplied by the angular velocity of the rotor poles with respect to the magnetic field (frequency), results in the damping torque. This value is often zero when the sources of damping torques (generator damper windings, load damping effects, etc.) are modeled in detail.~~
~~inertia~~		~~Seconds~~	~~Inertia constant of generator or motor and mechanical load. Must be greater than zero. This is the specification for the stored energy in the rotating mass when operating at rated speed. For a generator, this includes the generator plus all other elements (turbine, exciter) on the same shaft and has units of MW-sec. For a motor, it includes the motor plus its mechanical load. Conventional units are per unit on the generator MVA base, usually expressed as MW-second/MVA or just second. This value is used in the accelerating power reference frame for operator training simulator solutions.~~
ratedPowerFactor	0..1	Float	Power factor (nameplate data). It is primarily used for short circuit data exchange according to IEC 60909.
p	0..1	ActivePower	Active power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.
ratedS	0..1	ApparentPower	Nameplate apparent power rating for the unit. The attribute shall have a positive value.
~~saturationFactor~~		~~Float~~	~~Saturation factor at rated terminal voltage. Should be greather than or equal to zero.~~
~~saturationFactor120~~		~~Float~~	~~Saturation factor at 120% of rated terminal voltage. Should be greater than or equal to the saturation factor at rated terminal voltage.~~
~~statorLeakageReactance~~		~~Reactance~~	~~Stator leakage reactance. Should be greater than or equal to 0.~~
~~statorResistance~~		~~Resistance~~	~~Stator (armature) resistance. Should be greather than or equal to zero. Equivalent resistance when used for GenEquiv model.~~
q	0..1	ReactivePower	Reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.
ratedU	0..1	Voltage	Rated voltage (nameplate data, Ur in IEC 60909-0). It is primarily used for short circuit data exchange according to IEC 60909.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 290 shows all association ends of RotatingMachine with other classes.

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Table 290 – Association ends of Wires::RotatingMachine with other classes

mult from	name	mult to	type	description
1..1	HydroPump	0..1	HydroPump	The synchronous machine drives the turbine which moves the water from a low elevation to a higher elevation. The direction of machine rotation for pumping may or may not be the same as for generating.
1..*	GeneratingUnit	0..1	GeneratingUnit	A synchronous machine may operate as a generator and as such becomes a member of a generating unit.
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	~~[1..*]~~ Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.55 RegulatingControl

Specifies a set of equipment that works together to control a power system quantity such as voltage or flow.

Remote bus voltage control is possible by specifying the controlled terminal located at some place remote from the controlling equipment.

In case multiple equipments, possibly of different types, control the same terminal, there shall be only one RegulatingControl at that terminal. The most specific subtype of RegulatingControl shall be used in case such equipments participate in the control, e.g. TapChangerControl for tap changers.

For flow control, load sign convention is used, i.e. positive sign means flow out from a TopologicalNode (bus) into the conducting equipment.

Table 291 shows all attributes of RegulatingControl.

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Table 291 – Attributes of Wires::RegulatingControl

name	mult	type	description
discrete	0..1	Boolean	The regulation is performed in a discrete mode. This applies to equipment with discrete controls, e.g. tap changers and shunt compensators.
enabled	0..1	Boolean	The flag tells if regulation is enabled.
mode	0..1	RegulatingControlModeKind	The regulating control mode presently available. This specification allows for determining the kind of regulation without need for obtaining the units from a schedule.
monitoredPhase	0..1	PhaseCode	Phase voltage controlling this regulator, measured at regulator location.
~~targetRange~~		~~Float~~	~~This is the case input target range. This performs the same function as the value2 attribute on the regulation schedule in the case that schedules are not used. The units of those appropriate for the mode.~~
targetDeadband	0..1	Float	This is a deadband used with discrete control to avoid excessive update of controls like tap changers and shunt compensator banks while regulating. The units of those appropriate for the mode.
targetValue	0..1	Float	The target value specified for case input. This value can be used for the target value without the use of schedules. The value has the units appropriate to the mode attribute.
targetValueUnitMultiplier	0..1	UnitMultiplier	Specify the multiplier for used for the targetValue.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 292 shows all association ends of RegulatingControl with other classes.

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Table 292 – Association ends of Wires::RegulatingControl with other classes

mult from	name	mult to	type	description
0..*	Terminal	0..1	Terminal	The terminal associated with this regulating control. The terminal is associated, instead of a node, since the terminal could connect into either a topological node (bus in bus-branch model) or a connectivity node (detailed switch model). Sometimes it is useful to model regulation at a terminal of a busbar object since the busbar can be present in both a bus-branch model or a model with switch detail.
1..1	RegulationSchedule	0..*	RegulationSchedule	Schedule for this Regulating regulating control.
0..1	RegulatingCondEq	0..*	RegulatingCondEq	The equipment that participates in this regulating control scheme.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.56 PhaseImpedanceData root class

Triplet of resistance, reactance, and susceptance matrix element values.

Table 293 shows all attributes of PhaseImpedanceData.

Table 293 – Attributes of Wires::PhaseImpedanceData

name	mult	type	description
sequenceNumber	0..1	Integer	Column-wise element index, assuming a symmetrical matrix. Ranges from 1 to N + N*(N-−1)/2.
b	0..1	SusceptancePerLength	Susceptance matrix element value, per length of unit.
r	0..1	ResistancePerLength	Resistance matrix element value, per length of unit.
x	0..1	ReactancePerLength	Reactance matrix element value, per length of unit.

Table 294 shows all association ends of PhaseImpedanceData with other classes.

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Table 294 – Association ends of Wires::PhaseImpedanceData with other classes

mult from	name	mult to	type	description
1..*	PhaseImpedance	1..1	PerLengthPhaseImpedance	Conductor phase impedance to which this data belongs.

6.9.57 ShuntCompensator

A shunt capacitor or reactor or switchable bank of shunt capacitors or reactors. A section of a shunt compensator is an individual capacitor or reactor. A negative value for reactivePerSection indicates that the compensator is a reactor. ShuntCompensator is a single terminal device. Ground is implied.

Table 295 shows all attributes of ShuntCompensator.

Table 295 – Attributes of Wires::ShuntCompensator

name	mult	type	description
aVRDelay	0..1	Seconds	Time delay required for the device to be connected or disconnected by automatic voltage regulation (AVR).
~~b0PerSection~~		~~Susceptance~~	~~Zero sequence shunt (charging) susceptance per section~~
~~bPerSection~~		~~Susceptance~~	~~Positive sequence shunt (charging) susceptance per section~~
~~g0PerSection~~		~~Conductance~~	~~Zero sequence shunt (charging) conductance per section~~
~~gPerSection~~		~~Conductance~~	~~Positive sequence shunt (charging) conductance per section~~
grounded	0..1	~~WindingConnection~~ Boolean	Used for Yn and Zn connections. True if the neutral is solidly grounded.
maximumSections	0..1	Integer	The maximum number of sections that may be switched in.
nomU	0..1	Voltage	The voltage at which the nominal reactive power may be calculated. This should normally be within 10 % of the voltage at which the capacitor is connected to the network.
normalSections	0..1	Integer	The normal number of sections switched in.
phaseConnection	0..1	PhaseShuntConnectionKind	The type of phase connection, such as wye or delta.
switchOnCount	0..1	Integer	The switch on count since the capacitor count was last reset or initialized.
switchOnDate	0..1	DateTime	The date and time when the capacitor bank was last switched on.
voltageSensitivity	0..1	VoltagePerReactivePower	Voltage sensitivity required for the device to regulate the bus voltage, in voltage/reactive power.
sections	0..1	Float	Shunt compensator sections in use. Starting value for steady state solution. Non integer values are allowed to support continuous variables. The reasons for continuous value are to support study cases where no discrete shunt compensators has yet been designed, a solutions where a narrow voltage band force the sections to oscillate or accommodate for a continuous solution as input.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment

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name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 296 shows all association ends of ShuntCompensator with other classes.

Table 296 – Association ends of Wires::ShuntCompensator with other classes

mult from	name	mult to	type	description
1..1	ShuntCompensatorPhase	0..*	ShuntCompensatorPhase	The individual phases models for the shunt compensator.
1..1	SvShuntCompensatorSections	0..1	SvShuntCompensatorSections	The state for the number of shunt compensator sections in service.
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	~~[1..*]~~ Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.58 EarthFaultCompensator

A conducting equipment used to represent a connection to ground which is typically used to compensate for earth faults.. An earth fault compensator device modeled with a single terminal implies a second terminal solidly connected to ground. If two terminals are modeled, the ground is not assumed and normal connection rules apply.

Table 297 shows all attributes of EarthFaultCompensator.

Table 297 – Attributes of Wires::EarthFaultCompensator

name	mult	type	description
r	0..1	Resistance	Nominal resistance of device.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 298 shows all association ends of EarthFaultCompensator with other classes.

Table 298 – Association ends of Wires::EarthFaultCompensator with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.59 MutualCoupling

This class represents the zero sequence line mutual coupling.

Table 299 shows all attributes of MutualCoupling.

Table 299 – Attributes of Wires::MutualCoupling

name	mult	type	description
b0ch	0..1	Susceptance	Zero sequence mutual coupling shunt (charging) susceptance, uniformly distributed, of the entire line section.
distance11	0..1	Length	Distance to the start of the coupled region from the first line's terminal having sequence number equal to 1.
distance12	0..1	Length	Distance to the end of the coupled region from the first line's terminal with sequence number equal to 1.

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name	mult	type	description
distance21	0..1	Length	Distance to the start of coupled region from the second line's terminal with sequence number equal to 1.
distance22	0..1	Length	Distance to the end of coupled region from the second line's terminal with sequence number equal to 1.
g0ch	0..1	Conductance	Zero sequence mutual coupling shunt (charging) conductance, uniformly distributed, of the entire line section.
r0	0..1	Resistance	Zero sequence branch-to-branch mutual impedance coupling, resistance.
x0	0..1	Reactance	Zero sequence branch-to-branch mutual impedance coupling, reactance.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 300 shows all association ends of MutualCoupling with other classes.

Table 300 – Association ends of Wires::MutualCoupling with other classes

mult from	name	mult to	type	description
0..*	First_Terminal	1..1	Terminal	The starting terminal for the calculation of distances along the first branch of the mutual coupling. Normally MutualCoupling would only be used for terminals of AC line segments. The first and second terminals of a mutual coupling should point to different AC line segments.
0..*	Second_Terminal	1..1	Terminal	The starting terminal for the calculation of distances along the second branch of the mutual coupling.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.60 Cut

A cut separates a line segment into two parts. The cut appears as a switch inserted between these two parts and connects them together. As the cut is normally open there is no galvanic connection between the two line segment parts. But it is possible to close the cut to get galvanic connection.

The cut terminals are oriented towards the line segment terminals with the same sequence number. Hence the cut terminal with sequence number equal to 1 is oriented to the line segment's terminal with sequence number equal to 1.

The cut terminals also act as connection points for jumpers and other equipment, e.g. a mobile generator. To enable this, connectivity nodes are placed at the cut terminals. Once the connectivity nodes are in place any conducting equipment can be connected at them.

Table 301 shows all attributes of Cut.

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Table 301 – Attributes of Wires::Cut

name	mult	type	description
lengthFromTerminal1	0..1	Length	The length to the place where the cut is located starting from side one of the cut line segment, i.e. the line segment Terminal with sequenceNumber equal to 1.
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 302 shows all association ends of Cut with other classes.

Table 302 – Association ends of Wires::Cut with other classes

mult from	name	mult to	type	description
0..*	ACLineSegment	1..1	ACLineSegment	The line segment to which the cut is applied.
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
~~[0..*]~~	~~[0..*] SwitchingOperations~~		~~SwitchingOperation~~	~~inherited from: Switch~~
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.8.46 RatioTapChangerTabular

Describes a curve for how the voltage magnitude and impedance vary with the tap step.

Table 250 shows all attributes of RatioTapChangerTabular.

Table 250 – Attributes of Wires::RatioTapChangerTabular

name	type	description
aliasName	String	inherited from: IdentifiedObject
mRID	String	inherited from: IdentifiedObject
name	String	inherited from: IdentifiedObject

Table 251 shows all association ends of RatioTapChangerTabular with other classes.

Table 251 – Association ends of Wires::RatioTapChangerTabular with other classes

[mult from]	[mult to] name	type	description
[0..1]	[0..*] RatioTapChanger	RatioTapChanger	The ratio tap changer of this tap ratio table.
[1..1]	[1..*] RatioTapChangerTabularPoint	RatioTapChangerTabularPoint	Points of this table.
[0..1]	[0..*] DiagramObjects	DiagramObject	inherited from: IdentifiedObject
[1..1]	[0..*] Names	Name	inherited from: IdentifiedObject

6.8.47 RatioTapChangerTabularPoint root class

Describes each tap step in the ratio tap changer tabular curve.

Table 252 shows all attributes of RatioTapChangerTabularPoint.

Table 252 – Attributes of Wires::RatioTapChangerTabularPoint

name	type	description
b	PerCent	The magnetizing branch susceptance deviation in percent of nominal value. The actual susceptance is calculated as follows: calculated magnetizing susceptance = b(nominal) * (1 + b(from this class)/100). The b(nominal) is defined as the static magnetizing susceptance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.
g	PerCent	The magnetizing branch conductance deviation in percent of nominal value. The actual conductance is calculated as follows: calculated magnetizing conductance = g(nominal) * (1 + g(from this class)/100). The g(nominal) is defined as the static magnetizing conductance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.
r	PerCent	The resistance deviation in percent of nominal value. The actual reactance is calculated as follows: calculated resistance = r(nominal) * (1 + r(from this class)/100). The r(nominal) is defined as the static resistance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.

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name	type	description
ratio	Float	The voltage ratio in per unit. Hence this is a value close to one.
step	Integer	The tap step.
x	PerCent	The series reactance deviation in percent of nominal value. The actual reactance is calculated as follows: calculated reactance = x(nominal) * (1 + x(from this class)/100). The x(nominal) is defined as the static series reactance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.

Table 253 shows all association ends of RatioTapChangerTabularPoint with other classes.

Table 253 – Association ends of Wires::RatioTapChangerTabularPoint with other classes

[mult from]	[mult to] name	type	description
[1..*]	[1..1] RatioTapChangerTabular	RatioTapChangerTabular	Table of this point.

6.9.61 ReactiveCapabilityCurve

Reactive power rating envelope versus the synchronous machine's active power, in both the generating and motoring modes. For each active power value there is a corresponding high and low reactive power limit value. Typically there will be a separate curve for each coolant condition, such as hydrogen pressure. The Y1-axis values represent reactive minimum and the Y2-axis values represent reactive maximum.

Table 303 shows all attributes of ReactiveCapabilityCurve.

Table 303 – Attributes of Wires::ReactiveCapabilityCurve

name	mult	type	description
coolantTemperature	0..1	Temperature	The machine's coolant temperature (e.g., ambient air or stator circulating water).
hydrogenPressure	0..1	Pressure	The hydrogen coolant pressure
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 304 shows all association ends of ReactiveCapabilityCurve with other classes.

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Table 304 – Association ends of Wires::ReactiveCapabilityCurve with other classes

mult from	name	mult to	type	description
0..1	InitiallyUsedBySynchronousMachines	1..*	SynchronousMachine	Synchronous machines using this curve as default.
0..*	SynchronousMachines	1..*	SynchronousMachine	Synchronous machines using this curve.
0..1	EquivalentInjection	0..*	EquivalentInjection	The equivalent injection using this reactive capability curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.62 Switch

A generic device designed to close, or open, or both, one or more electric circuits. All switches are two terminal devices including grounding switches.

Table 305 shows all attributes of Switch.

Table 305 – Attributes of Wires::Switch

name	mult	type	description
normalOpen	0..1	Boolean	The attribute is used in cases when no Measurement for the status value is present. If the Switch has a status measurement the Discrete.normalValue is expected to match with the Switch.normalOpen.
ratedCurrent	0..1	CurrentFlow	The maximum continuous current carrying capacity in amps governed by the device material and construction.
switchOnCount	0..1	Integer	The switch on count since the switch was last reset or initialized.
switchOnDate	0..1	DateTime	The date and time when the switch was last switched on.
retained	0..1	Boolean	Branch is retained in a bus branch model. The flow through retained switches will normally be calculated in power flow.
open	0..1	Boolean	The attribute tells if the switch is considered open when used as input to topology processing.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 306 shows all association ends of Switch with other classes.

Table 306 – Association ends of Wires::Switch with other classes

mult from	name	mult to	type	description
1..1	SwitchSchedules	0..*	SwitchSchedule	A Switch can be associated with SwitchSchedules.

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mult from	name	mult to	type	description
1..1	SwitchPhase	0..*	SwitchPhase	The individual switch phases for the switch.
0..*	CompositeSwitch	0..1	CompositeSwitch	Composite switch to which this Switch belongs.
~~[0..*]~~	~~[0..*] SwitchingOperations~~		~~SwitchingOperation~~	~~A switch may be operated by many schedules.~~
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.63 StaticVarCompensator

A facility for providing variable and controllable shunt reactive power. The SVC typically consists of a stepdown transformer, filter, thyristor-controlled reactor, and thyristor-switched capacitor arms.

The SVC may operate in fixed MVar output mode or in voltage control mode. When in voltage control mode, the output of the SVC will be proportional to the deviation of voltage at the controlled bus from the voltage setpoint. The SVC characteristic slope defines the proportion. If the voltage at the controlled bus is equal to the voltage setpoint, the SVC MVar output is zero.

Table 307 shows all attributes of StaticVarCompensator.

Table 307 – Attributes of Wires::StaticVarCompensator

name	mult	type	description
capacitiveRating	0..1	Reactance	Maximum available capacitive reactance.
inductiveRating	0..1	Reactance	Maximum available inductive reactance.
slope	0..1	VoltagePerReactivePower	The characteristics slope of an SVC defines how the reactive power output changes in proportion to the difference between the regulated bus voltage and the voltage setpoint.

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name	mult	type	description
q	0..1	ReactivePower	Reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.
sVCControlMode	0..1	SVCControlMode	SVC control mode.
voltageSetPoint	0..1	Voltage	The reactive power output of the SVC is proportional to the difference between the voltage at the regulated bus and the voltage setpoint. When the regulated bus voltage is equal to the voltage setpoint, the reactive power output is zero.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 308 shows all association ends of StaticVarCompensator with other classes.

Table 308 – Association ends of Wires::StaticVarCompensator with other classes

mult from	name	mult to	type	description
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	~~[1..*]~~ Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.64 CoolantType enumeration

Method of cooling a machine.

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Table 309 shows all literals of CoolantType.

Table 309 – Literals of Wires::CoolantType

literal	value	description
air		Air.
hydrogenGas		Hydrogen gas.
water		Water.

6.9.65 ProtectedSwitch

A ProtectedSwitch is a switching device that can be operated by ProtectionEquipment.

Table 310 shows all attributes of ProtectedSwitch.

Table 310 – Attributes of Wires::ProtectedSwitch

name	mult	type	description
breakingCapacity	0..1	CurrentFlow	The maximum fault current a breaking device can break safely under prescribed conditions of use.
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 311 shows all association ends of ProtectedSwitch with other classes.

Table 311 – Association ends of Wires::ProtectedSwitch with other classes

mult from	name	mult to	type	description
0..*	OperatedByProtectionEquipment	0..*	ProtectionEquipment	Protection equipments that operate this ProtectedSwitch.
1..1	RecloseSequences	0..*	RecloseSequence	A breaker may have zero or more automatic reclosures after a trip occurs.
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
~~[0..*]~~	~~[0..*] SwitchingOperations~~		~~SwitchingOperation~~	~~A switch may be operated by many schedules.~~
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment

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mult from	name	mult to	type	description
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.66 EnergyConsumer

Generic user of energy – a point of consumption on the power system model.

Table 312 shows all attributes of EnergyConsumer.

Table 312 – Attributes of Wires::EnergyConsumer

name	mult	type	description
customerCount	0..1	Integer	Number of individual customers represented by this demand.
grounded	0..1	~~WindingConnection~~ Boolean	Used for Yn and Zn connections. True if the neutral is solidly grounded.
pfixed	0..1	ActivePower	Active power of the load that is a fixed quantity. Load sign convention is used, i.e. positive sign means flow out from a node.
pfixedPct	0..1	PerCent	Fixed active power as a percentage of load group fixed active power. Load sign convention is used, i.e. positive sign means flow out from a node.
phaseConnection	0..1	PhaseShuntConnectionKind	The type of phase connection, such as wye or delta.
qfixed	0..1	ReactivePower	Reactive power of the load that is a fixed quantity. Load sign convention is used, i.e. positive sign means flow out from a node.
qfixedPct	0..1	PerCent	Fixed reactive power as a percentage of load group fixed reactive power. Load sign convention is used, i.e. positive sign means flow out from a node.
p	0..1	ActivePower	Active power of the load. Load sign convention is used, i.e. positive sign means flow out from a node. For voltage dependent loads the value is at rated voltage. Starting value for a steady state solution.

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name	mult	type	description
q	0..1	ReactivePower	Reactive power of the load. Load sign convention is used, i.e. positive sign means flow out from a node. For voltage dependent loads the value is at rated voltage. Starting value for a steady state solution.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 313 shows all association ends of EnergyConsumer with other classes.

Table 313 – Association ends of Wires::EnergyConsumer with other classes

mult from	name	mult to	type	description
1..1	EnergyConsumerPhase	0..*	EnergyConsumerPhase	The individual phase models for this energy consumer.
0..*	LoadResponse	0..1	LoadResponseCharacteristic	The load response characteristic of this load. If missing, this load is assumed to be constant power.
1..*	PowerCutZone	0..1	PowerCutZone	The energy consumer is assigned to this power cut zone.
0..*	LoadDynamics	0..1	LoadDynamics	Load dynamics model used to describe dynamic behavior of this energy consumer.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.67 Junction

A point where one or more conducting equipments are connected with zero resistance.

Table 314 shows all attributes of Junction.

Table 314 – Attributes of Wires::Junction

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 315 shows all association ends of Junction with other classes.

Table 315 – Association ends of Wires::Junction with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

~~**6.8.35 PhaseTapChangerAsymetrical**~~

~~Describes the tap model for an asymmetrical phase shifting tranformer in which the difference voltage vector adds to the primary side voltage. The angle between the primary side voltage and the difference voltage is named the winding connection angle. The phase shift depends on both the difference voltage magnitude and the winding connection angle.~~

~~Table 228 shows all attributes of PhaseTapChangerAsymetrical.~~

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Table 228 – Attributes of Wires::PhaseTapChangerAsymetrical

name	type	description
windingConnectionAngle	AngleDegrees	The phase angle between the in-phase winding and the out-of -phase winding used for creating phase shift. The out-of-phase winding produces what is known as the difference voltage. Setting this angle to 90 degrees is not the same as a symmemtrical transformer.
voltageStepIncrement	PerCent	inherited from: PhaseTapChangerNonLinear
xMax	Reactance	inherited from: PhaseTapChangerNonLinear
xMedian	Reactance	inherited from: PhaseTapChangerNonLinear
highStep	Integer	inherited from: TapChanger
initialDelay	Seconds	inherited from: TapChanger
lowStep	Integer	inherited from: TapChanger
ltcFlag	Boolean	inherited from: TapChanger
neutralStep	Integer	inherited from: TapChanger
neutralU	Voltage	inherited from: TapChanger
normalStep	Integer	inherited from: TapChanger
regulationStatus	Boolean	inherited from: TapChanger
subsequentDelay	Seconds	inherited from: TapChanger
aliasName	String	inherited from: IdentifiedObject
mRID	String	inherited from: IdentifiedObject
name	String	inherited from: IdentifiedObject

Table 229 shows all association ends of PhaseTapChangerAsymetrical with other classes.

Table 229 – Association ends of Wires::PhaseTapChangerAsymetrical with other classes

[mult from]	[mult to] name	type	description
[0..1]	[1..1] TransformerEnd	TransformerEnd	inherited from: PhaseTapChanger
[0..*]	[0..1] PhaseTapChangerTabular	PhaseTapChangerTabular	inherited from: PhaseTapChanger
[0..*]	[0..1] TapChangerControl	TapChangerControl	inherited from: TapChanger
[1..1]	[0..1] SvTapStep	SvTapStep	inherited from: TapChanger
[1..1]	[0..*] TapSchedules	TapSchedule	inherited from: TapChanger
[0..*]	[0..1] PSRType	PSRType	inherited from: PowerSystemResource
[0..1]	[0..*] Measurements	Measurement	inherited from: PowerSystemResource
[1..1]	[0..*] OperatingShare	OperatingShare	inherited from: PowerSystemResource
[0..*]	[0..*] PsrLists	PsrList	inherited from: PowerSystemResource
[1..1]	[0..1] OutageSchedule	OutageSchedule	inherited from: PowerSystemResource
[0..*]	[0..*] ReportingGroup	ReportingGroup	inherited from: PowerSystemResource
[0..1]	[0..*] DiagramObjects	DiagramObject	inherited from: IdentifiedObject
[1..1]	[0..*] Names	Name	inherited from: IdentifiedObject

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6.8.38 PhaseTapChangerSymetrical

Describes a symmetrical phase shifting transformer tap model in which the secondary side voltage magnitude is the same as at the primary side. The difference voltage magnitude is the base in an equal-sided triangle where the sides corresponds to the primary and secondary voltages. The phase angle difference corresponds to the top angle and can be expressed as twice the arctangent of half the total difference voltage.

Table 234 shows all attributes of PhaseTapChangerSymetrical.

Table 234 – Attributes of Wires::PhaseTapChangerSymetrical

name	type	description
voltageStepIncrement	PerCent	inherited from: PhaseTapChangerNonLinear
xMax	Reactance	inherited from: PhaseTapChangerNonLinear
xMedian	Reactance	inherited from: PhaseTapChangerNonLinear
highStep	Integer	inherited from: TapChanger
initialDelay	Seconds	inherited from: TapChanger
lowStep	Integer	inherited from: TapChanger
ltcFlag	Boolean	inherited from: TapChanger
neutralStep	Integer	inherited from: TapChanger
neutralU	Voltage	inherited from: TapChanger
normalStep	Integer	inherited from: TapChanger
regulationStatus	Boolean	inherited from: TapChanger
subsequentDelay	Seconds	inherited from: TapChanger
aliasName	String	inherited from: IdentifiedObject
mRID	String	inherited from: IdentifiedObject
name	String	inherited from: IdentifiedObject

Table 235 shows all association ends of PhaseTapChangerSymetrical with other classes.

Table 235 – Association ends of Wires::PhaseTapChangerSymetrical with other classes

[mult from]	[mult to] name	type	description
[0..1]	[1..1] TransformerEnd	TransformerEnd	inherited from: PhaseTapChanger
[0..*]	[0..1] PhaseTapChangerTabular	PhaseTapChangerTabular	inherited from: PhaseTapChanger
[0..*]	[0..1] TapChangerControl	TapChangerControl	inherited from: TapChanger
[1..1]	[0..1] SvTapStep	SvTapStep	inherited from: TapChanger
[1..1]	[0..*] TapSchedules	TapSchedule	inherited from: TapChanger
[0..*]	[0..1] PSRType	PSRType	inherited from: PowerSystemResource
[0..1]	[0..*] Measurements	Measurement	inherited from: PowerSystemResource
[1..1]	[0..*] OperatingShare	OperatingShare	inherited from: PowerSystemResource
[0..*]	[0..*] PsrLists	PsrList	inherited from: PowerSystemResource
[1..1]	[0..1] OutageSchedule	OutageSchedule	inherited from: PowerSystemResource
[0..*]	[0..*] ReportingGroup	ReportingGroup	inherited from: PowerSystemResource
[0..1]	[0..*] DiagramObjects	DiagramObject	inherited from: IdentifiedObject
[1..1]	[0..*] Names	Name	inherited from: IdentifiedObject

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6.9.68 PhaseTapChangerLinear

Describes a tap changer with a linear relation between the tap step and the phase angle difference across the transformer. This is a mathematical model that is an approximation of a real phase tap changer.

The phase angle is computed as stepPhaseShiftIncrement times the tap position.

The secondary side voltage magnitude is the same as at the primary side.

Table 316 shows all attributes of PhaseTapChangerLinear.

Table 316 – Attributes of Wires::PhaseTapChangerLinear

name	mult	type	description
stepPhaseShiftIncrement	0..1	AngleDegrees	Phase shift per step position. A positive value indicates a positive phase shift from the winding where the tap is located to the other winding (for a two-winding transformer). The actual phase shift increment might be more accurately computed from the symmetrical or asymmetrical models or a tap step table lookup if those are available.
xMax	0..1	Reactance	The reactance depends on the tap position according to a "u" shaped curve. The maximum reactance (xMax) appears at the low and high tap positions.
xMin	0..1	Reactance	The reactance depends on the tap position according to a "u" shaped curve. The minimum reactance (xMin) appears at the mid tap position.
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger
~~regulationStatus~~		~~Boolean~~	~~inherited from: TapChanger~~
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 317 shows all association ends of PhaseTapChangerLinear with other classes.

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Table 317 – Association ends of Wires::PhaseTapChangerLinear with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
~~[0..*]~~	~~[0..1] PhaseTapChangerTabular~~		~~PhaseTapChangerTabular~~	~~inherited from: PhaseTapChanger~~
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

~~6.8.9 CompositeSwitchType datatype~~

~~An alphanumeric code that can be used as a reference to extra information such as the description of the interlocking scheme if any.~~

~~Table 180 shows all attributes of CompositeSwitchType.~~

~~Table 180 – Attributes of Wires::CompositeSwitchType~~

~~name~~	~~type~~	~~description~~
~~multiplier~~	~~UnitMultiplier~~	~~Multiplier.~~
~~unit~~	~~UnitSymbol~~	~~Units.~~
~~value~~	~~String~~	~~Value.~~

6.9.69 Conductor

Combination of conducting material with consistent electrical characteristics, building a single electrical system, used to carry current between points in the power system.

Table 318 shows all attributes of Conductor.

Table 318 – Attributes of Wires::Conductor

name	mult	type	description
length	0..1	Length	Segment length for calculating line section capabilities
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 319 shows all association ends of Conductor with other classes.

Table 319 – Association ends of Wires::Conductor with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

~~6.8.28 OperatingMode datatype~~

~~Textual name for an operating mode.~~

~~Table 216 shows all attributes of OperatingMode.~~

~~Table 216 – Attributes of Wires::OperatingMode~~

~~name~~	~~type~~	~~description~~
~~multiplier~~	~~UnitMultiplier~~	
~~unit~~	~~UnitSymbol~~	
~~value~~	~~String~~	

6.9.70 PerLengthImpedance

Common type for per-length impedance electrical catalogues.

Table 320 shows all attributes of PerLengthImpedance.

Table 320 – Attributes of Wires::PerLengthImpedance

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name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 321 shows all association ends of PerLengthImpedance with other classes.

Table 321 – Association ends of Wires::PerLengthImpedance with other classes

mult from	name	mult to	type	description
0..1	ACLineSegments	0..*	ACLineSegment	All line segments described by this per-length impedance.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.71 FrequencyConverter

A device to convert from one frequency to another (e.g. frequency F1 to F2) comprises a pair of FrequencyConverter instances. One converts from F1 to DC, the other converts the DC to F2.

Table 322 shows all attributes of FrequencyConverter.

Table 322 – Attributes of Wires::FrequencyConverter

name	mult	type	description
frequency	0..1	Frequency	Frequency on the AC side.
maxP	0..1	ActivePower	The maximum active power on the DC side at which the frequence converter should operate.
maxU	0..1	Voltage	The maximum voltage on the DC side at which the frequency converter should operate.
minP	0..1	ActivePower	The minimum active power on the DC side at which the frequence converter should operate.
minU	0..1	Voltage	The minimum voltage on the DC side at which the frequency converter should operate.
~~operatingMode~~		~~OperatingMode~~	~~Operating mode for the frequency converter~~
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 323 shows all association ends of FrequencyConverter with other classes.

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Table 323 – Association ends of Wires::FrequencyConverter with other classes

mult from	name	mult to	type	description
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	~~[1..*]~~ Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.72 Plant

A Plant is a collection of equipment for purposes of generation.

Table 324 shows all attributes of Plant.

Table 324 – Attributes of Wires::Plant

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 325 shows all association ends of Plant with other classes.

Table 325 – Association ends of Wires::Plant with other classes

mult from	name	mult to	type	description
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.73 PhaseTapChangerTablePoint ~~root class~~

Describes each tap step in the phase tap changer tabular curve.

Table 326 shows all attributes of PhaseTapChangerTablePoint.

Table 326 – Attributes of Wires::PhaseTapChangerTablePoint

name	mult	type	description
angle	0..1	AngleDegrees	The angle difference in degrees. A positive value indicates a positive phase shift from the winding where the tap is located to the other winding (for a two-winding transformer).
b	0..1	PerCent	~~The magnetizing branch susceptance deviation in percent of nominal value. The actual susceptance is calculated as follows:~~ ~~calculated magnetizing susceptance = b(nominal) * (1 + b(from this class)/100). The b(nominal) is defined as the static magnetizing susceptance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.~~ inherited from: TapChangerTablePoint
g	0..1	PerCent	~~The magnetizing branch conductance deviation in percent of nominal value. The actual conductance is calculated as follows:~~ ~~calculated magnetizing conductance = b(nominal) * (1 + g(from this class)/100). The g(nominal) is defined as the static magnetizing conductance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.~~ inherited from: TapChangerTablePoint
r	0..1	PerCent	~~The resistance deviation in percent of nominal value. The actual resistance is calculated as follows:~~ ~~calculated resistance = r(nominal) * (1 + r(from this class)/100). The r(nominal) is defined as the static resistance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.~~ inherited from: TapChangerTablePoint
ratio	0..1	Float	inherited from: TapChangerTablePoint
step	0..1	Integer	~~The tap step.~~ inherited from: TapChangerTablePoint

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name	mult	type	description
x	0..1	PerCent	~~The series reactance deviation in percent of nominal value. The actual reactance is calculated as follows:~~ ~~calculated reactance = x(nominal) * (1 + x(from this class)/100). The x(nominal) is defined as the static series reactance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.~~ inherited from: TapChangerTablePoint

Table 327 shows all association ends of PhaseTapChangerTablePoint with other classes.

Table 327 – Association ends of Wires::PhaseTapChangerTablePoint with other classes

mult from	name	mult to	type	description
1..*	PhaseTapChangerTable	1..1	PhaseTapChangerTable	The table of this point.

6.9.74 LoadBreakSwitch

A mechanical switching device capable of making, carrying, and breaking currents under normal operating conditions.

Table 328 shows all attributes of LoadBreakSwitch.

Table 328 – Attributes of Wires::LoadBreakSwitch

name	mult	type	description
breakingCapacity	0..1	CurrentFlow	inherited from: ProtectedSwitch
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 329 shows all association ends of LoadBreakSwitch with other classes.

Table 329 – Association ends of Wires::LoadBreakSwitch with other classes

mult from	name	mult to	type	description
0..*	OperatedByProtectionEquipment	0..*	ProtectionEquipment	inherited from: ProtectedSwitch
1..1	RecloseSequences	0..*	RecloseSequence	inherited from: ProtectedSwitch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch

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mult from	name	mult to	type	description
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
~~[0..*]~~	~~[0..*] SwitchingOperations~~		~~SwitchingOperation~~	~~inherited from: Switch~~
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.75 PetersenCoilModeKind enumeration

The mode of operation for a Petersen coil.

Table 330 shows all literals of PetersenCoilModeKind.

Table 330 – Literals of Wires::PetersenCoilModeKind

literal	value	description
fixed		Fixed position.
manual		Manual positioning.
automaticPositioning		Automatic positioning.

6.9.76 SynchronousMachineKind enumeration

Synchronous machine type.

Table 331 shows all literals of SynchronousMachineKind.

Table 331 – Literals of Wires::SynchronousMachineKind

literal	value	description
generator		
condenser		

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literal	value	description
generatorOrCondenser		
motor		
generatorOrMotor		
motorOrCondenser		
generatorOrCondenserOrMotor		

6.9.77 Connector

A conductor, or group of conductors, with negligible impedance, that serve to connect other conducting equipment within a single substation and are modeled with a single logical terminal.

Table 332 shows all attributes of Connector.

Table 332 – Attributes of Wires::Connector

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 333 shows all association ends of Connector with other classes.

Table 333 – Association ends of Wires::Connector with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.78 AsynchronousMachine

A rotating machine whose shaft rotates asynchronously with the electrical field. Also known as an induction machine with no external connection to the rotor windings, e.g squirrel-cage induction machine.

Table 334 shows all attributes of AsynchronousMachine.

Table 334 – Attributes of Wires::AsynchronousMachine

name	mult	type	description
asynchronousMachineType	0..1	AsynchronousMachineKind	Indicates the type of Asynchronous Machine (motor or generator).
converterFedDrive	0..1	Boolean	Indicates whether the machine is a converter fed drive. Used for short circuit data exchange according to IEC 60909
efficiency	0..1	PerCent	Efficiency of the asynchronous machine at nominal operation as a percentage. Indicator for converter drive motors. Used for short circuit data exchange according to IEC 60909
iaIrRatio	0..1	Float	Ratio of locked-rotor current to the rated current of the motor (Ia/Ir). Used for short circuit data exchange according to IEC 60909
nominalFrequency	0..1	Frequency	Nameplate data indicates if the machine is 50 Hz or 60 Hz.
nominalSpeed	0..1	RotationSpeed	Nameplate data. Depends on the slip and number of pole pairs.
polePairNumber	0..1	Integer	Number of pole pairs of stator. Used for short circuit data exchange according to IEC 60909.
ratedMechanicalPower	0..1	ActivePower	Rated mechanical power (Pr in the IEC 60909-0). Used for short circuit data exchange according to IEC 60909.
reversible	0..1	Boolean	Indicates for converter drive motors if the power can be reversible. Used for short circuit data exchange according to IEC 60909
rr1	0..1	Resistance	Damper 1 winding resistance.
rr2	0..1	Resistance	Damper 2 winding resistance.
rxLockedRotorRatio	0..1	Float	Locked rotor ratio (R/X). Used for short circuit data exchange according to IEC 60909
tpo	0..1	Seconds	Transient rotor time constant (greater than tppo).
tppo	0..1	Seconds	Sub-transient rotor time constant (greater than 0).
xlr1	0..1	Reactance	Damper 1 winding leakage reactance.
xlr2	0..1	Reactance	Damper 2 winding leakage reactance.
xm	0..1	Reactance	Magnetizing reactance.
xp	0..1	Reactance	Transient reactance (unsaturated) (greater than or equal to xpp).
xpp	0..1	Reactance	Sub-transient reactance (unsaturated) (greater than Xl).
xs	0..1	Reactance	Synchronous reactance (greater than xp).
~~damping~~		~~Float~~	~~inherited from: RotatingMachine~~
~~inertia~~		~~Seconds~~	~~inherited from: RotatingMachine~~
ratedPowerFactor	0..1	Float	inherited from: RotatingMachine
p	0..1	ActivePower	inherited from: RotatingMachine
ratedS	0..1	ApparentPower	inherited from: RotatingMachine
~~saturationFactor~~		~~Float~~	~~inherited from: RotatingMachine~~
~~saturationFactor120~~		~~Float~~	~~inherited from: RotatingMachine~~
~~statorLeakageReactance~~		~~Reactance~~	~~inherited from: RotatingMachine~~

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name	mult	type	description
~~statorResistance~~		~~Resistance~~	~~inherited from: RotatingMachine~~
q	0..1	ReactivePower	inherited from: RotatingMachine
ratedU	0..1	Voltage	inherited from: RotatingMachine
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 335 shows all association ends of AsynchronousMachine with other classes.

Table 335 – Association ends of Wires::AsynchronousMachine with other classes

mult from	name	mul t to	type	description
1..1	AsynchronousMachineDynamics	0..1	AsynchronousMachineDynamics	Asynchronous machine dynamics model used to describe dynamic behavior of this asynchronous machine.
1..1	HydroPump	0..1	HydroPump	inherited from: RotatingMachine
1..*	GeneratingUnit	0..1	GeneratingUnit	inherited from: RotatingMachine
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	~~[1..*]~~ Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.79 TapChanger

Mechanism for changing transformer winding tap positions.

Table 336 shows all attributes of TapChanger.

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Table 336 – Attributes of Wires::TapChanger

name	mult	type	description
controlEnabled	0..1	Boolean	Specifies the regulation status of the equipment. True is regulating, false is not regulating.
highStep	0..1	Integer	Highest possible tap step position, advance from neutral. The attribute shall be greater than lowStep.
initialDelay	0..1	Seconds	For an LTC, the delay for initial tap changer operation (first step change)
lowStep	0..1	Integer	Lowest possible tap step position, retard from neutral
ltcFlag	0..1	Boolean	Specifies whether or not a TapChanger has load tap changing capabilities.
neutralStep	0..1	Integer	The neutral tap step position for this winding. The attribute shall be equal or greater than lowStep and equal or less than highStep.
neutralU	0..1	Voltage	Voltage at which the winding operates at the neutral tap setting.
normalStep	0..1	Integer	The tap step position used in "normal" network operation for this winding. For a "Fixed" tap changer indicates the current physical tap setting. The attribute shall be equal to or greater than lowStep and equal to or less than highStep.
~~regulationStatus~~		~~Boolean~~	~~Specifies the default regulation status of the TapChanger. True is regulating. False is not regulating.~~
subsequentDelay	0..1	Seconds	For an LTC, the delay for subsequent tap changer operation (second and later step changes)
step	0..1	Float	Tap changer position. Starting step for a steady state solution. Non integer values are allowed to support continuous tap variables. The reasons for continuous value are to support study cases where no discrete tap changer has yet been designed, a solution where a narrow voltage band forces the tap step to oscillate or accommodate for a continuous solution as input. The attribute shall be equal to or greater than lowStep and equal to or less than highStep.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 337 shows all association ends of TapChanger with other classes.

Table 337 – Association ends of Wires::TapChanger with other classes

mult from	name	mult to	type	description
0..*	TapChangerControl	0..1	TapChangerControl	The regulating control scheme in which this tap changer participates.
1..1	TapSchedules	0..*	TapSchedule	A TapChanger can have TapSchedules.

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mult from	name	mult to	type	description
1..1	SvTapStep	0..1	SvTapStep	The tap step state associated with the tap changer.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.80 ShortCircuitRotorKind enumeration

Type of rotor, used by short circuit applications.

Table 338 shows all literals of ShortCircuitRotorKind.

Table 338 – Literals of Wires::ShortCircuitRotorKind

literal	value	description
salientPole1		Salient pole 1 in the IEC 60909
salientPole2		Salient pole 2 in IEC 60909
turboSeries1		Turbo Series 1 in the IEC 60909
turboSeries2		Turbo series 2 in IEC 60909

6.9.81 WindingConnection enumeration

Winding connection type.

Table 339 shows all literals of WindingConnection.

Table 339 – Literals of Wires::WindingConnection

literal	value	description
D		Delta
Y		Wye
Z		ZigZag
Yn		Wye, with neutral brought out for grounding.
Zn		ZigZag, with neutral brought out for grounding.
A		Autotransformer common winding
I		Independent winding, for single-phase connections.

6.9.82 ExternalNetworkInjection

This class represents the external network and it is used for IEC 60909 calculations.

Table 340 shows all attributes of ExternalNetworkInjection.

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Table 340 – Attributes of Wires::ExternalNetworkInjection

name	mult	type	description
governorSCD	0..1	ActivePowerPerFrequency	Power Frequency Bias. This is the change in power injection divided by the change in frequency and negated. A positive value of the power frequency bias provides additional power injection upon a drop in frequency.
ikSecond	0..1	Boolean	Indicates whether initial symmetrical short-circuit current and power have been calculated according to IEC (Ik").
maxInitialSymShCCurrent	0..1	CurrentFlow	Maximum initial symmetrical short-circuit currents (Ik" max) in A (Ik" = Sk"/(SQRT(3) Un)). Used for short circuit data exchange according to IEC 60909
maxP	0..1	ActivePower	Maximum active power of the injection.
maxQ	0..1	ReactivePower	Not for short circuit modeling; It is used for modeling of infeed for load flow exchange. If maxQ and minQ are not used ReactiveCapabilityCurve can be used
maxR0ToX0Ratio	0..1	Float	Maximum ratio of zero sequence resistance of Network Feeder to its zero sequence reactance (R(0)/X(0) max). Used for short circuit data exchange according to IEC 60909
maxR1ToX1Ratio	0..1	Float	Maximum ratio of positive sequence resistance of Network Feeder to its positive sequence reactance (R(1)/X(1) max). Used for short circuit data exchange according to IEC 60909
maxZ0ToZ1Ratio	0..1	Float	Maximum ratio of zero sequence impedance to its positive sequence impedance (Z(0)/Z(1) max). Used for short circuit data exchange according to IEC 60909
minInitialSymShCCurrent	0..1	CurrentFlow	Minimum initial symmetrical short-circuit currents (Ik" min) in A (Ik" = Sk"/(SQRT(3) Un)). Used for short circuit data exchange according to IEC 60909
minP	0..1	ActivePower	Minimum active power of the injection.
minQ	0..1	ReactivePower	Not for short circuit modeling; It is used for modeling of infeed for load flow exchange. If maxQ and minQ are not used ReactiveCapabilityCurve can be used
minR0ToX0Ratio	0..1	Float	Indicates whether initial symmetrical short-circuit current and power have been calculated according to IEC (Ik"). Used for short circuit data exchange according to IEC 6090
minR1ToX1Ratio	0..1	Float	Minimum ratio of positive sequence resistance of Network Feeder to its positive sequence reactance (R(1)/X(1) min). Used for short circuit data exchange according to IEC 60909
minZ0ToZ1Ratio	0..1	Float	Minimum ratio of zero sequence impedance to its positive sequence impedance (Z(0)/Z(1) min). Used for short circuit data exchange according to IEC 60909
referencePriority	0..1	Integer	Priority of unit for use as powerflow voltage phase angle reference bus selection. 0 = don't care (default) 1 = highest priority. 2 is less than 1 and so on.
voltageFactor	0..1	PU	Voltage factor in pu, which was used to calculate short-circuit current Ik" and power Sk".
p	0..1	ActivePower	Active power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.

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name	mult	type	description
q	0..1	ReactivePower	Reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 341 shows all association ends of ExternalNetworkInjection with other classes.

Table 341 – Association ends of Wires::ExternalNetworkInjection with other classes

mult from	name	mult to	type	description
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.83 AsynchronousMachineKind enumeration

Kind of Asynchronous Machine.

Table 342 shows all literals of AsynchronousMachineKind.

Table 342 – Literals of Wires::AsynchronousMachineKind

literal	value	description
generator		The Asynchronous Machine is a generator.
motor		The Asynchronous Machine is a motor.

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6.9.84 LinearShuntCompensator

A linear shunt compensator has banks or sections with equal admittance values.

Table 343 shows all attributes of LinearShuntCompensator.

Table 343 – Attributes of Wires::LinearShuntCompensator

name	mult	type	description
b0PerSection	0..1	Susceptance	Zero sequence shunt (charging) susceptance per section
bPerSection	0..1	Susceptance	Positive sequence shunt (charging) susceptance per section
g0PerSection	0..1	Conductance	Zero sequence shunt (charging) conductance per section
gPerSection	0..1	Conductance	Positive sequence shunt (charging) conductance per section
aVRDelay	0..1	Seconds	inherited from: ShuntCompensator
grounded	0..1	Boolean	inherited from: ShuntCompensator
maximumSections	0..1	Integer	inherited from: ShuntCompensator
nomU	0..1	Voltage	inherited from: ShuntCompensator
normalSections	0..1	Integer	inherited from: ShuntCompensator
phaseConnection	0..1	PhaseShuntConnectionKind	inherited from: ShuntCompensator
switchOnCount	0..1	Integer	inherited from: ShuntCompensator
switchOnDate	0..1	DateTime	inherited from: ShuntCompensator
voltageSensitivity	0..1	VoltagePerReactivePower	inherited from: ShuntCompensator
sections	0..1	Float	inherited from: ShuntCompensator
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 344 shows all association ends of LinearShuntCompensator with other classes.

Table 344 – Association ends of Wires::LinearShuntCompensator with other classes

mult from	name	mult to	type	description
1..1	ShuntCompensatorPhase	0..*	ShuntCompensatorPhase	inherited from: ShuntCompensator
1..1	SvShuntCompensatorSections	0..1	SvShuntCompensatorSections	inherited from: ShuntCompensator
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment

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mult from	name	mult to	type	description
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.85 NonlinearShuntCompensator

A non linear shunt compensator has bank or section admittance values that differ.

Table 345 shows all attributes of NonlinearShuntCompensator.

Table 345 – Attributes of Wires::NonlinearShuntCompensator

name	mult	type	description
aVRDelay	0..1	Seconds	inherited from: ShuntCompensator
grounded	0..1	Boolean	inherited from: ShuntCompensator
maximumSections	0..1	Integer	inherited from: ShuntCompensator
nomU	0..1	Voltage	inherited from: ShuntCompensator
normalSections	0..1	Integer	inherited from: ShuntCompensator
phaseConnection	0..1	PhaseShuntConnectionKind	inherited from: ShuntCompensator
switchOnCount	0..1	Integer	inherited from: ShuntCompensator
switchOnDate	0..1	DateTime	inherited from: ShuntCompensator
voltageSensitivity	0..1	VoltagePerReactivePower	inherited from: ShuntCompensator
sections	0..1	Float	inherited from: ShuntCompensator
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 346 shows all association ends of NonlinearShuntCompensator with other classes.

Table 346 – Association ends of Wires::NonlinearShuntCompensator with other classes

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mult from	name	mult to	type	description
1..1	NonlinearShuntCompensatorPoints	1..*	NonlinearShuntCompensatorPoint	All points of the non-linear shunt compensator.
1..1	ShuntCompensatorPhase	0..*	ShuntCompensatorPhase	inherited from: ShuntCompensator
1..1	SvShuntCompensatorSections	0..1	SvShuntCompensatorSections	inherited from: ShuntCompensator
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.86 NonlinearShuntCompensatorPoint root class

A non linear shunt compensator bank or section admittance value.

Table 347 shows all attributes of NonlinearShuntCompensatorPoint.

Table 347 – Attributes of Wires::NonlinearShuntCompensatorPoint

name	mult	type	description
b	0..1	Susceptance	Positive sequence shunt (charging) susceptance per section
b0	0..1	Susceptance	Zero sequence shunt (charging) susceptance per section
g	0..1	Conductance	Positive sequence shunt (charging) conductance per section
g0	0..1	Conductance	Zero sequence shunt (charging) conductance per section
sectionNumber	0..1	Integer	The number of the section.

Table 348 shows all association ends of NonlinearShuntCompensatorPoint with other classes.

Table 348 – Association ends of Wires::NonlinearShuntCompensatorPoint with other classes

mult from	name	mult to	type	description
1..*	NonlinearShuntCompensator	1..1	NonlinearShuntCompensator	Non-linear shunt compensator owning this point.

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6.9.87 LinearShuntCompensatorPhase

A per phase linear shunt compensator has banks or sections with equal admittance values.

Table 349 shows all attributes of LinearShuntCompensatorPhase.

Table 349 – Attributes of Wires::LinearShuntCompensatorPhase

name	mult	type	description
bPerSection	0..1	Susceptance	Susceptance per section of the phase if shunt compensator is wye connected. Susceptance per section phase to phase if shunt compensator is delta connected.
gPerSection	0..1	Conductance	Conductance per section for this phase if shunt compensator is wye connected. Conductance per section phase to phase if shunt compensator is delta connected.
maximumSections	0..1	Integer	inherited from: ShuntCompensatorPhase
normalSections	0..1	Integer	inherited from: ShuntCompensatorPhase
phase	0..1	SinglePhaseKind	inherited from: ShuntCompensatorPhase
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 350 shows all association ends of LinearShuntCompensatorPhase with other classes.

Table 350 – Association ends of Wires::LinearShuntCompensatorPhase with other classes

mult from	name	mult to	type	description
0..*	ShuntCompensator	1..1	ShuntCompensator	inherited from: ShuntCompensatorPhase
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.88 NonlinearShuntCompensatorPhase

A per phase non linear shunt compensator has bank or section admittance values that differ.

Table 351 shows all attributes of NonlinearShuntCompensatorPhase.

Table 351 – Attributes of Wires::NonlinearShuntCompensatorPhase

name	mult	type	description
maximumSections	0..1	Integer	inherited from: ShuntCompensatorPhase
normalSections	0..1	Integer	inherited from: ShuntCompensatorPhase
phase	0..1	SinglePhaseKind	inherited from: ShuntCompensatorPhase

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name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 352 shows all association ends of NonlinearShuntCompensatorPhase with other classes.

Table 352 – Association ends of Wires::NonlinearShuntCompensatorPhase with other classes

mult from	name	mult to	type	description
1..1	NonlinearShuntCompensatorPhasePoints	1..*	NonlinearShuntCompensatorPhasePoint	All points of the non-linear shunt compensator phase.
0..*	ShuntCompensator	1..1	ShuntCompensator	inherited from: ShuntCompensatorPhase
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.89 NonlinearShuntCompensatorPhasePoint root class

A per phase non linear shunt compensator bank or section admittance value.

Table 353 shows all attributes of NonlinearShuntCompensatorPhasePoint.

Table 353 – Attributes of Wires::NonlinearShuntCompensatorPhasePoint

name	mult	type	description
b	0..1	Susceptance	Positive sequence shunt (charging) susceptance per section
g	0..1	Conductance	Positive sequence shunt (charging) conductance per section
sectionNumber	0..1	Integer	The number of the section.

Table 354 shows all association ends of NonlinearShuntCompensatorPhasePoint with other classes.

Table 354 – Association ends of Wires::NonlinearShuntCompensatorPhasePoint with other classes

mult from	name	mult to	type	description
1..*	NonlinearShuntCompensatorPhase	1..1	NonlinearShuntCompensatorPhase	Non-linear shunt compensator phase owning this point.

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6.9.90 PerLengthLineParameter

Common type for per-length electrical catalogues describing line parameters.

Table 355 shows all attributes of PerLengthLineParameter.

Table 355 – Attributes of Wires::PerLengthLineParameter

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 356 shows all association ends of PerLengthLineParameter with other classes.

Table 356 – Association ends of Wires::PerLengthLineParameter with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.91 TapChangerTablePoint root class

Table 357 shows all attributes of TapChangerTablePoint.

Table 357 – Attributes of Wires::TapChangerTablePoint

name	mult	type	description
b	0..1	PerCent	The magnetizing branch susceptance deviation as a percentage of nominal value. The actual susceptance is calculated as follows: calculated magnetizing susceptance = b(nominal) * (1 + b(from this class)/100). The b(nominal) is defined as the static magnetizing susceptance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.
g	0..1	PerCent	The magnetizing branch conductance deviation as a percentage of nominal value. The actual conductance is calculated as follows: calculated magnetizing conductance = g(nominal) * (1 + g(from this class)/100). The g(nominal) is defined as the static magnetizing conductance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.
r	0..1	PerCent	The resistance deviation as a percentage of nominal value. The actual reactance is calculated as follows: calculated resistance = r(nominal) * (1 + r(from this class)/100). The r(nominal) is defined as the static resistance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.
ratio	0..1	Float	The voltage ratio in per unit. Hence this is a value close to one.

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name	mult	type	description
step	0..1	Integer	The tap step.
x	0..1	PerCent	The series reactance deviation as a percentage of nominal value. The actual reactance is calculated as follows: calculated reactance = x(nominal) * (1 + x(from this class)/100). The x(nominal) is defined as the static series reactance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.

6.9.92 PhaseTapChangerTabular

~~Describes a tabular curve for how the the phase angle difference and impedance varies with the tap step.~~

Table 358 shows all attributes of PhaseTapChangerTabular.

Table 358 – Attributes of Wires::PhaseTapChangerTabular

name	mult	type	description
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 359 shows all association ends of PhaseTapChangerTabular with other classes.

Table 359 – Association ends of Wires::PhaseTapChangerTabular with other classes

mult from	name	mult to	type	description
~~[0..1]~~	~~[0..*] PhaseTapChanger~~		~~PhaseTapChanger~~	~~The phase tap changers to which this phase tap table applies.~~
~~[1..1]~~	~~[1..*] PhaseTapChangerTabularPoint~~		~~PhaseTapChangerTabularPoint~~	~~The points of this table.~~
0..*	PhaseTapChangerTable	0..1	PhaseTapChangerTable	The phase tap changer table for this phase tap changer.
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.93 PowerElectronicsConnection

A connection to the AC network for energy production or consumption that uses power electronics rather than rotating machines.

Table 360 shows all attributes of PowerElectronicsConnection.

Table 360 – Attributes of Wires::PowerElectronicsConnection

name	mult	type	description
maxQ	0..1	ReactivePower	Maximum reactive power limit. This is the maximum (nameplate) limit for the unit.
minQ	0..1	ReactivePower	Minimum reactive power limit for the unit. This is the minimum (nameplate) limit for the unit.
ratedS	0..1	ApparentPower	Nameplate apparent power rating for the unit. The attribute shall have a positive value.
ratedU	0..1	Voltage	Rated voltage (nameplate data, Ur in IEC 60909-0). It is primarily used for short circuit data exchange according to IEC 60909.
p	0..1	ActivePower	Active power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.
q	0..1	ReactivePower	Reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.
r	0..1	Resistance	Equivalent resistance (RG) of generator. RG is considered for the calculation of all currents, except for the calculation of the peak current ip. Used for short circuit data exchange according to IEC 60909.
r0	0..1	Resistance	Zero sequence resistance of the synchronous machine.
rn	0..1	Resistance	Negative sequence Thevenin resistance.
x	0..1	Reactance	Positive sequence Thevenin reactance.
x0	0..1	Reactance	Zero sequence Thevenin reactance.
xn	0..1	Reactance	Negative sequence Thevenin reactance.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 361 shows all association ends of PowerElectronicsConnection with other classes.

Table 361 – Association ends of Wires::PowerElectronicsConnection with other classes

mult from	name	mult to	type	description
1..1	PowerElectronicsUnit	0..*	PowerElectronicsUnit	An AC network connection may have several power electronics units connecting through it.
1..1	WindTurbineType3or4Dynamics	0..1	WindTurbineType3or4Dynamics	The wind turbine type 3 or 4 dynamics model associated with this power electronics connection.
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10 Package Generation

6.10.1 General

This package contains packages that have information for Unit Commitment and Economic Dispatch of Hydro and Thermal Generating Units, Load Forecasting, Automatic Generation Control, and Unit Modeling for Dynamic Training Simulator.

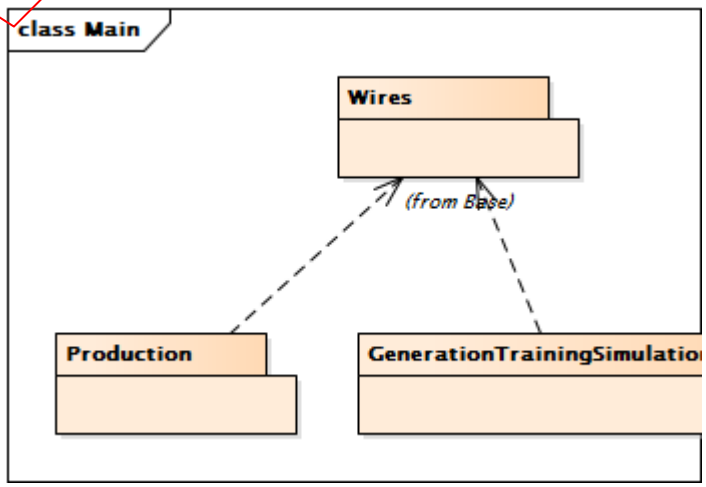


Figure 99 – Class diagram Generation::Main

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Figure 99: This diagram shows the main generation packages and their dependency relationships to other packages.

6.10.2 Package Generation~~Dynamics~~TrainingSimulation

6.10.2.1 General

The Generation Dynamics package contains prime movers, such as turbines and boilers, which are needed for simulation and educational purposes.

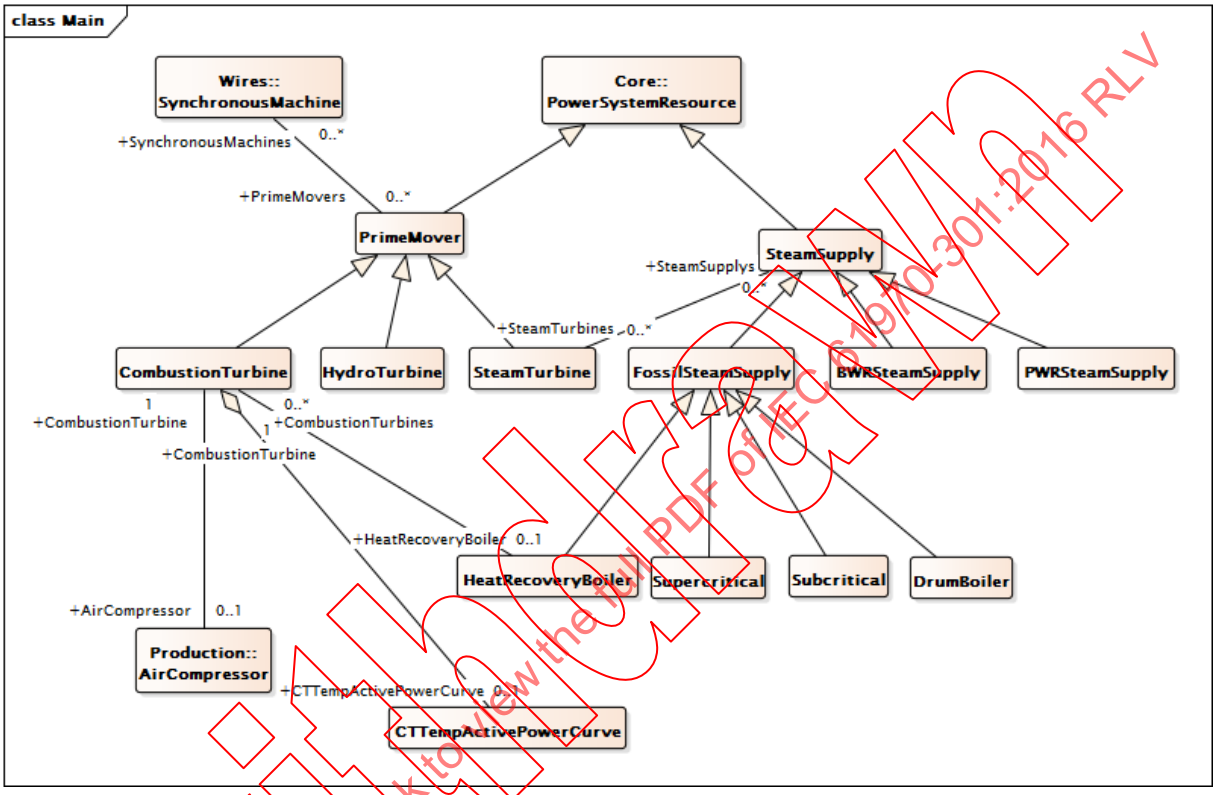


Figure 100 – Class diagram Generation~~Dynamics~~TrainingSimulation::Main

Figure 100: This diagram shows all classes included in the GenerationDynamics package as well as the key external classes that have associations with these classes.

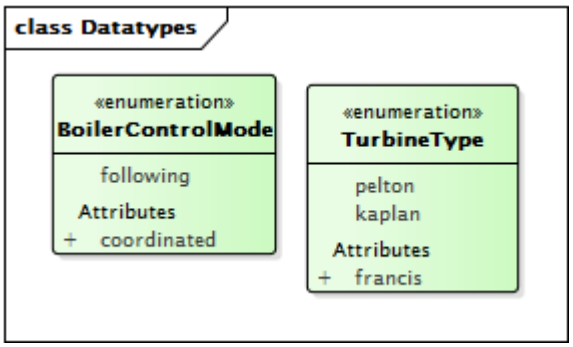


Figure 101 – Class diagram Generation~~Dynamics~~TrainingSimulation::Datatypes

Figure 101: This diagram shows the data types specific to the GenerationDynamics package.

6.10.2.2 BWRSteamSupply

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Boiling water reactor used as a steam supply to a steam turbine.

Table 362 shows all attributes of BWRSteamSupply.

Table 362 – Attributes of Generation~~Dynamics~~TrainingSimulation::BWRSteamSupply

name	mult	type	description
highPowerLimit	0..1	PU	High power limit.
inCoreThermalTC	0..1	Seconds	In-core thermal time constant.
integralGain	0..1	Float	Integral gain.
lowerLimit	0..1	PU	Initial lower limit.
lowPowerLimit	0..1	PU	Low power limit.
pressureLimit	0..1	PU	Pressure limit.
pressureSetpointGA	0..1	Float	Pressure setpoint gain adjuster.
pressureSetpointTC1	0..1	Seconds	Pressure setpoint time constant.
pressureSetpointTC2	0..1	Seconds	Pressure setpoint time constant.
proportionalGain	0..1	Float	Proportional gain.
rfAux1	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux2	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux3	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux4	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux5	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux6	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux7	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux8	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rodPattern	0..1	PU	Rod pattern.
rodPatternConstant	0..1	Float	Constant associated with rod pattern.
upperLimit	0..1	PU	Initial upper limit.
steamSupplyRating	0..1	Float	inherited from: SteamSupply
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 363 shows all association ends of BWRSteamSupply with other classes.

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Table 363 – Association ends of GenerationDynamicsTrainingSimulation::BWRSteamSupply with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
[0..*]	[0..*] PsrLists		PsrList	inherited from: PowerSystemResource
[1..1]	[0..1] OutageSchedule		OutageSchedule	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.3 BoilerControlMode enumeration

Boiler control mode.

Table 364 shows all literals of BoilerControlMode.

Table 364 – Literals of GenerationDynamicsTrainingSimulation::BoilerControlMode

literal	value	description
following		Following.
coordinated		Coordinated.

6.10.2.4 CTTempActivePowerCurve

Relationship between the combustion turbine's power output rating in gross active power (X-axis) and the ambient air temperature (Y-axis).

Table 365 shows all attributes of CTTempActivePowerCurve.

Table 365 – Attributes of GenerationDynamicsTrainingSimulation::CTTempActivePowerCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 366 shows all association ends of CTTempActivePowerCurve with other classes.

Table 366 – Association ends of GenerationDynamicsTrainingSimulation::CTTempActivePowerCurve with other classes

mult from	name	mult to	type	description
0..1	CombustionTurbine	1..1	CombustionTurbine	A combustion turbine may have an active power versus ambient temperature relationship.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.5 CombustionTurbine

A prime mover that is typically fueled by gas or light oil.

Table 367 shows all attributes of CombustionTurbine.

Table 367 – Attributes of GenerationDynamicsTrainingSimulation::CombustionTurbine

name	mult	type	description
ambientTemp	0..1	Temperature	Default ambient temperature to be used in modeling applications.
auxPowerVersusFrequency	0..1	PU	Off-nominal frequency effect on turbine auxiliaries. Per unit reduction in auxiliary active power consumption versus per unit reduction in frequency (from rated frequency).
auxPowerVersusVoltage	0..1	PU	Off-nominal voltage effect on turbine auxiliaries. Per unit reduction in auxiliary active power consumption versus per unit reduction in auxiliary bus voltage (from a specified voltage level).
capabilityVersusFrequency	0..1	PU	Off-nominal frequency effect on turbine capability. Per unit reduction in unit active power capability versus per unit reduction in frequency (from rated frequency).
heatRecoveryFlag	0..1	Boolean	Flag that is set to true if the combustion turbine is associated with a heat recovery boiler.
powerVariationByTemp	0..1	PU	Per unit change in power per (versus) unit change in ambient temperature.
referenceTemp	0..1	Temperature	Reference temperature at which the output of the turbine was defined.
timeConstant	0..1	Seconds	The time constant for the turbine.
primeMoverRating	0..1	Float	inherited from: PrimeMover
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 368 shows all association ends of CombustionTurbine with other classes.

Table 368 – Association ends of Generation~~Dynamics~~ TrainingSimulation::CombustionTurbine with other classes

mult from	name	mult to	type	description
1..1	AirCompressor	0..1	AirCompressor	A CAES air compressor is driven by combustion turbine.
1..1	CTTempActivePowerCurve	0..1	CTTempActivePowerCurve	A combustion turbine may have an active power versus ambient temperature relationship.
0..*	HeatRecoveryBoiler	0..1	HeatRecoveryBoiler	A combustion turbine may have a heat recovery boiler for making steam.
0..*	SynchronousMachines	0..*	SynchronousMachine	inherited from: PrimeMover
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.6 DrumBoiler

Drum boiler.

Table 369 shows all attributes of DrumBoiler.

Table 369 – Attributes of Generation~~Dynamics~~TrainingSimulation::DrumBoiler

name	mult	type	description
drumBoilerRating	0..1	Float	Rating of drum boiler in steam units.
auxPowerVersusFrequency	0..1	PU	inherited from: FossilSteamSupply
auxPowerVersusVoltage	0..1	PU	inherited from: FossilSteamSupply
boilerControlMode	0..1	BoilerControlMode	inherited from: FossilSteamSupply
controlErrorBiasP	0..1	Float	inherited from: FossilSteamSupply
controlIC	0..1	Float	inherited from: FossilSteamSupply
controlPC	0..1	Float	inherited from: FossilSteamSupply
controlPEB	0..1	Float	inherited from: FossilSteamSupply
controlPED	0..1	PU	inherited from: FossilSteamSupply
controlTC	0..1	Float	inherited from: FossilSteamSupply
feedWaterIG	0..1	Float	inherited from: FossilSteamSupply
feedWaterPG	0..1	Float	inherited from: FossilSteamSupply
feedWaterTC	0..1	Seconds	inherited from: FossilSteamSupply
fuelDemandLimit	0..1	PU	inherited from: FossilSteamSupply
fuelSupplyDelay	0..1	Seconds	inherited from: FossilSteamSupply

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name	mult	type	description
fuelSupplyTC	0..1	Seconds	inherited from: FossilSteamSupply
maxErrorRateP	0..1	Float	inherited from: FossilSteamSupply
mechPowerSensorLag	0..1	Seconds	inherited from: FossilSteamSupply
minErrorRateP	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlDG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlIG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlPG	0..1	Float	inherited from: FossilSteamSupply
pressureFeedback	0..1	Integer	inherited from: FossilSteamSupply
superHeater1Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeater2Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeaterPipePD	0..1	Float	inherited from: FossilSteamSupply
throttlePressureSP	0..1	PU	inherited from: FossilSteamSupply
steamSupplyRating	0..1	Float	inherited from: SteamSupply
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 370 shows all association ends of DrumBoiler with other classes.

Table 370 – Association ends of Generation~~Dynamics~~TrainingSimulation::DrumBoiler with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.7 FossilSteamSupply

Fossil fueled boiler (e.g. coal, oil, gas).

Table 371 shows all attributes of FossilSteamSupply.

Table 371 – Attributes of Generation~~Dynamics~~TrainingSimulation::FossilSteamSupply

name	mult	type	description
auxPowerVersusFrequency	0..1	PU	Off nominal frequency effect on auxiliary real power. Per unit active power variation versus per unit frequency variation.

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name	mult	type	description
auxPowerVersusVoltage	0..1	PU	Off nominal voltage effect on auxiliary real power. Per unit active power variation versus per unit voltage variation.
boilerControlMode	0..1	BoilerControlMode	The control mode of the boiler.
controlErrorBiasP	0..1	Float	Active power error bias ratio.
controlIC	0..1	Float	Integral constant.
controlPC	0..1	Float	Proportional constant.
controlPEB	0..1	Float	Pressure error bias ratio.
controlPED	0..1	PU	Pressure error deadband.
controlTC	0..1	Float	Time constant.
feedWaterIG	0..1	Float	Feedwater integral gain ratio.
feedWaterPG	0..1	Float	Feedwater proportional gain ratio.
feedWaterTC	0..1	Seconds	Feedwater time constant ratio.
fuelDemandLimit	0..1	PU	Fuel demand limit.
fuelSupplyDelay	0..1	Seconds	Fuel delay.
fuelSupplyTC	0..1	Seconds	Fuel supply time constant.
maxErrorRateP	0..1	Float	Active power maximum error rate limit.
mechPowerSensorLag	0..1	Seconds	Mechanical power sensor lag.
minErrorRateP	0..1	Float	Active power minimum error rate limit.
pressureCtrlDG	0..1	Float	Pressure control derivative gain ratio.
pressureCtrlIG	0..1	Float	Pressure control integral gain ratio.
pressureCtrlPG	0..1	Float	Pressure control proportional gain ratio.
pressureFeedback	0..1	Integer	Pressure feedback indicator.
superHeater1Capacity	0..1	Float	Drum/primary superheater capacity.
superHeater2Capacity	0..1	Float	Secondary superheater capacity.
superHeaterPipePD	0..1	Float	Superheater pipe pressure drop constant.
throttlePressureSP	0..1	PU	Throttle pressure setpoint.
steamSupplyRating	0..1	Float	inherited from: SteamSupply
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 372 shows all association ends of FossilSteamSupply with other classes.

Table 372 – Association ends of GenerationDynamicsTrainingSimulation::FossilSteamSupply with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~

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mult from	name	mult to	type	description
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.8 HeatRecoveryBoiler

The heat recovery system associated with combustion turbines in order to produce steam for combined cycle plants.

Table 373 shows all attributes of HeatRecoveryBoiler.

Table 373 – Attributes of Generation~~Dynamics~~TrainingSimulation::HeatRecoveryBoiler

name	mult	type	description
steamSupplyRating2	0..1	Float	The steam supply rating in kilopounds per hour, if dual pressure boiler.
auxPowerVersusFrequency	0..1	PU	inherited from: FossilSteamSupply
auxPowerVersusVoltage	0..1	PU	inherited from: FossilSteamSupply
boilerControlMode	0..1	BoilerControlMode	inherited from: FossilSteamSupply
controlErrorBiasP	0..1	Float	inherited from: FossilSteamSupply
controlIC	0..1	Float	inherited from: FossilSteamSupply
controlPC	0..1	Float	inherited from: FossilSteamSupply
controlPEB	0..1	Float	inherited from: FossilSteamSupply
controlPED	0..1	PU	inherited from: FossilSteamSupply
controlTC	0..1	Float	inherited from: FossilSteamSupply
feedWaterIG	0..1	Float	inherited from: FossilSteamSupply
feedWaterPG	0..1	Float	inherited from: FossilSteamSupply
feedWaterTC	0..1	Seconds	inherited from: FossilSteamSupply
fuelDemandLimit	0..1	PU	inherited from: FossilSteamSupply
fuelSupplyDelay	0..1	Seconds	inherited from: FossilSteamSupply
fuelSupplyTC	0..1	Seconds	inherited from: FossilSteamSupply
maxErrorRateP	0..1	Float	inherited from: FossilSteamSupply
mechPowerSensorLag	0..1	Seconds	inherited from: FossilSteamSupply
minErrorRateP	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlDG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlIG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlPG	0..1	Float	inherited from: FossilSteamSupply
pressureFeedback	0..1	Integer	inherited from: FossilSteamSupply
superHeater1Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeater2Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeaterPipePD	0..1	Float	inherited from: FossilSteamSupply
throttlePressureSP	0..1	PU	inherited from: FossilSteamSupply
steamSupplyRating	0..1	Float	inherited from: SteamSupply
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 374 shows all association ends of HeatRecoveryBoiler with other classes.

Table 374 – Association ends of GenerationDynamicsTrainingSimulation::HeatRecoveryBoiler with other classes

mult from	name	mult to	type	description
0..1	CombustionTurbines	0..*	CombustionTurbine	A combustion turbine may have a heat recovery boiler for making steam.
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.9 HydroTurbine

A water driven prime mover. Typical turbine types are: Francis, Kaplan, and Pelton.

Table 375 shows all attributes of HydroTurbine.

Table 375 – Attributes of GenerationDynamicsTrainingSimulation::HydroTurbine

name	mult	type	description
gateRateLimit	0..1	Float	Gate rate limit.
gateUpperLimit	0..1	PU	Gate upper limit.
maxHeadMaxP	0..1	ActivePower	Maximum efficiency active power at maximum head conditions.
minHeadMaxP	0..1	ActivePower	Maximum efficiency active power at minimum head conditions.
speedRating	0..1	RotationSpeed	Rated speed in number of revolutions.
speedRegulation	0..1	PU	Speed regulation.
transientDroopTime	0..1	Seconds	Transient droop time constant.
transientRegulation	0..1	PU	Transient regulation.
turbineRating	0..1	ActivePower	Rated turbine active power.
turbineType	0..1	TurbineType	Type of turbine.
waterStartingTime	0..1	Seconds	Water starting time.
primeMoverRating	0..1	Float	inherited from: PrimeMover
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
name	0..1	String	inherited from: IdentifiedObject

Table 376 shows all association ends of HydroTurbine with other classes.

Table 376 – Association ends of Generation~~Dynamics~~TrainingSimulation::HydroTurbine with other classes

mult from	name	mult to	type	description
0..*	SynchronousMachines	0..*	SynchronousMachine	inherited from: PrimeMover
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.10 PWRSteamSupply

Pressurized water reactor used as a steam supply to a steam turbine.

Table 377 shows all attributes of PWRSteamSupply.

Table 377 – Attributes of Generation~~Dynamics~~TrainingSimulation::PWRSteamSupply

name	mult	type	description
coldLegFBLagTC	0..1	PU	Cold leg feedback lag time constant.
coldLegFBLeadTC1	0..1	PU	Cold leg feedback lead time constant.
coldLegFBLeadTC2	0..1	PU	Cold leg feedback lead time constant.
coldLegFG1	0..1	PU	Cold leg feedback gain 1.
coldLegFG2	0..1	PU	Cold leg feedback gain 2.
coldLegLagTC	0..1	PU	Cold leg lag time constant.
coreHTLagTC1	0..1	PU	Core heat transfer lag time constant.
coreHTLagTC2	0..1	PU	Core heat transfer lag time constant.
coreNeutronicsEffTC	0..1	PU	Core neutronics effective time constant.
coreNeutronicsHT	0..1	PU	Core neutronics and heat transfer.
feedbackFactor	0..1	PU	Feedback factor.
hotLegLagTC	0..1	PU	Hot leg lag time constant.
hotLegSteamGain	0..1	PU	Hot leg steam gain.
hotLegToColdLegGain	0..1	PU	Hot leg to cold leg gain.
pressureCG	0..1	PU	Pressure control gain.
steamFlowFG	0..1	PU	Steam flow feedback gain.
steamPressureDropLagTC	0..1	PU	Steam pressure drop lag time constant.
steamPressureFG	0..1	PU	Steam pressure feedback gain.
throttlePressureFactor	0..1	PU	Throttle pressure factor.
throttlePressureSP	0..1	PU	Throttle pressure setpoint.
steamSupplyRating	0..1	Float	inherited from: SteamSupply

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name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 378 shows all association ends of PWRSteamSupply with other classes.

Table 378 – Association ends of GenerationDynamicsTrainingSimulation::PWRSteamSupply with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.11 PrimeMover

The machine used to develop mechanical energy used to drive a generator.

Table 379 shows all attributes of PrimeMover.

Table 379 – Attributes of GenerationDynamicsTrainingSimulation::PrimeMover

name	mult	type	description
primeMoverRating	0..1	Float	Rating of prime mover.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 380 shows all association ends of PrimeMover with other classes.

Table 380 – Association ends of GenerationDynamicsTrainingSimulation::PrimeMover with other classes

mult from	name	mult to	type	description
0..*	SynchronousMachines	0..*	SynchronousMachine	Synchronous machines this Prime mover drives.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.12 SteamSupply

Steam supply for steam turbine.

Table 381 shows all attributes of SteamSupply.

Table 381 – Attributes of Generation~~Dynamics~~TrainingSimulation::SteamSupply

name	mult	type	description
steamSupplyRating	0..1	Float	Rating of steam supply.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 382 shows all association ends of SteamSupply with other classes.

Table 382 – Association ends of Generation~~Dynamics~~TrainingSimulation::SteamSupply with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	Steam turbines may have steam supplied by a steam supply.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.13 SteamTurbine

Steam turbine.

Table 383 shows all attributes of SteamTurbine.

Table 383 – Attributes of Generation~~Dynamics~~TrainingSimulation::SteamTurbine

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name	mult	type	description
crossoverTC	0..1	Seconds	Crossover time constant.
reheater1TC	0..1	Seconds	First reheater time constant.
reheater2TC	0..1	Seconds	Second reheater time constant.
shaft1PowerHP	0..1	Float	Fraction of power from shaft 1 high pressure turbine output.
shaft1PowerIP	0..1	Float	Fraction of power from shaft 1 intermediate pressure turbine output.
shaft1PowerLP1	0..1	Float	Fraction of power from shaft 1 first low pressure turbine output.
shaft1PowerLP2	0..1	Float	Fraction of power from shaft 1 second low pressure turbine output.
shaft2PowerHP	0..1	Float	Fraction of power from shaft 2 high pressure turbine output.
shaft2PowerIP	0..1	Float	Fraction of power from shaft 2 intermediate pressure turbine output.
shaft2PowerLP1	0..1	Float	Fraction of power from shaft 2 first low pressure turbine output.
shaft2PowerLP2	0..1	Float	Fraction of power from shaft 2 second low pressure turbine output.
steamChestTC	0..1	Seconds	Steam chest time constant.
primeMoverRating	0..1	Float	inherited from: PrimeMover
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 384 shows all association ends of SteamTurbine with other classes.

Table 384 – Association ends of Generation~~Dynamics~~TrainingSimulation::SteamTurbine with other classes

mult from	name	mult to	type	description
0..*	SteamSupplys	0..*	SteamSupply	Steam turbines may have steam supplied by a steam supply.
0..*	SynchronousMachines	0..*	SynchronousMachine	inherited from: PrimeMover
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.14 Subcritical

Once-through subcritical boiler.

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Table 385 shows all attributes of Subcritical.

Table 385 – Attributes of Generation~~Dynamics~~TrainingSimulation::Subcritical

name	mult	type	description
auxPowerVersusFrequency	0..1	PU	inherited from: FossilSteamSupply
auxPowerVersusVoltage	0..1	PU	inherited from: FossilSteamSupply
boilerControlMode	0..1	BoilerControlMode	inherited from: FossilSteamSupply
controlErrorBiasP	0..1	Float	inherited from: FossilSteamSupply
controlIC	0..1	Float	inherited from: FossilSteamSupply
controlPC	0..1	Float	inherited from: FossilSteamSupply
controlPEB	0..1	Float	inherited from: FossilSteamSupply
controlPED	0..1	PU	inherited from: FossilSteamSupply
controlTC	0..1	Float	inherited from: FossilSteamSupply
feedWaterIG	0..1	Float	inherited from: FossilSteamSupply
feedWaterPG	0..1	Float	inherited from: FossilSteamSupply
feedWaterTC	0..1	Seconds	inherited from: FossilSteamSupply
fuelDemandLimit	0..1	PU	inherited from: FossilSteamSupply
fuelSupplyDelay	0..1	Seconds	inherited from: FossilSteamSupply
fuelSupplyTC	0..1	Seconds	inherited from: FossilSteamSupply
maxErrorRateP	0..1	Float	inherited from: FossilSteamSupply
mechPowerSensorLag	0..1	Seconds	inherited from: FossilSteamSupply
minErrorRateP	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlDG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlIG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlPG	0..1	Float	inherited from: FossilSteamSupply
pressureFeedback	0..1	Integer	inherited from: FossilSteamSupply
superHeater1Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeater2Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeaterPipePD	0..1	Float	inherited from: FossilSteamSupply
throttlePressureSP	0..1	PU	inherited from: FossilSteamSupply
steamSupplyRating	0..1	Float	inherited from: SteamSupply
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 386 shows all association ends of Subcritical with other classes.

Table 386 – Association ends of Generation~~Dynamics~~TrainingSimulation::Subcritical with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.15 Supercritical

Once-through supercritical boiler.

Table 387 shows all attributes of Supercritical.

Table 387 – Attributes of Generation~~Dynamics~~TrainingSimulation::Supercritical

name	mult	type	description
auxPowerVersusFrequency	0..1	PU	inherited from: FossilSteamSupply
auxPowerVersusVoltage	0..1	PU	inherited from: FossilSteamSupply
boilerControlMode	0..1	BoilerControlMode	inherited from: FossilSteamSupply
controlErrorBiasP	0..1	Float	inherited from: FossilSteamSupply
controlIC	0..1	Float	inherited from: FossilSteamSupply
controlPC	0..1	Float	inherited from: FossilSteamSupply
controlPEB	0..1	Float	inherited from: FossilSteamSupply
controlPED	0..1	PU	inherited from: FossilSteamSupply
controlTC	0..1	Float	inherited from: FossilSteamSupply
feedWaterIG	0..1	Float	inherited from: FossilSteamSupply
feedWaterPG	0..1	Float	inherited from: FossilSteamSupply
feedWaterTC	0..1	Seconds	inherited from: FossilSteamSupply
fuelDemandLimit	0..1	PU	inherited from: FossilSteamSupply
fuelSupplyDelay	0..1	Seconds	inherited from: FossilSteamSupply
fuelSupplyTC	0..1	Seconds	inherited from: FossilSteamSupply
maxErrorRateP	0..1	Float	inherited from: FossilSteamSupply
mechPowerSensorLag	0..1	Seconds	inherited from: FossilSteamSupply
minErrorRateP	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlDG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlIG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlPG	0..1	Float	inherited from: FossilSteamSupply
pressureFeedback	0..1	Integer	inherited from: FossilSteamSupply
superHeater1Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeater2Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeaterPipePD	0..1	Float	inherited from: FossilSteamSupply
throttlePressureSP	0..1	PU	inherited from: FossilSteamSupply
steamSupplyRating	0..1	Float	inherited from: SteamSupply
aliasName	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 388 shows all association ends of Supercritical with other classes.

Table 388 – Association ends of Generation~~Dynamics~~TrainingSimulation::Supercritical with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.16 TurbineType enumeration

Type of turbine.

Table 389 shows all literals of TurbineType.

Table 389 – Literals of Generation~~Dynamics~~TrainingSimulation::TurbineType

literal	value	description
francis		Francis.
pelton		Pelton.
kaplan		Kaplan.

6.10.3 Package Production

6.10.3.1 General

The production package is responsible for classes which describe various kinds of generators. These classes also provide production costing information which is used to economically allocate demand among committed units and calculate reserve quantities.

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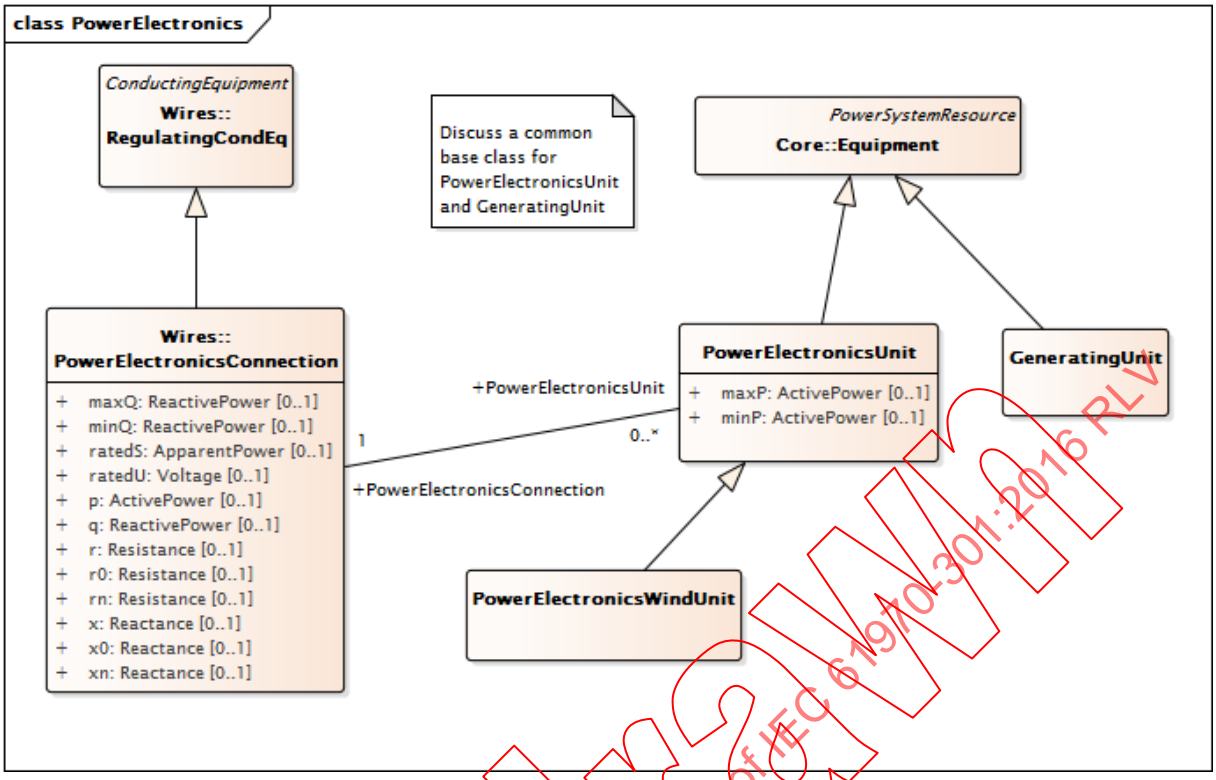


Figure 102 – Class diagram Production::PowerElectronics

Figure 102:

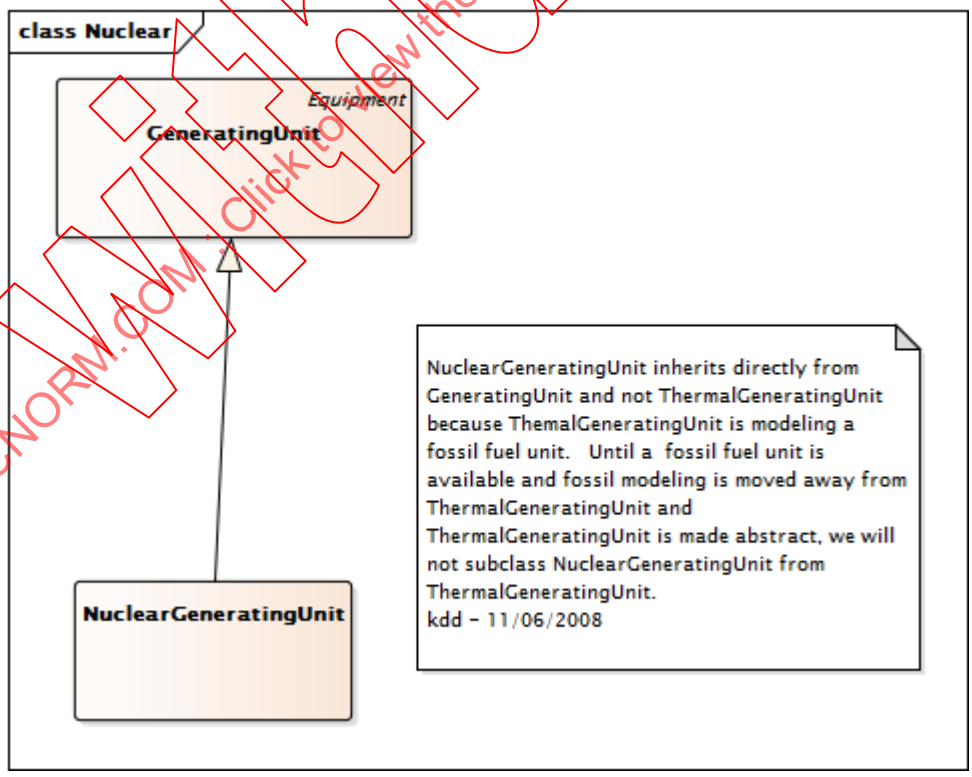


Figure 103 – Class diagram Production::Nuclear

Figure 103: This diagram shows nuclear generation inheritance.

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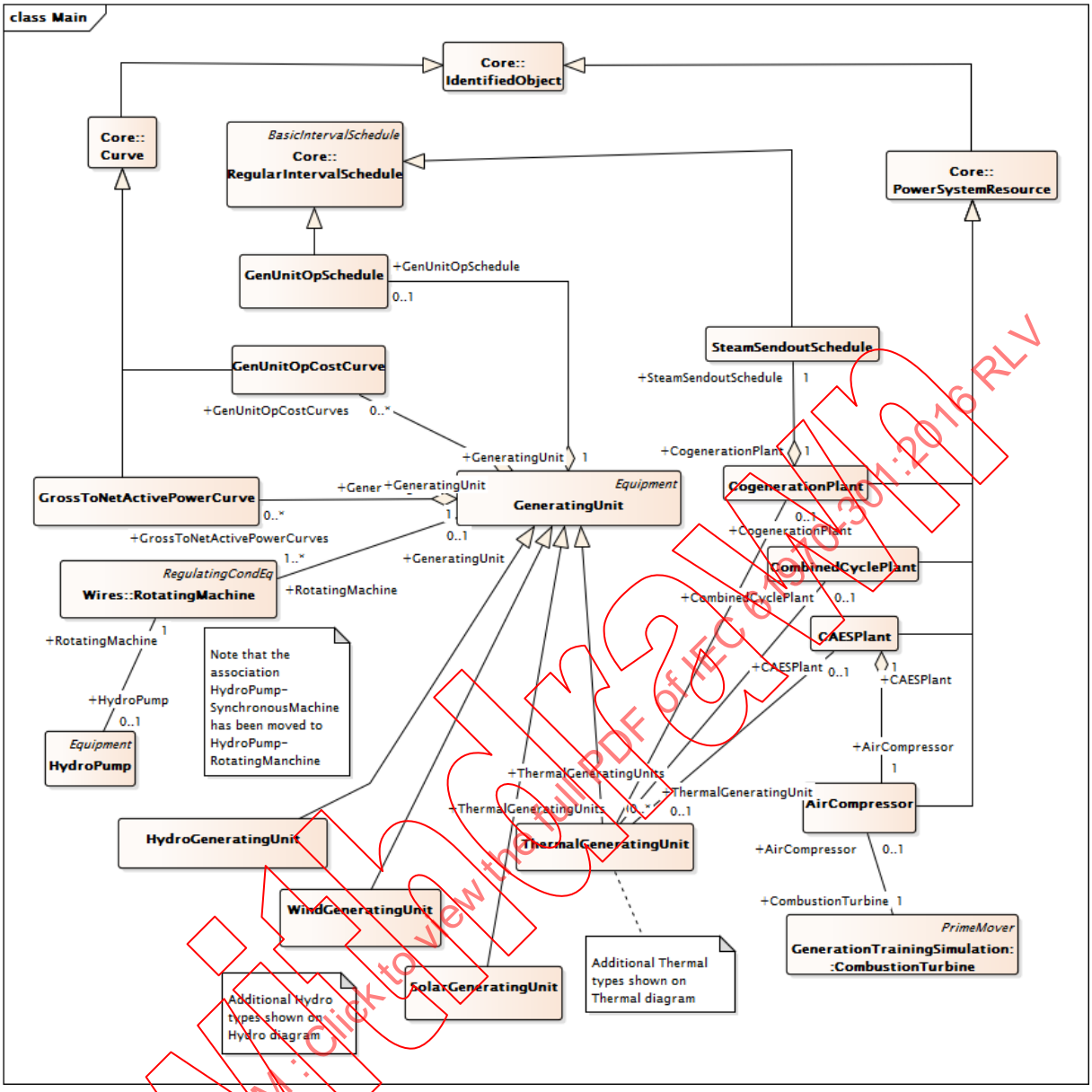
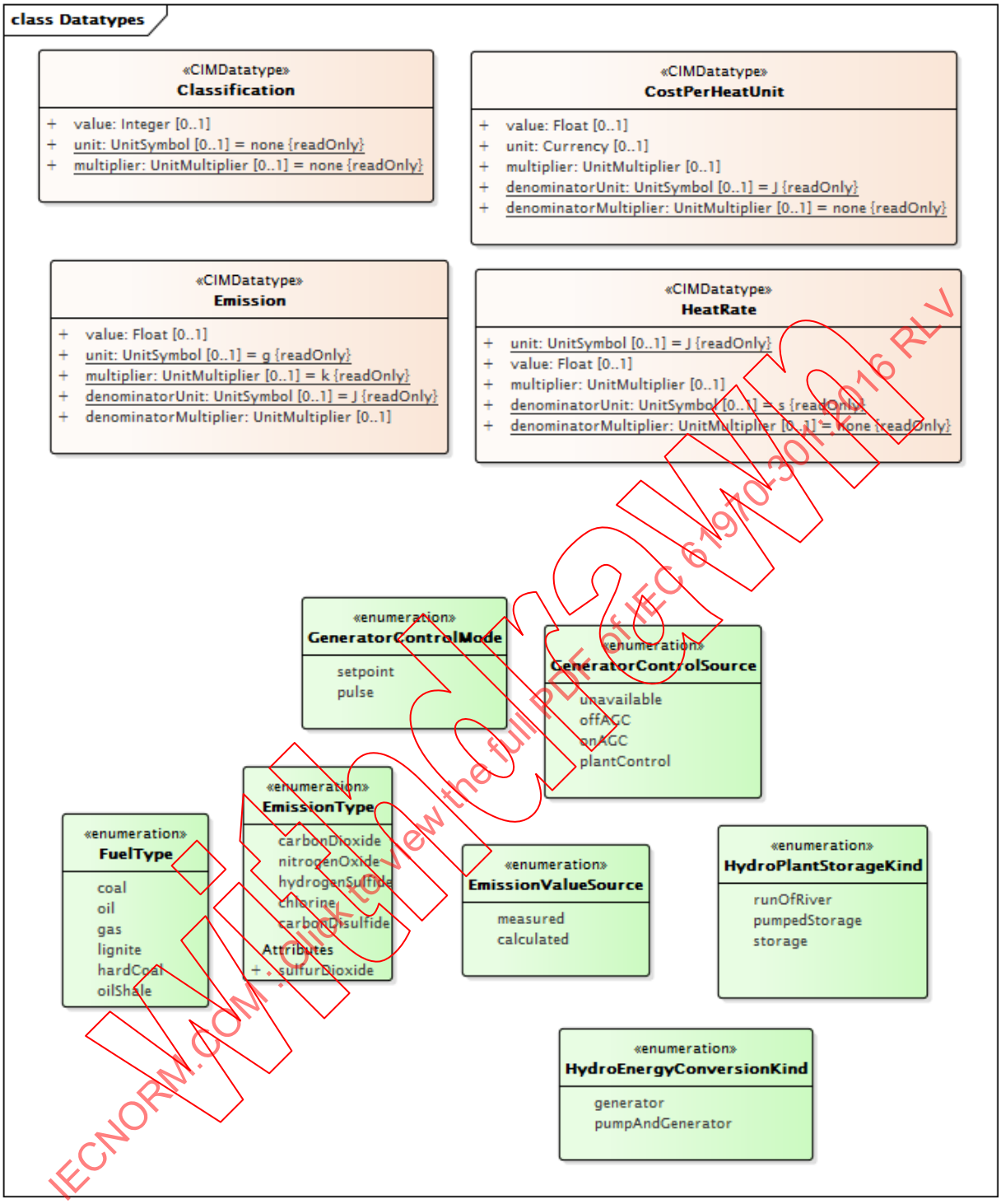


Figure 104 – Class diagram Production::Main

Figure 104: This diagram shows all classes included in the Production package that are needed by both Hydro and Thermal generation. It also shows key external classes that have associations with Production classes.

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Figure 105 – Class diagram Production::Datatypes

Figure 105: This diagram show the data types specific to the Production package.

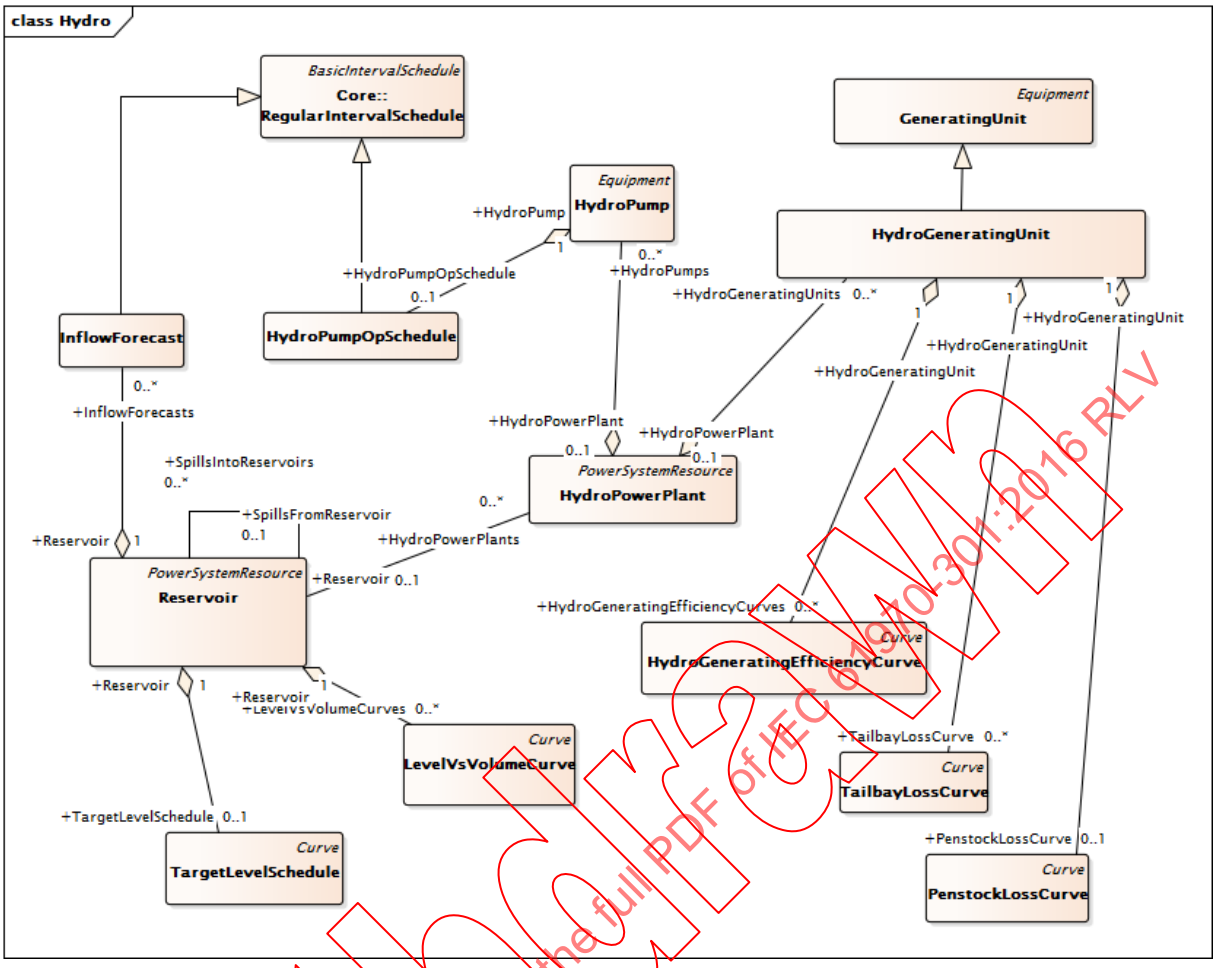


Figure 106 – Class diagram Production::Hydro

Figure 106: This diagram shows all classes included in the Hydro package as well as the key external classes that have associations with Hydro classes.

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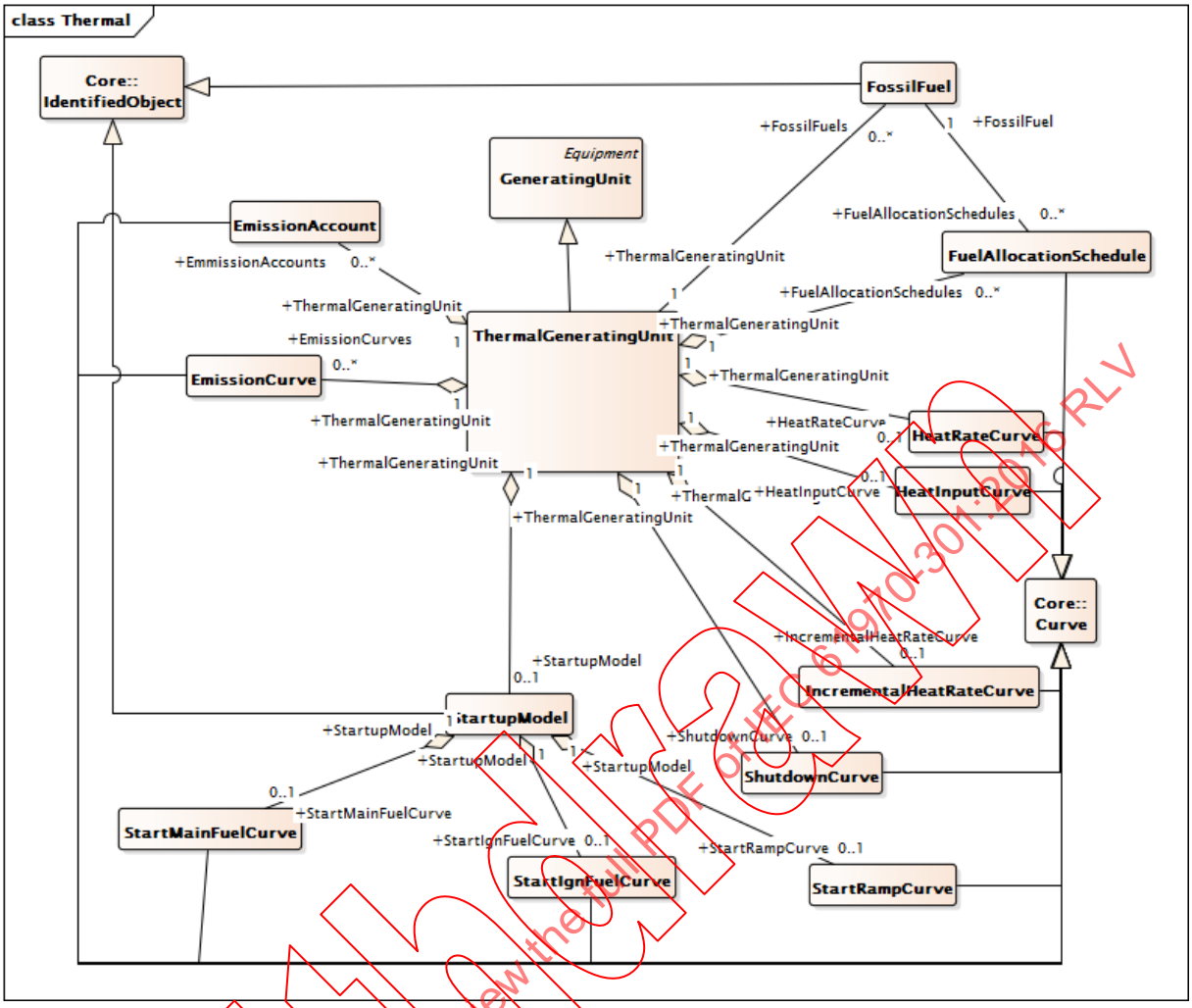


Figure 107 – Class diagram Production::Thermal

Figure 107: This diagram shows all classes included in the Thermal package as well as the key external classes that have associations with Thermal classes.

6.10.3.2 TargetLevelSchedule

Reservoir water level targets from advanced studies or "rule curves". Typically in one hour increments for up to 10 days.

Table 390 shows all attributes of TargetLevelSchedule.

Table 390 – Attributes of Production::TargetLevelSchedule

name	mult	type	description
highLevelLimit	0..1	WaterLevel	High target level limit, above which the reservoir operation will be penalized.
lowLevelLimit	0..1	WaterLevel	Low target level limit, below which the reservoir operation will be penalized.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve

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name	mult	type	description
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 391 shows all association ends of TargetLevelSchedule with other classes.

Table 391 – Association ends of Production::TargetLevelSchedule with other classes

mult from	name	mult to	type	description
0..1	Reservoir	1..1	Reservoir	A reservoir may have a water level target schedule.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.3 PenstockLossCurve

Relationship between penstock head loss (in metres) and total discharge through the penstock (in cubic metres per second). One or more turbines may be connected to the same penstock.

Table 392 shows all attributes of PenstockLossCurve.

Table 392 – Attributes of Production::PenstockLossCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 393 shows all association ends of PenstockLossCurve with other classes.

Table 393 – Association ends of Production::PenstockLossCurve with other classes

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mult from	name	mult to	type	description
0..1	HydroGeneratingUnit	1..1	HydroGeneratingUnit	A hydro generating unit has a penstock loss curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.4 HydroGeneratingUnit

A generating unit whose prime mover is a hydraulic turbine (e.g. Francis, Pelton, Kaplan).

Table 394 shows all attributes of HydroGeneratingUnit.

Table 394 – Attributes of Production::HydroGeneratingUnit

name	mult	type	description
energyConversionCapability	0..1	HydroEnergyConversionKind	Energy conversion capability for generating.
hydroUnitWaterCost	0..1	CostPerVolume	The equivalent cost of water that drives the hydro turbine.
allocSpinResP	0..1	ActivePower	inherited from: GeneratingUnit
autoCntrlMarginP	0..1	ActivePower	inherited from: GeneratingUnit
baseP	0..1	ActivePower	inherited from: GeneratingUnit
controlDeadband	0..1	ActivePower	inherited from: GeneratingUnit
controlPulseHigh	0..1	Seconds	inherited from: GeneratingUnit
controlPulseLow	0..1	Seconds	inherited from: GeneratingUnit
controlResponseRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
~~dispReserveFlag~~		~~Boolean~~	~~inherited from: GeneratingUnit~~
efficiency	0..1	PerCent	inherited from: GeneratingUnit
~~energyMinP~~		~~HeatRate~~	~~inherited from: GeneratingUnit~~
~~fastStartFlag~~		~~Boolean~~	~~inherited from: GeneratingUnit~~
~~fuelPriority~~		~~Integer~~	~~inherited from: GeneratingUnit~~
genControlMode	0..1	GeneratorControlMode	inherited from: GeneratingUnit
genControlSource	0..1	GeneratorControlSource	inherited from: GeneratingUnit
~~genOperatingMode~~		~~GeneratorOperatingMode~~	~~inherited from: GeneratingUnit~~
governorMPL	0..1	PU	inherited from: GeneratingUnit
governorSCD	0..1	PerCent	inherited from: GeneratingUnit
highControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
initialP	0..1	ActivePower	inherited from: GeneratingUnit
longPF	0..1	Float	inherited from: GeneratingUnit
lowControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
lowerRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
maxEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
maximumAllowableSpinningReserve	0..1	ActivePower	inherited from: GeneratingUnit
maxOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
minEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
minimumOffTime	0..1	Seconds	inherited from: GeneratingUnit

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name	mult	type	description
minOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
modelDetail	0..1	Classification	inherited from: GeneratingUnit
nominalP	0..1	ActivePower	inherited from: GeneratingUnit
normalPF	0..1	Float	inherited from: GeneratingUnit
penaltyFactor	0..1	Float	inherited from: GeneratingUnit
raiseRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
ratedGrossMaxP	0..1	ActivePower	inherited from: GeneratingUnit
ratedGrossMinP	0..1	ActivePower	inherited from: GeneratingUnit
ratedNetMaxP	0..1	ActivePower	inherited from: GeneratingUnit
shortPF	0..1	Float	inherited from: GeneratingUnit
~~spinReserveRamp~~		~~ActivePowerChangeRate~~	~~inherited from: GeneratingUnit~~
startupCost	0..1	Money	inherited from: GeneratingUnit
startupTime	0..1	Seconds	inherited from: GeneratingUnit
~~stepChange~~		~~ActivePower~~	~~inherited from: GeneratingUnit~~
tieLinePF	0..1	Float	inherited from: GeneratingUnit
totalEfficiency	0..1	PerCent	inherited from: GeneratingUnit
variableCost	0..1	Money	inherited from: GeneratingUnit
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 395 shows all association ends of HydroGeneratingUnit with other classes.

Table 395 – Association ends of Production::HydroGeneratingUnit with other classes

mult from	name	mult to	type	description
1..1	PenstockLossCurve	0..1	PenstockLossCurve	A hydro generating unit has a penstock loss curve.
1..1	TailbayLossCurve	0..*	TailbayLossCurve	A hydro generating unit has a tailbay loss curve.
0..*	HydroPowerPlant	0..1	HydroPowerPlant	The hydro generating unit belongs to a hydro power plant.
1..1	HydroGeneratingEfficiencyCurves	0..*	HydroGeneratingEfficiencyCurve	A hydro generating unit has an efficiency curve.
0..1	~~Synchronous~~RotatingMachine	1..*	~~Synchronous~~RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment

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mult from	name	mul t to	type	description
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.5 AirCompressor

Combustion turbine air compressor which is an integral part of a compressed air energy storage (CAES) plant.

Table 396 shows all attributes of AirCompressor.

Table 396 – Attributes of Production::AirCompressor

name	mult	type	description
airCompressorRating	0..1	Float	Rating of the CAES air compressor.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 397 shows all association ends of AirCompressor with other classes.

Table 397 – Association ends of Production::AirCompressor with other classes

mult from	name	mult to	type	description
0..1	CombustionTurbine	1..1	CombustionTurbine	A CAES air compressor is driven by combustion turbine.
1..1	CAESPlant	1..1	CAESPlant	An air compressor may be a member of a compressed air energy storage plant.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.10.3.6 HydroPowerPlant

A hydro power station which can generate or pump. When generating, the generator turbines receive water from an upper reservoir. When pumping, the pumps receive their water from a lower reservoir.

Table 398 shows all attributes of HydroPowerPlant.

Table 398 – Attributes of Production::HydroPowerPlant

name	mult	type	description
dischargeTravelDelay	0..1	Seconds	Water travel delay from tailbay to next downstream hydro power station.
genRatedP	0..1	ActivePower	The hydro plant's generating rating active power for rated head conditions.
hydroPlantStorageType	0..1	HydroPlantStorageKind	The type of hydro power plant water storage.
penstockType	0..1	~~PenstockType~~ String	Type and configuration of hydro plant penstock(s).
plantDischargeCapacity	0..1	VolumeFlowRate	Total plant discharge capacity.
plantRatedHead	0..1	Length	The plant's rated gross head.
pumpRatedP	0..1	ActivePower	The hydro plant's pumping rating active power for rated head conditions.
surgeTankCode	0..1	~~SurgeTankCode~~ String	A code describing the type (or absence) of surge tank that is associated with the hydro power plant.
surgeTankCrestLevel	0..1	WaterLevel	The level at which the surge tank spills.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 399 shows all association ends of HydroPowerPlant with other classes.

Table 399 – Association ends of Production::HydroPowerPlant with other classes

mult from	name	mult to	type	description
0..1	HydroGeneratingUnits	0..*	HydroGeneratingUnit	The hydro generating unit belongs to a hydro power plant.
0..1	HydroPumps	0..*	HydroPump	The hydro pump may be a member of a pumped storage plant or a pump for distributing water.
0..*	Reservoir	0..1	Reservoir	Generators discharge water to or pumps are supplied water from a downstream reservoir.
0..*	GenSourcePumpDischargeReservoir	1..1	Reservoir	Generators are supplied water from or pumps discharge water to an upstream reservoir.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~

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mult from	name	mult to	type	description
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.7 GeneratorControlSource enumeration

The source of controls for a generating unit.

Table 400 shows all literals of GeneratorControlSource.

Table 400 – Literals of Production::GeneratorControlSource

literal	value	description
unavailable		Not available.
offAGC		Off of automatic generation control (AGC).
onAGC		On automatic generation control (AGC).
plantControl		Plant is controlling.

6.10.3.8 InflowForecast

Natural water inflow to a reservoir, usually forecasted from predicted rain and snowmelt. Typically in one hour increments for up to 10 days. The forecast is given in average cubic metres per second over the time increment.

Table 401 shows all attributes of InflowForecast.

Table 401 – Attributes of Production::InflowForecast

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 402 shows all association ends of InflowForecast with other classes.

Table 402 – Association ends of Production::InflowForecast with other classes

mult from	name	mult to	type	description
0..*	Reservoir	1..1	Reservoir	A reservoir may have a "natural" inflow forecast.

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mult from	name	mult to	type	description
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.9 SteamSendoutSchedule

The cogeneration plant's steam sendout schedule in volume per time unit.

Table 403 shows all attributes of SteamSendoutSchedule.

Table 403 – Attributes of Production::SteamSendoutSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 404 shows all association ends of SteamSendoutSchedule with other classes.

Table 404 – Association ends of Production::SteamSendoutSchedule with other classes

mult from	name	mult to	type	description
1..1	CogenerationPlant	1..1	CogenerationPlant	A cogeneration plant has a steam sendout schedule.
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.10 HydroPump

A synchronous motor-driven pump, typically associated with a pumped storage plant.

Table 405 shows all attributes of HydroPump.

Table 405 – Attributes of Production::HydroPump

name	mult	type	description
pumpDischAtMaxHead	0..1	VolumeFlowRate	The pumping discharge under maximum head conditions, usually at full gate.
pumpDischAtMinHead	0..1	VolumeFlowRate	The pumping discharge under minimum head conditions, usually at full gate.

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name	mult	type	description
pumpPowerAtMaxHead	0..1	ActivePower	The pumping power under maximum head conditions, usually at full gate.
pumpPowerAtMinHead	0..1	ActivePower	The pumping power under minimum head conditions, usually at full gate.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 406 shows all association ends of HydroPump with other classes.

Table 406 – Association ends of Production::HydroPump with other classes

mult from	name	mult to	type	description
0..1	~~Synchronous~~RotatingMachine	1..1	~~Synchronous~~RotatingMachine	The synchronous machine drives the turbine which moves the water from a low elevation to a higher elevation. The direction of machine rotation for pumping may or may not be the same as for generating.
0..*	HydroPowerPlant	0..1	HydroPowerPlant	The hydro pump may be a member of a pumped storage plant or a pump for distributing water.
1..1	HydroPumpOpSchedule	0..1	HydroPumpOpSchedule	The hydro pump has a pumping schedule over time, indicating when pumping is to occur.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.11 HydroEnergyConversionKind enumeration

Specifies the capability of the hydro generating unit to convert energy as a generator or pump.

Table 407 shows all literals of HydroEnergyConversionKind.

Table 407 – Literals of Production::HydroEnergyConversionKind

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literal	value	description
generator		Able to generate power, but not able to pump water for energy storage.
pumpAndGenerator		Able to both generate power and pump water for energy storage.

6.10.3.12 Classification datatype

Classification of level. Specify as 1..n, with 1 being the most detailed, highest priority, etc as described on the attribue using this data type.

Table 408 shows all attributes of Classification.

Table 408 – Attributes of Production::Classification

name	mult	type	description
value	0..1	Integer	
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	(const=none)

6.10.3.13 HeatInputCurve

Relationship between unit heat input in energy per time for main fuel (Y1-axis) and supplemental fuel (Y2-axis) versus unit output in active power (X-axis). The quantity of main fuel used to sustain generation at this output level is prorated for throttling between definition points. The quantity of supplemental fuel used at this output level is fixed and not prorated.

Table 409 shows all attributes of HeatInputCurve.

Table 409 – Attributes of Production::HeatInputCurve

name	mult	type	description
auxPowerMult	0..1	PU	Power output – auxiliary power multiplier adjustment factor.
auxPowerOffset	0..1	ActivePower	Power output – auxiliary power offset adjustment factor.
heatInputEff	0..1	PU	Heat input – efficiency multiplier adjustment factor.
heatInputOffset	0..1	HeatRate	Heat input – offset adjustment factor.
isNetGrossP	0..1	Boolean	Flag is set to true when output is expressed in net active power.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 410 shows all association ends of HeatInputCurve with other classes.

Table 410 – Association ends of Production::HeatInputCurve with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have a heat input curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

~~6.9.3.19 GeneratorOperatingMode enumeration~~

~~Operating mode for secondary generator control.~~

~~Table 371 shows all literals of GeneratorOperatingMode.~~

~~**Table 371 – Literals of Production::GeneratorOperatingMode**~~

~~literal~~	~~description~~
~~off~~	~~Off.~~
~~manual~~	~~Manual.~~
~~fixed~~	~~Fixed.~~
~~LFC~~	~~Load frequency control.~~
~~AGC~~	~~Automatic generation control (AGC).~~
~~EDC~~	~~Economic dispatch control.~~
~~MRN~~	~~MRN.~~
~~REG~~	~~REG.~~

6.10.3.14 GenUnitOpCostCurve

Relationship between unit operating cost (Y-axis) and unit output active power (X-axis). The operating cost curve for thermal units is derived from heat input and fuel costs. The operating cost curve for hydro units is derived from water flow rates and equivalent water costs.

Table 411 shows all attributes of GenUnitOpCostCurve.

Table 411 – Attributes of Production::GenUnitOpCostCurve

name	mult	type	description
isNetGrossP	0..1	Boolean	Flag is set to true when output is expressed in net active power.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve

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name	mult	type	description
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 412 shows all association ends of GenUnitOpCostCurve with other classes.

Table 412 – Association ends of Production::GenUnitOpCostCurve with other classes

mult from	name	mult to	type	description
0..*	GeneratingUnit	1..1	GeneratingUnit	A generating unit may have one or more cost curves, depending upon fuel mixture and fuel cost.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.15 EmissionType enumeration

The type of emission.

Table 413 shows all literals of EmissionType.

Table 413 – Literals of Production::EmissionType

literal	value	description
sulfurDioxide		Sulfur dioxide.
carbonDioxide		Carbon dioxide.
nitrogenOxide		Nitrogen oxide.
hydrogenSulfide		Hydrogen sulfide.
chlorine		Chlorine.
carbonDisulfide		Carbon disulfide.

6.10.3.16 ThermalGeneratingUnit

A generating unit whose prime mover could be a steam turbine, combustion turbine, or diesel engine.

Table 414 shows all attributes of ThermalGeneratingUnit.

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Table 414 – Attributes of Production::ThermalGeneratingUnit

name	mult	type	description
oMCost	0..1	CostPerHeatUnit	Operating and maintenance cost for the thermal unit.
allocSpinResP	0..1	ActivePower	inherited from: GeneratingUnit
autoCntrlMarginP	0..1	ActivePower	inherited from: GeneratingUnit
baseP	0..1	ActivePower	inherited from: GeneratingUnit
controlDeadband	0..1	ActivePower	inherited from: GeneratingUnit
controlPulseHigh	0..1	Seconds	inherited from: GeneratingUnit
controlPulseLow	0..1	Seconds	inherited from: GeneratingUnit
controlResponseRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
~~dispReserveFlag~~		~~Boolean~~	~~inherited from: GeneratingUnit~~
efficiency	0..1	PerCent	inherited from: GeneratingUnit
~~energyMinP~~		~~HeatRate~~	~~inherited from: GeneratingUnit~~
~~fastStartFlag~~		~~Boolean~~	~~inherited from: GeneratingUnit~~
~~fuelPriority~~		~~Integer~~	~~inherited from: GeneratingUnit~~
genControlMode	0..1	GeneratorControlMode	inherited from: GeneratingUnit
genControlSource	0..1	GeneratorControlSource	inherited from: GeneratingUnit
~~genOperatingMode~~		~~GeneratorOperatingMode~~	~~inherited from: GeneratingUnit~~
governorMPL	0..1	PU	inherited from: GeneratingUnit
governorSCD	0..1	PerCent	inherited from: GeneratingUnit
highControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
initialP	0..1	ActivePower	inherited from: GeneratingUnit
longPF	0..1	Float	inherited from: GeneratingUnit
lowControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
lowerRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
maxEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
maximumAllowableSpinningReserve	0..1	ActivePower	inherited from: GeneratingUnit
maxOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
minEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
minimumOffTime	0..1	Seconds	inherited from: GeneratingUnit
minOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
modelDetail	0..1	Classification	inherited from: GeneratingUnit
nominalP	0..1	ActivePower	inherited from: GeneratingUnit
normalPF	0..1	Float	inherited from: GeneratingUnit
penaltyFactor	0..1	Float	inherited from: GeneratingUnit
raiseRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
ratedGrossMaxP	0..1	ActivePower	inherited from: GeneratingUnit
ratedGrossMinP	0..1	ActivePower	inherited from: GeneratingUnit
ratedNetMaxP	0..1	ActivePower	inherited from: GeneratingUnit
shortPF	0..1	Float	inherited from: GeneratingUnit
startupCost	0..1	Money	inherited from: GeneratingUnit
startupTime	0..1	Seconds	inherited from: GeneratingUnit
~~stepChange~~		~~ActivePower~~	~~inherited from: GeneratingUnit~~

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name	mult	type	description
tieLinePF	0..1	Float	inherited from: GeneratingUnit
totalEfficiency	0..1	PerCent	inherited from: GeneratingUnit
variableCost	0..1	Money	inherited from: GeneratingUnit
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 415 shows all association ends of ThermalGeneratingUnit with other classes.

Table 415 – Association ends of Production::ThermalGeneratingUnit with other classes

mult from	name	mult to	type	description
1..1	HeatInputCurve	0..1	HeatInputCurve	A thermal generating unit may have a heat input curve.
1..1	HeatRateCurve	0..1	HeatRateCurve	A thermal generating unit may have a heat rate curve.
0..*	CogenerationPlant	0..1	CogenerationPlant	A thermal generating unit may be a member of a cogeneration plant.
1..1	FuelAllocationSchedules	0..*	FuelAllocationSchedule	A thermal generating unit may have one or more fuel allocation schedules.
1..1	StartupModel	0..1	StartupModel	A thermal generating unit may have a startup model.
1..1	EmissionCurves	0..*	EmissionCurve	A thermal generating unit may have one or more emission curves.
1..1	ShutdownCurve	0..1	ShutdownCurve	A thermal generating unit may have a shutdown curve.
1..1	IncrementalHeatRateCurve	0..1	IncrementalHeatRateCurve	A thermal generating unit may have an incremental heat rate curve.
1..1	FossilFuels	0..*	FossilFuel	A thermal generating unit may have one or more fossil fuels.
0..1	CAESPlant	0..1	CAESPlant	A thermal generating unit may be a member of a compressed air energy storage plant.
0..*	CombinedCyclePlant	0..1	CombinedCyclePlant	A thermal generating unit may be a member of a combined cycle plant.
1..1	EmmissionAccounts	0..*	EmissionAccount	A thermal generating unit may have one or more emission allowance accounts.
0..1	~~Synchronous~~RotatingMachine	1..*	~~Synchronous~~RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment

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mult from	name	mult to	type	description
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.17 NuclearGeneratingUnit

A nuclear generating unit.

Table 416 shows all attributes of NuclearGeneratingUnit.

Table 416 – Attributes of Production::NuclearGeneratingUnit

name	mult	type	description
allocSpinResP	0..1	ActivePower	inherited from: GeneratingUnit
autoCntrlMarginP	0..1	ActivePower	inherited from: GeneratingUnit
baseP	0..1	ActivePower	inherited from: GeneratingUnit
controlDeadband	0..1	ActivePower	inherited from: GeneratingUnit
controlPulseHigh	0..1	Seconds	inherited from: GeneratingUnit
controlPulseLow	0..1	Seconds	inherited from: GeneratingUnit
controlResponseRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
~~dispReserveFlag~~		~~Boolean~~	~~inherited from: GeneratingUnit~~
efficiency	0..1	PerCent	inherited from: GeneratingUnit
~~energyMinP~~		~~HeatRate~~	~~inherited from: GeneratingUnit~~
~~fastStartFlag~~		~~Boolean~~	~~inherited from: GeneratingUnit~~
~~fuelPriority~~		~~Integer~~	~~inherited from: GeneratingUnit~~
genControlMode	0..1	GeneratorControlMode	inherited from: GeneratingUnit
genControlSource	0..1	GeneratorControlSource	inherited from: GeneratingUnit
~~genOperatingMode~~		~~GeneratorOperatingMode~~	~~inherited from: GeneratingUnit~~
governorMPL	0..1	PU	inherited from: GeneratingUnit
governorSCD	0..1	PerCent	inherited from: GeneratingUnit
highControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
initialP	0..1	ActivePower	inherited from: GeneratingUnit
longPF	0..1	Float	inherited from: GeneratingUnit
lowControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
lowerRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
maxEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
maximumAllowableSpinningReserve	0..1	ActivePower	inherited from: GeneratingUnit
maxOperatingP	0..1	ActivePower	inherited from: GeneratingUnit

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name	mult	type	description
minEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
minimumOffTime	0..1	Seconds	inherited from: GeneratingUnit
minOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
modelDetail	0..1	Classification	inherited from: GeneratingUnit
nominalP	0..1	ActivePower	inherited from: GeneratingUnit
normalPF	0..1	Float	inherited from: GeneratingUnit
penaltyFactor	0..1	Float	inherited from: GeneratingUnit
raiseRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
ratedGrossMaxP	0..1	ActivePower	inherited from: GeneratingUnit
ratedGrossMinP	0..1	ActivePower	inherited from: GeneratingUnit
ratedNetMaxP	0..1	ActivePower	inherited from: GeneratingUnit
shortPF	0..1	Float	inherited from: GeneratingUnit
~~spinReserveRamp~~		~~ActivePowerChangeRate~~	~~inherited from: GeneratingUnit~~
startupCost	0..1	Money	inherited from: GeneratingUnit
startupTime	0..1	Seconds	inherited from: GeneratingUnit
~~stepChange~~		~~ActivePower~~	~~inherited from: GeneratingUnit~~
tieLinePF	0..1	Float	inherited from: GeneratingUnit
totalEfficiency	0..1	PerCent	inherited from: GeneratingUnit
variableCost	0..1	Money	inherited from: GeneratingUnit
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 417 shows all association ends of NuclearGeneratingUnit with other classes.

Table 417 – Association ends of Production::NuclearGeneratingUnit with other classes

mult from	name	mult to	type	description
0..1	~~Synchronous~~RotatingMachine	1..*	~~Synchronous~~RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

~~**6.9.3.38 PenstockType enumeration**~~

~~Type of hydro plant penstock.~~

~~Table 405 shows all literals of PenstockType.~~

~~**Table 405 – Literals of Production::PenstockType**~~

~~literal~~	~~description~~
~~undefined~~	~~The penstock type is undefined.~~

6.10.3.18 Reservoir

A water storage facility within a hydro system, including: ponds, lakes, lagoons, and rivers. The storage is usually behind some type of dam.

Table 418 shows all attributes of Reservoir.

Table 418 – Attributes of Production::Reservoir

name	mult	type	description
activeStorageCapacity	0..1	Volume	Storage volume between the full supply level and the normal minimum operating level.
energyStorageRating	0..1	Float	The reservoir's energy storage rating in energy for given head conditions.
fullSupplyLevel	0..1	WaterLevel	Full supply level, above which water will spill. This can be the spillway crest level or the top of closed gates.
grossCapacity	0..1	Volume	Total capacity of reservoir.
normalMinOperateLevel	0..1	WaterLevel	Normal minimum operating level below which the penstocks will draw air.
riverOutletWorks	0..1	String	River outlet works for riparian right releases or other purposes.
spillTravelDelay	0..1	Seconds	The spillway water travel delay to the next downstream reservoir.
spillwayCapacity	0..1	Float	The flow capacity of the spillway in cubic metres per second.
spillwayCrestLength	0..1	Length	The length of the spillway crest.
spillwayCrestLevel	0..1	WaterLevel	Spillway crest level above which water will spill.
spillWayGateType	0..1	String	Type of spillway gate, including parameters.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 419 shows all association ends of Reservoir with other classes.

Table 419 – Association ends of Production::Reservoir with other classes

mult from	name	mult to	type	description
0..1	SpillsIntoReservoirs	0..*	Reservoir	A reservoir may spill into a downstream reservoir.
1..1	TargetLevelSchedule	0..1	TargetLevelSchedule	A reservoir may have a water level target schedule.
0..1	HydroPowerPlants	0..*	HydroPowerPlant	Generators discharge water to or pumps are supplied water from a downstream reservoir.
1..1	UpstreamFromHydroPowerPlants	0..*	HydroPowerPlant	Generators are supplied water from or pumps discharge water to an upstream reservoir.
1..1	InflowForecasts	0..*	InflowForecast	A reservoir may have a "natural" inflow forecast.
1..1	LevelVsVolumeCurves	0..*	LevelVsVolumeCurve	A reservoir may have a level versus volume relationship.
0..*	SpillsFromReservoir	0..1	Reservoir	A reservoir may spill into a downstream reservoir.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.19 WindGeneratingUnit

A wind driven generating unit. May be used to represent a single turbine or an aggregation.

Table 420 shows all attributes of WindGeneratingUnit.

Table 420 – Attributes of Production::WindGeneratingUnit

name	mult	type	description
windGenUnitType	0..1	WindGenUnitKind	The kind of wind generating unit
allocSpinResP	0..1	ActivePower	inherited from: GeneratingUnit
autoCntrlMarginP	0..1	ActivePower	inherited from: GeneratingUnit
baseP	0..1	ActivePower	inherited from: GeneratingUnit
controlDeadband	0..1	ActivePower	inherited from: GeneratingUnit
controlPulseHigh	0..1	Seconds	inherited from: GeneratingUnit
controlPulseLow	0..1	Seconds	inherited from: GeneratingUnit

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name	mult	type	description
controlResponseRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
~~dispReserveFlag~~		~~Boolean~~	~~inherited from: GeneratingUnit~~
efficiency	0..1	PerCent	inherited from: GeneratingUnit
~~energyMinP~~		~~HeatRate~~	~~inherited from: GeneratingUnit~~
~~fastStartFlag~~		~~Boolean~~	~~inherited from: GeneratingUnit~~
~~fuelPriority~~		~~Integer~~	~~inherited from: GeneratingUnit~~
genControlMode	0..1	GeneratorControlMode	inherited from: GeneratingUnit
genControlSource	0..1	GeneratorControlSource	inherited from: GeneratingUnit
~~genOperatingMode~~		~~GeneratorOperatingMode~~	~~inherited from: GeneratingUnit~~
governorMPL	0..1	PU	inherited from: GeneratingUnit
governorSCD	0..1	PerCent	inherited from: GeneratingUnit
highControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
initialP	0..1	ActivePower	inherited from: GeneratingUnit
longPF	0..1	Float	inherited from: GeneratingUnit
lowControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
lowerRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
maxEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
maximumAllowableSpinningReserve	0..1	ActivePower	inherited from: GeneratingUnit
maxOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
minEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
minimumOffTime	0..1	Seconds	inherited from: GeneratingUnit
minOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
modelDetail	0..1	Classification	inherited from: GeneratingUnit
nominalP	0..1	ActivePower	inherited from: GeneratingUnit
normalPF	0..1	Float	inherited from: GeneratingUnit
penaltyFactor	0..1	Float	inherited from: GeneratingUnit
raiseRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
ratedGrossMaxP	0..1	ActivePower	inherited from: GeneratingUnit
ratedGrossMinP	0..1	ActivePower	inherited from: GeneratingUnit
ratedNetMaxP	0..1	ActivePower	inherited from: GeneratingUnit
shortPF	0..1	Float	inherited from: GeneratingUnit
~~spinReserveRamp~~		~~ActivePowerChangeRate~~	~~inherited from: GeneratingUnit~~
startupCost	0..1	Money	inherited from: GeneratingUnit
startupTime	0..1	Seconds	inherited from: GeneratingUnit
~~stepChange~~		~~ActivePower~~	~~inherited from: GeneratingUnit~~
tieLinePF	0..1	Float	inherited from: GeneratingUnit
totalEfficiency	0..1	PerCent	inherited from: GeneratingUnit
variableCost	0..1	Money	inherited from: GeneratingUnit
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
name	0..1	String	inherited from: IdentifiedObject

Table 421 shows all association ends of WindGeneratingUnit with other classes.

Table 421 – Association ends of Production::WindGeneratingUnit with other classes

mult from	name	mult to	type	description
0..1	~~Synchronous~~RotatingMachine	1..*	~~Synchronous~~RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.20 StartMainFuelCurve

The quantity of main fuel (Y-axis) used to restart and repay the auxiliary power consumed versus the number of hours (X-axis) the unit was off line.

Table 422 shows all attributes of StartMainFuelCurve.

Table 422 – Attributes of Production::StartMainFuelCurve

name	mult	type	description
mainFuelType	0..1	FuelType	Type of main fuel.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve

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name	mult	type	description
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 423 shows all association ends of StartMainFuelCurve with other classes.

Table 423 – Association ends of Production::StartMainFuelCurve with other classes

mult from	name	mult to	type	description
0..1	StartupModel	1..1	StartupModel	The unit's startup model may have a startup main fuel curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.21 GrossToNetActivePowerCurve

Relationship between the generating unit's gross active power output on the X-axis (measured at the terminals of the machine(s)) and the generating unit's net active power output on the Y-axis (based on utility-defined measurements at the power station). Station service loads, when modeled, should be treated as non-conforming bus loads. There may be more than one curve, depending on the auxiliary equipment that is in service.

Table 424 shows all attributes of GrossToNetActivePowerCurve.

Table 424 – Attributes of Production::GrossToNetActivePowerCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 425 shows all association ends of GrossToNetActivePowerCurve with other classes.

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Table 425 – Association ends of Production::GrossToNetActivePowerCurve with other classes

mult from	name	mult to	type	description
0..*	GeneratingUnit	1..1	GeneratingUnit	A generating unit may have a gross active power to net active power curve, describing the losses and auxiliary power requirements of the unit.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.22 EmissionAccount

Accounts for tracking emissions usage and credits for thermal generating units. A unit may have zero or more emission accounts, and will typically have one for tracking usage and one for tracking credits.

Table 426 shows all attributes of EmissionAccount.

Table 426 – Attributes of Production::EmissionAccount

name	mult	type	description
emissionType	0..1	EmissionType	The type of emission, for example sulfur dioxide (SO2). The y1AxisUnits of the curve contains the unit of measure (e.g. kg) and the emissionType is the type of emission (e.g. sulfur dioxide).
emissionValueSource	0..1	EmissionValueSource	The source of the emission value.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 427 shows all association ends of EmissionAccount with other classes.

Table 427 – Association ends of Production::EmissionAccount with other classes

mult from	name	mult to	type	description
0..*	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have one or more emission allowance accounts.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject

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mult from	name	mult to	type	description
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.23 HeatRateCurve

Relationship between unit heat rate per active power (Y-axis) and unit output (X-axis). The heat input is from all fuels.

Table 428 shows all attributes of HeatRateCurve.

Table 428 – Attributes of Production::HeatRateCurve

name	mult	type	description
isNetGrossP	0..1	Boolean	Flag is set to true when output is expressed in net active power.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 429 shows all association ends of HeatRateCurve with other classes.

Table 429 – Association ends of Production::HeatRateCurve with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have a heat rate curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.24 HeatRate datatype

Heat generated, in energy pertime unit of elapsed time.

Table 430 shows all attributes of HeatRate.

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Table 430 – Attributes of Production::HeatRate

name	mult	type	description
unit	0..1	UnitSymbol	(const=J)
value	0..1	Float	
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.10.3.25 CAESPlant

Compressed air energy storage plant.

Table 431 shows all attributes of CAESPlant.

Table 431 – Attributes of Production::CAESPlant

name	mult	type	description
energyStorageCapacity	0..1	RealEnergy	The rated energy storage capacity.
ratedCapacityP	0..1	ActivePower	The CAES plant's gross rated generating capacity.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 432 shows all association ends of CAESPlant with other classes.

Table 432 – Association ends of Production::CAESPlant with other classes

mult from	name	mult to	type	description
1..1	AirCompressor	1..1	AirCompressor	An air compressor may be a member of a compressed air energy storage plant.
0..1	ThermalGeneratingUnit	0..1	ThermalGeneratingUnit	A thermal generating unit may be a member of a compressed air energy storage plant.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.26 HydroPlant~~Type~~StorageKind enumeration

The type of hydro power plant.

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Table 433 shows all literals of HydroPlantStorageKind.

Table 433 – Literals of Production::HydroPlant~~Type~~StorageKind

literal	value	description
runOfRiver		Run of river.
pumpedStorage		Pumped storage.
~~majorStorage~~		~~Major storage~~
~~minorStorage~~		~~Minor storage~~
storage		Storage.

6.10.3.27 GeneratingUnit

A single or set of synchronous machines for converting mechanical power into alternating-current power. For example, individual machines within a set may be defined for scheduling purposes while a single control signal is derived for the set. In this case there would be a GeneratingUnit for each member of the set and an additional GeneratingUnit corresponding to the set.

Table 434 shows all attributes of GeneratingUnit.

Table 434 – Attributes of Production::GeneratingUnit

name	mult	type	description
allocSpinResP	0..1	ActivePower	The planned unused capacity (spinning reserve) which can be used to support emergency load.
autoCntrlMarginP	0..1	ActivePower	The planned unused capacity which can be used to support automatic control overruns.
baseP	0..1	ActivePower	For dispatchable units, this value represents the economic active power basepoint, for units that are not dispatchable, this value represents the fixed generation value. The value ~~must~~ shall be between the operating low and high limits.
controlDeadband	0..1	ActivePower	Unit control error deadband. When a unit's desired active power change is less than this deadband, then no control pulses will be sent to the unit.
controlPulseHigh	0..1	Seconds	Pulse high limit which is the largest control pulse that the unit can respond to.
controlPulseLow	0..1	Seconds	Pulse low limit which is the smallest control pulse that the unit can respond to.
controlResponseRate	0..1	ActivePowerChangeRate	Unit response rate which specifies the active power change for a control pulse of one second in the most responsive loading level of the unit.
~~dispReserveFlag~~		~~Boolean~~	~~Recommended to be deleted from standard.~~
efficiency	0..1	PerCent	The efficiency of the unit in converting mechanical energy, from the prime mover, into electrical energy.
~~energyMinP~~		~~HeatRate~~	~~Recommended to be deleted from standard.~~
~~fastStartFlag~~		~~Boolean~~	~~Indicates the generating unit has a fast start capability and implies the generating unit can potentially contribute to spinning reserve even while not spinning.~~
~~fuelPriority~~		~~Integer~~	~~Recommended to be deleted from standard.~~
genControlMode	0..1	GeneratorControlMode	The unit control mode.

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name	mult	type	description
genControlSource	0..1	GeneratorControlSource	The source of controls for a generating unit.
~~genOperatingMode~~		~~GeneratorOperatingMode~~	~~Operating mode for secondary control.~~
governorMPL	0..1	PU	Governor motor position limit.
governorSCD	0..1	PerCent	Governor Speed Changer Droop. This is the change in generator power output divided by the change in frequency normalized by the nominal power of the generator and the nominal frequency and expressed in percent and negated. A positive value of speed change droop provides additional generator output upon a drop in frequency.
highControlLimit	0..1	ActivePower	High limit for secondary (AGC) control.
initialP	0..1	ActivePower	Default initial active power which is used to store a powerflow result for the initial active power for this unit in this network configuration.
longPF	0..1	Float	Generating unit long term economic participation factor.
lowControlLimit	0..1	ActivePower	Low limit for secondary (AGC) control.
lowerRampRate	0..1	ActivePowerChangeRate	The normal maximum rate the generating unit active power output can be lowered by control actions.
maxEconomicP	0..1	ActivePower	Maximum high economic active power limit, that should not exceed the maximum operating active power limit.
maximumAllowableSpinningReserve	0..1	ActivePower	Maximum allowable spinning reserve. Spinning reserve will never be considered greater than this value regardless of the current operating point.
maxOperatingP	0..1	ActivePower	This is the maximum operating active power limit the dispatcher can enter for this unit.
minEconomicP	0..1	ActivePower	Low economic active power limit that ~~must~~ shall be greater than or equal to the minimum operating active power limit.
minimumOffTime	0..1	Seconds	Minimum time interval between unit shutdown and startup.
minOperatingP	0..1	ActivePower	This is the minimum operating active power limit the dispatcher can enter for this unit.
modelDetail	0..1	Classification	Detail level of the generator model data.
nominalP	0..1	ActivePower	The nominal power of the generating unit. Used to give precise meaning to percentage based attributes such as the governor speed change droop (governorSCD attribute). The attribute shall be a positive value equal to or less than RotatingMachine.ratedS.
normalPF	0..1	Float	Generating unit economic participation factor.
penaltyFactor	0..1	Float	Defined as: 1 / (1 − Incremental Transmission Loss); with the Incremental Transmission Loss expressed as a plus or minus value. The typical range of penalty factors is (0,9 to 1,1).
raiseRampRate	0..1	ActivePowerChangeRate	The normal maximum rate the generating unit active power output can be raised by control actions.
ratedGrossMaxP	0..1	ActivePower	The unit's gross rated maximum capacity (book value).
ratedGrossMinP	0..1	ActivePower	The gross rated minimum generation level which the unit can safely operate at while delivering power to the transmission grid.

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name	mult	type	description
ratedNetMaxP	0..1	ActivePower	The net rated maximum capacity determined by subtracting the auxiliary power used to operate the internal plant machinery from the rated gross maximum capacity.
shortPF	0..1	Float	Generating unit short term economic participation factor.
~~spinReserveRamp~~		~~ActivePowerChangeRate~~	~~Reccommended to be deleted from standard.~~
startupCost	0..1	Money	The initial startup cost incurred for each start of the GeneratingUnit.
startupTime	0..1	Seconds	Time it takes to get the unit on-line, from the time that the prime mover mechanical power is applied.
~~stepChange~~		~~ActivePower~~	~~Recommended to be deleted from standard.~~
tieLinePF	0..1	Float	Generating unit economic participation factor.
totalEfficiency	0..1	PerCent	The efficiency of the unit in converting the fuel into electrical energy.
variableCost	0..1	Money	The variable cost component of production per unit of ActivePower.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 435 shows all association ends of GeneratingUnit with other classes.

Table 435 – Association ends of Production::GeneratingUnit with other classes

mult from	name	mult to	type	description
0..1	~~SynchronousMachines~~ RotatingMachine	1..*	~~Synchronous~~RotatingMachine	A synchronous machine may operate as a generator and as such becomes a member of a generating unit.
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	A generating unit may have one or more cost curves, depending upon fuel mixture and fuel cost.
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	A generating unit may have a gross active power to net active power curve, describing the losses and auxiliary power requirements of the unit.
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	A generating unit may have an operating schedule, indicating the planned operation of the unit.
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	ControlArea specifications for this generating unit.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.28 EmissionCurve

Relationship between the unit's emission rate in units of mass per hour (Y-axis) and output active power (X-axis) for a given type of emission. This curve applies when only one type of fuel is being burned.

Table 436 shows all attributes of EmissionCurve.

Table 436 – Attributes of Production::EmissionCurve

name	mult	type	description
emissionContent	0..1	Emission	The emission content per quantity of fuel burned.
emissionType	0..1	EmissionType	The type of emission, which also gives the production rate measurement unit. The y1AxisUnits of the curve contains the unit of measure (e.g. kg) and the emissionType is the type of emission (e.g. sulfur dioxide).
isNetGrossP	0..1	Boolean	Flag is set to true when output is expressed in net active power.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 437 shows all association ends of EmissionCurve with other classes.

Table 437 – Association ends of Production::EmissionCurve with other classes

mult from	name	mult to	type	description
0..*	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have one or more emission curves.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve

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mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.29 ShutdownCurve

Relationship between the rate in gross active power per minute (Y-axis) at which a unit should be shutdown and its present gross MW output (X-axis).

Table 438 shows all attributes of ShutdownCurve.

Table 438 – Attributes of Production::ShutdownCurve

name	mult	type	description
shutdownCost	0..1	Money	Fixed shutdown cost.
shutdownDate	0..1	DateTime	The date and time of the most recent generating unit shutdown.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 439 shows all association ends of ShutdownCurve with other classes.

Table 439 – Association ends of Production::ShutdownCurve with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have a shutdown curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.30 FuelType enumeration

Type of fuel.

Table 440 shows all literals of FuelType.

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Table 440 – Literals of Production::FuelType

literal	value	description
coal		Generic coal, not including lignite type.
oil		Oil.
gas		Natural gas.
lignite		The fuel is lignite coal. Note that this is a special type of coal, so the other enum of coal is reserved for hard coal types or if the exact type of coal is not known.
hardCoal		Hard coal
oilShale		Oil Shale

6.10.3.31 FuelAllocationSchedule

The amount of fuel of a given type which is allocated for consumption over a specified period of time.

Table 441 shows all attributes of FuelAllocationSchedule.

Table 441 – Attributes of Production::FuelAllocationSchedule

name	mult	type	description
fuelAllocationEndDate	0..1	DateTime	The end time and date of the fuel allocation schedule.
fuelAllocationStartDate	0..1	DateTime	The start time and date of the fuel allocation schedule.
fuelType	0..1	FuelType	The type of fuel, which also indicates the corresponding measurement unit.
maxFuelAllocation	0..1	Float	The maximum amount of fuel that is allocated for consumption for the scheduled time period.
minFuelAllocation	0..1	Float	The minimum amount of fuel that is allocated for consumption for the scheduled time period, e.g. based on a "take-or-pay" contract.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 442 shows all association ends of FuelAllocationSchedule with other classes.

Table 442 – Association ends of Production::FuelAllocationSchedule with other classes

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mult from	name	mult to	type	description
0..*	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have one or more fuel allocation schedules.
0..*	FossilFuel	1..1	FossilFuel	A fuel allocation schedule ~~must~~ shall have a fossil fuel.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.32 CombinedCyclePlant

A set of combustion turbines and steam turbines where the exhaust heat from the combustion turbines is recovered to make steam for the steam turbines, resulting in greater overall plant efficiency.

Table 443 shows all attributes of CombinedCyclePlant.

Table 443 – Attributes of Production::CombinedCyclePlant

name	mult	type	description
combCyclePlantRating	0..1	ActivePower	The combined cycle plant's active power output rating.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 444 shows all association ends of CombinedCyclePlant with other classes.

Table 444 – Association ends of Production::CombinedCyclePlant with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnits	0..*	ThermalGeneratingUnit	A thermal generating unit may be a member of a combined cycle plant.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

~~**6.9.3.47 SurgeTankCode enumeration**~~

~~Type (or absence) of surge tank that is associated with the hydro power plant.~~

~~Table 421 shows all literals of SurgeTankCode.~~

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~~Table 421 – Literals of Production::SurgeTankCode~~

~~literal~~	~~description~~
~~undefined~~	~~The surge tank code is undefined.~~

6.10.3.33 TailbayLossCurve

Relationship between tailbay head loss hight (Y-axis) and the total discharge into the power station's tailbay volume per time unit (X-axis). There could be more than one curve depending on the level of the tailbay reservoir or river level.

Table 445 shows all attributes of TailbayLossCurve.

Table 445 – Attributes of Production::TailbayLossCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 446 shows all association ends of TailbayLossCurve with other classes.

Table 446 – Association ends of Production::TailbayLossCurve with other classes

mult from	name	mult to	type	description
0..*	HydroGeneratingUnit	1..1	HydroGeneratingUnit	A hydro generating unit has a tailbay loss curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.34 IncrementalHeatRateCurve

Relationship between unit incremental heat rate in (delta energy/time) per (delta active power) and unit output in active power. The IHR curve represents the slope of the HeatInputCurve. Note that the "incremental heat rate" and the "heat rate" have the same engineering units.

Table 447 shows all attributes of IncrementalHeatRateCurve.

Table 447 – Attributes of Production::IncrementalHeatRateCurve

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name	mult	type	description
isNetGrossP	0..1	Boolean	Flag is set to true when output is expressed in net active power.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 448 shows all association ends of IncrementalHeatRateCurve with other classes.

Table 448 – Association ends of Production::IncrementalHeatRateCurve with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have an incremental heat rate curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.35 FossilFuel

The fossil fuel consumed by the non-nuclear thermal generating unit. For example, coal, oil, gas, etc. These are the specific fuels that the generating unit can consume.

Table 449 shows all attributes of FossilFuel.

Table 449 – Attributes of Production::FossilFuel

name	mult	type	description
fossilFuelType	0..1	FuelType	The type of fossil fuel, such as coal, oil, or gas.
fuelCost	0..1	CostPerHeatUnit	The cost in terms of heat value for the given type of fuel.
fuelDispatchCost	0..1	CostPerHeatUnit	The cost of fuel used for economic dispatching which includes: fuel cost, transportation cost, and incremental maintenance cost.
fuelEffFactor	0..1	PU	The efficiency factor for the fuel (per unit) in terms of the effective energy absorbed.
fuelHandlingCost	0..1	CostPerHeatUnit	Handling and processing cost associated with this fuel.
fuelHeatContent	0..1	Float	The amount of heat per weight (or volume) of the given type of fuel.

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name	mult	type	description
fuelMixture	0..1	PerCent	Relative amount of the given type of fuel, when multiple fuels are being consumed.
fuelSulfur	0..1	PU	The fuel's fraction of pollution credit per unit of heat content.
highBreakpointP	0..1	ActivePower	The active power output level of the unit at which the given type of fuel is switched on. This fuel (e.g. oil) is sometimes used to supplement the base fuel (e.g. coal) at high active power output levels.
lowBreakpointP	0..1	ActivePower	The active power output level of the unit at which the given type of fuel is switched off. This fuel (e.g. oil) is sometimes used to stabilize the base fuel (e.g. coal) at low active power output levels.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 450 shows all association ends of FossilFuel with other classes.

Table 450 – Association ends of Production::FossilFuel with other classes

mult from	name	mult to	type	description
0..*	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have one or more fossil fuels.
1..1	FuelAllocationSchedules	0..*	FuelAllocationSchedule	A fuel allocation schedule ~~must~~ shall have a fossil fuel.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.36 EmissionValueSource enumeration

The source of the emission value.

Table 451 shows all literals of EmissionValueSource.

Table 451 – Literals of Production::EmissionValueSource

literal	value	description
measured		Measured.
calculated		Calculated.

~~6.9.3.41 SpillwayGateType enumeration~~

~~Type of spillway gate.~~

~~Table 410 shows all literals of SpillwayGateType.~~

~~Table 410 – Literals of Production::SpillwayGateType~~

~~literal~~	~~description~~
~~undefined~~	~~The type is spillway gate type is undefined.~~

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6.10.3.37 StartIgnFuelCurve

The quantity of ignition fuel (Y-axis) used to restart and repay the auxiliary power consumed versus the number of hours (X-axis) the unit was off line.

Table 452 shows all attributes of StartIgnFuelCurve.

Table 452 – Attributes of Production::StartIgnFuelCurve

name	mult	type	description
ignitionFuelType	0..1	FuelType	Type of ignition fuel.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 453 shows all association ends of StartIgnFuelCurve with other classes.

Table 453 – Association ends of Production::StartIgnFuelCurve with other classes

mult from	name	mult to	type	description
0..1	StartupModel	1..1	StartupModel	The unit's startup model may have a startup ignition fuel curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.38 HydroPumpOpSchedule

The hydro pump's Operator-approved current operating schedule (or plan), typically produced with the aid of unit commitment type analyses.The unit's operating schedule status is typically given as: (0 = unavailable) (1 = available to startup or shutdown) (2 = must pump).

Table 454 shows all attributes of HydroPumpOpSchedule.

Table 454 – Attributes of Production::HydroPumpOpSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule

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name	mult	type	description
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 455 shows all association ends of HydroPumpOpSchedule with other classes.

Table 455 – Association ends of Production::HydroPumpOpSchedule with other classes

mult from	name	mult to	type	description
0..1	HydroPump	1..1	HydroPump	The hydro pump has a pumping schedule over time, indicating when pumping is to occur.
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.39 HydroGeneratingEfficiencyCurve

Relationship between unit efficiency as a percentage and unit output active power for a given net head in metres. The relationship between efficiency, discharge, head, and power output is expressed as follows: $E = KP/HQ$

where (E=percentage) (P=active power) (H= height) (Q=volume/time unit) (K=constant)

For example, a curve instance for a given net head could relate efficiency (Y-axis) versus active power output (X-axis) or versus discharge on the X-axis.

Table 456 shows all attributes of HydroGeneratingEfficiencyCurve.

Table 456 – Attributes of Production::HydroGeneratingEfficiencyCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 457 shows all association ends of HydroGeneratingEfficiencyCurve with other classes.

Table 457 – Association ends of Production::HydroGeneratingEfficiencyCurve with other classes

mult from	name	mult to	type	description
0..*	HydroGeneratingUnit	1..1	HydroGeneratingUnit	A hydro generating unit has an efficiency curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.40 Emission datatype

Quantity of emission per fuel heat content.

Table 458 shows all attributes of Emission.

Table 458 – Attributes of Production::Emission

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=g)
multiplier	0..1	UnitMultiplier	(const=k)
denominatorUnit	0..1	UnitSymbol	(const=J)
denominatorMultiplier	0..1	UnitMultiplier	

6.10.3.41 CostPerHeatUnit datatype

Cost, in units of currency, per quantity of heat generated.

Table 459 shows all attributes of CostPerHeatUnit.

Table 459 – Attributes of Production::CostPerHeatUnit

name	mult	type	description
value	0..1	Float	
unit	0..1	Currency	
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=J)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.10.3.42 CogenerationPlant

A set of thermal generating units for the production of electrical energy and process steam (usually from the output of the steam turbines). The steam sendout is typically used for industrial purposes or for municipal heating and cooling.

Table 460 shows all attributes of CogenerationPlant.

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Table 460 – Attributes of Production::CogenerationPlant

name	mult	type	description
cogenHPSendoutRating	0..1	Float	The high pressure steam sendout.
cogenHPSteamRating	0..1	Float	The high pressure steam rating.
cogenLPSendoutRating	0..1	Float	The low pressure steam sendout.
cogenLPSteamRating	0..1	Float	The low pressure steam rating.
ratedP	0..1	ActivePower	The rated output active power of the cogeneration plant.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 461 shows all association ends of CogenerationPlant with other classes.

Table 461 – Association ends of Production::CogenerationPlant with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnits	0..*	ThermalGeneratingUnit	A thermal generating unit may be a member of a cogeneration plant.
1..1	SteamSendoutSchedule	1..1	SteamSendoutSchedule	A cogeneration plant has a steam sendout schedule.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.43 StartRampCurve

Rate in gross active power per minute (Y-axis) at which a unit can be loaded versus the number of hours (X-axis) the unit was off line.

Table 462 shows all attributes of StartRampCurve.

Table 462 – Attributes of Production::StartRampCurve

name	mult	type	description
hotStandbyRamp	0..1	ActivePowerChangeRate	The startup ramp rate in gross for a unit that is on hot standby.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve

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name	mult	type	description
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 463 shows all association ends of StartRampCurve with other classes.

Table 463 – Association ends of Production::StartRampCurve with other classes

mult from	name	mult to	type	description
0..1	StartupModel	1..1	StartupModel	The unit's startup model may have a startup ramp curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.44 GeneratorControlMode enumeration

Unit control modes.

Table 464 shows all literals of GeneratorControlMode.

Table 464 – Literals of Production::GeneratorControlMode

literal	value	description
setpoint		Setpoint control mode.
pulse		Pulse control mode.

6.10.3.45 LevelVsVolumeCurve

Relationship between reservoir volume and reservoir level. The volume is at the Y-axis and the reservoir level at the X-axis.

Table 465 shows all attributes of LevelVsVolumeCurve.

Table 465 – Attributes of Production::LevelVsVolumeCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve

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name	mult	type	description
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 466 shows all association ends of LevelVsVolumeCurve with other classes.

Table 466 – Association ends of Production::LevelVsVolumeCurve with other classes

mult from	name	mult to	type	description
0..*	Reservoir	1..1	Reservoir	A reservoir may have a level versus volume relationship.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.46 StartupModel

Unit start up characteristics depending on how long the unit has been off line.

Table 467 shows all attributes of StartupModel.

Table 467 – Attributes of Production::StartupModel

name	mult	type	description
fixedMaintCost	0..1	CostRate	Fixed maintenance cost.
hotStandbyHeat	0..1	HeatRate	The amount of heat input per time unit required for hot standby operation.
incrementalMaintCost	0..1	CostPerEnergyUnit	Incremental maintenance cost.
minimumDownTime	0..1	Hours	The minimum number of hours the unit must be down before restart.
minimumRunTime	0..1	Hours	The minimum number of hours the unit must be operating before being allowed to shut down.
riskFactorCost	0..1	Money	The opportunity cost associated with the return in monetary unit. This represents the restart's "share" of the unit depreciation and risk of an event which would damage the unit.
startupCost	0..1	Money	Total miscellaneous start up costs.
startupDate	0..1	DateTime	The date and time of the most recent generating unit startup.
startupPriority	0..1	Integer	Startup priority within control area where lower numbers indicate higher priorities. More than one unit in an area may be assigned the same priority.
stbyAuxP	0..1	ActivePower	The unit's auxiliary active power consumption to maintain standby mode.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
name	0..1	String	inherited from: IdentifiedObject

Table 468 shows all association ends of StartupModel with other classes.

Table 468 – Association ends of Production::StartupModel with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have a startup model.
1..1	StartMainFuelCurve	0..1	Start~~Ign~~MainFuelCurve	The unit's startup model may have a startup ~~ignition~~ main fuel curve.
1..1	StartIgnFuelCurve	0..1	Start~~Main~~IgnFuelCurve	The unit's startup model may have a startup ~~main~~ ignition fuel curve.
1..1	StartRampCurve	0..1	StartRampCurve	The unit's startup model may have a startup ramp curve.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.47 GenUnitOpSchedule

The generating unit's Operator-approved current operating schedule (or plan), typically produced with the aid of unit commitment type analyses. The X-axis represents absolute time. The Y1-axis represents the status (0 = off-line and unavailable; 1 = available; 2 = must run; 3 = must run at fixed power value; etc.). The Y2-axis represents the must run fixed power value where required.

Table 469 shows all attributes of GenUnitOpSchedule.

Table 469 – Attributes of Production::GenUnitOpSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 470 shows all association ends of GenUnitOpSchedule with other classes.

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Table 470 – Association ends of Production::GenUnitOpSchedule with other classes

mult from	name	mult to	type	description
0..1	GeneratingUnit	1..1	GeneratingUnit	A generating unit may have an operating schedule, indicating the planned operation of the unit.
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.48 WindGenUnitKind enumeration

Kind of wind generating unit.

Table 471 shows all literals of WindGenUnitKind.

Table 471 – Literals of Production::WindGenUnitKind

literal	value	description
offshore		The wind generating unit is located offshore.
onshore		The wind generating unit is located onshore.

6.10.3.49 SolarGeneratingUnit

A solar thermal generating unit.

Table 472 shows all attributes of SolarGeneratingUnit.

Table 472 – Attributes of Production::SolarGeneratingUnit

name	mult	type	description
allocSpinResP	0..1	ActivePower	inherited from: GeneratingUnit
autoCntrlMarginP	0..1	ActivePower	inherited from: GeneratingUnit
baseP	0..1	ActivePower	inherited from: GeneratingUnit
controlDeadband	0..1	ActivePower	inherited from: GeneratingUnit
controlPulseHigh	0..1	Seconds	inherited from: GeneratingUnit
controlPulseLow	0..1	Seconds	inherited from: GeneratingUnit
controlResponseRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
efficiency	0..1	PerCent	inherited from: GeneratingUnit
genControlMode	0..1	GeneratorControlMode	inherited from: GeneratingUnit
genControlSource	0..1	GeneratorControlSource	inherited from: GeneratingUnit
governorMPL	0..1	PU	inherited from: GeneratingUnit
governorSCD	0..1	PerCent	inherited from: GeneratingUnit
highControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
initialP	0..1	ActivePower	inherited from: GeneratingUnit
longPF	0..1	Float	inherited from: GeneratingUnit
lowControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
lowerRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
maxEconomicP	0..1	ActivePower	inherited from: GeneratingUnit

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name	mult	type	description
maximumAllowableSpinningReserve	0..1	ActivePower	inherited from: GeneratingUnit
maxOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
minEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
minimumOffTime	0..1	Seconds	inherited from: GeneratingUnit
minOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
modelDetail	0..1	Classification	inherited from: GeneratingUnit
nominalP	0..1	ActivePower	inherited from: GeneratingUnit
normalPF	0..1	Float	inherited from: GeneratingUnit
penaltyFactor	0..1	Float	inherited from: GeneratingUnit
raiseRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
ratedGrossMaxP	0..1	ActivePower	inherited from: GeneratingUnit
ratedGrossMinP	0..1	ActivePower	inherited from: GeneratingUnit
ratedNetMaxP	0..1	ActivePower	inherited from: GeneratingUnit
shortPF	0..1	Float	inherited from: GeneratingUnit
startupCost	0..1	Money	inherited from: GeneratingUnit
startupTime	0..1	Seconds	inherited from: GeneratingUnit
tieLinePF	0..1	Float	inherited from: GeneratingUnit
totalEfficiency	0..1	PerCent	inherited from: GeneratingUnit
variableCost	0..1	Money	inherited from: GeneratingUnit
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 473 shows all association ends of SolarGeneratingUnit with other classes.

Table 473 – Association ends of Production::SolarGeneratingUnit with other classes

mult from	name	mult to	type	description
0..1	RotatingMachine	1..*	RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.50 PowerElectronicsUnit

A generating unit or battery or aggregation that connects to the AC network using power electronics rather than rotating machines.

Table 474 shows all attributes of PowerElectronicsUnit.

Table 474 – Attributes of Production::PowerElectronicsUnit

name	mult	type	description
maxP	0..1	ActivePower	Maximum active power limit. This is the maximum (nameplate) limit for the unit.
minP	0..1	ActivePower	Minimum active power limit. This is the minimum (nameplate) limit for the unit.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 475 shows all association ends of PowerElectronicsUnit with other classes.

Table 475 – Association ends of Production::PowerElectronicsUnit with other classes

mult from	name	mult to	type	description
0..*	PowerElectronicsConnection	1..1	PowerElectronicsConnection	A power electronics unit has a connection to the AC network.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.10.3.51 PowerElectronicsWindUnit

A wind generating unit that connects to the AC network with power electronics rather than rotating machines or an aggregation of such units.

Table 476 shows all attributes of PowerElectronicsWindUnit.

Table 476 – Attributes of Production::PowerElectronicsWindUnit

name	mult	type	description
maxP	0..1	ActivePower	inherited from: PowerElectronicsUnit
minP	0..1	ActivePower	inherited from: PowerElectronicsUnit
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject

Table 477 – Association ends of Production::PowerElectronicsWindUnit with other classes

mult from	name	mult to	type	description
0..*	PowerElectronicsConnection	1..1	PowerElectronicsConnection	inherited from: PowerElectronicsUnit
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.11 Package DC

6.11.1 General

This package contains model for direct current equipment and controls.

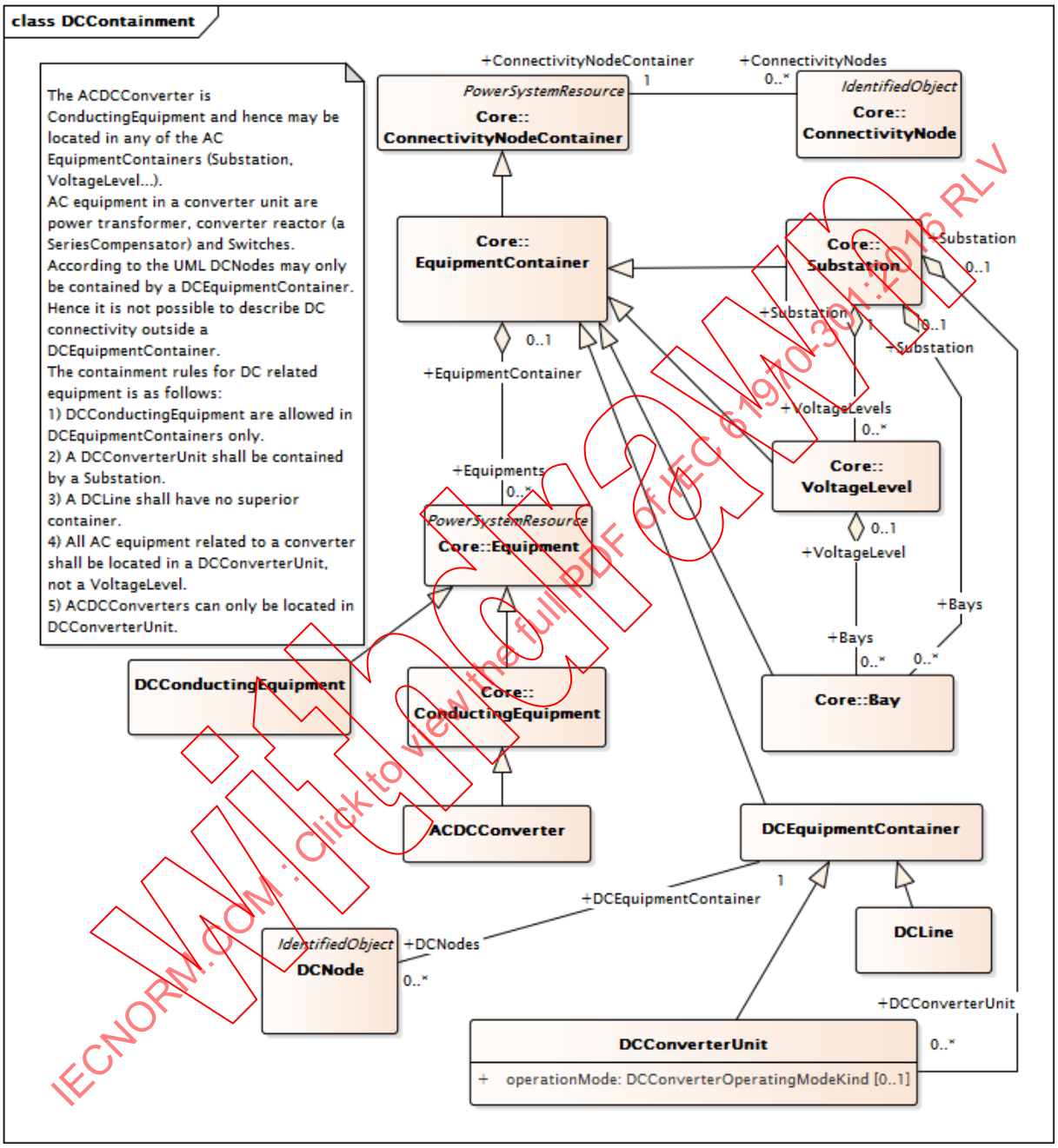


Figure 108 – Class diagram DC::DCContainment

Figure 108:

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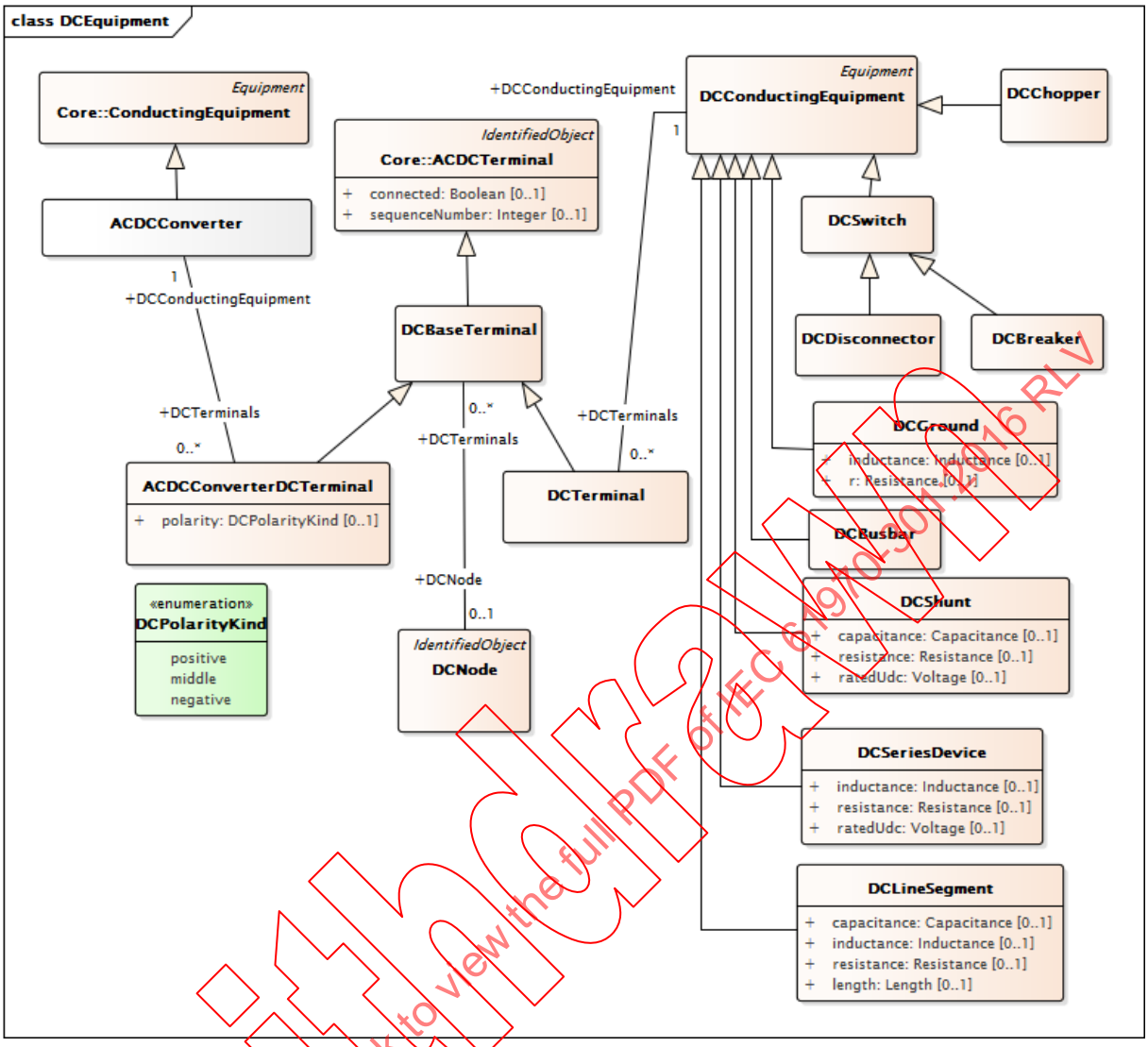


Figure 109 – Class diagram DC::DCEquipment

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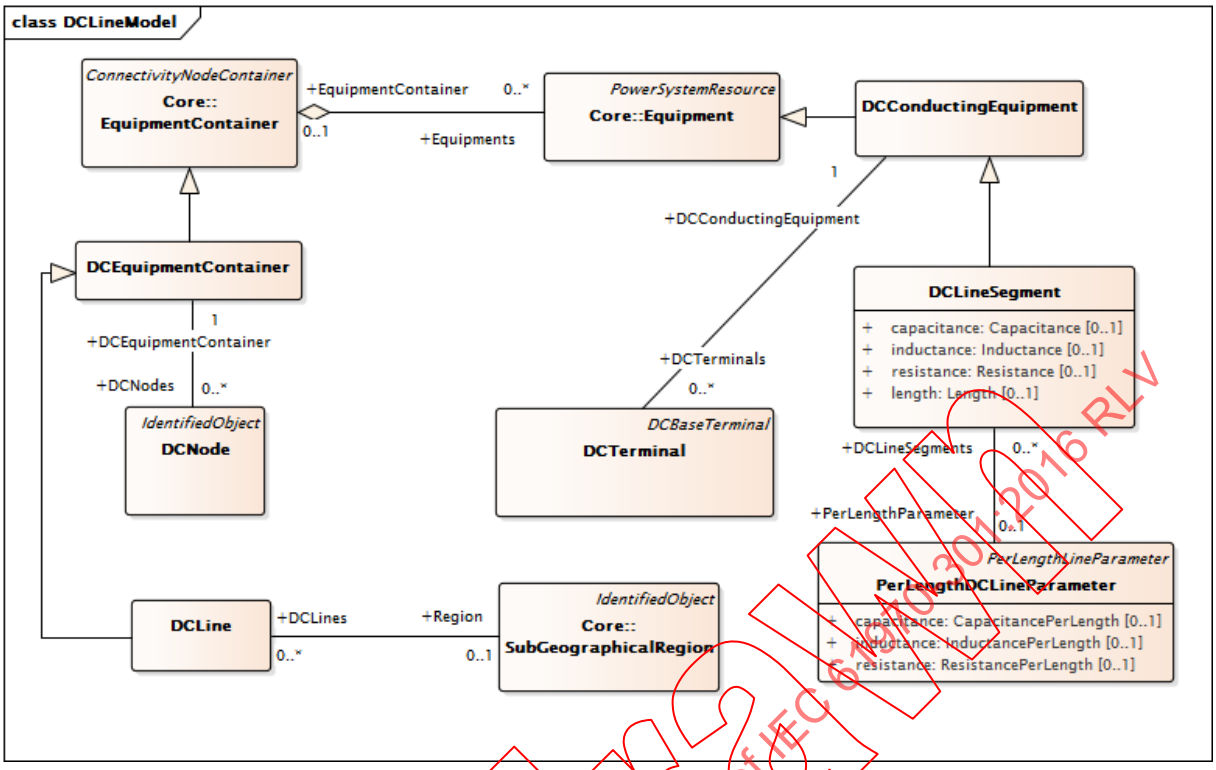
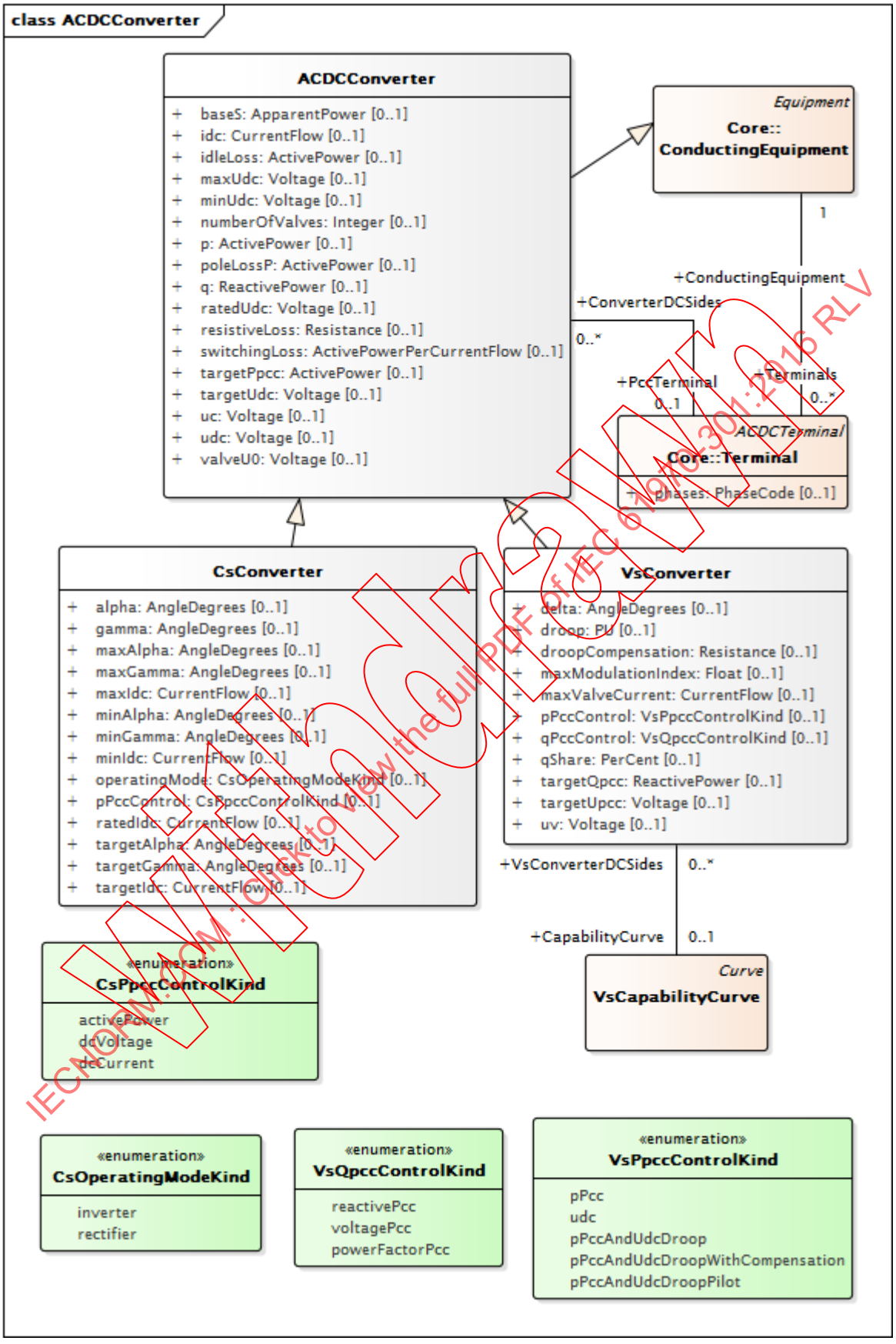


Figure 110 – Class diagram DC::DCLineModel

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Figure 111 – Class diagram DC::ACDCConverter

Figure 111: This diagram shows classes used to model DC equipment.

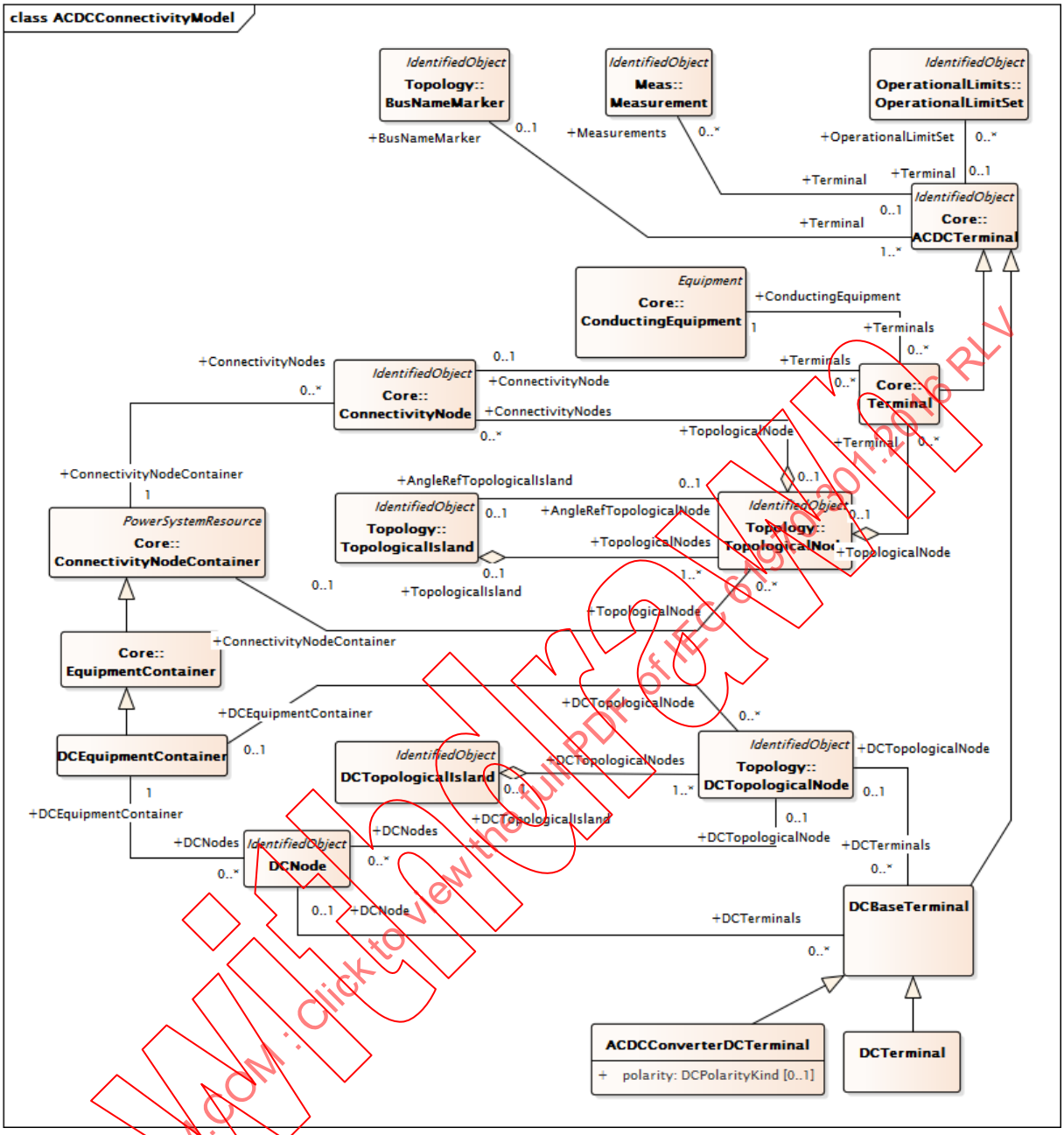


Figure 112 – Class diagram DC::ACDCConnectivityModel

Figure 112: This diagram shows connectivity and topology model for both AC and DC networks.

6.11.2 ACDCConverter

A unit with valves for three phases, together with unit control equipment, essential protective and switching devices, DC storage capacitors, phase reactors and auxiliaries, if any, used for conversion.

Table 478 shows all attributes of ACDCConverter.

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Table 478 – Attributes of DC::ACDCConverter

name	mult	type	description
baseS	0..1	ApparentPower	Base apparent power of the converter pole.
idc	0..1	CurrentFlow	Converter DC current, also called Id. Converter state variable, result from power flow.
idleLoss	0..1	ActivePower	Active power loss in pole at no power transfer. Converter configuration data used in power flow.
maxUdc	0..1	Voltage	The maximum voltage on the DC side at which the converter should operate. Converter configuration data used in power flow.
minUdc	0..1	Voltage	Minimum allowed converter DC voltage. Converter configuration data used in power flow.
numberOfValves	0..1	Integer	Number of valves in the converter. Used in loss calculations.
p	0..1	ActivePower	Active power at the point of common coupling. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution in the case a simplified power flow model is used.
poleLossP	0..1	ActivePower	The active power loss at a DC Pole = idleLoss + switchingLoss*|Idc| + resitiveLoss*Idc^2 For lossless operation Pdc=Pac For rectifier operation with losses Pdc=Pac-lossP For inverter operation with losses Pdc=Pac+lossP Converter state variable used in power flow.
q	0..1	ReactivePower	Reactive power at the point of common coupling. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution in the case a simplified power flow model is used.
ratedUdc	0..1	Voltage	Rated converter DC voltage, also called UdN. Converter configuration data used in power flow.
resistiveLoss	0..1	Resistance	Converter configuration data used in power flow. Refer to poleLossP.
switchingLoss	0..1	ActivePowerPerCurrentFlow	Switching losses, relative to the base apparent power 'baseS'. Refer to poleLossP.
targetPpcc	0..1	ActivePower	Real power injection target in AC grid, at point of common coupling.
targetUdc	0..1	Voltage	Target value for DC voltage magnitude.
uc	0..1	Voltage	Line-to-line converter voltage, the voltage at the AC side of the valve. Converter state variable, result from power flow.
udc	0..1	Voltage	Converter voltage at the DC side, also called Ud. Converter state variable, result from power flow.
valveU0	0..1	Voltage	Valve threshold voltage, also called Uvalve. Forward voltage drop when the valve is conducting. Used in loss calculations, i.e. the switchLoss depends on numberOfValves * valveU0.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 479 shows all association ends of ACDCConverter with other classes.

Table 479 – Association ends of DC::ACDCConverter with other classes

mult from	name	mult to	type	description
0..*	PccTerminal	0..1	Terminal	Point of common coupling terminal for this converter DC side. It is typically the terminal on the power transformer (or switch) closest to the AC network. The power flow measurement shall be the sum of all flows into the transformer.
1..1	DCTerminals	0..*	ACDCConverterDCTerminal	A DC converter have DC converter terminals. A converter has two DC converter terminals.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.3 ACDCConverterDCTerminal

A DC electrical connection point at the AC/DC converter. The AC/DC converter is electrically connected also to the AC side. The AC connection is inherited from the AC conducting equipment in the same way as any other AC equipment. The AC/DC converter DC terminal is separate from generic DC terminal to restrict the connection with the AC side to AC/DC converter and so that no other DC conducting equipment can be connected to the AC side.

Table 480 shows all attributes of ACDCConverterDCTerminal.

Table 480 – Attributes of DC::ACDCConverterDCTerminal

name	mult	type	description
polarity	0..1	DCPolarityKind	Represents the normal network polarity condition.
connected	0..1	Boolean	inherited from: ACDCTerminal

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name	mult	type	description
sequenceNumber	0..1	Integer	inherited from: ACDCTerminal
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 481 shows all association ends of ACDCConverterDCTerminal with other classes.

Table 481 – Association ends of DC::ACDCConverterDCTerminal with other classes

mult from	name	mult to	type	description
0..*	DCConductingEquipment	1..1	ACDCConverter	A DC converter terminal belong to an DC converter.
0..*	DCTopologicalNode	0..1	DCTopologicalNode	inherited from: DCBaseTerminal
0..*	DCNode	0..1	DCNode	inherited from: DCBaseTerminal
1..*	BusNameMarker	0..1	BusNameMarker	inherited from: ACDCTerminal
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: ACDCTerminal
0..1	Measurements	0..*	Measurement	inherited from: ACDCTerminal
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.4 DCBaseTerminal

An electrical connection point at a piece of DC conducting equipment. DC terminals are connected at one physical DC node that may have multiple DC terminals connected. A DC node is similar to an AC connectivity node. The model enforces that DC connections are distinct from AC connections.

Table 482 shows all attributes of DCBaseTerminal.

Table 482 – Attributes of DC::DCBaseTerminal

name	mult	type	description
connected	0..1	Boolean	inherited from: ACDCTerminal
sequenceNumber	0..1	Integer	inherited from: ACDCTerminal
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 483 shows all association ends of DCBaseTerminal with other classes.

Table 483 – Association ends of DC::DCBaseTerminal with other classes

mult from	name	mult to	type	description
0..*	DCTopologicalNode	0..1	DCTopologicalNode	The DC topological node associated with the DC base terminal.

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mult from	name	mult to	type	description
0..*	DCNode	0..1	DCNode	The DC connectivity node to which this DC base terminal connects with zero impedance.
1..*	BusNameMarker	0..1	BusNameMarker	inherited from: ACDCTerminal
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: ACDCTerminal
0..1	Measurements	0..*	Measurement	inherited from: ACDCTerminal
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.5 DCConverterUnit

Indivisible operative unit comprising all equipment between the point of common coupling on the AC side and the point of common coupling – DC side, essentially one or more converters, together with one or more converter transformers, converter control equipment, essential protective and switching devices and auxiliaries, if any, used for conversion.

Table 484 shows all attributes of DCConverterUnit.

Table 484 – Attributes of DC::DCConverterUnit

name	mult	type	description
operationMode	0..1	DCConverterOperatingModeKind	
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 485 shows all association ends of DCConverterUnit with other classes.

Table 485 – Association ends of DC::DCConverterUnit with other classes

mult from	name	mult to	type	description
0..*	Substation	0..1	Substation	The containing substation of the DC converter unit.
0..1	DCTopologicalNode	0..*	DCTopologicalNode	inherited from: DCEquipmentContainer
1..1	DCNodes	0..*	DCNode	inherited from: DCEquipmentContainer
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.11.6 DCLine

Overhead lines and/or cables connecting two or more HVDC substations.

Table 486 shows all attributes of DCLine.

Table 486 – Attributes of DC::DCLine

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 487 shows all association ends of DCLine with other classes.

Table 487 – Association ends of DC::DCLine with other classes

mult from	name	mult to	type	description
0..*	Region	0..1	SubGeographicalRegion	The SubGeographicalRegion containing the DC line.
0..1	DCTopologicalNode	0..*	DCTopologicalNode	inherited from: DCEquipmentContainer
1..1	DCNodes	0..*	DCNode	inherited from: DCEquipmentContainer
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.7 DCSeriesDevice

A series device within the DC system, typically a reactor used for filtering or smoothing. Needed for transient and short circuit studies.

Table 488 shows all attributes of DCSeriesDevice.

Table 488 – Attributes of DC::DCSeriesDevice

name	mult	type	description
inductance	0..1	Inductance	Inductance of the device.
resistance	0..1	Resistance	Resistance of the DC device.
ratedUdc	0..1	Voltage	Rated DC device voltage. Converter configuration data used in power flow.
aggregate	0..1	Boolean	inherited from: Equipment

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name	mult	type	description
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 489 shows all association ends of DCSeriesDevice with other classes.

Table 489 – Association ends of DC::DCSeriesDevice with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.8 VsQpccControlKind enumeration

Table 490 shows all literals of VsQpccControlKind.

Table 490 – Literals of DC::VsQpccControlKind

literal	value	description
reactivePcc		
voltagePcc		
powerFactorPcc		

6.11.9 CsPpccControlKind enumeration

Active power control modes for HVDC line operating as Current Source Converter.

Table 491 shows all literals of CsPpccControlKind.

Table 491 – Literals of DC::CsPpccControlKind

literal	value	description
activePower		Active power control at AC side.
dcVoltage		DC voltage control.
dcCurrent		DC current control

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6.11.10 CsOperatingModeKind enumeration

Operating mode for HVDC line operating as Current Source Converter.

Table 492 shows all literals of CsOperatingModeKind.

Table 492 – Literals of DC::CsOperatingModeKind

literal	value	description
inverter		Operating as inverter
rectifier		Operating as rectifier.

6.11.11 CsConverter

DC side of the current source converter (CSC).

Table 493 shows all attributes of CsConverter.

Table 493 – Attributes of DC::CsConverter

name	mult	type	description
alpha	0..1	AngleDegrees	Firing angle, typical value between 10 degrees and 18 degrees for a rectifier. CSC state variable, result from power flow.
gamma	0..1	AngleDegrees	Extinction angle. CSC state variable, result from power flow.
maxAlpha	0..1	AngleDegrees	Maximum firing angle. CSC configuration data used in power flow.
maxGamma	0..1	AngleDegrees	Maximum extinction angle. CSC configuration data used in power flow.
maxIdc	0..1	CurrentFlow	The maximum direct current (Id) on the DC side at which the converter should operate. Converter configuration data use in power flow.
minAlpha	0..1	AngleDegrees	Minimum firing angle. CSC configuration data used in power flow.
minGamma	0..1	AngleDegrees	Minimum extinction angle. CSC configuration data used in power flow.
minIdc	0..1	CurrentFlow	The minimum direct current (Id) on the DC side at which the converter should operate. CSC configuration data used in power flow.
operatingMode	0..1	CsOperatingModeKind	Indicates whether the DC pole is operating as an inverter or as a rectifier. CSC control variable used in power flow.
pPccControl	0..1	CsPpccControlKind	Kind of active power control.
ratedIdc	0..1	CurrentFlow	Rated converter DC current, also called IdN. Converter configuration data used in power flow.
targetAlpha	0..1	AngleDegrees	Target firing angle. CSC control variable used in power flow.
targetGamma	0..1	AngleDegrees	Target extinction angle. CSC control variable used in power flow.
targetIdc	0..1	CurrentFlow	DC current target value. CSC control variable used in power flow.
baseS	0..1	ApparentPower	inherited from: ACDCConverter
idc	0..1	CurrentFlow	inherited from: ACDCConverter
idleLoss	0..1	ActivePower	inherited from: ACDCConverter
maxUdc	0..1	Voltage	inherited from: ACDCConverter

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name	mult	type	description
minUdc	0..1	Voltage	inherited from: ACDCConverter
numberOfValves	0..1	Integer	inherited from: ACDCConverter
p	0..1	ActivePower	inherited from: ACDCConverter
poleLossP	0..1	ActivePower	inherited from: ACDCConverter
q	0..1	ReactivePower	inherited from: ACDCConverter
ratedUdc	0..1	Voltage	inherited from: ACDCConverter
resistiveLoss	0..1	Resistance	inherited from: ACDCConverter
switchingLoss	0..1	ActivePowerPerCurrentFlow	inherited from: ACDCConverter
targetPpcc	0..1	ActivePower	inherited from: ACDCConverter
targetUdc	0..1	Voltage	inherited from: ACDCConverter
uc	0..1	Voltage	inherited from: ACDCConverter
udc	0..1	Voltage	inherited from: ACDCConverter
valveU0	0..1	Voltage	inherited from: ACDCConverter
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 494 shows all association ends of CsConverter with other classes.

Table 494 – Association ends of DC::CsConverter with other classes

mult from	name	mult to	type	description
0..*	PccTerminal	0..1	Terminal	inherited from: ACDCConverter
1..1	DCTerminals	0..*	ACDCConverterDCTerminal	inherited from: ACDCConverter
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.11.12 DCBreaker

A breaker within a DC system.

Table 495 shows all attributes of DCBreaker.

Table 495 – Attributes of DC::DCBreaker

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 496 shows all association ends of DCBreaker with other classes.

Table 496 – Association ends of DC::DCBreaker with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.13 DCEquipmentContainer

A modeling construct to provide a root class for containment of DC as well as AC equipment. The class differs from the EquipmentContaner for AC in that it may also contain DCNodes. Hence it can contain both AC and DC equipment.

Table 497 shows all attributes of DCEquipmentContainer.

Table 497 – Attributes of DC::DCEquipmentContainer

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 498 shows all association ends of DCEquipmentContainer with other classes.

Table 498 – Association ends of DC::DCEquipmentContainer with other classes

mult from	name	mult to	type	description
0..1	DCTopologicalNode	0..*	DCTopologicalNode	The topological nodes which belong to this connectivity node container.
1..1	DCNodes	0..*	DCNode	The DC nodes contained in the DC equipment container.
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.14 DCBusbar

A busbar within a DC system.

Table 499 shows all attributes of DCBusbar.

Table 499 – Attributes of DC::DCBusbar

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 500 shows all association ends of DCBusbar with other classes.

Table 500 – Association ends of DC::DCBusbar with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.15 DCConverterOperatingModeKind enumeration

The operating mode of an HVDC bipole.

Table 501 shows all literals of DCConverterOperatingModeKind.

Table 501 – Literals of DC::DCConverterOperatingModeKind

literal	value	description
bipolar		Bipolar operation.
monopolarMetallicReturn		Monopolar operation with metallic return
monopolarGroundReturn		Monopolar operation with ground return

6.11.16 DCChopper

Low resistance equipment used in the internal DC circuit to balance voltages. It has typically positive and negative pole terminals and a ground.

Table 502 shows all attributes of DCChopper.

Table 502 – Attributes of DC::DCChopper

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 503 shows all association ends of DCChopper with other classes.

Table 503 – Association ends of DC::DCChopper with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.17 DCDisconnector

A disconnector within a DC system.

Table 504 shows all attributes of DCDisconnector.

Table 504 – Attributes of DC::DCDisconnector

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 505 shows all association ends of DCDisconnector with other classes.

Table 505 – Association ends of DC::DCDisconnector with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.11.18 DCGround

A ground within a DC system.

Table 506 shows all attributes of DCGround.

Table 506 – Attributes of DC::DCGround

name	mult	type	description
inductance	0..1	Inductance	Inductance to ground.
r	0..1	Resistance	Resistance to ground.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 507 shows all association ends of DCGround with other classes.

Table 507 – Association ends of DC::DCGround with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.19 DCLineSegment

A wire or combination of wires not insulated from one another, with consistent electrical characteristics, used to carry direct current between points in the DC region of the power system.

Table 508 shows all attributes of DCLineSegment.

Table 508 – Attributes of DC::DCLineSegment

name	mult	type	description
~~dcSegmentInductance~~		~~Inductance~~	~~Inductance of the DC line segment.~~
~~dcSegmentResistance~~		~~Resistance~~	~~Resistance of the DC line segment.~~

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name	mult	type	description
capacitance	0..1	Capacitance	Capacitance of the DC line segment. Significant for cables only.
inductance	0..1	Inductance	Inductance of the DC line segment. Negligible compared with DCSeriesDevice used for smoothing.
resistance	0..1	Resistance	Resistance of the DC line segment.
length	0..1	Length	~~inherited from: Conductor~~ Segment length for calculating line section capabilities.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 509 shows all association ends of DCLineSegment with other classes.

Table 509 – Association ends of DC::DCLineSegment with other classes

mult from	name	mult to	type	description
~~[0..*]~~	~~[0..1] BaseVoltage~~		~~BaseVoltage~~	~~inherited from: ConductingEquipment~~
~~[0..*]~~	~~[0..*] ProtectionEquipments~~		~~ProtectionEquipment~~	~~inherited from: ConductingEquipment~~
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
~~[1..1]~~	~~[0..1] SvStatus~~		~~SvStatus~~	~~inherited from: ConductingEquipment~~
0..*	PerLengthParameter	0..1	PerLengthDCLineParameter	Set of per-length parameters for this line segment.
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.20 DCShunt

A shunt device within the DC system, typically used for filtering. Needed for transient and short circuit studies.

Table 510 shows all attributes of DCShunt.

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Table 510 – Attributes of DC::DCShunt

name	mult	type	description
capacitance	0..1	Capacitance	Capacitance of the DC shunt.
resistance	0..1	Resistance	Resistance of the DC device.
ratedUdc	0..1	Voltage	Rated DC device voltage. Converter configuration data used in power flow.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 511 shows all association ends of DCShunt with other classes.

Table 511 – Association ends of DC::DCShunt with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.21 DCConductingEquipment

The parts of the DC power system that are designed to carry current or that are conductively connected through DC terminals.

Table 512 shows all attributes of DCConductingEquipment.

Table 512 – Attributes of DC::DCConductingEquipment

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 513 shows all association ends of DCConductingEquipment with other classes.

Table 513 – Association ends of DC::DCConductingEquipment with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	A DC conducting equipment has DC terminals.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.22 DCSwitch

A switch within the DC system.

Table 514 shows all attributes of DCSwitch.

Table 514 – Attributes of DC::DCSwitch

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 515 shows all association ends of DCSwitch with other classes.

Table 515 – Association ends of DC::DCSwitch with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.23 DCNode

DC nodes are points where terminals of DC conducting equipment are connected together with zero impedance.

Table 516 shows all attributes of DCNode.

Table 516 – Attributes of DC::DCNode

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 517 shows all association ends of DCNode with other classes.

Table 517 – Association ends of DC::DCNode with other classes

mult from	name	mult to	type	description
0..*	DCTopologicalNode	0..1	DCTopologicalNode	The DC topological node to which this DC connectivity node is assigned. May depend on the current state of switches in the network.
0..1	DCTerminals	0..*	DCBaseTerminal	DC base terminals interconnected with zero impedance at a this DC connectivity node.
0..*	DCEquipmentContainer	1..1	DCEquipmentContainer	The DC container for the DC nodes.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.24 DCTopologicalIsland

An electrically connected subset of the network. DC topological islands can change as the current network state changes, e.g. due to

– disconnect switches or breakers changing state in a SCADA/EMS,

– manual creation, change or deletion of topological nodes in a planning tool.

Table 518 shows all attributes of DCTopologicalIsland.

Table 518 – Attributes of DC::DCTopologicalIsland

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 519 shows all association ends of DCTopologicalIsland with other classes.

Table 519 – Association ends of DC::DCTopologicalIsland with other classes

mult from	name	mult to	type	description
0..1	DCTopologicalNodes	1..*	DCTopologicalNode	The DC topological nodes in a DC topological island.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.25 DCPolarityKind enumeration

Polarity for DC circuits.

Table 520 shows all literals of DCPolarityKind.

Table 520 – Literals of DC::DCPolarityKind

literal	value	description
positive		Positive pole.
middle		Middle pole, potentially grounded.
negative		Negative pole.

6.11.26 PerLengthDCLineParameter

Table 521 shows all attributes of PerLengthDCLineParameter.

Table 521 – Attributes of DC::PerLengthDCLineParameter

name	mult	type	description
capacitance	0..1	CapacitancePerLength	Capacitance per unit of length of the DC line segment; significant for cables only.
inductance	0..1	InductancePerLength	Inductance per unit of length of the DC line segment.
resistance	0..1	ResistancePerLength	Resistance per length of the DC line segment.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 522 shows all association ends of PerLengthDCLineParameter with other classes.

Table 522 – Association ends of DC::PerLengthDCLineParameter with other classes

mult from	name	mult to	type	description
0..1	DCLineSegments	0..*	DCLineSegment	All line segments described by this set of per-length parameters.

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mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.27 DCTerminal

An electrical connection point to generic DC conducting equipment.

Table 523 shows all attributes of DCTerminal.

Table 523 – Attributes of DC::DCTerminal

name	mult	type	description
connected	0..1	Boolean	inherited from: ACDCTerminal
sequenceNumber	0..1	Integer	inherited from: ACDCTerminal
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 524 shows all association ends of DCTerminal with other classes.

Table 524 – Association ends of DC::DCTerminal with other classes

mult from	name	mult to	type	description
0..*	DCConductingEquipment	1..1	DCConductingEquipment	A DC terminal belonging to a DC conducting equipment.
0..*	DCTopologicalNode	0..1	DCTopologicalNode	inherited from: DCBaseTerminal
0..*	DCNode	0..1	DCNode	inherited from: DCBaseTerminal
1..*	BusNameMarker	0..1	BusNameMarker	inherited from: ACDCTerminal
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: ACDCTerminal
0..1	Measurements	0..*	Measurement	inherited from: ACDCTerminal
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.28 VsPpccControlKind enumeration

Types applicable to the control of real power and/or DC voltage by voltage source converter.

Table 525 shows all literals of VsPpccControlKind.

Table 525 – Literals of DC::VsPpccControlKind

literal	value	description
pPcc		Control variable (target) is real power at PCC bus.
udc		Control variable (target) is DC voltage and real power at PCC bus is derived.

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literal	value	description
pPccAndUdcDroop		Control variables (targets) are both active power at point of common coupling and local DC voltage, with the droop.
pPccAndUdcDroopWithCompensation		Control variables (targets) are both active power at point of common coupling and compensated DC voltage, with the droop; compensation factor is the resistance, as an approximation of the DC voltage of a common (real or virtual) node in the DC network.
pPccAndUdcDroopPilot		Control variables (targets) are both active power at point of common coupling and the pilot DC voltage, with the droop.

6.11.29 VsCapabilityCurve

The *P*-*Q* capability curve for a voltage source converter, with *P* on X-axis and Qmin and Qmax on Y1-axis and Y2-axis.

Table 526 shows all attributes of VsCapabilityCurve.

Table 526 – Attributes of DC::VsCapabilityCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 527 shows all association ends of VsCapabilityCurve with other classes.

Table 527 – Association ends of DC::VsCapabilityCurve with other classes

mult from	name	mult to	type	description
0..1	VsConverterDCSides	0..*	VsConverter	All converters with this capability curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.30 VsConverter

DC side of the voltage source converter (VSC).

Table 528 shows all attributes of VsConverter.

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Table 528 – Attributes of DC::VsConverter

name	mult	type	description
delta	0..1	AngleDegrees	Angle between uf and uc. Converter state variable used in power flow.
droop	0..1	PU	Droop constant; pu value is obtained as D [kV/MW] * Sb / Ubdc.
droopCompensation	0..1	Resistance	Compensation constant. Used to compensate for voltage drop when controlling voltage at a distant bus.
maxModulationIndex	0..1	Float	The maximum quotient between the AC converter voltage (Uc) and DC voltage (Ud). A factor typically less than 1. VSC configuration data used in power flow.
maxValveCurrent	0..1	CurrentFlow	The maximum current through a valve. This current limit is the basis for calculating the capability diagram. VSC configuration data.
pPccControl	0..1	VsPpccControlKind	Kind of active power control.
qPccControl	0..1	VsQpccControlKind	Kind of reactive power control.
qShare	0..1	PerCent	Reactive power sharing factor among parallel converters on Uac control.
targetQpcc	0..1	ReactivePower	Reactive power injection target in AC grid, at point of common coupling.
targetUpcc	0..1	Voltage	Voltage target in AC grid, at point of common coupling.
uv	0..1	Voltage	Line-to-line voltage on the valve side of the converter transformer. Converter state variable, result from power flow.
baseS	0..1	ApparentPower	inherited from: ACDCConverter
idc	0..1	CurrentFlow	inherited from: ACDCConverter
idleLoss	0..1	ActivePower	inherited from: ACDCConverter
maxUdc	0..1	Voltage	inherited from: ACDCConverter
minUdc	0..1	Voltage	inherited from: ACDCConverter
numberOfValves	0..1	Integer	inherited from: ACDCConverter
p	0..1	ActivePower	inherited from: ACDCConverter
poleLossP	0..1	ActivePower	inherited from: ACDCConverter
q	0..1	ReactivePower	inherited from: ACDCConverter
ratedUdc	0..1	Voltage	inherited from: ACDCConverter
resistiveLoss	0..1	Resistance	inherited from: ACDCConverter
switchingLoss	0..1	ActivePowerPerCurrentFlow	inherited from: ACDCConverter
targetPpcc	0..1	ActivePower	inherited from: ACDCConverter
targetUdc	0..1	Voltage	inherited from: ACDCConverter
uc	0..1	Voltage	inherited from: ACDCConverter
udc	0..1	Voltage	inherited from: ACDCConverter
valveU0	0..1	Voltage	inherited from: ACDCConverter
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 529 shows all association ends of VsConverter with other classes.

Table 529 – Association ends of DC::VsConverter with other classes

mult from	name	mult to	type	description
0..*	CapabilityCurve	0..1	VsCapabilityCurve	Capability curve of this converter.
0..*	PccTerminal	0..1	Terminal	inherited from: ACDCConverter
1..1	DCTerminals	0..*	ACDCConverterDCTerminal	inherited from: ACDCConverter
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12 Package LoadModel

6.12.1 General

This package is responsible for modeling the energy consumers and the system load as curves and associated curve data. Special circumstances that may affect the load, such as seasons and daytypes, are also included here.

This information is used by Load Forecasting and Load Management.

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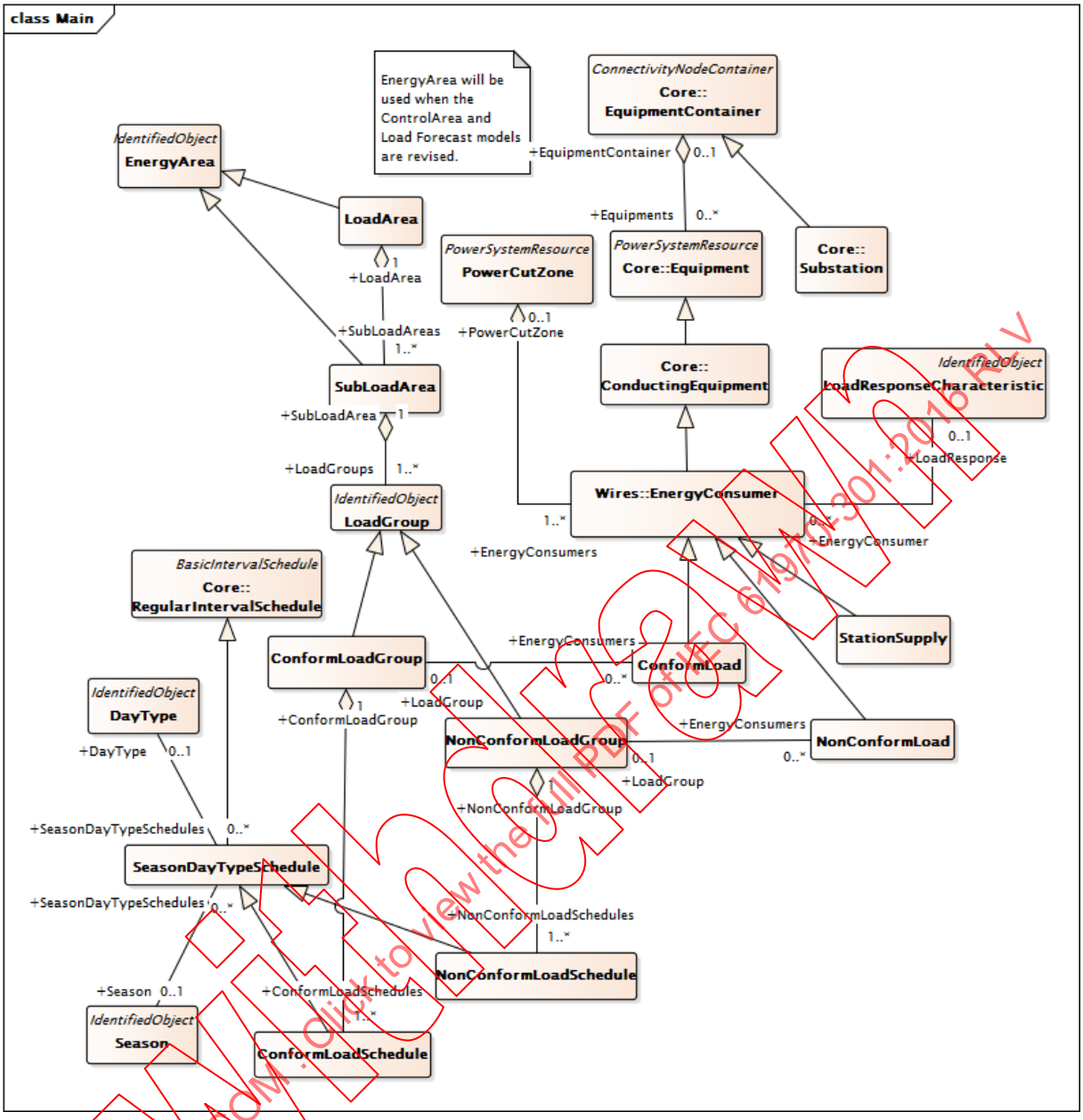


Figure 113 – Class diagram LoadModel::Main

Figure 113: This diagram shows all classes included in the LoadModel package as well as the key external classes that have associations with LoadModel classes.

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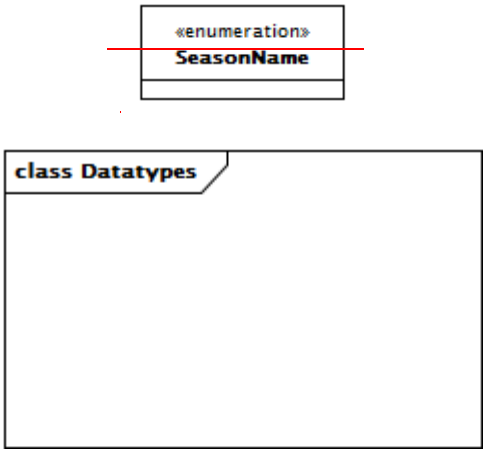


Figure 114 – Class diagram LoadModel::Datatypes

Figure 114: Shows datatypes for load model.

6.12.2 ConformLoad

ConformLoad represent loads that follow a daily load change pattern where the pattern can be used to scale the load with a system load.

Table 530 shows all attributes of ConformLoad.

Table 530 – Attributes of LoadModel::ConformLoad

name	mult	type	description
customerCount	0..1	Integer	inherited from: EnergyConsumer
grounded	0..1	~~WindingConnection~~ Boolean	inherited from: EnergyConsumer
pfixed	0..1	ActivePower	inherited from: EnergyConsumer
pfixedPct	0..1	PerCent	inherited from: EnergyConsumer
phaseConnection	0..1	PhaseShuntConnectionKind	inherited from: EnergyConsumer
qfixed	0..1	ReactivePower	inherited from: EnergyConsumer
qfixedPct	0..1	PerCent	inherited from: EnergyConsumer
p	0..1	ActivePower	inherited from: EnergyConsumer
q	0..1	ReactivePower	inherited from: EnergyConsumer
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 531 shows all association ends of ConformLoad with other classes.

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Table 531 – Association ends of LoadModel::ConformLoad with other classes

mult from	name	mult to	type	description
0..*	LoadGroup	0..1	ConformLoadGroup	Group of this ConformLoad.
1..1	EnergyConsumerPhase	0..*	EnergyConsumerPhase	inherited from: EnergyConsumer
0..*	LoadResponse	0..1	LoadResponseCharacteristic	inherited from: EnergyConsumer
1..*	PowerCutZone	0..1	PowerCutZone	inherited from: EnergyConsumer
0..*	LoadDynamics	0..1	LoadDynamics	inherited from: EnergyConsumer
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.3 ConformLoadGroup

A group of loads conforming to an allocation pattern.

Table 532 shows all attributes of ConformLoadGroup.

Table 532 – Attributes of LoadModel::ConformLoadGroup

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 533 shows all association ends of ConformLoadGroup with other classes.

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Table 533 – Association ends of LoadModel::ConformLoadGroup with other classes

mult from	name	mult to	type	description
0..1	EnergyConsumers	0..*	ConformLoad	Conform loads assigned to this ConformLoadGroup.
1..1	ConformLoadSchedules	1..*	ConformLoadSchedule	The ConformLoadSchedules in the ConformLoadGroup.
1..*	SubLoadArea	1..1	SubLoadArea	inherited from: LoadGroup
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.4 ConformLoadSchedule

A curve of load versus time (X-axis) showing the active power values (Y1-axis) and reactive power (Y2-axis) for each unit of the period covered. This curve represents a typical pattern of load over the time period for a given day type and season.

Table 534 shows all attributes of ConformLoadSchedule.

Table 534 – Attributes of LoadModel::ConformLoadSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 535 shows all association ends of ConformLoadSchedule with other classes.

Table 535 – Association ends of LoadModel::ConformLoadSchedule with other classes

mult from	name	mult to	type	description
1..*	ConformLoadGroup	1..1	ConformLoadGroup	The ConformLoadGroup where the ConformLoadSchedule belongs.
0..*	DayType	0..1	DayType	inherited from: SeasonDayTypeSchedule
0..*	Season	0..1	Season	inherited from: SeasonDayTypeSchedule
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.12.5 DayType

Group of similar days. For example it could be used to represent weekdays, weekend, or holidays.

Table 536 shows all attributes of DayType.

Table 536 – Attributes of LoadModel::DayType

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 537 shows all association ends of DayType with other classes.

Table 537 – Association ends of LoadModel::DayType with other classes

mult from	name	mult to	type	description
0..1	SeasonDayTypeSchedules	0..*	SeasonDayTypeSchedule	Schedules that use this DayType.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.6 EnergyArea

~~The class Describes an area having energy production or consumption.~~

Describes an area having energy production or consumption. Specializations are intended to support the load allocation function as typically required in energy management systems or planning studies to allocate hypothesized load levels to individual load points for power flow analysis. Often the energy area can be linked to both measured and forecast load levels.

Table 538 shows all attributes of EnergyArea.

Table 538 – Attributes of LoadModel::EnergyArea

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 539 shows all association ends of EnergyArea with other classes.

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Table 539 – Association ends of LoadModel::EnergyArea with other classes

mult from	name	mult to	type	description
0..1	ControlArea	0..1	ControlArea	The control area specification that is used for the load forecast.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.7 LoadArea

The class is the root or first level in a hierarchical structure for grouping of loads for the purpose of load flow load scaling.

Table 540 shows all attributes of LoadArea.

Table 540 – Attributes of LoadModel::LoadArea

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 541 shows all association ends of LoadArea with other classes.

Table 541 – Association ends of LoadModel::LoadArea with other classes

mult from	name	mult to	type	description
1..1	SubLoadAreas	1..*	SubLoadArea	The SubLoadAreas in the LoadArea.
0..1	ControlArea	0..1	ControlArea	inherited from: EnergyArea
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.8 LoadGroup

The class is the third level in a hierarchical structure for grouping of loads for the purpose of load flow load scaling.

Table 542 shows all attributes of LoadGroup.

Table 542 – Attributes of LoadModel::LoadGroup

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 543 shows all association ends of LoadGroup with other classes.

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Table 543 – Association ends of LoadModel::LoadGroup with other classes

mult from	name	mult to	type	description
1..*	SubLoadArea	1..1	SubLoadArea	The SubLoadArea where the Loadgroup belongs.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.9 LoadResponseCharacteristic

Models the characteristic response of the load demand due to changes in system conditions such as voltage and frequency. This is not related to demand response.

If LoadResponseCharacteristic.exponentModel is True, the voltage exponents are specified and used to calculate:

Active power component = Pnominal * (Voltage/cim:BaseVoltage.nominalVoltage) ** cim:LoadResponseCharacteristic.pVoltageExponent

Reactive power component = Qnominal * (Voltage/cim:BaseVoltage.nominalVoltage) ** cim:LoadResponseCharacteristic.qVoltageExponent

where * means "multiply" and ** is "raised to power of".

Table 544 shows all attributes of LoadResponseCharacteristic.

Table 544 – Attributes of LoadModel::LoadResponseCharacteristic

name	mult	type	description
exponentModel	0..1	Boolean	Indicates the exponential voltage dependency model ~~(pVoltateExponent and qVoltageExponent)~~ is to be used. If false, the coefficient model is to be used. The exponential voltage dependency model consist of the attributes - pVoltageExponent - qVoltageExponent. The coefficient model consist of the attributes - pConstantImpedance - pConstantCurrent - pConstantPower - qConstantImpedance - qConstantCurrent - qConstantPower. The sum of pConstantImpedance, pConstantCurrent and pConstantPower shall equal 1. The sum of qConstantImpedance, qConstantCurrent and qConstantPower shall equal 1.
pConstantCurrent	0..1	Float	Portion of active power load modeled as constant current. ~~Used only if the useExponentModel is false. This value is noralized against the sum of pZ, pI, and pP.~~
pConstantImpedance	0..1	Float	Portion of active power load modeled as constant impedance. ~~Used only if the useExponentModel is false. This value is noralized against the sum of pZ, pI, and pP.~~

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name	mult	type	description
pConstantPower	0..1	Float	Portion of active power load modeled as constant power. ~~Used only if the useExponentModel is false. This value is noralized against the sum of pZ, pI, and pP.~~
pFrequencyExponent	0..1	Float	Exponent of per unit frequency effecting active power.
pVoltageExponent	0..1	Float	Exponent of per unit voltage effecting real power. ~~This model used only when "useExponentModel" is true.~~
qConstantCurrent	0..1	Float	Portion of reactive power load modeled as constant current. ~~Used only if the useExponentModel is false. This value is noralized against the sum of qZ, qI, and qP.~~
qConstantImpedance	0..1	Float	Portion of reactive power load modeled as constant impedance. ~~Used only if the useExponentModel is false. This value is noralized against the sum of qZ, qI, and qP.~~
qConstantPower	0..1	Float	Portion of reactive power load modeled as constant power. ~~Used only if the useExponentModel is false. This value is noralized against the sum of qZ, qI, and qP.~~
qFrequencyExponent	0..1	Float	Exponent of per unit frequency effecting reactive power.
qVoltageExponent	0..1	Float	Exponent of per unit voltage effecting reactive power. ~~This model used only when "useExponentModel" is true.~~
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 545 shows all association ends of LoadResponseCharacteristic with other classes.

Table 545 – Association ends of LoadModel::LoadResponseCharacteristic with other classes

mult from	name	mult to	type	description
0..1	EnergyConsumer	0..*	EnergyConsumer	The set of loads that have the response characteristics.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.10 NonConformLoad

NonConformLoad represent loads that do not follow a daily load change pattern and changes are not correlated with the daily load change pattern.

Table 546 shows all attributes of NonConformLoad.

Table 546 – Attributes of LoadModel::NonConformLoad

name	mult	type	description
customerCount	0..1	Integer	inherited from: EnergyConsumer
grounded	0..1	~~WindingConnection~~ Boolean	inherited from: EnergyConsumer

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name	mult	type	description
pfixed	0..1	ActivePower	inherited from: EnergyConsumer
pfixedPct	0..1	PerCent	inherited from: EnergyConsumer
phaseConnection	0..1	PhaseShuntConnectionKind	inherited from: EnergyConsumer
qfixed	0..1	ReactivePower	inherited from: EnergyConsumer
qfixedPct	0..1	PerCent	inherited from: EnergyConsumer
p	0..1	ActivePower	inherited from: EnergyConsumer
q	0..1	ReactivePower	inherited from: EnergyConsumer
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 547 shows all association ends of NonConformLoad with other classes.

Table 547 – Association ends of LoadModel::NonConformLoad with other classes

mult from	name	mult to	type	description
0..*	LoadGroup	0..1	NonConformLoadGroup	Group of this ConformLoad.
1..1	EnergyConsumerPhase	0..*	EnergyConsumerPhase	inherited from: EnergyConsumer
0..*	LoadResponse	0..1	LoadResponseCharacteristic	inherited from: EnergyConsumer
1..*	PowerCutZone	0..1	PowerCutZone	inherited from: EnergyConsumer
0..*	LoadDynamics	0..1	LoadDynamics	inherited from: EnergyConsumer
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.12.11 NonConformLoadGroup

Loads that do not follow a daily and seasonal load variation pattern.

Table 548 shows all attributes of NonConformLoadGroup.

Table 548 – Attributes of LoadModel::NonConformLoadGroup

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 549 shows all association ends of NonConformLoadGroup with other classes.

Table 549 – Association ends of LoadModel::NonConformLoadGroup with other classes

mult from	name	mult to	type	description
0..1	EnergyConsumers	0..*	NonConformLoad	Conform loads assigned to this ConformLoadGroup.
1..1	NonConformLoadSchedules	1..*	NonConformLoadSchedule	The NonConformLoadSchedules in the NonConformLoadGroup.
1..*	SubLoadArea	1..1	SubLoadArea	inherited from: LoadGroup
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.12 NonConformLoadSchedule

An active power (Y1-axis) and reactive power (Y2-axis) schedule (curves) versus time (X-axis) for non-conforming loads, e.g. large industrial load or power station service (where modeled).

Table 550 shows all attributes of NonConformLoadSchedule.

Table 550 – Attributes of LoadModel::NonConformLoadSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 551 shows all association ends of NonConformLoadSchedule with other classes.

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Table 551 – Association ends of LoadModel::NonConformLoadSchedule with other classes

mult from	name	mult to	type	description
1..*	NonConformLoadGroup	1..1	NonConformLoadGroup	The NonConformLoadGroup where the NonConformLoadSchedule belongs.
0..*	DayType	0..1	DayType	inherited from: SeasonDayTypeSchedule
0..*	Season	0..1	Season	inherited from: SeasonDayTypeSchedule
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.13 PowerCutZone

An area or zone of the power system which is used for load shedding purposes.

Table 552 shows all attributes of PowerCutZone.

Table 552 – Attributes of LoadModel::PowerCutZone

name	mult	type	description
cutLevel1	0..1	PerCent	First level (amount) of load to cut as a percentage of total zone load.
cutLevel2	0..1	PerCent	Second level (amount) of load to cut as a percentage of total zone load.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 553 shows all association ends of PowerCutZone with other classes.

Table 553 – Association ends of LoadModel::PowerCutZone with other classes

mult from	name	mult to	type	description
0..1	EnergyConsumers	1..*	EnergyConsumer	Energy consumer is assigned to the power cut zone.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.12.14 Season ~~root class~~

A specified time period of the year.

Table 554 shows all attributes of Season.

Table 554 – Attributes of LoadModel::Season

name	mult	type	description
endDate	0..1	~~DateTime~~ MonthDay	Date season ends.
startDate	0..1	~~DateTime~~ MonthDay	Date season starts.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	~~SeasonName~~ String	inherited from: IdentifiedObject

Table 555 shows all association ends of Season with other classes.

Table 555 – Association ends of LoadModel::Season with other classes

mult from	name	mult to	type	description
0..1	SeasonDayTypeSchedules	0..*	SeasonDayTypeSchedule	Schedules that use this Season.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.15 SeasonDayTypeSchedule

A time schedule covering a 24 hour period, with curve data for a specific type of season and day.

Table 556 shows all attributes of SeasonDayTypeSchedule.

Table 556 – Attributes of LoadModel::SeasonDayTypeSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 557 shows all association ends of SeasonDayTypeSchedule with other classes.

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Table 557 – Association ends of LoadModel::SeasonDayTypeSchedule with other classes

mult from	name	mult to	type	description
0..*	DayType	0..1	DayType	DayType for the Schedule.
0..*	Season	0..1	Season	Season for the Schedule.
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

~~**6.10.16 SeasonName enumeration**~~

~~Name of season.~~

~~Table 458 shows all literals of SeasonName.~~

~~**Table 458 – Literals of LoadModel::SeasonName**~~

~~literal~~	~~description~~
~~winter~~	~~Winter.~~
~~spring~~	~~Spring.~~
~~summer~~	~~Summer.~~
~~fall~~	~~Fall.~~

6.12.16 StationSupply

Station supply with load derived from the station output.

Table 558 shows all attributes of StationSupply.

Table 558 – Attributes of LoadModel::StationSupply

name	mult	type	description
customerCount	0..1	Integer	inherited from: EnergyConsumer
grounded	0..1	~~WindingConnection~~ Boolean	inherited from: EnergyConsumer
pfixed	0..1	ActivePower	inherited from: EnergyConsumer
pfixedPct	0..1	PerCent	inherited from: EnergyConsumer
phaseConnection	0..1	PhaseShuntConnectionKind	inherited from: EnergyConsumer
qfixed	0..1	ReactivePower	inherited from: EnergyConsumer
qfixedPct	0..1	PerCent	inherited from: EnergyConsumer
p	0..1	ActivePower	inherited from: EnergyConsumer
q	0..1	ReactivePower	inherited from: EnergyConsumer
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 559 shows all association ends of StationSupply with other classes.

Table 559 – Association ends of LoadModel::StationSupply with other classes

mult from	name	mult to	type	description
1..1	EnergyConsumerPhase	0..*	EnergyConsumerPhase	inherited from: EnergyConsumer
0..*	LoadResponse	0..1	LoadResponseCharacteristic	inherited from: EnergyConsumer
1..*	PowerCutZone	0..1	PowerCutZone	inherited from: EnergyConsumer
0..*	LoadDynamics	0..1	LoadDynamics	inherited from: EnergyConsumer
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.17 SubLoadArea

The class is the second level in a hierarchical structure for grouping of loads for the purpose of load flow load scaling.

Table 560 shows all attributes of SubLoadArea.

Table 560 – Attributes of LoadModel::SubLoadArea

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 561 shows all association ends of SubLoadArea with other classes.

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Table 561 – Association ends of LoadModel::SubLoadArea with other classes

mult from	name	mult to	type	description
1..1	LoadGroups	1..*	LoadGroup	The Loadgroups in the SubLoadArea.
1..*	LoadArea	1..1	LoadArea	The LoadArea where the SubLoadArea belongs.
0..1	ControlArea	0..1	ControlArea	inherited from: EnergyArea
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11 Package Outage

6.11.1 General

An extension to the Core and Wires packages that models information on the current and planned network configuration. These entities are optional within typical network applications.

Figure 70 shows class diagram Datatypes.

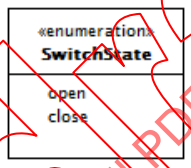


Figure 70 – Class diagram Outage::Datatypes

This diagram shows the data types specific to the Outage package.

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Figure 71 shows class diagram Main.

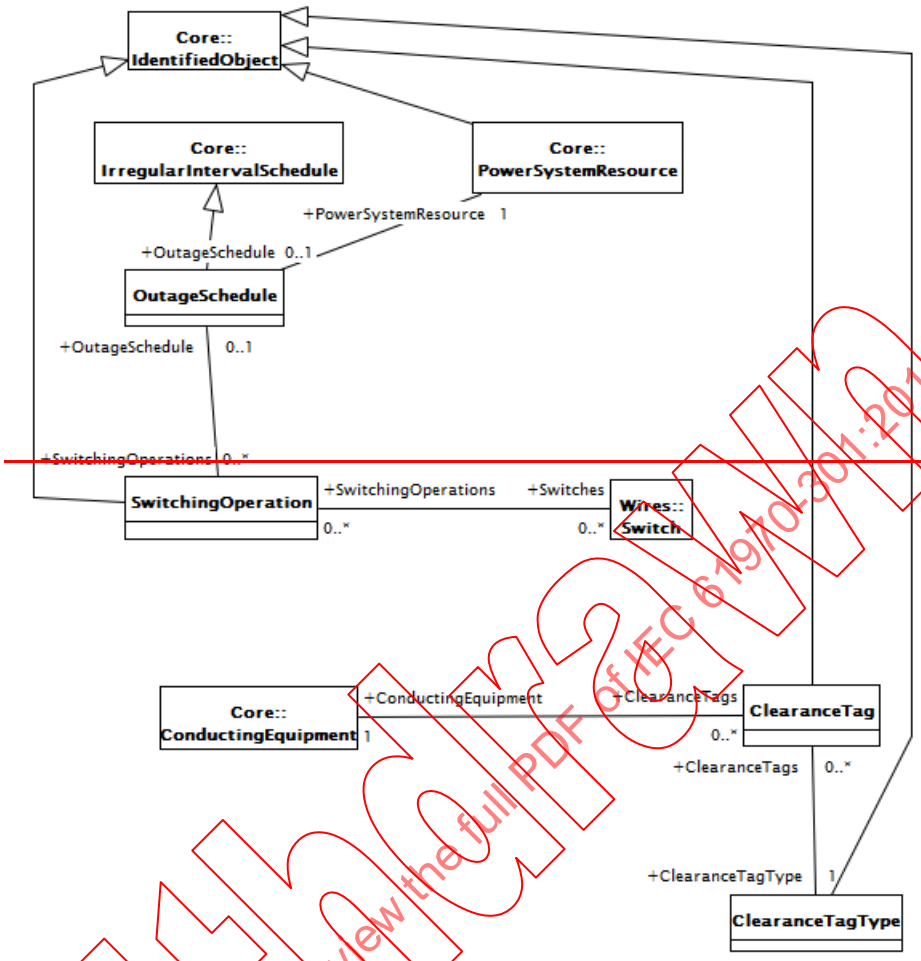


Figure 71 – Class diagram Outage::Main

This diagram shows all classes included in the Outage package as well as the key external classes that have associations with Outage classes.

6.11.2 ClearanceTag

A clearance tag that is used to authorize and schedule work on conducting equipment in the field. Tagged equipment is not available for commercial service.

Table 463 shows all attributes of ClearanceTag.

Table 463 – Attributes of Outage::ClearanceTag

name	type	description
authorityName	String	The name of the person who is authorized to issue the tag.
deenergizeReqFlag	Boolean	Set true if equipment must be deenergized.
groundReqFlag	Boolean	Set true if equipment must be grounded.
phaseCheckReqFlag	Boolean	Set true if equipment phasing must be checked.
tagIssueTime	DateTime	The time at which the clearance tag was issued.
workDescription	String	Description of the work to be performed.

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name	type	description
workEndTime	DateTime	The time at which the clearance tag is scheduled to be removed.
workStartTime	DateTime	The time at which the clearance tag is scheduled to be set.
aliasName	String	inherited from: IdentifiedObject
mRID	String	inherited from: IdentifiedObject
name	String	inherited from: IdentifiedObject

Table 464 shows all association ends of ClearanceTag with other classes.

Table 464 – Association ends of Outage::ClearanceTag with other classes

[mult from]	[mult to] name	type	description
[0..*]	[1..1] ConductingEquipment	ConductingEquipment	Conducting equipment of this clearance tags for authorized field work.
[0..*]	[1..1] ClearanceTagType	ClearanceTagType	The type of tag, depending on the purpose of the work to be performed and/or the type of supervisory control allowed.
[0..1]	[0..*] DiagramObjects	DiagramObject	Inherited from: IdentifiedObject
[1..1]	[0..*] Names	Name	inherited from: IdentifiedObject

6.11.3 ClearanceTagType

Type of ClearanceTag. Could indicate the type of work to be performed and/or the type of supervisory control.

Table 465 shows all attributes of ClearanceTagType.

Table 465 – Attributes of Outage::ClearanceTagType

name	type	description
aliasName	String	inherited from: IdentifiedObject
mRID	String	inherited from: IdentifiedObject
name	String	inherited from: IdentifiedObject

Table 466 shows all association ends of ClearanceTagType with other classes.

Table 466 – Association ends of Outage::ClearanceTagType with other classes

[mult from]	[mult to] name	type	description
[1..1]	[0..*] ClearanceTags	ClearanceTag	The ClearanceTags currently being defined for this type.
[0..1]	[0..*] DiagramObjects	DiagramObject	inherited from: IdentifiedObject
[1..1]	[0..*] Names	Name	inherited from: IdentifiedObject

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6.11.4 OutageSchedule

The period of time that a piece of equipment is out of service, for example, for maintenance or testing; including the equipment's active power rating while under maintenance. The X-axis represents absolute time and the Y-axis represents the equipment's available rating while out of service.

Table 467 shows all attributes of OutageSchedule.

Table 467 – Attributes of Outage::OutageSchedule

name	type	description
startTime	DateTime	inherited from: BasicIntervalSchedule
value1Unit	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	String	inherited from: IdentifiedObject
mRID	String	inherited from: IdentifiedObject
name	String	inherited from: IdentifiedObject

Table 468 shows all association ends of OutageSchedule with other classes.

Table 468 – Association ends of Outage::OutageSchedule with other classes

[mult from]	[mult to] name	type	description
[0..1]	[1..1] PowerSystemResource	PowerSystemResource	A power system resource may have an outage schedule.
[0..1]	[0..*] SwitchingOperations	SwitchingOperation	An OutageSchedule may operate many switches.
[1..1]	[1..*] TimePoints	IrregularTimePoint	inherited from: IrregularIntervalSchedule
[0..1]	[0..*] DiagramObjects	DiagramObject	inherited from: IdentifiedObject
[1..1]	[0..*] Names	Name	inherited from: IdentifiedObject

6.11.5 SwitchingOperation

A SwitchingOperation is used to define individual switch operations for an OutageSchedule. This OutageSchedule may be associated with another item of Substation such as a Transformer, Line, or Generator; or with the Switch itself as a PowerSystemResource. A Switch may be referenced by many OutageSchedules.

Table 469 shows all attributes of SwitchingOperation.

Table 469 – Attributes of Outage::SwitchingOperation

name	type	description
newState	SwitchState	The switch position that shall result from this SwitchingOperation.
operationTime	DateTime	Time of operation in same units as OutageSchedule.xAxixUnits.

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name	type	description
aliasName	String	inherited from: IdentifiedObject
mRID	String	inherited from: IdentifiedObject
name	String	inherited from: IdentifiedObject

Table 470 shows all association ends of SwitchingOperation with other classes.

Table 470 – Association ends of Outage::SwitchingOperation with other classes

[mult from]	[mult to] name	type	description
[0..*]	[0..*] Switches	Switch	A switch may be operated by many schedules.
[0..*]	[0..1] OutageSchedule	OutageSchedule	An OutageSchedule may operate many switches.
[0..1]	[0..*] DiagramObjects	DiagramObject	inherited from: IdentifiedObject
[1..1]	[0..*] Names	Name	inherited from: IdentifiedObject

6.11.6 SwitchState enumeration

Possible states for a switch.

Table 471 shows all literals of SwitchState.

Table 471 – Literals of Outage::SwitchState

literal	description
open	Switch is open.
close	Switch is closed.

6.13 Package AuxiliaryEquipment

6.13.1 General

Contains equipment which is not normal conducting equipment such as sensors, fault locators and surge protectors. These devices do not define power carrying topological connections as conducting equipment, but are associated to terminals of other conducting equipment.

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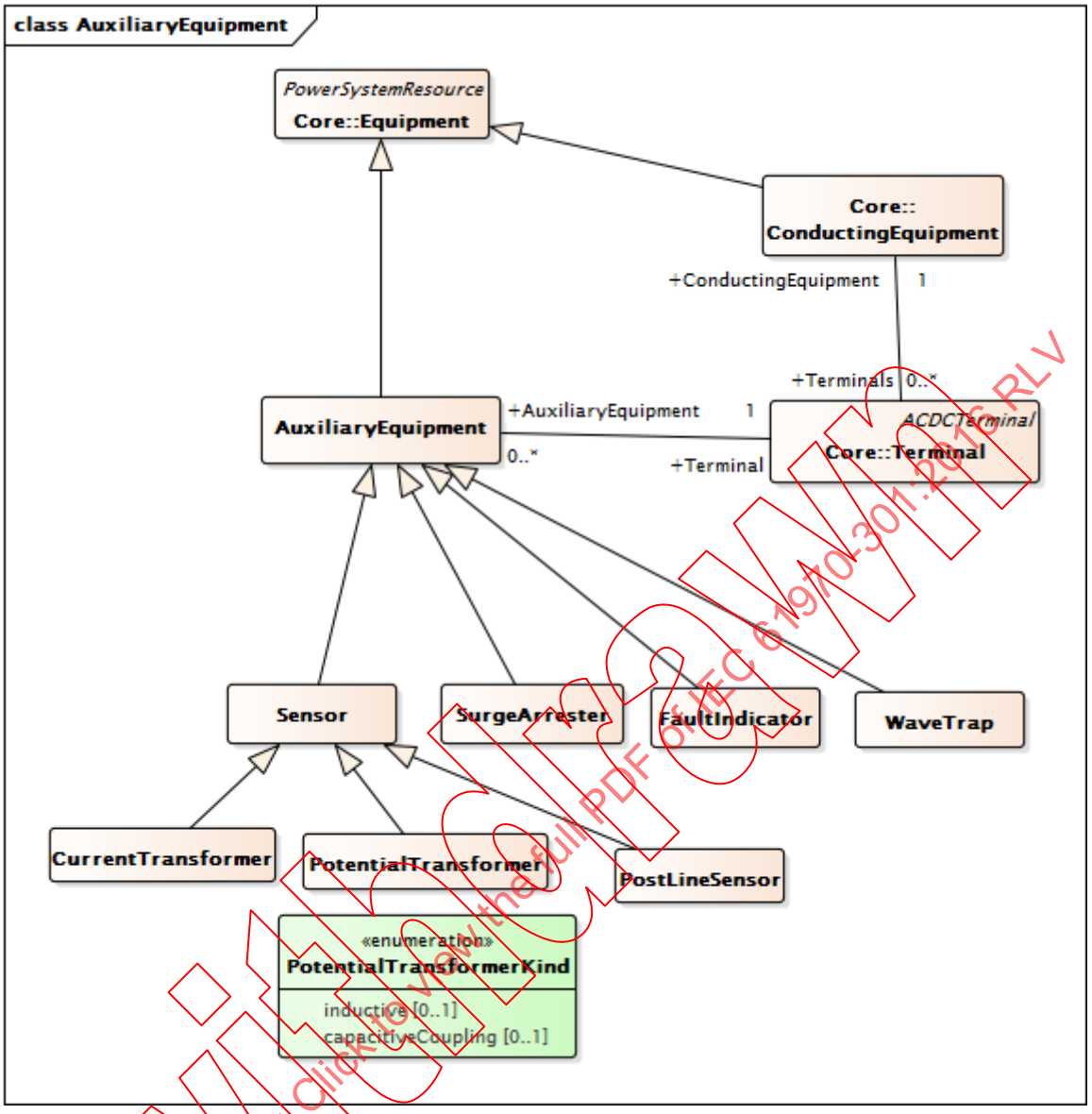


Figure 115 – Class diagram AuxiliaryEquipment::AuxiliaryEquipment

Figure 115: Inheritance and associations for auxiliary equipment.

6.13.2 AuxiliaryEquipment

AuxiliaryEquipment describes equipment that is not performing any primary functions but support for the equipment performing the primary function.

AuxiliaryEquipment is attached to primary eqipment via an association with Terminal.

Table 562 shows all attributes of AuxiliaryEquipment.

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Table 562 – Attributes of AuxiliaryEquipment::AuxiliaryEquipment

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 563 shows all association ends of AuxiliaryEquipment with other classes.

Table 563 – Association ends of AuxiliaryEquipment::AuxiliaryEquipment with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	The Terminal at the equipment where the AuxiliaryEquipment is attached.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.13.3 CurrentTransformer

Instrument transformer used to measure electrical qualities of the circuit that is being protected and/or monitored. Typically used as current transducer for the purpose of metering or protection. A typical secondary current rating would be 5 A.

Table 564 shows all attributes of CurrentTransformer.

Table 564 – Attributes of AuxiliaryEquipment::CurrentTransformer

name	mult	type	description
accuracyClass	0..1	String	CT accuracy classification.
accuracyLimit	0..1	PerCent	Percent of rated current for which the CT remains accurate within specified limits.
~~coreCount~~		~~Integer~~	~~Number of cores.~~
ctClass	0..1	String	CT classification; i.e. class 10P.
~~maxRatio~~		~~Float~~	~~For multi-ratio CT's, the maximum permissable ratio attainable.~~

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name	mult	type	description
usage	0..1	String	Intended usage of the CT; i.e. metering, protection.
coreBurden	0..1	ActivePower	Power burden of the CT core.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 565 shows all association ends of CurrentTransformer with other classes.

Table 565 – Association ends of AuxiliaryEquipment::CurrentTransformer with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.13.4 FaultIndicator

A FaultIndicator is typically only an indicator (which may or may not be remotely monitored), and not a piece of equipment that actually initiates a protection event. It is used for FLISR (Fault Location, Isolation and Restoration) purposes, assisting with the dispatch of crews to "most likely" part of the network (i.e. assists with determining circuit section where the fault most likely happened).

Table 566 shows all attributes of FaultIndicator.

Table 566 – Attributes of AuxiliaryEquipment::FaultIndicator

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 567 shows all association ends of FaultIndicator with other classes.

Table 567 – Association ends of AuxiliaryEquipment::FaultIndicator with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.13.5 PostLineSensor

A sensor used mainly in overhead distribution networks as the source of both current and voltage measurements.

Table 568 shows all attributes of PostLineSensor.

Table 568 – Attributes of AuxiliaryEquipment::PostLineSensor

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 569 shows all association ends of PostLineSensor with other classes.

Table 569 – Association ends of AuxiliaryEquipment::PostLineSensor with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment

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mult from	name	mult to	type	description
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.13.6 PotentialTransformer

Instrument transformer (also known as Voltage Transformer) used to measure electrical qualities of the circuit that is being protected and/or monitored. Typically used as voltage transducer for the purpose of metering, protection, or sometimes auxiliary substation supply. A typical secondary voltage rating would be 120 V.

Table 570 shows all attributes of PotentialTransformer.

Table 570 – Attributes of AuxiliaryEquipment::PotentialTransformer

name	mult	type	description
accuracyClass	0..1	String	PT accuracy classification.
nominalRatio	0..1	Float	Nominal ratio between the primary and secondary voltage.
ptClass	0..1	String	Potential transformer (PT) classification covering burden.
type	0..1	PotentialTransformerKind	Potential transformer construction type.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 571 shows all association ends of PotentialTransformer with other classes.

Table 571 – Association ends of AuxiliaryEquipment::PotentialTransformer with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment

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mult from	name	mult to	type	description
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.13.7 PotentialTransformerKind enumeration

The construction kind of the potential transformer.

Table 572 shows all literals of PotentialTransformerKind.

Table 572 – Literals of AuxiliaryEquipment::PotentialTransformerKind

literal	value	description
inductive		The potential transformer is using induction coils to create secondary voltage.
capacitiveCoupling		The potential transformer is using capacitive coupling to create secondary voltage.

6.13.8 Sensor

This class describes devices that transform a measured quantity into signals that can be presented at displays, used in control or be recorded.

Table 573 shows all attributes of Sensor.

Table 573 – Attributes of AuxiliaryEquipment::Sensor

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 574 shows all association ends of Sensor with other classes.

Table 574 – Association ends of AuxiliaryEquipment::Sensor with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment

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mult from	name	mult to	type	description
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.13.9 Surge~~Protector~~Arrester

Shunt device, installed on the network, usually in the proximity of electrical equipment in order to protect the said equipment against transient voltage ~~spikes~~ transients caused by lightning or switching activity.

Table 575 shows all attributes of Surge~~Protector~~Arrester.

Table 575 – Attributes of AuxiliaryEquipment::Surge~~Protector~~Arrester

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 576 shows all association ends of Surge~~Protector~~Arrester with other classes.

Table 576 – Association ends of AuxiliaryEquipment::Surge~~Protector~~Arrester with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.13.10 WaveTrap

Line traps are devices that impede high frequency power line carrier signals yet present a negligible impedance at the main power frequency.

Table 577 shows all attributes of WaveTrap.

Table 577 – Attributes of AuxiliaryEquipment::WaveTrap

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 578 shows all association ends of WaveTrap with other classes.

Table 578 – Association ends of AuxiliaryEquipment::WaveTrap with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.14 Package Protection

6.14.1 General

An extension to the Core and Wires packages that models information for protection equipment such as relays. These entities are used within training simulators and distribution network fault location applications.

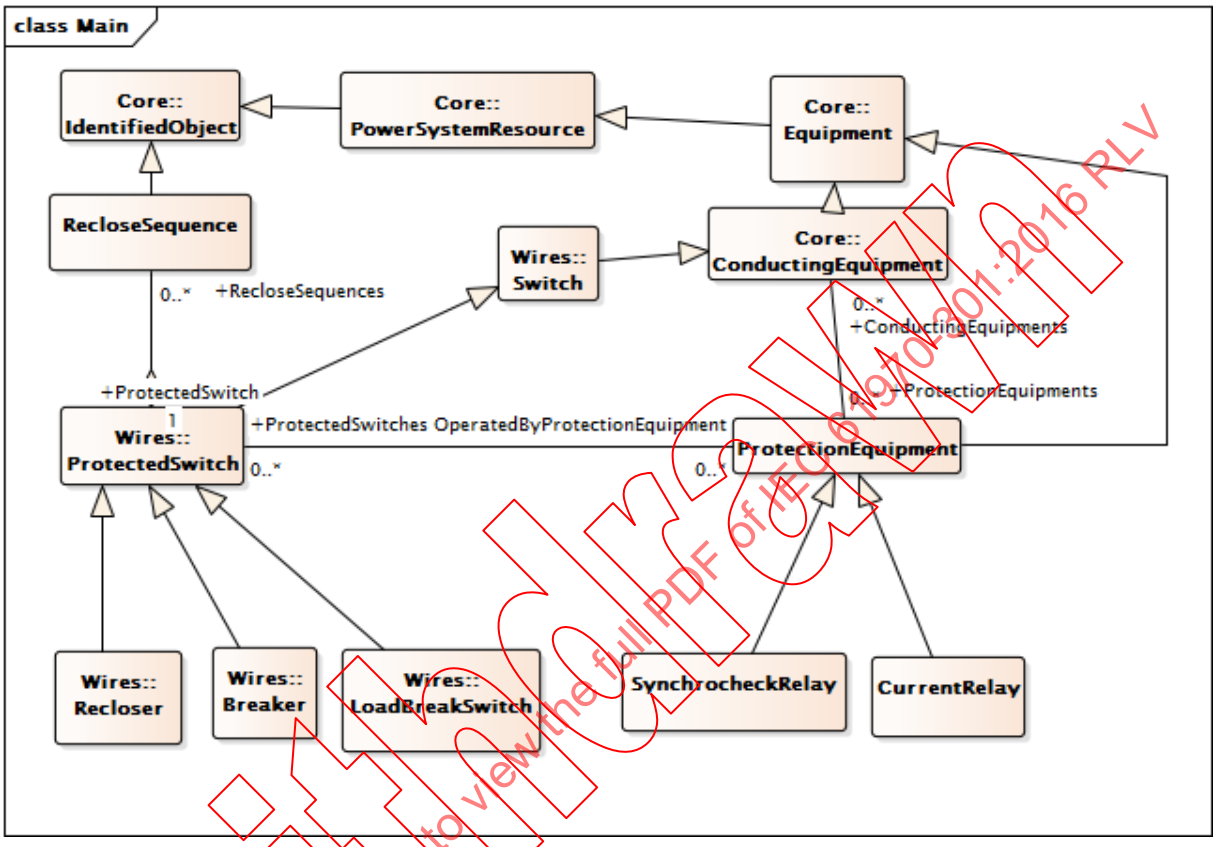


Figure 116 – Class diagram Protection::Main

Figure 116: This diagram shows all classes included in the Protection package as well as the key external classes that have associations with Protection classes.

6.14.2 CurrentRelay

A device that checks current flow values in any direction or designated direction.

Table 579 shows all attributes of CurrentRelay.

Table 579 – Attributes of Protection::CurrentRelay

name	mult	type	description
currentLimit1	0..1	CurrentFlow	Current limit number 1 for inverse time pickup.
currentLimit2	0..1	CurrentFlow	Current limit number 2 for inverse time pickup.
currentLimit3	0..1	CurrentFlow	Current limit number 3 for inverse time pickup.
inverseTimeFlag	0..1	Boolean	Set true if the current relay has inverse time characteristic.
timeDelay1	0..1	Seconds	Inverse time delay number 1 for current limit number 1.

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name	mult	type	description
timeDelay2	0..1	Seconds	Inverse time delay number 2 for current limit number 2.
timeDelay3	0..1	Seconds	Inverse time delay number 3 for current limit number 3.
relayDelayTime	0..1	Seconds	inherited from: ProtectionEquipment
highLimit	0..1	Float	inherited from: ProtectionEquipment
lowLimit	0..1	Float	inherited from: ProtectionEquipment
powerDirectionFlag	0..1	Boolean	inherited from: ProtectionEquipment
unitSymbol	0..1	UnitSymbol	inherited from: ProtectionEquipment
unitMultiplier	0..1	UnitMultiplier	inherited from: ProtectionEquipment
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 580 shows all association ends of CurrentRelay with other classes.

Table 580 – Association ends of Protection::CurrentRelay with other classes

mult from	name	mult to	type	description
0..*	ConductingEquipments	0..*	ConductingEquipment	inherited from: ProtectionEquipment
0..*	ProtectedSwitches	0..*	ProtectedSwitch	inherited from: ProtectionEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.14.3 ProtectionEquipment

An electrical device designed to respond to input conditions in a prescribed manner and after specified conditions are met to cause contact operation or similar abrupt change in associated electric control circuits, or simply to display the detected condition. Protection equipment are associated with conducting equipment and usually operate circuit breakers.

Table 581 shows all attributes of ProtectionEquipment.

Table 581 – Attributes of Protection::ProtectionEquipment

name	mult	type	description
relayDelayTime	0..1	Seconds	The time delay from detection of abnormal conditions to relay operation.
highLimit	0..1	Float	The maximum allowable value.
lowLimit	0..1	Float	The minimum allowable value.
powerDirectionFlag	0..1	Boolean	Direction same as positive active power flow value.
unitSymbol	0..1	UnitSymbol	The unit of measure of the value.
unitMultiplier	0..1	UnitMultiplier	The unit multiplier of the value.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 582 shows all association ends of ProtectionEquipment with other classes.

Table 582 – Association ends of Protection::ProtectionEquipment with other classes

mult from	name	mult to	type	description
0..*	ConductingEquipments	0..*	ConductingEquipment	Protection equipment may be used to protect specific conducting equipment.
0..*	ProtectedSwitches	0..*	ProtectedSwitch	Protected switches operated by this ProtectionEquipment.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.14.4 RecloseSequence

A reclose sequence (open and close) is defined for each possible reclosure of a breaker.

Table 583 shows all attributes of RecloseSequence.

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Table 583 – Attributes of Protection::RecloseSequence

name	mult	type	description
recloseDelay	0..1	Seconds	Indicates the time lapse before the reclose step will execute a reclose.
recloseStep	0..1	Integer	Indicates the ordinal position of the reclose step relative to other steps in the sequence.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 584 shows all association ends of RecloseSequence with other classes.

Table 584 – Association ends of Protection::RecloseSequence with other classes

mult from	name	mult to	type	description
0..*	ProtectedSwitch	1..1	ProtectedSwitch	A breaker may have zero or more automatic reclosures after a trip occurs.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.14.5 SynchrocheckRelay

A device that operates when two AC circuits are within the desired limits of frequency, phase angle, and voltage, to permit or to cause the paralleling of these two circuits. Used to prevent the paralleling of non-synchronous topological islands.

Table 585 shows all attributes of SynchrocheckRelay.

Table 585 – Attributes of Protection::SynchrocheckRelay

name	mult	type	description
maxAngleDiff	0..1	AngleRadians	The maximum allowable voltage vector phase angle difference across the open device.
maxFreqDiff	0..1	Frequency	The maximum allowable frequency difference across the open device.
maxVoltDiff	0..1	Voltage	The maximum allowable difference voltage across the open device.
relayDelayTime	0..1	Seconds	inherited from: ProtectionEquipment
highLimit	0..1	Float	inherited from: ProtectionEquipment
lowLimit	0..1	Float	inherited from: ProtectionEquipment
powerDirectionFlag	0..1	Boolean	inherited from: ProtectionEquipment
unitSymbol	0..1	UnitSymbol	inherited from: ProtectionEquipment
unitMultiplier	0..1	UnitMultiplier	inherited from: ProtectionEquipment
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 586 shows all association ends of SynchrocheckRelay with other classes.

Table 586 – Association ends of Protection::SynchrocheckRelay with other classes

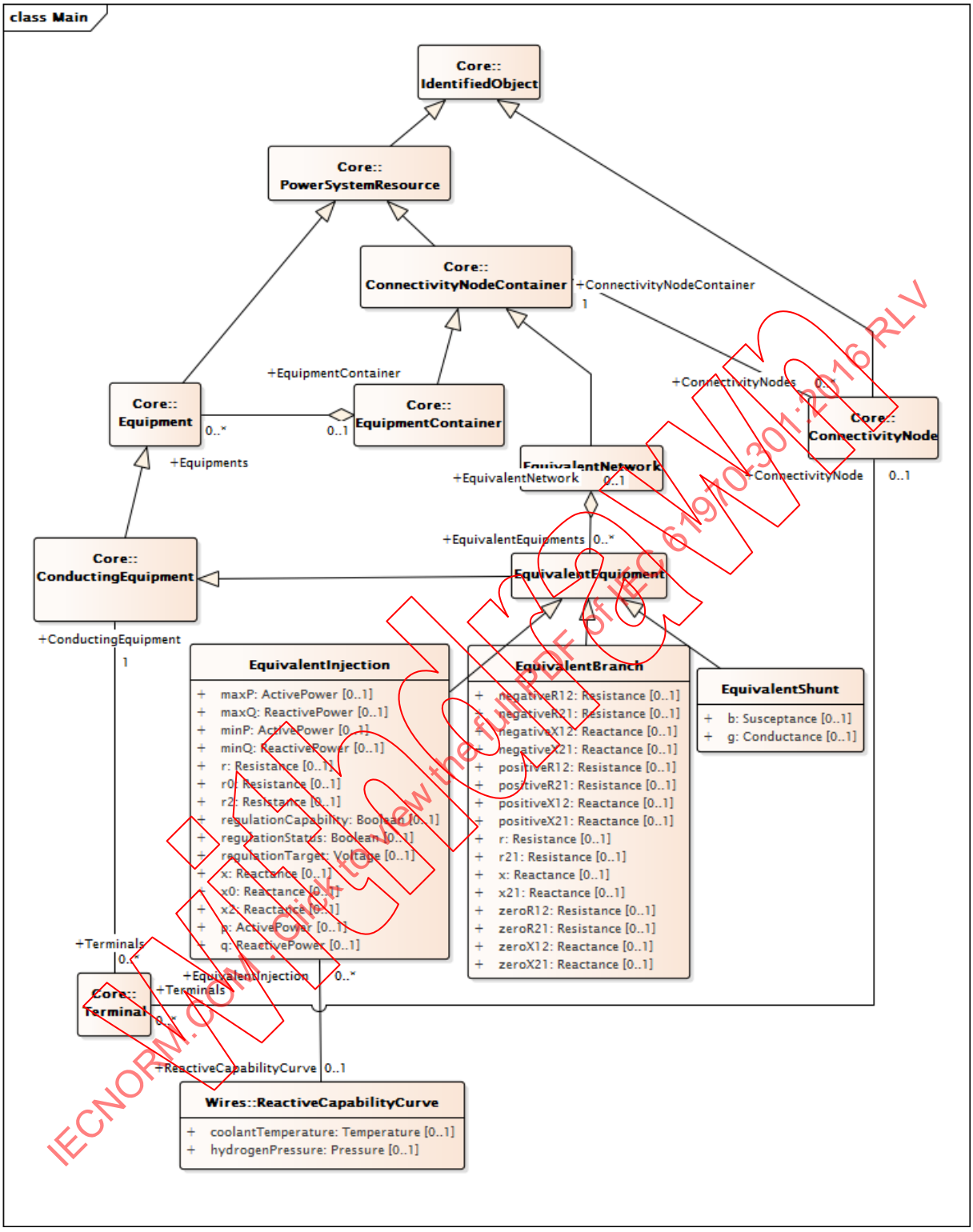
mult from	name	mult to	type	description
0..*	ConductingEquipments	0..*	ConductingEquipment	inherited from: ProtectionEquipment
0..*	ProtectedSwitches	0..*	ProtectedSwitch	inherited from: ProtectionEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.15 Package Equivalents

6.15.1 General

The equivalents package models equivalent networks.

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Figure 117 – Class diagram Equivalents::Main

Figure 117: Shows model for equivalent networks.

6.15.2 EquivalentBranch

The class represents equivalent branches.

Table 587 shows all attributes of EquivalentBranch.

Table 587 – Attributes of Equivalents::EquivalentBranch

name	mult	type	description
negativeR12	0..1	Resistance	Negative sequence series resistance from terminal sequence 1 to terminal sequence 2. Used for short circuit data exchange according to IEC 60909 EquivalentBranch is a result of network reduction prior to the data exchange
negativeR21	0..1	Resistance	Negative sequence series resistance from terminal sequence 2 to terminal sequence 1. Used for short circuit data exchange according to IEC 60909 EquivalentBranch is a result of network reduction prior to the data exchange
negativeX12	0..1	Reactance	Negative sequence series reactance from terminal sequence 1 to terminal sequence 2. Used for short circuit data exchange according to IEC 60909 Usage: EquivalentBranch is a result of network reduction prior to the data exchange
negativeX21	0..1	Reactance	Negative sequence series reactance from terminal sequence 2 to terminal sequence 1. Used for short circuit data exchange according to IEC 60909. Usage: EquivalentBranch is a result of network reduction prior to the data exchange
positiveR12	0..1	Resistance	Positive sequence series resistance from terminal sequence 1 to terminal sequence 2 . Used for short circuit data exchange according to IEC 60909. EquivalentBranch is a result of network reduction prior to the data exchange.
positiveR21	0..1	Resistance	Positive sequence series resistance from terminal sequence 2 to terminal sequence 1. Used for short circuit data exchange according to IEC 60909 EquivalentBranch is a result of network reduction prior to the data exchange
positiveX12	0..1	Reactance	Positive sequence series reactance from terminal sequence 1 to terminal sequence 2. Used for short circuit data exchange according to IEC 60909 Usage: EquivalentBranch is a result of network reduction prior to the data exchange
positiveX21	0..1	Reactance	Positive sequence series reactance from terminal sequence 2 to terminal sequence 1. Used for short circuit data exchange according to IEC 60909 Usage: EquivalentBranch is a result of network reduction prior to the data exchange
r	0..1	Resistance	Positive sequence series resistance of the reduced branch.
r21	0..1	Resistance	Resistance from terminal sequence 2 to terminal sequence 1. Used for steady state power flow. This attribute is optional and represents an unbalanced network such as off-nominal phase shifter. If only EquivalentBranch.r is given, then EquivalentBranch.r21 is assumed equal to EquivalentBranch.r. Usage rule: EquivalentBranch is a result of network reduction prior to the data exchange.

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name	mult	type	description
x	0..1	Reactance	Positive sequence series reactance of the reduced branch.
x21	0..1	Reactance	Reactance from terminal sequence 2 to terminal sequence 1 .Used for steady state power flow. This attribute is optional and represents an unbalanced network such as off-nominal phase shifter. If only EquivalentBranch.x is given, then EquivalentBranch.x21 is assumed equal to EquivalentBranch.x. Usage rule: EquivalentBranch is a result of network reduction prior to the data exchange.
zeroR12	0..1	Resistance	Zero sequence series resistance from terminal sequence 1 to terminal sequence 2. Used for short circuit data exchange according to IEC 60909 EquivalentBranch is a result of network reduction prior to the data exchange
zeroR21	0..1	Resistance	Zero sequence series resistance from terminal sequence 2 to terminal sequence 1. Used for short circuit data exchange according to IEC 60909 Usage: EquivalentBranch is a result of network reduction prior to the data exchange
zeroX12	0..1	Reactance	Zero sequence series reactance from terminal sequence 1 to terminal sequence 2. Used for short circuit data exchange according to IEC 60909 Usage: EquivalentBranch is a result of network reduction prior to the data exchange
zeroX21	0..1	Reactance	Zero sequence series reactance from terminal sequence 2 to terminal sequence 1. Used for short circuit data exchange according to IEC 60909 Usage: EquivalentBranch is a result of network reduction prior to the data exchange
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 588 shows all association ends of EquivalentBranch with other classes.

Table 588 – Association ends of Equivalents::EquivalentBranch with other classes

mult from	name	mult to	type	description
0..*	EquivalentNetwork	0..1	EquivalentNetwork	inherited from: EquivalentEquipment
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment

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mult from	name	mult to	type	description
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.15.3 EquivalentEquipment

The class represents equivalent objects that are the result of a network reduction. The class is the base for equivalent objects of different types.

Table 589 shows all attributes of EquivalentEquipment.

Table 589 – Attributes of Equivalents::EquivalentEquipment

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 590 shows all association ends of EquivalentEquipment with other classes.

Table 590 – Association ends of Equivalents::EquivalentEquipment with other classes

mult from	name	mult to	type	description
0..*	EquivalentNetwork	0..1	EquivalentNetwork	The equivalent where the reduced model belongs.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment

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mult from	name	mult to	type	description
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.15.4 EquivalentInjection

This class represents equivalent injections (generation or load). Voltage regulation is allowed only at the point of connection.

Table 591 shows all attributes of EquivalentInjection.

Table 591 – Attributes of Equivalents::EquivalentInjection

name	mult	type	description
maxP	0..1	ActivePower	Maximum active power of the injection.
maxQ	0..1	ReactivePower	Used for modeling of infeed for load flow exchange. Not used for short circuit modeling. If maxQ and minQ are not used ReactiveCapabilityCurve can be used.
minP	0..1	ActivePower	Minimum active power of the injection.
minQ	0..1	ReactivePower	Used for modeling of infeed for load flow exchange. Not used for short circuit modeling. If maxQ and minQ are not used ReactiveCapabilityCurve can be used.
r	0..1	Resistance	Positive sequence resistance. Used to represent Extended-Ward (IEC 60909). Usage: Extended-Ward is a result of network reduction prior to the data exchange.
r0	0..1	Resistance	Zero sequence resistance. Used to represent Extended-Ward (IEC 60909). Usage: Extended-Ward is a result of network reduction prior to the data exchange.
r2	0..1	Resistance	Negative sequence resistance. Used to represent Extended-Ward (IEC 60909). Usage: Extended-Ward is a result of network reduction prior to the data exchange.
regulationCapability	0..1	Boolean	Specifies whether or not the EquivalentInjection has the capability to regulate the local voltage.
regulationStatus	0..1	Boolean	Specifies the default regulation status of the EquivalentInjection. True is regulating. False is not regulating.
regulationTarget	0..1	Voltage	The target voltage for voltage regulation.
x	0..1	Reactance	Positive sequence reactance. Used to represent Extended-Ward (IEC 60909). Usage: Extended-Ward is a result of network reduction prior to the data exchange.

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name	mult	type	description
x0	0..1	Reactance	Zero sequence reactance. Used to represent Extended-Ward (IEC 60909). Usage: Extended-Ward is a result of network reduction prior to the data exchange.
x2	0..1	Reactance	Negative sequence reactance. Used to represent Extended-Ward (IEC 60909). Usage: Extended-Ward is a result of network reduction prior to the data exchange.
p	0..1	ActivePower	Equivalent active power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
q	0..1	ReactivePower	Equivalent reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 592 shows all association ends of EquivalentInjection with other classes.

Table 592 – Association ends of Equivalents::EquivalentInjection with other classes

mult from	name	mult to	type	description
0..*	ReactiveCapabilityCurve	0..1	ReactiveCapabilityCurve	The reactive capability curve used by this equivalent injection.
0..*	EquivalentNetwork	0..1	EquivalentNetwork	inherited from: EquivalentEquipment
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject

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mult from	name	mult to	type	description
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.15.5 EquivalentNetwork

A class that represents an external meshed network that has been reduced to an electrically equivalent model. The ConnectivityNodes contained in the equivalent are intended to reflect internal nodes of the equivalent. The boundary Connectivity nodes where the equivalent connects outside itself are not contained by the equivalent.

Table 593 shows all attributes of EquivalentNetwork.

Table 593 – Attributes of Equivalents::EquivalentNetwork

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 594 shows all association ends of EquivalentNetwork with other classes.

Table 594 – Association ends of Equivalents::EquivalentNetwork with other classes

mult from	name	mult to	type	description
0..1	EquivalentEquipments	0..*	EquivalentEquipment	The associated reduced equivalents.
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.15.6 EquivalentShunt

The class represents equivalent shunts.

Table 595 shows all attributes of EquivalentShunt.

Table 595 – Attributes of Equivalents::EquivalentShunt

name	mult	type	description
b	0..1	Susceptance	Positive sequence shunt susceptance.

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name	mult	type	description
g	0..1	Conductance	Positive sequence shunt conductance.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 596 shows all association ends of EquivalentShunt with other classes.

Table 596 – Association ends of Equivalents::EquivalentShunt with other classes

mult from	name	mult to	type	description
0..*	EquivalentNetwork	0..1	EquivalentNetwork	inherited from: EquivalentEquipment
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
~~[1..1]~~	~~[0..*] ClearanceTags~~		~~ClearanceTag~~	~~inherited from: ConductingEquipment~~
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.16 Package Meas

6.16.1 General

Contains entities that describe dynamic measurement data exchanged between applications.

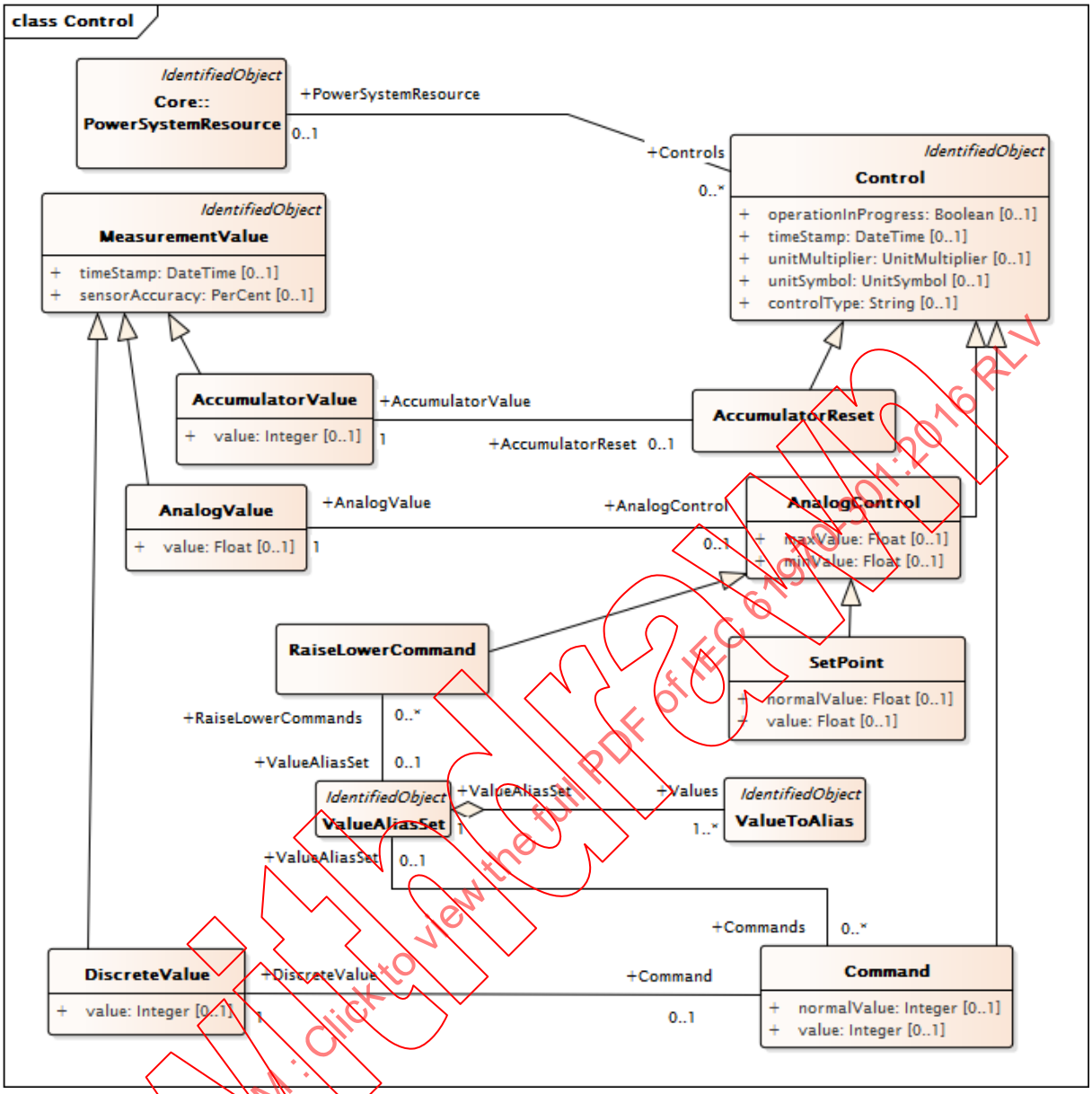


Figure 118 – Class diagram Meas::Control

Figure 118: This diagram shows all classes included in the Meas package.

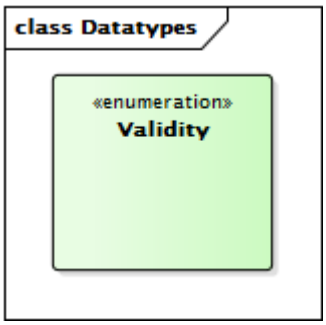
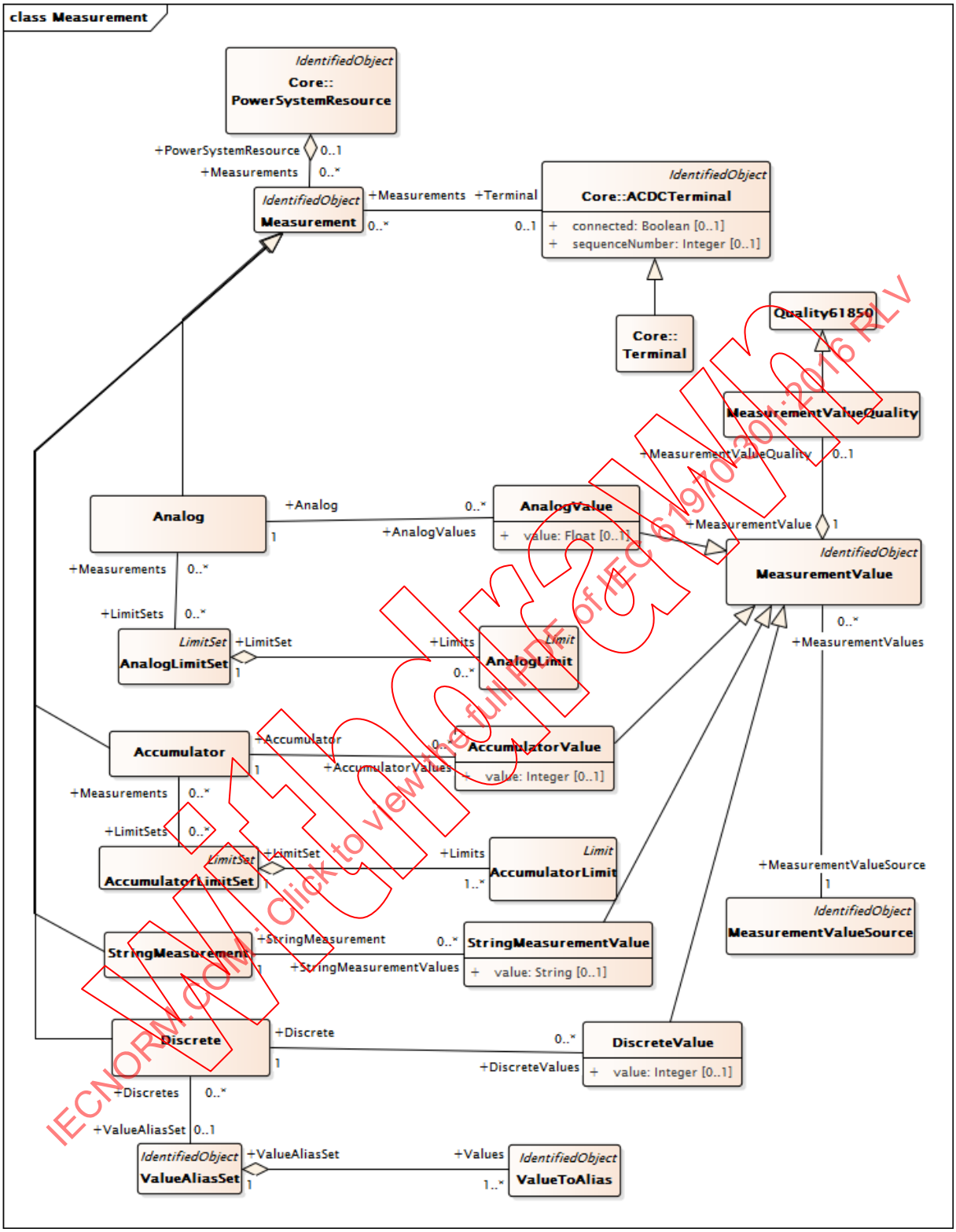


Figure 119 – Class diagram Meas::Datatypes

Figure 119: Shows datatypes for measurements.

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Figure 120 – Class diagram Meas::Measurement

Figure 120: This diagram shows classes central to the Measurement package and connections to some external classes.

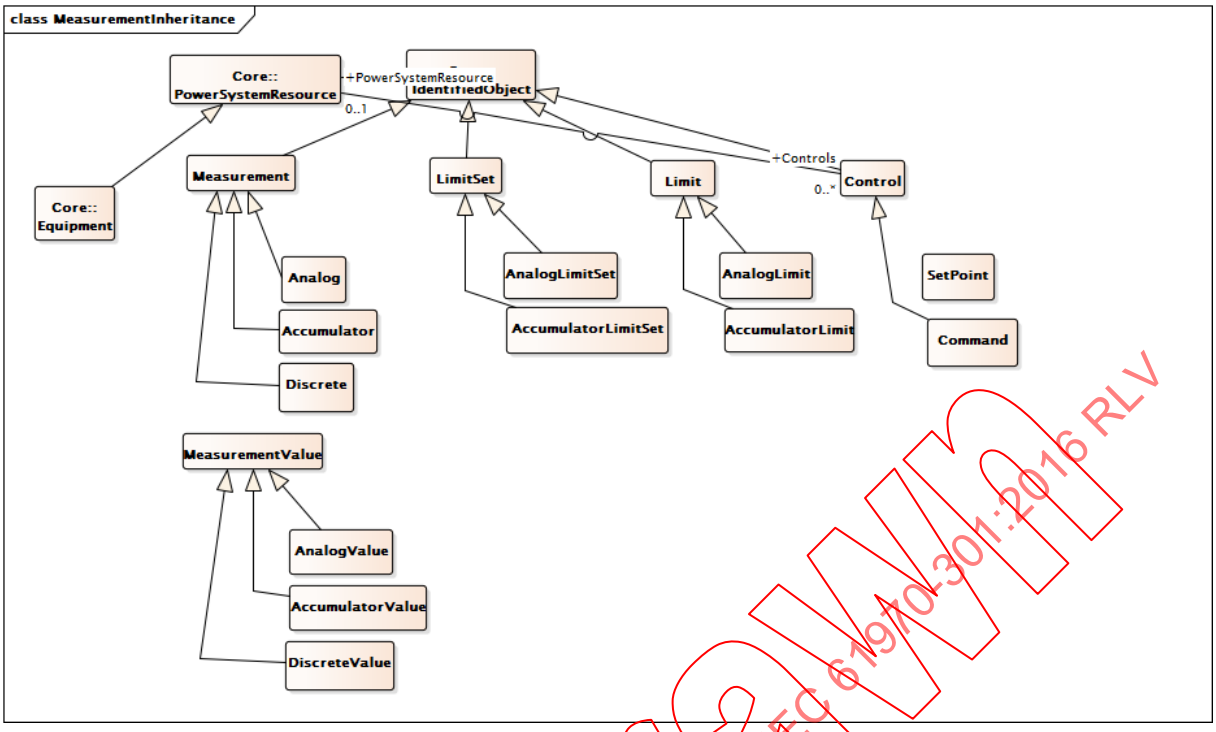


Figure 121 – Class diagram Meas::MeasurementInheritance

Figure 121: This diagram shows the measurement classes inheritance.

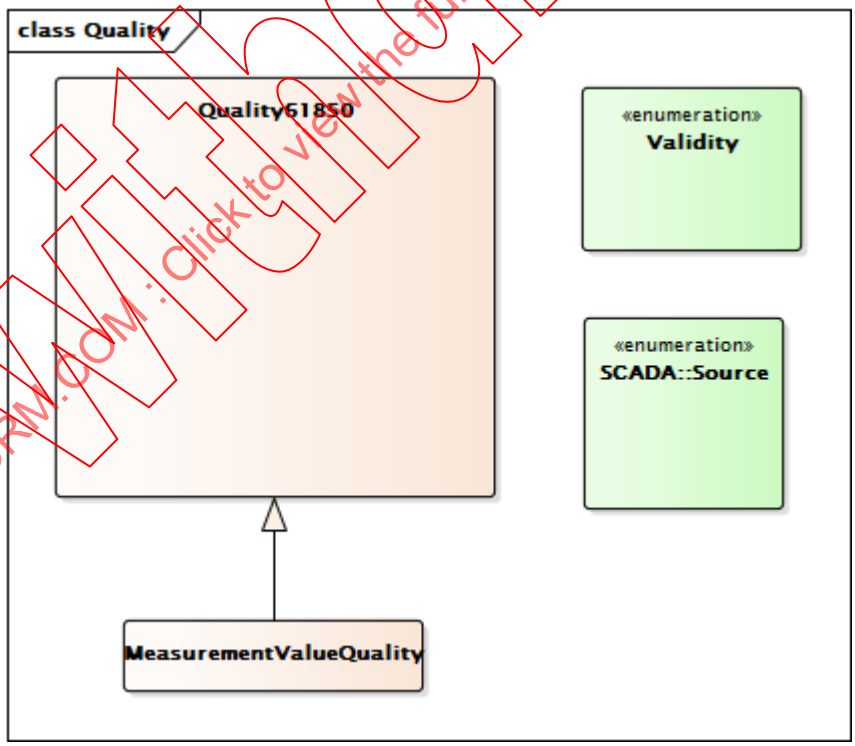


Figure 122 – Class diagram Meas::Quality

Figure 122: This diagram shows the details of the quality codes. The quality flags can be used also in other packages not only specific to MeasurementValues. A generalized Quality class is added and inherited into MeasurementValueQuality.

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6.16.2 Accumulator

Accumulator represents an accumulated (counted) Measurement, e.g. an energy value.

Table 597 shows all attributes of Accumulator.

Table 597 – Attributes of Meas::Accumulator

name	mult	type	description
maxValue	0..1	Integer	Normal value range maximum for any of the MeasurementValue.values. Used for scaling, e.g. in bar graphs or of telemetered raw values.
measurementType	0..1	String	inherited from: Measurement
phases	0..1	PhaseCode	inherited from: Measurement
unitMultiplier	0..1	UnitMultiplier	inherited from: Measurement
unitSymbol	0..1	UnitSymbol	inherited from: Measurement
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 598 shows all association ends of Accumulator with other classes.

Table 598 – Association ends of Meas::Accumulator with other classes

mult from	name	mult to	type	description
1..1	AccumulatorValues	0..*	AccumulatorValue	The values connected to this measurement.
0..*	LimitSets	0..*	AccumulatorLimitSet	A measurement may have zero or more limit ranges defined for it.
0..*	Terminal	0..1	ACDCTerminal	inherited from: Measurement
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Measurement
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.3 AccumulatorLimit

Limit values for Accumulator measurements.

Table 599 shows all attributes of AccumulatorLimit.

Table 599 – Attributes of Meas::AccumulatorLimit

name	mult	type	description
value	0..1	Integer	The value to supervise against. The value is positive.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 600 shows all association ends of AccumulatorLimit with other classes.

Table 600 – Association ends of Meas::AccumulatorLimit with other classes

mult from	name	mult to	type	description
1..*	LimitSet	1..1	AccumulatorLimitSet	The set of limits.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.4 AccumulatorLimitSet

An AccumulatorLimitSet specifies a set of Limits that are associated with an Accumulator measurement.

Table 601 shows all attributes of AccumulatorLimitSet.

Table 601 – Attributes of Meas::AccumulatorLimitSet

name	mult	type	description
isPercentageLimits	0..1	Boolean	inherited from: LimitSet
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 602 shows all association ends of AccumulatorLimitSet with other classes.

Table 602 – Association ends of Meas::AccumulatorLimitSet with other classes

mult from	name	mult to	type	description
1..1	Limits	1..*	AccumulatorLimit	The limit values used for supervision of Measurements.
0..*	Measurements	0..*	Accumulator	The Measurements using the LimitSet.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.5 AccumulatorReset

This command resets the counter value to zero.

Table 603 shows all attributes of AccumulatorReset.

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Table 603 – Attributes of Meas::AccumulatorReset

name	mult	type	description
operationInProgress	0..1	Boolean	inherited from: Control
timeStamp	0..1	DateTime	inherited from: Control
unitMultiplier	0..1	UnitMultiplier	inherited from: Control
unitSymbol	0..1	UnitSymbol	inherited from: Control
controlType	0..1	String	inherited from: Control
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 604 shows all association ends of AccumulatorReset with other classes.

Table 604 – Association ends of Meas::AccumulatorReset with other classes

mult from	name	mult to	type	description
0..1	AccumulatorValue	1..1	AccumulatorValue	The accumulator value that is reset by the command.
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Control
1..1	RemoteControl	0..1	RemoteControl	inherited from: Control
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.6 AccumulatorValue

AccumulatorValue represents an accumulated (counted) MeasurementValue.

Table 605 shows all attributes of AccumulatorValue.

Table 605 – Attributes of Meas::AccumulatorValue

name	mult	type	description
value	0..1	Integer	The value to supervise. The value is positive.
timeStamp	0..1	DateTime	inherited from: MeasurementValue
sensorAccuracy	0..1	PerCent	inherited from: MeasurementValue
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 606 shows all association ends of AccumulatorValue with other classes.

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Table 606 – Association ends of Meas::AccumulatorValue with other classes

mult from	name	mult to	type	description
0..*	Accumulator	1..1	Accumulator	Measurement to which this value is connected.
1..1	AccumulatorReset	0..1	AccumulatorReset	The command that resets the accumulator value.
1..1	RemoteSource	0..1	RemoteSource	inherited from: MeasurementValue
1..1	MeasurementValueQuality	0..1	MeasurementValueQuality	inherited from: MeasurementValue
0..*	MeasurementValueSource	1..1	MeasurementValueSource	inherited from: MeasurementValue
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.7 Analog

Analog represents an analog Measurement.

Table 607 shows all attributes of Analog.

Table 607 – Attributes of Meas::Analog

name	mult	type	description
maxValue	0..1	Float	Normal value range maximum for any of the MeasurementValue.values. Used for scaling, e.g. in bar graphs or of telemetered raw values.
minValue	0..1	Float	Normal value range minimum for any of the MeasurementValue.values. Used for scaling, e.g. in bar graphs or of telemetered raw values.
normalValue	0..1	Float	Normal measurement value, e.g., used for percentage calculations.
positiveFlowIn	0..1	Boolean	If true then this measurement is an active power, reactive power or current with the convention that a positive value measured at the Terminal means power is flowing into the related PowerSystemResource.
measurementType	0..1	String	inherited from: Measurement
phases	0..1	PhaseCode	inherited from: Measurement
unitMultiplier	0..1	UnitMultiplier	inherited from: Measurement
unitSymbol	0..1	UnitSymbol	inherited from: Measurement
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 608 shows all association ends of Analog with other classes.

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Table 608 – Association ends of Meas::Analog with other classes

mult from	name	mult to	type	description
1..1	AnalogValues	0..*	AnalogValue	The values connected to this measurement.
0..*	LimitSets	0..*	AnalogLimitSet	A measurement may have zero or more limit ranges defined for it.
0..*	Terminal	0..1	ACDCTerminal	inherited from: Measurement
~~[0..1]~~	~~[0..1] SetPoint~~		~~SetPoint~~	~~The Control variable associated with the Measurement.~~
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Measurement
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.8 AnalogControl

An analog control used for supervisory control.

Table 609 shows all attributes of AnalogControl.

Table 609 – Attributes of Meas::AnalogControl

name	mult	type	description
maxValue	0..1	Float	Normal value range maximum for any of the Control.value. Used for scaling, e.g. in bar graphs.
minValue	0..1	Float	Normal value range minimum for any of the Control.value. Used for scaling, e.g. in bar graphs.
operationInProgress	0..1	Boolean	inherited from: Control
timeStamp	0..1	DateTime	inherited from: Control
unitMultiplier	0..1	UnitMultiplier	inherited from: Control
unitSymbol	0..1	UnitSymbol	inherited from: Control
controlType	0..1	String	inherited from: Control
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 610 shows all association ends of AnalogControl with other classes.

Table 610 – Association ends of Meas::AnalogControl with other classes

mult from	name	mult to	type	description
0..1	AnalogValue	1..1	AnalogValue	The MeasurementValue that is controlled.
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Control
1..1	RemoteControl	0..1	RemoteControl	inherited from: Control
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.16.9 AnalogLimit

Limit values for Analog measurements.

Table 611 shows all attributes of AnalogLimit.

Table 611 – Attributes of Meas::AnalogLimit

name	mult	type	description
value	0..1	Float	The value to supervise against.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 612 shows all association ends of AnalogLimit with other classes.

Table 612 – Association ends of Meas::AnalogLimit with other classes

mult from	name	mult to	type	description
0..*	LimitSet	1..1	AnalogLimitSet	The set of limits.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.10 AnalogLimitSet

An AnalogLimitSet specifies a set of Limits that are associated with an Analog measurement.

Table 613 shows all attributes of AnalogLimitSet.

Table 613 – Attributes of Meas::AnalogLimitSet

name	mult	type	description
isPercentageLimits	0..1	Boolean	inherited from: LimitSet
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 614 shows all association ends of AnalogLimitSet with other classes.

Table 614 – Association ends of Meas::AnalogLimitSet with other classes

mult from	name	mult to	type	description
1..1	Limits	0..*	AnalogLimit	The limit values used for supervision of Measurements.
0..*	Measurements	0..*	Analog	The Measurements using the LimitSet.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.16.11 AnalogValue

AnalogValue represents an analog MeasurementValue.

Table 615 shows all attributes of AnalogValue.

Table 615 – Attributes of Meas::AnalogValue

name	mult	type	description
value	0..1	Float	The value to supervise.
timeStamp	0..1	DateTime	inherited from: MeasurementValue
sensorAccuracy	0..1	PerCent	inherited from: MeasurementValue
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 616 shows all association ends of AnalogValue with other classes.

Table 616 – Association ends of Meas::AnalogValue with other classes

mult from	name	mult to	type	description
1..1	AnalogControl	0..1	AnalogControl	The Control variable associated with the MeasurementValue.
0..*	Analog	1..1	Analog	Measurement to which this value is connected.
1..1	AltTieMeas	0..*	AltTieMeas	The usage of the measurement within the control area specification.
1..1	AltGeneratingUnit	0..*	AltGeneratingUnitMeas	The alternate generating unit for which this measurement value applies.
1..1	RemoteSource	0..1	RemoteSource	inherited from: MeasurementValue
1..1	MeasurementValueQuality	0..1	MeasurementValueQuality	inherited from: MeasurementValue
0..*	MeasurementValueSource	1..1	MeasurementValueSource	inherited from: MeasurementValue
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.12 Command

A Command is a discrete control used for supervisory control.

Table 617 shows all attributes of Command.

Table 617 – Attributes of Meas::Command

name	mult	type	description
normalValue	0..1	Integer	Normal value for Control.value, e.g. used for percentage scaling.
value	0..1	Integer	The value representing the actuator output.
operationInProgress	0..1	Boolean	inherited from: Control
timeStamp	0..1	DateTime	inherited from: Control

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name	mult	type	description
unitMultiplier	0..1	UnitMultiplier	inherited from: Control
unitSymbol	0..1	UnitSymbol	inherited from: Control
controlType	0..1	String	inherited from: Control
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 618 shows all association ends of Command with other classes.

Table 618 – Association ends of Meas::Command with other classes

mult from	name	mult to	type	description
0..*	ValueAliasSet	0..1	ValueAliasSet	The ValueAliasSet used for translation of a Control value to a name.
0..1	DiscreteValue	1..1	DiscreteValue	The MeasurementValue that is controlled.
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Control
~~[0..1]~~	~~[0..1] Discrete~~		~~Discrete~~	~~The Measurement variable used for control.~~
~~[1..*]~~	~~[0..1] RegulatingCondEq~~		~~RegulatingCondEq~~	~~inherited from: Control~~
1..1	RemoteControl	0..1	RemoteControl	inherited from: Control
~~[0..*]~~	~~[1..1] ControlType~~		~~ControlType~~	~~inherited from: Control~~
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.13 Control

Control is used for supervisory/device control. It represents control outputs that are used to change the state in a process, e.g. close or open breaker, a set point value or a raise/lower command.

Table 619 shows all attributes of Control.

Table 619 – Attributes of Meas::Control

name	mult	type	description
operationInProgress	0..1	Boolean	Indicates that a client is currently sending control commands that has not completed.
timeStamp	0..1	DateTime	The last time a control output was sent.
unitMultiplier	0..1	UnitMultiplier	The unit multiplier of the controlled quantity.
unitSymbol	0..1	UnitSymbol	The unit of measure of the controlled quantity.
controlType	0..1	String	Specifies the type of Control, e.g. BreakerOn/Off, GeneratorVoltageSetPoint, TieLineFlow, etc. The ControlType.name shall be unique among all specified types and describe the type.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
name	0..1	String	inherited from: IdentifiedObject

Table 620 shows all association ends of Control with other classes.

Table 620 – Association ends of Meas::Control with other classes

mult from	name	mult to	type	description
0..*	PowerSystemResource	0..1	PowerSystemResource	Regulating device governed by this control output.
~~[1..*]~~	~~[0..1] RegulatingCondEq~~		~~RegulatingCondEq~~	~~Regulating device governed by this control output.~~
1..1	RemoteControl	0..1	RemoteControl	The remote point controlling the physical actuator.
~~[0..*]~~	~~[1..1] ControlType~~		~~ControlType~~	~~The type of control.~~
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

~~6.15.12 ControlType~~

~~Specifies the type of Control, e.g. BreakerOn/Off, GeneratorVoltageSetPoint, TieLineFlow, etc. The ControlType.name shall be unique among all specified types and describe the type. The ControlType.aliasName is meant to be used for localization.~~

~~Table 524 shows all attributes of ControlType.~~

~~Table 524 – Attributes of Meas::ControlType~~

~~name~~	~~type~~	~~description~~
~~aliasName~~	~~String~~	~~inherited from: IdentifiedObject~~
~~mRID~~	~~String~~	~~inherited from: IdentifiedObject~~
~~name~~	~~String~~	~~inherited from: IdentifiedObject~~

~~Table 525 shows all association ends of ControlType with other classes.~~

~~Table 525 – Association ends of Meas::ControlType with other classes~~

~~[mult from]~~	~~[mult to] name~~	~~type~~	~~description~~
~~[1..1]~~	~~[0..*] Controls~~	~~Control~~	~~The controls having the control type.~~
~~[0..1]~~	~~[0..*] DiagramObjects~~	~~DiagramObject~~	~~inherited from: IdentifiedObject~~
~~[1..1]~~	~~[0..*] Names~~	~~Name~~	~~inherited from: IdentifiedObject~~

6.16.14 Discrete

Discrete represents a discrete Measurement, i.e. a Measurement representing discrete values, e.g. a Breaker position.

Table 621 shows all attributes of Discrete.

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Table 621 – Attributes of Meas::Discrete

name	mult	type	description
maxValue	0..1	Integer	Normal value range maximum for any of the MeasurementValue.values. Used for scaling, e.g. in bar graphs or of telemetered raw values.
minValue	0..1	Integer	Normal value range minimum for any of the MeasurementValue.values. Used for scaling, e.g. in bar graphs or of telemetered raw values.
normalValue	0..1	Integer	Normal measurement value, e.g. used for percentage calculations.
measurementType	0..1	String	inherited from: Measurement
phases	0..1	PhaseCode	inherited from: Measurement
unitMultiplier	0..1	UnitMultiplier	inherited from: Measurement
unitSymbol	0..1	UnitSymbol	inherited from: Measurement
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 622 shows all association ends of Discrete with other classes.

Table 622 – Association ends of Meas::Discrete with other classes

mult from	name	mult to	type	description
~~[0..1]~~	~~[0..1] Command~~		~~Command~~	~~The Control variable associated with the Measurement.~~
1..1	DiscreteValues	0..*	DiscreteValue	The values connected to this measurement.
0..*	ValueAliasSet	0..1	ValueAliasSet	The ValueAliasSet used for translation of a MeasurementValue.value to a name.
0..*	Terminal	0..1	ACDCTerminal	inherited from: Measurement
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Measurement
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.15 DiscreteCommand

Table 623 shows all attributes of DiscreteCommand.

Table 623 – Attributes of Meas::DiscreteCommand

name	mult	type	description
normalValue	0..1	Integer	inherited from: Command
value	0..1	Integer	inherited from: Command
operationInProgress	0..1	Boolean	inherited from: Control
timeStamp	0..1	DateTime	inherited from: Control
unitMultiplier	0..1	UnitMultiplier	inherited from: Control
unitSymbol	0..1	UnitSymbol	inherited from: Control

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name	mult	type	description
controlType	0..1	String	inherited from: Control
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 624 shows all association ends of DiscreteCommand with other classes.

Table 624 – Association ends of Meas::DiscreteCommand with other classes

mult from	name	mult to	type	description
0..*	ValueAliasSet	0..1	ValueAliasSet	inherited from: Command
0..1	DiscreteValue	1..1	DiscreteValue	inherited from: Command
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Control
1..1	RemoteControl	0..1	RemoteControl	inherited from: Control
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.16 DiscreteValue

DiscreteValue represents a discrete MeasurementValue.

Table 625 shows all attributes of DiscreteValue.

Table 625 – Attributes of Meas::DiscreteValue

name	mult	type	description
value	0..1	Integer	The value to supervise.
timeStamp	0..1	DateTime	inherited from: MeasurementValue
sensorAccuracy	0..1	PerCent	inherited from: MeasurementValue
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 626 shows all association ends of DiscreteValue with other classes.

Table 626 – Association ends of Meas::DiscreteValue with other classes

mult from	name	mult to	type	description
1..1	Command	0..1	Command	The Control variable associated with the MeasurementValue.
0..*	Discrete	1..1	Discrete	Measurement to which this value is connected.
1..1	RemoteSource	0..1	RemoteSource	inherited from: MeasurementValue
1..1	MeasurementValueQuality	0..1	MeasurementValueQuality	inherited from: MeasurementValue

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mult from	name	mult to	type	description
0..*	MeasurementValueSource	1..1	MeasurementValueSource	inherited from: MeasurementValue
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.17 Limit

Specifies one limit value for a Measurement. A Measurement typically has several limits that are kept together by the LimitSet class. The actual meaning and use of a Limit instance (i.e. if it is an alarm or warning limit or if it is a high or low limit) is not captured in the Limit class. However the name of a Limit instance may indicate both meaning and use.

Table 627 shows all attributes of Limit.

Table 627 – Attributes of Meas::Limit

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 628 shows all association ends of Limit with other classes.

Table 628 – Association ends of Meas::Limit with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.18 LimitSet

Specifies a set of Limits that are associated with a Measurement. A Measurement may have several LimitSets corresponding to seasonal or other changing conditions. The condition is captured in the name and description attributes. The same LimitSet may be used for several Measurements. In particular, percentage limits are used this way.

Table 629 shows all attributes of LimitSet.

Table 629 – Attributes of Meas::LimitSet

name	mult	type	description
isPercentageLimits	0..1	Boolean	Tells if the limit values are in percentage of normalValue or the specified Unit for Measurements and Controls.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 630 shows all association ends of LimitSet with other classes.

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Table 630 – Association ends of Meas::LimitSet with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.19 Measurement

A Measurement represents any measured, calculated or non-measured non-calculated quantity. Any piece of equipment may contain Measurements, e.g. a substation may have temperature measurements and door open indications, a transformer may have oil temperature and tank pressure measurements, a bay may contain a number of power flow measurements and a Breaker may contain a switch status measurement.

The PSR–Measurement association is intended to capture this use of Measurement and is included in the naming hierarchy based on EquipmentContainer. The naming hierarchy typically has Measurements as leafs, e.g. Substation-VoltageLevel-Bay-Switch-Measurement.

Some Measurements represent quantities related to a particular sensor location in the network, e.g. a voltage transformer (PT) at a busbar or a current transformer (CT) at the bar between a breaker and an isolator. The sensing position is not captured in the PSR–Measurement association. Instead it is captured by the Measurement–Terminal association that is used to define the sensing location in the network topology. The location is defined by the connection of the Terminal to ConductingEquipment.

If both a Terminal and PSR are associated, and the PSR is of type ConductingEquipment, the associated Terminal should belong to that ConductingEquipment instance.

When the sensor location is needed both Measurement–PSR and Measurement–Terminal are used. The Measurement–Terminal association is never used alone.

Table 631 shows all attributes of Measurement.

Table 631 – Attributes of Meas::Measurement

name	mult	type	description
measurementType	0..1	String	Specifies the type of measurement. For example, this specifies if the measurement represents an indoor temperature, outdoor temperature, bus voltage, line flow, etc.
phases	0..1	PhaseCode	Indicates to which phases the measurement applies and avoids the need to use 'measurementType' to also encode phase information (which would explode the types). ~~Since Controls have associations with Measurements, they will have the capability to handle each phase.~~ The phase information in Measurement, along with 'measurementType' and 'phases' uniquely defines a Measurement for a device, based on normal network phase. Their meaning will not change when the computed energizing phasing is changed due to jumpers or other reasons. If the attribute is missing three phases (ABC) shall be assumed.
unitMultiplier	0..1	UnitMultiplier	The unit multiplier of the measured quantity.
unitSymbol	0..1	UnitSymbol	The unit of measure of the measured quantity.
aliasName	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 632 shows all association ends of Measurement with other classes.

Table 632 – Association ends of Meas::Measurement with other classes

mult from	name	mult to	type	description
0..*	Terminal	0..1	ACDCTerminal	One or more measurements may be associated with a terminal in the network.
0..*	PowerSystemResource	0..1	PowerSystemResource	The power system resource that contains the measurement.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.20 MeasurementValue

The current state for a measurement. A state value is an instance of a measurement from a specific source. Measurements can be associated with many state values, each representing a different source for the measurement.

Table 633 shows all attributes of MeasurementValue.

Table 633 – Attributes of Meas::MeasurementValue

name	mult	type	description
timeStamp	0..1	DateTime	The time when the value was last updated
sensorAccuracy	0..1	PerCent	The limit, expressed as a percentage of the sensor maximum, that errors will not exceed when the sensor is used under reference conditions.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 634 shows all association ends of MeasurementValue with other classes.

Table 634 – Association ends of Meas::MeasurementValue with other classes

mult from	name	mult to	type	description
1..1	RemoteSource	0..1	RemoteSource	Link to the physical telemetered point associated with this measurement.
1..1	MeasurementValueQuality	0..1	MeasurementValueQuality	A MeasurementValue has a MeasurementValueQuality associated with it.

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mult from	name	mult to	type	description
0..*	MeasurementValueSource	1..1	MeasurementValueSource	A reference to the type of source that updates the MeasurementValue, e.g. SCADA, CCLink, manual, etc. User conventions for the names of sources are contained in the introduction to IEC 61970-301.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.21 MeasurementValueQuality

Measurement quality flags. Bits 0-10 are defined for substation automation in IEC 61850-7-3. Bits 11-15 are reserved for future expansion by that document. Bits 16-31 are reserved for EMS applications.

Table 635 shows all attributes of MeasurementValueQuality.

Table 635 – Attributes of Meas::MeasurementValueQuality

name	mult	type	description
badReference	0..1	Boolean	inherited from: Quality61850
estimatorReplaced	0..1	Boolean	inherited from: Quality61850
failure	0..1	Boolean	inherited from: Quality61850
oldData	0..1	Boolean	inherited from: Quality61850
operatorBlocked	0..1	Boolean	inherited from: Quality61850
oscillatory	0..1	Boolean	inherited from: Quality61850
outOfRange	0..1	Boolean	inherited from: Quality61850
overFlow	0..1	Boolean	inherited from: Quality61850
source	0..1	Source	inherited from: Quality61850
suspect	0..1	Boolean	inherited from: Quality61850
test	0..1	Boolean	inherited from: Quality61850
validity	0..1	Validity	inherited from: Quality61850

Table 636 shows all association ends of MeasurementValueQuality with other classes.

Table 636 – Association ends of Meas::MeasurementValueQuality with other classes

mult from	name	mult to	type	description
0..1	MeasurementValue	1..1	MeasurementValue	A MeasurementValue has a MeasurementValueQuality associated with it.

6.16.22 MeasurementValueSource

MeasurementValueSource describes the alternative sources updating a MeasurementValue. User conventions for how to use the MeasurementValueSource attributes are described in the introduction to IEC 61970-301.

Table 637 shows all attributes of MeasurementValueSource.

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Table 637 – Attributes of Meas::MeasurementValueSource

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 638 shows all association ends of MeasurementValueSource with other classes.

Table 638 – Association ends of Meas::MeasurementValueSource with other classes

mult from	name	mult to	type	description
1..1	MeasurementValues	0..*	MeasurementValue	The MeasurementValues updated by the source.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.23 Quality61850 root class

Quality flags in this class are as defined in IEC 61850-7-3, except for estimatorReplaced, which has been included in this class for convenience.

Table 639 shows all attributes of Quality61850.

Table 639 – Attributes of Meas::Quality61850

name	mult	type	description
badReference	0..1	Boolean	Measurement value may be incorrect due to a reference being out of calibration.
estimatorReplaced	0..1	Boolean	Value has been replaced by State Estimator. estimatorReplaced is not an IEC 61850 quality bit but has been put in this class for convenience.
failure	0..1	Boolean	This identifier indicates that a supervision function has detected an internal or external failure, e.g. communication failure.
oldData	0..1	Boolean	Measurement value is old and possibly invalid, as it has not been successfully updated during a specified time interval.
operatorBlocked	0..1	Boolean	Measurement value is blocked and hence unavailable for transmission.

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name	mult	type	description
oscillatory	0..1	Boolean	To prevent some overload of the communication it is sensible to detect and suppress oscillating (fast changing) binary inputs. If a signal changes in a defined time (tosc) twice in the same direction (from 0 to 1 or from 1 to 0) then oscillation is detected and the detail quality identifier "oscillatory" is set. If it is detected a configured numbers of transient changes could be passed by. In this time the validity status "questionable" is set. If after this defined numbers of changes the signal is still in the oscillating state the value shall be set either to the opposite state of the previous stable value or to a defined default value. In this case the validity status "questionable" is reset and "invalid" is set as long as the signal is oscillating. If it is configured such that no transient changes should be passed by then the validity status "invalid" is set immediately in addition to the detail quality identifier "oscillatory" (used for status information only).
outOfRange	0..1	Boolean	Measurement value is beyond a predefined range of value.
overFlow	0..1	Boolean	Measurement value is beyond the capability of being represented properly. For example, a counter value overflows from maximum count back to a value of zero.
source	0..1	Source	Source gives information related to the origin of a value. The value may be acquired from the process, defaulted or substituted.
suspect	0..1	Boolean	A correlation function has detected that the value is not consistent with other values. Typically set by a network State Estimator.
test	0..1	Boolean	Measurement value is transmitted for test purposes.
validity	0..1	Validity	Validity of the measurement value.

6.16.24 RaiseLowerCommand

An analog control that increases or decreases a set point value with pulses.

Table 640 shows all attributes of RaiseLowerCommand.

Table 640 – Attributes of Meas::RaiseLowerCommand

name	mult	type	description
maxValue	0..1	Float	inherited from: AnalogControl
minValue	0..1	Float	inherited from: AnalogControl
operationInProgress	0..1	Boolean	inherited from: Control
timeStamp	0..1	DateTime	inherited from: Control
unitMultiplier	0..1	UnitMultiplier	inherited from: Control
unitSymbol	0..1	UnitSymbol	inherited from: Control
controlType	0..1	String	inherited from: Control
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 641 shows all association ends of RaiseLowerCommand with other classes.

Table 641 – Association ends of Meas::RaiseLowerCommand with other classes

mult from	name	mult to	type	description
0..*	ValueAliasSet	0..1	ValueAliasSet	The ValueAliasSet used for translation of a Control value to a name.
0..1	AnalogValue	1..1	AnalogValue	inherited from: AnalogControl
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Control
1..1	RemoteControl	0..1	RemoteControl	inherited from: Control
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.25 SetPoint

~~A SetPoint is an analog control used for supervisory control.~~

An analog control that issues a set point value.

Table 642 shows all attributes of SetPoint.

Table 642 – Attributes of Meas::SetPoint

name	mult	type	description
normalValue	0..1	Float	Normal value for Control.value, e.g. used for percentage scaling.
value	0..1	Float	The value representing the actuator output.
maxValue	0..1	Float	~~Normal value range maximum for any of the Control.value. Used for scaling, e.g. in bar graphs.~~ inherited from: AnalogControl
minValue	0..1	Float	~~Normal value range minimum for any of the Control.value. Used for scaling, e.g. in bar graphs.~~ inherited from: AnalogControl
operationInProgress	0..1	Boolean	inherited from: Control
timeStamp	0..1	DateTime	inherited from: Control
unitMultiplier	0..1	UnitMultiplier	inherited from: Control
unitSymbol	0..1	UnitSymbol	inherited from: Control
controlType	0..1	String	inherited from: Control
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 643 shows all association ends of SetPoint with other classes.

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Table 643 – Association ends of Meas::SetPoint with other classes

mult from	name	mult to	type	description
~~[0..1]~~	~~[0..1] Analog~~		~~Analog~~	~~The Measurement variable used for control.~~
~~[1..*]~~	~~[0..1] RegulatingCondEq~~		~~RegulatingCondEq~~	~~inherited from: Control~~
0..1	AnalogValue	1..1	AnalogValue	inherited from: AnalogControl
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Control
1..1	RemoteControl	0..1	RemoteControl	inherited from: Control
~~[0..*]~~	~~[1..1] ControlType~~		~~ControlType~~	~~inherited from: Control~~
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.26 StringMeasurement

StringMeasurement represents a measurement with values of type string.

Table 644 shows all attributes of StringMeasurement.

Table 644 – Attributes of Meas::StringMeasurement

name	mult	type	description
measurementType	0..1	String	inherited from: Measurement
phases	0..1	PhaseCode	inherited from: Measurement
unitMultiplier	0..1	UnitMultiplier	inherited from: Measurement
unitSymbol	0..1	UnitSymbol	inherited from: Measurement
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 645 shows all association ends of StringMeasurement with other classes.

Table 645 – Association ends of Meas::StringMeasurement with other classes

mult from	name	mult to	type	description
1..1	StringMeasurementValues	0..*	StringMeasurementValue	The values connected to this measurement.
0..*	Terminal	0..1	ACDCTerminal	inherited from: Measurement
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Measurement
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.27 StringMeasurementValue

StringMeasurementValue represents a measurement value of type string.

Table 646 shows all attributes of StringMeasurementValue.

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Table 646 – Attributes of Meas::StringMeasurementValue

name	mult	type	description
value	0..1	String	The value to supervise.
timeStamp	0..1	DateTime	inherited from: MeasurementValue
sensorAccuracy	0..1	PerCent	inherited from: MeasurementValue
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 647 shows all association ends of StringMeasurementValue with other classes.

Table 647 – Association ends of Meas::StringMeasurementValue with other classes

mult from	name	mult to	type	description
0..*	StringMeasurement	1..1	StringMeasurement	Measurement to which this value is connected.
1..1	RemoteSource	0..1	RemoteSource	inherited from: MeasurementValue
1..1	MeasurementValueQuality	0..1	MeasurementValueQuality	inherited from: MeasurementValue
0..*	MeasurementValueSource	1..1	MeasurementValueSource	inherited from: MeasurementValue
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.28 Validity enumeration

Validity for MeasurementValue.

Table 648 shows all literals of Validity.

Table 648 – Literals of Meas::Validity

literal	value	description
GOOD		The value is marked good if no abnormal condition of the acquisition function or the information source is detected.
QUESTIONABLE		The value is marked questionable if a supervision function detects an abnormal behavior, however the value could still be valid. The client is responsible for determining whether or not values marked "questionable" should be used.
INVALID		The value is marked invalid when a supervision function recognizes abnormal conditions of the acquisition function or the information source (missing or non-operating updating devices). The value is not defined under this condition. The mark invalid is used to indicate to the client that the value may be incorrect and shall not be used.

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6.16.29 ValueAliasSet

Describes the translation of a set of values into a name and is intendend to facilitate custom translations. Each ValueAliasSet has a name, description, etc. A specific Measurement may represent a discrete state like Open, Closed, Intermediate, etc. This requires a translation from the MeasurementValue.value number to a string, e.g. 0->"Invalid", 1->"Open", 2->"Closed", 3->"Intermediate". Each ValueToAlias member in ValueAliasSet.Value describes a mapping for one particular value to a name.

Table 649 shows all attributes of ValueAliasSet.

Table 649 – Attributes of Meas::ValueAliasSet

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 650 shows all association ends of ValueAliasSet with other classes.

Table 650 – Association ends of Meas::ValueAliasSet with other classes

mult from	name	mult to	type	description
0..1	Discretes	0..*	Discrete	The Measurements using the set for translation.
1..1	Values	1..*	ValueToAlias	The ValueToAlias mappings included in the set.
0..1	Commands	0..*	Command	~~The ValueAliasSet used for translation of a Control value to a name.~~ The Commands using the set for translation.
0..1	RaiseLowerCommands	0..*	RaiseLowerCommand	The Commands using the set for translation.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.30 ValueToAlias

Describes the translation of one particular value into a name, e.g. 1 as "Open".

Table 651 shows all attributes of ValueToAlias.

Table 651 – Attributes of Meas::ValueToAlias

name	mult	type	description
value	0..1	Integer	The value that is mapped.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 652 shows all association ends of ValueToAlias with other classes.

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Table 652 – Association ends of Meas::ValueToAlias with other classes

mult from	name	mult to	type	description
1..*	ValueAliasSet	1..1	ValueAliasSet	The ValueAliasSet having the ValueToAlias mappings.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.17 Package SCADA

6.17.1 General

Contains entities to model information used by Supervisory Control and Data Acquisition (SCADA) applications. Supervisory control supports operator control of equipment, such as opening or closing a breaker. Data acquisition gathers telemetered data from various sources. The subtypes of the Telemetry entity deliberately match the UCA and IEC 61850 definitions.

This package also supports alarm presentation but it is not expected to be used by other applications.

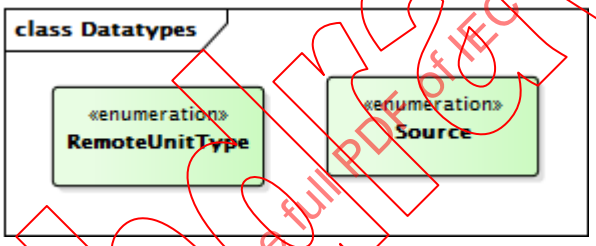


Figure 123 – Class diagram SCADA::Datatypes

Figure 123: Shows datatypes for SCADA model.

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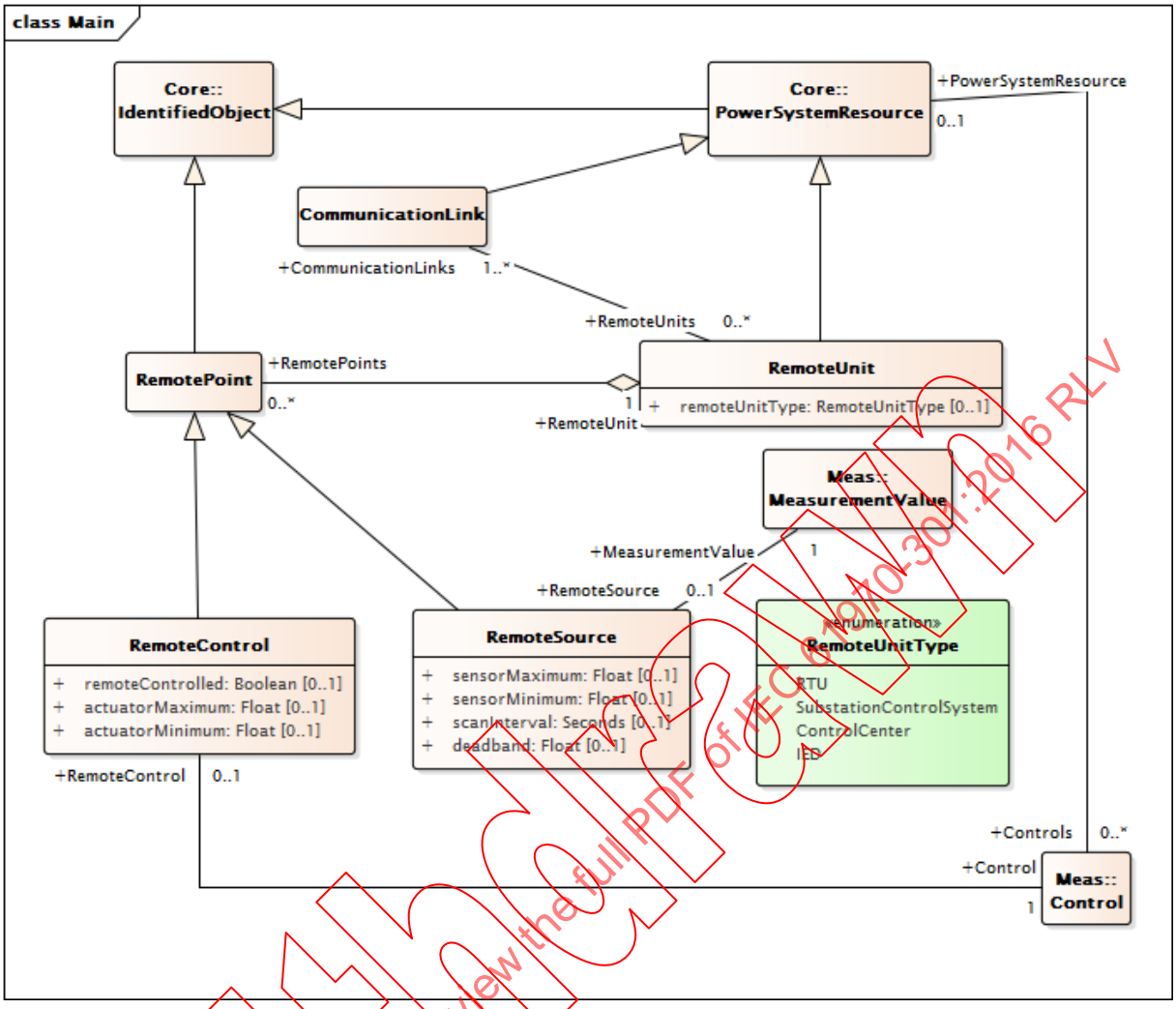


Figure 124 – Class diagram SCADA::Main

Figure 124: This diagram shows all classes included in the SCADA package as well as the key external classes that have associations with SCADA classes.

6.17.2 CommunicationLink

The connection to remote units is through one or more communication links. Reduntant links may exist. The CommunicationLink class inherits PowerSystemResource. The intention is to allow CommunicationLinks to have Measurements. These Measurements can be used to model link status as operational, out of service, unit failure, etc.

Table 653 shows all attributes of CommunicationLink.

Table 653 – Attributes of SCADA::CommunicationLink

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 654 shows all association ends of CommunicationLink with other classes.

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Table 654 – Association ends of SCADA::CommunicationLink with other classes

mult from	name	mult to	type	description
1..*	RemoteUnits	0..*	RemoteUnit	RTUs may be attached to communication links.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.17.3 RemoteControl

Remote controls are outputs that are sent by the remote unit to actuators in the process.

Table 655 shows all attributes of RemoteControl.

Table 655 – Attributes of SCADA::RemoteControl

name	mult	type	description
remoteControlled	0..1	Boolean	Set to true if the actuator is remotely controlled.
actuatorMaximum	0..1	Float	The maximum set point value accepted by the remote control point.
actuatorMinimum	0..1	Float	The minimum set point value accepted by the remote control point.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 656 shows all association ends of RemoteControl with other classes.

Table 656 – Association ends of SCADA::RemoteControl with other classes

mult from	name	mult to	type	description
0..1	Control	1..1	Control	The Control for the RemoteControl point.
0..*	RemoteUnit	1..1	RemoteUnit	inherited from: RemotePoint
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.17.4 RemotePoint

For an RTU, remote points correspond to telemetered values or control outputs. Other units (e.g. control centres) usually also contain calculated values.

Table 657 shows all attributes of RemotePoint.

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Table 657 – Attributes of SCADA::RemotePoint

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 658 shows all association ends of RemotePoint with other classes.

Table 658 – Association ends of SCADA::RemotePoint with other classes

mult from	name	mult to	type	description
0..*	RemoteUnit	1..1	RemoteUnit	Remote unit this point belongs to.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.17.5 RemoteSource

Remote sources are state variables that are telemetered or calculated within the remote unit.

Table 659 shows all attributes of RemoteSource.

Table 659 – Attributes of SCADA::RemoteSource

name	mult	type	description
sensorMaximum	0..1	Float	The maximum value the telemetry item can return.
sensorMinimum	0..1	Float	The minimum value the telemetry item can return.
scanInterval	0..1	Seconds	The time interval between scans.
deadband	0..1	Float	The smallest change in value to be reported.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 660 shows all association ends of RemoteSource with other classes.

Table 660 – Association ends of SCADA::RemoteSource with other classes

mult from	name	mult to	type	description
0..1	MeasurementValue	1..1	MeasurementValue	Link to the physical telemetered point associated with this measurement.
0..*	RemoteUnit	1..1	RemoteUnit	inherited from: RemotePoint
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.17.6 RemoteUnit

A remote unit can be an RTU, IED, substation control system, control centre, etc. The communication with the remote unit can be through various standard protocols (e.g. IEC 61870, IEC 61850) or non standard protocols (e.g. DNP, RP570, etc.). A remote unit contains remote data points that might be telemetered, collected or calculated. The RemoteUnit class inherits PowerSystemResource. The intention is to allow RemoteUnits to have Measurements. These Measurements can be used to model unit status as operational, out of service, unit failure, etc.

Table 661 shows all attributes of RemoteUnit.

Table 661 – Attributes of SCADA::RemoteUnit

name	mult	type	description
remoteUnitType	0..1	RemoteUnitType	Type of remote unit.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 662 shows all association ends of RemoteUnit with other classes.

Table 662 – Association ends of SCADA::RemoteUnit with other classes

mult from	name	mult to	type	description
0..*	CommunicationLinks	1..*	CommunicationLink	RTUs may be attached to communication links.
1..1	RemotePoints	0..*	RemotePoint	Remote points this Remote unit contains.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.17.7 RemoteUnitType enumeration

Type of remote unit.

Table 663 shows all literals of RemoteUnitType.

Table 663 – Literals of SCADA::RemoteUnitType

literal	value	description
RTU		Remote terminal unit.
SubstationControlSystem		Substation control system.

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literal	value	description
ControlCenter		Control centre.
IED		Intelligent electronic device (IED).

6.17.8 Source enumeration

Source gives information related to the origin of a value.

Table 664 shows all literals of Source.

Table 664 – Literals of SCADA::Source

literal	value	description
PROCESS		The value is provided by input from the process I/O or being calculated from some function.
DEFAULTED		The value contains a default value.
SUBSTITUTED		The value is provided by input of an operator or by an automatic source.

6.18 Package ControlArea

6.18.1 General

The ControlArea package models area specifications which can be used for a variety of purposes. The package as a whole models potentially overlapping control area specifications for the purpose of actual generation control, load forecast area load capture, or powerflow based analysis.

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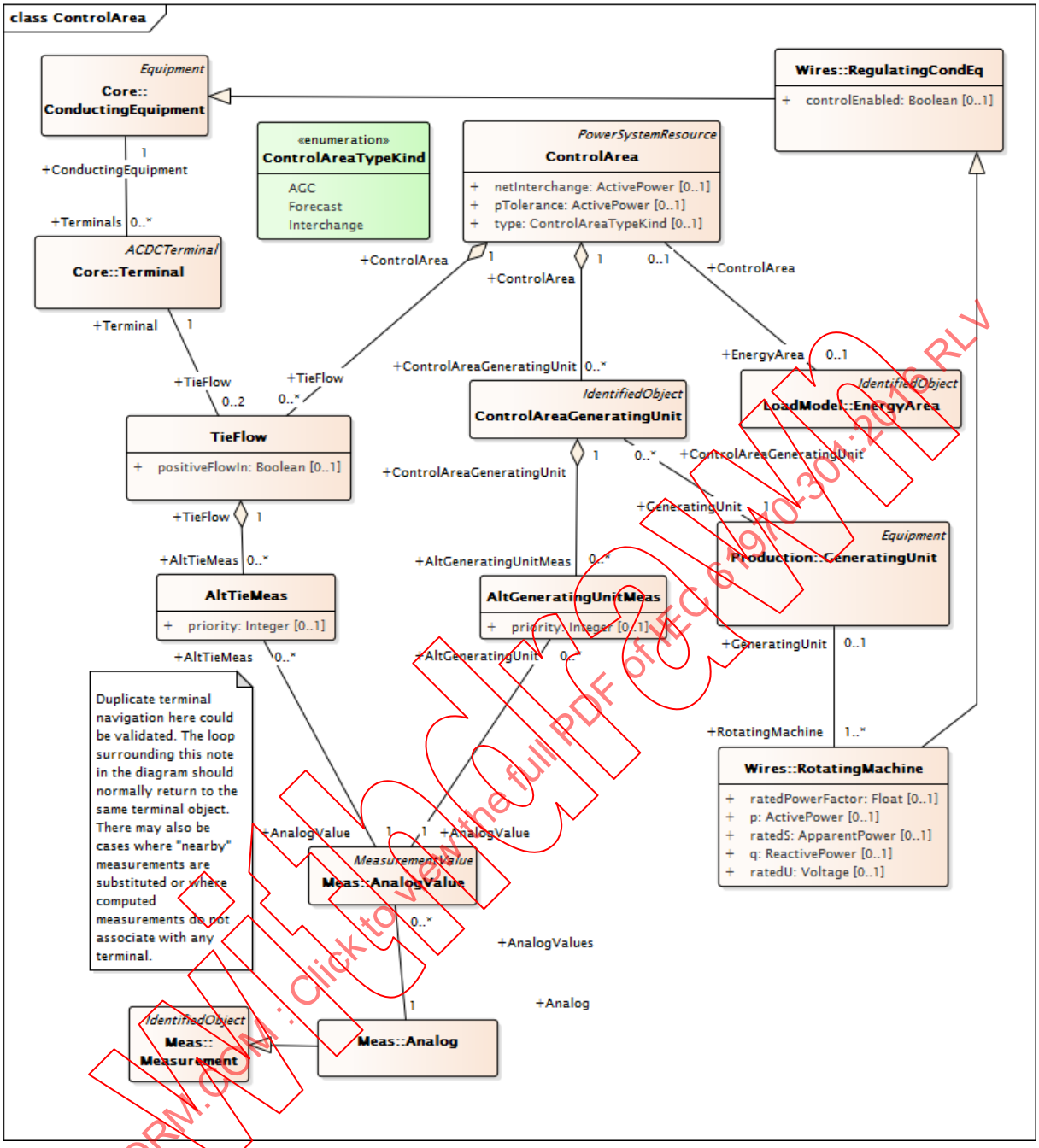


Figure 125 – Class diagram ControlArea::ControlArea

Figure 125: This diagram shows control area specification and some related classes. The Terminal to AnalogValue linkages are shown for clarity in understanding the control area specificaiton. The GeneratingUnit to Terminal linkages are also shown to illustrate how generation flows are specifically tied to the network.

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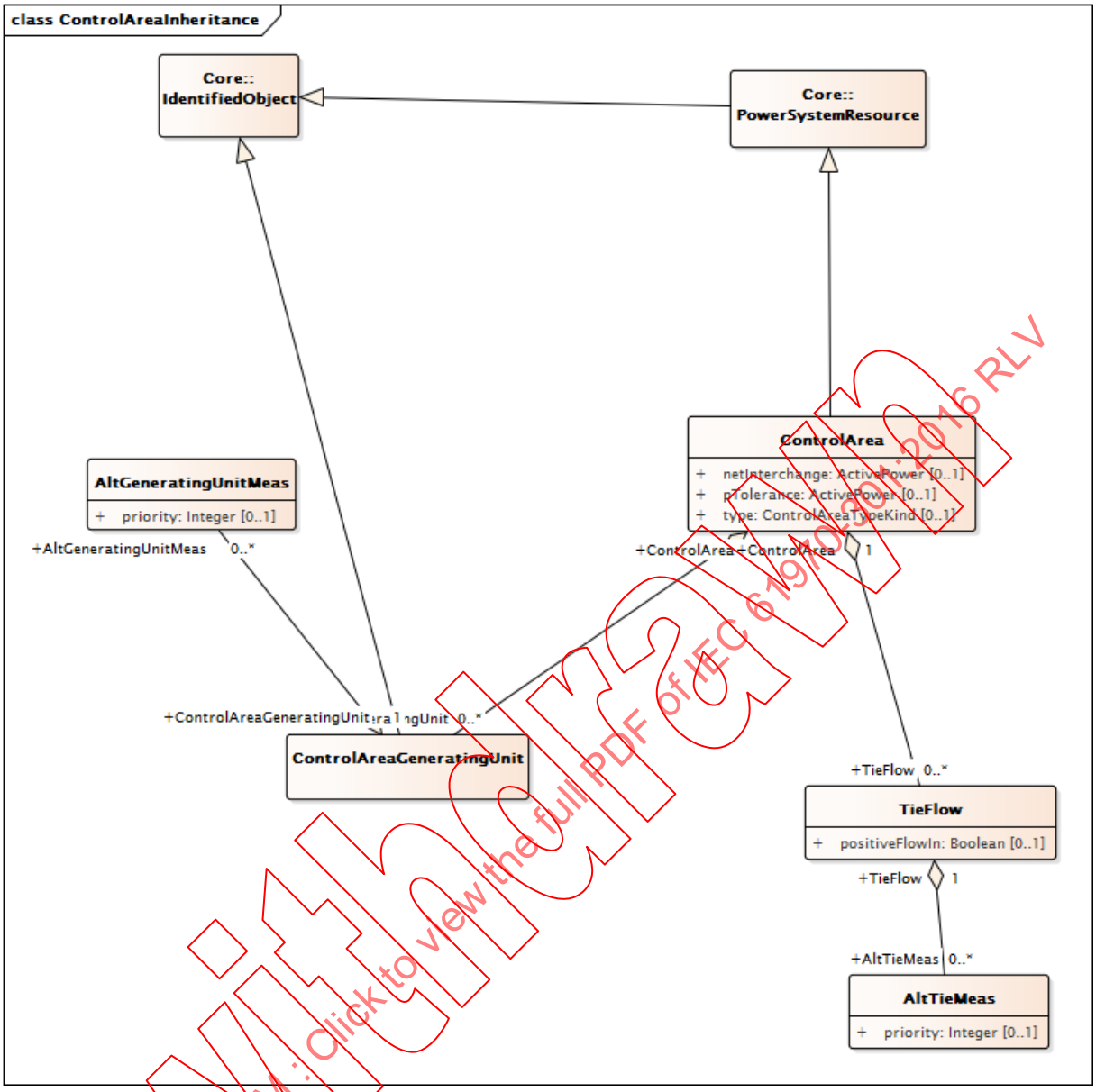


Figure 126 – Class diagram ControlArea::ControlAreaInheritance

Figure 126: Shows the inheritance of classes in this package.

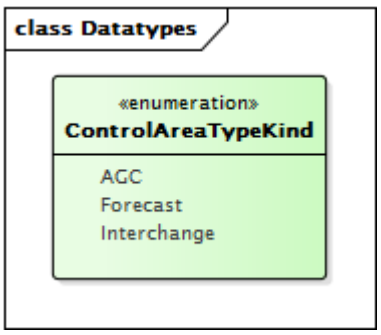


Figure 127 – Class diagram ControlArea::Datatypes

Figure 127: Shows datatypes for control areas.

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6.18.2 AltGeneratingUnitMeas root class

A prioritized measurement to be used for the generating unit in the control area specification.

Table 665 shows all attributes of AltGeneratingUnitMeas.

Table 665 – Attributes of ControlArea::AltGeneratingUnitMeas

name	mult	type	description
priority	0..1	Integer	Priority of a measurement usage. Lower numbers have first priority.

Table 666 shows all association ends of AltGeneratingUnitMeas with other classes.

Table 666 – Association ends of ControlArea::AltGeneratingUnitMeas with other classes

mult from	name	mult to	type	description
0..*	AnalogValue	1..1	AnalogValue	The specific analog value used as a source.
0..*	ControlAreaGeneratingUnit	1..1	ControlAreaGeneratingUnit	The control area generating unit to which the prioritized measurement assignment is applied.

6.18.3 AltTieMeas root class

A prioritized measurement to be used for the tie flow as part of the control area specification.

Table 667 shows all attributes of AltTieMeas.

Table 667 – Attributes of ControlArea::AltTieMeas

name	mult	type	description
priority	0..1	Integer	Priority of a measurement usage. Lower numbers have first priority.

Table 668 shows all association ends of AltTieMeas with other classes.

Table 668 – Association ends of ControlArea::AltTieMeas with other classes

mult from	name	mult to	type	description
0..*	AnalogValue	1..1	AnalogValue	The specific analog value used as a source.
0..*	TieFlow	1..1	TieFlow	The tie flow of the alternate measurements.

6.18.4 ControlArea

A control area is a grouping of generating units and/or loads and a cutset of tie lines (as terminals) which may be used for a variety of purposes including automatic generation control, powerflow solution area interchange control specification, and input to load forecasting. Note that any number of overlapping control area specifications can be superimposed on the physical model.

Table 669 shows all attributes of ControlArea.

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Table 669 – Attributes of ControlArea::ControlArea

name	mult	type	description
netInterchange	0..1	ActivePower	The specified positive net interchange into the control area, i.e. positive sign means flow in to the area.
pTolerance	0..1	ActivePower	Active power net interchange tolerance
type	0..1	ControlAreaTypeKind	The primary type of control area definition used to determine if this is used for automatic generation control, for planning interchange control, or other purposes. A control area specified with primary type of automatic generation control could still be forecast and used as an interchange area in power flow analysis.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 670 shows all association ends of ControlArea with other classes.

Table 670 – Association ends of ControlArea::ControlArea with other classes

mult from	name	mult to	type	description
0..1	EnergyArea	0..1	EnergyArea	The energy area that is forecast from this control area specification.
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	The generating unit specificaitons for the control area.
1..1	TieFlow	0..*	TieFlow	The tie flows associated with the control area.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
~~[0..*]~~	~~[0..*] PsrLists~~		~~PsrList~~	~~inherited from: PowerSystemResource~~
~~[1..1]~~	~~[0..1] OutageSchedule~~		~~OutageSchedule~~	~~inherited from: PowerSystemResource~~
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.18.5 ControlAreaGeneratingUnit ~~root class~~

A control area generating unit. This class is needed so that alternate control area definitions may include the same generating unit. Note only one instance within a control area should reference a specific generating unit.

Table 671 shows all attributes of ControlAreaGeneratingUnit.

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Table 671 – Attributes of ControlArea::ControlAreaGeneratingUnit

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 672 shows all association ends of ControlAreaGeneratingUnit with other classes.

Table 672 – Association ends of ControlArea::ControlAreaGeneratingUnit with other classes

mult from	name	mult to	type	description
0..*	GeneratingUnit	1..1	GeneratingUnit	The generating unit specified for this control area. Note that a control area should include a GeneratingUnit only once.
0..*	ControlArea	1..1	ControlArea	The parent control area for the generating unit specifications.
1..1	AltGeneratingUnitMeas	0..*	AltGeneratingUnitMeas	The link to prioritized measurements for this GeneratingUnit.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.18.6 ControlAreaTypeKind enumeration

The type of control area.

Table 673 shows all literals of ControlAreaTypeKind.

Table 673 – Literals of ControlArea::ControlAreaTypeKind

literal	value	description
AGC		Used for automatic generation control.
Forecast		Used for load forecast.
Interchange		Used for interchange specification or control.

6.18.7 TieFlow root class

A flow specification in terms of location and direction for a control area.

Table 674 shows all attributes of TieFlow.

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Table 674 – Attributes of ControlArea::TieFlow

name	mult	type	description
positiveFlowIn	0..1	Boolean	~~The flow is positive into the terminal. A flow is positive if it is an import into the control area.~~ True if the flow into the terminal (load convention) is also flow into the control area. For example, this attribute should be true if using the tie line terminal further away from the control area. For example to represent a tie to a shunt component (like a load or generator) in another area, this is the near end of a branch and this attribute would be specified as false.

Table 675 shows all association ends of TieFlow with other classes.

Table 675 – Association ends of ControlArea::TieFlow with other classes

mult from	name	mult to	type	description
0..2	Terminal	1..1	Terminal	The terminal to which this tie flow belongs.
0..*	ControlArea	1..1	ControlArea	The control area of the tie flows.
1..1	AltTieMeas	0..*	AltTieMeas	The primary and alternate tie flow measurements associated with the tie flow.

6.19 Package Contingency

6.19.1 General

Contingencies to be studied.

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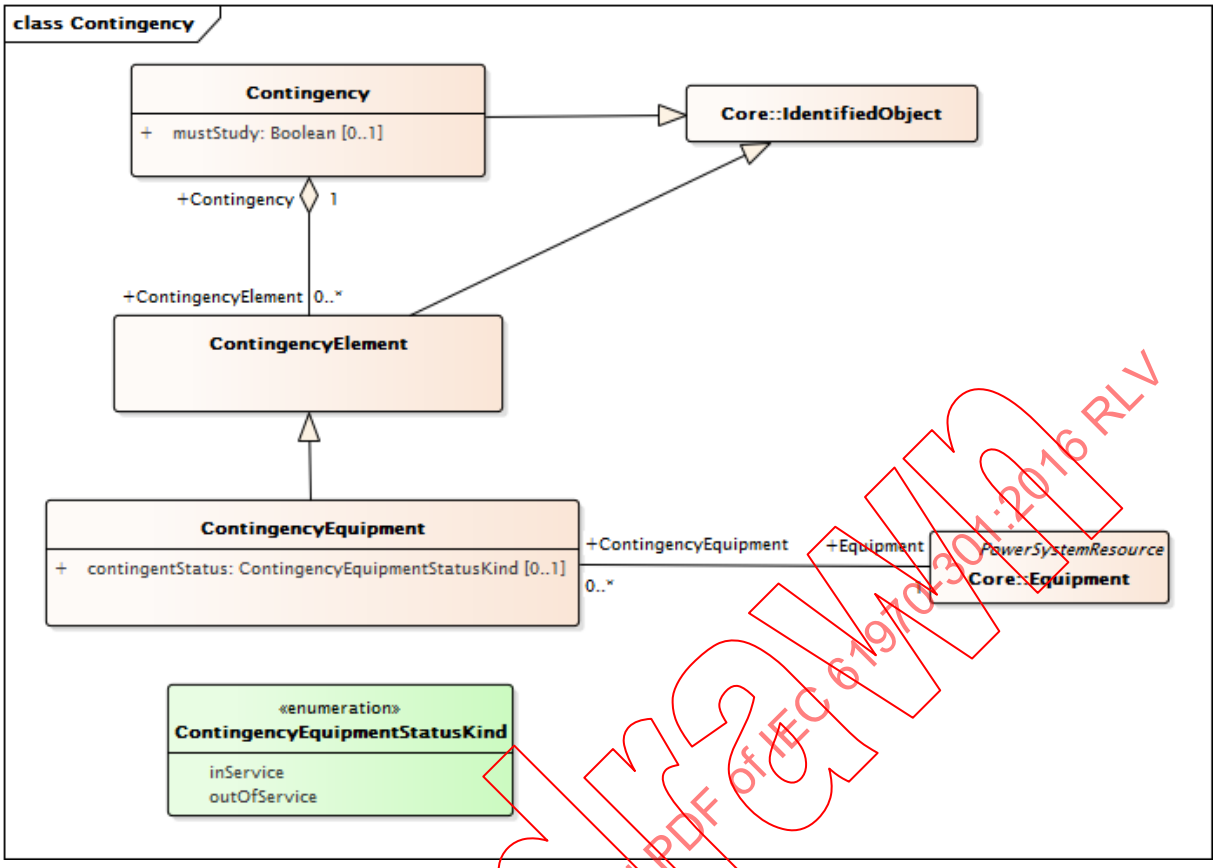


Figure 128 – Class diagram Contingency::Contingency

Figure 128: This diagram shows contingency model inheritance and associations.

6.19.2 Contingency

An event threatening system reliability, consisting of one or more contingency elements.

Table 676 shows all attributes of Contingency.

Table 676 – Attributes of Contingency::Contingency

name	mult	type	description
mustStudy	0..1	Boolean	Set true if must study this contingency.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 677 shows all association ends of Contingency with other classes.

Table 677 – Association ends of Contingency::Contingency with other classes

mult from	name	mult to	type	description
1..1	ContingencyElement	0..*	ContingencyElement	A contingency can have any number of contingency elements.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject

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mult from	name	mult to	type	description
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.19.3 ContingencyElement

An element of a system event to be studied by contingency analysis, representing a change in status of a single piece of equipment.

Table 678 shows all attributes of ContingencyElement.

Table 678 – Attributes of Contingency::ContingencyElement

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 679 shows all association ends of ContingencyElement with other classes.

Table 679 – Association ends of Contingency::ContingencyElement with other classes

mult from	name	mult to	type	description
0..*	Contingency	1..1	Contingency	A contingency element belongs to one contingency.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.19.4 ContingencyEquipment

Equipment whose in service status is to change, such as a power transformer or AC line segment.

Table 680 shows all attributes of ContingencyEquipment.

Table 680 – Attributes of Contingency::ContingencyEquipment

name	mult	type	description
contingentStatus	0..1	ContingencyEquipmentStatusKind	The status for the associated equipment when in the contingency state. This status is independent of the case to which the contingency is originally applied, but defines the equipment status when the contingency is applied.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 681 shows all association ends of ContingencyEquipment with other classes.

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Table 681 – Association ends of Contingency::ContingencyEquipment with other classes

mult from	name	mult to	type	description
0..*	Equipment	1..1	Equipment	The single piece of equipment to which to apply the contingency.
0..*	Contingency	1..1	Contingency	inherited from: ContingencyElement
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.19.5 ContingencyEquipmentStatusKind enumeration

Indicates the state which the contingency equipment is to be in when the contingency is applied.

Table 682 shows all literals of ContingencyEquipmentStatusKind.

Table 682 – Literals of Contingency::ContingencyEquipmentStatusKind

literal	value	description
inService		The equipment is in service.
outOfService		The equipment is to be taken out of service.

6.20 Package StateVariables

6.20.1 General

State variables for analysis solutions such as powerflow.

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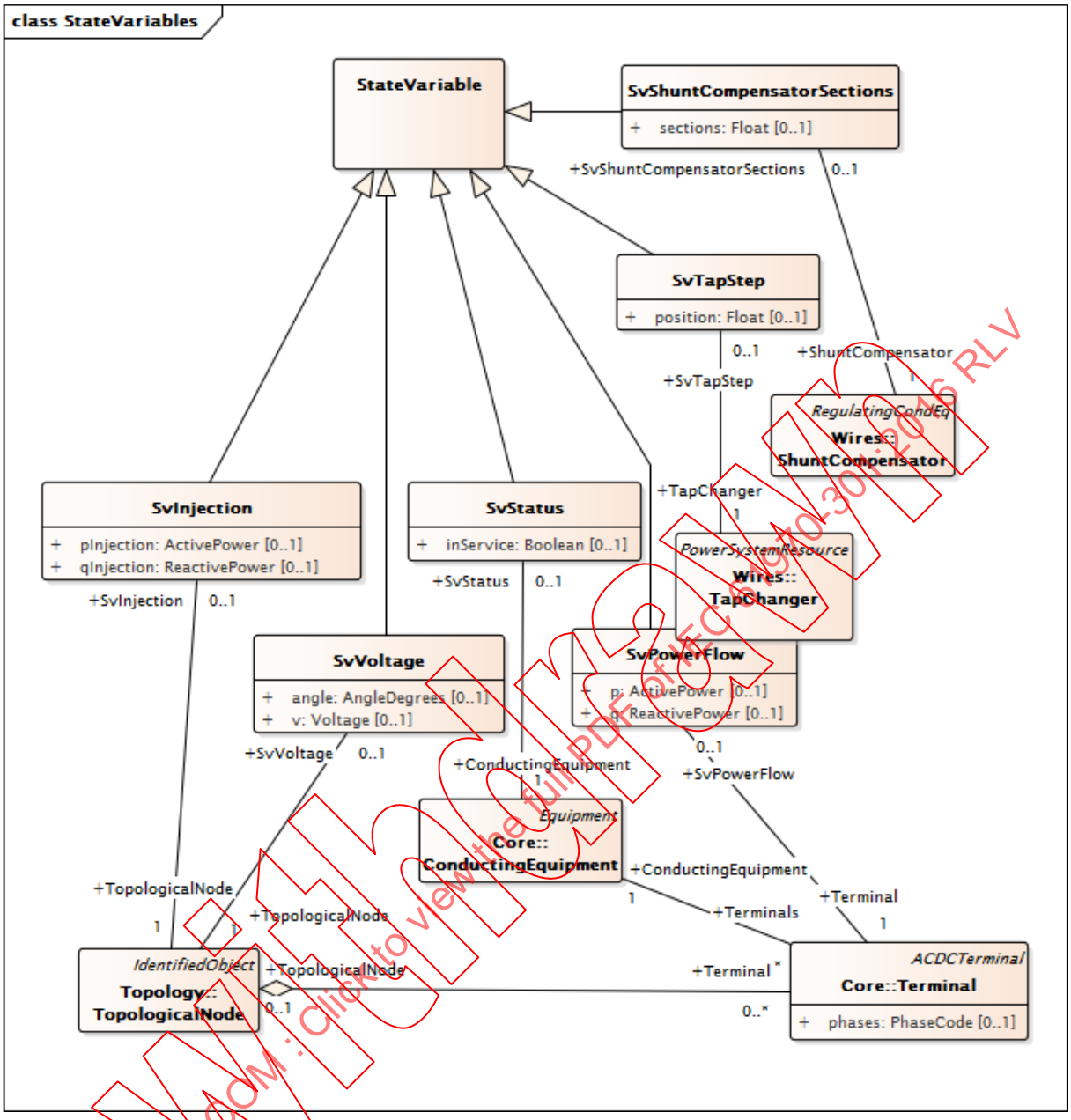


Figure 129 – Class diagram StateVariables::StateVariables

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Figure 129: The state solution variables as derived from base StateVariable class. Note that specialized state variables are associated with objects derived from IdentifiedObject, but StateVariable does not derive from IdentifiedObject.

6.20.2 StateVariable root class

An abstract class for state variables.

6.20.3 SvInjection

~~Injection state variable. Used for addressing situations where the exchanged models have a Kirchof's law mismatch at a bus. This includes exchange of partial models with boundary flows and state estimator solutions with residual mismatch.~~

The SvInjection reports the calculated bus injection minus the sum of the terminal flows. The terminal flow is positive out from the bus (load sign convention) and bus injection has positive

flow into the bus. SvInjection may have the remainder after state estimation or slack after power flow calculation.

Table 683 shows all attributes of SvInjection.

Table 683 – Attributes of StateVariables::SvInjection

name	mult	type	description
p~~Net~~Injection	0..1	ActivePower	The active power ~~injected into the bus at this location.~~mismatch between calculated injection and initial injection. Positive sign means injection into the TopologicalNode (bus~~.~~).
q~~Net~~Injection	0..1	ReactivePower	The reactive power ~~injected into the bus at this location.~~mismatch between calculated injection and initial injection. Positive sign means injection into the TopologicalNode (bus~~.~~).

Table 684 shows all association ends of SvInjection with other classes.

Table 684 – Association ends of StateVariables::SvInjection with other classes

mult from	name	mult to	type	description
0..1	TopologicalNode	1..1	TopologicalNode	The topological node associated with the flow injection state variable.

6.20.4 SvPowerFlow

State variable for power flow. Load convention is used for flow direction. This means flow out from the TopologicalNode into the equipment is positive.

Table 685 shows all attributes of SvPowerFlow.

Table 685 – Attributes of StateVariables::SvPowerFlow

name	mult	type	description
p	0..1	ActivePower	The active power flow. Load sign convention is used, i.e. positive sign means flow out from a ~~node~~TopologicalNode (bus) into the conducting equipment.
q	0..1	ReactivePower	The reactive power flow. Load sign convention is used, i.e. positive sign means flow out from a ~~node~~TopologicalNode (bus) into the conducting equipment.

Table 686 shows all association ends of SvPowerFlow with other classes.

Table 686 – Association ends of StateVariables::SvPowerFlow with other classes

mult from	name	mult to	type	description
0..1	Terminal	1..1	Terminal	The terminal associated with the power flow state variable.

~~**6.19.5 SvShortCircuit**~~

~~State variable for short circuit.~~

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~~Table 587 shows all attributes of SvShortCircuit.~~

~~Table 587 – Attributes of StateVariables::SvShortCircuit~~

~~name~~	~~type~~	~~description~~
~~r0PerR~~	~~Float~~	~~The ratio of zero sequence resistance to positive sequence resistance.~~
~~sShortCircuit~~	~~ApparentPower~~	~~The short circuit apparent power drawn at this node when faulted.~~
~~x0PerX~~	~~Float~~	~~The ratio of zero sequence reactance per positive sequence reactance.~~
~~xPerR~~	~~Float~~	~~Ratio of positive sequence reactance per postive sequence resistance.~~

~~Table 588 shows all association ends of SvShortCircuit with other classes.~~

~~Table 588 – Association ends of StateVariables::SvShortCircuit with other classes~~

~~[mult from]~~	~~[mult to] name~~	~~type~~	~~description~~
~~[0..1]~~	~~[1..1] TopologicalNode~~	~~TopologicalNode~~	~~The topological node associated with the state variables for short circuit.~~

6.20.5 SvShuntCompensatorSections

State variable for the number of sections in service for a shunt compensator.

Table 687 shows all attributes of SvShuntCompensatorSections.

Table 687 – Attributes of StateVariables::SvShuntCompensatorSections

name	mult	type	description
sections	0..1	Float	The number of sections in service as a continous variable. To get integer value scale with ShuntCompensator.bPerSection.

Table 688 shows all association ends of SvShuntCompensatorSections with other classes.

Table 688 – Association ends of StateVariables::SvShuntCompensatorSections with other classes

mult from	name	mult to	type	description
0..1	ShuntCompensator	1..1	ShuntCompensator	The shunt compensator for which the state applies.

6.20.6 SvStatus

State variable for status.

Table 689 shows all attributes of SvStatus.

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Table 689 – Attributes of StateVariables::SvStatus

name	mult	type	description
inService	0..1	Boolean	The in service status as a result of topology processing.

Table 690 shows all association ends of SvStatus with other classes.

Table 690 – Association ends of StateVariables::SvStatus with other classes

mult from	name	mult to	type	description
0..1	ConductingEquipment	1..1	ConductingEquipment	The conducting equipment associated with the status state variable.

6.20.7 SvTapStep

State variable for transformer tap step.

~~This class is to be used for taps of LTC (load tap changing) transformers, not fixed tap transformers. Normally a profile specifies only one of the attributes "position"or "tapRatio".~~

Table 691 shows all attributes of SvTapStep.

Table 691 – Attributes of StateVariables::SvTapStep

name	mult	type	description
position	0..1	Float	The floating point tap position. This is not the tap ratio, but rather the tap step position as defined by the related tap changer model and normally is constrained to be within the range of minimum and maximum tap positions.

Table 692 shows all association ends of SvTapStep with other classes.

Table 692 – Association ends of StateVariables::SvTapStep with other classes

mult from	name	mult to	type	description
0..1	TapChanger	1..1	TapChanger	The tap changer associated with the tap step state.

6.20.8 SvVoltage

State variable for voltage.

Table 693 shows all attributes of SvVoltage.

Table 693 – Attributes of StateVariables::SvVoltage

name	mult	type	description
angle	0..1	AngleDegrees	The voltage angle of the topological node complex voltage with respect to system reference.
v	0..1	Voltage	The voltage magnitude of the topological node.

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Table 694 shows all association ends of SvVoltage with other classes.

Table 694 – Association ends of StateVariables::SvVoltage with other classes

mult from	name	mult to	type	description
0..1	TopologicalNode	1..1	TopologicalNode	The topological node associated with the voltage state.

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Annex A
(informative)

Custom extensions

A.1 Overview

Annex A is not normative and contains custom extensions with widespread use that may be useful to more than the organizations that created them.

A.2 European extensions

A.2.1 Overview

Clause A.2 describes the European extensions to IEC 61970-301 which are used in profiles derived from IEC 61970-452 and IEC 61970-456.

Subclauses A.2.2 to A.2.7 contain only the extended classes and attributes, hence they do not include classes or attributes already defined in this document.

A.2.2 OperationalLimitType

Table A.1 shows extended attributes of OperationalLimitType.

Table A.1 – Attributes of OperationalLimitType

name	mult	type	description
limitType	0..1	LimitTypeKind	Types of limits defined in the ENTSO-E Operational Handbook Policy 3.

A.2.3 LimitTypeKind enumeration

The enumeration defines the kinds of the limit types.

Table A.2 shows all literals of LimitTypeKind.

Table A.2 – Literals of LimitTypeKind

literal	value	description
patl		The Permanent Admissible Transmission Loading (PATL) is the loading in amperes, MVA or MW that can be accepted by a network branch for an unlimited duration without any risk for the material. The duration attribute is not used and shall be excluded for the PATL limit type. Hence only one limit value exists for the PATL type.
patlt		Permanent Admissible Transmission Loading Threshold (PATLT) is a value in engineering units defined for PATL and calculated using a percentage less than 100 % of the PATL type intended to alert operators of an arising condition. The percentage should be given in the name of the OperationalLimitSet. The aceptableDuration is another way to express the severity of the limit.

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literal	value	description
tatl		Temporarily Admissible Transmission Loading (TATL) which is the loading in amperes, MVA or MW that can be accepted by a branch for a certain limited duration. The TATL can be defined in different ways: • as a fixed percentage of the PATL for a given time (for example, 115 % of the PATL that can be accepted during 15 minutes), • pairs of TATL type and Duration calculated for each line taking into account its particular configuration and conditions of functioning (for example, it can define a TATL acceptable during 20 minutes and another one acceptable during 10 minutes). Such a definition of TATL can depend on the initial operating conditions of the network element (sag situation of a line). The duration attribute can be used to define several TATL limit types. Hence multiple TATL limit values may exist having different durations.
tc		Tripping Current (TC) is the ultimate intensity without any delay. It is defined as the threshold the line will trip without any possible remedial actions. The tripping of the network element is ordered by protections against short circuits or by overload protections, but in any case, the activation delay of these protections is not compatible with the reaction delay of an operator (less than one minute). The duration is always zero and the duration attribute may be left out. Hence only one limit value exists for the TC type.
tct		Tripping Current Threshold (TCT) is a value in engineering units defined for TC and calculated using a percentage less than 100 % of the TC type intended to alert operators of an arising condition. The percentage should be given in the name of the OperationalLimitSet. The aceptableDuration is another way to express the severity of the limit.
highVoltage		Referring to the rating of the equipments, a voltage too high can lead to accelerated ageing or the destruction of the equipment. This limit type may or may not have duration.
lowVoltage		A too low voltage can disturb the normal operation of some protections and transformer equipped with on-load tap changers, electronic power devices or can affect the behavior of the auxiliaries of generation units. This limit type may or may not have duration.

A.2.4 IdentifiedObject

Table A.3 shows extended attributes of IdentifiedObject.

Table A.3 – Attributes of IdentifiedObject

name	mult	type	description
energyIdentCodeEic	0..1	String	The attribute is used for an exchange of the EIC code (Energy identification Code). The length of the string is 16 characters as defined by the EIC code. References: Local issuing offices for EIC: https://www.entsoe.eu/data/energy-identification-codes-eic/eic-lio-websites/Pages/default.aspx [viewed 2016-08-17] EIC description: https://www.entsoe.eu/data/energy-identification-codes-eic/eic-documentation/Pages/default.aspx [viewed 2016-08-17]
shortName	0..1	String	The attribute is used for an exchange of a human readable short name with length of the string 12 characters maximum.

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A.2.5 EnergySchedulingType

Used to define the type of generation for scheduling purposes. The class inherits from IdentifiedObject. Table A.4 shows all association ends of EnergySchedulingType with other classes.

Table A.4 – Association ends of EnergySchedulingType

mult from	name	mult to	type	description
0..*	EnergySource	0..1	EnergySchedulingType	Energy Source of a particular Energy Scheduling Type.

A.2.6 ConnectivityNode

Table A.5 shows extended attributes of ConnectivityNode. These extensions are used in the boundary profiles only.

Table A.5 – Attributes of ConnectivityNode

name	mult	type	description
boundaryPoint	0..1	Boolean	Identifies if a node is a BoundaryPoint. If boundaryPoint=true the ConnectivityNode or the TopologicalNode represents a BoundaryPoint.
fromEndIsoCode	0..1	String	The attribute is used for an exchange of the ISO code of the region which the "From" side of the Boundary point belongs to or is connected to. The ISO code is a two-character country code as defined by ISO 3166 (http://www.iso.org/iso/country_codes). The length of the string is 2 characters maximum. The attribute is required for the Boundary Model Authority Set where this attribute is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
fromEndName	0..1	String	The attribute is used for an exchange of a human readable name with length of the string 32 characters maximum. The attribute covers two cases: • If the Boundary point is placed on a tie-line the attribute is used for exchange of the geographical name of the substation which the "From" side of the tie-line is connected to. • If the Boundary point is placed in a substation the attribute is used for exchange of the name of the element (e.g. PowerTransformer, ACLineSegment, Switch, etc.) which the "From" side of the Boundary point is connected to. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
fromEndNameTso	0..1	String	The attribute is used for an exchange of the name of the TSO which the "From" side of the Boundary point belongs to or is connected to. The length of the string is 32 characters maximum. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.

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name	mult	type	description
toEndIsoCode	0..1	String	The attribute is used for an exchange of the ISO code of the region which the “To” side of the Boundary point belongs to or is connected to. The ISO code is a two-character country code as defined by ISO 3166 (http://www.iso.org/iso/country_codes). The length of the string is 2 characters maximum. The attribute is required for the Boundary Model Authority Set where this attribute is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
toEndName	0..1	String	The attribute is used for an exchange of a human readable name with length of the string 32 characters maximum. The attribute covers two cases: • If the Boundary point is placed on a tie-line the attribute is used for exchange of the geographical name of the substation which the “To” side of the tie-line is connected to. • If the Boundary point is placed in a substation the attribute is used for exchange of the name of the element (e.g. PowerTransformer, ACLineSegment, Switch, etc.) which the “To” side of the Boundary point is connected to. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
toEndNameTso	0..1	String	The attribute is used for an exchange of the name of the TSO which the “To” side of the Boundary point belongs to or is connected to. The length of the string is 32 characters maximum. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.

A.2.7 TopologicalNode

Table A.6 shows extended attributes of TopologicalNode. These extensions are used in the boundary profiles only.

Table A.6 – Attributes of TopologicalNode

name	mult	type	description
boundaryPoint	0..1	Boolean	Identifies if a node is a BoundaryPoint. If boundaryPoint=true the ConnectivityNode or the TopologicalNode represents a BoundaryPoint.
fromEndIsoCode	0..1	String	The attribute is used for an exchange of the ISO code of the region which the “From” side of the Boundary point belongs to or is connected to. The ISO code is a two-character country code as defined by ISO 3166 (http://www.iso.org/iso/country_codes). The length of the string is 2 characters maximum. The attribute is required for the Boundary Model Authority Set where this attribute is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.

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name	mult	type	description
fromEndName	0..1	String	The attribute is used for an exchange of a human readable name with length of the string 32 characters maximum. The attribute covers two cases: • If the Boundary point is placed on a tie-line the attribute is used for exchange of the geographical name of the substation which the “From” side of the tie-line is connected to. • If the Boundary point is placed in a substation the attribute is used for exchange of the name of the element (e.g. PowerTransformer, ACLineSegment, Switch, etc.) which the “From” side of the Boundary point is connected to. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
fromEndNameTso	0..1	String	The attribute is used for an exchange of the name of the TSO which the “From” side of the Boundary point belongs to or is connected to. The length of the string is 32 characters maximum. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
toEndIsoCode	0..1	String	The attribute is used for an exchange of the ISO code of the region which the “To” side of the Boundary point belongs to or is connected to. The ISO code is a two-character country code as defined by ISO 3166 (http://www.iso.org/iso/country_codes). The length of the string is 2 characters maximum. The attribute is required for the Boundary Model Authority Set where this attribute is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
toEndName	0..1	String	The attribute is used for an exchange of a human readable name with length of the string 32 characters maximum. The attribute covers two cases: • If the Boundary point is placed on a tie-line the attribute is used for exchange of the geographical name of the substation which the “To” side of the tie-line is connected to. • If the Boundary point is placed in a substation the attribute is used for exchange of the name of the element (e.g. PowerTransformer, ACLineSegment, Switch, etc) which the “To” side of the Boundary point is connected to. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
toEndNameTso	0..1	String	The attribute is used for an exchange of the name of the TSO which the “To” side of the Boundary point belongs to or is connected to. The length of the string is 32 characters maximum. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.

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Interface de programmation d'application pour système de gestion d'énergie (EMS-API) – Partie 301: Base de modèle d'information commun (CIM)

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ENERGY MANAGEMENT SYSTEM APPLICATION PROGRAM INTERFACE (EMS-API) –

Part 301: Common information model (CIM) base

FOREWORD

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International Standard IEC 61970-301 has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

This sixth edition cancels and replaces the fifth edition, published in 2013. This sixth edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) new model for grounding including Petersen coils;
b) models for HVDC;
c) addition of Static Var Compensation models;
d) phase shift transformer updates - the section has been added;
e) short circuit calculations based on IEC 60909;
f) addition of non-linear shunt compensator;

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g) addition of model for steady state calculation inputs, Steady State Hypothesis;

h) addition of base frequency model;

i) corrections of several smaller issues, e.g. issues found at ENTSO-E interoperability tests;

j) UML clean up;

k) new model for PowerElectronicUnits and their connection to the AC network added;

l) new section on relation between TapChanger.ltcFlag and TapChanger.TapChangerControl;

m) Annex A with custom extensions added.

The text of this standard is based on the following documents:

FDIS	Report on voting
57/1779/FDIS	57/1788/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61970 series, under the general title: *Energy management system application program interface (EMS-API)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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INTRODUCTION

This document is one of the IEC 61970 series which defines an application program interface (API) for an energy management system (EMS). IEC 61970 was originally based upon the work of the EPRI Control Center API (CCAPI) research project (RP-3654-1). The principle objectives of the EPRI CCAPI project were to:

- reduce the cost and time needed to add new applications to an EMS;
- protect the investment of existing applications or systems that are working effectively with an EMS.

The principal objective of the IEC 61970 series is to produce standards which facilitate the integration of EMS applications developed independently by different vendors, between entire EMS systems developed independently, or between an EMS system and other systems concerned with different aspects of power system operations, such as generation or distribution management systems (DMS). This is accomplished by defining application program interfaces to enable these applications or systems access to public data and exchange information independent of how such information is represented internally.

The Common Information Model (CIM) specifies the semantics for this API. The Component Interface Specifications (CIS), which are contained in other parts of the IEC 61970 series, specify the content of the messages exchanged.

The CIM is an abstract model that represents all the major objects in an electric utility enterprise typically needed to model the operational aspects of a utility. This model includes public classes and attributes for these objects, as well as the relationships between them.

This document defines the CIM Base set of packages which provide a logical view of the functional aspects of an Energy Management System including Supervisory Control and Data Acquisition (SCADA). Other functional areas are standardized in separate IEC documents that augment and reference this document. For example, IEC 61968-11 addresses distribution models and references this document. While there are multiple IEC standards dealing with different parts of the CIM, there is a single, unified information model comprising the CIM behind all these individual standards documents.

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning a computer-based implementation of an object-oriented power system model in a relational database. As such, it does not conflict with the development of any logical power system model including the Common Information Model (CIM), where implementation of the model is not defined.

The IEC takes no position concerning the evidence, validity and scope of this patent right.

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ISO (www.iso.org/patents) and IEC (http://www.iec.ch/tctools/patent_decl.htm) maintain on-line data bases of patents relevant to their standards. Users are encouraged to consult the data bases for the most up to date information concerning patents.

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ENERGY MANAGEMENT SYSTEM APPLICATION PROGRAM INTERFACE (EMS-API) –

Part 301: Common information model (CIM) base

1 Scope

The common information model (CIM) is an abstract model that represents all the major objects in an electric utility enterprise typically involved in utility operations. By providing a standard way of representing power system resources as object classes and attributes, along with their relationships, the CIM facilitates the integration of network applications developed independently by different vendors, between entire systems running network applications developed independently, or between a system running network applications and other systems concerned with different aspects of power system operations, such as generation or distribution management. SCADA is modeled to the extent necessary to support power system simulation and inter-control centre communication. The CIM facilitates integration by defining a common language (i.e. semantics) based on the CIM to enable these applications or systems to access public data and exchange information independent of how such information is represented internally.

The object classes represented in the CIM are abstract in nature and may be used in a wide variety of applications. The use of the CIM goes far beyond its application in an EMS. This document should be understood as a tool to enable integration in any domain where a common power system model is needed to facilitate interoperability and plug compatibility between applications and systems independent of any particular implementation.

Due to the size of the complete CIM, the object classes contained in the CIM are grouped into a number of logical Packages, each of which represents a certain part of the overall power system being modeled. Collections of these Packages are progressed as separate International Standards. This document specifies a Base set of packages which provide a logical view of the functional aspects of Energy Management System (EMS) information within the electric utility enterprise that is shared between all applications. Other standards specify more specific parts of the model that are needed by only certain applications. Subclause 4.3 of this document provides the current grouping of packages into standards documents.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at www.electropedia.org)

IEC 61850 (all parts), *Communication networks and systems for power utility automation*

IEC 61850-7-4:2010, *Communication networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes*

IEC 61968 (all parts), *Application integration at electric utilities – System interfaces for distribution management*

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IEC TS 61970-2, *Energy management system application program interface (EMS-API) – Part 2: Glossary*

Object Management Group: UML 2.0 Specification – http://www.omg.org

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61970-2, IEC 60050 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
energy management system
EMS
computer system comprising a software platform providing basic support services and a set of applications providing the functionality needed for the effective operation of electrical generation and transmission facilities so as to assure adequate security of energy supply at minimum cost

3.1.2
application program interface
API
set of public functions provided by an executable application component for use by other executable application components

3.1.3
unified modeling language
UML
formal and comprehensive descriptive language with diagramming techniques used to represent software systems, from requirements analysis, through design and implementation, to documentation

Note 1 to entry: UML has evolved from a collection of methods contributed by different practitioners, into an International Standard (ISO/IEC 19505, published in 2012). The CIM relies on UML for defining the model, and automated tools generate the documentation, schemas, and other artifacts directly from the UML. A basic understanding of UML is necessary to understand the CIM.

3.1.4
profile
subset of CIM classes, associations and attributes needed to accomplish a specific type of interface

Note 1 to entry: This may be expressed in XSD, RDF, and/or OWL files. A profile can be tested between applications. A profile is necessary in order to "use" the CIM. Several profiles are defined in the IEC 61968 and IEC 62325 series.

4 CIM specification

4.1 Overview

The CIM model is described in the Unified Modeling Language (UML) that is maintained as a UML file managed by a UML editing tool. The UML file exists in different formats:

- a tool proprietary format,

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- a standardized xmi format.

The CIM model is described in Clause 6, which is a report generated from the UML file. The name of the UML file use to generate Clause 6 is:

- IEC 61970cim16v33_IEC 61968cim12v08_IEC 62325cim03v01a.

This file can be obtained from CIM users group.

4.2 CIM modeling notation

The CIM is defined using object-oriented modeling techniques. Specifically, the CIM specification uses the Unified Modeling Language (UML) notation, which defines the CIM as a group of packages.

Each package in the CIM contains one or more class diagrams showing graphically all the classes in that package and their relationships. Each class is then defined in text in terms of its attributes and relationships to other classes.

The UML notation is described in Object Management Group (OMG) documents and several published textbooks.

4.3 CIM packages

The CIM is partitioned into a set of packages. A package is a general purpose means of grouping related model elements. The packages have been chosen to make the model easier to design, understand and review. The common information model consists of the complete set of packages. Entities may have associations that cross many package boundaries. Each application will use information represented in several packages.

The comprehensive CIM is partitioned into groups of packages for convenience in managing and maintaining them. Packages included in IEC 61970-301 (this document) are contained within the IEC 61970 package. The IEC 61970 packages do not depend upon other outside packages. As shown in Figure 1, the IEC 61970 package and its subpackages are used as a core or base model for other CIM packages. The dashed lines indicate dependency relationships, with the arrowhead pointing from the dependent package to the package on which it has a dependency. Packages for the IEC 61968 series of standards describe additional parts of the CIM that deal with other logical views of utility operations including assets, locations, activities, consumers, documentation, work management, and metering. Packages for the IEC 62325 series of standards describe electric energy markets.

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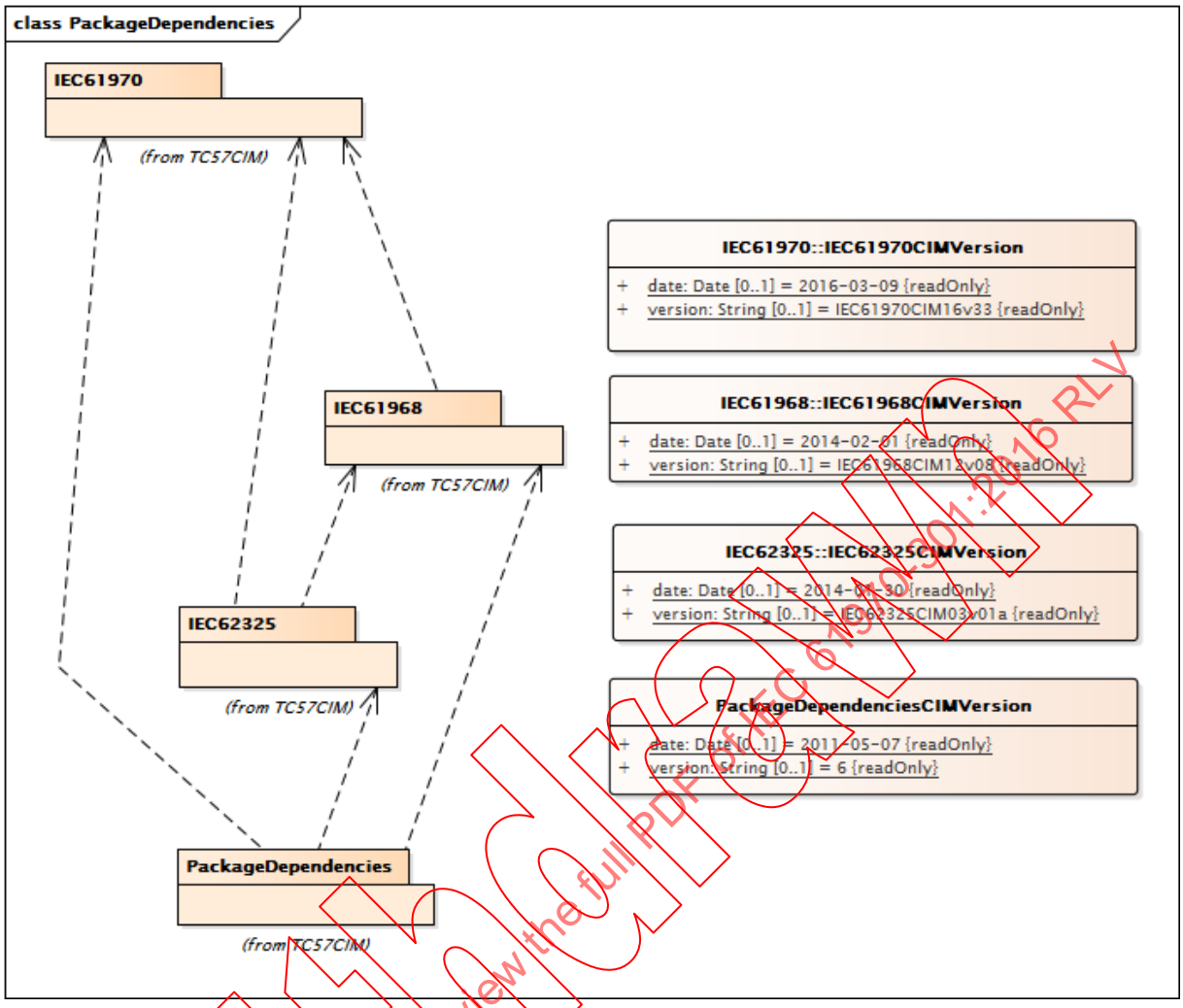


Figure 1 – Example working group package dependencies

Note that the package boundaries do not imply application boundaries. An application may use CIM entities from several packages. It is also anticipated CIM packages outside of this document will have dependencies upon some of the packages described in this document, and particularly the Domain and Core packages, though other dependencies will also exist.

Figure 2 shows the packages defined for IEC 61970-301 CIM Base and their dependency relationships.

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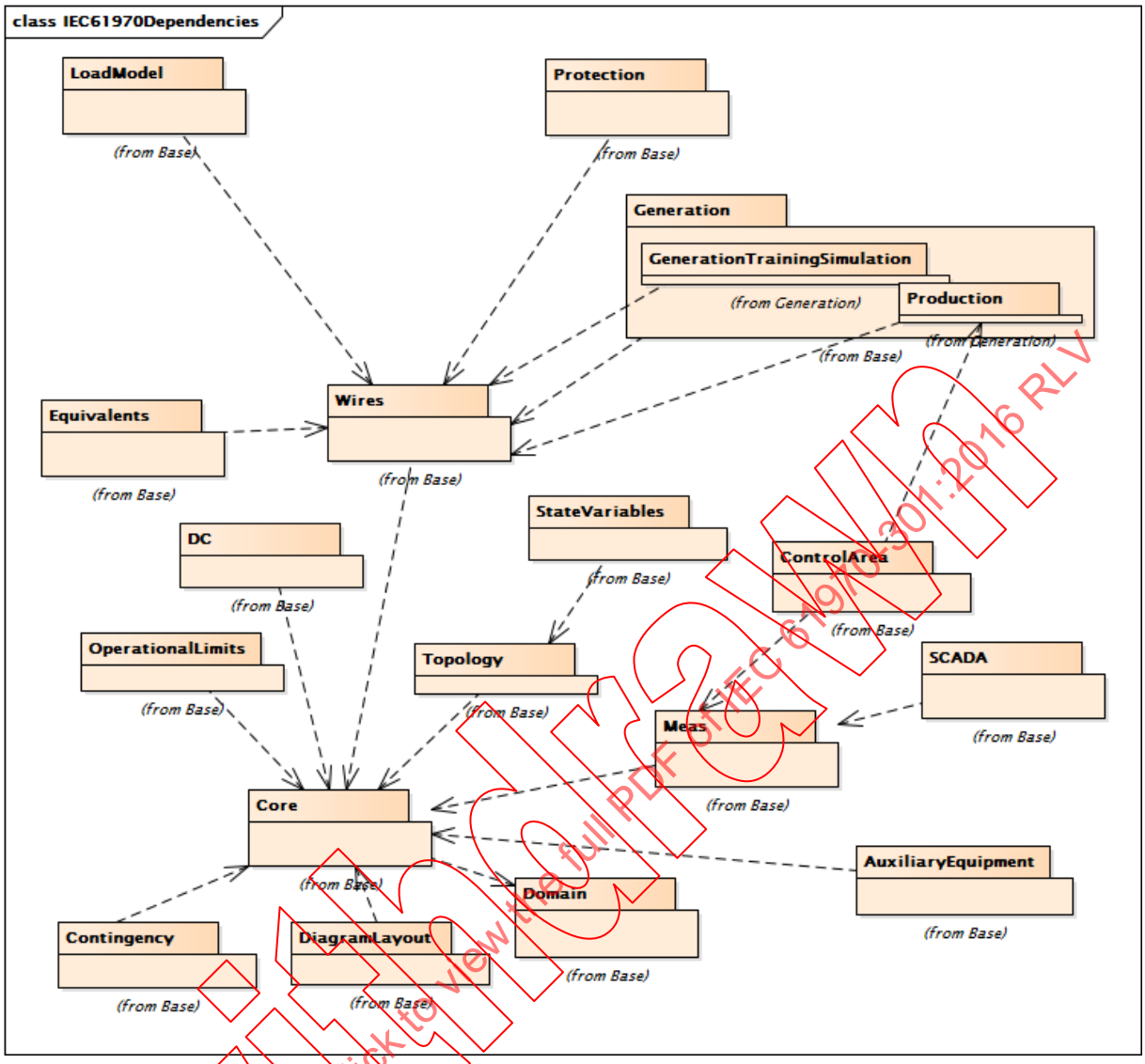


Figure 2 – CIM IEC 61970-301 package diagram

4.4 CIM classes and relationships

4.4.1 Classes

The class diagram(s) for each CIM package shows all the classes in the package and their relationships. Where relationships exist with classes in other packages, those classes may also be shown.

Classes and objects model what is in a power system that needs to be represented in a common way to power system applications. A class is a description of an object found in the real world, such as a power transformer, generator, or load that needs to be represented as part of the overall power system model in, for example, an EMS. Other types of objects include things such as schedules and measurements that EMS applications also need to process, analyze, and store. Such objects need a common representation to achieve the purposes of the EMS-API standard for plug-compatibility and interoperability. A particular object in a power system with a unique identity is modeled as an instance of the class to which it belongs.

It should also be noted that the CIM is defined to facilitate data exchange. As defined in this document, CIM entities have no behavior. For a specific interface, a profile is defined

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consisting of subsets of CIM classes, attributes, and associations. A profile defines the message payload for an interface.

Classes have attributes that describe the characteristics of the objects. Each class in the CIM contains the attributes that describe and identify a specific instance of the class. Only the attributes that are of public interest to network applications are included in the class descriptions.

Each attribute has a type, which identifies what kind of attribute it is. Typical attributes are of type Integer, Float, Boolean, String, Date, and Decimal, which are called primitive types. However, many additional types are defined as part of the CIM specification. For example, ShuntCompensator has a "maxU" attribute of type Voltage. The definition of many shared types is contained in the Domain package. The UML stereotypes of Primitive, enumeration, CIMDatatype, and Compound are added to classes used as types. The CIMDatatype stereotype is used with a specific CIM semantics for a simple value with additional attributes describing the unit and multiplier of the value, e.g. unit, multiplier, denominatorUnit and denominatorMultiplier. This implies custom mapping to serialization artifacts such as RDFS, OWL, and XSD. Classes with these stereotypes do not participate in generalization or association relationships and are simply used as types for attributes. The enumeration stereotype is used to describe an attribute with an enumerated list of choices. The Compound stereotype is used to describe sets of related attributes that are commonly reused. Compound classes may consist of Primitive, enumeration, CIMDatatype or other Compound classes as long as the Compound classes do not recurse.

All CIM attributes are implicitly optional in the sense that profiles using the CIM may eliminate any attributes.

Relationships between classes reveal how they are structured in terms of each other. CIM classes are related in a variety of ways, as described in 4.4.2 to 4.4.4.

4.4.2 Generalization

A generalization is a relationship between a more general and a more specific class. The more specific class can contain only additional information. Generalization provides for the specific class to inherit attributes and relationships from all the more general classes above it.

Figure 3 is an example of generalization. In this example taken from the Wires package, a Breaker is a more specific type of ProtectedSwitch, which in turn is a more specific type of Switch, which is a more specific type of ConductingEquipment, etc. A PowerTransformer is another more specific type of ConductingEquipment. Note that PowerSystemResource inherits from class IdentifiedObject which is not on the diagram. Therefore, IdentifiedObject is shown in italic type in the upper right corner of class PowerSystemResource.

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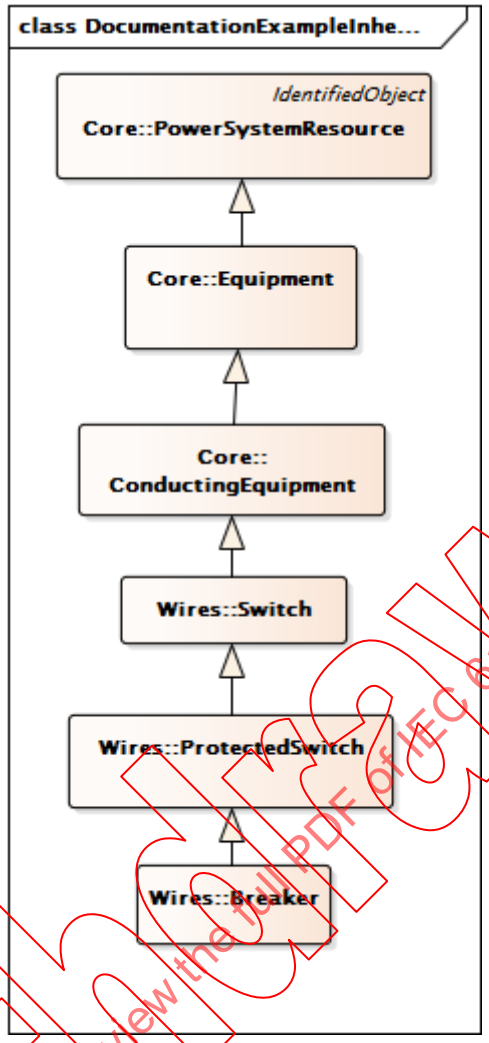


Figure 3 – Example of generalization

4.4.3 Simple association

An association is a conceptual connection between classes. Each association has two "association ends". The "association ends" were called "roles" prior to the UML 2.0 specification. Each association end describes the role the target class (i.e. the class the association end goes *to*) has in relation to the source class (i.e. the class the association end goes *from*). Association ends are usually given the name of the target class with or without a verb phrase. Each association end also has multiplicity/cardinality, which is an indication of how many objects may participate in the given relationship. In the CIM, associations are not named, only association ends are named. For example, as shown by Figure 4, in the CIM there is an association between a BaseVoltage and a VoltageLevel. Multiplicity is shown at both ends of the association. In this example, a VoltageLevel object may reference 1 BaseVoltage, and a BaseVoltage may be referenced by 0 or more VoltageLevel objects.

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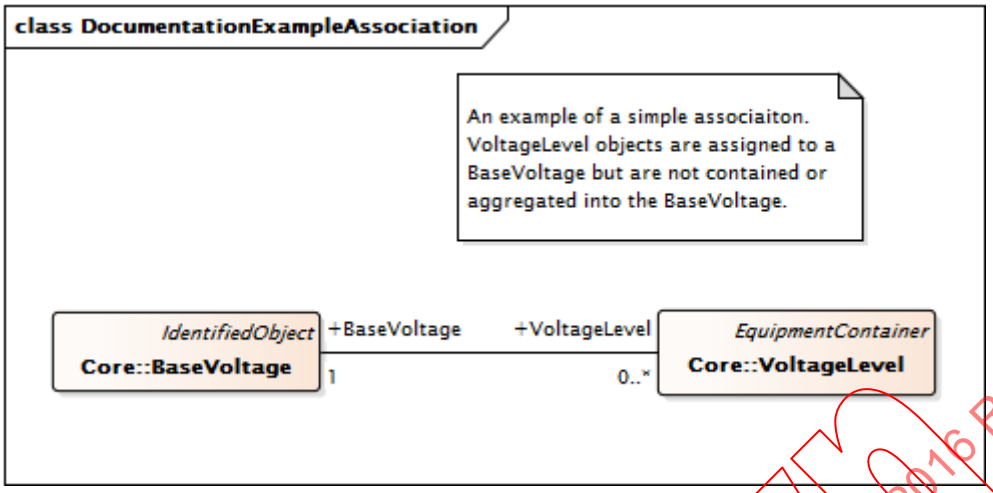


Figure 4 – Example of simple association

4.4.4 Aggregation

Aggregation is a special case of association. Aggregation indicates that the relationship between the classes is some sort of whole-part relationship, where the whole class "consists of" or "contains" the part class, and the part class is "part of" the whole class. The part class does not inherit from the whole class as in generalization. Figure 5 illustrates an aggregation between the EquipmentContainer class and the Equipment class, which is taken from the Core package. As shown, an Equipment can be a member of zero or one EquipmentContainer objects, but an EquipmentContainer object can contain any number of Equipment objects. In the context of using CIM as an information model, aggregation does not have a precise or formal interpretation beyond a simple association and is intended to visually assist in representing normal usage.

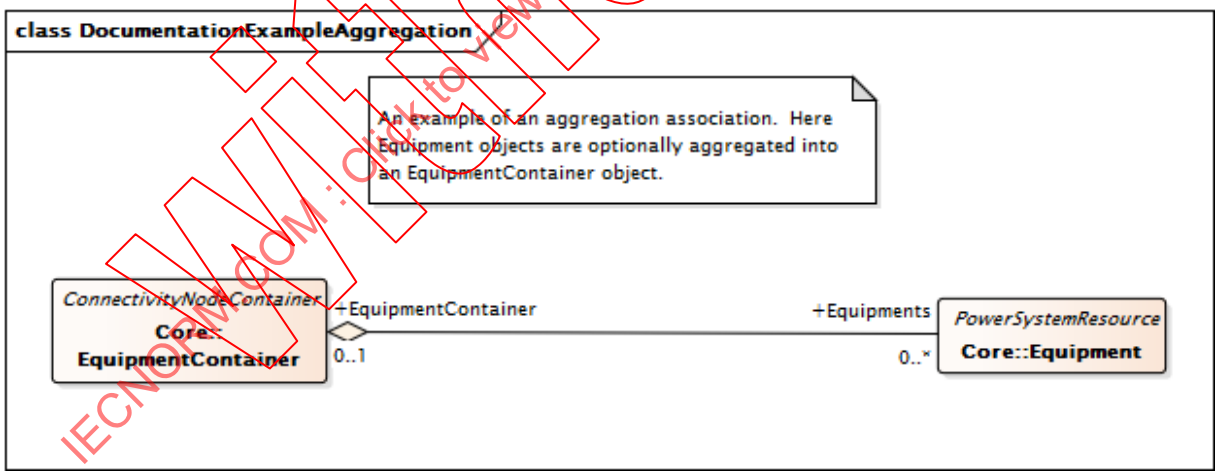


Figure 5 – Example of aggregation

4.5 CIM model concepts and examples

4.5.1 Concepts

To help understand how to interpret the CIM, some key model concepts used in the CIM are introduced and described in 4.5.2 to 4.5.14.

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4.5.2 Containment, equipment hierarchies and naming

4.5.2.1 Containment structure

Figure 6 shows the concept of equipment containers to form hierarchies in the CIM. Equipment containers represent ways of organizing and naming equipment typically found within a substation. As may be seen, there is some flexibility provided in which containers are used in a specific application of the CIM in order to accommodate different international practices as well as differences typically found between transmission and distribution substations. Bay, VoltageLevel, Substation, Line, and Plant are all types of EquipmentContainers. In general, a Bay is contained within a specific VoltageLevel, which in turn is contained within a Substation. Substations and Lines may be contained within SubGeographicRegions and GeographicRegions.

One containment hierarchy is used with the IdentifiedObject class to create hierarchical naming intended for human consumption. This hierarchy is specifically used to name equipment according to its function in the power system. This is the functional naming hierarchy. Other common identifications beside functional names are asset serial numbers. The functional name is different from a serial number in that it relates to the function of a particular equipment position or location in the power system. Regardless of what specific piece of physical equipment is placed at a location, the functional name is the same but the serial number varies depending on the physical equipment currently used.

4.5.2.2 IdentifiedObject class

The IdentifiedObject class contained in the Core package is inherited by all PowerSystemResource and many other classes. This class has attributes and associations to be used for naming all CIM objects. The mRID attribute of the IdentifiedObject class provides a straight forward and rigorous means of identity for CIM objects.

The following are definitions and conventions for how to use the IdentifiedObject attributes when naming PowerSystemResource objects.

- mRID (Master Resource ID): A globally unique machine-readable identifier for an object instance.
- name: The name is any free human readable and possibly non unique text naming the object.
- aliasName: This attribute is an additional name but the Name classes of 4.5.3 provide a better alternative. The aliasName is free text human readable name of the object alternative to IdentifiedObject.name. It may be non unique and may not correlate to a naming hierarchy. The attribute aliasName is retained because of backwards compatibility between CIM releases. It is however recommended to replace aliasName with the Name class as aliasName is planned for retirement at a future time.

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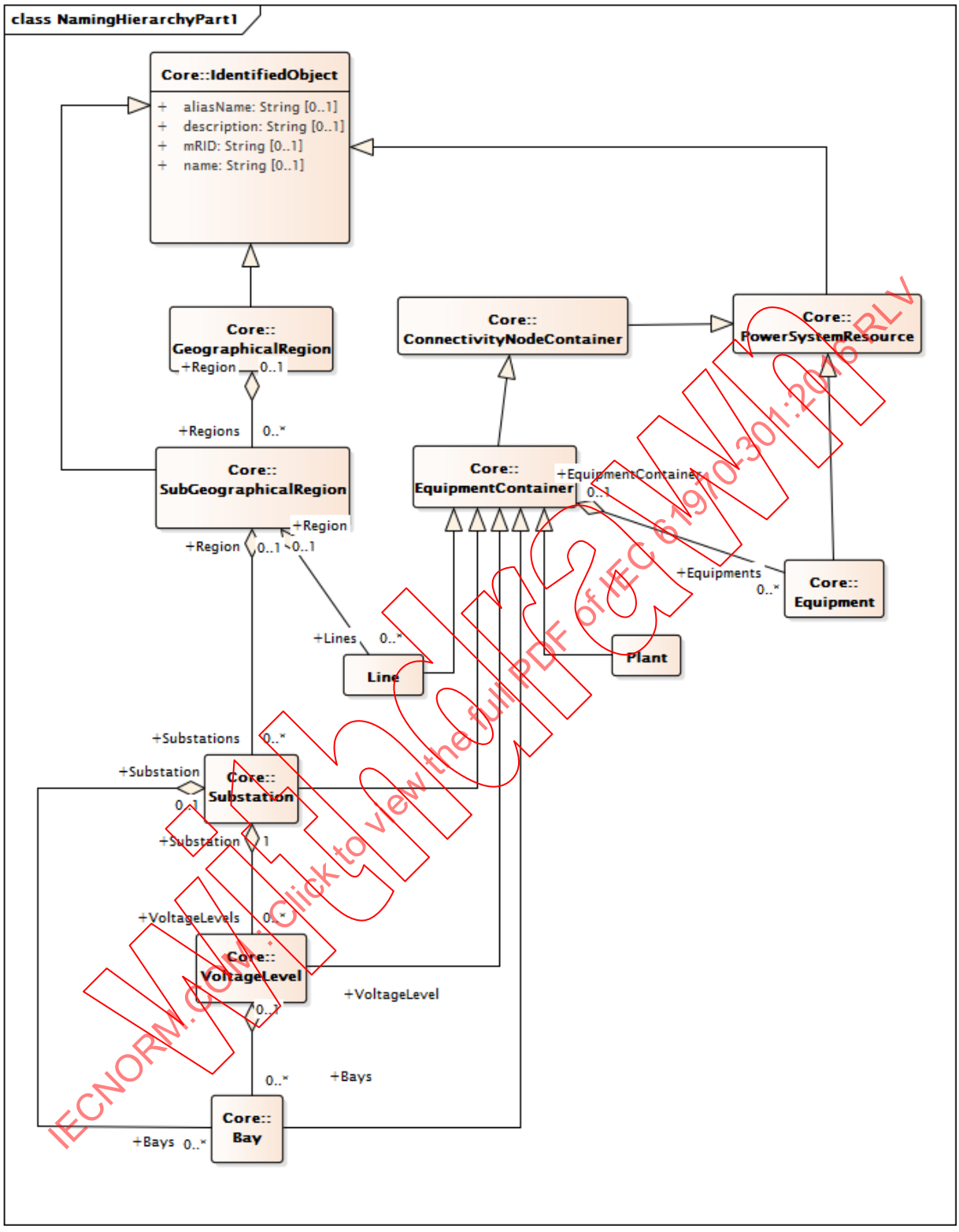


Figure 6 – Equipment containers

The diagrams NamingHierarchyPart1 and NamingHierarchyPart2 in the Wires package show the functional naming hierarchy.

4.5.3 Names model

A flexible and extensible naming model is provided to specify alternate names for objects. A use cases where the names model is useful is when multiple applications or systems have

different names for the same object. The names model then enables exchange of these names.

Figure 7 shows the class diagram for alternate names and how they can be associated to a specific user defined name type. This model allows for specific definition of names within a particular domain and enforces no specific naming rules. The concepts of alias names, path names, and local names can all be accommodated by this model. The CIM models do not enforce or promote specific naming conventions, but allow for such naming conventions to be exchanged in a clear context.

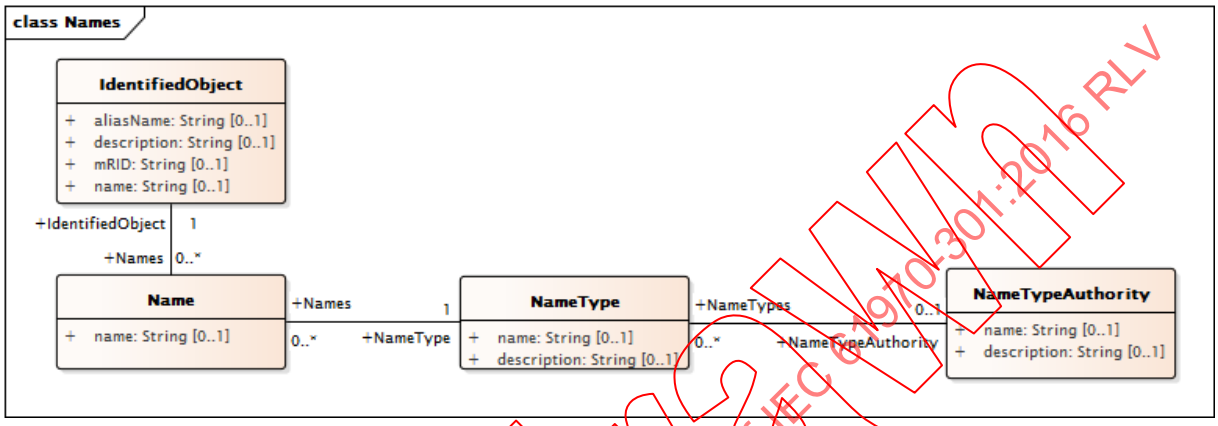


Figure 7 – Names

Table 1 – NameType class naming conventions

name	description
ICCP	Reserved for ICCP (TASE-2) names. Used to describe ICCP point names for the MeasurementValue class and ICCP source names for the MeasurementValueSource class.

Table 1 describes various name conventions for name types. The meanings of the columns in Table 1 are as follows:

name: The name attribute value.

description: The use of the name type.

Note that Table 1 is not an exhaustive list of values that can be used for the name attribute of the class Name.

4.5.4 Connectivity model

4.5.4.1 Connectivity description

Figure 8 shows the Topology class diagram which models connectivity between different types of ConductingEquipment. Also included is a portion of the Meas package class diagram dealing with measurements to illustrate how measurements are associated with conducting equipment.

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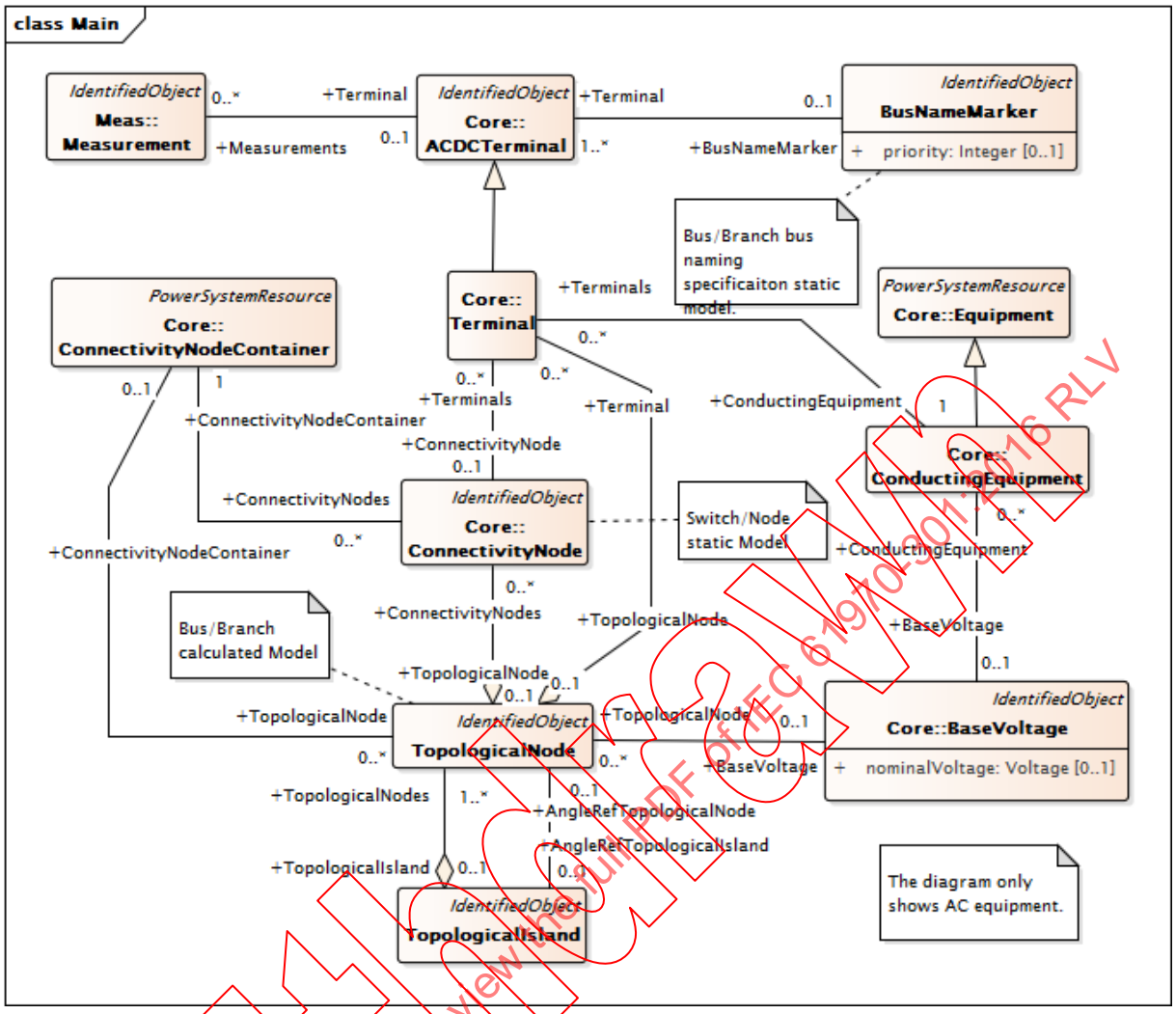


Figure 8 – Connectivity model

To model connectivity, Terminal and ConnectivityNode classes are defined. A Terminal belongs to one ConductingEquipment, although ConductingEquipment may have any number of Terminals. Each Terminal may be connected to a ConnectivityNode, which is a point where terminals of conducting equipment are connected together with zero impedance. A ConnectivityNode may have any number of terminals connected, and may be a member of a TopologicalNode (i.e. a bus), which is in turn a member of a TopologicalIsland. TopologicalNodes and TopologicalIslands are created as a result of a topology processor evaluating the "as built" connectivity and the actual Switch positions.

It is possible to exchange messages directly involving TopologicalNode and bypassing the ConnectivityNode details by using the TopologicalNode to Terminal association. This is often useful for exchanges involving bus/branch models which do not typically contain switch detail. When the TopologicalNode model is exchanged it is useful to also exchange the "connected" attribute on the Terminal class. This allows for the topological structure of the bus/branch model to be retained, yet indicate a terminal is not completely connected. Normally this disconnection is the result of one or more switches opening in the detailed model which is not represented in a bus/branch model exchange.

EquipmentContainers, which are a specialization of a ConnectivityNodeContainer, may contain zero or more ConnectivityNodes. The associations, ConductingEquipment–Terminal and Terminal–ConnectivityNode, capture the as-built connectivity of an actual power system network. For each Terminal connected to a ConnectivityNode, the associations of the other Terminal(s) connected to the same ConectivityNode identify the ConductingEqupment object(s) that are electrically connected. Similar connectivity at the "bus/branch" level of detail

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can be expressed using the TopologicalNode instead of the ConnectivityNode. The BusNameMarker class, which has an association to ConnectivityNode, is used to carry user bus names to be applied to TopologicalNodes. TopologicalNodes are created from ConnectivityNodes as a result of topology processing and various names might be applied depending upon which ConnectivityNode instances are present.

To model the analog values such as voltage and power, each Terminal has an association with a Measurement class from the Meas package. Although not shown in Figure 8, a Measurement object is associated with at least one MeasurementValue object. Each MeasurementValue object is an instance of a measurement from a specific source, for example, a telemetered measurement.

4.5.4.2 Connectivity and containment example

To illustrate how the connectivity model and containment model would appear as objects, a small example is presented in Figure 9. The example shows a transmission line with a T-junction spanning two substations and a substation having two voltage levels with a transformer between them. The transmission line consists of two different cables. One of the voltage levels is shown with a busbar section having a single busbar and two very simple switchgear bays connecting to the busbar.

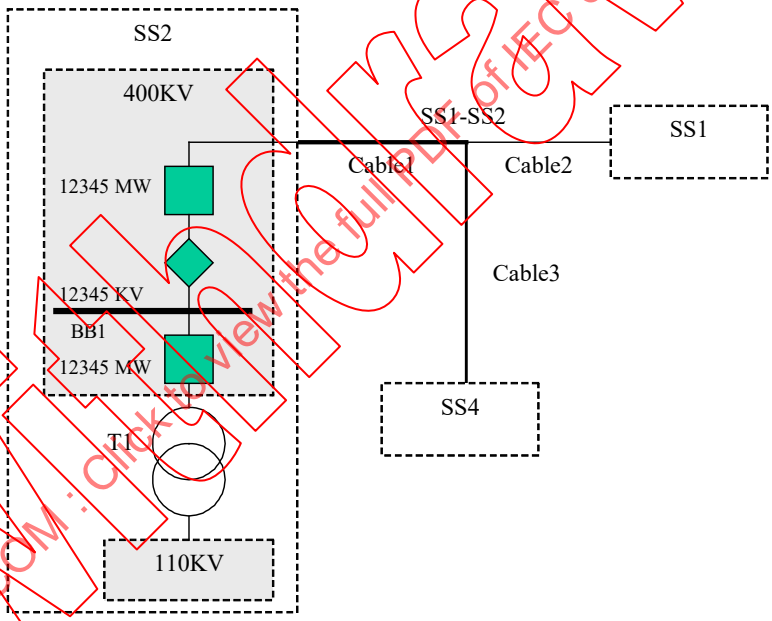


Figure 9 – Simple network example

Figure 10 shows how connectivity is modeled in the CIM as well as one way (but not necessarily the only way) containment is modeled for the diagram in Figure 9 The shaded square boxes represent EquipmentContainers, and the white square boxes represent ConductingEquipment. Darker shading indicates the EquipmentContainer is higher up in the containment hierarchy (i.e. Substation is highest, VoltageLevel next, etc.). White circles represent ConnectivityNodes, and black small circles represent Terminals. A Terminal belongs to a ConductingEquipment, and a ConnectivityNode belongs to an EquipmentContainer. This means that the borders (or contact points) between ConductingEquipment are their Terminals interconnected via ConnectivityNodes.

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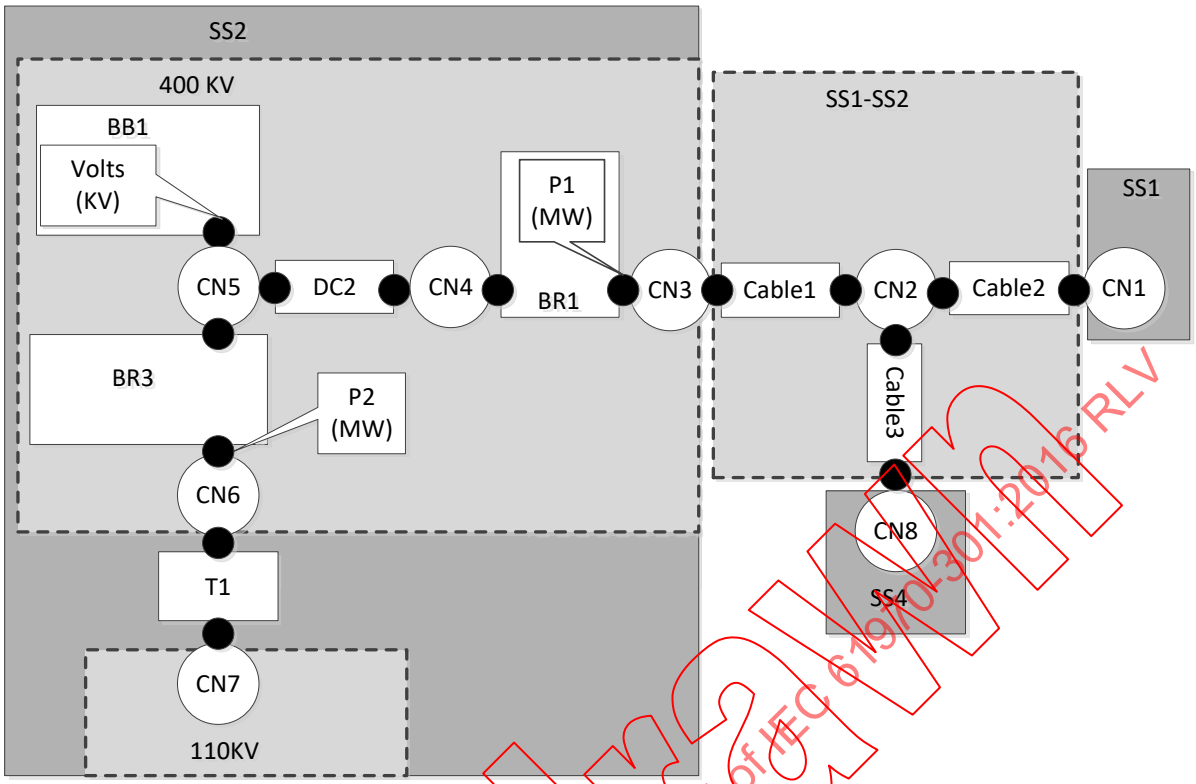


Figure 10 – Simple network connectivity modeled with CIM Topology

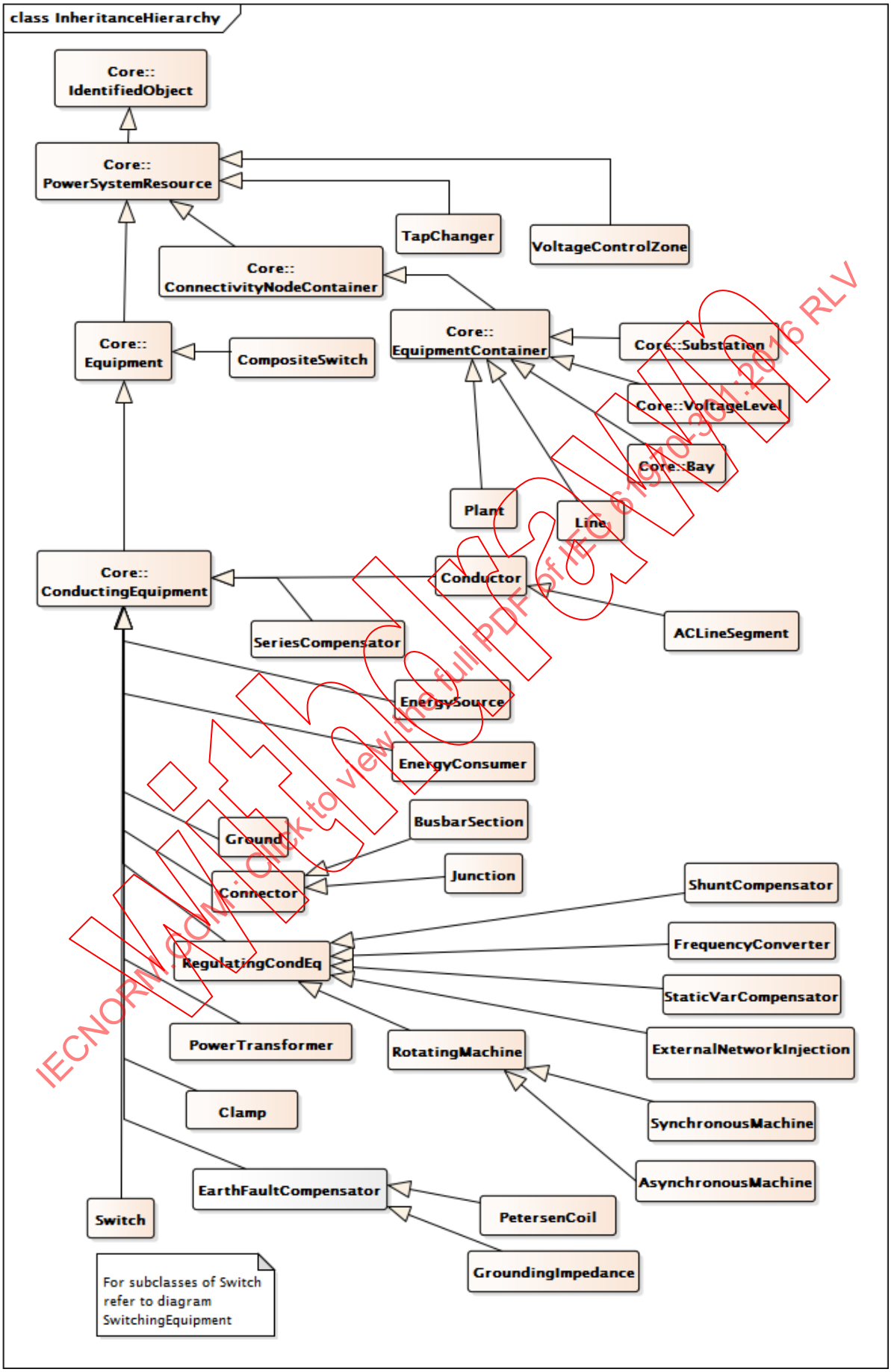
The Line SS1-SS2 contains three ACLineSegments (Cable1, Cable2, and Cable3) and associated ConnectivityNode (CN2) to model a T-junction, which provides a connection to SS4. This represents just one way that this configuration could be modeled. Each ACLineSegment has two Terminals. Cable1 is connected to CN3 and CN2 via these Terminals. CN3 is contained by the VoltageLevel 400 kV. The breaker BR1 has two terminals, one of which is connected to CN3.

Measurements are represented by square callouts where the arrow points to a Terminal. P1 is connected to the right Terminal belonging to Breaker BR1. Note that P1 is drawn inside the box representing BR1. This is because a Measurement may belong to a PowerSystemResource (PSR), as is the case with BR1. P2 is drawn inside the VoltageLevel 400 kV, which means it belongs to the 400 kV VoltageLevel instead of BR3.

4.5.5 Inheritance hierarchy

Figure 11 shows an overview of the inheritance hierarchy modeled in the CIM. This overview, which is included as one of the Wires package diagrams, spans several of the CIM packages.

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Figure 11 – Equipment inheritance hierarchy

4.5.6 Transformer model

Figure 13 shows a portion of the Wires package in a class diagram which models a PowerTransformer device.

The transformer model has been revised from previous versions to allow for use of the same instance model in both balanced and unbalanced models. Additionally the PowerTransformer itself is now a ConductingEquipment with potentially multiple terminals to more directly model transformers with one, two, three, or more terminals. As typical of ConductingEquipment, when in service, the PowerTransformer conducts power from one of its terminals to another.

As shown in Figure 12, the PowerTransformer is also able to optionally model tank details, which can be used to describe in detail the transformer internal winding phase connections and imbalances. In all cases a PowerTransformer models a group of physical devices acting together to transform power among terminals and in one physical location. Often for transmission systems three physical, single phase devices are represented by one PowerTransformer instance. If detail of the individual single phase devices were required, the TransformerTank objects should additionally be modeled.

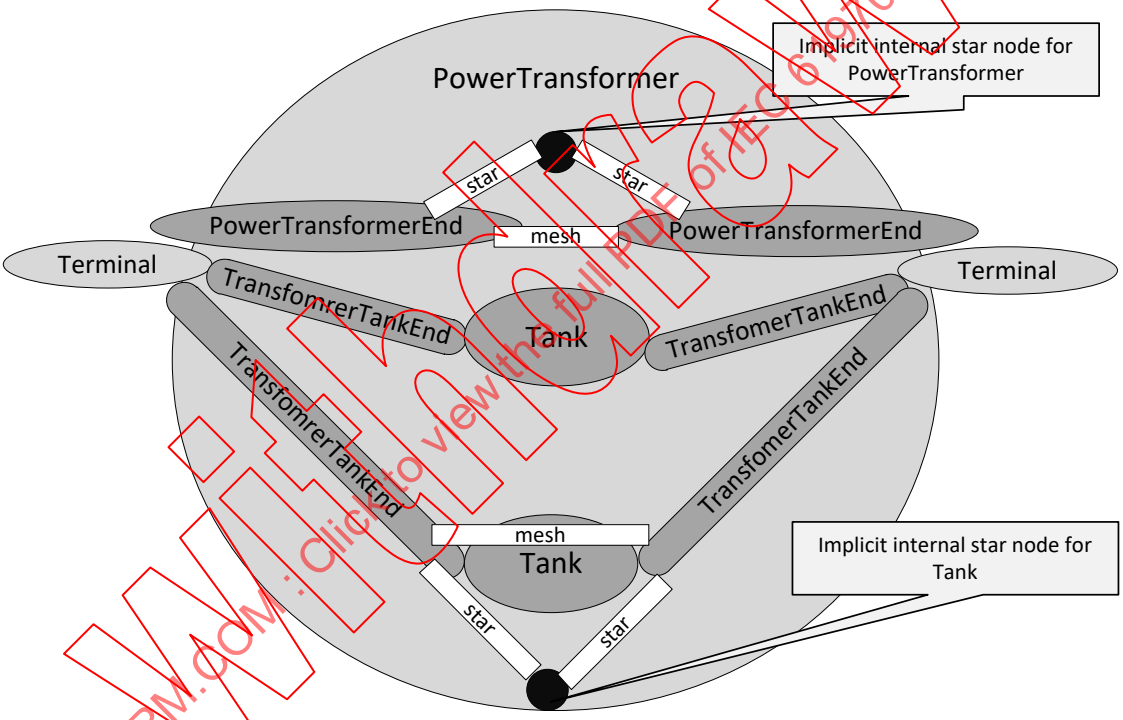


Figure 12 – Transformer and Tank model

Both a PowerTransformer and a TransformerTank can have impedance described in either an assumed star connection with implied centre connection or with mesh impedance form by using the optional TransformerMeshImpedance class. The mesh form of impedance is required to accurately model transfromers with more than three terminals. If using the mesh impedance form, you would specify a TransformerMeshImpedance class for each possible terminal to terminal connection, thus one instance for two terminals, three for three terminals, and six for four terminals and so on. If using the star connection, the impedance parameters can be specified directly on the PowerTransformerEnd class, or alternatively shared among transformers using the TransformerStarImpedance class.

As shown in Figure 11, a PowerTransformer is a specialized class of ConductingEquipment, which is a specialized class of Equipment. This is shown by the use of the generalization-type of relationship, which uses an arrow to point to the general class. The ConductingEquipment is shown to be a specialized class of Equipment by use of the italic "*Equipment*" class name in the upper right corner. The inheritance permits the PowerTransformer to inherit attributes

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from ConductingEquipment, Equipment, and all generalizations of Equipment that are not shown in Figure 11.

A PowerTransformer also has relationships to PowerTransformerEnd and TransformerTank which are modeled with association type relationships. As shown, a PowerTransformer may associate zero or more PowerTransformerEnds, but a PowerTransformerEnd may associate to only zero or one PowerTransformer. Simlarly, the PowerTransformer may associate to zero or more TransformerTank objects, but a TransformerTank may associate to only zero or one PowerTransformer object.

The PowerTransformerEnd specializes the TransformerEnd class which has other relationships as well:

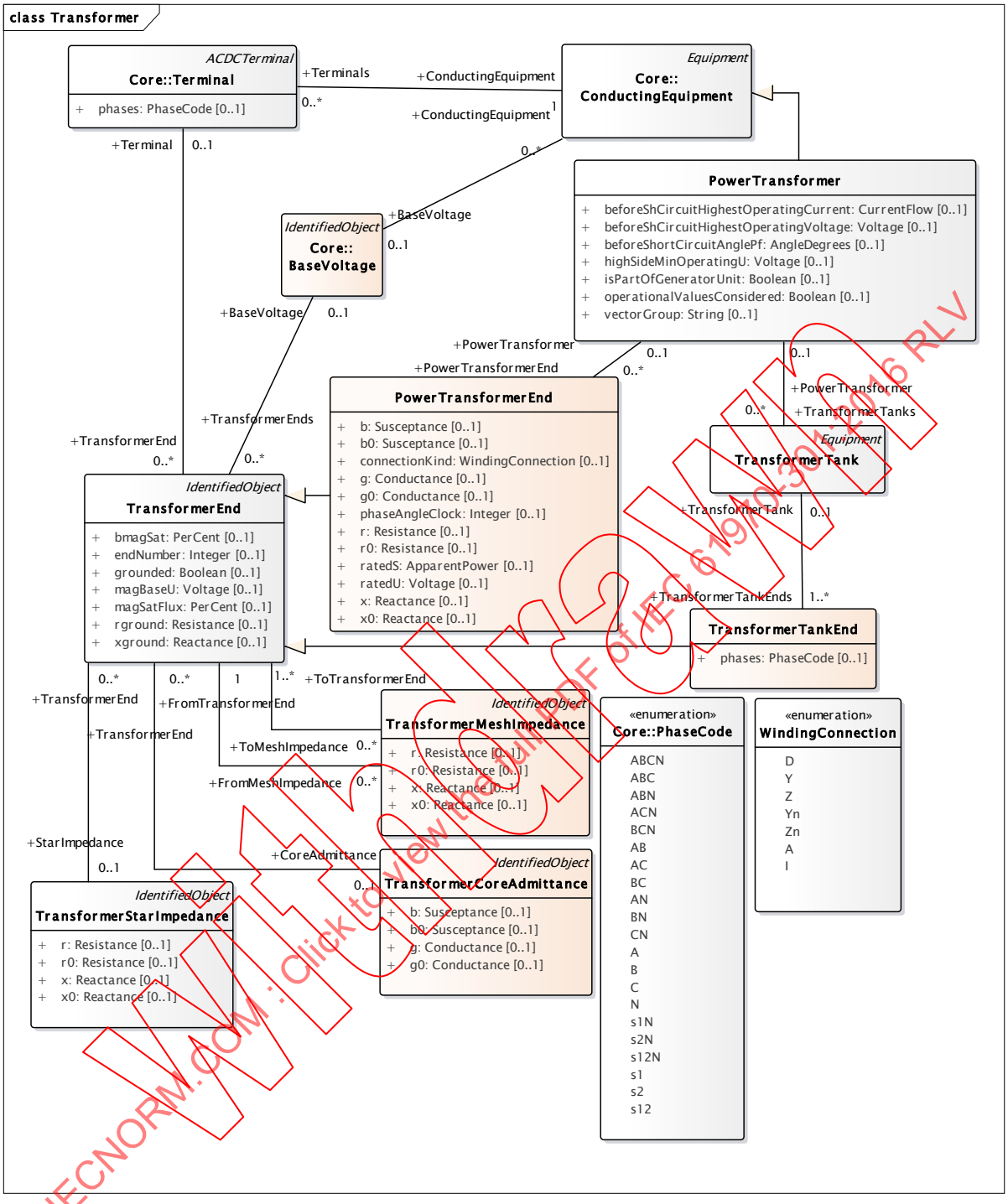
- a generalization relationship with IdentifiedObject;
- two association relationships with the TransformerMeshImpedance class, such that a TransformerEnd object may be “From” 0, 1, or more TransformerMeshImpedance objects and “To” 0, 1, or more TransformerMeshImpedance objects;
- aggregation relationships with the PhaseTapChanger and RatioTapChanger classes, such that a TransformerWinding object may have 0 or 1 PhaseTapChanger objects and 0 or 1 RatioTapChanger objects associated with it.

For a transmission network PowerTransfomer that has two or three ends, the equivalent pi-model impedances appear in the PowerTransformerEnd r, r0, x, x0, g, g0, b and b0 attributes. The following rules apply to such a PowerTransformer.

- The PowerTransformerEnd and its connected Terminal both have sequence numbers TransformerEnd.endNumber and ACDCTerminal.sequenceNumber. Those numbers may or may not be in synch.
- The TransformerEnd.endNumber 1 shall always be at the PowerTransformerEnd with the highest rated voltage (PowerTransformerEnd.ratedU).
- In case of a two terminal transformer with same rated voltage (PowerTransformerEnd.ratedU) on both sides, the system where the transformer is defined shall make sure that only one side has TransformerEnd.endNumber equal to 1.
- For a two terminal transformer the PowerTransformerEnd with the end number equal to 1 shall have values specified for r, r0, x, x0, g, g0, b and b0.
- For a two terminal transformer the PowerTransformerEnd with the end number different from 1, the values r, r0, x, x0, g, g0, b and b0 shall be zero.
- For a three terminal transformer each PowerTransformerEnd shall have r, r0, x and x0 values corresponding to that leg's equivalent impedance.
- For a three terminal transformer each PowerTransformerEnd shall have g, g0, b and b0 values corresponding the no load losses distributed on the three PowerTransformerEnds. The total no load loss shunt impedances may also be placed at one of the PowerTransformerEnds, preferably the end number 1, having the shunt values on end 1 is the preferred way.
- For a PowerTransformer with more than three terminals the PowerTransformerEnd impedance values cannot be used. Instead use the TransformerMeshImpedance or split the transformer into multiple PowerTransformers.

Figure 13 shows UML for the transformer model.

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Figure 13 – Transformer model

4.5.7 Transformer tap modeling

4.5.7.1 Generalized tap modeling

Multiple types of transformer tap models are supported by the CIM model. Depending on the physical construction, the effects of tap movement will be defined using either the RatioTapChanger class or the PhaseTapChanger class and its various specializations. The PhaseTapChanger can be specialized into a number of different types representing the physical construction and hence behavior. The attributes of TapChanger are applicable for all the RatioTapChanger specializations. Figure 14 shows the UML model for the transformer taps.

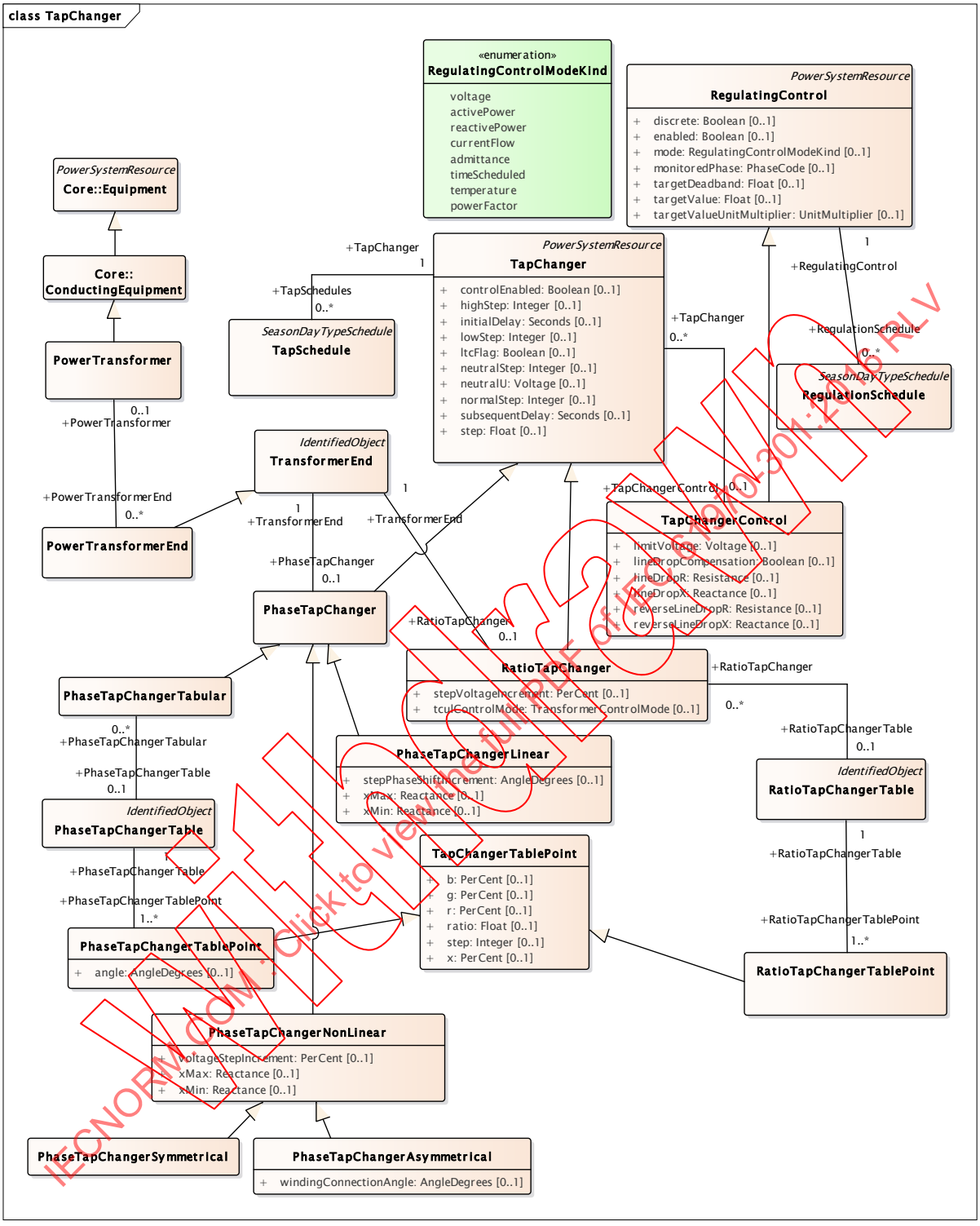


Figure 14 – Transformer tap model

Multiple tap changers can be combined within one power transformer, but it is expected that only one phase shifting and one ratio changing tap changer would be modeled on any given terminal. We document the ratio or phase shift change relative to the other terminal(s) assuming those terminals are at the nominal (1 PU) ratio and nominal (zero) phase angle shift. It is permitted to combine both a phase shifting and ratio tap changer on one terminal, though this practice is discouraged to avoid interpretation issues on the order of these tap changers. Tabular representation is preferred in such cases, as it conveys the explicit values of the resulting phases and angles..

Tabular representations for both ratio and phase shifting transformers can be used where the available CIM models do not appropriately reflect the physical behavior. The tabular models are optional to the other CIM tap models. Tabular models may be used to describe the change in impedance through the tap range.

In 4.5.7.2 to 4.5.7.7 the various tap changer models are described in more detail.

4.5.7.2 Voltage ratio transformer modeling

The RatioTapChanger class is used to define a transformer tap that changes the voltage magnitude ratio without changing the phase angle across the transformer. A RatioTapChanger may be used in cases the where the transformer inherently introduces a fixed phase shift, such as from a wye-delta winding connection.

4.5.7.3 Voltage ratio transformer tabular modeling

A RatioTapChangerTabular may be optionally associated to any RatioTapChanger and may represent a non-linear relationship between tap number, tap ratio, and impedances. If associated, the tabular ratio model takes precedence.

4.5.7.4 Linear phase shifter transformer modeling

A phase shifting transformer is linear if the phase shift increment per tap step is uniform and the voltage magnitude is constant over the full range of the tap changer. A linear phase shifter is modeled using the PhaseTapChangerLinear class.

4.5.7.5 Symmetrical and asymmetrical phase shifter modeling

4.5.7.5.1 Symmetrical and asymmetrical phase shifter – common information

Subclause 4.5.7.5 describes Phase-Shifting Transformer (PST) modeling according to the type and technology of the equipment; and more specifically, equivalent series reactance of phase shifters in the positive sequence as a function of the phase shift angle. In these specific models, the resistances and the magnetizing currents are always neglected.

The phase shift transformers within 4.5.7.5 are mapped to CIM classes as described in Table 2.

Table 2 – Mapping of phase shift transformers to CIM classes

Phase shifter type	CIM class
General Case	cim:PhaseTapChangerTabular
Symmetrical phase shifters	cim:PhaseTapChangerSymmetrical or cim:PhaseTapChangerLinear
Asymmetrical phase shifter	cim:PhaseTapChangerAsymmetrical
In-phase transformer and symmetrical phase shifter	cim:PhaseTapChangerSymmetrical and cim:RatioTapChanger
In-phase transformer and asymmetrical phase shifter	cim:PhaseTapChangerAsymmetrical and cim:RatioTapChanger

It is highly recommended to use tabular data to exchange PST parameters (cim:PhaseTapChangerTabular) instead of having to recalculate the parameters per tap according to each model type.

The symbols used in formulas within 4.5.7.5 are mapped to CIM classes as described in Table 3.

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Table 3 – Mapping of symbols used in formulas to CIM attributes

Power Shifter Transformer attribute	CIM attribute
n	cim:PhaseTapChangerTablePoint.step
n_0	cim:TapChanger.neutralStep
δu	cim:PhaseTapChangerNonLinear.voltageStepIncrement
r	cim:TapChangerTablePoint.ratio
α	cim:PhaseTapChangerTablePoint.angle
$\delta\alpha$	cim:PhaseTapChangerLinear.stepPhaseShiftIncrement
$X(\alpha)$	cim:TapChangerTablePoint.x
$X(0)$	cim:PhaseTapChangerLinear.xMin or cim:PhaseTapChangerNonLinear.xMin
$X(\alpha_{max})$	cim:PhaseTapChangerLinear.xMax or cim:PhaseTapChangerNonLinear.xMax
θ	cim:PhaseTapChangerAsymmetrical.windingConnectionAngle

The impedance variation depending on tap position on a phase shift transformer is described in Table 4.

Table 4 – Impedance variations in a phase shift transformer

Equipment type	Equivalent series reactance as a function of the phase shift angle
Symmetrical phase shifters	$X(\alpha) = X(0) + \left(X(\alpha_{max}) - X(0)\right)\left(\frac{\sin(\alpha/2)}{\sin(\alpha_{max}/2)}\right)^2$
Asymmetrical phase shifter	$X(\alpha) = X(0) + \left(X(\alpha_{max}) - X(0)\right)\left(\frac{\tan\alpha}{\tan\alpha_{max}}\frac{\sin\theta - \tan\alpha_{max}\cos\theta}{\sin\theta - \tan\alpha\cos\theta}\right)^2$
In-phase transformer and symmetrical phase shifter	$X(r,\alpha) = X_r(r_{nom})\left(\frac{r}{r_{nom}}\right)^2 + X_\alpha(0) + \left(X_\alpha(\alpha_{max}) - X_\alpha(0)\right)\left(\frac{\sin(\alpha/2)}{\sin(\alpha_{max}/2)}\right)^2$
In-phase transformer and asymmetrical phase shifter	$X(r,\alpha) = X_r(r_{nom})\left(\frac{r}{r_{nom}}\right)^2 + X_\alpha(0)$ $+ \left(X_\alpha(\alpha^0_{max}) - X_\alpha(0)\right)\left(\frac{\tan\alpha}{\tan\alpha_{max}(r)}\frac{\sin\theta - \tan\alpha_{max}(r)\cos\theta}{\sin\theta - \tan\alpha\cos\theta}\right)^2$ with $\alpha_{max}(r) = A\tan\left(\frac{\sin\theta}{\frac{r}{r_{nom}\tan\alpha^0_{max}}\left(\sin\theta - \tan\alpha^0_{max}\cos\theta\right) + \cos\theta}\right)$ and $\alpha^0_{max} = \alpha_{max}(r_{nom})$

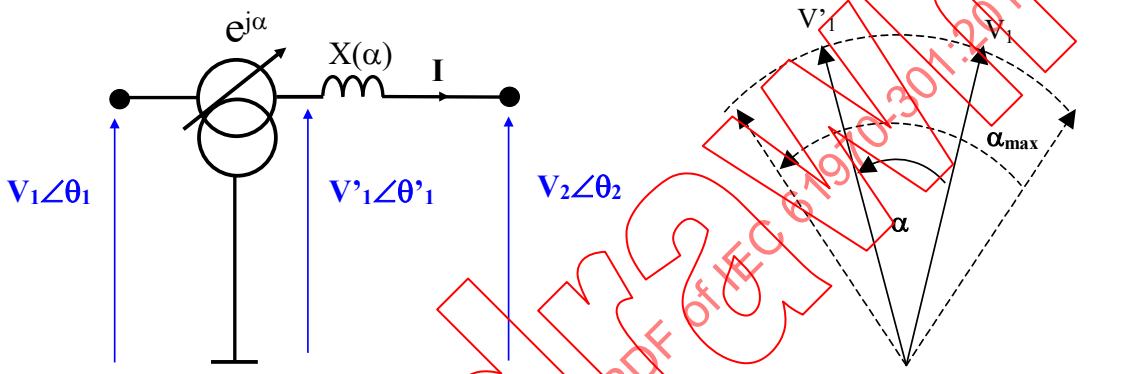
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Table 5 – Description of variables

Variable	Meaning
α_{max}	Maximal phase shift: the maximum angle value of the phase shifter angles table
r_{nom}	Nominal ratio of the in-phase transformer
α_{max}^{0}	Maximal phase shift when the in-phase transformer ratio is nominal

4.5.7.5.2 Symmetrical phase shifters

Phasor diagram and equations are shown in Figure 15.



$$V_2 = V_1 e^{j\alpha} - jX(\alpha)I \qquad V'_1 = V_1\left(1 + 2j\sin\frac{\alpha}{2}e^{j\frac{\alpha}{2}}\right) = e^{j\alpha}V_1$$

Figure 15 – Phasor diagram and equations

Expression of the angle and ratio per tap

Based on Figure 15:

$$\alpha = (n - n_0)\cdot\delta\alpha \quad \text{or} \quad \alpha = 2A\tan\left(\frac{(n - n_0)\cdot\delta u}{2}\right)$$

$$r = 1$$

Expression of the equivalent series reactance given the angle

Assuming the reactance of the regulating winding varies as the square of the number of turns, the equivalent reactance can be written as follows for non delta-hexagonal technologies.

$$X(\alpha) = X(0) + \left(X(\alpha_{max}) - X(0)\right)\left(\frac{\sin(\alpha/2)}{\sin(\alpha_{max}/2)}\right)^2$$

Parameters:

α_{max} maximal phase shift

$X(0)$ equivalent series reactance at zero phase shift $\alpha = 0$

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$X(\alpha_{max})$ equivalent series reactance at maximal phase shift $\alpha = \alpha_{max}$

Variable:

α current phase shift

The formula above is valid for single or double core symmetrical phase shifters except for the hexagonal technology.

For single core symmetrical phase shifters: $X(0) = 0$. An example of impedance variation is shown in Figure 16.

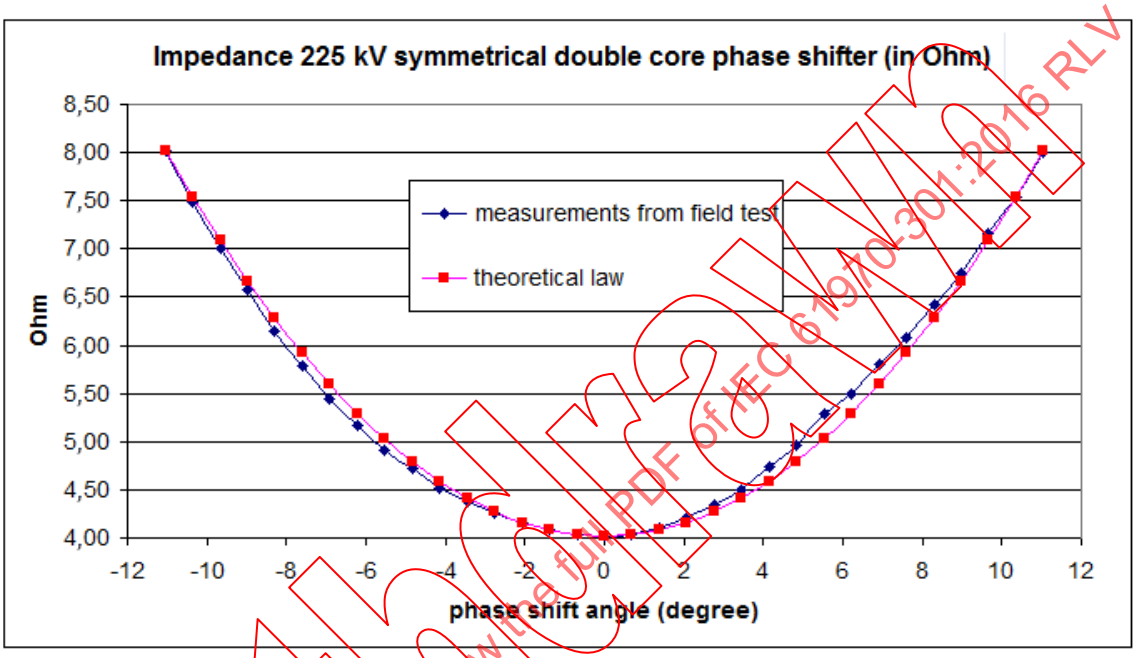
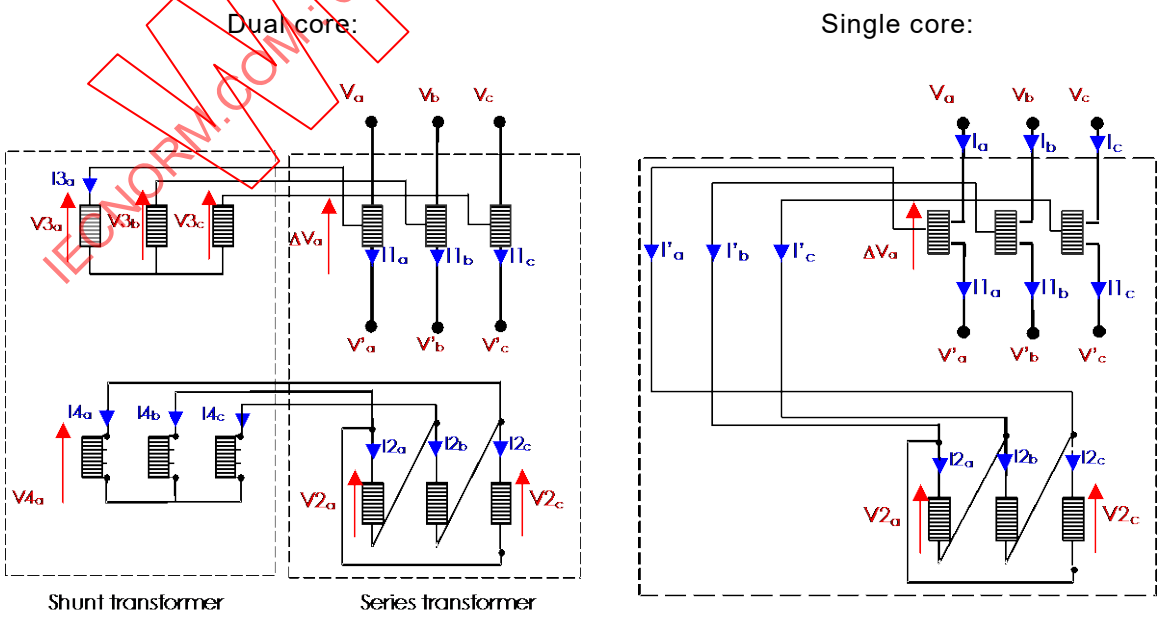


Figure 16 – Symmetrical phase shifter impedance variation

Three-phase core organization is shown in Figure 17.



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Single core, delta hexagonal:

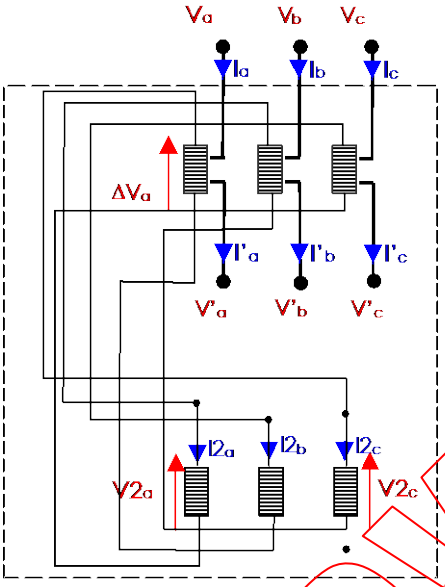
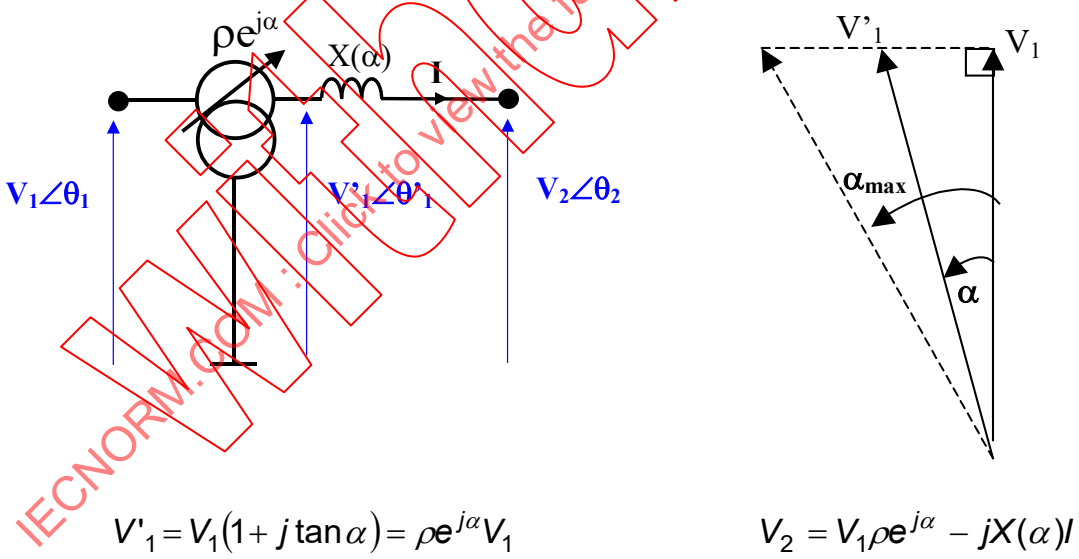


Figure 17 – Core organization

4.5.7.5.3 Quadrature booster

Phasor diagram and equations are shown in Figure 18.



$$V'_1 = V_1(1 + j\tan\alpha) = \rho e^{j\alpha} V_1 \qquad V_2 = V_1 \rho e^{j\alpha} - jX(\alpha)I$$

ρ and α vary with $\rho\cos\alpha$ = constant.

Figure 18 – Phasor diagram and equations

Expression of the angle and ratio per tap

Based on Figure 18:

$$\alpha = A\tan((n - n_0)\cdot\delta u)$$

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$$r = \frac{1}{\sqrt{((n - n_0) \cdot \delta u)^2 + 1}}$$

Expression of the equivalent series reactance given the angle

Assuming the reactance of the regulating winding varies as the square of the number of turns, the equivalent reactance of the quadrature booster can be written as follows.

$$X(\alpha) = X(0) + (X(\alpha_{max}) - X(0)) \left(\frac{\tan(\alpha)}{\tan(\alpha_{max})} \right)^2$$

Parameters:

α_{max}	maximal phase shift
$X(0)$	equivalent series reactance at zero phase shift
$X(\alpha_{max})$	equivalent series reactance at maximal phase shift

Variable:

α	current phase shift

For quadrature boosters with a single core: $X(0) = 0$

Three-phase core organization is shown in Figure 19.

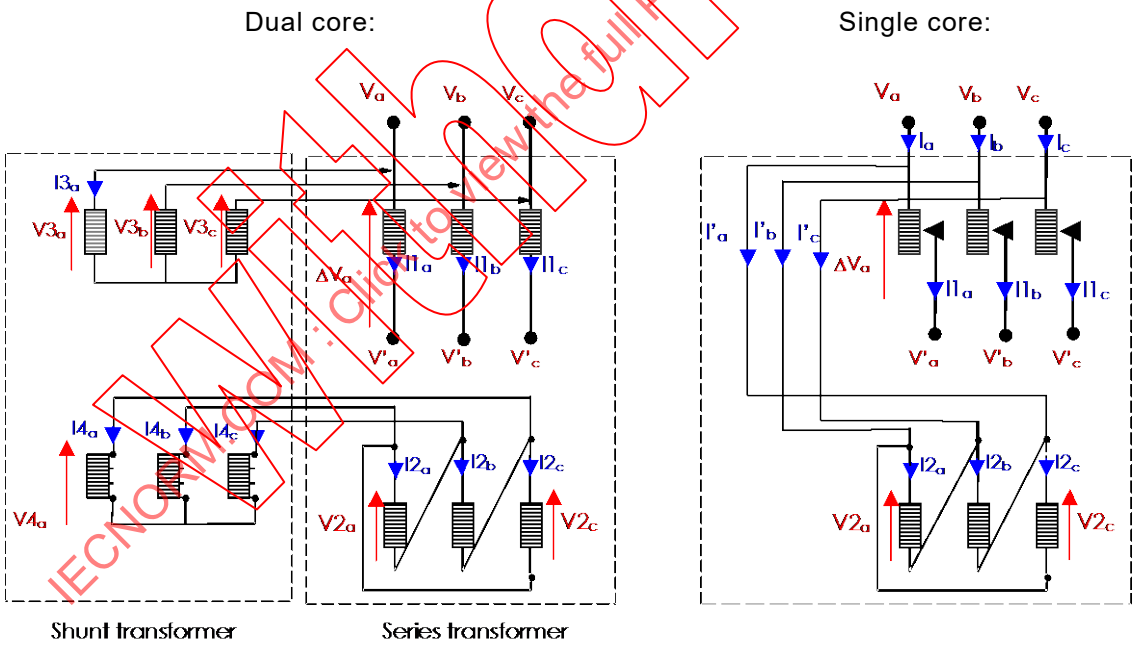
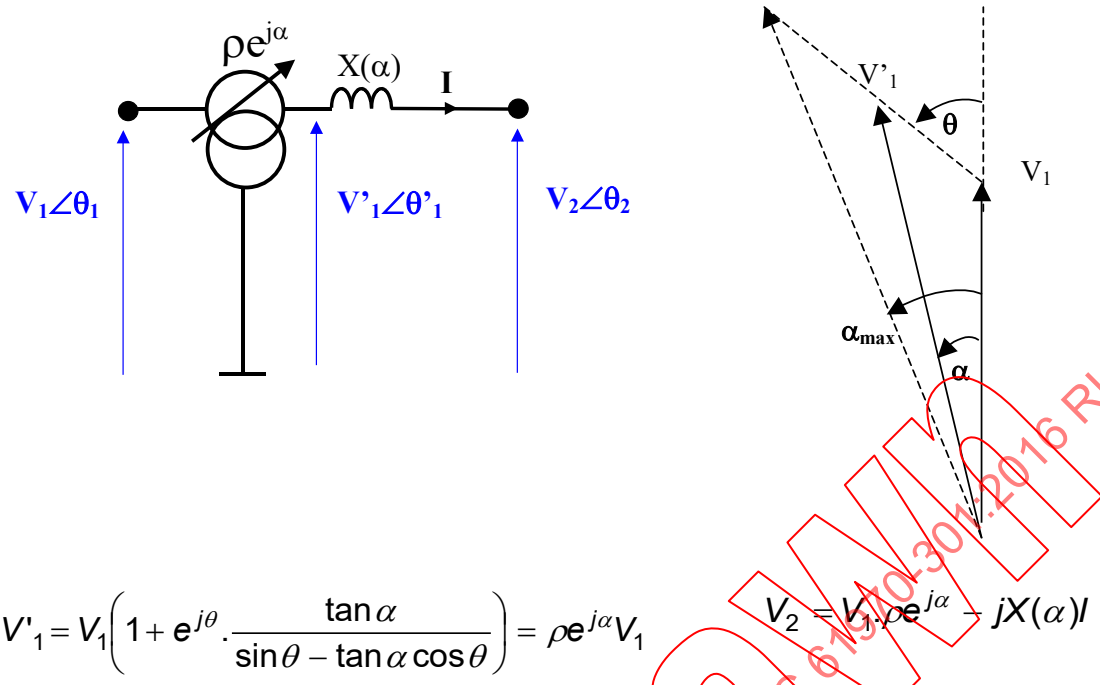


Figure 19 – Core organization

4.5.7.5.4 Asymmetrical phase shifter modeling

Phasor diagram and equations are shown in Figure 20.

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$$V'_1 = V_1\left(1 + e^{j\theta}.\frac{\tan\alpha}{\sin\theta - \tan\alpha\cos\theta}\right) = \rho e^{j\alpha}V_1 \qquad V_2 = V_1.\rho e^{j\alpha} - jX(\alpha)I$$

θ is fixed, only α and ρ vary.

Figure 20 – Phasor diagram and equations

Expression of the angle and ratio per tap

Based on Figure 20:

$$\alpha = A\tan\left(\frac{(n-n_0)\cdot\delta u\cdot\sin\theta}{1+(n-n_0)\cdot\delta u\cdot\cos\theta}\right)$$

$$r = \frac{1}{\sqrt{((n-n_0)\cdot\delta u\cdot\sin\theta)^2 + (1+(n-n_0)\cdot\delta u\cdot\sin\theta)^2}}$$

Expression of the equivalent series reactance given the angle

Assuming the reactance of the regulating winding varies as the square of the number of turns, the equivalent reactance can be written as follows.

$$X(\alpha) = X(0) + (X(\alpha_{max}) - X(0))\left(\frac{\tan\alpha}{\tan\alpha_{max}}\frac{\sin\theta - \tan\alpha_{max}\cos\theta}{\sin\theta - \tan\alpha\cos\theta}\right)^2$$

Parameters:

α_{max}	maximal phase shift
$X(0)$	equivalent series reactance at zero phase shift
$X(\alpha_{max})$	equivalent series reactance at maximal phase shift
θ	boost voltage angle

Variable:

α	current phase shift

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Three-phase organizations are shown in Figure 21.

Dual core:

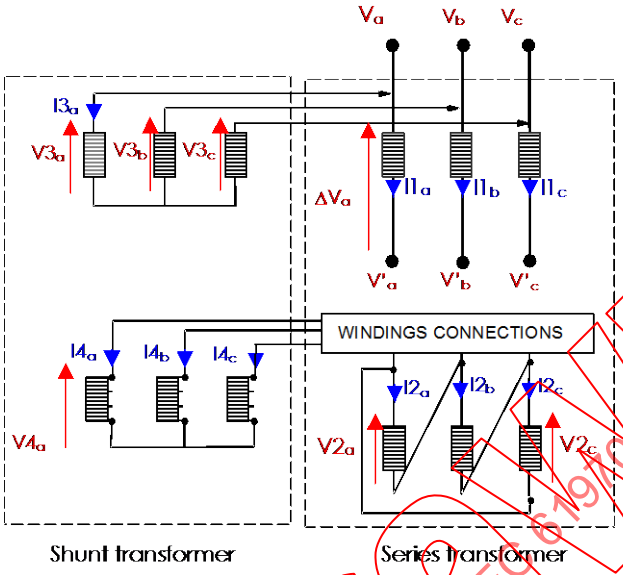
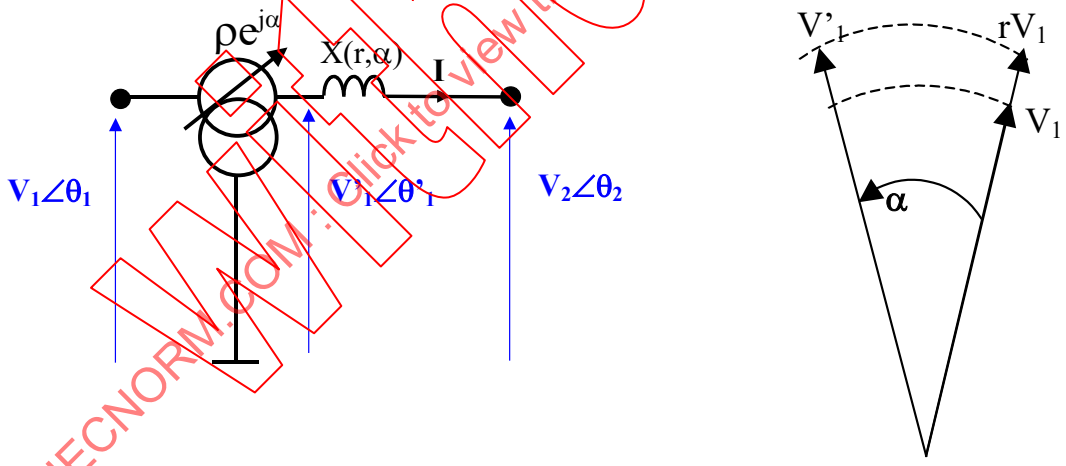


Figure 21 – Core organization

4.5.7.5.5 In-phase transformer and symmetrical phase shifter

Phasor diagram and equations are shown in Figure 22.



$$V_2 = \rho V_1 e^{j\alpha} - jX(\alpha)I.$$

$$V'_1 = rV_1\left(1 + 2j\sin\frac{\alpha}{2}e^{j\frac{\alpha}{2}}\right) = \rho e^{j\alpha}V_1$$

r and α vary, and $\rho = r$.

Figure 22 – Phasor diagram and equations

Expression of the angle and ratio per tap

Same as 4.5.7.5.2 with the addition of the in-phase transformer ratio r.

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Equivalent series reactance given the angle and the in-phase transformer ratio

Assumptions:

- The reactance of the regulating winding varies as the square of the number of turns.
- The equivalent reactance is the sum of the reactance of the in-phase transformer X_r and the reactance of the phase shifter part X_α.
- The phase shifting angle α does not depend on the in-phase ratio r.

The equivalent reactance can be written as follows:

$$X(r,\alpha) = X_r(r_{nom})\left(\frac{r}{r_{nom}}\right)^2 + X_\alpha(0) + \left(X_\alpha(\alpha_{max}) - X_\alpha(0)\right)\left(\frac{\sin(\alpha/2)}{\sin(\alpha_{max}/2)}\right)^2$$

Parameters:

r_{nom}	nominal ratio of the in-phase transformer
$X_r(r_{nom})$	equivalent series reactance of the in-phase transformer at nominal in-phase ratio
α_{max}	maximal phase shift
$X_\alpha(0)$	equivalent series reactance of the phase shifter part at zero phase shift
$X_\alpha(\alpha_{max})$	equivalent series reactance of the phase shifter part at maximal phase shift at nominal in-phase ratio (r_{nom})

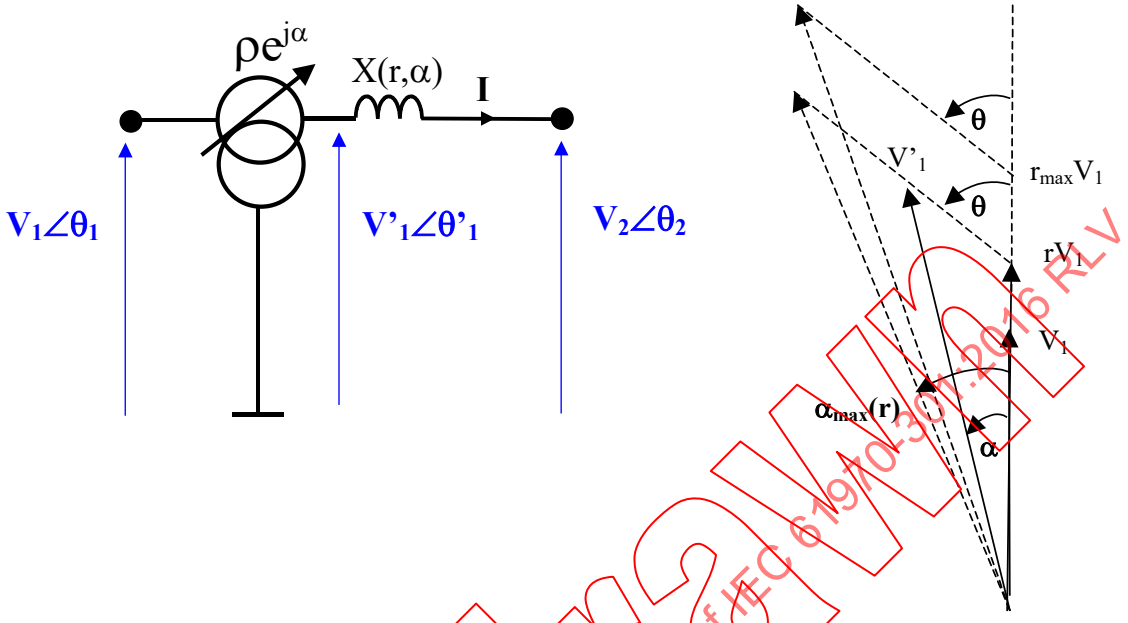
Variables:

r	current ratio of the in-phase transformer
α	current phase shift

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4.5.7.5.6 In-phase transformer and asymmetrical phase shifter

Phasor diagram and equations are shown in Figure 23.



$$V'_1 = rV_1\left(1 + e^{j\theta}.\frac{\tan\alpha}{\sin\theta - \tan\alpha\cos\theta}\right) = \rho e^{j\alpha}V_1 \qquad V_2 = (V_1 - jX(\alpha)I)\rho e^{j\alpha}$$

θ is fixed, only r and α are variables, ρ varies as a consequence.

Figure 23 – Phasor diagrams and equations

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Equivalent series reactance given the angle and the in-phase transformer ratio

Assumptions:

- The reactance of the regulating winding varies as the square of the number of turns.
- The equivalent reactance is the sum of the reactance of the in-phase transformer X_r and the reactance of the phase shifter part X_α.

The equivalent series reactance can be written as follows:

$$X(r,\alpha) = X_r(r_{nom})\left(\frac{r}{r_{nom}}\right)^2 + X_\alpha(0) + \left(X_\alpha(\alpha^0_{max}) - X_\alpha(0)\right)\left(\frac{\tan\alpha}{\tan\alpha_{max}(r)}\,\frac{\sin\theta - \tan\alpha_{max}(r)\cos\theta}{\sin\theta - \tan\alpha\cos\theta}\right)^2$$

with $\alpha_{max}(r) = A\tan\left(\dfrac{\sin\theta}{\dfrac{r}{r_{nom}\tan\alpha^0_{max}}\left(\sin\theta - \tan\alpha^0_{max}\cos\theta\right) + \cos\theta}\right)$ with $\alpha^0_{max} = \alpha_{max}(r_{nom})$

Parameters:

r_{nom}	nominal ratio of the in-phase transformer
$X_r(r_{nom})$	equivalent series reactance of the in-phase transformer at nominal in-phase ratio r_{nom}
θ	fixed boost voltage angle

$\alpha^0_{max} = \alpha_{max}(r_{nom})$ maximal phase shift for nominal in-phase ratio (r_{nom})

$X_\alpha(0)$ equivalent series reactance of the phase shifter part at zero phase shift

$X_\alpha(\alpha^0_{max})$ equivalent series reactance of the phase shifter part at maximal phase shift at nominal in-phase ratio (r_{nom})

Variables:

r current ratio of the in-phase transformer

α current phase shift

For $\theta = \pi/2$ (quadrature booster): $\alpha_{max}(r) = A\tan\left(\frac{r_{nom}}{r}\tan\alpha^0_{max}\right)$

Three-phase organization is shown in Figure 24.

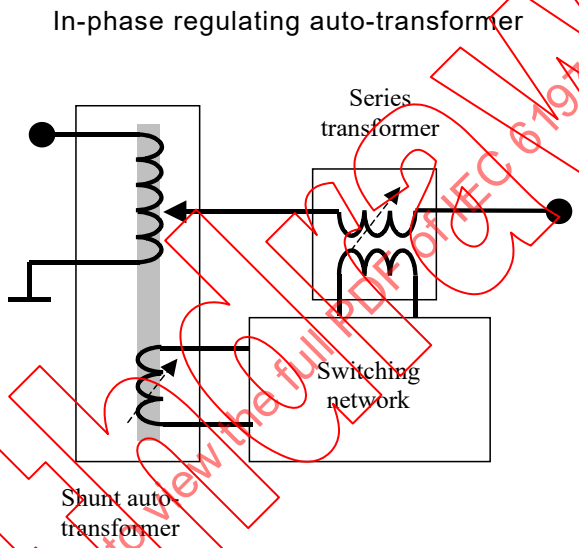


Figure 24 – Core organization

The phase shift regulation may be on the shunt or on the series transformer.

4.5.7.6 Phase shifter transformer tabular modeling

A PhaseTapChangerTabular is an explicit tabular representation of the phase shift, ratio and impedance change over the range of the tap changer. The PhaseTapChangerTabular may be associated with PhaseTapChangerTable representing a non-linear relationship between tap number, phase shift, ratios and impedances.

4.5.7.7 Tap changer control

Control of tap changers in a power flow type of application is made using the TapChangerControl class and the TapChanger.ltcFlag. If a TapChanger has a TapChangerControl (referenced TapChanger.TapChangerControl), this means that the power flow application may control the tap changer. The TapChanger.ltcFlag provides information that the TapChanger has physical capability to move the tap under load. Also used in the IEC 60909 calculations to indicate if the tap can move on load.

The meaning of the combinations for TapChanger.TapChangerControl and TapChanger.ltcFlag are described in Table 6.

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Table 6 – Tap changer control options

TapChanger. ltcFlag	TapChanger. TapChangerControl	Description
False	Not present	A real and fixed tap that is not controlled and cannot be moved on load (manual tap change). Power flow cannot be set to change the tap for voltage control during the calculation.
True	Not present	A real and fixed tap that is not controlled but can be moved under load, e.g. manually. Power flow cannot be set to change the tap for voltage control during the calculation. Optimal power flow might have access to these taps and change in order to optimize. Also State Estimator may estimate the tap position to find a better solution for the system state.
True	Present	A real tap with a possibility to change taps automatically for voltage control/active power (load flow) enabled. Depending on the RegulatingControl.enabled and TapChanger.controlEnabled in SSH, the power flow shall or shall not participate in the regulation. In cases where the RegulatingControl is associated with more than one tap changer or other devices, the attribute TapChanger.controlEnabled can be set to false in order to set which of the taps are not enabled.
False	Present	An artificial tap changer can be used to simulate control behavior in power flow.

4.5.8 Phase wire modeling

The CIM models provide a means to specify equivalent single-line representation of balanced three phase networks or to additionally and optionally specify individual phase detail. In single phase networks there is a direct correspondence between Terminal objects and physical wire connections. In the single-line representation of balanced three phase networks we use one Terminal to represent the group of coordinating phase connections. Thus one Terminal can be used to specify one or more coordinated phase connections using the Terminal.phases attribute which is of enumeration type PhaseCode. PhaseCode has the possible phase connection combinations of ABC, ABCN, AB, BC, CA, A, B, C and so forth. The specification of phases at each terminal allows for modeling jumpers or switches that connect different phases. This phase connectivity specification is intended as a nominal or normal phase specification. The result of energization source is not reflected in this specification. This phase specification provides a means to locally connect like phases. Figure 25 show the phase wire data model.

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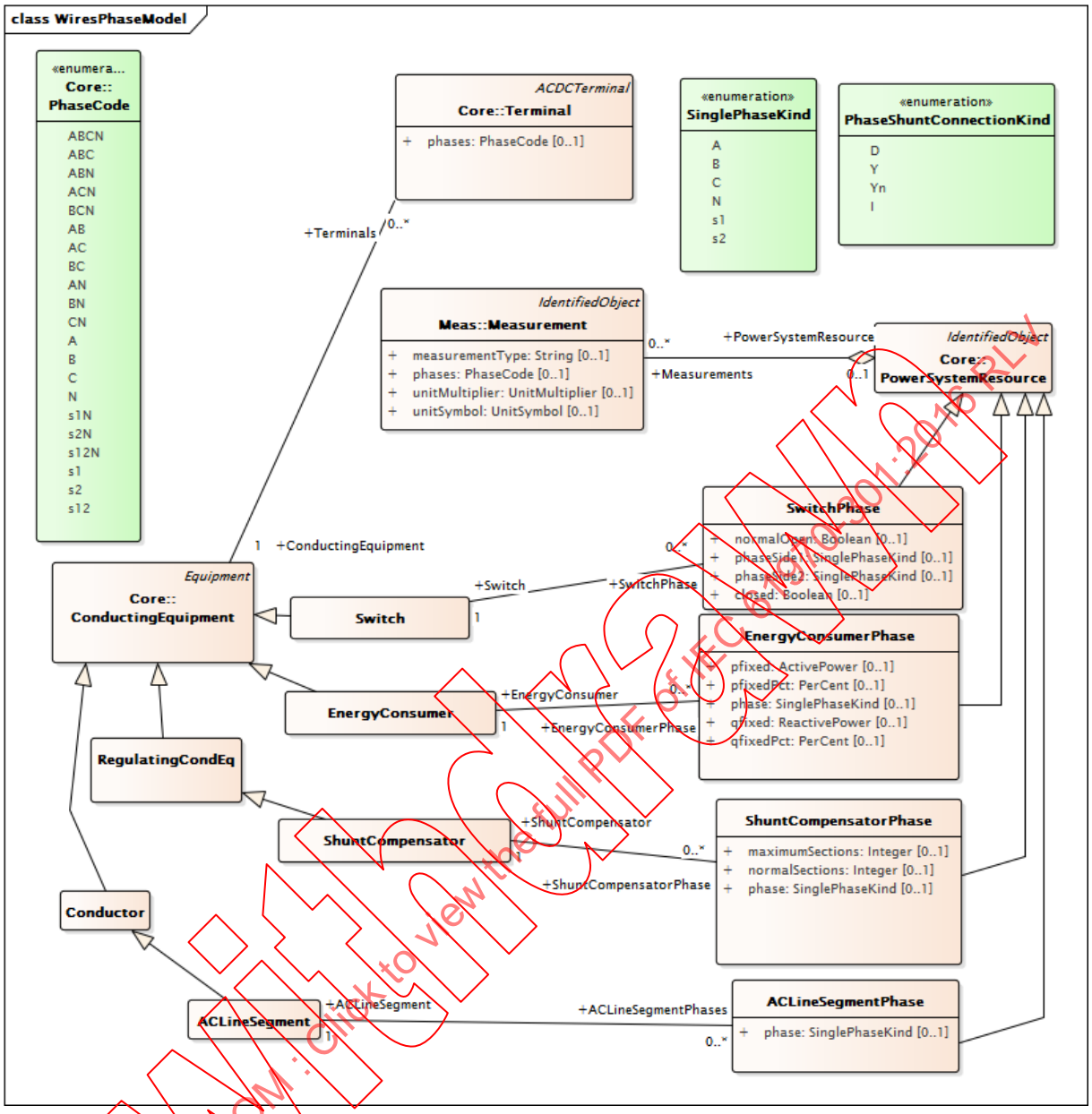


Figure 25 – Phase wire data model

Figure 26 provides an example for specifying phase connections. This example shows a ConnectivityNode instance on the left with A, B, and C phases implied. Note that ConnectivityNode does not specify its phase content but rather implicitly connects like phases of terminals associated to the ConnectivityNode. The example shows a two phase jumper connecting on the left (Terminal.sequenceNumber=1) phases A and C and on the right (Terminal.sequenceNumber=2) phases A and B, with the internals of the jumper model SwitchPhase objects which specify in detail how the phase connections route. The Terminal.phases attribute only specifies the external connection of a device. Continuing to the right, two line segments are connected. The upper line segment is a two phase line on phases A and B. The lower line segment is single phase on phase B. The dark lines indicate CIM associations while the lighter arrows indicate the represented electrical connections at the phase level.

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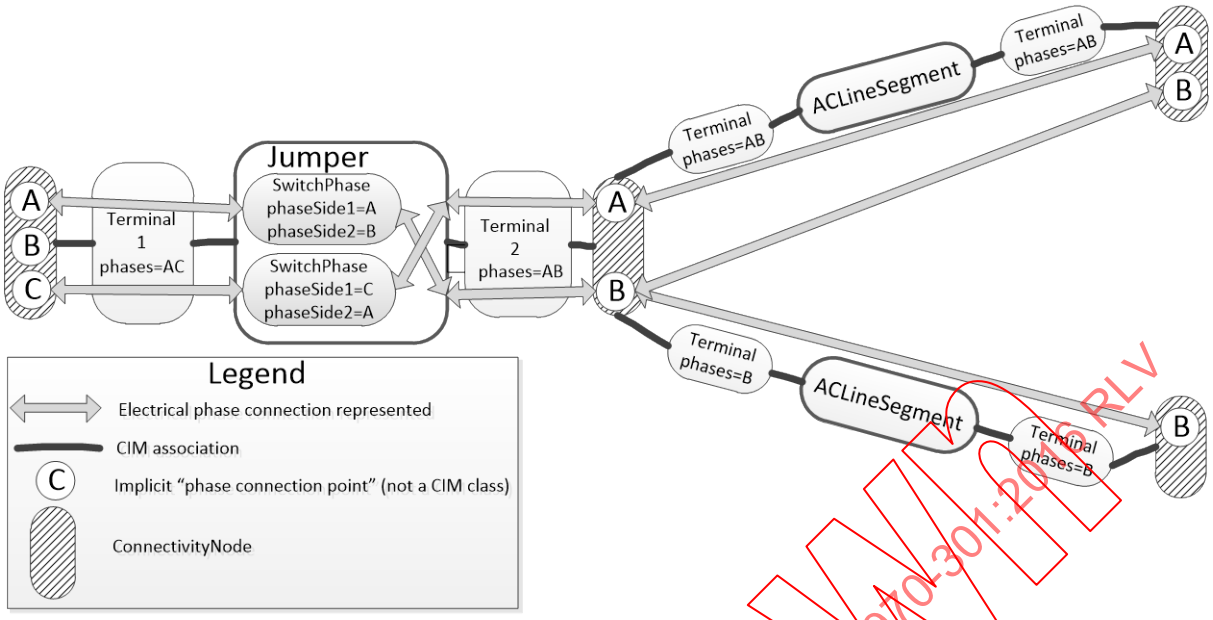


Figure 26 – Phase connectivity

As a clarification, the SwitchPhase attribute named phaseSide1 specifies any single phase (such as A, B, C, or N) and refers to the Terminal with sequenceNumber equal to 1. The SwitchPhase attribute named phaseSide2 refers to the Terminal with sequenceNumber equal to 2.

The switch model allows for cross phase connections to be modeled in general within the device. The transformer model also has explicit internal device modeling of phase connectivity. At this time all other ConductingEquipment branch specializations such as ACLineSegment assume like phases connect at both terminals. The CIM model is open for future extensions to introduce internal device phase connectivity.

4.5.9 Grounding devices modeling

4.5.9.1 Use case for modeling grounding devices.

These devices have significant impact on short circuit currents for unbalanced faults. The devices are switched around in operation with switches when transformer to line switching is reconfigured. Additionally Petersen coils are "tuned" to match the charging current expected from unbalanced faults. The impedance of Petersen coils can be "tuned" by adjusting a step position like a tap. This step position is telemetered sometimes. Sometimes a linear model is sufficient for relating step position to impedance value and sometimes a table is needed to reflect the non-linear relationship between step position and impedance.

4.5.9.2 Background and example

A Petersen coil is a grounding reactor, used in alternating-current power transmission systems, designed to limit the current flowing to ground at the location of a fault by setting up a reactive current to ground that balances the capacitive current to ground flowing from the lines. A design example is given in Figure 27.

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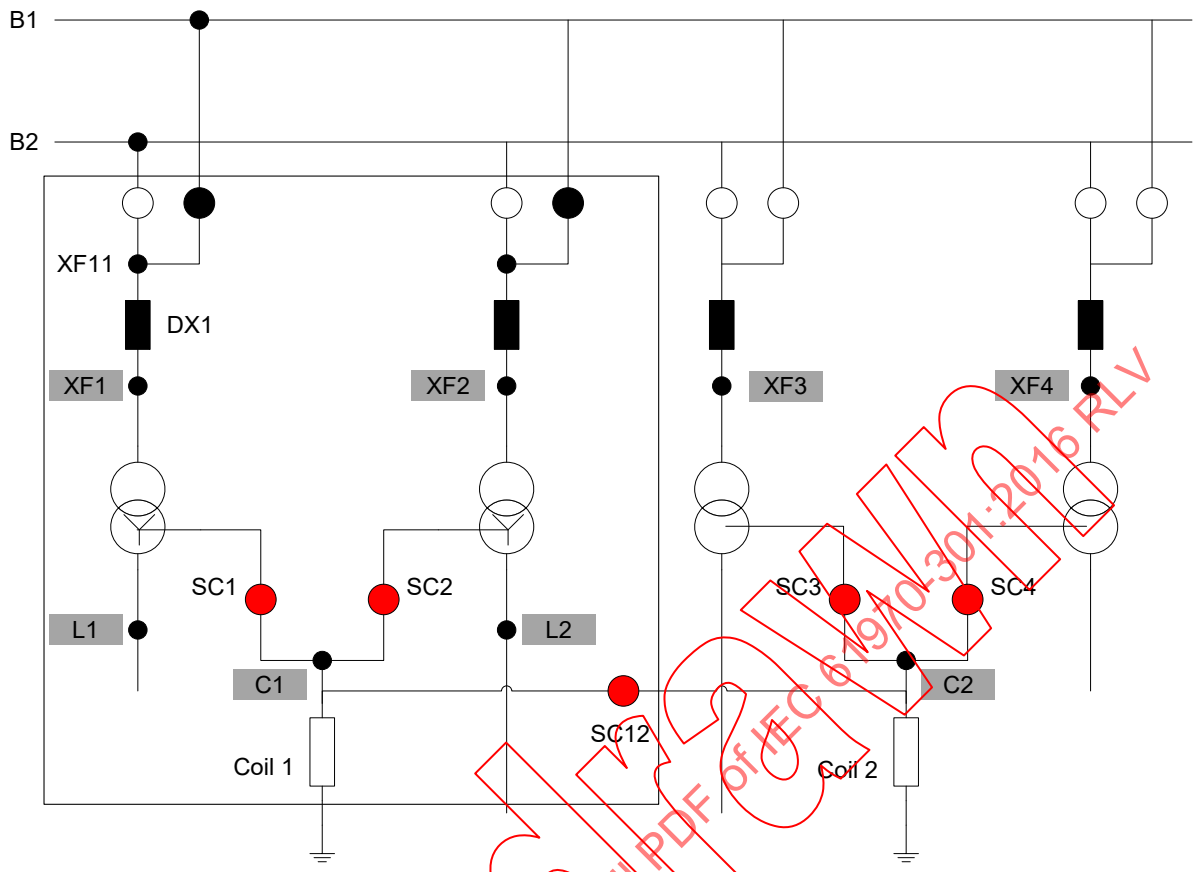


Figure 27 – Station including Petersen coils drawing example

In the example above, SC1, SC2, SC3, SC4 and SC12 are the ground circuit disconnectors. B1and B2 are busbar sections. XF1, XF2, XF3, XF4, C1, C2, L1 and L2 are connectivity nodes.

The grounding point in a transformer is the midpoint of the Y-connected windings and the ground circuit disconnectors are connected to these midpoints. In CIM the midpoint is described by the phasing attribute of the Terminal at the Y-connected windings. This means that ground circuit switches are connected to the connectivity node at the Terminal with the Y-connected windings. In Figure 27 this means SC1 is connected to L1 and SC2 is connected to L2 and that L1/L2 has the phases ABC as well as the N phase for the midpoint.

4.5.9.3 Model

The EarthFaultCompensator is a type of abstract conducting equipment intended to model grounding equipment. The EarthFaultCompensator is a specialization of ConductingEquipment because a short circuit requires proper connections and various switches may open or close to change the topology configuration. This is not the same thing as a branch like ACLineSegment, ShuntCompensator, or PowerTransformer; it does not regulate voltage and is never connected to Y or delta. A zig-zag grounding transformer is still a PowerTransformer, because of all the other complexities of the transformer. Two specializations are proposed to handle fixed impedance devices (GroundingImpedance) and adjustable (tunable) Petersen coil devices (PetersenCoil).

The EarthFaultCompensator could have either one or two terminals modeled. If the second terminal of an EarthFaultCompensator is omitted, it is assumed the terminal solidly connects to ground. If there is some kind of topology or local earth resistivity that is important to model on the ground side of the device, then a second terminal is added.

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A separate class for ground disconnector (GroundDisconnector) is included since these are typically physically very different from most other switches and often excluded from normal power flow analysis. For the data model refer to Figure 28.

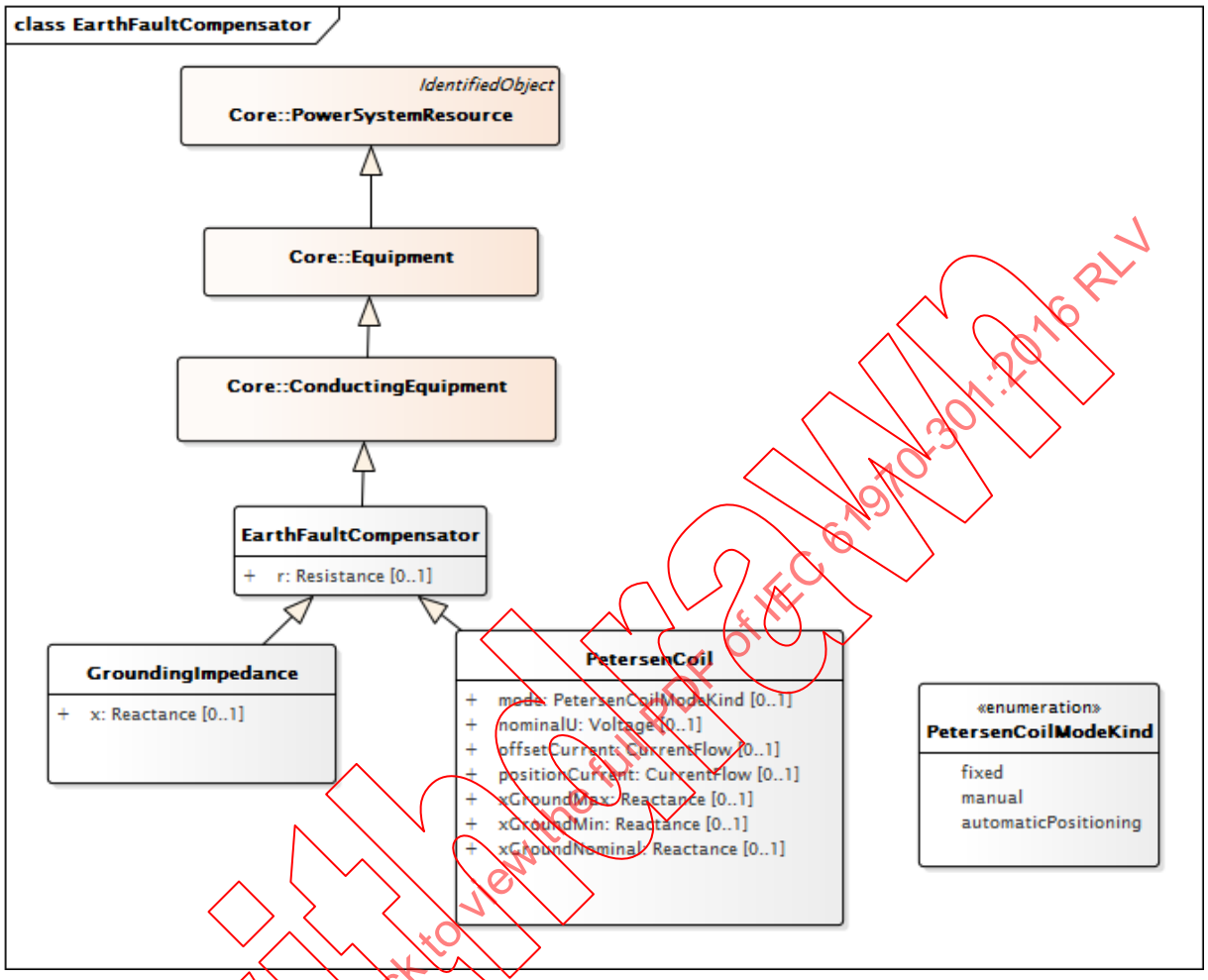


Figure 28 – Grounding device data model

4.5.9.4 CIM Instance model example

In Figure 29 the PetersenCoil is modeled as CIM objects with only one terminal and the grounding is implicit, which are a part of Figure 27.

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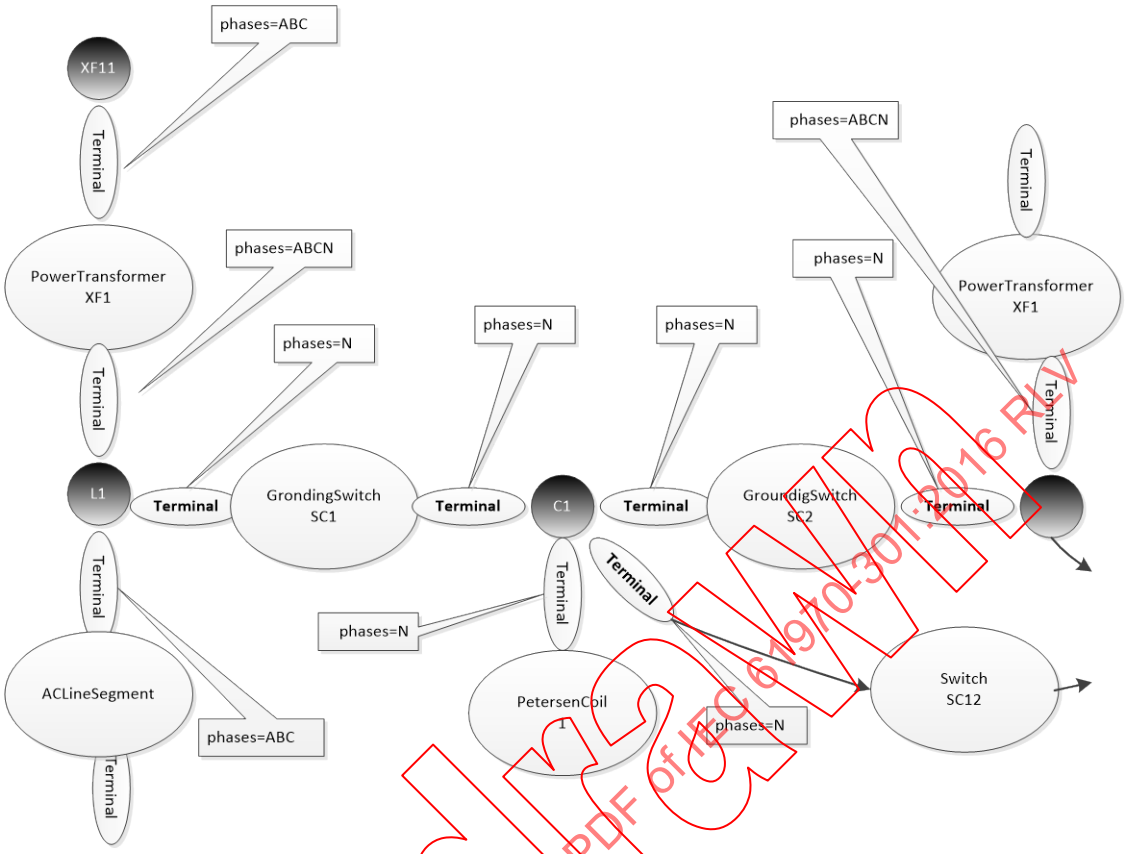


Figure 29 – Instance diagram objects with one terminal coil

Figure 29 shows how the switch SC1 has a Terminal with N phase and the transformer Terminal connected to L1 has the phases ABCN.

4.5.10 Cuts, clamps and jumpers model

The UML model for cuts and jumpers on a line segment and the additional connections are described in Figure 30. The Jumper class is a specialization of the more general Switch class and provides for phase crossings and phase connectivity as was illustrated in Figure 26. The jumpers therefore can connect terminals in the normal manner. The CIM classes Cut and Clamp provide a means to effectively add Terminals to an ACLineSegment at a specified distance down the line by associating new CIM objects to an ACLineSegment object, without other modification of ACLineSegment as-built model. Each Clamp instance introduces one new terminal connected at the specified distance down the line and without interruption of the line. Each Cut instance introduces two new terminals which are effectively the ends of the cut. By convention, each terminal of a cut is oriented toward the ACLineSegment terminal with the same sequenceNumber. If the cut is open, no flow passes through the ACLineSegment across the point of the cut, but flow can pass through either side of the ACLineSegment and through the appropriate cut terminal. Commonly, jumpers are connected to the ends of cuts, but they can also be connected to any type of conducting equipment in the normal manner using ConnectivityNode or TopologicalNode.

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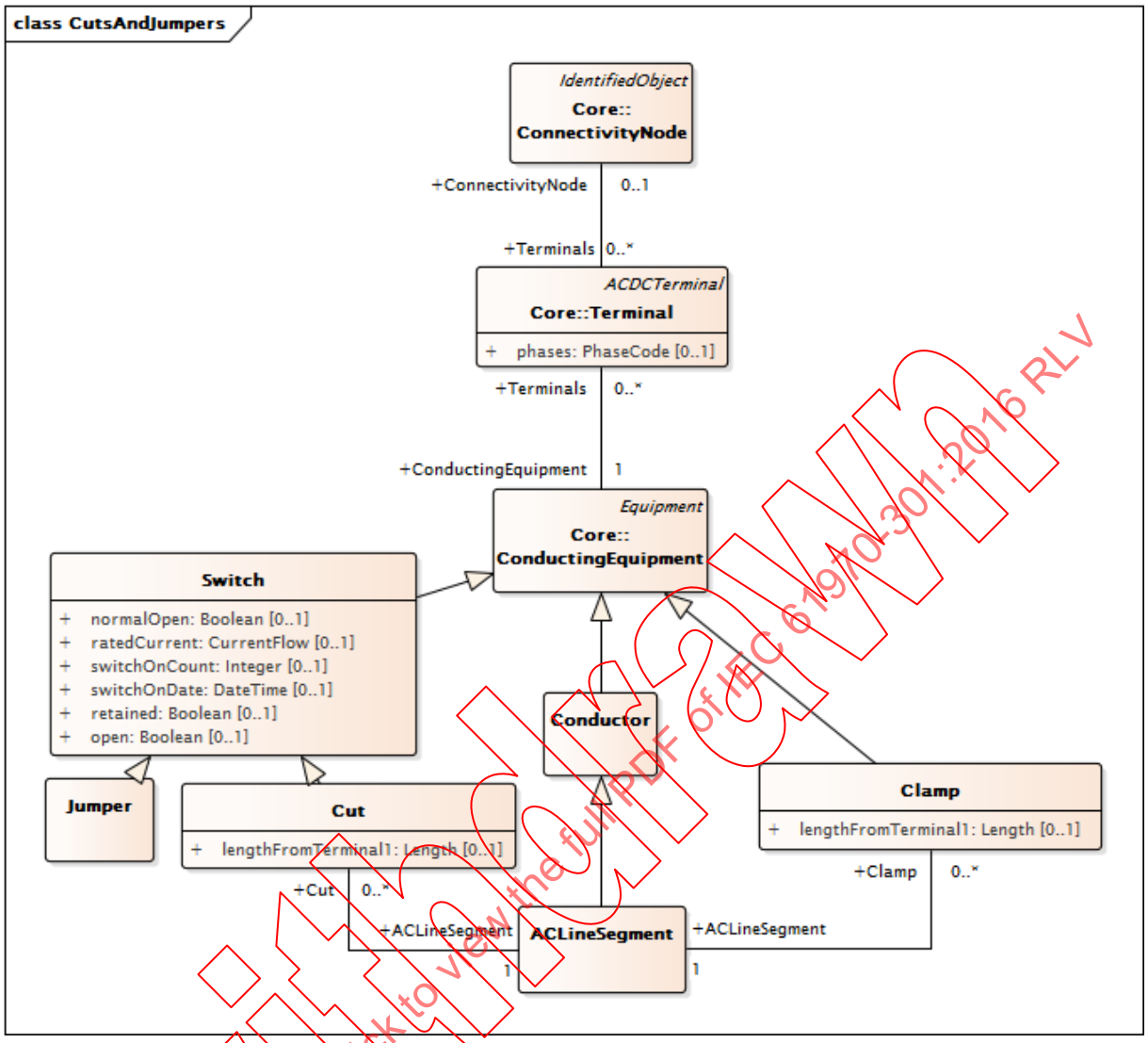


Figure 30 – Cuts, clamps, and jumpers UML model

An example of the addition of cuts and clamps to an existing CIM model is illustrated in Figure 31 and Figure 32. Figure 31 shows two physically parallel line segments named "FRED" and "LEROY". In this example the system is energized from the right, the switch on the left is closed, and the loads named "ONE" and "TWO" are being supplied. Then the three faults are applied at the specified distances from Terminal 1 of the respective line segments. In this example the phase detail is not specified for simplicity, but phase detail can follow the same approach outlined in 4.5.8.

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Figure 31 – Example before cuts and jumpers are applied

Figure 32 shows how the pure addition of Cut, ConnectivityNode, Jumper, Clamp and potentially other ConductingEquipment can represent model changes reflecting typical temporary work. These same models can also be used for permanent model changes. The example shows how cuts applied at the specified distances can isolate the faults, leaving the faulted ends of cuts dangling, while the unfaulted network is connected to supply the loads. This example also demonstrates how multiple cuts can be applied to one line segment. This example shows open cuts, but if a cut were closed, flow could continue through the ACLineSegment with part of the flow potentially redirected to the terminals of the cut, much like the case for a clamp.

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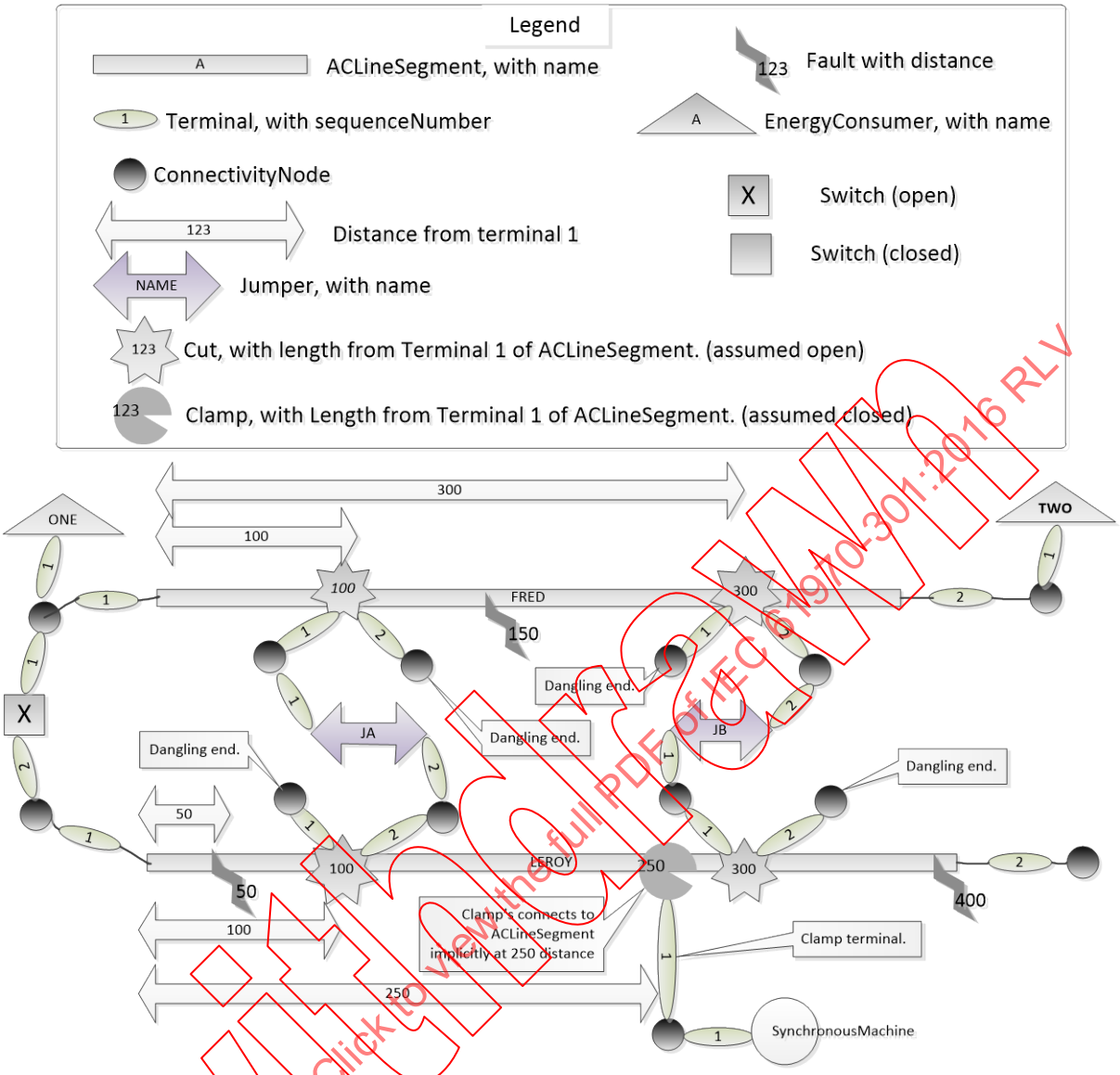


Figure 32 – Example after cuts and jumpers are applied

A cut provides two terminals, and although not shown in the example above, connections could be made to either or both terminals of the cut. An example case might involve introducing a cut and connecting both cut terminals with a jumper that crosses phases.

A jumper may be used without clamps or cuts in a situation where existing terminals are to be connected. Figure 33 shows an example of using a jumper without a cut or clamp. In this case a temporary jumper might be used to bypass a switch under maintenance.

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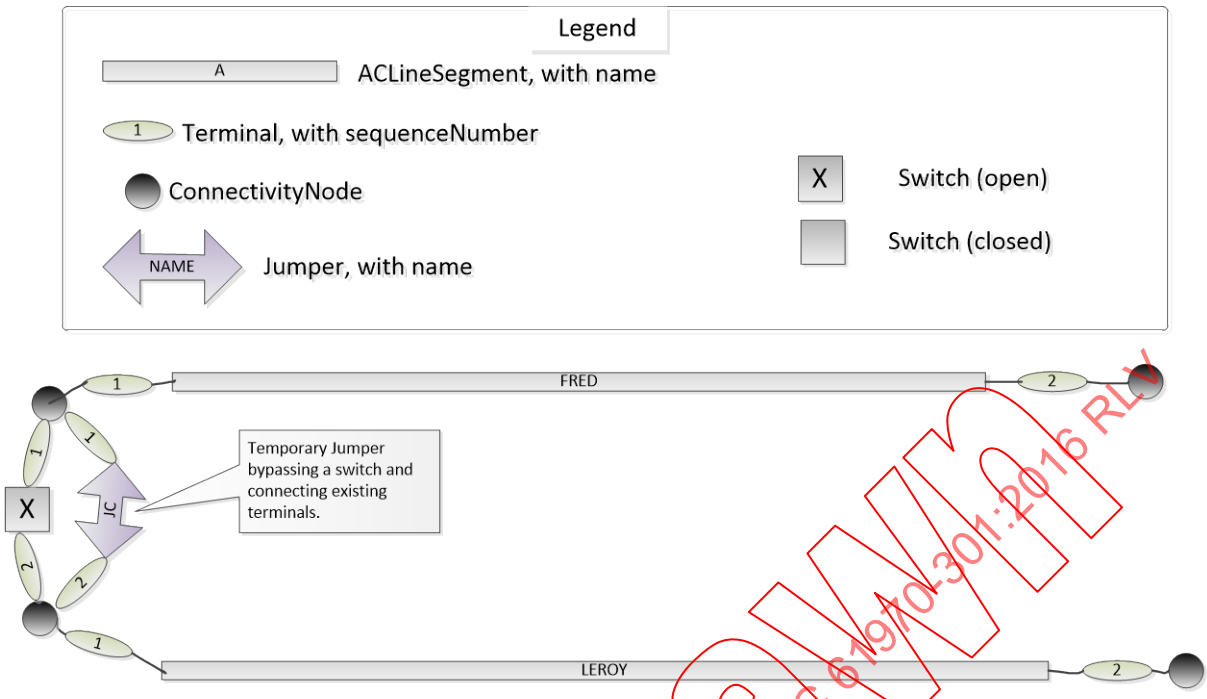


Figure 33 – Example of jumper without cut or clamp

4.5.11 Measurements and controls

4.5.11.1 Measurement overview

Measurements are used to represent the state variables that can be found in industrial processes. Each industrial process has its specific types of measurements. A power system typically has power flows, voltages, positions (e.g. breakers, isolators), fault indications (air pressure, oil pressure over temperature, etc.), counters (e.g. energy), etc.

The name "Measurement" would seem to indicate that all the state variables are measured. This is not always strictly the case as many measurements are calculated by SCADA or EMS/DMS functions, such as state estimator or power flow calculations. As a consequence, a measurement may have a number of alternate values (e.g. manually supplied, telemetered, state estimated, optimized etc.). This is supported by the Measurement and MeasurementValue models in the Meas package. The classes in the StateVariable package have been added to the CIM model specifically for the purpose of supporting exchange of values calculated by functions such as state estimator and power flow.

The measurement model now allows for optionally specifying the specific phases of a measurement.

4.5.11.2 Control overview

Controls are used to represent control variables. Power system control variables typically are set points, raise/lower commands, select before execute commands and on/off commands. The Meas package supports control variables with the Control model.

4.5.11.3 Use of measurement-related classes

A PowerSystemResource (PSR) may have zero to many measurements associated with it by containing one or more measurements. Each measurement may have one or more measurement values. Observing the following guidelines will enable applications to navigate and find the required measurement values in a consistent way (see Figure 34).

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a) Measurements of a PowerSystemResource are classified by the attribute measurementType. The values to be used for Measurement.measurementType are specified in Table 7.

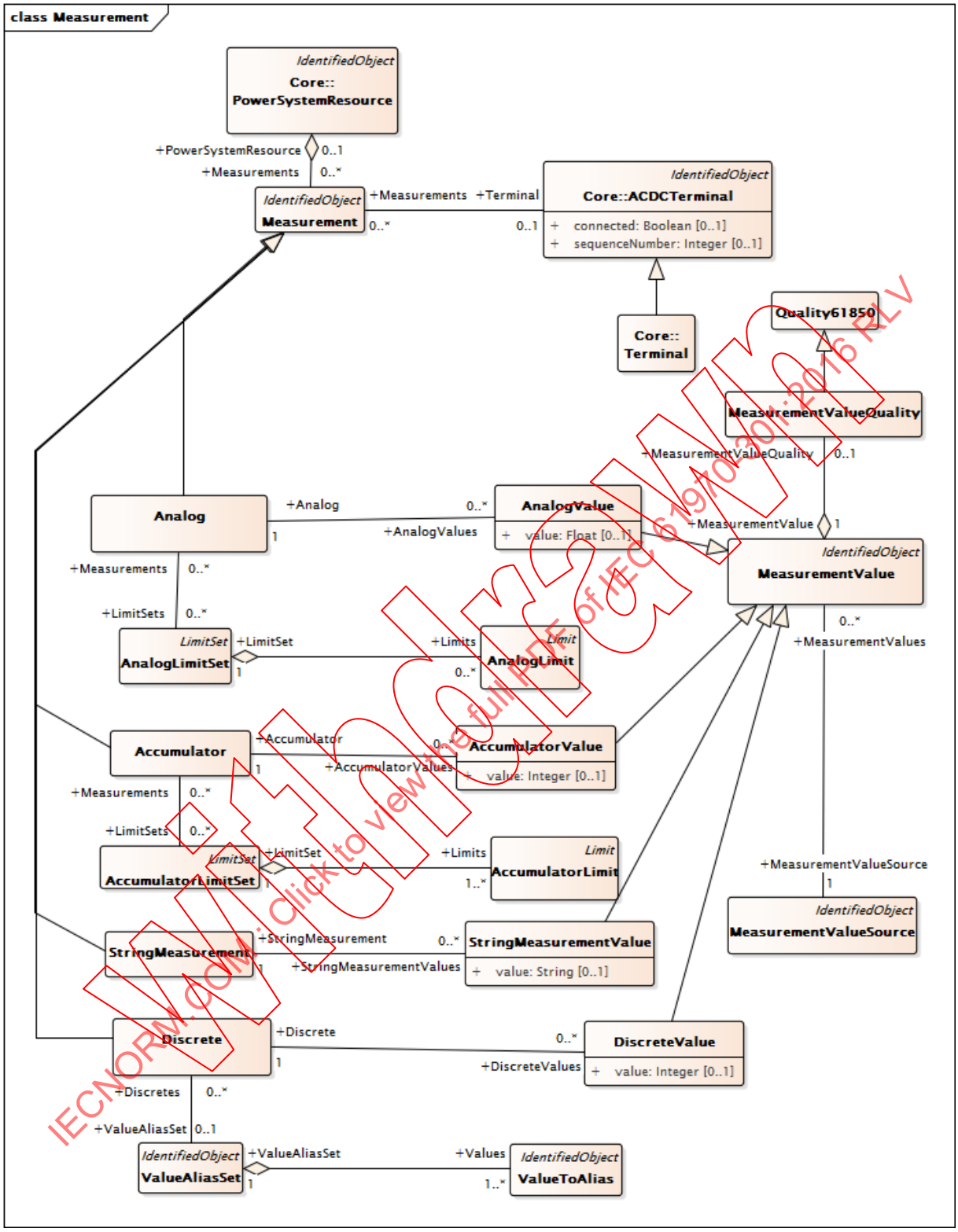
b) MeasurementValues of a Measurement are classified by MeasurementValueSource.

c) MeasurementValueSource inherits from IdentifiedObject. The values to be used for MeasurementValueSource.name are given in Table 8. This table provides a number of source names to be used where possible. However, the exact names to be used for specific applications are defined in related IEC 61970 Component Interface Specifications (CIS).

d) The tables may be extended for proprietary needs. The names added shall start with a unique name (e.g. the company name) and an underscore. Example: xyz_AverageTemperature.

e) The ValueAliasSet is used for discrete measurements and describes mappings from values to symbolic names, such as enumeration literals having specific integer values. Different communication protocols (e.g. for RTUs and for control centres such as ICCP or ELCOM) use different data encodings. A system may have a system wide mapping for all Discrete values or group the Discrete values and make a mapping per group. Creation of a single system wide mapping that covers existing communication protocols is outside the scope of this document.

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Figure 34 – Navigating from PSR to MeasurementValue

Table 7 – measurementType naming conventions

measurementType	61850 Name	description
Current	Amp	Current (rms) of a non-three phase circuit
ThreePhaseCurrent	AvAmps	Total current (rms) in a three phase circuit
PhaseCurrent	A	Measured phase current.
Frequency	Hz	Frequency
PowerFactor	PwrFact	Power factor not allocated to a phase
ThreePhasePowerFactor	TotPF	Average power factor in a three phase circuit
ThreePhaseApparentPower	TotVA	Total apparent power in a three phase circuit
ThreePhaseReactivePower	TotVAr	Total reactive power in a three phase circuit
ThreePhaseActivePower	TotW	Total real power in a three phase circuit.
ApparentPower	VolAmp	Apparent power in a non-three phase circuit
ReactivePower	VolAmpr	Reactive power in a non-three phase circuit
Voltage	Vol	Voltage (rms) not allocated to a phase
ActivePower	Watt	Real power in a non-three phase circuit
Pressure	Pres	Pressure
Temperature	Tmp	Temperature
Angle	Ang	Angle between voltage and current
ApparentEnergy	TotVAh	Apparent energy
ReactiveEnergy	TotVArh	Reactive energy
ActiveEnergy	TotWh	Real energy
Automatic	Auto	Automatic operation (not manual)
LocalOperation	Loc	Local operation (not remote)
SwitchPosition	Pos	Switch position [2bits= intermediate,open,closed,ignore]
TapPosition	TapPos	Tap position of power transformer or phaseshifter
Operation Count	OperCnt	Operation count – typically for switches
LineToNeutralVoltage		Line to neutral voltage.
LineToGroundVoltage		Line to ground voltage.

Table 7 describes various types of measurements also defined in IEC 61850. The meanings of the columns in Table 7 are as follows:

- measurementType (Measurement.measurementType) is the IEC 61970 measurement type name.
- 61850 Name is the name assigned to the data object in IEC 61850. IEC 61850-7-4:2010, data object name semantics).
- description is the description of the data.

It shall be noted that Table 7 is not an exhaustive list and that the mapping between measurements as defined in a control centre and a substation is non-trivial.

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Table 8 – MeasurementValueSource naming conventions

Name	description
SCADA	Telemetered values received from a local SCADA system
CCLink	Value received from a remote control centre via TASE.2 or other control centre protocol
Operator	Operator entered value (always manually maintained, PSR is not connected to an RTU)
Estimated	Value updated by a state estimator
PowerFlow	Value updated as result of a Powerflow
Forecasted	Value that is planned or forecasted.
Calculated	Calculated from other measurement values (e.g. a sum)
Allocated	Calculated by a load allocator

Following these conventions:

- each Measurement instance represents a technological quantity of a PowerSystemResource;
- each MeasurementValue of a Measurement represents a value for the technological quantity, as supplied from a single source;
- the source attribute in MeasurementValueQuality then indicates whether the source actually provided the current value, or whether it had been substituted or defaulted.

Note that a new MeasurementValue identity is not normally created for each exchange of a measured value. It is expected that the same MeasurementValue instance could exchange new values in subsequent messages. Therefore the identity of a MeasurementValue instance can be established a priori to exchange of measured values. The modeling of a time series of values is not explicitly expressed in the CIM model, though the model allows for systems to internally build such time series models through a series of measurement value exchanges.

4.5.11.4 Attachment of measurements

As mentioned in 4.5.11.3 and as shown in Figure 34, Measurements are contained by a PowerSystemResource. This is sufficient for Measurements that are not related to connectivity, e.g. temperature, weight, size.

To specify the location of a Measurement in the network, an association to Terminal is used. Examples include power flows, voltages, and currents. Voltages have no direction and can be attached wherever appropriate in relation to the sensor placement. Flows have direction and shall be attached such that the flow direction is evident from the placement.

Figure 35 shows two examples of the placement of Measurements.

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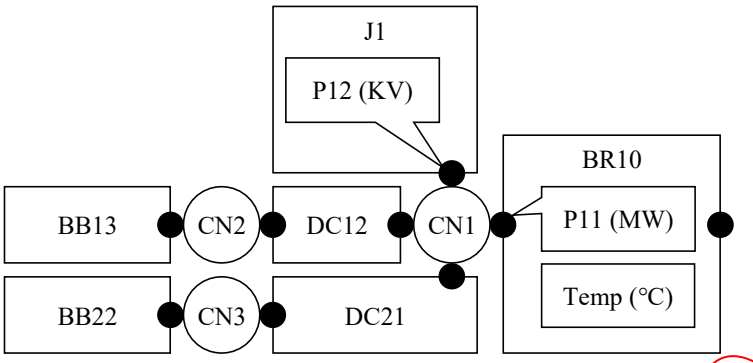


Figure 35 – Measurement placement

P12 is a voltage Measurement that measures the voltage at the Junction J1. P12 is topologically related to the ConnectivityNode CN1 via the Terminal in Junction J1. P11 is a Measurement that measures the flow through Breaker BR10 at the side connected to the ConnectivityNode CN1. P11 is topologically related to the ConnectivityNode CN1 via the left Terminal in Breaker BR10. Temp is a Measurement that measures the Breaker temperature. As a temperature is not related to connectivity, it has no relation to a Terminal – it just belongs to the Breaker BR10.

4.5.11.5 ICCP measurements

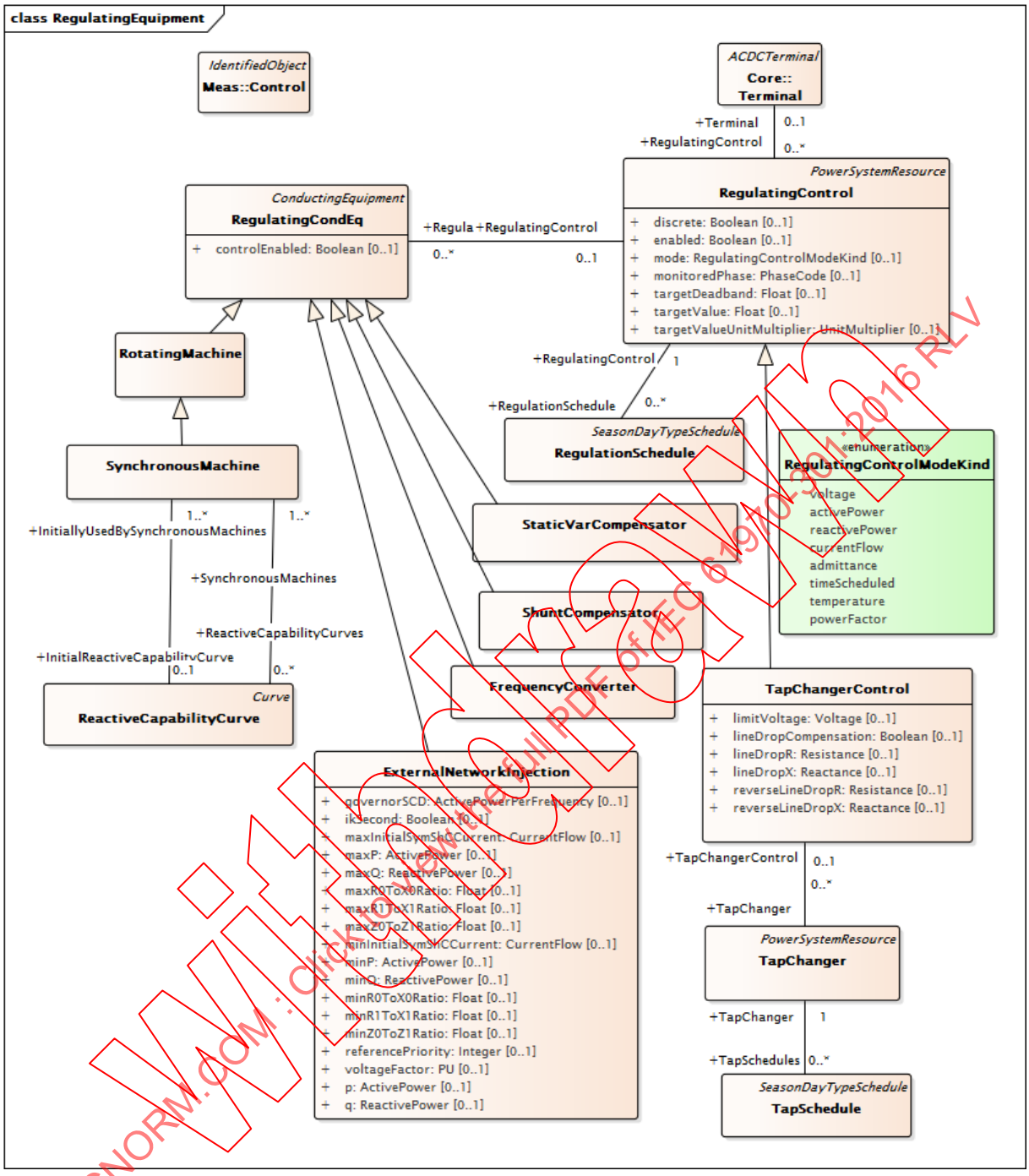
ICCP (known officially as IEC 60870-6 TASE.2) data sources are specified using the MeasurementValue classes (and its specializations) and the MeasurementValueSource class. The MeasurementValueSource class is used to define the control centre supplying the ICCP data. The MeasurementValueSource shall be associated with an instance of Name where the attribute Name.name holds the name of the supplying control centre. The instance of NameType associated with the control centre Name shall have the NameType.name attribute set to “ICCP”.

The MeasurementValue classes are used to specify the ICCP ID. The MeasurementValue shall be associated with an instance of Name where the attribute Name.name holds the ICCP ID. The instance of NameType associated with the ICCP ID Name shall have the NameType.name attribute set to “ICCP”. The MeasurementValue.name attribute holds the SCADA point name. Each MeasurementValue will be associated with one Measurement. Each MeasurementValue being supplied via ICCP shall also have an association to a MeasurementValueSource.

4.5.12 Regulating control models

Regulation control, such as automatic voltage control at generators or voltage tap control at transformers is modeled using the RegulatingControl class which provides the capability to model multiple instances of equipment participating in a regulation scheme. These regulation schemes may be physical or manually implemented in actual power system operation, but are reflected in the models used for power system analysis purposes. Figure 36 shows how RegulatingCondEq and TapChanger classes can participate in regulation.

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Figure 36 – Regulating control models

4.5.13 DC model for CIM

4.5.13.1 General

Control systems modeling HVDC stations typically have three levels of detail:

- simplified system model used in operations and planning;
- simplified system model supporting dynamic studies;
- detailed for transient studies of an HVDC station.

The purpose of this document is to outline the most minimal HVDC model possible for use in SCADA/EMS/planning power flow, short circuit calculations and dynamic studies. Transient studies are not covered.

4.5.13.2 HVDC basic design

4.5.13.2.1 General

The proposed model is based on the following documents:

- IEC 60633:1998+AMD1:2009, *Terminology for high-voltage direct current (HVDC) transmission*
- "VSC Transmission", CIGRÉ B4-37 April 2005
- IEC 62747, *Terminology for voltage-sourced converters (VSC) for high-voltage direct current (HVDC) systems*
- HVDC Transmission by Dennis A. Woodford, Manitoba HVDC Research Centre
- "ABB technical description of HVDC light technology"
- Flexible Power Transmission. Jos Arrillaga, Y. H. Liu, Neville R. Watson, 2007
- "Power System Stability Benefits with VSC DC-Transmission Systems", CIGRÉ B4-204, 2004

4.5.13.2.2 CSC Topology

A current source HVDC link is modeled as shown in Figure 37.

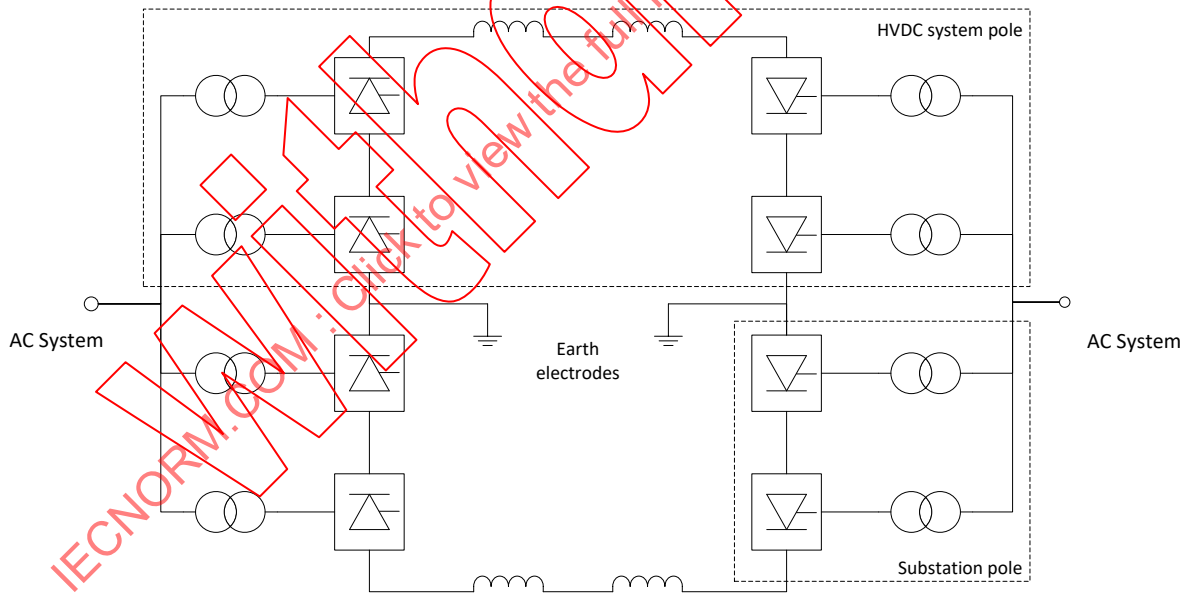


Figure 37 – HVDC bipolar link from IEC 60633

HVDC Bipolar link consists of two poles, one with positive polarity and another with negative polarity having both their natural points grounded. No current flows in the ground return because the current flowing in the poles is the same.

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4.5.13.2.3 VSC Topology

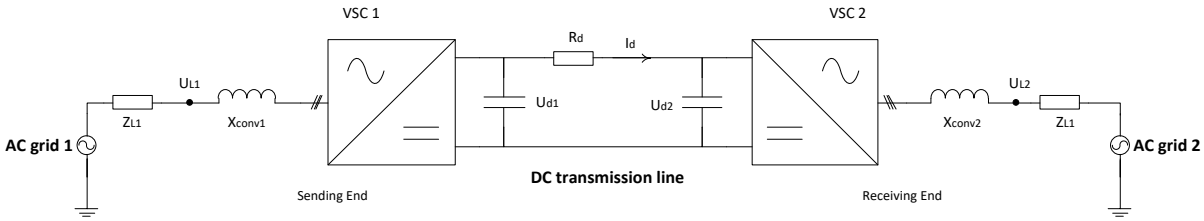


Figure 38 – A point-to-point VSC transmission scheme

The point-to-point VSC transmission scheme shown in Figure 38 consists of two VSCs interconnected on the DC side via a DC transmission line and connected to two different AC systems on the AC side. One of VSC characteristics is that the DC voltage polarity is always the same. Therefore, the direction of the power flow on the DC line is determined by the direction of the DC current.

The direction of a DC current is always from a higher DC voltage level to a lower DC voltage level. The DC voltage at the sending end of the DC line shall therefore be higher than DC voltage at the receiving end.

In line-commutated converter (LCC) HVDC, the DC line power flow can be controlled by holding the DC voltage at the receiving end converter (the inverter) at a constant value, and by letting the sending end converter (the rectifier) control the DC current. The same approach can be used in VSC transmission. However, one main difference is that in LCC HVDC the current direction is always the same; therefore, the power direction is changed by changing the DC voltage polarity.

4.5.13.3 HVDC power flow modeling

4.5.13.3.1 General

A power flow model derived from Figure 38 is shown in Figure 39.

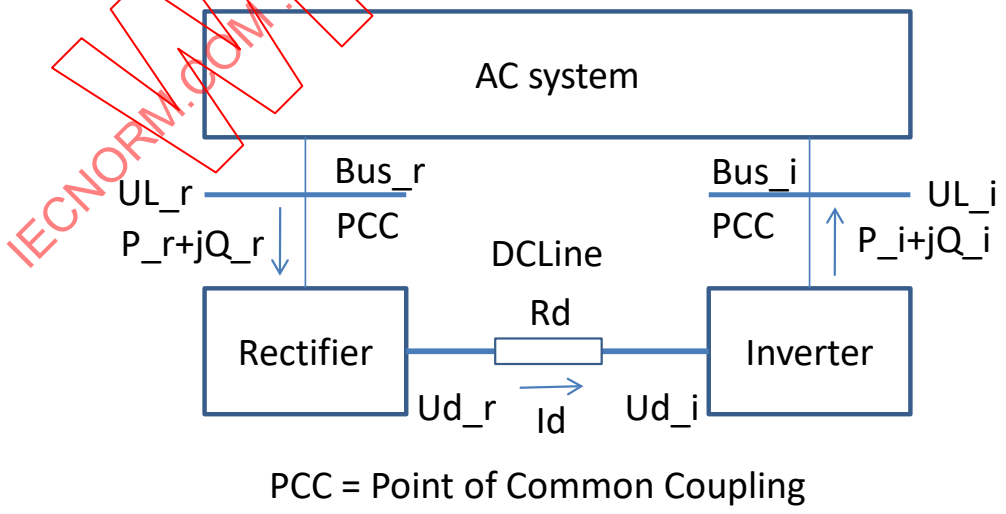


Figure 39 – HVDC power flow model

The AC side variables are as follows:

- *P* is the AC side active power injection at the rectifier (index r) and inverter (index i).

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- Q is the AC side reactive power injection at the rectifier (index r) and inverter (index i).
- U_L is the AC side voltage at the rectifier (index r) and inverter (index i).

The DC side variables are as follows:

- U_d is the DC voltage at the rectifier (index r) and inverter (index i).
- U_{dN} is the rated DC voltage.
- I_d is the DC line current.
- I_{dN} is rated DC line current.
- R_d is the DC line resistance.

The interface between the HVDC system and the AC system are the two busses Bus_r and Bus_i. The voltage at Bus_r is U_{L_r} and the voltage at Bus_i is U_{L_i}. Power injected into the Rectifier from the AC system is $P_r + jQ_r$ and power injected into the Inverter is $P_i + jQ_i$ .The busses Bus_r and Bus_i are from the AC system seen as PQ nodes for current source HVDC and PV nodes for voltage source HVDC. For PQ nodes the injections $P_r + jQ_r$ and $P_i + jQ_i$ and for PV nodes the active power injection and voltage P_r, UL_r and P_i, UL_i are computed from the HVDC link. Initial conditions for the HVDC link are given in two ways.

- P_r or P_i
- U_{d_r} or U_{d_i}

The relations between the variables are $I_d = P_r / U_{d_r} = P_i / U_{d_i}$.

The power flow is illustrated in Figure 40 and Figure 41.

4.5.13.3.2 Current Source Converter

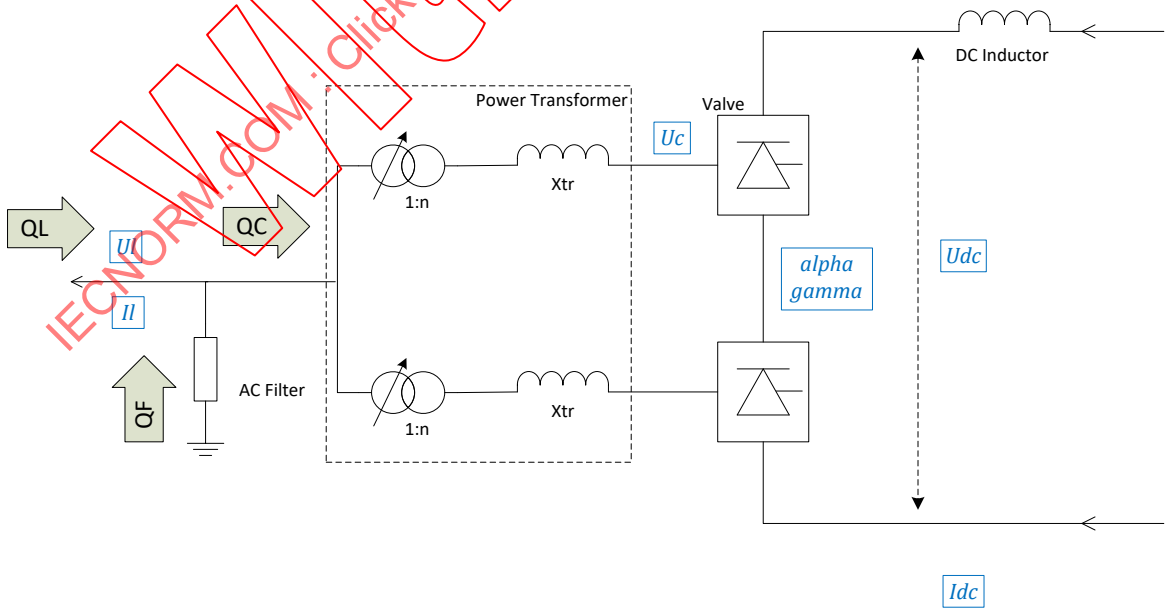


Figure 40 – Current Source Converter power flow

In a current source converter the reactive power is not controlled. Instead it is determined by the bridge firing angle that impacts the power factor:

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- α is the firing angle, typical value between 10° and 18°
- $U_d = U_{d0} \times \cos\alpha - \left(\frac{3}{\pi}\right)\left(\frac{X_{tr}}{2}\right) I_d$
- the rated direct voltage: $U_{d0} = \left(\left(3 \times \sqrt{2}\right)/\pi\right) \times U_C$
- $U_t = U_L \times tapratio$

The approximation of reactive power injection could be presented in the following way:

- $Q_L = Q_C - Q_F = \left(\frac{P}{2}\right) - Q_F \approx \frac{P}{2}$

4.5.13.3.3 Voltage Source Converter

The electrical components and their interconnections within a converter are shown in Figure 41. Figure 41 is the reference for the formulas in 4.5.13.3.3.

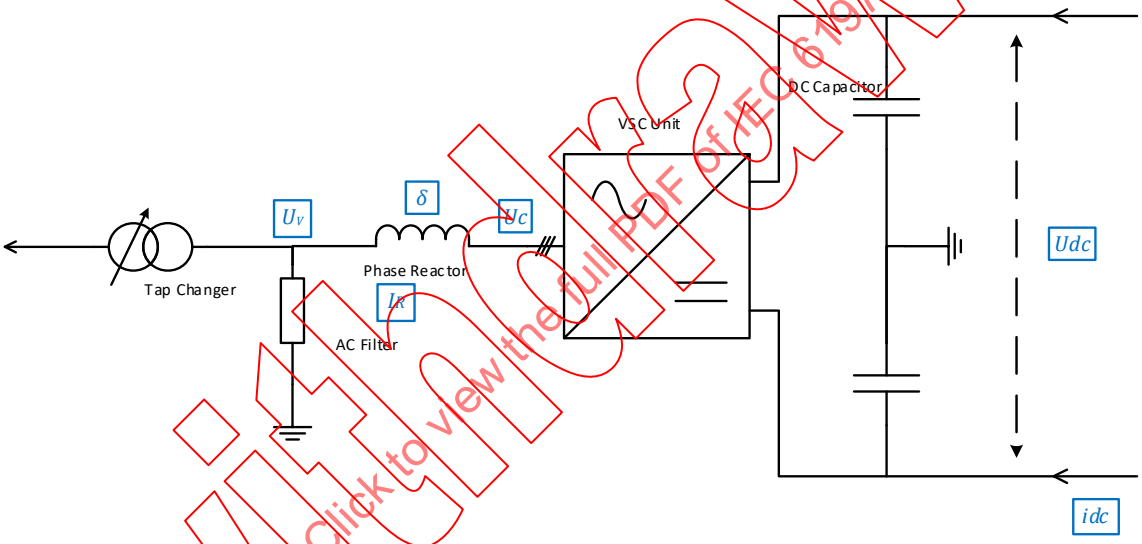


Figure 41 – Voltage Source Converter power flow

Additional parameters to those previously listed are as follows:

- U_{dc} is the voltage at the DC side of the VSC Unit.
- I_{dc} is the current at the DC side of the VSC Unit.
- U_C is the voltage at the AC side of the VSC Unit, also called converter voltage.
- U_V is the voltage at the filter bus.
- modulation index is the ratio between U_{dc} and U_C, this is a VSC parameter and has typical values between 0 and 1
- I_R is the current through the phase reactor.
- X_C is the phase reactor reactance.
- δ is the angle between the U_V and U_C voltages.

The diagrams in Figure 42 show the voltage vectors and the resulting power flow cases.

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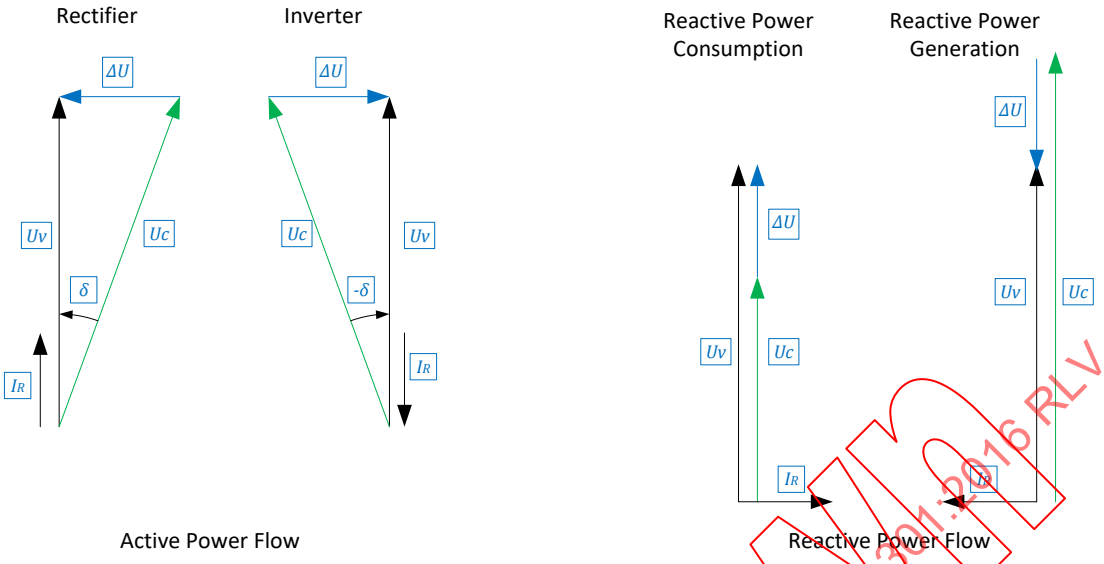


Figure 42 – Power flow cases

The behavior of the Rectifier and Inverter can be described by a set of formulas having the following parameters, some of which are shown in Figure 39 and Figure 41.

- U_{rated} is the converter rated AC voltage (one each for rectifier and inverter).
- S_{rated} is the converter rated AC power.
- R_C is the phase reactor resistance.
- number of converter bridges (one each for rectifier and inverter).
- I_{dmax} and I_{dmin} are the DC flow upper and lower limits.
- R_d is the DC line resistance.
- The active and reactive components (refer to Figure 42) are computed as $P = U_V \times U_C \times (\sin(\delta)/X_C)$.
- $Q = U_V \times (U_V - U_C) \times (\cos(\delta)/X_C)$.

The losses at a pole are described by the equation:

- $P(poleLoss) = idleLossFactor + switchLossFactor \times I_{dc} + resistiveLossFactor \times I_{dc} + resistiveLossFactor \times I_{dc}^2$

where

- $P_{dc} = P_{ac}$ for lossless operation;
- $P_{dc} = P_{ac} - P_{loss}$ for rectifier operation with losses;
- $P_{dc} = P_{ac} + P_{loss}$ for inverter operation with losses.

Figure 43 shows a diagram for a symmetric monopole Voltage Source Converter.

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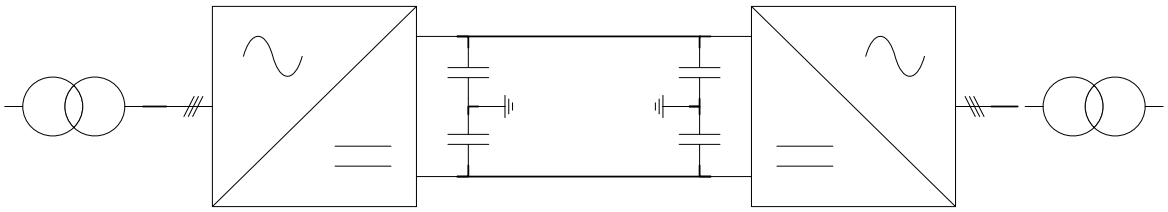


Figure 43 – VSC transmission with a symmetrical monopole illustrated with capacitive earthing on the DC side (IEC 62747)

By controlling the angle δ between the voltages U_V/U_C and voltage difference $U_V - U_C$, independent active and reactive power control is achieved.

Limitations of the VSC results in a *P*-*Q* curve. An example *P*-*Q* curve is shown in Figure 44.

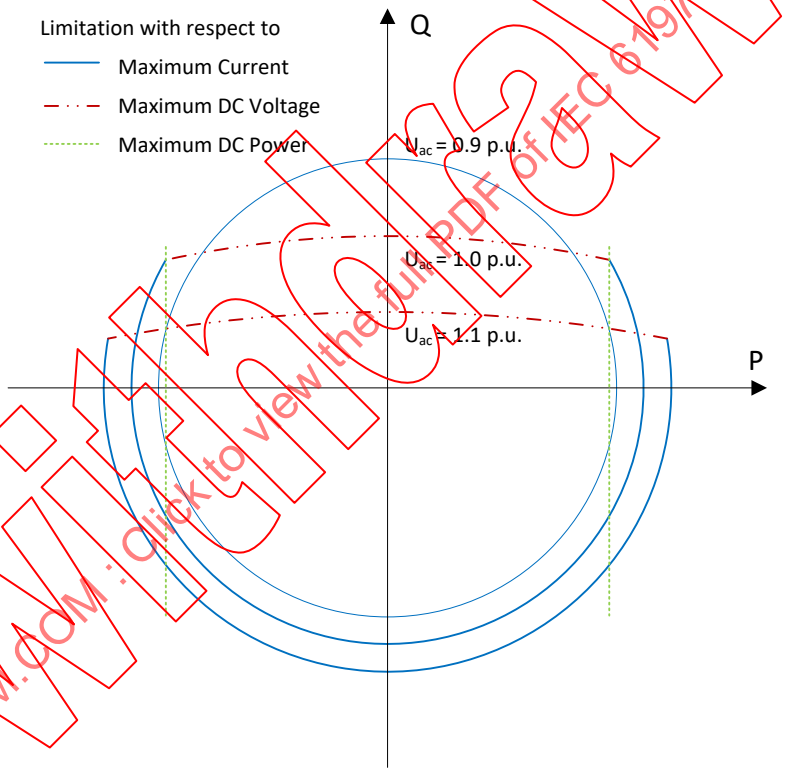


Figure 44 – VSC *P*-*Q* capability curve

It is also possible to use VSC in bipolar configurations as shown in Figure 45.

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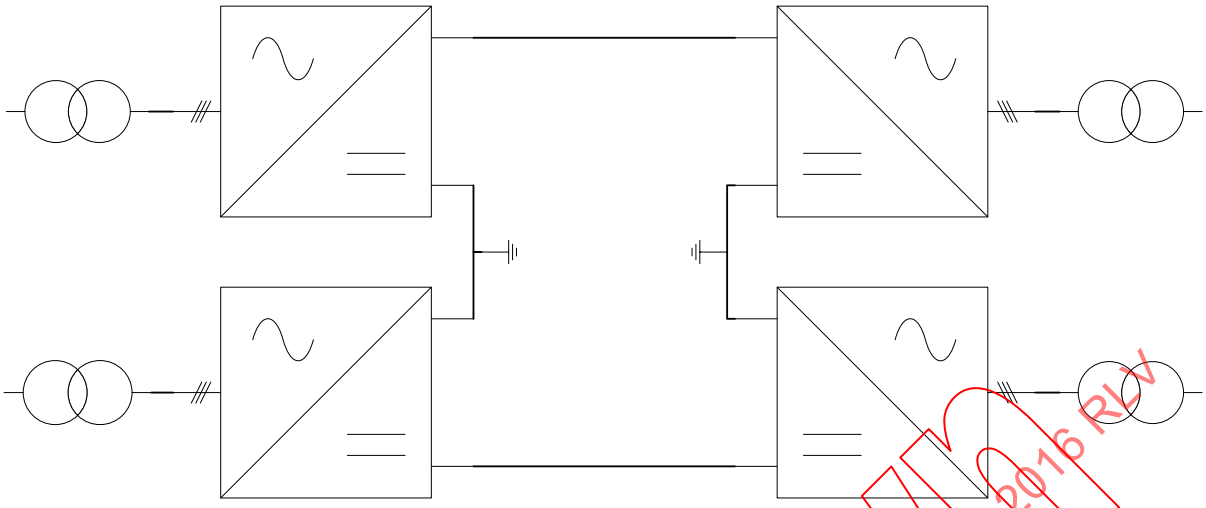


Figure 45 – Bipolar VSC transmission with earth return (IEC 62747)

In this configuration two high voltage DC cables are used for the positive (+DC) and negative (−DC) voltages. A medium voltage cable is used for the neutral.

4.5.13.4 Data model

4.5.13.4.1 General

A data model is created using the following assumptions.

- The DCConverterUnit in CIM is identical with IEC 60633 Substation Pole that is a container.
- The old CIM RectifierInverter is identical with the Converter.
- The IEC 60633 System Pole is not modeled in CIM. The reason is that the IEC 60633 System Pole is not relevant in DC grids. The bridges, filters and bridge units are not modeled explicitly in CIM and are considered part of the Converter.
- Using ConnectivityNode and Terminal for the connectivity also in DC grids enables DC and AC components to be connected together, which is an error. Attributes will also have different meanings in AC and DC grids, e.g. DCNode does not have phase angle or reactive power injection. Hence different artifacts are used to describe AC and DC grids.

Figure 46 shows an example with the modeled objects of a bipolar current source HVDC line.

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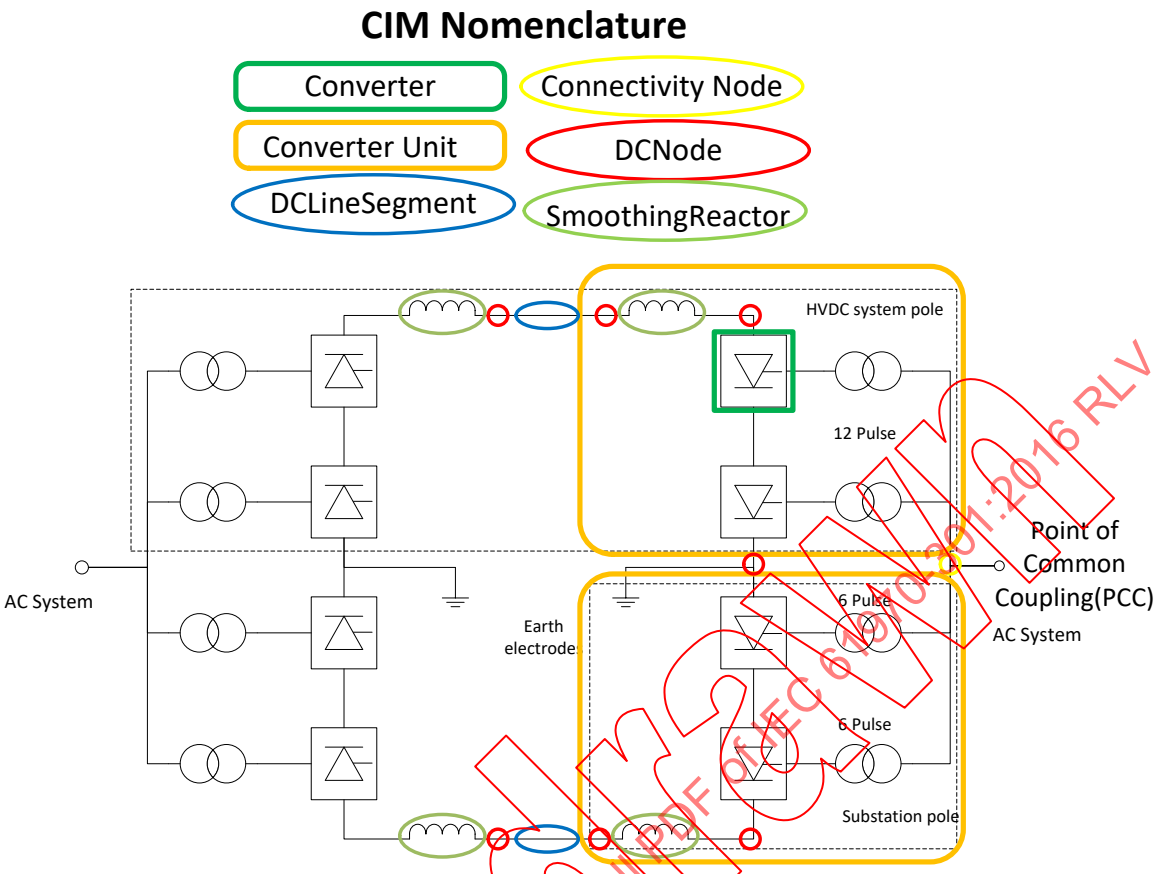


Figure 46 – Object instances for a bipolar current source HVDC line

The Converter Unit is the object bridging the AC and DC networks.

The corresponding diagram for VSC is shown in Figure 47.

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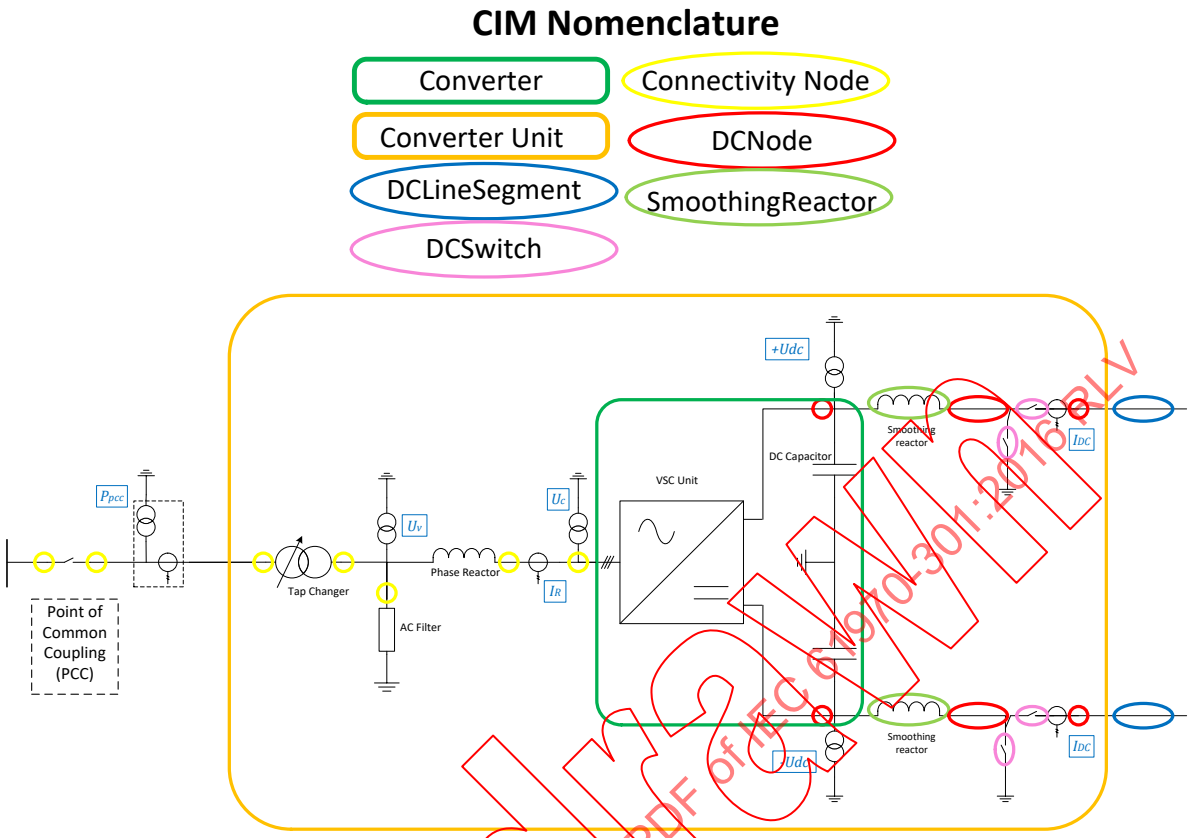


Figure 47 – Object instances for symmetric monopole VSC HVDC data model

As indicated in Figure 46 and Figure 47, an HVDC substation consists of

- one or more Converters;
- SmoothingReactors;
- DC switches for reconfiguration of the DC-lines;
- a Point of Common Coupling (PCC) that is the interface with the AC system.

A Converter consists of one or more sets of

- bridges;
- a PowerTransformer;
- an AC filter;
- a converter or phase reactor for VSC, in multi-level HVDC several Bridges exists in the converter arms. The Converter reactor is then part of the arms rather than a single reactor as shown in Figure 47;
- breakers and disconnectors.

HVDC Link can be operated in different ways:

- bipolar, refer to Figure 45;
- symmetrical monopole with capacitive earthing on the DC side – refer to Figure 43;
- asymmetrical monopole with ground return – this lower active power capacity and sustained operation is not allowed;
- asymmetrical monopole with metallic return – this lower active power capacity and sustained operation is allowed.

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A Converter with several Bridges may have the capability to reconfigure how Bridges are connected. A reconfiguration normally results in down rating of limits.

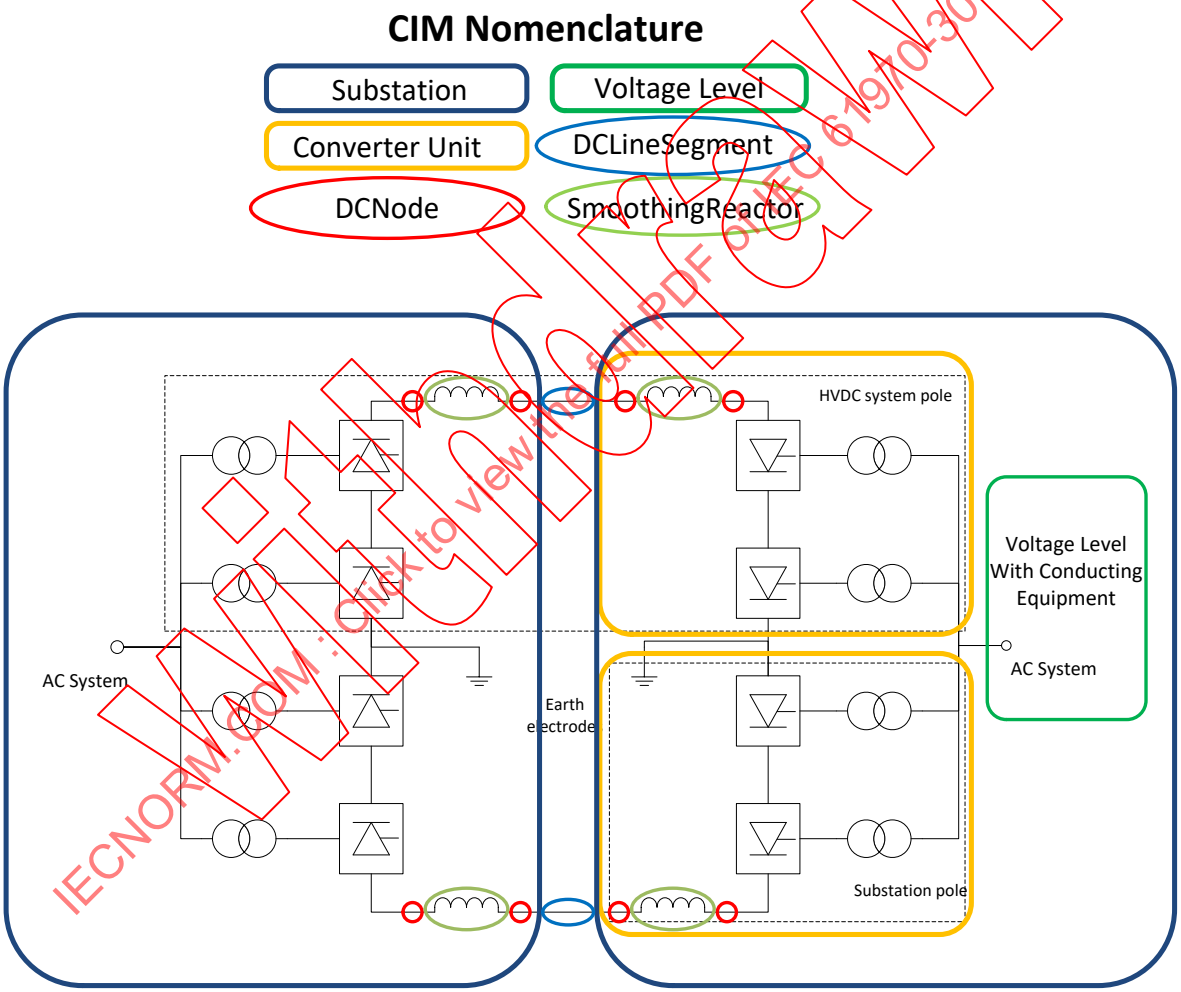
An HVDC substation sends operational status as SCADA signals to a superior SCADA. In bipolar operation mode, down rated Converter limits are typically sent to the superior SCADA.

The containment structures for two cases are shown in Figure 48 and Figure 49.

For the transformers note that

- they are not in a Substation but a DCConverterUnit;
- no VoltageLevels exist at the low and high voltage sides of a transformer.

Hence the containment rules for transformers in the AC network are replaced by rules specific to the DCConverterUnit.



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Figure 48 – Containment structure for a bipolar HVDC line

The two DCLineSegments are part of a Line. The reason is that the DCLineSegments typically are at the same tower or in the same cable channel.

The two substations are regular Substations mixing DC and AC equipment. The DCConverterUnit and Converters are at Substation level and connect to AC equipment in a VoltageLevel.

As Converters can operate at different voltages it does not make sense to have a BaseVoltage. Hence the flag BaseVoltage.isDC shall be removed.

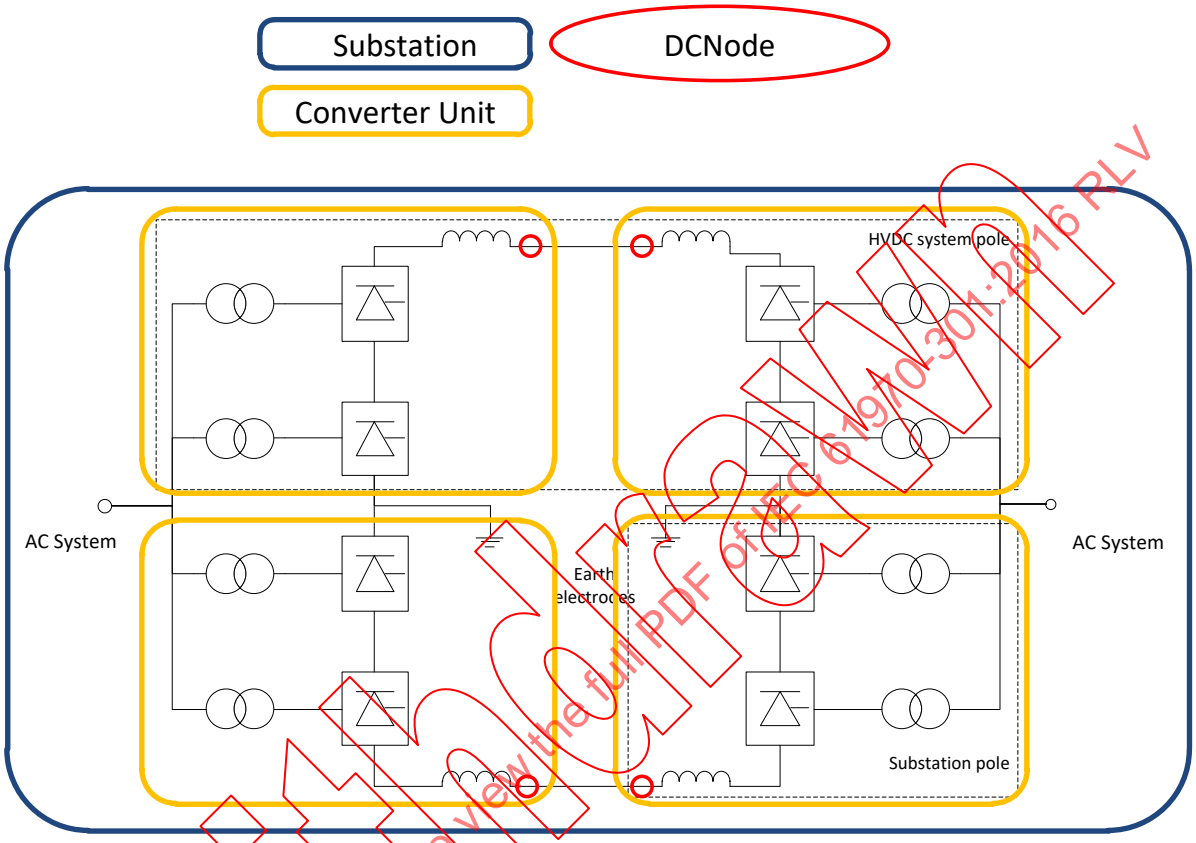


Figure 49 – Containment structure for a bipolar back-to-back HVDC station

4.5.13.4.2 DC grids

DC grids will have switches that are used to reconfigure the DCLines in the grid. To do this it is important that the switches are included in the model and are placed at the appropriate locations in the grid. Figure 47 shows a DCLine connected at a Converter with a simple switch arrangement. As the smoothing reactor belongs to the Substation rather than the DCLine it cannot be included in the DCLine inductance. For DCGrids the incoming DCLine connections with the Converters will have more switches and the information model needs to support this. DC grid topology processing will be required in the same way as AC grid topology processing is currently done.

4.5.13.5 Data model

4.5.13.5.1 Topology

The basic AC system connectivity is shown in Figure 50.

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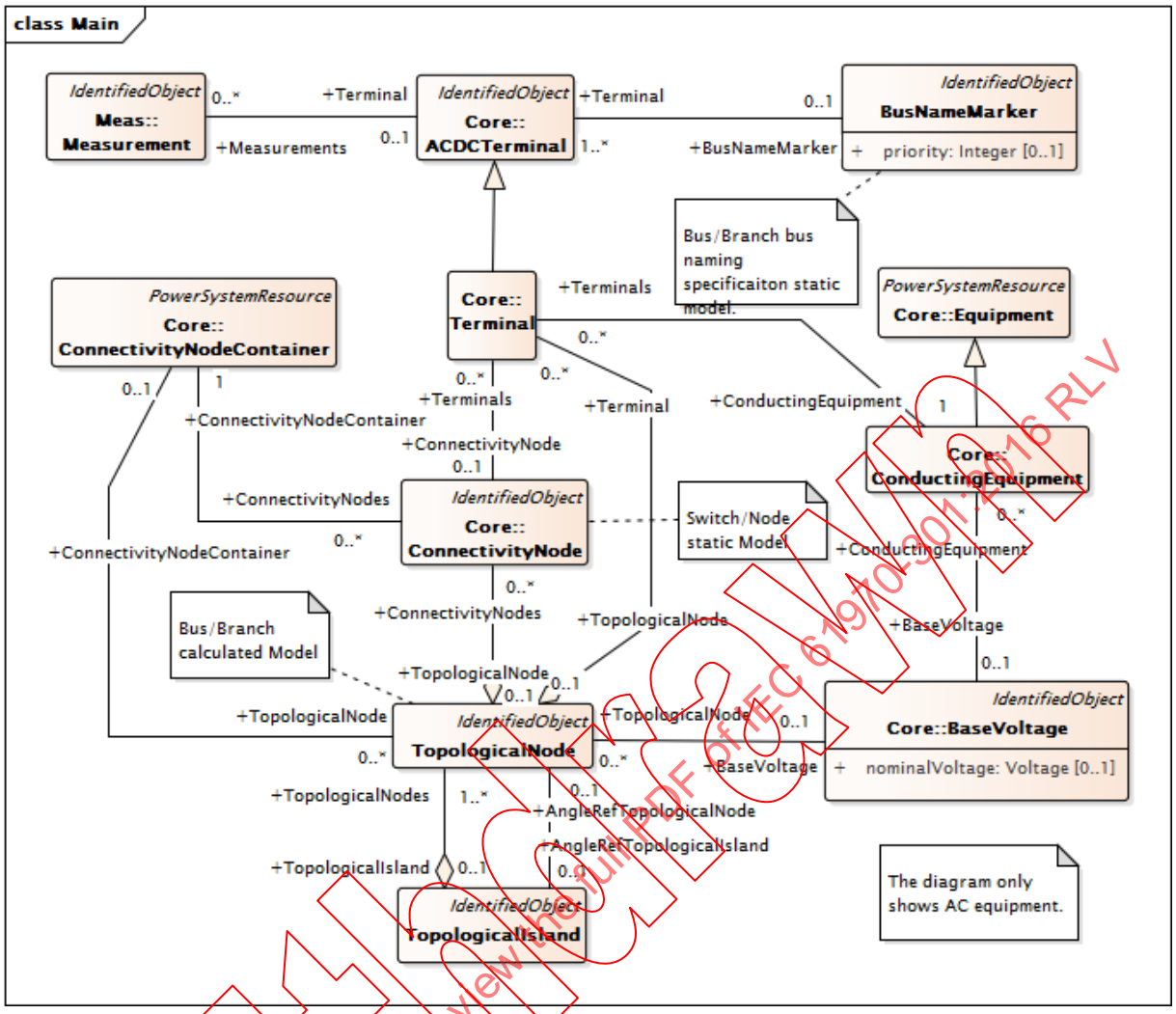


Figure 50 – The Basic topology in package Core

As shown in Figure 50, Terminal is used only for AC ConductingEquipment. A new class ACDCTerminal has been introduced to hold characteristics common between AC and DC.

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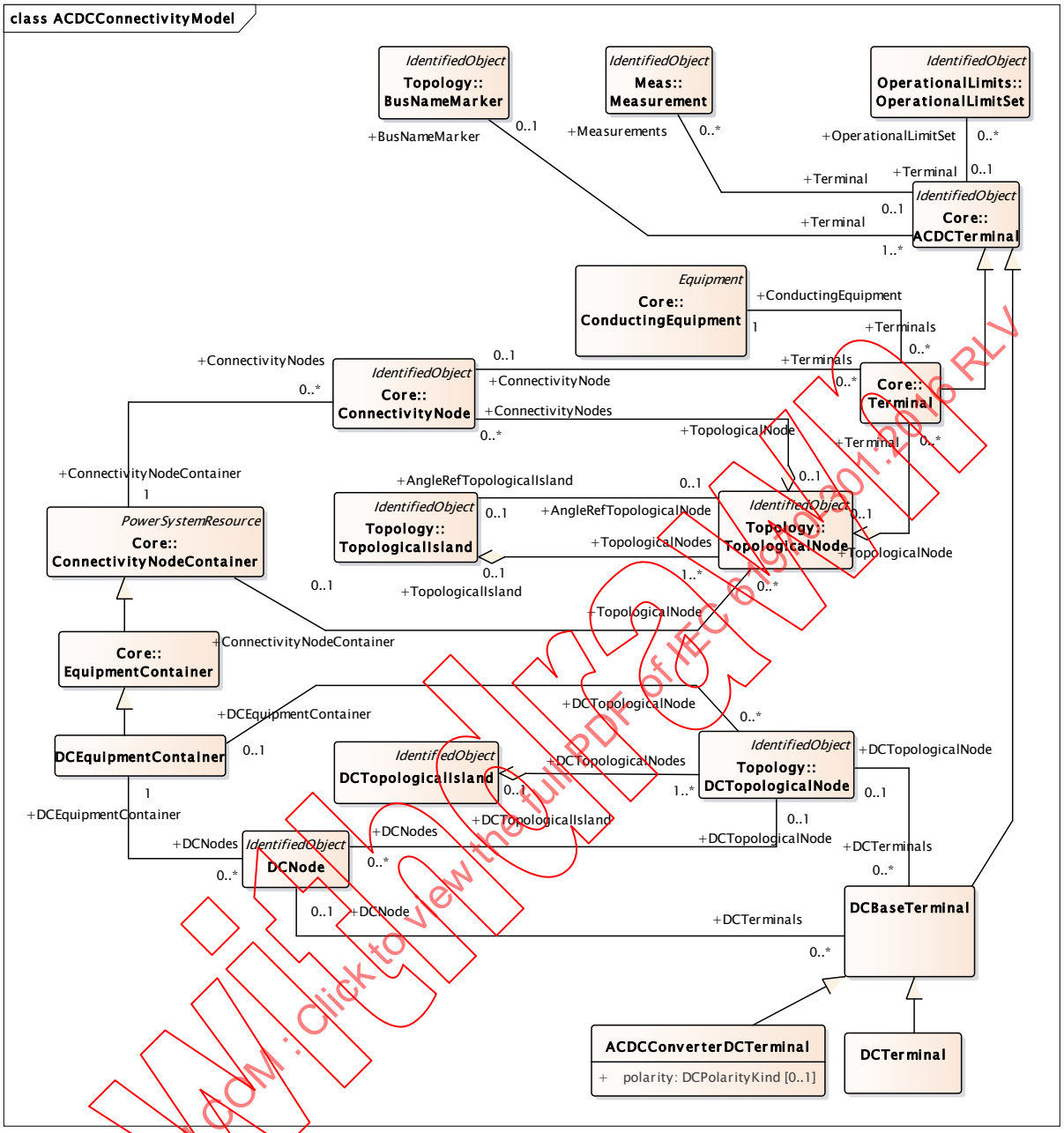


Figure 51 – DC and AC topology

As shown in Figure 51, the ConductingEquipment-Terminal-ConnectivityNode pattern from the AC network is repeated for the DC network with the classes DCConductingEquipment-DCTerminal-DCNode.

The association from Measurement to Terminal is moved from Terminal to ACDCTerminal. Hence DCTerminals may also have Measurements. The role “Measurement.Terminal” keeps its old name for backwards compatibility.

If more features will be common between DCTerminal and Terminal they are moved to ACDCTerminal.

DCNode and ConnectivityNode do not have a common ACDCNode base class as it does not seem to be needed.

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4.5.13.5.2 Containment

The containment structure for the DC model is shown in Figure 52.

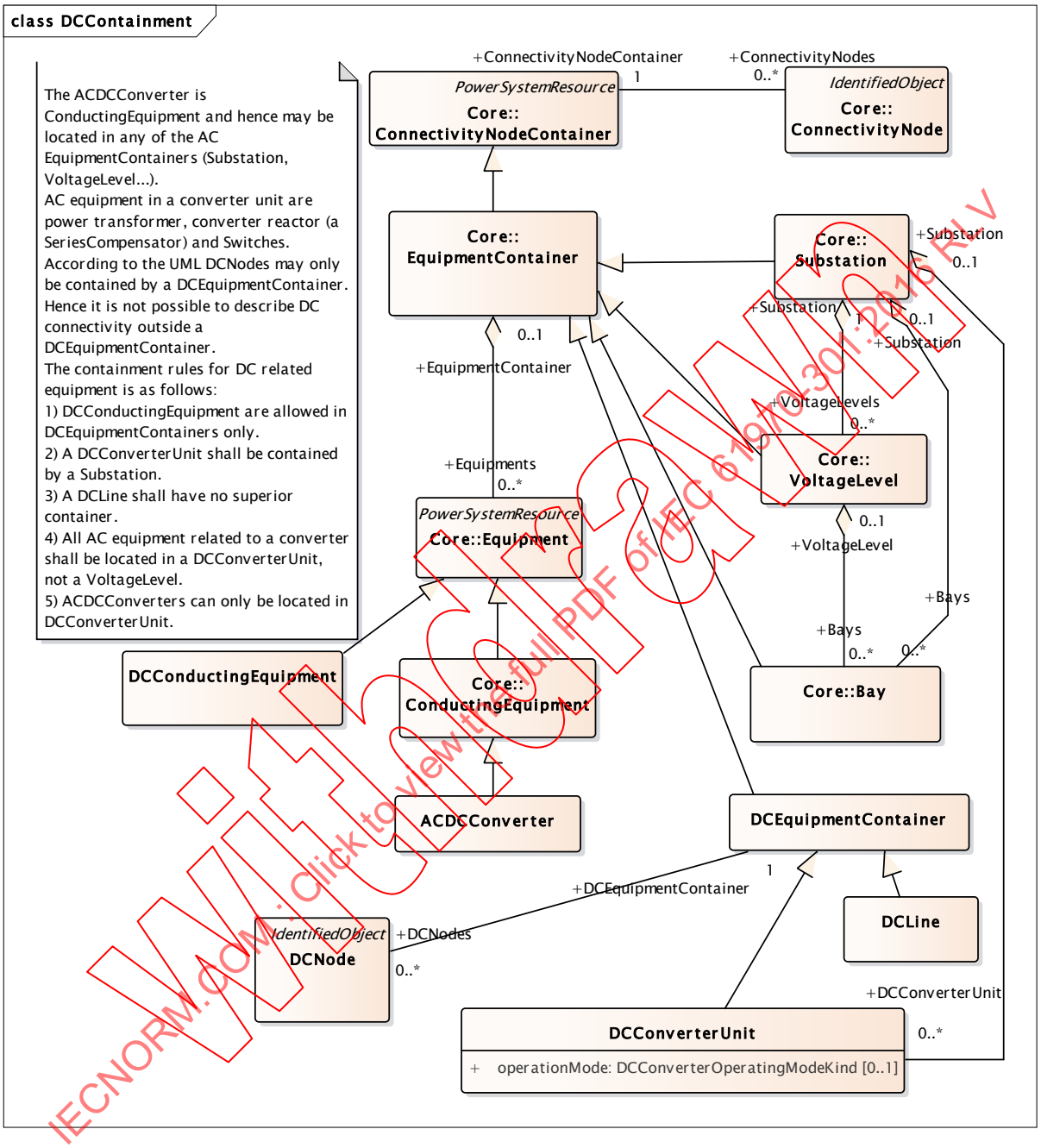


Figure 52 – HVDC Containment

As shown in Figure 52, DCConductingEquipment has the same features as Equipment, hence it can be placed in a Substation, Voltagelevel or Bay. However the DC topology requires DCNodes that only exist in a DCEquipmentContainer. Hence DCConductingEquipment will reside in DCConverterUnits or DCLines, subclasses to DCEquipmentContainer.

DCConverterUnits are part of Substation while DCLines are not. Hence DCLines can span between Substations.

DCConverterUnits can be mixed with AC equipment in a Substation. Hence both AC and DC equipment can coexist in Substations.

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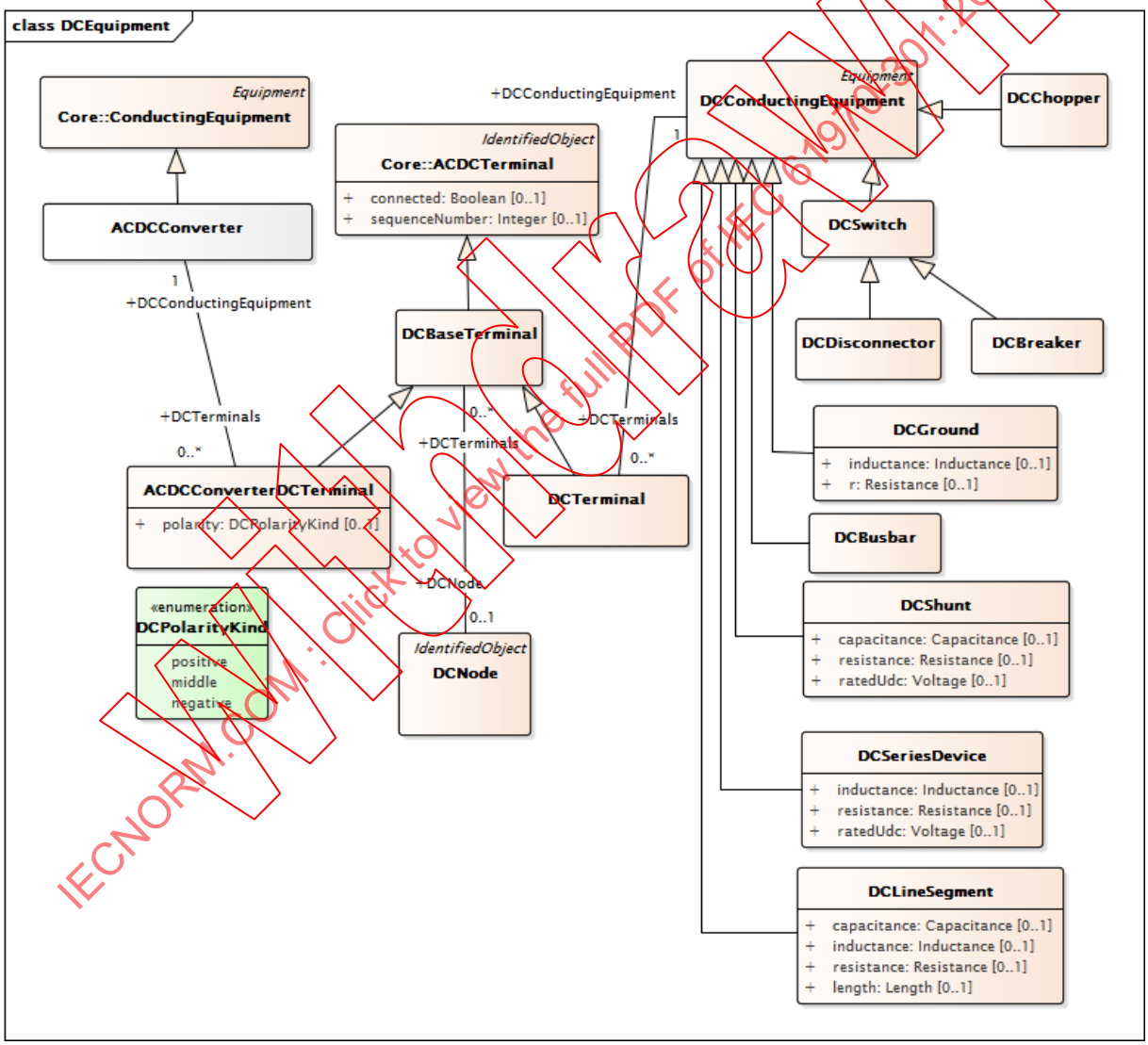
The back to back configuration in Figure 49 is solved by placing the DCLineSegment in the Substation instead of a DCLine.

The CIM containment model is open and which container classes shall contain what equipment needs to be specified in writing as follows.

- DCLineSegments are allowed in Substations (back to back configuration) and DCLines.
- All other DC equipment go into DCConverterUnit.
- AC equipment specific to a converter go into DCConverterUnit.

4.5.13.5.3 Equipment

The DC equipment model is shown in Figure 53.



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Figure 53 – Equipment model

In order for the ACDCTerminal to feature both ACDCConverter and DCConductingEquipment, two types of DC terminals have been implemented as shown in Figure 53: ACDCConverterDCTerminal and DCTerminal. ACDCConverterDCTerminal is associated with ACDCConverter. The DCTerminal is in association with DCConductingEquipment. In order to associate DCNode with DCTerminal and ACDCConverterDCTerminal, DCBaseTerminal is introduced which is inherited from ACDCTerminal.

As DCConductingEquipment in many cases will have different parameters compared with corresponding AC equipment, specific DC classes are needed anyway, e.g. the DCBreaker and DCBusbar.

The SvPowerFlows at the PCCTerminals hold the AC injections into the converter.

The DC line model is shown in Figure 54.

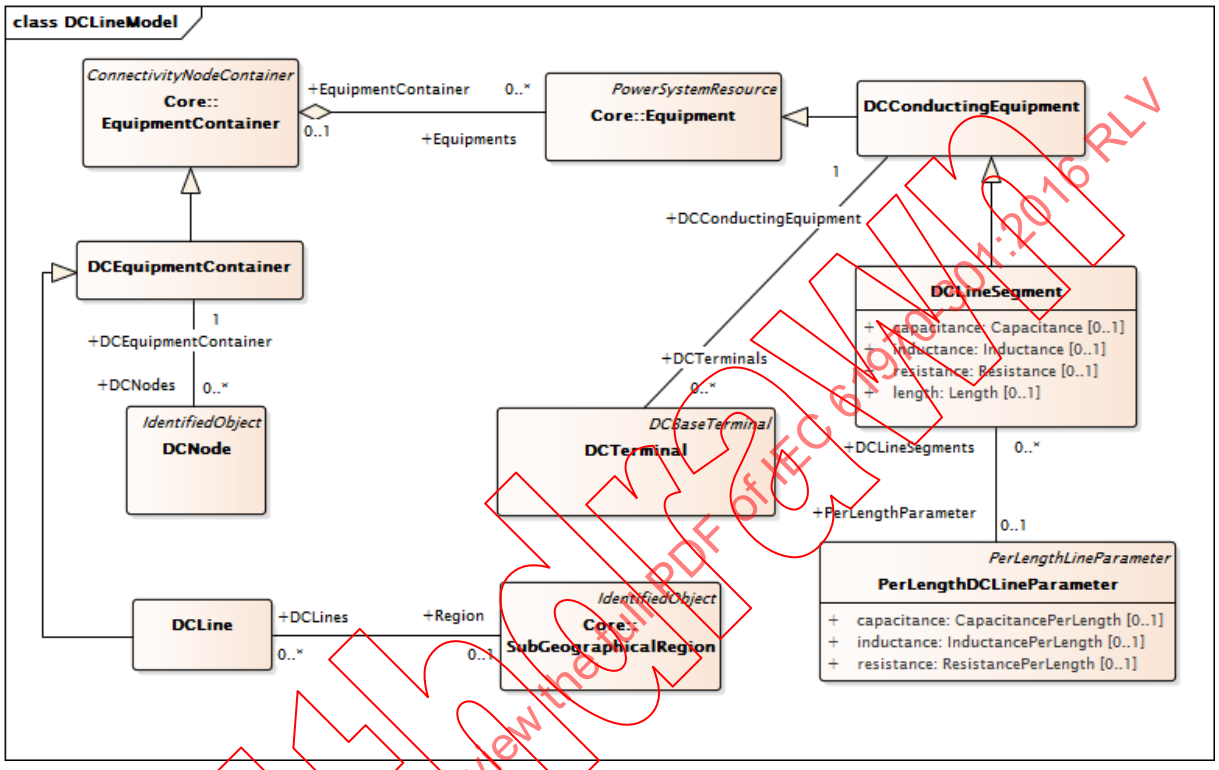


Figure 54 – HVDC line model

As shown in Figure 54, DCLineSegment is no longer a Conductor but DCConductingEquipment and does not connect to the AC network. It has its own attributes and per length class PerLengthDCLineParameter.

Every type of equipment in an HVDC grid will need its DC…class. Possible equipment types are

- DCSwitch,
- DCGround.

The method of specific DC… classes may result in duplication of attributes with the corresponding AC… classes.

4.5.13.6 Instance diagrams

Figure 58 show examples of DC equipment: a simple monopole, a simple bipolar and a detailed side of a monopole.

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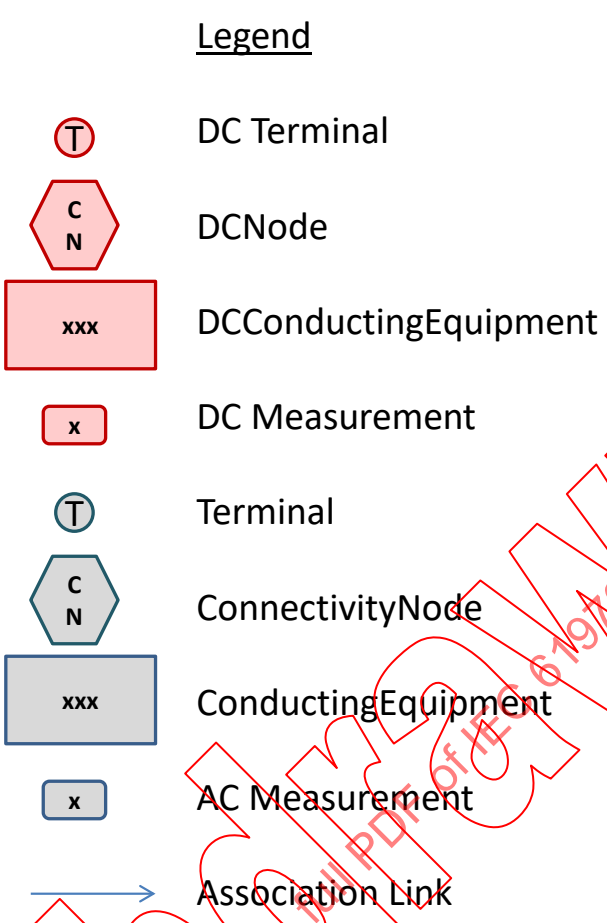
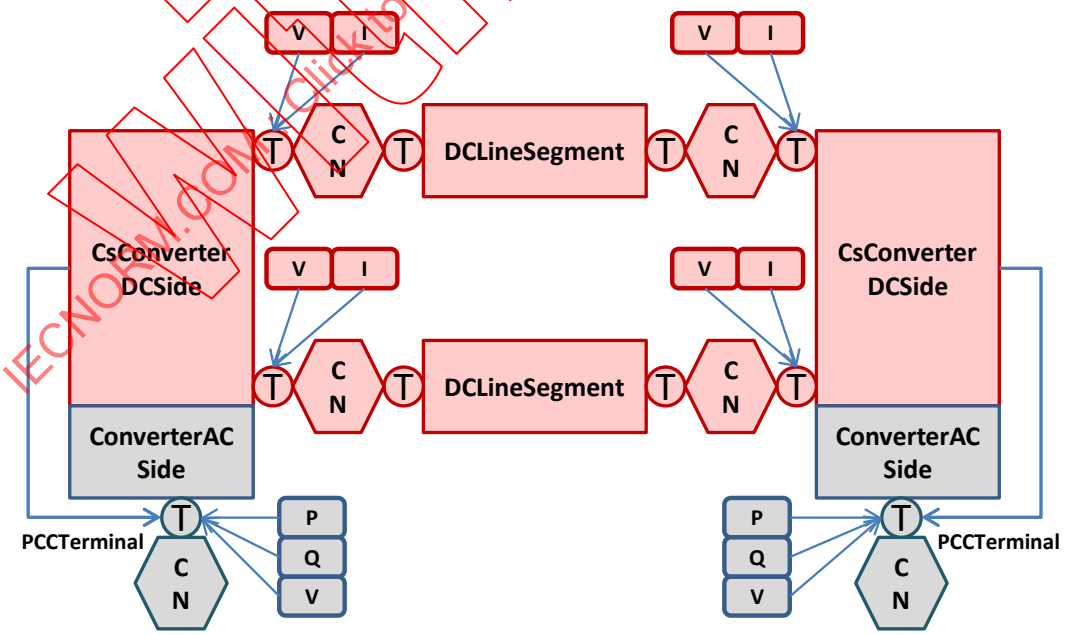


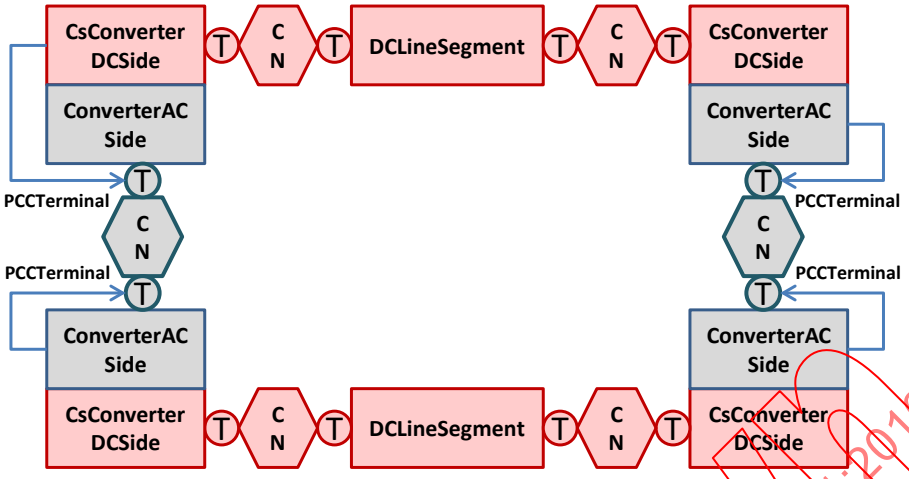
Figure 55 – Key for Figure 56, Figure 57 and Figure 58



Refer to Figure 55 for an explanation of the symbols.

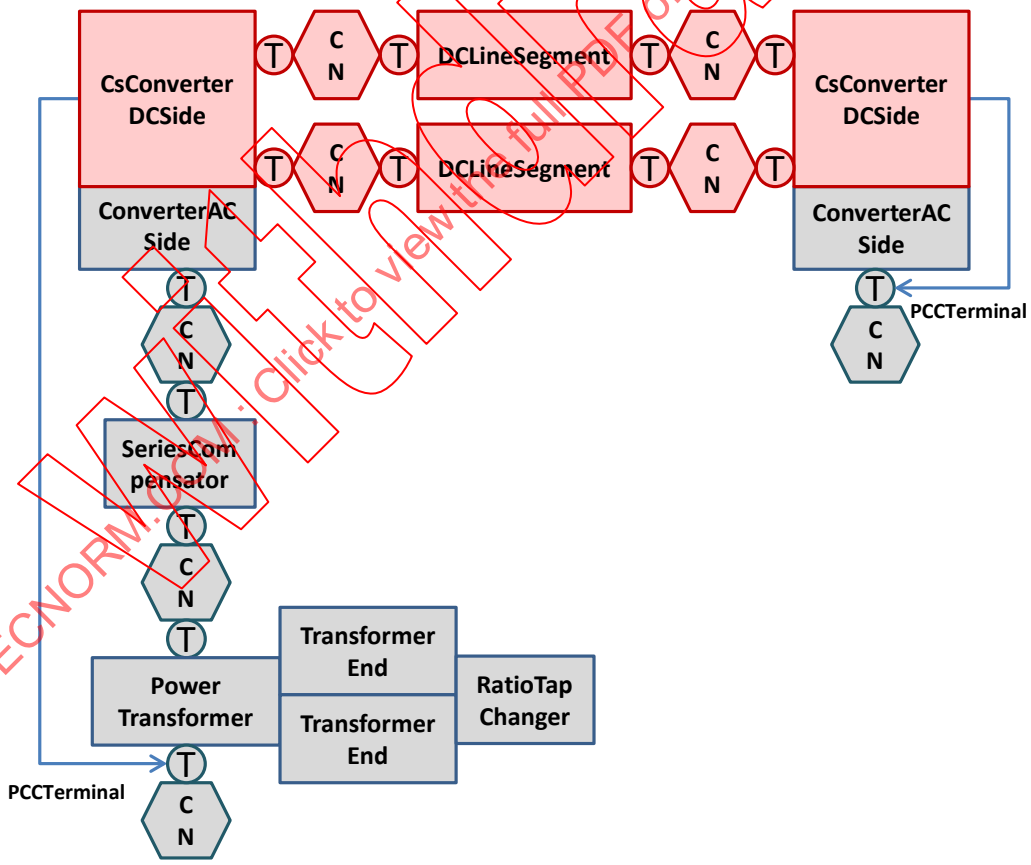
Figure 56 – Simple monopole with measurements

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Refer to Figure 55 for an explanation of the symbols.

Figure 57 – Simple bipolar



Refer to Figure 55 for an explanation of the symbols.

Figure 58 – Monopole one side with detailed model

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4.5.14 Static Var Compensator voltage regulation

4.5.14.1 Background

The Static Var Compensator (SVC) is a shunt device of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow and improve transient stability on power grids. The SVC can be operated in two different modes:

- voltage regulation mode (the voltage is regulated within limits as explained below);
- var control mode (the SVC susceptance is kept constant).

When the SVC is operated in voltage regulation mode, it implements the *V-I* characteristic shown in Figure 59.

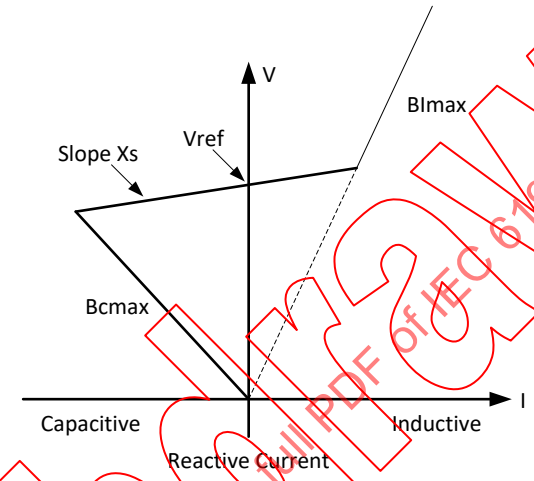


Figure 59 – *V-I* characteristic of SVC

As long as the SVC susceptance *B* stays within the maximum and minimum susceptance values imposed by the total reactive power of capacitor banks (Bc_{max}) and reactor banks (BI_{max}), the voltage is regulated at the reference voltage V_{ref} (also referred to as voltage set point). The voltage at which the SVC neither absorbs nor generates reactive power is the reference voltage (V_{ref}).

A voltage droop is normally used (usually between 1 % and 4 % at maximum reactive power output), and the *V-I* characteristic has the slope indicated in Figure 59. The *V-I* characteristic is described by the following three equations:

$$V = \begin{cases} V_{ref} + X_S \times I & \text{if SVC is in regulation mode} \quad (-Bc_{max} < B < BI_{max}) \\ -\dfrac{I}{Bc_{max}} & \text{if SVC is fully capacitive} \quad (B = Bc_{max}) \\ \dfrac{I}{BI_{max}} & \text{if SVC is fully inductive} \quad (B = BI_{max}) \end{cases}$$

where

V is the positive sequence voltage (pu) at regulated bus;

I is the reactive current ($I > 0$ indicates an inductive current);

X_S is the slope or droop reactance;

V_{ref} is the voltage reference (voltage set point);

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Bc_{max} is the maximum capacitive susceptance;

Bl_{max} is the maximum inductive susceptance.

The voltage set point is typically chosen such that under normal operating conditions the SVC delivers close to zero reactive power so that the full control range of the SVC is available.

The voltage set point of an SVC is fundamentally different from a target voltage. The reactive output of an SVC is proportional to the square of the difference between the regulated bus voltage and the voltage set point. If the SVC is generating or absorbing reactive power, then there will by definition be a difference between the regulated bus voltage and the voltage set point.

4.5.14.2 Current CIM Model

StaticVarCompensator is defined as a class in CIM with the following description:

A facility for providing variable and controllable shunt reactive power. The SVC typically consists of a stepdown transformer, filter, thyristor-controlled reactor, and thyristor-switched capacitor arms.

The SVC may operate in fixed MVar output mode or in voltage control mode. When in voltage control mode, the output of the SVC will be proportional to the deviation of voltage at the controlled bus from the voltage setpoint. The SVC characteristic slope defines the proportion. If the voltage at the controlled bus is equal to the voltage setpoint, the SVC MVar output is zero.

StaticVarCompensator has the following attributes:

capacitiveRating – Maximum available capacitive reactance.

inductiveRating – Maximum available inductive reactance.

q – Reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.

slope – The characteristics slope of an SVC defines how the reactive power output changes in proportion to the difference between the regulated bus voltage and the voltage setpoint.

sVCControlMode – SVC control mode. The values are

- reactivePower,
- voltage.

voltageSetPoint – The reactive power output of the SVC is proportional to the difference between the voltage at the regulated bus and the voltage setpoint. When the regulated bus voltage is equal to the voltage setpoint, the reactive power output is zero.

StaticVarCompensator inherits the following attributes from RegulatingCondEq:

controlEnabled – Specifies the regulation status of the equipment. True is regulating, false is not regulating.

StaticVarCompensator gets its regulated Terminal through the association to RegulatingControl inherited from RegulatingCondEq.

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4.5.14.3 Known issues

The physical characteristics of Static Var Compensators are handled with the attributes defined in CIM. However a few questions and issues remain.

a) None

Proposals

a) Consider changing StaticVarCompensator to inherit from ConductingEquipment rather than from RegulatingCondEq and adding a direct association from StaticVarCompensator to Terminal. The current model using RegulatingControl works for SVCs, but most of the attributes of RegulatingControl would be ignored.

4.6 Modeling guidelines

4.6.1 Modeling for change

Subclauses 4.6.2 to 4.6.5 provide guidelines on how to maintain and extend the CIM.

The CIM is meant to contain classes and attributes that will be exchanged over public interfaces between major applications. The goal is to keep, as much as possible, only the generic features from which a detailed implementation may be derived. In general, it is easier to change the value or domain of an attribute than to change a class definition. This makes the model more robust because it is able to support a broader class of requirements, and more stable because new requirements may be able to be handled without requiring changes to the model.

4.6.2 Process for amendments to the CIM

It may be desirable to amend the CIM to either revise the existing model or to extend the CIM to model additional elements of an electric utility power system. The recommended process for such amendments is as follows.

1) Prepare use case(s) and a request for change to describe the desired changes. This should include proposed changes to the appropriate class diagrams showing new/revised classes, attributes, and associations.
2) The use case(s) and request for change are then reviewed by the appropriate IEC Working Group to decide if the requested changes should be treated as revisions to the current CIM standard, or if they should be treated as private amendments, not requiring a change to the standard itself.
3) Proposed amendments accepted by the working group will be added to a list of outstanding issues, and, at the appropriate time, a new version of the CIM model will be prepared and an update made to the appropriate IEC CIM specification.

4.6.3 Changes to the CIM UML model

From a modeling perspective, when the CIM is extended, the approach is to start with the existing CIM UML model. The extensions may be added in any of several ways that are available in UML, but in all cases the approach is to inspect the current model and determine the best way to build off of the existing class diagrams. The extensions may take the form of any of the following, starting from the simplest to the most complex:

- adding additional attributes to existing classes;
- adding new classes that are specializations of existing classes;
- adding new classes via associations with existing classes.

For the purpose of extending this standard, the main objective is to reuse the existing CIM to the maximum extent possible. From a packaging point of view, extensions should be made to existing packages where possible. If the extensions comprise a new domain of application, then consideration should be given to creating a new package for the additions, but still

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creating the necessary associations to the existing package, keeping in mind that even though a new package is being created, the CIM is still a single model.

For the purpose of creating non-standard changes to the information model, the standard CIM should be extended without modifying the standard CIM. Preferably, such extensions should be placed in new packages to both identify the changes as non-standard and to facilitate transferring changes to an updated version of the standard.

4.6.4 Changes to the CIM standards documents

From a documentation perspective, when the CIM is extended, a decision shall be made whether the changes constitute updates to existing CIM standards documents, or whether a new IEC 61970-3x is required. In either case, the extensions will then become part of the IEC standard CIM.

4.6.5 Deprecations

The CIM model may at times contain packages, classes, attributes, or associations that have been identifed as deprecated. These items will be noted in the documentation or with a UML stereotype of “deprecated”. A deprecated item is retained in the present version of the model, but is expected to be removed from future versions. An item that has not been deprecated is not guaranteed to be retained in future versions, but using an item marked as deprecated should be avoided if possible.

4.6.6 CIM profiles

An implementation of the CIM need not include all classes, attributes, or associations in the standard CIM specification to be compliant with the CIM standard. Profiles may be defined to specify which elements shall be included (i.e. mandatory elements) in a particular use of the CIM, as well as which are optional. These profiles are defined in the profile documents of IEC 61970 series, as well as in other IEC series that use and extend the base CIM specified in this document.

An example is the profile for exchanging power system models. This profile specifies how the CIM is to be used for exchanging power system models in XML, and also specifies the mandatory and optional classes, attributes, and associations to be supported for this use of the CIM. Profiles can be maintained using a variety of tools such as the open source CIMTool[1)].

4.7 Modeling tools

This CIM release was constructed using Enterprise Architect[2)]. The entire CIM UML model exists as an Enterprise Architect project file and is viewable with that tool, including the class diagrams and descriptions of classes, attributes, types, and relationships. Viewing the CIM in this fashion provides a graphical navigation interface that permits all CIM specification data to be viewed via point-and-click from the class diagram in each package. A free viewer is available through Sparx Systems.

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1) Available at <http://www.CIMTool.org>. CIMTool is the trade name of a product supplied by the Free Software Foundation. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

2) Enterprise Architect is the trade name of a product supplied by Sparx Systems. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Ideally, the CIM information model is independent of any specific UML tool, though experience has shown that exchanges between different tools are often less than perfect. Until tool interoperability is proven effective, future changes to the CIM specification, resulting in new versions of this standard, will be incorporated first into the Enterprise Architect project description to ensure a single source for the CIM model data.

Clause 6 of this document was auto-generated using the open source tool jCleanCim[3)], which uses the automation interfaces of Microsoft® Word[4)] and Enterprise Architect and the standard IEC format and styles.

4.8 User implementation conventions

4.8.1 Conventions beyond UML

Subclause 4.8.2 provides recommended user conventions when using the CIM in actual system implementations.

4.8.2 Number of terminals for ConductingEquipment objects

The following ConductingEquipment classes have two terminals: ACLineSegment, DCLineSegment, Switch and all its specializations (including Jumper, Fuse, Breaker, Disconnector, LoadBreakSwitch, and Cut), SeriesCompensator, and EquivalentBranch. The PowerTransformer class typically has two terminals, but may also have one or more terminals. For example a zig-zag connected grounding transformer may have one terminal. Three terminal transformers are commonly used in transmission systems and in special cases transformers may have four, five, or more terminals. All other ConductingEquipment leaf classes (notably also including Clamp and BusbarSection) have a single terminal.

4.9 CIM modeling examples

Power system models have been created from the CIM UML model in various ways. The first example is an RDF (Resource Description Framework) Schema version of the CIM, which uses XML (eXtensible Markup Language) to describe a power system network model. IEC 61970-501 and other profile standards in development are used to specify the model exchange format. RDF Schema versions of the CIM have been used to create XML model files of actual networks for purposes of interoperability testing. An RDF Schema version of the CIM is generated from the CIM UML model file using software tools based on the RDF Schema specification of the CIM.

It should be noted that an RDF schema version of the CIM is still metadata rather than an instantiation of an actual network. However, complete network model files with descriptions of all network elements and their electrical connectivity can be generated by system suppliers using proprietary export tools, and then imported by other systems via a similar import tool, which is used to populate a local network engineering tool database. Examples of such CIM XML models include the Siemens 100 bus model, the Alstom 60 bus model, and the ABB 40 bus model files[5)] used for CIM XML interoperability testing.

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3) Available at <http://cimug.ucaiug.org/MTEI/Shared%20Documents/jCleanCim>. JCleanCim is the trade name of a product supplied by the Free Software Foundation. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

4) Word is the trade name of a product supplied by Microsoft. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

5) Siemens100 bus model, Alstom 60 bus model, and ABB 40 model are the trade names of products supplied by Siemens, Alstom Grid, and ABB. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

5 Detailed model

5.1 Overview

The portion of the common information model (CIM) covered by IEC 61970-301 represents a comprehensive logical view of information exchanged among different systems in electrical utilities. This definition includes the public classes and attributes, as well as the relationships between them.

5.2 Context

The CIM is partitioned into subpackages. Classes within the packages are listed in the order they are defined in the UML model. Native class attributes are listed first, followed by inherited attributes in order of depth of inheritance. Native associations are listed first for each class, followed by inherited associations in order of depth of inheritance, then alphabetically by association end name. The associations are described according to the role of each class participating in the association. The association ends are listed under the class at each end of an association.

Figure 60 shows the top level packages included in this document.

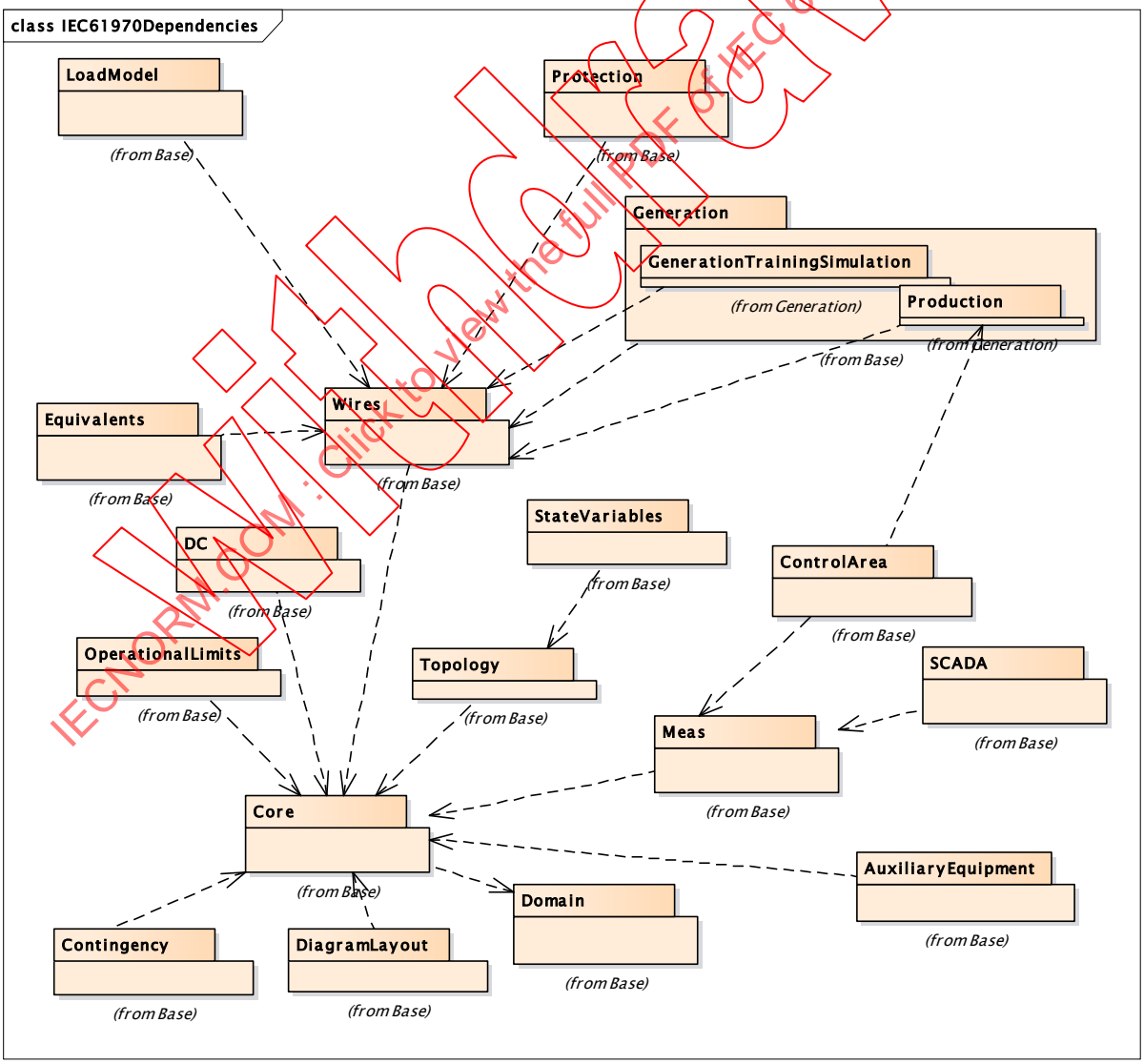


Figure 60 – CIM top level packages

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For each package, the model information for each class is fully described. Attribute and association end information for native and inherited attributes is listed as in Table 9 and Table 10 for an example class named “Class1” in example package “Package1”. For any inherited attributes or association ends the “description” column will contain text indicating the attributes are inherited from a specific class. In this example we assume Class1 inherits from class IdentifiedObject. The description column for native attributes and association ends contains the actual description. For inherited attributes, the base class is noted in the description and the full attribute documentation is available in that base class as a native attribute.

Table 9 – Attributes of Package1::Class1

name	type	description
native1	Float	A floating point native attribute of the class is described here.
native2	ActivePower	Documentation for another native attribute of type ActivePower.
name	String	Inherited from: IdentifiedObject

For cases where an attribute is a constant, Table 9 will add the phrase “(const)” to the name column. In such cases, the attribute normally has an initial value also which is preceded by an equal sign and appended to the attribute name.

Table 10 – Association ends of Package1::Class1 with other classes

[mult from]	[mult to] name	type	description
[0..*]	[0..1] Class2	Class2	The description of the association end to another class named “Class1”. Note it is typical, but not required, that the association end is the same as the referenced type. This association end may reference zero or one objects. The other end of the association may reference any number of Class1 instances.
[0..1]	[0..*] SecondClass2	Class2	The description of references to class named “Class2”. In this case any number of references may be made. The reverse reference may reference zero or one Class1 instances.
[1..1]	[0..*] Class3	Class3	References any number of Class3 instances. The reverse reference shall reference only one instance of Class1.
[0..*]	[0..*] Class4	Class4	A many to many association.
[0..1]	[0..*] DiagramObjects	DiagramObject	inherited from: IdentifiedObject
[1..1]	[0..*] Names	Name	inherited from: IdentifiedObject

In Table 10, the first column describes the multiplicity at this end of the association (i.e. how this class participates in association). Second column describes the other association end. Its multiplicity is included in brackets. The association end name is listed in plain text. The class at the other end of the association is in the third column. A multiplicity of zero indicates an optional association. A multiplicity of “*” indicates any number is allowed. For example, a multiplicity of [1..*] indicates a range from 1 to any larger number is allowed.

In the case that a class is an enumeration named “Enumeration1”, the attributes table is replaced by the literals documentation as shown in Table 11 since enumeration literals have no type. There are no inherited enumeration literals for an enumeration class.

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Table 11 – Literals of Package1::Enumeration1

literal	description
native1	This is the first native enumeration value.
native2	This is the second native enumeration value.
native3	There are typically no inherited attributes for enumerations.

6 Package Base

6.1 General

Empty.

6.2 Package Faults

6.2.1 General

The package describes faults that may happen to conducting equipment, e.g. tree falling on a power line.

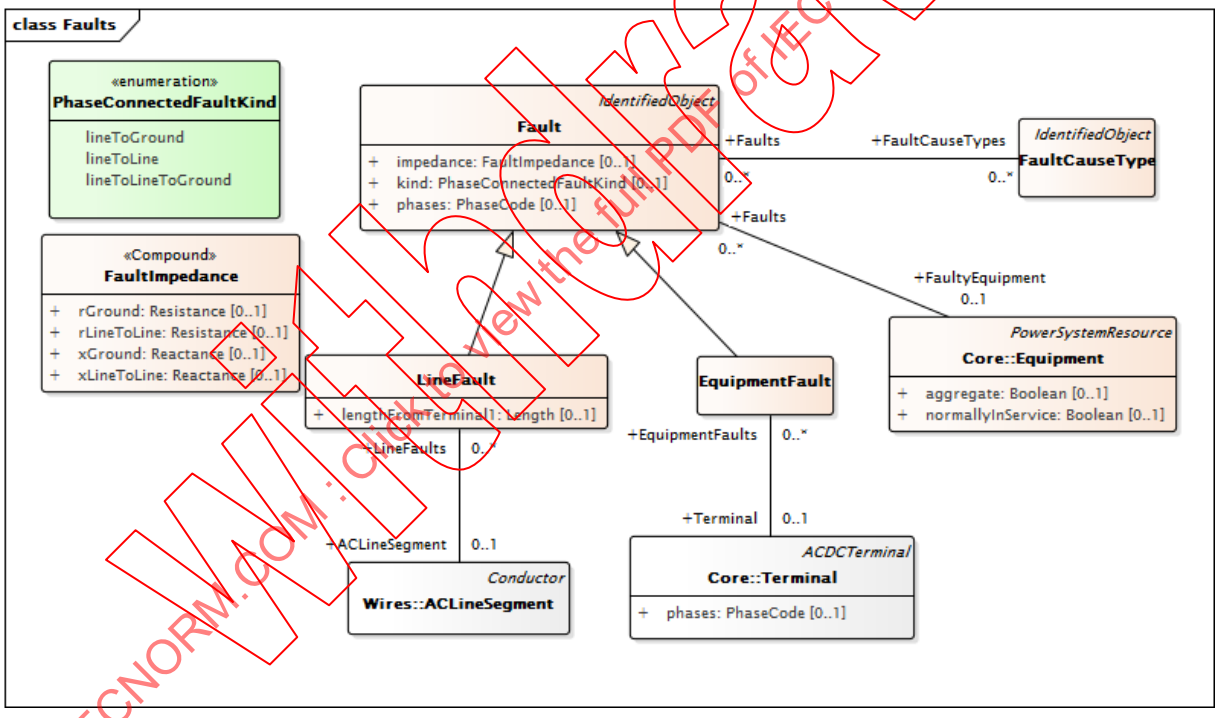


Figure 61 – Class diagram Faults::Faults

Figure 61: Classes used to model faults.

6.2.2 EquipmentFault

A fault applied at the terminal, external to the equipment. This class is not used to specify faults internal to the equipment.

Table 12 shows all attributes of EquipmentFault.

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Table 12 – Attributes of Faults::EquipmentFault

name	mult	type	description
impedance	0..1	FaultImpedance	inherited from: Fault
kind	0..1	PhaseConnectedFaultKind	inherited from: Fault
phases	0..1	PhaseCode	inherited from: Fault
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 13 shows all association ends of EquipmentFault with other classes.

Table 13 – Association ends of Faults::EquipmentFault with other classes

mult from	name	mult to	type	description
0..*	Terminal	0..1	Terminal	The terminal connecting to the bus to which the fault is applied.
0..*	FaultyEquipment	0..1	Equipment	inherited from: Fault
0..*	FaultCauseTypes	0..*	FaultCauseType	inherited from: Fault
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.2.3 Fault

Abnormal condition causing current flow through conducting equipment, such as caused by equipment failure or short circuits from objects not typically modeled (for example, a tree falling on a line).

Table 14 shows all attributes of Fault.

Table 14 – Attributes of Faults::Fault

name	mult	type	description
impedance	0..1	FaultImpedance	Fault impedance. Its usage is described by 'kind'.
kind	0..1	PhaseConnectedFaultKind	The kind of phase fault.
phases	0..1	PhaseCode	The phases participating in the fault. The fault connections into these phases are further specified by the type of fault.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 15 shows all association ends of Fault with other classes.

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Table 15 – Association ends of Faults::Fault with other classes

mult from	name	mult to	type	description
0..*	FaultyEquipment	0..1	Equipment	Equipment carrying this fault.
0..*	FaultCauseTypes	0..*	FaultCauseType	All types of fault cause.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.2.4 FaultCauseType

Type of cause of the fault.

Table 16 shows all attributes of FaultCauseType.

Table 16 – Attributes of Faults::FaultCauseType

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 17 shows all association ends of FaultCauseType with other classes.

Table 17 – Association ends of Faults::FaultCauseType with other classes

mult from	name	mult to	type	description
0..*	Faults	0..*	Fault	All faults with this cause type.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.2.5 FaultImpedance compound

Impedance description for the fault.

Table 18 shows all attributes of FaultImpedance.

Table 18 – Attributes of Faults::FaultImpedance

name	mult	type	description
rGround	0..1	Resistance	The resistance of the fault between phases and ground.
rLineToLine	0..1	Resistance	The resistance of the fault between phases.
xGround	0..1	Reactance	The reactance of the fault between phases and ground.
xLineToLine	0..1	Reactance	The reactance of the fault between phases.

6.2.6 LineFault

A fault that occurs on an AC line segment at some point along the length.

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Table 19 shows all attributes of LineFault.

Table 19 – Attributes of Faults::LineFault

name	mult	type	description
lengthFromTerminal1	0..1	Length	The length to the place where the fault is located starting from terminal with sequence number 1 of the faulted line segment.
impedance	0..1	FaultImpedance	inherited from: Fault
kind	0..1	PhaseConnectedFaultKind	inherited from: Fault
phases	0..1	PhaseCode	inherited from: Fault
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 20 shows all association ends of LineFault with other classes.

Table 20 – Association ends of Faults::LineFault with other classes

mult from	name	mult to	type	description
0..*	ACLineSegment	0..1	ACLineSegment	The line segment of this line fault.
0..*	FaultyEquipment	0..1	Equipment	inherited from: Fault
0..*	FaultCauseTypes	0..*	FaultCauseType	inherited from: Fault
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.2.7 PhaseConnectedFaultKind enumeration

The type of fault connection among phases.

Table 21 shows all literals of PhaseConnectedFaultKind.

Table 21 – Literals of Faults::PhaseConnectedFaultKind

literal	value	description
lineToGround		The fault connects the indicated phases to ground. The line to line fault impedance is not used and assumed infinite. The full ground impedance is connected between each phase specified in the fault and ground, but not between the phases.
lineToLine		The fault connects the specified phases together without a connection to ground. The ground impedance of this fault is ignored. The line to line impedance is connected between each of the phases specified in the fault. For example three times for a three phase fault, one time for a two phase fault. A single phase fault should not be specified.

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literal	value	description
lineToLineToGround		The fault connects the indicated phases to ground and to each other. The line to line impedance is connected between each of the phases specified in the fault in a full mesh. For example three times for a three phase fault, one time for a two phase fault. A single phase fault should not be specified. The full ground impedance is connected between each phase specified in the fault and ground.

6.3 Package DocIEC 61970

This package contains example documentation diagrams not intended to be documented in IEC 61970-301 with the rest of the normative packages. The diagrams within this package are individually included in the introductory text of the IEC 61970-301 document.

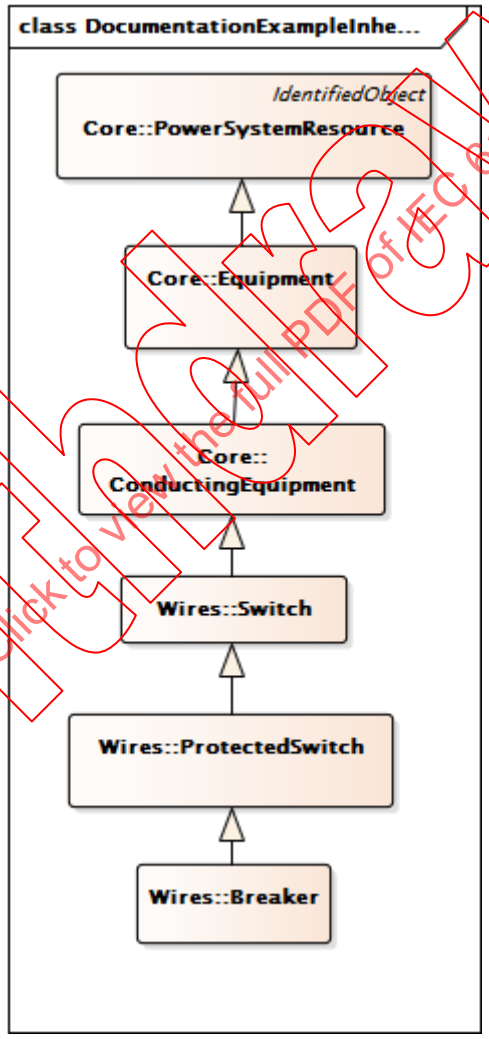


Figure 62 – Class diagram DocIEC 61970::DocumentationExampleInheritance

Figure 62: This shows an example of inheritance in UML. This diagram is only to support figures in the documentation.

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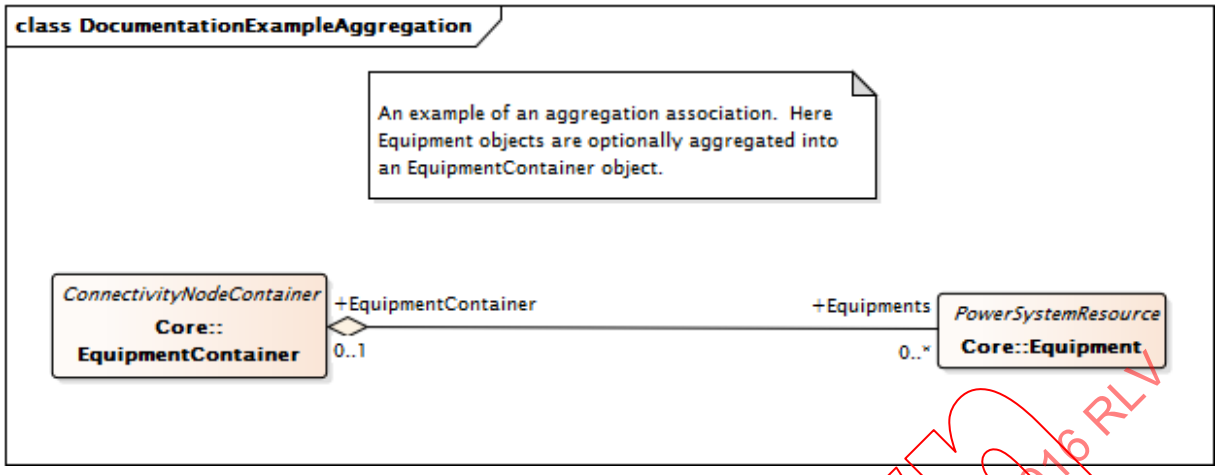


Figure 63 – Class diagram DocIEC 61970::DocumentationExampleAggregation

Figure 63: This shows an example of aggregation in UML. This diagram is only to support figures in the documentation.

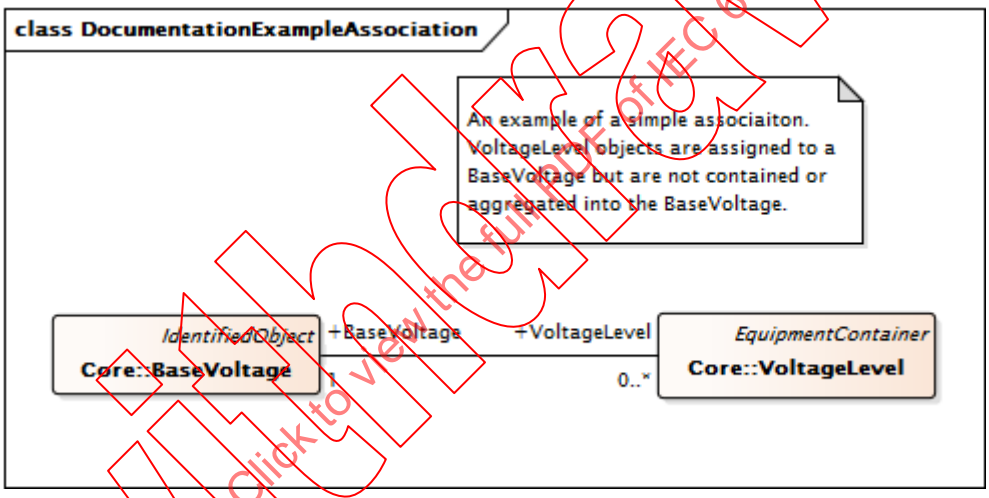


Figure 64 – Class diagram DocIEC 61970::DocumentationExampleAssociation

Figure 64: This diagram is an example used for documentation purposes. It shows how a simple association and an aggregation association are expressed in UML diagrams.

6.4 Package Domain

6.4.1 General

The domain package defines primitive datatypes that are used by classes in other packages. Stereotypes are used to describe the datatypes. The following stereotypes are defined:

<<enumeration>> A list of permissible constant values.

<<Primitive>> The most basic data types used to compose all other data types.

<<CIMDatatype>> A datatype that contains a value attribute, an optional unit of measure and a unit multiplier. The unit and multiplier may be specified as a static variable initialized to the allowed value.

<<Compound>> A composite of Primitive, enumeration, CIMDatatype or othe Compound classes, as long as the Compound classes do not recurse.

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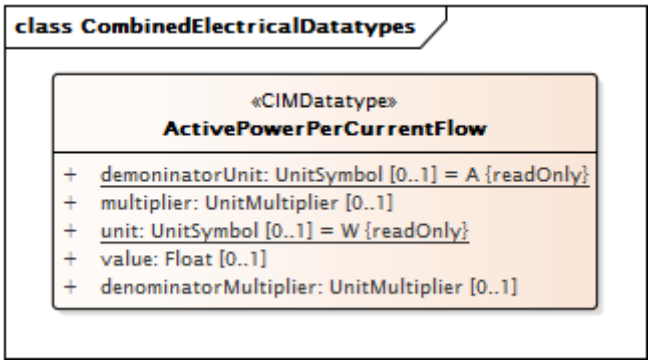


Figure 65 – Class diagram Domain::CombinedElectricalDatatypes

Figure 65: This diagram shows electrical datatypes that are combinations of other electrical datatypes.

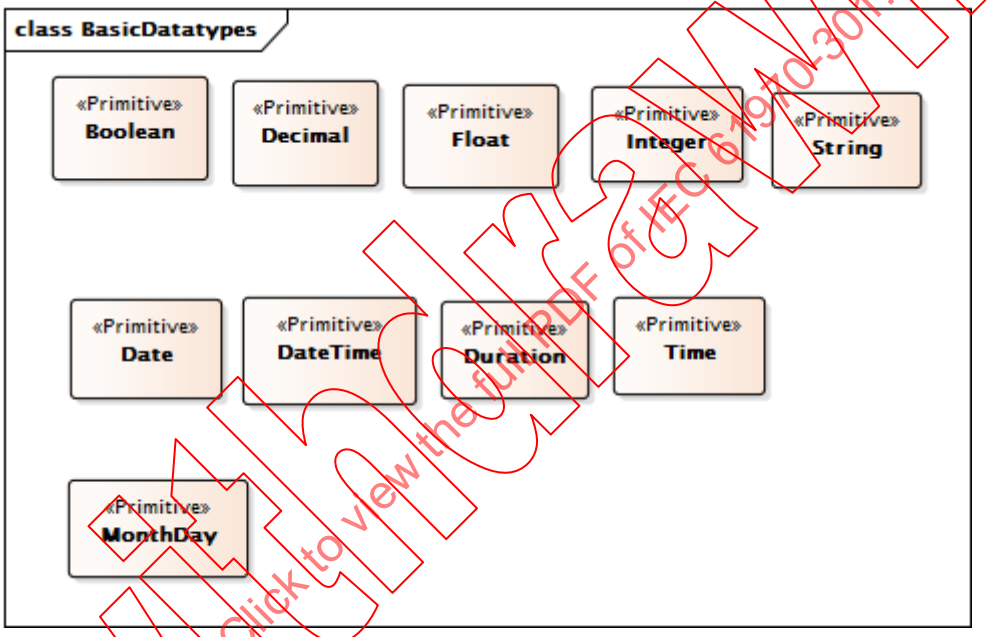
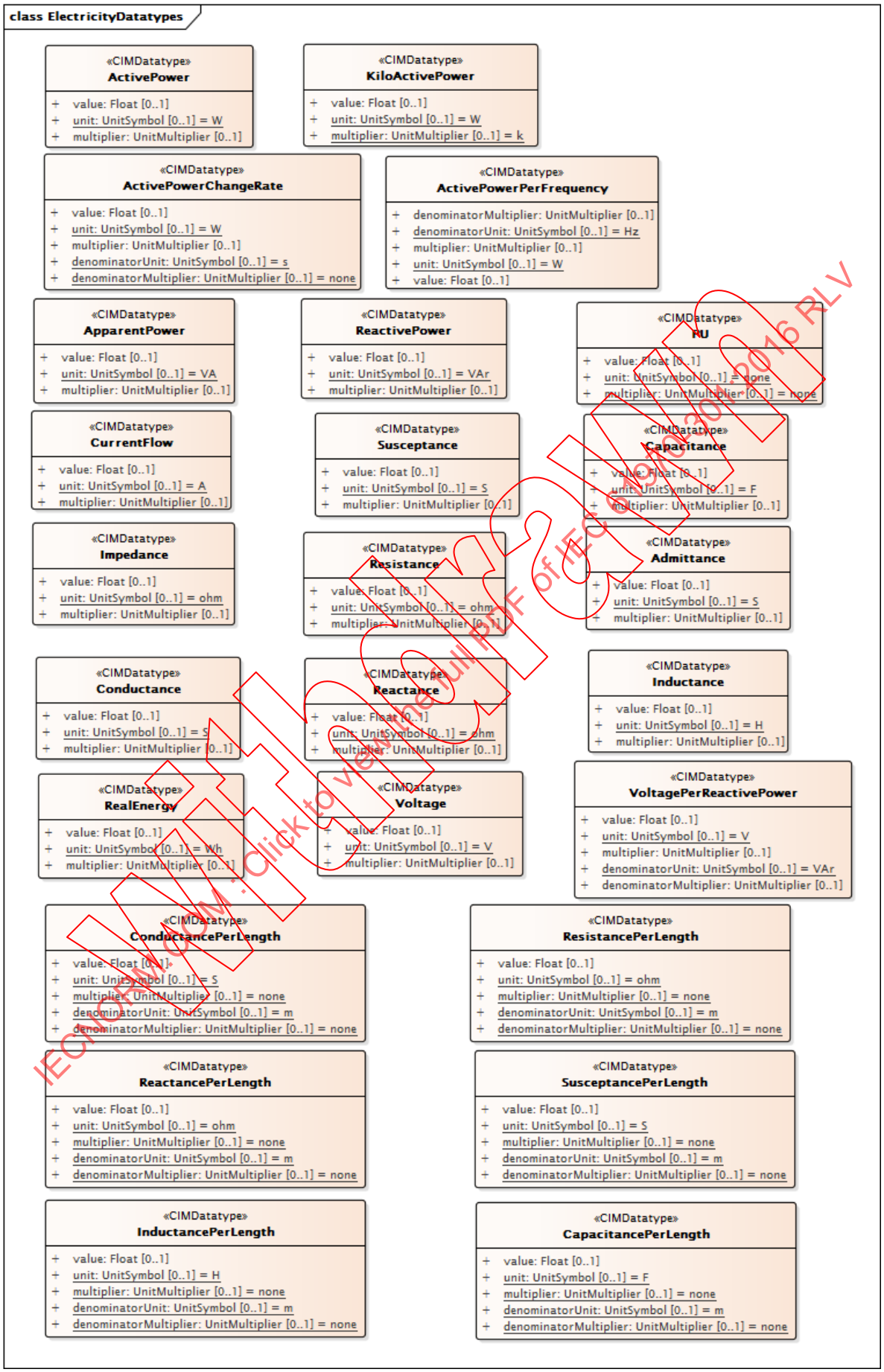


Figure 66 – Class diagram Domain::BasicDatatypes

Figure 66: This diagram shows basic datatypes that are the basis for all other datatypes.

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Figure 67 – Class diagram Domain::ElectricityDatatypes

Figure 67: This diagram shows electricity related data types.

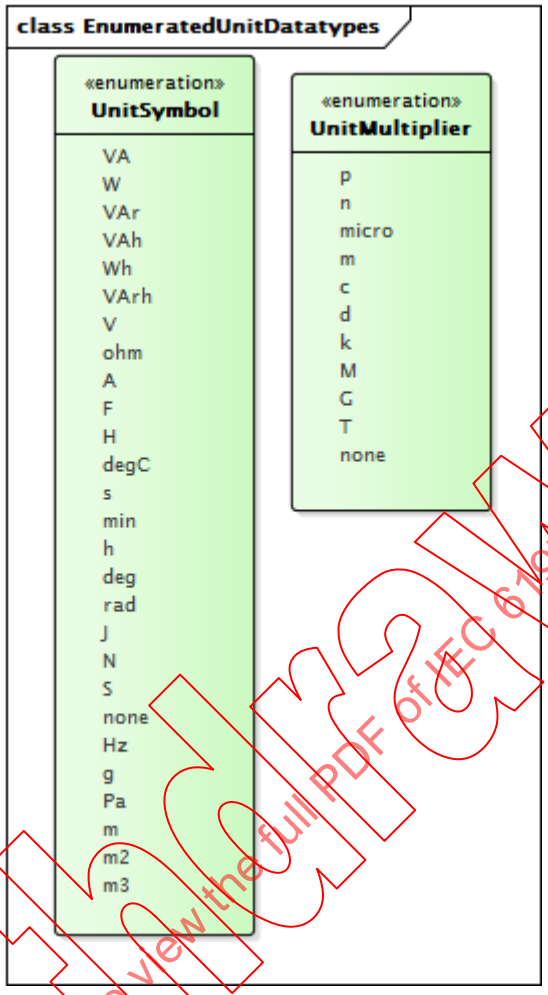
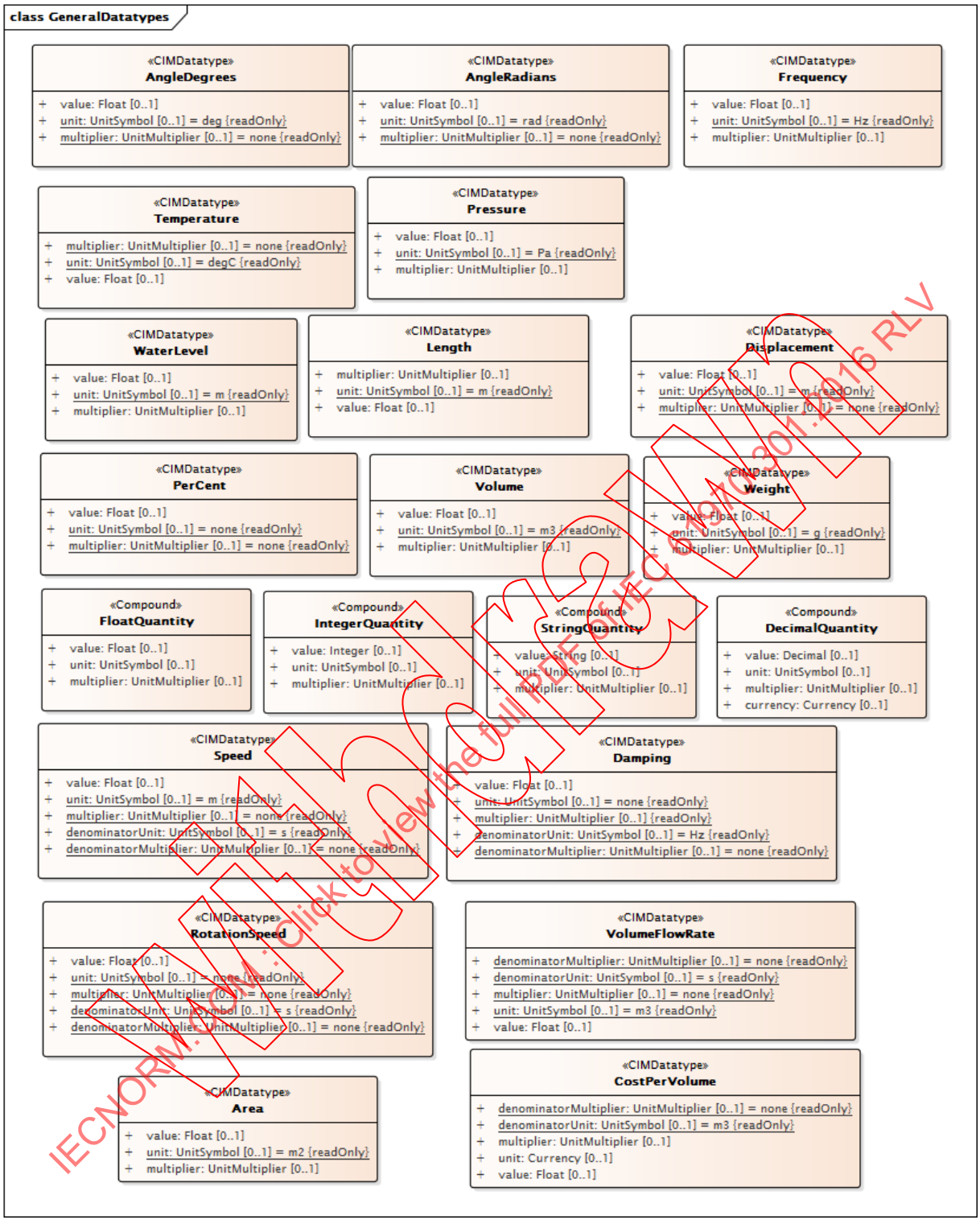


Figure 68 – Class diagram Domain::EnumeratedUnitDatatypes

Figure 68: This diagram shows enumerated data types related to the SI unit system.

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Figure 69 – Class diagram Domain::GeneralDatatypes

Figure 69: This diagram shows general data types.

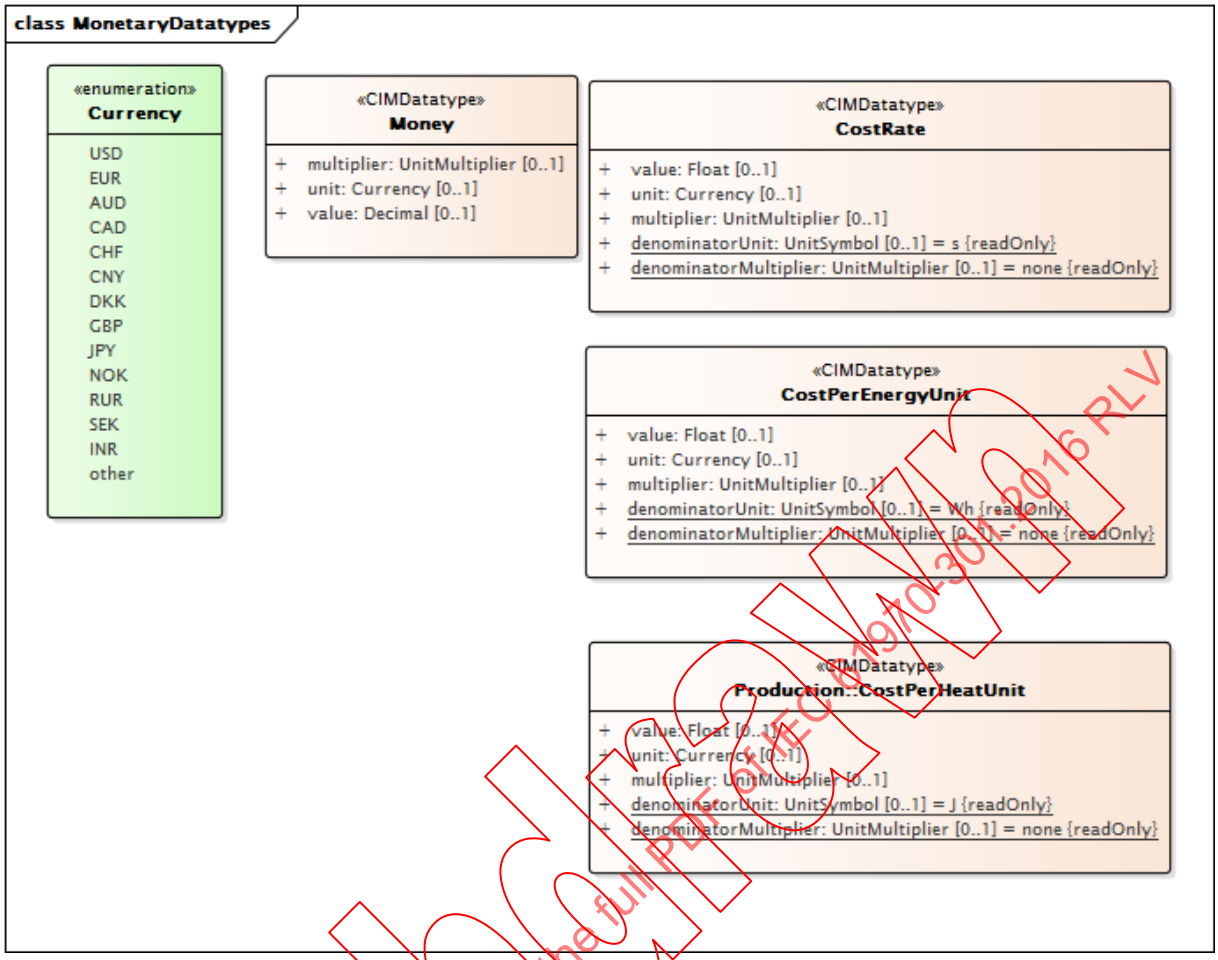


Figure 70 – Class diagram Domain::MonetaryDatatypes

Figure 70: This diagram shows monetary related data types.

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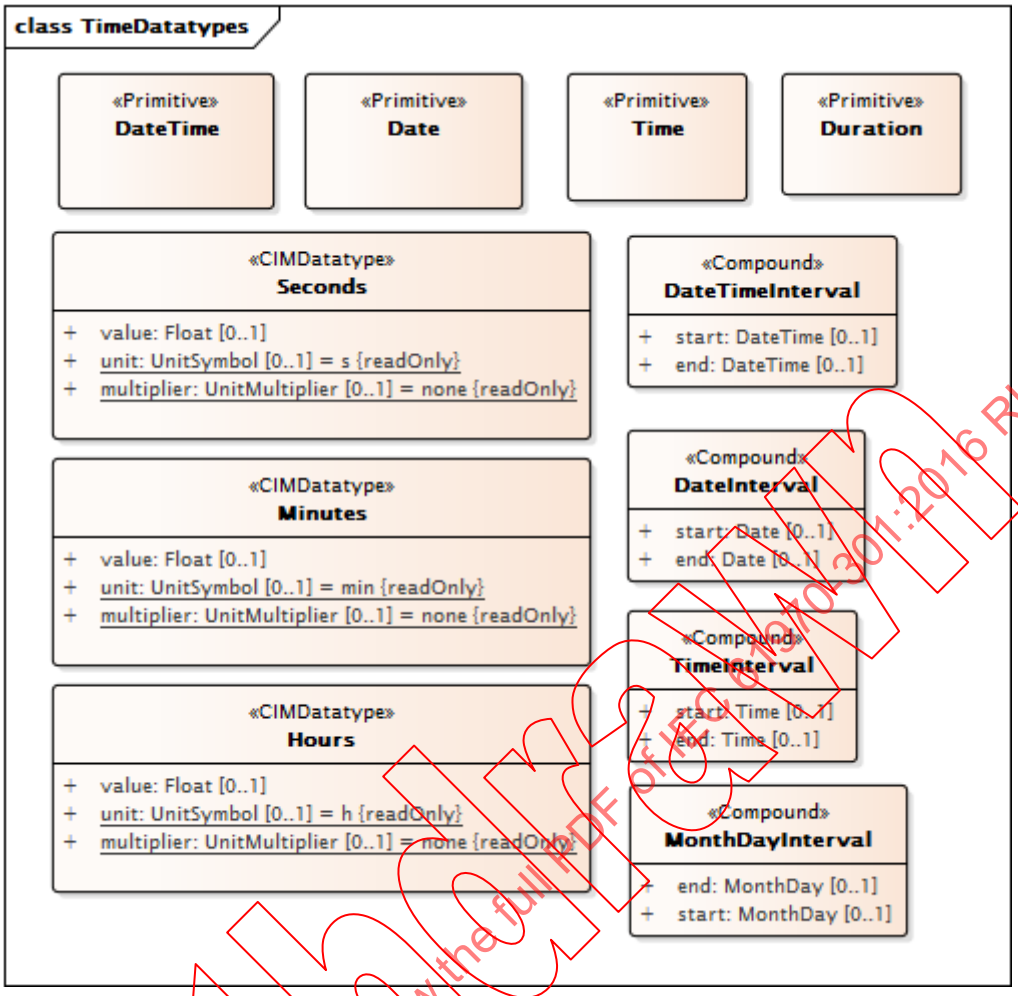


Figure 71 – Class diagram Domain::TimeDatatypes

Figure 71: This diagram shows time related data types.

6.4.2 ActivePower datatype

Product of RMS value of the voltage and the RMS value of the in-phase component of the current.

Table 22 shows all attributes of ActivePower.

Table 22 – Attributes of Domain::ActivePower

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=W)
multiplier	0..1	UnitMultiplier	

6.4.3 ActivePowerChangeRate datatype

Rate of change of active power per time.

Table 23 shows all attributes of ActivePowerChangeRate.

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Table 23 – Attributes of Domain::ActivePowerChangeRate

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=W)
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.4 ActivePowerPerCurrentFlow datatype

Table 24 shows all attributes of ActivePowerPerCurrentFlow.

Table 24 – Attributes of Domain::ActivePowerPerCurrentFlow

name	mult	type	description
denominatorUnit	0..1	UnitSymbol	(const=A)
multiplier	0..1	UnitMultiplier	
unit	0..1	UnitSymbol	(const=W)
value	0..1	Float	
denominatorMultiplier	0..1	UnitMultiplier	

6.4.5 ActivePowerPerFrequency datatype

Active power variation with frequency.

Table 25 shows all attributes of ActivePowerPerFrequency.

Table 25 – Attributes of Domain::ActivePowerPerFrequency

name	mult	type	description
denominatorMultiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=Hz)
multiplier	0..1	UnitMultiplier	
unit	0..1	UnitSymbol	(const=W)
value	0..1	Float	

6.4.6 Admittance datatype

Ratio of current to voltage.

Table 26 shows all attributes of Admittance.

Table 26 – Attributes of Domain::Admittance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	

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6.4.7 AngleDegrees datatype

Measurement of angle in degrees.

Table 27 shows all attributes of AngleDegrees.

Table 27 – Attributes of Domain::AngleDegrees

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=deg)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.8 AngleRadians datatype

Phase angle in radians.

Table 28 shows all attributes of AngleRadians.

Table 28 – Attributes of Domain::AngleRadians

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=rad)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.9 ApparentPower datatype

Product of the RMS value of the voltage and the RMS value of the current.

Table 29 shows all attributes of ApparentPower.

Table 29 – Attributes of Domain::ApparentPower

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=VA)
multiplier	0..1	UnitMultiplier	

6.4.10 Area datatype

Area.

Table 30 shows all attributes of Area.

Table 30 – Attributes of Domain::Area

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m2)
multiplier	0..1	UnitMultiplier	

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6.4.11 Boolean primitive

A type with the value space "true" and "false".

6.4.12 Capacitance datatype

Capacitive part of reactance (imaginary part of impedance), at rated frequency.

Table 31 shows all attributes of Capacitance.

Table 31 – Attributes of Domain::Capacitance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=F)
multiplier	0..1	UnitMultiplier	

6.4.13 CapacitancePerLength datatype

Capacitance per unit of length.

Table 32 shows all attributes of CapacitancePerLength.

Table 32 – Attributes of Domain::CapacitancePerLength

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=F)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.14 Conductance datatype

Factor by which voltage must be multiplied to give corresponding power lost from a circuit. Real part of admittance.

Table 33 shows all attributes of Conductance.

Table 33 – Attributes of Domain::Conductance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	

6.4.15 ConductancePerLength datatype

Real part of admittance per unit of length.

Table 34 shows all attributes of ConductancePerLength.

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Table 34 – Attributes of Domain::ConductancePerLength

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.16 CostPerEnergyUnit datatype

Cost, in units of currency, per quantity of electrical energy generated.

Table 35 shows all attributes of CostPerEnergyUnit.

Table 35 – Attributes of Domain::CostPerEnergyUnit

name	mult	type	description
value	0..1	Float	
unit	0..1	Currency	
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=Wh)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.17 CostPerVolume datatype

Cost per unit volume.

Table 36 shows all attributes of CostPerVolume.

Table 36 – Attributes of Domain::CostPerVolume

name	mult	type	description
denominatorMultiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m3)
multiplier	0..1	UnitMultiplier	
unit	0..1	Currency	
value	0..1	Float	

6.4.18 CostRate datatype

Cost, in units of currency, per elapsed time.

Table 37 shows all attributes of CostRate.

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Table 37 – Attributes of Domain::CostRate

name	mult	type	description
value	0..1	Float	
unit	0..1	Currency	
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.19 Currency enumeration

Monetary currencies. This list is not exhaustive.

Table 38 shows all literals of Currency.

Table 38 – Literals of Domain::Currency

literal	value	description
USD		US dollar
EUR		European euro
AUD		Australian dollar
CAD		Canadian dollar
CHF		Swiss franc
CNY		Chinese yuan renminbi
DKK		Danish crown
GBP		British pound
JPY		Japanese yen
NOK		Norwegian crown
RUR		Russian ruble
SEK		Swedish crown
INR		India rupees
other		Another type of currency.

6.4.20 CurrentFlow datatype

Electrical current with sign convention: positive flow is out of the conducting equipment into the connectivity node. Can be both AC and DC.

Table 39 shows all attributes of CurrentFlow.

Table 39 – Attributes of Domain::CurrentFlow

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=A)
multiplier	0..1	UnitMultiplier	

6.4.21 Damping datatype

Per-unit active power variation with frequency referenced on the system apparent power base. Typical values are in the range 1,0 to 2,0.

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Table 40 shows all attributes of Damping.

Table 40 – Attributes of Domain::Damping

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=Hz)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.22 Date primitive

Date as "yyyy-mm-dd", which conforms with ISO 8601. UTC time zone is specified as "yyyy-mm-ddZ". A local timezone relative UTC is specified as "yyyy-mm-dd(+/-)hh:mm".

6.4.23 DateInterval compound

Interval between two dates.

Table 41 shows all attributes of DateInterval.

Table 41 – Attributes of Domain::DateInterval

name	mult	type	description
start	0..1	Date	Start date of this interval.
end	0..1	Date	End date of this interval.

6.4.24 DateTime primitive

Date and time as "yyyy-mm-ddThh:mm:ss.sss", which conforms with ISO 8601. UTC time zone is specified as "yyyy-mm-ddThh:mm:ss.sssZ". A local timezone relative UTC is specified as "yyyy-mm-ddThh:mm:ss.sss-hh:mm". The second component (shown here as "ss.sss") could have any number of digits in its fractional part to allow any kind of precision beyond seconds.

6.4.25 DateTimeInterval compound

Interval between two date and time points.

Table 42 shows all attributes of DateTimeInterval.

Table 42 – Attributes of Domain::DateTimeInterval

name	mult	type	description
start	0..1	DateTime	Start date and time of this interval.
end	0..1	DateTime	End date and time of this interval.

6.4.26 Decimal primitive

Decimal is the base-10 notational system for representing real numbers.

6.4.27 DecimalQuantity compound

Table 43 shows all attributes of DecimalQuantity.

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Table 43 – Attributes of Domain::DecimalQuantity

name	mult	type	description
value	0..1	Decimal	
unit	0..1	UnitSymbol	
multiplier	0..1	UnitMultiplier	
currency	0..1	Currency	Quantity with decimal value and associated unit or currency information.

6.4.28 Displacement datatype

Unit of displacement relative to a reference position, hence can be negative.

Table 44 shows all attributes of Displacement.

Table 44 – Attributes of Domain::Displacement

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.29 Duration primitive

Duration as "PnYnMnDTnHnMnS" which conforms to ISO 8601, where nY expresses a number of years, nM a number of months, nD a number of days. The letter T separates the date expression from the time expression and, after it, nH identifies a number of hours, nM a number of minutes and nS a number of seconds. The number of seconds could be expressed as a decimal number, but all other numbers are integers.

6.4.30 Float primitive

A floating point number. The range is unspecified and not limited.

6.4.31 FloatQuantity compound

Quantity with float value and associated unit information.

Table 45 shows all attributes of FloatQuantity.

Table 45 – Attributes of Domain::FloatQuantity

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	
multiplier	0..1	UnitMultiplier	

6.4.32 Frequency datatype

Cycles per second.

Table 46 shows all attributes of Frequency.

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Table 46 – Attributes of Domain::Frequency

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=Hz)
multiplier	0..1	UnitMultiplier	

6.4.33 Hours datatype

Time specified in hours.

Table 47 shows all attributes of Hours.

Table 47 – Attributes of Domain::Hours

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=h)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.34 Impedance datatype

Ratio of voltage to current.

Table 48 shows all attributes of Impedance.

Table 48 – Attributes of Domain::Impedance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	

6.4.35 Inductance datatype

Inductive part of reactance (imaginary part of impedance), at rated frequency.

Table 49 shows all attributes of Inductance.

Table 49 – Attributes of Domain::Inductance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=H)
multiplier	0..1	UnitMultiplier	

6.4.36 InductancePerLength datatype

Inductance per unit of length.

Table 50 shows all attributes of InductancePerLength.

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Table 50 – Attributes of Domain::InductancePerLength

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=H)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.37 Integer primitive

An integer number. The range is unspecified and not limited.

6.4.38 IntegerQuantity compound

Quantity with integer value and associated unit information.

Table 51 shows all attributes of IntegerQuantity.

Table 51 – Attributes of Domain::IntegerQuantity

name	mult	type	description
value	0..1	Integer	
unit	0..1	UnitSymbol	
multiplier	0..1	UnitMultiplier	

6.4.39 KiloActivePower datatype

Active power in kilowatts.

Table 52 shows all attributes of KiloActivePower.

Table 52 – Attributes of Domain::KiloActivePower

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=W)
multiplier	0..1	UnitMultiplier	(const=k)

6.4.40 Length datatype

Unit of length. Never negative.

Table 53 shows all attributes of Length.

Table 53 – Attributes of Domain::Length

name	mult	type	description
multiplier	0..1	UnitMultiplier	
unit	0..1	UnitSymbol	(const=m)
value	0..1	Float	

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6.4.41 Minutes datatype

Time in minutes.

Table 54 shows all attributes of Minutes.

Table 54 – Attributes of Domain::Minutes

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=min)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.42 Money datatype

Amount of money.

Table 55 shows all attributes of Money.

Table 55 – Attributes of Domain::Money

name	mult	type	description
multiplier	0..1	UnitMultiplier	
unit	0..1	Currency	
value	0..1	Decimal	

6.4.43 MonthDay primitive

MonthDay format as "--mm-dd", which conforms with XSD data type gMonthDay.

6.4.44 MonthDayInterval compound

Interval between two times specified as month and day.

Table 56 shows all attributes of MonthDayInterval.

Table 56 – Attributes of Domain::MonthDayInterval

name	mult	type	description
end	0..1	MonthDay	End time of this interval.
start	0..1	MonthDay	Start time of this interval.

6.4.45 PU datatype

Per Unit – a positive or negative value referred to a defined base. Values typically range from −10 to +10.

Table 57 shows all attributes of PU.

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Table 57 – Attributes of Domain::PU

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.46 PerCent datatype

Percentage on a defined base. For example, specify as 100 to indicate the defined base.

Table 58 shows all attributes of PerCent.

Table 58 – Attributes of Domain::PerCent

name	mult	type	description
value	0..1	Float	Normally 0 to 100 on a defined base
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.47 Pressure datatype

Pressure in pascals.

Table 59 shows all attributes of Pressure.

Table 59 – Attributes of Domain::Pressure

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=Pa)
multiplier	0..1	UnitMultiplier	

6.4.48 Reactance datatype

Reactance (imaginary part of impedance), at rated frequency.

Table 60 shows all attributes of Reactance.

Table 60 – Attributes of Domain::Reactance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	

6.4.49 ReactancePerLength datatype

Reactance (imaginary part of impedance) per unit of length, at rated frequency.

Table 61 shows all attributes of ReactancePerLength.

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Table 61 – Attributes of Domain::ReactancePerLength

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.50 ReactivePower datatype

Product of RMS value of the voltage and the RMS value of the quadrature component of the current.

Table 62 shows all attributes of ReactivePower.

Table 62 – Attributes of Domain::ReactivePower

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=VAr)
multiplier	0..1	UnitMultiplier	

6.4.51 RealEnergy datatype

Real electrical energy.

Table 63 shows all attributes of RealEnergy.

Table 63 – Attributes of Domain::RealEnergy

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=Wh)
multiplier	0..1	UnitMultiplier	

6.4.52 Resistance datatype

Resistance (real part of impedance).

Table 64 shows all attributes of Resistance.

Table 64 – Attributes of Domain::Resistance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	

6.4.53 ResistancePerLength datatype

Resistance (real part of impedance) per unit of length.

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Table 65 shows all attributes of ResistancePerLength.

Table 65 – Attributes of Domain::ResistancePerLength

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.54 RotationSpeed datatype

Number of revolutions per second.

Table 66 shows all attributes of RotationSpeed.

Table 66 – Attributes of Domain::RotationSpeed

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.55 Seconds datatype

Time, in seconds.

Table 67 shows all attributes of Seconds.

Table 67 – Attributes of Domain::Seconds

name	mult	type	description
value	0..1	Float	Time, in seconds
unit	0..1	UnitSymbol	(const=s)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.56 Speed datatype

Distance per unit of time.

Table 68 shows all attributes of Speed.

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Table 68 – Attributes of Domain::Speed

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.57 String primitive

A string consisting of a sequence of characters. The character encoding is UTF-8. The string length is unspecified and unlimited.

6.4.58 StringQuantity compound

Quantity with string value (when it is not important whether it is an integral or a floating point number) and associated unit information.

Table 69 shows all attributes of StringQuantity.

Table 69 – Attributes of Domain::StringQuantity

name	mult	type	description
value	0..1	String	
unit	0..1	UnitSymbol	
multiplier	0..1	UnitMultiplier	

6.4.59 Susceptance datatype

Imaginary part of admittance.

Table 70 shows all attributes of Susceptance.

Table 70 – Attributes of Domain::Susceptance

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	

6.4.60 SusceptancePerLength datatype

Imaginary part of admittance per unit of length.

Table 71 shows all attributes of SusceptancePerLength.

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Table 71 – Attributes of Domain::SusceptancePerLength

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.61 Temperature datatype

Value of temperature in degrees Celsius.

Table 72 shows all attributes of Temperature.

Table 72 – Attributes of Domain::Temperature

name	mult	type	description
multiplier	0..1	UnitMultiplier	(const=none)
unit	0..1	UnitSymbol	(const=degC)
value	0..1	Float	

6.4.62 Time primitive

Time as "hh:mm:ss.sss", which conforms with ISO 8601. UTC time zone is specified as "hh:mm:ss.sssZ". A local timezone relative UTC is specified as "hh:mm:ss.sss±hh:mm". The second component (shown here as "ss.sss") could have any number of digits in its fractional part to allow any kind of precision beyond seconds.

6.4.63 TimeInterval compound

Interval between two times.

Table 73 shows all attributes of TimeInterval.

Table 73 – Attributes of Domain::TimeInterval

name	mult	type	description
start	0..1	Time	Start time of this interval.
end	0..1	Time	End time of this interval.

6.4.64 UnitMultiplier enumeration

The unit multipliers defined for the CIM.

Table 74 shows all literals of UnitMultiplier.

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Table 74 – Literals of Domain::UnitMultiplier

literal	value	description
p		Pico 10**-12.
n		Nano 10**-9.
micro		Micro 10**-6.
m		Milli 10**-3.
c		Centi 10**-2.
d		Deci 10**-1.
k		Kilo 10**3.
M		Mega 10**6.
G		Giga 10**9.
T		Tera 10**12.
none		No multiplier or equivalently multiply by 1.
** means "raised to power of".		

6.4.65 UnitSymbol enumeration

The units defined for usage in the CIM.

Table 75 shows all literals of UnitSymbol.

Table 75 – Literals of Domain::UnitSymbol

literal	value	description
VA		Apparent power in volt amperes.
W		Active power in watts.
VAr		Reactive power in volt amperes reactive.
VAh		Apparent energy in volt ampere hours.
Wh		Real energy in watt hours.
VArh		Reactive energy in volt ampere reactive hours.
V		Voltage in volts.
ohm		Resistance in ohms.
A		Current in amperes.
F		Capacitance in farads.
H		Inductance in henrys.
degC		Relative temperature in degrees Celsius. In the SI unit system the symbol is °C. Electric charge is measured in coulomb that has the unit symbol C. To distinguish degree Celsius from coulomb the symbol used in the UML is degC. The reason for not using °C is that the special character ° is difficult to manage in software.
s		Time in seconds.
min		Time in minutes.
h		Time in hours.
deg		Plane angle in degrees.
rad		Plane angle in radians.
J		Energy in joules.
N		Force in newtons.

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literal	value	description
S		Conductance in siemens.
none		Dimensionless quantity, e.g. count, per unit, etc.
Hz		Frequency in hertz.
g		Mass in grams.
Pa		Pressure in pascals (N/m2).
m		Length in metres.
m2		Area in square metres.
m3		Volume in cubic metres.

6.4.66 Voltage datatype

Electrical voltage, can be both AC and DC.

Table 76 shows all attributes of Voltage.

Table 76 – Attributes of Domain::Voltage

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=V)
multiplier	0..1	UnitMultiplier	

6.4.67 VoltagePerReactivePower datatype

Voltage variation with reactive power.

Table 77 shows all attributes of VoltagePerReactivePower.

Table 77 – Attributes of Domain::VoltagePerReactivePower

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=V)
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=VAr)
denominatorMultiplier	0..1	UnitMultiplier	

6.4.68 Volume datatype

Volume.

Table 78 shows all attributes of Volume.

Table 78 – Attributes of Domain::Volume

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m3)
multiplier	0..1	UnitMultiplier	

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6.4.69 VolumeFlowRate datatype

Volume per time.

Table 79 shows all attributes of VolumeFlowRate.

Table 79 – Attributes of Domain::VolumeFlowRate

name	mult	type	description
denominatorMultiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=s)
multiplier	0..1	UnitMultiplier	(const=none)
unit	0..1	UnitSymbol	(const=m3)
value	0..1	Float	

6.4.70 WaterLevel datatype

Reservoir water level referred to a given datum such as mean sea level.

Table 80 shows all attributes of WaterLevel.

Table 80 – Attributes of Domain::WaterLevel

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m)
multiplier	0..1	UnitMultiplier	

6.4.71 Weight datatype

The weight of an object.

Table 81 shows all attributes of Weight.

Table 81 – Attributes of Domain::Weight

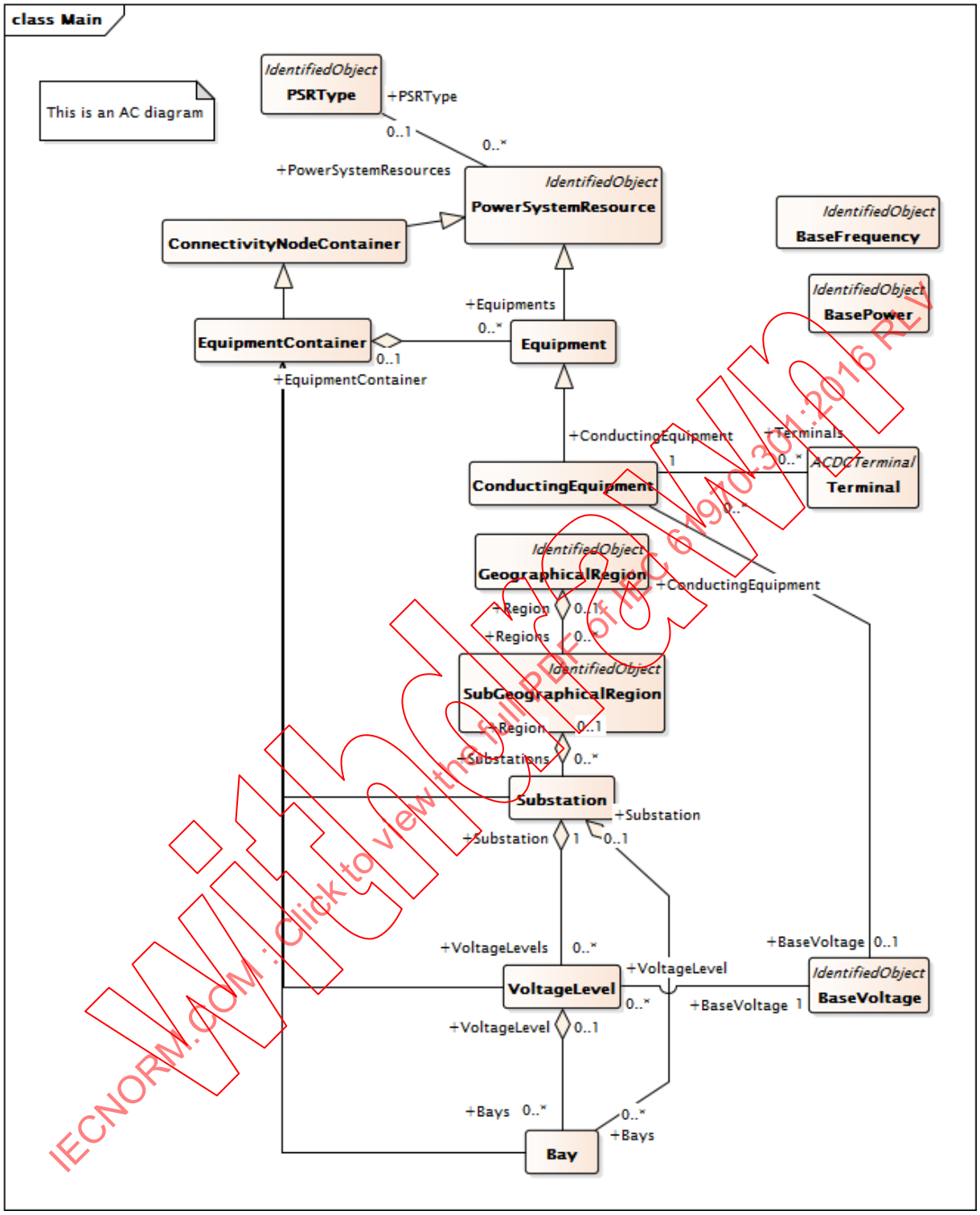
name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=g)
multiplier	0..1	UnitMultiplier	

6.5 Package Core

6.5.1 General

Contains the core PowerSystemResource and ConductingEquipment entities shared by all applications plus common collections of those entities. Not all applications require all the Core entities. This package does not depend on any other package except the Domain package, but most of the other packages have associations and generalizations that depend on it.

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Figure 72 – Class diagram Core::Main

Figure 72: This diagram shows the main classes needed for any application of the CIM for modeling transmission and generation systems.

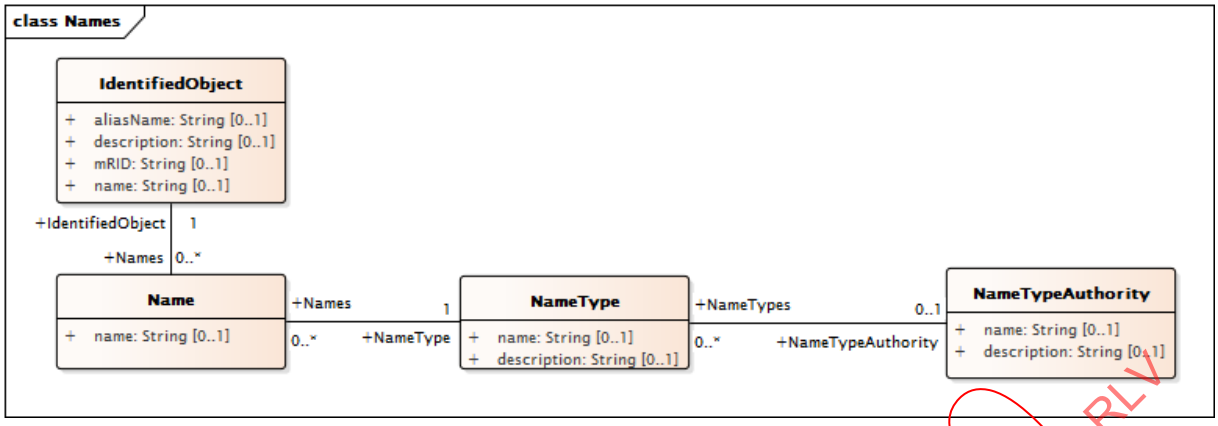
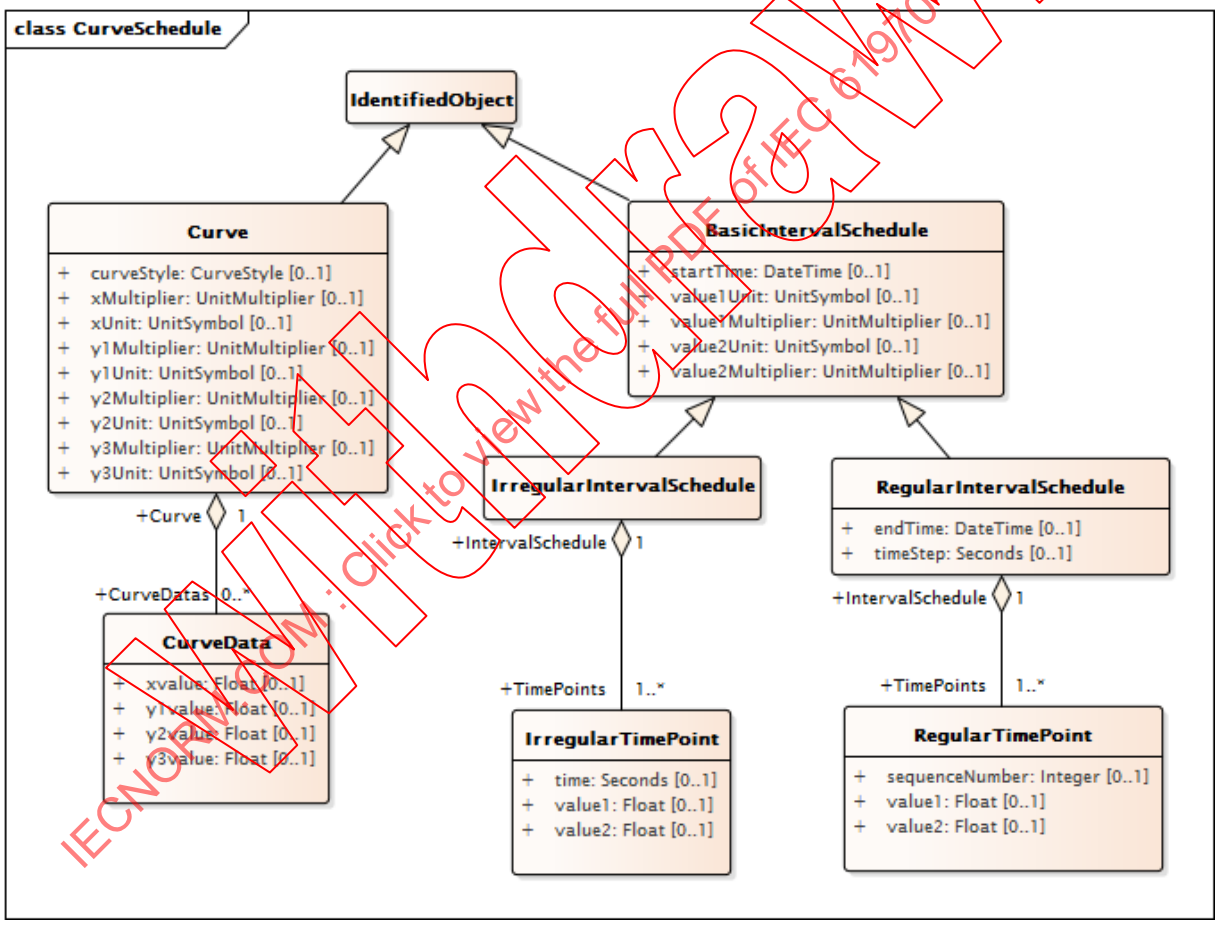


Figure 73 – Class diagram Core::Names

Figure 73: This diagram shows classes used to assign names to identified objects.



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Figure 74 – Class diagram Core::CurveSchedule

Figure 74: This diagram shows the common model for curves and time dependent schedules.

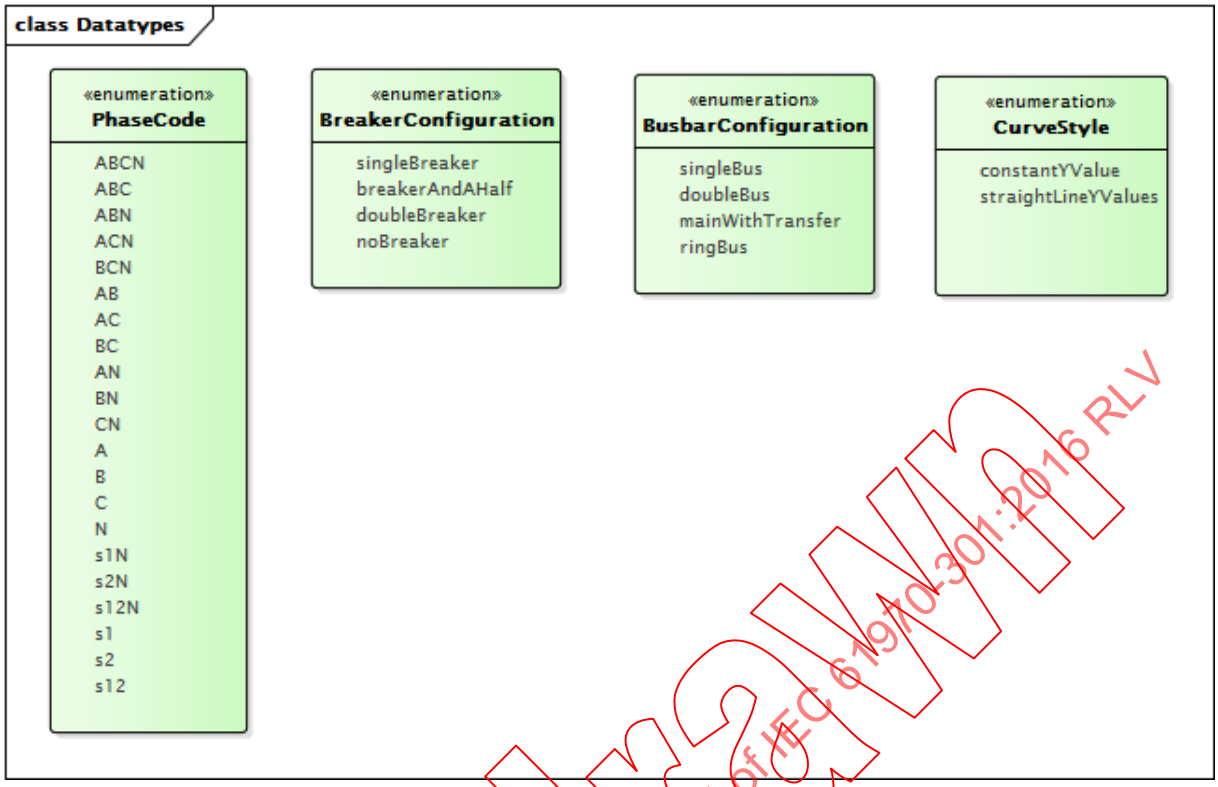


Figure 75 – Class diagram Core::Datatypes

Figure 75: This diagram shows the data types specific to the Core package.

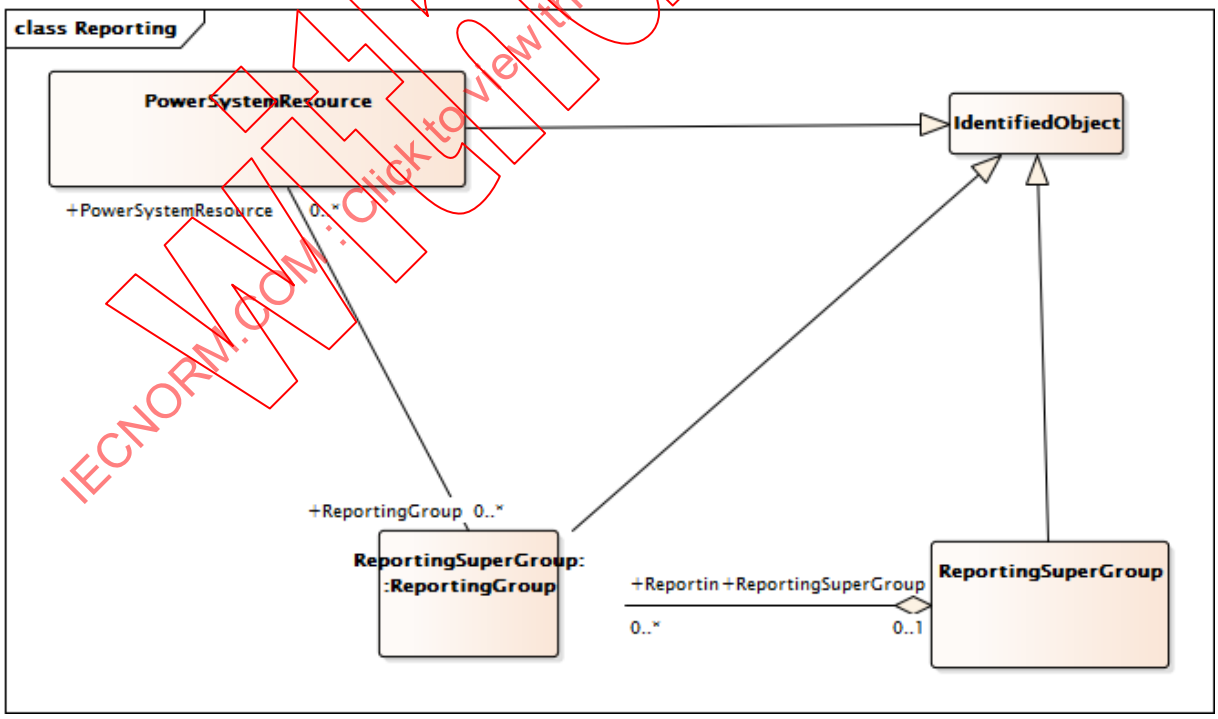


Figure 76 – Class diagram Core::Reporting

Figure 76: This diagram shows the common model for ad-hoc reporting.

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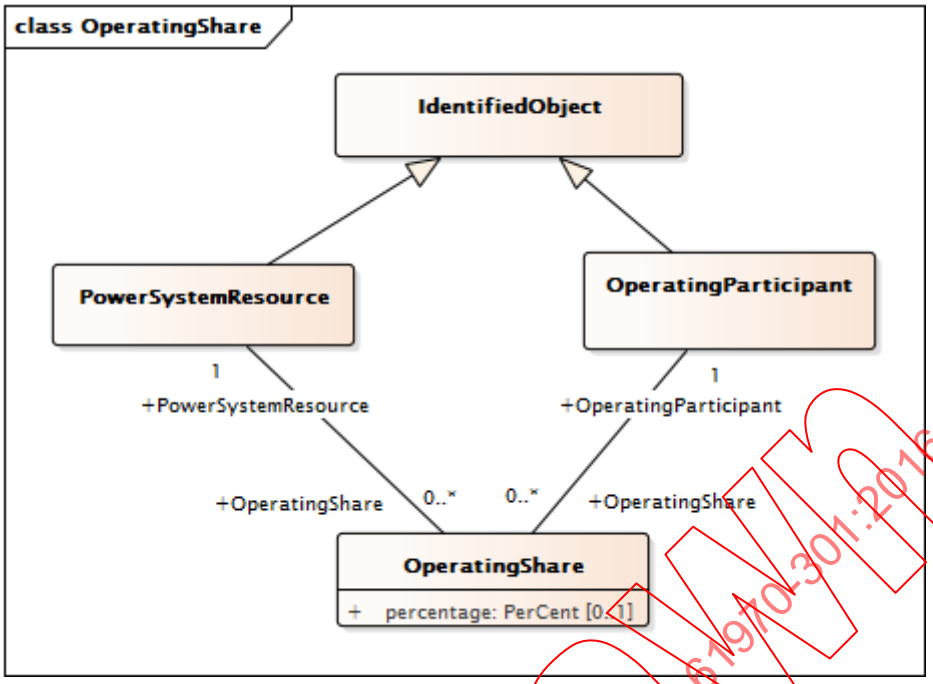


Figure 77 – Class diagram Core::OperatingShare

Figure 77: This diagram shows the common model for operating share.

6.5.2 ACDCTerminal

An electrical connection point (AC or DC) to a piece of conducting equipment. Terminals are connected at physical connection points called connectivity nodes.

Table 82 shows all attributes of ACDCTerminal.

Table 82 – Attributes of Core::ACDCTerminal

name	mult	type	description
connected	0..1	Boolean	The connected status is related to a bus-branch model and the topological node to terminal relation. True implies the terminal is connected to the related topological node and false implies it is not. In a bus-branch model, the connected status is used to tell if equipment is disconnected without having to change the connectivity described by the topological node to terminal relation. A valid case is that conducting equipment can be connected in one end and open in the other. In particular for an AC line segment, where the reactive line charging can be significant, this is a relevant case.
sequenceNumber	0..1	Integer	The orientation of the terminal connections for a multiple terminal conducting equipment. The sequence numbering starts with 1 and additional terminals should follow in increasing order. The first terminal is the "starting point" for a two terminal branch.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 83 shows all association ends of ACDCTerminal with other classes.

Table 83 – Association ends of Core::ACDCTerminal with other classes

mult from	name	mult to	type	description
1..*	BusNameMarker	0..1	BusNameMarker	The bus name marker used to name the bus (topological node).
0..1	OperationalLimitSet	0..*	OperationalLimitSet	The operational limit sets at the terminal.
0..1	Measurements	0..*	Measurement	Measurements associated with this terminal defining where the measurement is placed in the network topology. It may be used, for instance, to capture the sensor position, such as a voltage transformer (PT) at a busbar or a current transformer (CT) at the bar between a breaker and an isolator.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.3 BaseFrequency

The BaseFrequency class describes a base frequency for a power system network. In case of multiple power networks with different frequencies, e.g. 50 Hz or 60 Hz, each network will have it's own base frequency class. Hence it is assumed that power system objects having different base frequencies appear in separate documents where each document has a single base frequency instance.

Table 84 shows all attributes of BaseFrequency.

Table 84 – Attributes of Core::BaseFrequency

name	mult	type	description
frequency	0..1	Frequency	The base frequency.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 85 shows all association ends of BaseFrequency with other classes.

Table 85 – Association ends of Core::BaseFrequency with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.4 BasePower

The BasePower class defines the base power used in the per unit calculations.

Table 86 shows all attributes of BasePower.

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Table 86 – Attributes of Core::BasePower

name	mult	type	description
basePower	0..1	ApparentPower	Value used as base power.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 87 shows all association ends of BasePower with other classes.

Table 87 – Association ends of Core::BasePower with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.5 BaseVoltage

Defines a system base voltage which is referenced.

Table 88 shows all attributes of BaseVoltage.

Table 88 – Attributes of Core::BaseVoltage

name	mult	type	description
nominalVoltage	0..1	Voltage	The power system resource's base voltage.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 89 shows all association ends of BaseVoltage with other classes.

Table 89 – Association ends of Core::BaseVoltage with other classes

mult from	name	mult to	type	description
0..1	ConductingEquipment	0..*	ConductingEquipment	All conducting equipment with this base voltage. Use only when there is no voltage level container used and only one base voltage applies. For example, not used for transformers.
1..1	VoltageLevel	0..*	VoltageLevel	The voltage levels having this base voltage.
0..1	TransformerEnds	0..*	TransformerEnd	Transformer ends at the base voltage. This is essential for PU calculation.
0..1	TopologicalNode	0..*	TopologicalNode	The topological nodes at the base voltage.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.5.6 BasicIntervalSchedule

Schedule of values at points in time.

Table 90 shows all attributes of BasicIntervalSchedule.

Table 90 – Attributes of Core::BasicIntervalSchedule

name	mult	type	description
startTime	0..1	DateTime	The time for the first time point.
value1Unit	0..1	UnitSymbol	Value1 units of measure.
value1Multiplier	0..1	UnitMultiplier	Multiplier for value1.
value2Unit	0..1	UnitSymbol	Value2 units of measure.
value2Multiplier	0..1	UnitMultiplier	Multiplier for value2.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 91 shows all association ends of BasicIntervalSchedule with other classes.

Table 91 – Association ends of Core::BasicIntervalSchedule with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.7 Bay

A collection of power system resources (within a given substation) including conducting equipment, protection relays, measurements, and telemetry. A bay typically represents a physical grouping related to modularization of equipment.

Table 92 shows all attributes of Bay.

Table 92 – Attributes of Core::Bay

name	mult	type	description
bayEnergyMeasFlag	0..1	Boolean	Indicates the presence/absence of energy measurements.
bayPowerMeasFlag	0..1	Boolean	Indicates the presence/absence of active/reactive power measurements.
breakerConfiguration	0..1	BreakerConfiguration	Breaker configuration.
busBarConfiguration	0..1	BusbarConfiguration	Busbar configuration.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 93 shows all association ends of Bay with other classes.

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Table 93 – Association ends of Core::Bay with other classes

mult from	name	mult to	type	description
0..*	Substation	0..1	Substation	Substation containing the bay.
0..*	VoltageLevel	0..1	VoltageLevel	The voltage level containing this bay.
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.8 BreakerConfiguration enumeration

Switching arrangement for bay.

Table 94 shows all literals of BreakerConfiguration.

Table 94 – Literals of Core::BreakerConfiguration

literal	value	description
singleBreaker		Single breaker.
breakerAndAHalf		Breaker and a half.
doubleBreaker		Double breaker.
noBreaker		No breaker.

6.5.9 BusbarConfiguration enumeration

Busbar layout for bay.

Table 95 shows all literals of BusbarConfiguration.

Table 95 – Literals of Core::BusbarConfiguration

literal	value	description
singleBus		Single bus.
doubleBus		Double bus.
mainWithTransfer		Main bus with transfer bus.
ringBus		Ring bus.

6.5.10 ConductingEquipment

The parts of the AC power system that are designed to carry current or that are conductively connected through terminals.

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Table 96 shows all attributes of ConductingEquipment.

Table 96 – Attributes of Core::ConductingEquipment

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 97 shows all association ends of ConductingEquipment with other classes.

Table 97 – Association ends of Core::ConductingEquipment with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	Base voltage of this conducting equipment. Use only when there is no voltage level container used and only one base voltage applies. For example, not used for transformers.
1..1	SvStatus	0..1	SvStatus	The status state variable associated with this conducting equipment.
0..*	ProtectionEquipments	0..*	ProtectionEquipment	Protection equipment used to protect specific conducting equipment.
1..1	Terminals	0..*	Terminal	Conducting equipment have terminals that may be connected to other conducting equipment terminals via connectivity nodes or topological nodes.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.11 ConnectivityNode

Connectivity nodes are points where terminals of AC conducting equipment are connected together with zero impedance.

Table 98 shows all attributes of ConnectivityNode.

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Table 98 – Attributes of Core::ConnectivityNode

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 99 shows all association ends of ConnectivityNode with other classes.

Table 99 – Association ends of Core::ConnectivityNode with other classes

mult from	name	mult to	type	description
0..*	TopologicalNode	0..1	TopologicalNode	The topological node to which this connectivity node is assigned. May depend on the current state of switches in the network.
0..*	ConnectivityNodeContainer	1..1	ConnectivityNodeContainer	Container of this connectivity node.
0..1	Terminals	0..*	Terminal	Terminals interconnected with zero impedance at a this connectivity node.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.12 ConnectivityNodeContainer

A base class for all objects that may contain connectivity nodes or topological nodes.

Table 100 shows all attributes of ConnectivityNodeContainer.

Table 100 – Attributes of Core::ConnectivityNodeContainer

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 101 shows all association ends of ConnectivityNodeContainer with other classes.

Table 101 – Association ends of Core::ConnectivityNodeContainer with other classes

mult from	name	mult to	type	description
1..1	ConnectivityNodes	0..*	ConnectivityNode	Connectivity nodes which belong to this connectivity node container.
0..1	TopologicalNode	0..*	TopologicalNode	The topological nodes which belong to this connectivity node container.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.13 Curve

A multi-purpose curve or functional relationship between an independent variable (X-axis) and dependent (Y-axis) variables.

Table 102 shows all attributes of Curve.

Table 102 – Attributes of Core::Curve

name	mult	type	description
curveStyle	0..1	CurveStyle	The style or shape of the curve.
xMultiplier	0..1	UnitMultiplier	Multiplier for X-axis.
xUnit	0..1	UnitSymbol	The X-axis units of measure.
y1Multiplier	0..1	UnitMultiplier	Multiplier for Y1-axis.
y1Unit	0..1	UnitSymbol	The Y1-axis units of measure.
y2Multiplier	0..1	UnitMultiplier	Multiplier for Y2-axis.
y2Unit	0..1	UnitSymbol	The Y2-axis units of measure.
y3Multiplier	0..1	UnitMultiplier	Multiplier for Y3-axis.
y3Unit	0..1	UnitSymbol	The Y3-axis units of measure.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 103 shows all association ends of Curve with other classes.

Table 103 – Association ends of Core::Curve with other classes

mult from	name	mult to	type	description
1..1	CurveDatas	0..*	CurveData	The point data values that define this curve.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.14 CurveData root class

Multi-purpose data points for defining a curve. The use of this generic class is discouraged if a more specific class can be used to specify the X- and Y-axis values along with their specific data types.

Table 104 shows all attributes of CurveData.

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Table 104 – Attributes of Core::CurveData

name	mult	type	description
xvalue	0..1	Float	The data value of the X-axis variable, depending on the X-axis units.
y1value	0..1	Float	The data value of the first Y-axis variable, depending on the Y-axis units.
y2value	0..1	Float	The data value of the second Y-axis variable (if present), depending on the Y-axis units.
y3value	0..1	Float	The data value of the third Y-axis variable (if present), depending on the Y-axis units.

Table 105 shows all association ends of CurveData with other classes.

Table 105 – Association ends of Core::CurveData with other classes

mult from	name	mult to	type	description
0..*	Curve	1..1	Curve	The curve of this curve data point.

6.5.15 CurveStyle enumeration

Style or shape of curve.

Table 106 shows all literals of CurveStyle.

Table 106 – Literals of Core::CurveStyle

literal	value	description
constantYValue		The Y-axis values are assumed constant until the next curve point and prior to the first curve point.
straightLineYValues		The Y-axis values are assumed to be a straight line between values. Also known as linear interpolation.

6.5.16 Equipment

The parts of a power system that are physical devices, electronic or mechanical.

Table 107 shows all attributes of Equipment.

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Table 107 – Attributes of Core::Equipment

name	mult	type	description
aggregate	0..1	Boolean	The single instance of equipment represents multiple pieces of equipment that have been modeled together as an aggregate. Examples would be power transformers or synchronous machines operating in parallel modeled as a single aggregate power transformer or aggregate synchronous machine. This is not to be used to indicate equipment that is part of a group of interdependent equipment produced by a network production program.
normallyInService	0..1	Boolean	If true, the equipment is normally in service.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 108 shows all association ends of Equipment with other classes.

Table 108 – Association ends of Core::Equipment with other classes

mult from	name	mult to	type	description
0..1	Faults	0..*	Fault	All faults on this equipment.
0..1	OperationalLimitSet	0..*	OperationalLimitSet	The operational limit sets associated with this equipment.
1..1	ContingencyEquipment	0..*	ContingencyEquipment	The contingency equipments in which this equipment participates.
0..*	EquipmentContainer	0..1	EquipmentContainer	Container of this equipment.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.17 EquipmentContainer

A modeling construct to provide a root class for containing equipment.

Table 109 shows all attributes of EquipmentContainer.

Table 109 – Attributes of Core::EquipmentContainer

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 110 shows all association ends of EquipmentContainer with other classes.

Table 110 – Association ends of Core::EquipmentContainer with other classes

mult from	name	mult to	type	description
0..1	Equipments	0..*	Equipment	Contained equipment.
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.18 GeographicalRegion

A geographical region of a power system network model.

Table 111 shows all attributes of GeographicalRegion.

Table 111 – Attributes of Core::GeographicalRegion

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 112 shows all association ends of GeographicalRegion with other classes.

Table 112 – Association ends of Core::GeographicalRegion with other classes

mult from	name	mult to	type	description
0..1	Regions	0..*	SubGeographicalRegion	All sub-geographical regions within this geographical region.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.19 IdentifiedObject root class

This is a root class to provide common identification for all classes needing identification and naming attributes.

Table 113 shows all attributes of IdentifiedObject.

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Table 113 – Attributes of Core::IdentifiedObject

name	mult	type	description
aliasName	0..1	String	The aliasName is free text human readable name of the object alternative to IdentifiedObject.name. It may be non unique and may not correlate to a naming hierarchy. The attribute aliasName is retained because of backwards compatibility between CIM relases. It is however recommended to replace aliasName with the Name class as aliasName is planned for retirement at a future time.
description	0..1	String	The description is a free human readable text describing or naming the object. It may be non unique and may not correlate to a naming hierarchy.
mRID	0..1	String	Master resource identifier issued by a model authority. The mRID is globally unique within an exchange context. Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended. For CIMXML data files in RDF syntax conforming to IEC 61970-552:2013, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object elements.
name	0..1	String	The name is any free human readable and possibly non unique text naming the object.

Table 114 shows all association ends of IdentifiedObject with other classes.

Table 114 – Association ends of Core::IdentifiedObject with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	The diagram objects that are associated with the domain object.
1..1	Names	0..*	Name	All names of this identified object.

6.5.20 IrregularIntervalSchedule

The schedule has time points where the time between them varies.

Table 115 shows all attributes of IrregularIntervalSchedule.

Table 115 – Attributes of Core::IrregularIntervalSchedule

name	mult	type	description
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 116 shows all association ends of IrregularIntervalSchedule with other classes.

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Table 116 – Association ends of Core::IrregularIntervalSchedule with other classes

mult from	name	mult to	type	description
1..1	TimePoints	1..*	IrregularTimePoint	The point data values that define a curve.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.21 IrregularTimePoint root class

TimePoints for a schedule where the time between the points varies.

Table 117 shows all attributes of IrregularTimePoint.

Table 117 – Attributes of Core::IrregularTimePoint

name	mult	type	description
time	0..1	Seconds	The time is relative to the schedule starting time.
value1	0..1	Float	The first value at the time. The meaning of the value is defined by the derived type of the associated schedule.
value2	0..1	Float	The second value at the time. The meaning of the value is defined by the derived type of the associated schedule.

Table 118 shows all association ends of IrregularTimePoint with other classes.

Table 118 – Association ends of Core::IrregularTimePoint with other classes

mult from	name	mult to	type	description
1..*	IntervalSchedule	1..1	IrregularIntervalSchedule	An IrregularTimePoint belongs to an IrregularIntervalSchedule.

6.5.22 Name root class

The Name class provides the means to define any number of human readable names for an object. A name is not to be used for defining inter-object relationships. For inter-object relationships instead use the object identification 'mRID'.

Table 119 shows all attributes of Name.

Table 119 – Attributes of Core::Name

name	mult	type	description
name	0..1	String	Any free text that name the object.

Table 120 shows all association ends of Name with other classes.

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Table 120 – Association ends of Core::Name with other classes

mult from	name	mult to	type	description
0..*	IdentifiedObject	1..1	IdentifiedObject	Identified object that this name designates.
0..*	NameType	1..1	NameType	Type of this name.

6.5.23 NameType root class

Type of name. Possible values for attribute 'name' are implementation dependent but standard profiles may specify types. An enterprise may have multiple IT systems each having its own local name for the same object, e.g. a planning system may have different names from an EMS. An object may also have different names within the same IT system, e.g. localName as defined in CIM version 14. The definition from CIM14 is:

The localName is a human readable name of the object. It is a free text name local to a node in a naming hierarchy similar to a file directory structure. A power system related naming hierarchy may be: Substation, VoltageLevel, Equipment etc. Children of the same parent in such a hierarchy have names that typically are unique among them.

Table 121 shows all attributes of NameType.

Table 121 – Attributes of Core::NameType

name	mult	type	description
name	0..1	String	Name of the name type.
description	0..1	String	Description of the name type.

Table 122 shows all association ends of NameType with other classes.

Table 122 – Association ends of Core::NameType with other classes

mult from	name	mult to	type	description
0..*	NameTypeAuthority	0..1	NameTypeAuthority	Authority responsible for managing names of this type.
1..1	Names	0..*	Name	All names of this type.

6.5.24 NameTypeAuthority root class

Authority responsible for creation and management of names of a given type; typically an organization or an enterprise system.

Table 123 shows all attributes of NameTypeAuthority.

Table 123 – Attributes of Core::NameTypeAuthority

name	mult	type	description
name	0..1	String	Name of the name type authority.
description	0..1	String	Description of the name type authority.

Table 124 shows all association ends of NameTypeAuthority with other classes.

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Table 124 – Association ends of Core::NameTypeAuthority with other classes

mult from	name	mult to	type	description
0..1	NameTypes	0..*	NameType	All name types managed by this authority.

6.5.25 OperatingParticipant

An operator of multiple power system resource objects. Note multple operating participants may operate the same power system resource object. This can be used for modeling jointly owned units where each owner operates as a contractual share.

Table 125 shows all attributes of OperatingParticipant.

Table 125 – Attributes of Core::OperatingParticipant

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 126 shows all association ends of OperatingParticipant with other classes.

Table 126 – Association ends of Core::OperatingParticipant with other classes

mult from	name	mult to	type	description
1..1	OperatingShare	0..*	OperatingShare	The operating shares of this operating participant. An operating participant can be resused for any number of power system resources.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.26 OperatingShare root class

Specifies the operations contract relationship between a power system resource and a contract participant.

Table 127 shows all attributes of OperatingShare.

Table 127 – Attributes of Core::OperatingShare

name	mult	type	description
percentage	0..1	PerCent	Percentage operational ownership between the pair (power system resource and operating participant) associated with this share. The total percentage ownership for a power system resource should add to 100 %.

Table 128 shows all association ends of OperatingShare with other classes.

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Table 128 – Association ends of Core::OperatingShare with other classes

mult from	name	mult to	type	description
0..*	OperatingParticipant	1..1	OperatingParticipant	The operating participant having this share with the associated power system resource.
0..*	PowerSystemResource	1..1	PowerSystemResource	The power system resource to which the share applies.

6.5.27 PSRType

Classifying instances of the same class, e.g. overhead and underground ACLineSegments. This classification mechanism is intended to provide flexibility outside the scope of this standard, i.e. provide customization that is non standard.

Table 129 shows all attributes of PSRType.

Table 129 – Attributes of Core::PSRType

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 130 shows all association ends of PSRType with other classes.

Table 130 – Association ends of Core::PSRType with other classes

mult from	name	mult to	type	description
0..1	PowerSystemResources	0..*	PowerSystemResource	Power system resources classified with this power system resource type.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.28 PhaseCode enumeration

Enumeration of phase identifiers. Allows designation of phases for both transmission and distribution equipment, circuits and loads.

Residential and small commercial loads are often served from single-phase, or split-phase, secondary circuits. For the example of s12N, phases 1 and 2 refer to hot wires that are 180 degrees out of phase, while N refers to the neutral wire. Through single-phase transformer connections, these secondary circuits may be served from one or two of the primary phases A, B, and C. For three-phase loads, use the A, B, C phase codes instead of s12N.

Table 131 shows all literals of PhaseCode.

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Table 131 – Literals of Core::PhaseCode

literal	value	description
ABCN		Phases A, B, C, and N.
ABC		Phases A, B, and C.
ABN		Phases A, B, and neutral.
ACN		Phases A, C and neutral.
BCN		Phases B, C, and neutral.
AB		Phases A and B.
AC		Phases A and C.
BC		Phases B and C.
AN		Phases A and neutral.
BN		Phases B and neutral.
CN		Phases C and neutral.
A		Phase A.
B		Phase B.
C		Phase C.
N		Neutral phase.
s1N		Secondary phase 1 and neutral.
s2N		Secondary phase 2 and neutral.
s12N		Secondary phases 1, 2, and neutral.
s1		Secondary phase 1.
s2		Secondary phase 2.
s12		Secondary phase 1 and 2.

6.5.29 PowerSystemResource

A power system resource can be an item of equipment such as a switch, an equipment container containing many individual items of equipment such as a substation, or an organizational entity such as sub-control area. Power system resources can have measurements associated.

Table 132 shows all attributes of PowerSystemResource.

Table 132 – Attributes of Core::PowerSystemResource

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 133 shows all association ends of PowerSystemResource with other classes.

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Table 133 – Association ends of Core::PowerSystemResource with other classes

mult from	name	mult to	type	description
0..*	PSRType	0..1	PSRType	Custom classification for this power system resource.
0..1	Controls	0..*	Control	The controller outputs used to actually govern a regulating device, e.g. the magnetization of a synchronous machine or capacitor bank breaker actuator.
0..1	Measurements	0..*	Measurement	The measurements associated with this power system resource.
1..1	OperatingShare	0..*	OperatingShare	The operating shares of this power system resource.
0..*	ReportingGroup	0..*	ReportingGroup	Reporting groups to which this power system resource belongs.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.30 RegularIntervalSchedule

The schedule has time points where the time between them is constant.

Table 134 shows all attributes of RegularIntervalSchedule.

Table 134 – Attributes of Core::RegularIntervalSchedule

name	mult	type	description
endTime	0..1	DateTime	The time for the last time point.
timeStep	0..1	Seconds	The time between each pair of subsequent regular time points in sequence order.
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 135 shows all association ends of RegularIntervalSchedule with other classes.

Table 135 – Association ends of Core::RegularIntervalSchedule with other classes

mult from	name	mult to	type	description
1..1	TimePoints	1..*	RegularTimePoint	The regular interval time point data values that define this schedule.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.5.31 RegularTimePoint root class

Time point for a schedule where the time between the consecutive points is constant.

Table 136 shows all attributes of RegularTimePoint.

Table 136 – Attributes of Core::RegularTimePoint

name	mult	type	description
sequenceNumber	0..1	Integer	The position of the regular time point in the sequence. Note that time points don't have to be sequential, i.e. time points may be omitted. The actual time for a RegularTimePoint is computed by multiplying the associated regular interval schedule's time step with the regular time point sequence number and adding the associated schedule's start time.
value1	0..1	Float	The first value at the time. The meaning of the value is defined by the derived type of the associated schedule.
value2	0..1	Float	The second value at the time. The meaning of the value is defined by the derived type of the associated schedule.

Table 137 shows all association ends of RegularTimePoint with other classes.

Table 137 – Association ends of Core::RegularTimePoint with other classes

mult from	name	mult to	type	description
1..*	IntervalSchedule	1..1	RegularIntervalSchedule	Regular interval schedule containing this time point.

6.5.32 ReportingSuperGroup

A reporting super group, groups reporting groups for a higher level report.

Table 138 shows all attributes of ReportingSuperGroup.

Table 138 – Attributes of Core::ReportingSuperGroup

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 139 shows all association ends of ReportingSuperGroup with other classes.

Table 139 – Association ends of Core::ReportingSuperGroup with other classes

mult from	name	mult to	type	description
0..1	ReportingGroup	0..*	ReportingGroup	Reporting groups that are grouped under this super group.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.5.33 SubGeographicalRegion

A subset of a geographical region of a power system network model.

Table 140 shows all attributes of SubGeographicalRegion.

Table 140 – Attributes of Core::SubGeographicalRegion

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 141 shows all association ends of SubGeographicalRegion with other classes.

Table 141 – Association ends of Core::SubGeographicalRegion with other classes

mult from	name	mult to	type	description
0..1	Lines	0..*	Line	The lines within the sub-geographical region.
0..1	Substations	0..*	Substation	The substations in this sub-geographical region.
0..*	Region	0..1	GeographicalRegion	The geographical region which this sub-geographical region is within.
0..1	DCLines	0..*	DCLine	The DC lines in this sub-geographical region.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.34 Substation

A collection of equipment for purposes other than generation or utilization, through which electric energy in bulk is passed for the purposes of switching or modifying its characteristics.

Table 142 shows all attributes of Substation.

Table 142 – Attributes of Core::Substation

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 143 shows all association ends of Substation with other classes.

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Table 143 – Association ends of Core::Substation with other classes

mult from	name	mult to	type	description
1..1	VoltageLevels	0..*	VoltageLevel	The voltage levels within this substation.
0..1	Bays	0..*	Bay	Bays contained in the substation.
0..*	Region	0..1	SubGeographicalRegion	The SubGeographicalRegion containing the substation.
0..1	DCConverterUnit	0..*	DCConverterUnit	The DC converter unit belonging of the substation.
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.5.35 Terminal

An AC electrical connection point to a piece of conducting equipment. Terminals are connected at physical connection points called connectivity nodes.

Table 144 shows all attributes of Terminal.

Table 144 – Attributes of Core::Terminal

name	mult	type	description
phases	0..1	PhaseCode	Represents the normal network phasing condition. If the attribute is missing three phases (ABC or ABCN) shall be assumed.
connected	0..1	Boolean	inherited from: ACDCTerminal
sequenceNumber	0..1	Integer	inherited from: ACDCTerminal
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 145 shows all association ends of Terminal with other classes.

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Table 145 – Association ends of Core::Terminal with other classes

mult from	name	mult to	type	description
0..*	ConductingEquipment	1..1	ConductingEquipment	The conducting equipment of the terminal. Conducting equipment have terminals that may be connected to other conducting equipment terminals via connectivity nodes or topological nodes.
0..*	ConnectivityNode	0..1	ConnectivityNode	The connectivity node to which this terminal connects with zero impedance.
0..*	TopologicalNode	0..1	TopologicalNode	The topological node associated with the terminal. This can be used as an alternative to the connectivity node path to topological node, thus making it unneccesary to model connectivity nodes in some cases. Note that the if connectivity nodes are in the model, this association would probably not be used as an input specification.
0..1	RegulatingControl	0..*	RegulatingControl	The controls regulating this terminal.
0..1	EquipmentFaults	0..*	EquipmentFault	The equipment faults at this terminal.
1..1	HasFirstMutualCoupling	0..*	MutualCoupling	Mutual couplings associated with the branch as the first branch.
0..1	TransformerEnd	0..*	TransformerEnd	All transformer ends connected at this terminal.
1..1	BranchGroupTerminal	0..*	BranchGroupTerminal	The directed branch group terminals for which this terminal is monitored.
1..1	SvPowerFlow	0..1	SvPowerFlow	The power flow state variable associated with the terminal.
1..1	AuxiliaryEquipment	0..*	AuxiliaryEquipment	The auxiliary equipment connected to the terminal.
1..1	HasSecondMutualCoupling	0..*	MutualCoupling	Mutual couplings with the branch associated as the first branch.
1..1	TieFlow	0..2	TieFlow	The control area tie flows to which this terminal associates.
0..1	ConverterDCSides	0..*	ACDCConverter	All converters' DC sides linked to this point of common coupling terminal.
1..1	RemoteInputSignal	0..*	RemoteInputSignal	Input signal coming from this terminal.
1..*	BusNameMarker	0..1	BusNameMarker	inherited from: ACDCTerminal
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: ACDCTerminal
0..1	Measurements	0..*	Measurement	inherited from: ACDCTerminal
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.5.36 VoltageLevel

A collection of equipment at one common system voltage forming a switchgear. The equipment typically consist of breakers, busbars, instrumentation, control, regulation and protection devices as well as assemblies of all these.

Table 146 shows all attributes of VoltageLevel.

Table 146 – Attributes of Core::VoltageLevel

name	mult	type	description
highVoltageLimit	0..1	Voltage	The busbar's high voltage limit
lowVoltageLimit	0..1	Voltage	The busbar's low voltage limit
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 147 shows all association ends of VoltageLevel with other classes.

Table 147 – Association ends of Core::VoltageLevel with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	1..1	BaseVoltage	The base voltage used for all equipment within the voltage level.
0..1	Bays	0..*	Bay	The bays within this voltage level.
0..*	Substation	1..1	Substation	The substation of the voltage level.
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.6 Package DiagramLayout

6.6.1 General

This package describes diagram layout. This describes how objects are arranged in a coordinate system rather than how they are rendered.

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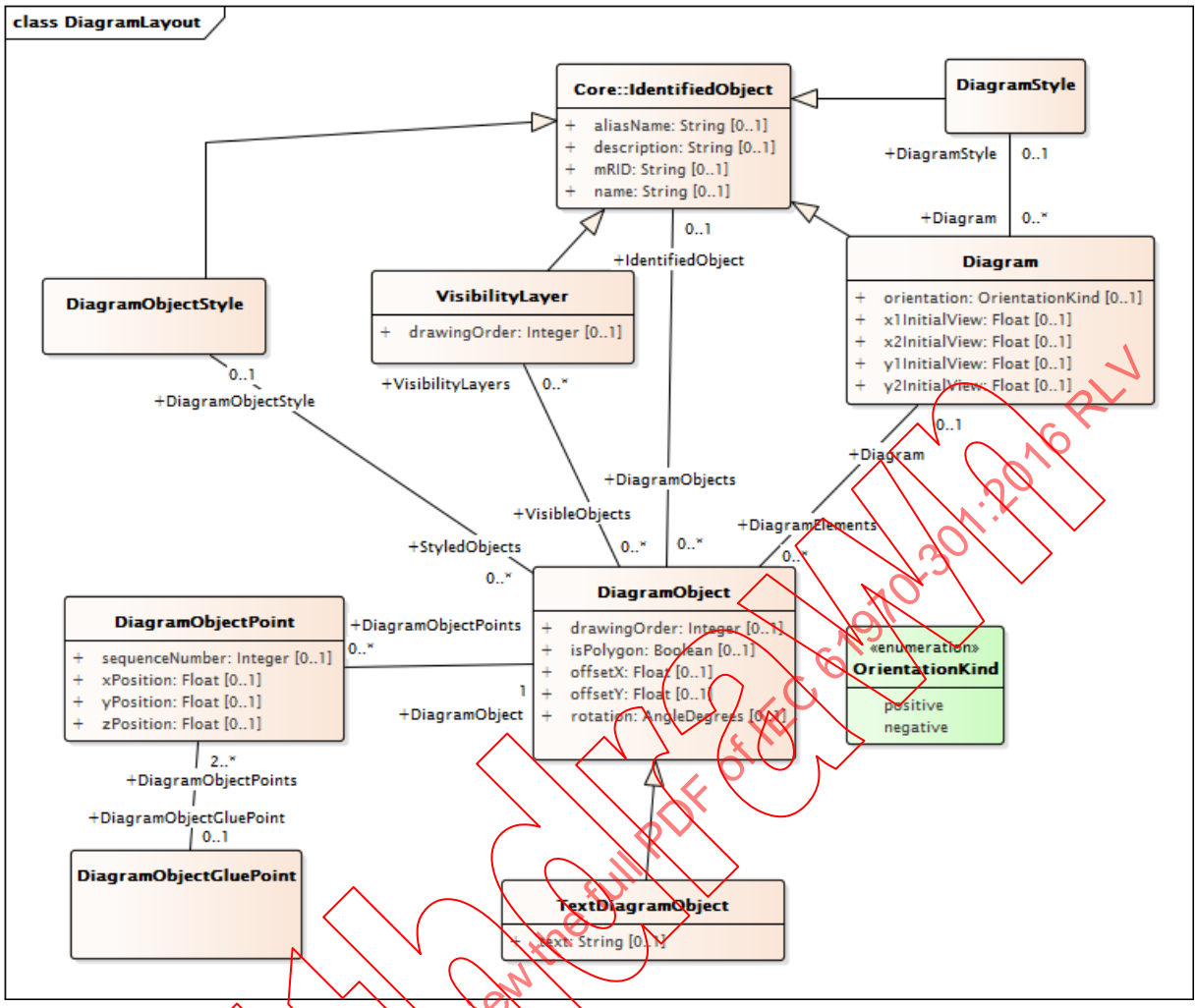


Figure 78 – Class diagram DiagramLayout::DiagramLayout

Figure 78: The diagram shows the diagram layout model.

6.6.2 DiagramStyle

The diagram style refers to a style used by the originating system for a diagram. A diagram style describes information such as schematic, geographic, bus-branch, etc.

Table 148 shows all attributes of DiagramStyle.

Table 148 – Attributes of DiagramLayout::DiagramStyle

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 149 shows all association ends of DiagramStyle with other classes.

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Table 149 – Association ends of DiagramLayout::DiagramStyle with other classes

mult from	name	mult to	type	description
0..1	Diagram	0..*	Diagram	A DiagramStyle can be used by many Diagrams.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.6.3 Diagram

The diagram being exchanged. The coordinate system is a standard Cartesian coordinate system and the orientation attribute defines the orientation.

Table 150 shows all attributes of Diagram.

Table 150 – Attributes of DiagramLayout::Diagram

name	mult	type	description
orientation	0..1	OrientationKind	Coordinate system orientation of the diagram.
x1InitialView	0..1	Float	X coordinate of the first corner of the initial view.
x2InitialView	0..1	Float	X coordinate of the second corner of the initial view.
y1InitialView	0..1	Float	Y coordinate of the first corner of the initial view.
y2InitialView	0..1	Float	Y coordinate of the second corner of the initial view.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 151 shows all association ends of Diagram with other classes.

Table 151 – Association ends of DiagramLayout::Diagram with other classes

mult from	name	mult to	type	description
0..*	DiagramStyle	0..1	DiagramStyle	A Diagram may have a DiagramStyle.
0..1	DiagramElements	0..*	DiagramObject	A diagram is made up of multiple diagram objects.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.6.4 DiagramObject

An object that defines one or more points in a given space. This object can be associated with anything that specializes IdentifiedObject. For single line diagrams such objects typically include such items as analog values, breakers, disconnectors, power transformers, and transmission lines.

Table 152 shows all attributes of DiagramObject.

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Table 152 – Attributes of DiagramLayout::DiagramObject

name	mult	type	description
drawingOrder	0..1	Integer	The drawing order of this element. The higher the number, the later the element is drawn in sequence. This is used to ensure that elements that overlap are rendered in the correct order.
isPolygon	0..1	Boolean	Defines whether or not the diagram objects points define the boundaries of a polygon or the routing of a polyline. If this value is true then a receiving application should consider the first and last points to be connected.
offsetX	0..1	Float	The offset in the X direction. This is used for defining the offset from centre for rendering an icon (the default is that a single point specifies the centre of the icon). The offset is in per-unit with 0 indicating there is no offset from the horizontal centre of the icon. -0.5 indicates it is offset by 50 % to the left and 0.5 indicates an offset of 50 % to the right.
offsetY	0..1	Float	The offset in the Y direction. This is used for defining the offset from centre for rendering an icon (the default is that a single point specifies the centre of the icon). The offset is in per-unit with 0 indicating there is no offset from the vertical centre of the icon. The offset direction is dependent on the orientation of the diagram, with -0.5 and 0.5 indicating an offset of +/- 50 % on the vertical axis.
rotation	0..1	AngleDegrees	Sets the angle of rotation of the diagram object. Zero degrees is pointing to the top of the diagram. Rotation is clockwise.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 153 shows all association ends of DiagramObject with other classes.

Table 153 – Association ends of DiagramLayout::DiagramObject with other classes

mult from	name	mult to	type	description
0..*	Diagram	0..1	Diagram	A diagram object is part of a diagram.
0..*	VisibilityLayers	0..*	VisibilityLayer	A diagram object can be part of multiple visibility layers.
1..1	DiagramObjectPoints	0..*	DiagramObjectPoint	A diagram object can have 0 or more points to reflect its layout position, routing (for polylines) or boundary (for polygons).
0..*	DiagramObjectStyle	0..1	DiagramObjectStyle	A diagram object has a style associated that provides a reference for the style used in the originating system.
0..*	IdentifiedObject	0..1	IdentifiedObject	The domain object to which this diagram object is associated.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.6.5 DiagramObjectGluePoint root class

This is used for grouping diagram object points from different diagram objects that are considered to be glued together in a diagram even if they are not at the exact same coordinates.

Table 154 shows all association ends of DiagramObjectGluePoint with other classes.

Table 154 – Association ends of DiagramLayout::DiagramObjectGluePoint with other classes

mult from	name	mult to	type	description
0..1	DiagramObjectPoints	2..*	DiagramObjectPoint	A diagram object glue point is associated with 2 or more object points that are considered to be 'glued' together.

6.6.6 DiagramObjectPoint root class

A point in a given space defined by 3 coordinates and associated to a diagram object. The coordinates may be positive or negative as the origin does not have to be in the corner of a diagram.

Table 155 shows all attributes of DiagramObjectPoint.

Table 155 – Attributes of DiagramLayout::DiagramObjectPoint

name	mult	type	description
sequenceNumber	0..1	Integer	The sequence position of the point, used for defining the order of points for diagram objects acting as a polyline or polygon with more than one point.
xPosition	0..1	Float	The X coordinate of this point.
yPosition	0..1	Float	The Y coordinate of this point.
zPosition	0..1	Float	The Z coordinate of this point.

Table 156 shows all association ends of DiagramObjectPoint with other classes.

Table 156 – Association ends of DiagramLayout::DiagramObjectPoint with other classes

mult from	name	mult to	type	description
2..*	DiagramObjectGluePoint	0..1	DiagramObjectGluePoint	The 'glue' point to which this point is associated.
0..*	DiagramObject	1..1	DiagramObject	The diagram object with which the points are associated.

6.6.7 DiagramObjectStyle

A reference to a style used by the originating system for a diagram object. A diagram object style describes information such as line thickness, shape such as circle or rectangle etc, and color.

Table 157 shows all attributes of DiagramObjectStyle.

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Table 157 – Attributes of DiagramLayout::DiagramObjectStyle

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 158 shows all association ends of DiagramObjectStyle with other classes.

Table 158 – Association ends of DiagramLayout::DiagramObjectStyle with other classes

mult from	name	mult to	type	description
0..1	StyledObjects	0..*	DiagramObject	A style can be assigned to multiple diagram objects.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.6.8 OrientationKind enumeration

The orientation of the coordinate system with respect to top, left, and the coordinate number system.

Table 159 shows all literals of OrientationKind.

Table 159 – Literals of DiagramLayout::OrientationKind

literal	value	description
positive		For 2D diagrams, a positive orientation will result in X values increasing from left to right and Y values increasing from bottom to top. This is also known as a right hand orientation.
negative		For 2D diagrams, a negative orientation gives the left-hand orientation (favoured by computer graphics displays) with X values increasing from left to right and Y values increasing from top to bottom. This is also known as a left hand orientation.

6.6.9 TextDiagramObject

A diagram object for placing free-text or text derived from an associated domain object.

Table 160 shows all attributes of TextDiagramObject.

Table 160 – Attributes of DiagramLayout::TextDiagramObject

name	mult	type	description
text	0..1	String	The text that is displayed by this text diagram object.
drawingOrder	0..1	Integer	inherited from: DiagramObject
isPolygon	0..1	Boolean	inherited from: DiagramObject
offsetX	0..1	Float	inherited from: DiagramObject
offsetY	0..1	Float	inherited from: DiagramObject

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name	mult	type	description
rotation	0..1	AngleDegrees	inherited from: DiagramObject
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 161 shows all association ends of TextDiagramObject with other classes.

Table 161 – Association ends of DiagramLayout::TextDiagramObject with other classes

mult from	name	mult to	type	description
0..*	Diagram	0..1	Diagram	inherited from: DiagramObject
0..*	VisibilityLayers	0..*	VisibilityLayer	inherited from: DiagramObject
1..1	DiagramObjectPoints	0..*	DiagramObjectPoint	inherited from: DiagramObject
0..*	DiagramObjectStyle	0..1	DiagramObjectStyle	inherited from: DiagramObject
0..*	IdentifiedObject	0..1	IdentifiedObject	inherited from: DiagramObject
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.6.10 VisibilityLayer

Layers are typically used for grouping diagram objects according to themes and scales. Themes are used to display or hide certain information (e.g. lakes, borders), while scales are used for hiding or displaying information depending on the current zoom level (hide text when it is too small to be read, or when it exceeds the screen size). This is also called de-cluttering.

CIM based graphics exchange will support an m:n relationship between diagram objects and layers. It will be the task of the importing system to convert an m:n case into an appropriate 1:n representation if the importing system does not support m:n.

Table 162 shows all attributes of VisibilityLayer.

Table 162 – Attributes of DiagramLayout::VisibilityLayer

name	mult	type	description
drawingOrder	0..1	Integer	The drawing order for this layer. The higher the number, the later the layer and the objects within it are rendered.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 163 shows all association ends of VisibilityLayer with other classes.

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Table 163 – Association ends of DiagramLayout::VisibilityLayer with other classes

mult from	name	mult to	type	description
0..*	VisibleObjects	0..*	DiagramObject	A visibility layer can contain one or more diagram objects.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7 Package OperationalLimits

6.7.1 General

This package models a specification of limits associated with equipment and other operational entities.

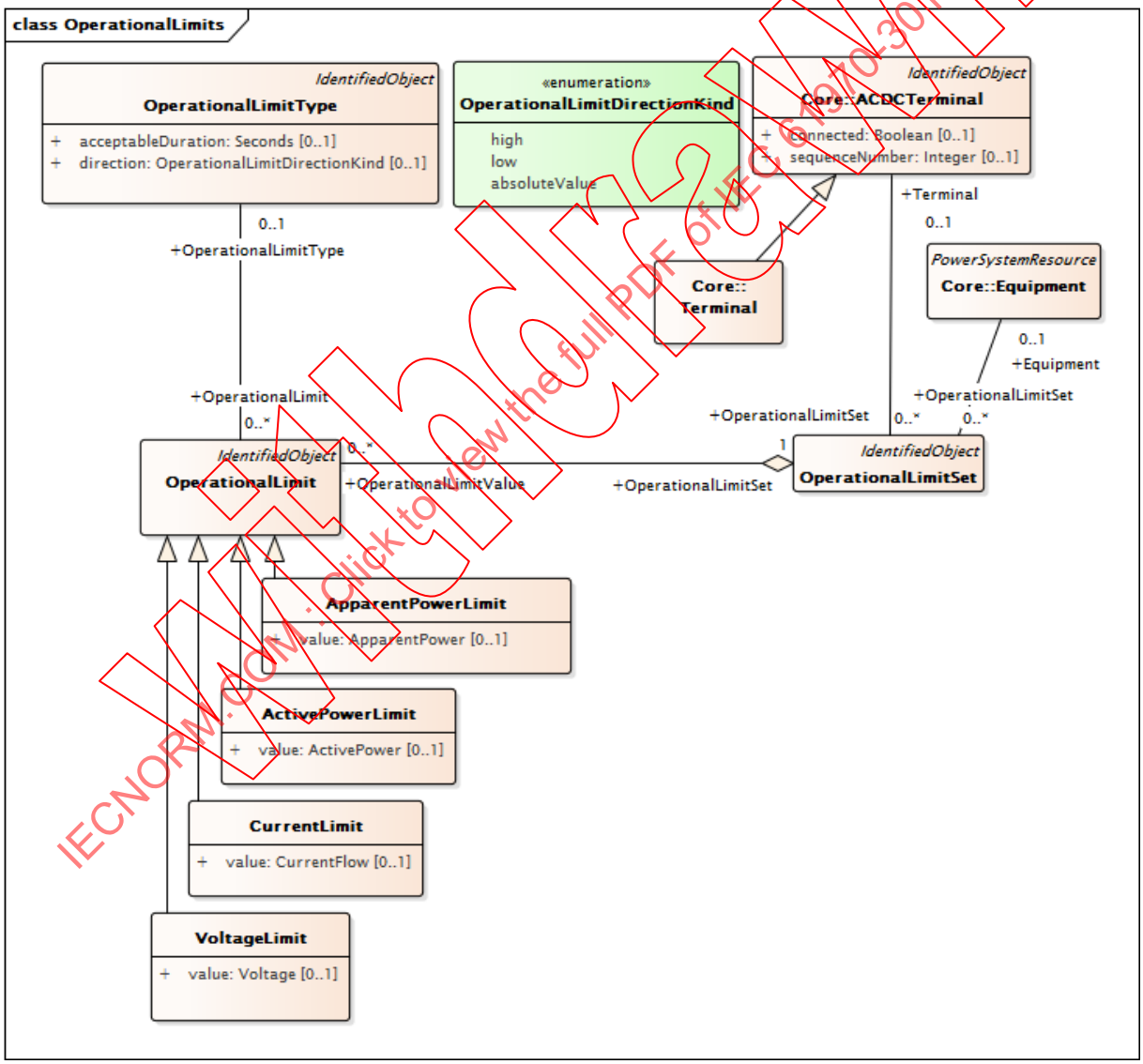


Figure 79 – Class diagram OperationalLimits::OperationalLimits

Figure 79: This diagram shows operational limits as they tie back into the core model.

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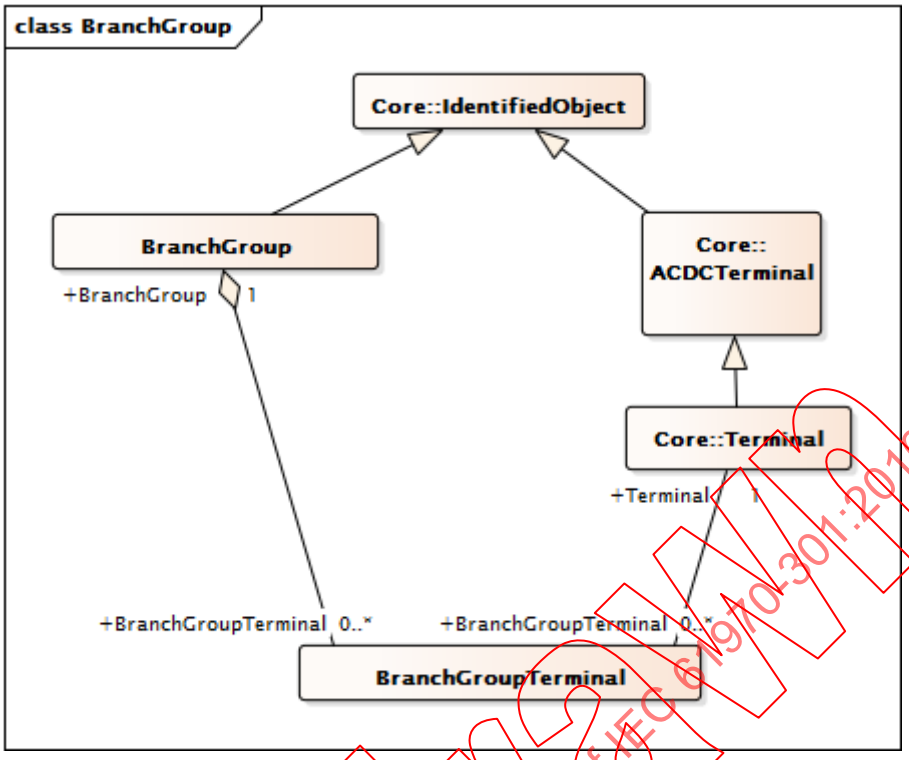


Figure 80 – Class diagram OperationalLimits::BranchGroup

Figure 80: This diagram shows the model for monitoring combined flows on groups of branches.

6.7.2 ActivePowerLimit

Limit on active power flow.

Table 164 shows all attributes of ActivePowerLimit.

Table 164 – Attributes of OperationalLimits::ActivePowerLimit

name	mult	type	description
value	0..1	ActivePower	Value of active power limit.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 165 shows all association ends of ActivePowerLimit with other classes.

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Table 165 – Association ends of OperationalLimits::ActivePowerLimit with other classes

mult from	name	mult to	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	inherited from: OperationalLimit
0..*	OperationalLimitType	0..1	OperationalLimitType	inherited from: OperationalLimit
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.3 ApparentPowerLimit

Apparent power limit.

Table 166 shows all attributes of ApparentPowerLimit.

Table 166 – Attributes of OperationalLimits::ApparentPowerLimit

name	mult	type	description
value	0..1	ApparentPower	The apparent power limit.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 167 shows all association ends of ApparentPowerLimit with other classes.

Table 167 – Association ends of OperationalLimits::ApparentPowerLimit with other classes

mult from	name	mult to	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	inherited from: OperationalLimit
0..*	OperationalLimitType	0..1	OperationalLimitType	inherited from: OperationalLimit
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.4 BranchGroup

A group of branch terminals whose directed flow summation is to be monitored. A branch group need not form a cutset of the network.

Table 168 shows all attributes of BranchGroup.

Table 168 – Attributes of OperationalLimits::BranchGroup

name	mult	type	description
maximumActivePower	0..1	ActivePower	The maximum active power flow.
maximumReactivePower	0..1	ReactivePower	The maximum reactive power flow.
minimumActivePower	0..1	ActivePower	The minimum active power flow.
minimumReactivePower	0..1	ReactivePower	The minimum reactive power flow.
monitorActivePower	0..1	Boolean	Monitor the active power flow.

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name	mult	type	description
monitorReactivePower	0..1	Boolean	Monitor the reactive power flow.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 169 shows all association ends of BranchGroup with other classes.

Table 169 – Association ends of OperationalLimits::BranchGroup with other classes

mult from	name	mult to	type	description
1..1	BranchGroupTerminal	0..*	BranchGroupTerminal	The directed branch group terminals to be summed.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.5 BranchGroupTerminal root class

A specific directed terminal flow for a branch group.

Table 170 shows all attributes of BranchGroupTerminal.

Table 170 – Attributes of OperationalLimits::BranchGroupTerminal

name	mult	type	description
positiveFlowIn	0..1	Boolean	The flow into the terminal is summed if set true. The flow out of the terminal is summed if set false.

Table 171 shows all association ends of BranchGroupTerminal with other classes.

Table 171 – Association ends of OperationalLimits::BranchGroupTerminal with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	The terminal to be summed.
0..*	BranchGroup	1..1	BranchGroup	The branch group to which the directed branch group terminals belong.

6.7.6 CurrentLimit

Operational limit on current.

Table 172 shows all attributes of CurrentLimit.

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Table 172 – Attributes of OperationalLimits::CurrentLimit

name	mult	type	description
value	0..1	CurrentFlow	Limit on current flow.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 173 shows all association ends of CurrentLimit with other classes.

Table 173 – Association ends of OperationalLimits::CurrentLimit with other classes

mult from	name	mult to	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	inherited from: OperationalLimit
0..*	OperationalLimitType	0..1	OperationalLimitType	inherited from: OperationalLimit
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.7 OperationalLimit

A value associated with a specific kind of limit.

The sub class value attribute shall be positive.

The sub class value attribute is inversely proportional to OperationalLimitType.acceptableDuration (acceptableDuration for short). A pair of value_x and acceptableDuration_x are related to each other as follows:

if value_1 > value_2 > value_3 > ..., then

acceptableDuration_1 < acceptableDuration_2 < acceptableDuration_3 < ...

A value_x with direction="high" shall be greater than a value_y with direction="low".

Table 174 shows all attributes of OperationalLimit.

Table 174 – Attributes of OperationalLimits::OperationalLimit

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 175 shows all association ends of OperationalLimit with other classes.

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Table 175 – Association ends of OperationalLimits::OperationalLimit with other classes

mult from	name	mult to	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	The limit set to which the limit values belong.
0..*	OperationalLimitType	0..1	OperationalLimitType	The limit type associated with this limit.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.8 OperationalLimitDirectionKind enumeration

The direction attribute describes the side of a limit that is a violation.

Table 176 shows all literals of OperationalLimitDirectionKind.

Table 176 – Literals of OperationalLimits::OperationalLimitDirectionKind

literal	value	description
high		High means that a monitored value above the limit value is a violation. If applied to a terminal flow, the positive direction is into the terminal.
low		Low means a monitored value below the limit is a violation. If applied to a terminal flow, the positive direction is into the terminal.
absoluteValue		An absoluteValue limit means that a monitored absolute value above the limit value is a violation.

6.7.9 OperationalLimitSet

A set of limits associated with equipment. Sets of limits might apply to a specific temperature, or season for example. A set of limits may contain different severities of limit levels that would apply to the same equipment. The set may contain limits of different types such as apparent power and current limits or high and low voltage limits that are logically applied together as a set.

Table 177 shows all attributes of OperationalLimitSet.

Table 177 – Attributes of OperationalLimits::OperationalLimitSet

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 178 shows all association ends of OperationalLimitSet with other classes.

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Table 178 – Association ends of OperationalLimits::OperationalLimitSet with other classes

mult from	name	mult to	type	description
0..*	Terminal	0..1	ACDCTerminal	The terminal where the operational limit set apply.
0..*	Equipment	0..1	Equipment	The equipment to which the limit set applies.
1..1	OperationalLimitValue	0..*	OperationalLimit	Values of equipment limits.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.10 OperationalLimitType

The operational meaning of a category of limits.

Table 179 shows all attributes of OperationalLimitType.

Table 179 – Attributes of OperationalLimits::OperationalLimitType

name	mult	type	description
acceptableDuration	0..1	Seconds	The nominal acceptable duration of the limit. Limits are commonly expressed in terms of the time limit for which the limit is normally acceptable. The actual acceptable duration of a specific limit may depend on other local factors such as temperature or wind speed.
direction	0..1	OperationalLimitDirectionKind	The direction of the limit.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 180 shows all association ends of OperationalLimitType with other classes.

Table 180 – Association ends of OperationalLimits::OperationalLimitType with other classes

mult from	name	mult to	type	description
0..1	OperationalLimit	0..*	OperationalLimit	The operational limits associated with this type of limit.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.11 VoltageLimit

Operational limit applied to voltage.

Table 181 shows all attributes of VoltageLimit.

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Table 181 – Attributes of OperationalLimits::VoltageLimit

name	mult	type	description
value	0..1	Voltage	Limit on voltage. High or low limit nature of the limit depends upon the properties of the operational limit type.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 182 shows all association ends of VoltageLimit with other classes.

Table 182 – Association ends of OperationalLimits::VoltageLimit with other classes

mult from	name	mult to	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	inherited from: OperationalLimit
0..*	OperationalLimitType	0..1	OperationalLimitType	inherited from: OperationalLimit
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.8 Package Topology

6.8.1 General

An extension to the Core Package that, in association with the Terminal class, models Connectivity, that is the physical definition of how equipment is connected together. In addition it models Topology, that is the logical definition of how equipment is connected via closed switches. The Topology definition is independent of the other electrical characteristics.

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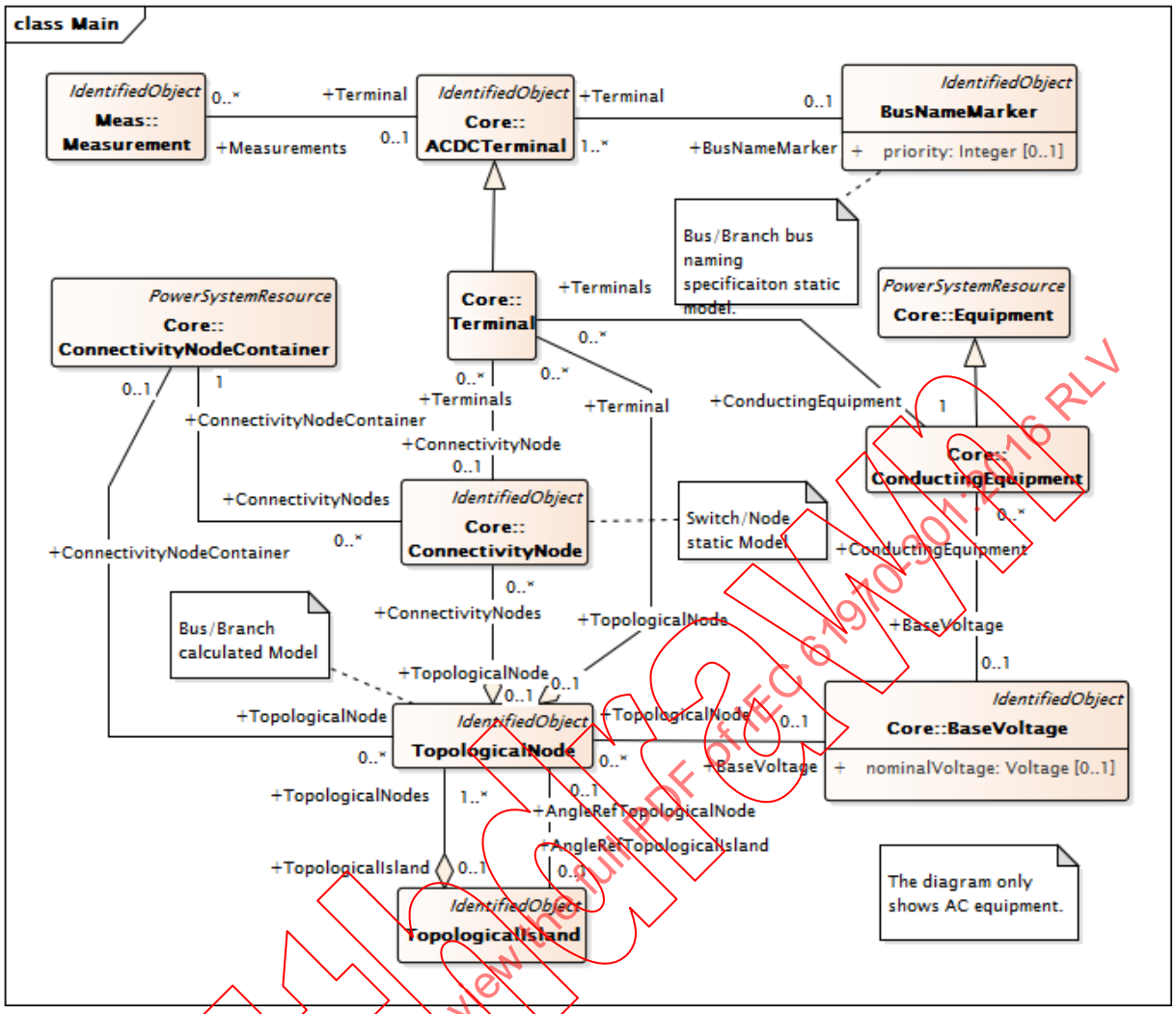


Figure 81 – Class diagram Topology::Main

Figure 81: This diagram shows all classes included in the Topology package as well as the key external classes that have associations with Topology classes.

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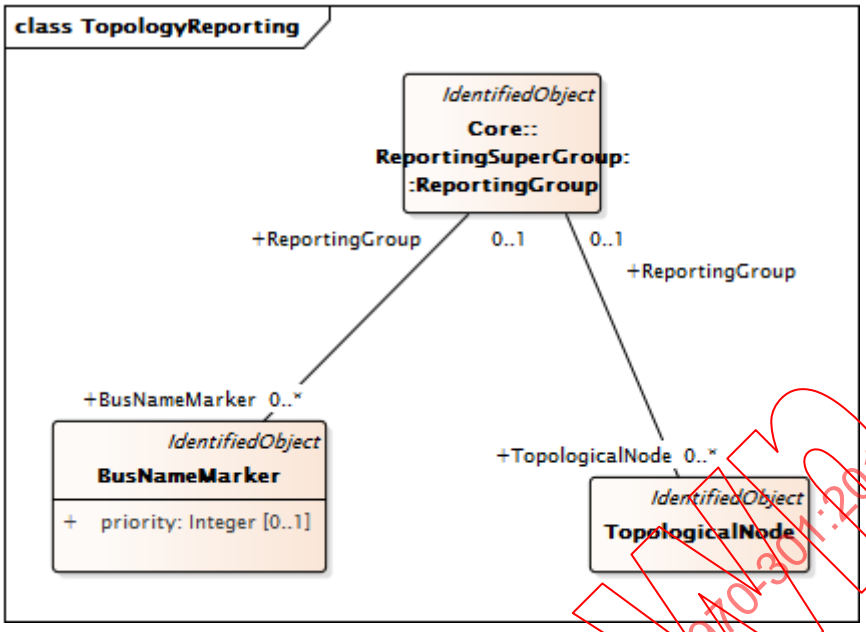


Figure 82 – Class diagram Topology::TopologyReporting

Figure 82: Shows topology reporting relationships.

6.8.2 BusNameMarker

Used to apply user standard names to topology buses. Typically used for "bus/branch" case generation. Associated with one or more terminals that are normally connected with the bus name. The associated terminals are normally connected by non-retained switches. For a ring bus station configuration, all busbar terminals in the ring are typically associated. For a breaker and a half scheme, both busbars would normally be associated. For a ring bus, all busbars would normally be associated. For a "straight" busbar configuration, normally only the main terminal at the busbar would be associated.

Table 183 shows all attributes of BusNameMarker.

Table 183 – Attributes of Topology::BusNameMarker

name	mult	type	description
priority	0..1	Integer	Priority of bus name marker for use as topology bus name. Use 0 for don't care. Use 1 for highest priority. Use 2 as priority is less than 1 and so on.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 184 shows all association ends of BusNameMarker with other classes.

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Table 184 – Association ends of Topology::BusNameMarker with other classes

mult from	name	mult to	type	description
0..1	Terminal	1..*	ACDCTerminal	The terminals associated with this bus name marker.
0..*	ReportingGroup	0..1	ReportingGroup	The reporting group to which this bus name marker belongs.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.8.3 DCTopologicalNode

DC bus.

Table 185 shows all attributes of DCTopologicalNode.

Table 185 – Attributes of Topology::DCTopologicalNode

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 186 shows all association ends of DCTopologicalNode with other classes.

Table 186 – Association ends of Topology::DCTopologicalNode with other classes

mult from	name	mult to	type	description
1..*	DCTopologicalIsland	0..1	DCTopologicalIsland	A DC topological node belongs to a DC topological island.
0..1	DCTerminals	0..*	DCBaseTerminal	The DC base terminals associated with the DC topological node.
0..1	DCNodes	0..*	DCNode	The DC connectivity nodes combined together to form this DC topological node. May depend on the current state of switches in the network.
0..*	DCEquipmentContainer	0..1	DCEquipmentContainer	The connectivity node container to which the toplogical node belongs.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.8.4 TopologicalIsland

An electrically connected subset of the network. Topological islands can change as the current network state changes: e.g. due to

– disconnect switches or breakers changing state in a SCADA/EMS
– manual creation, change or deletion of topological nodes in a planning tool.

Table 187 shows all attributes of TopologicalIsland.

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Table 187 – Attributes of Topology::TopologicalIsland

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 188 shows all association ends of TopologicalIsland with other classes.

Table 188 – Association ends of Topology::TopologicalIsland with other classes

mult from	name	mult to	type	description
0..1	AngleRefTopologicalNode	0..1	TopologicalNode	The angle reference for the island. Normally there is one TopologicalNode that is selected as the angle reference for each island. Other reference schemes exist, so the association is typically optional.
0..1	TopologicalNodes	1..*	TopologicalNode	A topological node belongs to a topological island.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.8.5 TopologicalNode

For a detailed substation model a topological node is a set of connectivity nodes that, in the current network state, are connected together through any type of closed switches, including jumpers. Topological nodes change as the current network state changes (i.e. switches, breakers, etc. change state).

For a planning model, switch statuses are not used to form topological nodes. Instead they are manually created or deleted in a model builder tool. Topological nodes maintained this way are also called "busses".

Table 189 shows all attributes of TopologicalNode.

Table 189 – Attributes of Topology::TopologicalNode

name	mult	type	description
pInjection	0..1	ActivePower	The active power injected into the bus at this location in addition to injections from equipment. Positive sign means injection into the TopologicalNode (bus). Starting value for a steady state solution.
qInjection	0..1	ReactivePower	The reactive power injected into the bus at this location in addition to injections from equipment. Positive sign means injection into the TopologicalNode (bus). Starting value for a steady state solution.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 190 shows all association ends of TopologicalNode with other classes.

Table 190 – Association ends of Topology::TopologicalNode with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	The base voltage of the topologocial node.
0..*	ConnectivityNodeContainer	0..1	ConnectivityNodeContainer	The connectivity node container to which the toplogical node belongs.
0..*	ReportingGroup	0..1	ReportingGroup	The reporting group to which the topological node belongs.
1..*	TopologicalIsland	0..1	TopologicalIsland	A topological node belongs to a topological island.
0..1	ConnectivityNodes	0..*	ConnectivityNode	The connectivity nodes combined together to form this topological node. May depend on the current state of switches in the network.
0..1	Terminal	0..*	Terminal	The terminals associated with the topological node. This can be used as an alternative to the connectivity node path to terminal, thus making it unneccesary to model connectivity nodes in some cases. Note that if connectivity nodes are in the model, this association would probably not be used as an input specification.
0..1	AngleRefTopologicalIsland	0..1	TopologicalIsland	The island for which the node is an angle reference. Normally there is one angle reference node for each island.
1..1	SvInjection	0..1	SvInjection	The injection flows state variables associated with the topological node.
1..1	SvVoltage	0..1	SvVoltage	The state voltage associated with the topological node.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9 Package Wires

6.9.1 General

An extension to the Core and Topology package that models information on the electrical characteristics of Transmission and Distribution networks. This package is used by network applications such as State Estimation, Load Flow and Optimal Power Flow.

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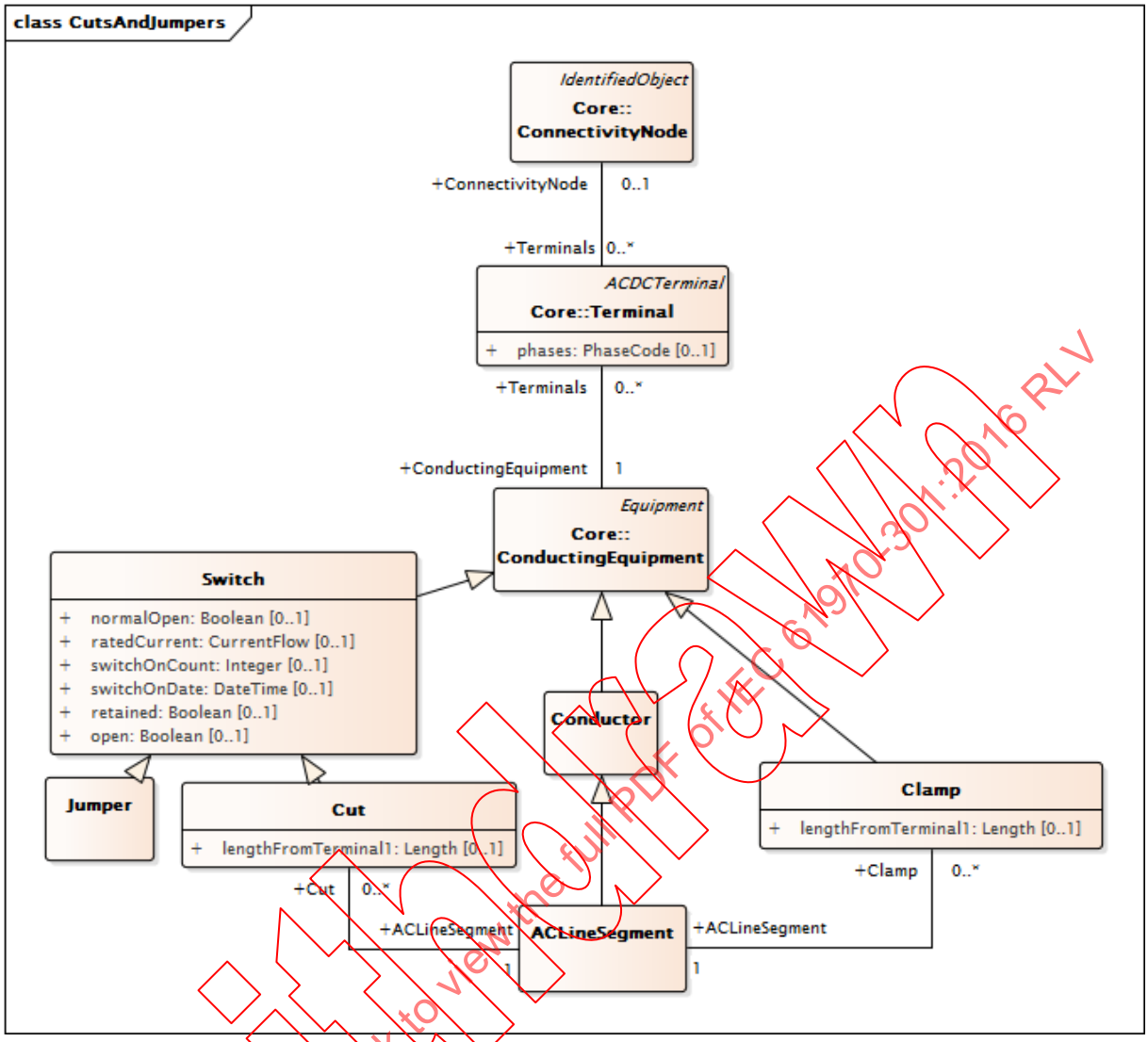


Figure 83 – Class diagram Wires::CutsAndJumpers

Figure 83: The diagram show the cuts and jumpers data model.

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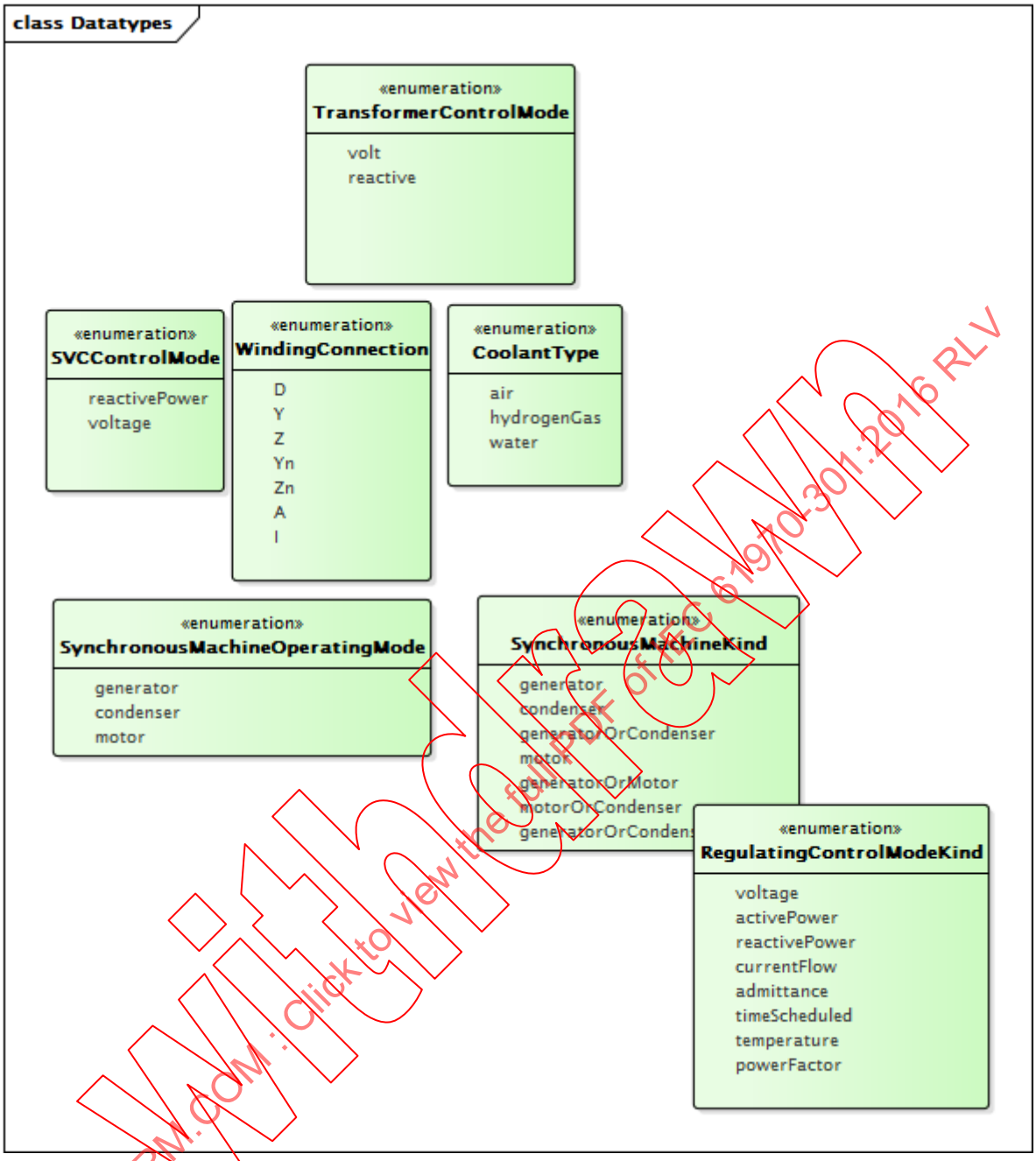


Figure 84 – Class diagram Wires::Datatypes

Figure 84: This diagram shows the data types specific to the Wires package.

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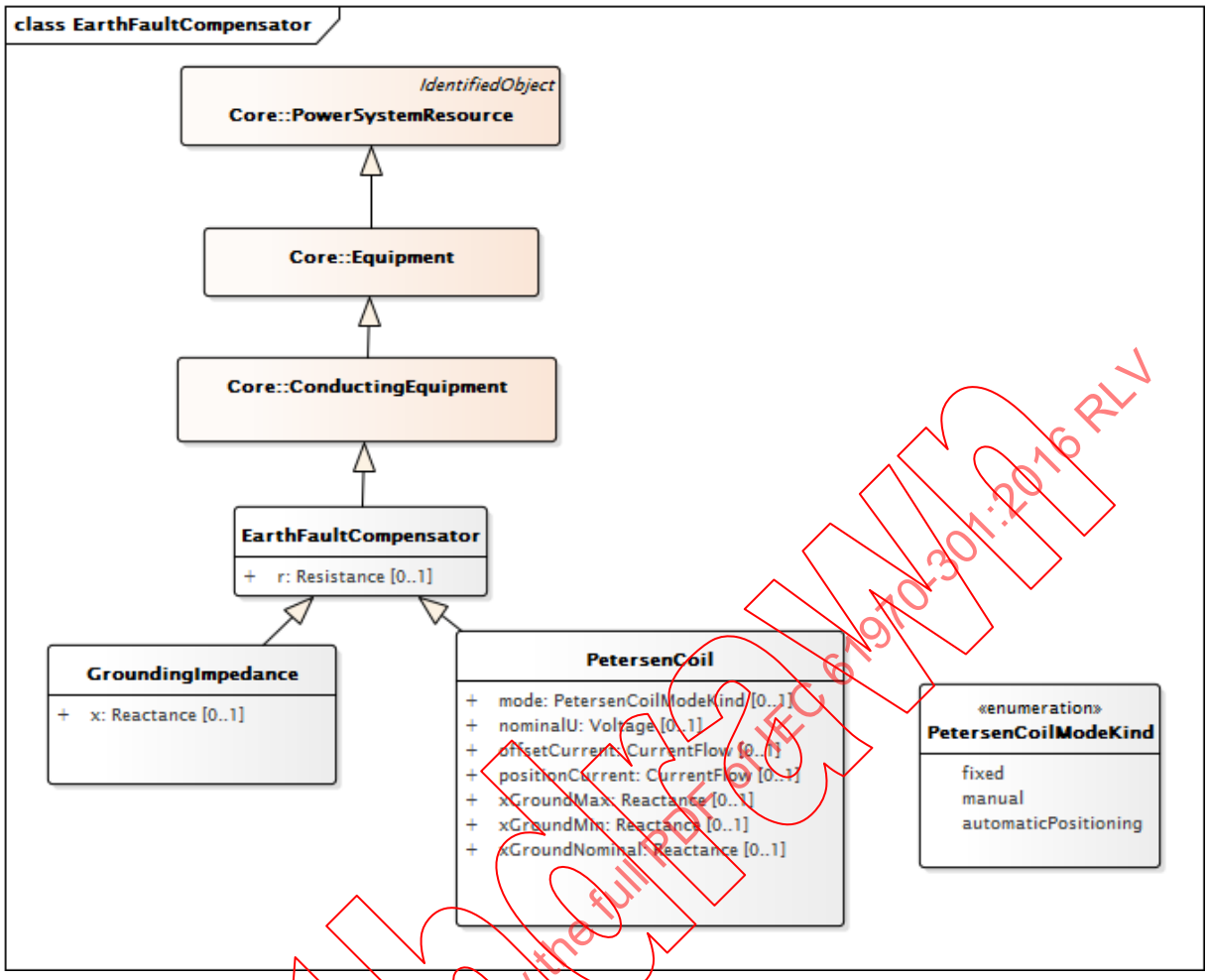
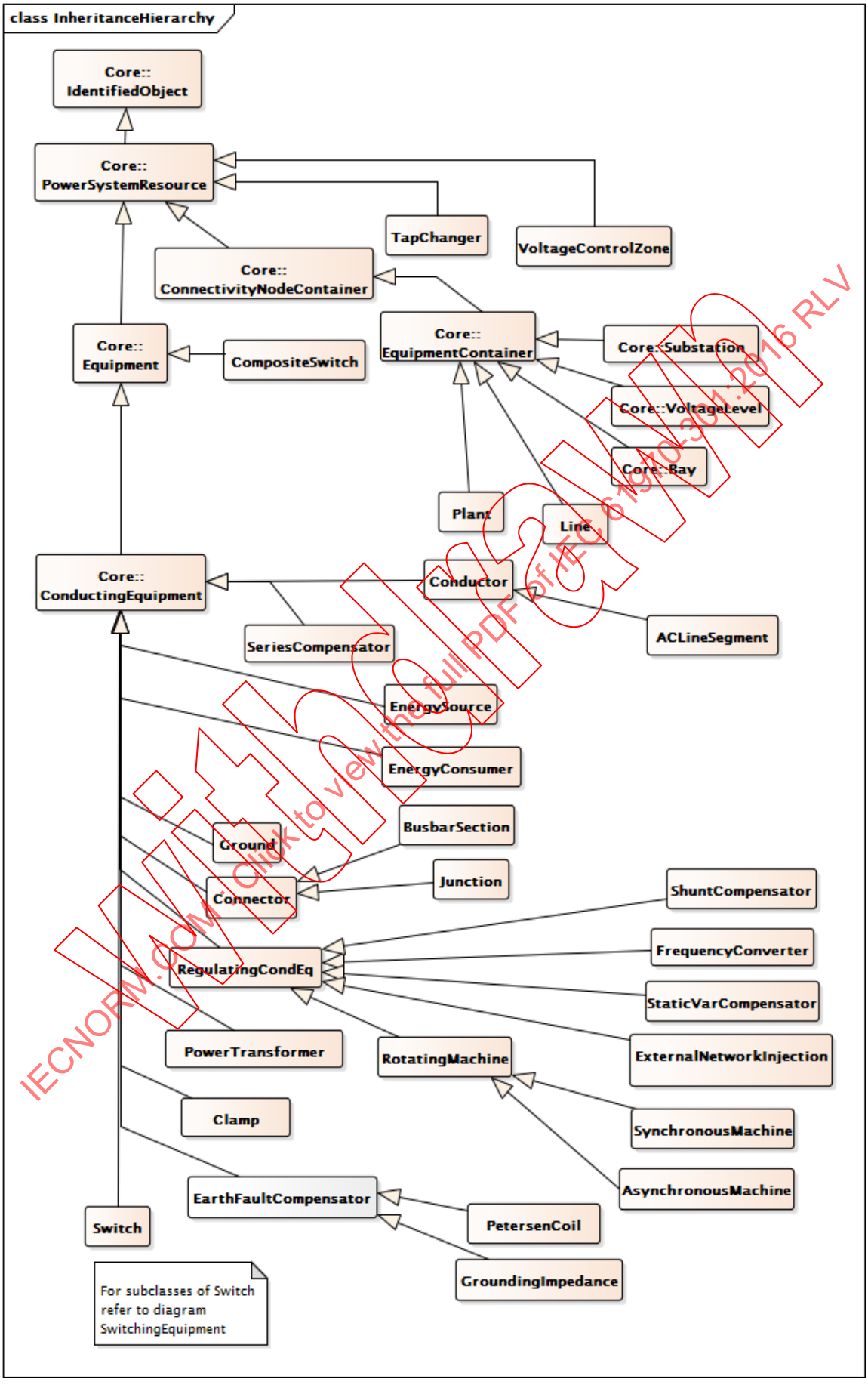


Figure 85 – Class diagram Wires::EarthFaultCompensator

Figure 85: Shows earth fault compensating devices.

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Figure 86 – Class diagram Wires::InheritanceHierarchy

Figure 86: This diagram describes inheritance between classes in and related to the Wires package.

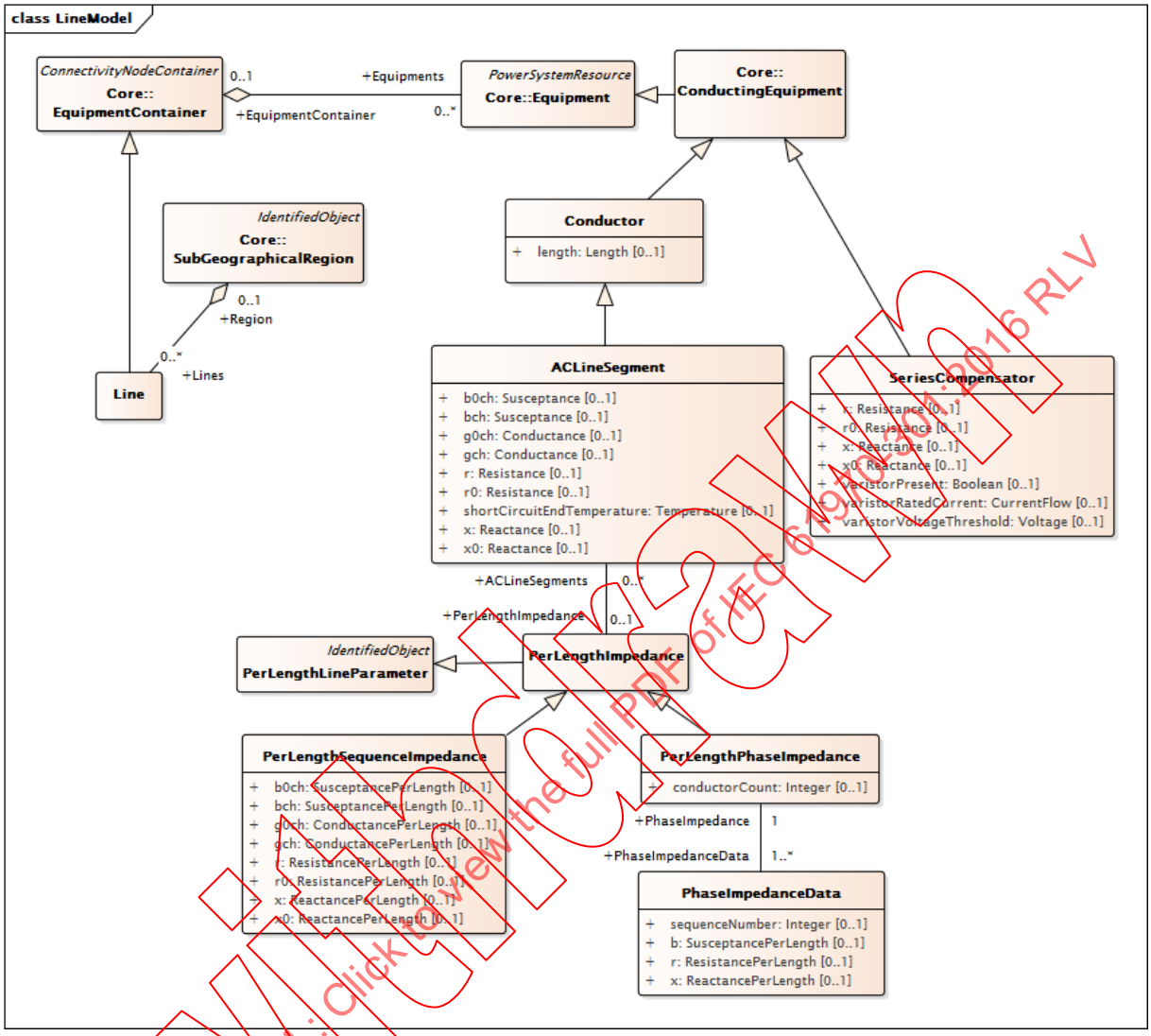


Figure 87 – Class diagram Wires::LineModel

Figure 87: This diagram shows all classes related to the transmission line model.

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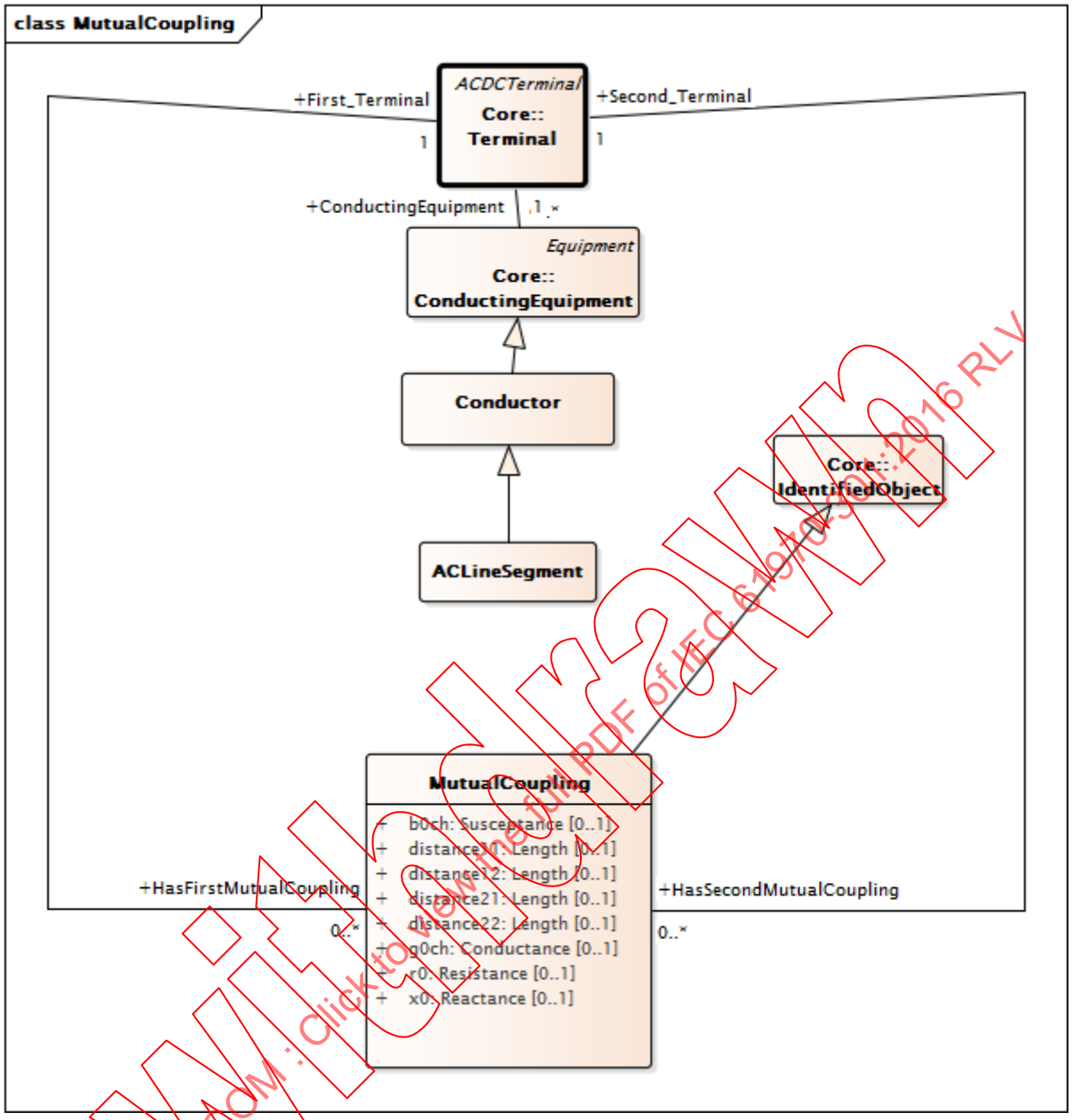
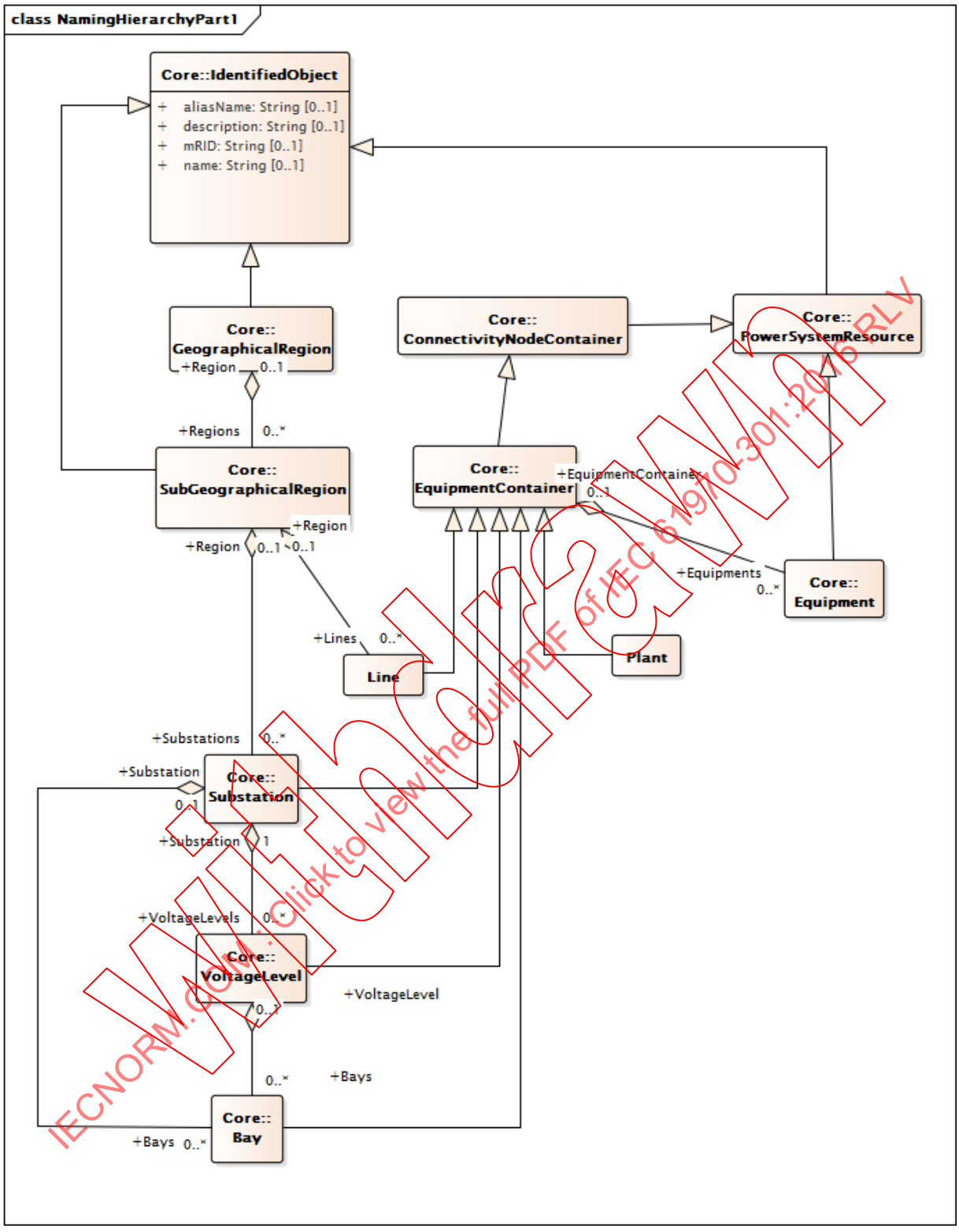


Figure 88 – Class diagram Wires::MutualCoupling

Figure 88: Shows mutual coupling models.

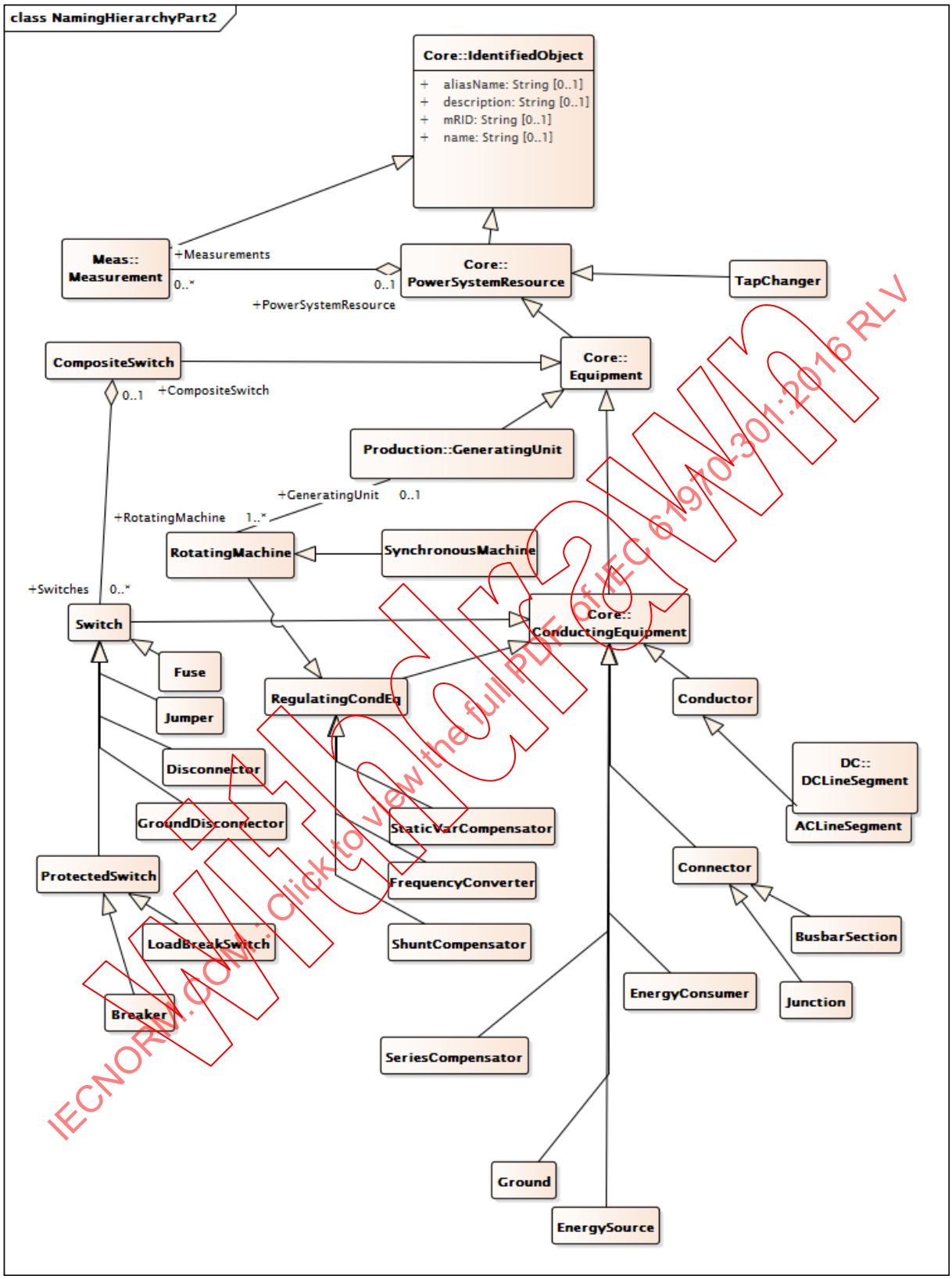
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Figure 89 – Class diagram Wires::NamingHierarchyPart1

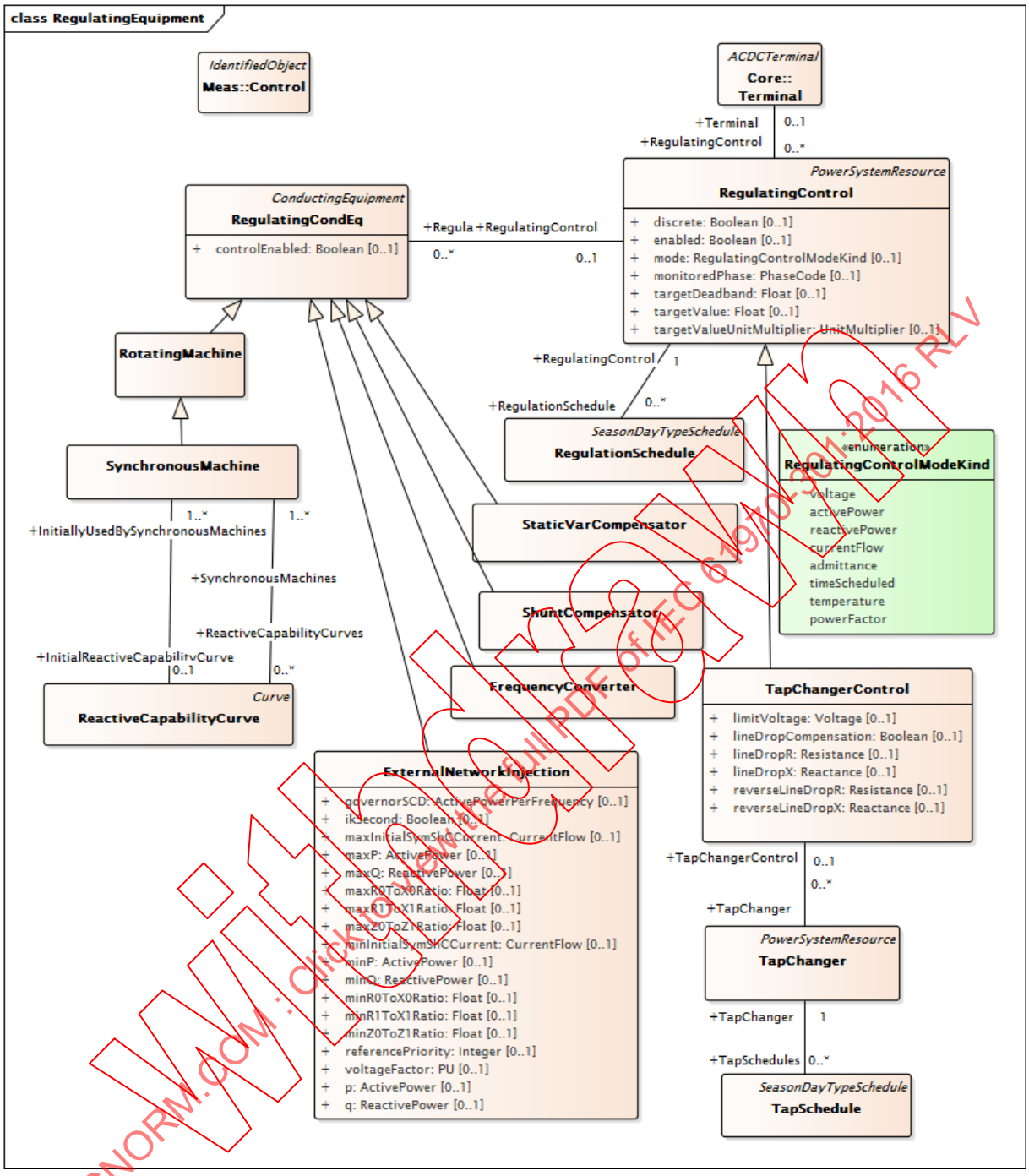
Figure 89: The diagram shows the upper part of the naming hierarchy. The hierarchy is a way to organize and name equipment. Hence it is tightly related to the IdentifiedObject and it's attributes. The Equipment class is further specialized into many subtypes that are all contained by subclasses of the EquipmentContainer.



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Figure 90 – Class diagram Wires::NamingHierarchyPart2

Figure 90: The diagram shows the lower part of the naming hierarchy. It shows how the Equipment class is further specialized into many subtypes that are all contained by subclasses of the EquipmentContainer. For the subclasses of equipment container refer to Figure 89.



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Figure 91 – Class diagram Wires::RegulatingEquipment

Figure 91: The diagram shows all classes related to equipment regulation and reactive power compensation.

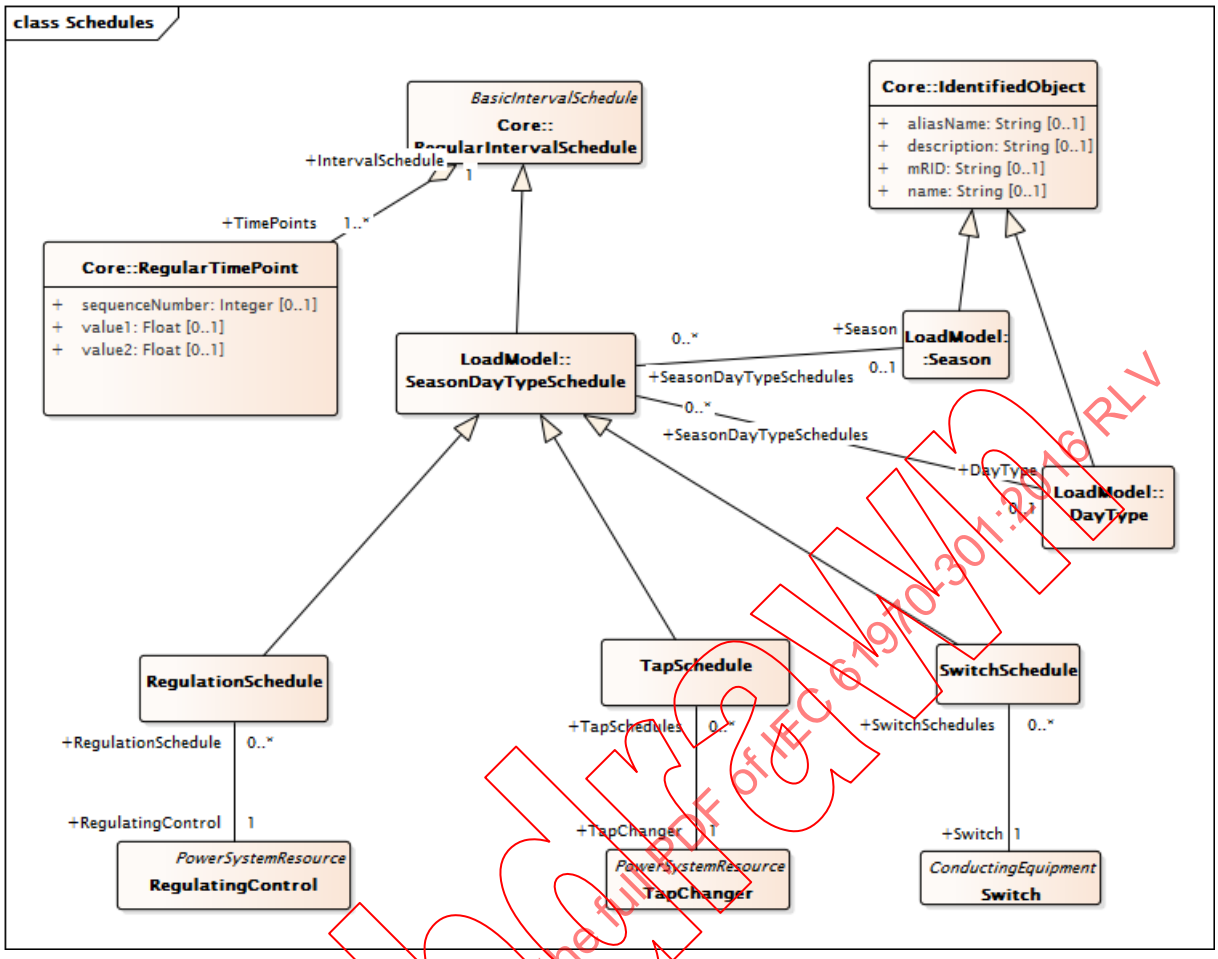


Figure 92 – Class diagram Wires::Schedules

Figure 92: Shows schedules of wires model.

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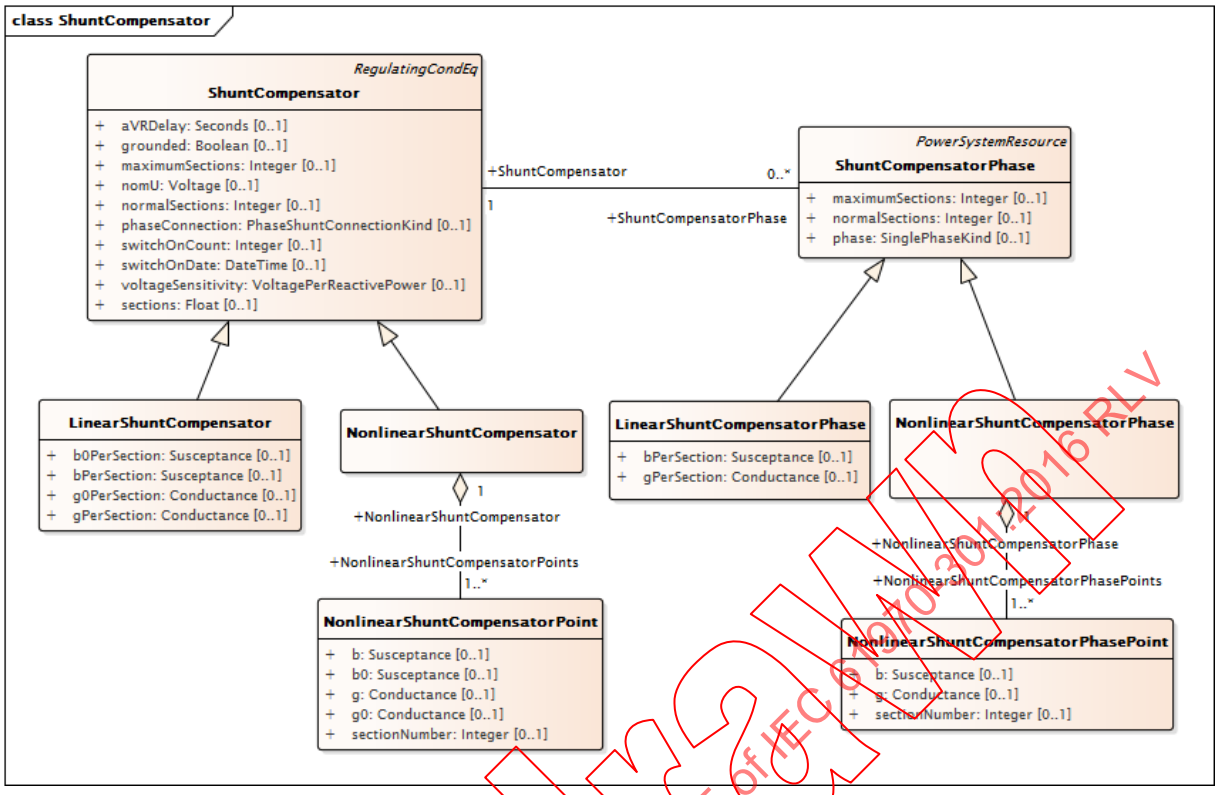


Figure 93 – Class diagram Wires::ShuntCompensator

Figure 93:.

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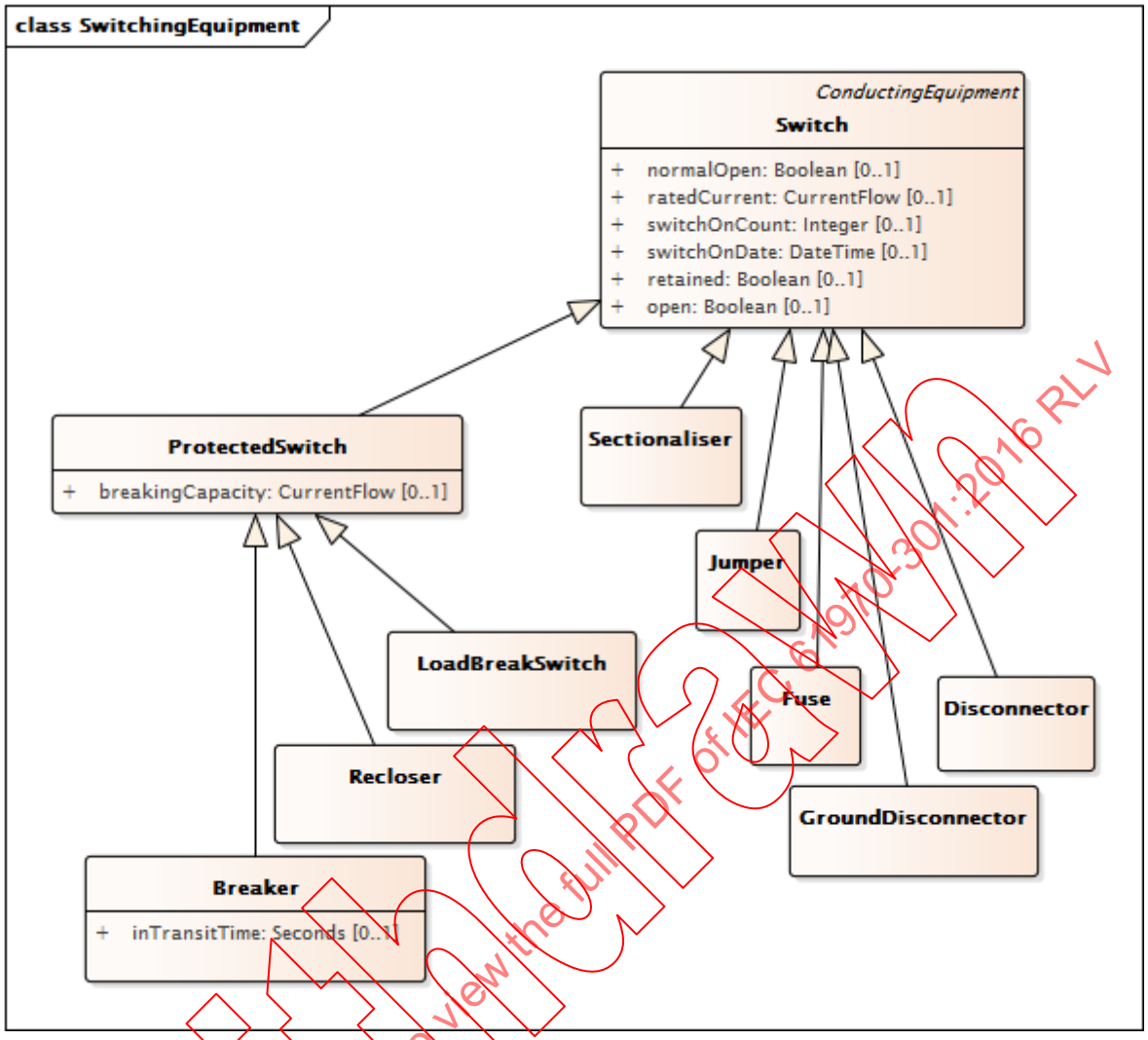


Figure 94 – Class diagram Wires::SwitchingEquipment

Figure 94: Shows switching equipment inheritance structure.

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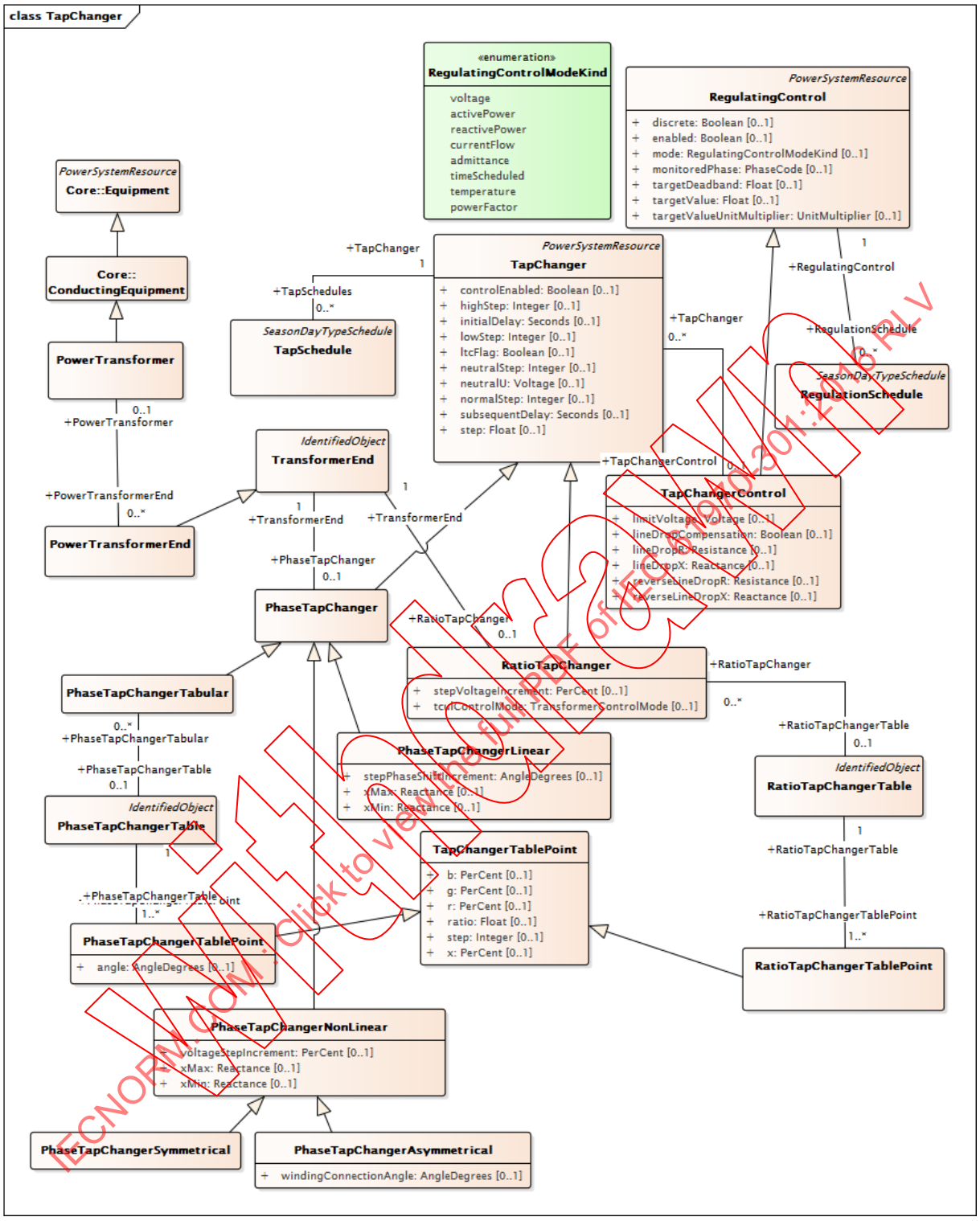


Figure 95 – Class diagram Wires::TapChanger

Figure 95: This diagram shows all classes related to the transformer tap model.

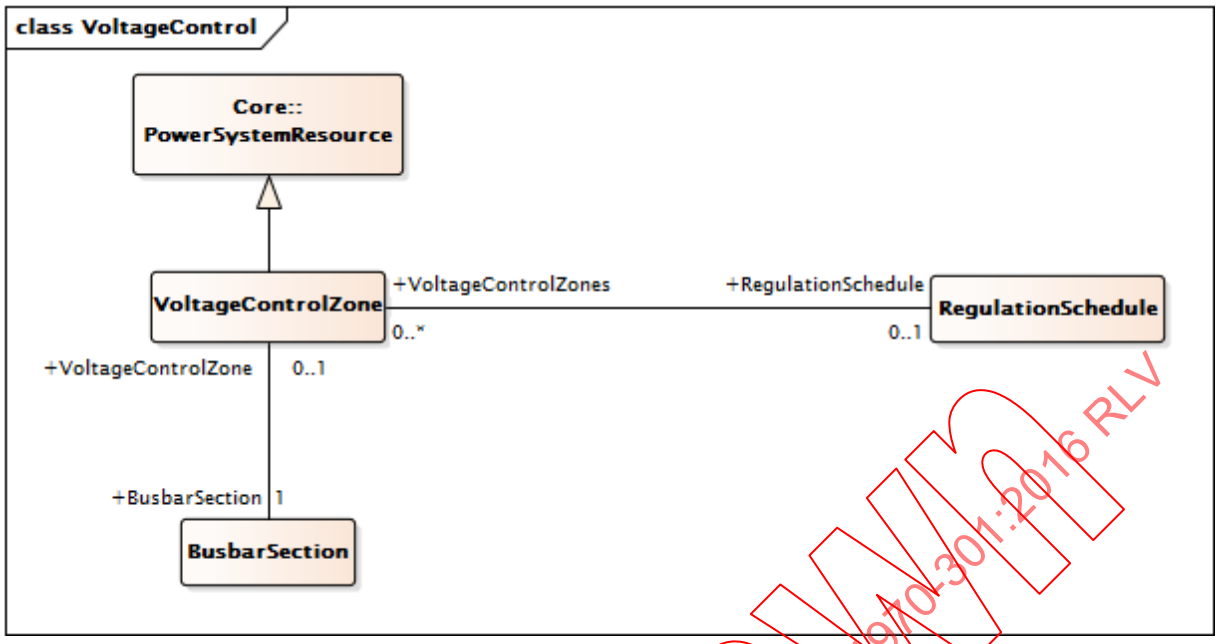


Figure 96 – Class diagram Wires::VoltageControl

Figure 96: This diagram shows all classes related to area voltage control.

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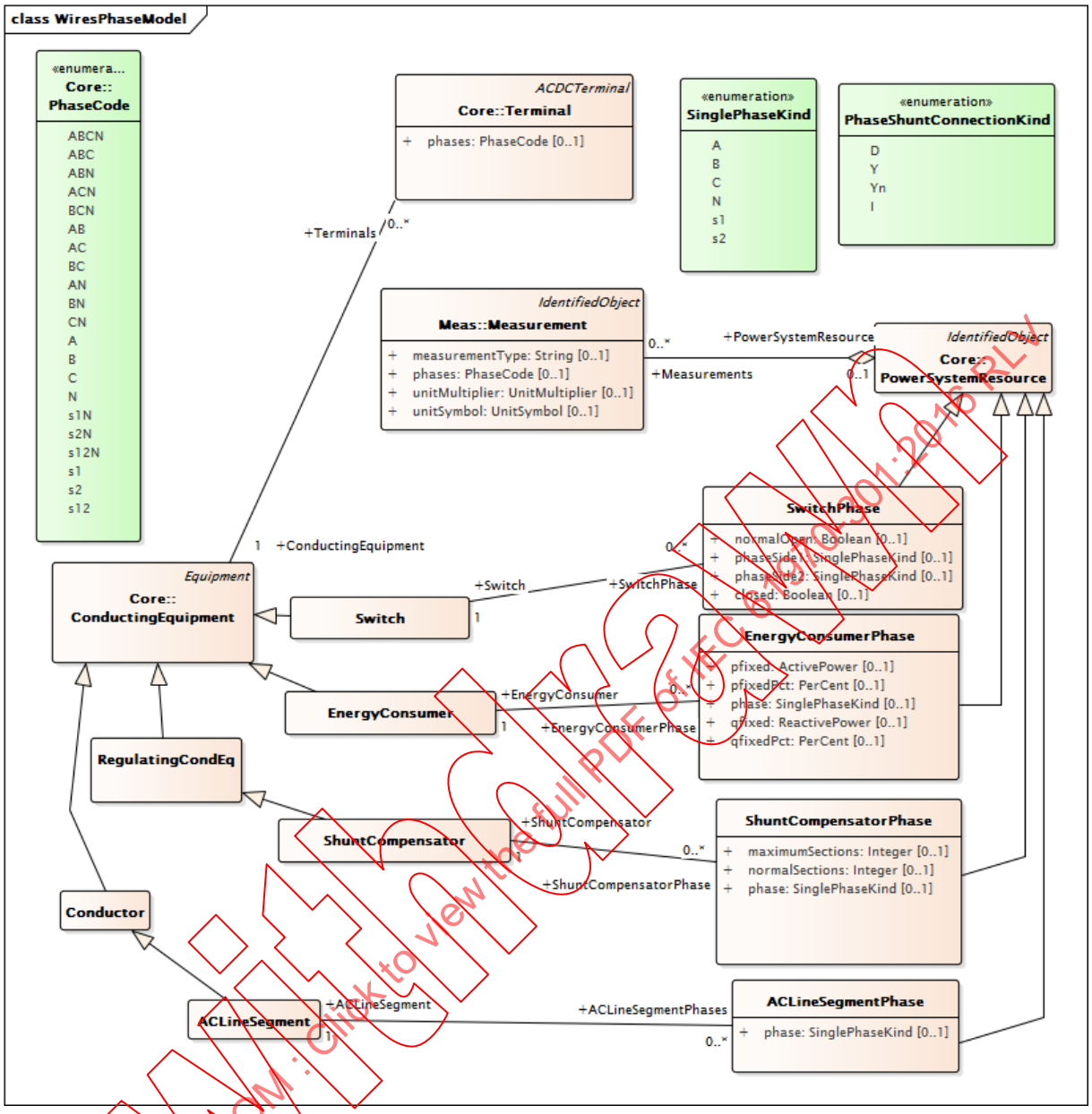
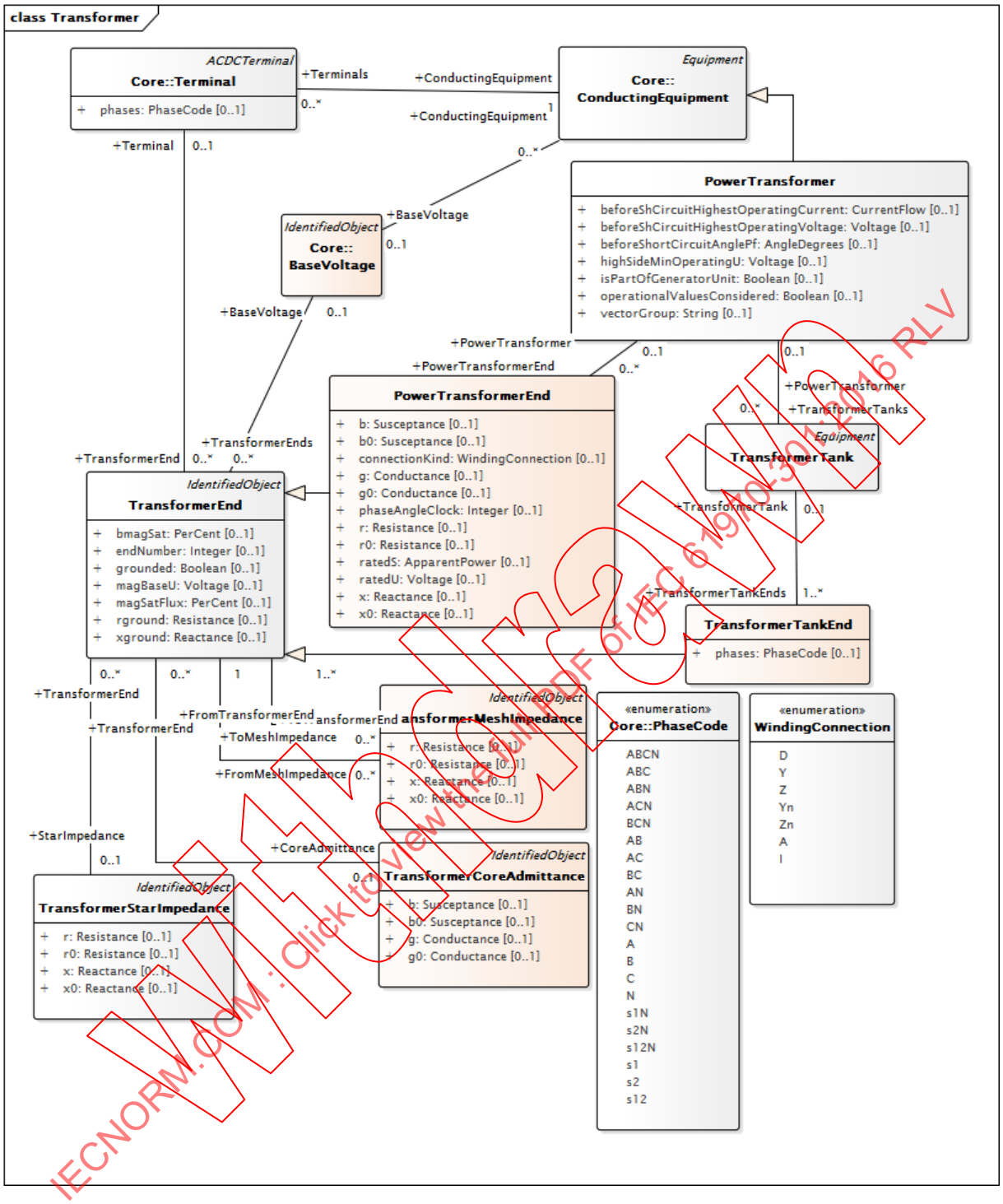


Figure 97 – Class diagram Wires::WiresPhaseModel

Figure 97: Show the phase connection detail when modeling devices down to the phase components within a conducting equipment.

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Figure 98 – Class diagram Wires::Transformer

Figure 98: This diagram shows classes related to the core transformer model, but does not show the tap changer details.

6.9.2 PerLengthSequenceImpedance

Sequence impedance and admittance parameters per unit length, for transposed lines of 1, 2, or 3 phases. For 1-phase lines, define x=x0=xself. For 2-phase lines, define x=xs-xm and x0=xs+xm.

Table 191 shows all attributes of PerLengthSequenceImpedance.

Table 191 – Attributes of Wires::PerLengthSequenceImpedance

name	mult	type	description
b0ch	0..1	SusceptancePerLength	Zero sequence shunt (charging) susceptance, per unit of length.
bch	0..1	SusceptancePerLength	Positive sequence shunt (charging) susceptance, per unit of length.
g0ch	0..1	ConductancePerLength	Zero sequence shunt (charging) conductance, per unit of length.
gch	0..1	ConductancePerLength	Positive sequence shunt (charging) conductance, per unit of length.
r	0..1	ResistancePerLength	Positive sequence series resistance, per unit of length.
r0	0..1	ResistancePerLength	Zero sequence series resistance, per unit of length.
x	0..1	ReactancePerLength	Positive sequence series reactance, per unit of length.
x0	0..1	ReactancePerLength	Zero sequence series reactance, per unit of length.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 192 shows all association ends of PerLengthSequenceImpedance with other classes.

Table 192 – Association ends of Wires::PerLengthSequenceImpedance with other classes

mult from	name	mult to	type	description
0..1	ACLineSegments	0..*	ACLineSegment	inherited from: PerLengthImpedance
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.3 PerLengthPhaseImpedance

Impedance and admittance parameters per unit length for n-wire unbalanced lines, in matrix form.

Table 193 shows all attributes of PerLengthPhaseImpedance.

Table 193 – Attributes of Wires::PerLengthPhaseImpedance

name	mult	type	description
conductorCount	0..1	Integer	Number of phase, neutral, and other wires retained. Constrains the number of matrix elements and the phase codes that can be used with this matrix.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 194 shows all association ends of PerLengthPhaseImpedance with other classes.

Table 194 – Association ends of Wires::PerLengthPhaseImpedance with other classes

mult from	name	mult to	type	description
1..1	PhaseImpedanceData	1..*	PhaseImpedanceData	All data that belong to this conductor phase impedance.
0..1	ACLineSegments	0..*	ACLineSegment	inherited from: PerLengthImpedance
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.4 ShuntCompensatorPhase

Single phase of a multi-phase shunt compensator when its attributes might be different per phase.

Table 195 shows all attributes of ShuntCompensatorPhase.

Table 195 – Attributes of Wires::ShuntCompensatorPhase

name	mult	type	description
maximumSections	0..1	Integer	The maximum number of sections that may be switched in for this phase.
normalSections	0..1	Integer	For the capacitor phase, the normal number of sections switched in.
phase	0..1	SinglePhaseKind	Phase of this shunt compensator component. If the shunt compensator is wye connected, the connection is from the indicated phase to the central ground or neutral point. If the shunt compensator is delta connected, the phase indicates a shunt compensator connected from the indicated phase to the next logical non-neutral phase.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 196 shows all association ends of ShuntCompensatorPhase with other classes.

Table 196 – Association ends of Wires::ShuntCompensatorPhase with other classes

mult from	name	mult to	type	description
0..*	ShuntCompensator	1..1	ShuntCompensator	Shunt compensator of this shunt compensator phase.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.5 RatioTapChanger

A tap changer that changes the voltage ratio impacting the voltage magnitude but not the phase angle across the transformer.

Table 197 shows all attributes of RatioTapChanger.

Table 197 – Attributes of Wires::RatioTapChanger

name	mult	type	description
stepVoltageIncrement	0..1	PerCent	Tap step increment, in per cent of nominal voltage, per step position.
tculControlMode	0..1	TransformerControlMode	Specifies the regulation control mode (voltage or reactive) of the RatioTapChanger.
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 198 shows all association ends of RatioTapChanger with other classes.

Table 198 – Association ends of Wires::RatioTapChanger with other classes

mult from	name	mult to	type	description
0..*	RatioTapChangerTable	0..1	RatioTapChangerTable	The tap ratio table for this ratio tap changer.
0..1	TransformerEnd	1..1	TransformerEnd	Transformer end to which this ratio tap changer belongs.
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.6 BusbarSection

A conductor, or group of conductors, with negligible impedance, that serve to connect other conducting equipment within a single substation.

Voltage measurements are typically obtained from VoltageTransformers that are connected to busbar sections. A busbar section may have many physical terminals but for analysis is modeled with exactly one logical terminal.

Table 199 shows all attributes of BusbarSection.

Table 199 – Attributes of Wires::BusbarSection

name	mult	type	description
ipMax	0..1	CurrentFlow	Maximum allowable peak short-circuit current of busbar (Ipmax in IEC 60909-0). Mechanical limit of the busbar in the substation itself. Used for short circuit data exchange according to IEC 60909.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 200 shows all association ends of BusbarSection with other classes.

Table 200 – Association ends of Wires::BusbarSection with other classes

mult from	name	mult to	type	description
1..1	VoltageControlZone	0..1	VoltageControlZone	A VoltageControlZone is controlled by a designated BusbarSection.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.7 SinglePhaseKind enumeration

Enumeration of single phase identifiers. Allows designation of single phases for both transmission and distribution equipment, circuits and loads.

Table 201 shows all literals of SinglePhaseKind.

Table 201 – Literals of Wires::SinglePhaseKind

literal	value	description
A		Phase A.
B		Phase B.
C		Phase C.
N		Neutral.
s1		Secondary phase 1.
s2		Secondary phase 2.

6.9.8 TransformerTank

An assembly of two or more coupled windings that transform electrical power between voltage levels. These windings are bound on a common core and place in the same tank. Transformer tank can be used to model both single-phase and 3-phase transformers.

Table 202 shows all attributes of TransformerTank.

Table 202 – Attributes of Wires::TransformerTank

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 203 shows all association ends of TransformerTank with other classes.

Table 203 – Association ends of Wires::TransformerTank with other classes

mult from	name	mult to	type	description
0..*	PowerTransformer	0..1	PowerTransformer	Bank this transformer belongs to.
0..1	TransformerTankEnds	1..*	TransformerTankEnd	All windings of this transformer.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.9 Disconnector

A manually operated or motor operated mechanical switching device used for changing the connections in a circuit, or for isolating a circuit or equipment from a source of power. It is required to open or close circuits when negligible current is broken or made.

Table 204 shows all attributes of Disconnector.

Table 204 – Attributes of Wires::Disconnector

name	mult	type	description
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 205 shows all association ends of Disconnector with other classes.

Table 205 – Association ends of Wires::Disconnector with other classes

mult from	name	mult to	type	description
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.10 Jumper

A short section of conductor with negligible impedance which can be manually removed and replaced if the circuit is de-energized. Note that zero-impedance branches can potentially be modeled by other equipment types.

Table 206 shows all attributes of Jumper.

Table 206 – Attributes of Wires::Jumper

name	mult	type	description
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 207 shows all association ends of Jumper with other classes.

Table 207 – Association ends of Wires::Jumper with other classes

mult from	name	mult to	type	description
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment

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mult from	name	mult to	type	description
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.11 TapSchedule

A pre-established pattern over time for a tap step.

Table 208 shows all attributes of TapSchedule.

Table 208 – Attributes of Wires::TapSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 209 shows all association ends of TapSchedule with other classes.

Table 209 – Association ends of Wires::TapSchedule with other classes

mult from	name	mult to	type	description
0..*	TapChanger	1..1	TapChanger	A TapSchedule is associated with a TapChanger.
0..*	DayType	0..1	DayType	inherited from: SeasonDayTypeSchedule
0..*	Season	0..1	Season	inherited from: SeasonDayTypeSchedule
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.12 TransformerCoreAdmittance

The transformer core admittance. Used to specify the core admittance of a transformer in a manner that can be shared among power transformers.

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Table 210 shows all attributes of TransformerCoreAdmittance.

Table 210 – Attributes of Wires::TransformerCoreAdmittance

name	mult	type	description
b	0..1	Susceptance	Magnetizing branch susceptance (B mag). The value can be positive or negative.
b0	0..1	Susceptance	Zero sequence magnetizing branch susceptance.
g	0..1	Conductance	Magnetizing branch conductance (G mag).
g0	0..1	Conductance	Zero sequence magnetizing branch conductance.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 211 shows all association ends of TransformerCoreAdmittance with other classes.

Table 211 – Association ends of Wires::TransformerCoreAdmittance with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	0..*	TransformerEnd	All transformer ends having this core admittance.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.13 SVCControlMode enumeration

Static VAr Compensator control mode.

Table 212 shows all literals of SVCControlMode.

Table 212 – Literals of Wires::SVCControlMode

literal	value	description
reactivePower		
voltage		

6.9.14 EnergyConsumerPhase

A single phase of an energy consumer.

Table 213 shows all attributes of EnergyConsumerPhase.

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Table 213 – Attributes of Wires::EnergyConsumerPhase

name	mult	type	description
pfixed	0..1	ActivePower	Active power of the load that is a fixed quantity. Load sign convention is used, i.e. positive sign means flow out from a node.
pfixedPct	0..1	PerCent	Fixed active power as per cent of load group fixed active power. Load sign convention is used, i.e. positive sign means flow out from a node.
phase	0..1	SinglePhaseKind	Phase of this energy consumer component. If the energy consumer is wye connected, the connection is from the indicated phase to the central ground or neutral point. If the energy consumer is delta connected, the phase indicates an energy consumer connected from the indicated phase to the next logical non-neutral phase.
qfixed	0..1	ReactivePower	Reactive power of the load that is a fixed quantity. Load sign convention is used, i.e. positive sign means flow out from a node.
qfixedPct	0..1	PerCent	Fixed reactive power as per cent of load group fixed reactive power. Load sign convention is used, i.e. positive sign means flow out from a node.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 214 shows all association ends of EnergyConsumerPhase with other classes.

Table 214 – Association ends of Wires::EnergyConsumerPhase with other classes

mult from	name	mult to	type	description
0..*	EnergyConsumer	1..1	EnergyConsumer	The energy consumer to which this phase belongs.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.15 SynchronousMachineOperatingMode enumeration

Synchronous machine operating mode.

Table 215 shows all literals of SynchronousMachineOperatingMode.

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Table 215 – Literals of Wires::SynchronousMachineOperatingMode

literal	value	description
generator		
condenser		
motor		

6.9.16 TapChangerControl

Describes behavior specific to tap changers, e.g. how the voltage at the end of a line varies with the load level and compensation of the voltage drop by tap adjustment.

Table 216 shows all attributes of TapChangerControl.

Table 216 – Attributes of Wires::TapChangerControl

name	mult	type	description
limitVoltage	0..1	Voltage	Maximum allowed regulated voltage on the PT secondary, regardless of line drop compensation. Sometimes referred to as first-house protection.
lineDropCompensation	0..1	Boolean	If true, the line drop compensation is to be applied.
lineDropR	0..1	Resistance	Line drop compensator resistance setting for normal (forward) power flow.
lineDropX	0..1	Reactance	Line drop compensator reactance setting for normal (forward) power flow.
reverseLineDropR	0..1	Resistance	Line drop compensator resistance setting for reverse power flow.
reverseLineDropX	0..1	Reactance	Line drop compensator reactance setting for reverse power flow.
discrete	0..1	Boolean	inherited from: RegulatingControl
enabled	0..1	Boolean	inherited from: RegulatingControl
mode	0..1	RegulatingControlModeKind	inherited from: RegulatingControl
monitoredPhase	0..1	PhaseCode	inherited from: RegulatingControl
targetDeadband	0..1	Float	inherited from: RegulatingControl
targetValue	0..1	Float	inherited from: RegulatingControl
targetValueUnitMultiplier	0..1	UnitMultiplier	inherited from: RegulatingControl
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 217 shows all association ends of TapChangerControl with other classes.

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Table 217 – Association ends of Wires::TapChangerControl with other classes

mult from	name	mult to	type	description
0..1	TapChanger	0..*	TapChanger	The tap changers that participate in this regulating tap control scheme.
0..*	Terminal	0..1	Terminal	inherited from: RegulatingControl
1..1	RegulationSchedule	0..*	RegulationSchedule	inherited from: RegulatingControl
0..1	RegulatingCondEq	0..*	RegulatingCondEq	inherited from: RegulatingControl
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.17 PhaseTapChangerTable

Describes a tabular curve for how the phase angle difference and impedance varies with the tap step.

Table 218 shows all attributes of PhaseTapChangerTable.

Table 218 – Attributes of Wires::PhaseTapChangerTable

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 219 shows all association ends of PhaseTapChangerTable with other classes.

Table 219 – Association ends of Wires::PhaseTapChangerTable with other classes

mult from	name	mult to	type	description
0..1	PhaseTapChangerTabular	0..*	PhaseTapChangerTabular	The phase tap changers to which this phase tap table applies.
1..1	PhaseTapChangerTablePoint	1..*	PhaseTapChangerTablePoint	The points of this table.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.18 TransformerStarImpedance

Transformer star impedance (Pi-model) that accurately reflects impedance for transformers with 2 or 3 windings. For transformers with 4 or more windings, TransformerMeshImpedance class shall be used.

For transmission networks use PowerTransformerEnd impedances (r, r0, x, x0, b, b0, g and g0).

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Table 220 shows all attributes of TransformerStarImpedance.

Table 220 – Attributes of Wires::TransformerStarImpedance

name	mult	type	description
r	0..1	Resistance	Resistance of the transformer end.
r0	0..1	Resistance	Zero sequence series resistance of the transformer end.
x	0..1	Reactance	Positive sequence series reactance of the transformer end.
x0	0..1	Reactance	Zero sequence series reactance of the transformer end.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 221 shows all association ends of TransformerStarImpedance with other classes.

Table 221 – Association ends of Wires::TransformerStarImpedance with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	0..*	TransformerEnd	All transformer ends having this star impedance.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.19 Breaker

A mechanical switching device capable of making, carrying, and breaking currents under normal circuit conditions and also making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions e.g. those of short circuit.

Table 222 shows all attributes of Breaker.

Table 222 – Attributes of Wires::Breaker

name	mult	type	description
inTransitTime	0..1	Seconds	The transition time from open to close.
breakingCapacity	0..1	CurrentFlow	inherited from: ProtectedSwitch
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 223 shows all association ends of Breaker with other classes.

Table 223 – Association ends of Wires::Breaker with other classes

mult from	name	mult to	type	description
0..*	OperatedByProtectionEquipment	0..*	ProtectionEquipment	inherited from: ProtectedSwitch
1..1	RecloseSequences	0..*	RecloseSequence	inherited from: ProtectedSwitch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.20 GroundDisconnector

A manually operated or motor operated mechanical switching device used for isolating a circuit or equipment from ground.

Table 224 shows all attributes of GroundDisconnector.

Table 224 – Attributes of Wires::GroundDisconnector

name	mult	type	description
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment

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name	mult	type	description
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 225 shows all association ends of GroundDisconnector with other classes.

Table 225 – Association ends of Wires::GroundDisconnector with other classes

mult from	name	mult to	type	description
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.21 SwitchSchedule

A schedule of switch positions. If RegularTimePoint.value1 is 0, the switch is open. If 1, the switch is closed.

Table 226 shows all attributes of SwitchSchedule.

Table 226 – Attributes of Wires::SwitchSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule

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name	mult	type	description
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 227 shows all association ends of SwitchSchedule with other classes.

Table 227 – Association ends of Wires::SwitchSchedule with other classes

mult from	name	mult to	type	description
0..*	Switch	1..1	Switch	A SwitchSchedule is associated with a Switch.
0..*	DayType	0..1	DayType	inherited from: SeasonDayTypeSchedule
0..*	Season	0..1	Season	inherited from: SeasonDayTypeSchedule
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.22 PowerTransformer

An electrical device consisting of two or more coupled windings, with or without a magnetic core, for introducing mutual coupling between electric circuits. Transformers can be used to control voltage and phase shift (active power flow).

A power transformer may be composed of separate transformer tanks that need not be identical.

A power transformer can be modeled with or without tanks and is intended for use in both balanced and unbalanced representations. A power transformer typically has two terminals, but may have one (grounding), three or more terminals.

The inherited association ConductingEquipment.BaseVoltage should not be used. The association from TransformerEnd to BaseVoltage should be used instead.

Table 228 shows all attributes of PowerTransformer.

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Table 228 – Attributes of Wires::PowerTransformer

name	mult	type	description
beforeShCircuitHighestOperatingCurrent	0..1	CurrentFlow	The highest operating current (Ib in the IEC 60909-0) before short circuit (depends on network configuration and relevant reliability philosophy). It is used for calculation of the impedance correction factor KT defined in IEC 60909-0.
beforeShCircuitHighestOperatingVoltage	0..1	Voltage	The highest operating voltage (Ub in the IEC 60909-0) before short circuit. It is used for calculation of the impedance correction factor KT defined in IEC 60909-0. This is worst case voltage on the low side winding (Section 3.7.1 in the standard). Used to define operating conditions.
beforeShortCircuitAnglePf	0..1	AngleDegrees	The angle of power factor before short circuit (phib in IEC 60909-0). It is used for calculation of the impedance correction factor KT defined in IEC 60909-0. This is the worst case power factor. Used to define operating conditions.
highSideMinOperatingU	0..1	Voltage	The minimum operating voltage (uQmin in the IEC 60909-0) at the high voltage side (Q side) of the unit transformer of the power station unit. A value well established from long-term operating experience of the system. It is used for calculation of the impedance correction factor KG defined in IEC 60909-0
isPartOfGeneratorUnit	0..1	Boolean	Indicates whether the machine is part of a power station unit. Used for short circuit data exchange according to IEC 60909
operationalValuesConsidered	0..1	Boolean	It is used to define if the data (other attributes related to short circuit data exchange) defines long term operational conditions or not. Used for short circuit data exchange according to IEC 60909.

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name	mult	type	description
vectorGroup	0..1	String	Vector group of the transformer for protective relaying, e.g. Dyn1. For unbalanced transformers, this may not be simply determined from the constituent winding connections and phase angle dispacements. The vectorGroup string consists of the following components in the order listed: high voltage winding connection, mid voltage winding connection (for three winding transformers), phase displacement clock number from 0 to 11, low voltage winding connection phase displacement clock number from 0 to 11. The winding connections are D (delta), Y (wye), YN (wye with neutral), Z (zigzag), ZN (zigzag with neutral), A (auto transformer). Upper case means the high voltage, lower case mid or low. The high voltage winding always has clock postion 0 and is not included in the vector group string. Some examples: YNy0 (two winding wye to wye with no phase displacement), YNd11 (two winding wye to delta with 330 degrees phase displacement), YNyn0d5 (three winding transformer wye with neutral high voltgage, wye with neutral mid voltgage and no phase displacement, delta low voltage with 150 degrees displacement). Phase displacement is defined as the angular difference between the phasors representing the voltages between the neutral point (real or imaginary) and the corresponding terminals of two windings, a positive sequence voltage system being applied to the high-voltage terminals, following each other in alphabetical sequence if they are lettered, or in numerical sequence if they are numbered: the phasors are assumed to rotate in a counter-clockwise sense.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 229 shows all association ends of PowerTransformer with other classes.

Table 229 – Association ends of Wires::PowerTransformer with other classes

mult from	name	mult to	type	description
0..1	PowerTransformerEnd	0..*	PowerTransformerEnd	The ends of this power transformer.
0..1	TransformerTanks	0..*	TransformerTank	All transformers that belong to this bank.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment

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mult from	name	mult to	type	description
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.23 PhaseTapChangerAsymmetrical

Describes the tap model for an asymmetrical phase shifting transformer in which the difference voltage vector adds to the primary side voltage. The angle between the primary side voltage and the difference voltage is named the winding connection angle. The phase shift depends on both the difference voltage magnitude and the winding connection angle.

Table 230 shows all attributes of PhaseTapChangerAsymmetrical.

Table 230 – Attributes of Wires::PhaseTapChangerAsymmetrical

name	mult	type	description
windingConnectionAngle	0..1	AngleDegrees	The phase angle between the in-phase winding and the out-of-phase winding used for creating phase shift. The out-of-phase winding produces what is known as the difference voltage. Setting this angle to 90 degrees is not the same as a symmetrical transformer.
voltageStepIncrement	0..1	PerCent	inherited from: PhaseTapChangerNonLinear
xMax	0..1	Reactance	inherited from: PhaseTapChangerNonLinear
xMin	0..1	Reactance	inherited from: PhaseTapChangerNonLinear
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 231 shows all association ends of PhaseTapChangerAsymmetrical with other classes.

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Table 231 – Association ends of Wires::PhaseTapChangerAsymmetrical with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.24 Ground

A point where the system is grounded used for connecting conducting equipment to ground. The power system model can have any number of grounds.

Table 232 shows all attributes of Ground.

Table 232 – Attributes of Wires::Ground

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 233 shows all association ends of Ground with other classes.

Table 233 – Association ends of Wires::Ground with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.25 Line

Contains equipment beyond a substation belonging to a power transmission line.

Table 234 shows all attributes of Line.

Table 234 – Attributes of Wires::Line

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 235 shows all association ends of Line with other classes.

Table 235 – Association ends of Wires::Line with other classes

mult from	name	mult to	type	description
0..*	Region	0..1	SubGeographicalRegion	The sub-geographical region of the line.
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.26 PhaseTapChangerSymmetrical

Describes a symmetrical phase shifting transformer tap model in which the secondary side voltage magnitude is the same as at the primary side. The difference voltage magnitude is the base in an equal-sided triangle where the sides corresponds to the primary and secondary voltages. The phase angle difference corresponds to the top angle and can be expressed as twice the arctangent of half the total difference voltage.

Table 236 shows all attributes of PhaseTapChangerSymmetrical.

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Table 236 – Attributes of Wires::PhaseTapChangerSymmetrical

name	mult	type	description
voltageStepIncrement	0..1	PerCent	inherited from: PhaseTapChangerNonLinear
xMax	0..1	Reactance	inherited from: PhaseTapChangerNonLinear
xMin	0..1	Reactance	inherited from: PhaseTapChangerNonLinear
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 237 shows all association ends of PhaseTapChangerSymmetrical with other classes.

Table 237 – Association ends of Wires::PhaseTapChangerSymmetrical with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.27 RegulationSchedule

A pre-established pattern over time for a controlled variable, e.g. busbar voltage.

Table 238 shows all attributes of RegulationSchedule.

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Table 238 – Attributes of Wires::RegulationSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 239 shows all association ends of RegulationSchedule with other classes.

Table 239 – Association ends of Wires::RegulationSchedule with other classes

mult from	name	mult to	type	description
0..*	RegulatingControl	1..1	RegulatingControl	Regulating controls that have this Schedule.
0..1	VoltageControlZones	0..*	VoltageControlZone	A VoltageControlZone may have a voltage regulation schedule.
0..*	DayType	0..1	DayType	inherited from: SeasonDayTypeSchedule
0..*	Season	0..1	Season	inherited from: SeasonDayTypeSchedule
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.28 Fuse

An overcurrent protective device with a circuit opening fusible part that is heated and severed by the passage of overcurrent through it. A fuse is considered a switching device because it breaks current.

Table 240 shows all attributes of Fuse.

Table 240 – Attributes of Wires::Fuse

name	mult	type	description
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment

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name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 241 shows all association ends of Fuse with other classes.

Table 241 – Association ends of Wires::Fuse with other classes

mult from	name	mult to	type	description
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.29 TransformerMeshImpedance

Transformer mesh impedance (Delta-model) between transformer ends.

The typical case is that this class describes the impedance between two transformer ends pair-wise, i.e. the cardinalities at both tranformer end associations are 1. But in cases where two or more transformer ends are modeled the cardinalities are larger than 1.

Table 242 shows all attributes of TransformerMeshImpedance.

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Table 242 – Attributes of Wires::TransformerMeshImpedance

name	mult	type	description
r	0..1	Resistance	Resistance between the 'from' and the 'to' end, seen from the 'from' end.
r0	0..1	Resistance	Zero-sequence resistance between the 'from' and the 'to' end, seen from the 'from' end.
x	0..1	Reactance	Reactance between the 'from' and the 'to' end, seen from the 'from' end.
x0	0..1	Reactance	Zero-sequence reactance between the 'from' and the 'to' end, seen from the 'from' end.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 243 shows all association ends of TransformerMeshImpedance with other classes.

Table 243 – Association ends of Wires::TransformerMeshImpedance with other classes

mult from	name	mult to	type	description
0..*	ToTransformerEnd	1..*	TransformerEnd	All transformer ends this mesh impedance is connected to.
0..*	FromTransformerEnd	1..1	TransformerEnd	From end this mesh impedance is connected to. It determines the voltage reference.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.30 SwitchPhase

Single phase of a multi-phase switch when its attributes might be different per phase.

Table 244 shows all attributes of SwitchPhase.

Table 244 – Attributes of Wires::SwitchPhase

name	mult	type	description
normalOpen	0..1	Boolean	Used in cases when no Measurement for the status value is present. If the SwitchPhase has a status measurement the Discrete.normalValue is expected to match with this value.
phaseSide1	0..1	SinglePhaseKind	Phase of this SwitchPhase on the side with terminal sequence number equal to 1. Should be a phase contained in that terminal's phases attribute.
phaseSide2	0..1	SinglePhaseKind	Phase of this SwitchPhase on the side with terminal sequence number equal to 2. Should be a phase contained in that terminal's Terminal.phases attribute.
closed	0..1	Boolean	The attribute tells if the switch is considered closed when used as input to topology processing.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 245 shows all association ends of SwitchPhase with other classes.

Table 245 – Association ends of Wires::SwitchPhase with other classes

mult from	name	mult to	type	description
0..*	Switch	1..1	Switch	The switch of the switch phase.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.31 PowerTransformerEnd

A PowerTransformerEnd is associated with each Terminal of a PowerTransformer.

The impedance values r, r0, x, and x0 of a PowerTransformerEnd represent a star equivalent as follows.

1) For a two Terminal PowerTransformer the high voltage (TransformerEnd.endNumber=1) PowerTransformerEnd has non zero values on r, r0, x, and x0 while the low voltage (TransformerEnd.endNumber=0) PowerTransformerEnd has zero values for r, r0, x, and x0.
2) For a three Terminal PowerTransformer the three PowerTransformerEnds represent a star equivalent with each leg in the star represented by r, r0, x, and x0 values.
3) For a three Terminal transformer each PowerTransformerEnd shall have g, g0, b and b0 values corresponding to the no load losses distributed on the three PowerTransformerEnds. The total no load loss shunt impedances may also be placed at one of the PowerTransformerEnds, preferably the end numbered 1, having the shunt values on end 1 is the preferred way.
4) For a PowerTransformer with more than three Terminals the PowerTransformerEnd impedance values cannot be used. Instead use the TransformerMeshImpedance or split the transformer into multiple PowerTransformers.

Table 246 shows all attributes of PowerTransformerEnd.

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Table 246 – Attributes of Wires::PowerTransformerEnd

name	mult	type	description
b	0..1	Susceptance	Magnetizing branch susceptance (B mag). The value can be positive or negative.
b0	0..1	Susceptance	Zero sequence magnetizing branch susceptance.
connectionKind	0..1	WindingConnection	Kind of connection.
g	0..1	Conductance	Magnetizing branch conductance.
g0	0..1	Conductance	Zero sequence magnetizing branch conductance (star-model).
phaseAngleClock	0..1	Integer	Terminal voltage phase angle displacement where 360 degrees are represented with clock hours. The valid values are 0 to 11. For example, for the secondary side end of a transformer with vector group code of 'Dyn11', specify the connection kind as wye with neutral and specify the phase angle of the clock as 11. The clock value of the transformer end number specified as 1 is assumed to be zero. Note the transformer end number is not assumed to be the same as the terminal sequence number.
r	0..1	Resistance	Resistance (star-model) of the transformer end. The attribute shall be equal to or greater than zero for non-equivalent transformers.
r0	0..1	Resistance	Zero sequence series resistance (star-model) of the transformer end.
ratedS	0..1	ApparentPower	Normal apparent power rating. The attribute shall be a positive value. For a two-winding transformer the values for the high and low voltage sides shall be identical.
ratedU	0..1	Voltage	Rated voltage: phase-phase for three-phase windings, and either phase-phase or phase-neutral for single-phase windings. A high voltage side, as given by TransformerEnd.endNumber, shall have a ratedU that is greater than or equal to ratedU for the lower voltage sides.
x	0..1	Reactance	Positive sequence series reactance (star-model) of the transformer end.
x0	0..1	Reactance	Zero sequence series reactance of the transformer end.
bmagSat	0..1	PerCent	inherited from: TransformerEnd
endNumber	0..1	Integer	inherited from: TransformerEnd
grounded	0..1	Boolean	inherited from: TransformerEnd
magBaseU	0..1	Voltage	inherited from: TransformerEnd
magSatFlux	0..1	PerCent	inherited from: TransformerEnd
rground	0..1	Resistance	inherited from: TransformerEnd
xground	0..1	Reactance	inherited from: TransformerEnd
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 247 shows all association ends of PowerTransformerEnd with other classes.

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Table 247 – Association ends of Wires::PowerTransformerEnd with other classes

mult from	name	mult to	type	description
0..*	PowerTransformer	0..1	PowerTransformer	The power transformer of this power transformer end.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: TransformerEnd
0..*	Terminal	0..1	Terminal	inherited from: TransformerEnd
1..1	RatioTapChanger	0..1	RatioTapChanger	inherited from: TransformerEnd
0..*	StarImpedance	0..1	TransformerStarImpedance	inherited from: TransformerEnd
1..1	PhaseTapChanger	0..1	PhaseTapChanger	inherited from: TransformerEnd
0..*	CoreAdmittance	0..1	TransformerCoreAdmittance	inherited from: TransformerEnd
1..*	ToMeshImpedance	0..*	TransformerMeshImpedance	inherited from: TransformerEnd
1..1	FromMeshImpedance	0..*	TransformerMeshImpedance	inherited from: TransformerEnd
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.32 PetersenCoil

A tunable impedance device normally used to offset line charging during single line faults in an ungrounded section of network.

Table 248 shows all attributes of PetersenCoil.

Table 248 – Attributes of Wires::PetersenCoil

name	mult	type	description
mode	0..1	PetersenCoilModeKind	The mode of operation of the Petersen coil.
nominalU	0..1	Voltage	The nominal voltage for which the coil is designed.
offsetCurrent	0..1	CurrentFlow	The offset current that the Petersen coil controller is operating from the resonant point. This is normally a fixed amount for which the controller is configured and could be positive or negative. Typically 0 to 60 A depending on voltage and resonance conditions.
positionCurrent	0..1	CurrentFlow	The control current used to control the Petersen coil also known as the position current. Typically in the range of 20 mA to 200 mA.
xGroundMax	0..1	Reactance	The maximum reactance.
xGroundMin	0..1	Reactance	The minimum reactance.
xGroundNominal	0..1	Reactance	The nominal reactance. This is the operating point (normally over compensation) that is defined based on the resonance point in the healthy network condition. The impedance is calculated based on nominal voltage divided by position current.
r	0..1	Resistance	inherited from: EarthFaultCompensator
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 249 shows all association ends of PetersenCoil with other classes.

Table 249 – Association ends of Wires::PetersenCoil with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.33 RegulatingCondEq

A type of conducting equipment that can regulate a quantity (i.e. voltage or flow) at a specific point in the network.

Table 250 shows all attributes of RegulatingCondEq.

Table 250 – Attributes of Wires::RegulatingCondEq

name	mult	type	description
controlEnabled	0..1	Boolean	Specifies the regulation status of the equipment. True is regulating, false is not regulating.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 251 shows all association ends of RegulatingCondEq with other classes.

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Table 251 – Association ends of Wires::RegulatingCondEq with other classes

mult from	name	mult to	type	description
0..*	RegulatingControl	0..1	RegulatingControl	The regulating control scheme in which this equipment participates.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.34 PhaseTapChangerNonLinear

The non-linear phase tap changer describes the non-linear behavior of a phase tap changer. This is a base class for the symmetrical and asymmetrical phase tap changer models. The details of these models can be found in the IEC 61970-301 document.

Table 252 shows all attributes of PhaseTapChangerNonLinear.

Table 252 – Attributes of Wires::PhaseTapChangerNonLinear

name	mult	type	description
voltageStepIncrement	0..1	PerCent	The voltage step increment on the out of phase winding specified in percent of nominal voltage of the transformer end.
xMax	0..1	Reactance	The reactance depends on the tap position according to a "u" shaped curve. The maximum reactance (xMax) appear at the low and high tap positions.
xMin	0..1	Reactance	The reactance depend on the tap position according to a "u" shaped curve. The minimum reactance (xMin) appears at the mid tap position.
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger

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name	mult	type	description
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 253 shows all association ends of PhaseTapChangerNonLinear with other classes.

Table 253 – Association ends of Wires::PhaseTapChangerNonLinear with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.35 SeriesCompensator

A Series Compensator is a series capacitor or reactor or an AC transmission line without charging susceptance. It is a two terminal device.

Table 254 shows all attributes of SeriesCompensator.

Table 254 – Attributes of Wires::SeriesCompensator

name	mult	type	description
r	0..1	Resistance	Positive sequence resistance.
r0	0..1	Resistance	Zero sequence resistance.
x	0..1	Reactance	Positive sequence reactance.
x0	0..1	Reactance	Zero sequence reactance.
varistorPresent	0..1	Boolean	Describe if a metal oxide varistor (mov) for over voltage protection is configured at the series compensator.
varistorRatedCurrent	0..1	CurrentFlow	The maximum current the varistor is designed to handle at specified duration.
varistorVoltageThreshold	0..1	Voltage	The DC voltage at which the varistor starts conducting.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 255 shows all association ends of SeriesCompensator with other classes.

Table 255 – Association ends of Wires::SeriesCompensator with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.36 PhaseShuntConnectionKind enumeration

The configuration of phase connections for a single terminal device such as a load or capacitor.

Table 256 shows all literals of PhaseShuntConnectionKind.

Table 256 – Literals of Wires::PhaseShuntConnectionKind

literal	value	description
D		Delta connection.
Y		Wye connection.
Yn		Wye, with neutral brought out for grounding.
I		Independent winding, for single-phase connections.

6.9.37 GroundingImpedance

A fixed impedance device used for grounding.

Table 257 shows all attributes of GroundingImpedance.

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Table 257 – Attributes of Wires::GroundingImpedance

name	mult	type	description
x	0..1	Reactance	Reactance of device.
r	0..1	Resistance	inherited from: EarthFaultCompensator
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 258 shows all association ends of GroundingImpedance with other classes.

Table 258 – Association ends of Wires::GroundingImpedance with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.38 TransformerControlMode enumeration

Control modes for a transformer.

Table 259 shows all literals of TransformerControlMode.

Table 259 – Literals of Wires::TransformerControlMode

literal	value	description
volt		Voltage control
reactive		Reactive power flow control

6.9.39 RatioTapChangerTablePoint

Describes each tap step in the ratio tap changer tabular curve.

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Table 260 shows all attributes of RatioTapChangerTablePoint.

Table 260 – Attributes of Wires::RatioTapChangerTablePoint

name	mult	type	description
b	0..1	PerCent	inherited from: TapChangerTablePoint
g	0..1	PerCent	inherited from: TapChangerTablePoint
r	0..1	PerCent	inherited from: TapChangerTablePoint
ratio	0..1	Float	inherited from: TapChangerTablePoint
step	0..1	Integer	inherited from: TapChangerTablePoint
x	0..1	PerCent	inherited from: TapChangerTablePoint

Table 261 shows all association ends of RatioTapChangerTablePoint with other classes.

Table 261 – Association ends of Wires::RatioTapChangerTablePoint with other classes

mult from	name	mult to	type	description
1..*	RatioTapChangerTable	1..1	RatioTapChangerTable	Table of this point.

6.9.40 ACLineSegment

A wire or combination of wires, with consistent electrical characteristics, building a single electrical system, used to carry alternating current between points in the power system.

For symmetrical, transposed three phase lines, it is sufficient to use attributes of the line segment, which describe impedances and admittances for the entire length of the segment. Additionally impedances can be computed by using length and associated per length impedances.

The BaseVoltage at the two ends of ACLineSegments in a Line shall have the same BaseVoltage.nominalVoltage. However, boundary lines may have slightly different BaseVoltage.nominalVoltages and variation is allowed. Larger voltage difference in general requires use of an equivalent branch.

Table 262 shows all attributes of ACLineSegment.

Table 262 – Attributes of Wires::ACLineSegment

name	mult	type	description
b0ch	0..1	Susceptance	Zero sequence shunt (charging) susceptance, uniformly distributed, of the entire line section.
bch	0..1	Susceptance	Positive sequence shunt (charging) susceptance, uniformly distributed, of the entire line section. This value represents the full charging over the full length of the line.
g0ch	0..1	Conductance	Zero sequence shunt (charging) conductance, uniformly distributed, of the entire line section.
gch	0..1	Conductance	Positive sequence shunt (charging) conductance, uniformly distributed, of the entire line section.
r	0..1	Resistance	Positive sequence series resistance of the entire line section.
r0	0..1	Resistance	Zero sequence series resistance of the entire line section.

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name	mult	type	description
shortCircuitEndTemperature	0..1	Temperature	Maximum permitted temperature at the end of SC for the calculation of minimum short-circuit currents. Used for short circuit data exchange according to IEC 60909.
x	0..1	Reactance	Positive sequence series reactance of the entire line section.
x0	0..1	Reactance	Zero sequence series reactance of the entire line section.
length	0..1	Length	inherited from: Conductor
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 263 shows all association ends of ACLineSegment with other classes.

Table 263 – Association ends of Wires::ACLineSegment with other classes

mult from	name	mult to	type	description
1..1	Clamp	0..*	Clamp	The clamps connected to the line segment.
0..1	LineFaults	0..*	LineFault	The line faults of the line segment.
0..*	PerLengthImpedance	0..1	PerLengthImpedance	Per-length impedance of this line segment.
1..1	Cut	0..*	Cut	Cuts applied to the line segment.
1..1	ACLineSegmentPhases	0..*	ACLineSegmentPhase	The line segment phases which belong to the line segment.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.41 Recloser

Pole-mounted fault interrupter with built-in phase and ground relays, current transformer (CT), and supplemental controls.

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Table 264 shows all attributes of Recloser.

Table 264 – Attributes of Wires::Recloser

name	mult	type	description
breakingCapacity	0..1	CurrentFlow	inherited from: ProtectedSwitch
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 265 shows all association ends of Recloser with other classes.

Table 265 – Association ends of Wires::Recloser with other classes

mult from	name	mult to	type	description
0..*	OperatedByProtectionEquipment	0..*	ProtectionEquipment	inherited from: ProtectedSwitch
1..1	RecloseSequences	0..*	RecloseSequence	inherited from: ProtectedSwitch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.42 CompositeSwitch

A model of a set of individual Switches normally enclosed within the same cabinet and possibly with interlocks that restrict the combination of switch positions. These are typically found in medium voltage distribution networks.

A CompositeSwitch could represent a Ring-Main-Unit (RMU), or pad-mounted switchgear, with primitive internal devices such as an internal busbar plus 3 or 4 internal switches each of which may individually be open or closed. A CompositeSwitch and a set of contained Switches can also be used to represent a multi-position switch, e.g. a switch that can connect a circuit to Ground, Open or Busbar.

Table 266 shows all attributes of CompositeSwitch.

Table 266 – Attributes of Wires::CompositeSwitch

name	mult	type	description
compositeSwitchType	0..1	String	An alphanumeric code that can be used as a reference to extra information such as the description of the interlocking scheme if any.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 267 shows all association ends of CompositeSwitch with other classes.

Table 267 – Association ends of Wires::CompositeSwitch with other classes

mult from	name	mult to	type	description
0..1	Switches	0..*	Switch	Switches contained in this Composite switch.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.43 TransformerEnd

A conducting connection point of a power transformer. It corresponds to a physical transformer winding terminal. In earlier CIM versions, the TransformerWinding class served a similar purpose, but this class is more flexible because it associates to terminal but is not a specialization of ConductingEquipment.

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Table 268 shows all attributes of TransformerEnd.

Table 268 – Attributes of Wires::TransformerEnd

name	mult	type	description
bmagSat	0..1	PerCent	Core shunt magnetizing susceptance in the saturation region.
endNumber	0..1	Integer	Number for this transformer end, corresponding to the end's order in the power transformer vector group or phase angle clock number. Highest voltage winding should be 1. Each end within a power transformer should have a unique subsequent end number. Note the transformer end number need not match the terminal sequence number.
grounded	0..1	Boolean	(for Yn and Zn connections) True if the neutral is solidly grounded.
magBaseU	0..1	Voltage	The reference voltage at which the magnetizing saturation measurements were made.
magSatFlux	0..1	PerCent	Core magnetizing saturation curve knee flux level.
rground	0..1	Resistance	(for Yn and Zn connections) Resistance part of neutral impedance where 'grounded' is true.
xground	0..1	Reactance	(for Yn and Zn connections) Reactive part of neutral impedance where 'grounded' is true.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 269 shows all association ends of TransformerEnd with other classes.

Table 269 – Association ends of Wires::TransformerEnd with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	Base voltage of the transformer end. This is essential for PU calculation.
0..*	Terminal	0..1	Terminal	Terminal of the power transformer to which this transformer end belongs.
1..1	RatioTapChanger	0..1	RatioTapChanger	Ratio tap changer associated with this transformer end.
0..*	StarImpedance	0..1	TransformerStarImpedance	(accurate for 2- or 3-winding transformers only) Pi-model impedances of this transformer end. By convention, for a two winding transformer, the full values of the transformer should be entered on the high voltage end (endNumber=1).
1..1	PhaseTapChanger	0..1	PhaseTapChanger	Phase tap changer associated with this transformer end.
0..*	CoreAdmittance	0..1	TransformerCoreAdmittance	Core admittance of this transformer end, representing magnetizing current and core losses. The full values of the transformer should be supplied for one transformer end only.
1..*	ToMeshImpedance	0..*	TransformerMeshImpedance	All mesh impedances between this 'from' and other 'to' transformer ends.

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mult from	name	mult to	type	description
1..1	FromMeshImpedance	0..*	TransformerMeshImpedance	All mesh impedances between this 'to' and other 'from' transformer ends.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.44 Sectionaliser

Automatic switch that will lock open to isolate a faulted section. It may, or may not, have load breaking capability. Its primary purpose is to provide fault sectionalising at locations where the fault current is either too high, or too low, for proper coordination of fuses.

Table 270 shows all attributes of Sectionaliser.

Table 270 – Attributes of Wires::Sectionaliser

name	mult	type	description
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 271 shows all association ends of Sectionaliser with other classes.

Table 271 – Association ends of Wires::Sectionaliser with other classes

mult from	name	mult to	type	description
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.45 VoltageControlZone

An area of the power system network which is defined for secondary voltage control purposes. A voltage control zone consists of a collection of substations with a designated busbar section whose voltage will be controlled.

Table 272 shows all attributes of VoltageControlZone.

Table 272 – Attributes of Wires::VoltageControlZone

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 273 shows all association ends of VoltageControlZone with other classes.

Table 273 – Association ends of Wires::VoltageControlZone with other classes

mult from	name	mult to	type	description
0..1	BusbarSection	1..1	BusbarSection	A VoltageControlZone is controlled by a designated BusbarSection.
0..*	RegulationSchedule	0..1	RegulationSchedule	A VoltageControlZone may have a voltage regulation schedule.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.46 EnergySource

A generic equivalent for an energy supplier on a transmission or distribution voltage level.

Table 274 shows all attributes of EnergySource.

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Table 274 – Attributes of Wires::EnergySource

name	mult	type	description
activePower	0..1	ActivePower	High voltage source active injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
reactivePower	0..1	ReactivePower	High voltage source reactive injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
nominalVoltage	0..1	Voltage	Phase-to-phase nominal voltage.
r	0..1	Resistance	Positive sequence Thevenin resistance.
r0	0..1	Resistance	Zero sequence Thevenin resistance.
rn	0..1	Resistance	Negative sequence Thevenin resistance.
voltageAngle	0..1	AngleRadians	Phase angle of a phase open circuit.
voltageMagnitude	0..1	Voltage	Phase-to-phase open circuit voltage magnitude.
x	0..1	Reactance	Positive sequence Thevenin reactance.
x0	0..1	Reactance	Zero sequence Thevenin reactance.
xn	0..1	Reactance	Negative sequence Thevenin reactance.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 275 shows all association ends of EnergySource with other classes.

Table 275 – Association ends of Wires::EnergySource with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.47 SynchronousMachine

An electromechanical device that operates with shaft rotating synchronously with the network. It is a single machine operating either as a generator or synchronous condenser or pump.

Table 276 shows all attributes of SynchronousMachine.

Table 276 – Attributes of Wires::SynchronousMachine

name	mult	type	description
aVRToManualLag	0..1	Seconds	Time delay required when switching from Automatic Voltage Regulation (AVR) to Manual for a lagging MVAr violation.
aVRToManualLead	0..1	Seconds	Time delay required when switching from Automatic Voltage Regulation (AVR) to Manual for a leading MVAr violation.
baseQ	0..1	ReactivePower	Default base reactive power value. This value represents the initial reactive power that can be used by any application function.
condenserP	0..1	ActivePower	Active power consumed when in condenser mode operation.
coolantCondition	0..1	Float	Temperature or pressure of coolant medium
coolantType	0..1	CoolantType	Method of cooling the machine.
earthing	0..1	Boolean	Indicates whether or not the generator is earthed. Used for short circuit data exchange according to IEC 60909
earthingStarPointR	0..1	Resistance	Generator star point earthing resistance (Re). Used for short circuit data exchange according to IEC 60909
earthingStarPointX	0..1	Reactance	Generator star point earthing reactance (Xe). Used for short circuit data exchange according to IEC 60909
ikk	0..1	CurrentFlow	Steady-state short-circuit current (in A for the profile) of generator with compound excitation during 3-phase short circuit. - Ikk=0: Generator with no compound excitation. - Ikk?0: Generator with compound excitation. Ikk is used to calculate the minimum steady-state short-circuit current for generators with compound excitation (Section 4.6.1.2 in the IEC 60909-0) Used only for single fed short circuit on a generator. (Section 4.3.4.2. in the IEC 60909-0)
manualToAVR	0..1	Seconds	Time delay required when switching from Manual to Automatic Voltage Regulation. This value is used in the accelerating power reference frame for powerflow solutions
maxQ	0..1	ReactivePower	Maximum reactive power limit. This is the maximum (nameplate) limit for the unit.
maxU	0..1	Voltage	Maximum voltage limit for the unit.
minQ	0..1	ReactivePower	Minimum reactive power limit for the unit.
minU	0..1	Voltage	Minimum voltage limit for the unit.
mu	0..1	Float	Factor to calculate the breaking current (Section 4.5.2.1 in the IEC 60909-0). Used only for single fed short circuit on a generator (Section 4.3.4.2. in the IEC 60909-0).
operatingMode	0..1	SynchronousMachineOperatingMode	Current mode of operation.

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name	mult	type	description
qPercent	0..1	PerCent	Part of the coordinated reactive control that comes from this machine. The attribute is used as a participation factor not necessarily summing up to 100% for the devices participating in the control.
r	0..1	Resistance	Equivalent resistance (RG) of generator. RG is considered for the calculation of all currents, except for the calculation of the peak current ip. Used for short circuit data exchange according to IEC 60909
r0	0..1	Resistance	Zero sequence resistance of the synchronous machine.
r2	0..1	Resistance	Negative sequence resistance.
referencePriority	0..1	Integer	Priority of unit for use as powerflow voltage phase angle reference bus selection. 0 = don't care (default) 1 = highest priority. 2 is less than 1 and so on.
satDirectSubtransX	0..1	PU	Direct-axis subtransient reactance saturated, also known as Xd"sat.
satDirectSyncX	0..1	PU	Direct-axes saturated synchronous reactance (xdsat); reciprocal of short-circuit ration. Used for short circuit data exchange, only for single fed short circuit on a generator. (Section 4.3.4.2. in the IEC 60909-0.
satDirectTransX	0..1	PU	Saturated Direct-axis transient reactance. The attribute is primarily used for short circuit calculations according to ANSI.
shortCircuitRotorType	0..1	ShortCircuitRotorKind	Type of rotor, used by short circuit applications, only for single fed short circuit according to IEC 60909.
type	0..1	SynchronousMachineKind	Modes that this synchronous machine can operate in.
voltageRegulationRange	0..1	PerCent	Range of generator voltage regulation (PG in the IEC 60909-0) used for calculation of the impedance correction factor KG defined in IEC 60909-0 This attribute is used to describe the operating voltage of the generating unit.
x0	0..1	Reactance	Zero sequence reactance of the synchronous machine.
x2	0..1	Reactance	Negative sequence reactance.
ratedPowerFactor	0..1	Float	inherited from: RotatingMachine
p	0..1	ActivePower	inherited from: RotatingMachine
ratedS	0..1	ApparentPower	inherited from: RotatingMachine
q	0..1	ReactivePower	inherited from: RotatingMachine
ratedU	0..1	Voltage	inherited from: RotatingMachine
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 277 shows all association ends of SynchronousMachine with other classes.

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Table 277 – Association ends of Wires::SynchronousMachine with other classes

mult from	name	mult to	type	description
0..*	PrimeMovers	0..*	PrimeMover	Prime movers that drive this SynchronousMachine.
1..*	InitialReactiveCapabilityCurve	0..1	ReactiveCapabilityCurve	The default reactive capability curve for use by a synchronous machine.
1..*	ReactiveCapabilityCurves	0..*	ReactiveCapabilityCurve	All available reactive capability curves for this synchronous machine.
1..1	SynchronousMachineDynamics	0..1	SynchronousMachineDynamics	Synchronous machine dynamics model used to describe dynamic behavior of this synchronous machine.
1..1	HydroPump	0..1	HydroPump	inherited from: RotatingMachine
1..*	GeneratingUnit	0..1	GeneratingUnit	inherited from: RotatingMachine
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.48 RegulatingControlModeKind enumeration

The kind of regulation model. For example regulating voltage, reactive power, active power, etc.

Table 278 shows all literals of RegulatingControlModeKind.

Table 278 – Literals of Wires::RegulatingControlModeKind

literal	value	description
voltage		Voltage is specified.
activePower		Active power is specified.
reactivePower		Reactive power is specified.
currentFlow		Current flow is specified.
admittance		Admittance is specified.
timeScheduled		Control switches on/off by time of day. The times may change on the weekend, or in different seasons.

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literal	value	description
temperature		Control switches on/off based on the local temperature (i.e. a thermostat).
powerFactor		Power factor is specified.

6.9.49 Clamp

A Clamp is a galvanic connection at a line segment where other equipment is connected. A Clamp does not cut the line segment.

A Clamp is ConductingEquipment and has one Terminal with an associated ConnectivityNode. Any other ConductingEquipment can be connected to the Clamp ConnectivityNode.

Table 279 shows all attributes of Clamp.

Table 279 – Attributes of Wires::Clamp

name	mult	type	description
lengthFromTerminal1	0..1	Length	The length to the place where the clamp is located starting from side one of the line segment, i.e. the line segment terminal with sequence number equal to 1.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 280 shows all association ends of Clamp with other classes.

Table 280 – Association ends of Wires::Clamp with other classes

mult from	name	mult to	type	description
0..*	ACLineSegment	1..1	ACLineSegment	The line segment to which the clamp is connected.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject

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mult from	name	mult to	type	description
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.50 TransformerTankEnd

Transformer tank end represents an individual winding for unbalanced models or for transformer tanks connected into a bank (and bank is modeled with the PowerTransformer).

Table 281 shows all attributes of TransformerTankEnd.

Table 281 – Attributes of Wires::TransformerTankEnd

name	mult	type	description
phases	0..1	PhaseCode	Describes the phases carried by a conducting equipment.
bmagSat	0..1	PerCent	inherited from: TransformerEnd
endNumber	0..1	Integer	inherited from: TransformerEnd
grounded	0..1	Boolean	inherited from: TransformerEnd
magBaseU	0..1	Voltage	inherited from: TransformerEnd
magSatFlux	0..1	PerCent	inherited from: TransformerEnd
rground	0..1	Resistance	inherited from: TransformerEnd
xground	0..1	Reactance	inherited from: TransformerEnd
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 282 shows all association ends of TransformerTankEnd with other classes.

Table 282 – Association ends of Wires::TransformerTankEnd with other classes

mult from	name	mult to	type	description
1..*	TransformerTank	0..1	TransformerTank	Transformer this winding belongs to.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: TransformerEnd
0..*	Terminal	0..1	Terminal	inherited from: TransformerEnd
1..1	RatioTapChanger	0..1	RatioTapChanger	inherited from: TransformerEnd
0..*	StarImpedance	0..1	TransformerStarImpedance	inherited from: TransformerEnd
1..1	PhaseTapChanger	0..1	PhaseTapChanger	inherited from: TransformerEnd
0..*	CoreAdmittance	0..1	TransformerCoreAdmittance	inherited from: TransformerEnd
1..*	ToMeshImpedance	0..*	TransformerMeshImpedance	inherited from: TransformerEnd
1..1	FromMeshImpedance	0..*	TransformerMeshImpedance	inherited from: TransformerEnd
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.51 PhaseTapChanger

A transformer phase shifting tap model that controls the phase angle difference across the power transformer and potentially the active power flow through the power transformer. This phase tap model may also impact the voltage magnitude.

Table 283 shows all attributes of PhaseTapChanger.

Table 283 – Attributes of Wires::PhaseTapChanger

name	mult	type	description
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 284 shows all association ends of PhaseTapChanger with other classes.

Table 284 – Association ends of Wires::PhaseTapChanger with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	Transformer end to which this phase tap changer belongs.
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.52 ACLineSegmentPhase

Represents a single wire of an alternating current line segment.

Table 285 shows all attributes of ACLineSegmentPhase.

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Table 285 – Attributes of Wires::ACLineSegmentPhase

name	mult	type	description
phase	0..1	SinglePhaseKind	The phase connection of the wire at both ends.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 286 shows all association ends of ACLineSegmentPhase with other classes.

Table 286 – Association ends of Wires::ACLineSegmentPhase with other classes

mult from	name	mult to	type	description
0..*	ACLineSegment	1..1	ACLineSegment	The line segment to which the phase belongs.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.53 RatioTapChangerTable

Describes a curve for how the voltage magnitude and impedance varies with the tap step.

Table 287 shows all attributes of RatioTapChangerTable.

Table 287 – Attributes of Wires::RatioTapChangerTable

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 288 shows all association ends of RatioTapChangerTable with other classes.

Table 288 – Association ends of Wires::RatioTapChangerTable with other classes

mult from	name	mult to	type	description
0..1	RatioTapChanger	0..*	RatioTapChanger	The ratio tap changer of this tap ratio table.
1..1	RatioTapChangerTablePoint	1..*	RatioTapChangerTablePoint	Points of this table.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.54 RotatingMachine

A rotating machine which may be used as a generator or motor.

Table 289 shows all attributes of RotatingMachine.

Table 289 – Attributes of Wires::RotatingMachine

name	mult	type	description
ratedPowerFactor	0..1	Float	Power factor (nameplate data). It is primarily used for short circuit data exchange according to IEC 60909.
p	0..1	ActivePower	Active power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.
ratedS	0..1	ApparentPower	Nameplate apparent power rating for the unit. The attribute shall have a positive value.
q	0..1	ReactivePower	Reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.
ratedU	0..1	Voltage	Rated voltage (nameplate data, Ur in IEC 60909-0). It is primarily used for short circuit data exchange according to IEC 60909.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 290 shows all association ends of RotatingMachine with other classes.

Table 290 – Association ends of Wires::RotatingMachine with other classes

mult from	name	mult to	type	description
1..1	HydroPump	0..1	HydroPump	The synchronous machine drives the turbine which moves the water from a low elevation to a higher elevation. The direction of machine rotation for pumping may or may not be the same as for generating.
1..*	GeneratingUnit	0..1	GeneratingUnit	A synchronous machine may operate as a generator and as such becomes a member of a generating unit.
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment

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mult from	name	mult to	type	description
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.55 RegulatingControl

Specifies a set of equipment that works together to control a power system quantity such as voltage or flow.

Remote bus voltage control is possible by specifying the controlled terminal located at some place remote from the controlling equipment.

In case multiple equipments, possibly of different types, control the same terminal, there shall be only one RegulatingControl at that terminal. The most specific subtype of RegulatingControl shall be used in case such equipments participate in the control, e.g. TapChangerControl for tap changers.

For flow control, load sign convention is used, i.e. positive sign means flow out from a TopologicalNode (bus) into the conducting equipment.

Table 291 shows all attributes of RegulatingControl.

Table 291 – Attributes of Wires::RegulatingControl

name	mult	type	description
discrete	0..1	Boolean	The regulation is performed in a discrete mode. This applies to equipment with discrete controls, e.g. tap changers and shunt compensators.
enabled	0..1	Boolean	The flag tells if regulation is enabled.
mode	0..1	RegulatingControlModeKind	The regulating control mode presently available. This specification allows for determining the kind of regulation without need for obtaining the units from a schedule.
monitoredPhase	0..1	PhaseCode	Phase voltage controlling this regulator, measured at regulator location.
targetDeadband	0..1	Float	This is a deadband used with discrete control to avoid excessive update of controls like tap changers and shunt compensator banks while regulating. The units of those appropriate for the mode.
targetValue	0..1	Float	The target value specified for case input. This value can be used for the target value without the use of schedules. The value has the units appropriate to the mode attribute.
targetValueUnitMultiplier	0..1	UnitMultiplier	Specify the multiplier for used for the targetValue.

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name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 292 shows all association ends of RegulatingControl with other classes.

Table 292 – Association ends of Wires::RegulatingControl with other classes

mult from	name	mult to	type	description
0..*	Terminal	0..1	Terminal	The terminal associated with this regulating control. The terminal is associated, instead of a node, since the terminal could connect into either a topological node (bus in bus-branch model) or a connectivity node (detailed switch model). Sometimes it is useful to model regulation at a terminal of a busbar object since the busbar can be present in both a bus-branch model or a model with switch detail.
1..1	RegulationSchedule	0..*	RegulationSchedule	Schedule for this Regulating regulating control.
0..1	RegulatingCondEq	0..*	RegulatingCondEq	The equipment that participates in this regulating control scheme.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.56 PhaseImpedanceData root class

Triplet of resistance, reactance, and susceptance matrix element values.

Table 293 shows all attributes of PhaseImpedanceData.

Table 293 – Attributes of Wires::PhaseImpedanceData

name	mult	type	description
sequenceNumber	0..1	Integer	Column-wise element index, assuming a symmetrical matrix. Ranges from 1 to N + N*(N−1)/2.
b	0..1	SusceptancePerLength	Susceptance matrix element value, per length of unit.
r	0..1	ResistancePerLength	Resistance matrix element value, per length of unit.
x	0..1	ReactancePerLength	Reactance matrix element value, per length of unit.

Table 294 shows all association ends of PhaseImpedanceData with other classes.

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Table 294 – Association ends of Wires::PhaseImpedanceData with other classes

mult from	name	mult to	type	description
1..*	PhaseImpedance	1..1	PerLengthPhaseImpedance	Conductor phase impedance to which this data belongs.

6.9.57 ShuntCompensator

A shunt capacitor or reactor or switchable bank of shunt capacitors or reactors. A section of a shunt compensator is an individual capacitor or reactor. A negative value for reactivePerSection indicates that the compensator is a reactor. ShuntCompensator is a single terminal device. Ground is implied.

Table 295 shows all attributes of ShuntCompensator.

Table 295 – Attributes of Wires::ShuntCompensator

name	mult	type	description
aVRDelay	0..1	Seconds	Time delay required for the device to be connected or disconnected by automatic voltage regulation (AVR).
grounded	0..1	Boolean	Used for Yn and Zn connections. True if the neutral is solidly grounded.
maximumSections	0..1	Integer	The maximum number of sections that may be switched in.
nomU	0..1	Voltage	The voltage at which the nominal reactive power may be calculated. This should normally be within 10 % of the voltage at which the capacitor is connected to the network.
normalSections	0..1	Integer	The normal number of sections switched in.
phaseConnection	0..1	PhaseShuntConnectionKind	The type of phase connection, such as wye or delta.
switchOnCount	0..1	Integer	The switch on count since the capacitor count was last reset or initialized.
switchOnDate	0..1	DateTime	The date and time when the capacitor bank was last switched on.
voltageSensitivity	0..1	VoltagePerReactivePower	Voltage sensitivity required for the device to regulate the bus voltage, in voltage/reactive power.
sections	0..1	Float	Shunt compensator sections in use. Starting value for steady state solution. Non integer values are allowed to support continuous variables. The reasons for continuous value are to support study cases where no discrete shunt compensators has yet been designed, a solutions where a narrow voltage band force the sections to oscillate or accommodate for a continuous solution as input.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 296 shows all association ends of ShuntCompensator with other classes.

Table 296 – Association ends of Wires::ShuntCompensator with other classes

mult from	name	mult to	type	description
1..1	ShuntCompensatorPhase	0..*	ShuntCompensatorPhase	The individual phases models for the shunt compensator.
1..1	SvShuntCompensatorSections	0..1	SvShuntCompensatorSections	The state for the number of shunt compensator sections in service.
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.58 EarthFaultCompensator

A conducting equipment used to represent a connection to ground which is typically used to compensate for earth faults.. An earth fault compensator device modeled with a single terminal implies a second terminal solidly connected to ground. If two terminals are modeled, the ground is not assumed and normal connection rules apply.

Table 297 shows all attributes of EarthFaultCompensator.

Table 297 – Attributes of Wires::EarthFaultCompensator

name	mult	type	description
r	0..1	Resistance	Nominal resistance of device.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 298 shows all association ends of EarthFaultCompensator with other classes.

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Table 298 – Association ends of Wires::EarthFaultCompensator with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.59 MutualCoupling

This class represents the zero sequence line mutual coupling.

Table 299 shows all attributes of MutualCoupling.

Table 299 – Attributes of Wires::MutualCoupling

name	mult	type	description
b0ch	0..1	Susceptance	Zero sequence mutual coupling shunt (charging) susceptance, uniformly distributed, of the entire line section.
distance11	0..1	Length	Distance to the start of the coupled region from the first line's terminal having sequence number equal to 1.
distance12	0..1	Length	Distance to the end of the coupled region from the first line's terminal with sequence number equal to 1.
distance21	0..1	Length	Distance to the start of coupled region from the second line's terminal with sequence number equal to 1.
distance22	0..1	Length	Distance to the end of coupled region from the second line's terminal with sequence number equal to 1.
g0ch	0..1	Conductance	Zero sequence mutual coupling shunt (charging) conductance, uniformly distributed, of the entire line section.
r0	0..1	Resistance	Zero sequence branch-to-branch mutual impedance coupling, resistance.
x0	0..1	Reactance	Zero sequence branch-to-branch mutual impedance coupling, reactance.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
name	0..1	String	inherited from: IdentifiedObject

Table 300 shows all association ends of MutualCoupling with other classes.

Table 300 – Association ends of Wires::MutualCoupling with other classes

mult from	name	mult to	type	description
0..*	First_Terminal	1..1	Terminal	The starting terminal for the calculation of distances along the first branch of the mutual coupling. Normally MutualCoupling would only be used for terminals of AC line segments. The first and second terminals of a mutual coupling should point to different AC line segments.
0..*	Second_Terminal	1..1	Terminal	The starting terminal for the calculation of distances along the second branch of the mutual coupling.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.60 Cut

A cut separates a line segment into two parts. The cut appears as a switch inserted between these two parts and connects them together. As the cut is normally open there is no galvanic connection between the two line segment parts. But it is possible to close the cut to get galvanic connection.

The cut terminals are oriented towards the line segment terminals with the same sequence number. Hence the cut terminal with sequence number equal to 1 is oriented to the line segment's terminal with sequence number equal to 1.

The cut terminals also act as connection points for jumpers and other equipment, e.g. a mobile generator. To enable this, connectivity nodes are placed at the cut terminals. Once the connectivity nodes are in place any conducting equipment can be connected at them.

Table 301 shows all attributes of Cut.

Table 301 – Attributes of Wires::Cut

name	mult	type	description
lengthFromTerminal1	0..1	Length	The length to the place where the cut is located starting from side one of the cut line segment, i.e. the line segment Terminal with sequenceNumber equal to 1.
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 302 shows all association ends of Cut with other classes.

Table 302 – Association ends of Wires::Cut with other classes

mult from	name	mult to	type	description
0..*	ACLineSegment	1..1	ACLineSegment	The line segment to which the cut is applied.
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.61 ReactiveCapabilityCurve

Reactive power rating envelope versus the synchronous machine's active power, in both the generating and motoring modes. For each active power value there is a corresponding high and low reactive power limit value. Typically there will be a separate curve for each coolant condition, such as hydrogen pressure. The Y1-axis values represent reactive minimum and the Y2-axis values represent reactive maximum.

Table 303 shows all attributes of ReactiveCapabilityCurve.

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Table 303 – Attributes of Wires::ReactiveCapabilityCurve

name	mult	type	description
coolantTemperature	0..1	Temperature	The machine's coolant temperature (e.g. ambient air or stator circulating water).
hydrogenPressure	0..1	Pressure	The hydrogen coolant pressure
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 304 shows all association ends of ReactiveCapabilityCurve with other classes.

Table 304 – Association ends of Wires::ReactiveCapabilityCurve with other classes

mult from	name	mult to	type	description
0..1	InitiallyUsedBySynchronousMachines	1..*	SynchronousMachine	Synchronous machines using this curve as default.
0..*	SynchronousMachines	1..*	SynchronousMachine	Synchronous machines using this curve.
0..1	EquivalentInjection	0..*	EquivalentInjection	The equivalent injection using this reactive capability curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.62 Switch

A generic device designed to close, or open, or both, one or more electric circuits. All switches are two terminal devices including grounding switches.

Table 305 shows all attributes of Switch.

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Table 305 – Attributes of Wires::Switch

name	mult	type	description
normalOpen	0..1	Boolean	The attribute is used in cases when no Measurement for the status value is present. If the Switch has a status measurement the Discrete.normalValue is expected to match with the Switch.normalOpen.
ratedCurrent	0..1	CurrentFlow	The maximum continuous current carrying capacity in amps governed by the device material and construction.
switchOnCount	0..1	Integer	The switch on count since the switch was last reset or initialized.
switchOnDate	0..1	DateTime	The date and time when the switch was last switched on.
retained	0..1	Boolean	Branch is retained in a bus branch model. The flow through retained switches will normally be calculated in power flow.
open	0..1	Boolean	The attribute tells if the switch is considered open when used as input to topology processing.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 306 shows all association ends of Switch with other classes.

Table 306 – Association ends of Wires::Switch with other classes

mult from	name	mult to	type	description
1..1	SwitchSchedules	0..*	SwitchSchedule	A Switch can be associated with SwitchSchedules.
1..1	SwitchPhase	0..*	SwitchPhase	The individual switch phases for the switch.
0..*	CompositeSwitch	0..1	CompositeSwitch	Composite switch to which this Switch belongs.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject

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mult from	name	mult to	type	description
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.63 StaticVarCompensator

A facility for providing variable and controllable shunt reactive power. The SVC typically consists of a stepdown transformer, filter, thyristor-controlled reactor, and thyristor-switched capacitor arms.

The SVC may operate in fixed MVar output mode or in voltage control mode. When in voltage control mode, the output of the SVC will be proportional to the deviation of voltage at the controlled bus from the voltage setpoint. The SVC characteristic slope defines the proportion. If the voltage at the controlled bus is equal to the voltage setpoint, the SVC MVar output is zero.

Table 307 shows all attributes of StaticVarCompensator.

Table 307 – Attributes of Wires::StaticVarCompensator

name	mult	type	description
capacitiveRating	0..1	Reactance	Maximum available capacitive reactance.
inductiveRating	0..1	Reactance	Maximum available inductive reactance.
slope	0..1	VoltagePerReactivePower	The characteristics slope of an SVC defines how the reactive power output changes in proportion to the difference between the regulated bus voltage and the voltage setpoint.
q	0..1	ReactivePower	Reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.
sVCControlMode	0..1	SVCControlMode	SVC control mode.
voltageSetPoint	0..1	Voltage	The reactive power output of the SVC is proportional to the difference between the voltage at the regulated bus and the voltage setpoint. When the regulated bus voltage is equal to the voltage setpoint, the reactive power output is zero.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 308 shows all association ends of StaticVarCompensator with other classes.

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Table 308 – Association ends of Wires::StaticVarCompensator with other classes

mult from	name	mult to	type	description
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.64 CoolantType enumeration

Method of cooling a machine.

Table 309 shows all literals of CoolantType.

Table 309 – Literals of Wires::CoolantType

literal	value	description
air		Air.
hydrogenGas		Hydrogen gas.
water		Water.

6.9.65 ProtectedSwitch

A ProtectedSwitch is a switching device that can be operated by ProtectionEquipment.

Table 310 shows all attributes of ProtectedSwitch.

Table 310 – Attributes of Wires::ProtectedSwitch

name	mult	type	description
breakingCapacity	0..1	CurrentFlow	The maximum fault current a breaking device can break safely under prescribed conditions of use.
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch

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name	mult	type	description
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 311 shows all association ends of ProtectedSwitch with other classes.

Table 311 – Association ends of Wires::ProtectedSwitch with other classes

mult from	name	mult to	type	description
0..*	OperatedByProtectionEquipment	0..*	ProtectionEquipment	Protection equipments that operate this ProtectedSwitch.
1..1	RecloseSequences	0..*	RecloseSequence	A breaker may have zero or more automatic reclosures after a trip occurs.
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.66 EnergyConsumer

Generic user of energy – a point of consumption on the power system model.

Table 312 shows all attributes of EnergyConsumer.

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Table 312 – Attributes of Wires::EnergyConsumer

name	mult	type	description
customerCount	0..1	Integer	Number of individual customers represented by this demand.
grounded	0..1	Boolean	Used for Yn and Zn connections. True if the neutral is solidly grounded.
pfixed	0..1	ActivePower	Active power of the load that is a fixed quantity. Load sign convention is used, i.e. positive sign means flow out from a node.
pfixedPct	0..1	PerCent	Fixed active power as a percentage of load group fixed active power. Load sign convention is used, i.e. positive sign means flow out from a node.
phaseConnection	0..1	PhaseShuntConnectionKind	The type of phase connection, such as wye or delta.
qfixed	0..1	ReactivePower	Reactive power of the load that is a fixed quantity. Load sign convention is used, i.e. positive sign means flow out from a node.
qfixedPct	0..1	PerCent	Fixed reactive power as a percentage of load group fixed reactive power. Load sign convention is used, i.e. positive sign means flow out from a node.
p	0..1	ActivePower	Active power of the load. Load sign convention is used, i.e. positive sign means flow out from a node For voltage dependent loads the value is at rated voltage. Starting value for a steady state solution.
q	0..1	ReactivePower	Reactive power of the load. Load sign convention is used, i.e. positive sign means flow out from a node. For voltage dependent loads the value is at rated voltage. Starting value for a steady state solution.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 313 shows all association ends of EnergyConsumer with other classes.

Table 313 – Association ends of Wires::EnergyConsumer with other classes

mult from	name	mult to	type	description
1..1	EnergyConsumerPhase	0..*	EnergyConsumerPhase	The individual phase models for this energy consumer.
0..*	LoadResponse	0..1	LoadResponseCharacteristic	The load response characteristic of this load. If missing, this load is assumed to be constant power.
1..*	PowerCutZone	0..1	PowerCutZone	The energy consumer is assigned to this power cut zone.

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mult from	name	mult to	type	description
0..*	LoadDynamics	0..1	LoadDynamics	Load dynamics model used to describe dynamic behavior of this energy consumer.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.67 Junction

A point where one or more conducting equipments are connected with zero resistance.

Table 314 shows all attributes of Junction.

Table 314 – Attributes of Wires::Junction

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 315 shows all association ends of Junction with other classes.

Table 315 – Association ends of Wires::Junction with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment

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mult from	name	mult to	type	description
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.68 PhaseTapChangerLinear

Describes a tap changer with a linear relation between the tap step and the phase angle difference across the transformer. This is a mathematical model that is an approximation of a real phase tap changer.

The phase angle is computed as stepPhaseShiftIncrement times the tap position.

The secondary side voltage magnitude is the same as at the primary side.

Table 316 shows all attributes of PhaseTapChangerLinear.

Table 316 – Attributes of Wires::PhaseTapChangerLinear

name	mult	type	description
stepPhaseShiftIncrement	0..1	AngleDegrees	Phase shift per step position. A positive value indicates a positive phase shift from the winding where the tap is located to the other winding (for a two-winding transformer). The actual phase shift increment might be more accurately computed from the symmetrical or asymmetrical models or a tap step table lookup if those are available.
xMax	0..1	Reactance	The reactance depends on the tap position according to a "u" shaped curve. The maximum reactance (xMax) appears at the low and high tap positions.
xMin	0..1	Reactance	The reactance depends on the tap position according to a "u" shaped curve. The minimum reactance (xMin) appears at the mid tap position.
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger

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name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 317 shows all association ends of PhaseTapChangerLinear with other classes.

Table 317 – Association ends of Wires::PhaseTapChangerLinear with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.69 Conductor

Combination of conducting material with consistent electrical characteristics, building a single electrical system, used to carry current between points in the power system.

Table 318 shows all attributes of Conductor.

Table 318 – Attributes of Wires::Conductor

name	mult	type	description
length	0..1	Length	Segment length for calculating line section capabilities
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 319 shows all association ends of Conductor with other classes.

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Table 319 – Association ends of Wires::Conductor with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.70 PerLengthImpedance

Common type for per-length impedance electrical catalogues.

Table 320 shows all attributes of PerLengthImpedance.

Table 320 – Attributes of Wires::PerLengthImpedance

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 321 shows all association ends of PerLengthImpedance with other classes.

Table 321 – Association ends of Wires::PerLengthImpedance with other classes

mult from	name	mult to	type	description
0..1	ACLineSegments	0..*	ACLineSegment	All line segments described by this per-length impedance.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.71 FrequencyConverter

A device to convert from one frequency to another (e.g. frequency F1 to F2) comprises a pair of FrequencyConverter instances. One converts from F1 to DC, the other converts the DC to F2.

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Table 322 shows all attributes of FrequencyConverter.

Table 322 – Attributes of Wires::FrequencyConverter

name	mult	type	description
frequency	0..1	Frequency	Frequency on the AC side.
maxP	0..1	ActivePower	The maximum active power on the DC side at which the frequence converter should operate.
maxU	0..1	Voltage	The maximum voltage on the DC side at which the frequency converter should operate.
minP	0..1	ActivePower	The minimum active power on the DC side at which the frequence converter should operate.
minU	0..1	Voltage	The minimum voltage on the DC side at which the frequency converter should operate.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 323 shows all association ends of FrequencyConverter with other classes.

Table 323 – Association ends of Wires::FrequencyConverter with other classes

mult from	name	mult to	type	description
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.72 Plant

A Plant is a collection of equipment for purposes of generation.

Table 324 shows all attributes of Plant.

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Table 324 – Attributes of Wires::Plant

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 325 shows all association ends of Plant with other classes.

Table 325 – Association ends of Wires::Plant with other classes

mult from	name	mult to	type	description
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.73 PhaseTapChangerTablePoint

Describes each tap step in the phase tap changer tabular curve.

Table 326 shows all attributes of PhaseTapChangerTablePoint.

Table 326 – Attributes of Wires::PhaseTapChangerTablePoint

name	mult	type	description
angle	0..1	AngleDegrees	The angle difference in degrees. A positive value indicates a positive phase shift from the winding where the tap is located to the other winding (for a two-winding transformer).
b	0..1	PerCent	inherited from: TapChangerTablePoint
g	0..1	PerCent	inherited from: TapChangerTablePoint
r	0..1	PerCent	inherited from: TapChangerTablePoint
ratio	0..1	Float	inherited from: TapChangerTablePoint
step	0..1	Integer	inherited from: TapChangerTablePoint
x	0..1	PerCent	inherited from: TapChangerTablePoint

Table 327 shows all association ends of PhaseTapChangerTablePoint with other classes.

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Table 327 – Association ends of Wires::PhaseTapChangerTablePoint with other classes

mult from	name	mult to	type	description
1..*	PhaseTapChangerTable	1..1	PhaseTapChangerTable	The table of this point.

6.9.74 LoadBreakSwitch

A mechanical switching device capable of making, carrying, and breaking currents under normal operating conditions.

Table 328 shows all attributes of LoadBreakSwitch.

Table 328 – Attributes of Wires::LoadBreakSwitch

name	mult	type	description
breakingCapacity	0..1	CurrentFlow	inherited from: ProtectedSwitch
normalOpen	0..1	Boolean	inherited from: Switch
ratedCurrent	0..1	CurrentFlow	inherited from: Switch
switchOnCount	0..1	Integer	inherited from: Switch
switchOnDate	0..1	DateTime	inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 329 shows all association ends of LoadBreakSwitch with other classes.

Table 329 – Association ends of Wires::LoadBreakSwitch with other classes

mult from	name	mult to	type	description
0..*	OperatedByProtectionEquipment	0..*	ProtectionEquipment	inherited from: ProtectedSwitch
1..1	RecloseSequences	0..*	RecloseSequence	inherited from: ProtectedSwitch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment

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mult from	name	mult to	type	description
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.75 PetersenCoilModeKind enumeration

The mode of operation for a Petersen coil.

Table 330 shows all literals of PetersenCoilModeKind.

Table 330 – Literals of Wires::PetersenCoilModeKind

literal	value	description
fixed		Fixed position.
manual		Manual positioning.
automaticPositioning		Automatic positioning.

6.9.76 SynchronousMachineKind enumeration

Synchronous machine type.

Table 331 shows all literals of SynchronousMachineKind.

Table 331 – Literals of Wires::SynchronousMachineKind

literal	value	description
generator		
condenser		
generatorOrCondenser		
motor		
generatorOrMotor		
motorOrCondenser		
generatorOrCondenserOrMotor		

6.9.77 Connector

A conductor, or group of conductors, with negligible impedance, that serve to connect other conducting equipment within a single substation and are modeled with a single logical terminal.

Table 332 shows all attributes of Connector.

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Table 332 – Attributes of Wires::Connector

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 333 shows all association ends of Connector with other classes.

Table 333 – Association ends of Wires::Connector with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.78 AsynchronousMachine

A rotating machine whose shaft rotates asynchronously with the electrical field. Also known as an induction machine with no external connection to the rotor windings, e.g squirrel-cage induction machine.

Table 334 shows all attributes of AsynchronousMachine.

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Table 334 – Attributes of Wires::AsynchronousMachine

name	mult	type	description
asynchronousMachineType	0..1	AsynchronousMachineKind	Indicates the type of Asynchronous Machine (motor or generator).
converterFedDrive	0..1	Boolean	Indicates whether the machine is a converter fed drive. Used for short circuit data exchange according to IEC 60909
efficiency	0..1	PerCent	Efficiency of the asynchronous machine at nominal operation as a percentage. Indicator for converter drive motors. Used for short circuit data exchange according to IEC 60909
iaIrRatio	0..1	Float	Ratio of locked-rotor current to the rated current of the motor (Ia/Ir). Used for short circuit data exchange according to IEC 60909
nominalFrequency	0..1	Frequency	Nameplate data indicates if the machine is 50 Hz or 60 Hz.
nominalSpeed	0..1	RotationSpeed	Nameplate data. Depends on the slip and number of pole pairs.
polePairNumber	0..1	Integer	Number of pole pairs of stator. Used for short circuit data exchange according to IEC 60909.
ratedMechanicalPower	0..1	ActivePower	Rated mechanical power (Pr in the IEC 60909-0). Used for short circuit data exchange according to IEC 60909
reversible	0..1	Boolean	Indicates for converter drive motors if the power can be reversible. Used for short circuit data exchange according to IEC 60909
rr1	0..1	Resistance	Damper 1 winding resistance.
rr2	0..1	Resistance	Damper 2 winding resistance.
rxLockedRotorRatio	0..1	Float	Locked rotor ratio (R/X). Used for short circuit data exchange according to IEC 60909
tpo	0..1	Seconds	Transient rotor time constant (greater than tppo).
tppo	0..1	Seconds	Sub-transient rotor time constant (greater than 0).
xlr1	0..1	Reactance	Damper 1 winding leakage reactance.
xlr2	0..1	Reactance	Damper 2 winding leakage reactance.
xm	0..1	Reactance	Magnetizing reactance.
xp	0..1	Reactance	Transient reactance (unsaturated) (greater than or equal to xpp).
xpp	0..1	Reactance	Sub-transient reactance (unsaturated) (greater than Xl).
xs	0..1	Reactance	Synchronous reactance (greater than xp).
ratedPowerFactor	0..1	Float	inherited from: RotatingMachine
p	0..1	ActivePower	inherited from: RotatingMachine
ratedS	0..1	ApparentPower	inherited from: RotatingMachine
q	0..1	ReactivePower	inherited from: RotatingMachine
ratedU	0..1	Voltage	inherited from: RotatingMachine
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 335 shows all association ends of AsynchronousMachine with other classes.

Table 335 – Association ends of Wires::AsynchronousMachine with other classes

mult from	name	mult to	type	description
1..1	AsynchronousMachineDynamics	0..1	AsynchronousMachineDynamics	Asynchronous machine dynamics model used to describe dynamic behavior of this asynchronous machine.
1..1	HydroPump	0..1	HydroPump	inherited from: RotatingMachine
1..*	GeneratingUnit	0..1	GeneratingUnit	inherited from: RotatingMachine
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.79 TapChanger

Mechanism for changing transformer winding tap positions.

Table 336 shows all attributes of TapChanger.

Table 336 – Attributes of Wires::TapChanger

name	mult	type	description
controlEnabled	0..1	Boolean	Specifies the regulation status of the equipment. True is regulating, false is not regulating.
highStep	0..1	Integer	Highest possible tap step position, advance from neutral. The attribute shall be greater than lowStep.
initialDelay	0..1	Seconds	For an LTC, the delay for initial tap changer operation (first step change)
lowStep	0..1	Integer	Lowest possible tap step position, retard from neutral
ltcFlag	0..1	Boolean	Specifies whether or not a TapChanger has load tap changing capabilities.
neutralStep	0..1	Integer	The neutral tap step position for this winding. The attribute shall be equal or greater than lowStep and equal or less than highStep.

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name	mult	type	description
neutralU	0..1	Voltage	Voltage at which the winding operates at the neutral tap setting.
normalStep	0..1	Integer	The tap step position used in "normal" network operation for this winding. For a "Fixed" tap changer indicates the current physical tap setting. The attribute shall be equal to or greater than lowStep and equal to or less than highStep.
subsequentDelay	0..1	Seconds	For an LTC, the delay for subsequent tap changer operation (second and later step changes)
step	0..1	Float	Tap changer position. Starting step for a steady state solution. Non integer values are allowed to support continuous tap variables. The reasons for continuous value are to support study cases where no discrete tap changer has yet been designed, a solution where a narrow voltage band forces the tap step to oscillate or accommodate for a continuous solution as input. The attribute shall be equal to or greater than lowStep and equal to or less than highStep.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 337 shows all association ends of TapChanger with other classes.

Table 337 – Association ends of Wires::TapChanger with other classes

mult from	name	mult to	type	description
0..*	TapChangerControl	0..1	TapChangerControl	The regulating control scheme in which this tap changer participates.
1..1	TapSchedules	0..*	TapSchedule	A TapChanger can have TapSchedules.
1..1	SvTapStep	0..1	SvTapStep	The tap step state associated with the tap changer.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.80 ShortCircuitRotorKind enumeration

Type of rotor, used by short circuit applications.

Table 338 shows all literals of ShortCircuitRotorKind.

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Table 338 – Literals of Wires::ShortCircuitRotorKind

literal	value	description
salientPole1		Salient pole 1 in the IEC 60909
salientPole2		Salient pole 2 in IEC 60909
turboSeries1		Turbo Series 1 in the IEC 60909
turboSeries2		Turbo series 2 in IEC 60909

6.9.81 WindingConnection enumeration

Winding connection type.

Table 339 shows all literals of WindingConnection.

Table 339 – Literals of Wires::WindingConnection

literal	value	description
D		Delta.
Y		Wye
Z		ZigZag
Yn		Wye, with neutral brought out for grounding.
Zn		ZigZag, with neutral brought out for grounding.
A		Autotransformer common winding
I		Independent winding, for single-phase connections.

6.9.82 ExternalNetworkInjection

This class represents the external network and it is used for IEC 60909 calculations.

Table 340 shows all attributes of ExternalNetworkInjection.

Table 340 – Attributes of Wires::ExternalNetworkInjection

name	mult	type	description
governorSCD	0..1	ActivePowerPerFrequency	Power Frequency Bias. This is the change in power injection divided by the change in frequency and negated. A positive value of the power frequency bias provides additional power injection upon a drop in frequency.
ikSecond	0..1	Boolean	Indicates whether initial symmetrical short-circuit current and power have been calculated according to IEC (Ik").
maxInitialSymShCCurrent	0..1	CurrentFlow	Maximum initial symmetrical short-circuit currents (Ik" max) in A (Ik" = Sk"/(SQRT(3) Un)). Used for short circuit data exchange according to IEC 60909
maxP	0..1	ActivePower	Maximum active power of the injection.
maxQ	0..1	ReactivePower	Not for short circuit modeling; It is used for modeling of infeed for load flow exchange. If maxQ and minQ are not used ReactiveCapabilityCurve can be used
maxR0ToX0Ratio	0..1	Float	Maximum ratio of zero sequence resistance of Network Feeder to its zero sequence reactance (R(0)/X(0) max). Used for short circuit data exchange according to IEC 60909

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name	mult	type	description
maxR1ToX1Ratio	0..1	Float	Maximum ratio of positive sequence resistance of Network Feeder to its positive sequence reactance (R(1)/X(1) max). Used for short circuit data exchange according to IEC 60909
maxZ0ToZ1Ratio	0..1	Float	Maximum ratio of zero sequence impedance to its positive sequence impedance (Z(0)/Z(1) max). Used for short circuit data exchange according to IEC 60909
minInitialSymShCCurrent	0..1	CurrentFlow	Minimum initial symmetrical short-circuit currents (Ik" min) in A (Ik" = Sk"/(SQRT(3) Un)). Used for short circuit data exchange according to IEC 60909
minP	0..1	ActivePower	Minimum active power of the injection.
minQ	0..1	ReactivePower	Not for short circuit modeling; It is used for modeling of infeed for load flow exchange. If maxQ and minQ are not used ReactiveCapabilityCurve can be used
minR0ToX0Ratio	0..1	Float	Indicates whether initial symmetrical short-circuit current and power have been calculated according to IEC (Ik"). Used for short circuit data exchange according to IEC 6090
minR1ToX1Ratio	0..1	Float	Minimum ratio of positive sequence resistance of Network Feeder to its positive sequence reactance (R(1)/X(1) min). Used for short circuit data exchange according to IEC 60909
minZ0ToZ1Ratio	0..1	Float	Minimum ratio of zero sequence impedance to its positive sequence impedance (Z(0)/Z(1) min). Used for short circuit data exchange according to IEC 60909
referencePriority	0..1	Integer	Priority of unit for use as powerflow voltage phase angle reference bus selection. 0 = don't care (default) 1 = highest priority. 2 is less than 1 and so on.
voltageFactor	0..1	PU	Voltage factor in pu, which was used to calculate short-circuit current Ik" and power Sk".
p	0..1	ActivePower	Active power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
q	0..1	ReactivePower	Reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 341 shows all association ends of ExternalNetworkInjection with other classes.

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Table 341 – Association ends of Wires::ExternalNetworkInjection with other classes

mult from	name	mult to	type	description
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.83 AsynchronousMachineKind enumeration

Kind of Asynchronous Machine.

Table 342 shows all literals of AsynchronousMachineKind.

Table 342 – Literals of Wires::AsynchronousMachineKind

literal	value	description
generator		The Asynchronous Machine is a generator.
motor		The Asynchronous Machine is a motor.

6.9.84 LinearShuntCompensator

A linear shunt compensator has banks or sections with equal admittance values.

Table 343 shows all attributes of LinearShuntCompensator.

Table 343 – Attributes of Wires::LinearShuntCompensator

name	mult	type	description
b0PerSection	0..1	Susceptance	Zero sequence shunt (charging) susceptance per section
bPerSection	0..1	Susceptance	Positive sequence shunt (charging) susceptance per section
g0PerSection	0..1	Conductance	Zero sequence shunt (charging) conductance per section
gPerSection	0..1	Conductance	Positive sequence shunt (charging) conductance per section
aVRDelay	0..1	Seconds	inherited from: ShuntCompensator

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name	mult	type	description
grounded	0..1	Boolean	inherited from: ShuntCompensator
maximumSections	0..1	Integer	inherited from: ShuntCompensator
nomU	0..1	Voltage	inherited from: ShuntCompensator
normalSections	0..1	Integer	inherited from: ShuntCompensator
phaseConnection	0..1	PhaseShuntConnectionKind	inherited from: ShuntCompensator
switchOnCount	0..1	Integer	inherited from: ShuntCompensator
switchOnDate	0..1	DateTime	inherited from: ShuntCompensator
voltageSensitivity	0..1	VoltagePerReactivePower	inherited from: ShuntCompensator
sections	0..1	Float	inherited from: ShuntCompensator
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 344 shows all association ends of LinearShuntCompensator with other classes.

Table 344 – Association ends of Wires::LinearShuntCompensator with other classes

mult from	name	mult to	type	description
1..1	ShuntCompensatorPhase	0..*	ShuntCompensatorPhase	inherited from: ShuntCompensator
1..1	SvShuntCompensatorSections	0..1	SvShuntCompensatorSections	inherited from: ShuntCompensator
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.85 NonlinearShuntCompensator

A non linear shunt compensator has bank or section admittance values that differ.

Table 345 shows all attributes of NonlinearShuntCompensator.

Table 345 – Attributes of Wires::NonlinearShuntCompensator

name	mult	type	description
aVRDelay	0..1	Seconds	inherited from: ShuntCompensator
grounded	0..1	Boolean	inherited from: ShuntCompensator
maximumSections	0..1	Integer	inherited from: ShuntCompensator
nomU	0..1	Voltage	inherited from: ShuntCompensator
normalSections	0..1	Integer	inherited from: ShuntCompensator
phaseConnection	0..1	PhaseShuntConnectionKind	inherited from: ShuntCompensator
switchOnCount	0..1	Integer	inherited from: ShuntCompensator
switchOnDate	0..1	DateTime	inherited from: ShuntCompensator
voltageSensitivity	0..1	VoltagePerReactivePower	inherited from: ShuntCompensator
sections	0..1	Float	inherited from: ShuntCompensator
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 346 shows all association ends of NonlinearShuntCompensator with other classes.

Table 346 – Association ends of Wires::NonlinearShuntCompensator with other classes

mult from	name	mult to	type	description
1..1	NonlinearShuntCompensatorPoints	1..*	NonlinearShuntCompensatorPoint	All points of the non-linear shunt compensator.
1..1	ShuntCompensatorPhase	0..*	ShuntCompensatorPhase	inherited from: ShuntCompensator
1..1	SvShuntCompensatorSections	0..1	SvShuntCompensatorSections	inherited from: ShuntCompensator
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment

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mult from	name	mult to	type	description
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.86 NonlinearShuntCompensatorPoint root class

A non linear shunt compensator bank or section admittance value.

Table 347 shows all attributes of NonlinearShuntCompensatorPoint.

Table 347 – Attributes of Wires::NonlinearShuntCompensatorPoint

name	mult	type	description
b	0..1	Susceptance	Positive sequence shunt (charging) susceptance per section
b0	0..1	Susceptance	Zero sequence shunt (charging) susceptance per section
g	0..1	Conductance	Positive sequence shunt (charging) conductance per section
g0	0..1	Conductance	Zero sequence shunt (charging) conductance per section
sectionNumber	0..1	Integer	The number of the section.

Table 348 shows all association ends of NonlinearShuntCompensatorPoint with other classes.

Table 348 – Association ends of Wires::NonlinearShuntCompensatorPoint with other classes

mult from	name	mult to	type	description
1..*	NonlinearShuntCompensator	1..1	NonlinearShuntCompensator	Non-linear shunt compensator owning this point.

6.9.87 LinearShuntCompensatorPhase

A per phase linear shunt compensator has banks or sections with equal admittance values.

Table 349 shows all attributes of LinearShuntCompensatorPhase.

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Table 349 – Attributes of Wires::LinearShuntCompensatorPhase

name	mult	type	description
bPerSection	0..1	Susceptance	Susceptance per section of the phase if shunt compensator is wye connected. Susceptance per section phase to phase if shunt compensator is delta connected.
gPerSection	0..1	Conductance	Conductance per section for this phase if shunt compensator is wye connected. Conductance per section phase to phase if shunt compensator is delta connected.
maximumSections	0..1	Integer	inherited from: ShuntCompensatorPhase
normalSections	0..1	Integer	inherited from: ShuntCompensatorPhase
phase	0..1	SinglePhaseKind	inherited from: ShuntCompensatorPhase
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 350 shows all association ends of LinearShuntCompensatorPhase with other classes.

Table 350 – Association ends of Wires::LinearShuntCompensatorPhase with other classes

mult from	name	mult to	type	description
0..*	ShuntCompensator	1..1	ShuntCompensator	inherited from: ShuntCompensatorPhase
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.88 NonlinearShuntCompensatorPhase

A per phase non linear shunt compensator has bank or section admittance values that differ.

Table 351 shows all attributes of NonlinearShuntCompensatorPhase.

Table 351 – Attributes of Wires::NonlinearShuntCompensatorPhase

name	mult	type	description
maximumSections	0..1	Integer	inherited from: ShuntCompensatorPhase
normalSections	0..1	Integer	inherited from: ShuntCompensatorPhase
phase	0..1	SinglePhaseKind	inherited from: ShuntCompensatorPhase
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 352 shows all association ends of NonlinearShuntCompensatorPhase with other classes.

Table 352 – Association ends of Wires::NonlinearShuntCompensatorPhase with other classes

mult from	name	mult to	type	description
1..1	NonlinearShuntCompensatorPhasePoints	1..*	NonlinearShuntCompensatorPhasePoint	All points of the non-linear shunt compensator phase.
0..*	ShuntCompensator	1..1	ShuntCompensator	inherited from: ShuntCompensatorPhase
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.89 NonlinearShuntCompensatorPhasePoint root class

A per phase non linear shunt compensator bank or section admittance value.

Table 353 shows all attributes of NonlinearShuntCompensatorPhasePoint.

Table 353 – Attributes of Wires::NonlinearShuntCompensatorPhasePoint

name	mult	type	description
b	0..1	Susceptance	Positive sequence shunt (charging) susceptance per section
g	0..1	Conductance	Positive sequence shunt (charging) conductance per section
sectionNumber	0..1	Integer	The number of the section.

Table 354 shows all association ends of NonlinearShuntCompensatorPhasePoint with other classes.

Table 354 – Association ends of Wires::NonlinearShuntCompensatorPhasePoint with other classes

mult from	name	mult to	type	description
1..*	NonlinearShuntCompensatorPhase	1..1	NonlinearShuntCompensatorPhase	Non-linear shunt compensator phase owning this point.

6.9.90 PerLengthLineParameter

Common type for per-length electrical catalogues describing line parameters.

Table 355 shows all attributes of PerLengthLineParameter.

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Table 355 – Attributes of Wires::PerLengthLineParameter

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 356 shows all association ends of PerLengthLineParameter with other classes.

Table 356 – Association ends of Wires::PerLengthLineParameter with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.9.91 TapChangerTablePoint root class

Table 357 shows all attributes of TapChangerTablePoint.

Table 357 – Attributes of Wires::TapChangerTablePoint

name	mult	type	description
b	0..1	PerCent	The magnetizing branch susceptance deviation as a percentage of nominal value. The actual susceptance is calculated as follows: calculated magnetizing susceptance = b(nominal) * (1 + b(from this class)/100). The b(nominal) is defined as the static magnetizing susceptance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.
g	0..1	PerCent	The magnetizing branch conductance deviation as a percentage of nominal value. The actual conductance is calculated as follows: calculated magnetizing conductance = g(nominal) * (1 + g(from this class)/100). The g(nominal) is defined as the static magnetizing conductance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.
r	0..1	PerCent	The resistance deviation as a percentage of nominal value. The actual reactance is calculated as follows: calculated resistance = r(nominal) * (1 + r(from this class)/100). The r(nominal) is defined as the static resistance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.
ratio	0..1	Float	The voltage ratio in per unit. Hence this is a value close to one.
step	0..1	Integer	The tap step.

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name	mult	type	description
x	0..1	PerCent	The series reactance deviation as a percentage of nominal value. The actual reactance is calculated as follows: calculated reactance = x(nominal) * (1 + x(from this class)/100). The x(nominal) is defined as the static series reactance on the associated power transformer end or ends. This model assumes the star impedance (pi model) form.

6.9.92 PhaseTapChangerTabular

Table 358 shows all attributes of PhaseTapChangerTabular.

Table 358 – Attributes of Wires::PhaseTapChangerTabular

name	mult	type	description
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger
initialDelay	0..1	Seconds	inherited from: TapChanger
lowStep	0..1	Integer	inherited from: TapChanger
ltcFlag	0..1	Boolean	inherited from: TapChanger
neutralStep	0..1	Integer	inherited from: TapChanger
neutralU	0..1	Voltage	inherited from: TapChanger
normalStep	0..1	Integer	inherited from: TapChanger
subsequentDelay	0..1	Seconds	inherited from: TapChanger
step	0..1	Float	inherited from: TapChanger
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 359 shows all association ends of PhaseTapChangerTabular with other classes.

Table 359 – Association ends of Wires::PhaseTapChangerTabular with other classes

mult from	name	mult to	type	description
0..*	PhaseTapChangerTable	0..1	PhaseTapChangerTable	The phase tap changer table for this phase tap changer.
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
0..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.9.93 PowerElectronicsConnection

A connection to the AC network for energy production or consumption that uses power electronics rather than rotating machines.

Table 360 shows all attributes of PowerElectronicsConnection.

Table 360 – Attributes of Wires::PowerElectronicsConnection

name	mult	type	description
maxQ	0..1	ReactivePower	Maximum reactive power limit. This is the maximum (nameplate) limit for the unit.
minQ	0..1	ReactivePower	Minimum reactive power limit for the unit. This is the minimum (nameplate) limit for the unit.
ratedS	0..1	ApparentPower	Nameplate apparent power rating for the unit. The attribute shall have a positive value.
ratedU	0..1	Voltage	Rated voltage (nameplate data, Ur in IEC 60909-0). It is primarily used for short circuit data exchange according to IEC 60909.
p	0..1	ActivePower	Active power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.
q	0..1	ReactivePower	Reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.
r	0..1	Resistance	Equivalent resistance (RG) of generator. RG is considered for the calculation of all currents, except for the calculation of the peak current ip. Used for short circuit data exchange according to IEC 60909.
r0	0..1	Resistance	Zero sequence resistance of the synchronous machine.
rn	0..1	Resistance	Negative sequence Thevenin resistance.
x	0..1	Reactance	Positive sequence Thevenin reactance.
x0	0..1	Reactance	Zero sequence Thevenin reactance.
xn	0..1	Reactance	Negative sequence Thevenin reactance.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 361 shows all association ends of PowerElectronicsConnection with other classes.

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Table 361 – Association ends of Wires::PowerElectronicsConnection with other classes

mult from	name	mult to	type	description
1..1	PowerElectronicsUnit	0..*	PowerElectronicsUnit	An AC network connection may have several power electronics units connecting through it.
1..1	WindTurbineType3or4Dynamics	0..1	WindTurbineType3or4Dynamics	The wind turbine type 3 or 4 dynamics model associated with this power electronics connection.
0..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10 Package Generation

6.10.1 General

This package contains packages that have information for Unit Commitment and Economic Dispatch of Hydro and Thermal Generating Units, Load Forecasting, Automatic Generation Control, and Unit Modeling for Dynamic Training Simulator.

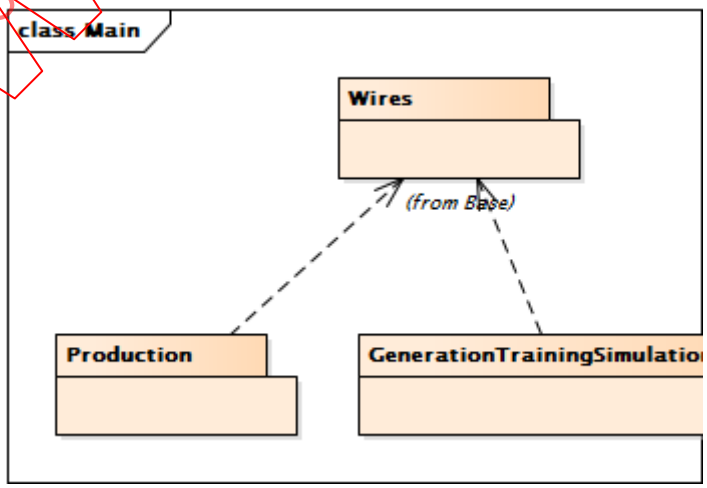


Figure 99 – Class diagram Generation::Main

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Figure 99: This diagram shows the main generation packages and their dependency relationships to other packages.

6.10.2 Package GenerationTrainingSimulation

6.10.2.1 General

The Generation Dynamics package contains prime movers, such as turbines and boilers, which are needed for simulation and educational purposes.

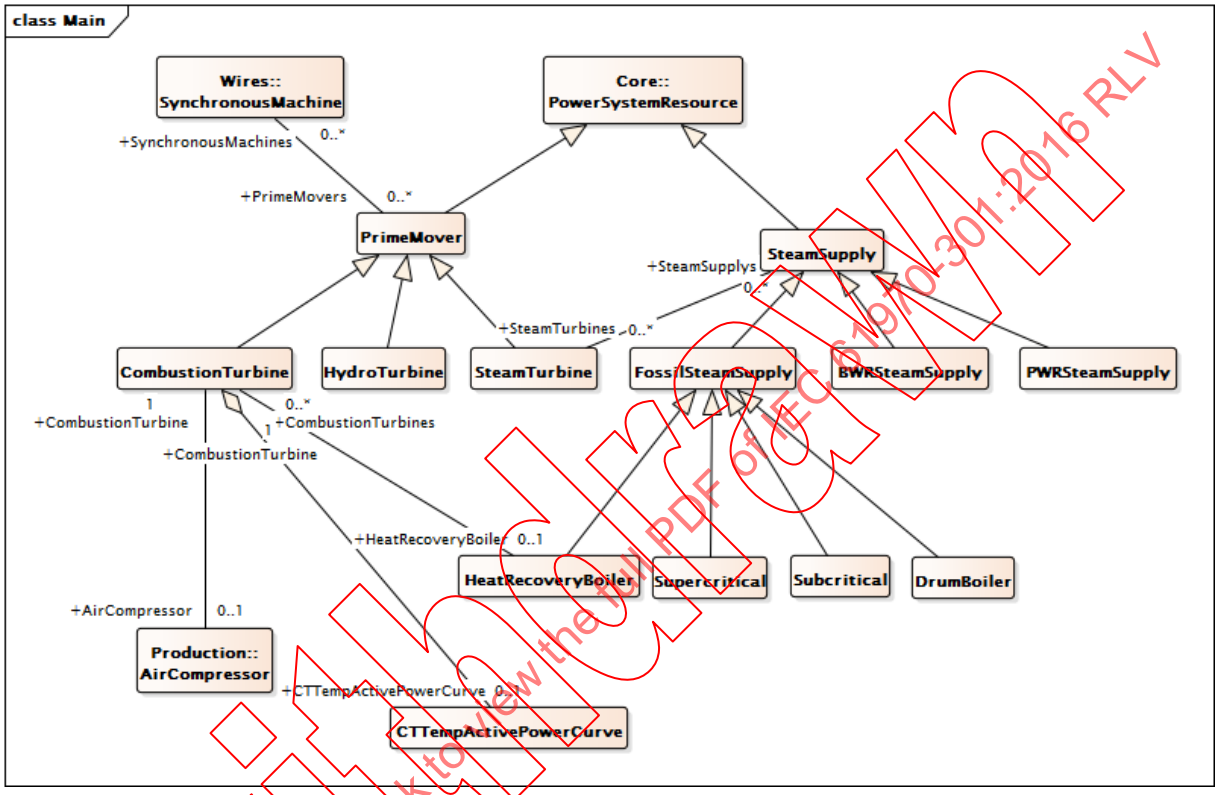


Figure 100 – Class diagram GenerationTrainingSimulation::Main

Figure 100: This diagram shows all classes included in the GenerationDynamics package as well as the key external classes that have associations with these classes.

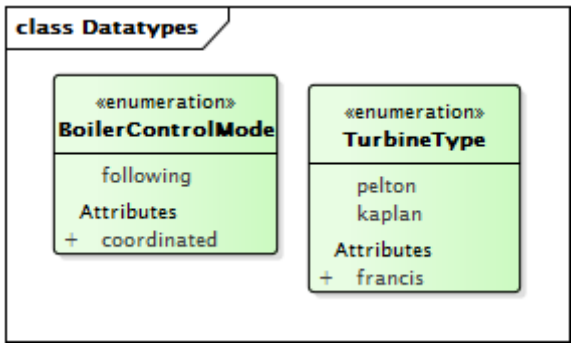


Figure 101 – Class diagram GenerationTrainingSimulation::Datatypes

Figure 101: This diagram shows the data types specific to the GenerationDynamics package.

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6.10.2.2 BWRSteamSupply

Boiling water reactor used as a steam supply to a steam turbine.

Table 362 shows all attributes of BWRSteamSupply.

Table 362 – Attributes of GenerationTrainingSimulation::BWRSteamSupply

name	mult	type	description
highPowerLimit	0..1	PU	High power limit.
inCoreThermalTC	0..1	Seconds	In-core thermal time constant.
integralGain	0..1	Float	Integral gain.
lowerLimit	0..1	PU	Initial lower limit.
lowPowerLimit	0..1	PU	Low power limit.
pressureLimit	0..1	PU	Pressure limit.
pressureSetpointGA	0..1	Float	Pressure setpoint gain adjuster.
pressureSetpointTC1	0..1	Seconds	Pressure setpoint time constant.
pressureSetpointTC2	0..1	Seconds	Pressure setpoint time constant.
proportionalGain	0..1	Float	Proportional gain.
rfAux1	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux2	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux3	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux4	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux5	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux6	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux7	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rfAux8	0..1	PU	Coefficient for modeling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.
rodPattern	0..1	PU	Rod pattern.
rodPatternConstant	0..1	Float	Constant associated with rod pattern.
upperLimit	0..1	PU	Initial upper limit.
steamSupplyRating	0..1	Float	inherited from: SteamSupply
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 363 shows all association ends of BWRSteamSupply with other classes.

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Table 363 – Association ends of GenerationTrainingSimulation::BWRSteamSupply with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.3 BoilerControlMode enumeration

Boiler control mode.

Table 364 shows all literals of BoilerControlMode.

Table 364 – Literals of GenerationTrainingSimulation::BoilerControlMode

literal	value	description
following		Following.
coordinated		Coordinated.

6.10.2.4 CTTempActivePowerCurve

Relationship between the combustion turbine's power output rating in gross active power (X-axis) and the ambient air temperature (Y-axis).

Table 365 shows all attributes of CTTempActivePowerCurve.

Table 365 – Attributes of GenerationTrainingSimulation::CTTempActivePowerCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 366 shows all association ends of CTTempActivePowerCurve with other classes.

Table 366 – Association ends of GenerationTrainingSimulation::CTTempActivePowerCurve with other classes

mult from	name	mult to	type	description
0..1	CombustionTurbine	1..1	CombustionTurbine	A combustion turbine may have an active power versus ambient temperature relationship.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.5 CombustionTurbine

A prime mover that is typically fueled by gas or light oil.

Table 367 shows all attributes of CombustionTurbine.

Table 367 – Attributes of GenerationTrainingSimulation::CombustionTurbine

name	mult	type	description
ambientTemp	0..1	Temperature	Default ambient temperature to be used in modeling applications.
auxPowerVersusFrequency	0..1	PU	Off-nominal frequency effect on turbine auxiliaries. Per unit reduction in auxiliary active power consumption versus per unit reduction in frequency (from rated frequency).
auxPowerVersusVoltage	0..1	PU	Off-nominal voltage effect on turbine auxiliaries. Per unit reduction in auxiliary active power consumption versus per unit reduction in auxiliary bus voltage (from a specified voltage level).
capabilityVersusFrequency	0..1	PU	Off-nominal frequency effect on turbine capability. Per unit reduction in unit active power capability versus per unit reduction in frequency (from rated frequency).
heatRecoveryFlag	0..1	Boolean	Flag that is set to true if the combustion turbine is associated with a heat recovery boiler.
powerVariationByTemp	0..1	PU	Per unit change in power per (versus) unit change in ambient temperature.
referenceTemp	0..1	Temperature	Reference temperature at which the output of the turbine was defined.
timeConstant	0..1	Seconds	The time constant for the turbine.
primeMoverRating	0..1	Float	inherited from: PrimeMover
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 368 shows all association ends of CombustionTurbine with other classes.

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Table 368 – Association ends of GenerationTrainingSimulation::CombustionTurbine with other classes

mult from	name	mult to	type	description
1..1	AirCompressor	0..1	AirCompressor	A CAES air compressor is driven by combustion turbine.
1..1	CTTempActivePowerCurve	0..1	CTTempActivePowerCurve	A combustion turbine may have an active power versus ambient temperature relationship.
0..*	HeatRecoveryBoiler	0..1	HeatRecoveryBoiler	A combustion turbine may have a heat recovery boiler for making steam.
0..*	SynchronousMachines	0..*	SynchronousMachine	inherited from: PrimeMover
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.6 DrumBoiler

Drum boiler.

Table 369 shows all attributes of DrumBoiler.

Table 369 – Attributes of GenerationTrainingSimulation::DrumBoiler

name	mult	type	description
drumBoilerRating	0..1	Float	Rating of drum boiler in steam units.
auxPowerVersusFrequency	0..1	PU	inherited from: FossilSteamSupply
auxPowerVersusVoltage	0..1	PU	inherited from: FossilSteamSupply
boilerControlMode	0..1	BoilerControlMode	inherited from: FossilSteamSupply
controlErrorBiasP	0..1	Float	inherited from: FossilSteamSupply
controlIC	0..1	Float	inherited from: FossilSteamSupply
controlPC	0..1	Float	inherited from: FossilSteamSupply
controlPEB	0..1	Float	inherited from: FossilSteamSupply
controlPED	0..1	PU	inherited from: FossilSteamSupply
controlTC	0..1	Float	inherited from: FossilSteamSupply
feedWaterIG	0..1	Float	inherited from: FossilSteamSupply
feedWaterPG	0..1	Float	inherited from: FossilSteamSupply
feedWaterTC	0..1	Seconds	inherited from: FossilSteamSupply
fuelDemandLimit	0..1	PU	inherited from: FossilSteamSupply
fuelSupplyDelay	0..1	Seconds	inherited from: FossilSteamSupply
fuelSupplyTC	0..1	Seconds	inherited from: FossilSteamSupply
maxErrorRateP	0..1	Float	inherited from: FossilSteamSupply
mechPowerSensorLag	0..1	Seconds	inherited from: FossilSteamSupply
minErrorRateP	0..1	Float	inherited from: FossilSteamSupply

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name	mult	type	description
pressureCtrlDG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlIG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlPG	0..1	Float	inherited from: FossilSteamSupply
pressureFeedback	0..1	Integer	inherited from: FossilSteamSupply
superHeater1Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeater2Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeaterPipePD	0..1	Float	inherited from: FossilSteamSupply
throttlePressureSP	0..1	PU	inherited from: FossilSteamSupply
steamSupplyRating	0..1	Float	inherited from: SteamSupply
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 370 shows all association ends of DrumBoiler with other classes.

Table 370 – Association ends of GenerationTrainingSimulation::DrumBoiler with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.7 FossilSteamSupply

Fossil fueled boiler (e.g. coal, oil, gas).

Table 371 shows all attributes of FossilSteamSupply.

Table 371 – Attributes of GenerationTrainingSimulation::FossilSteamSupply

name	mult	type	description
auxPowerVersusFrequency	0..1	PU	Off nominal frequency effect on auxiliary real power. Per unit active power variation versus per unit frequency variation.
auxPowerVersusVoltage	0..1	PU	Off nominal voltage effect on auxiliary real power. Per unit active power variation versus per unit voltage variation.
boilerControlMode	0..1	BoilerControlMode	The control mode of the boiler.
controlErrorBiasP	0..1	Float	Active power error bias ratio.
controlIC	0..1	Float	Integral constant.
controlPC	0..1	Float	Proportional constant.

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name	mult	type	description
controlPEB	0..1	Float	Pressure error bias ratio.
controlPED	0..1	PU	Pressure error deadband.
controlTC	0..1	Float	Time constant.
feedWaterIG	0..1	Float	Feedwater integral gain ratio.
feedWaterPG	0..1	Float	Feedwater proportional gain ratio.
feedWaterTC	0..1	Seconds	Feedwater time constant rato.
fuelDemandLimit	0..1	PU	Fuel demand limit.
fuelSupplyDelay	0..1	Seconds	Fuel delay.
fuelSupplyTC	0..1	Seconds	Fuel supply time constant.
maxErrorRateP	0..1	Float	Active power maximum error rate limit.
mechPowerSensorLag	0..1	Seconds	Mechanical power sensor lag.
minErrorRateP	0..1	Float	Active power minimum error rate limit.
pressureCtrlDG	0..1	Float	Pressure control derivative gain ratio.
pressureCtrlIG	0..1	Float	Pressure control integral gain ratio.
pressureCtrlPG	0..1	Float	Pressure control proportional gain ratio.
pressureFeedback	0..1	Integer	Pressure feedback indicator.
superHeater1Capacity	0..1	Float	Drum/primary superheater capacity.
superHeater2Capacity	0..1	Float	Secondary superheater capacity.
superHeaterPipePD	0..1	Float	Superheater pipe pressure drop constant.
throttlePressureSP	0..1	PU	Throttle pressure setpoint.
steamSupplyRating	0..1	Float	inherited from: SteamSupply
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 372 shows all association ends of FossilSteamSupply with other classes.

Table 372 – Association ends of GenerationTrainingSimulation::FossilSteamSupply with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.10.2.8 HeatRecoveryBoiler

The heat recovery system associated with combustion turbines in order to produce steam for combined cycle plants.

Table 373 shows all attributes of HeatRecoveryBoiler.

Table 373 – Attributes of GenerationTrainingSimulation::HeatRecoveryBoiler

name	mult	type	description
steamSupplyRating2	0..1	Float	The steam supply rating in kilopounds per hour, if dual pressure boiler.
auxPowerVersusFrequency	0..1	PU	inherited from: FossilSteamSupply
auxPowerVersusVoltage	0..1	PU	inherited from: FossilSteamSupply
boilerControlMode	0..1	BoilerControlMode	inherited from: FossilSteamSupply
controlErrorBiasP	0..1	Float	inherited from: FossilSteamSupply
controlIC	0..1	Float	inherited from: FossilSteamSupply
controlPC	0..1	Float	inherited from: FossilSteamSupply
controlPEB	0..1	Float	inherited from: FossilSteamSupply
controlPED	0..1	PU	inherited from: FossilSteamSupply
controlTC	0..1	Float	inherited from: FossilSteamSupply
feedWaterIG	0..1	Float	inherited from: FossilSteamSupply
feedWaterPG	0..1	Float	inherited from: FossilSteamSupply
feedWaterTC	0..1	Seconds	inherited from: FossilSteamSupply
fuelDemandLimit	0..1	PU	inherited from: FossilSteamSupply
fuelSupplyDelay	0..1	Seconds	inherited from: FossilSteamSupply
fuelSupplyTC	0..1	Seconds	inherited from: FossilSteamSupply
maxErrorRateP	0..1	Float	inherited from: FossilSteamSupply
mechPowerSensorLag	0..1	Seconds	inherited from: FossilSteamSupply
minErrorRateP	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlDG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlIG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlPG	0..1	Float	inherited from: FossilSteamSupply
pressureFeedback	0..1	Integer	inherited from: FossilSteamSupply
superHeater1Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeater2Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeaterPipePD	0..1	Float	inherited from: FossilSteamSupply
throttlePressureSP	0..1	PU	inherited from: FossilSteamSupply
steamSupplyRating	0..1	Float	inherited from: SteamSupply
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 374 shows all association ends of HeatRecoveryBoiler with other classes.

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Table 374 – Association ends of GenerationTrainingSimulation::HeatRecoveryBoiler with other classes

mult from	name	mult to	type	description
0..1	CombustionTurbines	0..*	CombustionTurbine	A combustion turbine may have a heat recovery boiler for making steam.
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.9 HydroTurbine

A water driven prime mover. Typical turbine types are: Francis, Kaplan, and Pelton.

Table 375 shows all attributes of HydroTurbine.

Table 375 – Attributes of GenerationTrainingSimulation::HydroTurbine

name	mult	type	description
gateRateLimit	0..1	Float	Gate rate limit.
gateUpperLimit	0..1	PU	Gate upper limit.
maxHeadMaxP	0..1	ActivePower	Maximum efficiency active power at maximum head conditions.
minHeadMaxP	0..1	ActivePower	Maximum efficiency active power at minimum head conditions.
speedRating	0..1	RotationSpeed	Rated speed in number of revolutions.
speedRegulation	0..1	PU	Speed regulation.
transientDroopTime	0..1	Seconds	Transient droop time constant.
transientRegulation	0..1	PU	Transient regulation.
turbineRating	0..1	ActivePower	Rated turbine active power.
turbineType	0..1	TurbineType	Type of turbine.
waterStartingTime	0..1	Seconds	Water starting time.
primeMoverRating	0..1	Float	inherited from: PrimeMover
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 376 shows all association ends of HydroTurbine with other classes.

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Table 376 – Association ends of GenerationTrainingSimulation::HydroTurbine with other classes

mult from	name	mult to	type	description
0..*	SynchronousMachines	0..*	SynchronousMachine	inherited from: PrimeMover
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.10 PWRSteamSupply

Pressurized water reactor used as a steam supply to a steam turbine.

Table 377 shows all attributes of PWRSteamSupply.

Table 377 – Attributes of GenerationTrainingSimulation::PWRSteamSupply

name	mult	type	description
coldLegFBLagTC	0..1	PU	Cold leg feedback lag time constant.
coldLegFBLeadTC1	0..1	PU	Cold leg feedback lead time constant.
coldLegFBLeadTC2	0..1	PU	Cold leg feedback lead time constant.
coldLegFG1	0..1	PU	Cold leg feedback gain 1.
coldLegFG2	0..1	PU	Cold leg feedback gain 2.
coldLegLagTC	0..1	PU	Cold leg lag time constant.
coreHTLagTC1	0..1	PU	Core heat transfer lag time constant.
coreHTLagTC2	0..1	PU	Core heat transfer lag time constant.
coreNeutronicsEffTC	0..1	PU	Core neutronics effective time constant.
coreNeutronicsHT	0..1	PU	Core neutronics and heat transfer.
feedbackFactor	0..1	PU	Feedback factor.
hotLegLagTC	0..1	PU	Hot leg lag time constant.
hotLegSteamGain	0..1	PU	Hot leg steam gain.
hotLegToColdLegGain	0..1	PU	Hot leg to cold leg gain.
pressureCG	0..1	PU	Pressure control gain.
steamFlowFG	0..1	PU	Steam flow feedback gain.
steamPressureDropLagTC	0..1	PU	Steam pressure drop lag time constant.
steamPressureFG	0..1	PU	Steam pressure feedback gain.
throttlePressureFactor	0..1	PU	Throttle pressure factor.
throttlePressureSP	0..1	PU	Throttle pressure setpoint.
steamSupplyRating	0..1	Float	inherited from: SteamSupply
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 378 shows all association ends of PWRSteamSupply with other classes.

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Table 378 – Association ends of GenerationTrainingSimulation::PWRSteamSupply with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.11 PrimeMover

The machine used to develop mechanical energy used to drive a generator.

Table 379 shows all attributes of PrimeMover.

Table 379 – Attributes of GenerationTrainingSimulation::PrimeMover

name	mult	type	description
primeMoverRating	0..1	Float	Rating of prime mover.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 380 shows all association ends of PrimeMover with other classes.

Table 380 – Association ends of GenerationTrainingSimulation::PrimeMover with other classes

mult from	name	mult to	type	description
0..*	SynchronousMachines	0..*	SynchronousMachine	Synchronous machines this Prime mover drives.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.12 SteamSupply

Steam supply for steam turbine.

Table 381 shows all attributes of SteamSupply.

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Table 381 – Attributes of GenerationTrainingSimulation::SteamSupply

name	mult	type	description
steamSupplyRating	0..1	Float	Rating of steam supply.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 382 shows all association ends of SteamSupply with other classes.

Table 382 – Association ends of GenerationTrainingSimulation::SteamSupply with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	Steam turbines may have steam supplied by a steam supply.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.13 SteamTurbine

Steam turbine.

Table 383 shows all attributes of SteamTurbine.

Table 383 – Attributes of GenerationTrainingSimulation::SteamTurbine

name	mult	type	description
crossoverTC	0..1	Seconds	Crossover time constant.
reheater1TC	0..1	Seconds	First reheater time constant.
reheater2TC	0..1	Seconds	Second reheater time constant.
shaft1PowerHP	0..1	Float	Fraction of power from shaft 1 high pressure turbine output.
shaft1PowerIP	0..1	Float	Fraction of power from shaft 1 intermediate pressure turbine output.
shaft1PowerLP1	0..1	Float	Fraction of power from shaft 1 first low pressure turbine output.
shaft1PowerLP2	0..1	Float	Fraction of power from shaft 1 second low pressure turbine output.
shaft2PowerHP	0..1	Float	Fraction of power from shaft 2 high pressure turbine output.
shaft2PowerIP	0..1	Float	Fraction of power from shaft 2 intermediate pressure turbine output.
shaft2PowerLP1	0..1	Float	Fraction of power from shaft 2 first low pressure turbine output.

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name	mult	type	description
shaft2PowerLP2	0..1	Float	Fraction of power from shaft 2 second low pressure turbine output.
steamChestTC	0..1	Seconds	Steam chest time constant.
primeMoverRating	0..1	Float	inherited from: PrimeMover
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 384 shows all association ends of SteamTurbine with other classes.

Table 384 – Association ends of GenerationTrainingSimulation::SteamTurbine with other classes

mult from	name	mult to	type	description
0..*	SteamSupplys	0..*	SteamSupply	Steam turbines may have steam supplied by a steam supply.
0..*	SynchronousMachines	0..*	SynchronousMachine	inherited from: PrimeMover
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.14 Subcritical

Once-through subcritical boiler.

Table 385 shows all attributes of Subcritical.

Table 385 – Attributes of GenerationTrainingSimulation::Subcritical

name	mult	type	description
auxPowerVersusFrequency	0..1	PU	inherited from: FossilSteamSupply
auxPowerVersusVoltage	0..1	PU	inherited from: FossilSteamSupply
boilerControlMode	0..1	BoilerControlMode	inherited from: FossilSteamSupply
controlErrorBiasP	0..1	Float	inherited from: FossilSteamSupply
controlIC	0..1	Float	inherited from: FossilSteamSupply
controlPC	0..1	Float	inherited from: FossilSteamSupply
controlPEB	0..1	Float	inherited from: FossilSteamSupply
controlPED	0..1	PU	inherited from: FossilSteamSupply
controlTC	0..1	Float	inherited from: FossilSteamSupply
feedWaterIG	0..1	Float	inherited from: FossilSteamSupply
feedWaterPG	0..1	Float	inherited from: FossilSteamSupply
feedWaterTC	0..1	Seconds	inherited from: FossilSteamSupply

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name	mult	type	description
fuelDemandLimit	0..1	PU	inherited from: FossilSteamSupply
fuelSupplyDelay	0..1	Seconds	inherited from: FossilSteamSupply
fuelSupplyTC	0..1	Seconds	inherited from: FossilSteamSupply
maxErrorRateP	0..1	Float	inherited from: FossilSteamSupply
mechPowerSensorLag	0..1	Seconds	inherited from: FossilSteamSupply
minErrorRateP	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlDG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlIG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlPG	0..1	Float	inherited from: FossilSteamSupply
pressureFeedback	0..1	Integer	inherited from: FossilSteamSupply
superHeater1Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeater2Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeaterPipePD	0..1	Float	inherited from: FossilSteamSupply
throttlePressureSP	0..1	PU	inherited from: FossilSteamSupply
steamSupplyRating	0..1	Float	inherited from: SteamSupply
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 386 shows all association ends of Subcritical with other classes.

Table 386 – Association ends of GenerationTrainingSimulation::Subcritical with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.10.2.15 Supercritical

Once-through supercritical boiler.

Table 387 shows all attributes of Supercritical.

Table 387 – Attributes of GenerationTrainingSimulation::Supercritical

name	mult	type	description
auxPowerVersusFrequency	0..1	PU	inherited from: FossilSteamSupply
auxPowerVersusVoltage	0..1	PU	inherited from: FossilSteamSupply
boilerControlMode	0..1	BoilerControlMode	inherited from: FossilSteamSupply
controlErrorBiasP	0..1	Float	inherited from: FossilSteamSupply
controlIC	0..1	Float	inherited from: FossilSteamSupply
controlPC	0..1	Float	inherited from: FossilSteamSupply
controlPEB	0..1	Float	inherited from: FossilSteamSupply
controlPED	0..1	PU	inherited from: FossilSteamSupply
controlTC	0..1	Float	inherited from: FossilSteamSupply
feedWaterIG	0..1	Float	inherited from: FossilSteamSupply
feedWaterPG	0..1	Float	inherited from: FossilSteamSupply
feedWaterTC	0..1	Seconds	inherited from: FossilSteamSupply
fuelDemandLimit	0..1	PU	inherited from: FossilSteamSupply
fuelSupplyDelay	0..1	Seconds	inherited from: FossilSteamSupply
fuelSupplyTC	0..1	Seconds	inherited from: FossilSteamSupply
maxErrorRateP	0..1	Float	inherited from: FossilSteamSupply
mechPowerSensorLag	0..1	Seconds	inherited from: FossilSteamSupply
minErrorRateP	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlDG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlIG	0..1	Float	inherited from: FossilSteamSupply
pressureCtrlPG	0..1	Float	inherited from: FossilSteamSupply
pressureFeedback	0..1	Integer	inherited from: FossilSteamSupply
superHeater1Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeater2Capacity	0..1	Float	inherited from: FossilSteamSupply
superHeaterPipePD	0..1	Float	inherited from: FossilSteamSupply
throttlePressureSP	0..1	PU	inherited from: FossilSteamSupply
steamSupplyRating	0..1	Float	inherited from: SteamSupply
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 388 shows all association ends of Supercritical with other classes.

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Table 388 – Association ends of GenerationTrainingSimulation::Supercritical with other classes

mult from	name	mult to	type	description
0..*	SteamTurbines	0..*	SteamTurbine	inherited from: SteamSupply
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.2.16 TurbineType enumeration

Type of turbine.

Table 389 shows all literals of TurbineType.

Table 389 – Literals of GenerationTrainingSimulation::TurbineType

literal	value	description
francis		Francis.
pelton		Pelton.
kaplan		Kaplan.

6.10.3 Package Production

6.10.3.1 General

The production package is responsible for classes which describe various kinds of generators. These classes also provide production costing information which is used to economically allocate demand among committed units and calculate reserve quantities.

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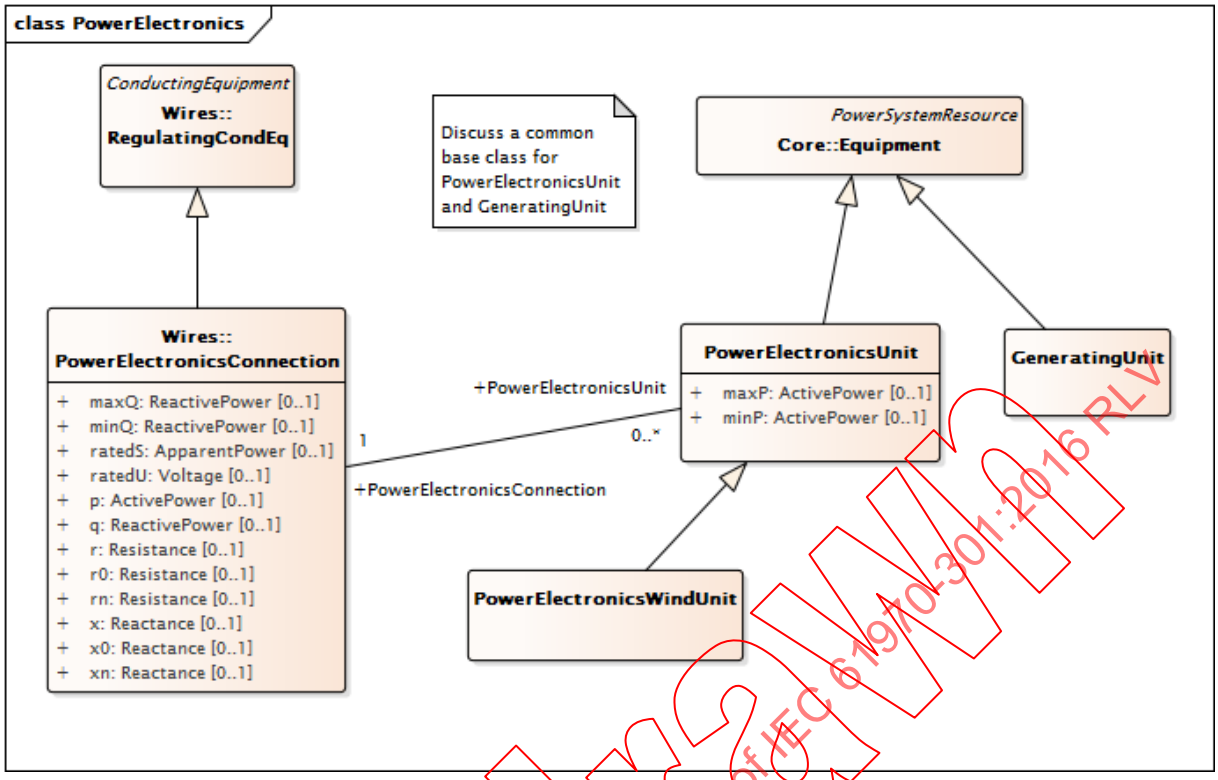


Figure 102 – Class diagram Production::PowerElectronics

Figure 102:

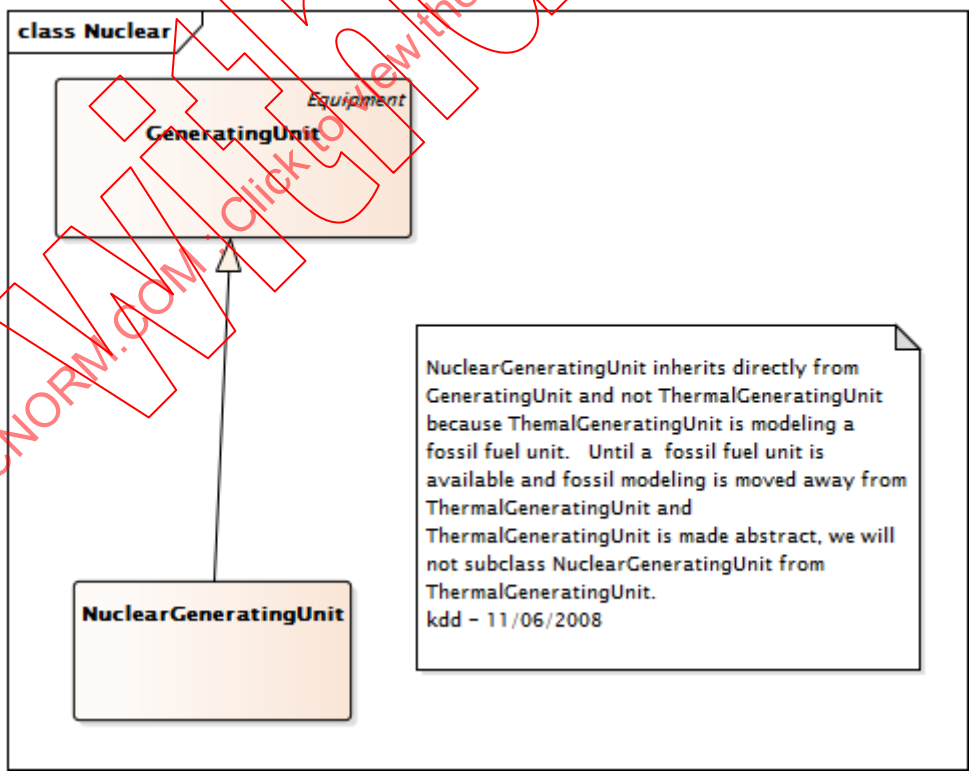


Figure 103 – Class diagram Production::Nuclear

Figure 103: This diagram shows nuclear generation inheritance.

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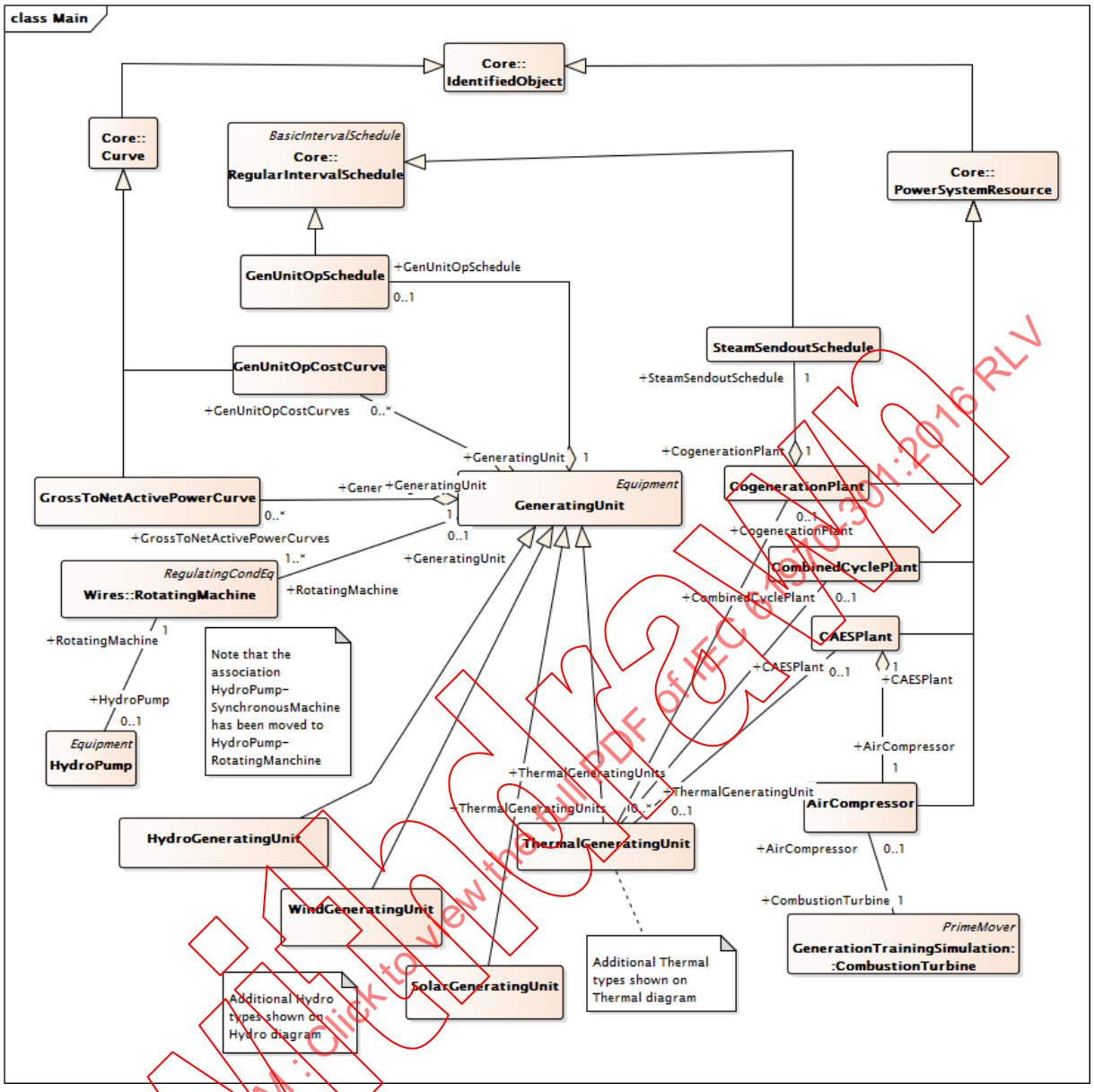
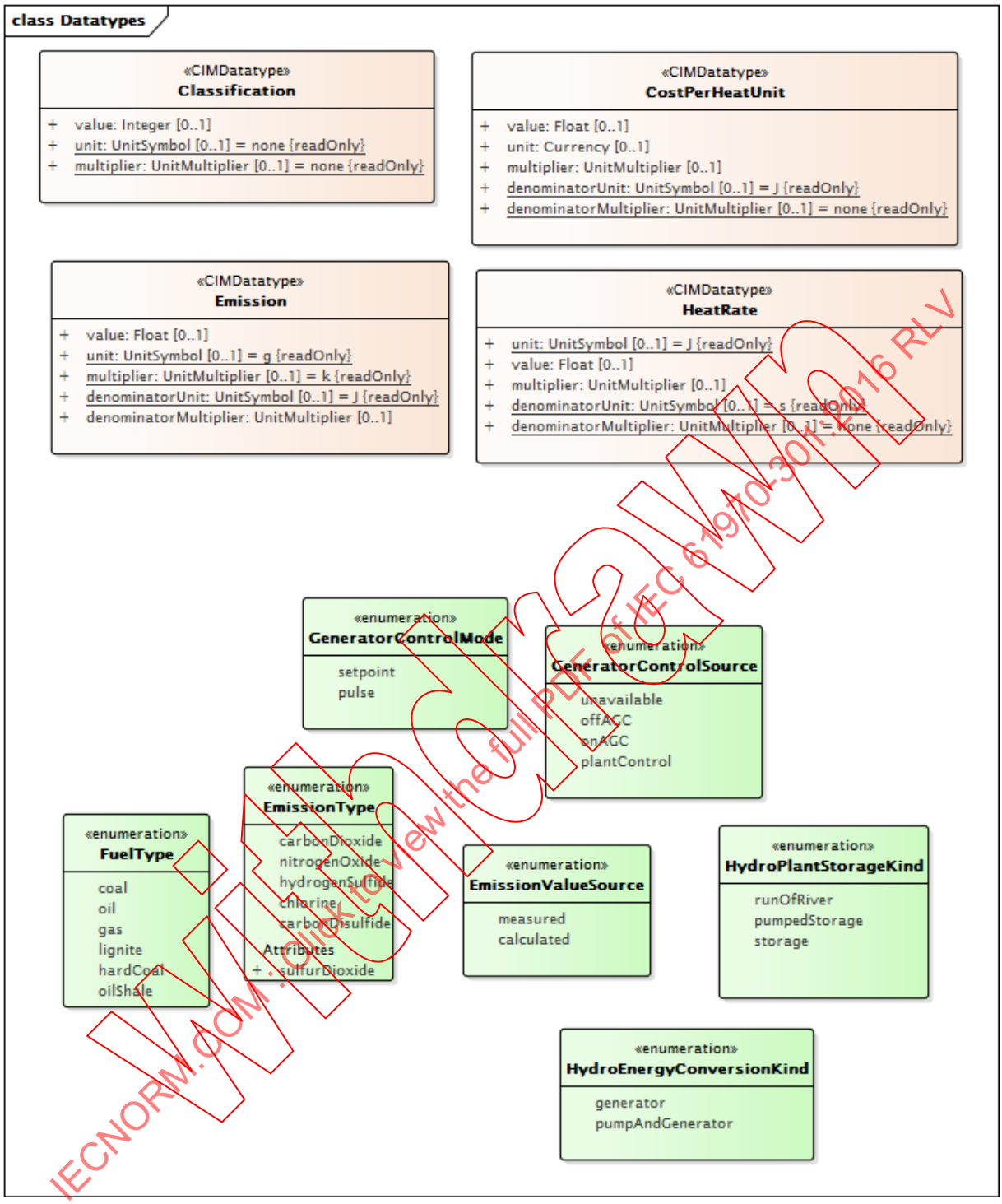


Figure 104 – Class diagram Production::Main

Figure 104: This diagram shows all classes included in the Production package that are needed by both Hydro and Thermal generation. It also shows key external classes that have associations with Production classes.

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Figure 105 – Class diagram Production::Datatypes

Figure 105: This diagram show the data types specific to the Production package.

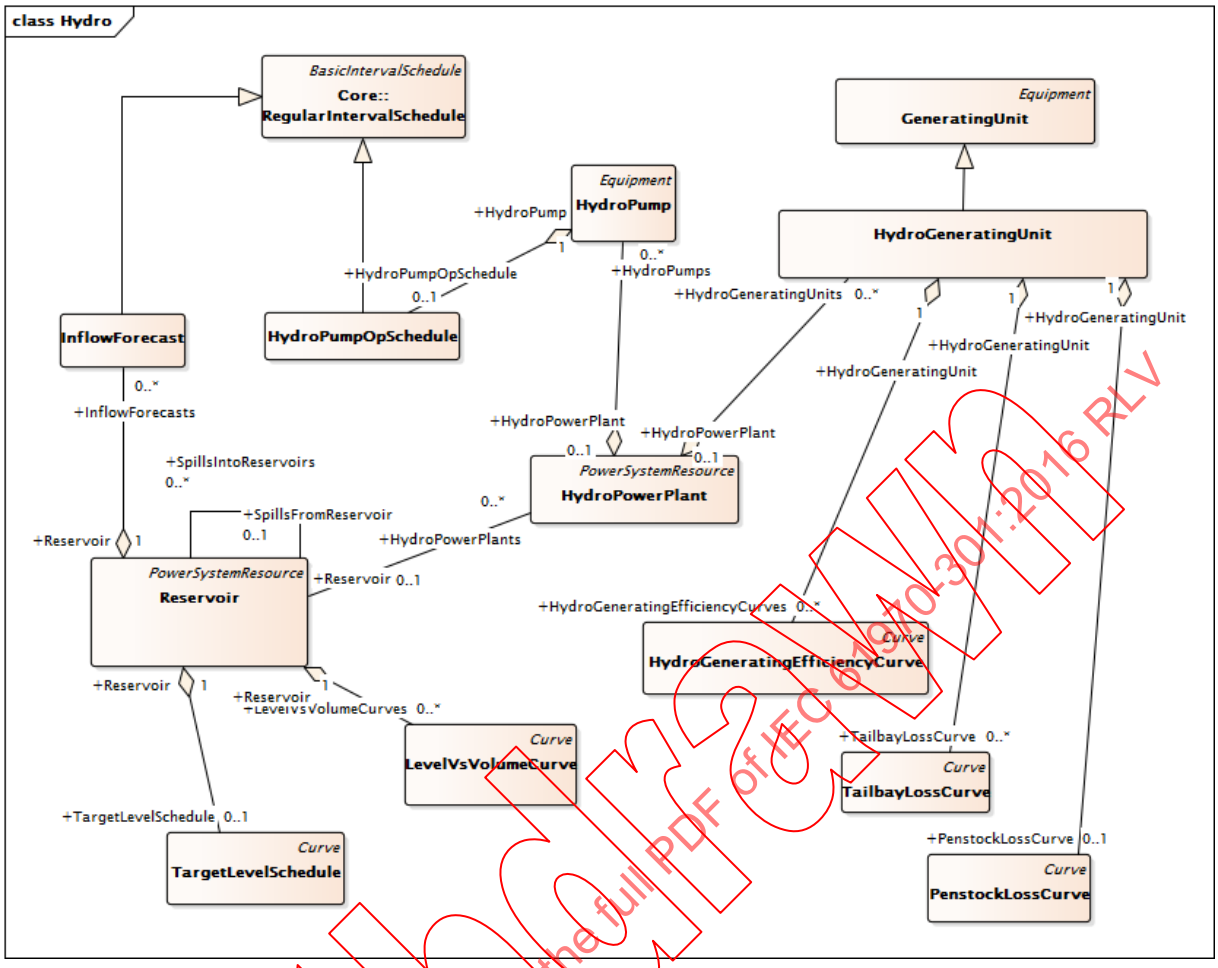


Figure 106 – Class diagram Production::Hydro

Figure 106: This diagram shows all classes included in the Hydro package as well as the key external classes that have associations with Hydro classes.

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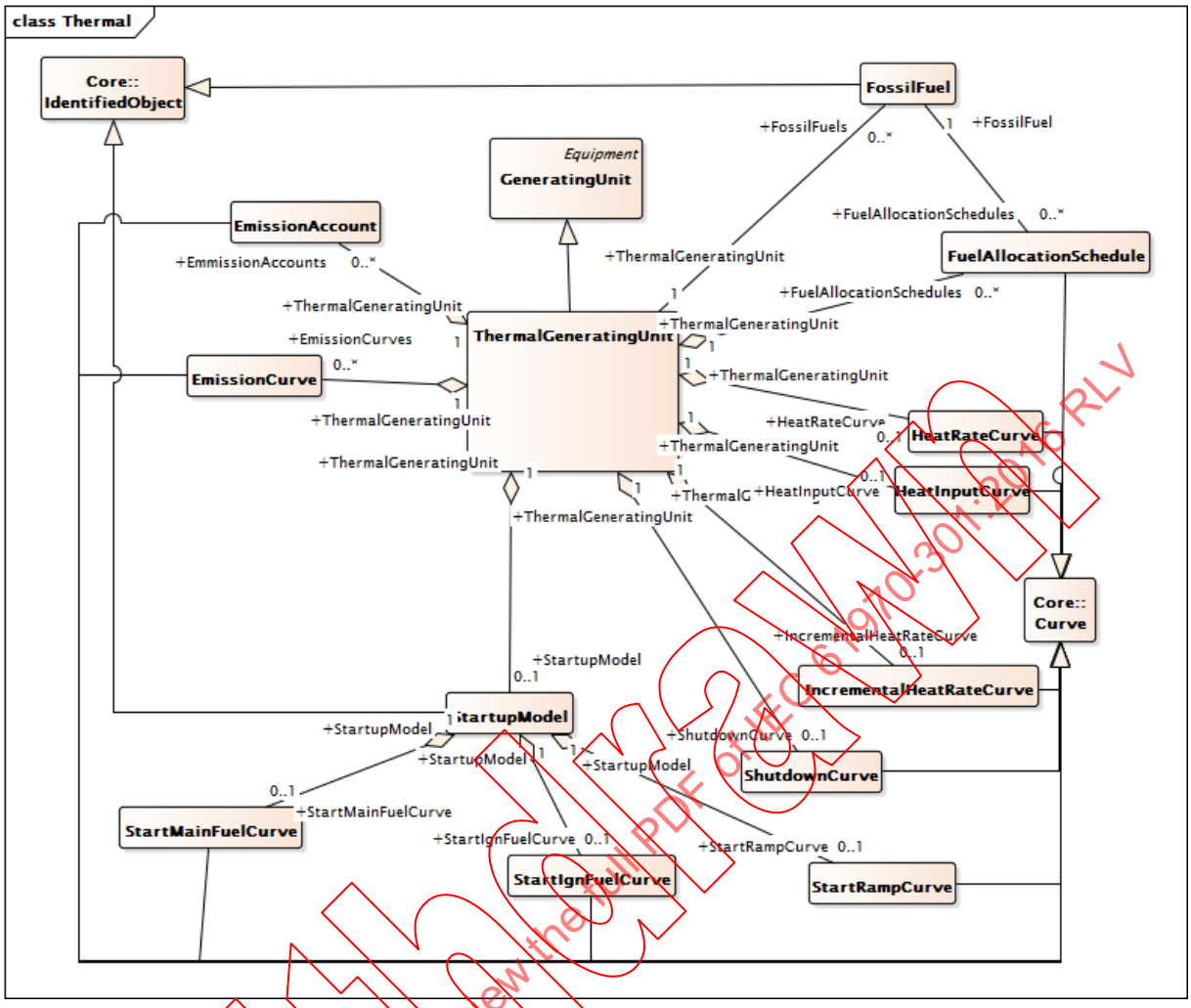


Figure 107 – Class diagram Production::Thermal

Figure 107: This diagram shows all classes included in the Thermal package as well as the key external classes that have associations with Thermal classes.

6.10.3.2 TargetLevelSchedule

Reservoir water level targets from advanced studies or "rule curves". Typically in one hour increments for up to 10 days.

Table 390 shows all attributes of TargetLevelSchedule.

Table 390 – Attributes of Production::TargetLevelSchedule

name	mult	type	description
highLevelLimit	0..1	WaterLevel	High target level limit, above which the reservoir operation will be penalized.
lowLevelLimit	0..1	WaterLevel	Low target level limit, below which the reservoir operation will be penalized.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve

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name	mult	type	description
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 391 shows all association ends of TargetLevelSchedule with other classes.

Table 391 – Association ends of Production::TargetLevelSchedule with other classes

mult from	name	mult to	type	description
0..1	Reservoir	1..1	Reservoir	A reservoir may have a water level target schedule.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.3 PenstockLossCurve

Relationship between penstock head loss (in metres) and total discharge through the penstock (in cubic metres per second). One or more turbines may be connected to the same penstock.

Table 392 shows all attributes of PenstockLossCurve.

Table 392 – Attributes of Production::PenstockLossCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 393 shows all association ends of PenstockLossCurve with other classes.

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Table 393 – Association ends of Production::PenstockLossCurve with other classes

mult from	name	mult to	type	description
0..1	HydroGeneratingUnit	1..1	HydroGeneratingUnit	A hydro generating unit has a penstock loss curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.4 HydroGeneratingUnit

A generating unit whose prime mover is a hydraulic turbine (e.g. Francis, Pelton, Kaplan).

Table 394 shows all attributes of HydroGeneratingUnit.

Table 394 – Attributes of Production::HydroGeneratingUnit

name	mult	type	description
energyConversionCapability	0..1	HydroEnergyConversionKind	Energy conversion capability for generating.
hydroUnitWaterCost	0..1	CostPerVolume	The equivalent cost of water that drives the hydro turbine.
allocSpinResP	0..1	ActivePower	inherited from: GeneratingUnit
autoCntrlMarginP	0..1	ActivePower	inherited from: GeneratingUnit
baseP	0..1	ActivePower	inherited from: GeneratingUnit
controlDeadband	0..1	ActivePower	inherited from: GeneratingUnit
controlPulseHigh	0..1	Seconds	inherited from: GeneratingUnit
controlPulseLow	0..1	Seconds	inherited from: GeneratingUnit
controlResponseRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
efficiency	0..1	PerCent	inherited from: GeneratingUnit
genControlMode	0..1	GeneratorControlMode	inherited from: GeneratingUnit
genControlSource	0..1	GeneratorControlSource	inherited from: GeneratingUnit
governorMPL	0..1	PU	inherited from: GeneratingUnit
governorSCD	0..1	PerCent	inherited from: GeneratingUnit
highControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
initialP	0..1	ActivePower	inherited from: GeneratingUnit
longPF	0..1	Float	inherited from: GeneratingUnit
lowControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
lowerRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
maxEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
maximumAllowableSpinningReserve	0..1	ActivePower	inherited from: GeneratingUnit
maxOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
minEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
minimumOffTime	0..1	Seconds	inherited from: GeneratingUnit
minOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
modelDetail	0..1	Classification	inherited from: GeneratingUnit
nominalP	0..1	ActivePower	inherited from: GeneratingUnit

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name	mult	type	description
normalPF	0..1	Float	inherited from: GeneratingUnit
penaltyFactor	0..1	Float	inherited from: GeneratingUnit
raiseRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
ratedGrossMaxP	0..1	ActivePower	inherited from: GeneratingUnit
ratedGrossMinP	0..1	ActivePower	inherited from: GeneratingUnit
ratedNetMaxP	0..1	ActivePower	inherited from: GeneratingUnit
shortPF	0..1	Float	inherited from: GeneratingUnit
startupCost	0..1	Money	inherited from: GeneratingUnit
startupTime	0..1	Seconds	inherited from: GeneratingUnit
tieLinePF	0..1	Float	inherited from: GeneratingUnit
totalEfficiency	0..1	PerCent	inherited from: GeneratingUnit
variableCost	0..1	Money	inherited from: GeneratingUnit
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 395 shows all association ends of HydroGeneratingUnit with other classes.

Table 395 – Association ends of Production::HydroGeneratingUnit with other classes

mult from	name	mult to	type	description
1..1	PenstockLossCurve	0..1	PenstockLossCurve	A hydro generating unit has a penstock loss curve.
1..1	TailbayLossCurve	0..*	TailbayLossCurve	A hydro generating unit has a tailbay loss curve.
0..*	HydroPowerPlant	0..1	HydroPowerPlant	The hydro generating unit belongs to a hydro power plant.
1..1	HydroGeneratingEfficiencyCurves	0..*	HydroGeneratingEfficiencyCurve	A hydro generating unit has an efficiency curve.
0..1	RotatingMachine	1..*	RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.5 AirCompressor

Combustion turbine air compressor which is an integral part of a compressed air energy storage (CAES) plant.

Table 396 shows all attributes of AirCompressor.

Table 396 – Attributes of Production::AirCompressor

name	mult	type	description
airCompressorRating	0..1	Float	Rating of the CAES air compressor.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 397 shows all association ends of AirCompressor with other classes.

Table 397 – Association ends of Production::AirCompressor with other classes

mult from	name	mult to	type	description
0..1	CombustionTurbine	1..1	CombustionTurbine	A CAES air compressor is driven by combustion turbine.
1..1	CAESPlant	1..1	CAESPlant	An air compressor may be a member of a compressed air energy storage plant.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.6 HydroPowerPlant

A hydro power station which can generate or pump. When generating, the generator turbines receive water from an upper reservoir. When pumping, the pumps receive their water from a lower reservoir.

Table 398 shows all attributes of HydroPowerPlant.

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Table 398 – Attributes of Production::HydroPowerPlant

name	mult	type	description
dischargeTravelDelay	0..1	Seconds	Water travel delay from tailbay to next downstream hydro power station.
genRatedP	0..1	ActivePower	The hydro plant's generating rating active power for rated head conditions.
hydroPlantStorageType	0..1	HydroPlantStorageKind	The type of hydro power plant water storage.
penstockType	0..1	String	Type and configuration of hydro plant penstock(s).
plantDischargeCapacity	0..1	VolumeFlowRate	Total plant discharge capacity.
plantRatedHead	0..1	Length	The plant's rated gross head.
pumpRatedP	0..1	ActivePower	The hydro plant's pumping rating active power for rated head conditions.
surgeTankCode	0..1	String	A code describing the type (or absence) of surge tank that is associated with the hydro power plant.
surgeTankCrestLevel	0..1	WaterLevel	The level at which the surge tank spills.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 399 shows all association ends of HydroPowerPlant with other classes.

Table 399 – Association ends of Production::HydroPowerPlant with other classes

mult from	name	mult to	type	description
0..1	HydroGeneratingUnits	0..*	HydroGeneratingUnit	The hydro generating unit belongs to a hydro power plant.
0..1	HydroPumps	0..*	HydroPump	The hydro pump may be a member of a pumped storage plant or a pump for distributing water.
0..*	Reservoir	0..1	Reservoir	Generators discharge water to or pumps are supplied water from a downstream reservoir.
0..*	GenSourcePumpDischargeReservoir	1..1	Reservoir	Generators are supplied water from or pumps discharge water to an upstream reservoir.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.7 GeneratorControlSource enumeration

The source of controls for a generating unit.

Table 400 shows all literals of GeneratorControlSource.

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Table 400 – Literals of Production::GeneratorControlSource

literal	value	description
unavailable		Not available.
offAGC		Off of automatic generation control (AGC).
onAGC		On automatic generation control (AGC).
plantControl		Plant is controlling.

6.10.3.8 InflowForecast

Natural water inflow to a reservoir, usually forecasted from predicted rain and snowmelt. Typically in one hour increments for up to 10 days. The forecast is given in average cubic metres per second over the time increment.

Table 401 shows all attributes of InflowForecast.

Table 401 – Attributes of Production::InflowForecast

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 402 shows all association ends of InflowForecast with other classes.

Table 402 – Association ends of Production::InflowForecast with other classes

mult from	name	mult to	type	description
0..*	Reservoir	1..1	Reservoir	A reservoir may have a "natural" inflow forecast.
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.9 SteamSendoutSchedule

The cogeneration plant's steam sendout schedule in volume per time unit.

Table 403 shows all attributes of SteamSendoutSchedule.

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Table 403 – Attributes of Production::SteamSendoutSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 404 shows all association ends of SteamSendoutSchedule with other classes.

Table 404 – Association ends of Production::SteamSendoutSchedule with other classes

mult from	name	mult to	type	description
1..1	CogenerationPlant	1..1	CogenerationPlant	A cogeneration plant has a steam sendout schedule.
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.10 HydroPump

A synchronous motor-driven pump, typically associated with a pumped storage plant.

Table 405 shows all attributes of HydroPump.

Table 405 – Attributes of Production::HydroPump

name	mult	type	description
pumpDischAtMaxHead	0..1	VolumeFlowRate	The pumping discharge under maximum head conditions, usually at full gate.
pumpDischAtMinHead	0..1	VolumeFlowRate	The pumping discharge under minimum head conditions, usually at full gate.
pumpPowerAtMaxHead	0..1	ActivePower	The pumping power under maximum head conditions, usually at full gate.
pumpPowerAtMinHead	0..1	ActivePower	The pumping power under minimum head conditions, usually at full gate.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 406 shows all association ends of HydroPump with other classes.

Table 406 – Association ends of Production::HydroPump with other classes

mult from	name	mult to	type	description
0..1	RotatingMachine	1..1	RotatingMachine	The synchronous machine drives the turbine which moves the water from a low elevation to a higher elevation. The direction of machine rotation for pumping may or may not be the same as for generating.
0..*	HydroPowerPlant	0..1	HydroPowerPlant	The hydro pump may be a member of a pumped storage plant or a pump for distributing water.
1..1	HydroPumpOpSchedule	0..1	HydroPumpOpSchedule	The hydro pump has a pumping schedule over time, indicating when pumping is to occur.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.11 HydroEnergyConversionKind enumeration

Specifies the capability of the hydro generating unit to convert energy as a generator or pump.

Table 407 shows all literals of HydroEnergyConversionKind.

Table 407 – Literals of Production::HydroEnergyConversionKind

literal	value	description
generator		Able to generate power, but not able to pump water for energy storage.
pumpAndGenerator		Able to both generate power and pump water for energy storage.

6.10.3.12 Classification datatype

Classification of level. Specify as 1..n, with 1 being the most detailed, highest priority, etc as described on the attribue using this data type.

Table 408 shows all attributes of Classification.

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Table 408 – Attributes of Production::Classification

name	mult	type	description
value	0..1	Integer	
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	(const=none)

6.10.3.13 HeatInputCurve

Relationship between unit heat input in energy per time for main fuel (Y1-axis) and supplemental fuel (Y2-axis) versus unit output in active power (X-axis). The quantity of main fuel used to sustain generation at this output level is prorated for throttling between definition points. The quantity of supplemental fuel used at this output level is fixed and not prorated.

Table 409 shows all attributes of HeatInputCurve.

Table 409 – Attributes of Production::HeatInputCurve

name	mult	type	description
auxPowerMult	0..1	PU	Power output – auxiliary power multiplier adjustment factor.
auxPowerOffset	0..1	ActivePower	Power output – auxiliary power offset adjustment factor.
heatInputEff	0..1	PU	Heat input – efficiency multiplier adjustment factor.
heatInputOffset	0..1	HeatRate	Heat input – offset adjustment factor.
isNetGrossP	0..1	Boolean	Flag is set to true when output is expressed in net active power.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 410 shows all association ends of HeatInputCurve with other classes.

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Table 410 – Association ends of Production::HeatInputCurve with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have a heat input curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.14 GenUnitOpCostCurve

Relationship between unit operating cost (Y-axis) and unit output active power (X-axis). The operating cost curve for thermal units is derived from heat input and fuel costs. The operating cost curve for hydro units is derived from water flow rates and equivalent water costs.

Table 411 shows all attributes of GenUnitOpCostCurve.

Table 411 – Attributes of Production::GenUnitOpCostCurve

name	mult	type	description
isNetGrossP	0..1	Boolean	Flag is set to true when output is expressed in net active power.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 412 shows all association ends of GenUnitOpCostCurve with other classes.

Table 412 – Association ends of Production::GenUnitOpCostCurve with other classes

mult from	name	mult to	type	description
0..*	GeneratingUnit	1..1	GeneratingUnit	A generating unit may have one or more cost curves, depending upon fuel mixture and fuel cost.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.10.3.15 EmissionType enumeration

The type of emission.

Table 413 shows all literals of EmissionType.

Table 413 – Literals of Production::EmissionType

literal	value	description
sulfurDioxide		Sulfur dioxide.
carbonDioxide		Carbon dioxide.
nitrogenOxide		Nitrogen oxide.
hydrogenSulfide		Hydrogen sulfide.
chlorine		Chlorine.
carbonDisulfide		Carbon disulfide.

6.10.3.16 ThermalGeneratingUnit

A generating unit whose prime mover could be a steam turbine, combustion turbine, or diesel engine.

Table 414 shows all attributes of ThermalGeneratingUnit.

Table 414 – Attributes of Production::ThermalGeneratingUnit

name	mult	type	description
oMCost	0..1	CostPerHeatUnit	Operating and maintenance cost for the thermal unit.
allocSpinResP	0..1	ActivePower	inherited from: GeneratingUnit
autoCntrlMarginP	0..1	ActivePower	inherited from: GeneratingUnit
baseP	0..1	ActivePower	inherited from: GeneratingUnit
controlDeadband	0..1	ActivePower	inherited from: GeneratingUnit
controlPulseHigh	0..1	Seconds	inherited from: GeneratingUnit
controlPulseLow	0..1	Seconds	inherited from: GeneratingUnit
controlResponseRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
efficiency	0..1	PerCent	inherited from: GeneratingUnit
genControlMode	0..1	GeneratorControlMode	inherited from: GeneratingUnit
genControlSource	0..1	GeneratorControlSource	inherited from: GeneratingUnit
governorMPL	0..1	PU	inherited from: GeneratingUnit
governorSCD	0..1	PerCent	inherited from: GeneratingUnit
highControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
initialP	0..1	ActivePower	inherited from: GeneratingUnit
longPF	0..1	Float	inherited from: GeneratingUnit
lowControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
lowerRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
maxEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
maximumAllowableSpinningReserve	0..1	ActivePower	inherited from: GeneratingUnit
maxOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
minEconomicP	0..1	ActivePower	inherited from: GeneratingUnit

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name	mult	type	description
minimumOffTime	0..1	Seconds	inherited from: GeneratingUnit
minOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
modelDetail	0..1	Classification	inherited from: GeneratingUnit
nominalP	0..1	ActivePower	inherited from: GeneratingUnit
normalPF	0..1	Float	inherited from: GeneratingUnit
penaltyFactor	0..1	Float	inherited from: GeneratingUnit
raiseRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
ratedGrossMaxP	0..1	ActivePower	inherited from: GeneratingUnit
ratedGrossMinP	0..1	ActivePower	inherited from: GeneratingUnit
ratedNetMaxP	0..1	ActivePower	inherited from: GeneratingUnit
shortPF	0..1	Float	inherited from: GeneratingUnit
startupCost	0..1	Money	inherited from: GeneratingUnit
startupTime	0..1	Seconds	inherited from: GeneratingUnit
tieLinePF	0..1	Float	inherited from: GeneratingUnit
totalEfficiency	0..1	PerCent	inherited from: GeneratingUnit
variableCost	0..1	Money	inherited from: GeneratingUnit
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 415 shows all association ends of ThermalGeneratingUnit with other classes.

Table 415 – Association ends of Production::ThermalGeneratingUnit with other classes

mult from	name	mult to	type	description
1..1	HeatInputCurve	0..1	HeatInputCurve	A thermal generating unit may have a heat input curve.
1..1	HeatRateCurve	0..1	HeatRateCurve	A thermal generating unit may have a heat rate curve.
0..*	CogenerationPlant	0..1	CogenerationPlant	A thermal generating unit may be a member of a cogeneration plant.
1..1	FuelAllocationSchedules	0..*	FuelAllocationSchedule	A thermal generating unit may have one or more fuel allocation schedules.
1..1	StartupModel	0..1	StartupModel	A thermal generating unit may have a startup model.
1..1	EmissionCurves	0..*	EmissionCurve	A thermal generating unit may have one or more emission curves.
1..1	ShutdownCurve	0..1	ShutdownCurve	A thermal generating unit may have a shutdown curve.
1..1	IncrementalHeatRateCurve	0..1	IncrementalHeatRateCurve	A thermal generating unit may have an incremental heat rate curve.
1..1	FossilFuels	0..*	FossilFuel	A thermal generating unit may have one or more fossil fuels.
0..1	CAESPlant	0..1	CAESPlant	A thermal generating unit may be a member of a compressed air energy storage plant.

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mult from	name	mult to	type	description
0..*	CombinedCyclePlant	0..1	CombinedCyclePlant	A thermal generating unit may be a member of a combined cycle plant.
1..1	EmmissionAccounts	0..*	EmissionAccount	A thermal generating unit may have one or more emission allowance accounts.
0..1	RotatingMachine	1..*	RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GrossToNetActivePower Curves	0..*	GrossToNetActivePower Curve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingU nit	0..*	ControlAreaGeneratingU nit	inherited from: GeneratingUnit
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.17 NuclearGeneratingUnit

A nuclear generating unit.

Table 416 shows all attributes of NuclearGeneratingUnit.

Table 416 – Attributes of Production::NuclearGeneratingUnit

name	mult	type	description
allocSpinResP	0..1	ActivePower	inherited from: GeneratingUnit
autoCntrlMarginP	0..1	ActivePower	inherited from: GeneratingUnit
baseP	0..1	ActivePower	inherited from: GeneratingUnit
controlDeadband	0..1	ActivePower	inherited from: GeneratingUnit
controlPulseHigh	0..1	Seconds	inherited from: GeneratingUnit
controlPulseLow	0..1	Seconds	inherited from: GeneratingUnit
controlResponseRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
efficiency	0..1	PerCent	inherited from: GeneratingUnit
genControlMode	0..1	GeneratorControlMode	inherited from: GeneratingUnit
genControlSource	0..1	GeneratorControlSource	inherited from: GeneratingUnit
governorMPL	0..1	PU	inherited from: GeneratingUnit
governorSCD	0..1	PerCent	inherited from: GeneratingUnit
highControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
initialP	0..1	ActivePower	inherited from: GeneratingUnit
longPF	0..1	Float	inherited from: GeneratingUnit

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name	mult	type	description
lowControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
lowerRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
maxEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
maximumAllowableSpinningReserve	0..1	ActivePower	inherited from: GeneratingUnit
maxOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
minEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
minimumOffTime	0..1	Seconds	inherited from: GeneratingUnit
minOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
modelDetail	0..1	Classification	inherited from: GeneratingUnit
nominalP	0..1	ActivePower	inherited from: GeneratingUnit
normalPF	0..1	Float	inherited from: GeneratingUnit
penaltyFactor	0..1	Float	inherited from: GeneratingUnit
raiseRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
ratedGrossMaxP	0..1	ActivePower	inherited from: GeneratingUnit
ratedGrossMinP	0..1	ActivePower	inherited from: GeneratingUnit
ratedNetMaxP	0..1	ActivePower	inherited from: GeneratingUnit
shortPF	0..1	Float	inherited from: GeneratingUnit
startupCost	0..1	Money	inherited from: GeneratingUnit
startupTime	0..1	Seconds	inherited from: GeneratingUnit
tieLinePF	0..1	Float	inherited from: GeneratingUnit
totalEfficiency	0..1	PerCent	inherited from: GeneratingUnit
variableCost	0..1	Money	inherited from: GeneratingUnit
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 417 shows all association ends of NuclearGeneratingUnit with other classes.

Table 417 – Association ends of Production::NuclearGeneratingUnit with other classes

mult from	name	mult to	type	description
0..1	RotatingMachine	1..*	RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment

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mult from	name	mult to	type	description
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.18 Reservoir

A water storage facility within a hydro system, including: ponds, lakes, lagoons, and rivers. The storage is usually behind some type of dam.

Table 418 shows all attributes of Reservoir.

Table 418 – Attributes of Production::Reservoir

name	mult	type	description
activeStorageCapacity	0..1	Volume	Storage volume between the full supply level and the normal minimum operating level.
energyStorageRating	0..1	Float	The reservoir's energy storage rating in energy for given head conditions.
fullSupplyLevel	0..1	WaterLevel	Full supply level, above which water will spill. This can be the spillway crest level or the top of closed gates.
grossCapacity	0..1	Volume	Total capacity of reservoir.
normalMinOperateLevel	0..1	WaterLevel	Normal minimum operating level below which the penstocks will draw air.
riverOutletWorks	0..1	String	River outlet works for riparian right releases or other purposes.
spillTravelDelay	0..1	Seconds	The spillway water travel delay to the next downstream reservoir.
spillwayCapacity	0..1	Float	The flow capacity of the spillway in cubic metres per second.
spillwayCrestLength	0..1	Length	The length of the spillway crest.
spillwayCrestLevel	0..1	WaterLevel	Spillway crest level above which water will spill.
spillWayGateType	0..1	String	Type of spillway gate, including parameters.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 419 shows all association ends of Reservoir with other classes.

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Table 419 – Association ends of Production::Reservoir with other classes

mult from	name	mult to	type	description
0..1	SpillsIntoReservoirs	0..*	Reservoir	A reservoir may spill into a downstream reservoir.
1..1	TargetLevelSchedule	0..1	TargetLevelSchedule	A reservoir may have a water level target schedule.
0..1	HydroPowerPlants	0..*	HydroPowerPlant	Generators discharge water to or pumps are supplied water from a downstream reservoir.
1..1	UpstreamFromHydroPowerPlants	0..*	HydroPowerPlant	Generators are supplied water from or pumps discharge water to an upstream reservoir.
1..1	InflowForecasts	0..*	InflowForecast	A reservoir may have a "natural" inflow forecast.
1..1	LevelVsVolumeCurves	0..*	LevelVsVolumeCurve	A reservoir may have a level versus volume relationship.
0..*	SpillsFromReservoir	0..1	Reservoir	A reservoir may spill into a downstream reservoir.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.19 WindGeneratingUnit

A wind driven generating unit. May be used to represent a single turbine or an aggregation.

Table 420 shows all attributes of WindGeneratingUnit.

Table 420 – Attributes of Production::WindGeneratingUnit

name	mult	type	description
windGenUnitType	0..1	WindGenUnitKind	The kind of wind generating unit
allocSpinResP	0..1	ActivePower	inherited from: GeneratingUnit
autoCntrlMarginP	0..1	ActivePower	inherited from: GeneratingUnit
baseP	0..1	ActivePower	inherited from: GeneratingUnit
controlDeadband	0..1	ActivePower	inherited from: GeneratingUnit
controlPulseHigh	0..1	Seconds	inherited from: GeneratingUnit
controlPulseLow	0..1	Seconds	inherited from: GeneratingUnit
controlResponseRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
efficiency	0..1	PerCent	inherited from: GeneratingUnit
genControlMode	0..1	GeneratorControlMode	inherited from: GeneratingUnit
genControlSource	0..1	GeneratorControlSource	inherited from: GeneratingUnit
governorMPL	0..1	PU	inherited from: GeneratingUnit
governorSCD	0..1	PerCent	inherited from: GeneratingUnit
highControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
initialP	0..1	ActivePower	inherited from: GeneratingUnit

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name	mult	type	description
longPF	0..1	Float	inherited from: GeneratingUnit
lowControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
lowerRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
maxEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
maximumAllowableSpinningReserve	0..1	ActivePower	inherited from: GeneratingUnit
maxOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
minEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
minimumOffTime	0..1	Seconds	inherited from: GeneratingUnit
minOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
modelDetail	0..1	Classification	inherited from: GeneratingUnit
nominalP	0..1	ActivePower	inherited from: GeneratingUnit
normalPF	0..1	Float	inherited from: GeneratingUnit
penaltyFactor	0..1	Float	inherited from: GeneratingUnit
raiseRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
ratedGrossMaxP	0..1	ActivePower	inherited from: GeneratingUnit
ratedGrossMinP	0..1	ActivePower	inherited from: GeneratingUnit
ratedNetMaxP	0..1	ActivePower	inherited from: GeneratingUnit
shortPF	0..1	Float	inherited from: GeneratingUnit
startupCost	0..1	Money	inherited from: GeneratingUnit
startupTime	0..1	Seconds	inherited from: GeneratingUnit
tieLinePF	0..1	Float	inherited from: GeneratingUnit
totalEfficiency	0..1	PerCent	inherited from: GeneratingUnit
variableCost	0..1	Money	inherited from: GeneratingUnit
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 421 shows all association ends of WindGeneratingUnit with other classes.

Table 421 – Association ends of Production::WindGeneratingUnit with other classes

mult from	name	mult to	type	description
0..1	RotatingMachine	1..*	RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment

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mult from	name	mult to	type	description
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.20 StartMainFuelCurve

The quantity of main fuel (Y-axis) used to restart and repay the auxiliary power consumed versus the number of hours (X-axis) the unit was off line.

Table 422 shows all attributes of StartMainFuelCurve.

Table 422 – Attributes of Production::StartMainFuelCurve

name	mult	type	description
mainFuelType	0..1	FuelType	Type of main fuel.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 423 shows all association ends of StartMainFuelCurve with other classes.

Table 423 – Association ends of Production::StartMainFuelCurve with other classes

mult from	name	mult to	type	description
0..1	StartupModel	1..1	StartupModel	The unit's startup model may have a startup main fuel curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.10.3.21 GrossToNetActivePowerCurve

Relationship between the generating unit's gross active power output on the X-axis (measured at the terminals of the machine(s)) and the generating unit's net active power output on the Y-axis (based on utility-defined measurements at the power station). Station service loads, when modeled, should be treated as non-conforming bus loads. There may be more than one curve, depending on the auxiliary equipment that is in service.

Table 424 shows all attributes of GrossToNetActivePowerCurve.

Table 424 – Attributes of Production::GrossToNetActivePowerCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 425 shows all association ends of GrossToNetActivePowerCurve with other classes.

Table 425 – Association ends of Production::GrossToNetActivePowerCurve with other classes

mult from	name	mult to	type	description
0..*	GeneratingUnit	1..1	GeneratingUnit	A generating unit may have a gross active power to net active power curve, describing the losses and auxiliary power requirements of the unit.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.22 EmissionAccount

Accounts for tracking emissions usage and credits for thermal generating units. A unit may have zero or more emission accounts, and will typically have one for tracking usage and one for tracking credits.

Table 426 shows all attributes of EmissionAccount.

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Table 426 – Attributes of Production::EmissionAccount

name	mult	type	description
emissionType	0..1	EmissionType	The type of emission, for example sulfur dioxide (SO2). The y1AxisUnits of the curve contains the unit of measure (e.g. kg) and the emissionType is the type of emission (e.g. sulfur dioxide).
emissionValueSource	0..1	EmissionValueSource	The source of the emission value.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 427 shows all association ends of EmissionAccount with other classes.

Table 427 – Association ends of Production::EmissionAccount with other classes

mult from	name	mult to	type	description
0..*	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have one or more emission allowance accounts.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.23 HeatRateCurve

Relationship between unit heat rate per active power (Y-axis) and unit output (X-axis). The heat input is from all fuels.

Table 428 shows all attributes of HeatRateCurve.

Table 428 – Attributes of Production::HeatRateCurve

name	mult	type	description
isNetGrossP	0..1	Boolean	Flag is set to true when output is expressed in net active power.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve

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name	mult	type	description
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 429 shows all association ends of HeatRateCurve with other classes.

Table 429 – Association ends of Production::HeatRateCurve with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have a heat rate curve
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.24 HeatRate datatype

Heat generated, in energy pertime unit of elapsed time.

Table 430 shows all attributes of HeatRate.

Table 430 – Attributes of Production::HeatRate

name	mult	type	description
unit	0..1	UnitSymbol	(const=J)
value	0..1	Float	
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.10.3.25 CAESPlant

Compressed air energy storage plant.

Table 431 shows all attributes of CAESPlant.

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Table 431 – Attributes of Production::CAESPlant

name	mult	type	description
energyStorageCapacity	0..1	RealEnergy	The rated energy storage capacity.
ratedCapacityP	0..1	ActivePower	The CAES plant's gross rated generating capacity.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 432 shows all association ends of CAESPlant with other classes.

Table 432 – Association ends of Production::CAESPlant with other classes

mult from	name	mult to	type	description
1..1	AirCompressor	1..1	AirCompressor	An air compressor may be a member of a compressed air energy storage plant.
0..1	ThermalGeneratingUnit	0..1	ThermalGeneratingUnit	A thermal generating unit may be a member of a compressed air energy storage plant.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.26 HydroPlantStorageKind enumeration

The type of hydro power plant.

Table 433 shows all literals of HydroPlantStorageKind.

Table 433 – Literals of Production::HydroPlantStorageKind

literal	value	description
runOfRiver		Run of river.
pumpedStorage		Pumped storage.
storage		Storage.

6.10.3.27 GeneratingUnit

A single or set of synchronous machines for converting mechanical power into alternating-current power. For example, individual machines within a set may be defined for scheduling purposes while a single control signal is derived for the set. In this case there would be a GeneratingUnit for each member of the set and an additional GeneratingUnit corresponding to the set.

Table 434 shows all attributes of GeneratingUnit.

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Table 434 – Attributes of Production::GeneratingUnit

name	mult	type	description
allocSpinResP	0..1	ActivePower	The planned unused capacity (spinning reserve) which can be used to support emergency load.
autoCntrlMarginP	0..1	ActivePower	The planned unused capacity which can be used to support automatic control overruns.
baseP	0..1	ActivePower	For dispatchable units, this value represents the economic active power basepoint, for units that are not dispatchable, this value represents the fixed generation value. The value shall be between the operating low and high limits.
controlDeadband	0..1	ActivePower	Unit control error deadband. When a unit's desired active power change is less than this deadband, then no control pulses will be sent to the unit.
controlPulseHigh	0..1	Seconds	Pulse high limit which is the largest control pulse that the unit can respond to.
controlPulseLow	0..1	Seconds	Pulse low limit which is the smallest control pulse that the unit can respond to.
controlResponseRate	0..1	ActivePowerChangeRate	Unit response rate which specifies the active power change for a control pulse of one second in the most responsive loading level of the unit.
efficiency	0..1	PerCent	The efficiency of the unit in converting mechanical energy, from the prime mover, into electrical energy.
genControlMode	0..1	GeneratorControlMode	The unit control mode.
genControlSource	0..1	GeneratorControlSource	The source of controls for a generating unit.
governorMPL	0..1	PU	Governor motor position limit.
governorSCD	0..1	PerCent	Governor Speed Changer Droop. This is the change in generator power output divided by the change in frequency normalized by the nominal power of the generator and the nominal frequency and expressed in percent and negated. A positive value of speed change droop provides additional generator output upon a drop in frequency.
highControlLimit	0..1	ActivePower	High limit for secondary (AGC) control.
initialP	0..1	ActivePower	Default initial active power which is used to store a powerflow result for the initial active power for this unit in this network configuration.
longPF	0..1	Float	Generating unit long term economic participation factor.
lowControlLimit	0..1	ActivePower	Low limit for secondary (AGC) control.
lowerRampRate	0..1	ActivePowerChangeRate	The normal maximum rate the generating unit active power output can be lowered by control actions.
maxEconomicP	0..1	ActivePower	Maximum high economic active power limit, that should not exceed the maximum operating active power limit.
maximumAllowableSpinningReserve	0..1	ActivePower	Maximum allowable spinning reserve. Spinning reserve will never be considered greater than this value regardless of the current operating point.
maxOperatingP	0..1	ActivePower	This is the maximum operating active power limit the dispatcher can enter for this unit.
minEconomicP	0..1	ActivePower	Low economic active power limit that shall be greater than or equal to the minimum operating active power limit.
minimumOffTime	0..1	Seconds	Minimum time interval between unit shutdown and startup.

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name	mult	type	description
minOperatingP	0..1	ActivePower	This is the minimum operating active power limit the dispatcher can enter for this unit.
modelDetail	0..1	Classification	Detail level of the generator model data.
nominalP	0..1	ActivePower	The nominal power of the generating unit. Used to give precise meaning to percentage based attributes such as the governor speed change droop (governorSCD attribute). The attribute shall be a positive value equal to or less than RotatingMachine.ratedS.
normalPF	0..1	Float	Generating unit economic participation factor.
penaltyFactor	0..1	Float	Defined as: 1 / (1 − Incremental Transmission Loss); with the Incremental Transmission Loss expressed as a plus or minus value. The typical range of penalty factors is (0,9 to 1,1).
raiseRampRate	0..1	ActivePowerChangeRate	The normal maximum rate the generating unit active power output can be raised by control actions.
ratedGrossMaxP	0..1	ActivePower	The unit's gross rated maximum capacity (book value).
ratedGrossMinP	0..1	ActivePower	The gross rated minimum generation level which the unit can safely operate at while delivering power to the transmission grid.
ratedNetMaxP	0..1	ActivePower	The net rated maximum capacity determined by subtracting the auxiliary power used to operate the internal plant machinery from the rated gross maximum capacity.
shortPF	0..1	Float	Generating unit short term economic participation factor.
startupCost	0..1	Money	The initial startup cost incurred for each start of the GeneratingUnit.
startupTime	0..1	Seconds	Time it takes to get the unit on-line, from the time that the prime mover mechanical power is applied.
tieLinePF	0..1	Float	Generating unit economic participation factor.
totalEfficiency	0..1	PerCent	The efficiency of the unit in converting the fuel into electrical energy.
variableCost	0..1	Money	The variable cost component of production per unit of ActivePower.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 435 shows all association ends of GeneratingUnit with other classes.

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Table 435 – Association ends of Production::GeneratingUnit with other classes

mult from	name	mult to	type	description
0..1	RotatingMachine	1..*	RotatingMachine	A synchronous machine may operate as a generator and as such becomes a member of a generating unit.
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	A generating unit may have one or more cost curves, depending upon fuel mixture and fuel cost.
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	A generating unit may have a gross active power to net active power curve, describing the losses and auxiliary power requirements of the unit.
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	A generating unit may have an operating schedule, indicating the planned operation of the unit.
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	ControlArea specifications for this generating unit.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.28 EmissionCurve

Relationship between the unit's emission rate in units of mass per hour (Y-axis) and output active power (X-axis) for a given type of emission. This curve applies when only one type of fuel is being burned.

Table 436 shows all attributes of EmissionCurve.

Table 436 – Attributes of Production::EmissionCurve

name	mult	type	description
emissionContent	0..1	Emission	The emission content per quantity of fuel burned.
emissionType	0..1	EmissionType	The type of emission, which also gives the production rate measurement unit. The y1AxisUnits of the curve contains the unit of measure (e.g. kg) and the emissionType is the type of emission (e.g. sulfur dioxide).
isNetGrossP	0..1	Boolean	Flag is set to true when output is expressed in net active power.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve

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name	mult	type	description
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 437 shows all association ends of EmissionCurve with other classes.

Table 437 – Association ends of Production::EmissionCurve with other classes

mult from	name	mult to	type	description
0..*	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have one or more emission curves.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.29 ShutdownCurve

Relationship between the rate in gross active power per minute (Y-axis) at which a unit should be shutdown and its present gross MW output (X-axis).

Table 438 shows all attributes of ShutdownCurve.

Table 438 – Attributes of Production::ShutdownCurve

name	mult	type	description
shutdownCost	0..1	Money	Fixed shutdown cost.
shutdownDate	0..1	DateTime	The date and time of the most recent generating unit shutdown.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 439 shows all association ends of ShutdownCurve with other classes.

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Table 439 – Association ends of Production::ShutdownCurve with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have a shutdown curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.30 FuelType enumeration

Type of fuel.

Table 440 shows all literals of FuelType.

Table 440 – Literals of Production::FuelType

literal	value	description
coal		Generic coal, not including lignite type.
oil		Oil.
gas		Natural gas.
lignite		The fuel is lignite coal. Note that this is a special type of coal, so the other enum of coal is reserved for hard coal types or if the exact type of coal is not known.
hardCoal		Hard coal
oilShale		Oil Shale

6.10.3.31 FuelAllocationSchedule

The amount of fuel of a given type which is allocated for consumption over a specified period of time.

Table 441 shows all attributes of FuelAllocationSchedule.

Table 441 – Attributes of Production::FuelAllocationSchedule

name	mult	type	description
fuelAllocationEndDate	0..1	DateTime	The end time and date of the fuel allocation schedule.
fuelAllocationStartDate	0..1	DateTime	The start time and date of the fuel allocation schedule.
fuelType	0..1	FuelType	The type of fuel, which also indicates the corresponding measurement unit.
maxFuelAllocation	0..1	Float	The maximum amount of fuel that is allocated for consumption for the scheduled time period.
minFuelAllocation	0..1	Float	The minimum amount of fuel that is allocated for consumption for the scheduled time period, e.g. based on a "take-or-pay" contract.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve

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name	mult	type	description
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 442 shows all association ends of FuelAllocationSchedule with other classes.

Table 442 – Association ends of Production::FuelAllocationSchedule with other classes

mult from	name	mult to	type	description
0..*	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have one or more fuel allocation schedules.
0..*	FossilFuel	1..1	FossilFuel	A fuel allocation schedule shall have a fossil fuel.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.32 CombinedCyclePlant

A set of combustion turbines and steam turbines where the exhaust heat from the combustion turbines is recovered to make steam for the steam turbines, resulting in greater overall plant efficiency.

Table 443 shows all attributes of CombinedCyclePlant.

Table 443 – Attributes of Production::CombinedCyclePlant

name	mult	type	description
combCyclePlantRating	0..1	ActivePower	The combined cycle plant's active power output rating.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 444 shows all association ends of CombinedCyclePlant with other classes.

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Table 444 – Association ends of Production::CombinedCyclePlant with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnits	0..*	ThermalGeneratingUnit	A thermal generating unit may be a member of a combined cycle plant.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.33 TailbayLossCurve

Relationship between tailbay head loss hight (Y-axis) and the total discharge into the power station's tailbay volume per time unit (X-axis). There could be more than one curve depending on the level of the tailbay reservoir or river level.

Table 445 shows all attributes of TailbayLossCurve.

Table 445 – Attributes of Production::TailbayLossCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 446 shows all association ends of TailbayLossCurve with other classes.

Table 446 – Association ends of Production::TailbayLossCurve with other classes

mult from	name	mult to	type	description
0..*	HydroGeneratingUnit	1..1	HydroGeneratingUnit	A hydro generating unit has a tailbay loss curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.10.3.34 IncrementalHeatRateCurve

Relationship between unit incremental heat rate in (delta energy/time) per (delta active power) and unit output in active power. The IHR curve represents the slope of the HeatInputCurve. Note that the "incremental heat rate" and the "heat rate" have the same engineering units.

Table 447 shows all attributes of IncrementalHeatRateCurve.

Table 447 – Attributes of Production::IncrementalHeatRateCurve

name	mult	type	description
isNetGrossP	0..1	Boolean	Flag is set to true when output is expressed in net active power.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 448 shows all association ends of IncrementalHeatRateCurve with other classes.

Table 448 – Association ends of Production::IncrementalHeatRateCurve with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have an incremental heat rate curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.35 FossilFuel

The fossil fuel consumed by the non-nuclear thermal generating unit. For example, coal, oil, gas, etc. These are the specific fuels that the generating unit can consume.

Table 449 shows all attributes of FossilFuel.

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Table 449 – Attributes of Production::FossilFuel

name	mult	type	description
fossilFuelType	0..1	FuelType	The type of fossil fuel, such as coal, oil, or gas.
fuelCost	0..1	CostPerHeatUnit	The cost in terms of heat value for the given type of fuel.
fuelDispatchCost	0..1	CostPerHeatUnit	The cost of fuel used for economic dispatching which includes: fuel cost, transportation cost, and incremental maintenance cost.
fuelEffFactor	0..1	PU	The efficiency factor for the fuel (per unit) in terms of the effective energy absorbed.
fuelHandlingCost	0..1	CostPerHeatUnit	Handling and processing cost associated with this fuel.
fuelHeatContent	0..1	Float	The amount of heat per weight (or volume) of the given type of fuel.
fuelMixture	0..1	PerCent	Relative amount of the given type of fuel, when multiple fuels are being consumed.
fuelSulfur	0..1	PU	The fuel's fraction of pollution credit per unit of heat content.
highBreakpointP	0..1	ActivePower	The active power output level of the unit at which the given type of fuel is switched on. This fuel (e.g. oil) is sometimes used to supplement the base fuel (e.g. coal) at high active power output levels.
lowBreakpointP	0..1	ActivePower	The active power output level of the unit at which the given type of fuel is switched off. This fuel (e.g. oil) is sometimes used to stabilize the base fuel (e.g. coal) at low active power output levels.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 450 shows all association ends of FossilFuel with other classes.

Table 450 – Association ends of Production::FossilFuel with other classes

mult from	name	mult to	type	description
0..*	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have one or more fossil fuels.
1..1	FuelAllocationSchedules	0..*	FuelAllocationSchedule	A fuel allocation schedule shall have a fossil fuel.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.36 EmissionValueSource enumeration

The source of the emission value.

Table 451 shows all literals of EmissionValueSource.

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Table 451 – Literals of Production::EmissionValueSource

literal	value	description
measured		Measured.
calculated		Calculated.

6.10.3.37 StartIgnFuelCurve

The quantity of ignition fuel (Y-axis) used to restart and repay the auxiliary power consumed versus the number of hours (X-axis) the unit was off line.

Table 452 shows all attributes of StartIgnFuelCurve.

Table 452 – Attributes of Production::StartIgnFuelCurve

name	mult	type	description
ignitionFuelType	0..1	FuelType	Type of ignition fuel.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 453 shows all association ends of StartIgnFuelCurve with other classes.

Table 453 – Association ends of Production::StartIgnFuelCurve with other classes

mult from	name	mult to	type	description
0..1	StartupModel	1..1	StartupModel	The unit's startup model may have a startup ignition fuel curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.38 HydroPumpOpSchedule

The hydro pump's Operator-approved current operating schedule (or plan), typically produced with the aid of unit commitment type analyses.The unit's operating schedule status is typically given as: (0 = unavailable) (1 = available to startup or shutdown) (2 = must pump).

Table 454 shows all attributes of HydroPumpOpSchedule.

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Table 454 – Attributes of Production::HydroPumpOpSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 455 shows all association ends of HydroPumpOpSchedule with other classes.

Table 455 – Association ends of Production::HydroPumpOpSchedule with other classes

mult from	name	mult to	type	description
0..1	HydroPump	1..1	HydroPump	The hydro pump has a pumping schedule over time, indicating when pumping is to occur.
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.39 HydroGeneratingEfficiencyCurve

Relationship between unit efficiency as a percentage and unit output active power for a given net head in metres. The relationship between efficiency, discharge, head, and power output is expressed as follows: $E = KP/HQ$

where (E=percentage) (P=active power) (H= height) (Q=volume/time unit) (K=constant)

For example, a curve instance for a given net head could relate efficiency (Y-axis) versus active power output (X-axis) or versus discharge on the X-axis.

Table 456 shows all attributes of HydroGeneratingEfficiencyCurve.

Table 456 – Attributes of Production::HydroGeneratingEfficiencyCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve

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name	mult	type	description
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 457 shows all association ends of HydroGeneratingEfficiencyCurve with other classes.

Table 457 – Association ends of Production::HydroGeneratingEfficiencyCurve with other classes

mult from	name	mult to	type	description
0..*	HydroGeneratingUnit	1..1	HydroGeneratingUnit	A hydro generating unit has an efficiency curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.40 Emission datatype

Quantity of emission per fuel heat content.

Table 458 shows all attributes of Emission.

Table 458 – Attributes of Production::Emission

name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=g)
multiplier	0..1	UnitMultiplier	(const=k)
denominatorUnit	0..1	UnitSymbol	(const=J)
denominatorMultiplier	0..1	UnitMultiplier	

6.10.3.41 CostPerHeatUnit datatype

Cost, in units of currency, per quantity of heat generated.

Table 459 shows all attributes of CostPerHeatUnit.

Table 459 – Attributes of Production::CostPerHeatUnit

name	mult	type	description
value	0..1	Float	
unit	0..1	Currency	
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=J)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

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6.10.3.42 CogenerationPlant

A set of thermal generating units for the production of electrical energy and process steam (usually from the output of the steam turbines). The steam sendout is typically used for industrial purposes or for municipal heating and cooling.

Table 460 shows all attributes of CogenerationPlant.

Table 460 – Attributes of Production::CogenerationPlant

name	mult	type	description
cogenHPSendoutRating	0..1	Float	The high pressure steam sendout.
cogenHPSteamRating	0..1	Float	The high pressure steam rating.
cogenLPSendoutRating	0..1	Float	The low pressure steam sendout.
cogenLPSteamRating	0..1	Float	The low pressure steam rating.
ratedP	0..1	ActivePower	The rated output active power of the cogeneration plant.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 461 shows all association ends of CogenerationPlant with other classes.

Table 461 – Association ends of Production::CogenerationPlant with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnits	0..*	ThermalGeneratingUnit	A thermal generating unit may be a member of a cogeneration plant.
1..1	SteamSendoutSchedule	1..1	SteamSendoutSchedule	A cogeneration plant has a steam sendout schedule.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.43 StartRampCurve

Rate in gross active power per minute (Y-axis) at which a unit can be loaded versus the number of hours (X-axis) the unit was off line.

Table 462 shows all attributes of StartRampCurve.

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Table 462 – Attributes of Production::StartRampCurve

name	mult	type	description
hotStandbyRamp	0..1	ActivePowerChangeRate	The startup ramp rate in gross for a unit that is on hot standby.
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 463 shows all association ends of StartRampCurve with other classes.

Table 463 – Association ends of Production::StartRampCurve with other classes

mult from	name	mult to	type	description
0..1	StartupModel	1..1	StartupModel	The unit's startup model may have a startup ramp curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.44 GeneratorControlMode enumeration

Unit control modes.

Table 464 shows all literals of GeneratorControlMode.

Table 464 – Literals of Production::GeneratorControlMode

literal	value	description
setpoint		Setpoint control mode.
pulse		Pulse control mode.

6.10.3.45 LevelVsVolumeCurve

Relationship between reservoir volume and reservoir level. The volume is at the Y-axis and the reservoir level at the X-axis.

Table 465 shows all attributes of LevelVsVolumeCurve.

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Table 465 – Attributes of Production::LevelVsVolumeCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 466 shows all association ends of LevelVsVolumeCurve with other classes.

Table 466 – Association ends of Production::LevelVsVolumeCurve with other classes

mult from	name	mult to	type	description
0..*	Reservoir	1..1	Reservoir	A reservoir may have a level versus volume relationship.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.46 StartupModel

Unit start up characteristics depending on how long the unit has been off line.

Table 467 shows all attributes of StartupModel.

Table 467 – Attributes of Production::StartupModel

name	mult	type	description
fixedMaintCost	0..1	CostRate	Fixed maintenance cost.
hotStandbyHeat	0..1	HeatRate	The amount of heat input per time uint required for hot standby operation.
incrementalMaintCost	0..1	CostPerEnergyUnit	Incremental maintenance cost.
minimumDownTime	0..1	Hours	The minimum number of hours the unit must be down before restart.
minimumRunTime	0..1	Hours	The minimum number of hours the unit must be operating before being allowed to shut down.
riskFactorCost	0..1	Money	The opportunity cost associated with the return in monetary unit. This represents the restart's "share" of the unit depreciation and risk of an event which would damage the unit.
startupCost	0..1	Money	Total miscellaneous start up costs.

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name	mult	type	description
startupDate	0..1	DateTime	The date and time of the most recent generating unit startup.
startupPriority	0..1	Integer	Startup priority within control area where lower numbers indicate higher priorities. More than one unit in an area may be assigned the same priority.
stbyAuxP	0..1	ActivePower	The unit's auxiliary active power consumption to maintain standby mode.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 468 shows all association ends of StartupModel with other classes.

Table 468 – Association ends of Production::StartupModel with other classes

mult from	name	mult to	type	description
0..1	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have a startup model.
1..1	StartMainFuelCurve	0..1	StartMainFuelCurve	The unit's startup model may have a startup main fuel curve.
1..1	StartIgnFuelCurve	0..1	StartIgnFuelCurve	The unit's startup model may have a startup ignition fuel curve.
1..1	StartRampCurve	0..1	StartRampCurve	The unit's startup model may have a startup ramp curve.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.47 GenUnitOpSchedule

The generating unit's Operator-approved current operating schedule (or plan), typically produced with the aid of unit commitment type analyses. The X-axis represents absolute time. The Y1-axis represents the status (0 = off-line and unavailable; 1 = available; 2 = must run; 3 = must run at fixed power value; etc.). The Y2-axis represents the must run fixed power value where required.

Table 469 shows all attributes of GenUnitOpSchedule.

Table 469 – Attributes of Production::GenUnitOpSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 470 shows all association ends of GenUnitOpSchedule with other classes.

Table 470 – Association ends of Production::GenUnitOpSchedule with other classes

mult from	name	mult to	type	description
0..1	GeneratingUnit	1..1	GeneratingUnit	A generating unit may have an operating schedule, indicating the planned operation of the unit.
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.48 WindGenUnitKind enumeration

Kind of wind generating unit.

Table 471 shows all literals of WindGenUnitKind.

Table 471 – Literals of Production::WindGenUnitKind

literal	value	description
offshore		The wind generating unit is located offshore.
onshore		The wind generating unit is located onshore.

6.10.3.49 SolarGeneratingUnit

A solar thermal generating unit.

Table 472 shows all attributes of SolarGeneratingUnit.

Table 472 – Attributes of Production::SolarGeneratingUnit

name	mult	type	description
allocSpinResP	0..1	ActivePower	inherited from: GeneratingUnit
autoCntrlMarginP	0..1	ActivePower	inherited from: GeneratingUnit
baseP	0..1	ActivePower	inherited from: GeneratingUnit
controlDeadband	0..1	ActivePower	inherited from: GeneratingUnit
controlPulseHigh	0..1	Seconds	inherited from: GeneratingUnit
controlPulseLow	0..1	Seconds	inherited from: GeneratingUnit
controlResponseRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
efficiency	0..1	PerCent	inherited from: GeneratingUnit
genControlMode	0..1	GeneratorControlMode	inherited from: GeneratingUnit
genControlSource	0..1	GeneratorControlSource	inherited from: GeneratingUnit
governorMPL	0..1	PU	inherited from: GeneratingUnit
governorSCD	0..1	PerCent	inherited from: GeneratingUnit
highControlLimit	0..1	ActivePower	inherited from: GeneratingUnit

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name	mult	type	description
initialP	0..1	ActivePower	inherited from: GeneratingUnit
longPF	0..1	Float	inherited from: GeneratingUnit
lowControlLimit	0..1	ActivePower	inherited from: GeneratingUnit
lowerRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
maxEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
maximumAllowableSpinningReserve	0..1	ActivePower	inherited from: GeneratingUnit
maxOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
minEconomicP	0..1	ActivePower	inherited from: GeneratingUnit
minimumOffTime	0..1	Seconds	inherited from: GeneratingUnit
minOperatingP	0..1	ActivePower	inherited from: GeneratingUnit
modelDetail	0..1	Classification	inherited from: GeneratingUnit
nominalP	0..1	ActivePower	inherited from: GeneratingUnit
normalPF	0..1	Float	inherited from: GeneratingUnit
penaltyFactor	0..1	Float	inherited from: GeneratingUnit
raiseRampRate	0..1	ActivePowerChangeRate	inherited from: GeneratingUnit
ratedGrossMaxP	0..1	ActivePower	inherited from: GeneratingUnit
ratedGrossMinP	0..1	ActivePower	inherited from: GeneratingUnit
ratedNetMaxP	0..1	ActivePower	inherited from: GeneratingUnit
shortPF	0..1	Float	inherited from: GeneratingUnit
startupCost	0..1	Money	inherited from: GeneratingUnit
startupTime	0..1	Seconds	inherited from: GeneratingUnit
tieLinePF	0..1	Float	inherited from: GeneratingUnit
totalEfficiency	0..1	PerCent	inherited from: GeneratingUnit
variableCost	0..1	Money	inherited from: GeneratingUnit
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 473 shows all association ends of SolarGeneratingUnit with other classes.

Table 473 – Association ends of Production::SolarGeneratingUnit with other classes

mult from	name	mult to	type	description
0..1	RotatingMachine	1..*	RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
0..1	Faults	0..*	Fault	inherited from: Equipment

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mult from	name	mult to	type	description
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.50 PowerElectronicsUnit

A generating unit or battery or aggregation that connects to the AC network using power electronics rather than rotating machines.

Table 474 shows all attributes of PowerElectronicsUnit.

Table 474 – Attributes of Production::PowerElectronicsUnit

name	mult	type	description
maxP	0..1	ActivePower	Maximum active power limit. This is the maximum (nameplate) limit for the unit.
minP	0..1	ActivePower	Minimum active power limit. This is the minimum (nameplate) limit for the unit.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 475 shows all association ends of PowerElectronicsUnit with other classes.

Table 475 – Association ends of Production::PowerElectronicsUnit with other classes

mult from	name	mult to	type	description
0..*	PowerElectronicsConnection	1..1	PowerElectronicsConnection	A power electronics unit has a connection to the AC network.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.3.51 PowerElectronicsWindUnit

A wind generating unit that connects to the AC network with power electronics rather than rotating machines or an aggregation of such units.

Table 476 shows all attributes of PowerElectronicsWindUnit.

Table 476 – Attributes of Production::PowerElectronicsWindUnit

name	mult	type	description
maxP	0..1	ActivePower	inherited from: PowerElectronicsUnit
minP	0..1	ActivePower	inherited from: PowerElectronicsUnit
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 477 shows all association ends of PowerElectronicsWindUnit with other classes.

Table 477 – Association ends of Production::PowerElectronicsWindUnit with other classes

mult from	name	mult to	type	description
0..*	PowerElectronicsConnection	1..1	PowerElectronicsConnection	inherited from: PowerElectronicsUnit
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11 Package DC

6.11.1 General

This package contains model for direct current equipment and controls.

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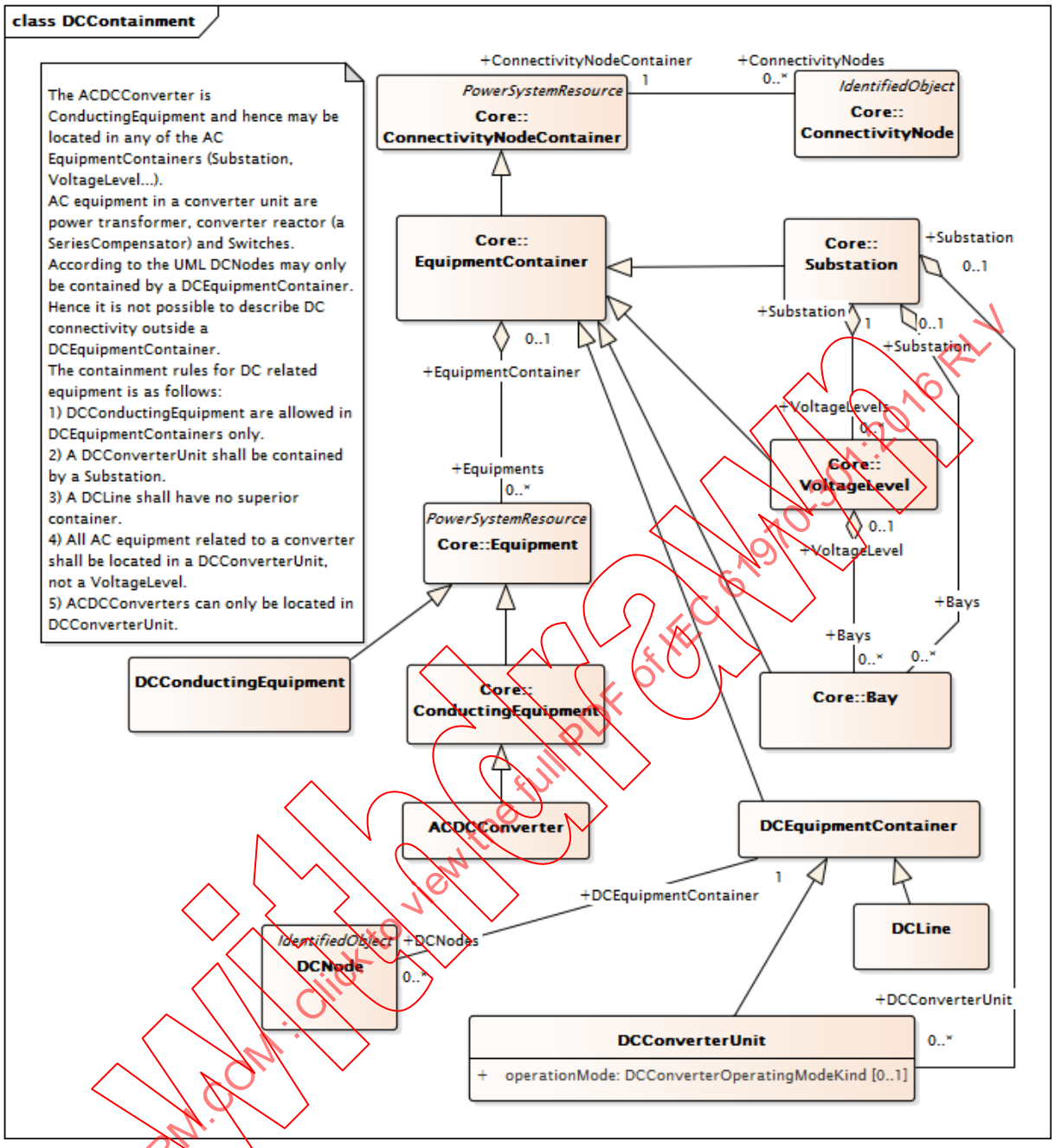


Figure 108 – Class diagram DC::DCContainment

Figure 108:

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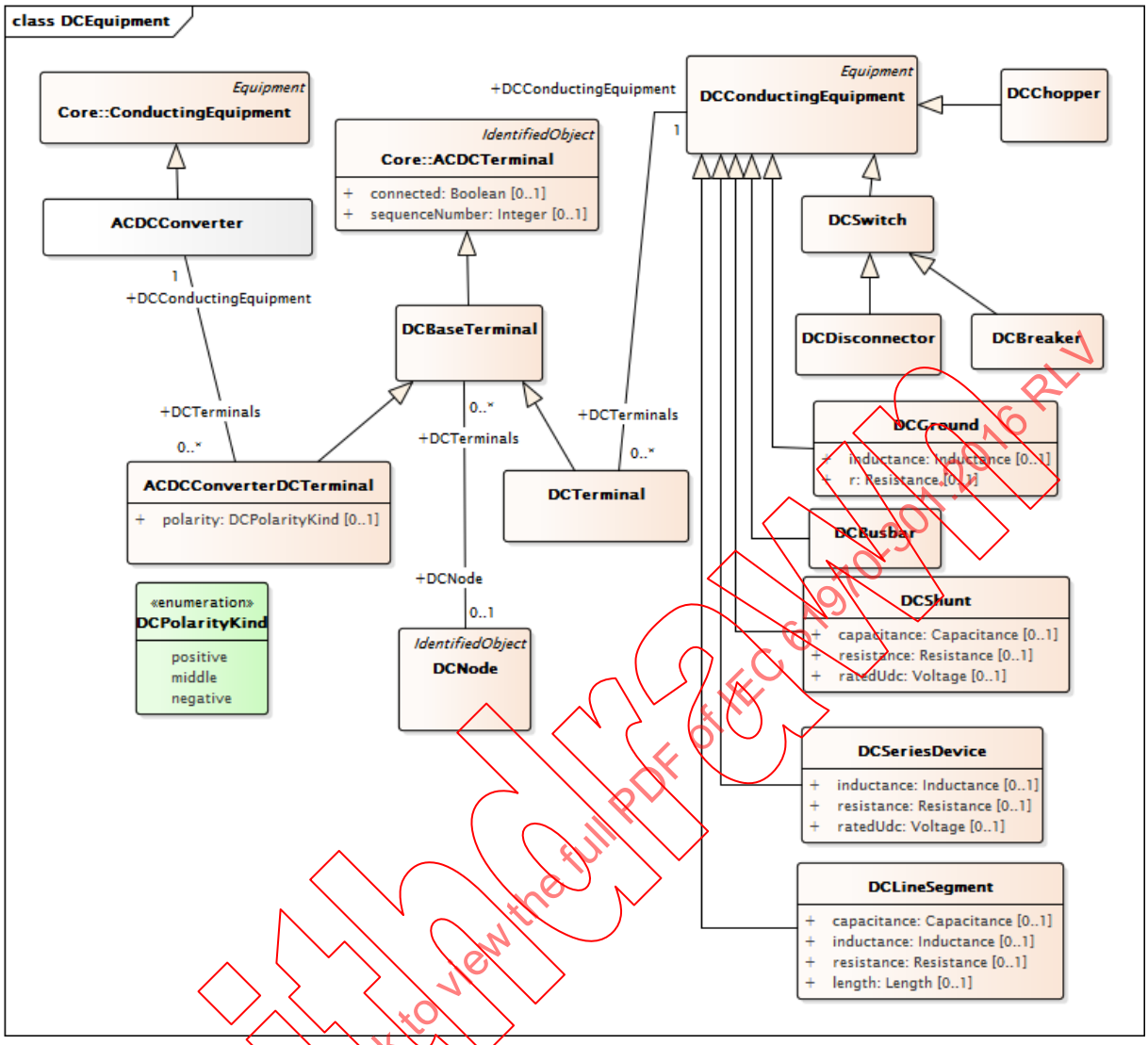


Figure 109 – Class diagram DC::DCEquipment

Figure 109:

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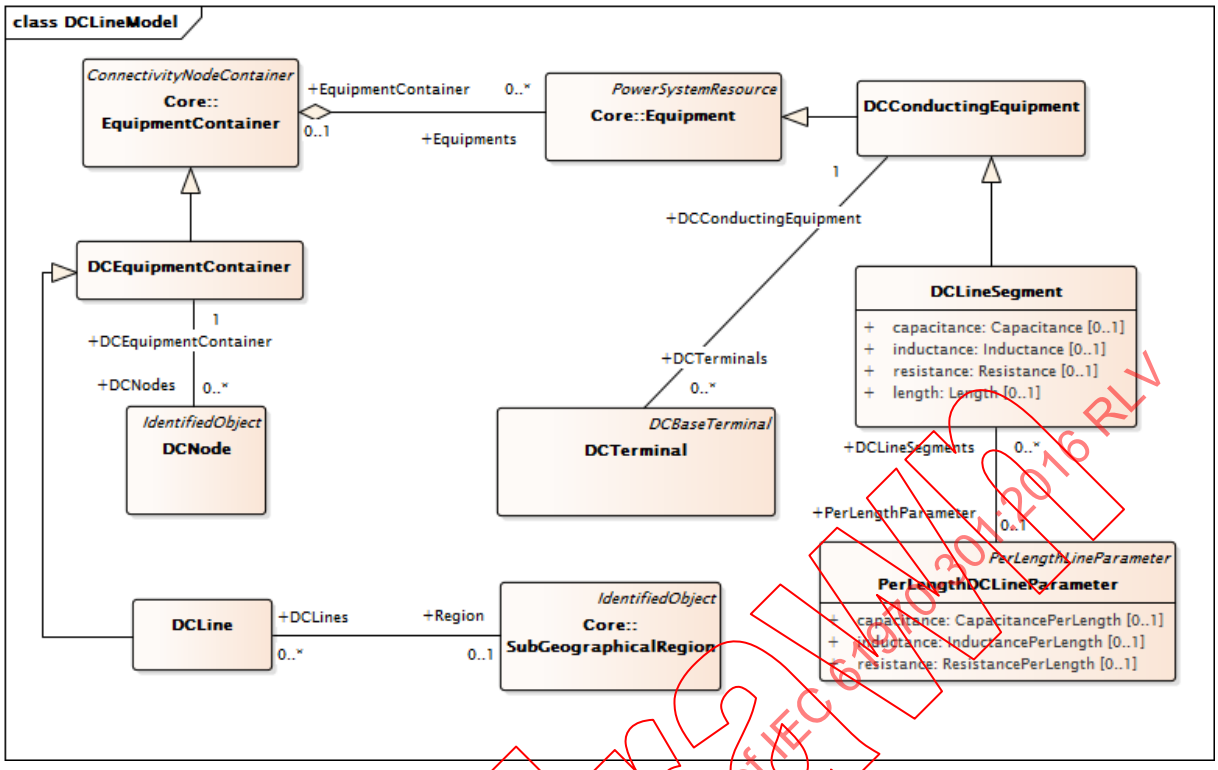
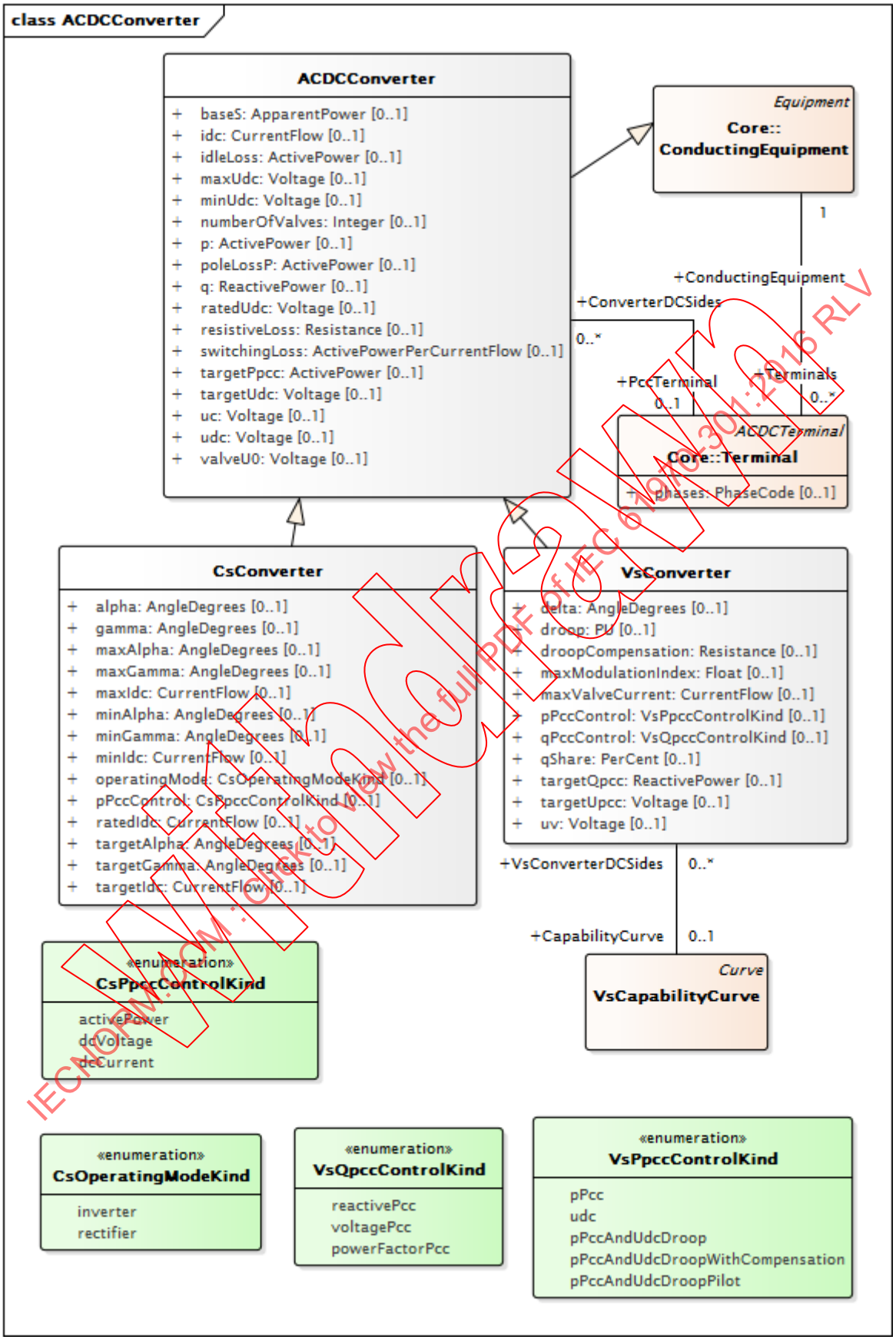


Figure 110 – Class diagram DC::DCLineModel

Figure 110:

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Figure 111 – Class diagram DC::ACDCConverter

Figure 111: This diagram shows classes used to model DC equipment.

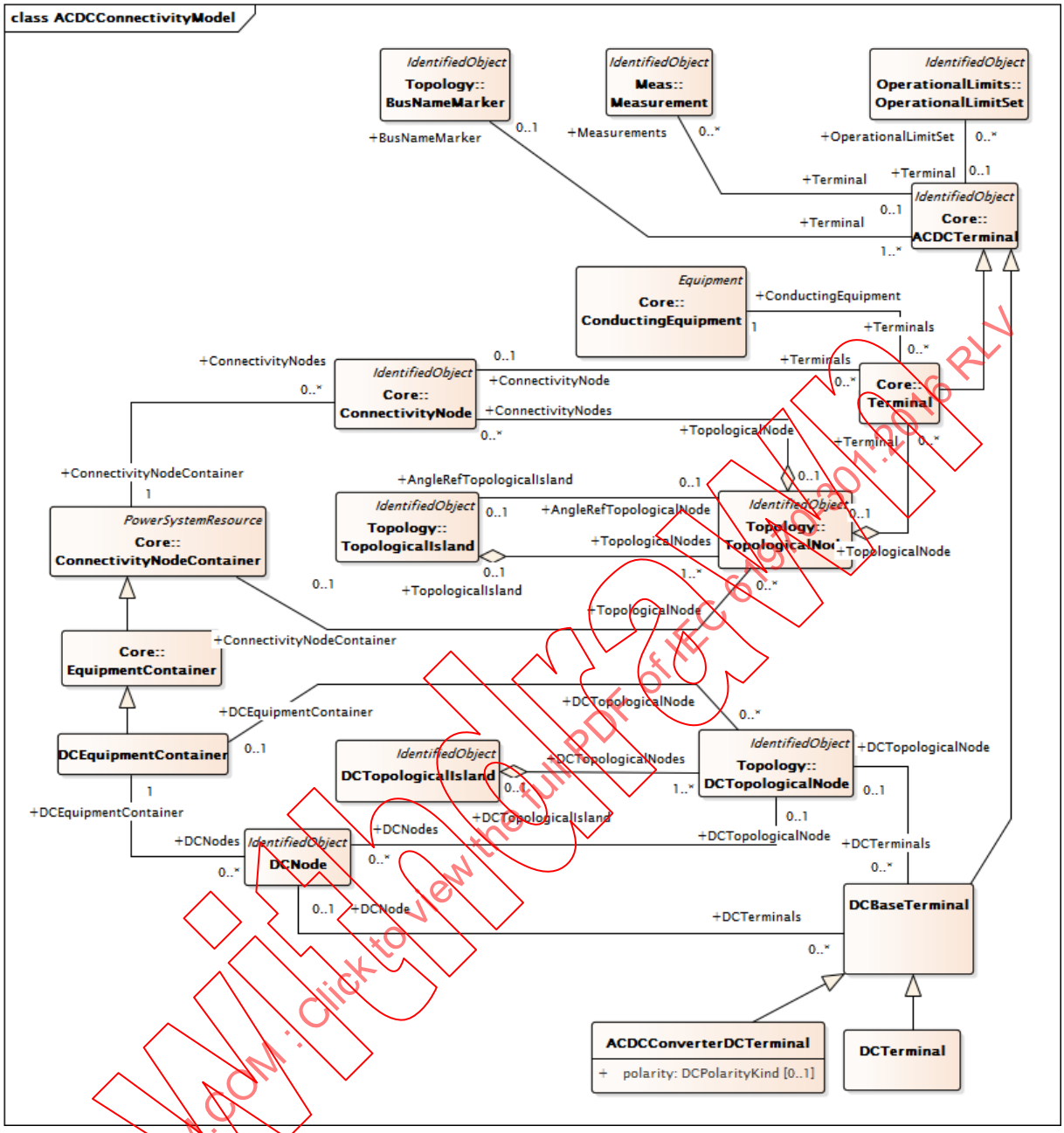


Figure 112 – Class diagram DC::ACDCConnectivityModel

Figure 112: This diagram shows connectivity and topology model for both AC and DC networks.

6.11.2 ACDCConverter

A unit with valves for three phases, together with unit control equipment, essential protective and switching devices, DC storage capacitors, phase reactors and auxiliaries, if any, used for conversion.

Table 478 shows all attributes of ACDCConverter.

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Table 478 – Attributes of DC::ACDCConverter

name	mult	type	description
baseS	0..1	ApparentPower	Base apparent power of the converter pole.
idc	0..1	CurrentFlow	Converter DC current, also called Id. Converter state variable, result from power flow.
idleLoss	0..1	ActivePower	Active power loss in pole at no power transfer. Converter configuration data used in power flow.
maxUdc	0..1	Voltage	The maximum voltage on the DC side at which the converter should operate. Converter configuration data used in power flow.
minUdc	0..1	Voltage	Minimum allowed converter DC voltage. Converter configuration data used in power flow.
numberOfValves	0..1	Integer	Number of valves in the converter. Used in loss calculations.
p	0..1	ActivePower	Active power at the point of common coupling. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution in the case a simplified power flow model is used.
poleLossP	0..1	ActivePower	The active power loss at a DC Pole = idleLoss + switchingLoss*|Idc| + resitiveLoss*Idc^2 For lossless operation Pdc=Pac For rectifier operation with losses Pdc=Pac-lossP For inverter operation with losses Pdc=Pac+lossP Converter state variable used in power flow.
q	0..1	ReactivePower	Reactive power at the point of common coupling. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution in the case a simplified power flow model is used.
ratedUdc	0..1	Voltage	Rated converter DC voltage, also called UdN. Converter configuration data used in power flow.
resistiveLoss	0..1	Resistance	Converter configuration data used in power flow. Refer to poleLossP.
switchingLoss	0..1	ActivePowerPerCurrentFlow	Switching losses, relative to the base apparent power 'baseS'. Refer to poleLossP.
targetPpcc	0..1	ActivePower	Real power injection target in AC grid, at point of common coupling.
targetUdc	0..1	Voltage	Target value for DC voltage magnitude.
uc	0..1	Voltage	Line-to-line converter voltage, the voltage at the AC side of the valve. Converter state variable, result from power flow.
udc	0..1	Voltage	Converter voltage at the DC side, also called Ud. Converter state variable, result from power flow.
valveU0	0..1	Voltage	Valve threshold voltage, also called Uvalve. Forward voltage drop when the valve is conducting. Used in loss calculations, i.e. the switchLoss depends on numberOfValves * valveU0.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 479 shows all association ends of ACDCConverter with other classes.

Table 479 – Association ends of DC::ACDCConverter with other classes

mult from	name	mult to	type	description
0..*	PccTerminal	0..1	Terminal	Point of common coupling terminal for this converter DC side. It is typically the terminal on the power transformer (or switch) closest to the AC network. The power flow measurement shall be the sum of all flows into the transformer.
1..1	DCTerminals	0..*	ACDCConverterDCTerminal	A DC converter have DC converter terminals. A converter has two DC converter terminals.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.3 ACDCConverterDCTerminal

A DC electrical connection point at the AC/DC converter. The AC/DC converter is electrically connected also to the AC side. The AC connection is inherited from the AC conducting equipment in the same way as any other AC equipment. The AC/DC converter DC terminal is separate from generic DC terminal to restrict the connection with the AC side to AC/DC converter and so that no other DC conducting equipment can be connected to the AC side.

Table 480 shows all attributes of ACDCConverterDCTerminal.

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Table 480 – Attributes of DC::ACDCConverterDCTerminal

name	mult	type	description
polarity	0..1	DCPolarityKind	Represents the normal network polarity condition.
connected	0..1	Boolean	inherited from: ACDCTerminal
sequenceNumber	0..1	Integer	inherited from: ACDCTerminal
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 481 shows all association ends of ACDCConverterDCTerminal with other classes.

Table 481 – Association ends of DC::ACDCConverterDCTerminal with other classes

mult from	name	mult to	type	description
0..*	DCConductingEquipment	1..1	ACDCConverter	A DC converter terminal belong to an DC converter.
0..*	DCTopologicalNode	0..1	DCTopologicalNode	inherited from: DCBaseTerminal
0..*	DCNode	0..1	DCNode	inherited from: DCBaseTerminal
1..*	BusNameMarker	0..1	BusNameMarker	inherited from: ACDCTerminal
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: ACDCTerminal
0..1	Measurements	0..*	Measurement	inherited from: ACDCTerminal
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.4 DCBaseTerminal

An electrical connection point at a piece of DC conducting equipment. DC terminals are connected at one physical DC node that may have multiple DC terminals connected. A DC node is similar to an AC connectivity node. The model enforces that DC connections are distinct from AC connections.

Table 482 shows all attributes of DCBaseTerminal.

Table 482 – Attributes of DC::DCBaseTerminal

name	mult	type	description
connected	0..1	Boolean	inherited from: ACDCTerminal
sequenceNumber	0..1	Integer	inherited from: ACDCTerminal
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 483 shows all association ends of DCBaseTerminal with other classes.

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Table 483 – Association ends of DC::DCBaseTerminal with other classes

mult from	name	mult to	type	description
0..*	DCTopologicalNode	0..1	DCTopologicalNode	The DC topological node associated with the DC base terminal.
0..*	DCNode	0..1	DCNode	The DC connectivity node to which this DC base terminal connects with zero impedance.
1..*	BusNameMarker	0..1	BusNameMarker	inherited from: ACDCTerminal
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: ACDCTerminal
0..1	Measurements	0..*	Measurement	inherited from: ACDCTerminal
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.5 DCConverterUnit

Indivisible operative unit comprising all equipment between the point of common coupling on the AC side and the point of common coupling – DC side, essentially one or more converters, together with one or more converter transformers, converter control equipment, essential protective and switching devices and auxiliaries, if any, used for conversion.

Table 484 shows all attributes of DCConverterUnit.

Table 484 – Attributes of DC::DCConverterUnit

name	mult	type	description
operationMode	0..1	DCConverterOperatingModeKind	
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 485 shows all association ends of DCConverterUnit with other classes.

Table 485 – Association ends of DC::DCConverterUnit with other classes

mult from	name	mult to	type	description
0..*	Substation	0..1	Substation	The containing substation of the DC converter unit.
0..1	DCTopologicalNode	0..*	DCTopologicalNode	inherited from: DCEquipmentContainer
1..1	DCNodes	0..*	DCNode	inherited from: DCEquipmentContainer
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.6 DCLine

Overhead lines and/or cables connecting two or more HVDC substations.

Table 486 shows all attributes of DCLine.

Table 486 – Attributes of DC::DCLine

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 487 shows all association ends of DCLine with other classes.

Table 487 – Association ends of DC::DCLine with other classes

mult from	name	mult to	type	description
0..*	Region	0..1	SubGeographicalRegion	The SubGeographicalRegion containing the DC line.
0..1	DCTopologicalNode	0..*	DCTopologicalNode	inherited from: DCEquipmentContainer
1..1	DCNodes	0..*	DCNode	inherited from: DCEquipmentContainer
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.7 DCSeriesDevice

A series device within the DC system, typically a reactor used for filtering or smoothing. Needed for transient and short circuit studies.

Table 488 shows all attributes of DCSeriesDevice.

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Table 488 – Attributes of DC::DCSeriesDevice

name	mult	type	description
inductance	0..1	Inductance	Inductance of the device.
resistance	0..1	Resistance	Resistance of the DC device.
ratedUdc	0..1	Voltage	Rated DC device voltage. Converter configuration data used in power flow.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 489 shows all association ends of DCSeriesDevice with other classes.

Table 489 – Association ends of DC::DCSeriesDevice with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.8 VsQpccControlKind enumeration

Table 490 shows all literals of VsQpccControlKind.

Table 490 – Literals of DC::VsQpccControlKind

literal	value	description
reactivePcc		
voltagePcc		
powerFactorPcc		

6.11.9 CsPpccControlKind enumeration

Active power control modes for HVDC line operating as Current Source Converter.

Table 491 shows all literals of CsPpccControlKind.

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Table 491 – Literals of DC::CsPpccControlKind

literal	value	description
activePower		Active power control at AC side.
dcVoltage		DC voltage control.
dcCurrent		DC current control

6.11.10 CsOperatingModeKind enumeration

Operating mode for HVDC line operating as Current Source Converter.

Table 492 shows all literals of CsOperatingModeKind.

Table 492 – Literals of DC::CsOperatingModeKind

literal	value	description
inverter		Operating as inverter.
rectifier		Operating as rectifier.

6.11.11 CsConverter

DC side of the current source converter (CSC).

Table 493 shows all attributes of CsConverter.

Table 493 – Attributes of DC::CsConverter

name	mult	type	description
alpha	0..1	AngleDegrees	Firing angle, typical value between 10 degrees and 18 degrees for a rectifier. CSC state variable, result from power flow.
gamma	0..1	AngleDegrees	Extinction angle. CSC state variable, result from power flow.
maxAlpha	0..1	AngleDegrees	Maximum firing angle. CSC configuration data used in power flow.
maxGamma	0..1	AngleDegrees	Maximum extinction angle. CSC configuration data used in power flow.
maxIdc	0..1	CurrentFlow	The maximum direct current (Id) on the DC side at which the converter should operate. Converter configuration data use in power flow.
minAlpha	0..1	AngleDegrees	Minimum firing angle. CSC configuration data used in power flow.
minGamma	0..1	AngleDegrees	Minimum extinction angle. CSC configuration data used in power flow.
minIdc	0..1	CurrentFlow	The minimum direct current (Id) on the DC side at which the converter should operate. CSC configuration data used in power flow.
operatingMode	0..1	CsOperatingModeKind	Indicates whether the DC pole is operating as an inverter or as a rectifier. CSC control variable used in power flow.
pPccControl	0..1	CsPpccControlKind	Kind of active power control.
ratedIdc	0..1	CurrentFlow	Rated converter DC current, also called IdN. Converter configuration data used in power flow.
targetAlpha	0..1	AngleDegrees	Target firing angle. CSC control variable used in power flow.

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name	mult	type	description
targetGamma	0..1	AngleDegrees	Target extinction angle. CSC control variable used in power flow.
targetIdc	0..1	CurrentFlow	DC current target value. CSC control variable used in power flow.
baseS	0..1	ApparentPower	inherited from: ACDCConverter
idc	0..1	CurrentFlow	inherited from: ACDCConverter
idleLoss	0..1	ActivePower	inherited from: ACDCConverter
maxUdc	0..1	Voltage	inherited from: ACDCConverter
minUdc	0..1	Voltage	inherited from: ACDCConverter
numberOfValves	0..1	Integer	inherited from: ACDCConverter
p	0..1	ActivePower	inherited from: ACDCConverter
poleLossP	0..1	ActivePower	inherited from: ACDCConverter
q	0..1	ReactivePower	inherited from: ACDCConverter
ratedUdc	0..1	Voltage	inherited from: ACDCConverter
resistiveLoss	0..1	Resistance	inherited from: ACDCConverter
switchingLoss	0..1	ActivePowerPerCurrentFlow	inherited from: ACDCConverter
targetPpcc	0..1	ActivePower	inherited from: ACDCConverter
targetUdc	0..1	Voltage	inherited from: ACDCConverter
uc	0..1	Voltage	inherited from: ACDCConverter
udc	0..1	Voltage	inherited from: ACDCConverter
valveU0	0..1	Voltage	inherited from: ACDCConverter
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 494 shows all association ends of CsConverter with other classes.

Table 494 – Association ends of DC::CsConverter with other classes

mult from	name	mult to	type	description
0..*	PccTerminal	0..1	Terminal	inherited from: ACDCConverter
1..1	DCTerminals	0..*	ACDCConverterDCTerminal	inherited from: ACDCConverter
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.12 DCBreaker

A breaker within a DC system.

Table 495 shows all attributes of DCBreaker.

Table 495 – Attributes of DC::DCBreaker

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 496 shows all association ends of DCBreaker with other classes.

Table 496 – Association ends of DC::DCBreaker with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.13 DCEquipmentContainer

A modeling construct to provide a root class for containment of DC as well as AC equipment. The class differs from the EquipmentContaner for AC in that it may also contain DCNodes. Hence it can contain both AC and DC equipment.

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Table 497 shows all attributes of DCEquipmentContainer.

Table 497 – Attributes of DC::DCEquipmentContainer

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 498 shows all association ends of DCEquipmentContainer with other classes.

Table 498 – Association ends of DC::DCEquipmentContainer with other classes

mult from	name	mult to	type	description
0..1	DCTopologicalNode	0..*	DCTopologicalNode	The topological nodes which belong to this connectivity node container.
1..1	DCNodes	0..*	DCNode	The DC nodes contained in the DC equipment container.
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.14 DCBusbar

A busbar within a DC system.

Table 499 shows all attributes of DCBusbar.

Table 499 – Attributes of DC::DCBusbar

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 500 shows all association ends of DCBusbar with other classes.

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Table 500 – Association ends of DC::DCBusbar with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.15 DCConverterOperatingModeKind enumeration

The operating mode of an HVDC bipole.

Table 501 shows all literals of DCConverterOperatingModeKind.

Table 501 – Literals of DC::DCConverterOperatingModeKind

literal	value	description
bipolar		Bipolar operation.
monopolarMetallicReturn		Monopolar operation with metallic return
monopolarGroundReturn		Monopolar operation with ground return

6.11.16 DCChopper

Low resistance equipment used in the internal DC circuit to balance voltages. It has typically positive and negative pole terminals and a ground.

Table 502 shows all attributes of DCChopper.

Table 502 – Attributes of DC::DCChopper

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 503 shows all association ends of DCChopper with other classes.

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Table 503 – Association ends of DC::DCChopper with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.17 DCDisconnector

A disconnector within a DC system.

Table 504 shows all attributes of DCDisconnector.

Table 504 – Attributes of DC::DCDisconnector

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 505 shows all association ends of DCDisconnector with other classes.

Table 505 – Association ends of DC::DCDisconnector with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.18 DCGround

A ground within a DC system.

Table 506 shows all attributes of DCGround.

Table 506 – Attributes of DC::DCGround

name	mult	type	description
inductance	0..1	Inductance	Inductance to ground.
r	0..1	Resistance	Resistance to ground.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 507 shows all association ends of DCGround with other classes.

Table 507 – Association ends of DC::DCGround with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.19 DCLineSegment

A wire or combination of wires not insulated from one another, with consistent electrical characteristics, used to carry direct current between points in the DC region of the power system.

Table 508 shows all attributes of DCLineSegment.

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Table 508 – Attributes of DC::DCLineSegment

name	mult	type	description
capacitance	0..1	Capacitance	Capacitance of the DC line segment. Significant for cables only.
inductance	0..1	Inductance	Inductance of the DC line segment. Negligible compared with DCSeriesDevice used for smoothing.
resistance	0..1	Resistance	Resistance of the DC line segment.
length	0..1	Length	Segment length for calculating line section capabilities.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 509 shows all association ends of DCLineSegment with other classes.

Table 509 – Association ends of DC::DCLineSegment with other classes

mult from	name	mult to	type	description
0..*	PerLengthParameter	0..1	PerLengthDCLineParameter	Set of per-length parameters for this line segment.
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.11.20 DCShunt

A shunt device within the DC system, typically used for filtering. Needed for transient and short circuit studies.

Table 510 shows all attributes of DCShunt.

Table 510 – Attributes of DC::DCShunt

name	mult	type	description
capacitance	0..1	Capacitance	Capacitance of the DC shunt.
resistance	0..1	Resistance	Resistance of the DC device.
ratedUdc	0..1	Voltage	Rated DC device voltage. Converter configuration data used in power flow.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 511 shows all association ends of DCShunt with other classes.

Table 511 – Association ends of DC::DCShunt with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.21 DCConductingEquipment

The parts of the DC power system that are designed to carry current or that are conductively connected through DC terminals.

Table 512 shows all attributes of DCConductingEquipment.

Table 512 – Attributes of DC::DCConductingEquipment

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 513 shows all association ends of DCConductingEquipment with other classes.

Table 513 – Association ends of DC::DCConductingEquipment with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	A DC conducting equipment has DC terminals.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.22 DCSwitch

A switch within the DC system.

Table 514 shows all attributes of DCSwitch.

Table 514 – Attributes of DC::DCSwitch

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 515 shows all association ends of DCSwitch with other classes.

Table 515 – Association ends of DC::DCSwitch with other classes

mult from	name	mult to	type	description
1..1	DCTerminals	0..*	DCTerminal	inherited from: DCConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.23 DCNode

DC nodes are points where terminals of DC conducting equipment are connected together with zero impedance.

Table 516 shows all attributes of DCNode.

Table 516 – Attributes of DC::DCNode

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 517 shows all association ends of DCNode with other classes.

Table 517 – Association ends of DC::DCNode with other classes

mult from	name	mult to	type	description
0..*	DCTopologicalNode	0..1	DCTopologicalNode	The DC topological node to which this DC connectivity node is assigned. May depend on the current state of switches in the network.
0..1	DCTerminals	0..*	DCBaseTerminal	DC base terminals interconnected with zero impedance at a this DC connectivity node.
0..*	DCEquipmentContainer	1..1	DCEquipmentContainer	The DC container for the DC nodes.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.24 DCTopologicalIsland

An electrically connected subset of the network. DC topological islands can change as the current network state changes, e.g. due to

– disconnect switches or breakers changing state in a SCADA/EMS,

– manual creation, change or deletion of topological nodes in a planning tool.

Table 518 shows all attributes of DCTopologicalIsland.

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Table 518 – Attributes of DC::DCTopologicalIsland

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 519 shows all association ends of DCTopologicalIsland with other classes.

Table 519 – Association ends of DC::DCTopologicalIsland with other classes

mult from	name	mult to	type	description
0..1	DCTopologicalNodes	1..*	DCTopologicalNode	The DC topological nodes in a DC topological island.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.25 DCPolarityKind enumeration

Polarity for DC circuits.

Table 520 shows all literals of DCPolarityKind.

Table 520 – Literals of DC::DCPolarityKind

literal	value	description
positive		Positive pole.
middle		Middle pole, potentially grounded.
negative		Negative pole.

6.11.26 PerLengthDCLineParameter

Table 521 shows all attributes of PerLengthDCLineParameter.

Table 521 – Attributes of DC::PerLengthDCLineParameter

name	mult	type	description
capacitance	0..1	CapacitancePerLength	Capacitance per unit of length of the DC line segment; significant for cables only.
inductance	0..1	InductancePerLength	Inductance per unit of length of the DC line segment.
resistance	0..1	ResistancePerLength	Resistance per length of the DC line segment.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 522 shows all association ends of PerLengthDCLineParameter with other classes.

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Table 522 – Association ends of DC::PerLengthDCLineParameter with other classes

mult from	name	mult to	type	description
0..1	DCLineSegments	0..*	DCLineSegment	All line segments described by this set of per-length parameters.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.27 DCTerminal

An electrical connection point to generic DC conducting equipment.

Table 523 shows all attributes of DCTerminal.

Table 523 – Attributes of DC::DCTerminal

name	mult	type	description
connected	0..1	Boolean	inherited from: ACDCTerminal
sequenceNumber	0..1	Integer	inherited from: ACDCTerminal
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 524 shows all association ends of DCTerminal with other classes.

Table 524 – Association ends of DC::DCTerminal with other classes

mult from	name	mult to	type	description
0..*	DCConductingEquipment	1..1	DCConductingEquipment	A DC terminal belonging to a DC conducting equipment.
0..*	DCTopologicalNode	0..1	DCTopologicalNode	inherited from: DCBaseTerminal
0..*	DCNode	0..1	DCNode	inherited from: DCBaseTerminal
1..*	BusNameMarker	0..1	BusNameMarker	inherited from: ACDCTerminal
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: ACDCTerminal
0..1	Measurements	0..*	Measurement	inherited from: ACDCTerminal
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.11.28 VsPpccControlKind enumeration

Types applicable to the control of real power and/or DC voltage by voltage source converter.

Table 525 shows all literals of VsPpccControlKind.

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Table 525 – Literals of DC::VsPpccControlKind

literal	value	description
pPcc		Control variable (target) is real power at PCC bus.
udc		Control variable (target) is DC voltage and real power at PCC bus is derived.
pPccAndUdcDroop		Control variables (targets) are both active power at point of common coupling and local DC voltage, with the droop.
pPccAndUdcDroopWithCompensation		Control variables (targets) are both active power at point of common coupling and compensated DC voltage, with the droop, compensation factor is the resistance, as an approximation of the DC voltage of a common (real or virtual) node in the DC network.
pPccAndUdcDroopPilot		Control variables (targets) are both active power at point of common coupling and the pilot DC voltage, with the droop.

6.11.29 VsCapabilityCurve

The *P*-*Q* capability curve for a voltage source converter, with *P* on X-axis and *Q*min and *Q*max on Y1-axis and Y2-axis.

Table 526 shows all attributes of VsCapabilityCurve.

Table 526 – Attributes of DC::VsCapabilityCurve

name	mult	type	description
curveStyle	0..1	CurveStyle	inherited from: Curve
xMultiplier	0..1	UnitMultiplier	inherited from: Curve
xUnit	0..1	UnitSymbol	inherited from: Curve
y1Multiplier	0..1	UnitMultiplier	inherited from: Curve
y1Unit	0..1	UnitSymbol	inherited from: Curve
y2Multiplier	0..1	UnitMultiplier	inherited from: Curve
y2Unit	0..1	UnitSymbol	inherited from: Curve
y3Multiplier	0..1	UnitMultiplier	inherited from: Curve
y3Unit	0..1	UnitSymbol	inherited from: Curve
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 527 shows all association ends of VsCapabilityCurve with other classes.

Table 527 – Association ends of DC::VsCapabilityCurve with other classes

mult from	name	mult to	type	description
0..1	VsConverterDCSides	0..*	VsConverter	All converters with this capability curve.
1..1	CurveDatas	0..*	CurveData	inherited from: Curve
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.11.30 VsConverter

DC side of the voltage source converter (VSC).

Table 528 shows all attributes of VsConverter.

Table 528 – Attributes of DC::VsConverter

name	mult	type	description
delta	0..1	AngleDegrees	Angle between uf and uc. Converter state variable used in power flow.
droop	0..1	PU	Droop constant; pu value is obtained as D [kV/MW] * Sb / Ubdc.
droopCompensation	0..1	Resistance	Compensation constant. Used to compensate for voltage drop when controlling voltage at a distant bus.
maxModulationIndex	0..1	Float	The maximum quotient between the AC converter voltage (Uc) and DC voltage (Ud). A factor typically less than 1. VSC configuration data used in power flow.
maxValveCurrent	0..1	CurrentFlow	The maximum current through a valve. This current limit is the basis for calculating the capability diagram. VSC configuration data.
pPccControl	0..1	VsPpccControlKind	Kind of active power control.
qPccControl	0..1	VsQpccControlKind	Kind of reactive power control.
qShare	0..1	PerCent	Reactive power sharing factor among parallel converters on Uac control.
targetQpcc	0..1	ReactivePower	Reactive power injection target in AC grid, at point of common coupling.
targetUpcc	0..1	Voltage	Voltage target in AC grid, at point of common coupling.
uv	0..1	Voltage	Line-to-line voltage on the valve side of the converter transformer. Converter state variable, result from power flow.
baseS	0..1	ApparentPower	inherited from: ACDCConverter
idc	0..1	CurrentFlow	inherited from: ACDCConverter
idleLoss	0..1	ActivePower	inherited from: ACDCConverter
maxUdc	0..1	Voltage	inherited from: ACDCConverter
minUdc	0..1	Voltage	inherited from: ACDCConverter
numberOfValves	0..1	Integer	inherited from: ACDCConverter
p	0..1	ActivePower	inherited from: ACDCConverter
poleLossP	0..1	ActivePower	inherited from: ACDCConverter
q	0..1	ReactivePower	inherited from: ACDCConverter
ratedUdc	0..1	Voltage	inherited from: ACDCConverter
resistiveLoss	0..1	Resistance	inherited from: ACDCConverter
switchingLoss	0..1	ActivePowerPerCurrentFlow	inherited from: ACDCConverter
targetPpcc	0..1	ActivePower	inherited from: ACDCConverter
targetUdc	0..1	Voltage	inherited from: ACDCConverter
uc	0..1	Voltage	inherited from: ACDCConverter
udc	0..1	Voltage	inherited from: ACDCConverter
valveU0	0..1	Voltage	inherited from: ACDCConverter
aggregate	0..1	Boolean	inherited from: Equipment

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name	mult	type	description
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 529 shows all association ends of VsConverter with other classes.

Table 529 – Association ends of DC::VsConverter with other classes

mult from	name	mult to	type	description
0..*	CapabilityCurve	0..1	VsCapabilityCurve	Capability curve of this converter.
0..*	PccTerminal	0..1	Terminal	inherited from: ACDCConverter
1..1	DCTerminals	0..*	ACDCConverterDCTerminal	inherited from: ACDCConverter
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.12 Package LoadModel

6.12.1 General

This package is responsible for modeling the energy consumers and the system load as curves and associated curve data. Special circumstances that may affect the load, such as seasons and daytypes, are also included here.

This information is used by Load Forecasting and Load Management.

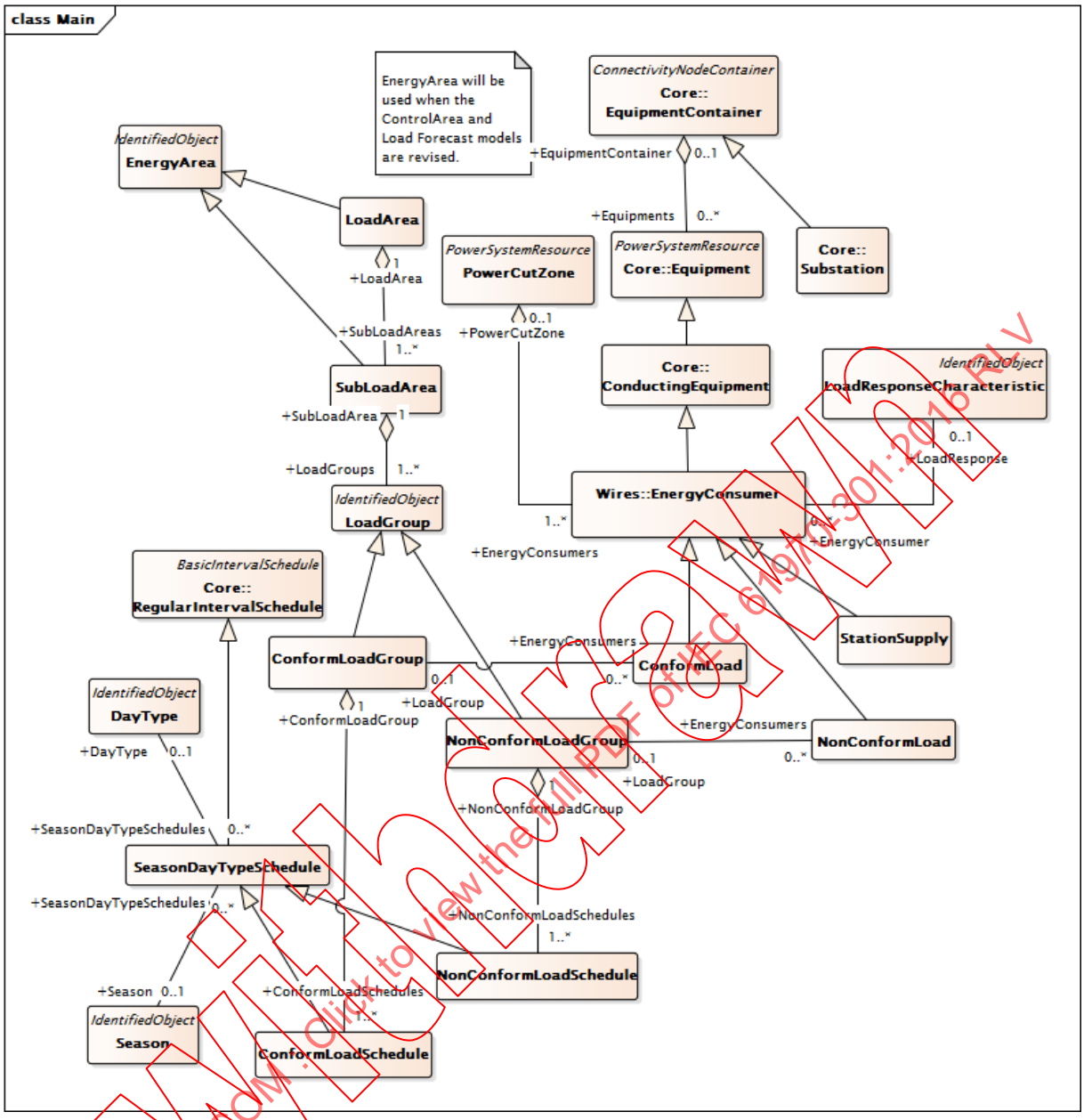


Figure 113 – Class diagram LoadModel::Main

Figure 113: This diagram shows all classes included in the LoadModel package as well as the key external classes that have associations with LoadModel classes.

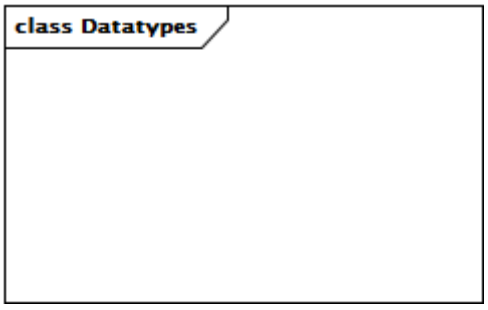


Figure 114 – Class diagram LoadModel::Datatypes

Figure 114: Shows datatypes for load model.

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6.12.2 ConformLoad

ConformLoad represent loads that follow a daily load change pattern where the pattern can be used to scale the load with a system load.

Table 530 shows all attributes of ConformLoad.

Table 530 – Attributes of LoadModel::ConformLoad

name	mult	type	description
customerCount	0..1	Integer	inherited from: EnergyConsumer
grounded	0..1	Boolean	inherited from: EnergyConsumer
pfixed	0..1	ActivePower	inherited from: EnergyConsumer
pfixedPct	0..1	PerCent	inherited from: EnergyConsumer
phaseConnection	0..1	PhaseShuntConnectionKind	inherited from: EnergyConsumer
qfixed	0..1	ReactivePower	inherited from: EnergyConsumer
qfixedPct	0..1	PerCent	inherited from: EnergyConsumer
p	0..1	ActivePower	inherited from: EnergyConsumer
q	0..1	ReactivePower	inherited from: EnergyConsumer
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 531 shows all association ends of ConformLoad with other classes.

Table 531 – Association ends of LoadModel::ConformLoad with other classes

mult from	name	mult to	type	description
0..*	LoadGroup	0..1	ConformLoadGroup	Group of this ConformLoad.
1..1	EnergyConsumerPhase	0..*	EnergyConsumerPhase	inherited from: EnergyConsumer
0..*	LoadResponse	0..1	LoadResponseCharacteristic	inherited from: EnergyConsumer
1..*	PowerCutZone	0..1	PowerCutZone	inherited from: EnergyConsumer
0..*	LoadDynamics	0..1	LoadDynamics	inherited from: EnergyConsumer
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.3 ConformLoadGroup

A group of loads conforming to an allocation pattern.

Table 532 shows all attributes of ConformLoadGroup.

Table 532 – Attributes of LoadModel::ConformLoadGroup

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 533 shows all association ends of ConformLoadGroup with other classes.

Table 533 – Association ends of LoadModel::ConformLoadGroup with other classes

mult from	name	mult to	type	description
0..1	EnergyConsumers	0..*	ConformLoad	Conform loads assigned to this ConformLoadGroup.
1..1	ConformLoadSchedules	1..*	ConformLoadSchedule	The ConformLoadSchedules in the ConformLoadGroup.
1..*	SubLoadArea	1..1	SubLoadArea	inherited from: LoadGroup
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.4 ConformLoadSchedule

A curve of load versus time (X-axis) showing the active power values (Y1-axis) and reactive power (Y2-axis) for each unit of the period covered. This curve represents a typical pattern of load over the time period for a given day type and season.

Table 534 shows all attributes of ConformLoadSchedule.

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Table 534 – Attributes of LoadModel::ConformLoadSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 535 shows all association ends of ConformLoadSchedule with other classes.

Table 535 – Association ends of LoadModel::ConformLoadSchedule with other classes

mult from	name	mult to	type	description
1..*	ConformLoadGroup	1..1	ConformLoadGroup	The ConformLoadGroup where the ConformLoadSchedule belongs.
0..*	DayType	0..1	DayType	inherited from: SeasonDayTypeSchedule
0..*	Season	0..1	Season	inherited from: SeasonDayTypeSchedule
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.5 DayType

Group of similar days. For example it could be used to represent weekdays, weekend, or holidays.

Table 536 shows all attributes of DayType.

Table 536 – Attributes of LoadModel::DayType

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 537 shows all association ends of DayType with other classes.

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Table 537 – Association ends of LoadModel::DayType with other classes

mult from	name	mult to	type	description
0..1	SeasonDayTypeSchedules	0..*	SeasonDayTypeSchedule	Schedules that use this DayType.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.6 EnergyArea

Describes an area having energy production or consumption. Specializations are intended to support the load allocation function as typically required in energy management systems or planning studies to allocate hypothesized load levels to individual load points for power flow analysis. Often the energy area can be linked to both measured and forecast load levels.

Table 538 shows all attributes of EnergyArea.

Table 538 – Attributes of LoadModel::EnergyArea

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 539 shows all association ends of EnergyArea with other classes.

Table 539 – Association ends of LoadModel::EnergyArea with other classes

mult from	name	mult to	type	description
0..1	ControlArea	0..1	ControlArea	The control area specification that is used for the load forecast.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.7 LoadArea

The class is the root or first level in a hierarchical structure for grouping of loads for the purpose of load flow load scaling.

Table 540 shows all attributes of LoadArea.

Table 540 – Attributes of LoadModel::LoadArea

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 541 shows all association ends of LoadArea with other classes.

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Table 541 – Association ends of LoadModel::LoadArea with other classes

mult from	name	mult to	type	description
1..1	SubLoadAreas	1..*	SubLoadArea	The SubLoadAreas in the LoadArea.
0..1	ControlArea	0..1	ControlArea	inherited from: EnergyArea
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.8 LoadGroup

The class is the third level in a hierarchical structure for grouping of loads for the purpose of load flow load scaling.

Table 542 shows all attributes of LoadGroup.

Table 542 – Attributes of LoadModel::LoadGroup

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 543 shows all association ends of LoadGroup with other classes.

Table 543 – Association ends of LoadModel::LoadGroup with other classes

mult from	name	mult to	type	description
1..*	SubLoadArea	1..1	SubLoadArea	The SubLoadArea where the Loadgroup belongs.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.9 LoadResponseCharacteristic

Models the characteristic response of the load demand due to changes in system conditions such as voltage and frequency. This is not related to demand response.

If LoadResponseCharacteristic.exponentModel is True, the voltage exponents are specified and used to calculate:

Active power component = Pnominal * (Voltage/cim:BaseVoltage.nominalVoltage) ** cim:LoadResponseCharacteristic.pVoltageExponent

Reactive power component = Qnominal * (Voltage/cim:BaseVoltage.nominalVoltage) ** cim:LoadResponseCharacteristic.qVoltageExponent

where * means "multiply" and ** is "raised to power of".

Table 544 shows all attributes of LoadResponseCharacteristic.

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Table 544 – Attributes of LoadModel::LoadResponseCharacteristic

name	mult	type	description
exponentModel	0..1	Boolean	Indicates the exponential voltage dependency model is to be used. If false, the coefficient model is to be used. The exponential voltage dependency model consist of the attributes - pVoltageExponent - qVoltageExponent. The coefficient model consist of the attributes - pConstantImpedance - pConstantCurrent - pConstantPower - qConstantImpedance - qConstantCurrent - qConstantPower. The sum of pConstantImpedance, pConstantCurrent and pConstantPower shall equal 1. The sum of qConstantImpedance, qConstantCurrent and qConstantPower shall equal 1.
pConstantCurrent	0..1	Float	Portion of active power load modeled as constant current.
pConstantImpedance	0..1	Float	Portion of active power load modeled as constant impedance.
pConstantPower	0..1	Float	Portion of active power load modeled as constant power.
pFrequencyExponent	0..1	Float	Exponent of per unit frequency effecting active power.
pVoltageExponent	0..1	Float	Exponent of per unit voltage effecting real power.
qConstantCurrent	0..1	Float	Portion of reactive power load modeled as constant current.
qConstantImpedance	0..1	Float	Portion of reactive power load modeled as constant impedance.
qConstantPower	0..1	Float	Portion of reactive power load modeled as constant power.
qFrequencyExponent	0..1	Float	Exponent of per unit frequency effecting reactive power.
qVoltageExponent	0..1	Float	Exponent of per unit voltage effecting reactive power.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 545 shows all association ends of LoadResponseCharacteristic with other classes.

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Table 545 – Association ends of LoadModel::LoadResponseCharacteristic with other classes

mult from	name	mult to	type	description
0..1	EnergyConsumer	0..*	EnergyConsumer	The set of loads that have the response characteristics.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.10 NonConformLoad

NonConformLoad represent loads that do not follow a daily load change pattern and changes are not correlated with the daily load change pattern.

Table 546 shows all attributes of NonConformLoad.

Table 546 – Attributes of LoadModel::NonConformLoad

name	mult	type	description
customerCount	0..1	Integer	inherited from: EnergyConsumer
grounded	0..1	Boolean	inherited from: EnergyConsumer
pfixed	0..1	ActivePower	inherited from: EnergyConsumer
pfixedPct	0..1	PerCent	inherited from: EnergyConsumer
phaseConnection	0..1	PhaseShuntConnectionKind	inherited from: EnergyConsumer
qfixed	0..1	ReactivePower	inherited from: EnergyConsumer
qfixedPct	0..1	PerCent	inherited from: EnergyConsumer
p	0..1	ActivePower	inherited from: EnergyConsumer
q	0..1	ReactivePower	inherited from: EnergyConsumer
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 547 shows all association ends of NonConformLoad with other classes.

Table 547 – Association ends of LoadModel::NonConformLoad with other classes

mult from	name	mult to	type	description
0..*	LoadGroup	0..1	NonConformLoadGroup	Group of this ConformLoad.
1..1	EnergyConsumerPhase	0..*	EnergyConsumerPhase	inherited from: EnergyConsumer
0..*	LoadResponse	0..1	LoadResponseCharacteristic	inherited from: EnergyConsumer
1..*	PowerCutZone	0..1	PowerCutZone	inherited from: EnergyConsumer
0..*	LoadDynamics	0..1	LoadDynamics	inherited from: EnergyConsumer
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment

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mult from	name	mult to	type	description
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.11 NonConformLoadGroup

Loads that do not follow a daily and seasonal load variation pattern.

Table 548 shows all attributes of NonConformLoadGroup.

Table 548 – Attributes of LoadModel::NonConformLoadGroup

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 549 shows all association ends of NonConformLoadGroup with other classes.

Table 549 – Association ends of LoadModel::NonConformLoadGroup with other classes

mult from	name	mult to	type	description
0..1	EnergyConsumers	0..*	NonConformLoad	Conform loads assigned to this ConformLoadGroup.
1..1	NonConformLoadSchedules	1..*	NonConformLoadSchedule	The NonConformLoadSchedules in the NonConformLoadGroup.
1..*	SubLoadArea	1..1	SubLoadArea	inherited from: LoadGroup
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.12 NonConformLoadSchedule

An active power (Y1-axis) and reactive power (Y2-axis) schedule (curves) versus time (X-axis) for non-conforming loads, e.g. large industrial load or power station service (where modeled).

Table 550 shows all attributes of NonConformLoadSchedule.

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Table 550 – Attributes of LoadModel::NonConformLoadSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 551 shows all association ends of NonConformLoadSchedule with other classes.

Table 551 – Association ends of LoadModel::NonConformLoadSchedule with other classes

mult from	name	mult to	type	description
1..*	NonConformLoadGroup	1..1	NonConformLoadGroup	The NonConformLoadGroup where the NonConformLoadSchedule belongs.
0..*	DayType	0..1	DayType	inherited from: SeasonDayTypeSchedule
0..*	Season	0..1	Season	inherited from: SeasonDayTypeSchedule
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.13 PowerCutZone

An area or zone of the power system which is used for load shedding purposes.

Table 552 shows all attributes of PowerCutZone.

Table 552 – Attributes of LoadModel::PowerCutZone

name	mult	type	description
cutLevel1	0..1	PerCent	First level (amount) of load to cut as a percentage of total zone load.
cutLevel2	0..1	PerCent	Second level (amount) of load to cut as a percentage of total zone load.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 553 shows all association ends of PowerCutZone with other classes.

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Table 553 – Association ends of LoadModel::PowerCutZone with other classes

mult from	name	mult to	type	description
0..1	EnergyConsumers	1..*	EnergyConsumer	Energy consumer is assigned to the power cut zone.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.14 Season

A specified time period of the year.

Table 554 shows all attributes of Season.

Table 554 – Attributes of LoadModel::Season

name	mult	type	description
endDate	0..1	MonthDay	Date season ends.
startDate	0..1	MonthDay	Date season starts.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 555 shows all association ends of Season with other classes.

Table 555 – Association ends of LoadModel::Season with other classes

mult from	name	mult to	type	description
0..1	SeasonDayTypeSchedules	0..*	SeasonDayTypeSchedule	Schedules that use this Season.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.15 SeasonDayTypeSchedule

A time schedule covering a 24 hour period, with curve data for a specific type of season and day.

Table 556 shows all attributes of SeasonDayTypeSchedule.

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Table 556 – Attributes of LoadModel::SeasonDayTypeSchedule

name	mult	type	description
endTime	0..1	DateTime	inherited from: RegularIntervalSchedule
timeStep	0..1	Seconds	inherited from: RegularIntervalSchedule
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 557 shows all association ends of SeasonDayTypeSchedule with other classes.

Table 557 – Association ends of LoadModel::SeasonDayTypeSchedule with other classes

mult from	name	mult to	type	description
0..*	DayType	0..1	DayType	DayType for the Schedule.
0..*	Season	0..1	Season	Season for the Schedule.
1..1	TimePoints	1..*	RegularTimePoint	inherited from: RegularIntervalSchedule
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.16 StationSupply

Station supply with load derived from the station output.

Table 558 shows all attributes of StationSupply.

Table 558 – Attributes of LoadModel::StationSupply

name	mult	type	description
customerCount	0..1	Integer	inherited from: EnergyConsumer
grounded	0..1	Boolean	inherited from: EnergyConsumer
pfixed	0..1	ActivePower	inherited from: EnergyConsumer
pfixedPct	0..1	PerCent	inherited from: EnergyConsumer
phaseConnection	0..1	PhaseShuntConnectionKind	inherited from: EnergyConsumer
qfixed	0..1	ReactivePower	inherited from: EnergyConsumer
qfixedPct	0..1	PerCent	inherited from: EnergyConsumer
p	0..1	ActivePower	inherited from: EnergyConsumer
q	0..1	ReactivePower	inherited from: EnergyConsumer
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment

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name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 559 shows all association ends of StationSupply with other classes.

Table 559 – Association ends of LoadModel::StationSupply with other classes

mult from	name	mult to	type	description
1..1	EnergyConsumerPhase	0..*	EnergyConsumerPhase	inherited from: EnergyConsumer
0..*	LoadResponse	0..1	LoadResponseCharacteristic	inherited from: EnergyConsumer
1..*	PowerCutZone	0..1	PowerCutZone	inherited from: EnergyConsumer
0..*	LoadDynamics	0..1	LoadDynamics	inherited from: EnergyConsumer
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.12.17 SubLoadArea

The class is the second level in a hierarchical structure for grouping of loads for the purpose of load flow load scaling.

Table 560 shows all attributes of SubLoadArea.

Table 560 – Attributes of LoadModel::SubLoadArea

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 561 shows all association ends of SubLoadArea with other classes.

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Table 561 – Association ends of LoadModel::SubLoadArea with other classes

mult from	name	mult to	type	description
1..1	LoadGroups	1..*	LoadGroup	The Loadgroups in the SubLoadArea.
1..*	LoadArea	1..1	LoadArea	The LoadArea where the SubLoadArea belongs.
0..1	ControlArea	0..1	ControlArea	inherited from: EnergyArea
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.13 Package AuxiliaryEquipment

6.13.1 General

Contains equipment which is not normal conducting equipment such as sensors, fault locators, and surge protectors. These devices do not define power carrying topological connections as conducting equipment, but are associated to terminals of other conducting equipment.

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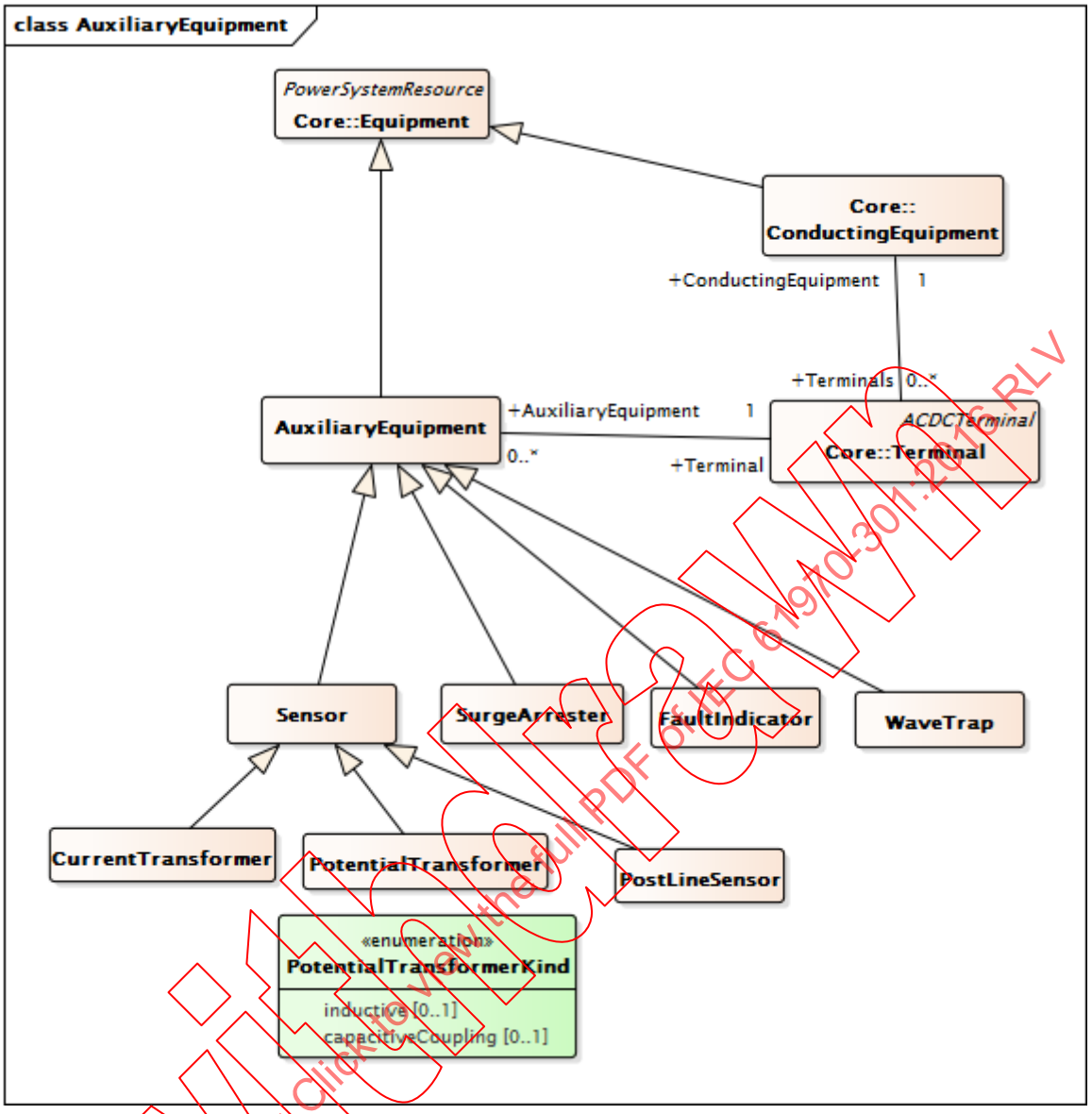


Figure 115 – Class diagram AuxiliaryEquipment::AuxiliaryEquipment

Figure 115: Inheritance and associations for auxiliary equipment.

6.13.2 AuxiliaryEquipment

AuxiliaryEquipment describes equipment that is not performing any primary functions but support for the equipment performing the primary function.

AuxiliaryEquipment is attached to primary eqipment via an association with Terminal.

Table 562 shows all attributes of AuxiliaryEquipment.

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Table 562 – Attributes of AuxiliaryEquipment::AuxiliaryEquipment

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 563 shows all association ends of AuxiliaryEquipment with other classes.

Table 563 – Association ends of AuxiliaryEquipment::AuxiliaryEquipment with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	The Terminal at the equipment where the AuxiliaryEquipment is attached.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.13.3 CurrentTransformer

Instrument transformer used to measure electrical qualities of the circuit that is being protected and/or monitored. Typically used as current transducer for the purpose of metering or protection. A typical secondary current rating would be 5 A.

Table 564 shows all attributes of CurrentTransformer.

Table 564 – Attributes of AuxiliaryEquipment::CurrentTransformer

name	mult	type	description
accuracyClass	0..1	String	CT accuracy classification.
accuracyLimit	0..1	PerCent	Percent of rated current for which the CT remains accurate within specified limits.
ctClass	0..1	String	CT classification; i.e. class 10P.
usage	0..1	String	Intended usage of the CT; i.e. metering, protection.
coreBurden	0..1	ActivePower	Power burden of the CT core.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment

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name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 565 shows all association ends of CurrentTransformer with other classes.

Table 565 – Association ends of AuxiliaryEquipment::CurrentTransformer with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.13.4 FaultIndicator

A FaultIndicator is typically only an indicator (which may or may not be remotely monitored), and not a piece of equipment that actually initiates a protection event. It is used for FLISR (Fault Location, Isolation and Restoration) purposes, assisting with the dispatch of crews to "most likely" part of the network (i.e. assists with determining circuit section where the fault most likely happened).

Table 566 shows all attributes of FaultIndicator.

Table 566 – Attributes of AuxiliaryEquipment::FaultIndicator

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 567 shows all association ends of FaultIndicator with other classes.

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Table 567 – Association ends of AuxiliaryEquipment::FaultIndicator with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.13.5 PostLineSensor

A sensor used mainly in overhead distribution networks as the source of both current and voltage measurements.

Table 568 shows all attributes of PostLineSensor.

Table 568 – Attributes of AuxiliaryEquipment::PostLineSensor

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 569 shows all association ends of PostLineSensor with other classes.

Table 569 – Association ends of AuxiliaryEquipment::PostLineSensor with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.13.6 PotentialTransformer

Instrument transformer (also known as Voltage Transformer) used to measure electrical qualities of the circuit that is being protected and/or monitored. Typically used as voltage transducer for the purpose of metering, protection, or sometimes auxiliary substation supply. A typical secondary voltage rating would be 120 V.

Table 570 shows all attributes of PotentialTransformer.

Table 570 – Attributes of AuxiliaryEquipment::PotentialTransformer

name	mult	type	description
accuracyClass	0..1	String	PT accuracy classification.
nominalRatio	0..1	Float	Nominal ratio between the primary and secondary voltage.
ptClass	0..1	String	Potential transformer (PT) classification covering burden.
type	0..1	PotentialTransformerKind	Potential transformer construction type.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 571 shows all association ends of PotentialTransformer with other classes.

Table 571 – Association ends of AuxiliaryEquipment::PotentialTransformer with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.13.7 PotentialTransformerKind enumeration

The construction kind of the potential transformer.

Table 572 shows all literals of PotentialTransformerKind.

Table 572 – Literals of AuxiliaryEquipment::PotentialTransformerKind

literal	value	description
inductive		The potential transformer is using induction coils to create secondary voltage.
capacitiveCoupling		The potential transformer is using capacitive coupling to create secondary voltage.

6.13.8 Sensor

This class describes devices that transform a measured quantity into signals that can be presented at displays, used in control or be recorded.

Table 573 shows all attributes of Sensor.

Table 573 – Attributes of AuxiliaryEquipment::Sensor

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 574 shows all association ends of Sensor with other classes.

Table 574 – Association ends of AuxiliaryEquipment::Sensor with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.13.9 SurgeArrester

Shunt device, installed on the network, usually in the proximity of electrical equipment in order to protect the said equipment against transient voltage transients caused by lightning or switching activity.

Table 575 shows all attributes of SurgeArrester.

Table 575 – Attributes of AuxiliaryEquipment::SurgeArrester

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 576 shows all association ends of SurgeArrester with other classes.

Table 576 – Association ends of AuxiliaryEquipment::SurgeArrester with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.13.10 WaveTrap

Line traps are devices that impede high frequency power line carrier signals yet present a negligible impedance at the main power frequency.

Table 577 shows all attributes of WaveTrap.

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Table 577 – Attributes of AuxiliaryEquipment::WaveTrap

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 578 shows all association ends of WaveTrap with other classes.

Table 578 – Association ends of AuxiliaryEquipment::WaveTrap with other classes

mult from	name	mult to	type	description
0..*	Terminal	1..1	Terminal	inherited from: AuxiliaryEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.14 Package Protection

6.14.1 General

An extension to the Core and Wires packages that models information for protection equipment such as relays. These entities are used within training simulators and distribution network fault location applications.

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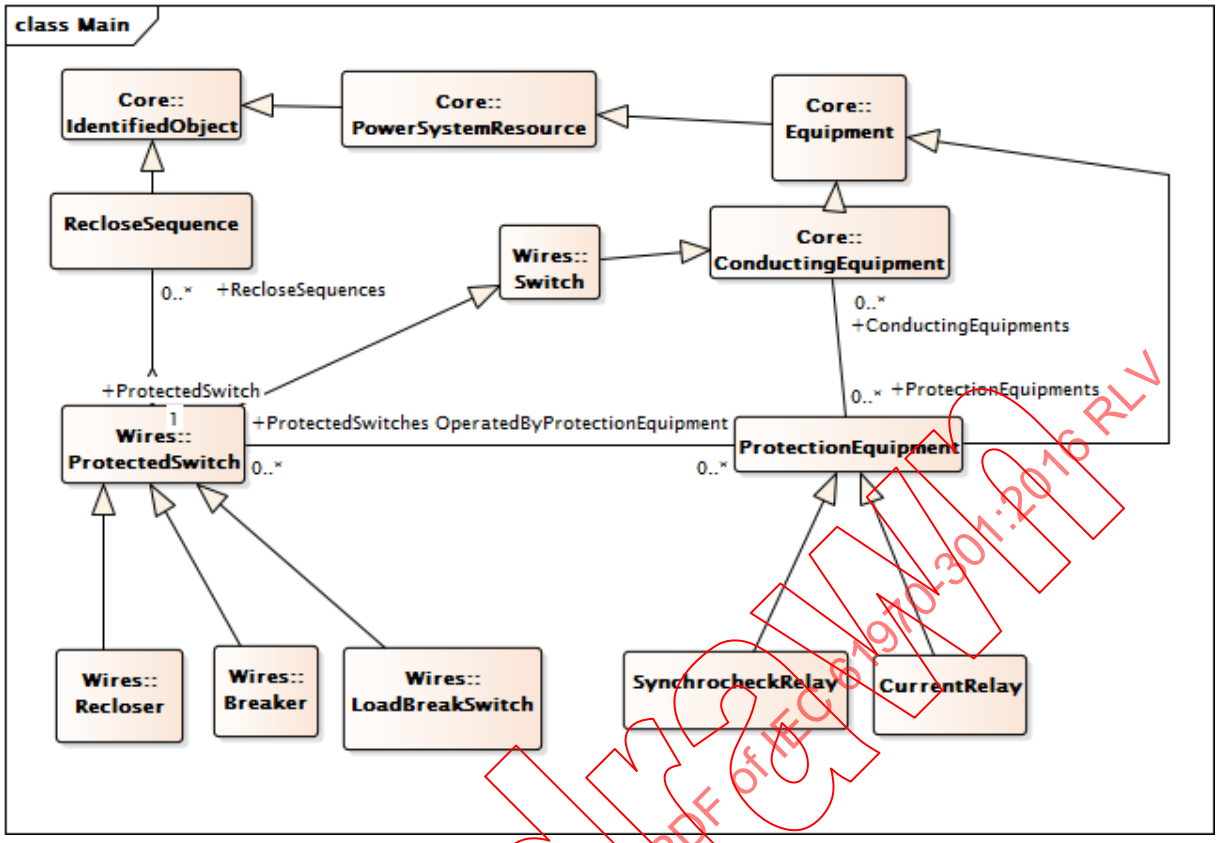


Figure 116 – Class diagram Protection::Main

Figure 116: This diagram shows all classes included in the Protection package as well as the key external classes that have associations with Protection classes.

6.14.2 CurrentRelay

A device that checks current flow values in any direction or designated direction.

Table 579 shows all attributes of CurrentRelay.

Table 579 – Attributes of Protection::CurrentRelay

name	mult	type	description
currentLimit1	0..1	CurrentFlow	Current limit number 1 for inverse time pickup.
currentLimit2	0..1	CurrentFlow	Current limit number 2 for inverse time pickup.
currentLimit3	0..1	CurrentFlow	Current limit number 3 for inverse time pickup.
inverseTimeFlag	0..1	Boolean	Set true if the current relay has inverse time characteristic.
timeDelay1	0..1	Seconds	Inverse time delay number 1 for current limit number 1.
timeDelay2	0..1	Seconds	Inverse time delay number 2 for current limit number 2.
timeDelay3	0..1	Seconds	Inverse time delay number 3 for current limit number 3.
relayDelayTime	0..1	Seconds	inherited from: ProtectionEquipment
highLimit	0..1	Float	inherited from: ProtectionEquipment
lowLimit	0..1	Float	inherited from: ProtectionEquipment
powerDirectionFlag	0..1	Boolean	inherited from: ProtectionEquipment

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name	mult	type	description
unitSymbol	0..1	UnitSymbol	inherited from: ProtectionEquipment
unitMultiplier	0..1	UnitMultiplier	inherited from: ProtectionEquipment
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 580 shows all association ends of CurrentRelay with other classes.

Table 580 – Association ends of Protection::CurrentRelay with other classes

mult from	name	mult to	type	description
0..*	ConductingEquipments	0..*	ConductingEquipment	inherited from: ProtectionEquipment
0..*	ProtectedSwitches	0..*	ProtectedSwitch	inherited from: ProtectionEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.14.3 ProtectionEquipment

An electrical device designed to respond to input conditions in a prescribed manner and after specified conditions are met to cause contact operation or similar abrupt change in associated electric control circuits, or simply to display the detected condition. Protection equipment are associated with conducting equipment and usually operate circuit breakers.

Table 581 shows all attributes of ProtectionEquipment.

Table 581 – Attributes of Protection::ProtectionEquipment

name	mult	type	description
relayDelayTime	0..1	Seconds	The time delay from detection of abnormal conditions to relay operation.
highLimit	0..1	Float	The maximum allowable value.
lowLimit	0..1	Float	The minimum allowable value.
powerDirectionFlag	0..1	Boolean	Direction same as positive active power flow value.
unitSymbol	0..1	UnitSymbol	The unit of measure of the value.
unitMultiplier	0..1	UnitMultiplier	The unit multiplier of the value.

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name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 582 shows all association ends of ProtectionEquipment with other classes.

Table 582 – Association ends of Protection::ProtectionEquipment with other classes

mult from	name	mult to	type	description
0..*	ConductingEquipments	0..*	ConductingEquipment	Protection equipment may be used to protect specific conducting equipment.
0..*	ProtectedSwitches	0..*	ProtectedSwitch	Protected switches operated by this ProtectionEquipment.
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.14.4 RecloseSequence

A reclose sequence (open and close) is defined for each possible reclosure of a breaker.

Table 583 shows all attributes of RecloseSequence.

Table 583 – Attributes of Protection::RecloseSequence

name	mult	type	description
recloseDelay	0..1	Seconds	Indicates the time lapse before the reclose step will execute a reclose.
recloseStep	0..1	Integer	Indicates the ordinal position of the reclose step relative to other steps in the sequence.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 584 shows all association ends of RecloseSequence with other classes.

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Table 584 – Association ends of Protection::RecloseSequence with other classes

mult from	name	mult to	type	description
0..*	ProtectedSwitch	1..1	ProtectedSwitch	A breaker may have zero or more automatic reclosures after a trip occurs.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.14.5 SynchrocheckRelay

A device that operates when two AC circuits are within the desired limits of frequency, phase angle, and voltage, to permit or to cause the paralleling of these two circuits. Used to prevent the paralleling of non-synchronous topological islands.

Table 585 shows all attributes of SynchrocheckRelay.

Table 585 – Attributes of Protection::SynchrocheckRelay

name	mult	type	description
maxAngleDiff	0..1	AngleRadians	The maximum allowable voltage vector phase angle difference across the open device.
maxFreqDiff	0..1	Frequency	The maximum allowable frequency difference across the open device.
maxVoltDiff	0..1	Voltage	The maximum allowable difference voltage across the open device.
relayDelayTime	0..1	Seconds	inherited from: ProtectionEquipment
highLimit	0..1	Float	inherited from: ProtectionEquipment
lowLimit	0..1	Float	inherited from: ProtectionEquipment
powerDirectionFlag	0..1	Boolean	inherited from: ProtectionEquipment
unitSymbol	0..1	UnitSymbol	inherited from: ProtectionEquipment
unitMultiplier	0..1	UnitMultiplier	inherited from: ProtectionEquipment
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 586 shows all association ends of SynchrocheckRelay with other classes.

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Table 586 – Association ends of Protection::SynchrocheckRelay with other classes

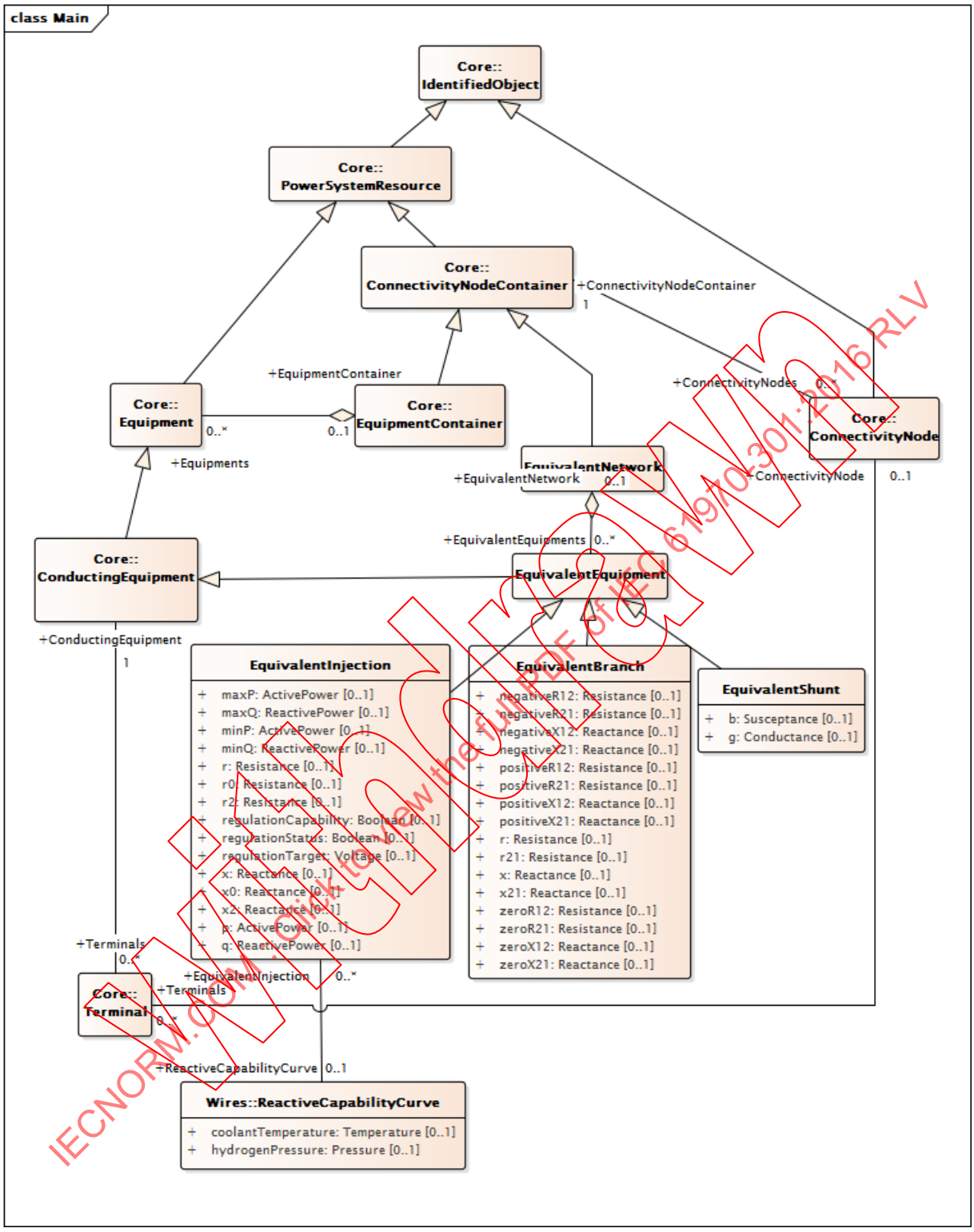
mult from	name	mult to	type	description
0..*	ConductingEquipments	0..*	ConductingEquipment	inherited from: ProtectionEquipment
0..*	ProtectedSwitches	0..*	ProtectedSwitch	inherited from: ProtectionEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.15 Package Equivalents

6.15.1 General

The equivalents package models equivalent networks.

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Figure 117 – Class diagram Equivalents::Main

Figure 117: Shows model for equivalent networks.

6.15.2 EquivalentBranch

The class represents equivalent branches.

Table 587 shows all attributes of EquivalentBranch.

Table 587 – Attributes of Equivalents::EquivalentBranch

name	mult	type	description
negativeR12	0..1	Resistance	Negative sequence series resistance from terminal sequence 1 to terminal sequence 2. Used for short circuit data exchange according to IEC 60909 EquivalentBranch is a result of network reduction prior to the data exchange
negativeR21	0..1	Resistance	Negative sequence series resistance from terminal sequence 2 to terminal sequence 1. Used for short circuit data exchange according to IEC 60909 EquivalentBranch is a result of network reduction prior to the data exchange
negativeX12	0..1	Reactance	Negative sequence series reactance from terminal sequence 1 to terminal sequence 2. Used for short circuit data exchange according to IEC 60909 Usage: EquivalentBranch is a result of network reduction prior to the data exchange
negativeX21	0..1	Reactance	Negative sequence series reactance from terminal sequence 2 to terminal sequence 1. Used for short circuit data exchange according to IEC 60909. Usage: EquivalentBranch is a result of network reduction prior to the data exchange
positiveR12	0..1	Resistance	Positive sequence series resistance from terminal sequence 1 to terminal sequence 2 . Used for short circuit data exchange according to IEC 60909. EquivalentBranch is a result of network reduction prior to the data exchange.
positiveR21	0..1	Resistance	Positive sequence series resistance from terminal sequence 2 to terminal sequence 1. Used for short circuit data exchange according to IEC 60909 EquivalentBranch is a result of network reduction prior to the data exchange
positiveX12	0..1	Reactance	Positive sequence series reactance from terminal sequence 1 to terminal sequence 2. Used for short circuit data exchange according to IEC 60909 Usage: EquivalentBranch is a result of network reduction prior to the data exchange
positiveX21	0..1	Reactance	Positive sequence series reactance from terminal sequence 2 to terminal sequence 1. Used for short circuit data exchange according to IEC 60909 Usage: EquivalentBranch is a result of network reduction prior to the data exchange
r	0..1	Resistance	Positive sequence series resistance of the reduced branch.
r21	0..1	Resistance	Resistance from terminal sequence 2 to terminal sequence 1. Used for steady state power flow. This attribute is optional and represents an unbalanced network such as off-nominal phase shifter. If only EquivalentBranch.r is given, then EquivalentBranch.r21 is assumed equal to EquivalentBranch.r. Usage rule: EquivalentBranch is a result of network reduction prior to the data exchange.

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name	mult	type	description
x	0..1	Reactance	Positive sequence series reactance of the reduced branch.
x21	0..1	Reactance	Reactance from terminal sequence 2 to terminal sequence 1 .Used for steady state power flow. This attribute is optional and represents an unbalanced network such as off-nominal phase shifter. If only EquivalentBranch.x is given, then EquivalentBranch.x21 is assumed equal to EquivalentBranch.x. Usage rule: EquivalentBranch is a result of network reduction prior to the data exchange.
zeroR12	0..1	Resistance	Zero sequence series resistance from terminal sequence 1 to terminal sequence 2. Used for short circuit data exchange according to IEC 60909 EquivalentBranch is a result of network reduction prior to the data exchange
zeroR21	0..1	Resistance	Zero sequence series resistance from terminal sequence 2 to terminal sequence 1. Used for short circuit data exchange according to IEC 60909 Usage: EquivalentBranch is a result of network reduction prior to the data exchange
zeroX12	0..1	Reactance	Zero sequence series reactance from terminal sequence 1 to terminal sequence 2. Used for short circuit data exchange according to IEC 60909 Usage: EquivalentBranch is a result of network reduction prior to the data exchange
zeroX21	0..1	Reactance	Zero sequence series reactance from terminal sequence 2 to terminal sequence 1. Used for short circuit data exchange according to IEC 60909 Usage: EquivalentBranch is a result of network reduction prior to the data exchange
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 588 shows all association ends of EquivalentBranch with other classes.

Table 588 – Association ends of Equivalents::EquivalentBranch with other classes

mult from	name	mult to	type	description
0..*	EquivalentNetwork	0..1	EquivalentNetwork	inherited from: EquivalentEquipment
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment

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mult from	name	mult to	type	description
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.15.3 EquivalentEquipment

The class represents equivalent objects that are the result of a network reduction. The class is the base for equivalent objects of different types.

Table 589 shows all attributes of EquivalentEquipment.

Table 589 – Attributes of Equivalents::EquivalentEquipment

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 590 shows all association ends of EquivalentEquipment with other classes.

Table 590 – Association ends of Equivalents::EquivalentEquipment with other classes

mult from	name	mult to	type	description
0..*	EquivalentNetwork	0..1	EquivalentNetwork	The equivalent where the reduced model belongs.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource

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mult from	name	mult to	type	description
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.15.4 EquivalentInjection

This class represents equivalent injections (generation or load). Voltage regulation is allowed only at the point of connection.

Table 591 shows all attributes of EquivalentInjection.

Table 591 – Attributes of Equivalents::EquivalentInjection

name	mult	type	description
maxP	0..1	ActivePower	Maximum active power of the injection.
maxQ	0..1	ReactivePower	Used for modeling of infeed for load flow exchange. Not used for short circuit modeling. If maxQ and minQ are not used ReactiveCapabilityCurve can be used.
minP	0..1	ActivePower	Minimum active power of the injection.
minQ	0..1	ReactivePower	Used for modeling of infeed for load flow exchange. Not used for short circuit modeling. If maxQ and minQ are not used ReactiveCapabilityCurve can be used.
r	0..1	Resistance	Positive sequence resistance. Used to represent Extended-Ward (IEC 60909). Usage: Extended-Ward is a result of network reduction prior to the data exchange.
r0	0..1	Resistance	Zero sequence resistance. Used to represent Extended-Ward (IEC 60909). Usage: Extended-Ward is a result of network reduction prior to the data exchange.
r2	0..1	Resistance	Negative sequence resistance. Used to represent Extended-Ward (IEC 60909). Usage: Extended-Ward is a result of network reduction prior to the data exchange.
regulationCapability	0..1	Boolean	Specifies whether or not the EquivalentInjection has the capability to regulate the local voltage.
regulationStatus	0..1	Boolean	Specifies the default regulation status of the EquivalentInjection. True is regulating. False is not regulating.
regulationTarget	0..1	Voltage	The target voltage for voltage regulation.
x	0..1	Reactance	Positive sequence reactance. Used to represent Extended-Ward (IEC 60909). Usage: Extended-Ward is a result of network reduction prior to the data exchange.
x0	0..1	Reactance	Zero sequence reactance. Used to represent Extended-Ward (IEC 60909). Usage: Extended-Ward is a result of network reduction prior to the data exchange.
x2	0..1	Reactance	Negative sequence reactance. Used to represent Extended-Ward (IEC 60909). Usage: Extended-Ward is a result of network reduction prior to the data exchange.

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name	mult	type	description
p	0..1	ActivePower	Equivalent active power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
q	0..1	ReactivePower	Equivalent reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 592 shows all association ends of EquivalentInjection with other classes.

Table 592 – Association ends of Equivalents::EquivalentInjection with other classes

mult from	name	mult to	type	description
0..*	ReactiveCapabilityCurve	0..1	ReactiveCapabilityCurve	The reactive capability curve used by this equivalent injection.
0..*	EquivalentNetwork	0..1	EquivalentNetwork	inherited from: EquivalentEquipment
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.15.5 EquivalentNetwork

A class that represents an external meshed network that has been reduced to an electrically equivalent model. The ConnectivityNodes contained in the equivalent are intended to reflect internal nodes of the equivalent. The boundary Connectivity nodes where the equivalent connects outside itself are not contained by the equivalent.

Table 593 shows all attributes of EquivalentNetwork.

Table 593 – Attributes of Equivalents::EquivalentNetwork

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 594 shows all association ends of EquivalentNetwork with other classes.

Table 594 – Association ends of Equivalents::EquivalentNetwork with other classes

mult from	name	mult to	type	description
0..1	EquivalentEquipments	0..*	EquivalentEquipment	The associated reduced equivalents.
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.15.6 EquivalentShunt

The class represents equivalent shunts.

Table 595 shows all attributes of EquivalentShunt.

Table 595 – Attributes of Equivalents::EquivalentShunt

name	mult	type	description
b	0..1	Susceptance	Positive sequence shunt susceptance.
g	0..1	Conductance	Positive sequence shunt conductance.
aggregate	0..1	Boolean	inherited from: Equipment
normallyInService	0..1	Boolean	inherited from: Equipment
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 596 shows all association ends of EquivalentShunt with other classes.

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Table 596 – Association ends of Equivalents::EquivalentShunt with other classes

mult from	name	mult to	type	description
0..*	EquivalentNetwork	0..1	EquivalentNetwork	inherited from: EquivalentEquipment
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..1	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16 Package Meas

6.16.1 General

Contains entities that describe dynamic measurement data exchanged between applications.

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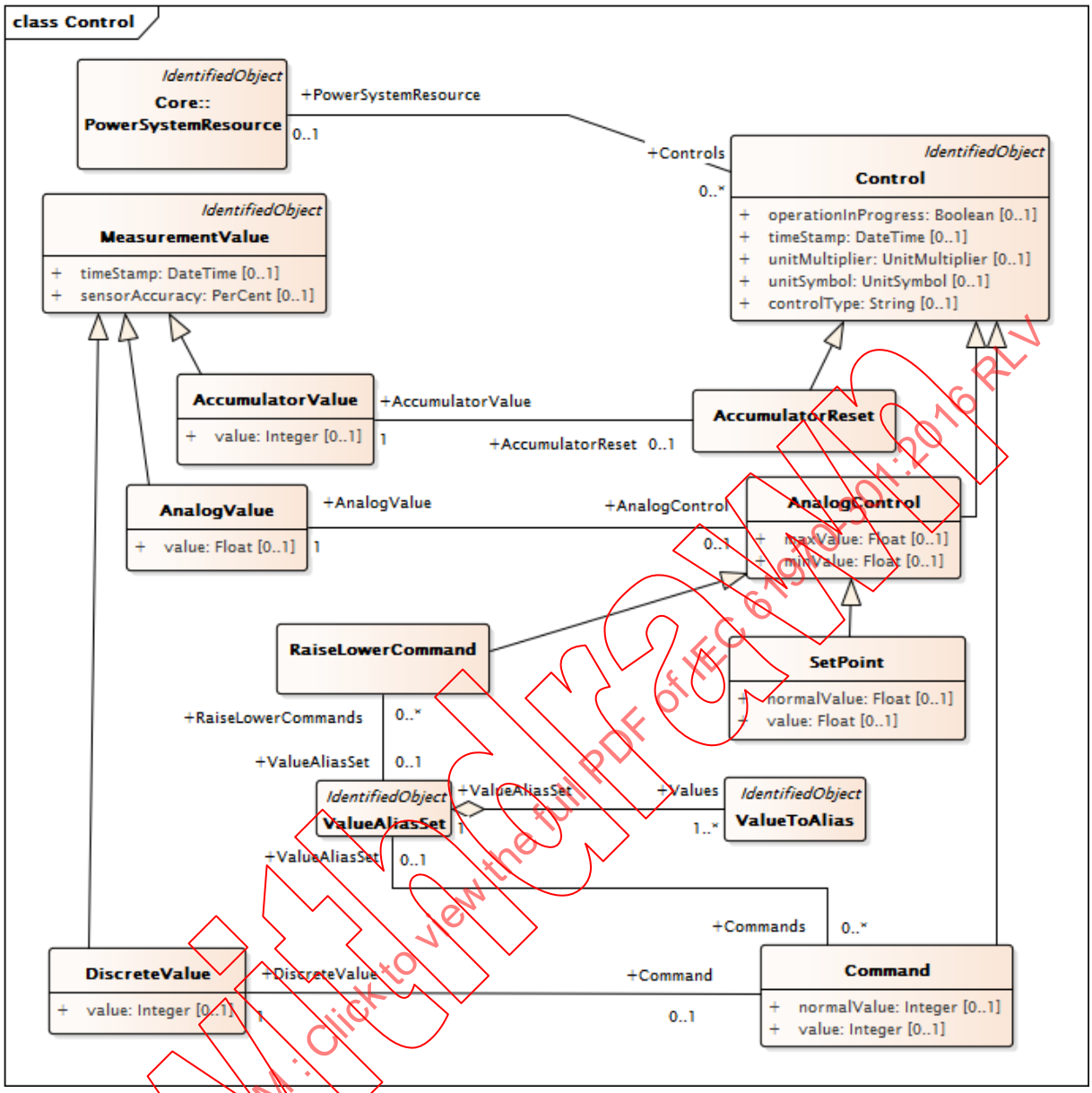


Figure 118 – Class diagram Meas::Control

Figure 118: This diagram shows all classes included in the Meas package.

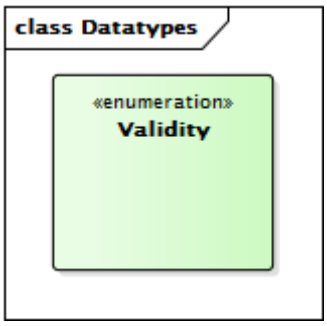
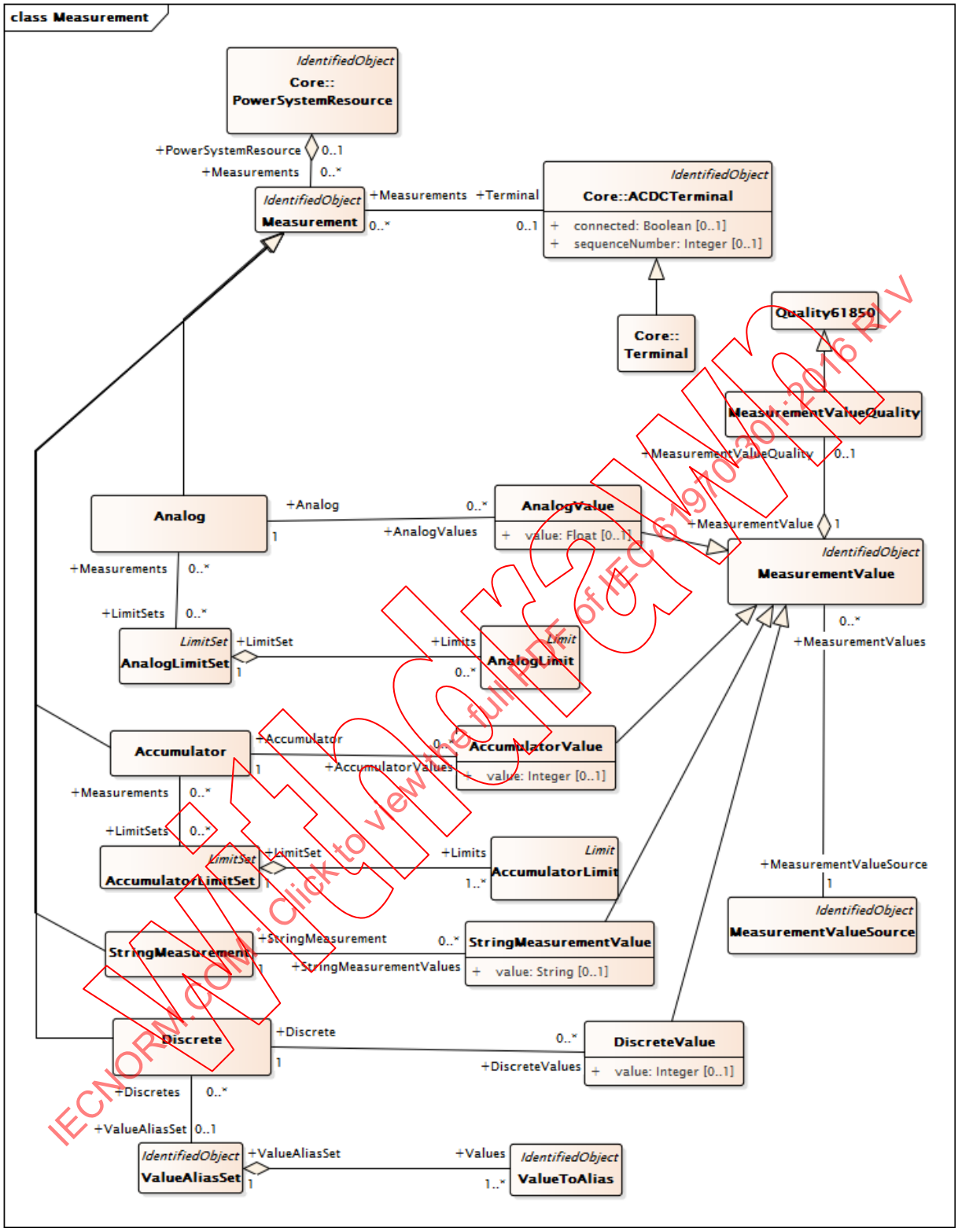


Figure 119 – Class diagram Meas::Datatypes

Figure 119: Shows datatypes for measurements.

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Figure 120 – Class diagram Meas::Measurement

Figure 120: This diagram shows classes central to the Measurement package and connections to some external classes.

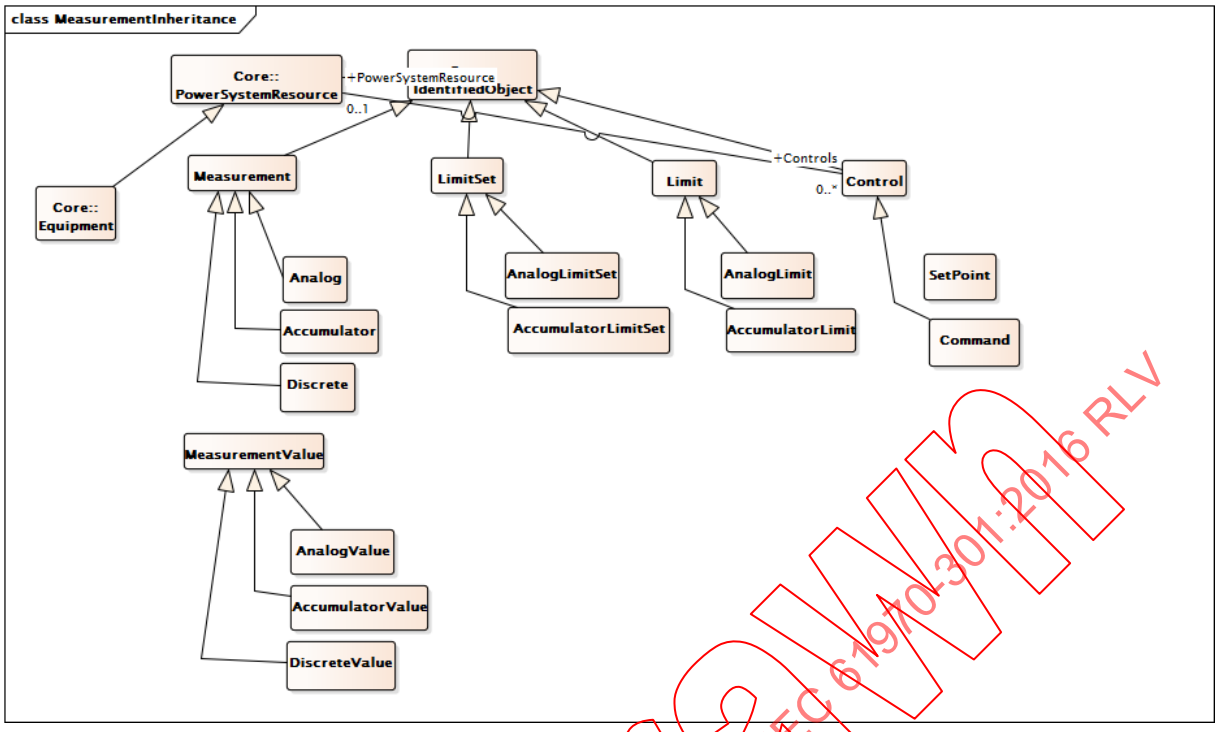


Figure 121 – Class diagram Meas::MeasurementInheritance

Figure 121: This diagram shows the measurement classes inheritance.

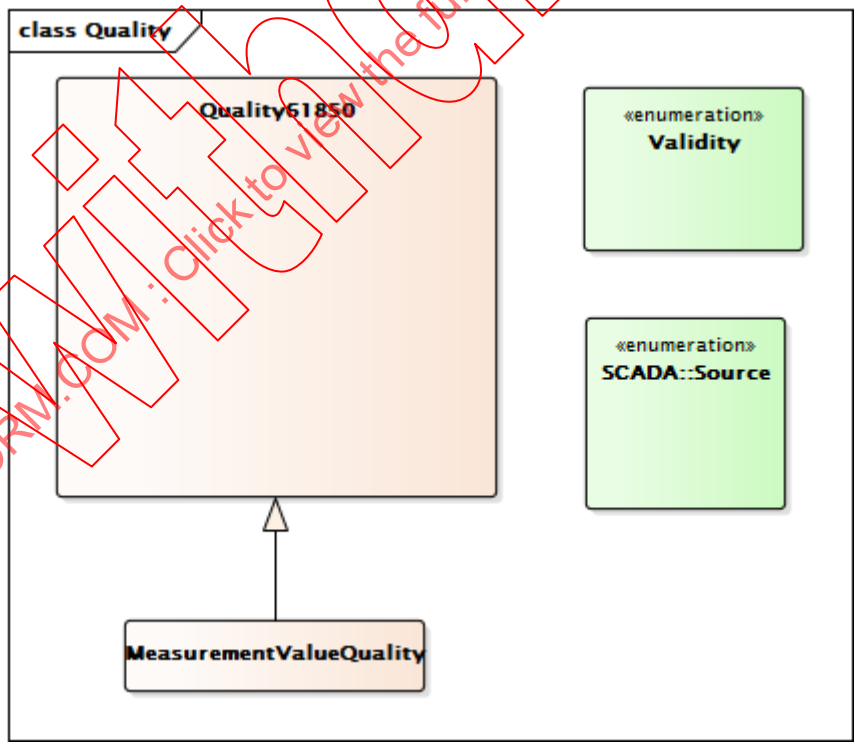


Figure 122 – Class diagram Meas::Quality

Figure 122: This diagram shows the details of the quality codes. The quality flags can be used also in other packages not only specific to MeasurementValues. A generalized Quality class is added and inherited into MeasurementValueQuality.

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6.16.2 Accumulator

Accumulator represents an accumulated (counted) Measurement, e.g. an energy value.

Table 597 shows all attributes of Accumulator.

Table 597 – Attributes of Meas::Accumulator

name	mult	type	description
maxValue	0..1	Integer	Normal value range maximum for any of the MeasurementValue.values. Used for scaling, e.g. in bar graphs or of telemetered raw values.
measurementType	0..1	String	inherited from: Measurement
phases	0..1	PhaseCode	inherited from: Measurement
unitMultiplier	0..1	UnitMultiplier	inherited from: Measurement
unitSymbol	0..1	UnitSymbol	inherited from: Measurement
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 598 shows all association ends of Accumulator with other classes.

Table 598 – Association ends of Meas::Accumulator with other classes

mult from	name	mult to	type	description
1..1	AccumulatorValues	0..*	AccumulatorValue	The values connected to this measurement.
0..*	LimitSets	0..*	AccumulatorLimitSet	A measurement may have zero or more limit ranges defined for it.
0..*	Terminal	0..1	ACDCTerminal	inherited from: Measurement
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Measurement
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.3 AccumulatorLimit

Limit values for Accumulator measurements.

Table 599 shows all attributes of AccumulatorLimit.

Table 599 – Attributes of Meas::AccumulatorLimit

name	mult	type	description
value	0..1	Integer	The value to supervise against. The value is positive.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

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Table 600 shows all association ends of AccumulatorLimit with other classes.

Table 600 – Association ends of Meas::AccumulatorLimit with other classes

mult from	name	mult to	type	description
1..*	LimitSet	1..1	AccumulatorLimitSet	The set of limits.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.4 AccumulatorLimitSet

An AccumulatorLimitSet specifies a set of Limits that are associated with an Accumulator measurement.

Table 601 shows all attributes of AccumulatorLimitSet.

Table 601 – Attributes of Meas::AccumulatorLimitSet

name	mult	type	description
isPercentageLimits	0..1	Boolean	inherited from: LimitSet
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 602 shows all association ends of AccumulatorLimitSet with other classes.

Table 602 – Association ends of Meas::AccumulatorLimitSet with other classes

mult from	name	mult to	type	description
1..1	Limits	1..*	AccumulatorLimit	The limit values used for supervision of Measurements.
0..*	Measurements	0..*	Accumulator	The Measurements using the LimitSet.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.5 AccumulatorReset

This command resets the counter value to zero.

Table 603 shows all attributes of AccumulatorReset.

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Table 603 – Attributes of Meas::AccumulatorReset

name	mult	type	description
operationInProgress	0..1	Boolean	inherited from: Control
timeStamp	0..1	DateTime	inherited from: Control
unitMultiplier	0..1	UnitMultiplier	inherited from: Control
unitSymbol	0..1	UnitSymbol	inherited from: Control
controlType	0..1	String	inherited from: Control
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 604 shows all association ends of AccumulatorReset with other classes.

Table 604 – Association ends of Meas::AccumulatorReset with other classes

mult from	name	mult to	type	description
0..1	AccumulatorValue	1..1	AccumulatorValue	The accumulator value that is reset by the command.
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Control
1..1	RemoteControl	0..1	RemoteControl	inherited from: Control
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.6 AccumulatorValue

AccumulatorValue represents an accumulated (counted) MeasurementValue.

Table 605 shows all attributes of AccumulatorValue.

Table 605 – Attributes of Meas::AccumulatorValue

name	mult	type	description
value	0..1	Integer	The value to supervise. The value is positive.
timeStamp	0..1	DateTime	inherited from: MeasurementValue
sensorAccuracy	0..1	PerCent	inherited from: MeasurementValue
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 606 shows all association ends of AccumulatorValue with other classes.

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Table 606 – Association ends of Meas::AccumulatorValue with other classes

mult from	name	mult to	type	description
0..*	Accumulator	1..1	Accumulator	Measurement to which this value is connected.
1..1	AccumulatorReset	0..1	AccumulatorReset	The command that resets the accumulator value.
1..1	RemoteSource	0..1	RemoteSource	inherited from: MeasurementValue
1..1	MeasurementValueQuality	0..1	MeasurementValueQuality	inherited from: MeasurementValue
0..*	MeasurementValueSource	1..1	MeasurementValueSource	inherited from: MeasurementValue
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.7 Analog

Analog represents an analog Measurement.

Table 607 shows all attributes of Analog.

Table 607 – Attributes of Meas::Analog

name	mult	type	description
maxValue	0..1	Float	Normal value range maximum for any of the MeasurementValue.values. Used for scaling, e.g. in bar graphs or of telemetered raw values.
minValue	0..1	Float	Normal value range minimum for any of the MeasurementValue.values. Used for scaling, e.g. in bar graphs or of telemetered raw values.
normalValue	0..1	Float	Normal measurement value, e.g. used for percentage calculations.
positiveFlowIn	0..1	Boolean	If true then this measurement is an active power, reactive power or current with the convention that a positive value measured at the Terminal means power is flowing into the related PowerSystemResource.
measurementType	0..1	String	inherited from: Measurement
phases	0..1	PhaseCode	inherited from: Measurement
unitMultiplier	0..1	UnitMultiplier	inherited from: Measurement
unitSymbol	0..1	UnitSymbol	inherited from: Measurement
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 608 shows all association ends of Analog with other classes.

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Table 608 – Association ends of Meas::Analog with other classes

mult from	name	mult to	type	description
1..1	AnalogValues	0..*	AnalogValue	The values connected to this measurement.
0..*	LimitSets	0..*	AnalogLimitSet	A measurement may have zero or more limit ranges defined for it.
0..*	Terminal	0..1	ACDCTerminal	inherited from: Measurement
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Measurement
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.8 AnalogControl

An analog control used for supervisory control.

Table 609 shows all attributes of AnalogControl.

Table 609 – Attributes of Meas::AnalogControl

name	mult	type	description
maxValue	0..1	Float	Normal value range maximum for any of the Control.value. Used for scaling, e.g. in bar graphs.
minValue	0..1	Float	Normal value range minimum for any of the Control.value. Used for scaling, e.g. in bar graphs.
operationInProgress	0..1	Boolean	inherited from: Control
timeStamp	0..1	DateTime	inherited from: Control
unitMultiplier	0..1	UnitMultiplier	inherited from: Control
unitSymbol	0..1	UnitSymbol	inherited from: Control
controlType	0..1	String	inherited from: Control
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 610 shows all association ends of AnalogControl with other classes.

Table 610 – Association ends of Meas::AnalogControl with other classes

mult from	name	mult to	type	description
0..1	AnalogValue	1..1	AnalogValue	The MeasurementValue that is controlled.
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Control
1..1	RemoteControl	0..1	RemoteControl	inherited from: Control
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.16.9 AnalogLimit

Limit values for Analog measurements.

Table 611 shows all attributes of AnalogLimit.

Table 611 – Attributes of Meas::AnalogLimit

name	mult	type	description
value	0..1	Float	The value to supervise against.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 612 shows all association ends of AnalogLimit with other classes.

Table 612 – Association ends of Meas::AnalogLimit with other classes

mult from	name	mult to	type	description
0..*	LimitSet	1..1	AnalogLimitSet	The set of limits.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.10 AnalogLimitSet

An AnalogLimitSet specifies a set of Limits that are associated with an Analog measurement.

Table 613 shows all attributes of AnalogLimitSet.

Table 613 – Attributes of Meas::AnalogLimitSet

name	mult	type	description
isPercentageLimits	0..1	Boolean	inherited from: LimitSet
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 614 shows all association ends of AnalogLimitSet with other classes.

Table 614 – Association ends of Meas::AnalogLimitSet with other classes

mult from	name	mult to	type	description
1..1	Limits	0..*	AnalogLimit	The limit values used for supervision of Measurements.
0..*	Measurements	0..*	Analog	The Measurements using the LimitSet.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.16.11 AnalogValue

AnalogValue represents an analog MeasurementValue.

Table 615 shows all attributes of AnalogValue.

Table 615 – Attributes of Meas::AnalogValue

name	mult	type	description
value	0..1	Float	The value to supervise.
timeStamp	0..1	DateTime	inherited from: MeasurementValue
sensorAccuracy	0..1	PerCent	inherited from: MeasurementValue
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 616 shows all association ends of AnalogValue with other classes.

Table 616 – Association ends of Meas::AnalogValue with other classes

mult from	name	mult to	type	description
1..1	AnalogControl	0..1	AnalogControl	The Control variable associated with the MeasurementValue.
0..*	Analog	1..1	Analog	Measurement to which this value is connected.
1..1	AltTieMeas	0..*	AltTieMeas	The usage of the measurement within the control area specification.
1..1	AltGeneratingUnit	0..*	AltGeneratingUnitMeas	The alternate generating unit for which this measurement value applies.
1..1	RemoteSource	0..1	RemoteSource	inherited from: MeasurementValue
1..1	MeasurementValueQuality	0..1	MeasurementValueQuality	inherited from: MeasurementValue
0..*	MeasurementValueSource	1..1	MeasurementValueSource	inherited from: MeasurementValue
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.12 Command

A Command is a discrete control used for supervisory control.

Table 617 shows all attributes of Command.

Table 617 – Attributes of Meas::Command

name	mult	type	description
normalValue	0..1	Integer	Normal value for Control.value, e.g. used for percentage scaling.
value	0..1	Integer	The value representing the actuator output.
operationInProgress	0..1	Boolean	inherited from: Control
timeStamp	0..1	DateTime	inherited from: Control

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name	mult	type	description
unitMultiplier	0..1	UnitMultiplier	inherited from: Control
unitSymbol	0..1	UnitSymbol	inherited from: Control
controlType	0..1	String	inherited from: Control
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 618 shows all association ends of Command with other classes.

Table 618 – Association ends of Meas::Command with other classes

mult from	name	mult to	type	description
0..*	ValueAliasSet	0..1	ValueAliasSet	The ValueAliasSet used for translation of a Control value to a name.
0..1	DiscreteValue	1..1	DiscreteValue	The MeasurementValue that is controlled.
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Control
1..1	RemoteControl	0..1	RemoteControl	inherited from: Control
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.13 Control

Control is used for supervisory/device control. It represents control outputs that are used to change the state in a process, e.g. close or open breaker, a set point value or a raise/lower command.

Table 619 shows all attributes of Control.

Table 619 – Attributes of Meas::Control

name	mult	type	description
operationInProgress	0..1	Boolean	Indicates that a client is currently sending control commands that has not completed.
timeStamp	0..1	DateTime	The last time a control output was sent.
unitMultiplier	0..1	UnitMultiplier	The unit multiplier of the controlled quantity.
unitSymbol	0..1	UnitSymbol	The unit of measure of the controlled quantity.
controlType	0..1	String	Specifies the type of Control, e.g. BreakerOn/Off, GeneratorVoltageSetPoint, TieLineFlow, etc. The ControlType.name shall be unique among all specified types and describe the type.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 620 shows all association ends of Control with other classes.

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Table 620 – Association ends of Meas::Control with other classes

mult from	name	mult to	type	description
0..*	PowerSystemResource	0..1	PowerSystemResource	Regulating device governed by this control output.
1..1	RemoteControl	0..1	RemoteControl	The remote point controlling the physical actuator.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.14 Discrete

Discrete represents a discrete Measurement, i.e. a Measurement representing discrete values, e.g. a Breaker position.

Table 621 shows all attributes of Discrete.

Table 621 – Attributes of Meas::Discrete

name	mult	type	description
maxValue	0..1	Integer	Normal value range maximum for any of the MeasurementValue.values. Used for scaling, e.g. in bar graphs or of telemetered raw values.
minValue	0..1	Integer	Normal value range minimum for any of the MeasurementValue.values. Used for scaling, e.g. in bar graphs or of telemetered raw values.
normalValue	0..1	Integer	Normal measurement value, e.g. used for percentage calculations.
measurementType	0..1	String	inherited from: Measurement
phases	0..1	PhaseCode	inherited from: Measurement
unitMultiplier	0..1	UnitMultiplier	inherited from: Measurement
unitSymbol	0..1	UnitSymbol	inherited from: Measurement
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 622 shows all association ends of Discrete with other classes.

Table 622 – Association ends of Meas::Discrete with other classes

mult from	name	mult to	type	description
1..1	DiscreteValues	0..*	DiscreteValue	The values connected to this measurement.
0..*	ValueAliasSet	0..1	ValueAliasSet	The ValueAliasSet used for translation of a MeasurementValue.value to a name.
0..*	Terminal	0..1	ACDCTerminal	inherited from: Measurement
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Measurement
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.16.15 DiscreteCommand

Table 623 shows all attributes of DiscreteCommand.

Table 623 – Attributes of Meas::DiscreteCommand

name	mult	type	description
normalValue	0..1	Integer	inherited from: Command
value	0..1	Integer	inherited from: Command
operationInProgress	0..1	Boolean	inherited from: Control
timeStamp	0..1	DateTime	inherited from: Control
unitMultiplier	0..1	UnitMultiplier	inherited from: Control
unitSymbol	0..1	UnitSymbol	inherited from: Control
controlType	0..1	String	inherited from: Control
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 624 shows all association ends of DiscreteCommand with other classes.

Table 624 – Association ends of Meas::DiscreteCommand with other classes

mult from	name	mult to	type	description
0..*	ValueAliasSet	0..1	ValueAliasSet	inherited from: Command
0..1	DiscreteValue	1..1	DiscreteValue	inherited from: Command
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Control
1..1	RemoteControl	0..1	RemoteControl	inherited from: Control
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.16 DiscreteValue

DiscreteValue represents a discrete MeasurementValue.

Table 625 shows all attributes of DiscreteValue.

Table 625 – Attributes of Meas::DiscreteValue

name	mult	type	description
value	0..1	Integer	The value to supervise.
timeStamp	0..1	DateTime	inherited from: MeasurementValue
sensorAccuracy	0..1	PerCent	inherited from: MeasurementValue
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 626 shows all association ends of DiscreteValue with other classes.

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Table 626 – Association ends of Meas::DiscreteValue with other classes

mult from	name	mult to	type	description
1..1	Command	0..1	Command	The Control variable associated with the MeasurementValue.
0..*	Discrete	1..1	Discrete	Measurement to which this value is connected.
1..1	RemoteSource	0..1	RemoteSource	inherited from: MeasurementValue
1..1	MeasurementValueQuality	0..1	MeasurementValueQuality	inherited from: MeasurementValue
0..*	MeasurementValueSource	1..1	MeasurementValueSource	inherited from: MeasurementValue
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.17 Limit

Specifies one limit value for a Measurement. A Measurement typically has several limits that are kept together by the LimitSet class. The actual meaning and use of a Limit instance (i.e. if it is an alarm or warning limit or if it is a high or low limit) is not captured in the Limit class. However the name of a Limit instance may indicate both meaning and use.

Table 627 shows all attributes of Limit.

Table 627 – Attributes of Meas::Limit

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 628 shows all association ends of Limit with other classes.

Table 628 – Association ends of Meas::Limit with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.18 LimitSet

Specifies a set of Limits that are associated with a Measurement. A Measurement may have several LimitSets corresponding to seasonal or other changing conditions. The condition is captured in the name and description attributes. The same LimitSet may be used for several Measurements. In particular, percentage limits are used this way.

Table 629 shows all attributes of LimitSet.

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Table 629 – Attributes of Meas::LimitSet

name	mult	type	description
isPercentageLimits	0..1	Boolean	Tells if the limit values are in percentage of normalValue or the specified Unit for Measurements and Controls.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 630 shows all association ends of LimitSet with other classes.

Table 630 – Association ends of Meas::LimitSet with other classes

mult from	name	mult to	type	description
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.19 Measurement

A Measurement represents any measured, calculated or non-measured non-calculated quantity. Any piece of equipment may contain Measurements, e.g. a substation may have temperature measurements and door open indications, a transformer may have oil temperature and tank pressure measurements, a bay may contain a number of power flow measurements and a Breaker may contain a switch status measurement.

The PSR–Measurement association is intended to capture this use of Measurement and is included in the naming hierarchy based on EquipmentContainer. The naming hierarchy typically has Measurements as leafs, e.g. Substation-VoltageLevel-Bay-Switch-Measurement.

Some Measurements represent quantities related to a particular sensor location in the network, e.g. a voltage transformer (PT) at a busbar or a current transformer (CT) at the bar between a breaker and an isolator. The sensing position is not captured in the PSR–Measurement association. Instead it is captured by the Measurement–Terminal association that is used to define the sensing location in the network topology. The location is defined by the connection of the Terminal to ConductingEquipment.

If both a Terminal and PSR are associated, and the PSR is of type ConductingEquipment, the associated Terminal should belong to that ConductingEquipment instance.

When the sensor location is needed both Measurement–PSR and Measurement–Terminal are used. The Measurement–Terminal association is never used alone.

Table 631 shows all attributes of Measurement.

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Table 631 – Attributes of Meas::Measurement

name	mult	type	description
measurementType	0..1	String	Specifies the type of measurement. For example, this specifies if the measurement represents an indoor temperature, outdoor temperature, bus voltage, line flow, etc.
phases	0..1	PhaseCode	Indicates to which phases the measurement applies and avoids the need to use 'measurementType' to also encode phase information (which would explode the types). The phase information in Measurement, along with 'measurementType' and 'phases' uniquely defines a Measurement for a device, based on normal network phase. Their meaning will not change when the computed energizing phasing is changed due to jumpers or other reasons. If the attribute is missing three phases (ABC) shall be assumed.
unitMultiplier	0..1	UnitMultiplier	The unit multiplier of the measured quantity.
unitSymbol	0..1	UnitSymbol	The unit of measure of the measured quantity.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 632 shows all association ends of Measurement with other classes.

Table 632 – Association ends of Meas::Measurement with other classes

mult from	name	mult to	type	description
0..*	Terminal	0..1	ACDCTerminal	One or more measurements may be associated with a terminal in the network.
0..*	PowerSystemResource	0..1	PowerSystemResource	The power system resource that contains the measurement.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.20 MeasurementValue

The current state for a measurement. A state value is an instance of a measurement from a specific source. Measurements can be associated with many state values, each representing a different source for the measurement.

Table 633 shows all attributes of MeasurementValue.

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Table 633 – Attributes of Meas::MeasurementValue

name	mult	type	description
timeStamp	0..1	DateTime	The time when the value was last updated
sensorAccuracy	0..1	PerCent	The limit, expressed as a percentage of the sensor maximum, that errors will not exceed when the sensor is used under reference conditions.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 634 shows all association ends of MeasurementValue with other classes.

Table 634 – Association ends of Meas::MeasurementValue with other classes

mult from	name	mult to	type	description
1..1	RemoteSource	0..1	RemoteSource	Link to the physical telemetered point associated with this measurement.
1..1	MeasurementValueQuality	0..1	MeasurementValueQuality	A MeasurementValue has a MeasurementValueQuality associated with it.
0..*	MeasurementValueSource	1..1	MeasurementValueSource	A reference to the type of source that updates the MeasurementValue, e.g. SCADA, CCLink, manual, etc. User conventions for the names of sources are contained in the introduction to IEC 61970-301.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.21 MeasurementValueQuality

Measurement quality flags. Bits 0-10 are defined for substation automation in IEC 61850-7-3. Bits 11-15 are reserved for future expansion by that document. Bits 16-31 are reserved for EMS applications.

Table 635 shows all attributes of MeasurementValueQuality.

Table 635 – Attributes of Meas::MeasurementValueQuality

name	mult	type	description
badReference	0..1	Boolean	inherited from: Quality61850
estimatorReplaced	0..1	Boolean	inherited from: Quality61850
failure	0..1	Boolean	inherited from: Quality61850
oldData	0..1	Boolean	inherited from: Quality61850
operatorBlocked	0..1	Boolean	inherited from: Quality61850
oscillatory	0..1	Boolean	inherited from: Quality61850
outOfRange	0..1	Boolean	inherited from: Quality61850
overFlow	0..1	Boolean	inherited from: Quality61850
source	0..1	Source	inherited from: Quality61850
suspect	0..1	Boolean	inherited from: Quality61850

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name	mult	type	description
test	0..1	Boolean	inherited from: Quality61850
validity	0..1	Validity	inherited from: Quality61850

Table 636 shows all association ends of MeasurementValueQuality with other classes.

Table 636 – Association ends of Meas::MeasurementValueQuality with other classes

mult from	name	mult to	type	description
0..1	MeasurementValue	1..1	MeasurementValue	A MeasurementValue has a MeasurementValueQuality associated with it.

6.16.22 MeasurementValueSource

MeasurementValueSource describes the alternative sources updating a MeasurementValue. User conventions for how to use the MeasurementValueSource attributes are described in the introduction to IEC 61970-301.

Table 637 shows all attributes of MeasurementValueSource.

Table 637 – Attributes of Meas::MeasurementValueSource

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 638 shows all association ends of MeasurementValueSource with other classes.

Table 638 – Association ends of Meas::MeasurementValueSource with other classes

mult from	name	mult to	type	description
1..1	MeasurementValues	0..*	MeasurementValue	The MeasurementValues updated by the source.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.23 Quality61850 root class

Quality flags in this class are as defined in IEC 61850, except for estimatorReplaced, which has been included in this class for convenience.

Table 639 shows all attributes of Quality61850.

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Table 639 – Attributes of Meas::Quality61850

name	mult	type	description
badReference	0..1	Boolean	Measurement value may be incorrect due to a reference being out of calibration.
estimatorReplaced	0..1	Boolean	Value has been replaced by State Estimator. estimatorReplaced is not an IEC 61850 quality bit but has been put in this class for convenience.
failure	0..1	Boolean	This identifier indicates that a supervision function has detected an internal or external failure, e.g. communication failure.
oldData	0..1	Boolean	Measurement value is old and possibly invalid, as it has not been successfully updated during a specified time interval.
operatorBlocked	0..1	Boolean	Measurement value is blocked and hence unavailable for transmission.
oscillatory	0..1	Boolean	To prevent some overload of the communication it is sensible to detect and suppress oscillating (fast changing) binary inputs. If a signal changes in a defined time (tosc) twice in the same direction (from 0 to 1 or from 1 to 0) then oscillation is detected and the detail quality identifier "oscillatory" is set. If it is detected a configured numbers of transient changes could be passed by. In this time the validity status "questionable" is set. If after this defined numbers of changes the signal is still in the oscillating state the value shall be set either to the opposite state of the previous stable value or to a defined default value. In this case the validity status "questionable" is reset and "invalid" is set as long as the signal is oscillating. If it is configured such that no transient changes should be passed by then the validity status "invalid" is set immediately in addition to the detail quality identifier "oscillatory" (used for status information only).
outOfRange	0..1	Boolean	Measurement value is beyond a predefined range of value.
overFlow	0..1	Boolean	Measurement value is beyond the capability of being represented properly. For example, a counter value overflows from maximum count back to a value of zero.
source	0..1	Source	Source gives information related to the origin of a value. The value may be acquired from the process, defaulted or substituted.
suspect	0..1	Boolean	A correlation function has detected that the value is not consistent with other values. Typically set by a network State Estimator.
test	0..1	Boolean	Measurement value is transmitted for test purposes.
validity	0..1	Validity	Validity of the measurement value.

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6.16.24 RaiseLowerCommand

An analog control that increases or decreases a set point value with pulses.

Table 640 shows all attributes of RaiseLowerCommand.

Table 640 – Attributes of Meas::RaiseLowerCommand

name	mult	type	description
maxValue	0..1	Float	inherited from: AnalogControl
minValue	0..1	Float	inherited from: AnalogControl
operationInProgress	0..1	Boolean	inherited from: Control
timeStamp	0..1	DateTime	inherited from: Control
unitMultiplier	0..1	UnitMultiplier	inherited from: Control
unitSymbol	0..1	UnitSymbol	inherited from: Control
controlType	0..1	String	inherited from: Control
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 641 shows all association ends of RaiseLowerCommand with other classes.

Table 641 – Association ends of Meas::RaiseLowerCommand with other classes

mult from	name	mult to	type	description
0..*	ValueAliasSet	0..1	ValueAliasSet	The ValueAliasSet used for translation of a Control value to a name.
0..1	AnalogValue	1..1	AnalogValue	inherited from: AnalogControl
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Control
1..1	RemoteControl	0..1	RemoteControl	inherited from: Control
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.25 SetPoint

An analog control that issues a set point value.

Table 642 shows all attributes of SetPoint.

Table 642 – Attributes of Meas::SetPoint

name	mult	type	description
normalValue	0..1	Float	Normal value for Control.value, e.g. used for percentage scaling.
value	0..1	Float	The value representing the actuator output.
maxValue	0..1	Float	inherited from: AnalogControl
minValue	0..1	Float	inherited from: AnalogControl
operationInProgress	0..1	Boolean	inherited from: Control
timeStamp	0..1	DateTime	inherited from: Control
unitMultiplier	0..1	UnitMultiplier	inherited from: Control
unitSymbol	0..1	UnitSymbol	inherited from: Control
controlType	0..1	String	inherited from: Control
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject

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name	mult	type	description
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 643 shows all association ends of SetPoint with other classes.

Table 643 – Association ends of Meas::SetPoint with other classes

mult from	name	mult to	type	description
0..1	AnalogValue	1..1	AnalogValue	inherited from: AnalogControl
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Control
1..1	RemoteControl	0..1	RemoteControl	inherited from: Control
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.26 StringMeasurement

StringMeasurement represents a measurement with values of type string.

Table 644 shows all attributes of StringMeasurement.

Table 644 – Attributes of Meas::StringMeasurement

name	mult	type	description
measurementType	0..1	String	inherited from: Measurement
phases	0..1	PhaseCode	inherited from: Measurement
unitMultiplier	0..1	UnitMultiplier	inherited from: Measurement
unitSymbol	0..1	UnitSymbol	inherited from: Measurement
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 645 shows all association ends of StringMeasurement with other classes.

Table 645 – Association ends of Meas::StringMeasurement with other classes

mult from	name	mult to	type	description
1..1	StringMeasurementValues	0..*	StringMeasurementValue	The values connected to this measurement.
0..*	Terminal	0..1	ACDCTerminal	inherited from: Measurement
0..*	PowerSystemResource	0..1	PowerSystemResource	inherited from: Measurement
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.27 StringMeasurementValue

StringMeasurementValue represents a measurement value of type string.

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Table 646 shows all attributes of StringMeasurementValue.

Table 646 – Attributes of Meas::StringMeasurementValue

name	mult	type	description
value	0..1	String	The value to supervise.
timeStamp	0..1	DateTime	inherited from: MeasurementValue
sensorAccuracy	0..1	PerCent	inherited from: MeasurementValue
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 647 shows all association ends of StringMeasurementValue with other classes.

Table 647 – Association ends of Meas::StringMeasurementValue with other classes

mult from	name	mult to	type	description
0..*	StringMeasurement	1..1	StringMeasurement	Measurement to which this value is connected.
1..1	RemoteSource	0..1	RemoteSource	inherited from: MeasurementValue
1..1	MeasurementValueQuality	0..1	MeasurementValueQuality	inherited from: MeasurementValue
0..*	MeasurementValueSource	1..1	MeasurementValueSource	inherited from: MeasurementValue
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.28 Validity enumeration

Validity for MeasurementValue.

Table 648 shows all literals of Validity.

Table 648 – Literals of Meas::Validity

literal	value	description
GOOD		The value is marked good if no abnormal condition of the acquisition function or the information source is detected.
QUESTIONABLE		The value is marked questionable if a supervision function detects an abnormal behavior, however the value could still be valid. The client is responsible for determining whether or not values marked "questionable" should be used.
INVALID		The value is marked invalid when a supervision function recognizes abnormal conditions of the acquisition function or the information source (missing or non-operating updating devices). The value is not defined under this condition. The mark invalid is used to indicate to the client that the value may be incorrect and shall not be used.

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6.16.29 ValueAliasSet

Describes the translation of a set of values into a name and is intendend to facilitate custom translations. Each ValueAliasSet has a name, description, etc. A specific Measurement may represent a discrete state like Open, Closed, Intermediate, etc. This requires a translation from the MeasurementValue.value number to a string, e.g. 0->"Invalid", 1->"Open", 2->"Closed", 3->"Intermediate". Each ValueToAlias member in ValueAliasSet.Value describes a mapping for one particular value to a name.

Table 649 shows all attributes of ValueAliasSet.

Table 649 – Attributes of Meas::ValueAliasSet

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 650 shows all association ends of ValueAliasSet with other classes.

Table 650 – Association ends of Meas::ValueAliasSet with other classes

mult from	name	mult to	type	description
0..1	Discretes	0..*	Discrete	The Measurements using the set for translation.
1..1	Values	1..*	ValueToAlias	The ValueToAlias mappings included in the set.
0..1	Commands	0..*	Command	The Commands using the set for translation.
0..1	RaiseLowerCommands	0..*	RaiseLowerCommand	The Commands using the set for translation.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.16.30 ValueToAlias

Describes the translation of one particular value into a name, e.g. 1 as "Open".

Table 651 shows all attributes of ValueToAlias.

Table 651 – Attributes of Meas::ValueToAlias

name	mult	type	description
value	0..1	Integer	The value that is mapped.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 652 shows all association ends of ValueToAlias with other classes.

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Table 652 – Association ends of Meas::ValueToAlias with other classes

mult from	name	mult to	type	description
1..*	ValueAliasSet	1..1	ValueAliasSet	The ValueAliasSet having the ValueToAlias mappings.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.17 Package SCADA

6.17.1 General

Contains entities to model information used by Supervisory Control and Data Acquisition (SCADA) applications. Supervisory control supports operator control of equipment, such as opening or closing a breaker. Data acquisition gathers telemetered data from various sources. The subtypes of the Telemetry entity deliberately match the UCA and IEC 61850 definitions.

This package also supports alarm presentation but it is not expected to be used by other applications.

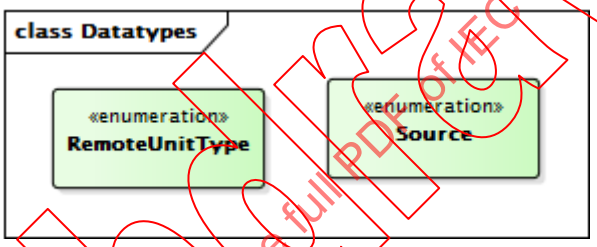


Figure 123 – Class diagram SCADA::Datatypes

Figure 123: Shows datatypes for SCADA model.

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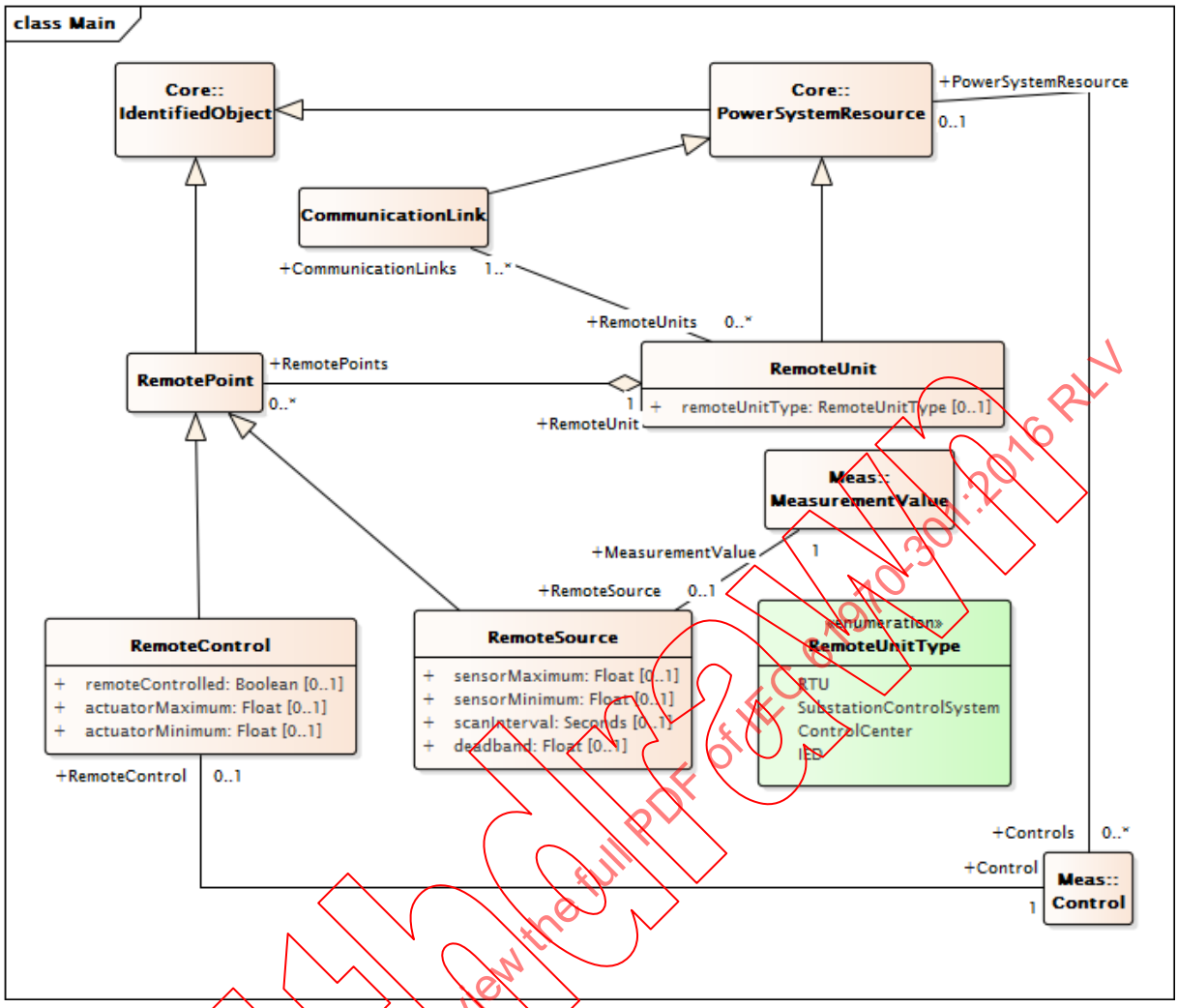


Figure 124 – Class diagram SCADA::Main

Figure 124: This diagram shows all classes included in the SCADA package as well as the key external classes that have associations with SCADA classes.

6.17.2 CommunicationLink

The connection to remote units is through one or more communication links. Reduntant links may exist. The CommunicationLink class inherits PowerSystemResource. The intention is to allow CommunicationLinks to have Measurements. These Measurements can be used to model link status as operational, out of service, unit failure, etc.

Table 653 shows all attributes of CommunicationLink.

Table 653 – Attributes of SCADA::CommunicationLink

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 654 shows all association ends of CommunicationLink with other classes.

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Table 654 – Association ends of SCADA::CommunicationLink with other classes

mult from	name	mult to	type	description
1..*	RemoteUnits	0..*	RemoteUnit	RTUs may be attached to communication links.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.17.3 RemoteControl

Remote controls are outputs that are sent by the remote unit to actuators in the process.

Table 655 shows all attributes of RemoteControl.

Table 655 – Attributes of SCADA::RemoteControl

name	mult	type	description
remoteControlled	0..1	Boolean	Set to true if the actuator is remotely controlled.
actuatorMaximum	0..1	Float	The maximum set point value accepted by the remote control point.
actuatorMinimum	0..1	Float	The minimum set point value accepted by the remote control point.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 656 shows all association ends of RemoteControl with other classes.

Table 656 – Association ends of SCADA::RemoteControl with other classes

mult from	name	mult to	type	description
0..1	Control	1..1	Control	The Control for the RemoteControl point.
0..*	RemoteUnit	1..1	RemoteUnit	inherited from: RemotePoint
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.17.4 RemotePoint

For an RTU, remote points correspond to telemetered values or control outputs. Other units (e.g. control centres) usually also contain calculated values.

Table 657 shows all attributes of RemotePoint.

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Table 657 – Attributes of SCADA::RemotePoint

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 658 shows all association ends of RemotePoint with other classes.

Table 658 – Association ends of SCADA::RemotePoint with other classes

mult from	name	mult to	type	description
0..*	RemoteUnit	1..1	RemoteUnit	Remote unit this point belongs to.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.17.5 RemoteSource

Remote sources are state variables that are telemetered or calculated within the remote unit.

Table 659 shows all attributes of RemoteSource.

Table 659 – Attributes of SCADA::RemoteSource

name	mult	type	description
sensorMaximum	0..1	Float	The maximum value the telemetry item can return.
sensorMinimum	0..1	Float	The minimum value the telemetry item can return.
scanInterval	0..1	Seconds	The time interval between scans.
deadband	0..1	Float	The smallest change in value to be reported.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 660 shows all association ends of RemoteSource with other classes.

Table 660 – Association ends of SCADA::RemoteSource with other classes

mult from	name	mult to	type	description
0..1	MeasurementValue	1..1	MeasurementValue	Link to the physical telemetered point associated with this measurement.
0..*	RemoteUnit	1..1	RemoteUnit	inherited from: RemotePoint
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.17.6 RemoteUnit

A remote unit can be an RTU, IED, substation control system, control centre, etc. The communication with the remote unit can be through various standard protocols (e.g. IEC 61870, IEC 61850) or non standard protocols (e.g. DNP, RP570, etc.). A remote unit contains remote data points that might be telemetered, collected or calculated. The RemoteUnit class inherits PowerSystemResource. The intention is to allow RemoteUnits to have Measurements. These Measurements can be used to model unit status as operational, out of service, unit failure, etc.

Table 661 shows all attributes of RemoteUnit.

Table 661 – Attributes of SCADA::RemoteUnit

name	mult	type	description
remoteUnitType	0..1	RemoteUnitType	Type of remote unit.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 662 shows all association ends of RemoteUnit with other classes.

Table 662 – Association ends of SCADA::RemoteUnit with other classes

mult from	name	mult to	type	description
0..*	CommunicationLinks	1..*	CommunicationLink	RTUs may be attached to communication links.
1..1	RemotePoints	0..*	RemotePoint	Remote points this Remote unit contains.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.17.7 RemoteUnitType enumeration

Type of remote unit.

Table 663 shows all literals of RemoteUnitType.

Table 663 – Literals of SCADA::RemoteUnitType

literal	value	description
RTU		Remote terminal unit.
SubstationControlSystem		Substation control system.
ControlCenter		Control centre.
IED		Intelligent electronic device (IED).

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6.17.8 Source enumeration

Source gives information related to the origin of a value.

Table 664 shows all literals of Source.

Table 664 – Literals of SCADA::Source

literal	value	description
PROCESS		The value is provided by input from the process I/O or being calculated from some function.
DEFAULTED		The value contains a default value.
SUBSTITUTED		The value is provided by input of an operator or by an automatic source.

6.18 Package ControlArea

6.18.1 General

The ControlArea package models area specifications which can be used for a variety of purposes. The package as a whole models potentially overlapping control area specifications for the purpose of actual generation control, load forecast area load capture, or powerflow based analysis.

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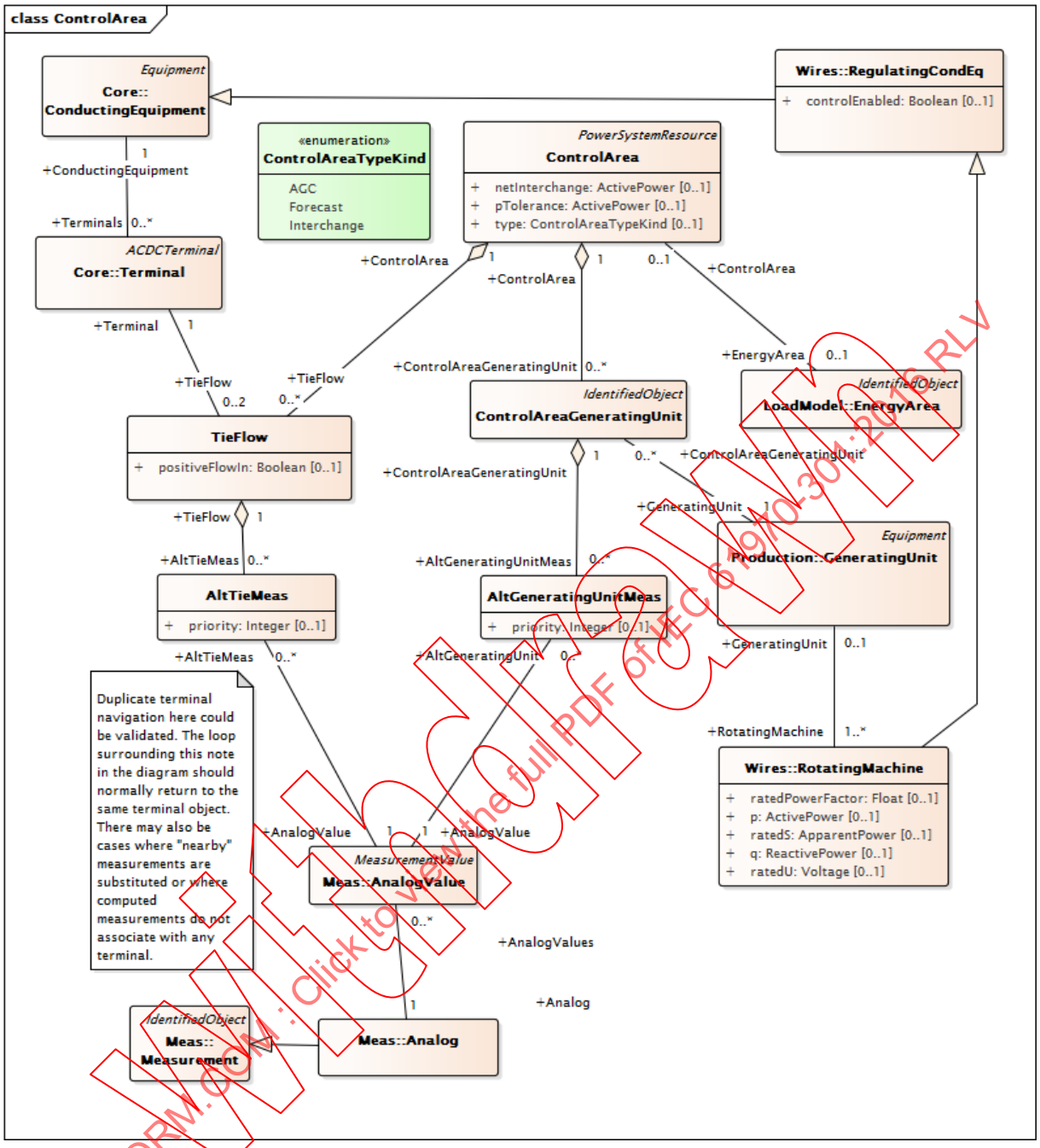


Figure 125 – Class diagram ControlArea::ControlArea

Figure 125: This diagram shows control area specification and some related classes. The Terminal to AnalogValue linkages are shown for clarity in understanding the control area specificaiton. The GeneratingUnit to Terminal linkages are also shown to illustrate how generation flows are specifically tied to the network.

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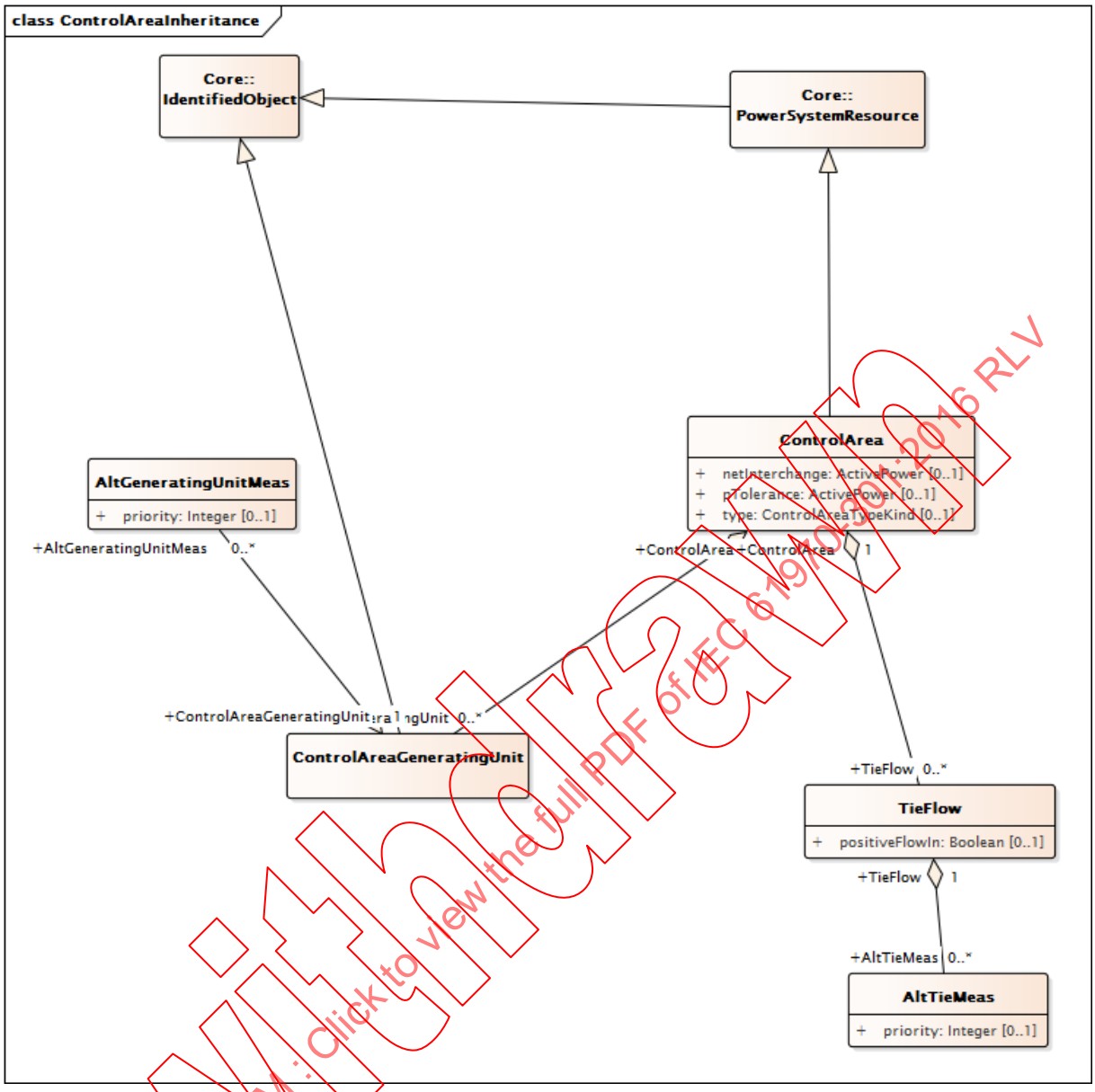


Figure 126 – Class diagram ControlArea::ControlAreaInheritance

Figure 126: Shows the inheritance of classes in this package.

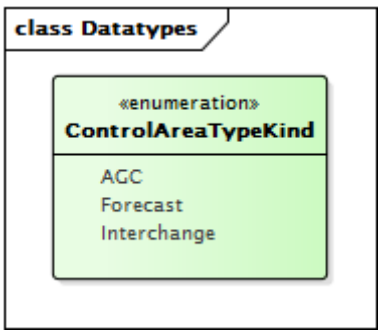


Figure 127 – Class diagram ControlArea::Datatypes

Figure 127: Shows datatypes for control areas.

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6.18.2 AltGeneratingUnitMeas root class

A prioritized measurement to be used for the generating unit in the control area specification.

Table 665 shows all attributes of AltGeneratingUnitMeas.

Table 665 – Attributes of ControlArea::AltGeneratingUnitMeas

name	mult	type	description
priority	0..1	Integer	Priority of a measurement usage. Lower numbers have first priority.

Table 666 shows all association ends of AltGeneratingUnitMeas with other classes.

Table 666 – Association ends of ControlArea::AltGeneratingUnitMeas with other classes

mult from	name	mult to	type	description
0..*	AnalogValue	1..1	AnalogValue	The specific analog value used as a source.
0..*	ControlAreaGeneratingUnit	1..1	ControlAreaGeneratingUnit	The control area generating unit to which the prioritized measurement assignment is applied.

6.18.3 AltTieMeas root class

A prioritized measurement to be used for the tie flow as part of the control area specification.

Table 667 shows all attributes of AltTieMeas.

Table 667 – Attributes of ControlArea::AltTieMeas

name	mult	type	description
priority	0..1	Integer	Priority of a measurement usage. Lower numbers have first priority.

Table 668 shows all association ends of AltTieMeas with other classes.

Table 668 – Association ends of ControlArea::AltTieMeas with other classes

mult from	name	mult to	type	description
0..*	AnalogValue	1..1	AnalogValue	The specific analog value used as a source.
0..*	TieFlow	1..1	TieFlow	The tie flow of the alternate measurements.

6.18.4 ControlArea

A control area is a grouping of generating units and/or loads and a cutset of tie lines (as terminals) which may be used for a variety of purposes including automatic generation control, powerflow solution area interchange control specification, and input to load forecasting. Note that any number of overlapping control area specifications can be superimposed on the physical model.

Table 669 shows all attributes of ControlArea.

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Table 669 – Attributes of ControlArea::ControlArea

name	mult	type	description
netInterchange	0..1	ActivePower	The specified positive net interchange into the control area, i.e. positive sign means flow in to the area.
pTolerance	0..1	ActivePower	Active power net interchange tolerance
type	0..1	ControlAreaTypeKind	The primary type of control area definition used to determine if this is used for automatic generation control, for planning interchange control, or other purposes. A control area specified with primary type of automatic generation control could still be forecast and used as an interchange area in power flow analysis.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 670 shows all association ends of ControlArea with other classes.

Table 670 – Association ends of ControlArea::ControlArea with other classes

mult from	name	mult to	type	description
0..1	EnergyArea	0..1	EnergyArea	The energy area that is forecast from this control area specification.
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	The generating unit specificaitons for the control area.
1..1	TieFlow	0..*	TieFlow	The tie flows associated with the control area.
0..*	PSRType	0..1	PSRType	inherited from: PowerSystemResource
0..1	Controls	0..*	Control	inherited from: PowerSystemResource
0..1	Measurements	0..*	Measurement	inherited from: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	inherited from: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.18.5 ControlAreaGeneratingUnit

A control area generating unit. This class is needed so that alternate control area definitions may include the same generating unit. Note only one instance within a control area should reference a specific generating unit.

Table 671 shows all attributes of ControlAreaGeneratingUnit.

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Table 671 – Attributes of ControlArea::ControlAreaGeneratingUnit

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 672 shows all association ends of ControlAreaGeneratingUnit with other classes.

Table 672 – Association ends of ControlArea::ControlAreaGeneratingUnit with other classes

mult from	name	mult to	type	description
0..*	GeneratingUnit	1..1	GeneratingUnit	The generating unit specified for this control area. Note that a control area should include a GeneratingUnit only once.
0..*	ControlArea	1..1	ControlArea	The parent control area for the generating unit specifications.
1..1	AltGeneratingUnitMeas	0..*	AltGeneratingUnitMeas	The link to prioritized measurements for this GeneratingUnit.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.18.6 ControlAreaTypeKind enumeration

The type of control area.

Table 673 shows all literals of ControlAreaTypeKind.

Table 673 – Literals of ControlArea::ControlAreaTypeKind

literal	value	description
AGC		Used for automatic generation control.
Forecast		Used for load forecast.
Interchange		Used for interchange specification or control.

6.18.7 TieFlow root class

A flow specification in terms of location and direction for a control area.

Table 674 shows all attributes of TieFlow.

Table 674 – Attributes of ControlArea::TieFlow

name	mult	type	description
positiveFlowIn	0..1	Boolean	True if the flow into the terminal (load convention) is also flow into the control area. For example, this attribute should be true if using the tie line terminal further away from the control area. For example to represent a tie to a shunt component (like a load or generator) in another area, this is the near end of a branch and this attribute would be specified as false.

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Table 675 shows all association ends of TieFlow with other classes.

Table 675 – Association ends of ControlArea::TieFlow with other classes

mult from	name	mult to	type	description
0..2	Terminal	1..1	Terminal	The terminal to which this tie flow belongs.
0..*	ControlArea	1..1	ControlArea	The control area of the tie flows.
1..1	AltTieMeas	0..*	AltTieMeas	The primary and alternate tie flow measurements associated with the tie flow.

6.19 Package Contingency

6.19.1 General

Contingencies to be studied.

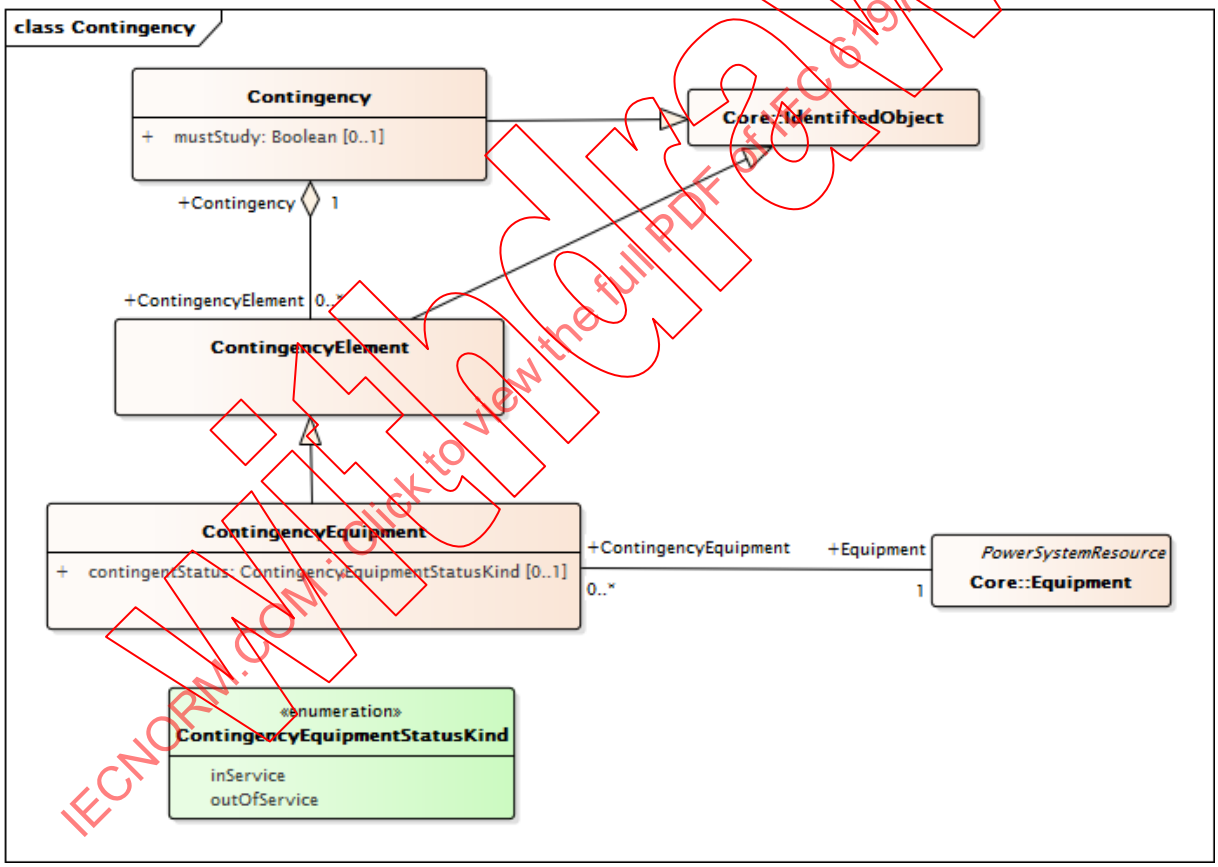


Figure 128 – Class diagram Contingency::Contingency

Figure 128: This diagram shows contingency model inheritance and associations.

6.19.2 Contingency

An event threatening system reliability, consisting of one or more contingency elements.

Table 676 shows all attributes of Contingency.

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Table 676 – Attributes of Contingency::Contingency

name	mult	type	description
mustStudy	0..1	Boolean	Set true if must study this contingency.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 677 shows all association ends of Contingency with other classes.

Table 677 – Association ends of Contingency::Contingency with other classes

mult from	name	mult to	type	description
1..1	ContingencyElement	0..*	ContingencyElement	A contingency can have any number of contingency elements.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.19.3 ContingencyElement

An element of a system event to be studied by contingency analysis, representing a change in status of a single piece of equipment.

Table 678 shows all attributes of ContingencyElement.

Table 678 – Attributes of Contingency::ContingencyElement

name	mult	type	description
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 679 shows all association ends of ContingencyElement with other classes.

Table 679 – Association ends of Contingency::ContingencyElement with other classes

mult from	name	mult to	type	description
0..*	Contingency	1..1	Contingency	A contingency element belongs to one contingency.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.19.4 ContingencyEquipment

Equipment whose in service status is to change, such as a power transformer or AC line segment.

Table 680 shows all attributes of ContingencyEquipment.

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Table 680 – Attributes of Contingency::ContingencyEquipment

name	mult	type	description
contingentStatus	0..1	ContingencyEquipmentStatusKind	The status for the associated equipment when in the contingency state. This status is independent of the case to which the contingency is originally applied, but defines the equipment status when the contingency is applied.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 681 shows all association ends of ContingencyEquipment with other classes.

Table 681 – Association ends of Contingency::ContingencyEquipment with other classes

mult from	name	mult to	type	description
0..*	Equipment	1..1	Equipment	The single piece of equipment to which to apply the contingency.
0..*	Contingency	1..1	Contingency	inherited from: ContingencyElement
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.19.5 ContingencyEquipmentStatusKind enumeration

Indicates the state which the contingency equipment is to be in when the contingency is applied.

Table 682 shows all literals of ContingencyEquipmentStatusKind.

Table 682 – Literals of Contingency::ContingencyEquipmentStatusKind

literal	value	description
inService		The equipment is in service.
outOfService		The equipment is to be taken out of service.

6.20 Package StateVariables

6.20.1 General

State variables for analysis solutions such as powerflow.

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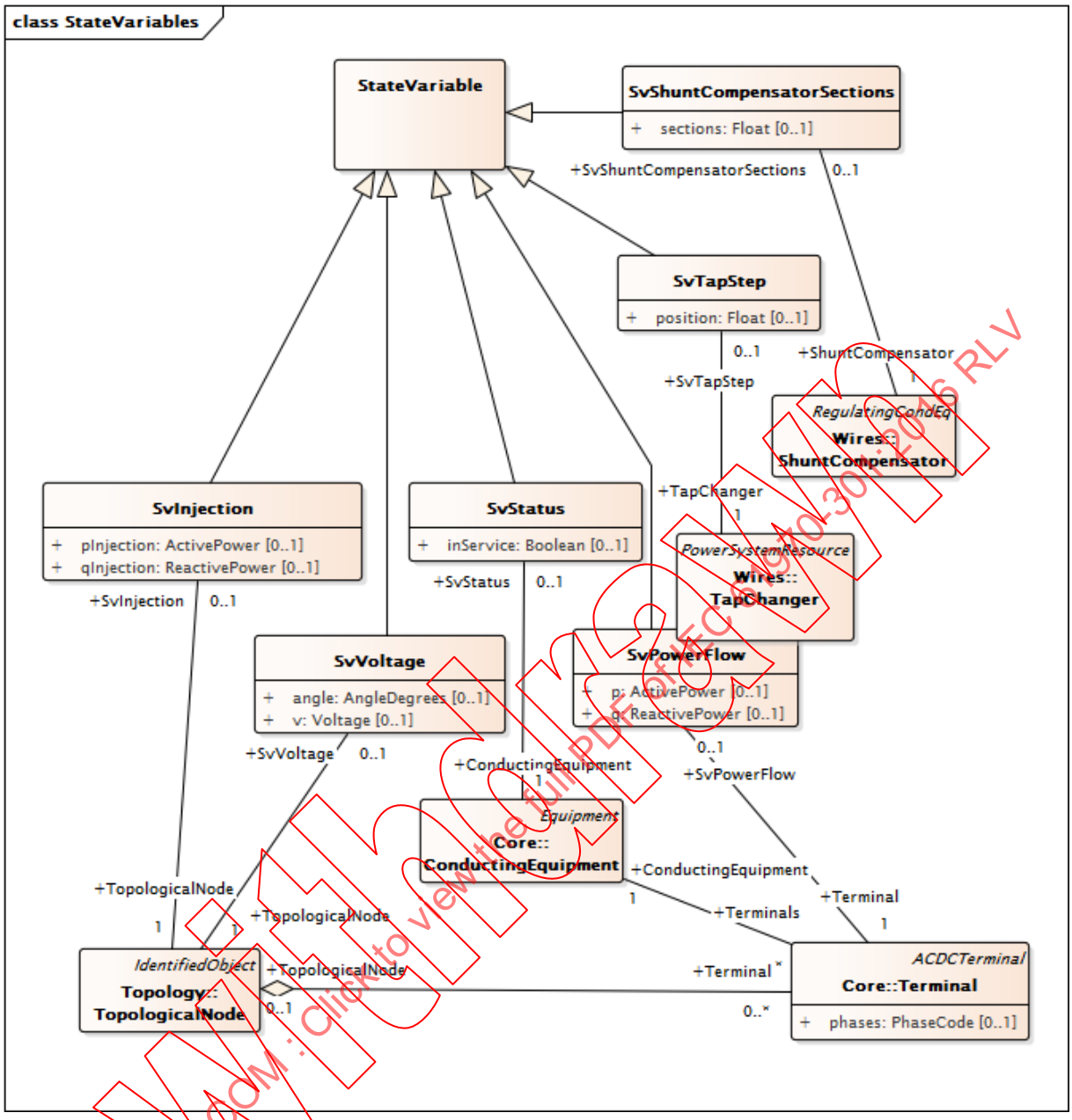


Figure 129 – Class diagram StateVariables::StateVariables

Figure 129: The state solution variables as derived from base StateVariable class. Note that specialized state variables are associated with objects derived from IdentifiedObject, but StateVariable does not derive from IdentifiedObject.

6.20.2 StateVariable root class

An abstract class for state variables.

6.20.3 SvInjection

The SvInjection reports the calculated bus injection minus the sum of the terminal flows. The terminal flow is positive out from the bus (load sign convention) and bus injection has positive flow into the bus. SvInjection may have the remainder after state estimation or slack after power flow calculation.

Table 683 shows all attributes of SvInjection.

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Table 683 – Attributes of StateVariables::SvInjection

name	mult	type	description
pInjection	0..1	ActivePower	The active power mismatch between calculated injection and initial injection. Positive sign means injection into the TopologicalNode (bus).
qInjection	0..1	ReactivePower	The reactive power mismatch between calculated injection and initial injection. Positive sign means injection into the TopologicalNode (bus).

Table 684 shows all association ends of SvInjection with other classes.

Table 684 – Association ends of StateVariables::SvInjection with other classes

mult from	name	mult to	type	description
0..1	TopologicalNode	1..1	TopologicalNode	The topological node associated with the flow injection state variable.

6.20.4 SvPowerFlow

State variable for power flow. Load convention is used for flow direction. This means flow out from the TopologicalNode into the equipment is positive.

Table 685 shows all attributes of SvPowerFlow.

Table 685 – Attributes of StateVariables::SvPowerFlow

name	mult	type	description
p	0..1	ActivePower	The active power flow. Load sign convention is used, i.e. positive sign means flow out from a TopologicalNode (bus) into the conducting equipment.
q	0..1	ReactivePower	The reactive power flow. Load sign convention is used, i.e. positive sign means flow out from a TopologicalNode (bus) into the conducting equipment.

Table 686 shows all association ends of SvPowerFlow with other classes.

Table 686 – Association ends of StateVariables::SvPowerFlow with other classes

mult from	name	mult to	type	description
0..1	Terminal	1..1	Terminal	The terminal associated with the power flow state variable.

6.20.5 SvShuntCompensatorSections

State variable for the number of sections in service for a shunt compensator.

Table 687 shows all attributes of SvShuntCompensatorSections.

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Table 687 – Attributes of StateVariables::SvShuntCompensatorSections

name	mult	type	description
sections	0..1	Float	The number of sections in service as a continous variable. To get integer value scale with ShuntCompensator.bPerSection.

Table 688 shows all association ends of SvShuntCompensatorSections with other classes.

Table 688 – Association ends of StateVariables::SvShuntCompensatorSections with other classes

mult from	name	mult to	type	description
0..1	ShuntCompensator	1..1	ShuntCompensator	The shunt compensator for which the state applies.

6.20.6 SvStatus

State variable for status.

Table 689 shows all attributes of SvStatus.

Table 689 – Attributes of StateVariables::SvStatus

name	mult	type	description
inService	0..1	Boolean	The in service status as a result of topology processing.

Table 690 shows all association ends of SvStatus with other classes.

Table 690 – Association ends of StateVariables::SvStatus with other classes

mult from	name	mult to	type	description
0..1	ConductingEquipment	1..1	ConductingEquipment	The conducting equipment associated with the status state variable.

6.20.7 SvTapStep

State variable for transformer tap step.

Table 691 shows all attributes of SvTapStep.

Table 691 – Attributes of StateVariables::SvTapStep

name	mult	type	description
position	0..1	Float	The floating point tap position. This is not the tap ratio, but rather the tap step position as defined by the related tap changer model and normally is constrained to be within the range of minimum and maximum tap positions.

Table 692 shows all association ends of SvTapStep with other classes.

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Table 692 – Association ends of StateVariables::SvTapStep with other classes

mult from	name	mult to	type	description
0..1	TapChanger	1..1	TapChanger	The tap changer associated with the tap step state.

6.20.8 SvVoltage

State variable for voltage.

Table 693 shows all attributes of SvVoltage.

Table 693 – Attributes of StateVariables::SvVoltage

name	mult	type	description
angle	0..1	AngleDegrees	The voltage angle of the topological node complex voltage with respect to system reference.
v	0..1	Voltage	The voltage magnitude of the topological node.

Table 694 shows all association ends of SvVoltage with other classes.

Table 694 – Association ends of StateVariables::SvVoltage with other classes

mult from	name	mult to	type	description
0..1	TopologicalNode	1..1	TopologicalNode	The topological node associated with the voltage state.

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Annex A
(informative)

Custom extensions

A.1 Overview

Annex A is not normative and contains custom extensions with widespread use that may be useful to more than the organizations that created them.

A.2 European extensions

A.2.1 Overview

Clause A.2 describes the European extensions to IEC 61970-301 which are used in profiles derived from IEC 61970-452 and IEC 61970-456.

Subclauses A.2.2 to A.2.7 contain only the extended classes and attributes, hence they do not include classes or attributes already defined in this document.

A.2.2 OperationalLimitType

Table A.1 shows extended attributes of OperationalLimitType.

Table A.1 – Attributes of OperationalLimitType

name	mult	type	description
limitType	0..1	LimitTypeKind	Types of limits defined in the ENTSO-E Operational Handbook Policy 3.

A.2.3 LimitTypeKind enumeration

The enumeration defines the kinds of the limit types.

Table A.2 shows all literals of LimitTypeKind.

Table A.2 – Literals of LimitTypeKind

literal	value	description
patl		The Permanent Admissible Transmission Loading (PATL) is the loading in amperes, MVA or MW that can be accepted by a network branch for an unlimited duration without any risk for the material. The duration attribute is not used and shall be excluded for the PATL limit type. Hence only one limit value exists for the PATL type.
patlt		Permanent Admissible Transmission Loading Threshold (PATLT) is a value in engineering units defined for PATL and calculated using a percentage less than 100 % of the PATL type intended to alert operators of an arising condition. The percentage should be given in the name of the OperationalLimitSet. The aceptableDuration is another way to express the severity of the limit.

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literal	value	description
tatl		Temporarily Admissible Transmission Loading (TATL) which is the loading in amperes, MVA or MW that can be accepted by a branch for a certain limited duration. The TATL can be defined in different ways: • as a fixed percentage of the PATL for a given time (for example, 115 % of the PATL that can be accepted during 15 minutes), • pairs of TATL type and Duration calculated for each line taking into account its particular configuration and conditions of functioning (for example, it can define a TATL acceptable during 20 minutes and another one acceptable during 10 minutes). Such a definition of TATL can depend on the initial operating conditions of the network element (sag situation of a line). The duration attribute can be used to define several TATL limit types. Hence multiple TATL limit values may exist having different durations.
tc		Tripping Current (TC) is the ultimate intensity without any delay. It is defined as the threshold the line will trip without any possible remedial actions. The tripping of the network element is ordered by protections against short circuits or by overload protections, but in any case, the activation delay of these protections is not compatible with the reaction delay of an operator (less than one minute). The duration is always zero and the duration attribute may be left out. Hence only one limit value exists for the TC type.
tct		Tripping Current Threshold (TCT) is a value in engineering units defined for TC and calculated using a percentage less than 100 % of the TC type intended to alert operators of an arising condition. The percentage should be given in the name of the OperationalLimitSet. The aceptableDuration is another way to express the severity of the limit.
highVoltage		Referring to the rating of the equipments, a voltage too high can lead to accelerated ageing or the destruction of the equipment. This limit type may or may not have duration.
lowVoltage		A too low voltage can disturb the normal operation of some protections and transformer equipped with on-load tap changers, electronic power devices or can affect the behavior of the auxiliaries of generation units. This limit type may or may not have duration.

A.2.4 IdentifiedObject

Table A.3 shows extended attributes of IdentifiedObject.

Table A.3 – Attributes of IdentifiedObject

name	mult	type	description
energyIdentCodeEic	0..1	String	The attribute is used for an exchange of the EIC code (Energy identification Code). The length of the string is 16 characters as defined by the EIC code. References: Local issuing offices for EIC: https://www.entsoe.eu/data/energy-identification-codes-eic/eic-lio-websites/Pages/default.aspx [viewed 2016-08-17] EIC description: https://www.entsoe.eu/data/energy-identification-codes-eic/eic-documentation/Pages/default.aspx [viewed 2016-08-17]
shortName	0..1	String	The attribute is used for an exchange of a human readable short name with length of the string 12 characters maximum.

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A.2.5 EnergySchedulingType

Used to define the type of generation for scheduling purposes. The class inherits from IdentifiedObject. Table A.4 shows all association ends of EnergySchedulingType with other classes.

Table A.4 – Association ends of EnergySchedulingType

mult from	name	mult to	type	description
0..*	EnergySource	0..1	EnergySchedulingType	Energy Source of a particular Energy Scheduling Type.

A.2.6 ConnectivityNode

Table A.5 shows extended attributes of ConnectivityNode. These extensions are used in the boundary profiles only.

Table A.5 – Attributes of ConnectivityNode

name	mult	type	description
boundaryPoint	0..1	Boolean	Identifies if a node is a BoundaryPoint. If boundaryPoint=true the ConnectivityNode or the TopologicalNode represents a BoundaryPoint.
fromEndIsoCode	0..1	String	The attribute is used for an exchange of the ISO code of the region which the "From" side of the Boundary point belongs to or is connected to. The ISO code is a two-character country code as defined by ISO 3166 (http://www.iso.org/iso/country_codes). The length of the string is 2 characters maximum. The attribute is required for the Boundary Model Authority Set where this attribute is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
fromEndName	0..1	String	The attribute is used for an exchange of a human readable name with length of the string 32 characters maximum. The attribute covers two cases: • If the Boundary point is placed on a tie-line the attribute is used for exchange of the geographical name of the substation which the "From" side of the tie-line is connected to. • If the Boundary point is placed in a substation the attribute is used for exchange of the name of the element (e.g. PowerTransformer, ACLineSegment, Switch, etc.) which the "From" side of the Boundary point is connected to. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
fromEndNameTso	0..1	String	The attribute is used for an exchange of the name of the TSO which the "From" side of the Boundary point belongs to or is connected to. The length of the string is 32 characters maximum. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.

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name	mult	type	description
toEndIsoCode	0..1	String	The attribute is used for an exchange of the ISO code of the region which the “To” side of the Boundary point belongs to or is connected to. The ISO code is a two-character country code as defined by ISO 3166 (http://www.iso.org/iso/country_codes). The length of the string is 2 characters maximum. The attribute is required for the Boundary Model Authority Set where this attribute is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
toEndName	0..1	String	The attribute is used for an exchange of a human readable name with length of the string 32 characters maximum. The attribute covers two cases: • If the Boundary point is placed on a tie-line the attribute is used for exchange of the geographical name of the substation which the “To” side of the tie-line is connected to. • If the Boundary point is placed in a substation the attribute is used for exchange of the name of the element (e.g. PowerTransformer, ACLineSegment, Switch, etc.) which the “To” side of the Boundary point is connected to. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
toEndNameTso	0..1	String	The attribute is used for an exchange of the name of the TSO which the “To” side of the Boundary point belongs to or is connected to. The length of the string is 32 characters maximum. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.

A.2.7 TopologicalNode

Table A.6 shows extended attributes of TopologicalNode. These extensions are used in the boundary profiles only.

Table A.6 – Attributes of TopologicalNode

name	mult	type	description
boundaryPoint	0..1	Boolean	Identifies if a node is a BoundaryPoint. If boundaryPoint=true the ConnectivityNode or the TopologicalNode represents a BoundaryPoint.
fromEndIsoCode	0..1	String	The attribute is used for an exchange of the ISO code of the region which the “From” side of the Boundary point belongs to or is connected to. The ISO code is a two-character country code as defined by ISO 3166 (http://www.iso.org/iso/country_codes). The length of the string is 2 characters maximum. The attribute is required for the Boundary Model Authority Set where this attribute is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.

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name	mult	type	description
fromEndName	0..1	String	The attribute is used for an exchange of a human readable name with length of the string 32 characters maximum. The attribute covers two cases: • If the Boundary point is placed on a tie-line the attribute is used for exchange of the geographical name of the substation which the “From” side of the tie-line is connected to. • If the Boundary point is placed in a substation the attribute is used for exchange of the name of the element (e.g. PowerTransformer, ACLineSegment, Switch, etc.) which the “From” side of the Boundary point is connected to. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
fromEndNameTso	0..1	String	The attribute is used for an exchange of the name of the TSO which the “From” side of the Boundary point belongs to or is connected to. The length of the string is 32 characters maximum. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
toEndIsoCode	0..1	String	The attribute is used for an exchange of the ISO code of the region which the “To” side of the Boundary point belongs to or is connected to. The ISO code is a two-character country code as defined by ISO 3166 (http://www.iso.org/iso/country_codes). The length of the string is 2 characters maximum. The attribute is required for the Boundary Model Authority Set where this attribute is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
toEndName	0..1	String	The attribute is used for an exchange of a human readable name with length of the string 32 characters maximum. The attribute covers two cases: • If the Boundary point is placed on a tie-line the attribute is used for exchange of the geographical name of the substation which the “To” side of the tie-line is connected to. • If the Boundary point is placed in a substation the attribute is used for exchange of the name of the element (e.g. PowerTransformer, ACLineSegment, Switch, etc) which the “To” side of the Boundary point is connected to. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.
toEndNameTso	0..1	String	The attribute is used for an exchange of the name of the TSO which the “To” side of the Boundary point belongs to or is connected to. The length of the string is 32 characters maximum. The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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INTERFACE DE PROGRAMMATION D'APPLICATION POUR SYSTÈME DE GESTION D'ÉNERGIE (EMS-API) –

Partie 301: Base de modèle d'information commun (CIM)

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La Norme internationale IEC 61970-301 a été établie par le comité d'études 57 de l'IEC: Gestion des systèmes de puissance et échanges d'informations associés

Cette sixième édition annule et remplace la cinquième édition parue en 2013. Cette sixième édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) un nouveau modèle de mise à la terre, y compris les bobines Petersen;
b) des modèles de courant continu à haute tension (CCHT);
c) l'ajout de modèles de compensation de var statique;
d) des mises à jour concernant les transformateurs déphaseurs; la section a été ajoutée;
e) des calculs de courts-circuits issus de l'IEC 60909;

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f) l'ajout d'un compensateur shunt non linéaire;

g) l'ajout d'un modèle pour les données d'entrée des calculs du régime établi, Steady State Hypothesis (hypothèse en régime établi);

h) l'ajout d'un modèle de fréquence de base;

i) des corrections relatives à des problèmes de moindre importance, par exemple problèmes trouvés lors des essais d'interopérabilité de l'ENTSO-E;

j) le nettoyage de l'UML;

k) l'ajout d'un nouveau modèle de PowerElectronicUnits et de leur connexion au réseau en courant alternatif;

l) une nouvelle section concernant la relation entre TapChanger.ltcFlag et TapChanger.TapChangerControl;

m) une Annexe A comprenant l'ajout d'extensions personnalisées.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
57/1779/FDIS	57/1788/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 61970, publiées sous le titre général: *Interface de programmation d'application pour système de gestion d'énergie (EMS-API)*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. À cette date, la publication sera

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- supprimée,
- remplacée par une édition révisée, ou
- amendée.

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INTRODUCTION

Le présent document est l'une des parties de la série IEC 61970 qui définit une interface de programmation d'application (API – Application program interface) pour un système de gestion d'énergie (EMS – Energy management system). L'IEC 61970 a été initialement fondée sur les travaux réalisés dans le cadre du projet de recherche (RP-3654-1) sur les API de centres de conduite (CCAPI) de l'EPRI. Le projet CCAPI de l'EPRI avait principalement pour objet de:

- réduire les coûts et le temps nécessaires à l'ajout de nouvelles applications à un EMS;
- protéger l'investissement dans les applications ou systèmes existant(e)s qui fonctionnent efficacement dans un EMS.

Le principal objet de la série IEC 61970 est de produire les normes destinées à faciliter l'intégration d'applications EMS développées de façon indépendante par différents fournisseurs, entre des systèmes EMS complets développés de façon indépendante ou entre un système EMS et d'autres systèmes concernés par différents aspects de l'exploitation d'un système de puissance, tels que les systèmes de gestion de la distribution (DMS – Distribution management systems) ou de la production. Cela est réalisé en définissant des API pour permettre à ces applications ou systèmes d'accéder aux données publiques et d'échanger des informations indépendamment de la représentation interne de ces informations.

Le modèle d'information commun (CIM – Common Information Model) spécifie la sémantique de cette API. Les spécifications des composants d'interface (CIS – Component Interface Specifications), qui sont contenues dans d'autres parties de la série de normes IEC 61970, précisent le contenu des messages échangés.

Le CIM est un modèle abstrait contenant tous les objets principaux d'une entreprise de service public d'électricité habituellement nécessaires pour représenter les opérations d'une entreprise de service public d'électricité. Ce modèle inclut les classes et les attributs publics de ces objets, ainsi que les relations entre eux.

Le présent document définit la base du CIM constituée d'un ensemble de paquetages qui offrent une vue logique des aspects fonctionnels d'un EMS incluant SCADA (Supervisory control and data acquisition – système de supervision, contrôle et acquisition de données). D'autres domaines fonctionnels sont normalisés dans des documents IEC distincts qui complètent et référencent le présent document. Par exemple, l'IEC 61968-11 traite des modèles de distribution et référence le présent document. Alors qu'il existe plusieurs normes de l'IEC qui traitent des différentes parties du CIM, un seul modèle d'information unifié comprenant le CIM est sous-jacent à tous ces documents normatifs individuels.

La commission électrotechnique internationale (IEC) attire l'attention sur le fait qu'il est déclaré que la conformité au présent document peut impliquer l'utilisation d'un brevet intéressant une mise en œuvre gérée par ordinateur d'un modèle de système de puissance orienté objet dans une base de données relationnelle. À ce titre, elle n'est en conflit avec aucun développement de modèle logique de système de puissance incluant le CIM, lorsque la mise en œuvre du modèle n'est pas définie.

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INTERFACE DE PROGRAMMATION D'APPLICATION POUR SYSTÈME DE GESTION D'ÉNERGIE (EMS-API) –

Partie 301: Base de modèle d'information commun (CIM)

1 Domaine d'application

Le modèle d'information commun (CIM – common information model) est un modèle abstrait qui représente tous les objets principaux d'une entreprise de service public d'électricité habituellement nécessaires aux opérations d'une entreprise de service public d'électricité. La représentation normalisée des ressources de systèmes de puissance comme classes et attributs d'objets ainsi que leurs relations que fournit le CIM facilite l'intégration des applications réseau développées de façon indépendante par différents fournisseurs, entre des systèmes complets exploitant des applications réseau développés de façon indépendante ou entre un système exploitant des applications réseau et d'autres systèmes concernés par différents aspects des opérations d'un système de puissance tels que la gestion de la production ou de la distribution. Le système SCADA (système de supervision, contrôle et acquisition de données – supervisory control and data acquisition) est modélisé dans toute la mesure nécessaire pour prendre en charge la simulation des systèmes de puissance et la communication entre des centres de conduite. Le CIM facilite l'intégration en définissant un langage commun (c'est-à-dire une sémantique) fondé sur le modèle CIM pour permettre à ces applications ou systèmes d'accéder aux données publiques et d'échanger des informations indépendamment de la représentation interne de ces informations.

Les classes d'objets représentées dans le CIM sont de nature abstraite et peuvent être utilisées dans une large gamme d'applications. L'utilisation du CIM n'est pas limitée à son application dans un EMS. Il convient de considérer le présent document comme un outil permettant l'intégration dans tout domaine nécessitant d'appliquer un modèle commun de système de puissance pour faciliter l'interopérabilité et la compatibilité de connexion entre des applications et des systèmes indépendants de toute mise en œuvre particulière.

En raison de la taille du CIM complet, les classes d'objets qui le composent sont regroupées en un certain nombre de Paquetages logiques, qui représentent chacun une certaine partie du système de puissance global modélisé. Les ensembles de ces Paquetages sont fournis progressivement sous forme de Normes internationales distinctes. Le présent document spécifie un ensemble de Base de paquetages qui offrent une vue logique sur les aspects fonctionnels des informations relatives à un EMS d'une entreprise de service public d'électricité qui sont partagées par toutes les applications. D'autres normes spécifient des aspects plus spécifiques du modèle qui ne sont nécessaires qu'à certaines applications. Le Paragraphe 4.3 du présent document définit le découpage actuel des paquetages dans les documents normatifs.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60050 (toutes les parties), *Vocabulaire électrotechnique international (IEV)* (disponible sous www.electropedia.org)

IEC 61850 (toutes les parties), *Réseaux et systèmes de communication pour l'automatisation des systèmes électriques*

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IEC 61850-7-4:2010, *Communication networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes* (disponible en anglais seulement)

IEC 61968 (toutes les parties), *Intégration d'applications pour les services électriques – Interfaces système pour la gestion de distribution*

IEC TS 61970-2, *Energy management system application program interface (EMS-API) – Part 2: Glossary* (disponible en anglais seulement)

Object Management Group: UML 2.0 Specification – http://www.omg.org

3 Termes et définitions

Pour les besoins du présent document, les termes et les définitions de l'IEC TS 61970-2 et de l'IEC 60050, ainsi que les suivants, s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1.1
système de gestion d'énergie
EMS
système informatique comprenant une plate-forme logicielle offrant les services de support de base et un ensemble d'applications offrant les fonctionnalités requises pour le bon fonctionnement des installations de production et de transport d'électricité afin d'assurer la sécurité adéquate d'approvisionnement énergétique à un coût minimal

Note 1 à l'article: L'abréviation «EMS» est dérivée du terme anglais développé correspondant «energy management system».

3.1.2
interface de programmation d'application
API
ensemble des fonctions publiques qu'offre un composant exécutable d'application pour être utilisées par d'autres composants exécutables d'application

Note 1 à l'article: L'abréviation «API» est dérivée du terme anglais développé correspondant «application program interface».

3.1.3
langage de modélisation unifié
UML
langage descriptif formel et complet avec des techniques de présentation de diagrammes utilisées pour représenter des systèmes logiciels, depuis l'analyse des exigences, en passant par la conception et la mise en œuvre, jusqu'à la documentation

Note 1 à l'article: Le langage UML a évolué pour devenir une Norme internationale (ISO/IEC 19505, publiée en 2012) en passant d'un ensemble de méthodes apportées par différents pratiquants. Le CIM se réfère à l'UML pour définir le modèle, des outils automatiques génèrent directement à partir de l'UML la documentation, les schémas ainsi que d'autres artéfacts. Il est nécessaire d'avoir des notions d'UML pour comprendre le CIM.

Note 2 à l'article: L'abréviation «UML» est dérivée du terme anglais développé correspondant «unified modeling language».

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3.1.4
profil
sous-ensemble des classes, associations et attributs du CIM nécessaires pour accomplir un type spécifique d'interface

Note 1 à l'article: Ceci peut être exprimé dans des fichiers XSD, RDF et/ou OWL. Un profil peut être soumis à l'essai entre des applications. Un profil est nécessaire pour "utiliser" le CIM. Plusieurs profils sont définis dans les séries IEC 61968 et IEC 62325.

4 Spécification du CIM

4.1 Vue d'ensemble

Le modèle CIM est décrit dans le langage de modélisation unifié (UML) qui est conservé comme un fichier UML géré par un outil d'édition UML. Le fichier UML existe dans différents formats:

- un format propriétaire d'outil,
- un format xmi normalisé.

Le modèle CIM est décrit à l'Article 6, qui présente un rapport généré à partir du fichier UML. Le nom du fichier UML utilisé pour la génération de l'Article 6 est:

- IEC 61970cim16v33_IEC 61968cim12v08_IEC 62325cim03v01a.

Ce fichier peut être obtenu auprès du groupe des utilisateurs du CIM.

4.2 Notation de modélisation du CIM

Le CIM est défini en utilisant des techniques de modélisation orientées objet. Plus précisément, la spécification du CIM utilise la notation du Langage de modélisation unifié (UML) qui définit le CIM comme un groupe de paquetages.

Chaque paquetage du CIM contient un ou plusieurs diagrammes de classe représentant sous forme graphique toutes les classes de ce paquetage et leurs relations. Chaque classe est ensuite définie de façon textuelle en mettant l'accent sur ses attributs et ses relations avec d'autres classes.

La notation UML est décrite dans les documents de l'Object Management Group (OMG) et dans plusieurs autres manuels.

4.3 Paquetages CIM

Le CIM est fractionné en un ensemble de paquetages. Un paquetage est un moyen général permettant de grouper des éléments liés à un modèle. Les paquetages ont été choisis pour simplifier la conception, la compréhension et la révision du modèle. Le modèle d'information commun se compose de l'ensemble complet de paquetages. Des entités peuvent avoir des associations dépassant les limites de plusieurs paquetages. Chaque application utilise des informations représentées dans plusieurs paquetages.

Le CIM complet est fractionné en groupes de paquetages afin de mieux les gérer et maintenir. Ces groupes sont affectés à différents groupes de travail (WG – working group) de l'IEC.

Les paquetages inclus dans la CEI 61970-301 (le présent document) sont contenus dans le paquetage de la CEI 61970. Les paquetages de la CEI 61970 ne dépendent pas d'autres paquetages externes. Comme le montre Figure 1, le paquetage de la CEI 61970 et ses sous-paquetages servent de modèle central ou de modèle de base à d'autres paquetages du CIM. Les lignes tiretées indiquent des relations de dépendance, la flèche allant du paquetage dépendant vers le paquetage dont il dépend. Les paquetages dans la série de normes CEI 61968 décrivent des parties supplémentaires du CIM qui traitent d'autres vues logiques

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des opérations d'une entreprise de service public, y compris la gestion du patrimoine, des emplacements, des activités, des clients, de la documentation et des travaux et des comptages. Les paquetages dans les séries de normes CEI 62325 décrivent les marchés de l'énergie électrique.

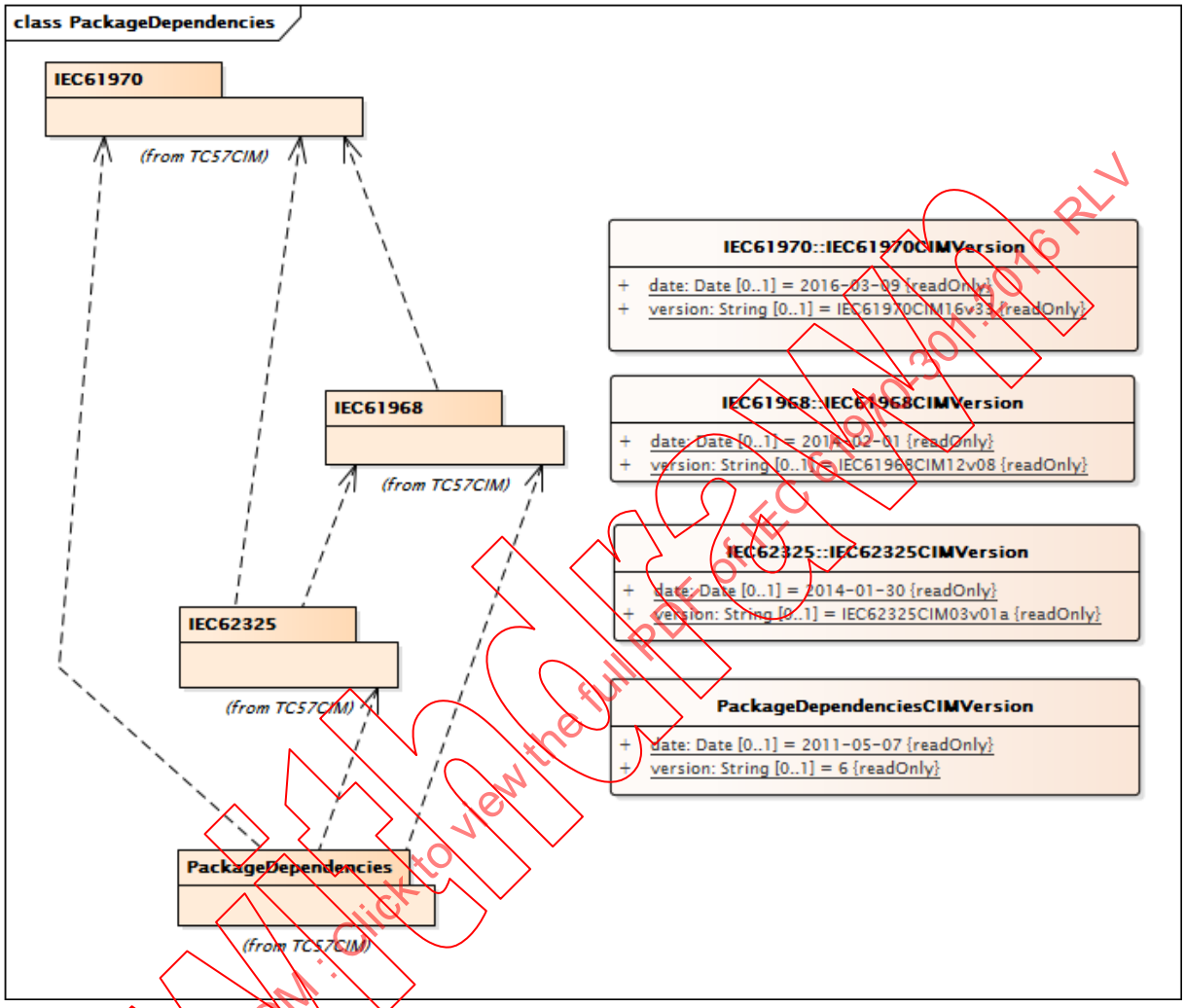


Figure 1 – Exemple de dépendances du paquetage de groupe de travail

Noter que les limites du paquetage n'impliquent pas de limites pour une application. Une application peut utiliser des entités CIM provenant de différents paquetages. Il est également prévu que des paquetages du CIM en dehors de ceux décrits dans le présent document auront des dépendances avec certains des paquetages décrits dans le présent document, notamment les paquetages Domain et Core, même si d'autres dépendances existeront aussi.

La Figure 2 représente les paquetages définis pour la Base de CIM de l'IEC 61970-301 et leurs relations de dépendance.

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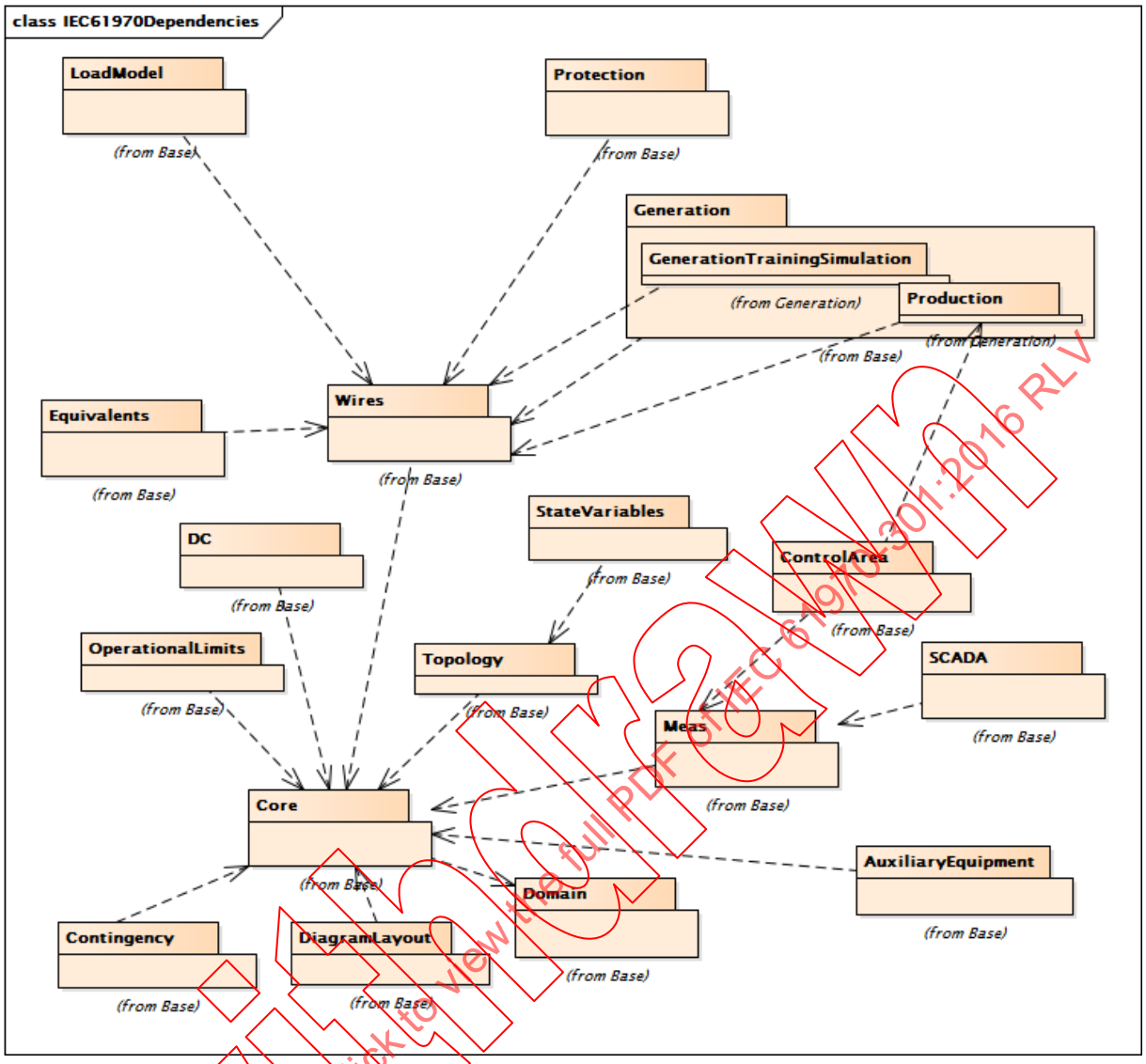


Figure 2 – Diagramme du paquetage CIM IEC 61970-301

4.4 Classes CIM et relations

4.4.1 Classes

Le ou les diagrammes de classe de chaque paquetage CIM représentent toutes les classes du paquetage et leurs relations. Lorsque des relations existent avec des classes dans d'autres paquetages, ces classes peuvent être également représentées.

Les classes et les objets modélisent ce qui se trouve dans un système de puissance et qui nécessite d'être représenté de la même façon pour des applications de système de puissance. Une classe est une description d'un objet réel, tel qu'un transformateur électrique, un générateur ou une charge, qui nécessite d'être représenté comme faisant partie du modèle global de système de puissance dans un EMS, par exemple. Parmi les autres types d'objets figurent des éléments tels que les programmes et les mesures qui nécessitent également d'être traités, analysés et enregistrés par des applications EMS. De tels objets nécessitent une représentation commune pour atteindre les objectifs de compatibilité de connexion et d'interopérabilité de la norme EMS-API. Un objet particulier dans un système de puissance ayant une identité unique est modélisé comme une instance de la classe à laquelle il appartient.

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Il convient également de noter que le CIM est défini pour faciliter l'échange de données. Comme défini dans le présent document, les entités du CIM n'ont pas de comportement. Pour une interface spécifique, un profil est défini et comprend des sous-ensembles de classes, attributs et associations du CIM. Un profil définit la charge utile de message pour une interface.

Les classes comportent des attributs qui décrivent les caractéristiques des objets. Chaque classe du CIM contient les attributs décrivant et identifiant une instance spécifique de la classe. Seuls les attributs d'intérêt public pour les applications réseau sont inclus dans les descriptions de classes.

Chaque attribut a un type qui identifie le type d'attribut dont il s'agit. Les attributs typiques sont de type Integer (entier), Float (valeur flottante), Boolean (valeur booléenne), String (chaîne de caractères), Date et Decimal (valeur décimale), qui sont appelés types primitifs. Cependant, de nombreux types supplémentaires sont définis comme partie intégrante de la spécification du CIM. Par exemple, ShuntCompensator a un attribut "maxU" du type Voltage. La définition de nombreux types partagés est contenue dans le paquetage Domain. Les stéréotypes Primitive, enumeration, CIMDatatype et Compound de l'UML sont ajoutés aux classes utilisées comme types. Le stéréotype CIMDatatype est utilisé avec une sémantique spécifique du CIM pour une valeur simple avec des attributs supplémentaires, qui décrit l'unité et le multiplicateur de la valeur, par exemple, unit, multiplier, denominatorUnit et denominatorMultiplier. Ceci implique une mise en correspondance personnalisée avec des artéfacts de sérialisation tels que RDFS, OWL et XSD. Les classes ayant ces stéréotypes ne participent pas à des relations de généralisation ou d'association et sont simplement utilisées comme types pour des attributs. Le stéréotype enumeration est utilisé pour décrire un attribut avec une liste énumérée de choix. Le stéréotype Compound est utilisé pour décrire des ensembles d'attributs liés qui sont couramment réutilisés. Les classes Compound peuvent se composer de Primitive, enumeration, CIMDatatype ou d'autres classes Compound à condition qu'elles ne participent pas à une récursion.

Tous les attributs du CIM sont implicitement facultatifs en ce sens que les profils utilisant le CIM peuvent les éliminer tous.

Les relations entre les classes révèlent la façon dont elles sont structurées l'une par rapport à l'autre. Les classes CIM sont reliées de différentes façons, comme décrit en 4.4.2 à 4.4.4.

4.4.2 Generalization

Une generalization (généralisation) est une relation entre une classe générale et une classe plus spécifique. La classe plus spécifique ne peut contenir que des informations supplémentaires. L'association de type Generalization permet à une classe spécifique d'hériter d'attributs et de relations de toutes les classes plus générales situées au-dessus d'elle.

La Figure 3 est un exemple de generalization (généralisation). Dans cet exemple issu du paquetage Wires (fils), un Breaker (disjoncteur) est un type plus spécifique de ProtectedSwitch (commutateur protégé), qui à son tour est un type plus spécifique de Switch (commutateur), qui est un type plus spécifique de ConductingEquipment (équipement conducteur), etc. Un PowerTransformer (transformateur de puissance) est un autre type plus spécifique de ConductingEquipment. Noter que PowerSystemResource (ressource de système de puissance) hérite de la classe IdentifiedObject (objet identifié) qui ne figure pas dans le diagramme. IdentifiedObject est donc représenté en italique dans l'angle supérieur droit de la classe PowerSystemResource.

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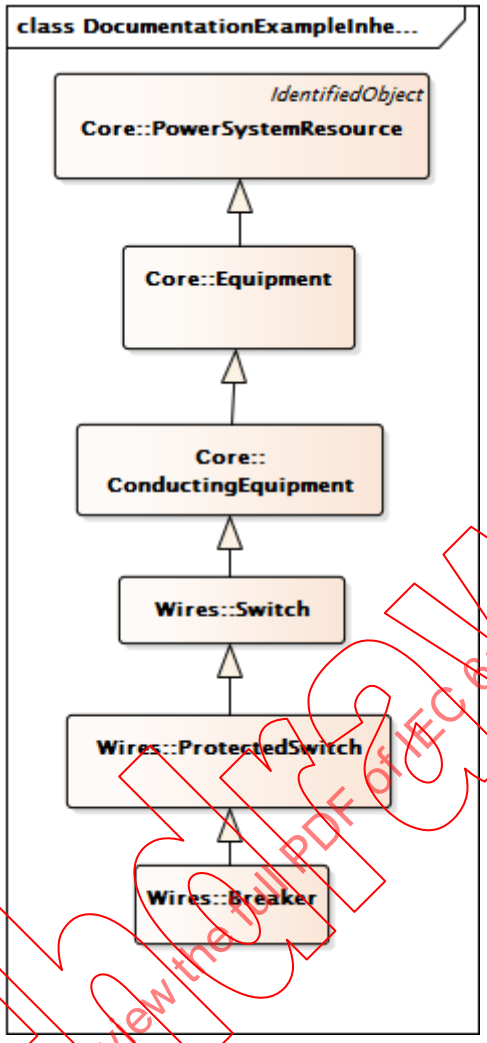
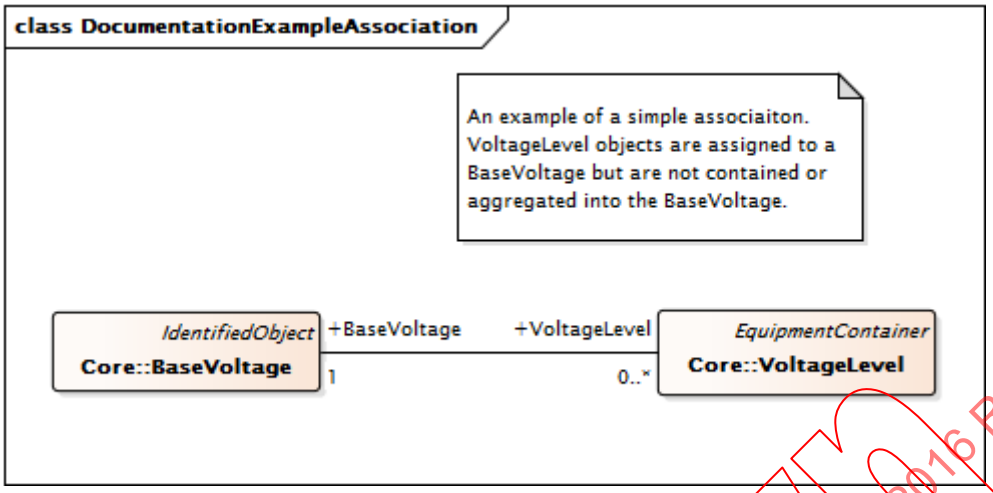


Figure 3 – Exemple de généralisation

4.4.3 Simple association (Association simple)

Une association est une connexion conceptuelle entre des classes. Chaque association a deux "extrémités d'association". Les "extrémités d'association" étaient appelées "rôles" avant la spécification UML 2.0. Chaque extrémité d'association décrit le rôle que la classe cible (c'est-à-dire, la classe *vers* laquelle l'extrémité d'association part) a en relation avec la classe source (c'est-à-dire, la classe *à partir de* laquelle l'extrémité d'association part). La coutume est d'attribuer aux extrémités d'association le nom de la classe cible avec ou sans expression verbale. Chaque extrémité d'association possède aussi une cardinalité/multiplicité, qui est une indication du nombre d'objets qui peuvent prendre part à la relation décrite. Dans le CIM, les associations ne sont pas nommées, seules les extrémités d'association sont nommées. Par exemple, comme représenté à la Figure 4, il y a dans le CIM une association entre une classe BaseVoltage (tension de base) et une classe VoltageLevel (niveau de tension). La multiplicité est représentée aux deux extrémités de l'association. Dans cet exemple, un objet VoltageLevel peut faire référence à 1 BaseVoltage, et une BaseVoltage peut être référencée par 0 ou plus d'objets VoltageLevel.

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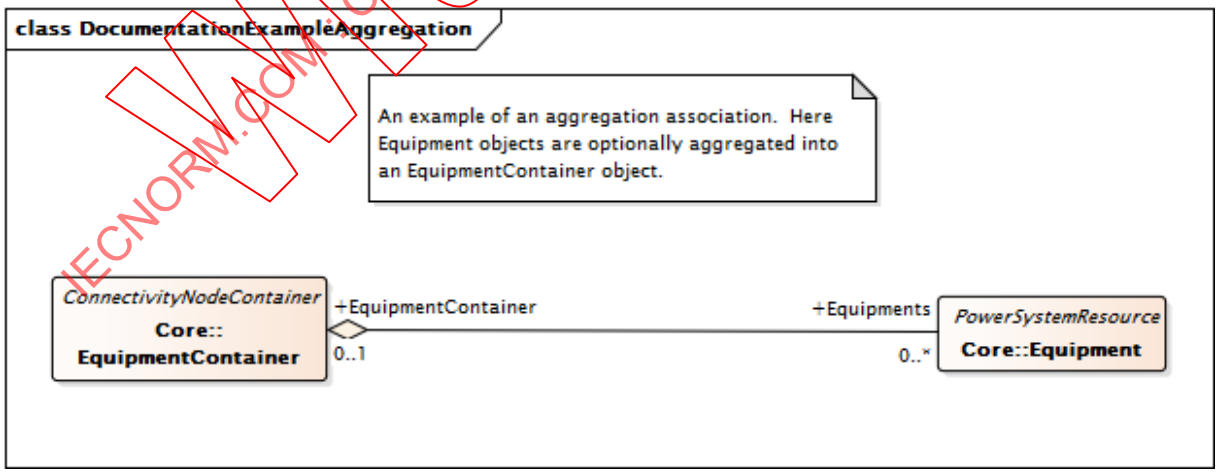


Anglais	Français
An example of a simple association. VoltageLevel objects are assigned to a BaseVoltage but are not contained or aggregated into the BaseVoltage.	Exemple d'association simple. Des objets VoltageLevel sont affectés à une BaseVoltage, mais ne sont ni contenus ni agrégés dans la BaseVoltage.

Figure 4 – Exemple d'association simple

4.4.4 Aggregation

Aggregation (agrégation) est un cas spécial d'association. L'agrégation indique que la relation entre les classes est une sorte de relation classe entière/classe partielle où la classe entière "consists of" (se compose de) ou "contains" (contient) la classe partielle, et cette classe partielle est une "part of" (partie de) la classe entière. La classe partielle n'hérite pas de la classe entière comme dans la généralisation. La Figure 5 représente une agrégation entre la classe EquipmentContainer (Conteneur d'équipements) et la classe Equipment, qui provient du paquetage Core. Comme représenté à la figure, un Equipment peut être un élément de un ou zéro objet EquipmentContainer mais l'objet EquipmentContainer peut contenir un nombre quelconque d'objets Equipment. Dans le cadre de l'utilisation du CIM comme modèle d'information, l'agrégation n'a pas d'interprétation précise ou formelle au-delà d'une association simple, et permet d'aider à représenter visuellement une utilisation normale.



Anglais	Français
An example of an aggregation association. Here Equipment objects are optionally aggregated into an EquipmentContainer object.	Exemple d'association d'agrégation. Ici, des objets Equipment sont facultativement agrégés en un objet EquipmentContainer.

Figure 5 – Exemple d'agrégation

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4.5 Concepts et exemples de modèles CIM

4.5.1 Concepts

Afin d'aider à comprendre comment interpréter le CIM, certains concepts-clés de modèles utilisés dans le CIM sont présentés et décrits en 4.5.2 à 4.5.14.

4.5.2 Hiérarchies d'emboîtement, d'équipements et dénomination

4.5.2.1 Structure de l'emboîtement

La Figure 6 représente le concept de conteneurs d'équipements (EquipmentContainer) pour former des hiérarchies dans le CIM. Les conteneurs d'équipements sont un moyen de regrouper et de nommer des équipements se trouvant généralement dans un poste (substation). Comme il peut être constaté de visu, les conteneurs offrent une certaine souplesse d'utilisation pour s'adapter aux différents usages internationaux, ainsi qu'aux différences observées habituellement entre les postes de transport et de distribution. Bay (cellule), VoltageLevel (niveau de tension), Substation (poste), Line (ligne) et Plant (centrale) sont tous des types de EquipmentContainers. En général, une Bay est contenue dans un VoltageLevel spécifique, qui à son tour est contenu dans un Substation. Les Substations et les Lines peuvent être contenus dans des SubGeographicRegions (sous-régions géographiques) et GeographicRegions (régions géographiques).

Une hiérarchie d'emboîtement est utilisée avec la classe IdentifiedObject pour créer une désignation hiérarchique destinée à décrire la consommation humaine. Cette hiérarchie est utilisée spécifiquement pour nommer les équipements selon leur fonction dans le système de puissance. Il s'agit de la hiérarchie de dénomination fonctionnelle. Outre les noms fonctionnels, d'autres identifications communes sont les numéros de série des biens. Le nom fonctionnel diffère d'un numéro de série en ce qu'il renvoie à la fonction d'une position ou localisation particulière d'un équipement dans le système de puissance. Quel que soit l'élément spécifique d'équipement physique qui est placé en un endroit, le nom fonctionnel est le même, mais le numéro de série varie en fonction de l'équipement physique actuellement utilisé.

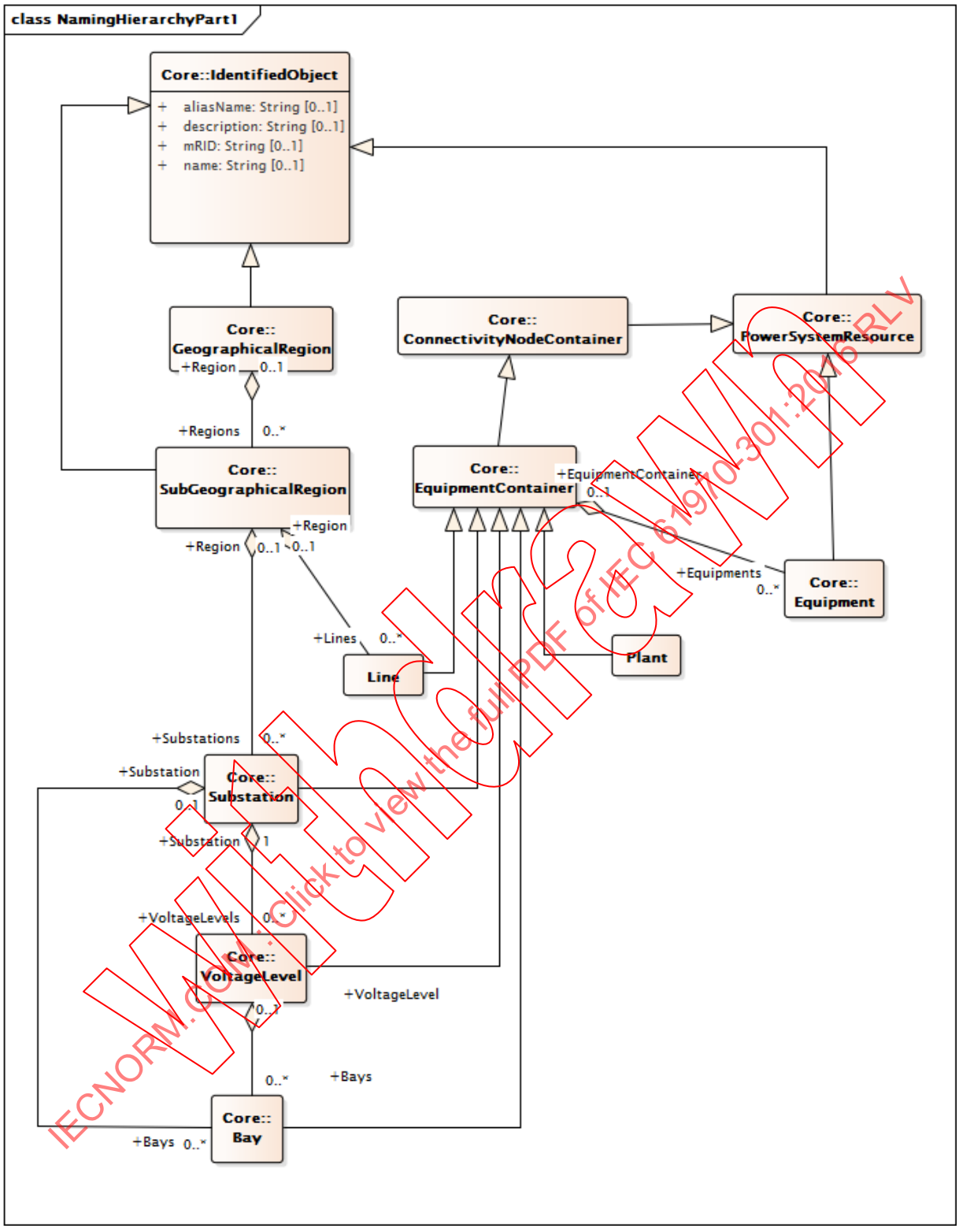
4.5.2.2 Classe IdentifiedObject

La classe IdentifiedObject (objet identifié) contenu dans le paquetage Core est héritée par tous les objets PowerSystemResource (ressource du système de puissance) et de nombreuses autres classes. Cette classe comporte les attributs et les associations à utiliser pour nommer tous les objets du CIM. L'attribut mRID de la classe IdentifiedObject est un moyen direct et rigoureux pour l'identité des objets du CIM.

Des définitions et des conventions relatives à la façon d'utiliser des attributs IdentifiedObject lors de la dénomination d'objets PowerSystemResource sont indiquées ci-après:

- mRID (Master Resource ID): Un identificateur lisible par une machine et unique au niveau global pour une instance d'objet.
- name: Le nom est un texte lisible par l'homme et, si possible, non unique, qui nomme l'objet.
- aliasName: Cet attribut est un nom supplémentaire, mais les classes Name de 4.5.3 constituent une meilleure solution. L'aliasName est un nom de l'objet en texte lisible par l'homme en remplacement de IdentifiedObject.name. Il peut ne pas être unique et peut ne pas se corréler à une hiérarchie de dénomination. L'attribut aliasName a été retenu parce qu'il est compatible avec les précédentes versions du CIM. Il est cependant recommandé de remplacer aliasName par la classe Name puisqu'il est prévu de supprimer aliasName à l'avenir.

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Figure 6 – EquipmentContainers

Les diagrammes NamingHierarchyPart1 et NamingHierarchyPart2 du paquetage Wires représentent la hiérarchie fonctionnelle de dénomination.

4.5.3 Modèle de Names

Un modèle de dénomination souple et extensible est fourni pour spécifier des noms différents pour les objets. Plusieurs applications ou systèmes ayant différents noms pour le même objet

constituent un cas d'utilisation dans lequel le modèle de Names est utile. Le modèle de Names permet alors l'échange de ces noms.

La Figure 7 représente le diagramme de classe pour des noms de remplacement et la manière dont ils peuvent être associés à un type de nom défini par un utilisateur spécifique. Ce modèle permet de définir spécifiquement les noms dans un domaine particulier et ne fait pas intervenir de règles spécifiques de dénomination. Les concepts de noms de remplacement, de noms de chemin et de noms locaux peuvent tous être utilisés avec ce modèle. Les modèles du CIM n'utilisent ni ne favorisent des conventions spécifiques de dénomination mais permettent d'échanger ces conventions de dénomination dans un contexte clair.

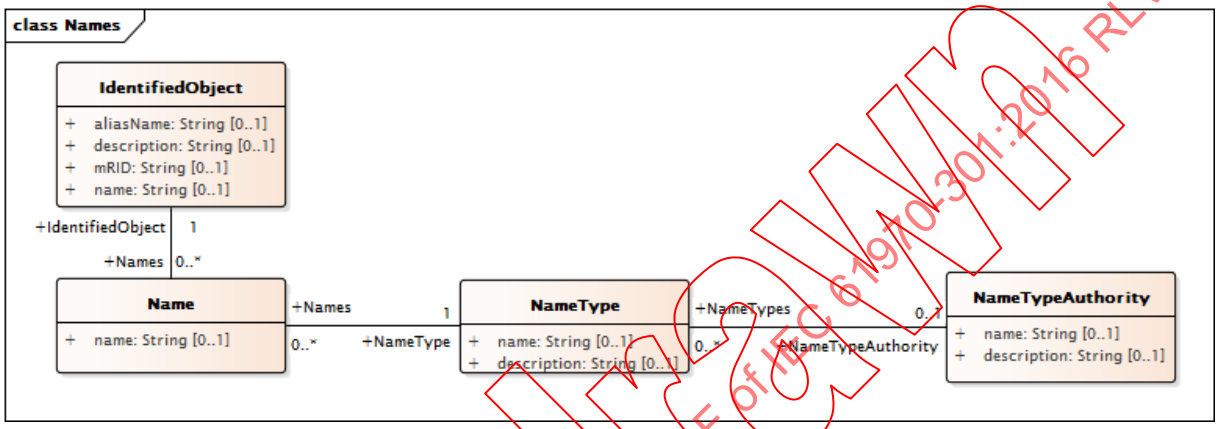


Figure 7 – Names

Tableau 1 – Conventions de dénomination de la classe NameType (type de nom)

name	description
ICCP	Réservé aux noms ICCP (TASE-2). Utilisée pour décrire les noms de point ICCP pour la classe MeasurementValue et les noms de source ICCP pour la classe MeasurementValueSource.

Le Tableau 1 donne différentes conventions de nom pour les types de noms. Les colonnes du Tableau 1 ont la signification suivante:

name: valeur de l'attribut name.

description: utilisation du type de nom.

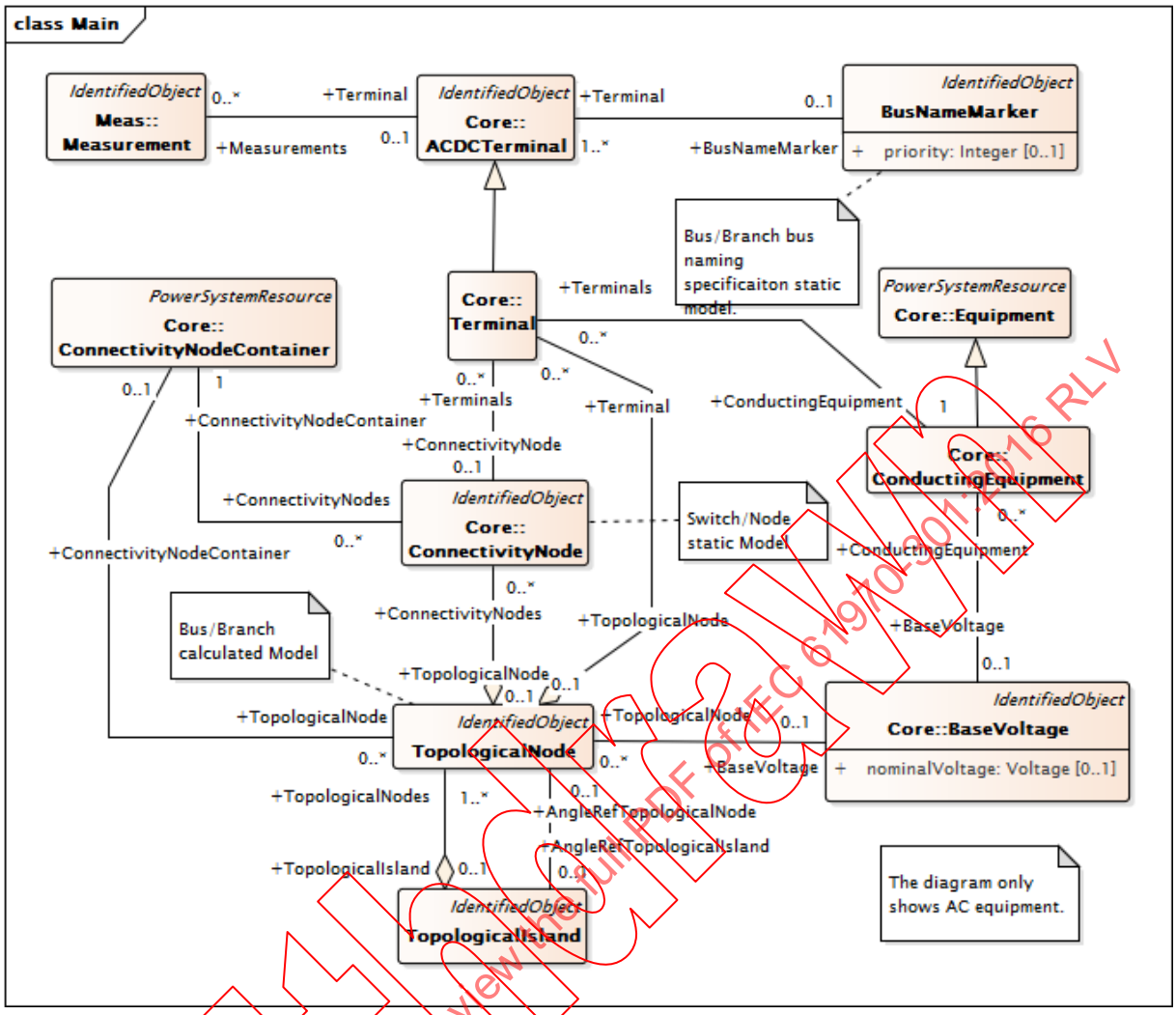
Noter que le Tableau 1 ne donne pas de liste exhaustive des valeurs qui peuvent être utilisées pour l'attribut nom de la classe Name.

4.5.4 Modèle de connectivité

4.5.4.1 Description de la connectivité

La Figure 8 représente le diagramme de classe Topology qui modélise la connectivité entre différents types de ConductingEquipment. Elle inclut également une partie du diagramme de classe du paquetage Meas traitant des mesures pour représenter la façon dont les mesures sont associées aux équipements conducteurs.

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Anglais	Français
Bus/Branch bus naming specification static model.	Modèle statique de spécification de dénomination de topologie nodale
Switch/Node static model	Modèle statique Commutateur/Nœud
Bus/Branch calculated model	Modèle calculé à topologie nodale
The diagram only shows AC equipment	Le diagramme ne représente que l'équipement en courant alternatif

Figure 8 – Modèle de connectivité

Pour modéliser la connectivité, les classes Terminal (borne) et ConnectivityNode (nœud de connectivité) ont été définies. Une Terminal appartient à un ConductingEquipment, mais un ConductingEquipment peut avoir un nombre quelconque de Terminals (bornes). Chaque Terminal peut être connectée à un ConnectivityNode qui est un point auquel les bornes des équipements conducteurs sont connectées ensemble avec une impédance nulle. Un ConnectivityNode peut avoir un nombre quelconque de bornes connectées et peut être membre d'un TopologicalNode (nœud topologique) (c'est-à-dire, un bus) qui est membre d'un TopologicalIsland (îlot topologique). Les TopologicalNode et TopologicalIsland sont créés comme résultat d'un processeur topologique qui prend en compte la connectivité prédéfinie et les positions réelles des Switchs (commutateurs).

Il est possible d'échanger des messages impliquant directement TopologicalNode et contournant les détails de ConnectivityNode en utilisant l'association TopologicalNode à Terminal. Cela est souvent utile pour les échanges impliquant des modèles de topologie nodale qui ne contiennent généralement pas de détails relatifs aux commutateurs. Quand le

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modèle TopologicalNode est échangé, il est utile d'échanger aussi l'attribut "connected" (connecté) dans la classe Terminal. Cela permet de retenir la structure topologique du modèle de topologie nodale mais indique qu'une borne n'est pas entièrement connectée. Cette déconnexion résulte normalement de ce qu'un ou plusieurs commutateurs s'ouvrent dans le modèle détaillé qui n'est pas représenté dans un échange de modèle de topologie nodale.

Les EquipmentContainers, qui sont une spécialisation d'un ConnectivityNodeContainer (Conteneur de nœuds de connectivité), peuvent avoir zéro à plusieurs de ConnectivityNodes. Les associations ConductingEquipment–Terminal et Terminal–ConnectivityNode permettent de représenter la connectivité prédéfinie d'un système de puissance réel. Pour chaque Terminal connectée à un ConnectivityNode, les associations des autres Terminal(s) connectées au même ConnectivityNode identifient le ou les objets ConductingEquipment qui sont connectés électriquement. Une connectivité similaire, au niveau de détail "topologie nodale", peut être exprimée à l'aide de TopologicalNode au lieu du ConnectivityNode. La classe BusNameMarker, qui a une association à ConnectivityNode, est utilisée pour contenir les noms de bus utilisateur devant être appliqués aux TopologicalNodes. Les TopologicalNodes sont créés à partir de ConnectivityNodes et résultent du traitement de la topologie, il est possible d'appliquer de nombreux noms en fonction des instances de ConnectivityNode en présence.

Pour modéliser les valeurs analogiques telles que la tension et la puissance, chaque Terminal a une association avec une classe Measurement du paquetage Meas. Bien qu'il ne soit pas représenté à la Figure 8, un objet Measurement est associé à au moins un objet MeasurementValue (valeur de mesure). Chaque objet MeasurementValue est une instance de mesure d'une source spécifique, par exemple, une télémesure.

4.5.4.2 Exemple de connectivité et d'emboîtement

Pour représenter comment le modèle de connectivité et le modèle d'emboîtement peuvent être représentés comme des objets, un petit exemple est présenté à la Figure 9. L'exemple représente une ligne de transport avec une jonction en T entre deux postes et un poste avec deux niveaux de tension et un transformateur entre eux. La ligne de transport contient deux câbles différents. Un des niveaux de tension est représenté avec un tronçon de jeux de barres contenant un seul jeu de barres et deux baies de commutation très simples connectées au jeu de barres.

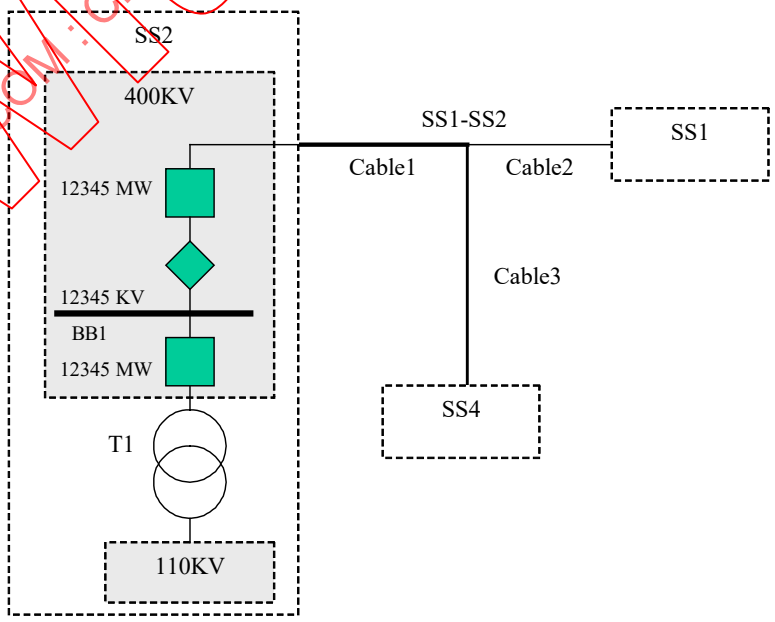


Figure 9 – Exemple de réseau simple

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La Figure 10 représente comment la connectivité est modélisée dans le CIM ainsi qu'une façon (mais pas nécessairement la seule) dont l'emboîtement est modélisé pour le diagramme de la Figure 9. Les carrés ombrés représentent les EquipmentContainers, et les carrés blancs les ConductingEquipments. Un ombrage plus sombre indique que l'EquipmentContainer est plus haut dans la hiérarchie d'emboîtement (à savoir, Substation est le plus haut, VoltageLevel vient ensuite, etc.). Les cercles blancs représentent les ConnectivityNodes, et les petits cercles noirs les Terminals. Une Terminal appartient à un ConductingEquipment, et un ConnectivityNode appartient à un EquipmentContainer. Cela signifie que les frontières (ou points de contact) entre ConductingEquipments sont leurs Terminals interconnectées via les ConnectivityNodes.

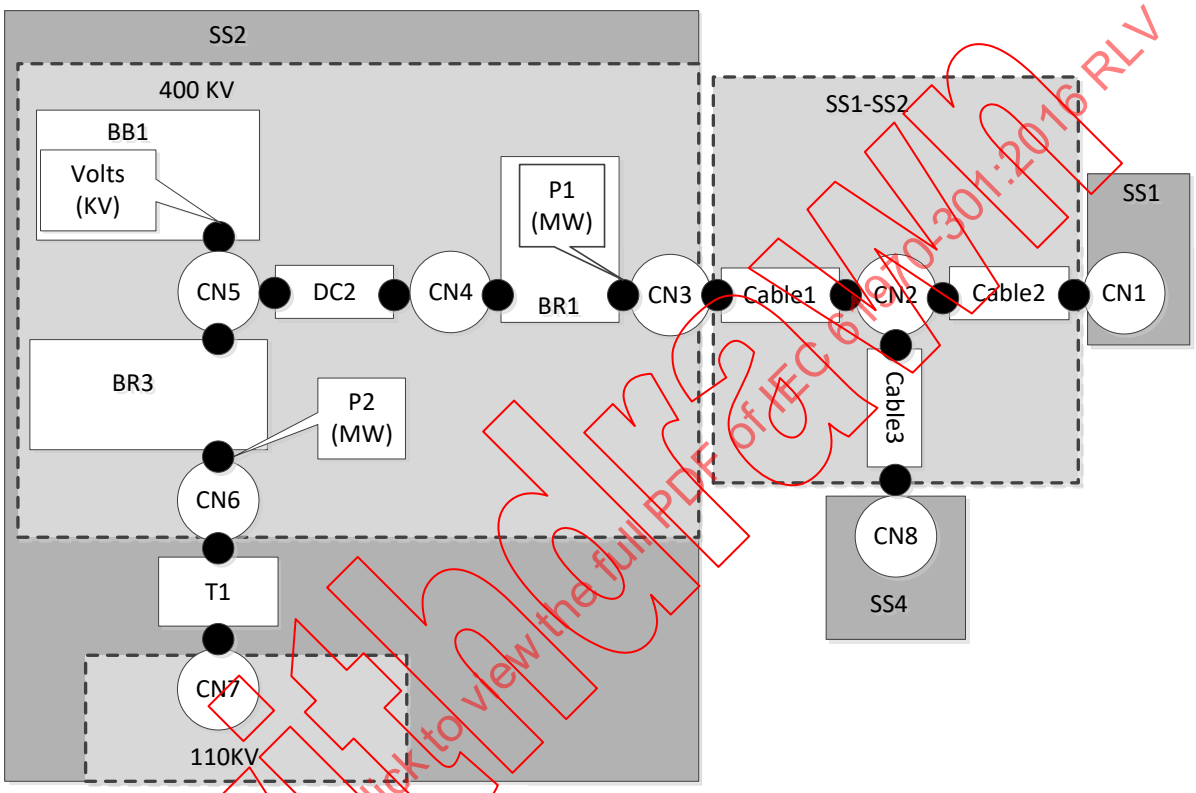


Figure 10 – Connectivité d'un réseau simple modélisé avec la topologie du CIM

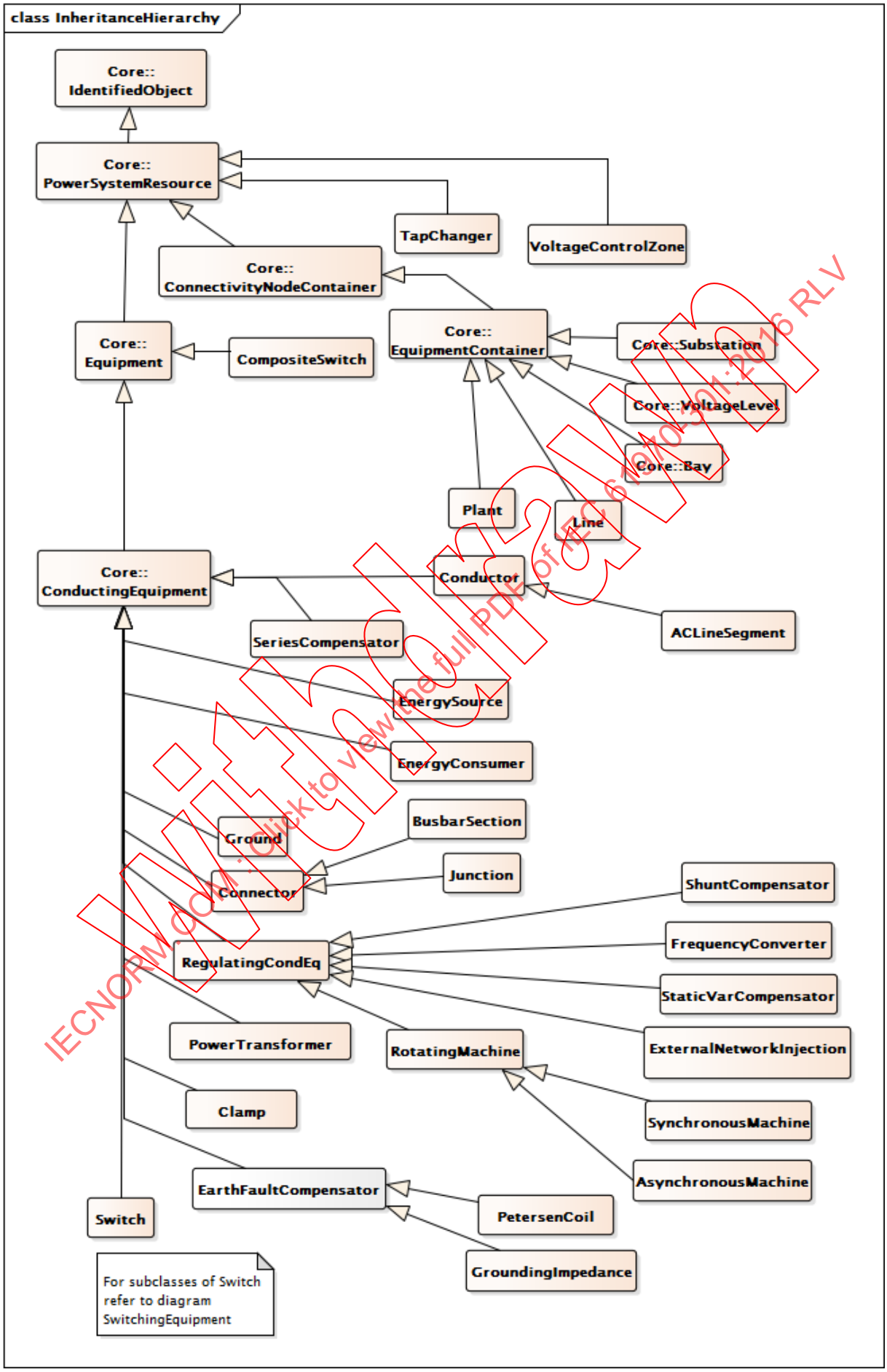
La Line (ligne) SS1-SS2 contient trois ACLineSegments (Cable1, Cable2, et Cable3) et le ConnectivityNode (CN2) associé pour modéliser une jonction en T, qui assure une connexion à SS4. Cela n'est qu'une façon dont cette configuration pourrait être modélisée. Chaque ACLineSegment a deux Terminals. Cable1 est connecté à CN3 et CN2 via ces Terminals. CN3 est contenu par le VoltageLevel 400 kV. Le disjoncteur ("Breaker") BR1 a deux bornes dont l'une est connectée à CN3.

Les Measurements sont représentés par des bulles carrées dont les flèches pointent vers une Terminal. P1 est connecté à la Terminal de droite appartenant au Breaker BR1. Noter que P1 est tracé dans la boîte représentant BR1. C'est parce qu'un Measurement peut appartenir à une PowerSystemResource (PSR), comme c'est le cas avec BR1. P2 est tracé dans le VoltageLevel 400 kV, ce qui signifie qu'il appartient au VoltageLevel 400 kV et non à BR3.

4.5.5 Hiérarchie des héritages

La Figure 11 représente une vue d'ensemble de la hiérarchie des héritages modélisée dans le CIM. Cette vue d'ensemble qui est incluse comme l'un des diagrammes du paquetage Wires couvre plusieurs paquetages du CIM.

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Anglais	Français
For subclasses of Switch refer to diagram SwitchingEquipment	Pour les sous-classes de Switch, se référer au diagramme SwitchingEquipment

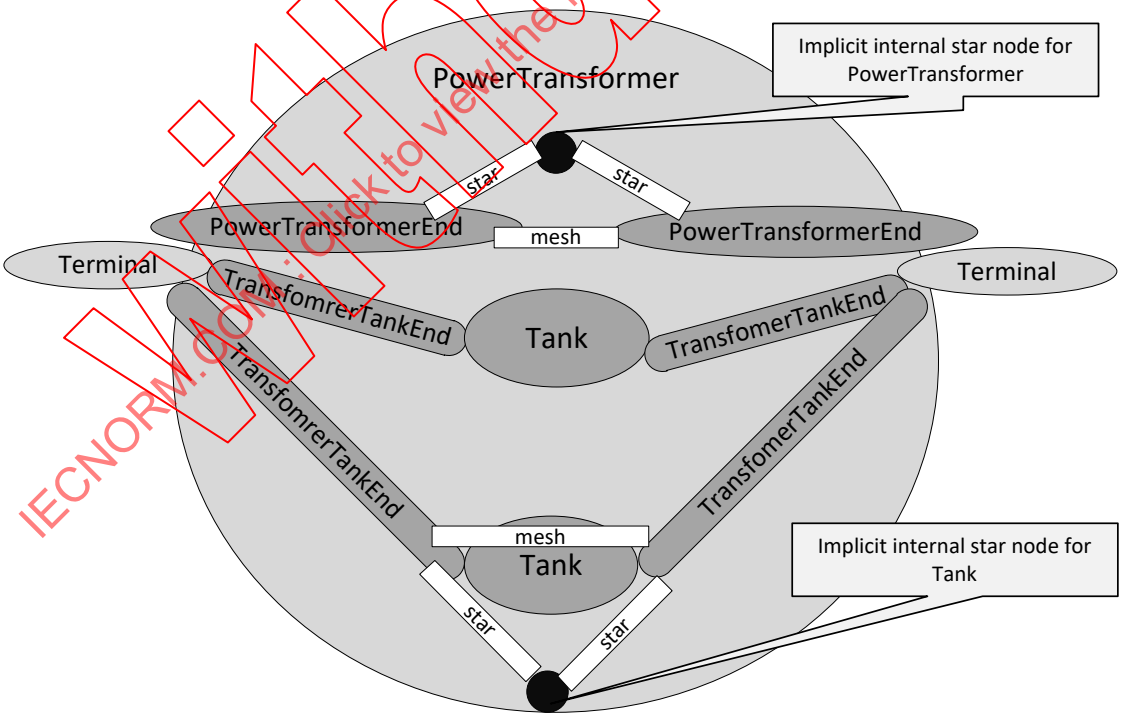
Figure 11 – Hiérarchie des héritages de Equipment

4.5.6 Modèle de Transformer

La Figure 13 représente une partie du paquetage Wires dans un diagramme de classe qui modélise un appareil PowerTransformer (Transformateur de puissance).

Le modèle de Transformer a été révisé par rapport aux versions antérieures pour qu'il soit possible d'utiliser le même modèle d'instance à la fois dans le modèle équilibré et le modèle déséquilibré. Le PowerTransformer est en outre désormais en soi un ConductingEquipment qui a potentiellement plusieurs bornes pour modéliser plus directement des transformateurs qui comportent une, deux, trois bornes ou davantage. Comme cela est typique pour un ConductingEquipment, quand il est en service, le PowerTransformer conduit la puissance d'une de ses bornes à une autre.

Comme représenté à la Figure 12, le PowerTransformer est aussi facultativement en mesure de modéliser des détails de cuve (Tank), qui peuvent être utilisés pour décrire en détail les déséquilibres et les connexions des phases de l'enroulement intérieur du transformateur. Dans tous les cas, un PowerTransformer modélise un groupe d'appareils physiques qui agissent conjointement pour transformer la puissance sur les bornes et en un emplacement physique. Il arrive souvent que, pour des systèmes de transport, une instance de PowerTransformer représente trois appareils physiques monophasés. Il convient de modéliser en outre les objets TransformerTank s'il est exigé d'obtenir des détails sur chaque appareil monophasé.



Anglais	Français
Implicit internal star node for PowerTransformer	Nœud d'étoile interne implicite pour PowerTransformer
Implicit internal star node for Tank	Noeud d'étoile interne implicite pour Tank

Figure 12 – Modèle de Transformer et Tank

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Un PowerTransformer et un TransformerTank peuvent tous deux avoir l'impédance décrite soit dans une connexion étoile hypothétique avec la connexion centrale implicite soit sous forme d'impédance de maille en utilisant la classe facultative TransformerMeshImpedance. La forme en maille de l'impédance est exigée pour modéliser correctement des transformateurs qui ont plus de trois bornes. Si la forme d'impédance en maille est utilisée, il faudrait spécifier la classe TransformerMeshImpedance pour chaque connexion possible borne à borne, donc une instance pour deux bornes, trois pour trois bornes, six pour quatre bornes et ainsi de suite. Si une connexion étoile est utilisée, les paramètres d'impédance peuvent être spécifiés directement dans la classe PowerTransformerEnd; une autre solution consiste à les répartir entre les transformateurs en utilisant la classe TransformerStarImpedance.

Comme représenté à la Figure 11, un PowerTransformer est une classe spécialisée de ConductingEquipment, elle-même classe spécialisée de Equipment. Ceci est représenté par l'utilisation du type généralisation de la relation qui utilise une flèche pour pointer vers la classe générale. Le ConductingEquipment est représenté comme une classe spécialisée de Equipment en utilisant le nom de classe "*Equipment*" en italique dans l'angle supérieur droit. L'héritage permet à PowerTransformer d'hériter des attributs de ConductingEquipment, de Equipment et de toutes les généralisations de Equipment que la Figure 11 ne représente pas.

Un PowerTransformer a aussi des relations avec PowerTransformerEnd et TransformerTank qui sont modélisés avec des relations de type association. Comme représenté dans la figure, un PowerTransformer peut être associé à zéro PowerTransformerEnd ou davantage, mais un PowerTransformerEnd ne peut être associé qu'à zéro ou un PowerTransformer seulement. De façon similaire, le PowerTransformer peut être associé à zéro objet TransformerTank ou davantage, mais un TransformerTank ne peut être associé qu'à zéro ou un PowerTransformer seulement.

Le PowerTransformerEnd spécialise la classe TransformerEnd qui a aussi d'autres relations:

- une relation de généralisation avec IdentifiedObject;
- deux relations d'association avec la classe TransformerMeshImpedance, de sorte qu'un objet TransformerEnd peut être de (From) 0, 1 ou plusieurs objets TransformerMeshImpedance et vers (To) 0, 1 ou plusieurs objets TransformerMeshImpedance;
- des relations d'agrégation avec les classes PhaseTapChanger et RatioTapChanger, de sorte qu'un objet TransformerWinding peut avoir 0 ou 1 objet PhaseTapChanger et 0 ou 1 objet RatioTapChanger qui lui sont associés.

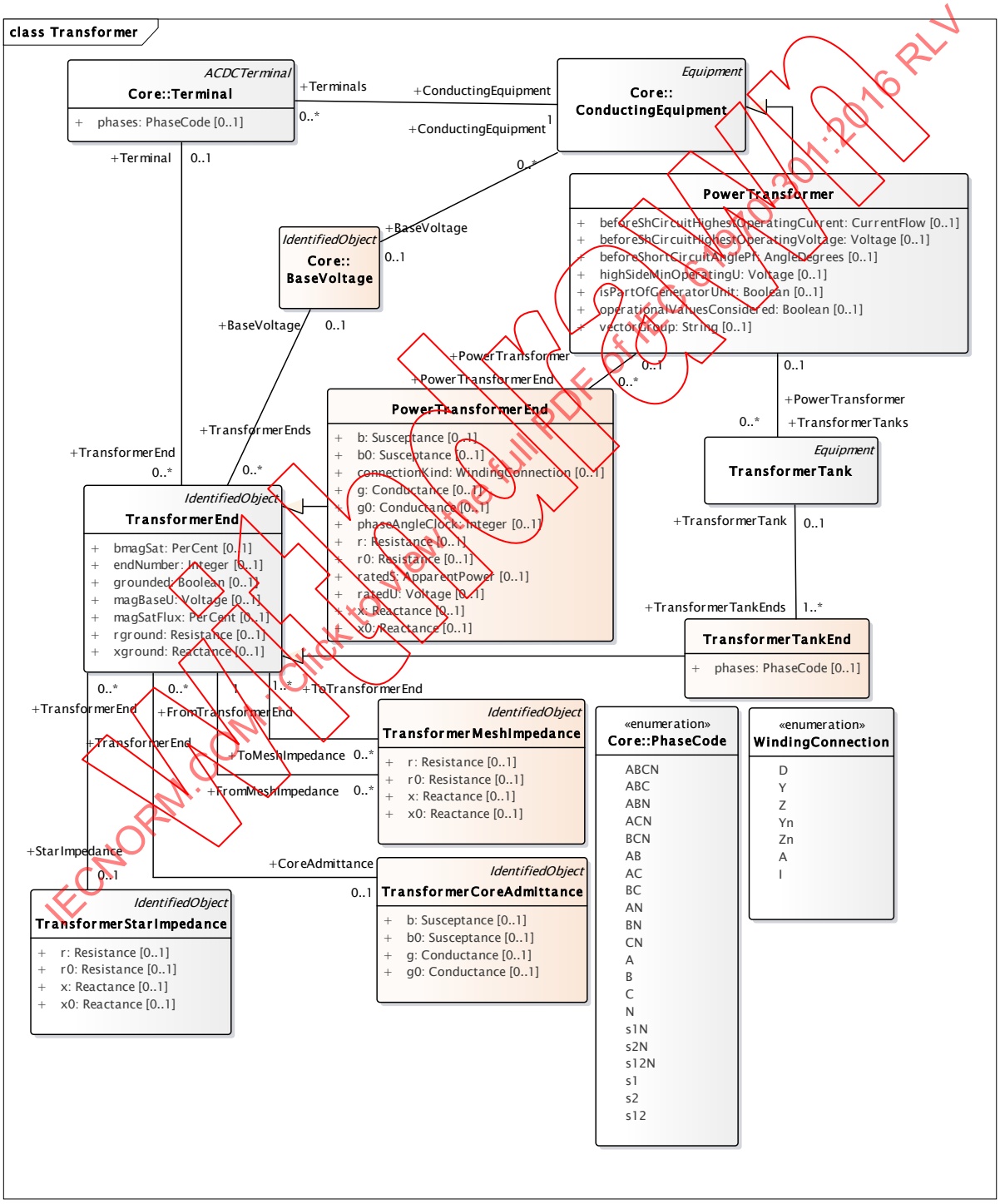
Pour un PowerTransfomer de réseau de transport ayant deux ou trois extrémités, les impédances équivalentes du modèle Pi apparaissent dans les attributs r, r0, x, x0, g, g0, b et b0 de la PowerTransformerEnd. Les règles suivantes s'appliquent à un tel PowerTransformer

- La PowerTransformerEnd et sa Terminal connectée ont toutes les deux des numéros d'ordre TransformerEnd.endNumber et ACDCTerminal.sequenceNumber. Ces numéros peuvent ou peuvent ne pas être synchronisés.
- Le TransformerEnd.endNumber 1 doit toujours être à la PowerTransformerEnd à la tension assignée la plus élevée (PowerTransformerEnd.ratedU).
- En cas de transformateur à deux bornes ayant la même tension assignée (PowerTransformerEnd.ratedU) des deux côtés, le système dans lequel le transformateur est défini doit garantir que seul un côté a un TransformerEnd.endNumber égal à 1.
- Pour un transformateur à deux bornes, la PowerTransformerEnd ayant un numéro d'extrémité égal à 1 doit avoir les valeurs spécifiées pour r, r0, x, x0, g, g0, b et b0.
- Pour un transformateur à deux bornes, la PowerTransformerEnd ayant un numéro d'extrémité différent de 1, les valeurs de r, r0, x, x0, g, g0, b et b0 doivent être égales à zéro.
- Pour un transformateur à trois bornes, chaque PowerTransformerEnd doit avoir des valeurs pour r, r0, x et x0 correspondant à l'impédance équivalente de la branche.

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- Pour un transformateur à trois bornes, chaque PowerTransformerEnd doit avoir des valeurs pour g, g0, b et b0 correspondant à des pertes à vide réparties sur les trois PowerTransformerEnds. Les impédances shunt totales de perte à vide peuvent également être placées au niveau d'une des PowerTransformerEnds, de préférence l'extrémité numéro 1 ayant les valeurs de shunt sur l'extrémité 1.
- Pour un PowerTransformer à plus de trois bornes, il n'est pas possible d'utiliser les valeurs d'impédance de PowerTransformerEnd. Utiliser dans ce cas TransformerMeshImpedance ou diviser le transformateur en plusieurs PowerTransformers.

La Figure 13 représente UML pour le modèle de Transformer.



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Figure 13 – Modèle de Transformer

4.5.7 Modélisation de prise du transformateur

4.5.7.1 Modélisation généralisée de prise

Plusieurs types de modèles de prise de transformateur sont pris en charge par le modèle CIM. En fonction de la structure physique, les effets du mouvement de prise sont définis en utilisant la classe RatioTapChanger ou la classe PhaseTapChanger et ses différentes spécialisations. Le PhaseTapChanger peut être spécialisé dans un certain nombre de types qui représentent la structure physique et donc le comportement. Les attributs de TapChanger sont applicables à toutes les spécialisations de RatioTapChanger. La Figure 14 représente le modèle UML pour les prises de transformateur.

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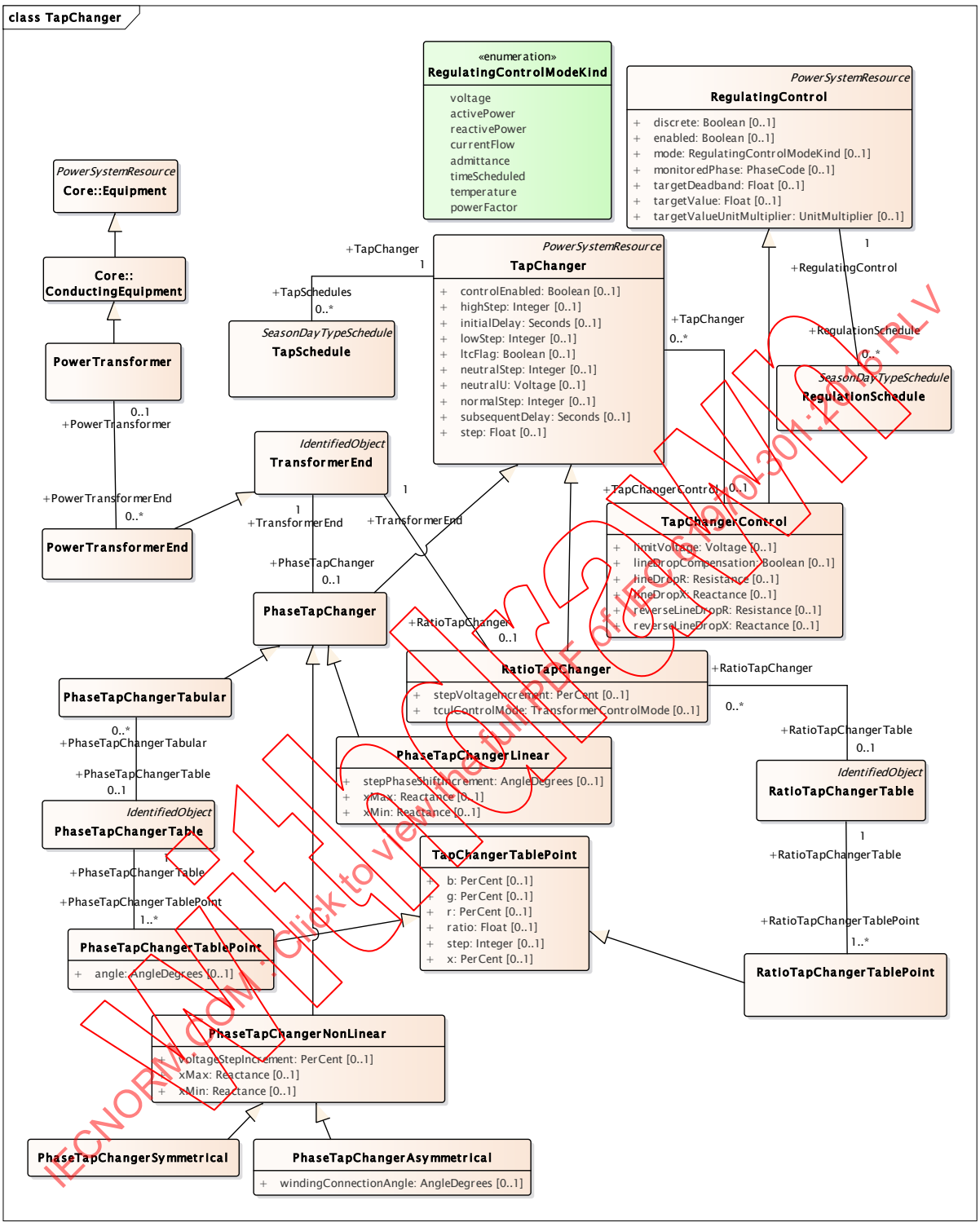


Figure 14 – Modèle de prise de transformateur

Plusieurs changeurs de prises peuvent être combinés à l'intérieur d'un transformateur de puissance, mais un seul changeur de prises déphaseur et un seul changeur de prises qui modifie le rapport sont censés être modélisés sur une borne donnée. Le changement de rapport ou le déphasage sont documentés par rapport à l'autre ou aux autres bornes en partant de l'hypothèse que ces bornes ont le rapport nominal (1 PU) et le déphasage angulaire nominal (zéro). Il est permis de combiner à la fois un changeur de prises déphaseur et un changeur de rapport de prise sur une borne bien que cette pratique ne soit pas recommandée afin d'éviter tout problème de mauvaise interprétation concernant l'ordre de ces

changeurs de prises. Les représentations tabulaires sont privilégiées dans de tels cas, car elles donnent les valeurs explicites des phases et des angles subséquents.

Des représentations tabulaires peuvent être utilisées à la fois pour des transformateurs déphaseurs et des transformateurs de rapport quand les modèles disponibles du CIM ne reflètent pas le comportement physique de manière appropriée. Les modèles tabulaires sont facultatifs pour les autres modèles de prises du CIM. Les modèles tabulaires peuvent être utilisés pour décrire la variation d'impédance dans la plage de prise.

Les différents modèles de changeurs de prises sont décrits plus en détail en 4.5.7.2 à 4.5.7.7.

4.5.7.2 Modélisation de transformateur de tension

La classe RatioTapChanger est utilisée pour définir une prise de transformateur qui change le rapport de la valeur de tension sans changer l'angle de phase à travers le transformateur. Un RatioTapChanger peut être utilisé dans des cas où le transformateur introduit intrinsèquement un déphasage fixe, comme à partir d'une connexion d'enroulement en étoile-triangle.

4.5.7.3 Modélisation tabulaire d'un transformateur de tension

Un RatioTapChangerTabular peut être facultativement associé à n'importe quel RatioTapChanger et représenter une relation non linéaire entre le nombre de prises, le rapport de prises et les impédances. S'il est associé, le modèle tabulaire de rapport a la priorité.

4.5.7.4 Modélisation d'un transformateur déphaseur linéaire

Un transformateur déphaseur est linéaire si l'incrément (accroissement) de déphasage par échelon de prise est uniforme et si la valeur de la tension est constante sur toute la plage du changeur de prises. Un déphaseur linéaire est modélisé en utilisant la classe PhaseTapChangerLinear.

4.5.7.5 Modélisation d'un déphaseur symétrique et asymétrique

4.5.7.5.1 Déphaseur symétrique et asymétrique – informations communes

Le paragraphe 4.5.7.5 décrit la modélisation de transformateurs déphaseurs (PST – Phase-Shifting Transformer) en fonction du type et de la technologie des équipements, et de manière plus spécifique, la réactance série équivalente des déphaseurs dans la séquence positive en fonction de l'angle de déphasage. Dans ces modèles spécifiques, les résistances et les courants magnétisants sont toujours négligés.

Les transformateurs déphaseurs compris dans 4.5.7.5 sont mis en correspondance avec les classes CIM comme décrit dans le Tableau 2.

Tableau 2 – Mise en correspondance des transformateurs déphaseurs avec les classes CIM

Type de déphaseur	Classe CIM
Cas général	cim:PhaseTapChangerTabular
Déphaseurs symétriques	cim:PhaseTapChangerSymmetrical ou cim:PhaseTapChangerLinear
Déphaseur asymétrique	cim:PhaseTapChangerAsymmetrical
Transformateur en phase et déphaseur symétrique	cim:PhaseTapChangerSymmetrical et cim:RatioTapChanger
Transformateur en phase et déphaseur asymétrique	cim:PhaseTapChangerAsymmetrical et cim:RatioTapChanger

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Il est fortement recommandé d'utiliser des données tabulaires pour échanger les paramètres PST (cim:PhaseTapChangerTabular) au lieu de devoir recalculer les paramètres par prise selon le type de chaque modèle.

Les symboles utilisés dans les formules de 4.5.7.5 sont mis en correspondance avec les classes CIM comme décrit dans le Tableau 3.

Tableau 3 – Mise en correspondance des symboles utilisés dans les formules avec les attributs CIM

Attribut de transformateur déphaseur	Attribut CIM
n	cim:PhaseTapChangerTablePoint.step
n_0	cim:TapChanger.neutralStep
δu	cim:PhaseTapChangerNonLinear.voltageStepIncrement
r	cim:TapChangerTablePoint.ratio
α	cim:PhaseTapChangerTablePoint.angle
$\delta\alpha$	cim:PhaseTapChangerLinear.stepPhaseShiftIncrement
$X(\alpha)$	cim:TapChangerTablePoint.x
$X(0)$	cim:PhaseTapChangerLinear.xMin ou cim:PhaseTapChangerNonLinear.xMin
$X(\alpha_{max})$	cim:PhaseTapChangerLinear.xMax ou cim:PhaseTapChangerNonLinear.xMax
θ	cim:PhaseTapChangerAsymmetrical.windingConnectionAngle

La variation d'impédance en fonction de la position de prise sur le transformateur déphaseur est décrite au Tableau 4.

Tableau 4 – Variations d'impédance dans un transformateur déphaseur

Type d'équipement	Réactance série équivalente en fonction de l'angle de déphasage
Déphaseurs symétriques	$X(\alpha) = X(0) + \left(X(\alpha_{max}) - X(0)\right)\left(\frac{\sin(\alpha/2)}{\sin(\alpha_{max}/2)}\right)^2$
Déphaseur asymétrique	$X(\alpha) = X(0) + \left(X(\alpha_{max}) - X(0)\right)\left(\frac{\tan\alpha}{\tan\alpha_{max}}\frac{\sin\theta - \tan\alpha_{max}\cos\theta}{\sin\theta - \tan\alpha\cos\theta}\right)^2$
Transformateur en phase et déphaseur symétrique	$X(r,\alpha) = X_r(r_{nom})\left(\frac{r}{r_{nom}}\right)^2 + X_\alpha(0) + \left(X_\alpha(\alpha_{max}) - X_\alpha(0)\right)\left(\frac{\sin(\alpha/2)}{\sin(\alpha_{max}/2)}\right)^2$

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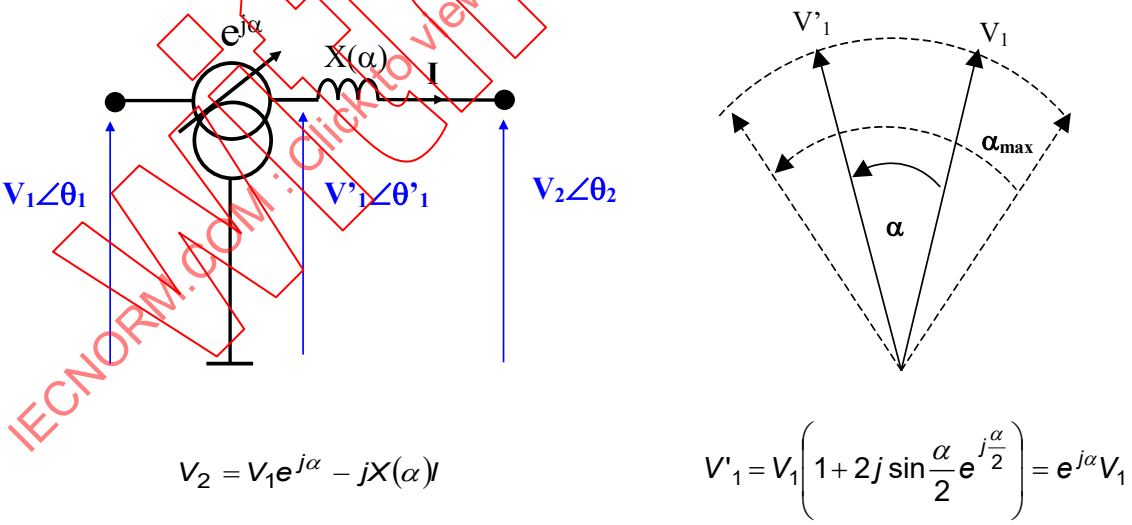
Type d'équipement	Réactance série équivalente en fonction de l'angle de déphasage
Transformateur en phase et déphaseur asymétrique	$X(r,\alpha) = X_r(r_{nom})\left(\frac{r}{r_{nom}}\right)^2 + X_\alpha(0)$ $+\left(X_\alpha(\alpha^0_{max}) - X_\alpha(0)\right)\left(\frac{\tan\alpha}{\tan\alpha_{max}(r)}\frac{\sin\theta - \tan\alpha_{max}(r)\cos\theta}{\sin\theta - \tan\alpha\cos\theta}\right)^2$ avec $\alpha_{max}(r) = A\tan\left(\frac{\sin\theta}{\frac{r}{r_{nom}\tan\alpha^0_{max}}\left(\sin\theta - \tan\alpha^0_{max}\cos\theta\right) + \cos\theta}\right)$ et $\alpha^0_{max} = \alpha_{max}(r_{nom})$

Tableau 5 – Description des variables

Variable	Signification
α_{max}	Déphasage maximal: valeur maximale d'angle figurant dans le tableau des angles de déphasage
r_{nom}	Rapport nominal du transformateur en phase
α^0_{max}	Déphasage maximal lorsque le rapport du transformateur en phase est nominal

4.5.7.5.2 Déphaseurs symétriques

Le diagramme et les équations du phaseur sont représentés à la Figure 15.



$$V_2 = V_1 e^{j\alpha} - jX(\alpha)I \qquad V'_1 = V_1\left(1 + 2j\sin\frac{\alpha}{2}e^{j\frac{\alpha}{2}}\right) = e^{j\alpha}V_1$$

Figure 15 – Schéma et équations du phaseur

Expression de l'angle et du rapport par prise

D'après la Figure 15:

$$\alpha = (n - n_0)\cdot\delta\alpha \quad \text{ou} \quad \alpha = 2A\tan\left(\frac{(n - n_0)\cdot\delta u}{2}\right)$$

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$r = 1$

Expression de la réactance série équivalente en fonction de l'angle

En partant de l'hypothèse que la réactance de l'enroulement de régulation varie à mesure que le carré du nombre de tours évolue, la réactance équivalente peut être écrite comme suit pour les technologies non triangulaires-hexagonales.

$$X(\alpha) = X(0) + \left(X(\alpha_{max}) - X(0)\right)\left(\frac{\sin(\alpha/2)}{\sin(\alpha_{max}/2)}\right)^2$$

Paramètres:

α_{max} déphasage maximal

$X(0)$ réactance série équivalente pour un déphasage nul $\alpha = 0$

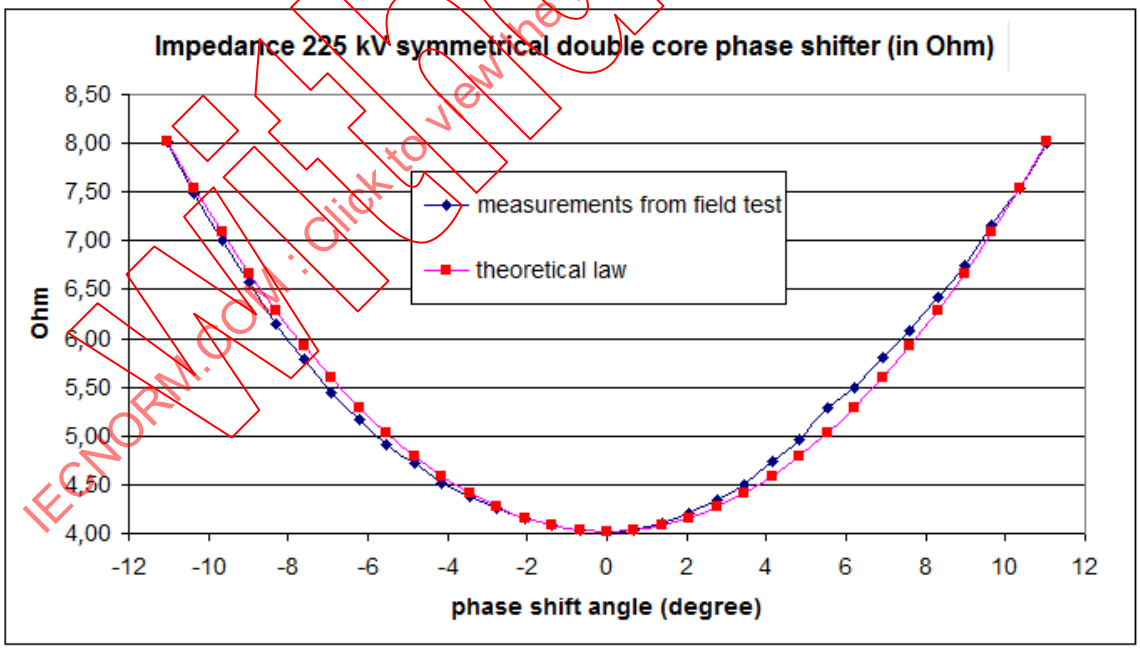
$X(\alpha_{max})$ réactance série équivalente pour un déphasage maximal $\alpha = \alpha_{max}$

Variable:

α déphasage de courant

La formule ci-dessus est valide pour les déphaseurs symétriques simple ou double noyau, à l'exception de la technologie hexagonale.

Pour les déphaseurs symétriques à noyau simple, $X(0) = 0$. Un exemple de variation d'impédance est représenté à la Figure 16.



Anglais	Français
Impedance 225kV symmetrical double core phase shifter (in Ohm)	Déphaseur symétrique double noyau à 225kV d'impédance (en ohms)
measurements from field test	mesures effectuées lors des essais sur site
theoretical law	loi théorique
phase shift angle (degree)	angle de déphasage (degrés)

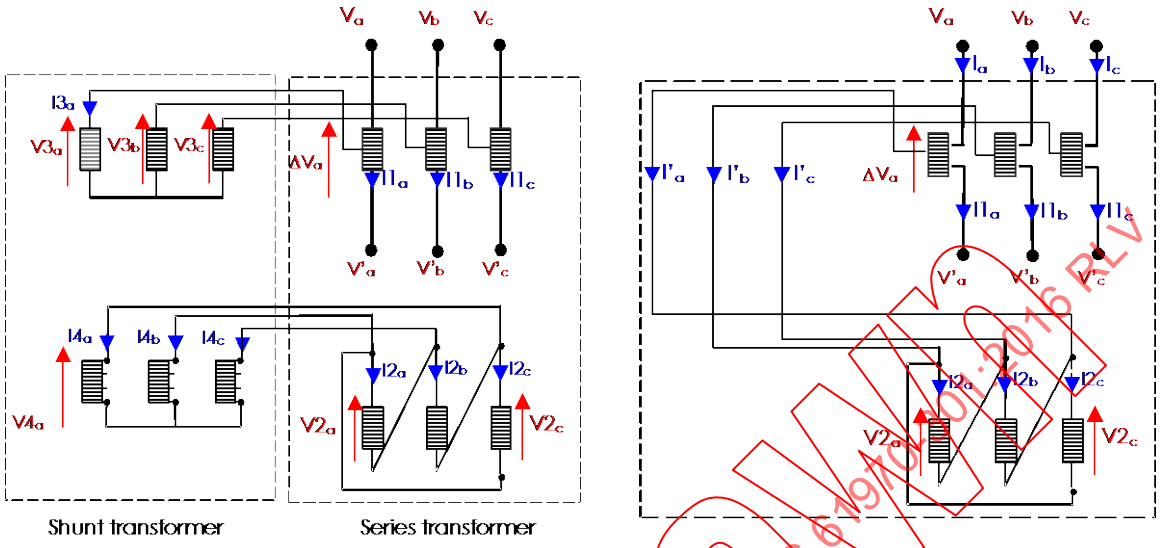
Figure 16 – Variation d'impédance de déphaseur symétrique

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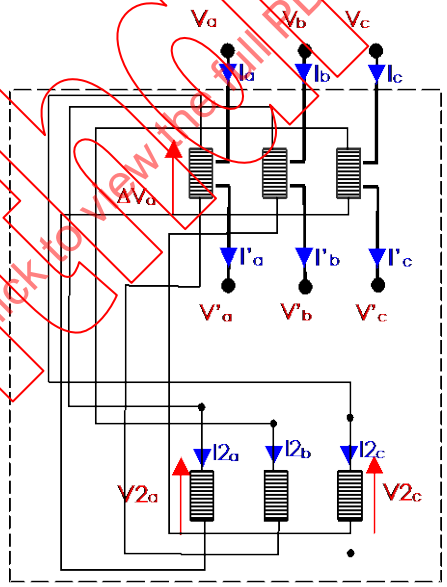
L'organisation triple noyau est représentée à la Figure 17.

Double noyau:

Noyau simple:



Noyau simple, triangle hexagonal:



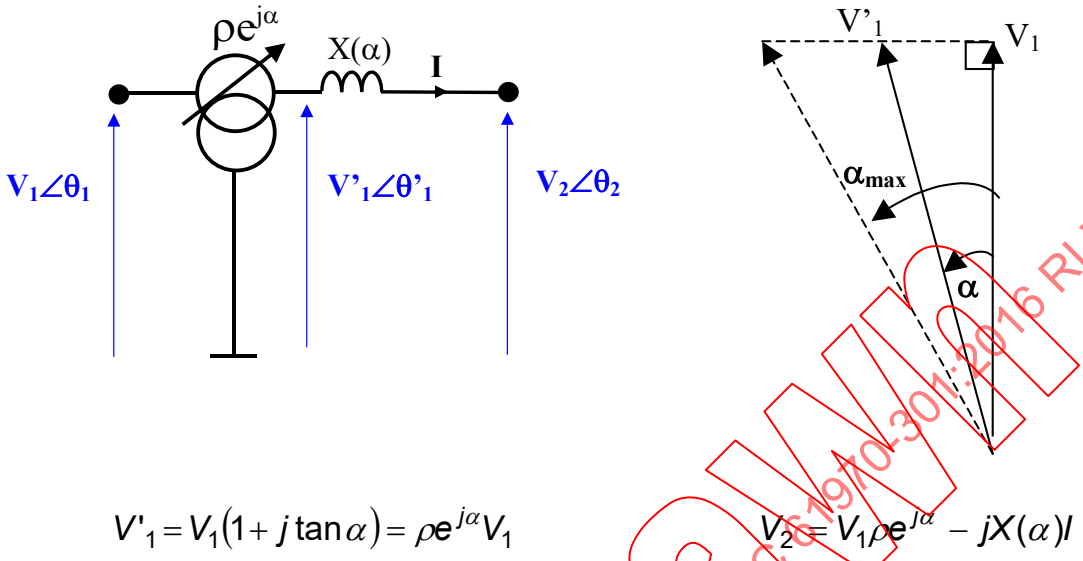
Anglais	Français
Shunt transformer	Transformateur shunt
Series transformer	Transformateur survolteur-dévolteur

Figure 17 – Organisation du noyau

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4.5.7.5.3 Transformateur déphaseur en quadrature

Le diagramme et les équations du phaseur sont représentés à la Figure 18.



$$V'_1 = V_1(1 + j\tan\alpha) = \rho e^{j\alpha} V_1 \qquad V_2 = V_1 \rho e^{j\alpha} - jX(\alpha)I$$

ρ et α varient avec $\rho\cos\alpha$ = constante.

Figure 18 – Schéma et équations du phaseur

Expression de l'angle et du rapport par prise

D'après la Figure 18:

$$\alpha = A\tan((n - n_0)\cdot\delta u)$$

$$r = \frac{1}{\sqrt{((n - n_0)\cdot\delta u)^2 + 1}}$$

Expression de la réactance série équivalente en fonction de l'angle

En partant de l'hypothèse que la réactance de l'enroulement de régulation varie à mesure que le carré du nombre de tours évolue, la réactance équivalente du transformateur déphaseur en quadrature peut être écrite comme suit.

$$X(\alpha) = X(0) + (X(\alpha_{max}) - X(0))\left(\frac{\tan(\alpha)}{\tan(\alpha_{max})}\right)^2$$

Paramètres:

α_{max} déphasage maximal

$X(0)$ réactance série équivalente pour un déphasage nul

$X(\alpha_{max})$ réactance série équivalente pour un déphasage maximal

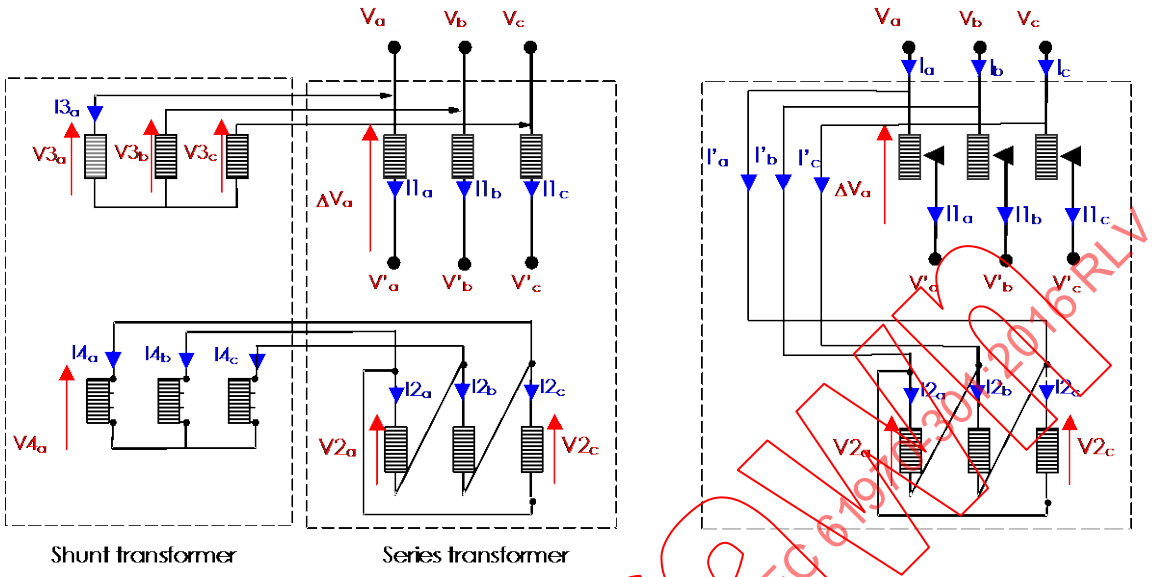
Variable:

α déphasage de courant

Pour des transformateurs déphaseurs en quadrature avec un noyau simple: $X(0) = 0$

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L'organisation triple noyau est représentée à la Figure 19.



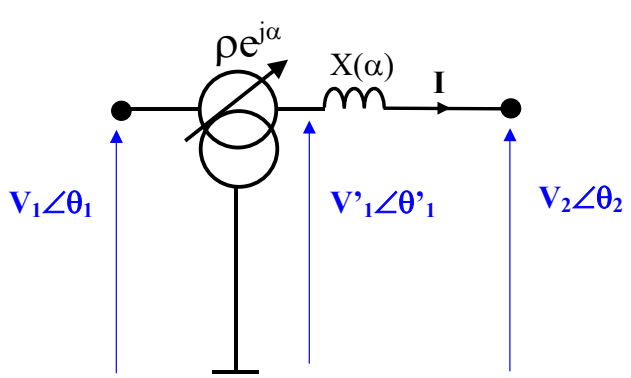
Anglais	Français
Shunt transformer	Transformateur shunt
Series transformer	Transformateur survolteur-dévolteur

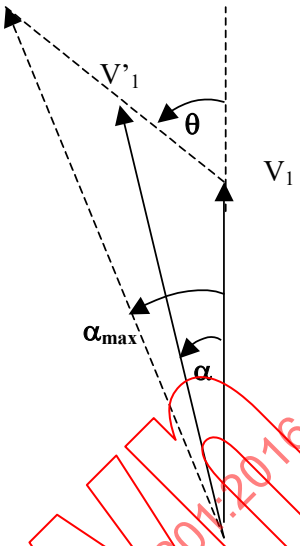
Figure 19 – Organisation du noyau

4.5.7.5.4 Modélisation d'un déphaseur asymétrique

Le diagramme et les équations du phaseur sont représentés à la Figure 20.

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$$V'_1 = V_1\left(1 + e^{j\theta}.\frac{\tan\alpha}{\sin\theta - \tan\alpha\cos\theta}\right) = \rho e^{j\alpha}V_1 \qquad V_2 = V_1.\rho e^{j\alpha} - jX(\alpha)I$$

θ est fixe, seuls α et ρ varient.

Figure 20 – Schéma et équations du phaseur

Expression de l'angle et du rapport par prise

D'après la Figure 20:

$$\alpha = A\tan\left(\frac{(n-n_0)\cdot\delta u\cdot\sin\theta}{1+(n-n_0)\cdot\delta u\cdot\cos\theta}\right)$$

$$r = \frac{1}{\sqrt{((n-n_0)\cdot\delta u\cdot\sin\theta)^2 + (1+(n-n_0)\cdot\delta u\cdot\sin\theta)^2}}$$

Expression de la réactance série équivalente en fonction de l'angle

En partant de l'hypothèse que la réactance de l'enroulement de régulation varie à mesure que le carré du nombre de tours évolue, la réactance équivalente peut être écrite comme suit.

$$X(\alpha) = X(0) + \left(X(\alpha_{max}) - X(0)\right)\left(\frac{\tan\alpha}{\tan\alpha_{max}}\frac{\sin\theta - \tan\alpha_{max}\cos\theta}{\sin\theta - \tan\alpha\cos\theta}\right)^2$$

Paramètres:

α_{max}	déphasage maximal
$X(0)$	réactance série équivalente pour un déphasage nul
$X(\alpha_{max})$	réactance série équivalente pour un déphasage maximal
θ	angle de la tension de charge rapide

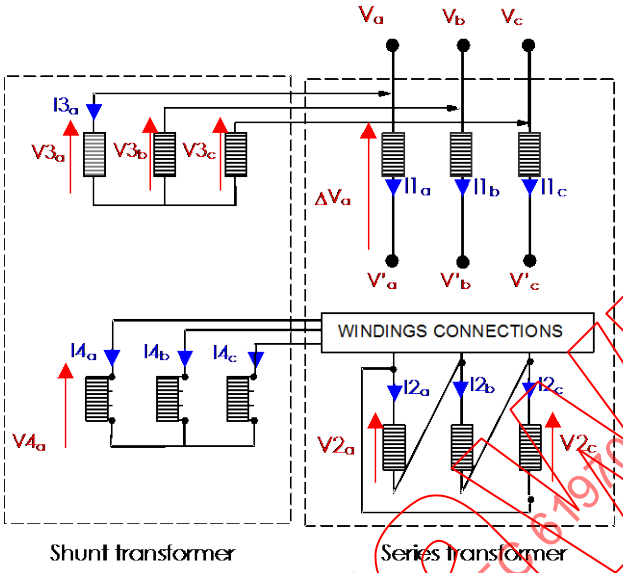
Variable:

α	déphasage de courant

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Organisations triphasées sont représentées à la Figure 21.

Double noyau:



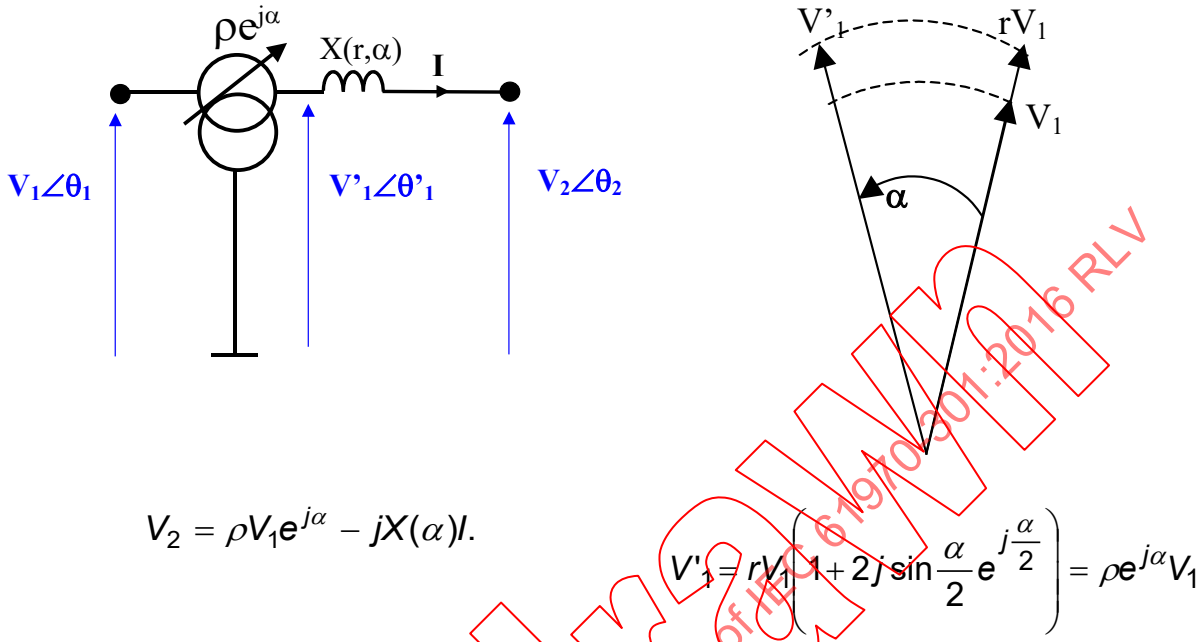
Anglais	Français
WINDINGS CONNECTIONS	CONNEXIONS ENTRE LES ENROULEMENTS
Shunt transformer	Transformateur shunt
Series transformer	Transformateur survolteur-dévolteur

Figure 21 – Organisation du noyau

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4.5.7.5.5 Transformateur en phase et déphaseur symétrique

Le schéma et les équations du phaseur sont représentés à la Figure 22.



r et α varient, et $\rho = r$.

Figure 22 – Schéma et équations du phaseur

Expression de l'angle et du rapport par prise

Idem qu'en 4.5.7.5.2 avec l'ajout du rapport r du transformateur en phase.

Réactance série équivalente en fonction de l'angle et du rapport du transformateur en phase

Hypothèses:

- La réactance de l'enroulement de régulation varie à mesure que le carré du nombre de tours évolue.
- La réactance équivalente est la somme de la réactance du transformateur en phase X_r et de la réactance de la partie X_α du déphaseur.
- L'angle de déphasage α ne dépend pas du rapport en phase r.

La réactance équivalente peut être écrite comme suit:

$$X(r,\alpha) = X_r(r_{nom})\left(\frac{r}{r_{nom}}\right)^2 + X_\alpha(0) + \left(X_\alpha(\alpha_{max}) - X_\alpha(0)\right)\left(\frac{\sin(\alpha/2)}{\sin(\alpha_{max}/2)}\right)^2$$

Paramètres:

r_{nom} rapport nominal du transformateur en phase

$X_r(r_{nom})$ réactance série équivalente du transformateur en phase pour le rapport nominal en phase

α_{max} déphasage maximal

$X_\alpha(0)$ réactance série équivalente de la partie du déphaseur en déphasage nul

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$X_\alpha(\alpha_{max})$ réactance série équivalente de la partie du déphaseur en déphasage maximal pour le rapport nominal en phase (r_{nom})

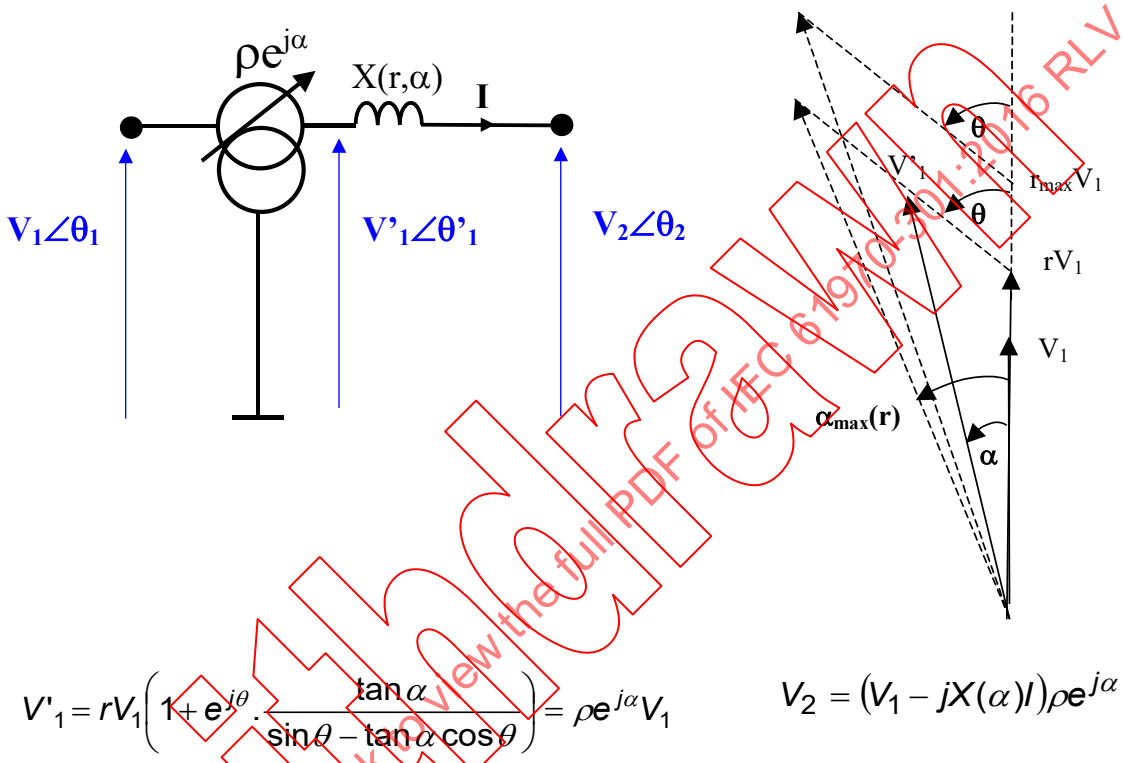
Variables:

r rapport de courant du transformateur en phase

α déphasage de courant

4.5.7.5.6 Transformateur en phase et déphaseur asymétrique

Le schéma et les équations du phaseur sont représentés à la Figure 23.



$$V'_1 = rV_1\left(1 + e^{j\theta}.\frac{\tan\alpha}{\sin\theta - \tan\alpha\cos\theta}\right) = \rho e^{j\alpha}V_1 \qquad V_2 = (V_1 - jX(\alpha)I)\rho e^{j\alpha}$$

θ est fixe, seuls r et α sont des variables, ρ varie de façon subséquente.

Figure 23 – Schémas et équations du phaseur

Réactance série équivalente en fonction de l'angle et du rapport du transformateur en phase

Hypothèses:

- La réactance de l'enroulement de régulation varie à mesure que le carré du nombre de tours évolue.
- La réactance équivalente est la somme de la réactance du transformateur en phase X_r et de la réactance de la partie X_α du déphaseur.

La réactance équivalente peut être écrite comme suit:

$$X(r,\alpha) = X_r(r_{nom})\left(\frac{r}{r_{nom}}\right)^2 + X_\alpha(0) + \left(X_\alpha(\alpha^0_{max}) - X_\alpha(0)\right)\left(\frac{\tan\alpha}{\tan\alpha_{max}(r)}\frac{\sin\theta - \tan\alpha_{max}(r)\cos\theta}{\sin\theta - \tan\alpha\cos\theta}\right)^2$$

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avec $\alpha_{max}(r) = A\tan\left(\frac{\sin\theta}{\frac{r}{r_{nom}\tan\alpha^0_{max}}\left(\sin\theta - \tan\alpha^0_{max}\cos\theta\right)+\cos\theta}\right)$ avec $\alpha^0_{max} = \alpha_{max}(r_{nom})$

Paramètres:

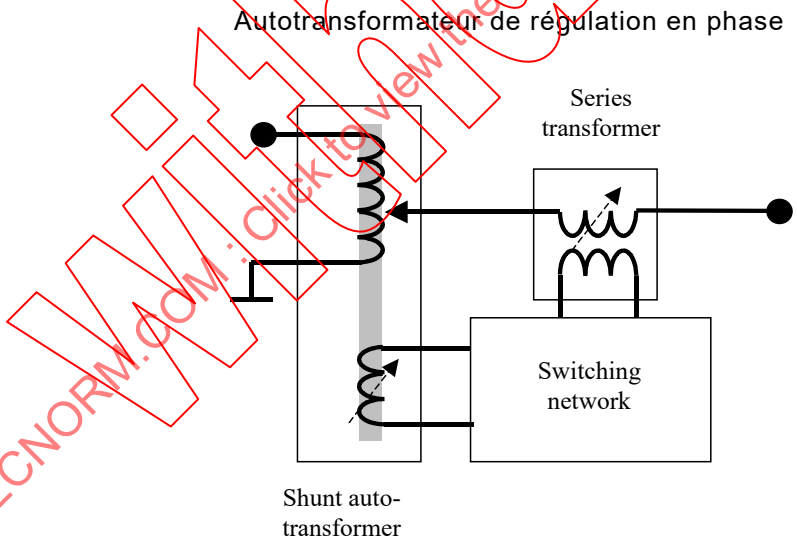
r_{nom}	rapport nominal du transformateur en phase
$X_r(r_{nom})$	réactance série équivalente du transformateur en phase pour le rapport nominal en phase r_{nom}
θ	angle fixe de la tension de charge rapide
$\alpha^0_{max} = \alpha_{max}(r_{nom})$	déphasage maximal pour le rapport nominal en phase (r_{nom})
$X_\alpha(0)$	réactance série équivalente de la partie du déphaseur en déphasage nul
$X_\alpha(\alpha^0_{max})$	réactance série équivalente de la partie du déphaseur en déphasage maximal pour le rapport nominal en phase (r_{nom})

Variables:

r	rapport de courant du transformateur en phase
α	déphasage de courant

Pour $\theta = \pi/2$ (transformateur déphaseur en quadrature): $\alpha_{max}(r) = A\tan\left(\frac{r_{nom}}{r}\tan\alpha^0_{max}\right)$

Organisations triphasées sont représentées à la Figure 24.



Anglais	Français
Series transformer	Transformateur survolteur-dévolteur
Switching network	Réseau de commutation
Shunt auto-transformer	Autotransformateur shunt

Figure 24 – Organisation du noyau

La régulation du déphasage peut se faire sur le shunt ou sur le transformateur survolteur-dévolteur.

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4.5.7.6 Modélisation tabulaire du transformateur déphaseur

Un PhaseTapChangerTabular est une représentation tabulaire explicite de la variation du déphasage, du rapport et de l'impédance sur la plage du changeur de prises. Le PhaseTapChangerTabular peut être associé au PhaseTapChanger représentant une relation non linéaire entre le nombre de prises, le déphasage, les rapports et les impédances.

4.5.7.7 Commande du changeur de prises

La commande des changeurs de prises dans un type de calcul de répartition est effectuée à l'aide de la classe TapChangerControl et de TapChanger.ltcFlag. Si un TapChanger a une TapChangerControl (référencée comme TapChanger.TapChangerControl), cela signifie que le calcul de répartition peut commander le changeur de prises. L'attribut TapChanger.ltcFlag donne des informations selon lesquelles le TapChanger a la capacité physique de déplacer la prise en charge. Cet attribut est également utilisé dans les calculs de l'IEC 60909 pour indiquer si la prise peut se déplacer en charge.

La signification des combinaisons de TapChanger.TapChangerControl et TapChanger.ltcFlag est décrite au Tableau 6.

Tableau 6 – Options de commande du changeur de prises

TapChanger. ltcFlag	TapChanger. TapChangerControl	Description
False (faux)	Not present (Non présent)	Prise réelle et fixe non commandée et ne pouvant pas être déplacée en charge (changement manuel de prise). Le flux de puissance ne peut pas être défini de sorte à changer de prise pour commander la tension au cours du calcul.
True (vrai)	Not present (Non présent)	Prise réelle et fixe non commandée mais pouvant être déplacée en charge, par exemple, manuellement. Le flux de puissance ne peut pas être défini de sorte à changer de prise pour commander la tension au cours du calcul. Le flux optimal de puissance peut avoir accès à ces prises et les changer à des fins d'optimisation. State Estimator (l'estimateur d'état) peut également estimer la position de prise afin de trouver une meilleure solution pour l'état du système.
True (vrai)	Present (Présent)	Prise réelle présentant une possibilité de changer les prises de façon automatique pour activer la commande de la tension/la puissance active (flux de charge) activée. Le fait que le flux de puissance doit ou ne doit pas intervenir dans la régulation dépend de RegulatingControl.enabled et de TapChanger.controlEnabled dans SSH. Dans les cas où RegulatingControl est associé à plus d'un changeur de prises ou à d'autres appareils, l'attribut TapChanger.controlEnabled peut être réglé sur False afin de définir les prises non activées.
False (faux)	Present (Présent)	Prise artificielle pouvant être utilisée pour simuler le comportement de commande du flux de puissance.

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4.5.8 Modélisation des phases

Les modèles du CIM fournissent des moyens de spécifier la représentation unifilaire équivalente de réseaux triphasés équilibrés ou, en sus ou en option, de spécifier le détail d'une phase donnée. Dans les réseaux monophasés, il y a correspondance directe entre les objets Terminal et les connexions physiques des fils. Dans une représentation unifilaire de réseaux triphasés équilibrés, une Terminal est utilisée pour représenter le groupe des connexions de phase de coordination. Une Terminal peut donc être utilisée pour spécifier une ou plusieurs connexions de phase de coordination en utilisant l'attribut Terminal.phases qui est un PhaseCode de type énumération. PhaseCode a pour combinaisons de phases possibles ABC, ABCN, AB, BC, CA, A, B, C et ainsi de suite. La spécification des phases à chaque borne permet de modéliser des cavaliers ou des commutateurs qui connectent différentes phases. Cette spécification de la connectivité de phase est entendue comme spécification de phase nominale ou normale. Le résultat de la source de mise sous tension

n'est pas reflété dans cette spécification. Cette spécification de phase fournit les moyens de connecter localement des phases semblables. La Figure 25 représente le modèle de données des phases.

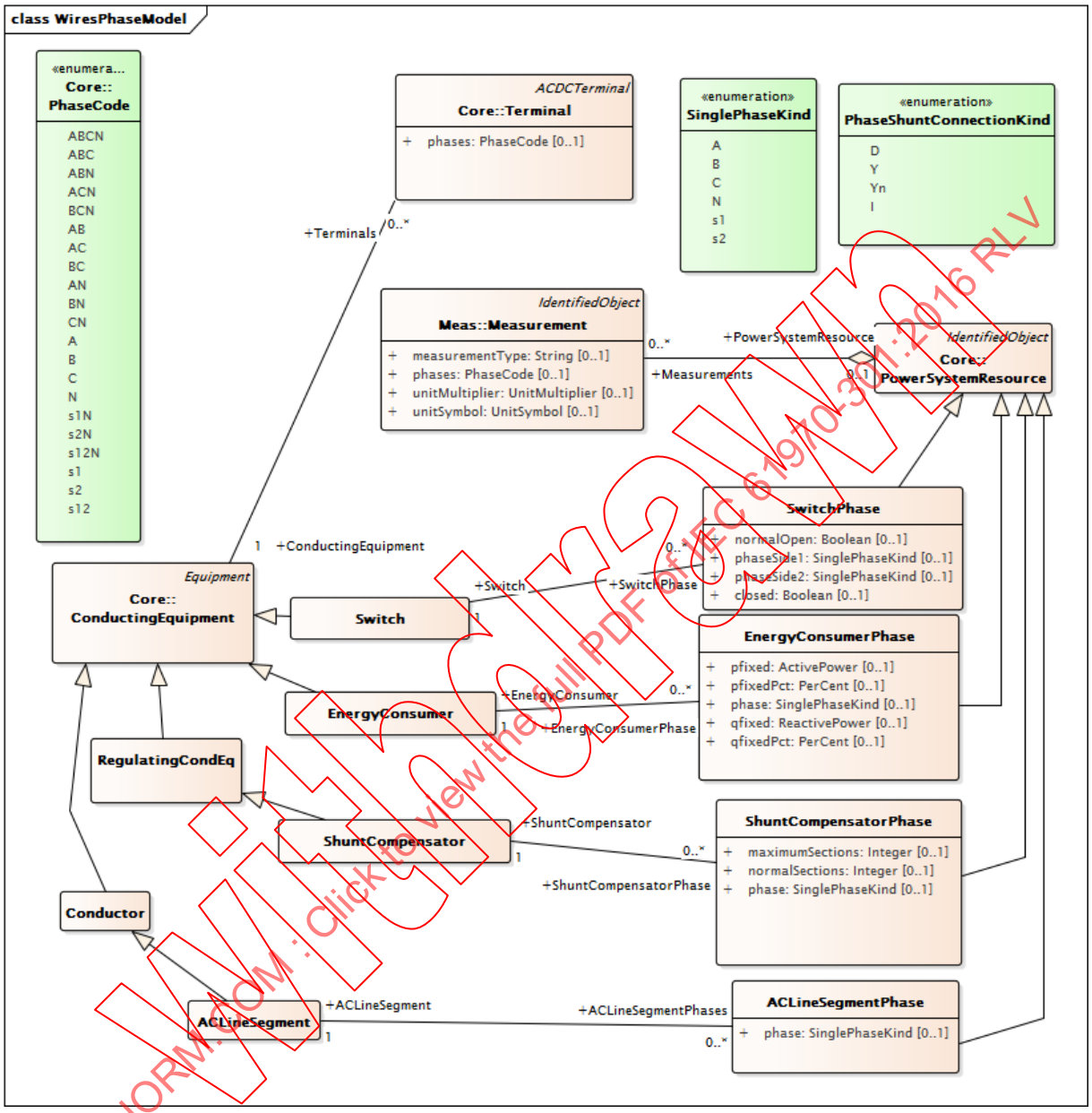
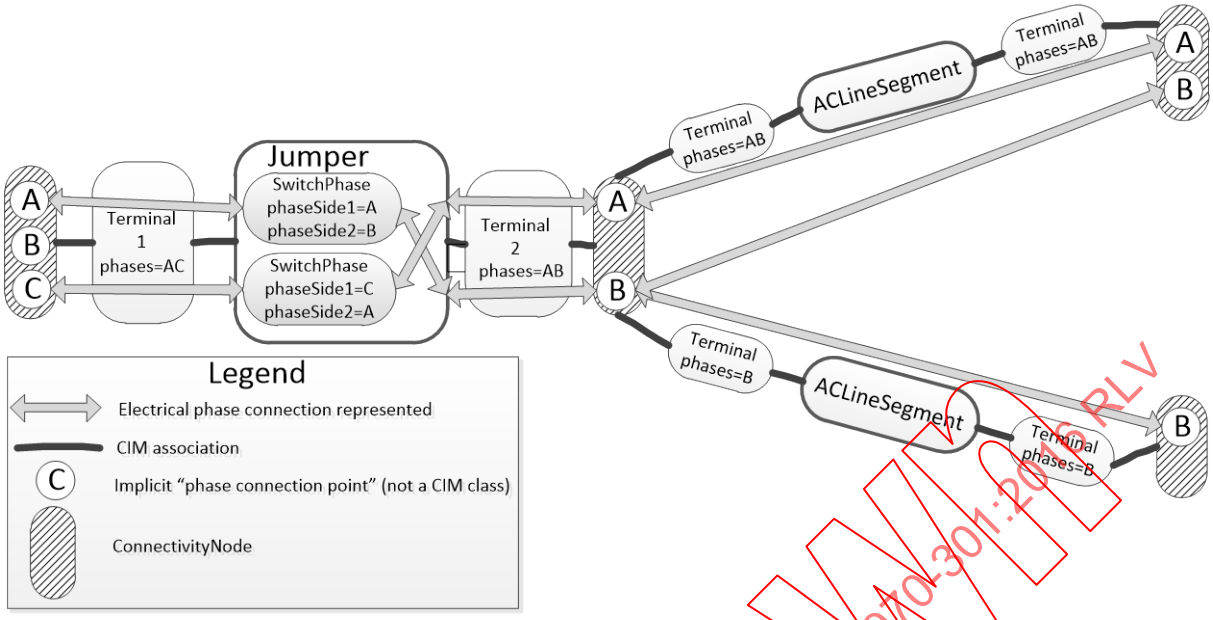


Figure 25 – Modèle de données des phases

La Figure 26 donne un exemple de connexions de phases. Cet exemple présente une instance ConnectivityNode sur la gauche, les phases A, B et C étant concernées. Noter que ConnectivityNode ne spécifie pas le contenu de sa phase mais connecte plutôt implicitement des phases semblables de bornes associées au ConnectivityNode. L'exemple présente un cavalier biphasé qui connecte sur la gauche (Terminal.sequenceNumber=1) les phases A et C et sur la droite (Terminal.sequenceNumber=2) les phases A et B, avec les parties intérieures des objets SwitchPhase du modèle de cavalier qui spécifient en détail le chemin des connexions de phases. L'attribut Terminal.phases spécifie uniquement la connexion externe d'un appareil. Plus loin sur la droite, deux tronçons de ligne sont raccordés. Le segment supérieur de la ligne est une ligne biphasée sur les phases A et B. Le segment inférieur de ligne est monophasé de phase B. Les lignes foncées indiquent les associations du CIM tandis que les flèches plus claires indiquent les connexions électriques représentées au niveau de la phase.

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Anglais	Français
Legend	Légende
Electrical phase connection represented	Connexion de phase électrique représentée
CIM association	Association CIM
Implicit ”phase connection point” (not a CIM class)	”Point de connexion de phase” implicite (pas une classe CIM)
ConnectivityNode	ConnectivityNode

Figure 26 – Connectivité de phase

À titre d’explication, l’attribut SwitchPhase appelé phaseSide1 spécifie une phase unique (comme A, B, C ou N) et se réfère à la Terminal dont le sequenceNumber est égal à 1. L’attribut SwitchPhase appelé phaseSide2 se réfère à la Terminal dont le sequenceNumber est égal à 2.

Le modèle de commutateur permet de modéliser les connexions entre phases de façon générale à l’intérieur de l’appareil. Le modèle de transformateur comporte aussi une modélisation explicite de la connectivité de phase interne de l’appareil. Actuellement, toutes les autres spécialisations de branche ConductingEquipment comme ACLineSegment supposent que des phases identiques sont connectées aux deux bornes. Le modèle du CIM est ouvert aux extensions futures pour introduire la connectivité de phase interne des appareils.

4.5.9 Modélisation des appareils de mise à la terre

4.5.9.1 Cas d'utilisation pour la modélisation des appareils de mise à la terre

Ces appareils ont un impact important sur les courants de court-circuit pour les défauts déséquilibrés. Le fonctionnement des appareils est interchangé par des commutateurs lorsque le transformateur vers la commutation de lignes est reconfiguré. De plus, les bobines Petersen sont “accordées” pour correspondre au courant de charge attendu des défauts déséquilibrés. L'impédance des bobines Petersen peut être “accordée” en ajustant la position du régleur à la manière d'une prise. La position du régleur est parfois télémesurée. Parfois, un modèle linéaire suffit pour mettre en relation la position du régleur et la valeur d'impédance et parfois un tableau est nécessaire pour présenter la relation non linéaire entre la position de régleur et l'impédance.

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4.5.9.2 Historique et exemple

Une bobine Petersen est une bobine de mise à la terre utilisée dans les systèmes de transport de puissance à courant alternatif et conçue pour limiter l'intensité du courant vers la terre à l'emplacement d'un défaut en établissant un courant réactif vers la terre permettant d'équilibrer le courant capacitif circulant des lignes vers la terre. Un exemple de conception est donné à la Figure 27.

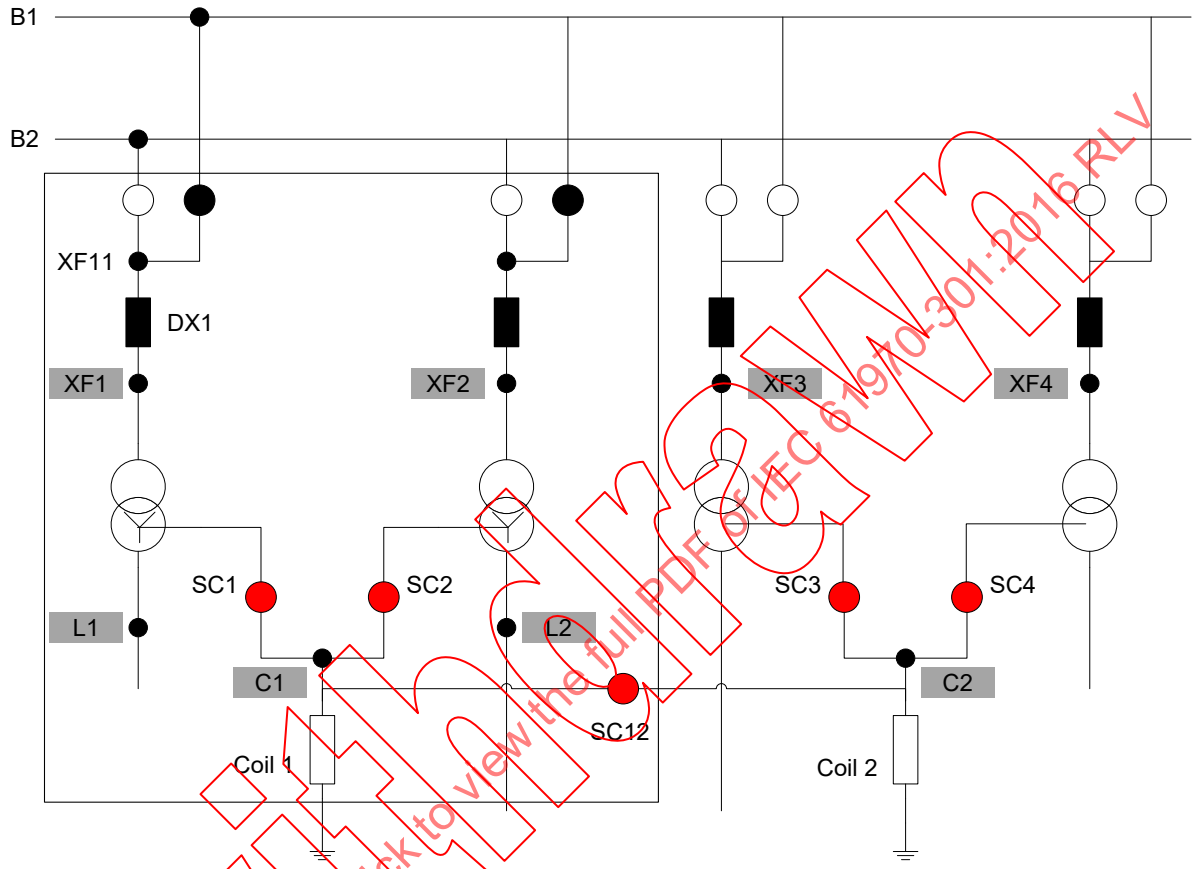


Figure 27 – Exemple de représentation de poste comprenant des bobines Petersen

Dans l'exemple ci-dessus, SC1, SC2, SC3, SC4 et SC12 sont les sectionneurs du circuit de mise à la terre. B1 et B2 sont les tronçons de jeux de barres. XF1, XF2, XF3, XF4, C1, C2, L1 et L2 sont les nœuds de connectivité.

Le point de mise à la terre d'un transformateur est le point médian des enroulements connectés en Y et les sectionneurs du circuit de mise à la terre sont connectés à ces points médians. Dans le CIM, le point médian est décrit par l'attribut de phasage de la Terminal au niveau des enroulements connectés en Y. Cela signifie que les commutateurs du circuit de mise à la terre sont connectés au nœud de connectivité au niveau de la Terminal avec les enroulements connectés en Y. Dans la Figure 27, cela signifie que SC1 est connecté à L1, que SC2 est connecté à L2 et que L1/L2 a les phases ABC ainsi que la phase N comme point médian.

4.5.9.3 Modèle

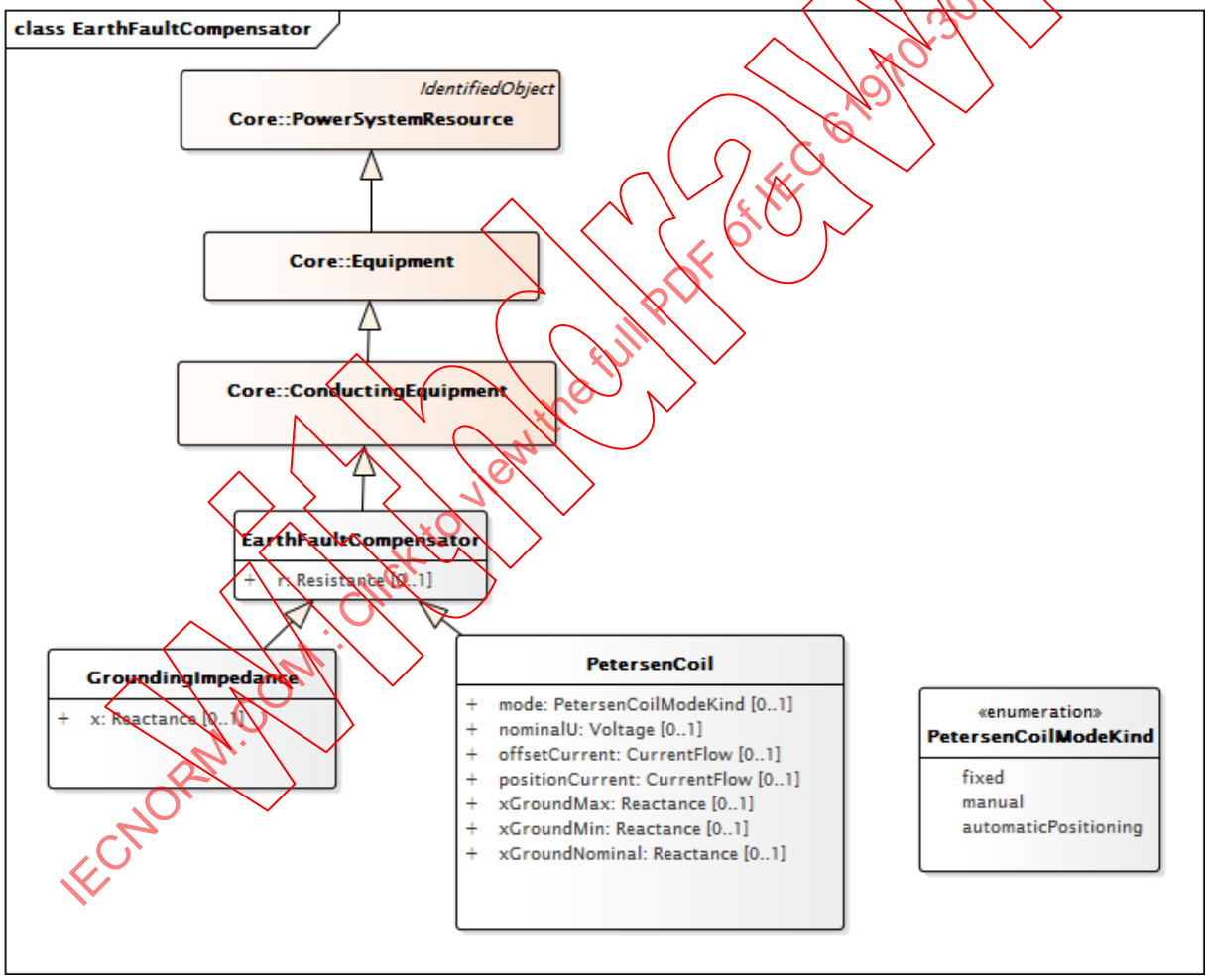
L'EarthFaultCompensator est un type d'équipement conducteur abstrait prévu pour modéliser les équipements de mise à la terre. L'EarthFaultCompensator est une spécialisation de ConductingEquipment, car un court-circuit exige des connexions appropriées et différents commutateurs qui peuvent s'ouvrir ou se fermer pour modifier la configuration de la topologie. L'EarthFaultCompensator est différent d'une branche telle que ACLineSegment, ShuntCompensator ou PowerTransformer dans le sens où il ne régule pas la tension et n'est

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jamais monté en étoile ou en triangle. Un transformateur de mise à la terre connecté en zigzag reste un PowerTransformer en raison de toutes les autres complexités du transformateur. Deux spécialisations sont proposées pour manipuler les appareils à impédance fixe (GroundingImpedance) et les appareils réglables (tunable) à bobine Petersen (PetersenCoil).

L'une ou les deux bornes de l'EarthFaultCompensator peuvent être modélisées. Si la deuxième borne d'un EarthFaultCompensator est omise, la borne est censée être solidement raccordée à la terre. S'il existe une sorte de topologie ou de résistivité locale à la terre qui est importante à la modélisation du côté terre de l'appareil, alors une deuxième borne est ajoutée.

Une classe séparée de sectionneurs de terre (GroundDisconnector) est incluse étant donné que ces sectionneurs sont généralement très différents physiquement de la plupart des autres commutateurs et souvent exclus de l'analyse du flux normal de puissance. Voir la Figure 28 pour la représentation du modèle de données.



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Figure 28 – Modèle de données de l'appareil de mise à la terre

4.5.9.4 Exemple de modèle d'instance CIM

Dans la Figure 29, la PetersenCoil est modélisée comme les objets CIM avec une borne uniquement, et la mise à la terre est implicite, comme représenté à la Figure 27.

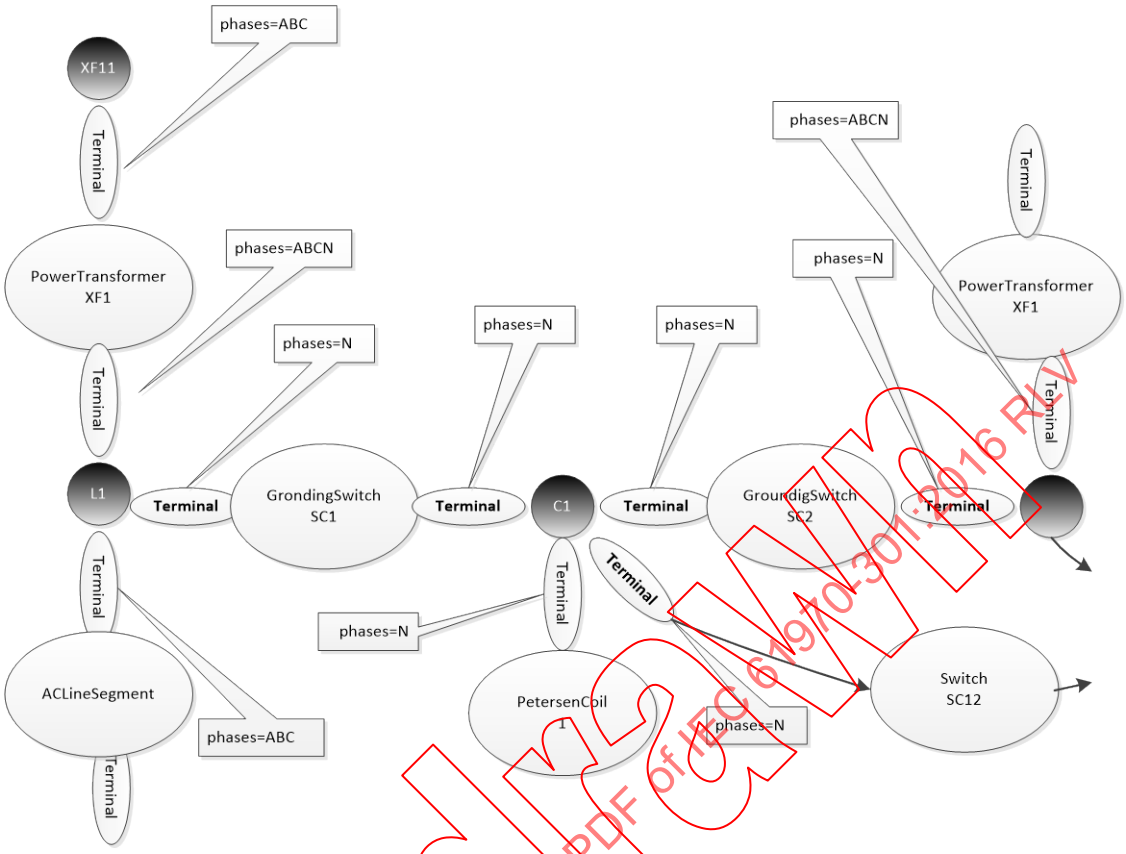


Figure 29 – Objets de diagramme d'instance avec une bobine à bornes

La Figure 29 représente la façon dont une Terminal du commutateur SC1 est en phase N et dont la Terminal du transformateur est connectée à L1 avec les phases ABCN.

4.5.10 Modèle de cuts, de clamps (serre-fils) et de jumpers (cavaliers)

Le modèle de l'UML pour les cuts et les jumpers (cavaliers) sur un segment de ligne et les connexions supplémentaires sont décrites à la Figure 30. La classe Jumper est une spécialisation de la classe plus générale Switch et permet des changements de phase ainsi qu'une connectivité de phase, comme représenté à la Figure 26. Les jumpers (cavaliers) peuvent donc connecter les bornes de façon normale. Les classes Cut et Clamp du CIM fournissent des moyens d'ajouter effectivement des Terminals à un ACLineSegment à une distance spécifiée sur la ligne en aval, en associant de nouveaux objets du CIM à un objet ACLineSegment sans autre modification du modèle ACLineSegment intégré. Chaque instance Clamp introduit une nouvelle borne connectée à la distance spécifiée en aval sur la ligne sans interrompre la ligne. Chaque instance Cut introduit deux nouvelles bornes qui sont effectivement les extrémités du cut. Par convention, chaque borne d'un cut est orientée vers la borne ACLineSegment dont le sequenceNumber est identique. Si le cut est ouvert, il n'y a pas de flux qui traverse l'ACLineSegment au point du cut mais le flux peut passer par l'un ou l'autre côté de l'ACLineSegment et par la borne de cut appropriée. Habituellement, les jumpers (cavaliers) sont connectés aux extrémités des cuts, mais ils peuvent aussi être connectés à un type quelconque d'équipement conducteur de façon normale en utilisant ConnectivityNode ou TopologicalNode.

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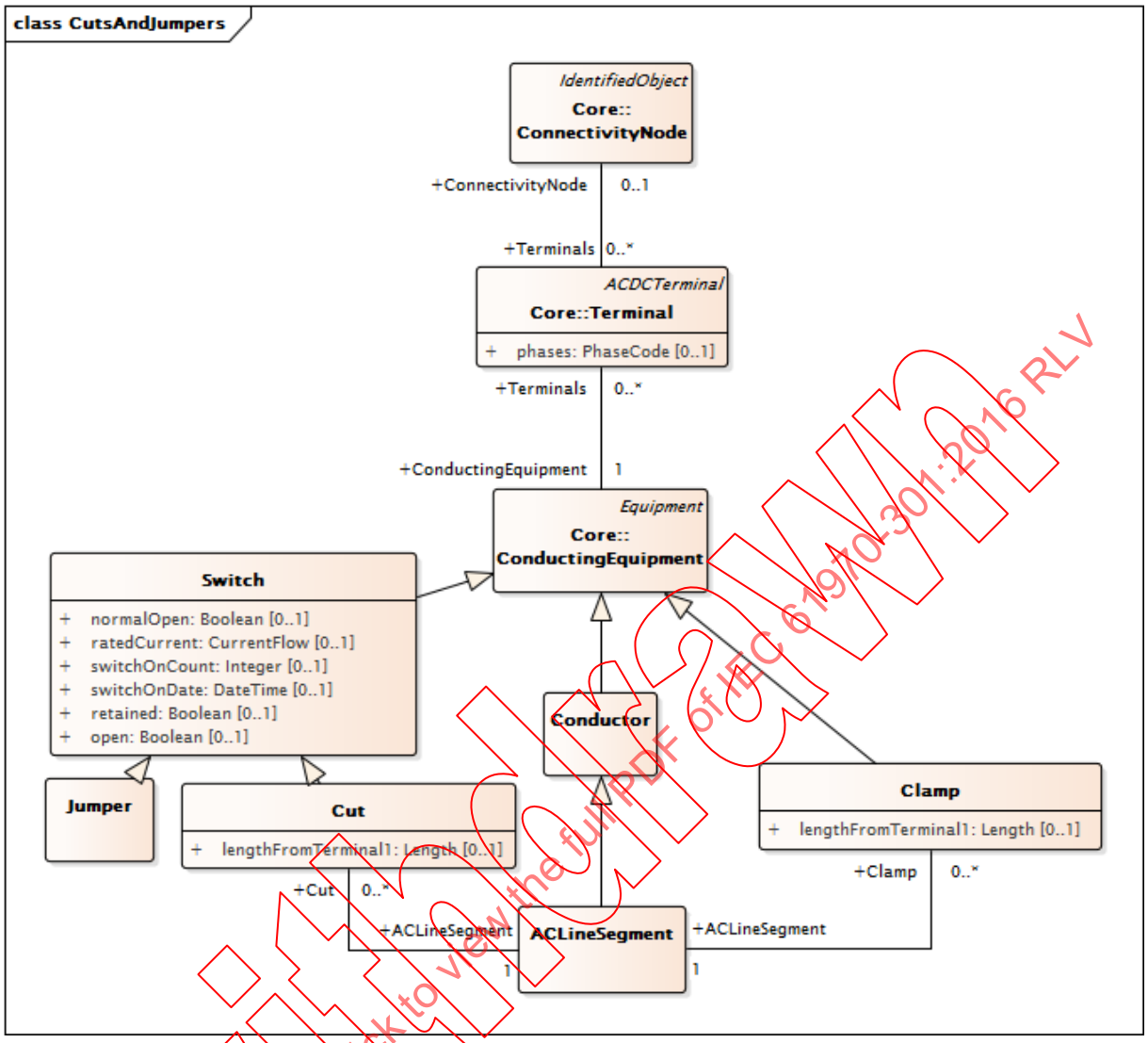
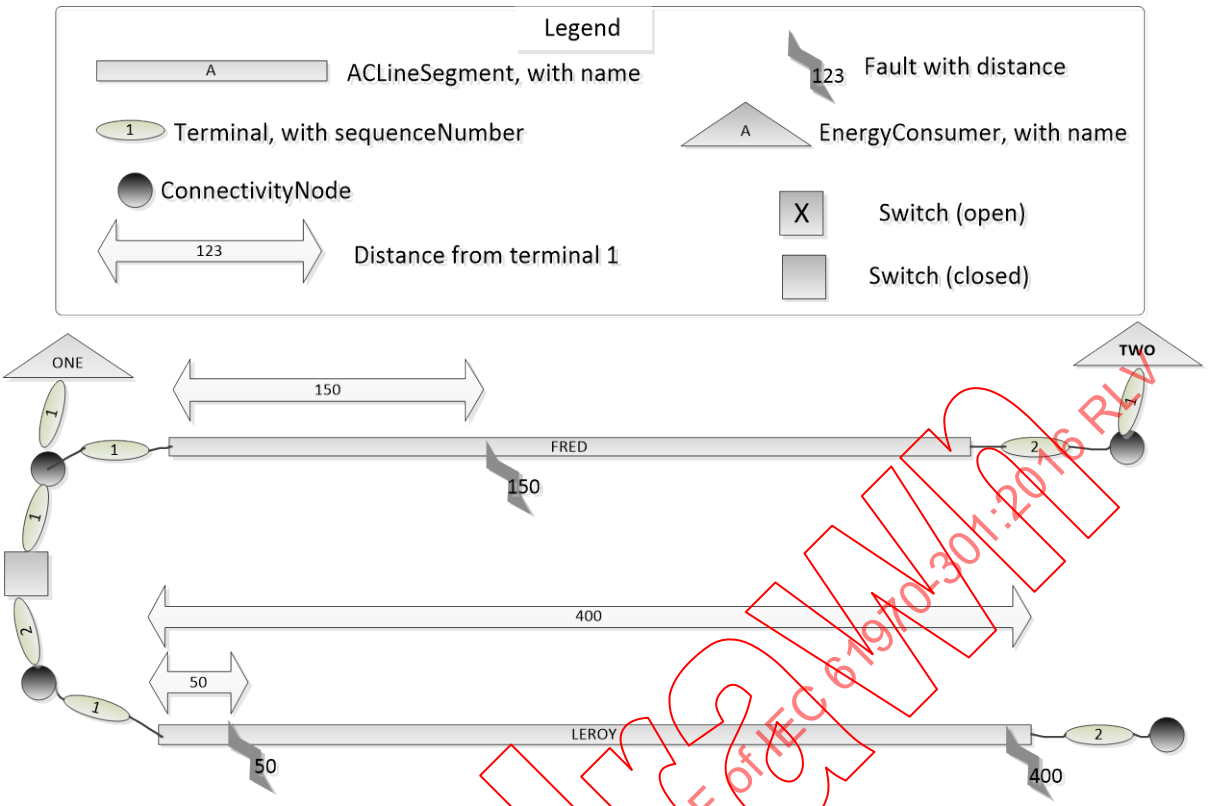


Figure 30 – Modèle UML de cuts, de clamps (serre-fils) et de jumpers (cavaliers)

La Figure 31 et la Figure 32 donnent un exemple d'ajout de cuts et de clamps (serre-fils) à un modèle existant de CIM. La Figure 31 représente deux tronçons de ligne physiques parallèles appelés "FRED" et "LEROY". Dans cet exemple, le système est mis sous tension à partir de la droite, le commutateur sur la gauche est fermé et les charges appelées "ONE" et "TWO" sont appliquées. Les trois défauts sont ensuite appliqués aux distances spécifiées par rapport à la Terminal 1 des tronçons respectifs de ligne. Dans cet exemple, le détail de phase n'est pas spécifié pour des raisons de simplicité mais le détail de phase peut suivre la même approche que celle présentée en 4.5.8.

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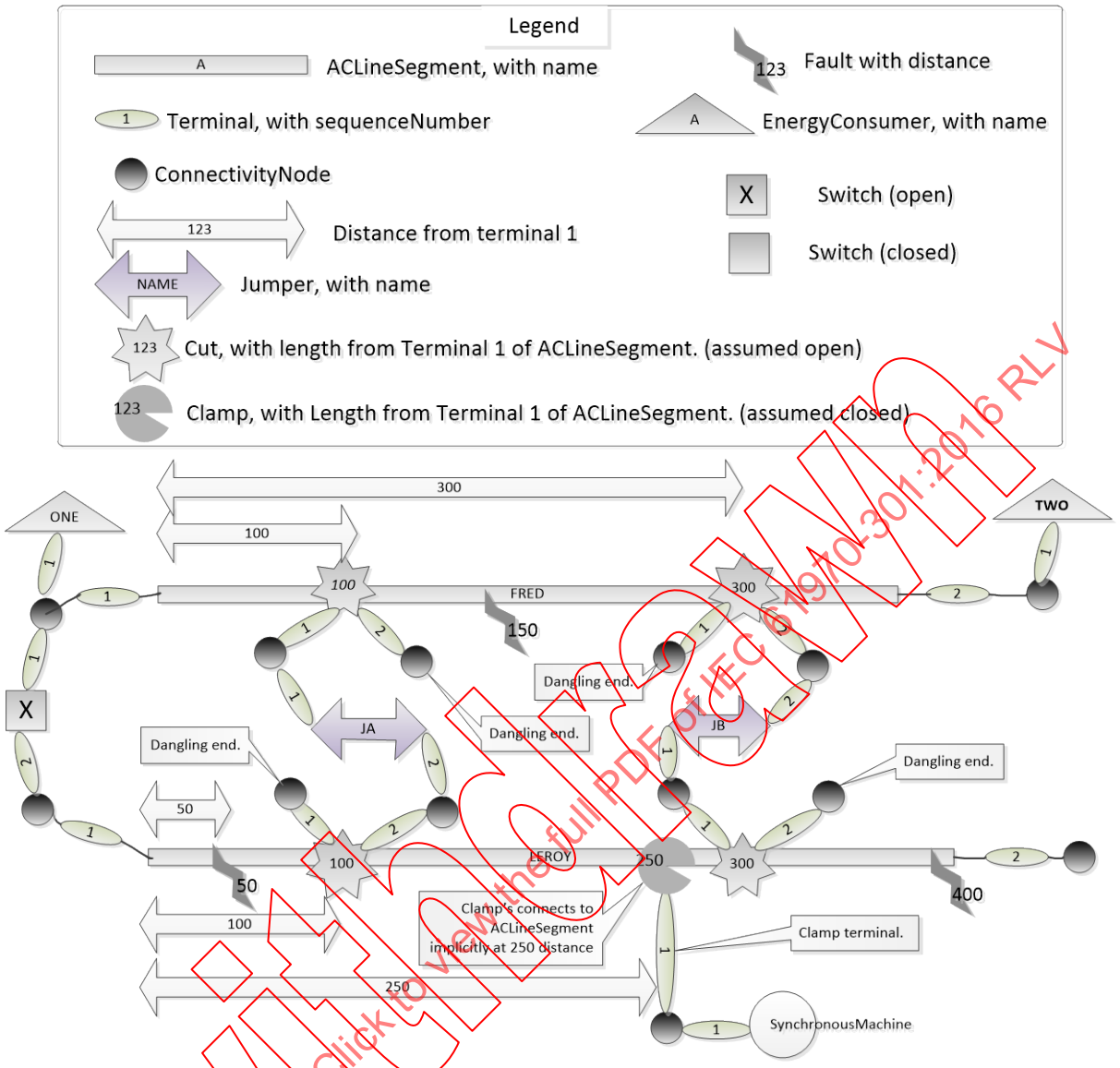


Anglais	Français
Legend	Légende
ACLineSegment, with name	ACLineSegment, avec nom
Terminal, with sequenceNumber	Borne, avec sequenceNumber
ConnectivityNode	ConnectivityNode
Distance from terminal 1	Distance du terminal 1
Fault with distance	Erreur avec distance
EnergyConsumer, with name	EnergyConsumer, avec nom
Switch (open)	Commutateur (ouvert)
Switch (closed)	Commutateur (fermé)

Figure 31 – Exemple avant application des cuts et des jumpers (cavaliers)

La Figure 32 représente la façon dont le simple ajout de Cut, ConnectivityNode, Jumper, Clamp et éventuellement d'un autre ConductingEquipment peut représenter des changements de modèle qui reflètent un travail temporaire typique. Les mêmes modèles peuvent donc être utilisés pour des changements permanents de modèle. L'exemple présente la façon dont des cuts appliqués aux distances spécifiées peuvent isoler les défauts en laissant pendre les extrémités défectueuses des cuts tandis que le réseau sans défaut est connecté pour fournir les charges. Cet exemple présente également la façon dont plusieurs cuts peuvent être appliqués à un segment de ligne. Cet exemple présente des cuts ouverts, mais si un cut était fermé, le flux pourrait continuer à traverser ACLineSegment, avec une partie du flux potentiellement redirigée vers les bornes du cut, à peu près comme dans le cas d'un clamp (serre-fil).

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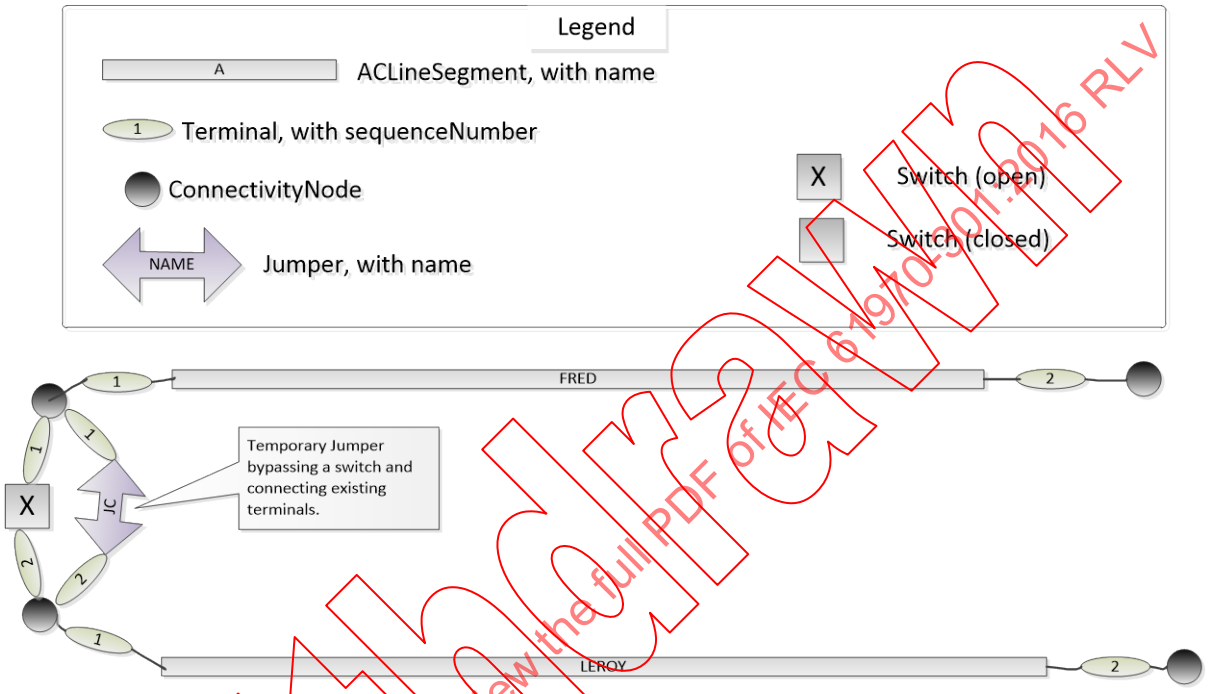
Anglais	Français
Legend	Légende
ACLineSegment, with name	ACLineSegment, avec nom
Terminal, with sequenceNumber	Borne, avec sequenceNumber
ConnectivityNode	ConnectivityNode
Distance from terminal 1	Distance du terminal 1
Jumper, with name	Cavalier, avec nom
Cut, with length from Terminal 1 of ACLineSegment. (assumed open)	Cut, avec longueur du Terminal 1 de ACLineSegment. (censé être comme ouvert)
Clamp, with length from Terminal 1 of ACLineSegment. (assumed closed)	Serre-fil, avec longueur du Terminal 1 de ACLineSegment. (censé être ouvert)
Fault with distance	Erreur avec distance
EnergyConsumer, with name	EnergyConsumer, avec nom
Switch (open)	Commutateur (ouvert)
Switch (closed)	Commutateur (fermé)
Dangling end	Extrémité qui pend
Clamp connects to ACLineSegment implicitly at 250 distance	Le serre-fil se connecte à ACLineSegment de façon implicite à une distance de 250
Clamp terminal	Borne du serre-fil

Figure 32 – Exemple après application des cuts et des jumpers (cavaliers)

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Un cut fournit deux bornes et bien que l'exemple ci-dessus ne le représente pas, des connexions sont possibles à l'une des bornes du cut ou aux deux. Un cas d'exemple pourrait impliquer l'introduction d'un cut et la connexion des deux bornes de cut à l'aide d'un cavalier qui croise les phases.

Un cavalier peut être utilisé sans serre-fil ni cut lorsque des bornes existantes doivent être connectées. La Figure 33 représente un exemple d'utilisation d'un cavalier sans cut ni serre-fil. Dans ce cas, un cavalier temporaire peut être utilisé pour contourner un commutateur qui fait l'objet d'une maintenance.



Anglais	Français
Legend	Légende
Terminal, with sequenceNumber	Borne, avec sequenceNumber
ConnectivityNode	ConnectivityNode
Jumper, with name	Cavalier, avec nom
Switch (open)	Commutateur (ouvert)
Switch (closed)	Commutateur (fermé)
Temporary Jumper bypassing a switch and connecting existing terminals	Cavalier (Jumper) temporaire de contournement du commutateur et connexion des bornes existantes

Figure 33 – Exemple de cavalier sans cut ni serre-fil

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4.5.11 Mesures et commandes

4.5.11.1 Vue d'ensemble des mesures (Measurements)

Les Measurements (mesures) sont utilisés pour représenter les variables d'état qui peuvent être rencontrées dans des processus industriels. Chaque processus industriel a ses types spécifiques de mesures. Un système de puissance a généralement des flux de puissance, des tensions, des positions (par exemple, disjoncteurs, isolateurs), des indicateurs de défauts (pression atmosphérique, pression d'huile, surchauffe, etc.), des compteurs (par exemple, énergie), etc.

Le nom "Measurement" semble indiquer que toutes les variables d'état sont mesurées. Tel n'est pas toujours strictement le cas, car de nombreux "Measurement" sont calculés par des

fonctions SCADA ou EMS/DMS, comme les calculs d'estimateur d'état ou de flux de puissance, par exemple. Par conséquent, un Measurement peut avoir un certain nombre de valeurs alternatives (par exemple, fournies manuellement, télémesurées, estimées par état, optimisées, etc.). Cela est pris en charge par les modèles Measurement et MeasurementValue dans le paquetage Meas. Les classes dans le paquetage StateVariable ont été ajoutées au modèle CIM, et ce, spécifiquement pour le besoin de prendre en charge l'échange de valeurs calculées par des fonctions telles que l'estimateur d'état et le calcul du flux de la puissance.

Le modèle de Measurement permet désormais de spécifier facultativement les phases spécifiques d'une mesure.

4.5.11.2 Vue d'ensemble des commandes

Les commandes sont utilisées pour représenter les variables de commande. Les variables de commande du système de puissance sont généralement des points de consigne, des commandes augmente/diminue, des commandes Sélectionner avant d'exécuter et des commandes marche/arrêt. Le paquetage Meas prend en charge les variables de commande avec le modèle Control.

4.5.11.3 Utilisation des classes liées à la classe Measurement

Un PowerSystemResource (PSR) peut avoir zéro à plusieurs Measurements qui lui sont associés en contenant un ou plusieurs Measurements. Chaque Measurement peut contenir une ou plusieurs valeurs de mesure. Le respect des lignes directrices suivantes permet aux applications de naviguer et de retrouver les valeurs de mesure exigées de manière cohérente (voir Figure 34).

a) Les Measurements d'un PowerSystemResource sont classées par l'attribut measurementType (type de mesure). Les valeurs devant être utilisées pour Measurement.measurementType sont spécifiées dans le Tableau 7.

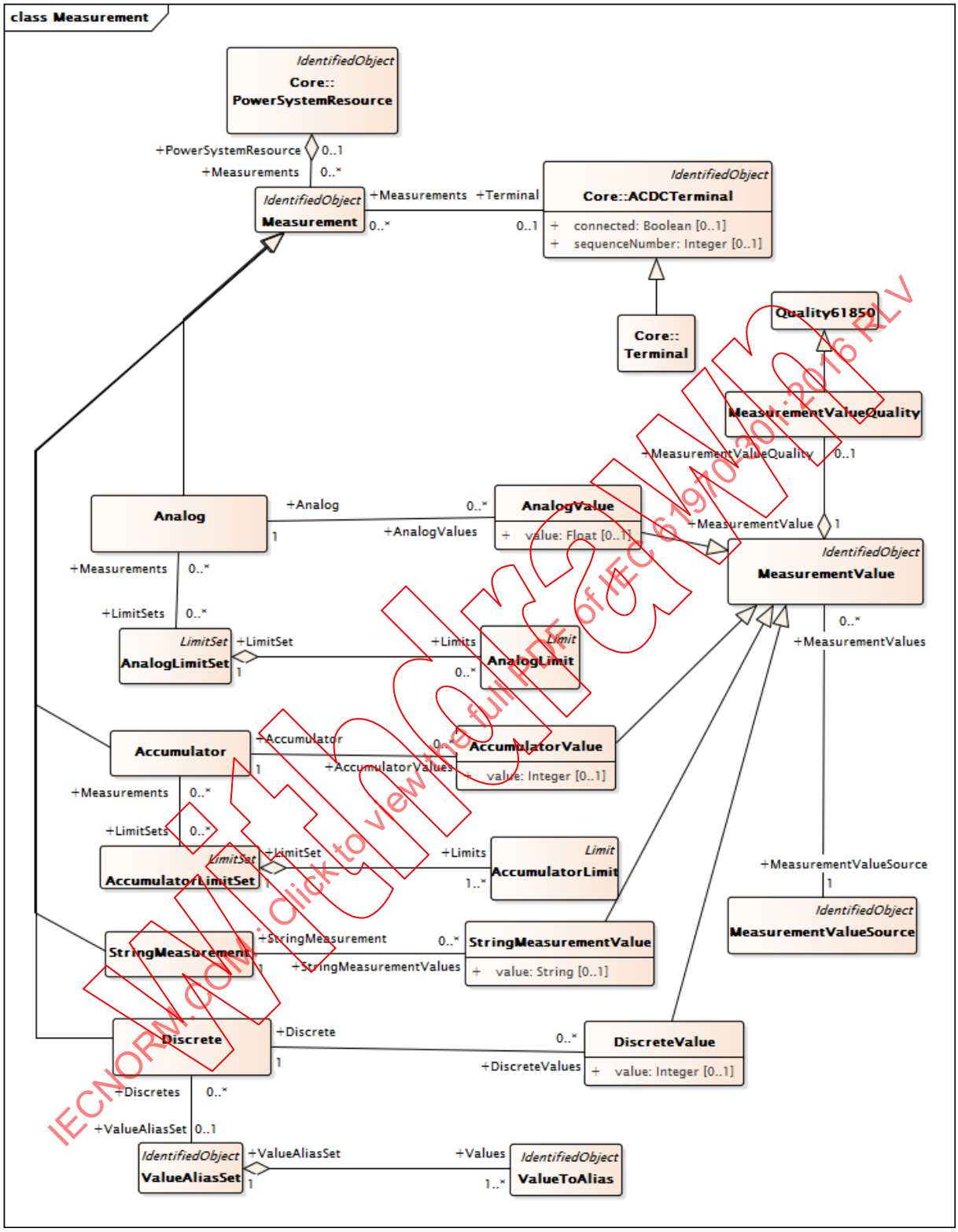
b) Les MeasurementValues (valeurs de mesure) d'un Measurement sont classées par MeasurementValueSource (source de valeur de mesure).

c) MeasurementValueSource hérite de IdentifiedObject. Les valeurs à utiliser pour MeasurementValueSource.name sont spécifiées dans le Tableau 8. Ce tableau fournit un certain nombre de noms de sources à utiliser lorsque cela est possible. Cependant, les noms exacts à utiliser pour des applications spécifiques sont définis dans le document correspondant IEC 61970 CIS (Component Interface Specifications – Spécification d'interface de composants)

d) Les tableaux peuvent être étendus pour des besoins propriétaires. Les noms ajoutés doivent commencer par un nom unique (par exemple, le nom de la société) et un caractère "souligné" ("underscore"). Exemple: xyz_AverageTemperature.

e) La valeur ValueAliasSet est utilisée pour des mesures discrètes et décrit des correspondances de valeurs vers des noms symboliques, comme des libellés d'énumération qui ont des valeurs entières spécifiques. Des protocoles de communication différents (par exemple pour les RTU (Remote Units – unités distantes) et pour les centres de conduite tels que ICCP (Intelligent Customer Contact Platform – plate-forme intelligente de relations avec l'abonné) ou ELCOM) utilisent des codages de données différents. Un système peut avoir une mise en correspondance à l'échelle du système pour toutes les valeurs Discrete (discrètes) ou regrouper les valeurs Discrete et effectuer la mise en correspondance par groupe. La création d'une seule mise en correspondance à l'échelle du système qui couvrirait des protocoles de communication existants ne relève pas du domaine d'application du présent document.

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Figure 34 – Navigation de PSR à MeasurementValue

Tableau 7 – Conventions de dénomination de measurementType

measurementType	61850 Name	description
Current	Amp	Courant (efficace) d'un circuit non triphasé
ThreePhaseCurrent	AvAmps	Courant total (efficace) dans un circuit triphasé
PhaseCurrent	A	Courant de phase mesuré
Frequency	Hz	Fréquence
PowerFactor	PwrFact	Facteur de puissance non alloué à une phase
ThreePhasePowerFactor	TotPF	Facteur de puissance moyen dans un circuit triphasé
ThreePhaseApparentPower	TotVA	Puissance apparente totale dans un circuit triphasé
ThreePhaseReactivePower	TotVAr	Puissance réactive totale dans un circuit triphasé
ThreePhaseActivePower	TotW	Puissance réelle totale dans un circuit triphasé.
ApparentPower	VolAmp	Puissance apparente dans un circuit non triphasé
ReactivePower	VolAmpr	Puissance réactive dans un circuit non triphasé
Voltage	Vol	Tension (efficace) non allouée à une phase
ActivePower	Watt	Puissance réelle dans un circuit non triphasé
Pressure	Pres	Pression
Temperature	Tmp	Température
Angle	Ang	Angle entre la tension et le courant
ApparentEnergy	TotVAh	Énergie apparente
ReactiveEnergy	TotVArh	Énergie réactive
ActiveEnergy	TotWh	Énergie réelle
Automatic	Auto	Fonctionnement automatique (non manuel)
LocalOperation	Loc	Fonctionnement local (non télécommandé)
SwitchPosition	Pos	Position de commutation [2bits= intermédiaire,ouvert,fermé,ignorer]
TapPosition	TapPos	Position de prise du transformateur de puissance ou du déphaseur
Operation Count	OperCnt	Compteur d'opérations – généralement pour les commutateurs
LineToNeutralVoltage		Tension phase à neutre
LineToGroundVoltage		Tension phase à terre

Le Tableau 7 décrit divers types de mesures qui sont aussi définies dans l'IEC 61850. Les colonnes du Tableau 7 ont la signification suivante:

- measurementType (Measurement.measurementType) est le nom du type de mesure selon l'IEC 61970.
- 61850 Name est le nom assigné à l'objet de données dans l'IEC 61850-7-4:2010, sémantique des noms d'objet de données.
- description est la description des données.

Il doit être noté que le Tableau 7 ne constitue pas une liste exhaustive et que la correspondance entre mesures telle que définie dans un centre de conduite et un poste n'est pas triviale.

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Tableau 8 – Conventions de dénomination de MeasurementValueSource (source de valeur de mesure)

Nom	description
SCADA	Valeurs télémesurées reçues d'un système SCADA local
CCLink	Valeur reçue d'un centre de conduite distant par l'intermédiaire de TASE.2 ou autre protocole
Operator	Valeur entrée par un opérateur (toujours maintenue manuellement, le PSR n'est pas connecté à une RTU)
Estimated	Valeur mise à jour par un estimateur d'état
PowerFlow	Valeur mise à jour par un Powerflow (flux de puissance)
Forecasted	Valeur qui est planifiée ou prévisionnelle.
Calculated	Valeur calculée à partir d'autres valeurs de mesure (par exemple, une somme)
Allocated	Valeur calculée par un allocateur de charge

En respectant ces conventions:

- chaque instance de Measurement représente une grandeur technique d'un PowerSystemResource;
- chaque MeasurementValue d'un Measurement représente une valeur pour la grandeur technique, fournie par une source unique;
- l'attribut source de MeasurementValueQuality indique alors si la source a vraiment fourni la valeur courante ou bien si elle est une valeur de substitution ou une valeur par défaut.

Noter qu'une nouvelle identité MeasurementValue n'est pas normalement créée pour chaque échange d'une valeur mesurée. Il est prévu que la même instance MeasurementValue puisse échanger de nouvelles valeurs dans des messages ultérieurs. C'est pourquoi l'identité d'une instance MeasurementValue peut être établie a priori pour échanger des valeurs mesurées. La modélisation d'une série chronologique de valeurs n'est pas explicitement mentionnée dans le modèle du CIM bien que le modèle permette aux systèmes de constituer en interne de tels modèles de série chronologique à l'aide d'une série d'échanges de valeurs de mesure.

4.5.11.4 Rattachement des Measurements

Comme mentionné en 4.5.11.3 et comme représenté à la Figure 34, les Measurements sont contenues par un PowerSystemResource. Cela est suffisant pour des Measurements qui ne sont pas reliées à la connectivité, par exemple la température, le poids, la taille.

Pour spécifier l'emplacement d'un Measurement dans le réseau, une association à Terminal est utilisée. Des exemples sont les flux de puissance, les tensions et les courants. Les tensions (Voltage) n'ont pas de sens et peuvent être jointes en fonction du placement du capteur. Les flux ont un sens et doivent être joints de façon à ce que le sens du flux soit évident d'après le placement.

La Figure 35 représente deux exemples de placement de Measurements.

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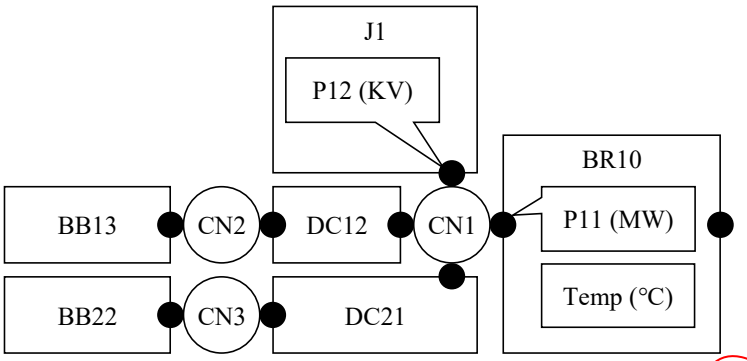


Figure 35 – Placement de Measurement

P12 est un Measurement de tension qui mesure la tension à la jonction J1. P12 est topologiquement relié au ConnectivityNode CN1 via la Terminal de la jonction J1. P11 est un Measurement qui mesure le flux traversant le disjoncteur BR10 du côté connecté au ConnectivityNode CN1. P11 est topologiquement relié au ConnectivityNode CN1 via la Terminal gauche du disjoncteur BR10. Temp est un Measurement qui mesure la température du disjoncteur. Comme la température n'est pas reliée à la connectivité, elle n'a pas de relation avec une Terminal – elle appartient seulement au disjoncteur BR10.

4.5.11.5 Mesures ICCP

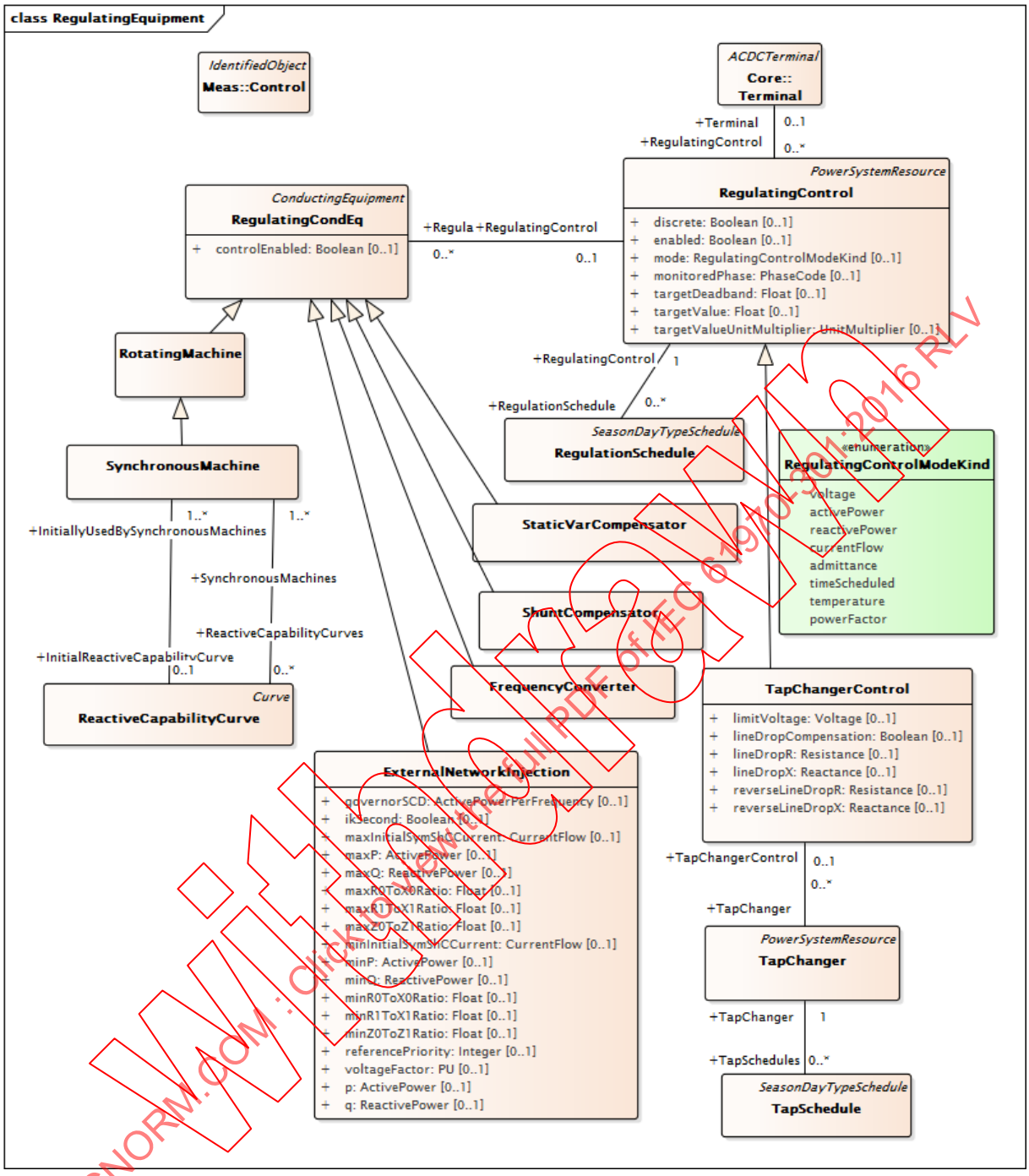
Les sources de données ICCP (officiellement connues comme IEC 60870-6 TASE.2) sont spécifiées en utilisant les classes MeasurementValue (et leurs spécialisations) et la classe MeasurementValueSource. La classe MeasurementValueSource est utilisée pour définir le centre de conduite qui fournit les données ICCP. La MeasurementValueSource doit être associée à une instance du Name dans laquelle l'attribut Name.name contient le nom du centre de conduite fournisseur. L'instance du NameType associée au Name du centre de conduite doit avoir "ICCP" pour attribut NameType.name.

Les classes MeasurementValue sont utilisées pour spécifier l'ICCP ID. La MeasurementValue doit être associée à une instance de Name dont l'attribut Name.name contient l'ICCP ID. L'instance du NameType associé à l'ICCP ID Name doit avoir "ICCP" pour attribut NameType.name. L'attribut MeasurementValue.name contient le nom de point SCADA. Chaque MeasurementValue est associée à un Measurement. Chaque MeasurementValue qui est fournie à l'aide d'ICCP doit aussi avoir une association à une MeasurementValueSource.

4.5.12 Modèles de commande de régulation

Une commande de régulation, par exemple une commande automatique de tension sur des générateurs ou une commande de prise de tension sur des transformateurs, est modélisée en utilisant la classe RegulatingControl qui offre la possibilité de modéliser plusieurs instances d'équipements qui participent à un plan de régulation. Ces plans de régulation peuvent être physiques ou mis en œuvre manuellement dans le fonctionnement réel du système de puissance, mais ils sont reflétés dans les modèles utilisés à des fins d'analyse des systèmes de puissance. La Figure 36 représente la façon dont les classes RegulatingCondEq et TapChanger peuvent participer à la régulation.

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Figure 36 – Modèles de commande de régulation

4.5.13 Modèle en courant continu pour le CIM

4.5.13.1 Généralités

Les systèmes de commande qui modélisent des postes en courant continu à haute tension ont généralement trois niveaux de détail:

- le modèle simplifié de système utilisé dans l'exploitation et la planification;
- le modèle simplifié de système prenant en charge les études dynamiques;
- le modèle détaillé des études transitoires d'un poste en courant continu à haute tension.

Le présent document a pour objet de présenter le modèle de courant continu à haute tension le plus minimaliste possible pouvant être utilisé dans les calculs de flux de puissance de systèmes SCADA/EMS/de planification et de court-circuit et dans les études dynamiques. Les études transitoires ne sont pas couvertes.

4.5.13.2 Conception de base de courant continu à haute tension

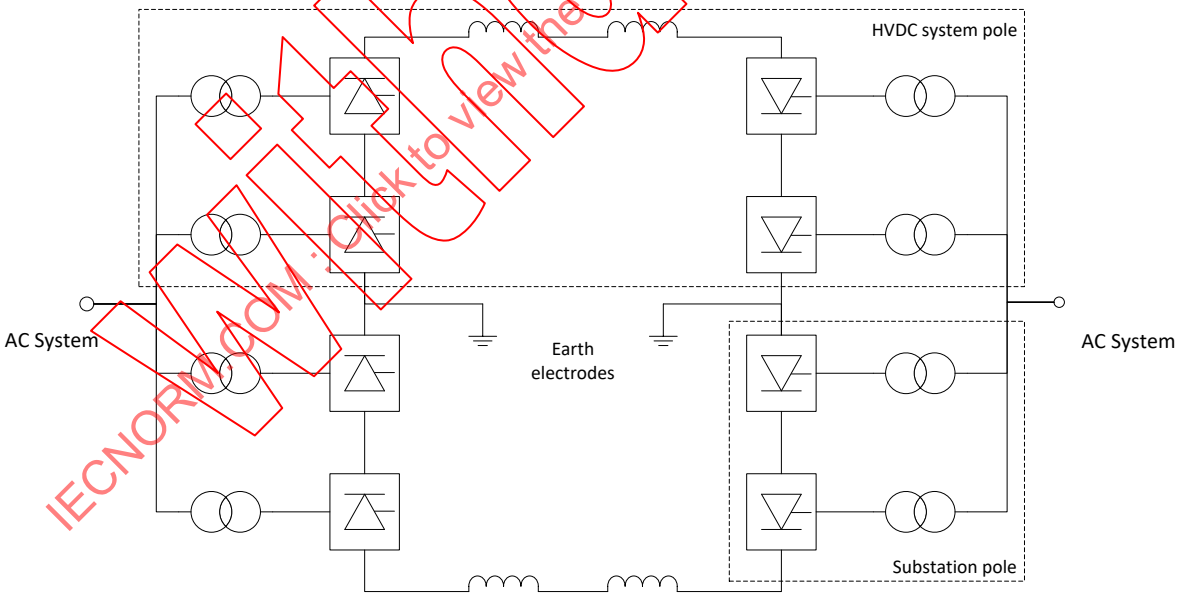
4.5.13.2.1 Généralités

Le modèle proposé est issu des documents suivants:

- IEC 60633:1998+AMD1:2009, *Terminologie pour le transport d'énergie en courant continu à haute tension (CCHT)*
- "VSC Transmission", CIGRÉ B4-37, avril 2005
- IEC 62747, *Terminologie relative aux convertisseurs de source de tension (VSC) des systèmes en courant continu à haute tension (CCHT)*
- HVDC Transmission de Dennis A. Woodford, Manitoba HVDC Research Centre
- "ABB technical description of HVDC light technology"
- Flexible Power Transmission. Jos Arrillaga, Y. H. Liu, Neville R. Watson, 2007
- "Power System Stability Benefits with VSC DC-Transmission Systems", CIGRÉ B4-204, 2004

4.5.13.2.2 Topologie d'un CSC (Current Source Converter – convertisseur de source de courant)

Une liaison CCHT d'une source de courant est modélisée comme représenté à la Figure 37.



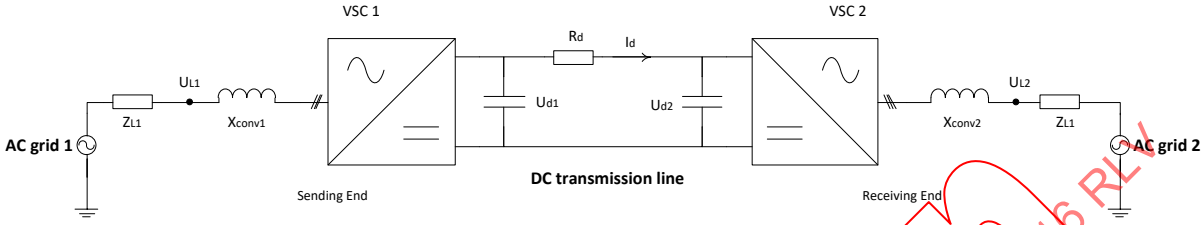
Anglais	Français
HVDC system pole	Pôle de système CCHT
AC System	Système en courant alternatif
Earth electrodes	Électrodes mises à la terre
Substation pole	Pôle du poste

Figure 37 – Liaison CCHT bipolaire issue de l'IEC 60633

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Une liaison CCHT bipolaire est constituée de deux pôles, l'un avec une polarité positive et l'autre avec une polarité négative, les deux ayant leurs points naturels mis à la terre. Aucun flux de courant à la terre ne revient car la circulation de courant dans les pôles est la même.

4.5.13.2.3 Topologie d'un VSC (voltage source converter – convertisseur de source de tension)



Anglais	Français
AC grid 1	Réseau en courant alternatif 1
Sending end	Extrémité émettrice
DC transmission line	Ligne de transport de courant continu
Receiving end	Extrémité de réception
AC grid 2	Réseau en courant alternatif 2

Figure 38 – Schéma de transport point à point par un VSC

Le schéma de transport point à point par un VSC représenté à la Figure 38 est constitué de deux VSC interconnectés du côté courant continu par le biais d'une ligne de transport de courant continu et connectés aux deux différents systèmes en courant alternatif du côté courant alternatif. L'une des caractéristiques du VSC est que la polarité de la tension continue est toujours la même. Par conséquent, le sens du flux de puissance sur la ligne de courant continu est déterminé par le sens du courant continu.

Le sens du courant continu va toujours du niveau de tension continue le plus élevé au niveau de tension continue le plus faible. La tension continue à l'extrémité émettrice de la ligne de courant continu doit, par conséquent, être plus élevée que la tension continue à l'extrémité de réception.

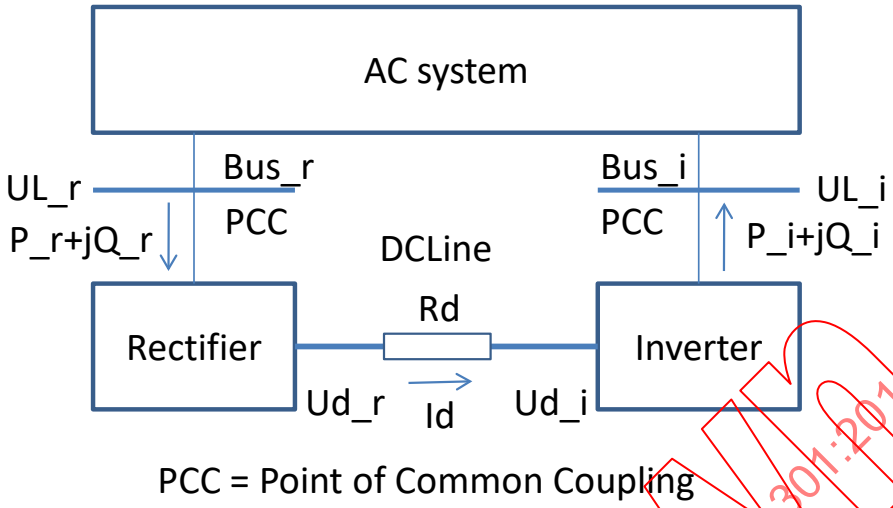
Dans un convertisseur commuté en ligne CCHT, le flux de puissance en courant continu peut être commandé en maintenant la tension continue au niveau du convertisseur à l'extrémité de réception (l'onduleur) à une valeur constante, et en laissant le convertisseur à l'extrémité émettrice (le redresseur) commander le courant continu. La même approche peut être utilisée pour le transport par VSC. Cependant, une des principales différences est que dans un convertisseur commuté en ligne CCHT, le sens du courant est toujours le même. Par conséquent, le sens de la puissance est modifié lors de la modification de la polarité de la tension continue.

4.5.13.3 Modélisation de flux de puissance CCHT

4.5.13.3.1 Généralités

Un modèle de flux de puissance dérivé de la Figure 38 est représenté à la Figure 39.

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Anglais	Français
AC system	Système en courant alternatif
Rectifier	Redresseur
Inverter	Onduleur
PCC = Point of Common Coupling	PCC = point de couplage commun

Figure 39 – Modèle de flux de puissance CCHT

Les variables côté courant alternatif sont les suivantes:

- P est l'injection de puissance active côté courant alternatif au niveau du redresseur (indice r) et de l'onduleur (indice i).
- Q est l'injection de puissance réactive côté courant alternatif au niveau du redresseur (indice r) et de l'onduleur (indice i).
- U_L est l'injection de tension côté courant alternatif au niveau du redresseur (indice r) et de l'onduleur (indice i).

Les variables côté courant continu sont les suivantes:

- U_d est l'injection de tension côté courant continu au niveau du redresseur (indice r) et de l'onduleur (indice i).
- U_{dN} est la tension continue assignée.
- I_d est le courant de la ligne de courant continu.
- I_{dN} est le courant assigné de la ligne de courant continu.
- R_d est la résistance de la ligne de courant continu.

L'interface entre le système CCHT et le système en courant alternatif est établie par les deux bus Bus_r et Bus_i. La tension aux bornes de Bus_r est U_{L_r} et la tension aux bornes de Bus_i est U_{L_i}. La puissance injectée dans le redresseur depuis le système en courant alternatif est $P_r + jQ_r$ et la puissance injectée dans l'onduleur est $P_i + jQ_i$. Les bus Bus_r et Bus_i proviennent du système en courant alternatif et sont perçus comme des nœuds PQ pour une source de courant CCHT et comme nœuds PV pour une source de tension CCHT. Pour les nœuds PQ, les injections $P_r + jQ_r$ et $P_i + jQ_i$ et pour les nœuds PV, l'injection de

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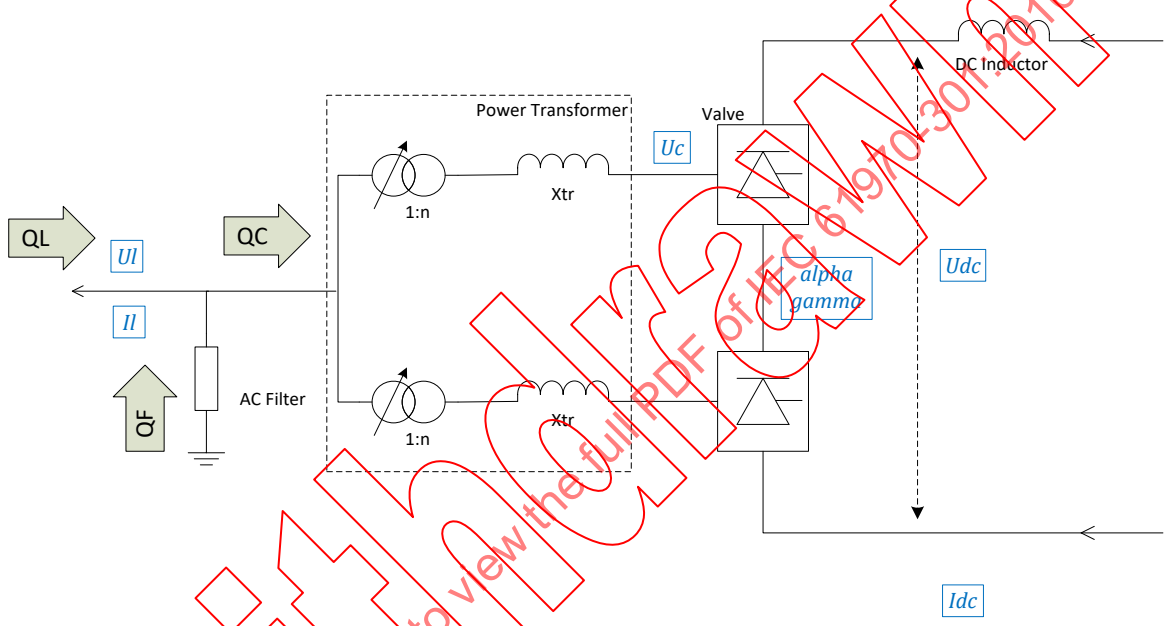
puissance active et la tension P_r, UL_r et P_i, UL_i sont calculées à partir de la liaison CCHT. Les conditions initiales de la liaison CCHT sont fournies de deux manières:

- P_r ou P_i
- U_{d_r} ou U_{d_i}

La relation entre les variables est donnée par $I_d = P_r / U_{d_r} = P_i / U_{d_i}$.

Le flux de puissance est représenté à la Figure 40 et à la Figure 41.

4.5.13.3.2 Convertisseur de source de courant



Anglais	Français
DC inductor	Inductance de courant continu
Power transformer	Transformateur de puissance
Valve	Valve
AC filter	Filtre de courant alternatif

Figure 40 – Flux de puissance d'un convertisseur de source de courant

Dans un convertisseur de source de courant, la puissance réactive n'est pas commandée. Au lieu de cela, elle est déterminée par l'angle d'amorçage de pont qui affecte le facteur de puissance:

- α est l'angle d'amorçage, valeur type comprise entre 10° et 18°
- $U_d = U_{d0} \times \cos\alpha - \left(\frac{3}{\pi}\right)\left(\frac{X_{tr}}{2}\right) I_d$
- tension continue assignée: $U_{d0} = \left(\left(3 \times \sqrt{2}\right)/\pi\right) \times U_C$
- $U_t = U_L \times tapratio$

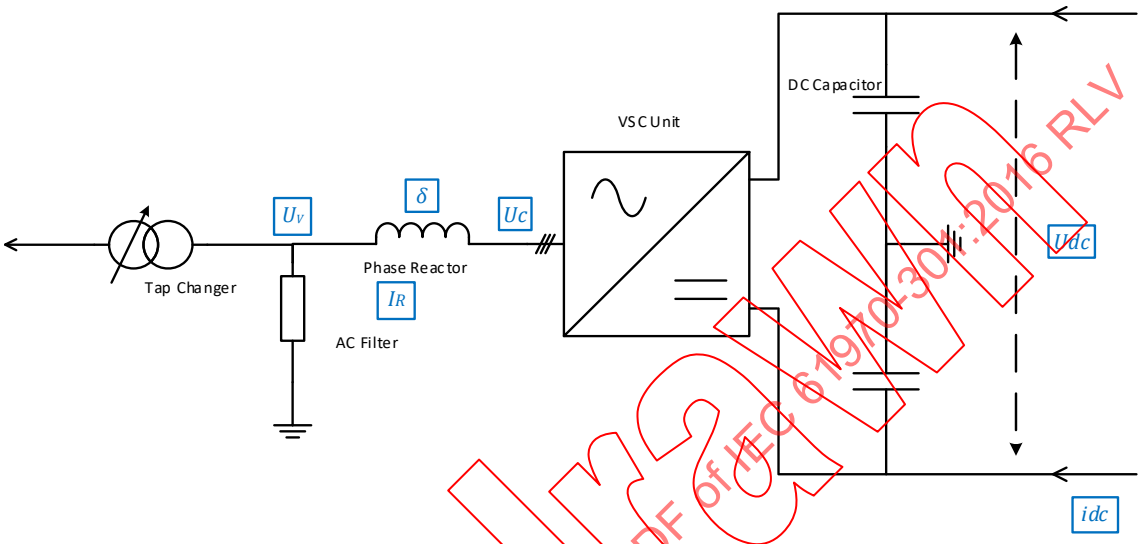
L'approximation de l'injection de puissance réactive peut être présentée de la manière suivante:

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- $Q_L = Q_C - Q_F = \left(\frac{P}{2}\right) - Q_F \approx \frac{P}{2}$

4.5.13.3.3 Convertisseur de source de tension

Les composants électriques et leurs interconnexions au sein d'un convertisseur sont représentés à la Figure 41. La Figure 41 sert de référence pour les formules en 4.5.13.3.3.



Anglais	Français
Tap Changer	Changeur de prises
Phase Reactor	Composant réactif de phase
VSC Unit	Unité de VSC
DC Capacitor	Condensateur de courant continu
AC Filter	Filtre de courant alternatif

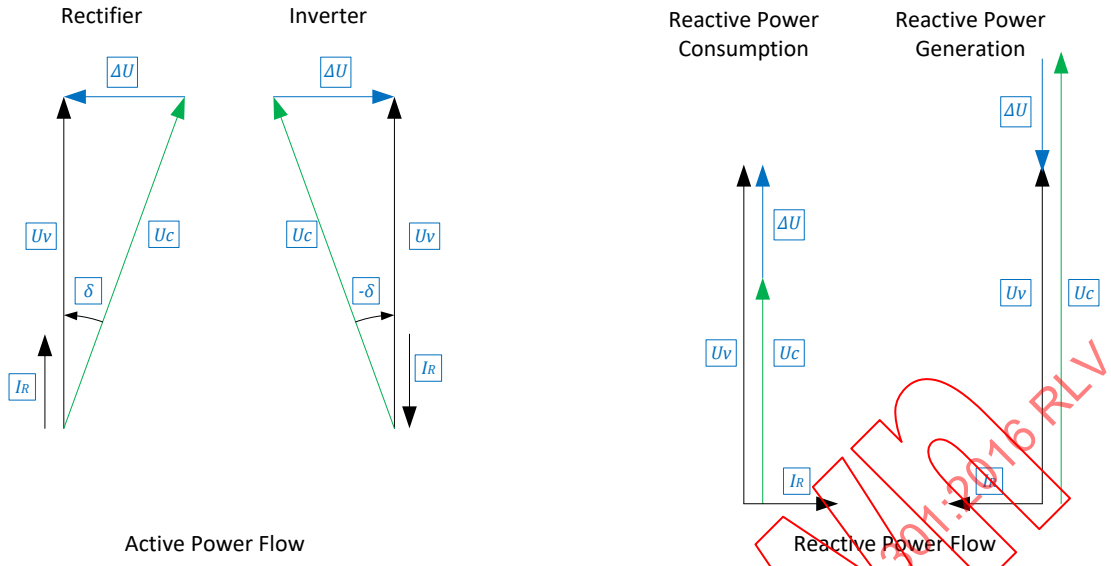
Figure 41 – Flux de puissance d'un convertisseur de source de tension

Les paramètres supplémentaires qui viennent s'ajouter à ceux énumérés précédemment sont les suivants:

- U_{dc} est la tension côté courant continu du VSC.
- I_{dc} est le courant côté courant continu du VSC.
- U_C est la tension côté courant alternatif du VSC, également appelée tension du convertisseur.
- U_V est la tension aux bornes du bus du filtre.
- l'indice de modulation est le rapport entre U_{dc} et U_C. Il s'agit d'un paramètre du VSC dont les valeurs types sont comprises entre 0 et 1.
- I_R est le courant qui circule dans le composant réactif de phase.
- X_C est la réactance du composant réactif de phase.
- δ est l'angle entre les tensions U_V et U_C.

Les diagrammes de la Figure 42 représentent les vecteurs de tension et les cas de flux de puissance subséquents.

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Anglais	Français
Rectifier	Redresseur
Inverter	Onduleur
Reactive Power Consumption	Consommation de puissance réactive
Reative Power Generation	Production de puissance réactive
Active Power Flow	Flux de puissance active
Reactive Power Flow	Flux de puissance réactive

Figure 42 – Cas de flux de puissance

Le comportement du redresseur et de l'onduleur peut être décrit par un ensemble de formules comportant les paramètres suivants dont certains sont représentés à la Figure 39 et à la Figure 41.

- U_{rated} est la tension alternative assignée du convertisseur (une pour le redresseur et une pour l'onduleur).
- S_{rated} est la puissance alternative assignée du convertisseur.
- R_C est la résistance du composant réactif de phase.
- nombre de ponts du convertisseur (pour le redresseur et pour l'onduleur).
- I_{dmax} et I_{dmin} sont les limites supérieure et inférieure du flux de courant continu.
- R_d est la résistance de la ligne de courant continu.
- Les composants actifs et réactifs (voir Figure 42) sont calculés de la manière suivante: $P = U_V \times U_C \times (\sin(\delta)/X_C)$.
- $Q = U_V \times (U_V - U_C) \times (\cos(\delta)/X_C)$.

Les pertes au niveau d'un pôle sont décrites par l'équation:

- $P(poleLoss) = idleLossFactor + switchLossFactor \times I_{dc} + resistiveLossFactor \times I_{dc} + resistiveLossFactor \times I_{dc}^2$

où

- $P_{dc} = P_{ac}$ pour un fonctionnement sans perte;

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- $P_{dc} = P_{ac} - P_{loss}$ pour un fonctionnement du redresseur avec des pertes;
- $P_{dc} = P_{ac} + P_{loss}$ pour un fonctionnement de l'onduleur avec des pertes.

La Figure 43 représente un diagramme de convertisseur de source de tension à monopole symétrique.

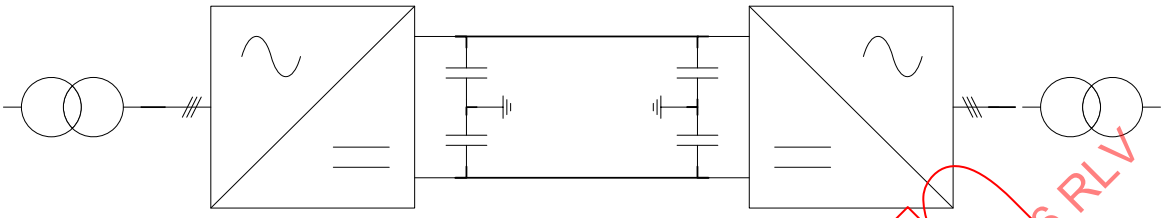
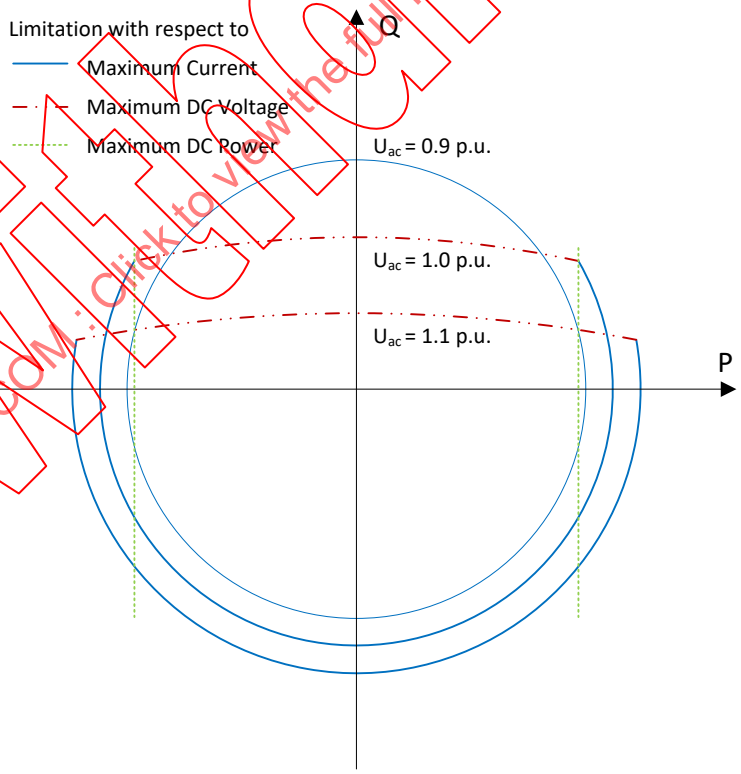


Figure 43 – Transport par VSC à monopole symétrique représenté avec mise à la terre capacitive côté courant continu (IEC 62747)

En commandant l'angle δ entre les tensions U_V / U_C et l'écart de tension $U_V - U_C$, la commande des puissances active et réactive est possible.

Les limites des résultats donnés par le VSC donnent lieu à une courbe *P*-*Q*. Un exemple de courbe *P*-*Q* est représenté à la Figure 44.



Anglais	Français
Limitation with respect to	Limite relative
Maximum Current	À l'intensité maximale
Maximum DC Voltage	À la tension continue maximale
Maximum DC Power	À la puissance continue maximale

Figure 44 – Courbe de capacité *P*-*Q* du VSC

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Il est également possible d'utiliser le VSC dans les configurations bipolaires, comme représenté à la Figure 45.

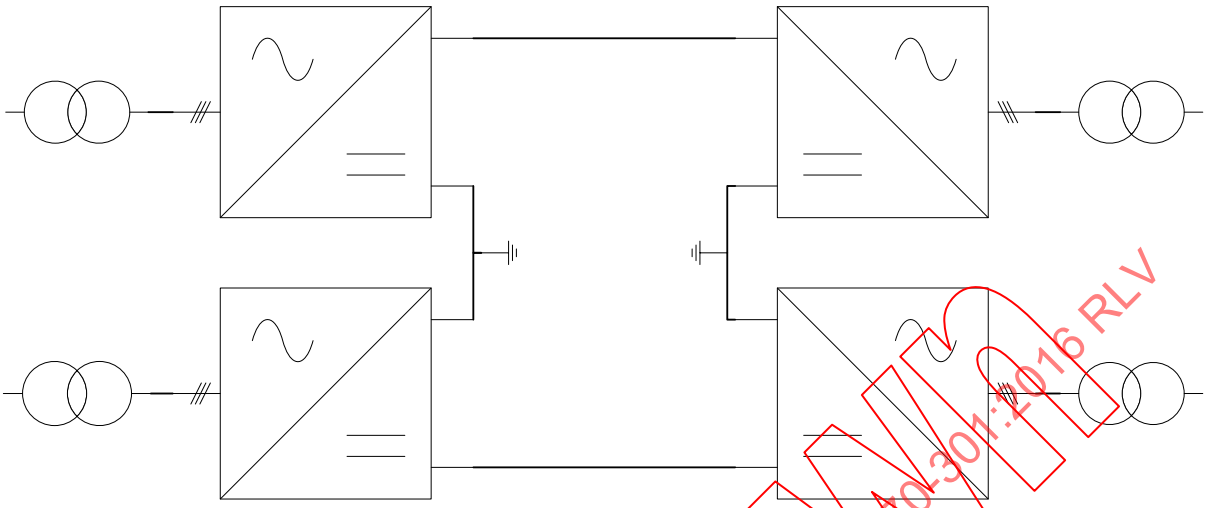


Figure 45 – Transport par VSC bipolaire avec retour par la terre (IEC 62747)

Dans cette configuration, deux câbles CCHT sont utilisés pour les tensions positives (+DC) et négatives (−DC). Une tension médiane est utilisée pour le neutre.

4.5.13.4 Modèle de données

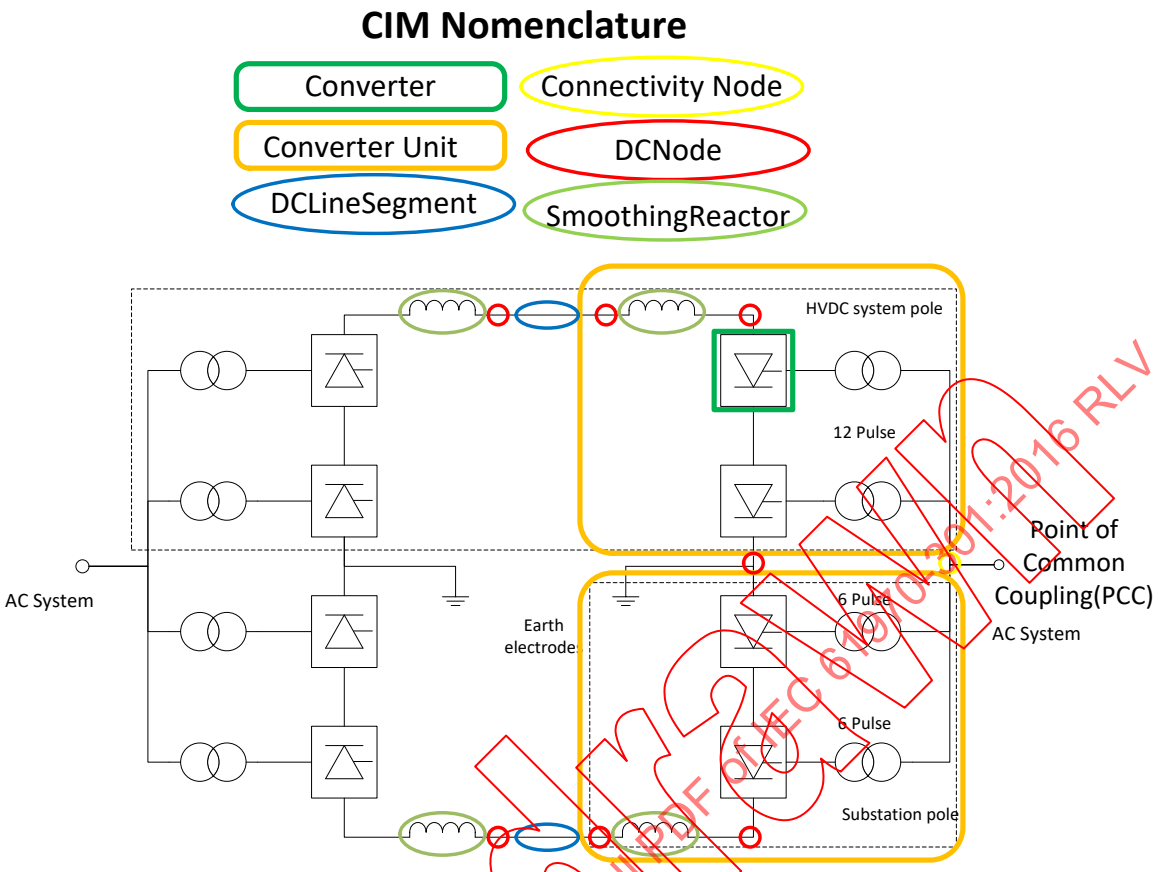
4.5.13.4.1 Généralités

Un modèle de données est créé sur la base des hypothèses suivantes.

- La DCConverterUnit du CIM est identique à celle du pôle de poste de l'IEC 60633 qui est un conteneur.
- L'ancien RectifierInverter du CIM est identique au Converter (convertisseur).
- Le pôle de système de l'IEC 60633 n'est pas modélisé dans le CIM. Ceci s'explique par le fait que le pôle de système de l'IEC°60633 n'est pas pertinent pour les réseaux en courant continu. Les ponts, les filtres et les montages en pont ne sont pas explicitement modélisés dans le CIM et sont considérés comme faisant partie du Converter.
- L'utilisation de ConnectivityNode et Terminal également pour la connectivité dans les réseaux en courant continu établit une connexion ensemble des composants en courant continu et en courant alternatif c'est-à-dire une erreur. Les attributs ont également différentes significations dans les réseaux en courant alternatif et en courant continu. Par exemple, DCNode n'a pas d'angle de phase ou d'injection de puissance réactive. Par conséquent, les artéfacts sont utilisés pour décrire les réseaux en courant alternatif et en courant continu.

La Figure 46 donne un exemple d'objets modélisés d'une ligne CCHT de source bipolaire de courant.

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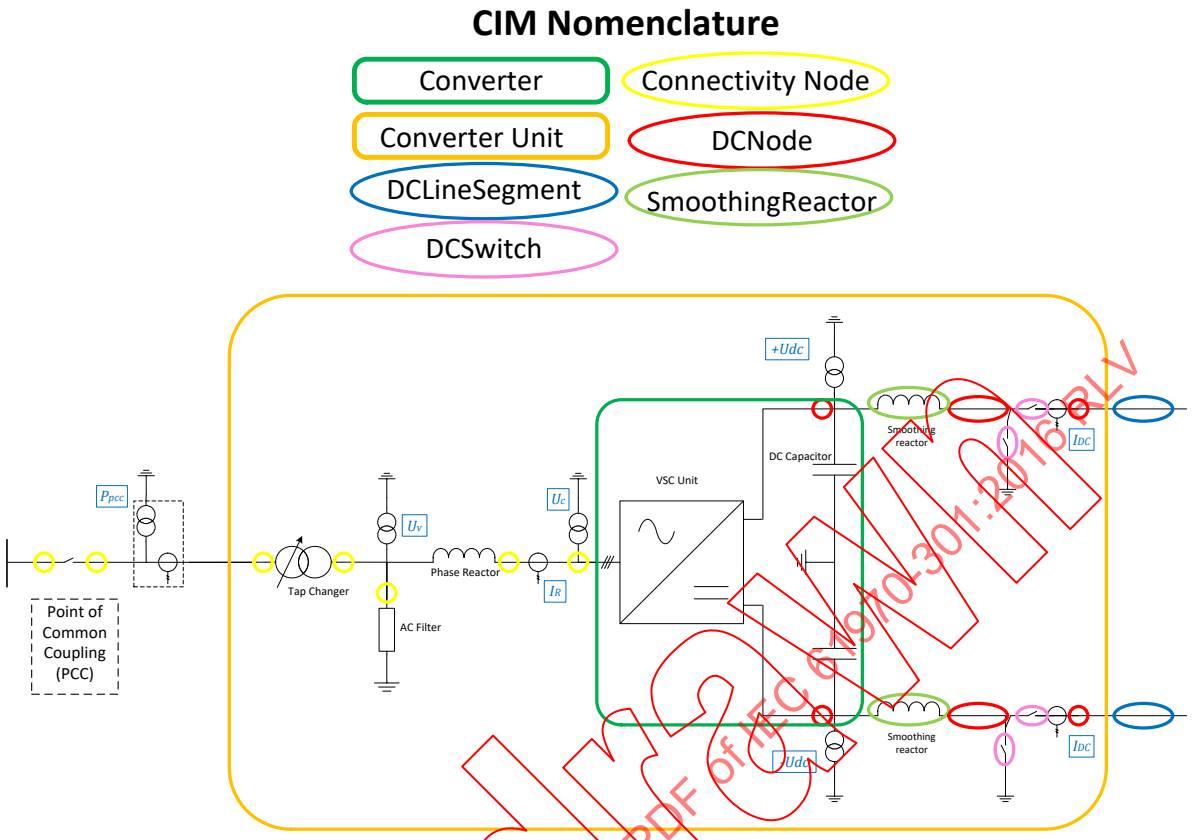
Anglais	Français
CIM Nomenclature	Nomenclature du CIM
Converter	Convertisseur
Connectivity Node	Nœud de connectivité
Converter Unit	Unité de convertisseur
DCNode	DCNode
DCLineSegment	DCLineSegment
SmoothingReactor	SmoothingReactor
HVDC System pole	Pôle du système CCHT
12 Pulse	12 impulsions
AC system	Système en courant alternatif
Earth electrode	Électrode de mise à la terre
Point of Common Coupling (PCC)	Point de couplage commun (PCC)
Substation pole	Pôle du poste

Figure 46 – Instances d'objets d'une ligne CCHT de source bipolaire de courant

La Converter Unit (unité de convertisseur) est l'objet qui établit un pont entre les réseaux en courant alternatif et ceux en courant continu.

Le diagramme correspondant pour les VSC est représenté à la Figure 47.

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Anglais	Français
CIM Nomenclature	Nomenclature du CIM
Converter	Convertisseur
Connectivity Node	Nœud de connectivité
Converter Unit	Unité de convertisseur
DCNode	DCNode
DCLineSegment	DCLineSegment
SmoothingReactor	SmoothingReactor
DCSwitch	DCSwitch
Point of Common Coupling (PCC)	Point de couplage commun (PCC)
Tap changer	Changeur de prises
AC Filter	Filtre de courant alternatif
Phase Reactor	Composant réactif de phase
VSC Unit	Unité de VSC
DC Capacitor	Condensateur de courant continu
Smoothing reactor	Inductance de lissage

Figure 47 – Instances d'objets d'un modèle de données CCHT d'un VSC à monopole symétrique

Comme indiqué dans la Figure 46 et la Figure 47, un poste CCHT est constitué

- d'un ou de plusieurs convertisseurs;
- de SmoothingReactors (inductances de lissage);
- de commutateurs de courant continu pour la reconfiguration des lignes de courant continu;

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- d'un point de couplage commun qui établit l'interface avec le système en courant alternatif.

Un Converter est constitué d'un ou de plusieurs ensembles des éléments suivants:

- des ponts;
- un PowerTransformer;
- un filtre de courant alternatif;
- un convertisseur ou un composant réactif de phase pour VSC, dans les systèmes CCHT à plusieurs niveaux, plusieurs Bridges (ponts) existent dans les bras de convertisseur. L'inductance de Converter fait alors partie des bras plutôt que d'être une inductance unique comme représentée à la Figure 47;
- des disjoncteurs et des sectionneurs.

La HVDC Link (liaison CCHT) peut être établie de plusieurs manières:

- bipolaire – voir la Figure 45;
- monopole symétrique avec mise à la terre capacitive côté courant continu – voir la Figure 43;
- monopole asymétrique avec retour par la terre – cette capacité de puissance active inférieure et le fonctionnement prolongé ne sont pas admis;
- monopole asymétrique avec retour métallique – cette capacité de puissance active inférieure et le fonctionnement prolongé sont admis.

Un Converter comprenant plusieurs Bridges peut avoir la capacité de reconfigurer la manière dont les Bridges sont connectés. Une reconfiguration donne normalement lieu à une réduction des limites assignées.

Un poste CCHT envoie l'état opérationnel sous forme des signaux SCADA à un SCADA supérieur. Dans le mode de fonctionnement bipolaire, la réduction des limites assignées du Converter sont généralement envoyés au SCADA de niveau supérieur.

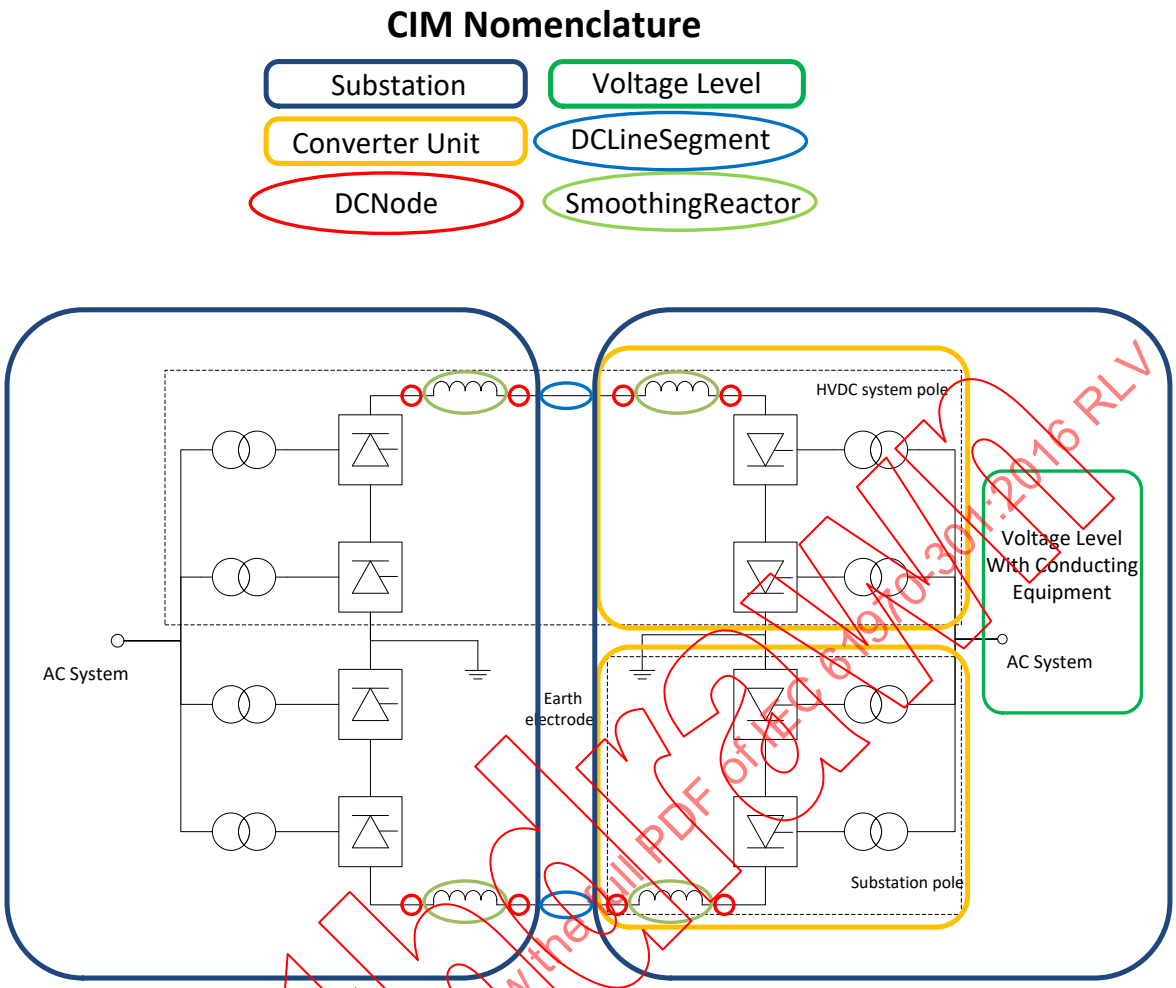
Les structures d'emboîtement pour deux cas distincts sont représentées à la Figure 48 et à la Figure 49.

Pour les transformateurs, noter que,

- ils ne sont pas situés dans un Substation (poste) mais dans une DCConverterUnit;
- aucun VoltageLevel n'existe des côtés haute tension et basse tension d'un transformateur.

Par conséquent, les règles d'emboîtement pour les transformateurs du réseau en courant alternatif sont remplacées par des règles spécifiques au DCConverterUnit.

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Anglais	Français
CIM Nomenclature	Nomenclature du CIM
Substation	Poste
Converter Unit	Unité de convertisseur
DCLineSegment	DCLineSegment
DCNode	DCNode
SmoothingReactor	SmoothingReactor
HVDC system pole	Pôle du système CCHT
AC system	Système en courant alternatif
Earth electrode	Électrode de mise à la terre
Voltage Level with Conducting Equipment	Niveau de tension avec équipement conducteur
Substation pole	Pôle du poste

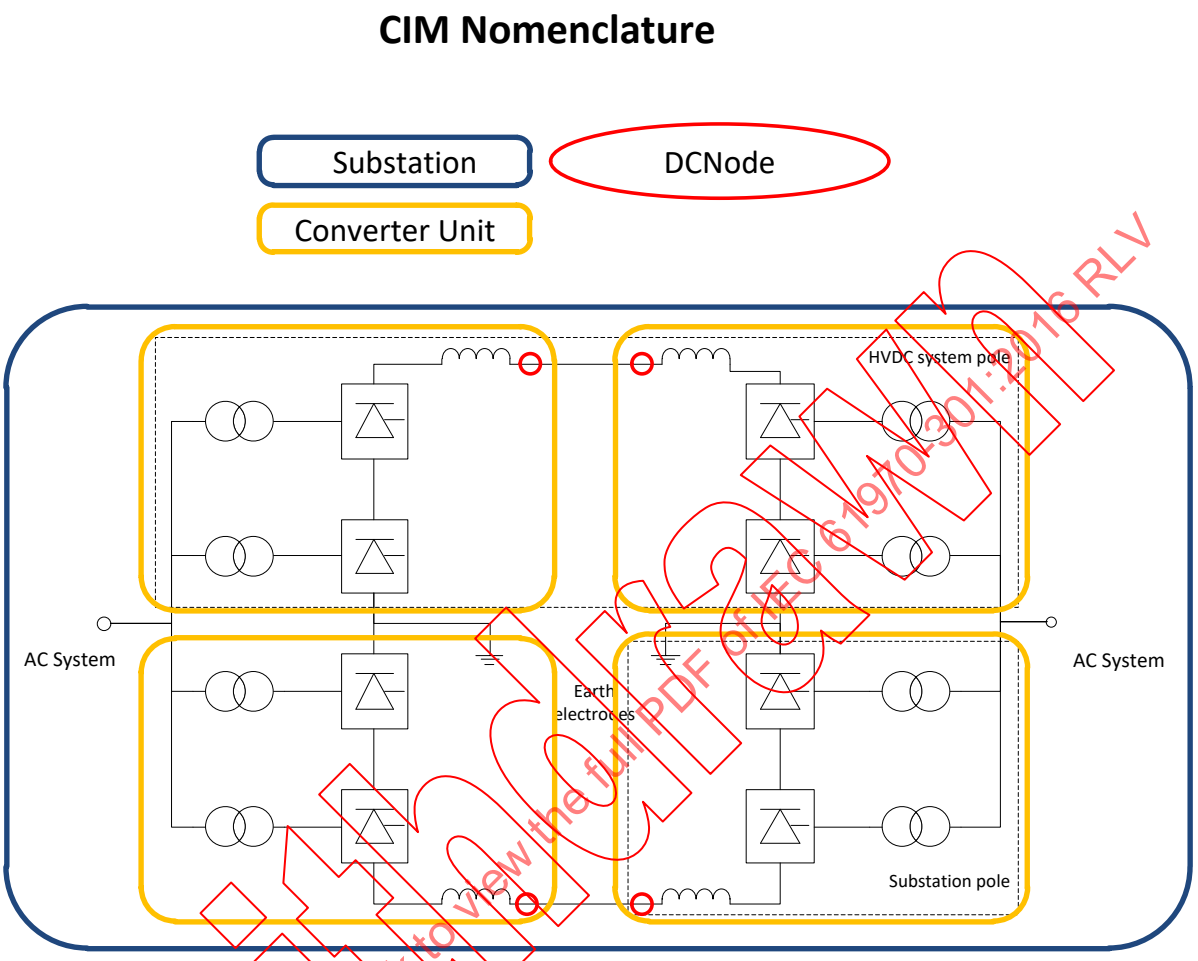
Figure 48 – Structure d'emboîtement d'une ligne CCHT bipolaire

Les deux DCLineSegments font partie d'une Line. Ceci s'explique par le fait que les DCLineSegments sont généralement au même pylône ou dans le même caniveau.

Les deux postes sont des Substations normaux qui mélangent des équipements en courant continu et en courant alternatif. La DCConverterUnit et les Converters sont au niveau Substation et sont connectés à l'équipement en courant alternatif d'un VoltageLevel.

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Étant donné que les Converters peuvent fonctionner à différentes tensions, avoir une BaseVoltage n'aurait pas de sens. Par conséquent, l'indicateur BaseVoltage.isDC doit être retiré.



Anglais	Français
CIM Nomenclature	Nomenclature du CIM
Substation	Poste
Converter Unit	Unité de convertisseur
DCNode	DCNode
HVDC system pole	Pôle du système CCHT
AC system	Système en courant alternatif
Earth electrodes	Électrodes de mise à la terre
Substation pole	Pôle du poste

Figure 49 – Structure d'emboîtement d'un poste CCHT bipolaire dos à dos

4.5.13.4.2 Réseaux en courant continu

Les réseaux en courant continu utilisent des commutateurs pour reconfigurer les DCLines du réseau. Pour ce faire, il est important d'inclure les commutateurs dans le modèle et de les placer aux emplacements appropriés du réseau. La Figure 47 représente une DCLine connectée à un Converter avec une disposition simple de commutateurs. Étant donné que l'inductance de lissage appartient au Substation plutôt qu'à la DCLine, elle ne peut pas être comprise comme l'inductance de la DCLine. Pour les DCGrids, les connexions DCLine entrantes établies avec le Converter ont plus de commutateurs et il est nécessaire que le modèle d'informations prenne ceci en charge. Le traitement de la topologie du réseau en

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courant continu est exigé de la même manière que le traitement de la topologie du réseau en courant alternatif déjà effectué.

4.5.13.5 Modèle de données

4.5.13.5.1 Topologie

La connectivité de base d'un système en courant alternatif est représentée à la Figure 50.

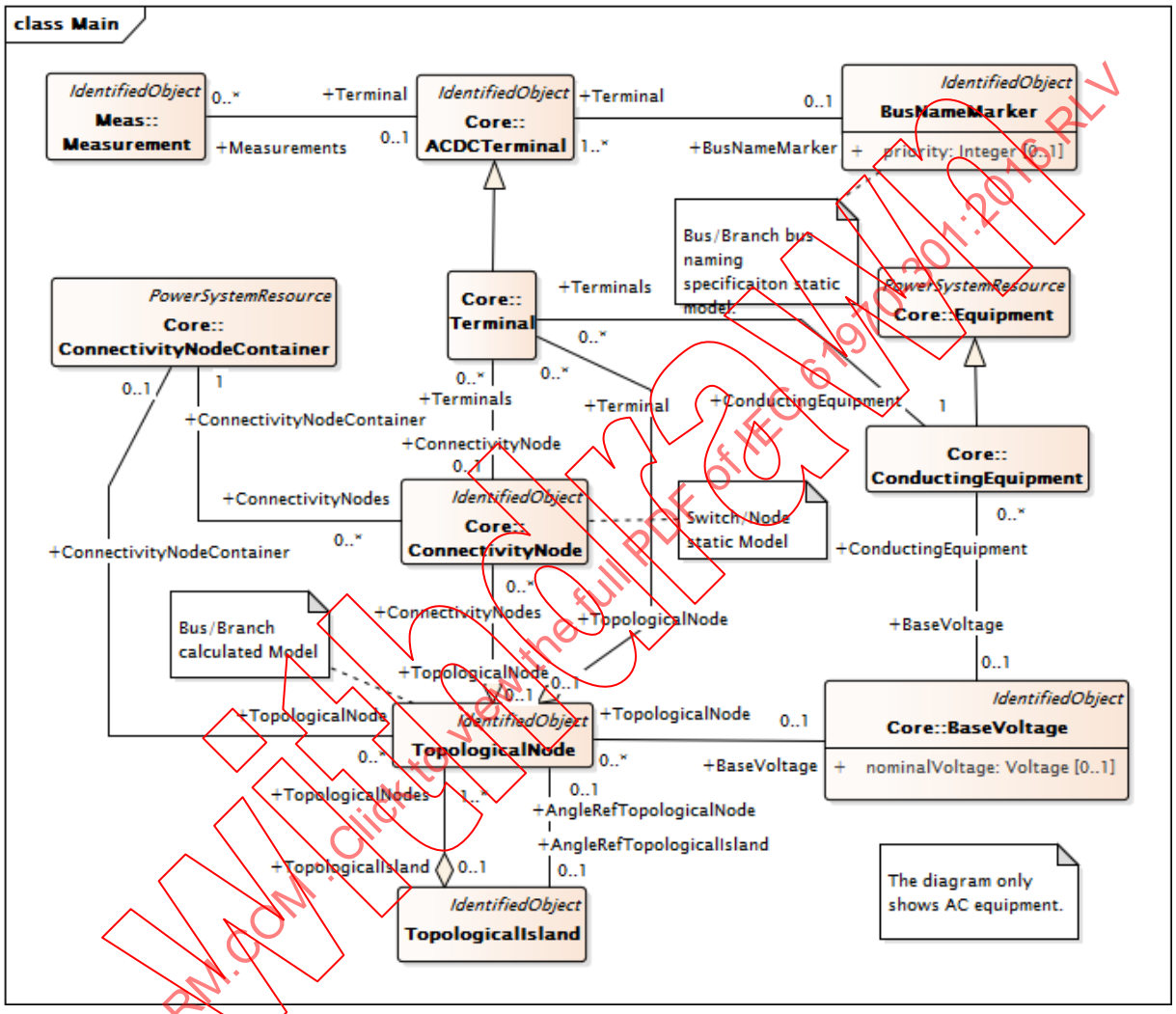


Figure 50 – Topologie de base (Basic) dans le paquetage Core

Comme représenté à la Figure 50, la Terminal est utilisée uniquement pour ConductingEquipment en courant alternatif. Une nouvelle classe ACDCTerminal a été ajoutée pour conserver les caractéristiques communes en courant alternatif et en courant continu.

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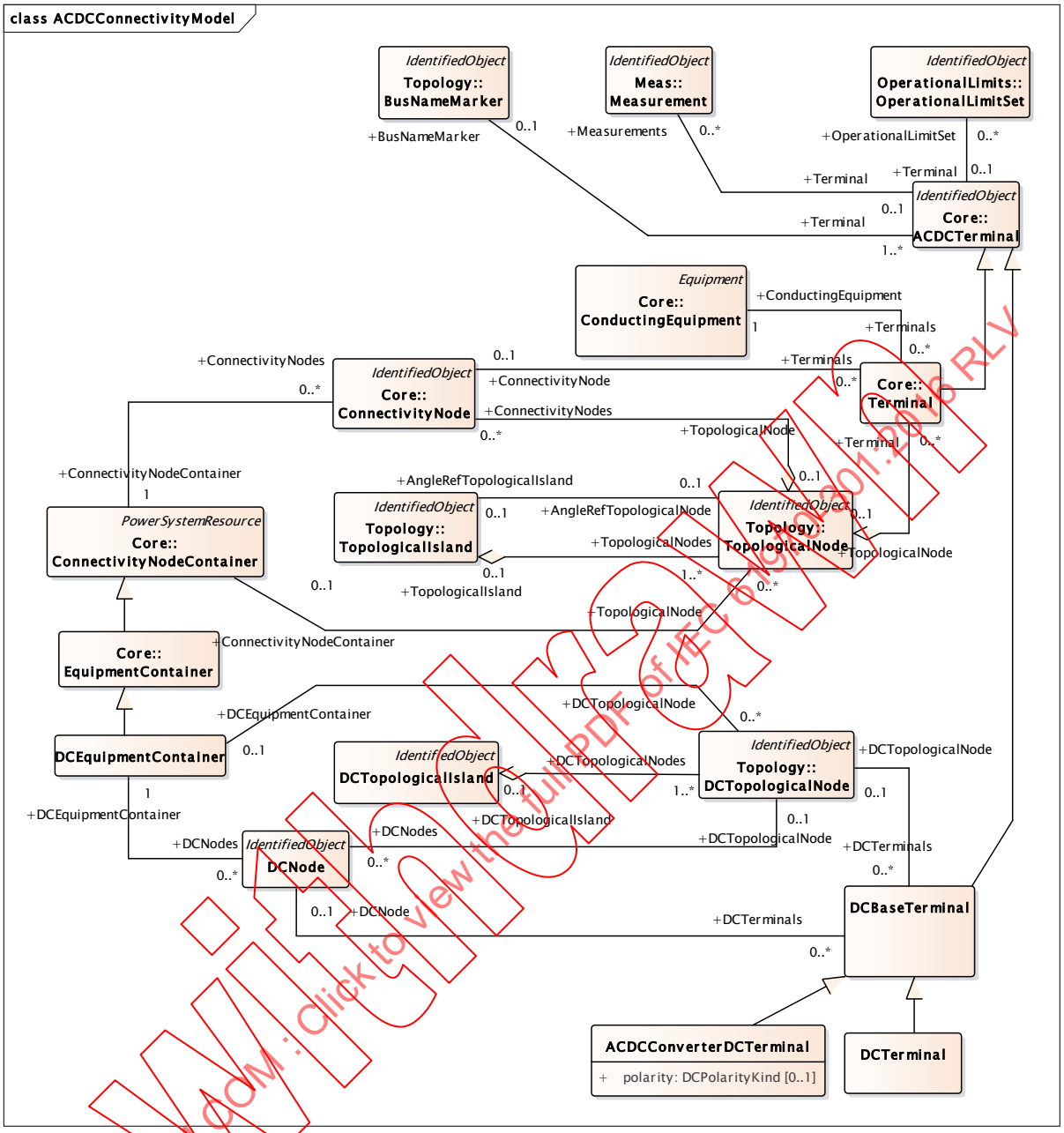


Figure 51 – Topologie en courant continu et en courant alternatif

Comme représenté à la Figure 51, le modèle ConductingEquipment-Terminal-ConnectivityNode provenant du réseau en courant alternatif est répété pour le réseau en courant continu avec les classes DCConductingEquipment-DCTerminal-DCNode.

L'association de Measurement à Terminal est déplacée et passe de Terminal à ACDCTerminal. Par conséquent, les DCTerminals peuvent également avoir des Measurements. Le rôle “Measurement.Terminal” conserve son ancien nom à des fins de rétrocompatibilité.

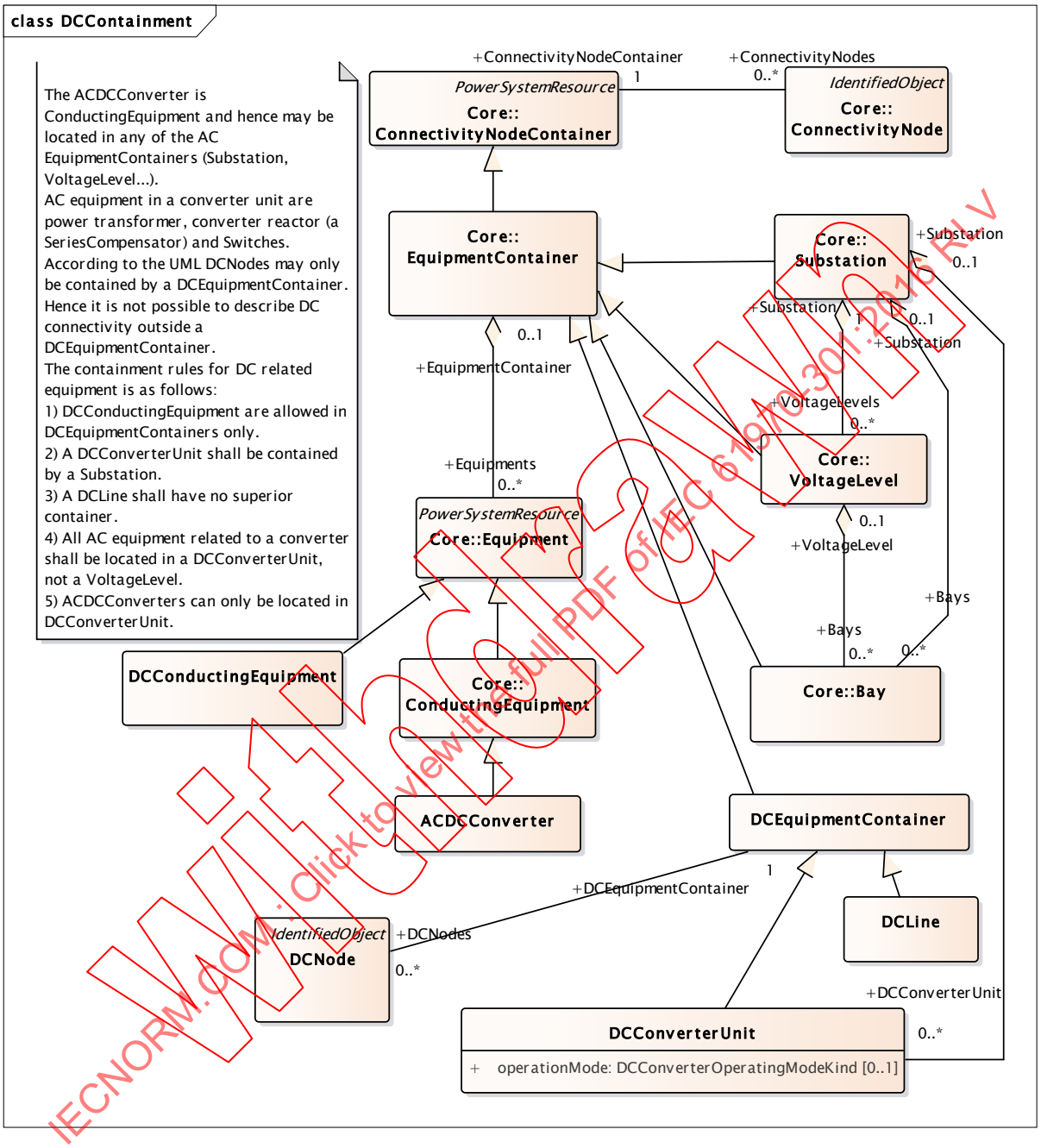
Si plus de caractéristiques sont communes entre DCTerminal et Terminal, celles-ci sont déplacées vers ACDCTerminal.

DCNode et ConnectivityNode n'ont pas de classe de base ACDCNode commune car cela ne semble pas nécessaire.

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4.5.13.5.2 Emboîtement

La structure d'emboîtement pour le modèle à courant continu est représentée à la Figure 52.



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Anglais	Français
The ACDCConverter is ConductingEquipment and hence may be located in any of the AC EquipmentContainers (Substation, VoltageLevel …). AC equipment in a converter unit are power transformer, converter reactor (a SeriesCompensator) and Switches. According to the UML DCNodes may only be contained by a DCEquipmentContainer. Hence it is not possible to describe DC connectivity outside a DCEquipmentContainer. The containment rules for DC related equipment are as follows: 1) DCConductingEquipment are allowed in DCEquipmentContainers only. 2) A DCConverterUnit shall be contained by a Substation. 3) A DCLine shall have no superior container. 4) All AC equipment related to a converter shall be located in a DCConverterUnit, not a VoltageLevel 5) ACDCConverters can only be located in DCConverterUnit.	L'ACDCConverter est ConductingEquipment. Par conséquent, il peut être situé dans n'importe quel EquipmentContainer à courant alternatif (Substation, VoltageLevel…). Les équipements à courant alternatif dans une unité de convertisseur sont des transformateurs de puissance, des inductances de convertisseurs (un SeriesCompensator) et des Switches. Selon le langage UML, les DCNodes peuvent uniquement être contenus par un DCEquipmentContainer. Par conséquent, il n'est pas possible de décrire la connectivité de courant continu en dehors d'un DCEquipmentContainer. Les règles d'emboîtement pour les équipements liés au courant continu sont les suivantes: 1) Les DCConductingEquipments sont uniquement autorisés dans les DCEquipmentContainers. 2) Une DCConverterUnit doit être contenue dans un Substation. 3) Une DCLine ne doit pas avoir un conteneur supérieur. 4) Tous les équipements de courant alternatif liés à un convertisseur doivent être situés dans une DCConverterUnit, non pas dans un VoltageLevel. 5) Les ACDCConverters peuvent uniquement être situés dans DCConverterUnit.

Figure 52 – Emboîtement CCHT

Comme représenté à la Figure 52, DCConductingEquipment a les mêmes caractéristiques que Equipment. Il ne peut donc pas être placé dans un Substation, Voltagelevel ou dans une Bay. Cependant, la topologie à courant continu exige des DCNodes qui n'existent que dans un DCEquipmentContainer. Par conséquent, DCConductingEquipment réside dans des DCConverterUnits ou des DCLines qui sont des sous-classes de DCEquipmentContainer.

Les DCConverterUnits font partie d'un Substation tandis que les DCLines n'en font pas partie. Par conséquent, les DCLines peuvent se déployer entre les Substations.

Les DCConverterUnits peuvent être mélangées avec l'équipement à courant alternatif dans un Substation. Par conséquent, l'équipement à courant alternatif et l'équipement à courant continu peuvent coexister dans les Substations.

La configuration dos à dos de la Figure 49 est résolue en plaçant le DCLineSegment dans le Substation au lieu de le placer dans une DCLine.

Le modèle d'emboîtement du CIM est ouvert et contient des classes conteneurs qui doivent comprendre ce qu'il est nécessaire de spécifier par écrit pour l'équipement comme suit.

- Les DCLineSegments sont admis dans les Substations (configuration dos à dos) et les DCLines.
- Tous les autres équipements à courant continu vont dans la DCConverterUnit.
- Les équipements à courant alternatif spécifiques à un convertisseur vont dans la DCConverterUnit.

4.5.13.5.3 Equipment

Le modèle d'Equipment à courant continu est représenté à la Figure 53.

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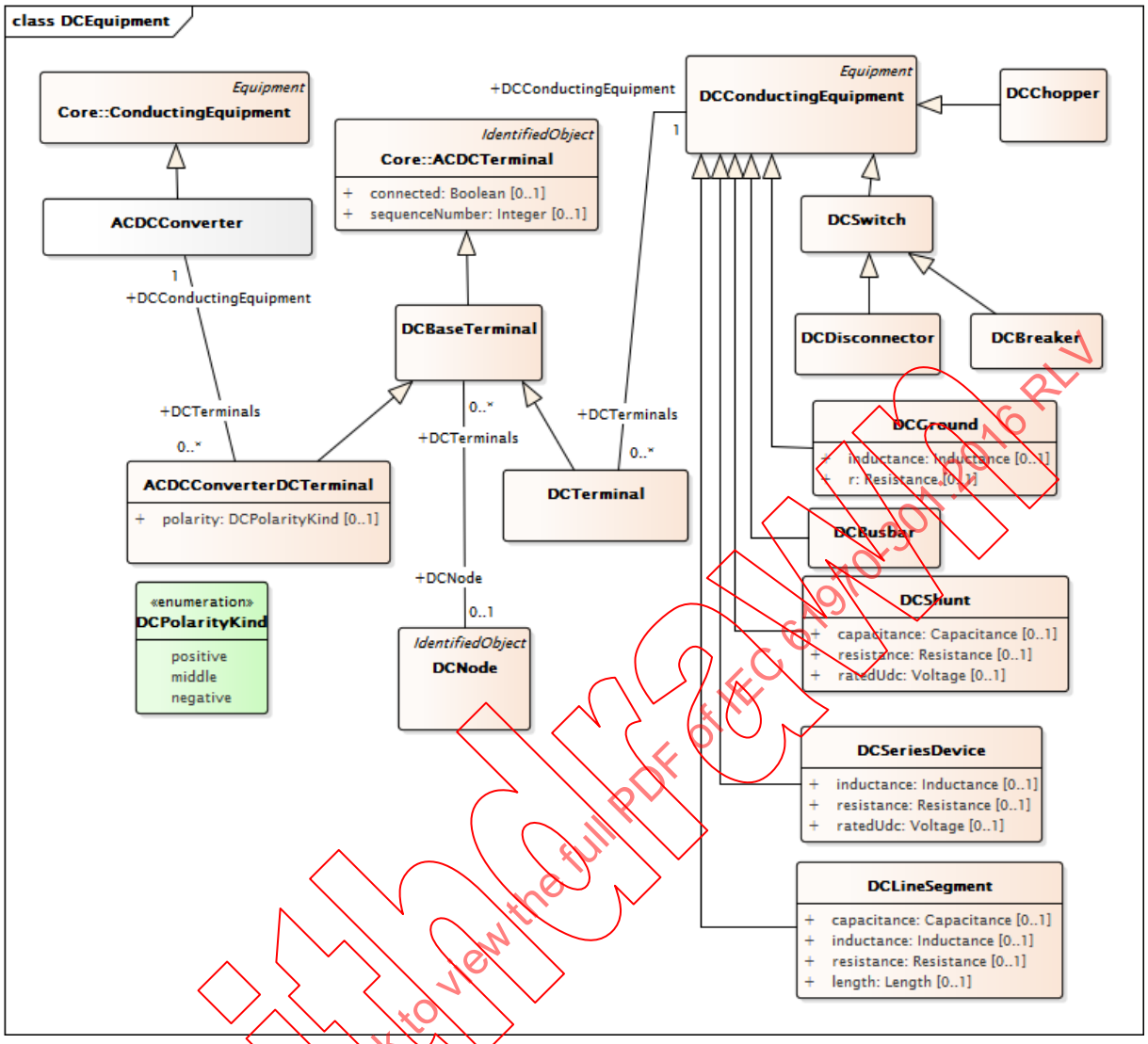


Figure 53 – Modèle d'Equipment

Afin que l'ACDCTerminal comprenne à la fois ACDCConverter et DCConductingEquipment, deux types de bornes à courant continu ont été mis en œuvre, comme représenté à la Figure 53: ACDCConverterDCTerminal et DCTerminal. ACDCConverterDCTerminal est associée à ACDCConverter. La DCTerminal est associée à DCConductingEquipment. Afin d'associer DCNode avec DCTerminal et ACDCConverterDCTerminal, DCBaseTerminal, héritée de ACDCTerminal, est ajoutée.

Étant donné que, dans de nombreux cas, DCConductingEquipment a des paramètres différents en comparaison avec l'équipement à courant alternatif correspondant, des classes spécifiques de courant continu sont nécessaires dans tous les cas, par exemple le DCBreaker et le DCBusbar.

Les SvPowerFlows aux bornes des PCCTerminals maintiennent les injections de courant alternatif dans le convertisseur.

Le modèle de ligne à courant continu est représenté à la Figure 54.

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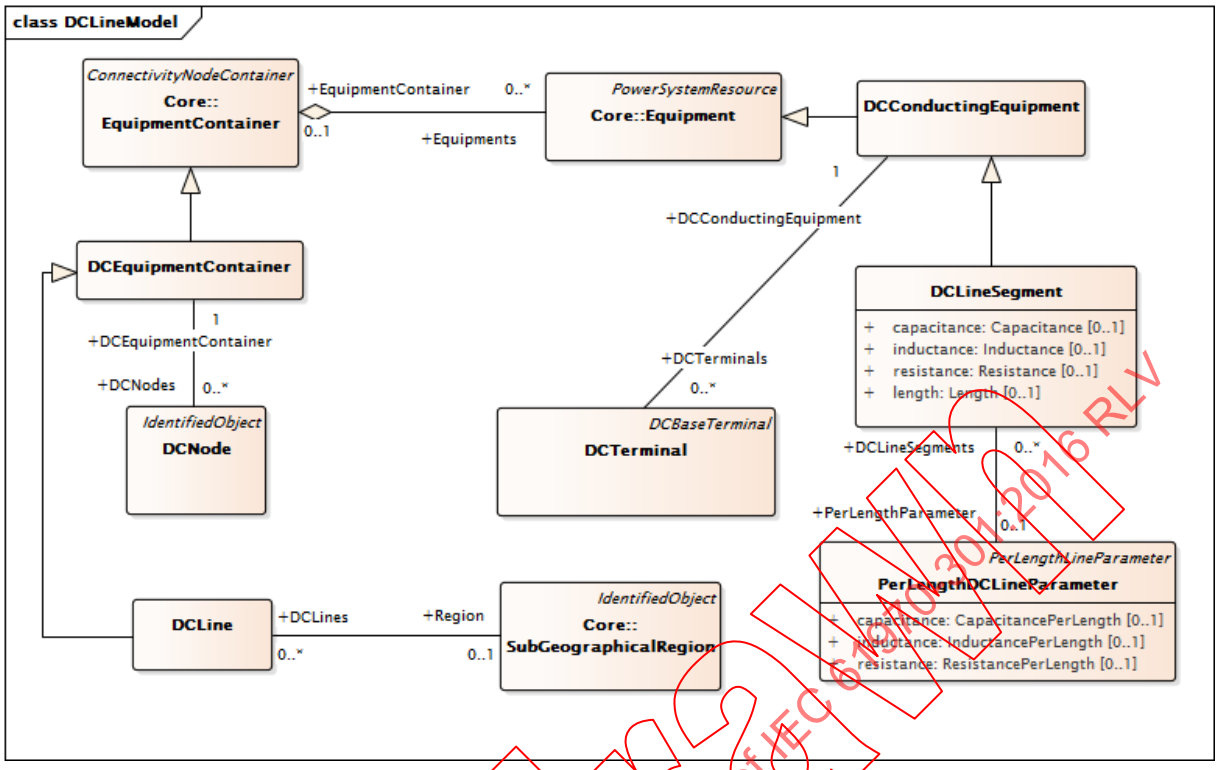


Figure 54 – Modèle de ligne CCHT

Comme représenté à la Figure 54, DCLineSegment n'est plus un Conductor mais un DCConductingEquipment et n'est pas connecté au réseau à courant alternatif. Il a ses propres attributs par classe de longueur PerLengthDCLineParameter.

Chaque type d'équipement d'un réseau CCHT nécessite sa classe... à courant continu. Les types existants d'équipements sont

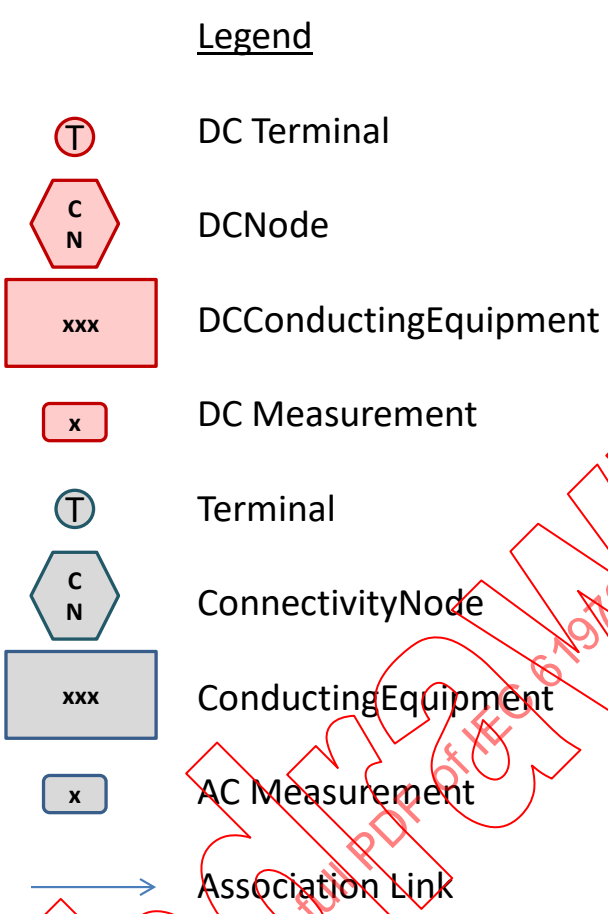
- DCSwitch,
- DCGround.

La méthode des classes... à courant continu spécifiques peut donner lieu à la duplication des attributs avec les classes... à courant alternatif correspondantes.

4.5.13.6 Diagrammes d'instances

Les Figures de la Figure 55 à la Figure 58 donnent des exemples d'équipements à courant continu, de monopole simple, de bipolaire simple et de côté détaillé d'un monopole.

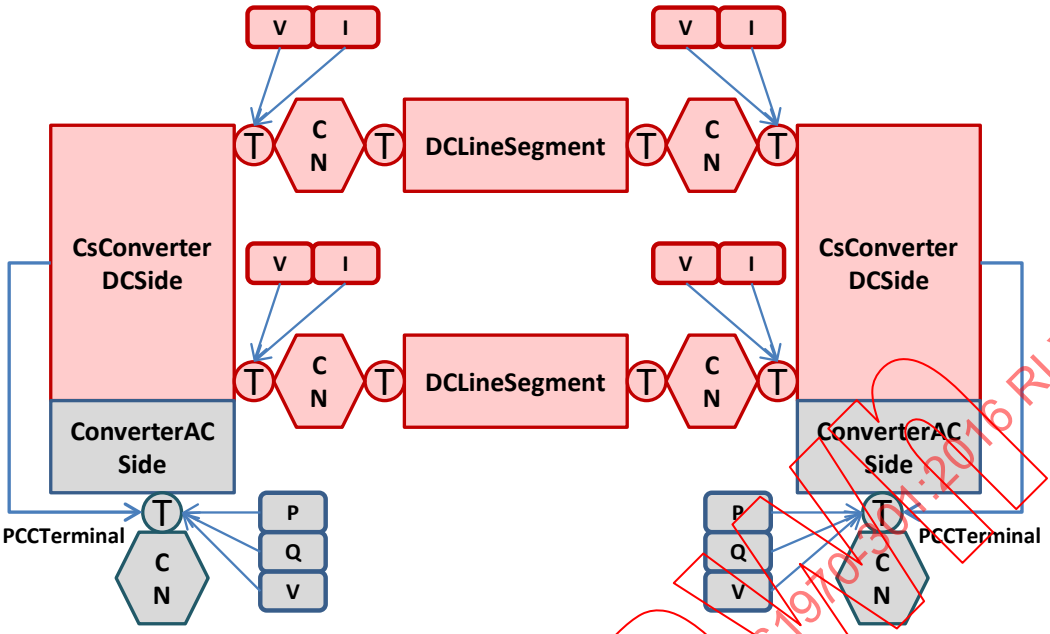
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Anglais	Français
Legend	Légende
DC Terminal	Borne de courant continu
DC Measurement	Mesure de courant continu
Terminal	Borne
AC Measurement	Mesure de courant alternatif
Association Link	Liaison d'association

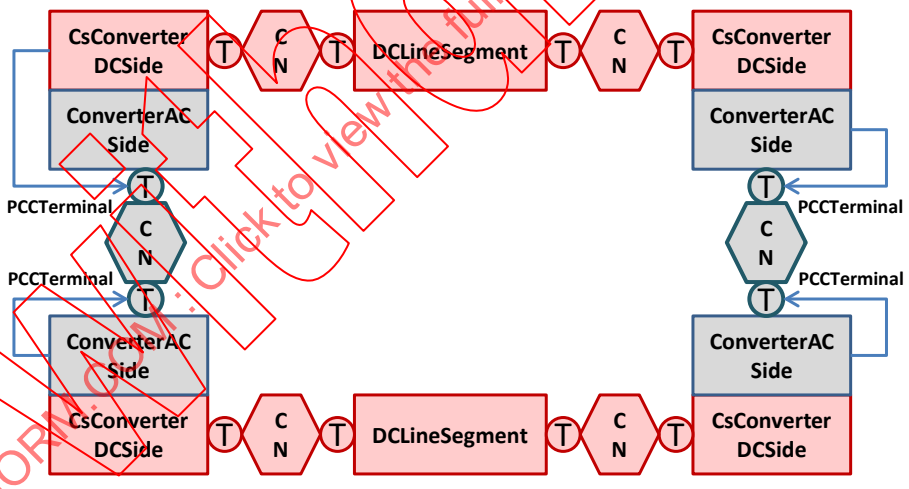
Figure 55 – Légende pour les Figure 56, Figure 57 et Figure 58

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Voir la Figure 55 pour avoir une explication concernant les symboles.

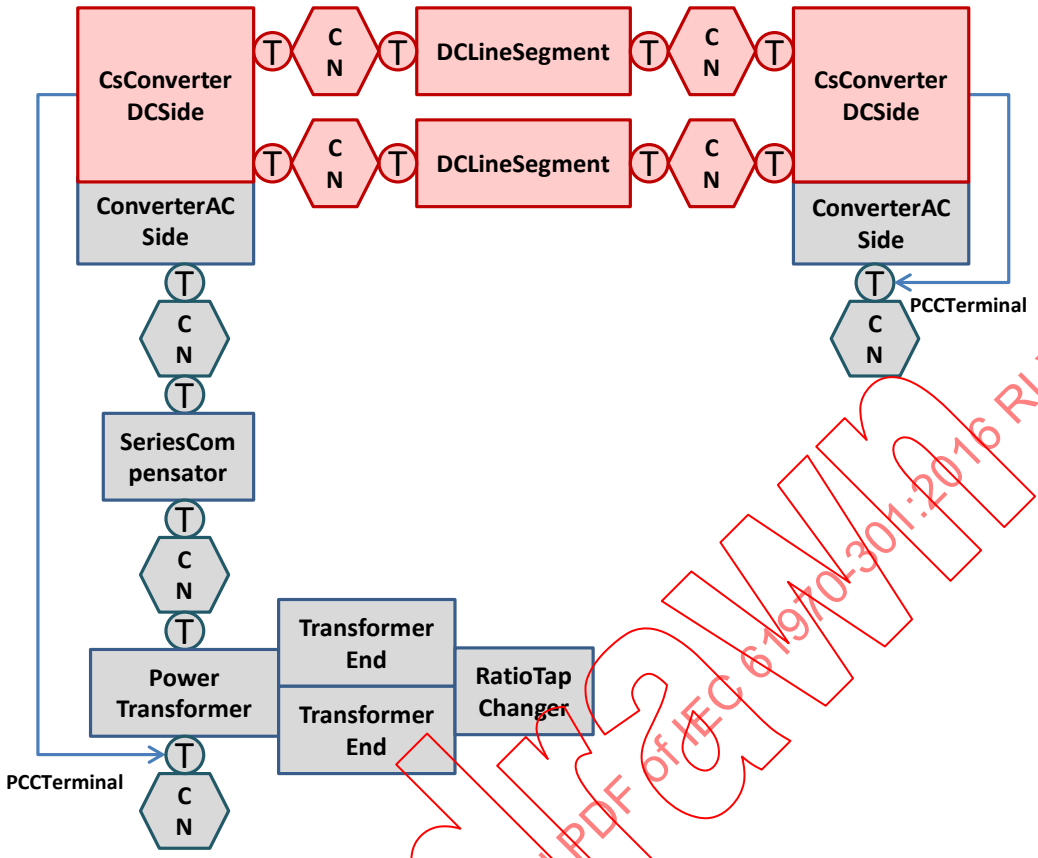
Figure 56 – Monopole simple et mesures



Voir la Figure 55 pour avoir une explication concernant les symboles.

Figure 57 – Bipolaire simple

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Voir la Figure 55 pour avoir une explication concernant les symboles.

Figure 58 – Côté de monopole avec modèle détaillé

4.5.14 Régulation de la tension du compensateur de Var statique

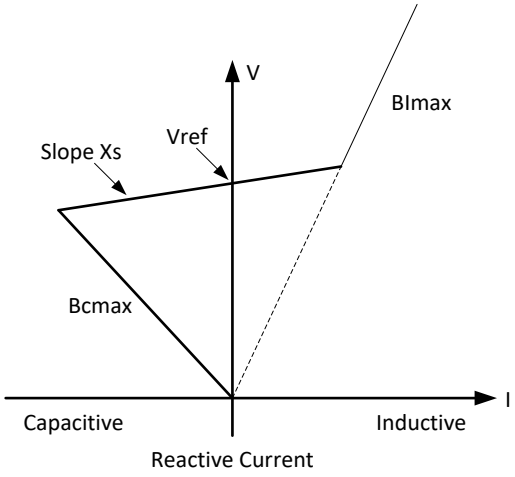
4.5.14.1 Historique

Le compensateur de var statique (SVC – Static VAR Compensator) est un appareil shunt de la famille des FACTS (systèmes flexibles de transport à courant alternatif) utilisant l'électronique de puissance pour commander le flux de puissance et améliorer la stabilité transitoire sur les réseaux de puissance. Le SVC peut fonctionner dans deux modes différents:

- le mode de régulation de la tension (la tension est régulée dans les limites spécifiées ci-dessous);
- le mode commande de la var (la susceptance du SVC reste constante).

Lorsque le SVC fonctionne en mode de régulation de la tension, il met en œuvre la caractéristique *V-I* représentée à la Figure 59.

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Anglais	Français
Capacitive	Capacitif
Reactive current	Courant réactif
Inductive	Inductif

Figure 59 – Caractéristique *V-I* du SVC

Tant que la susceptance *B* du SVC reste dans les valeurs maximale et minimale de susceptance imposées par la puissance réactive totale des batteries de condensateurs (Bc_{max}) et des batteries d'inductance (BI_{max}), la tension est régulée à la tension de référence V_{ref} (également appelée point de consigne de la tension). La tension à laquelle le SVC n'absorbe pas ou ne produit pas de puissance réactive est la tension de référence (V_{ref}).

Un statisme de tension est normalement utilisé (généralement entre 1 % et 4 % à la puissance réactive maximale en sortie), et la caractéristique *V-I* a la pente indiquée dans la Figure 59. La caractéristique *V-I* est décrite par les trois équations suivantes:

$$V = \begin{cases} V_{ref} + X_S \times I & \text{si le SVC est en mode de régulation} \quad (-Bc_{max} < B < BI_{max}) \\ -\dfrac{I}{Bc_{max}} & \text{si le SVC est entièrement capacitif} \quad (B = Bc_{max}) \\ -\dfrac{I}{BI_{max}} & \text{si le SVC est entièrement inductif} \quad (B = BI_{max}) \end{cases}$$

où:

V est la tension directe (pu) aux bornes du bus régulé;

I est le courant réactif ($I > 0$ indique un courant inductif);

X_S est la pente ou inductance de statisme;

V_{ref} est la tension de référence (point de consigne de la tension);

Bc_{max} est la susceptance capacitive maximale;

BI_{max} est la susceptance inductive maximale.

Le point de consigne de la tension est généralement choisi de sorte que, dans des conditions normales de fonctionnement, le SVC fournisse une puissance réactive proche de zéro et fonctionne sur sa plage totale de commande.

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Le point de consigne de la tension d'un SVC diffère fondamentalement d'une tension cible. La sortie de puissance réactive d'un SVC est proportionnelle au carré de la différence entre la tension régulée du bus et le point de consigne de la tension. Si le SVC produit ou absorbe de la puissance réactive, par définition, une différence s'établit entre la tension régulée du bus et le point de consigne de la tension.

4.5.14.2 Modèle actuel du CIM

StaticVarCompensator est défini comme une classe dans le CIM avec la description suivante.

Installation proposant une puissance réactive de shunt variable et modulable. Le SVC consiste généralement en un transformateur abaisseur, un filtre, un réacteur commandé par thyristor et des bras de condensateur commutés par thyristor.

Le SVC peut fonctionner dans le mode de sortie MVar fixe ou dans le mode de commande de tension. Dans le mode de commande de tension, la sortie du SVC est proportionnelle à l'écart de tension au niveau du bus commandé par rapport au point de consigne de la tension. La pente caractéristique du SVC définit la proportion. Si la tension au niveau du bus commandé est égale au point de consigne de la tension, la sortie MVar du SVC est nulle.

StaticVarCompensator a les attributs suivants:

capacitiveRating – Réactance capacitive maximale disponible.

inductiveRating – Réactance inductive maximale disponible.

q – Injection de puissance réactive. La convention de signe charge est utilisée, c'est-à-dire que le signe positif signifie un flux à partir d'un nœud. Valeur de départ pour une solution en régime établi.

slope – La pente de la caractéristique d'un SVC définit la manière dont la sortie de puissance réactive varie proportionnellement à la différence entre la tension régulée du bus et le point de consigne de la tension.

sVCControlMode – Mode de commande du SVC. Les valeurs sont

- reactivePower
- voltage.

voltageSetPoint – La sortie de puissance réactive du SVC est proportionnelle à la différence entre la tension régulée du bus et le point de consigne de la tension. Lorsque la tension régulée du bus est égale au point de consigne de la tension, la sortie de puissance réactive est nulle.

StaticVarCompensator hérite des attributs suivants de RegulatingCondEq:

controlEnabled – Spécifie le statut de régulation de l'équipement. True, il régule. False, il ne régule pas.

La Terminal de StaticVarCompensator est régulée par l'association à RegulatingControl, hérité de RegulatingCondEq.

4.5.14.3 Problèmes connus

Les caractéristiques physiques des compensateurs de var statique sont gérées par les attributs définis dans le CIM. Cependant, quelques interrogations et problèmes persistent.

a) Aucun

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Propositions

a) Envisager que StaticVarCompensator hérite de ConductingEquipment plutôt que de RegulatingCondEq et ajouter une association directe de StaticVarCompensator à la Terminal. Le modèle actuel utilisant RegulatingControl fonctionne pour les SVC, mais la plupart des attributs de RegulatingControl sont ignorés.

4.6 Lignes directrices de modélisation

4.6.1 Modélisation pour modifications

Les Paragraphes 4.6.2 à 4.6.5 donnent des lignes directrices sur la façon de maintenir et étendre le CIM.

Le CIM est destiné à contenir les classes et les attributs qui sont échangés sur des interfaces publiques entre des applications principales. L'objectif est de ne conserver, autant que possible, que les caractéristiques génériques à partir desquelles une mise en œuvre détaillée peut être extraite. Il est, en général, plus facile de modifier la valeur ou le domaine d'un attribut que de modifier une définition de classe. Cela rend le modèle plus solide, car il peut supporter une plus large classe d'exigences, et plus stable, car il peut être possible de gérer de nouvelles exigences sans avoir à modifier le modèle.

4.6.2 Processus pour les amendements au CIM

Il peut être souhaitable de modifier le CIM pour réviser le modèle existant ou pour étendre le CIM afin de modéliser des éléments supplémentaires d'un système de puissance. Le processus recommandé pour ces amendements est le suivant.

1) Préparer un ou plusieurs cas d'utilisation et une demande de modification qui décrivent les modifications souhaitées. Il convient que cela inclue les modifications proposées aux diagrammes de classes concernés avec représentation des classes, attributs et associations nouveaux ou révisés.
2) Le ou les cas d'utilisation et la demande de modification sont ensuite examinés par le Groupe de Travail approprié de l'IEC, qui va décider s'il convient que les modifications demandées soient traitées en tant que révisions de la norme CIM actuelle, ou s'il convient qu'elles soient traitées comme des amendements privés sans exigence de modification pour la norme.
3) Les propositions d'amendements acceptés par le groupe de travail seront ajoutées à la liste des sujets majeurs et le moment venu, une nouvelle version du modèle CIM sera élaborée et une mise à jour de la spécification du CIM appropriée de l'IEC sera faite.

4.6.3 Modifications apportées au modèle UML du CIM

Du point de vue de la modélisation, lorsque le CIM est étendu, l'approche consiste à partir du modèle UML de CIM existant. Les extensions peuvent être ajoutées de plusieurs façons disponibles avec UML, mais dans tous les cas, la bonne approche est d'examiner le modèle actuel et de déterminer la meilleure extension à partir des diagrammes de classes existants. Les extensions peuvent prendre une des formes suivantes, de la plus simple à la plus complexe:

- ajouter des attributs supplémentaires à des classes préexistantes;
- ajouter de nouvelles classes qui sont des spécialisations de classes préexistantes;
- ajouter de nouvelles classes à l'aide d'associations avec des classes préexistantes.

Dans le but d'étendre la présente norme, le principal objectif est de réutiliser le CIM existant dans toute la mesure du possible. Du point de vue des paquetages, il convient que les extensions soient faites aux paquetages existants chaque fois que c'est possible. Si les extensions comprennent un nouveau domaine d'application, il convient d'envisager de créer un nouveau paquetage pour les ajouts, mais en créant toujours les associations nécessaires

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au paquetage préexistant, en gardant à l'esprit que, bien qu'un nouveau paquetage soit créé, le CIM continue d'être un modèle unique.

Quand il s'agit d'apporter des modifications non normatives au modèle d'information, il convient d'étendre le CIM normalisé sans modifier le CIM normalisé. Il convient, de préférence, de placer ces extensions dans de nouveaux paquetages, à la fois pour identifier que les modifications ne sont pas normatives et pour faciliter le transfert des modifications vers une version de la norme mise à jour.

4.6.4 Modifications apportées aux documents normatifs du CIM

D'un point de vue documentaire, lorsque le CIM est étendu, une décision doit être prise quant à la question de savoir si les modifications constituent des mises à jour de documents normatifs existants sur le CIM ou si une nouvelle IEC 61970-3x spécifique est exigée. Dans les deux cas, les extensions deviendront une partie de la norme IEC sur le CIM.

4.6.5 Éléments déconseillés

Le modèle du CIM peut parfois contenir des paquetages, des classes, des attributs ou des associations qui sont considérés comme déconseillés. Ces éléments seront notés "déconseillés" dans la documentation ou porteront un stéréotype de l'UML "déconseillé". Un élément déconseillé figure dans la présente version du modèle mais il est prévu de le supprimer dans les versions futures. Il n'est pas garanti qu'un élément non déconseillé soit retenu dans les versions futures mais il convient d'éviter autant que possible l'utilisation d'un terme marqué comme déconseillé.

4.6.6 Profils CIM

Une mise en œuvre du CIM ne nécessite pas d'inclure toutes les classes, attributs et associations de la spécification de la norme CIM pour être conforme à la norme CIM. Des profils peuvent être définis pour spécifier les éléments qui doivent être inclus (c'est-à-dire, les éléments obligatoires) pour une utilisation particulière du CIM, ainsi que ceux qui sont facultatifs. Ces profils sont définis dans les documents concernant les profils de la série IEC 61970 ainsi que dans d'autres séries IEC qui utilisent et étendent le CIM de base spécifié dans le présent document.

Un exemple est le profil pour échanger des modèles de systèmes de puissance. Ce profil spécifie comment le CIM doit être utilisé pour échanger des modèles de systèmes de puissance en XML et il spécifie aussi les classes, attributs et associations, obligatoires et facultatifs, devant être pris en charge pour cette utilisation du CIM. Les profils peuvent être maintenus à l'aide de nombreux outils tels que l'outil open source (c'est-à-dire de source ouverte) CIMTool[1)].

4.7 Outils de modélisation

Cette version du CIM a été établie en utilisant le produit Enterprise Architect[2)]. Le modèle UML du CIM complet existe sous la forme d'un fichier de projet Enterprise Architect et peut être visualisé avec cet outil, y compris les diagrammes de classe et les descriptions des classes, des attributs, des types et des relations. La visualisation du CIM de cette façon offre

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1) Disponible à l'adresse <http://www.CIMTool.org>. CIMTool est l'appellation commerciale d'un produit distribué par Free Software Foundation. Cette information est donnée à l´intention des utilisateurs du présent document et ne signifie nullement que l'IEC approuve ou recommande l´emploi exclusif du produit ainsi désigné. Des produits équivalents peuvent être utilisés s'il peut être démontré qu'ils conduisent aux mêmes résultats.

2) Enterprise Architect est l'appellation commerciale d'un produit distribué par Sparx Systems. Cette information est donnée à l´intention des utilisateurs du présent document et ne signifie nullement que l'IEC approuve ou recommande l´emploi exclusif du produit ainsi désigné. Des produits équivalents peuvent être utilisés s'il peut être démontré qu'ils conduisent aux mêmes résultats.

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une interface de navigation graphique qui permet de visualiser toutes les données de spécification du CIM par simple pointer-cliquer sur le diagramme de classe dans chaque paquetage. Une visionneuse gratuite est disponible auprès de Sparx Systems.

Idéalement, le modèle d'informations du CIM est indépendant de tout outil UML spécifique, bien que l'expérience ait montré que les échanges entre des outils différents soient souvent loin d'être parfaits. En attendant la réalité de l'interopérabilité des outils, les futures modifications apportées à la spécification du CIM, débouchant sur de nouvelles versions de la présente norme, seront incorporées en premier lieu dans la description du projet Enterprise Architect pour garantir une source unique pour les données de modèle CIM.

L'Article 6 du présent document a été généré automatiquement en utilisant l'outil libre jCleanCim[3)], qui utilise les interfaces d'automatisation de Microsoft® Word[4)] et d'Enterprise Architect ainsi que le format et les styles normalisés de l'IEC.

4.8 Conventions de mise en œuvre pour les utilisateurs

4.8.1 Conventions au-delà de l'UML

Le paragraphe 4.8.2 propose des conventions d'utilisateur recommandées pour l'utilisation du CIM dans la mise en œuvre des systèmes réels.

4.8.2 Nombre de bornes pour les objets ConductingEquipment

Les ConductingEquipments (équipements conducteurs) suivants ont deux bornes: ACLineSegment, DCLineSegment, Switch et toutes leurs spécialisations (y compris Jumper, Fuse, Breaker, Disconnector, LoadBreakSwitch et Cut), SeriesCompensator et EquivalentBranch. La classe PowerTransformer a généralement deux bornes mais elle peut aussi avoir une borne ou davantage. Par exemple, un transformateur de mise à la terre connecté en zigzag peut avoir une borne. Des transformateurs à trois bornes sont couramment utilisés dans des systèmes de transport et les transformateurs pour cas spéciaux peuvent comporter quatre, cinq bornes ou davantage. Toutes les autres sous-classes ConductingEquipment (notamment qui comprennent Clamp et BusbarSection) ont une seule borne.

4.9 Exemples de modélisation CIM

Des modèles de systèmes de puissance ont été créés de plusieurs façons à partir du modèle UML du CIM. Le premier exemple est une version du schéma RDF (Resource Description Framework – cadre général pour la description des ressources) du CIM, qui utilise XML (eXtensible Markup Language – langage de balisage extensible) pour décrire un modèle de réseau de système de puissance. L'IEC 61970-501 et d'autres normes de profil en développement sont utilisées pour spécifier le format d'échange de modèles. Des versions de schémas RDF du CIM ont été utilisées pour créer les fichiers de modèles XML de réseaux réels pour des essais d'interopérabilité. Une version de schéma RDF du CIM est générée à partir du fichier de modèle UML du CIM en utilisant des outils logiciels basés sur une spécification de schéma RDF du CIM.

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3) Disponible à l'adresse http://cimug.ucaiug.org/MTEI/Shared%20Documents/jCleanCim. JCleanCim est l'appellation commerciale d'un produit distribué par Free Software Foundation. Cette information est donnée à l´intention des utilisateurs du présent document et ne signifie nullement que l'IEC approuve ou recommande l´emploi exclusif du produit ainsi désigné. Des produits équivalents peuvent être utilisés s'il peut être démontré qu'ils conduisent aux mêmes résultats.

4) Word est l'appellation commerciale d'un produit distribué par Microsoft. Cette information est donnée à l´intention des utilisateurs du présent document et ne signifie nullement que l'IEC approuve ou recommande l´emploi exclusif du produit ainsi désigné. Des produits équivalents peuvent être utilisés s'il peut être démontré qu'ils conduisent aux mêmes résultats.

Il convient de noter qu'une version de schéma RDF du CIM est du niveau métadonnées plutôt qu'une instanciation d'un réseau réel. Cependant, des fichiers de modélisation complets de réseaux avec tous les éléments du réseau ainsi que leurs connexions électriques peuvent être générés par des fournisseurs utilisant des outils d'exportation propriétaires, puis importés ensuite par d'autres systèmes avec un outil d'importation similaire, qui est utilisé pour remplir une base de données technique locale sur le réseau. Des exemples de ces modèles XML du CIM sont notamment les fichiers Siemens 100 bus model, Alstom 60 bus model et ABB 40 bus model[5)] utilisés pour des essais d'interopérabilité XML du CIM.

5 Modèle détaillé

5.1 Vue d'ensemble

La partie du Modèle d'Information Commun (CIM) dont traite l'IEC 61970-301 représente une vue logique complète des informations échangées parmi différents systèmes des entreprises de service public d'électricité. Cette définition inclut les classes et les attributs publics ainsi que leurs relations.

5.2 Contexte

Le CIM est fractionné en sous-paquetages. Les classes au sein des paquetages sont répertoriées dans l'ordre dans lequel elles sont définies dans le modèle UML. Les attributs natifs de la classe sont d'abord répertoriés, suivis des attributs hérités dans l'ordre de la hiérarchie d'héritage. Les associations natives sont énumérées en premier pour chaque classe, suivies des associations héritées dans l'ordre de profondeur d'héritage, puis par ordre alphabétique selon le nom de l'extrémité d'association. Les associations sont décrites selon le rôle de chaque classe participant à l'association. Les extrémités d'associations sont répertoriées pour chaque classe à chaque extrémité d'une association.

La Figure 60 représente les paquetages de haut niveau inclus dans le présent document.

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5) Siemens100 bus model, Alstom 60 bus model et ABB 40 bus model sont les appellations commerciales de produits distribués par Siemens, Alstom Grid et ABB. Cette information est donnée à l´intention des utilisateurs du présent document et ne signifie nullement que l'IEC approuve ou recommande l´emploi exclusif du produit ainsi désigné. Des produits équivalents peuvent être utilisés s'il peut être démontré qu'ils conduisent aux mêmes résultats.

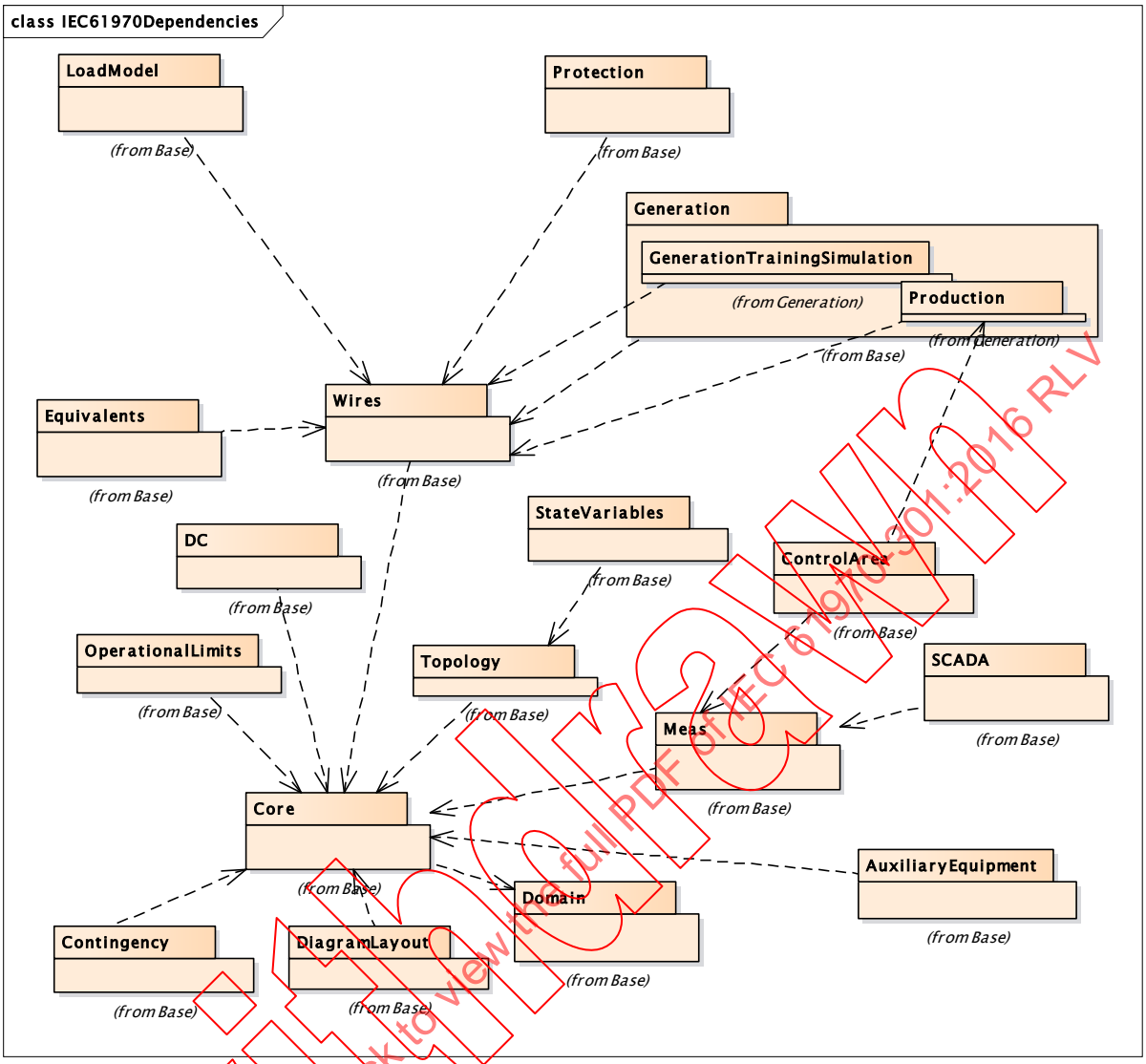


Figure 60 – Paquetages de haut niveau du CIM

Pour chaque paquetage, le modèle d'information de chaque classe est entièrement décrit. Les informations d'attribut et d'extrémité d'association pour des attributs natifs et hérités sont énumérées au Tableau 9 et au Tableau 10 en prenant une classe appelée “Class1” à titre d’exemple dans un paquetage “Package1” à titre d’exemple. Pour tous les éventuels attributs ou extrémités d'association hérités, la colonne "description" contient le texte indiquant que les attributs sont hérités d'une classe spécifique. Dans cet exemple, Class1 est censée être héritée de la classe IdentifiedObject. La colonne "description" pour les attributs natifs et extrémités d'associations contient la description réelle. Pour des attributs hérités, la classe de base est notée dans la description et la documentation complète sur l’attribut est disponible dans cette classe de base sous forme d’attribut natif.

Tableau 9 – Attributs de Package1::Class1

nom	type	description
native1	Float	Un attribut natif virgule flottante de la classe est décrit ici.
native2	ActivePower	Documentation pour un autre attribut natif du type ActivePower.
name	String	Hérité de: IdentifiedObject

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Dans les cas où un attribut est une constante, le Tableau 9 ajoute l'expression "(const)" à la colonne du nom. Dans ces cas, l'attribut a normalement une valeur initiale aussi qui est précédée du signal "égal" et accolée au nom d'attribut.

Tableau 10 – Extrémités d'association de Package1::Class1 avec d'autres classes

[mult à partir de]	[mult vers] nom	type	description
[0..*]	[0..1] Class2	Class2	Description de l'extrémité d'association à une autre classe appelée "Class1". Noter qu'il est typique mais non exigé que l'extrémité d'association soit identique au type de référence. Cette extrémité d'association peut référencer zéro ou un objet. L'autre extrémité de l'association peut référencer un nombre quelconque d'instances de Class1.
[0..1]	[0..*] SecondClass2	Class2	Description de références à la classe appelée "Class2". Dans ce cas, un nombre quelconque de références peut être effectué. La référence inverse peut référencer zéro ou une instance de Class1.
[1..1]	[0..*] Class3	Class3	Référence à un nombre quelconque d'instances de Class3. La référence inverse doit référencer une seule instance de Class1.
[0..*]	[0..*] Class4	Class4	Association plusieurs à plusieurs.
[0..1]	[0..*] DiagramObjects	DiagramObject	hérité de: IdentifiedObject
[1..1]	[0..*] Names	Name	hérité de: IdentifiedObject

Dans le Tableau 10, la première colonne décrit la multiplicité en cette extrémité de l'association (c'est-à-dire la façon dont cette classe participe à l'association). La deuxième colonne décrit l'autre extrémité d'association. Sa multiplicité est insérée entre des crochets. Le nom de l'extrémité d'association est répertorié en texte en clair. La classe à l'autre extrémité de l'association est donnée dans la troisième colonne. Une multiplicité zéro indique une association facultative. Une multiplicité "*" indique que n'importe quel nombre est autorisé. Par exemple, une multiplicité [1..*] indique qu'une plage allant de 1 à n'importe quel nombre plus grand est autorisée.

Lorsqu'une classe est une énumération appelée "Enumeration1", le tableau des attributs est remplacé par la documentation de libellés comme représenté au Tableau 11, puisque les libellés d'énumération n'ont pas de type. Il n'existe pas de libellés d'énumération hérités pour une classe d'énumération.

Tableau 11 – Libellés de Package1::Enumeration1

libellé	description
native1	Il s'agit de la première valeur enumeration native.
native2	Il s'agit de la deuxième valeur enumeration native.
native3	Il n'y a généralement pas d'attributs hérités pour les énumérations.

6 Paquetage Base

6.1 Généralités

Vide.

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6.2 Paquetage Faults

6.2.1 Généralités

Le paquetage décrit les défauts pouvant se produire sur les équipements conducteurs, par exemple un arbre qui tombe sur une ligne électrique.

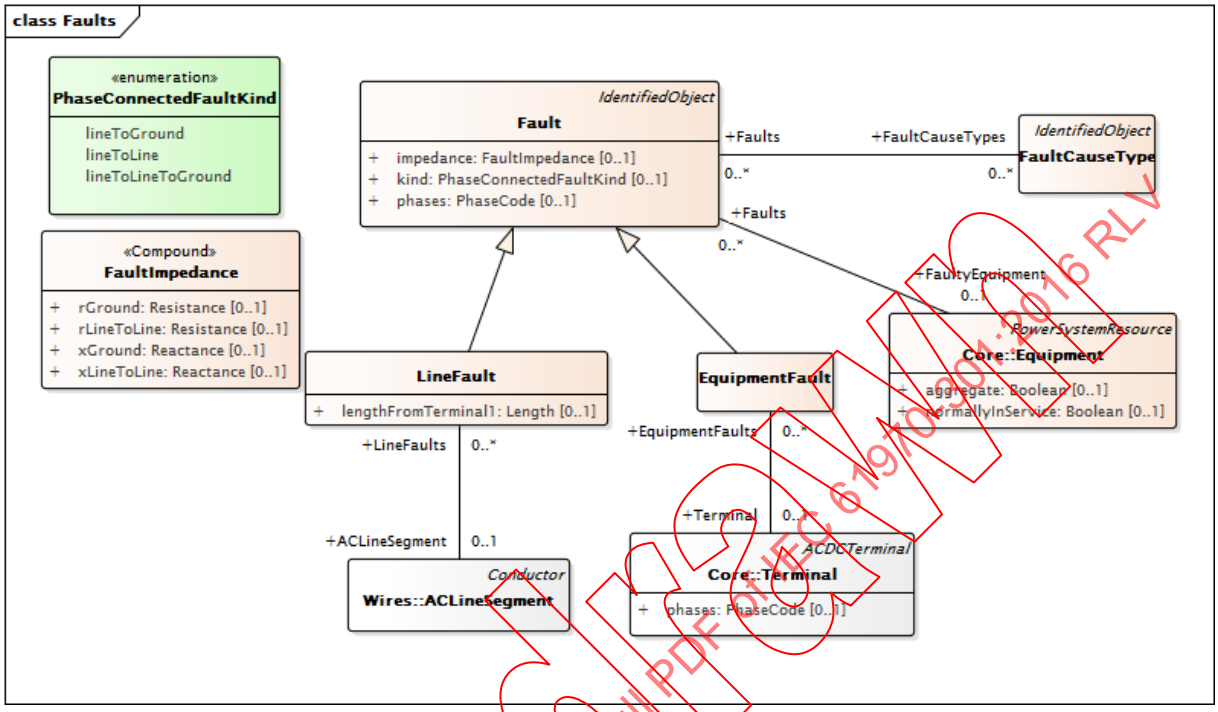


Figure 61 – Diagramme de classe Faults::Faults

Figure 61: Classes utilisées pour les défauts de modèles.

6.2.2 EquipmentFault

Un défaut appliqué à la borne, en dehors de l'équipement. Cette classe n'est pas utilisée pour spécifier les défauts internes à l'équipement.

Le Tableau 12 représente tous les attributs de EquipmentFault.

Tableau 12 – Attributs de Faults::EquipmentFault

nom	mult	type	description
impedance	0..1	FaultImpedance	hérité de: Fault
kind	0..1	PhaseConnectedFaultKind	hérité de: Fault
phases	0..1	PhaseCode	hérité de: Fault
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 13 présente toutes les extrémités d'association de EquipmentFault avec d'autres classes.

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Tableau 13 – Extrémités d'association de Faults::EquipmentFault avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	Terminal	0..1	Terminal	Borne qui se connecte au bus auquel le défaut est appliqué.
0..*	FaultyEquipment	0..1	Equipment	hérité de: Fault
0..*	FaultCauseTypes	0..*	FaultCauseType	hérité de: Fault
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.2.3 Fault

Condition anormale qui provoque un flux de courant dans l'équipement conducteur, par exemple provoqué par un équipement défaillant ou des courts-circuits provenant d'objets non généralement modélisés (par exemple, un arbre tombant sur une ligne électrique).

Le Tableau 14 présente tous les attributs de Fault.

Tableau 14 – Attributs de Faults::Fault

nom	mult	type	description
impedance	0..1	FaultImpedance	Impédance de défaut. Son utilisation est décrite par 'kind' (genre).
kind	0..1	PhaseConnectedFaultKind	Genre de défaut de phase.
phases	0..1	PhaseCode	Phases qui participent au défaut. Les connexions défectueuses dans ces phases sont en outre spécifiées en fonction du type de défaut.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 15 présente toutes les extrémités d'association de Fault avec d'autres classes.

Tableau 15 – Extrémités d'association de Faults::Fault avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	FaultyEquipment	0..1	Equipment	Équipement portant ce défaut.
0..*	FaultCauseTypes	0..*	FaultCauseType	Tous les types de causes de défauts.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.2.4 FaultCauseType

Type de cause du défaut.

Le Tableau 16 présente tous les attributs de FaultCauseType.

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Tableau 16 – Attributs de Faults::FaultCauseType

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 17 présente toutes les extrémités d'association de FaultCauseType avec d'autres classes.

Tableau 17 – Extrémités d'association de Faults::FaultCauseType avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	Faults	0..*	Fault	Tous les défauts ayant ce type de cause.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.2.5 Compound FaultImpedance

Description de l'impédance correspondant au défaut.

Le Tableau 18 présente tous les attributs de FaultImpedance.

Tableau 18 – Attributs de Faults::FaultImpedance

nom	mult	type	description
rGround	0..1	Resistance	Résistance du défaut entre les phases et la terre.
rLineToLine	0..1	Resistance	Résistance du défaut entre les phases.
xGround	0..1	Reactance	Réactance du défaut entre les phases et la terre.
xLineToLine	0..1	Reactance	Réactance du défaut entre les phases.

6.2.6 LineFault

Défaut qui se produit sur un segment de ligne de courant alternatif en un point quelconque de la longueur.

Le Tableau 19 présente tous les attributs de LineFault.

Tableau 19 – Attributs de Faults::LineFault

nom	mult	type	description
lengthFromTerminal1	0..1	Length	Longueur à placer à l'emplacement du défaut à partir d'une borne de numéro d'ordre 1 du segment de ligne défectueux.
impedance	0..1	FaultImpedance	hérité de: Fault
kind	0..1	PhaseConnectedFaultKind	hérité de: Fault
phases	0..1	PhaseCode	hérité de: Fault
aliasName	0..1	String	hérité de: IdentifiedObject

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nom	mult	type	description
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 20 présente toutes les extrémités d'association de LineFault avec d'autres classes.

Tableau 20 – Extrémités d'association de Faults::LineFault avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	ACLineSegment	0..1	ACLineSegment	Segment de ligne de ce défaut de ligne.
0..*	FaultyEquipment	0..1	Equipment	hérité de: Fault
0..*	FaultCauseTypes	0..*	FaultCauseType	hérité de: Fault
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.2.7 Énumération PhaseConnectedFaultKind

Type de connexion défectueuse parmi les phases.

Le Tableau 21 présente tous les libellés de PhaseConnectedFaultKind.

Tableau 21 – Libellés de Faults::PhaseConnectedFaultKind

libellé	valeur	description
lineToGround		Le défaut connecte les phases indiquées à la terre. L'impédance de défaut ligne à ligne n'est pas utilisée et est considérée comme infinie. L'impédance totale de terre est connectée entre chaque phase spécifiée dans le défaut et dans la terre, pas entre les phases.
lineToLine		Le défaut connecte les phases spécifiées ensemble sans connexion à la terre. L'impédance de terre de ce défaut est ignorée. L'impédance ligne à ligne est connectée entre chacune des phases spécifiées dans le défaut. Par exemple, trois fois pour un défaut triphasé, une fois pour un défaut biphasé. Il convient de ne pas spécifier un défaut monophasé.
lineToLineToGround		Le défaut connecte les phases indiquées à la terre et les unes aux autres. L'impédance ligne à ligne est connectée entre chacune des phases spécifiées dans le défaut dans un maillage complet. Par exemple, trois fois pour un défaut triphasé, une fois pour un défaut biphasé. Il convient de ne pas spécifier un défaut monophasé. L'impédance totale de terre est connectée entre chaque phase spécifiée dans le défaut et dans la terre.

6.3 Paquetage DocIEC 61970

Ce paquetage contient des exemples de diagrammes non destinés à être documentés dans l'IEC 61970-301 avec le reste des paquetages normatifs. Les diagrammes compris dans ce paquetage sont inclus individuellement dans le texte d'introduction de l'IEC 61970-301.

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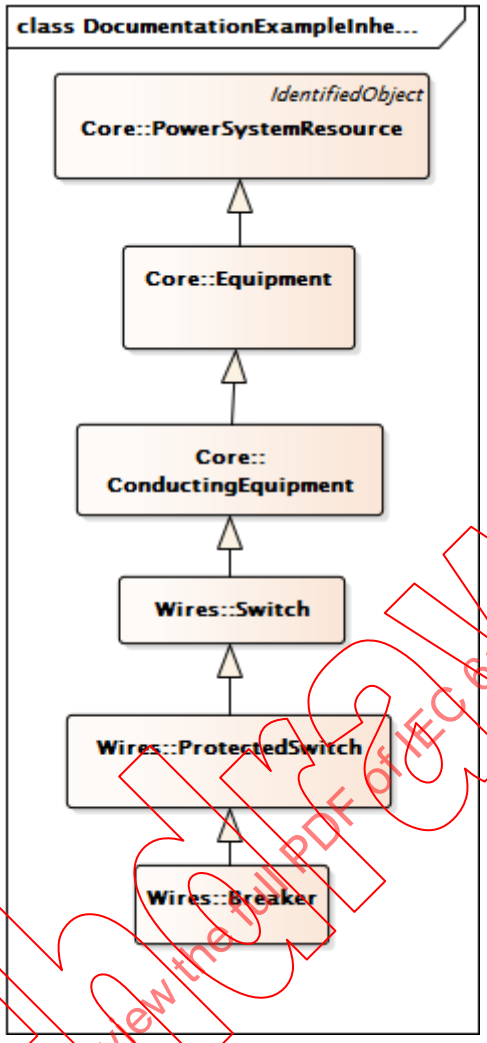
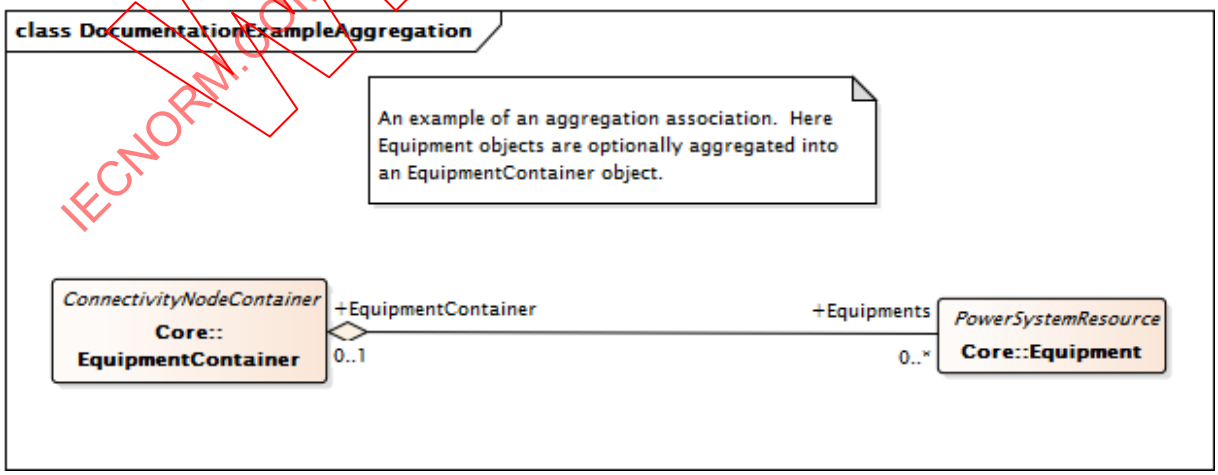


Figure 62 – Diagramme de classe DocIEC 61970::DocumentationExampleInheritance

Figure 62: Ceci est un exemple d'héritage en UML. Ce diagramme a pour seul objet de prendre en charge les Figures qui apparaissent dans la documentation.

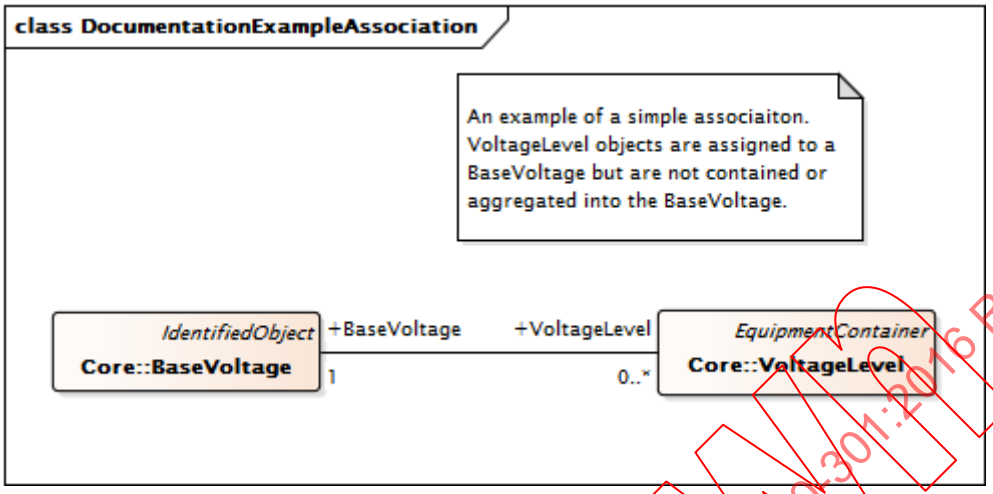


Anglais	Français
An example of an aggregation association. Here Equipment objects are optionally aggregated into an EquipmentContrainer object	Exemple d'association d'agrégation. Ici, des objets Equipment sont facultativement agrégés en un objet EquipmentContainer.

Figure 63 – Diagramme de classe DocIEC 61970::DocumentationExampleAggregation

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Figure 63: Ceci est un exemple d'agrégation en UML. Ce diagramme a pour seul objet de prendre en charge les Figures qui apparaissent dans la documentation.



Anglais	Français
An example of a simple association. VoltageLevel objects are assigned to a BaseVoltage but are not contained or aggregated into the BaseVoltage.	Exemple d'association simple. Des objets VoltageLevel sont affectés à une BaseVoltage, mais ne sont ni contenus ni agrégés dans la BaseVoltage.

Figure 64 – Diagramme de classe DocIEC 61970::DocumentationExampleAssociation

Figure 64: Ce diagramme est un exemple utilisé à des fins de documentation. Il représente la façon dont une association simple et une association agrégée sont exprimées en diagrammes UML.

6.4 Paquetage Domain

6.4.1 Généralités

Le paquetage Domain définit les types primitifs de données qui sont utilisés par des classes dans d'autres paquetages. Des stéréotypes sont utilisés pour décrire les types de données. Les stéréotypes suivants sont définis:

<<enumeration>> Liste des valeurs constantes permises.

<<Primitive>> type de données le plus simple qui est utilisé pour composer tous les autres types de données.

<<CIMDatatype>> Type de données qui contient un attribut de valeur, une unité facultative de mesure et un multiplicateur d'unité. L'unité et le multiplicateur peuvent être spécifiés comme des variables statiques initialisées à la valeur autorisée.

<<Compound>> Composé de Primitive, enumeration, CIMDatatype ou classes Compound, dans la mesure où les classes Compound ne sont pas inversées.

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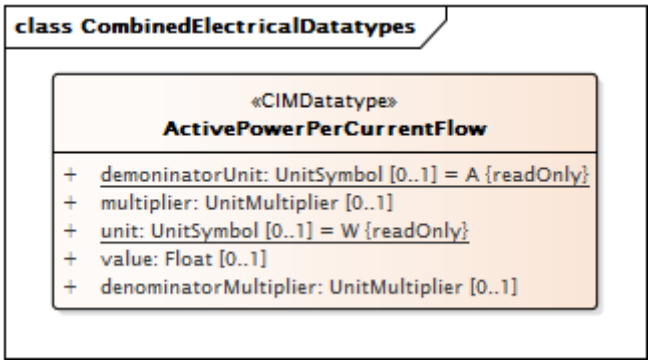


Figure 65 – Diagramme de classe Domain::CombinedElectricalDatatypes

Figure 65: Ce diagramme représente les types de données électriques qui sont des combinaisons d'autres types de données électriques.

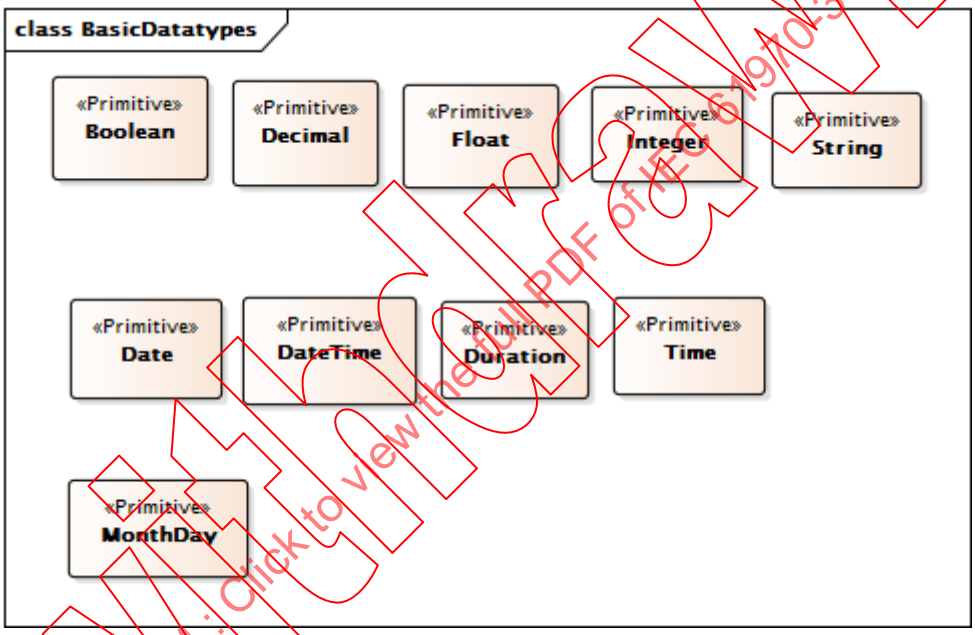
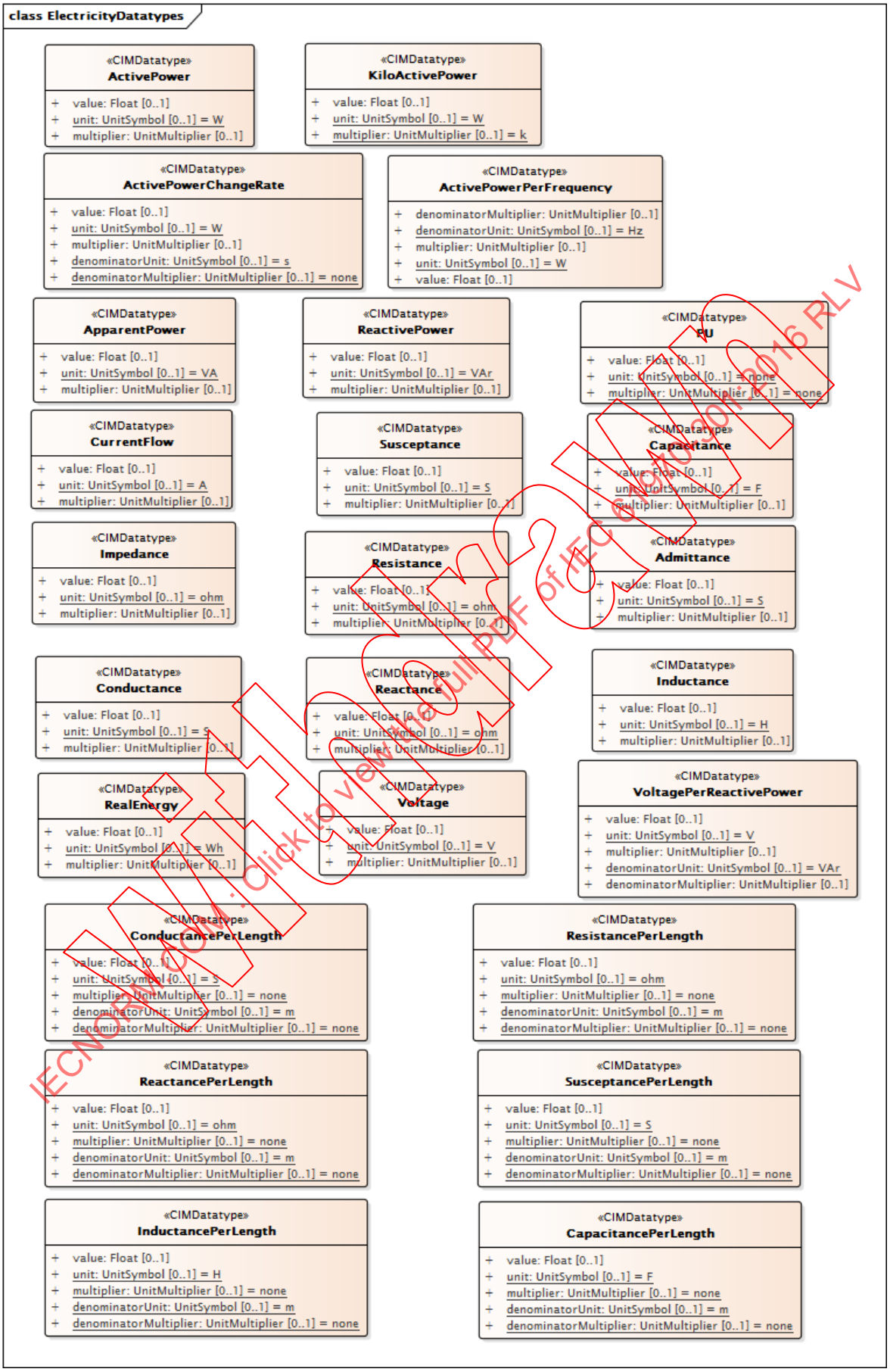


Figure 66 – Diagramme de classe Domain::BasicDatatypes

Figure 66: Ce diagramme représente les types de données de base qui sont à l'origine de tous les autres types de données.

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Figure 67 – Diagramme de classe Domain::ElectricityDatatypes

Figure 67: Ce diagramme représente les types de données liées à l'électricité.

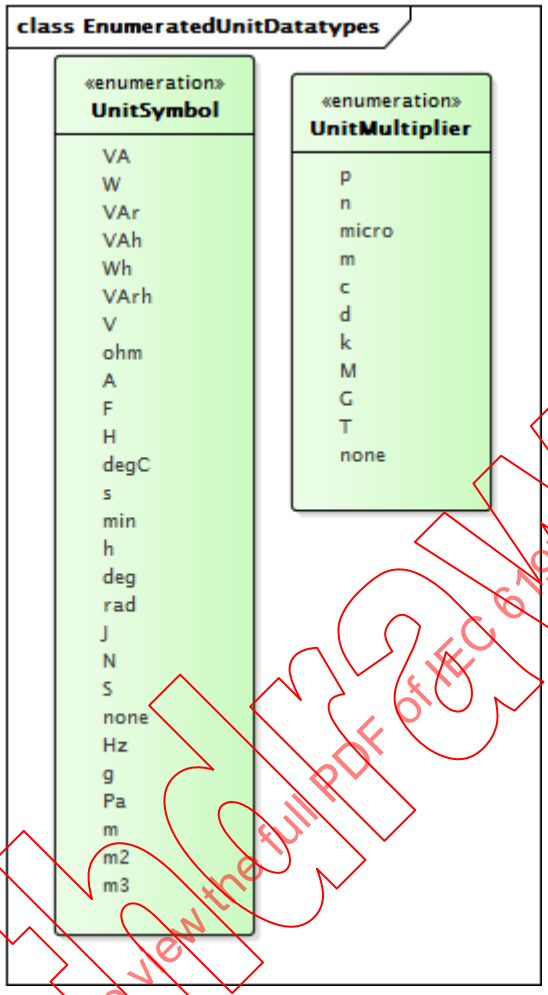
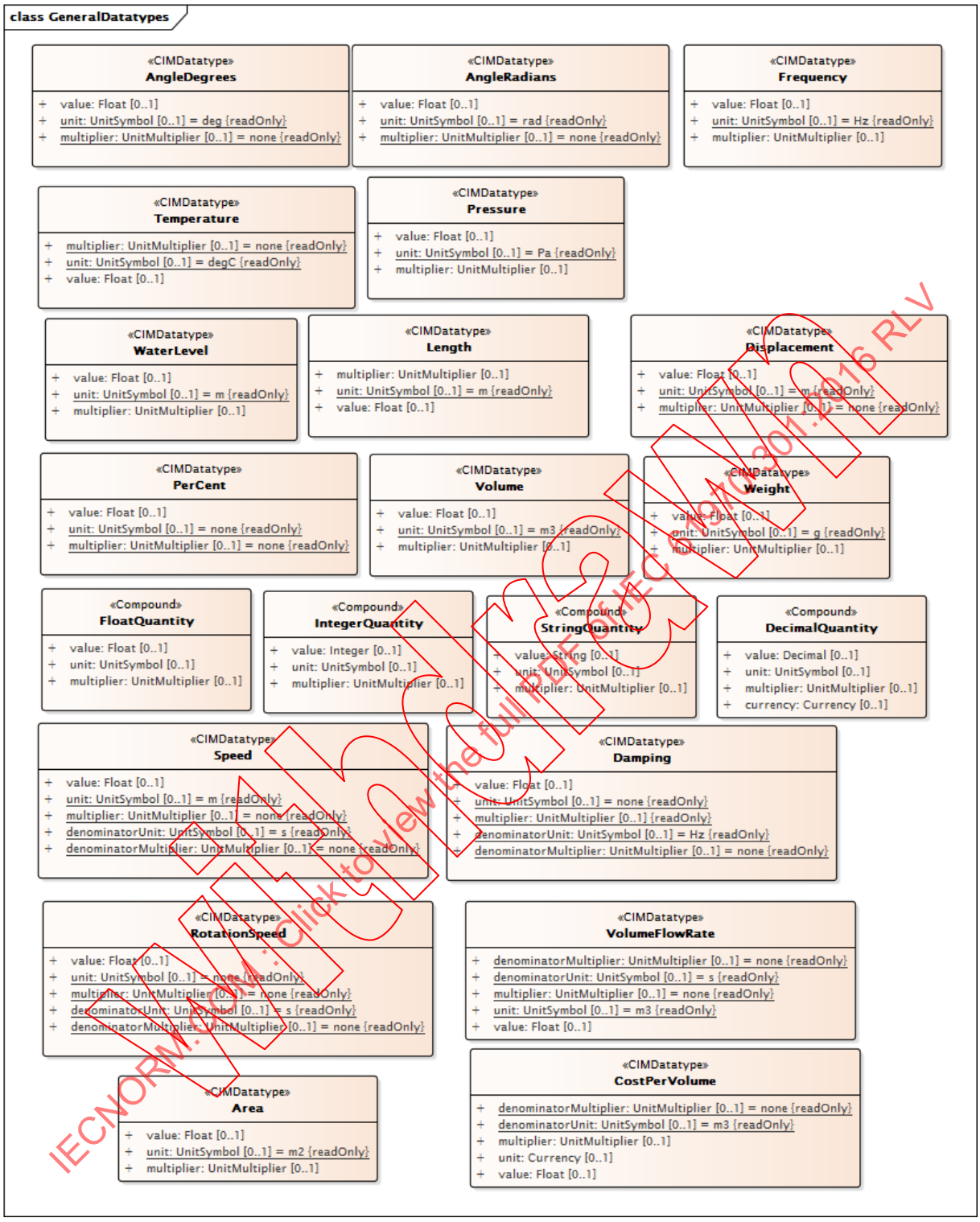


Figure 68 – Diagramme de classe Domain::EnumeratedUnitDatatypes

Figure 68: Ce diagramme représente les types de données énumérés liés au système d'unités SI.

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Figure 69 – Diagramme de classe Domain::GeneralDatatypes

Figure 69: Ce diagramme représente les types généraux de données.

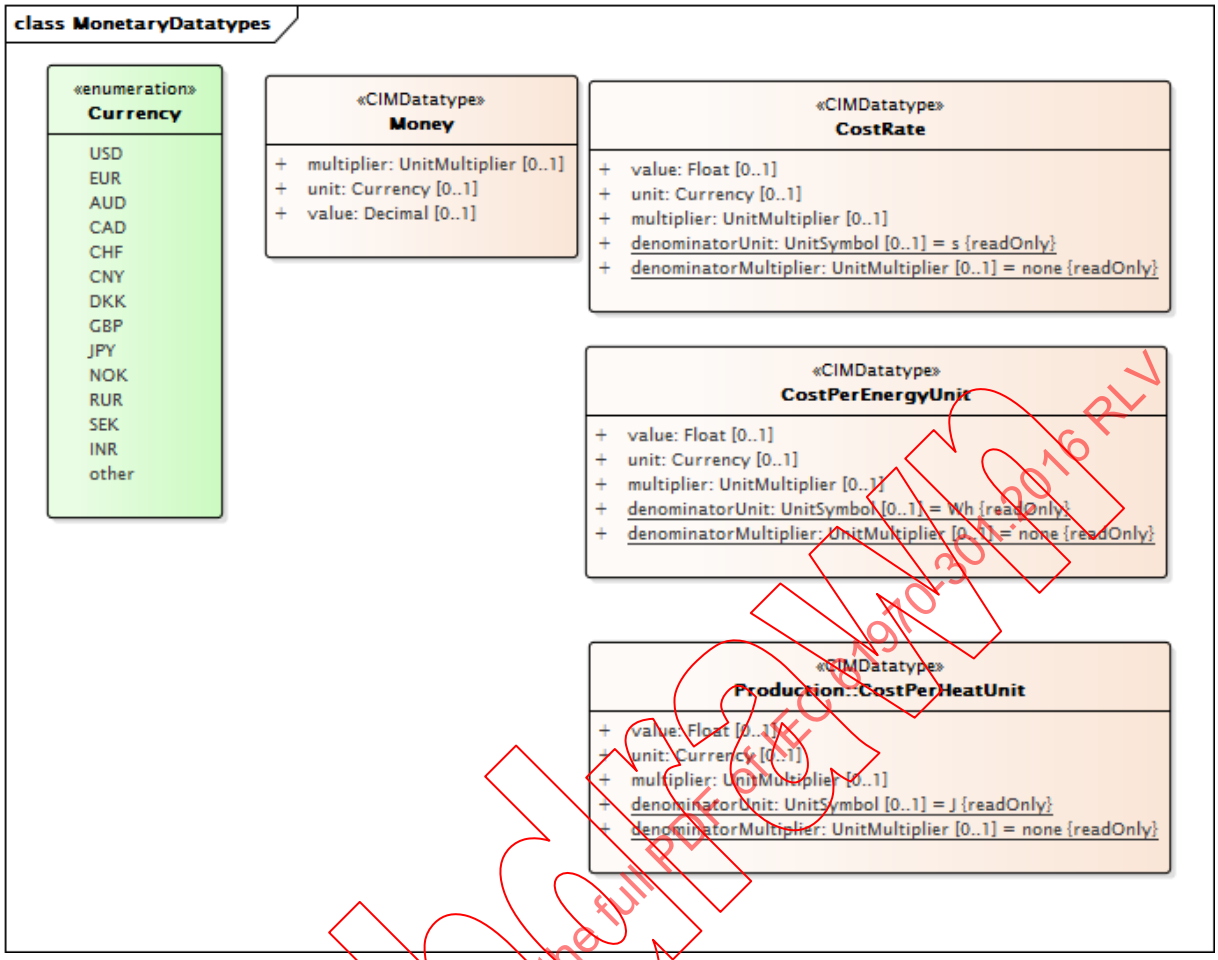


Figure 70 – Diagramme de classe Domain::MonetaryDatatypes

Figure 70: Ce diagramme représente les types de données liés à la monnaie.

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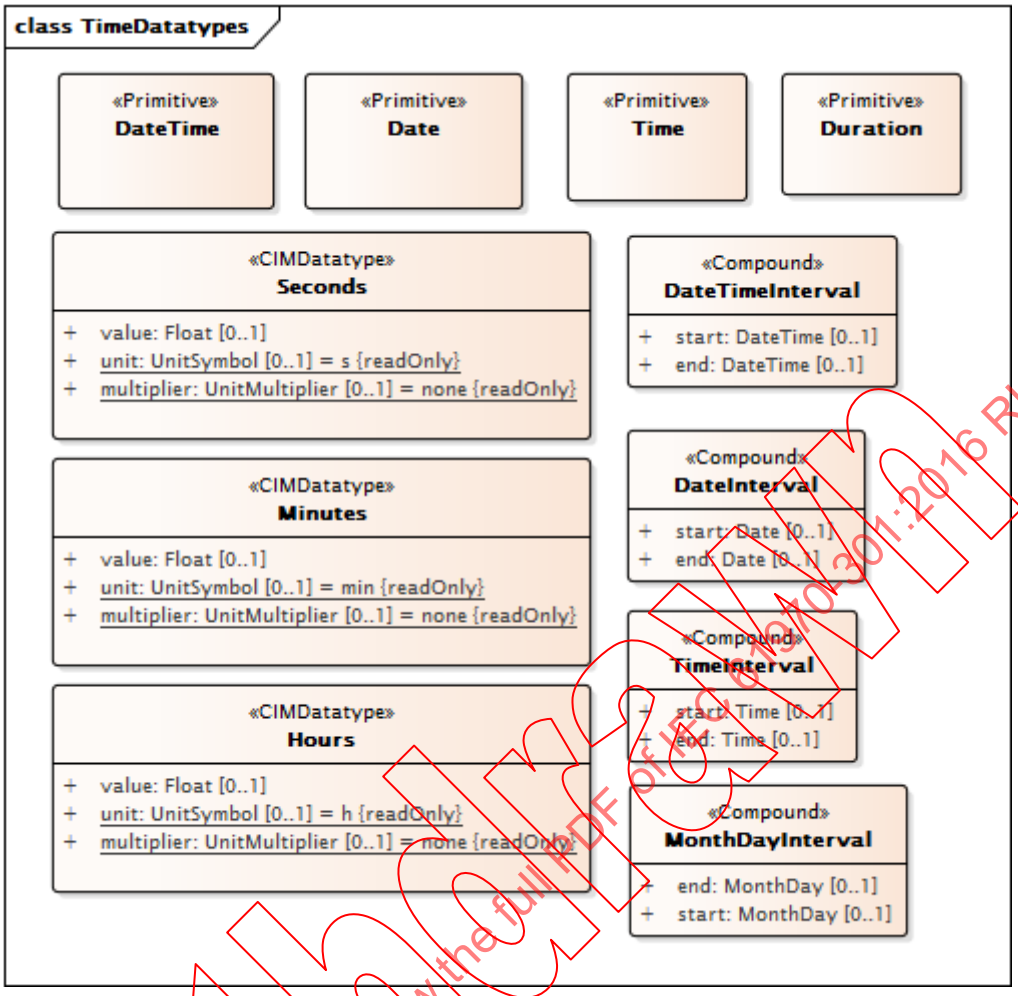


Figure 71 – Diagramme de classe Domain::TimeDatatypes

Figure 71: Ce diagramme représente les types de données liés au temps.

6.4.2 Type de données ActivePower

Produit de la valeur RMS (valeur efficace) de la tension et de la valeur RMS de l'élément en phase du courant.

Le Tableau 22 présente tous les attributs de ActivePower.

Tableau 22 – Attributs de Domain::ActivePower

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=W)
multiplier	0..1	UnitMultiplier	

6.4.3 Type de données ActivePowerChangeRate

Taux de variation de la puissance active par unité de temps.

Le Tableau 23 présente tous les attributs de ActivePowerChangeRate.

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Tableau 23 – Attributs de Domain::ActivePowerChangeRate

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=W)
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.4 Type de données ActivePowerPerCurrentFlow

Le Tableau 24 présente tous les attributs de ActivePowerPerCurrentFlow.

Tableau 24 – Attributs de Domain::ActivePowerPerCurrentFlow

nom	mult	type	description
denominatorUnit	0..1	UnitSymbol	(const=A)
multiplier	0..1	UnitMultiplier	
unit	0..1	UnitSymbol	(const=W)
value	0..1	Float	
denominatorMultiplier	0..1	UnitMultiplier	

6.4.5 Type de données ActivePowerPerFrequency

Variation de puissance active avec la fréquence.

Le Tableau 25 présente tous les attributs de ActivePowerPerFrequency.

Tableau 25 – Attributs de Domain::ActivePowerPerFrequency

nom	mult	type	description
denominatorMultiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=Hz)
multiplier	0..1	UnitMultiplier	
unit	0..1	UnitSymbol	(const=W)
value	0..1	Float	

6.4.6 Type de données Admittance

Rapport courant/tension.

Le Tableau 26 présente tous les attributs de Admittance.

Tableau 26 – Attributs de Domain::Admittance

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	

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6.4.7 Type de données AngleDegrees

Mesure d'angle en degrés.

Le Tableau 27 présente tous les attributs de AngleDegrees.

Tableau 27 – Attributs de Domain::AngleDegrees

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=deg)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.8 Type de données AngleRadians

Angle de phase en radians.

Le Tableau 28 présente tous les attributs de AngleRadians.

Tableau 28 – Attributs de Domain::AngleRadians

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=rad)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.9 Type de données ApparentPower

Produit de la valeur RMS (valeur efficace) de la tension et de la valeur RMS du courant.

Le Tableau 29 présente tous les attributs de ApparentPower.

Tableau 29 – Attributs de Domain::ApparentPower

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=VA)
multiplier	0..1	UnitMultiplier	

6.4.10 Type de données Area

Zone.

Le Tableau 30 présente tous les attributs de Area.

Tableau 30 – Attributs de Domain::Area

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m2)
multiplier	0..1	UnitMultiplier	

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6.4.11 Type primitif de données Boolean

Type avec l'espace de valeurs "true" (vrai) et "false" (faux).

6.4.12 Type de données Capacitance

Partie capacitive de la réactance (partie imaginaire de l'impédance), à la fréquence assignée.

Le Tableau 31 présente tous les attributs de Capacitance.

Tableau 31 – Attributs de Domain::Capacitance

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=F)
multiplier	0..1	UnitMultiplier	

6.4.13 Type de données CapacitancePerLength

Capacité par unité de longueur.

Le Tableau 32 présente tous les attributs de CapacitancePerLength.

Tableau 32 – Attributs de Domain::ConductancePerLength

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=F)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.14 Type de données Conductance

Facteur par lequel doit être multipliée la tension pour obtenir la puissance correspondante perdue dans un circuit. Partie réelle de l'admittance.

Le Tableau 33 présente tous les attributs de Conductance.

Tableau 33 – Attributs de Domain::Conductance

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	

6.4.15 Type de données ConductancePerLength

Partie réelle de l'admittance par unité de longueur.

Le Tableau 34 présente tous les attributs de ConductancePerLength.

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Tableau 34 – Attributs de Domain::ConductancePerLength

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.16 Type de données CostPerEnergyUnit

Coût, en unités monétaires, par quantité d'énergie électrique produite.

Le Tableau 35 présente tous les attributs de CostPerEnergyUnit.

Tableau 35 – Attributs de Domain::CostPerEnergyUnit

nom	mult	type	description
value	0..1	Float	
unit	0..1	Currency	
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=Wh)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.17 Type de données CostPerVolume

Coût par unité de volume.

Le Tableau 36 présente tous les attributs de CostPerVolume.

Tableau 36 – Attributs de Domain::CostPerVolume

nom	mult	type	description
denominatorMultiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m3)
multiplier	0..1	UnitMultiplier	
unit	0..1	Currency	
value	0..1	Float	

6.4.18 Type de données CostRate

Coût en unités monétaires, selon le temps écoulé.

Le Tableau 37 présente tous les attributs de CostRate.

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Tableau 37 – Attributs de Domain::CostRate

nom	mult	type	description
value	0..1	Float	
unit	0..1	Currency	
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.19 Énumération Currency

Devises monétaires. Noter que cette liste n'est pas exhaustive.

Le Tableau 38 présente tous les libellés de Currency.

Tableau 38 – Libellés de Domain::Currency

libellé	valeur	description
USD		Dollar US
EUR		Euro européen
AUD		Dollar australien
CAD		Dollar canadien
CHF		Franc suisse
CNY		Yuan renminbi chinois
DKK		Couronne danoise
GBP		Livre britannique
JPY		Yen japonais
NOK		Couronne norvégienne
RUR		Rouble russe
SEK		Couronne suédoise
INR		Roupie indienne
autre		Autre type de devise.

6.4.20 Type de données CurrentFlow

Courant électrique avec le signe conventionnel: un flux positif circule de l'équipement conducteur jusque dans le nœud de connectivité. Il peut être alternatif ou continu.

Le Tableau 39 présente tous les attributs de CurrentFlow.

Tableau 39 – Attributs de Domain::CurrentFlow

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=A)
multiplier	0..1	UnitMultiplier	

6.4.21 Type de données Damping

Variation de puissance active par unité avec une fréquence référencée dans la base de puissance apparente du système. Les valeurs types sont comprises entre 1,0 et 2,0.

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Le Tableau 40 présente tous les attributs de Damping.

Tableau 40 – Attributs de Domain::Damping

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=Hz)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.22 Type primitif de données Date

Date sous la forme "aaaa-mm-jj" conformément à ISO 8601. Le fuseau horaire TUC est spécifié sous forme "aaaa-mm-jjZ". Un temps TUC par rapport à un fuseau horaire local est spécifié sous la forme "aaaa-mm-jj(+/-)hh:mm".

6.4.23 Compound DateInterval

Intervalle de temps entre deux dates.

Le Tableau 41 présente tous les attributs de DateInterval.

Tableau 41 – Attributs de Domain::DateInterval

nom	mult	type	description
start	0..1	Date	Date à laquelle commence cet intervalle de temps.
end	0..1	Date	Date à laquelle finit cet intervalle de temps.

6.4.24 Type primitif de données DateTime

Date et heure sous la forme"aaaa-mm-jjThh:mm:ss.sss", conformément à ISO 8601. Le fuseau horaire TUC est spécifié sous la forme "aaaa-mm-jjThh:mm:ss.sssZ". Un temps TUC par rapport à un fuseau horaire local est spécifié sous la forme "aaaa-mm-jjThh:mm:ss.sss-hh:mm". La deuxième composante (représentée ici sous la forme "ss.sss") peut avoir un nombre quelconque de chiffres dans sa partie fractionnelle afin de permettre toute sorte de précision en quelques secondes.

6.4.25 DateTimeInterval

Intervalle de temps entre deux dates et instants.

Le Tableau 42 présente tous les attributs de DateTimeInterval.

Tableau 42 – Attributs de Domain::DateTimeInterval

nom	mult	type	description
start	0..1	DateTime	Date et heure auxquelles commence cet intervalle de temps.
end	0..1	DateTime	Date et heure auxquelles finit cet intervalle de temps.

6.4.26 Type primitif de données Decimal

Le type Decimal renvoie au système de notation décimal utilisant la base 10 pour représenter les nombres réels.

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6.4.27 Compound DecimalQuantity

Le Tableau 43 présente tous les attributs de DecimalQuantity.

Tableau 43 – Attributs de Domain::DecimalQuantity

nom	mult	type	description
value	0..1	Decimal	
unit	0..1	UnitSymbol	
multiplier	0..1	UnitMultiplier	
currency	0..1	Currency	Grandeur avec valeur décimale et unité ou informations relatives à la devise associées.

6.4.28 Type de données Displacement

Unité de déplacement par rapport à une position de référence. Elle peut donc être négative.

Le Tableau 44 présente tous les attributs de Displacement.

Tableau 44 – Attributs de Domain::Displacement

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.29 Type primitif de données Duration

Durée représentée sous le format "PnYnMnDTnHnMnS", conformément à l'ISO 8601, où nY exprime un nombre d'années, nM un nombre de mois, nD un nombre de jours. La lettre T sépare l'expression de la date de l'expression de l'heure; ensuite, nH identifie un nombre d'heures, nM un nombre de minutes et nS un nombre de secondes. Le nombre de secondes peut être exprimé en nombre décimal alors que tous les autres nombres sont des entiers.

6.4.30 Type primitif de données Float

Un nombre à virgule flottante. La plage est indéterminée et n'est pas limitée.

6.4.31 Compound FloatQuantity

Grandeur avec valeur float (flottante) et informations associées relatives aux unités.

Le Tableau 45 présente tous les attributs de FloatQuantity.

Tableau 45 – Attributs de Domain::FloatQuantity

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	
multiplier	0..1	UnitMultiplier	

6.4.32 Type de données Frequency

Cycles par seconde.

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Le Tableau 46 présente tous les attributs de Frequency.

Tableau 46 – Attributs de Domain::Frequency

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=Hz)
multiplier	0..1	UnitMultiplier	

6.4.33 Type de données Hours

Temps spécifié en heures.

Le Tableau 47 présente tous les attributs de Hours.

Tableau 47 – Attributs de Domain::Hours

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=h)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.34 Type de données Impedance

Rapport tension/courant.

Le Tableau 48 présente tous les attributs de Impedance.

Tableau 48 – Attributs de Domain::Impedance

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	

6.4.35 Type de données Inductance

Partie inductive de la réactance (partie imaginaire de l'impédance), à la fréquence assignée.

Le Tableau 49 présente tous les attributs de Inductance.

Tableau 49 – Attributs de Domain::Inductance

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=H)
multiplier	0..1	UnitMultiplier	

6.4.36 Type de données InductancePerLength

Inductance par unité de longueur.

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Le Tableau 50 présente tous les attributs de InductancePerLength.

Tableau 50 – Attributs de Domain::InductancePerLength

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=H)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.37 Type primitif de données Integer

Nombre entier. La plage est indéterminée et n'est pas limitée.

6.4.38 Compound IntegerQuantity

Grandeur avec valeur integer (entière) et informations associées relatives aux unités.

Le Tableau 51 présente tous les attributs de IntegerQuantity.

Tableau 51 – Attributs de Domain::IntegerQuantity

nom	mult	type	description
value	0..1	Integer	
unit	0..1	UnitSymbol	
multiplier	0..1	UnitMultiplier	

6.4.39 Type de données KiloActivePower

Puissance active, en kilowatts.

Le Tableau 52 présente tous les attributs de KiloActivePower.

Tableau 52 – Attributs de Domain::KiloActivePower

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=W)
multiplier	0..1	UnitMultiplier	(const=k)

6.4.40 Type de données Length

Unité de longueur. Jamais négative.

Le Tableau 53 présente tous les attributs de Length.

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Tableau 53 – Attributs de Domain::Length

nom	mult	type	description
multiplier	0..1	UnitMultiplier	
unit	0..1	UnitSymbol	(const=m)
value	0..1	Float	

6.4.41 Type de données Minutes

Temps, en minutes.

Le Tableau 54 présente tous les attributs de Minutes.

Tableau 54 – Attributs de Domain::Minutes

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=min)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.42 Type de données Money

Quantité d'argent.

Le Tableau 55 présente tous les attributs de Money.

Tableau 55 – Attributs de Domain::Money

nom	mult	type	description
multiplier	0..1	UnitMultiplier	
unit	0..1	Currency	
value	0..1	Decimal	

6.4.43 Type primitif de données MonthDay

Format MonthDay sous la forme "--mm-dd" conforme au type de données XSD gMonthDay.

6.4.44 Compound MonthDayInterval

Intervalle entre deux fois spécifiées comme "month" (mois) et "day" (jour).

Le Tableau 56 présente tous les attributs de MonthDayInterval.

Tableau 56 – Attributs de Domain::MonthDayInterval

nom	mult	type	description
end	0..1	MonthDay	Heure à laquelle finit cet intervalle de temps.
start	0..1	MonthDay	Heure à laquelle commence cet intervalle de temps.

6.4.45 Type de données PU

Par unité – valeur négative ou positive se référant à une base définie. Valeurs généralement comprises entre −10 et +10.

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Le Tableau 57 présente tous les attributs de PU.

Tableau 57 – Attributs de Domain::PU

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.46 Type de données PerCent

Pourcentage sur une base définie. Spécifier par exemple 100 pour indiquer la base définie.

Le Tableau 58 présente tous les attributs de PerCent.

Tableau 58 – Attributs de Domain::PerCent

nom	mult	type	description
value	0..1	Float	Normalement entre 0 et 100 sur une base définie
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.47 Type de données Pressure

Pression en pascals.

Le Tableau 59 présente tous les attributs de Pressure.

Tableau 59 – Attributs de Domain::Pressure

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=Pa)
multiplier	0..1	UnitMultiplier	

6.4.48 Type de données Reactance

Réactance (partie imaginaire de l'impédance), à une fréquence assignée.

Le Tableau 60 présente tous les attributs de Reactance.

Tableau 60 – Attributs de Domain::Reactance

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	

6.4.49 Type de données ReactancePerLength

Réactance (partie imaginaire de l'impédance) par unité de longueur, à la fréquence assignée.

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Le Tableau 61 présente tous les attributs de ReactancePerLength.

Tableau 61 – Attributs de Domain::ReactancePerLength

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.50 Type de données ReactivePower

Produit de la valeur RMS (valeur efficace) de la tension et de la valeur RMS de la composante en quadrature du courant.

Le Tableau 62 présente tous les attributs de ReactivePower.

Tableau 62 – Attributs de Domain::ReactivePower

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=VAr)
multiplier	0..1	UnitMultiplier	

6.4.51 Type de données RealEnergy

Énergie électrique réelle.

Le Tableau 63 présente tous les attributs de RealEnergy.

Tableau 63 – Attributs de Domain::RealEnergy

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=Wh)
multiplier	0..1	UnitMultiplier	

6.4.52 Type de données Resistance

Résistance (partie réelle de l'impédance).

Le Tableau 64 présente tous les attributs de Resistance.

Tableau 64 – Attributs de Domain::Resistance

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	

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6.4.53 Type de données ResistancePerLength

Résistance (partie réelle de l'impédance) par unité de longueur.

Le Tableau 65 présente tous les attributs de ResistancePerLength.

Tableau 65 – Attributs de Domain::ResistancePerLength

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=ohm)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.54 Type de données RotationSpeed

Nombre de tours par seconde.

Le Tableau 66 présente tous les attributs de RotationSpeed.

Tableau 66 – Attributs de Domain::RotationSpeed

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=none)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.55 Type de données Seconds

Temps, en secondes.

Le Tableau 67 présente tous les attributs de Seconds.

Tableau 67 – Attributs de Domain::Seconds

nom	mult	type	description
value	0..1	Float	Temps, en secondes
unit	0..1	UnitSymbol	(const=s)
multiplier	0..1	UnitMultiplier	(const=none)

6.4.56 Type de données Speed

Distance par unité de temps.

Le Tableau 68 présente tous les attributs de Speed.

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Tableau 68 – Attributs de Domain::Speed

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=s)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.57 Type primitif de données String

Chaîne constituée d'une séquence de caractères. Le codage de caractères est UTF-8. La longueur de la chaîne n'est ni spécifiée ni limitée.

6.4.58 Compoound StringQuantity

Grandeur avec valeur chaîne de caractères (lorsqu'il importe peu qu'il s'agisse d'un entier ou d'un nombre à virgule flottante) et informations associées relatives aux unités.

Le Tableau 69 présente tous les attributs de StringQuantity.

Tableau 69 – Attributs de Domain::StringQuantity

nom	mult	type	description
value	0..1	String	
unit	0..1	UnitSymbol	
multiplier	0..1	UnitMultiplier	

6.4.59 Type de données Susceptance

Partie imaginaire de l'admittance.

Le Tableau 70 présente tous les attributs de Susceptance.

Tableau 70 – Attributs de Domain::Susceptance

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	

6.4.60 Type de données SusceptancePerLength

Partie imaginaire de l'admittance par unité de longueur.

Le Tableau 71 présente tous les attributs de SusceptancePerLength.

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Tableau 71 – Attributs de Domain::SusceptancePerLength

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=S)
multiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=m)
denominatorMultiplier	0..1	UnitMultiplier	(const=none)

6.4.61 Type de données Temperature

Valeur de température en degrés Celsius.

Le Tableau 72 présente tous les attributs de Temperature.

Tableau 72 – Attributs de Domain::Temperature

nom	mult	type	description
multiplier	0..1	UnitMultiplier	(const=none)
unit	0..1	UnitSymbol	(const=degC)
value	0..1	Float	

6.4.62 Type primitif de données Time

Heure sous la forme "hh:mm:ss.sss", conformément à l'ISO 8601. Le fuseau horaire TUC est spécifié sous forme "hh:mm:ss.sssZ". Un temps TUC par rapport à un fuseau horaire local est spécifié sous la forme "hh:mm:ss.sss±hh:mm". La deuxième composante (représentée ici sous la forme "ss.sss") peut avoir un nombre quelconque de chiffres dans sa partie fractionnelle afin de permettre toute sorte de précision en quelques secondes.

6.4.63 Compound TimeInterval

Intervalle de temps entre deux instants.

Le Tableau 73 présente tous les attributs de TimeInterval.

Tableau 73 – Attributs de Domain::TimeInterval

nom	mult	type	description
start	0..1	Time	Heure à laquelle commence cet intervalle de temps.
end	0..1	Time	Heure à laquelle finit cet intervalle de temps.

6.4.64 Énumération UnitMultiplier

Multiplicateurs d'unité définis pour le CIM.

Le Tableau 74 présente tous les libellés de UnitMultiplier.

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Tableau 74 – Libellés de Domain::UnitMultiplier

libellé	valeur	description
p		Pico 10**-12.
n		Nano 10**-9.
micro		Micro 10**-6.
m		Milli 10**-3.
c		Centi 10**-2.
d		Déci 10**-1.
k		Kilo 10**3.
M		Méga 10**6.
G		Giga 10**9.
T		Téra 10**12.
none		Aucun multiplicateur ou multiplier par 1 de façon équivalente.
** signifie "à la puissance".		

6.4.65 Énumération UnitSymbol

Unités définies en vue de leur utilisation dans le CIM.

Le Tableau 75 présente tous les libellés de UnitSymbol.

Tableau 75 – Libellés de Domain::UnitSymbol

libellé	valeur	description
VA		Puissance apparente en volts ampères.
W		Puissance active en watts.
VAr		Puissance réactive en volts ampères réactifs.
VAh		Énergie apparente en heures volt-ampère.
Wh		Énergie réelle en wattheures.
VArh		Énergie réactive en heures réactives volt-ampère.
V		Tension en volts.
ohm		Résistance en ohms.
A		Courant en ampères.
F		Capacité en farads.
H		Inductance en henrys.
degC		Température relative en degrés Celsius. Le symbole est °C dans le système international d'unités (SI). La charge électrique est mesurée en coulombs qui a pour symbole C. Pour distinguer les degrés Celsius et le coulomb, le symbole utilisé dans l'UML est degC. La raison pour laquelle °C n'est pas utilisé tient à ce qu'il est difficile de gérer le caractère spécial ° dans le logiciel.
s		Temps en secondes.
min		Temps en minutes.
h		Temps en heures.
deg		Angle plan en degrés.
rad		Angle plan en radians.

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libellé	valeur	description
J		Énergie en joules.
N		Force en newtons.
S		Conductance en siemens.
none		Grandeur sans dimension, par exemple: compte, par unité, etc.
Hz		Fréquence en hertz.
g		Masse en grammes.
Pa		Pression en pascals (N/m2).
m		Longueur en mètres.
m2		Surface en mètres carrés.
m3		Volume en mètres cubes.

6.4.66 Type de données Voltage

Tension électrique. Elle peut être alternative ou continue.

Le Tableau 76 présente tous les attributs de Voltage.

Tableau 76 – Attributs de Domain::Voltage

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=V)
multiplier	0..1	UnitMultiplier	

6.4.67 Type de données VoltagePerReactivePower

Variation de la tension avec la puissance réactive.

Le Tableau 77 présente tous les attributs de VoltagePerReactivePower.

Tableau 77 – Attributs de Domain::VoltagePerReactivePower

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=V)
multiplier	0..1	UnitMultiplier	
denominatorUnit	0..1	UnitSymbol	(const=VAr)
denominatorMultiplier	0..1	UnitMultiplier	

6.4.68 Type de données Volume

Volume.

Le Tableau 78 présente tous les attributs de Volume.

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Tableau 78 – Attributs de Domain::Volume

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m3)
multiplier	0..1	UnitMultiplier	

6.4.69 Type de données VolumeFlowRate

Volume par unité de temps.

Le Tableau 79 présente tous les attributs de VolumeFlowRate.

Tableau 79 – Attributs de Domain::VolumeFlowRate

nom	mult	type	description
denominatorMultiplier	0..1	UnitMultiplier	(const=none)
denominatorUnit	0..1	UnitSymbol	(const=s)
multiplier	0..1	UnitMultiplier	(const=none)
unit	0..1	UnitSymbol	(const=m3)
value	0..1	Float	

6.4.70 Type de données WaterLevel

Niveau d'eau présente dans le réservoir par rapport à une référence de type niveau moyen de la mer.

Le Tableau 80 présente tous les attributs de WaterLevel.

Tableau 80 – Attributs de Domain::WaterLevel

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m)
multiplier	0..1	UnitMultiplier	

6.4.71 Type de données Weight

Poids d'un objet.

Le Tableau 81 présente tous les attributs de Weight.

Tableau 81 – Attributs de Domain::Weight

nom	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=g)
multiplier	0..1	UnitMultiplier	

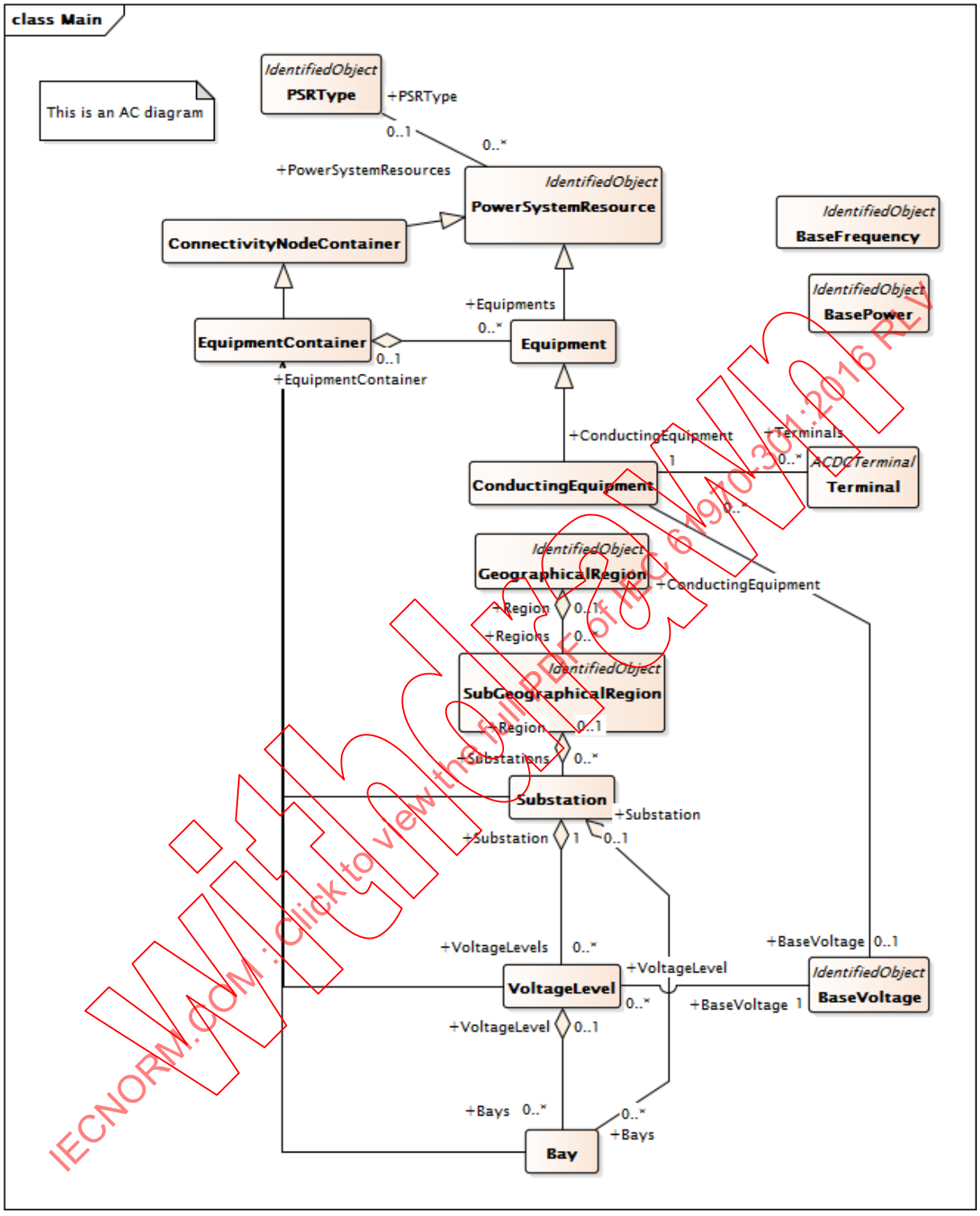
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6.5 Paquetage Core

6.5.1 Généralités

Contient les entités centrales PowerSystemResource (ressource du système de puissance) et ConductingEquipment (équipement conducteur) partagées par toutes les applications plus les collections communes de ces entités. Toutes les applications n'exigent pas toutes les entités Core. Ce paquetage ne dépend d'aucun autre paquetage (à l'exception du paquetage Domain), mais en revanche, la plupart des autres paquetages ont des associations et des généralisations qui dépendent de ce paquetage.

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Figure 72 – Diagramme de classe Core::Main

Figure 72: Ce diagramme représente les principales classes nécessaires à toute application du CIM pour modéliser des systèmes de transport et de production.

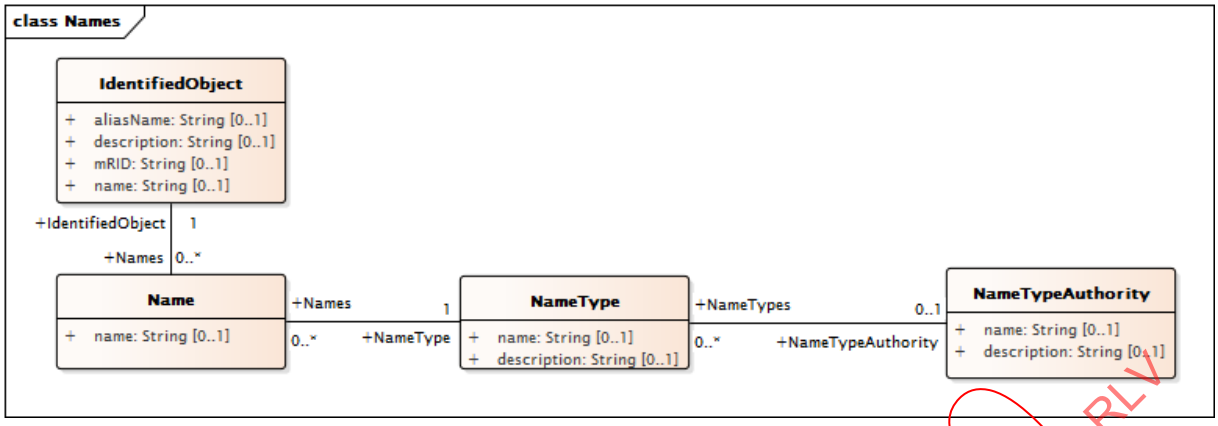


Figure 73 – Diagramme de classe Core::Names

Figure 73: Ce diagramme représente les classes utilisées pour attribuer des noms aux objets identifiés.

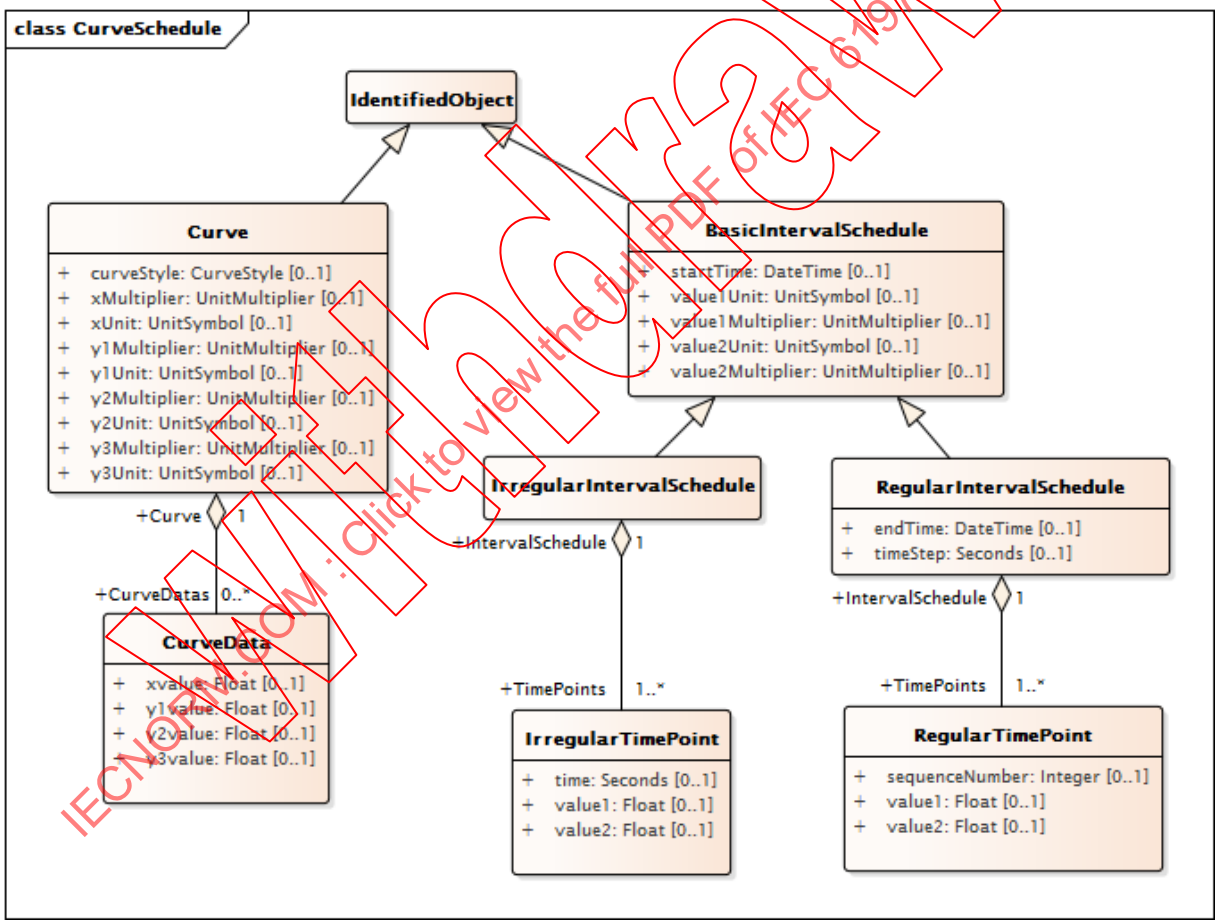


Figure 74 – Diagramme de classe Core::CurveSchedule

Figure 74: Ce diagramme représente le modèle commun pour des courbes et des programmes liés au temps.

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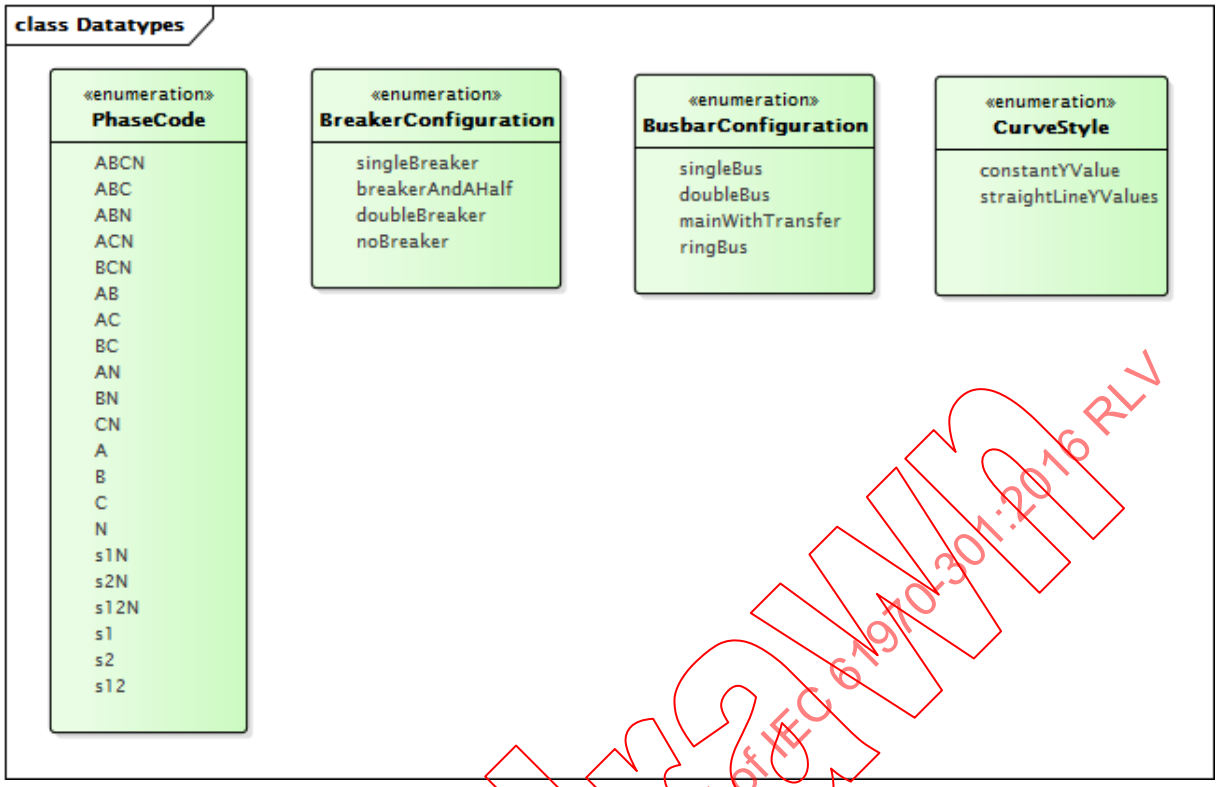


Figure 75 – Diagramme de classe Core::Datatypes

Figure 75: Ce diagramme représente les types de données spécifiques au paquetage Core.

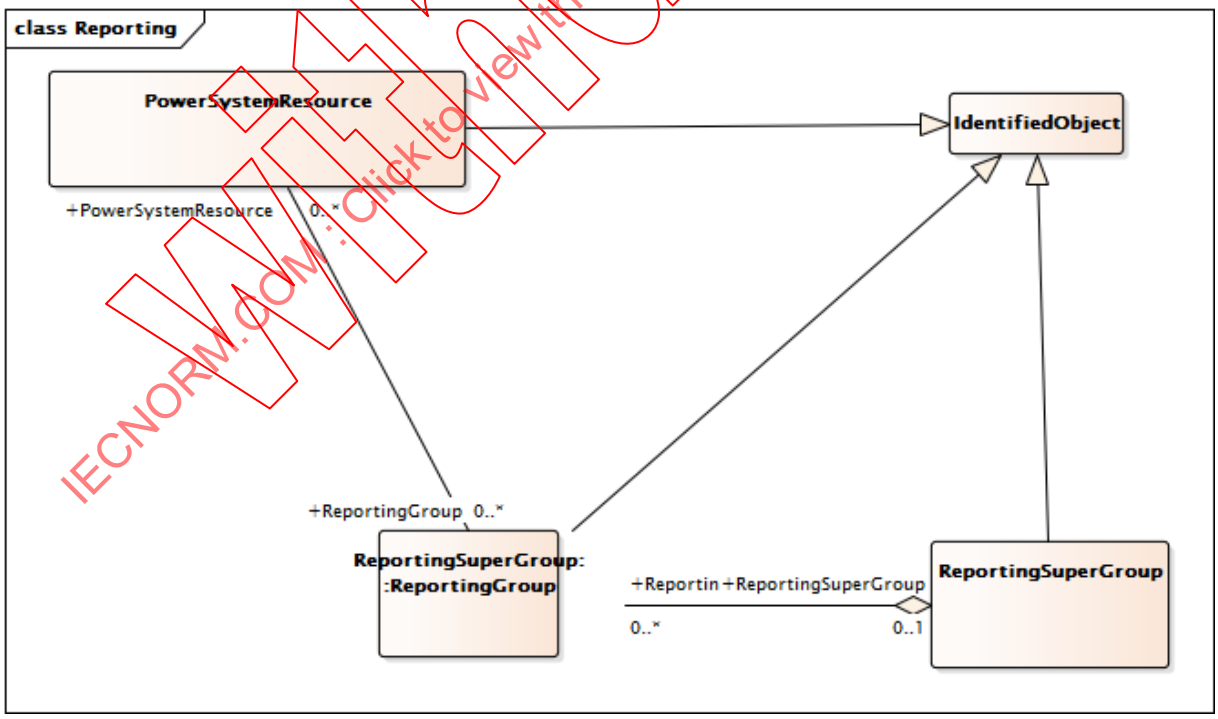


Figure 76 – Diagramme de classe Core::Reporting

Figure 76: Ce diagramme représente le modèle commun pour le reporting ad hoc.

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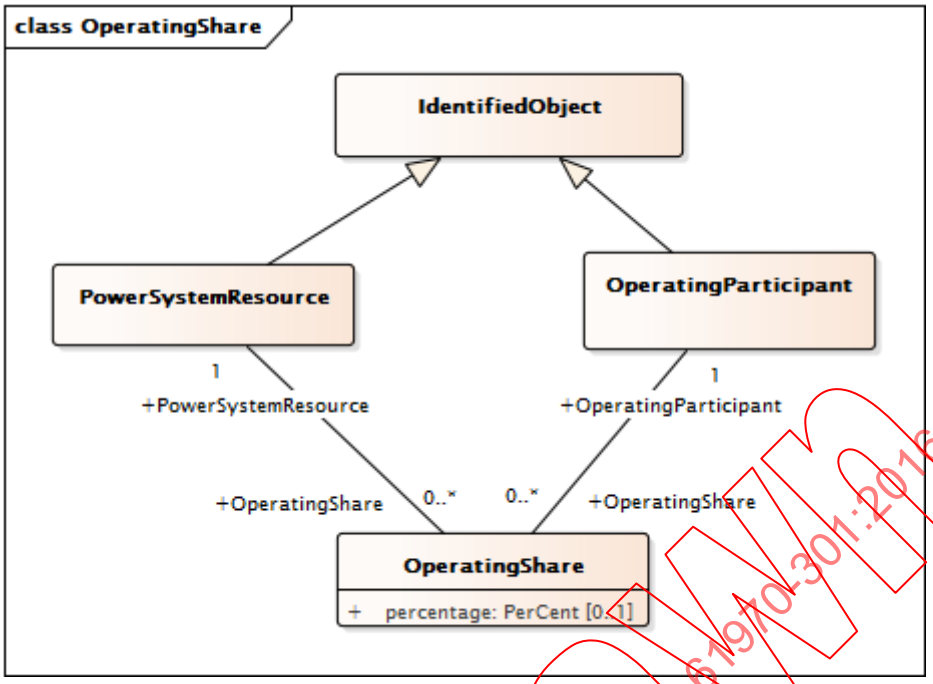


Figure 77 – Diagramme de classe Core::OperatingShare

Figure 77: Ce diagramme représente le modèle commun pour la quote-part d'exploitation.

6.5.2 ACDCTerminal

Point de connexion électrique (à courant alternatif ou à courant continu) à une partie d'un équipement conducteur. Les Terminals (bornes) sont connectées sur des points de connexion physiques appelés nœuds de connectivité (ConnectivityNode).

Le Tableau 82 présente tous les attributs de ACDCTerminal.

Tableau 82 – Attributs de Core::ACDCTerminal

nom	mult	type	description
connected	0..1	Boolean	Le statut "connected" (connecté) est relatif à un modèle de topologie nodale et à la relation nœud topologique-borne. "True" (vrai) implique que la borne est connectée au nœud topologique connexe et "false" (faux) implique qu'elle ne l'est pas. Dans un modèle de topologie nodale, le statut "connected" (connecté) est utilisé pour indiquer si l'équipement est déconnecté sans devoir changer la connectivité décrite par la relation nœud topologique-borne. Un cas valide est lorsque l'équipement conducteur peut être connecté à une extrémité et ouvert à l'autre. C'est un cas approprié, en particulier pour un segment de ligne de courant alternatif où la charge de ligne réactive peut être significative.
sequenceNumber	0..1	Integer	Orientation des connexions de bornes pour un équipement conducteur à plusieurs bornes. La numérotation séquentielle commence à 1 et il convient que les bornes supplémentaires suivent l'ordre croissant. La première borne est le "point de départ" d'une branche à deux bornes.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

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Le Tableau 83 présente toutes les extrémités d'association de ACDCTerminal avec d'autres classes.

Tableau 83 – Extrémités d'association de Core::ACDCTerminal avec d'autres classes

mult à partir de	nom	mult vers	type	description
1..*	BusNameMarker	0..1	BusNameMarker	Marqueur de nom du bus utilisé pour nommer le bus (nœud topologique).
0..1	OperationalLimitSet	0..*	OperationalLimitSet	Jeu de limites opérationnelles au niveau de la borne.
0..1	Measurements	0..*	Measurement	Les Measurements associées à cette borne définissent l'emplacement de Measurement dans la topologie de réseau. Elles peuvent être utilisées, par exemple, pour représenter la position d'un capteur, comme un transformateur de tension (PT: Voltage transformer) sur un jeu de barres ou un transformateur de courant (CT: Current transformer) sur une barre entre un disjoncteur et un isolateur.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.3 BaseFrequency

La classe décrit une fréquence de base pour un réseau de système de puissance. En cas de réseaux d'alimentation multiples avec différentes fréquences, par exemple 50 Hz ou 60 Hz, chaque réseau a sa propre classe de fréquence de base. Par conséquent, les objets de systèmes de puissance ayant différentes fréquences de base sont censés figurer dans des documents séparés dans lesquels chaque document a une instance de fréquence de base unique.

Le Tableau 84 présente tous les attributs de BaseFrequency.

Tableau 84 – Attributs de Core::BaseFrequency

nom	mult	type	description
frequency	0..1	Frequency	Fréquence de base.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 85 présente toutes les extrémités d'association de BaseFrequency avec d'autres classes.

Tableau 85 – Extrémités d'association de Core::BaseFrequency avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

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6.5.4 BasePower

La classe BasePower définit la puissance de base dans les calculs par unité.

Le Tableau 86 présente tous les attributs de BasePower.

Tableau 86 – Attributs de Core::BasePower

nom	mult	type	description
BasePower	0..1	ApparentPower	Valeur utilisée comme puissance de base.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 87 présente toutes les extrémités d'association de BasePower avec d'autres classes.

Tableau 87 – Extrémités d'association de Core::BasePower avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.5 BaseVoltage

Définit une tension de base du système qui est référencée.

Le Tableau 88 présente tous les attributs de BaseVoltage.

Tableau 88 – Attributs de Core::BaseVoltage

nom	mult	type	description
nominalVoltage	0..1	Voltage	Tension de base des ressources du système de puissance.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 89 présente toutes les extrémités d'association de BaseVoltage avec d'autres classes.

Tableau 89 – Extrémités d'association de Core::BaseVoltage avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	ConductingEquipment	0..*	ConductingEquipment	Tout équipement conducteur qui a cette tension de base. À n'utiliser que lorsqu'aucun conteneur de niveau de tension n'est utilisé et qu'une seule tension de base s'applique. Par exemple, n'est pas utilisé pour des transformateurs.

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mult à partir de	nom	mult vers	type	description
1..1	VoltageLevel	0..*	VoltageLevel	Niveaux de tension ayant cette tension de base.
0..1	TransformerEnds	0..*	TransformerEnd	Extrémités de transformateur à la tension de base. Elle est primordiale pour calculer le PU.
0..1	TopologicalNode	0..*	TopologicalNode	Nœuds topologiques à la tension de base.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.6 BasicIntervalSchedule

Programme de valeurs à des instants donnés.

Le Tableau 90 présente tous les attributs de BasicIntervalSchedule.

Tableau 90 – Attributs de Core::BasicIntervalSchedule

nom	mult	type	description
startTime	0..1	DateTime	Heure pour le premier TimePoint.
value1Unit	0..1	UnitSymbol	Unités de mesure pour value1.
value1Multiplier	0..1	UnitMultiplier	Multiplicateur de value1.
value2Unit	0..1	UnitSymbol	Unités de mesure pour value2.
value2Multiplier	0..1	UnitMultiplier	Multiplicateur de value2.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 91 présente toutes les extrémités d'association de BasicIntervalSchedule avec d'autres classes.

Tableau 91 – Extrémités d'association de Core::BasicIntervalSchedule avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.7 Bay

Ensemble des ressources du système de puissance (au sein d'un poste donné) comprenant équipement conducteur, relais de protection, mesures et télémesure. Une cellule (bay) représente généralement un groupement physique lié à la modularisation de l'équipement.

Le Tableau 92 présente tous les attributs de Bay.

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Tableau 92 – Attributs de Core::Bay

nom	mult	type	description
bayEnergyMeasFlag	0..1	Boolean	Indique la présence/l'absence de mesures d'énergie.
bayPowerMeasFlag	0..1	Boolean	Indique la présence/l'absence de mesures de puissance active/réactive.
breakerConfiguration	0..1	BreakerConfiguration	Configuration du disjoncteur.
busBarConfiguration	0..1	BusbarConfiguration	Configuration du jeu de barres.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 93 présente toutes les extrémités d'association de Bay avec d'autres classes.

Tableau 93 – Extrémités d'association de Core::Bay avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	Substation	0..1	Substation	Poste qui contient la cellule.
0..*	VoltageLevel	0..1	VoltageLevel	Niveau de tension qui contient cette cellule.
0..1	Equipments	0..*	Equipment	hérité de: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	hérité de: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	hérité de: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	hérité de: PowerSystemResource
0..1	Controls	0..*	Control	hérité de: PowerSystemResource
0..1	Measurements	0..*	Measurement	hérité de: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	hérité de: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	hérité de: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.8 Énumération BreakerConfiguration

Disposition de commutation pour Bay.

Le Tableau 94 présente tous les libellés de BreakerConfiguration.

Tableau 94 – Libellés de Core::BreakerConfiguration

libellé	valeur	description
singleBreaker		Disjoncteur unique.
breakerAndAHalf		Disjoncteur et demi.
doubleBreaker		Double disjoncteur.
noBreaker		Aucun disjoncteur.

6.5.9 Énumération BusbarConfiguration

Disposition du jeu de barres pour Bay.

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Le Tableau 95 présente tous les libellés de BusbarConfiguration.

Tableau 95 – Libellés de Core::BusbarConfiguration

libellé	valeur	description
singleBus		Barre de transfert unique.
doubleBus		Double barre de transfert.
mainWithTransfer		Barre de transfert principale avec barre de transfert.
ringBus		Barre de transfert en anneau

6.5.10 ConductingEquipment

Parties du système de puissance à courant alternatif conçues pour transporter du courant ou connectées par des bornes de façon à assurer la conduction.

Le Tableau 96 présente tous les attributs de ConductingEquipment.

Tableau 96 – Attributs de Core::ConductingEquipment

nom	mult	type	description
aggregate	0..1	Boolean	hérité de: Equipment
normallyInService	0..1	Boolean	hérité de: Equipment
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 97 présente toutes les extrémités d'association de ConductingEquipment avec d'autres classes.

Tableau 97 – Extrémités d'association de Core::ConductingEquipment avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	BaseVoltage	0..1	BaseVoltage	Tension de base pour cet équipement conducteur. À n'utiliser que lorsqu'aucun conteneur de niveau de tension n'est utilisé et qu'une seule tension de base s'applique. Par exemple, n'est pas utilisée pour des transformateurs.
1..1	SvStatus	0..1	SvStatus	Variable d'état de statut associée à cet équipement conducteur.
0..*	ProtectionEquipments	0..*	ProtectionEquipment	Équipement de protection utilisé pour protéger un équipement conducteur spécifique.
1..1	Terminals	0..*	Terminal	L'équipement conducteur a des bornes qui peuvent être connectées à d'autres bornes d'un équipement conducteur par des nœuds de connectivité ou des nœuds topologiques.
0..1	Faults	0..*	Fault	hérité de: Equipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	hérité de: Equipment

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mult à partir de	nom	mult vers	type	description
1..1	ContingencyEquipment	0..*	ContingencyEquipment	hérité de: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	hérité de: Equipment
0..*	PSRType	0..1	PSRType	hérité de: PowerSystemResource
0..1	Controls	0..*	Control	hérité de: PowerSystemResource
0..1	Measurements	0..*	Measurement	hérité de: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	hérité de: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	hérité de: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.11 ConnectivityNode

Les Connectivity nodes (nœuds de connectivité) sont des points auxquels les bornes d'un équipement conducteur à courant alternatif sont raccordées ensemble avec une impédance nulle.

Le Tableau 98 présente tous les attributs de ConnectivityNode.

Tableau 98 – Attributs de Core::ConnectivityNode

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
nom	0..1	String	hérité de: IdentifiedObject

Le Tableau 99 présente toutes les extrémités d'association de ConnectivityNode avec d'autres classes.

Tableau 99 – Extrémités d'association de Core::ConnectivityNode avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	TopologicalNode	0..1	TopologicalNode	Nœud topologique auquel est affecté ce nœud de connectivité. Peut dépendre de l'état courant des commutateurs dans le réseau.
0..*	ConnectivityNodeContainer	1..1	ConnectivityNodeContainer	Conteneur de ce nœud de connectivité
0..1	Terminals	0..*	Terminal	Bornes interconnectées à impédance zéro à ce nœud de connectivité.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.12 ConnectivityNodeContainer

Classe de base pour tous les objets qui peuvent contenir des nœuds de connectivité ou des nœuds topologiques.

Le Tableau 100 présente tous les attributs de ConnectivityNodeContainer.

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Tableau 100 – Attributs de Core::ConnectivityNodeContainer

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 101 présente toutes les extrémités d'association de ConnectivityNodeContainer avec d'autres classes.

Tableau 101 – Extrémités d'association de Core::ConnectivityNodeContainer avec d'autres classes

mult à partir de	nom	mult vers	type	description
1..1	ConnectivityNodes	0..*	ConnectivityNode	Nœuds de connectivité qui appartiennent à ce conteneur de nœuds de connectivité.
0..1	TopologicalNode	0..*	TopologicalNode	Les nœuds topologiques qui appartiennent à ce conteneur de nœuds de connectivité.
0..*	PSRType	0..1	PSRType	hérité de: PowerSystemResource
0..1	Controls	0..*	Control	hérité de: PowerSystemResource
0..1	Measurements	0..*	Measurement	hérité de: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	hérité de: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	hérité de: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.13 Curve

Courbe d'usage général ou relation fonctionnelle entre une variable indépendante (axe X) et des variables dépendantes (axe Y).

Le Tableau 102 présente tous les attributs de Curve.

Tableau 102 – Attributs de Core::Curve

nom	mult	type	description
curveStyle	0..1	CurveStyle	Style ou forme de la courbe.
xMultiplier	0..1	UnitMultiplier	Multiplicateur pour l'axe X.
xUnit	0..1	UnitSymbol	Unités de mesure de l'axe X.
y1Multiplier	0..1	UnitMultiplier	Multiplicateur pour l'axe Y1.
y1Unit	0..1	UnitSymbol	Unités de mesure de l'axe Y1.
y2Multiplier	0..1	UnitMultiplier	Multiplicateur pour l'axe Y2.
y2Unit	0..1	UnitSymbol	Unités de mesure de l'axe Y2.
y3Multiplier	0..1	UnitMultiplier	Multiplicateur pour l'axe Y3.
y3Unit	0..1	UnitSymbol	Unités de mesure de l'axe Y3.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject

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nom	mult	type	description
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 103 présente toutes les extrémités d'association de Curve avec d'autres classes.

Tableau 103 – Extrémités d'association de Core::Curve avec d'autres classes

mult à partir de	nom	mult vers	type	description
1..1	CurveDatas	0..*	CurveData	Valeurs de données du point définissant cette courbe.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.14 Classe racine CurveData

Points de données d'usage général pour définir une courbe. L'utilisation de cette classe générique est déconseillée si une classe plus spécifique peut être utilisée pour spécifier les valeurs des axes X et Y ainsi que leurs types de données spécifiques.

Le Tableau 104 présente tous les attributs de CurveData.

Tableau 104 – Attributs de Core::CurveData

nom	mult	type	description
xvalue	0..1	Float	Valeur de données de la variable de l'axe X, en fonction des unités de l'axe X.
y1value	0..1	Float	Valeur de données de la première variable de l'axe Y, en fonction des unités de l'axe Y.
y2value	0..1	Float	Valeur de données de la deuxième variable de l'axe Y (s'il y en a une), en fonction des unités de l'axe Y.
y3value	0..1	Float	Valeur de données de la troisième variable de l'axe Y (s'il y en a une), en fonction des unités de l'axe Y.

Le Tableau 105 présente toutes les extrémités d'association de CurveData avec d'autres classes.

Tableau 105 – Extrémités d'association de Core::CurveData avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	Curve	1..1	Curve	Courbe de ce point de données de courbe.

6.5.15 Énumération CurveStyle

Style ou forme de la courbe

Le Tableau 106 présente tous les libellés de CurveStyle.

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Tableau 106 – Libellés de Core::CurveStyle

libellé	valeur	description
constantYValue		Les valeurs de l'axe Y sont censées être constantes jusqu'au point suivant de courbe et avant le premier point de courbe.
straightLineYValues		Les valeurs de l'axe Y sont censées former une ligne droite entre les valeurs. Aussi appelé interpolation linéaire.

6.5.16 Equipment

Éléments d'un système de puissance qui sont des appareils matériels, électroniques ou mécaniques.

Le Tableau 107 présente tous les attributs de Equipment.

Tableau 107 – Attributs de Core::Equipment

nom	mult	type	description
aggregate	0..1	Boolean	L'instance unique de l'équipement représente plusieurs éléments d'équipement qui ont été modélisés ensemble comme un agrégat. Des exemples de cela sont les transformateurs de puissance ou les machines synchrones fonctionnant en parallèle, modélisées comme un seul agrégat de transformateur de puissance ou agrégat de machine synchrone. Cela ne doit pas être utilisé pour indiquer un équipement qui fait partie intégrante d'un groupe d'équipements interdépendants produits par un programme de production de réseau.
normallyInService	0..1	Boolean	Si true (vrai), l'équipement est normalement en service.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 108 présente toutes les extrémités d'association de Equipment avec d'autres classes.

Tableau 108 – Extrémités d'association de Core::Equipment avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	Faults	0..*	Fault	Tous les défauts présents sur cet équipement.
0..1	OperationalLimitSet	0..*	OperationalLimitSet	Jeux de limites opérationnelles associés à cet équipement.
1..1	ContingencyEquipment	0..*	ContingencyEquipment	Équipements de contingence auxquels cet équipement participe.
0..*	EquipmentContainer	0..1	EquipmentContainer	Conteneur de cet équipement.
0..*	PSRType	0..1	PSRType	hérité de: PowerSystemResource
0..1	Controls	0..*	Control	hérité de: PowerSystemResource
0..1	Measurements	0..*	Measurement	hérité de: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	hérité de: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	hérité de: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

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6.5.17 EquipmentContainer

Un choix de modélisation pour proposer une classe racine qui regroupe des équipements.

Le Tableau 109 pésente tous les attributs de EquipmentContainer.

Tableau 109 – Attributs de Core::EquipmentContainer

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 110 présente toutes les extrémités d'association de EquipmentContainer avec d'autres classes.

Tableau 110 – Extrémités d'association de Core::EquipmentContainer avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	Equipments	0..*	Equipment	Équipement contenu.
1..1	ConnectivityNodes	0..*	ConnectivityNode	hérité de: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	hérité de: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	hérité de: PowerSystemResource
0..1	Controls	0..*	Control	hérité de: PowerSystemResource
0..1	Measurements	0..*	Measurement	hérité de: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	hérité de: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	hérité de: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.18 GeographicalRegion

Région géographique d'un modèle de réseau de système de puissance.

Le Tableau 111 présente tous les attributs de GeographicalRegion.

Tableau 111 – Attributs de Core::GeographicalRegion

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 112 présente toutes les extrémités d'association de GeographicalRegion avec d'autres classes.

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Tableau 112 – Extrémités d'association de Core::GeographicalRegion avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	Regions	0..*	SubGeographicalRegion	Toutes les sous-régions géographiques de cette région géographique.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.19 Classe racine IdentifiedObject

Il s'agit d'une classe racine qui fournit une identification commune pour toutes les classes nécessitant des attributs d'identification et de dénomination.

Le Tableau 113 présente tous les attributs de IdentifiedObject.

Tableau 113 – Attributs de Core::IdentifiedObject

nom	mult	type	description
aliasName	0..1	String	L'aliasName est un nom de l'objet en texte lisible par l'homme en remplacement de IdentifiedObject.name. Elle peut ne pas être unique et peut ne pas se corréler à une hiérarchie de dénomination. L'attribut aliasName a été retenu parce qu'il est compatible avec les précédentes versions du CIM. Il est cependant recommandé de remplacer aliasName par la classe Name puisqu'il est prévu de supprimer aliasName à l'avenir.
description	0..1	String	La description est un texte lisible par l'homme qui décrit ou nomme l'objet. Elle peut ne pas être unique et peut ne pas se corréler à une hiérarchie de dénomination.
mRID	0..1	String	Identificateur Master resource publié par une autorité de modèle. Le mRID (identificateur Master resource) est globalement unique dans un contexte d'échange. Il est facile d'obtenir une unicité globale en utilisant un UUID tel que spécifié dans la RFC 4122 pour le mRID L'utilisation d'un UUID est fortement recommandée. Pour des fichiers de données CIMXML en syntaxe RDF, conformément à l'IEC 61970-552:2013, le mRID est mis en correspondance avec les attributs rdf:ID ou rdf:about qui identifient les éléments d'objet du CIM.
name	0..1	String	Le nom est un texte lisible par l'homme et, si possible, non unique, qui nomme l'objet.

Le Tableau 114 présente toutes les extrémités d'association de IdentifiedObject avec d'autres classes.

Tableau 114 – Extrémités d'association de Core::IdentifiedObject avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	DiagramObjects	0..*	DiagramObject	Objets de diagramme qui sont associés à l'objet de domaine.
1..1	Names	0..*	Name	Tous les noms de cet objet identifié.

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6.5.20 IrregularIntervalSchedule

Le programme comporte plusieurs instants entre lesquels le temps varie.

Le Tableau 115 présente tous les attributs de IrregularIntervalSchedule.

Tableau 115 – Attributs de Core::IrregularIntervalSchedule

nom	mult	type	description
startTime	0..1	DateTime	hérité de: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	hérité de: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	hérité de: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	hérité de: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	hérité de: BasicIntervalSchedule
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 116 présente toutes les extrémités d'association de IrregularIntervalSchedule avec d'autres classes.

Tableau 116 – Extrémités d'association de Core::IrregularIntervalSchedule avec d'autres classes

mult à partir de	nom	mult vers	type	description
1..1	TimePoints	1..*	IrregularTimePoint	Valeurs de données du point définissant une courbe.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.21 Classe racine IrregularTimePoint

Des TimePoints pour un programme dans lequel le temps entre les points varie.

Le Tableau 117 présente tous les attributs de IrregularTimePoint.

Tableau 117 – Attributs de Core::IrregularTimePoint

nom	mult	type	description
time	0..1	Seconds	Le temps est lié à l'instant où commence le programme.
value1	0..1	Float	Première valeur au temps indiqué. La signification de cette valeur est définie par le type dérivé du programme associé.
value2	0..1	Float	Deuxième valeur au temps indiqué. La signification de cette valeur est définie par le type dérivé du programme associé.

Le Tableau 118 présente toutes les extrémités d'association de IrregularTimePoint avec d'autres classes.

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Tableau 118 – Extrémités d'association de Core::IrregularTimePoint avec d'autres classes

mult à partir de	nom	mult vers	type	description
1..*	IntervalSchedule	1..1	IrregularIntervalSchedule	Un IrregularTimePoint appartient à un IrregularIntervalSchedule.

6.5.22 Classe racine Name

La classe Name fournit les moyens de définir un nombre quelconque de noms lisibles par l'homme pour un objet. Un nom ne doit pas être utilisé pour définir des relations entre objets. Utiliser plutôt l'identification d'objet 'mRID' pour les relations entre objets.

Le Tableau 119 présente tous les attributs de Name.

Tableau 119 – Attributs de Core::Name

nom	mult	type	description
name	0..1	String	Tout texte libre qui désigne l'objet.

Le Tableau 120 présente toutes les extrémités d'association de Name avec d'autres classes.

Tableau 120 – Extrémités d'association de Core::Name avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	IdentifiedObject	1..1	IdentifiedObject	Objet identifié que désigne ce nom.
0..*	NameType	1..1	NameType	Type de ce nom.

6.5.23 Classe racine NameType

Type de nom. Les valeurs possibles pour l'attribut 'name' dépendent de la mise en œuvre mais des profils normatifs peuvent spécifier des types. Une entreprise peut avoir plusieurs systèmes informatiques dont chacun a son propre nom local pour le même objet, par exemple un système de planification peut utiliser d'autres noms qu'un système de gestion de l'énergie (EMS – Energy Management System). Un objet peut aussi avoir des noms différents dans le même système informatique, par exemple localName tel que le définit le CIM version 14. La définition du CIM14 est:

Le localName (nom local) est un nom de l'objet lisible par l'homme. C'est un nom en texte libre se trouvant à un nœud dans une hiérarchie de dénomination similaire à une structure de répertoire de fichiers. Une hiérarchie de dénomination relative à un système de puissance peut être la suivante: Substation, VoltageLevel, Equipment etc. Dans une telle hiérarchie, les enfants du même parent ont des noms qui sont généralement uniques les uns par rapport aux autres.

Le Tableau 121 présente tous les attributs de NameType.

Tableau 121 – Attributs de Core::NameType

nom	mult	type	description
name	0..1	String	Nom du type de nom.
description	0..1	String	Description du type de nom.

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Le Tableau 122 présente toutes les extrémités d'association de NameType avec d'autres classes.

Tableau 122 – Extrémités d'association de Core::NameType avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	NameTypeAuthority	0..1	NameTypeAuthority	Autorité en charge de la gestion des noms de ce type.
1..1	Names	0..*	Name	Tous les noms de ce type.

6.5.24 Classe racine NameTypeAuthority

Autorité responsable de créer et de gérer les noms d'un type donné. Il s'agit en général d'une organisation ou d'un système d'entreprise.

Le Tableau 123 présente tous les attributs de NameTypeAuthority.

Tableau 123 – Attributs de Core::NameTypeAuthority

nom	mult	type	description
name	0..1	String	Nom de l'autorité pour le type de nom.
description	0..1	String	Description de l'autorité pour le type de nom.

Le Tableau 124 présente toutes les extrémités d'association de NameTypeAuthority avec d'autres classes.

Tableau 124 – Extrémités d'association de Core::NameTypeAuthority avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	NameTypes	0..*	NameType	Tous les types de noms gérés par cette autorité.

6.5.25 OperatingParticipant

Opérateur de plusieurs objets de ressources de systèmes de puissance. Noter que plusieurs participants opérateurs peuvent exploiter le même objet de ressource de système de puissance. Cela peut être utilisé pour modéliser des unités détenues en copropriété dans lesquelles chaque propriétaire agit selon une quote-part contractuelle.

Le Tableau 125 présente tous les attributs de OperatingParticipant.

Tableau 125 – Attributs de Core::OperatingParticipant

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 126 présente toutes les extrémités d'association de OperatingParticipant avec d'autres classes.

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Tableau 126 – Extrémités d'association de Core::OperatingParticipant avec d'autres classes

mult à partir de	nom	mult vers	type	description
1..1	OperatingShare	0..*	OperatingShare	Les quotes-parts d'exploitation d'un participant opérateur. Un participant opérateur peut être réutilisé pour un nombre quelconque de ressources du système de puissance.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.26 Classe racine OperatingShare

Spécifie les relations contractuelles d'exploitation entre une ressource de système de puissance et un participant au contrat.

Le Tableau 127 présente tous les attributs de OperatingShare.

Tableau 127 – Attributs de Core::OperatingShare

nom	mult	type	description
percentage	0..1	PerCent	Pourcentage de possession opérationnelle de la paire (ressource de système de puissance et participant opérateur) associée à cette quote-part. Il convient que la possession totale en pourcentage d'une ressource de système de puissance soit égale à 100 %.

Le Tableau 128 présente toutes les extrémités d'association de OperatingShare avec d'autres classes.

Tableau 128 – Extrémités d'association de Core::OperatingShare avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	OperatingParticipant	1..1	OperatingParticipant	Participant opérateur qui a cette quote-part avec la ressource de système de puissance associée.
0..*	PowerSystemResource	1..1	PowerSystemResource	Ressource de système de puissance à laquelle s'applique cette quote-part.

6.5.27 PSRType

Instances de classification de la même classe, par exemple, ACLineSegments (segments de ligne en courant alternatif) aériens et souterrains. Ce mécanisme de classification est destiné à procurer de la flexibilité au-delà du domaine de la présente norme, c'est-à-dire à apporter une personnalisation qui n'est pas dans la norme.

Le Tableau 129 présente tous les attributs de PSRType.

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Tableau 129 – Attributs de Core::PSRType

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 130 présente toutes les extrémités d'association de PSRType avec d'autres classes.

Tableau 130 – Extrémités d'association de Core::PSRType avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	PowerSystemResources	0..*	PowerSystemResource	Ressources de système de puissance classées avec ce type de ressource de système de puissance.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.28 Énumération PhaseCode

Énumération des identificateurs de phase. Permet de désigner des phases pour l'équipement, les circuits et les charges à la fois de transport et de distribution.

Les charges résidentielles et celles de petits commerces sont souvent fournies à partir de circuits secondaires monophasés, ou en phase auxiliaire. En prenant pour exemple s12N, les phases 1 et 2 se réfèrent à des fils chauds qui sont en décalage de phase de 180 degrés tandis que N se réfère au fil neutre. Par des connexions monophasées de transformateur, ces circuits secondaires peuvent être alimentés par une ou deux des phases primaires A, B et C. Pour des charges triphasées, utiliser les codes de phase A, B, C au lieu de s12N.

Le Tableau 131 présente tous les libellés de PhaseCode.

Tableau 131 – Libellés de Core::PhaseCode

libellé	valeur	description
ABCN		Phases A, B, C, et N.
ABC		Phases A, B, et C.
ABN		Phases A, B, et neutre.
ACN		Phases A, C et neutre.
BCN		Phases B, C, et neutre.
AB		Phases A et B.
AC		Phases A et C.
BC		Phases B et C.
AN		Phases A et neutre.
BN		Phases B et neutre.
CN		Phases C et neutre.
A		Phase A.
B		Phase B.
C		Phase C.

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libellé	valeur	description
N		Phase neutre.
s1N		Phase secondaire 1 et neutre.
s2N		Phase secondaire 2 et neutre.
s12N		Phases secondaires 1, 2, et neutre.
s1		Phase secondaire 1.
s2		Phase secondaire 2.
s12		Phases secondaires 1 et 2.

6.5.29 PowerSystemResource

Une ressource de système de puissance peut être un élément d'équipement tel qu'un commutateur, un conteneur d'équipements contenant de nombreux éléments d'équipements individuels tel qu'un poste ou une entité opérationnelle telle qu'une sous-zone de réglage. Les ressources de système de puissance peuvent comporter des mesures associées.

Le Tableau 132 présente tous les attributs de PowerSystemResource.

Tableau 132 – Attributs de Core::PowerSystemResource

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 133 présente toutes les extrémités d'association de PowerSystemResource avec d'autres classes.

Tableau 133 – Extrémités d'association de Core::PowerSystemResource avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	PSRType	0..1	PSRType	Classification personnalisée pour cette ressource de système de puissance.
0..1	Controls	0..*	Control	Les sorties de commande utilisées pour commander effectivement un appareil de régulation, par exemple la magnétisation d'une machine synchrone ou l'actionneur disjoncteur d'une batterie de condensateurs.
0..1	Measurements	0..*	Measurement	Les mesures associées à cette ressource de système de puissance.
1..1	OperatingShare	0..*	OperatingShare	Quotes-parts d'exploitation de cette ressource de système de puissance.
0..*	ReportingGroup	0..*	ReportingGroup	Groupes de reporting auxquels appartient cette ressource de système de puissance.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

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6.5.30 RegularIntervalSchedule

Le programme comporte plusieurs instants entre lesquels le temps est constant.

Le Tableau 134 présente tous les attributs de RegularIntervalSchedule.

Tableau 134 – Attributs de Core::RegularIntervalSchedule

nom	mult	type	description
endTime	0..1	DateTime	Heure du dernier instant (Time Point).
timeStep	0..1	Seconds	Temps entre chaque paire d'instants réguliers ultérieurs, en ordre séquentiel.
startTime	0..1	DateTime	hérité de: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	hérité de: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	hérité de: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	hérité de: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	hérité de: BasicIntervalSchedule
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 135 présente toutes les extrémités d'association de RegularIntervalSchedule avec d'autres classes.

Tableau 135 – Extrémités d'association de Core::RegularIntervalSchedule avec d'autres classes

mult à partir de	nom	mult vers	type	description
1..1	TimePoints	1..*	RegularTimePoint	Valeurs de données de l'instant d'intervalle régulier qui définissent ce programme.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.31 Classe racine RegularTimePoint

Instant pour un programme, l'intervalle de temps entre les instants consécutifs étant constant.

Le Tableau 136 présente tous les attributs de RegularTimePoint.

Tableau 136 – Attributs de Core::RegularTimePoint

nom	mult	type	description
sequenceNumber	0..1	Integer	Position du RegularTimePoint dans cette séquence. Noter que les Time Point ne doivent pas nécessairement être séquentiels, c'est-à-dire que des Time Point peuvent être omis. La durée réelle pour un RegularTimePoint est calculée en multipliant le pas de temps associé du programme à intervalle régulier par le numéro d'ordre de l'instant de l'intervalle régulier et en ajoutant l'heure de départ des programmes associés.

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nom	mult	type	description
value1	0..1	Float	Première valeur au temps indiqué. La signification de cette valeur est définie par le type dérivé du programme associé.
value2	0..1	Float	Deuxième valeur au temps indiqué. La signification de cette valeur est définie par le type dérivé du programme associé.

Le Tableau 137 présente toutes les extrémités d'association de RegularTimePoint avec d'autres classes.

Tableau 137 – Extrémités d'association de Core::RegularTimePoint avec d'autres classes

mult à partir de	nom	mult vers	type	description
1..*	IntervalSchedule	1..1	RegularIntervalSchedule	Programme d'intervalle régulier contenant cet instant.

6.5.32 ReportingSuperGroup

Un supergroupe de reporting regroupe des groupes de reporting pour un rapport de niveau plus haut.

Le Tableau 138 présente tous les attributs de ReportingSuperGroup.

Tableau 138 – Attributs de Core::ReportingSuperGroup

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 139 présente toutes les extrémités d'association de ReportingSuperGroup avec d'autres classes.

Tableau 139 – Extrémités d'association de Core::ReportingSuperGroup avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	ReportingGroup	0..*	ReportingGroup	Groupes de reporting qui sont regroupés sous ce supergroupe.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.33 SubGeographicalRegion

Sous-ensemble d'une région géographique d'un modèle de réseau de système de puissance.

Le Tableau 140 présente tous les attributs de SubGeographicalRegion.

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Tableau 140 – Attributs de Core::SubGeographicalRegion

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 141 présente toutes les extrémités d'association de SubGeographicalRegion avec d'autres classes.

Tableau 141 – Extrémités d'association de Core::SubGeographicalRegion avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	Lines	0..*	Line	Les lignes dans cette sous-région géographique.
0..1	Substations	0..*	Substation	Postes de cette sous-région géographique.
0..*	Region	0..1	GeographicalRegion	Région géographique dans laquelle se trouve cette sous-région géographique.
0..1	DCLines	0..*	DCLine	Lignes de courant continu de cette sous-région géographique.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.34 Substation

Ensemble d'équipements dans d'autres buts que la production ou l'utilisation, à travers lesquels passe de l'énergie électrique en vrac dans le but de commuter ou de modifier ses caractéristiques.

Le Tableau 142 présente tous les attributs de Substation.

Tableau 142 – Attributs de Core::Substation

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 143 présente toutes les extrémités d'association de Substation avec d'autres classes.

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Tableau 143 – Extrémités d'association de Core::Substation avec d'autres classes

mult à partir de	nom	mult vers	type	description
1..1	VoltageLevels	0..*	VoltageLevel	Niveaux de tension à l'intérieur de ce poste.
0..1	Bays	0..*	Bay	Cellules contenues dans ce poste.
0..*	Region	0..1	SubGeographicalRegion	SubGeographicalRegion contenant ce poste.
0..1	DCConverterUnit	0..*	DCConverterUnit	Unité de convertisseur de courant continu appartenant au poste.
0..1	Equipments	0..*	Equipment	hérité de: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	hérité de: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	hérité de: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	hérité de: PowerSystemResource
0..1	Controls	0..*	Control	hérité de: PowerSystemResource
0..1	Measurements	0..*	Measurement	hérité de: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	hérité de: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	hérité de: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.35 Terminal

Point de connexion électrique à courant alternatif à une partie d'un équipement conducteur. Les Terminals (bornes) sont connectées sur des points de connexion physiques appelés nœuds de connectivité (ConnectivityNode).

Le Tableau 144 présente tous les attributs de Terminal.

Tableau 144 – Attributs de Core::Terminal

nom	mult	type	description
phases	0..1	PhaseCode	Représente la condition de phase normale du réseau. Si l'attribut est manquant, trois phases (ABC et ABCN) doivent être considérées.
connected	0..1	Boolean	hérité de: ACDCTerminal
sequenceNumber	0..1	Integer	hérité de: ACDCTerminal
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 145 présente toutes les extrémités d'association de Terminal avec d'autres classes.

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Tableau 145 – Extrémités d'association de Core::Terminal avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	ConductingEquipment	1..1	ConductingEquipment	Équipement conducteur de la borne. L'équipement conducteur a des bornes qui peuvent être connectées à d'autres bornes d'un équipement conducteur à l'aide de nœuds de connectivité ou de nœuds topologiques.
0..*	ConnectivityNode	0..1	ConnectivityNode	Nœud de connectivité auquel cette borne est connectée à impédance zéro.
0..*	TopologicalNode	0..1	TopologicalNode	Le nœud topologique associé à la borne. Il peut être utilisé comme remplacement d'un chemin de nœuds de connectivité allant jusqu'au nœud topologique, éliminant donc la nécessité de modéliser les nœuds de connectivité dans certains cas. Noter que si les nœuds de connectivité sont présents dans le modèle, cette association n'est probablement pas utilisée comme spécification d'entrée.
0..1	RegulatingControl	0..*	RegulatingControl	Les commandes qui régulent cette borne.
0..1	EquipmentFaults	0..*	EquipmentFault	Les défauts d'équipement au niveau de cette borne.
1..1	HasFirstMutualCoupling	0..*	MutualCoupling	Couplages mutuels associés avec la branche comme première branche.
0..1	TransformerEnd	0..*	TransformerEnd	Toutes les extrémités de transformateur connectées à cette borne.
1..1	BranchGroupTerminal	0..*	BranchGroupTerminal	Bornes orientées de groupe de branches pour lesquelles cette borne est surveillée.
1..1	SvPowerFlow	0..1	SvPowerFlow	Variable d'état de flux de puissance associée à la borne.
1..1	AuxiliaryEquipment	0..*	AuxiliaryEquipment	Équipement auxiliaire connecté à la borne.
1..1	HasSecondMutualCoupling	0..*	MutualCoupling	Couplages mutuels avec la branche associée comme première branche.
1..1	TieFlow	0..2	TieFlow	Flux d'interconnexion de zone de commande auxquels cette borne est associée.
0..1	ConverterDCSides	0..*	ACDCConverter	Tous les côtés à courant continu des convertisseurs liés à cette borne de point de couplage commun.
1..1	RemoteInputSignal	0..*	RemoteInputSignal	Signal entrant venant de cette borne.
1..*	BusNameMarker	0..1	BusNameMarker	hérité de: ACDCTerminal
0..1	OperationalLimitSet	0..*	OperationalLimitSet	hérité de: ACDCTerminal
0..1	Measurements	0..*	Measurement	hérité de: ACDCTerminal
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.5.36 VoltageLevel

Ensemble d'équipements à un même niveau de tension, constituant un appareillage de connexion. L'équipement consiste généralement en disjoncteurs, jeux de barre, appareils d'instrumentation, de commande, de régulation et de protection, de même que des regroupements de ce type de constituants.

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Le Tableau 146 présente tous les attributs de VoltageLevel.

Tableau 146 – Attributs de Core::VoltageLevel

nom	mult	type	description
highVoltageLimit	0..1	Voltage	Limite de haute tension du jeu de barres
lowVoltageLimit	0..1	Voltage	Limite de basse tension du jeu de barres
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 147 présente toutes les extrémités d'association de VoltageLevel avec d'autres classes.

Tableau 147 – Extrémités d'association de Core::VoltageLevel avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	BaseVoltage	1..1	BaseVoltage	Tension de base utilisée pour tout l'équipement dans le niveau de tension.
0..1	Bays	0..*	Bay	Cellules qui se trouvent à ce niveau de tension.
0..*	Substation	1..1	Substation	Poste du niveau de tension.
0..1	Equipments	0..*	Equipment	hérité de: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	hérité de: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	hérité de: ConnectivityNodeContainer
0..*	PSRType	0..1	PSRType	hérité de: PowerSystemResource
0..1	Controls	0..*	Control	hérité de: PowerSystemResource
0..1	Measurements	0..*	Measurement	hérité de: PowerSystemResource
1..1	OperatingShare	0..*	OperatingShare	hérité de: PowerSystemResource
0..*	ReportingGroup	0..*	ReportingGroup	hérité de: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.6 Package DiagramLayout

6.6.1 Généralités

Ce paquetage décrit la présentation du diagramme. Il décrit la manière dont les objets sont disposés dans un système de coordonnées plutôt que la manière dont ils sont rendus.

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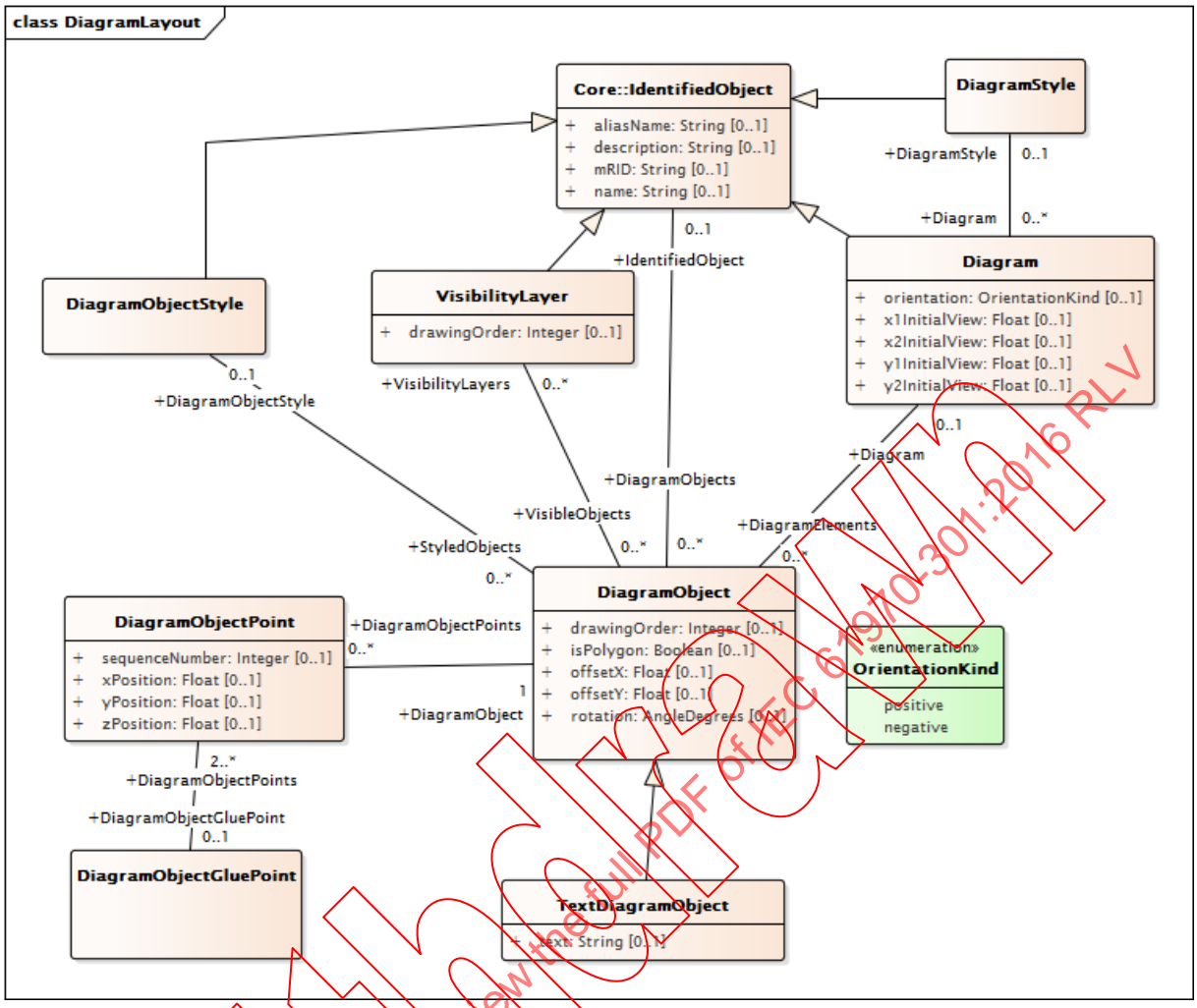


Figure 78 – Diagramme de classe DiagramLayout::DiagramLayout

Figure 78: Le diagramme représente le modèle de présentation du diagramme.

6.6.2 DiagramStyle

Le style de diagramme (DiagramStyle) fait référence à un style utilisé par le système d'origine pour un objet de diagramme. Un style de diagramme décrit des informations telles que les informations schématiques, géographiques, relatives à la topologie nodale, etc.

Le Tableau 148 présente tous les attributs de DiagramStyle.

Tableau 148 – Attributs de DiagramLayout::DiagramStyle

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 149 présente toutes les extrémités d'association de DiagramStyle avec d'autres classes.

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Tableau 149 – Extrémités d'association de DiagramLayout::Diagram avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	Diagram	0..*	Diagram	Un DiagramStyle peut être utilisé par de nombreux Diagrams.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.6.3 Diagram

Diagramme échangé. Le système de coordonnées est un système standard de coordonnées cartésiennes et l'attribut Orientation définit l'orientation.

Le Tableau 150 présente tous les attributs de Diagram.

Tableau 150 – Attributs de DiagramLayout::Diagram

nom	mult	type	description
orientation	0..1	OrientationKind	Orientation du système de coordonnées pour le diagramme.
x1InitialView	0..1	Float	Coordonnées X du premier coin de la vue initiale.
x2InitialView	0..1	Float	Coordonnées X du deuxième coin de la vue initiale.
y1InitialView	0..1	Float	Coordonnées Y du premier coin de la vue initiale.
y2InitialView	0..1	Float	Coordonnées Y du deuxième coin de la vue initiale.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 151 présente toutes les extrémités d'association de Diagram avec d'autres classes.

Tableau 151 – Extrémités d'association de DiagramLayout::Diagram avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	DiagramStyle	0..1	DiagramStyle	Un Diagram peut avoir un DiagramStyle.
0..1	DiagramElements	0..*	DiagramObject	Un diagramme est constitué de plusieurs objets de diagramme.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.6.4 DiagramObject

Objet qui définit un ou plusieurs points dans un espace donné. Cet objet peut être associé à tout ce qui spécialise IdentifiedObject. Pour des schémas unifilaires, ces objets comprennent généralement des éléments comme des valeurs analogiques, des disjoncteurs, des sectionneurs, des transformateurs de puissance et des lignes de transport.

Le Tableau 152 présente tous les attributs de DiagramObject.

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Tableau 152 – Attributs de DiagramLayout::DiagramObject

nom	mult	type	description
drawingOrder	0..1	Integer	Ordre de dessin dans cet élément. Plus le nombre est élevé, plus l'élément est dessiné tard dans la séquence. Il est utilisé pour s'assurer que les éléments qui se chevauchent sont rendus dans le bon ordre.
isPolygon	0..1	Boolean	Définit si les points des objets du diagramme définissent ou non les limites d'un polygone ou le tracé d'une polyligne. Si cette valeur est vraie, il convient que l'application de réception prenne en compte le premier et le dernier point à connecter.
offsetX	0..1	Float	Décalage en direction Y. Il sert à définir le décalage depuis le centre pour le rendu d'une icône (par défaut un point unique spécifie le centre de l'icône). Le décalage est exprimé par unité, 0 indique qu'il n'y a aucun décalage à partir du centre horizontal de l'icône. -0,5 indique que le décalage est de 50 % vers la gauche et 0,5 indique un décalage de 50 % vers la droite.
offsetY	0..1	Float	Décalage en direction Y. Il sert à définir le décalage depuis le centre pour le rendu d'une icône (par défaut un point unique spécifie le centre de l'icône). Le décalage est exprimé par unité, 0 indique qu'il n'y a aucun décalage à partir du centre vertical de l'icône. La direction du décalage dépend de l'orientation du diagramme. -0,5 et 0,5 indiquent un décalage de +/- 50 % sur l'axe vertical.
rotation	0..1	AngleDegrees	Définit l'angle de rotation de l'objet de diagramme. Zéro degré signifie que l'axe se dirige vers le haut du diagramme. La rotation s'effectue dans le sens des aiguilles d'une montre.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 153 présente toutes les extrémités d'association de DiagramObject avec d'autres classes.

Tableau 153 – Extrémités d'association de DiagramLayout::DiagramObject avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	Diagram	0..1	Diagram	Un objet de diagramme fait partie d'un diagramme.
0..*	VisibilityLayers	0..*	VisibilityLayer	Un objet de diagramme peut faire partie de plusieurs couches de visibilité.
1..1	DiagramObjectPoints	0..*	DiagramObjectPoint	Un objet de diagramme peut avoir 0 ou plusieurs points pour refléter la position de sa présentation, son tracé (pour des polylignes) ou sa limite (pour des polygones).
0..*	DiagramObjectStyle	0..1	DiagramObjectStyle	Un objet de diagramme a un style associé qui fournit une référence pour le style utilisé dans le système d'origine.
0..*	IdentifiedObject	0..1	IdentifiedObject	Objet de domaine auquel est associé cet objet de diagramme.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

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6.6.5 Classe racine DiagramObjectGluePoint

Celle-ci est utilisée pour regrouper des points d'un objet de diagramme à partir de différents objets de diagramme qui sont considérés comme indissociables l'un de l'autre ("collés") dans un diagramme, même s'ils ne se trouvent pas exactement aux mêmes coordonnées.

Le Tableau 154 présente toutes les extrémités d'association de DiagramObjectGluePoint avec d'autres classes.

Tableau 154 – Extrémités d'association de DiagramLayout::DiagramObjectGluePoint avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	DiagramObjectPoints	2..*	DiagramObjectPoint	Un point de collage d'un objet de diagramme est associé à 2 points d'objet ou davantage qui sont considérés comme collés l'un à l'autre.

6.6.6 Classe racine DiagramObjectPoint

Un point dans un espace donné défini par 3 coordonnées et associé à un objet de diagramme. Les coordonnées peuvent être positives ou négatives puisque l'origine ne se trouve pas nécessairement dans le coin d'un diagramme.

Le Tableau 155 présente tous les attributs de DiagramObjectPoint.

Tableau 155 – Attributs de DiagramLayout::DiagramObjectPoint

nom	mult	type	description
sequenceNumber	0..1	Integer	La position séquentielle du point, utilisée pour définir l'ordre des points pour des objets de diagramme qui forment une polyligne ou un polygone ayant plus d'un point.
xPosition	0..1	Float	Coordonnée X de ce point.
yPosition	0..1	Float	Coordonnée Y de ce point.
zPosition	0..1	Float	Coordonnée Z de ce point.

Le Tableau 156 présente toutes les extrémités d'association de DiagramObjectPoint avec d'autres classes.

Tableau 156 – Extrémités d'association de DiagramLayout::DiagramObjectPoint avec d'autres classes

mult à partir de	nom	mult vers	type	description
2..*	DiagramObjectGluePoint	0..1	DiagramObjectGluePoint	Point de collage auquel est associé ce point.
0..*	DiagramObject	1..1	DiagramObject	Objet de diagramme auquel sont associés les points.

6.6.7 DiagramObjectStyle

Référence à un style utilisé par le système d'origine pour un objet de diagramme. Un style d'objet de diagramme décrit des informations comme l'épaisseur de la ligne, la forme, comme un cercle ou un rectangle, etc., et la couleur.

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Le Tableau 157 présente tous les attributs de DiagramObjectStyle.

Tableau 157 – Attributs de DiagramLayout::DiagramObjectStyle

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 158 présente toutes les extrémités d'association de DiagramObjectStyle avec d'autres classes.

Tableau 158 – Extrémités d'association de DiagramLayout::DiagramObjectStyle avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	StyledObjects	0..*	DiagramObject	Un style peut être attribué à plusieurs objets de diagramme.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.6.8 Énumération OrientationKind

L'orientation du système de coordonnées par rapport au sommet, à la gauche et au système de numérotation des coordonnées.

Le Tableau 159 présente tous les libellés de OrientationKind.

Tableau 159 – Libellés de DiagramLayout::OrientationKind

libellé	valeur	description
positive		Pour des diagrammes en 2D, une orientation positive implique que les valeurs X croissent de la gauche vers la droite et les valeurs Y croissent du bas vers le haut. Cette orientation est également appelée orientation à droite.
negative		Pour des diagrammes en 2D, une orientation négative donne une orientation à gauche (tel que se présente généralement l'affichage graphique sur ordinateur), les valeurs X croissent de la gauche vers la droite et les valeurs Y croissent du haut vers le bas. Cette orientation est également appelée orientation à gauche.

6.6.9 TextDiagramObject

Un objet de diagramme pour placer un texte libre ou un texte dérivé d'un objet de domaine associé.

Le Tableau 160 présente tous les attributs de TextDiagramObject.

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Tableau 160 – Attributs de DiagramLayout::TextDiagramObject

nom	mult	type	description
text	0..1	String	Texte affiché par cet objet de diagramme de texte.
drawingOrder	0..1	Integer	hérité de: DiagramObject
isPolygon	0..1	Boolean	hérité de: DiagramObject
offsetX	0..1	Float	hérité de: DiagramObject
offsetY	0..1	Float	hérité de: DiagramObject
rotation	0..1	AngleDegrees	hérité de: DiagramObject
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 161 présente toutes les extrémités d'association de TextDiagramObject avec d'autres classes.

Tableau 161 – Extrémités d'association de DiagramLayout::TextDiagramObject avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	Diagram	0..1	Diagram	hérité de: DiagramObject
0..*	VisibilityLayers	0..*	VisibilityLayer	hérité de: DiagramObject
1..1	DiagramObjectPoints	0..*	DiagramObjectPoint	hérité de: DiagramObject
0..*	DiagramObjectStyle	0..1	DiagramObjectStyle	hérité de: DiagramObject
0..*	IdentifiedObject	0..1	IdentifiedObject	hérité de: DiagramObject
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.6.10 VisibilityLayer

Les couches sont généralement utilisées pour regrouper des objets de diagramme d'après des thèmes et des échelles. Les thèmes sont utilisés pour afficher ou masquer certaines informations (par exemple des lacs, des frontières) tandis que les échelles sont utilisées pour masquer ou afficher des informations qui dépendent du niveau réel de zoom (masquer le texte quand il est trop petit pour être lisible ou quand il dépasse la taille de l'écran). Cela s'appelle également la mise au net.

L'échange de graphique basé sur le CIM prend en charge une relation m:n entre les objets de diagramme et les couches. Il est du ressort du système d'importation de convertir un cas m:n en représentation 1:n appropriée si le système d'importation ne prend pas en charge m:n.

Le Tableau 162 présente tous les attributs de VisibilityLayer.

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Tableau 162 – Attributs de DiagramLayout::VisibilityLayer

nom	mult	type	description
drawingOrder	0..1	Integer	Ordre de dessin pour cette couche. Plus le nombre est grand, plus la couche et les objets qui s'y trouvent sont rendus tard.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 163 présente toutes les extrémités d'association de VisibilityLayer avec d'autres classes.

Tableau 163 – Extrémités d'association de DiagramLayout::VisibilityLayer avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	VisibleObjects	0..*	DiagramObject	Une couche de visibilité peut contenir un ou plusieurs objets de diagramme.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.7 Paquetage OperationalLimits

6.7.1 Généralités

Ce paquetage modélise une spécification des limites associées à des entités d'équipement et à d'autres entités opérationnelles.

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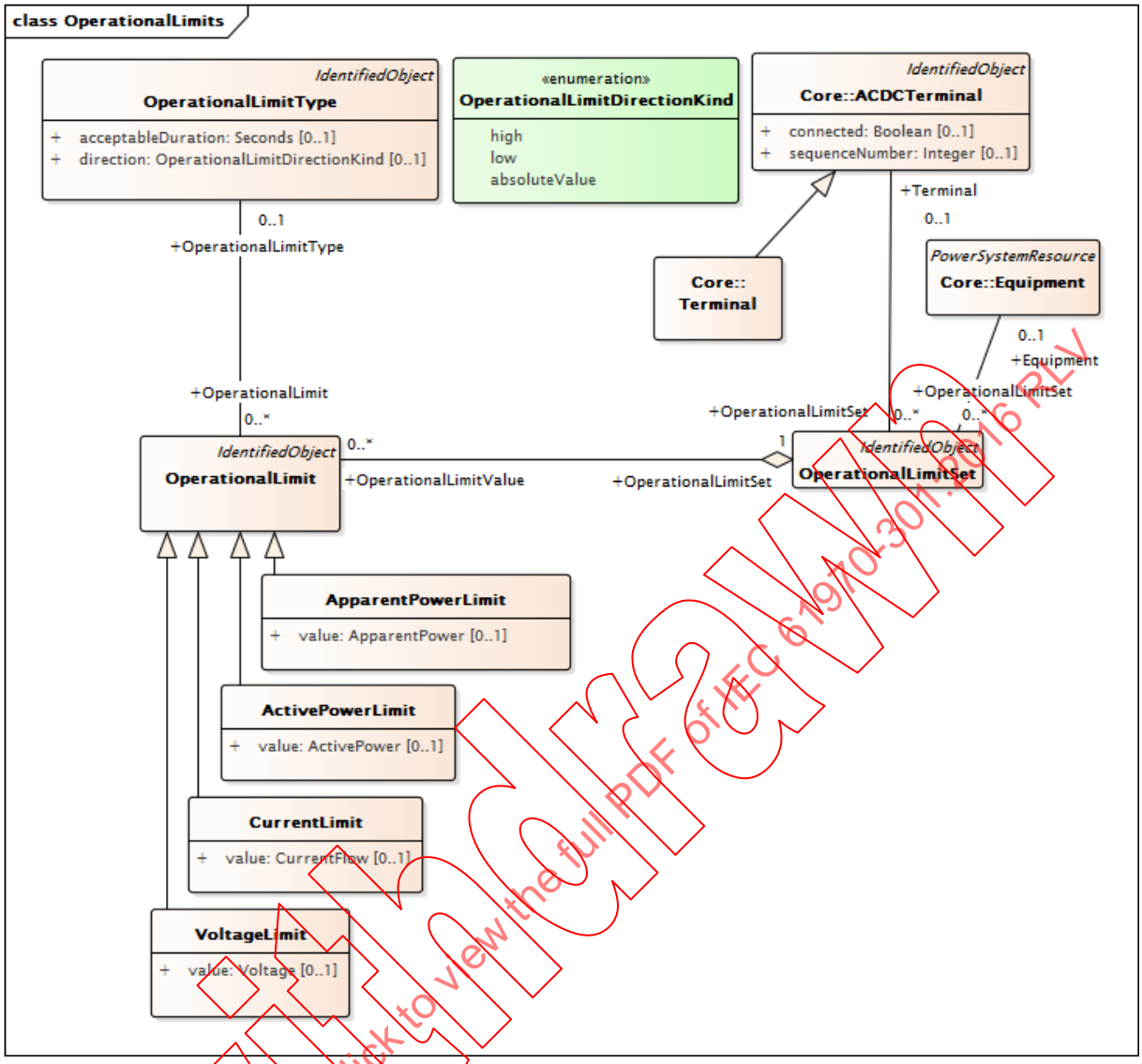


Figure 79 – Diagramme de classe OperationalLimits::OperationalLimits

Figure 79: Ce diagramme représente les limites opérationnelles telles qu'elles se rattachent dans le modèle central.

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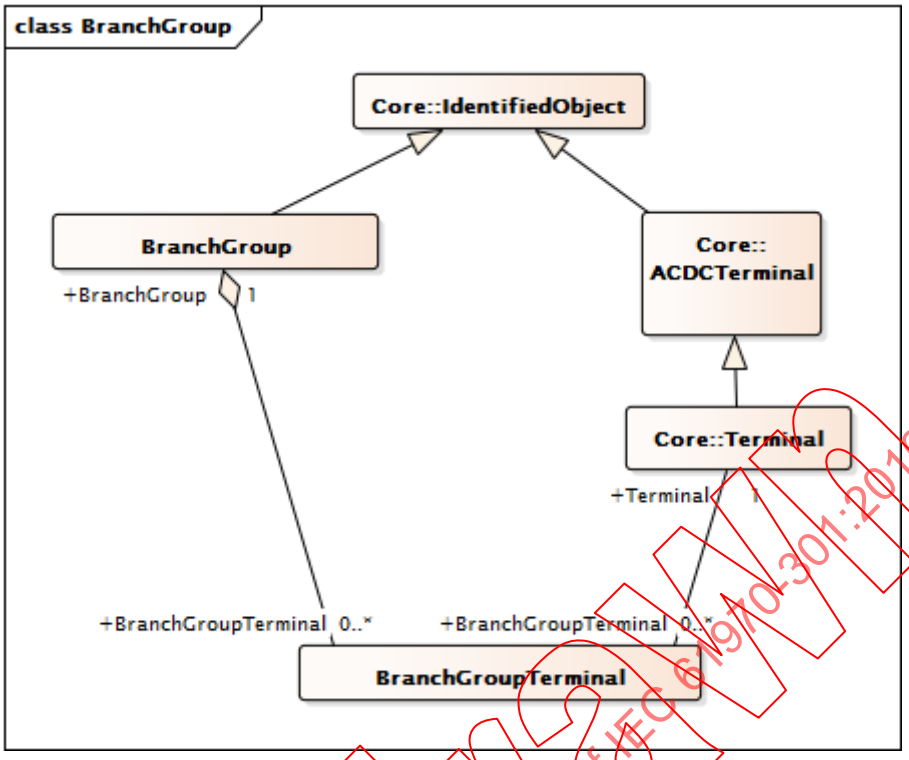


Figure 80 – Diagramme de classe OperationalLimits::BranchGroup

Figure 80: Ce diagramme représente le modèle pour contrôler des flux combinés sur des groupes de branches.

6.7.2 ActivePowerLimit

Limite sur le flux de puissance active.

Le Tableau 164 présente tous les attributs de ActivePowerLimit.

Tableau 164 – Attributs de OperationalLimits::ActivePowerLimit

nom	mult	type	description
value	0..1	ActivePower	Valeur de la limite de puissance active.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 165 présente toutes les extrémités d'association de ActivePowerLimit avec d'autres classes.

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Tableau 165 – Extrémités d'association de OperationalLimits::ActivePowerLimit avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	hérité de: OperationalLimit
0..*	OperationalLimitType	0..1	OperationalLimitType	hérité de: OperationalLimit
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.7.3 ApparentPowerLimit

Limite de puissance apparente.

Le Tableau 166 présente tous les attributs de ApparentPowerLimit.

Tableau 166 – Attributs de OperationalLimits::ApparentPowerLimit

nom	mult	type	description
value	0..1	ApparentPower	Limite de puissance apparente.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 167 présente toutes les extrémités d'association de ApparentPowerLimit avec d'autres classes.

Tableau 167 – Extrémités d'association de OperationalLimits::ApparentPowerLimit avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	hérité de: OperationalLimit
0..*	OperationalLimitType	0..1	OperationalLimitType	hérité de: OperationalLimit
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.7.4 BranchGroup

Groupe de bornes de branches dont la sommation des flux orientés doit être surveillée. Il n'est pas nécessaire qu'un groupe de branches forme un ensemble de coupure du réseau.

Le Tableau 168 présente tous les attributs de BranchGroup.

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Tableau 168 – Attributs de OperationalLimits::BranchGroup

nom	mult	type	description
maximumActivePower	0..1	ActivePower	Flux maximal de puissance active.
maximumReactivePower	0..1	ReactivePower	Flux maximal de puissance réactive.
minimumActivePower	0..1	ActivePower	Flux minimal de puissance active.
minimumReactivePower	0..1	ReactivePower	Flux minimal de puissance réactive.
monitorActivePower	0..1	Boolean	Surveiller le flux de puissance active.
monitorReactivePower	0..1	Boolean	Surveiller le flux de puissance réactive.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 169 présente toutes les extrémités d'association de BranchGroup avec d'autres classes.

Tableau 169 – Extrémités d'association de OperationalLimits::BranchGroup avec d'autres classes

mult à partir de	nom	mult vers	type	description
1..1	BranchGroupTerminal	0..*	BranchGroupTerminal	Bornes de BranchGroups orientées devant être sommées.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.7.5 Classe racine BranchGroupTerminal

Flux spécifique de bornes orienté pour un groupe de branches.

Le Tableau 170 présente tous les attributs de BranchGroupTerminal.

Tableau 170 – Attributs de OperationalLimits::BranchGroupTerminal

nom	mult	type	description
positiveFlowIn	0..1	Boolean	S'il est défini sur true (vrai), le flux pénétrant dans la borne est sommé. S'il est défini sur false (faux), le flux sortant de la borne est sommé.

Le Tableau 171 présente toutes les extrémités d'association de BranchGroupTerminal avec d'autres classes.

Tableau 171 – Extrémités d'association de OperationalLimits::BranchGroupTerminal avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	Terminal	1..1	Terminal	Borne devant être sommée.
0..*	BranchGroup	1..1	BranchGroup	BranchGroup auquel appartiennent les bornes de groupe de branches orientées.

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6.7.6 CurrentLimit

Limite opérationnelle sur le courant.

Le Tableau 172 présente tous les attributs de CurrentLimit.

Tableau 172 – Attributs de OperationalLimits::CurrentLimit

nom	mult	type	description
value	0..1	CurrentFlow	Limite sur le flux de courant.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 173 présente toutes les extrémités d'association de CurrentLimit avec d'autres classes.

Tableau 173 – Extrémités d'association de OperationalLimits::CurrentLimit avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	hérité de: OperationalLimit
0..*	OperationalLimitType	0..1	OperationalLimitType	hérité de: OperationalLimit
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.7.7 OperationalLimit

Valeur associée à une sorte spécifique de limite.

L'attribut de valeur de sous-classe doit être positif.

L'attribut de valeur de sous-classe est inversement proportionnel à OperationalLimitType.acceptableDuration (acceptableDuration en abrégé). value_x et acceptableDuration_x sont reliés l'un à l'autre comme suit:

si value_1 > value_2 > value_3 > …, alors

acceptableDuration_1 < acceptableDuration_2 < acceptableDuration_3 < …

Une valeur value_x avec direction="high" doit être supérieure à une valeur value_y avec direction="low".

Le Tableau 174 présente tous les attributs de OperationalLimit.

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Tableau 174 – Attributs de OperationalLimits::OperationalLimit

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 175 présente toutes les extrémités d'association de OperationalLimit avec d'autres classes.

Tableau 175 – Extrémités d'association de OperationalLimits::OperationalLimit avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	Jeu de limites auquel les valeurs limites appartiennent.
0..*	OperationalLimitType	0..1	OperationalLimitType	Le type de limite associé à cette limite.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.7.8 Énumération OperationalLimitDirectionKind

L'attribut de sens décrit le côté d'une limite qui constitue une infraction.

Le Tableau 176 présente tous les libellés de OperationalLimitDirectionKind.

Tableau 176 – Libellés de OperationalLimits::OperationalLimitDirectionKind

libellé	valeur	description
high		"High" signifie qu'une valeur surveillée supérieure à la valeur limite constitue une infraction. Si elle est appliquée au flux d'une borne, le sens positif est celui pénétrant dans la borne.
low		"Low" signifie qu'une valeur surveillée inférieure à la valeur limite constitue une infraction. Si elle est appliquée au flux d'une borne, le sens positif est celui pénétrant dans la borne.
absoluteValue		Une limite absoluteValue signifie qu'une valeur surveillée absolue supérieure à la valeur limite constitue une infraction.

6.7.9 OperationalLimitSet

Jeu de limites associées à un équipement. Les jeux de limites peuvent s'appliquer à une température spécifique, ou à une saison, par exemple. Un jeu de limites peut contenir des sévérités différentes pour les niveaux limites qui s'appliquent au même équipement. Le jeu peut contenir des limites de types différents telles que limites de puissance apparente et limites de courant ou bien limites de tension haute et basse qui sont logiquement appliquées ensemble comme un jeu.

Le Tableau 177 présente tous les attributs de OperationalLimitSet.

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Tableau 177 – Attributs de OperationalLimits::OperationalLimitSet

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 178 présente toutes les extrémités d'association de OperationalLimitSet avec d'autres classes.

Tableau 178 – Extrémités d'association de OperationalLimits::OperationalLimitSet avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	Terminal	0..1	ACDCTerminal	Borne à laquelle le jeu de limites opérationnelles s'applique.
0..*	Equipment	0..1	Equipment	Équipement auquel le jeu de limites s'applique.
1..1	OperationalLimitValue	0..*	OperationalLimit	Valeurs des limites opérationnelles.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.7.10 OperationalLimitType

Signification opérationnelle d'une catégorie de limites.

Le Tableau 179 présente tous les attributs de OperationalLimitType.

Tableau 179 – Attributs de OperationalLimits::OperationalLimitType

nom	mult	type	description
acceptableDuration	0..1	Seconds	Durée acceptable nominale de la limite. Les limites sont communément exprimées en termes de limites temporelles pour lesquelles la limite est normalement acceptable. La durée acceptable réelle d'une limite spécifique dépend d'autres facteurs locaux tels que la température ou la vitesse du vent.
direction	0..1	OperationalLimitDirectionKind	Sens de la limite.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 180 présente toutes les extrémités d'association de OperationalLimitType avec d'autres classes.

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Tableau 180 – Extrémités d'association de OperationalLimits::OperationalLimitSet avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	OperationalLimit	0..*	OperationalLimit	Limites opérationnelles associées à ce type de limite.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.7.11 VoltageLimit

Limite opérationnelle appliquée à la tension.

Le Tableau 181 présente tous les attributs de VoltageLimit.

Tableau 181 – Attributs de OperationalLimits::VoltageLimit

nom	mult	type	description
value	0..1	Voltage	Limite sur la tension. La nature basse ou haute de la limite dépend des propriétés du type de limite opérationnelle.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 182 présente toutes les extrémités d'association de VoltageLimit avec d'autres classes.

Tableau 182 – Extrémités d'association de OperationalLimits::VoltageLimit avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	OperationalLimitSet	1..1	OperationalLimitSet	hérité de: OperationalLimit
0..*	OperationalLimitType	0..1	OperationalLimitType	hérité de: OperationalLimit
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.8 Paquetage Topology

6.8.1 Généralités

Extension du paquetage Core qui, associé à la classe Terminal (borne), modélise la Connectivity (connectivité), à savoir la définition physique de la façon dont les équipements sont connectés ensemble. De plus, il modélise la Topology, à savoir la définition logique de la façon dont un équipement est connecté via des commutateurs fermés. La définition de Topology est indépendante des autres caractéristiques électriques.

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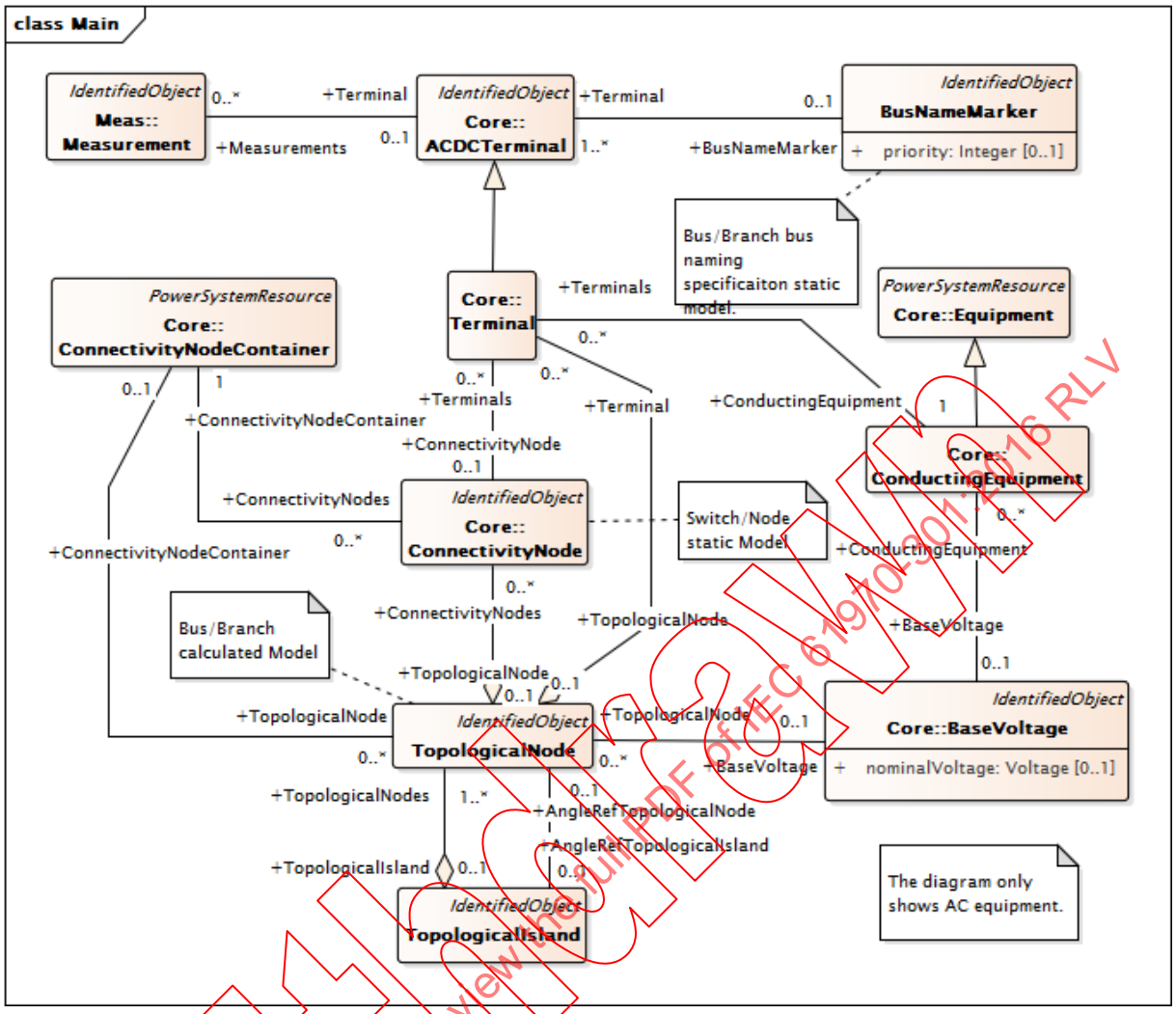


Figure 81 – Diagramme de classe Topology::Main

Figure 81: Ce diagramme représente toutes les classes incluses dans le paquetage Topology de même que les classes-clés externes, qui ont des associations avec des classes Topology.

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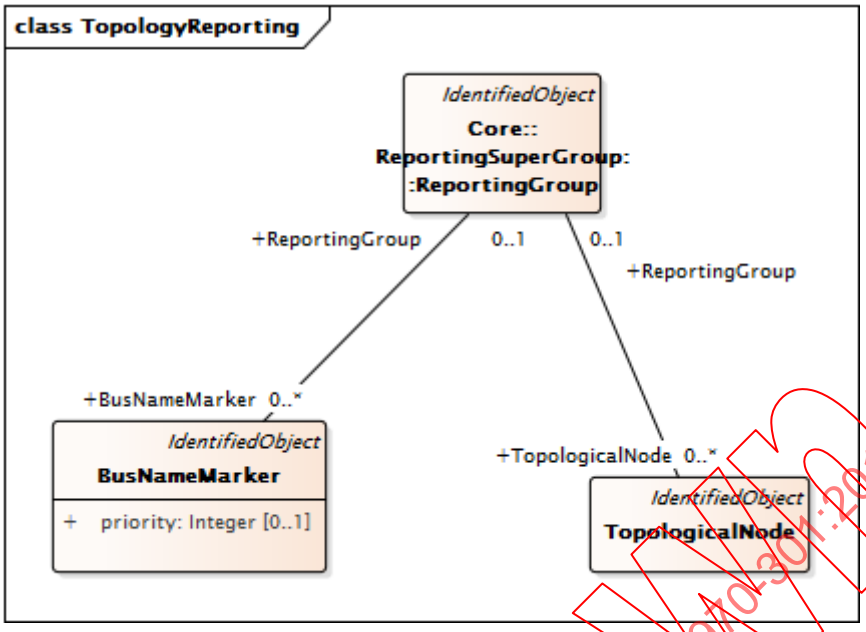


Figure 82 – Diagramme de classe Topology::TopologyReporting

Figure 82: Représente les relations de reporting de topologie.

6.8.2 BusNameMarker

Utilisé pour appliquer les noms normalisés d'utilisateur à des bus de topologie. Généralement utilisé pour la génération de cas "topologie nodale". Associé à une ou plusieurs bornes qui sont normalement connectées au nom du bus. Les bornes associées sont normalement reliées par des commutateurs sans retenue. Pour une configuration de poste à barre de transfert en anneau, toutes les bornes dans l'anneau sont généralement associées. Pour un disjoncteur et un demi-schéma, les deux jeux de barres sont normalement associés. Pour une barre de transfert en anneau, tous les jeux de barres sont normalement associés. Pour une configuration "rectiligne" de jeux de barres, seule la borne principale au niveau du jeu de barres est normalement associée.

Le Tableau 183 présente tous les attributs de BusNameMarker.

Tableau 183 – Attributs de Topology::BusNameMarker

nom	mult	type	description
priority	0..1	Integer	Priorité du marqueur de nom de bus pour une utilisation comme nom de bus de topologie. Utiliser 0 pour "don't care" (peu importe). Utiliser 1 pour la plus haute priorité. Utiliser 2 pour une priorité inférieure à 1 et ainsi de suite.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 184 présente toutes les extrémités d'association de BusNameMarker avec d'autres classes.

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Tableau 184 – Extrémités d'association de Topology::BusNameMarker avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	Terminal	1..*	ACDCTerminal	Bornes associées à ce marqueur de nom de bus.
0..*	ReportingGroup	0..1	ReportingGroup	Groupe de reporting auquel appartient ce marqueur de nom de bus.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.8.3 DCTopologicalNode

Bus à courant continu.

Le Tableau 185 présente tous les attributs de DCTopologicalNode.

Tableau 185 – Attributs de Topology::DCTopologicalNode

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 186 présente toutes les extrémités d'association de DCTopologicalNode avec d'autres classes.

Tableau 186 – Extrémités d'association de Topology::DCTopologicalNode avec d'autres classes

mult à partir de	nom	mult vers	type	description
1..*	DCTopologicalIsland	0..1	DCTopologicalIsland	Un TopologicalNode (nœud topologique) à courant continu appartient à un TopologicalIsland (îlot topologique) à courant continu.
0..1	DCTerminals	0..*	DCBaseTerminal	Bornes de base à courant continu associées au nœud topologique à courant continu.
0..1	DCNodes	0..*	DCNode	Les nœuds de connectivité à courant continu se sont combinés les uns aux autres pour former ce nœud topologique à courant continu. Peut dépendre de l'état courant des commutateurs dans le réseau.
0..*	DCEquipmentContainer	0..1	DCEquipmentContainer	Conteneur de nœuds de connectivité auquel le nœud topologique appartient.
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.8.4 TopologicalIsland

Sous-ensemble du réseau électriquement connecté. Les îlots topologiques peuvent changer lorsque l'état courant du réseau change, par exemple

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– la déconnexion de commutateurs ou de disjoncteurs modifie l'état dans un SCADA/EMS
– il y a création manuelle, modification ou suppression de nœuds topologiques dans un outil de planification.

Le Tableau 187 présente tous les attributs de TopologicalIsland.

Tableau 187 – Attributs de Topology::TopologicalIsland

nom	mult	type	description
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 188 présente toutes les extrémités d'association de TopologicalIsland avec d'autres classes.

Tableau 188 – Extrémités d'association de Topology::TopologicalIsland avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..1	AngleRefTopologicalNode	0..1	TopologicalNode	Référence angulaire de l'îlot. Normalement, il y a un TopologicalNode qui est sélectionné comme référence angulaire pour chaque îlot. D'autres schémas de référence existent et, donc, l'association est généralement facultative.
0..1	TopologicalNodes	1..*	TopologicalNode	Un TopologicalNode (nœud topologique) appartient à un TopologicalIsland (îlot topologique).
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.8.5 TopologicalNode

Pour un modèle de poste détaillé, un nœud topologique est un ensemble de nœuds de connectivité qui, dans l'état courant du réseau, sont reliés ensemble par une sorte quelconque de commutateurs fermés, y compris des cavaliers. Les nœuds topologiques changent en même temps que l'état du réseau change (c'est-à-dire que des commutateurs, des disjoncteurs, etc., modifient l'état).

Pour un modèle de planification, les états des commutateurs ne sont pas utilisés pour former des nœuds topologiques. Au contraire, ils sont créés ou supprimés manuellement dans un outil constructeur de modèle. Les nœuds topologiques conservés de cette manière sont également appelés "bus".

Le Tableau 189 présente tous les attributs de TopologicalNode.

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Tableau 189 – Attributs de Topology::TopologicalNode

nom	mult	type	description
pInjection	0..1	ActivePower	Puissance active injectée dans le bus à cet emplacement en plus des injections provenant d'équipements. Un signe positif signifie une injection vers le TopologicalNode (bus). Valeur de départ pour une solution en régime établi.
qInjection	0..1	ReactivePower	Puissance réactive injectée dans le bus à cet emplacement en plus des injections provenant d'équipements. Un signe positif signifie une injection vers le TopologicalNode (bus). Valeur de départ pour une solution en régime établi.
aliasName	0..1	String	hérité de: IdentifiedObject
description	0..1	String	hérité de: IdentifiedObject
mRID	0..1	String	hérité de: IdentifiedObject
name	0..1	String	hérité de: IdentifiedObject

Le Tableau 190 présente toutes les extrémités d'association de TopologicalNode avec d'autres classes.

Tableau 190 – Extrémités d'association de Topology::TopologicalNode avec d'autres classes

mult à partir de	nom	mult vers	type	description
0..*	BaseVoltage	0..1	BaseVoltage	Tension de base du nœud topologique.
0..*	ConnectivityNodeContainer	0..1	ConnectivityNodeContainer	Conteneur de nœuds de connectivité auquel le nœud topologique appartient.
0..*	ReportingGroup	0..1	ReportingGroup	Groupe de reporting auquel le nœud topologique appartient.
1..*	TopologicalIsland	0..1	TopologicalIsland	Un TopologicalNode (nœud topologique) appartient à un TopologicalIsland (îlot topologique).
0..1	ConnectivityNodes	0..*	ConnectivityNode	Les nœuds de connectivité se combinent les uns aux autres pour former ce nœud topologique. Peut dépendre de l'état courant des commutateurs dans le réseau.
0..1	Terminal	0..*	Terminal	Les bornes associées au nœud topologique. Ceci peut être utilisé à la place d'un chemin de nœuds de connectivité allant jusqu'à la borne, éliminant donc la nécessité de modéliser les nœuds de connectivité dans certains cas. Noter que si les nœuds de connectivité sont présents dans le modèle, cette association ne serait probablement pas utilisée en tant que spécification d'entrée.
0..1	AngleRefTopologicalIsland	0..1	TopologicalIsland	Îlot pour lequel le nœud est une référence angulaire. Normalement, il y a un nœud référence angulaire pour chaque îlot.
1..1	SvInjection	0..1	SvInjection	Variables d'état du flux d'injection associées au nœud topologique.
1..1	SvVoltage	0..1	SvVoltage	État de tension associé au nœud topologique.

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mult à partir de	nom	mult vers	type	description
0..1	DiagramObjects	0..*	DiagramObject	hérité de: IdentifiedObject
1..1	Names	0..*	Name	hérité de: IdentifiedObject

6.9 Paquetage Wires

6.9.1 Généralités

Extension des paquetages Core et Topology qui modélise les informations des caractéristiques électriques des réseaux Transport et Distribution. Ce paquetage est utilisé par des applications de réseau telles que State Estimation, Load Flow et Optimal Power Flow.

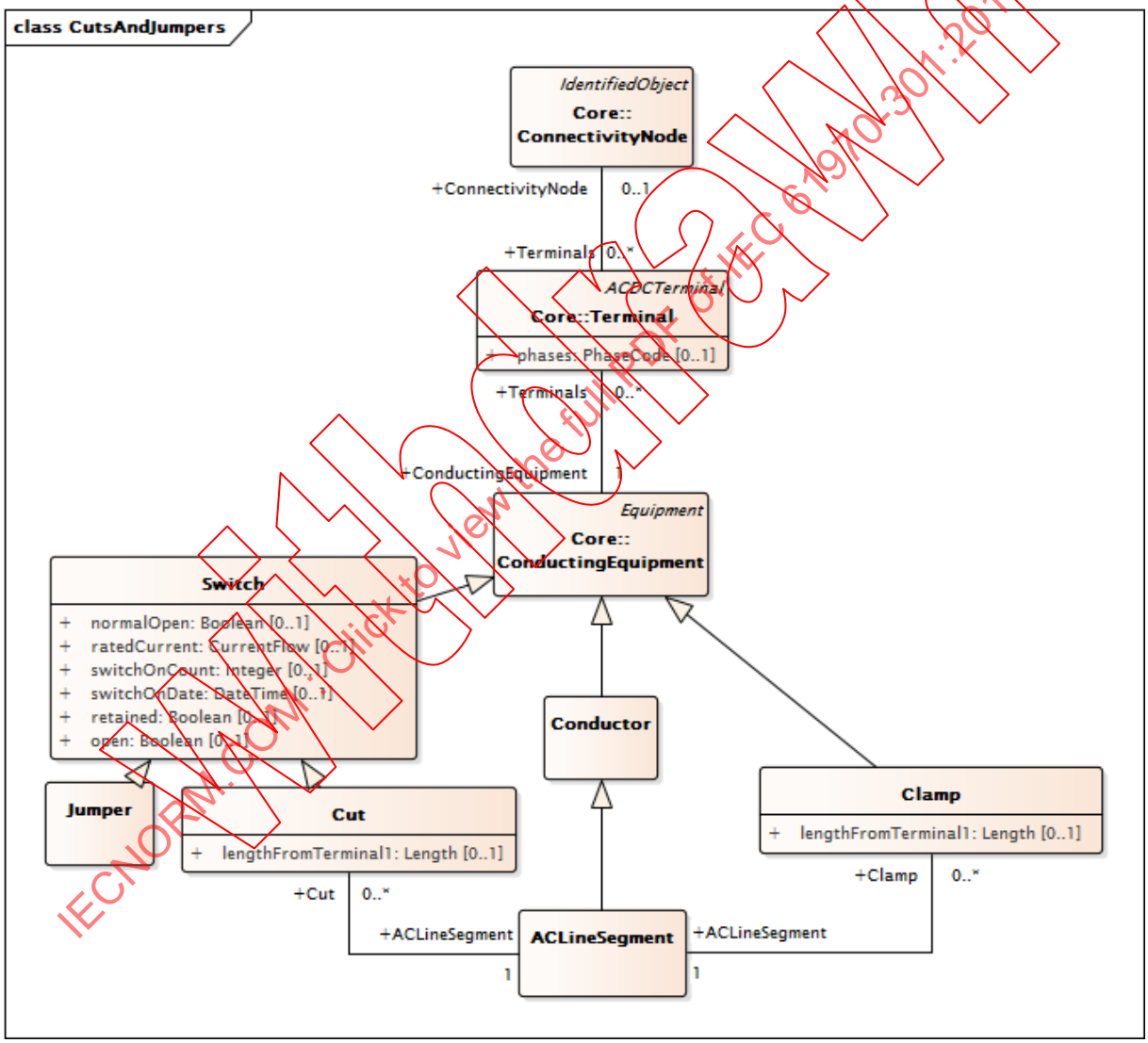


Figure 83 – Diagramme de classe Wires::CutsAndJumpers

Figure 83: Le diagramme représente le modèle de données des cuts et des cavaliers.

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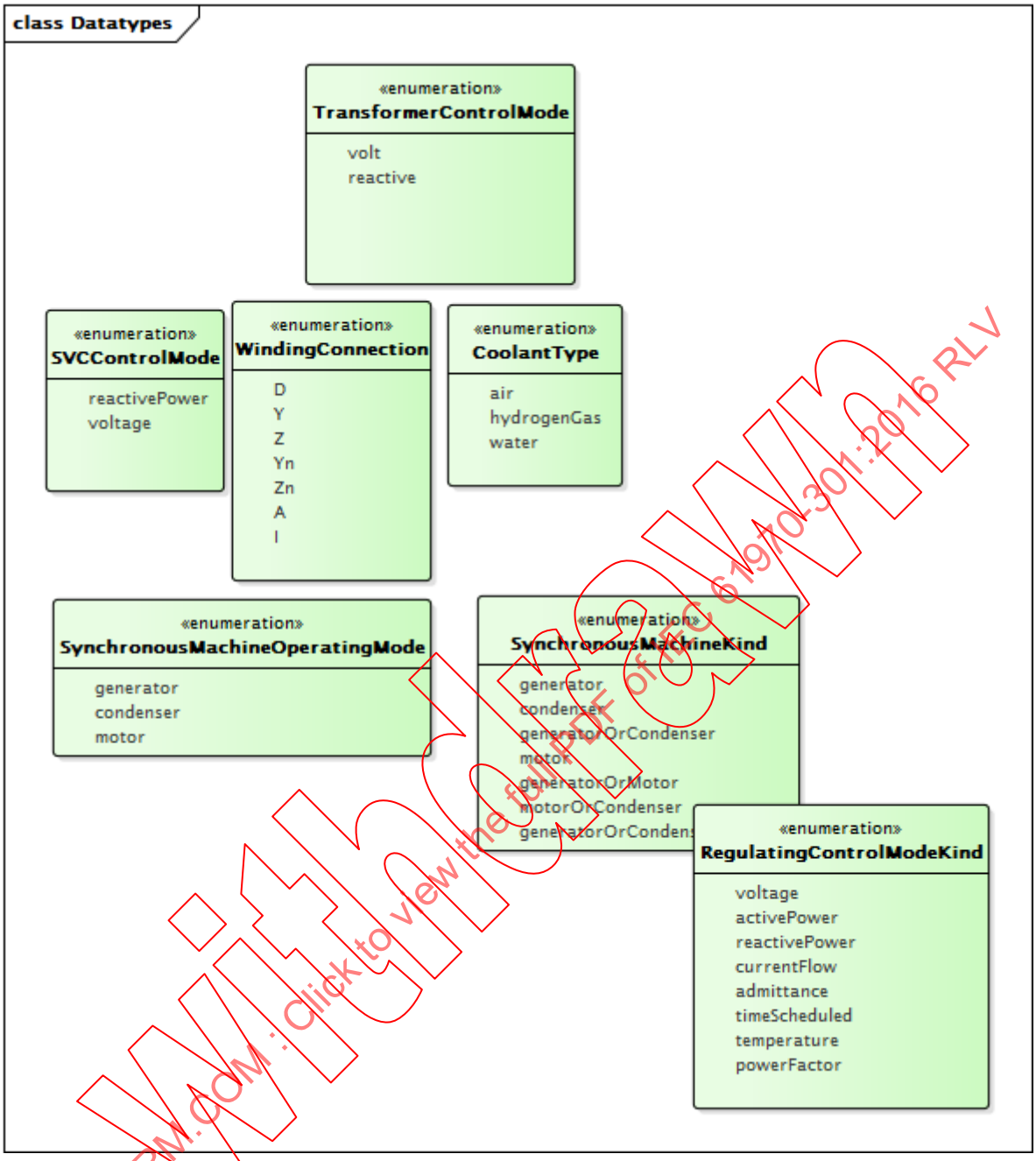


Figure 84 – Diagramme de classe Wires::Datatypes

Figure 84: Ce diagramme représente les types de données spécifiques au paquetage Wires.

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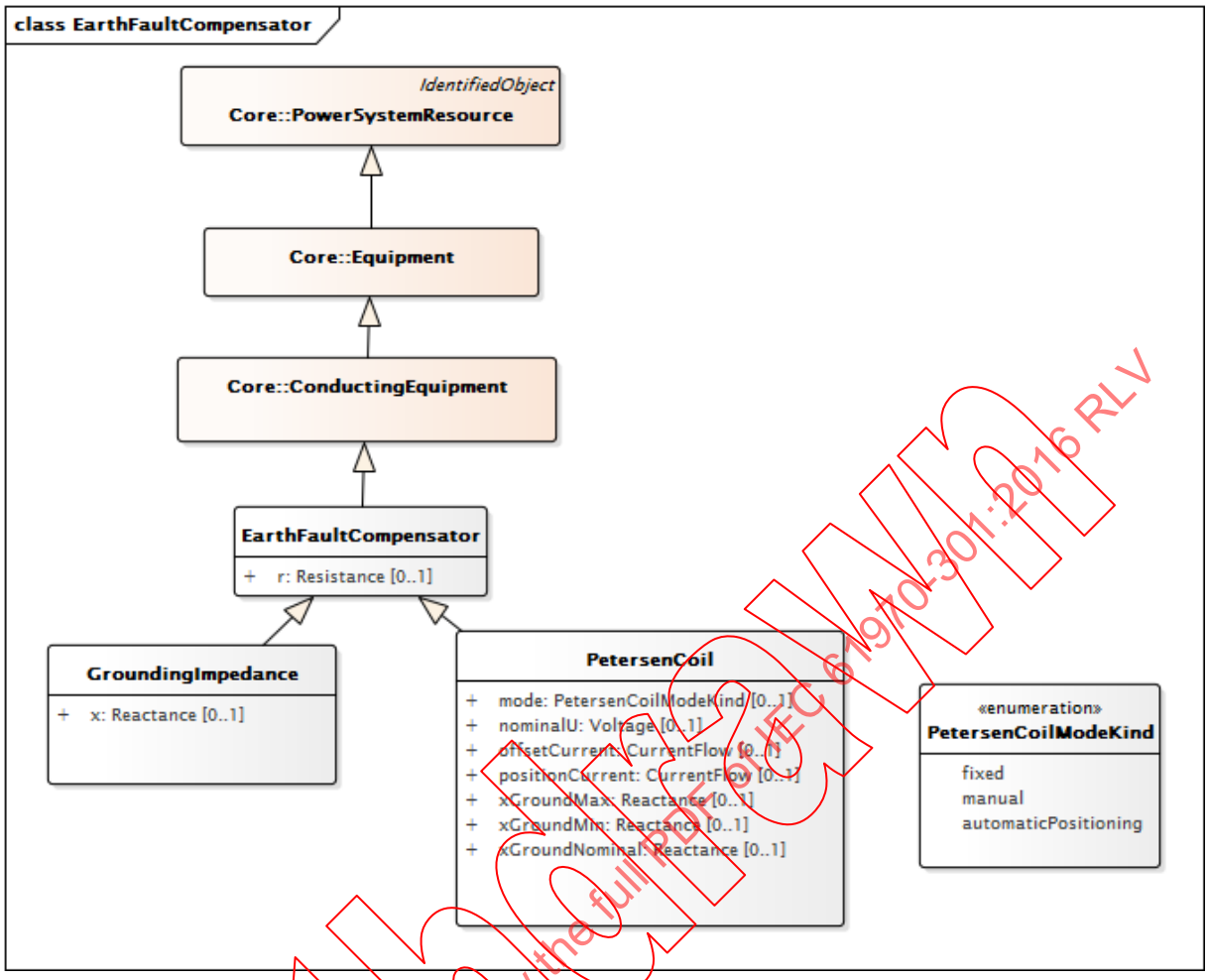
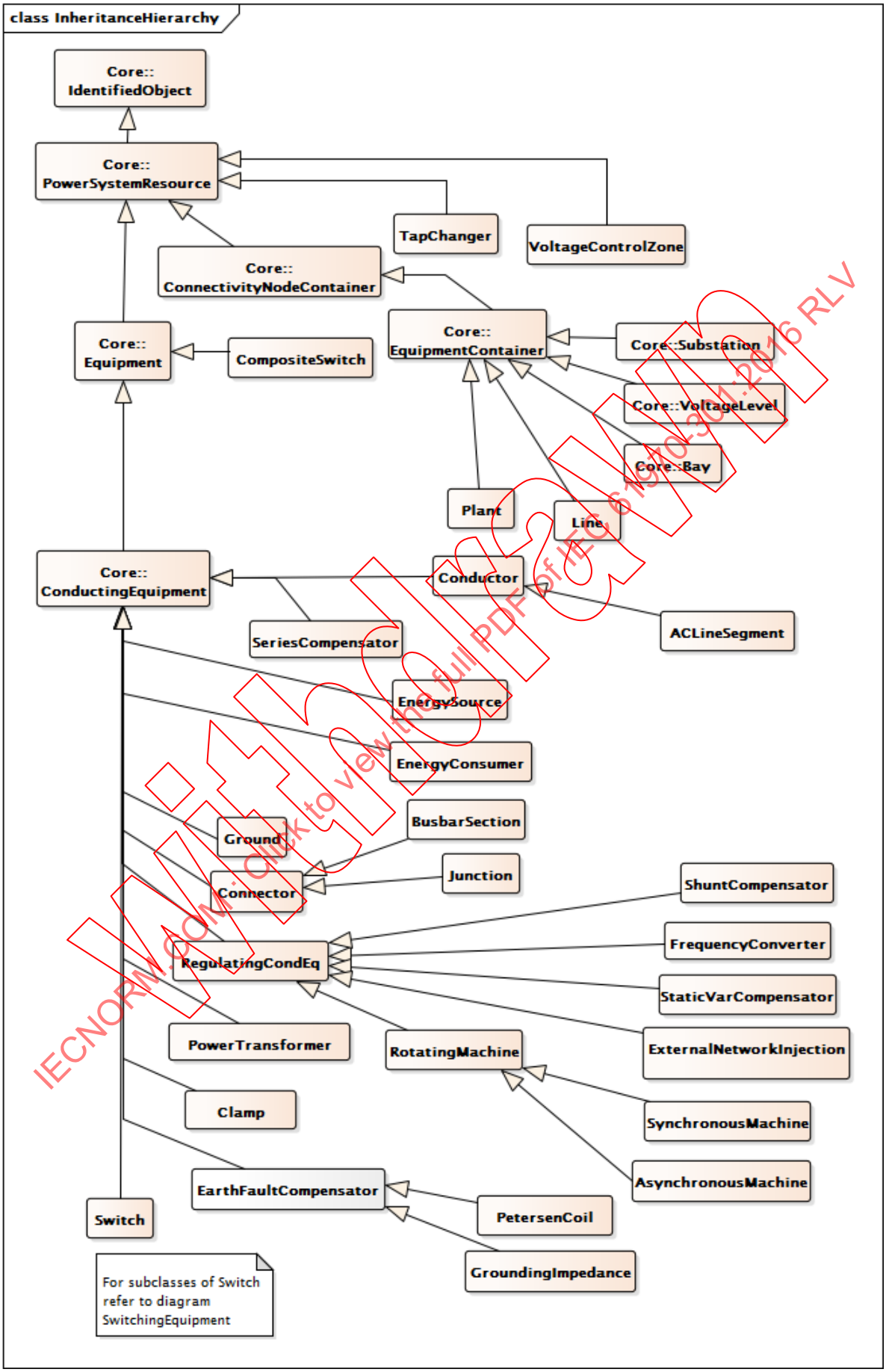


Figure 85 – Diagramme de classe Wires::EarthFaultCompensator

Figure 85: Représente les appareils de compensation de défaut à la terre.

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Figure 86 – Diagramme de classe Wires::InheritanceHierarchy

Figure 86: Ce diagramme décrit les relations d'héritage entre des classes de Wire ou liées à celui-ci.

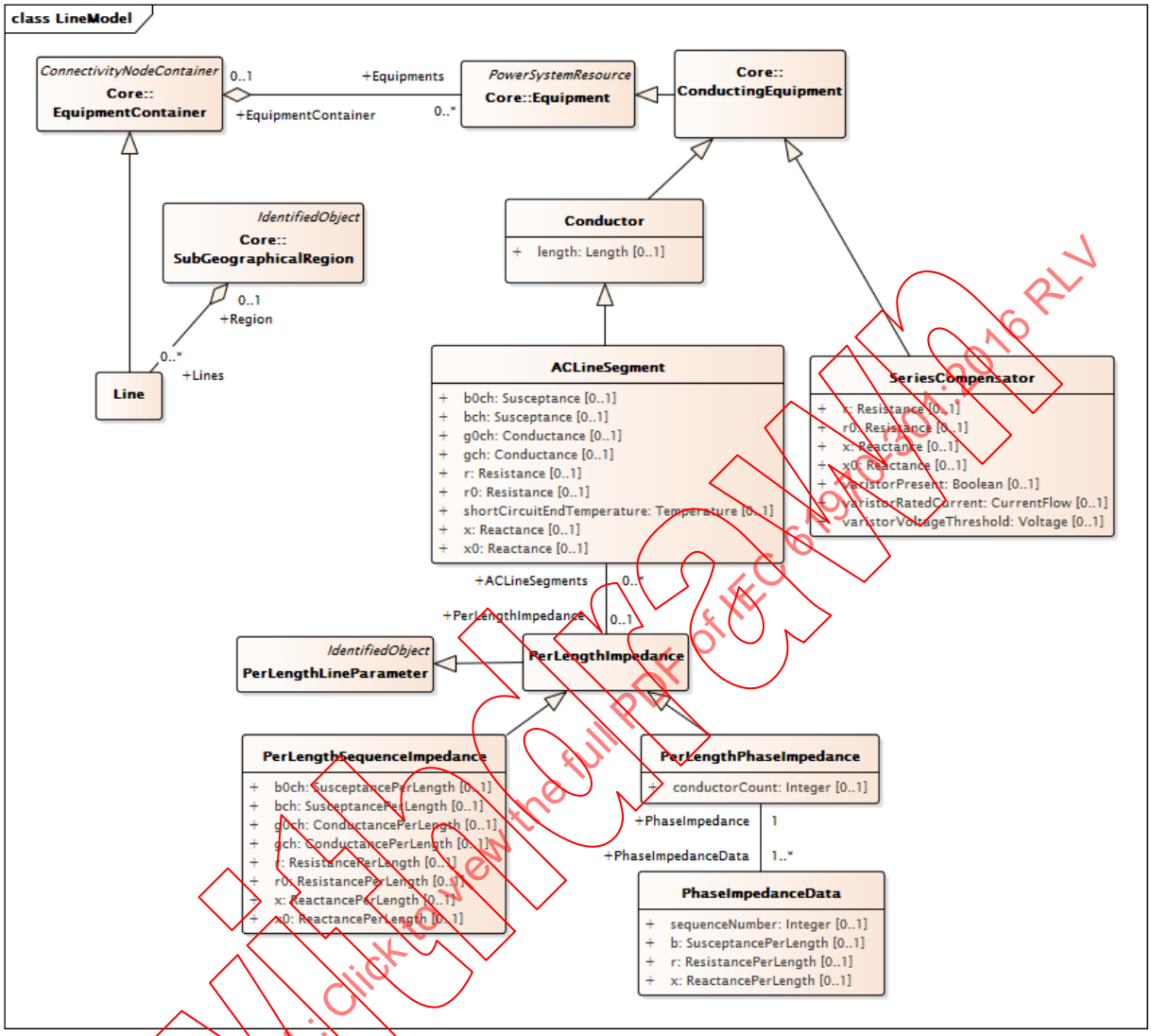


Figure 87 – Diagramme de classe Wires::LineModel

Figure 87: Ce diagramme représente toutes les classes liées au modèle de lignes de transport.

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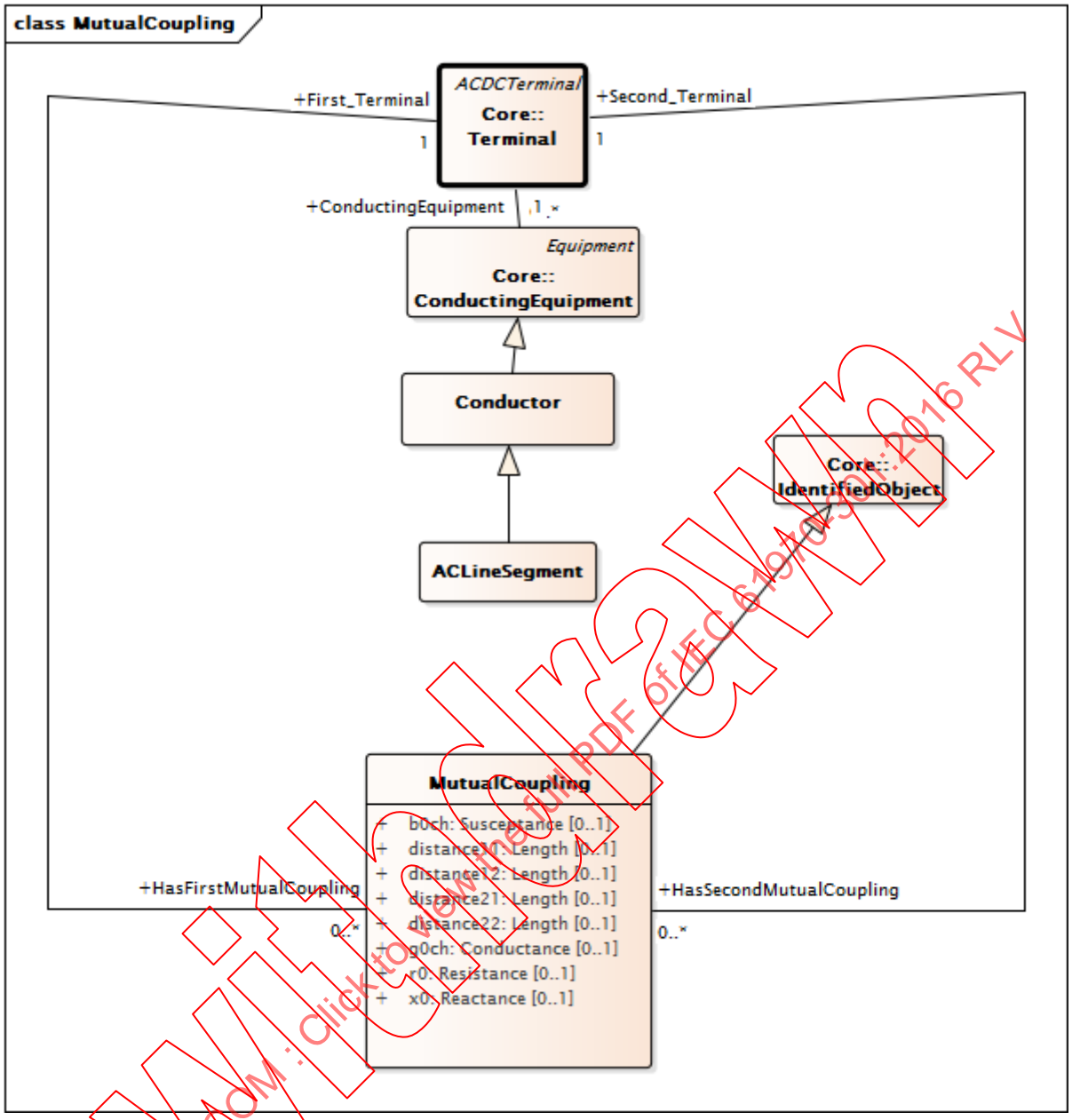
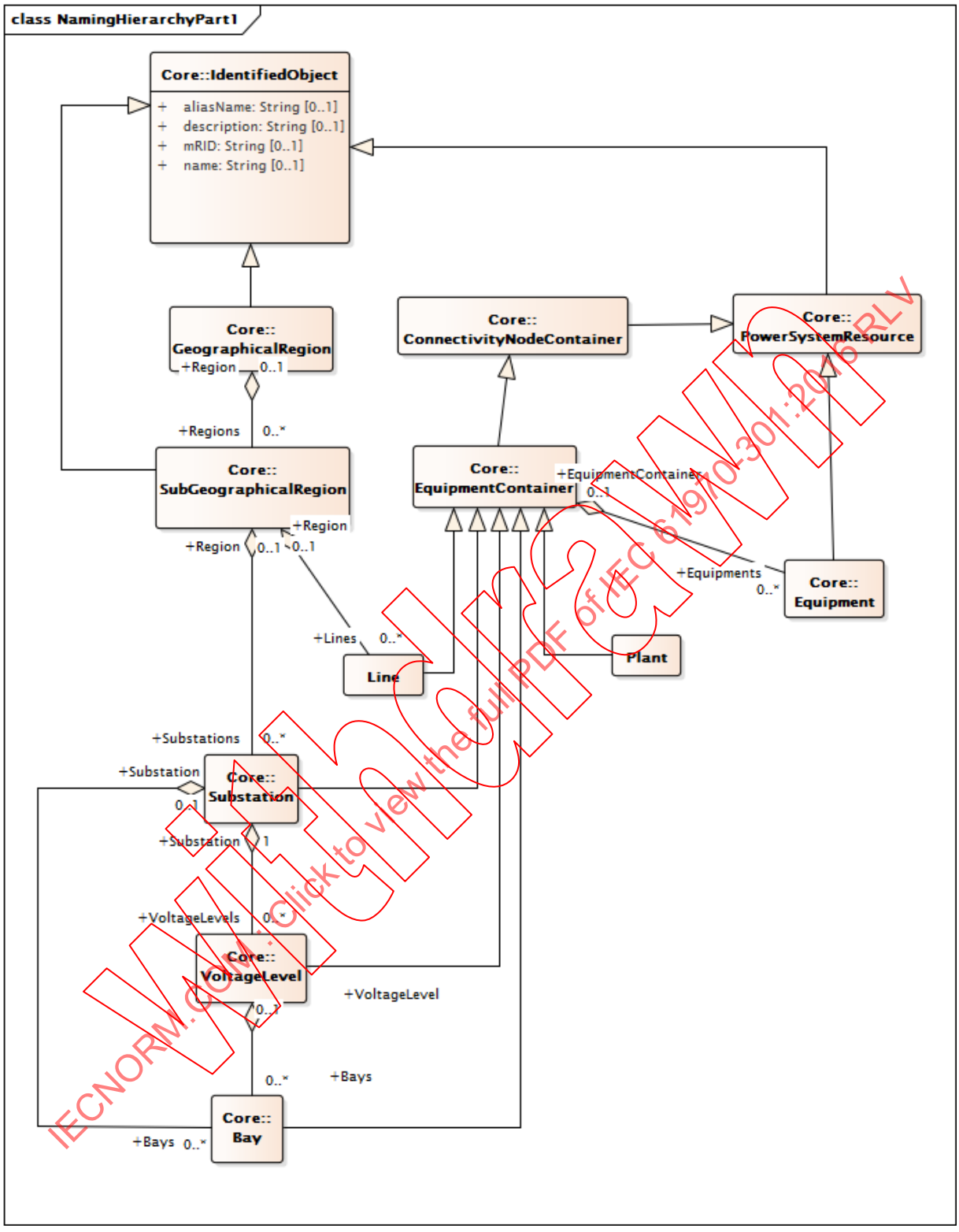


Figure 88 – Diagramme de classe Wires::MutualCoupling

Figure 88: Représente les modèles de couplage mutuel.

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Figure 89 – Diagramme de classe Wires::NamingHierarchyPart1

Figure 89: Le diagramme représente la partie supérieure de la hiérarchie de dénomination. La hiérarchie est une façon d'organiser et de nommer l'équipement. Par conséquent, elle est intimement liée à l'IdentifiedObject et à ses attributs. La classe Equipment est en outre spécialisée en de nombreux sous-types qui sont tous contenus par les sous-classes de EquipmentContainer.