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



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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

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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 seventh edition cancels and replaces the sixth edition, published in 2016. This edition constitutes a technical revision.

This edition reflects the model content version 'IEC61970CIM17v38', dated '2020-01-21', and includes the following significant technical changes with respect to the previous edition:

a) Added Feeder modelling;
b) Added ICCP configuration modelling;
c) Correction of issues found in interoperability testing or use of the standard;
d) Improved documentation;
e) Updated Annex A with custom extensions;
f) Added Annex B Examples of PST transformer modelling;

g) Added Annex C HVDC use cases.

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

FDIS	Report on voting
57/2210/FDIS	57/2224/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- withdrawn,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 part of the IEC 61970 series which define 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 documents 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.

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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 and interoperability 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 modelled 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 can 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 several logical Packages, each of which represents a certain part of the overall power system being modelled. 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) and power system modelling 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.

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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 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*

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 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
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

3.2
application program interface
API
set of public functions provided by an executable application component for use by other executable application components

3.3
unified modelling 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 artefacts directly from the UML. A basic understanding of UML is necessary to understand the CIM.

3.4
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 other parts of 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 Modelling Language (UML) which is maintained as a UML file managed by a UML editing tool. The UML file exists in two 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:

- iec61970cim17v38_iec61968cim13v12_iec62325cim03v17a.eap.

This file can be obtained from CIM users group.

4.2 CIM modelling notation

The CIM is defined using object-oriented modelling techniques. Specifically, the CIM specification uses the 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

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. Entities may have associations that cross many package boundaries. Each application will use information represented in several packages.

Different groups of packages are assigned to different working groups within the IEC for convenience in managing and maintaining them.

WG13 packages are included in this document and contained under the IEC61970 package. The IEC61970 packages do not depend upon other outside packages. As shown in Figure 1, the IEC61970 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. WG14 packages in the IEC 61968 series 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. WG16 packages in the IEC 62325 series describe electric energy markets.

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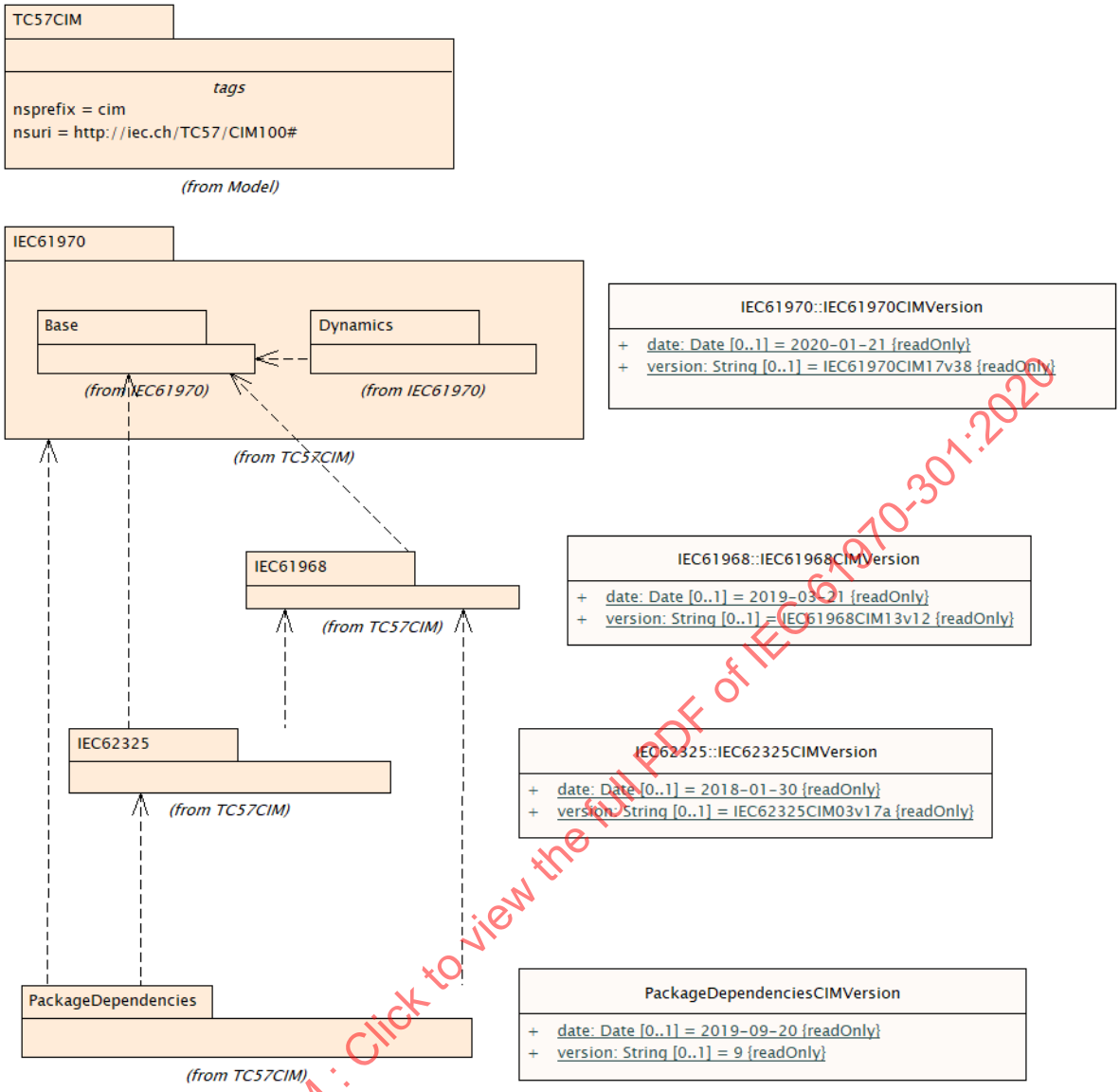


Figure 1 – Defined dependencies between CIM packages and packages' versions information

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Note that the package boundaries do not imply application boundaries. An application may use CIM entities from several packages. It is also anticipated that 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.

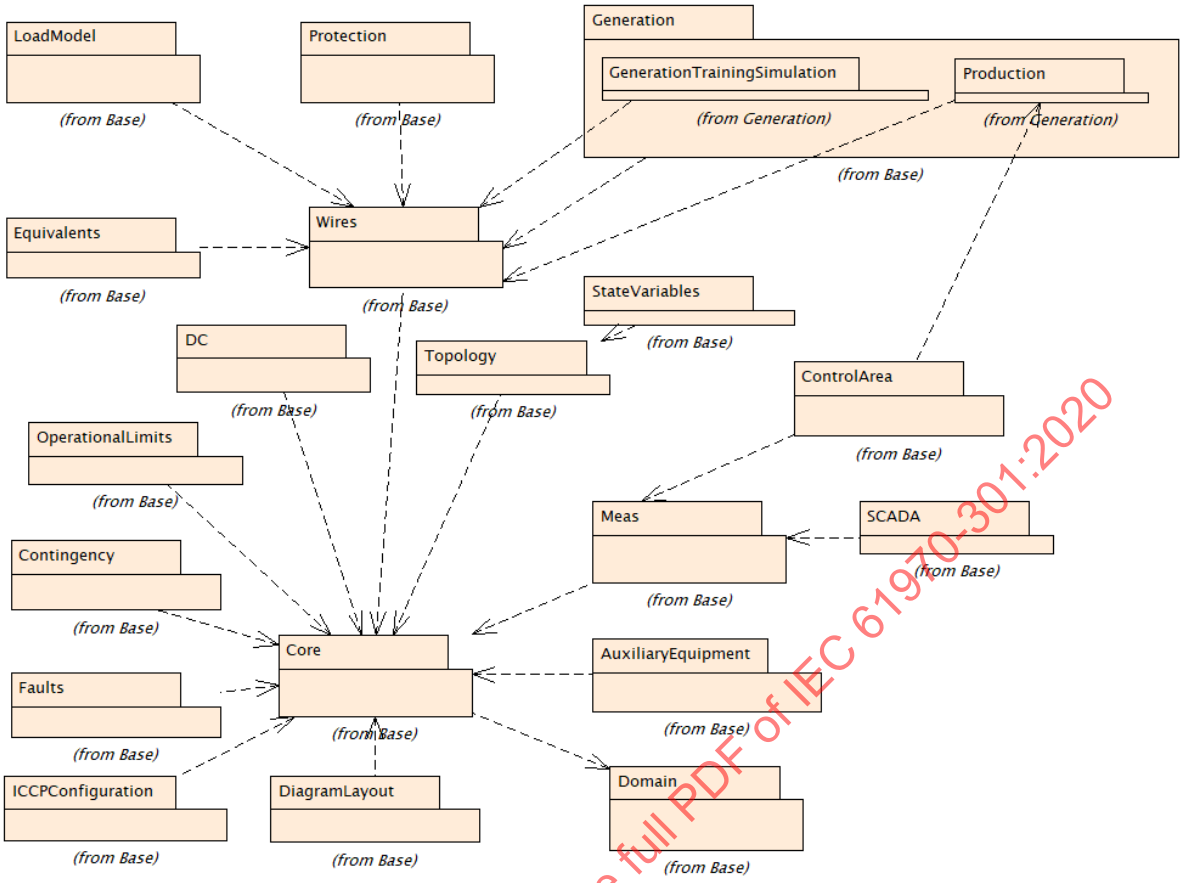


Figure 2 – CIM IEC 61970-301 package diagram

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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, analyse, 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 modelled 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, the properties of CIM entities are modelled, but not their behaviour. 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 important for the integration and interoperability of power system 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. This implies custom mapping to serialization artefacts 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 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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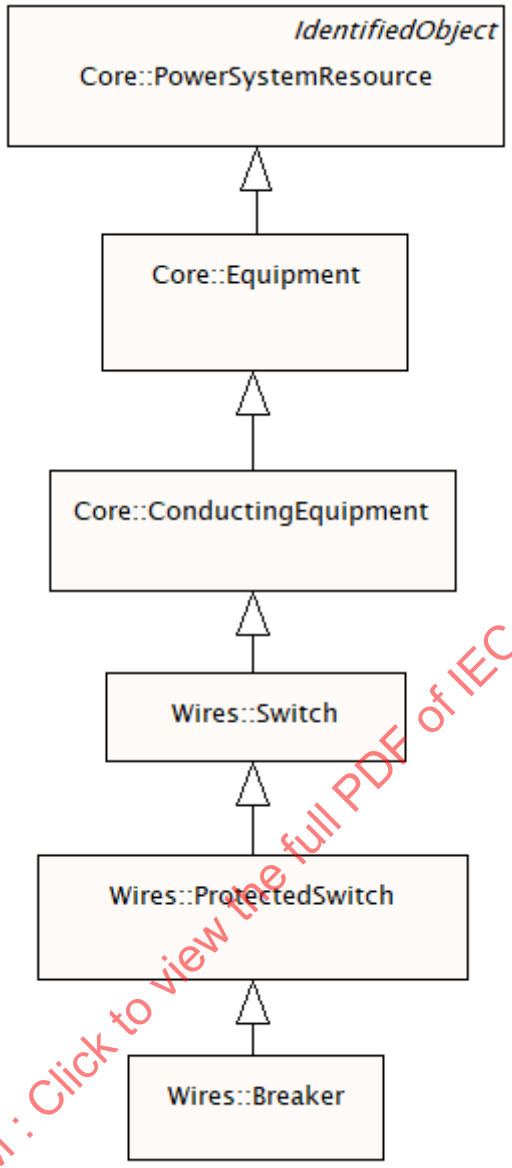


Figure 3 – Example of generalization

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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.

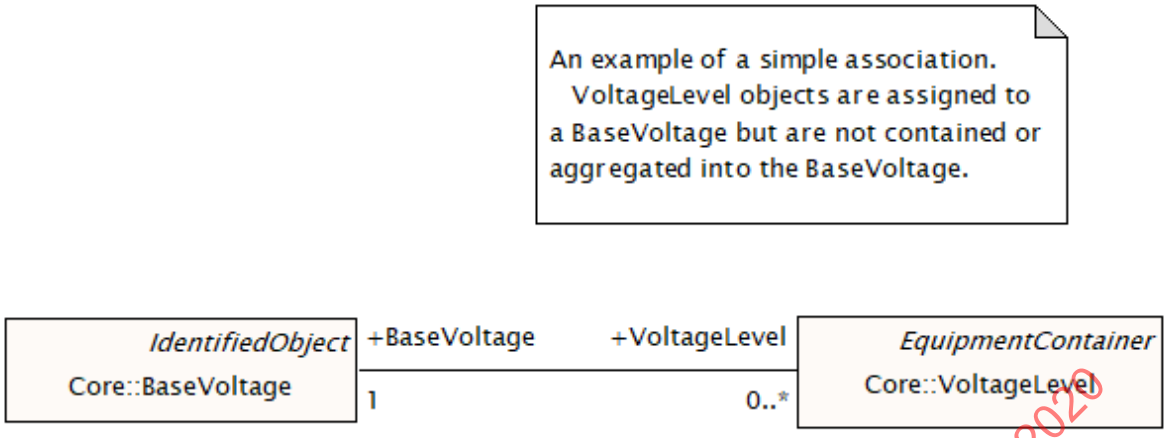


Figure 4 – Example of simple association

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.

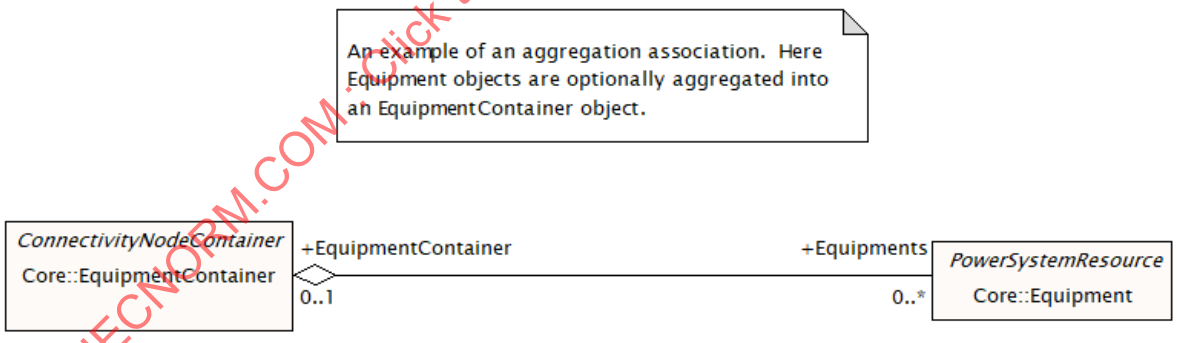


Figure 5 – Example of aggregation

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 4.5.16.

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4.5.2 Containment, equipment hierarchies and naming

4.5.2.1 Containment structure

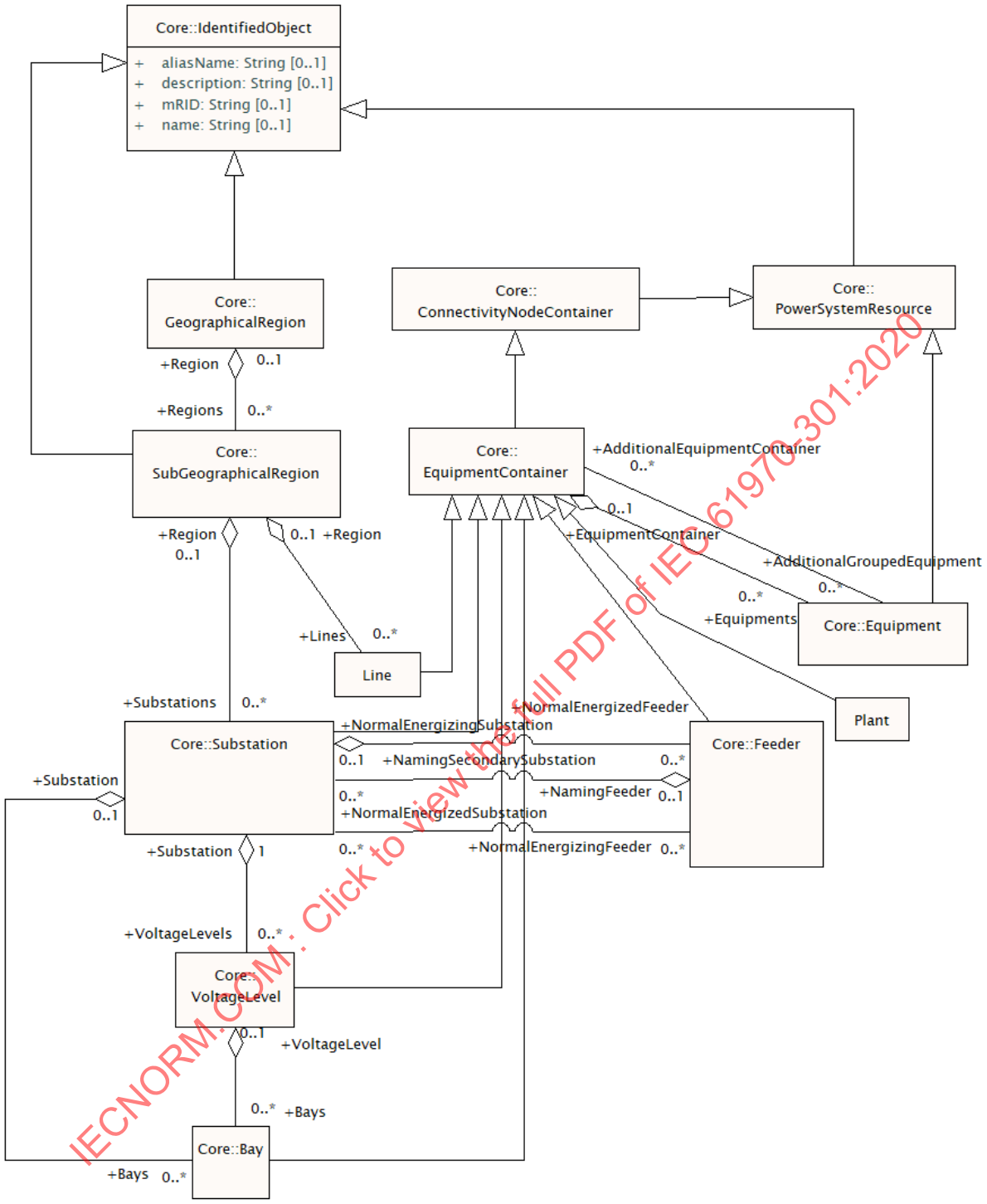
Figure 6 shows the concept of equipment containers to form hierarchies in the CIM. Equipment containers represent ways of organizing and naming equipment typically found within a substation. As may be seen, there is some flexibility provided in which containers are used in a specific application of the 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 EquipmentContainer(s). In general, a Bay is contained within a specific VoltageLevel, which in turn is contained within a Substation. Substation(s) and Line(s) may be contained within SubGeographicalRegion(s) and GeographicalRegion(s).

One containment hierarchy is used with the IdentifiedObject class to create human readable hierarchical naming. 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. Additional names can be defined by using name classes of 4.5.3 or by defining extensions. The mRID attribute of the IdentifiedObject class provides a straight forward and rigorous means of identity for CIM objects.

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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.

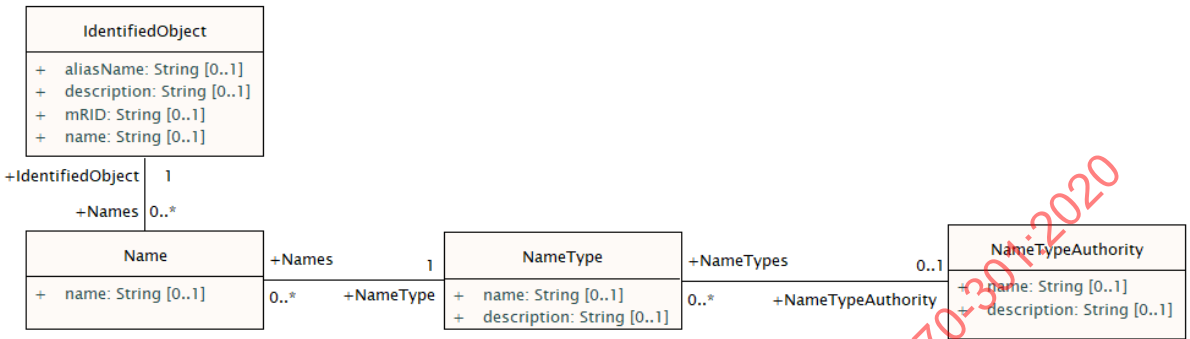


Figure 7 – Names

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 part of the Meas package class diagram dealing with measurements to illustrate how measurements are associated with conducting equipment.

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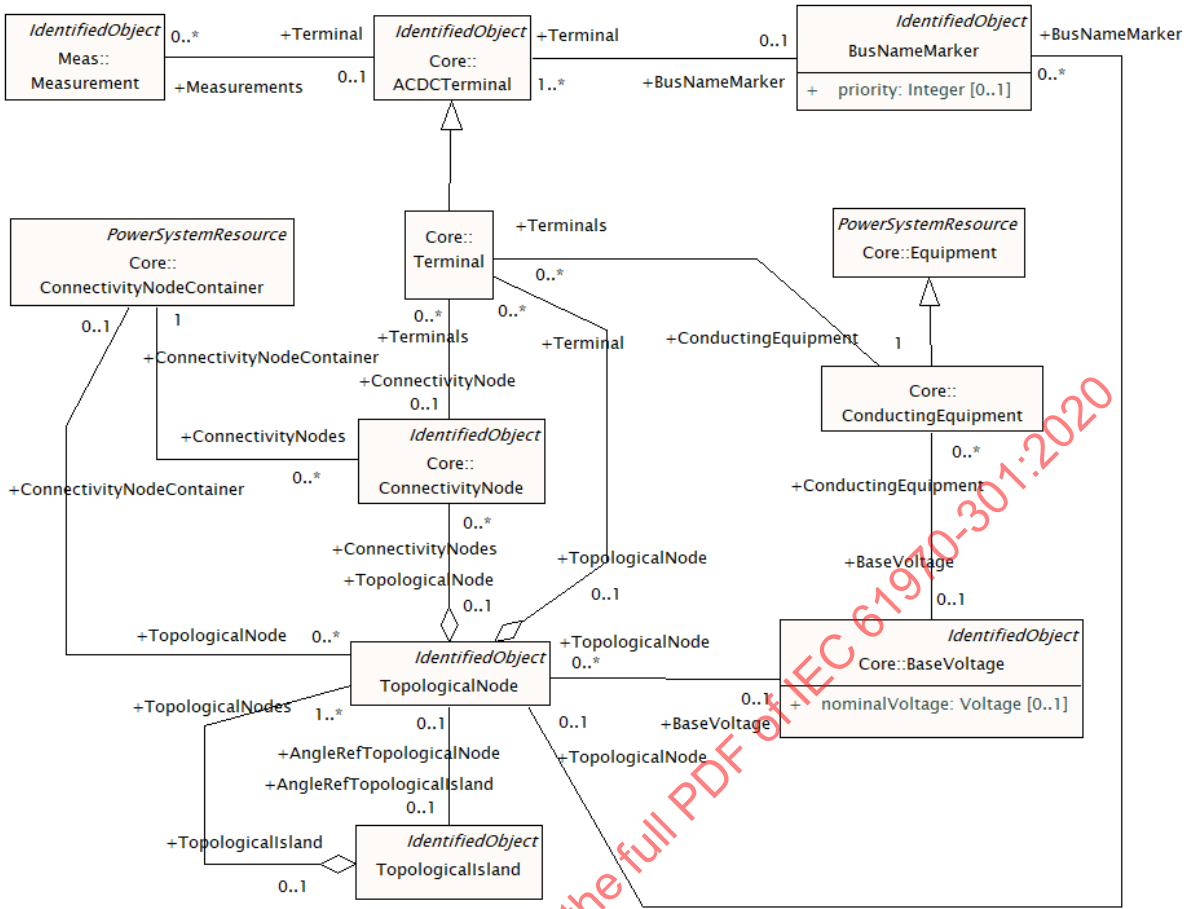


Figure 8 – Connectivity model

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. TopologicalNode-s and TopologicalIsland-s are created as a result of a topology processor evaluating the “as built” connectivity and the actual Switch positions.

It is possible to exchange documents directly involving TopologicalNode and bypassing the ConnectivityNode details by using the TopologicalNode to Terminal association. This is often useful for exchanges involving models which do not 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 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 model exchange without switch detail.

EquipmentContainer-s, which are a specialization of a ConnectivityNodeContainer, may contain zero or more ConnectivityNode-s. 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 ConnectivityNode identify the ConductingEqupment object(s) that are electrically connected. Similar connectivity at the “bus/branch” level of detail 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 TopologicalNode-s. TopologicalNode-s are created from

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ConnectivityNode-s 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.

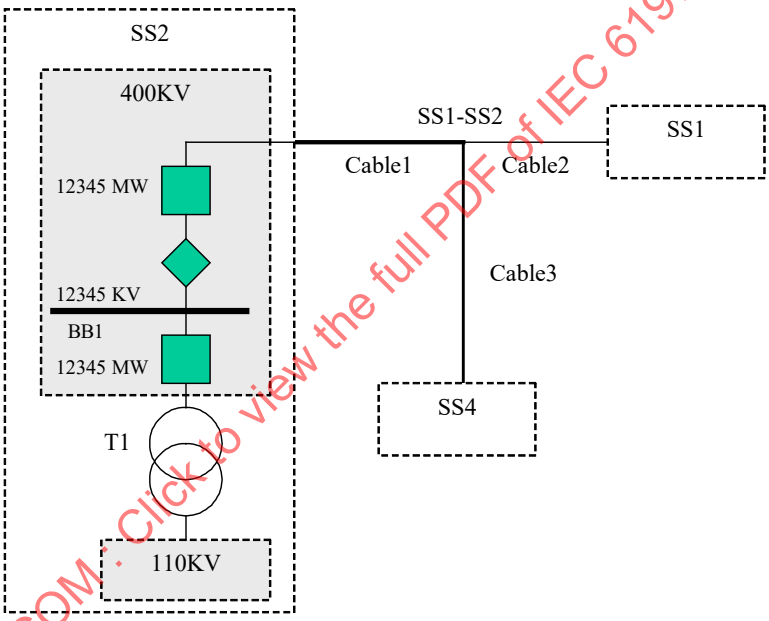


Figure 9 – Simple network example

Figure 10 shows how connectivity is modelled in the CIM as well as one way (but not necessarily the only way) containment is modelled for the diagram in Figure 9. The shaded square boxes represent EquipmentContainer-s, 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 ConnectivityNode-s, 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 ConnectivityNode-s.

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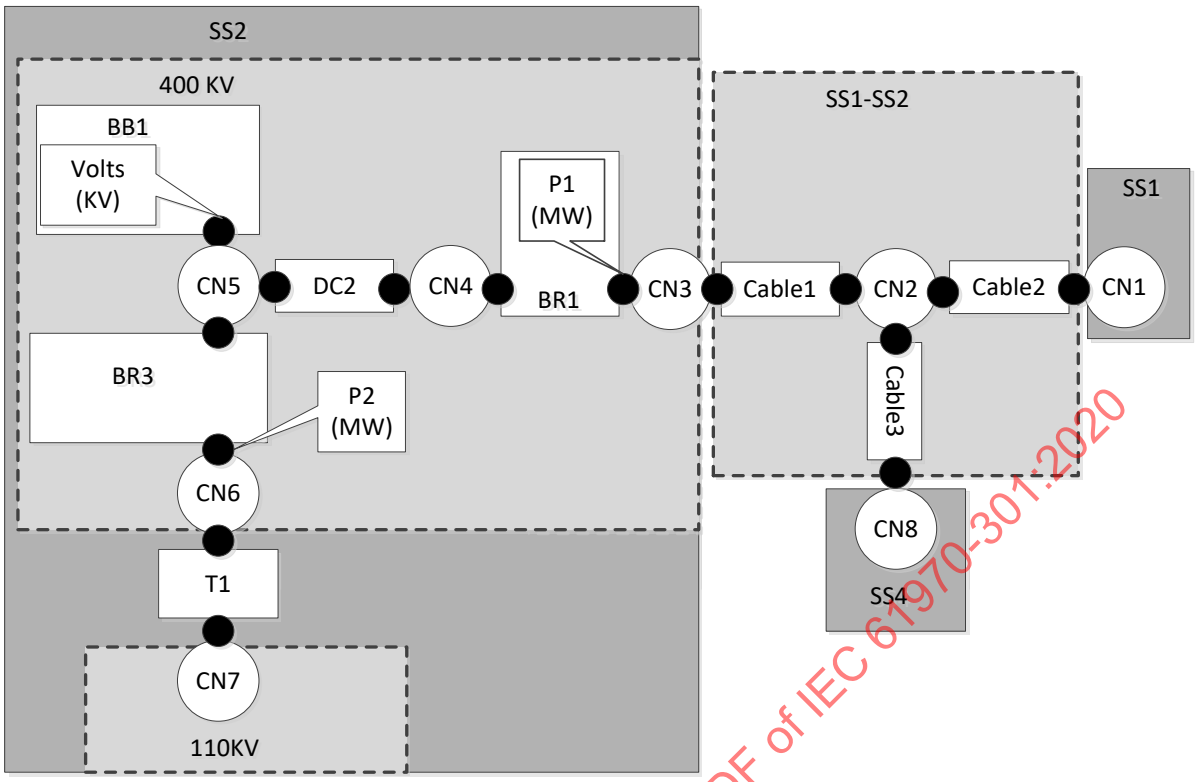


Figure 10 – Simple network connectivity modelled with CIM Topology

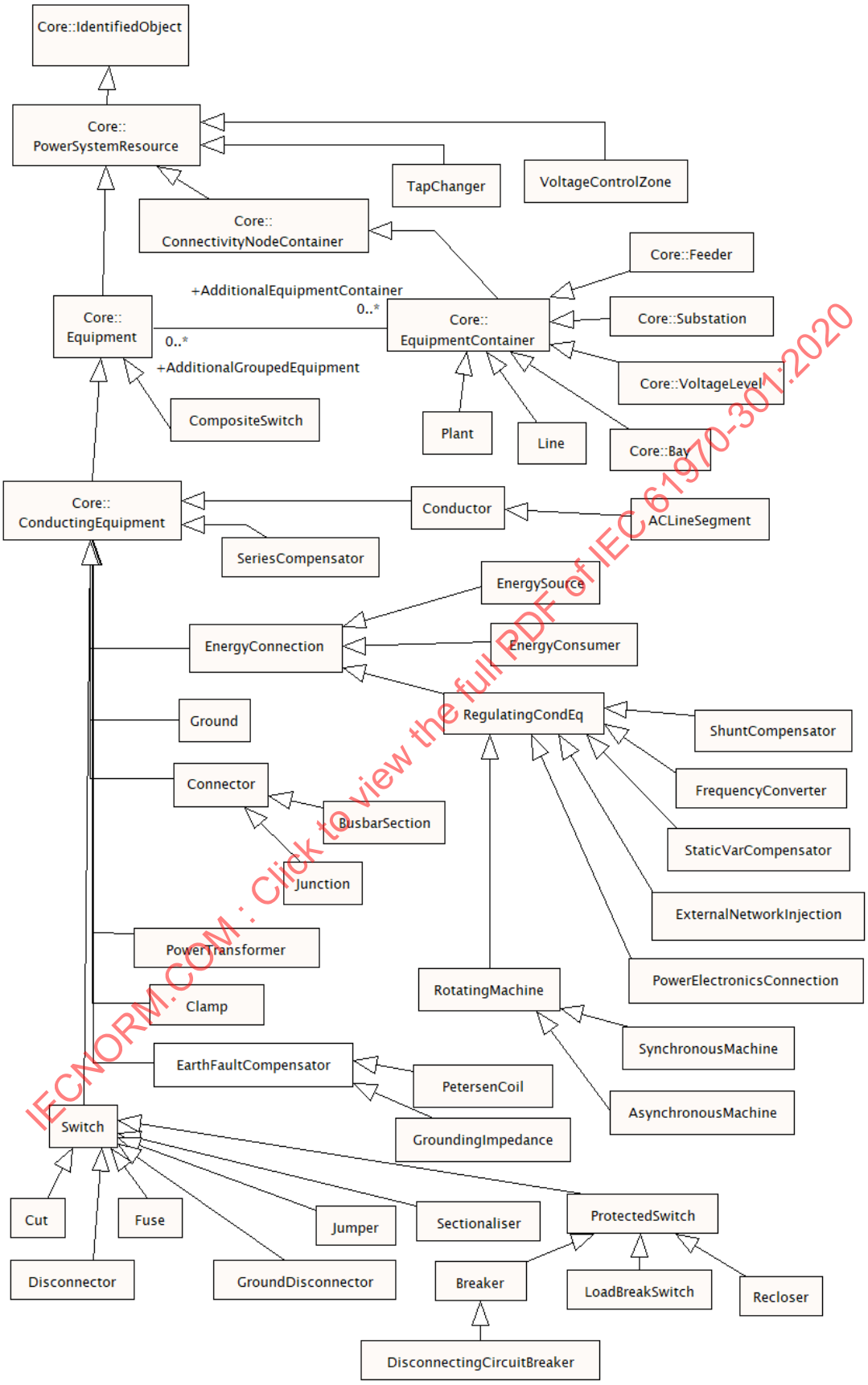
The Line SS1-SS2 contains three ACLineSegment-s (Cable1, Cable2, and Cable3) and associated ConnectivityNode (CN2) to model a T-junction, which provides a connection to SS4. This represents just one way that this configuration could be modelled. Each ACLineSegment has two Terminals. Cable1 is connected to CN3 and CN2 via these Terminals. CN3 is contained by the VoltageLevel 400KV. 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 modelled 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 part of the Wires package in a class diagram which models a PowerTransformer device.

The transformer model is applicable for 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 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. For transmission systems, three physical single phase devices are often represented by one PowerTransformer instance. If detail of the individual single phase devices were required, the TransformerTank objects should additionally be modelled.

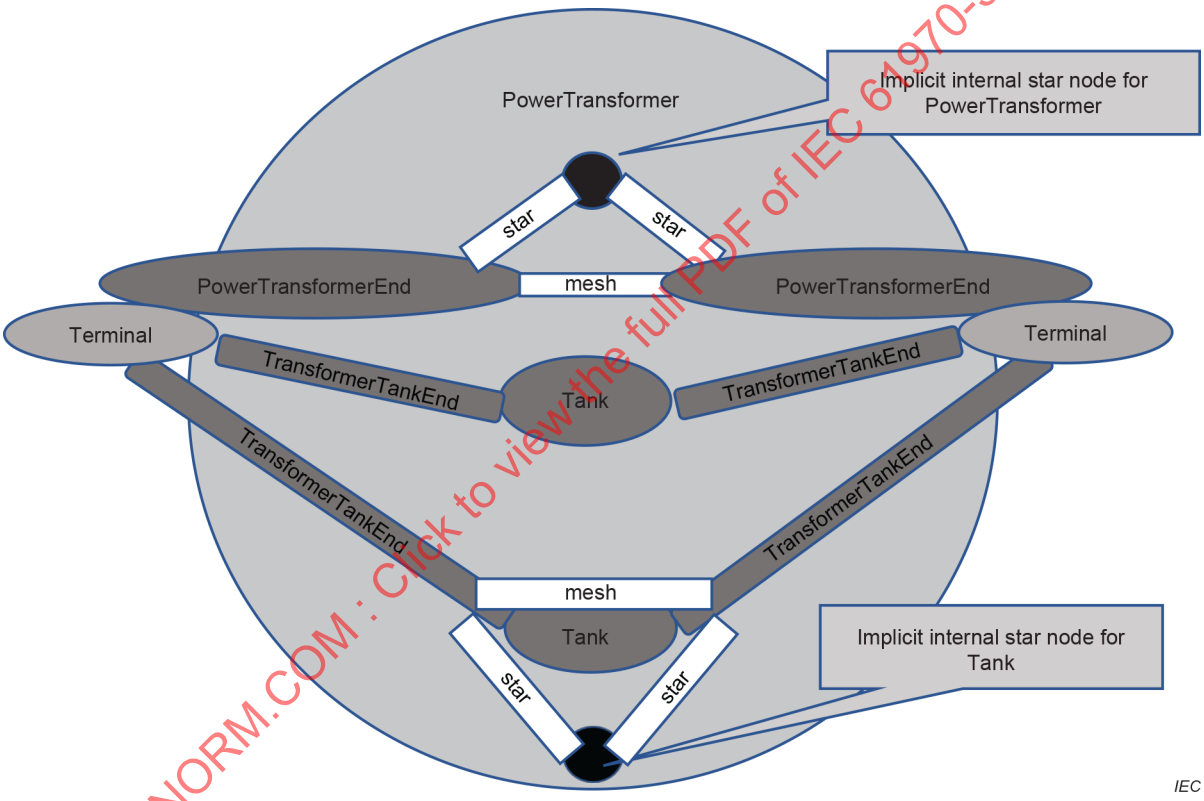


Figure 12 – Transformer and Tank model

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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 transformers 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 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 modelled with association type relationships. As shown, a PowerTransformer may associate zero or more PowerTransformerEnd-s, but a PowerTransformerEnd may associate to only zero or one PowerTransformer. Similarly, the PowerTransformer may associate to zero or more TransformerTank objects, but a TransformerTank may associate to only zero or one PowerTransformer object.

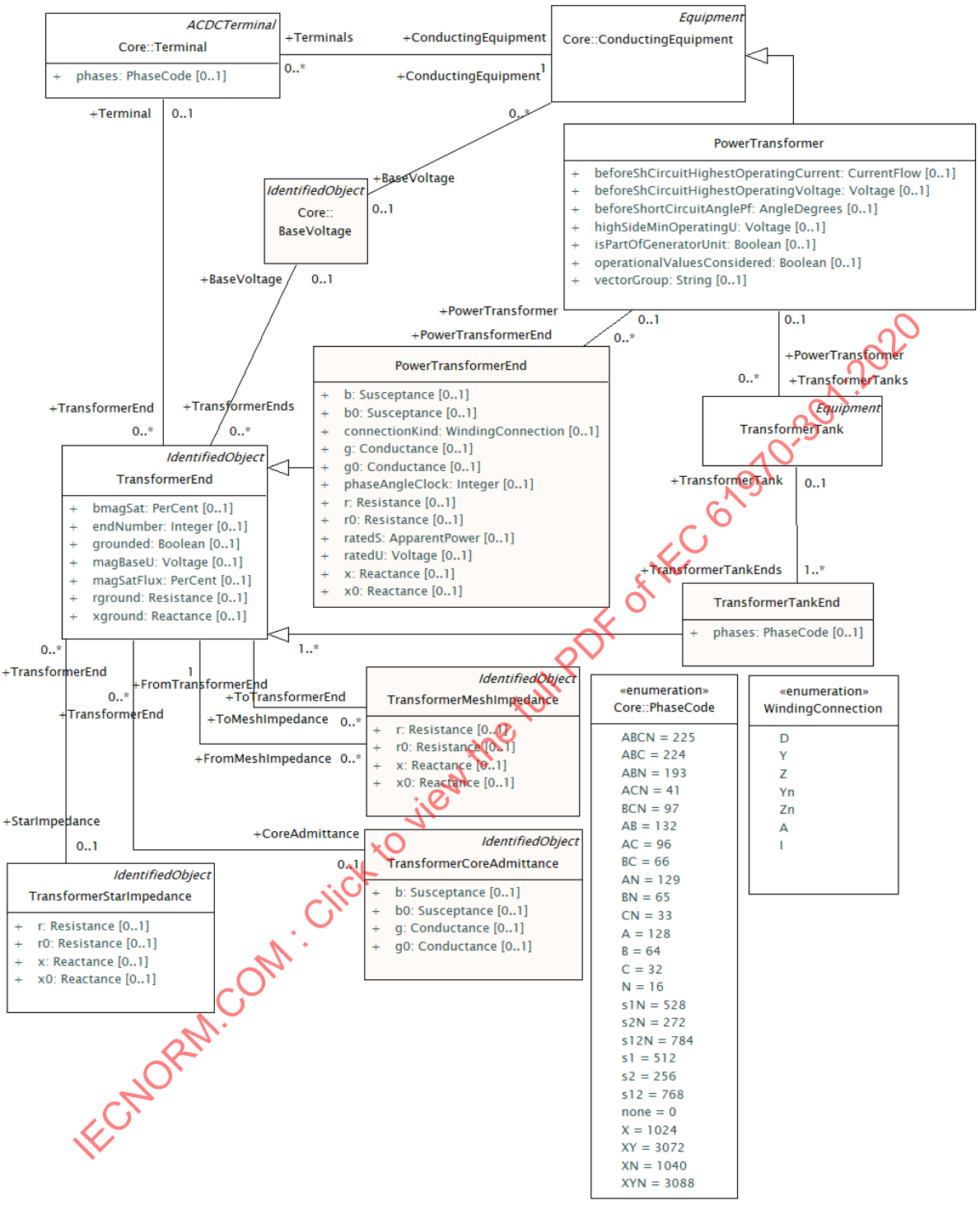
The PowerTransformerEnd specializes the TransformerEnd class which has other relationships as well:

- 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 PowerTransformerEnd and its connected Terminal both have sequence numbers TransformerEnd.endNumber and ACDCTerminal.sequenceNumber. Those numbers may or may not be in synch.

Figure 13 shows UML for the transformer model.

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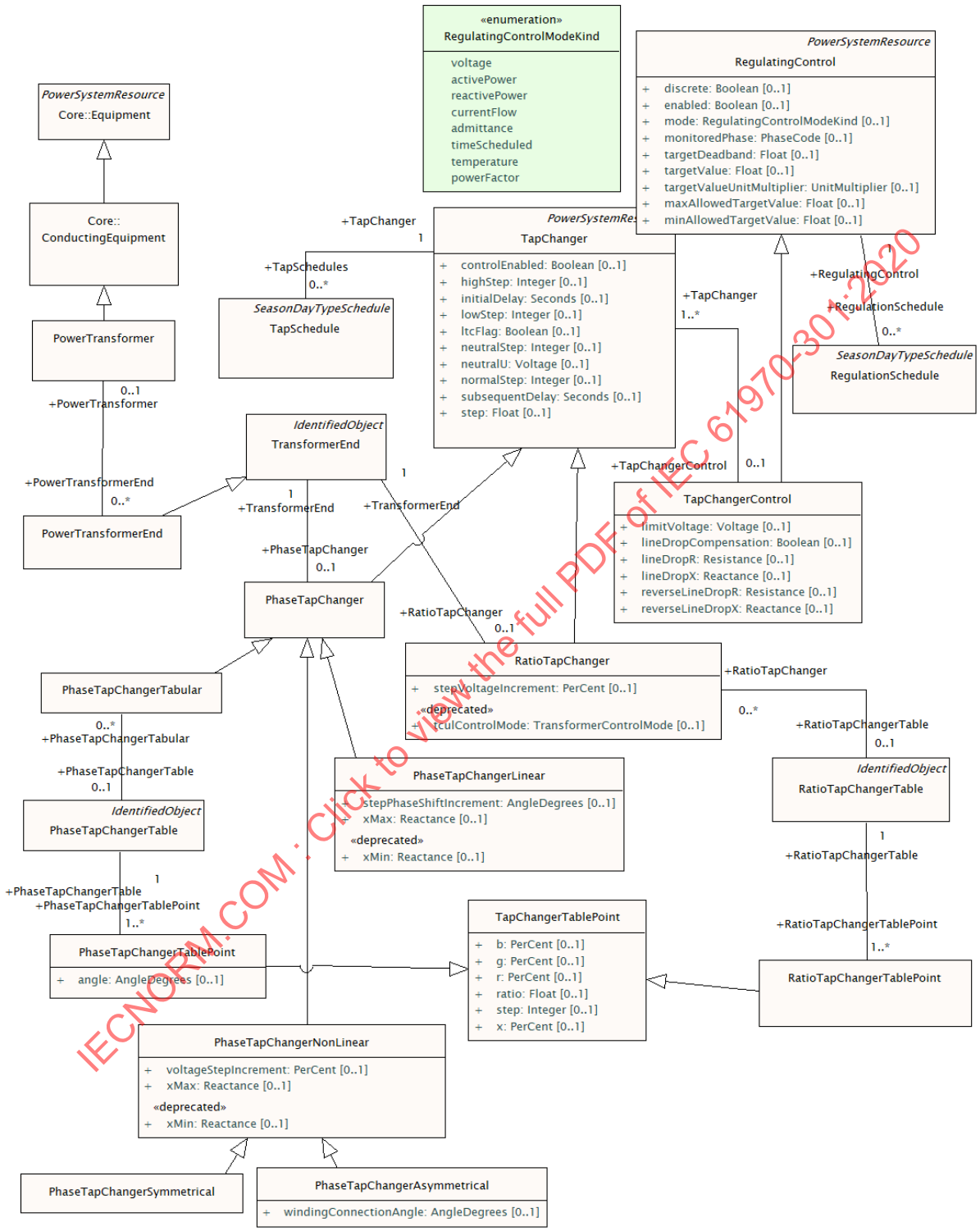
Figure 13 – Transformer model

4.5.7 Transformer tap modelling

4.5.7.1 Generalized tap modelling

Multiple types of transformer tap models are supported by the CIM model. Depending on the physical construction, the effects of tap movement shall be defined using either the RatioTapChanger class or the PhaseTapChanger class and its various specializations. The PhaseTapChanger can be specialized into several different types representing the physical

construction and hence behaviour. The attributes of TapChanger are applicable for all the RatioTapChanger specializations. Figure 14 shows the UML model for the transformer taps.



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Figure 14 – Transformer tap model

Multiple tap changers can be combined within one power transformer, but to avoid interpretation issues only one phase shifting and one ratio changing tap changer shall be modelled on any given terminal. The ratio or phase shift change is documented relative to the other terminal(s) assuming those terminals are at the nominal (1 PU) ratio and nominal (zero) phase angle shift. Tabular representation is required in cases where it is necessary to combine both phase shifting and ratio tap changer on one terminal, 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 behaviour. 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 modelling

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 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 modelling

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 modelling

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 modelled using the PhaseTapChangerLinear class.

4.5.7.5 Symmetrical and asymmetrical phase shifter modelling

4.5.7.5.1 Common information

Subclause 4.5.7.5 describes Phase-Shifting Transformer (PST) modelling 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 1.

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Table 1 – 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 2.

Table 2 – 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 or PowerTransformerEnd.x as .xMin is a deprecated attribute
$X(\alpha_{max})$	cim:PhaseTapChangerLinear.xMax or cim:PhaseTapChangerNonLinear.xMax or PowerTransformerEnd.x as .xMin is a deprecated attribute
θ	cim:PhaseTapChangerAsymmetrical.windingConnectionAngle

The impedance variation depending on tap position on a phase shift transformer is described in Table 3 and variables in Table 4.

Table 3 – 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	$X(r,\alpha) = X_r(r_{nom})\left(\frac{r}{r_{nom}}\right)^2 + X_\alpha(0)$ $+\left(X_\alpha(\alpha^0_{max}) - X_\alpha(0)\right)\left(\frac{\tan\alpha}{\tan\alpha_{max}(r)}\frac{\sin\theta - \tan\alpha_{max}(r)\cos\theta}{\sin\theta - \tan\alpha\cos\theta}\right)^2$

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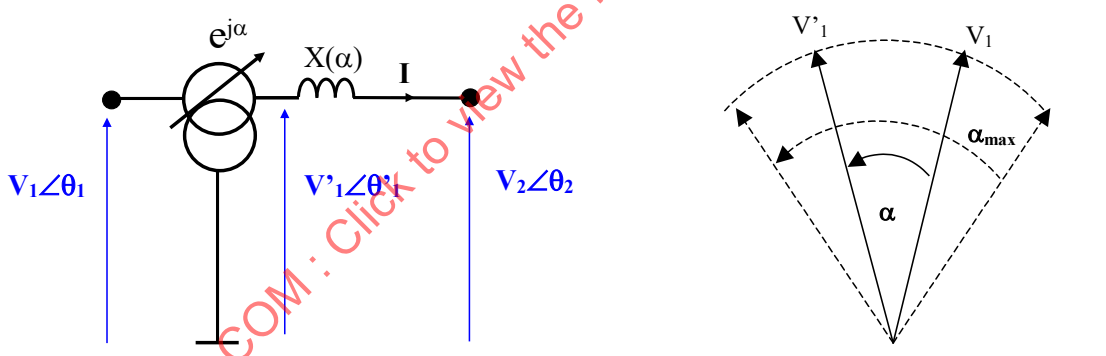
Equipment type	Equivalent series reactance as a function of the phase shift angle
	with $\alpha_{max}(r) = A\tan\left(\frac{\sin\theta}{\frac{r}{r_{nom}\tan\alpha^0_{max}}\left(\sin\theta - \tan\alpha^0_{max}\cos\theta\right)+\cos\theta}\right)$ and $\alpha^0_{max} = \alpha_{max}(r_{nom})$

Table 4 – Description of variables

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

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

$r = 1$

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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 for non-delta-hexagonal technologies can be written as follows:

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

Parameters:

α_{max} maximum phase shift

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

$X(\alpha_{max})$ equivalent series reactance at maximum 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.

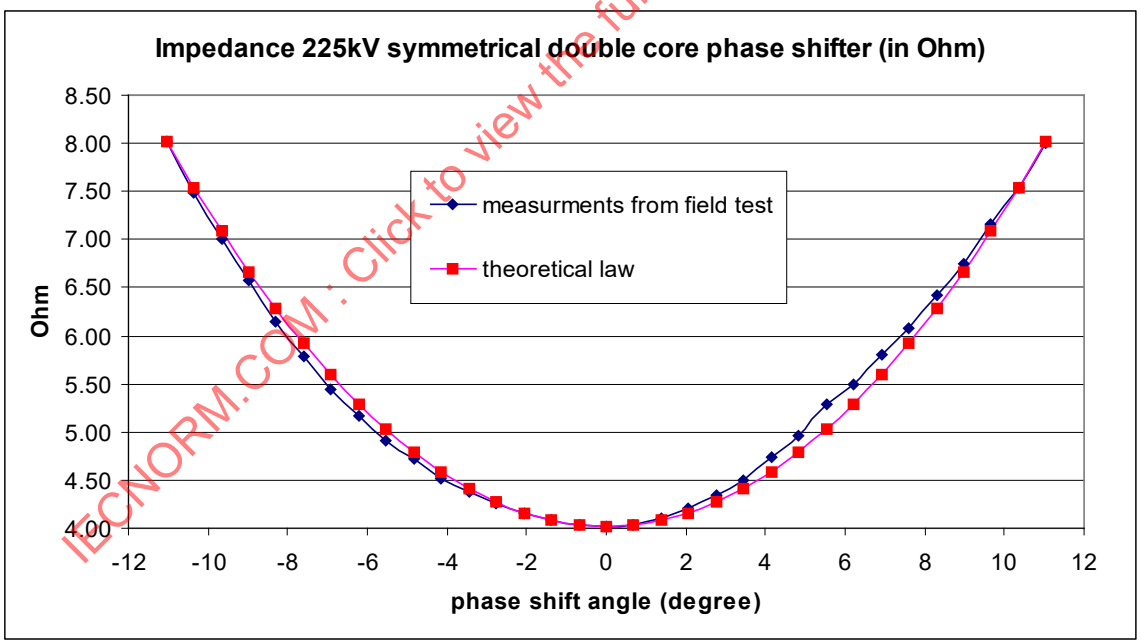


Figure 16 – Symmetrical phase shifter impedance variation

Three-phase core organization is shown in Figure 17.

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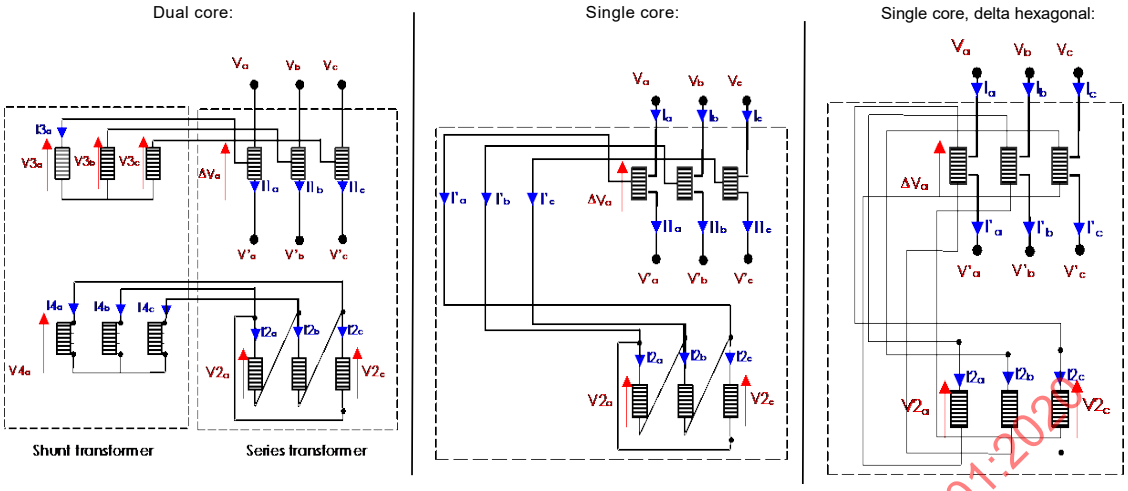
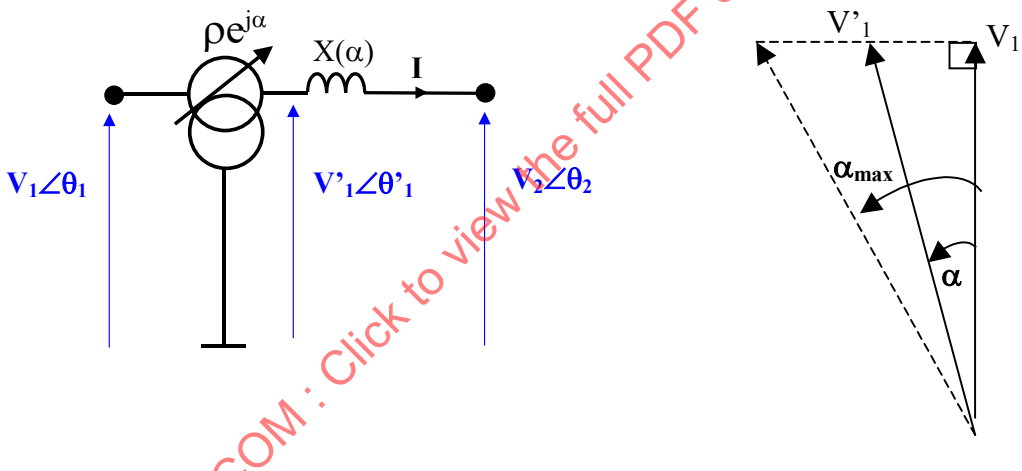


Figure 17 – Core organization

4.5.7.5.3 Quadrature booster

Phasor diagram and equations are shown in Figure 18.



$$V'_1 = V_1(1 + j\tan\alpha) = \rho e^{j\alpha} V_1$$

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

ρ and α vary with ρ.cos α = constant.

Figure 18 – Phasor diagram and equations

Expression of the angle and ratio per tap

Based on Figure 18:

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

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

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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.

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

Parameters:

α_{max} maximum phase shift

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

$X(\alpha_{max})$ equivalent series reactance at maximum 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.

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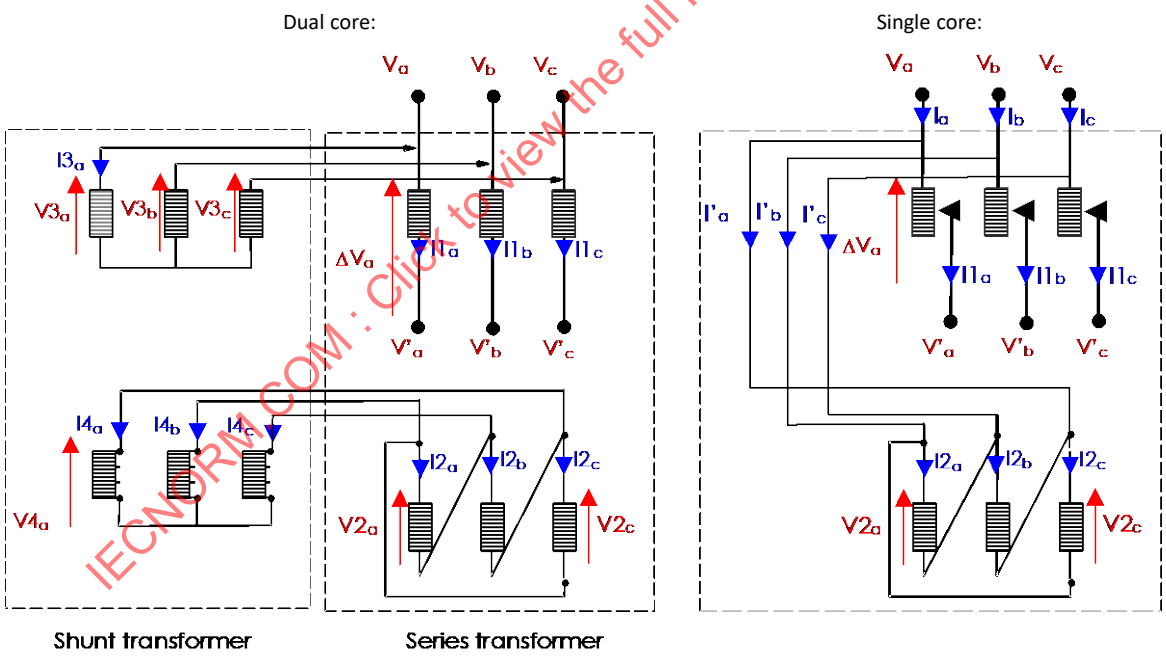
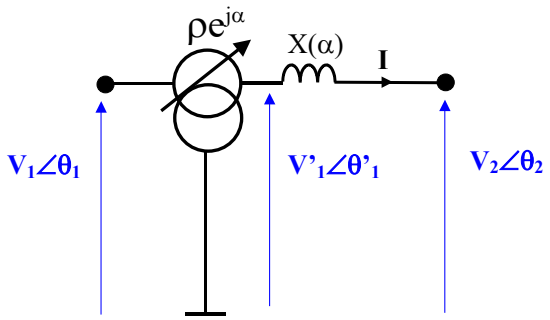
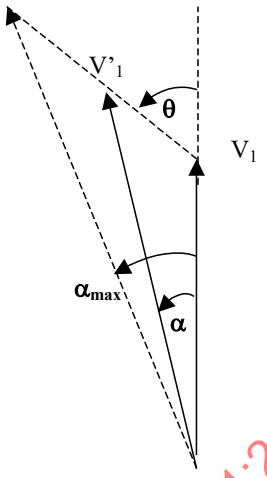


Figure 19 – Core organization

4.5.7.5.4 Asymmetrical phase shifter modelling

Phasor diagram and equations are shown in Figure 20.





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

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

θ is fixed, only α and ρ vary.

Figure 20 – Phasor diagram and equations

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

Variable:

α	current phase shift

Three-phase organizations are shown in Figure 21.

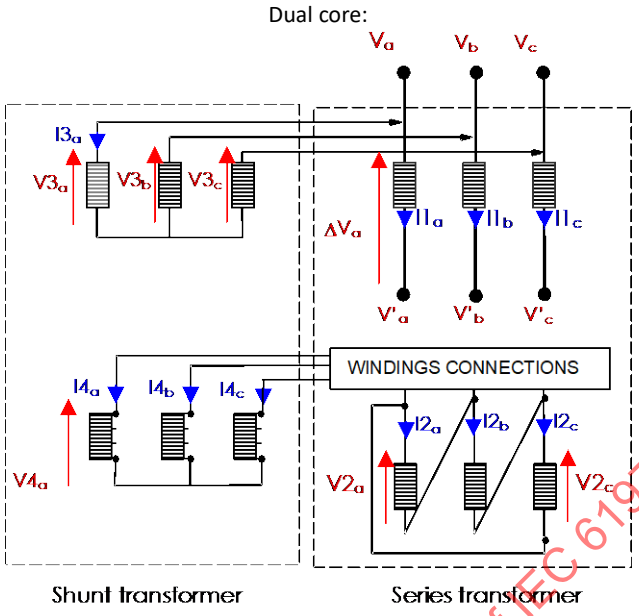
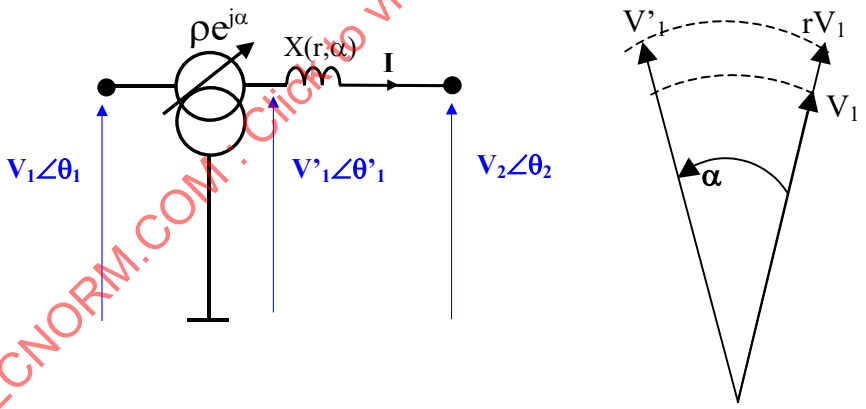


Figure 21 – Core organization

4.5.7.5.5 In-phase transformer and symmetrical phase shifter

Phasor diagram and equations are shown in Figure 22.



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

r and α vary, and ρ=r.

r and α vary, and ρ=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} maximum 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 maximum phase shift at nominal in-phase ratio (r_{nom})

Variables:

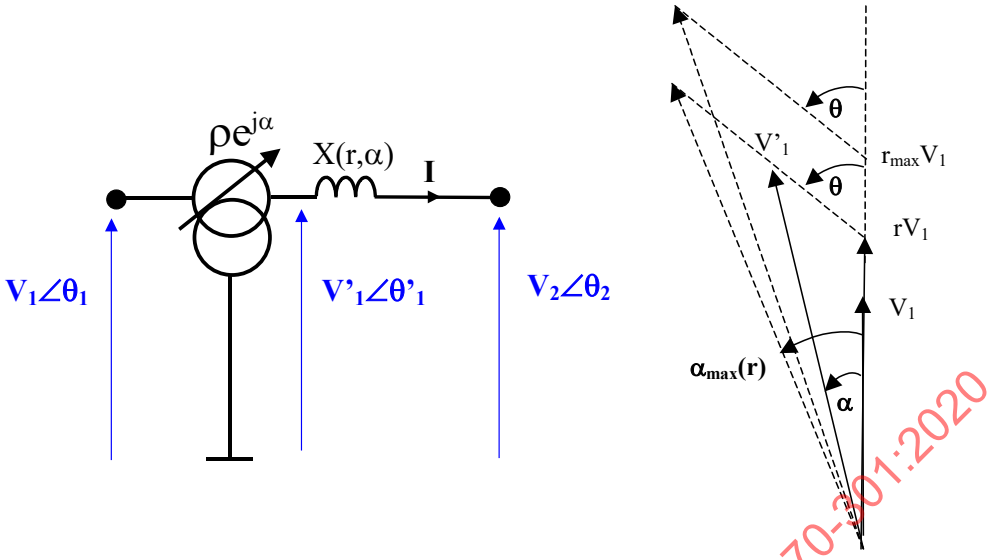
r current ratio of the in-phase transformer

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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$$V'_1 = rV_1\left(1 + e^{j\theta}.\frac{\tan\alpha}{\sin\theta - \tan\alpha\cos\theta}\right) = \rho e^{j\alpha}V_1 \qquad V_2 = (V1 - jX(\alpha)I).\rho e^{j\alpha}$$

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

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:

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

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

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

$\alpha^{0}_{\max} = \alpha_{\max}(r_{nom})$ maximum phase shift for nominal in-phase ratio (r_{nom})

X_{α} (0) equivalent series reactance of the phase shifter part at zero phase shift

X_{α} ($\alpha^{0}_{\max}$) equivalent series reactance of the phase shifter part at maximum 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 organizations shown in Figure 24.

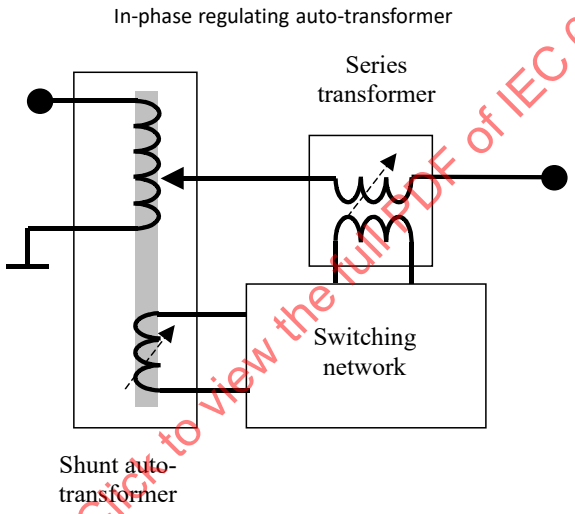


Figure 24 – Core organization

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

4.5.7.6 Phase shifter transformer tabular modelling

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), 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. The attribute is also used in the IEC 60909 calculations.

The meaning of the combinations for TapChanger.TapChangerControl and TapChanger.ltcFlag are described in Table 5.

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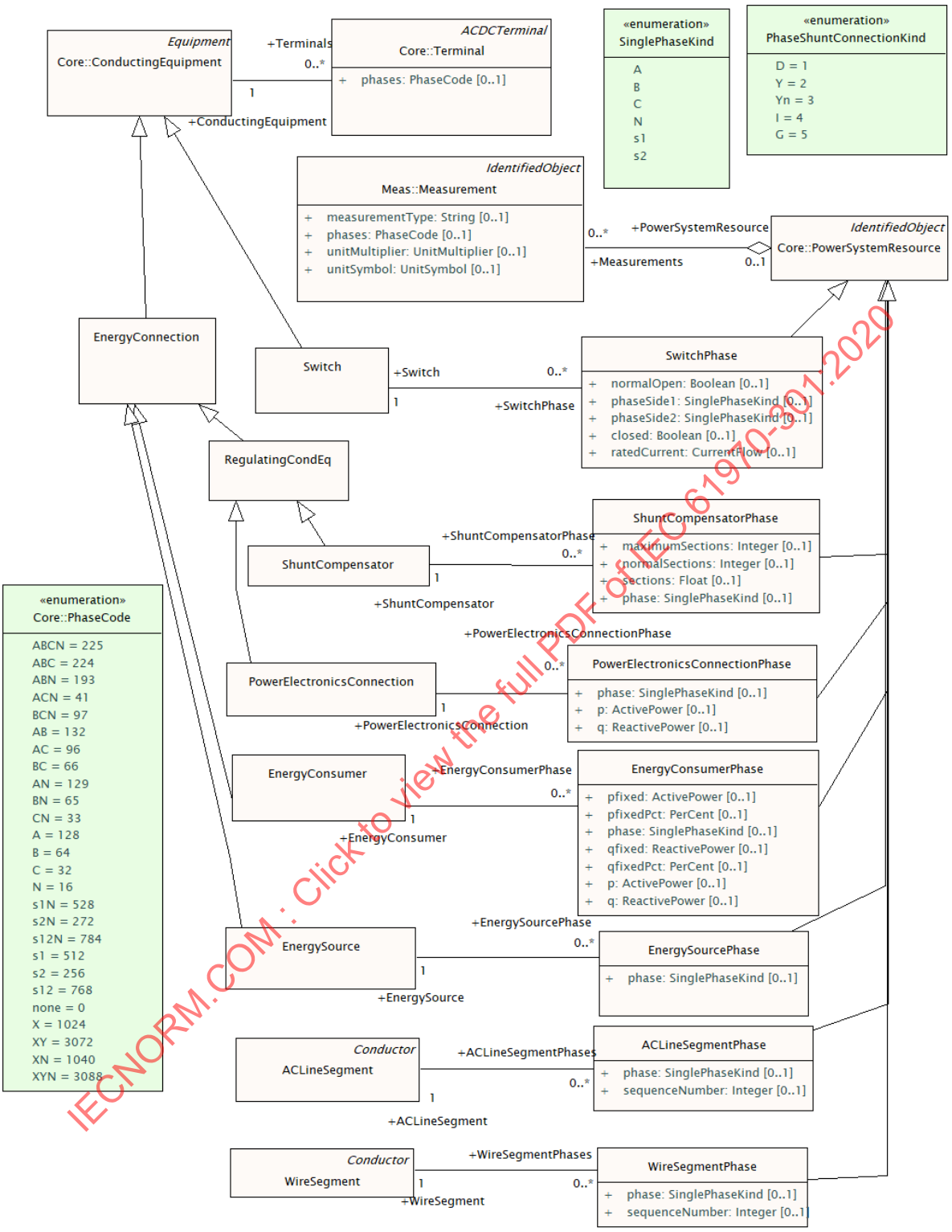
Table 5 – Tap changer control options

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 behaviour in power flow.

4.5.8 Phase wire modelling

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 modelling jumpers or switches that connect the same or 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 the same phases. Figure 25 shows 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 the same 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.

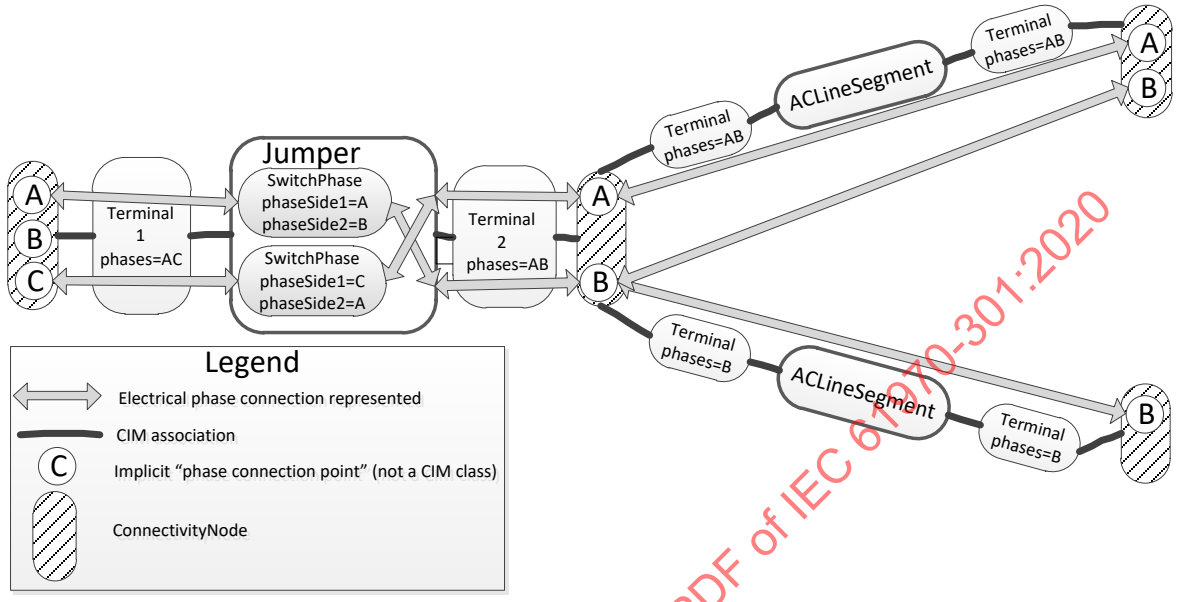


Figure 26 – Phase connectivity

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 modelled in general within the device. The transformer model also has explicit internal device modelling of phase connectivity. At this time all other ConductingEquipment branch specializations such as ACLineSegment assume the same phases connect at both terminals. The CIM model is open for future extensions to introduce internal device phase connectivity.

4.5.9 Grounding devices modelling

4.5.9.1 Use case for modelling 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. 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. 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.

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4.5.9.2 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 handle fixed impedance devices (GroundingImpedance) and adjustable (variable) Petersen coil devices (PetersenCoil).

The GroundingImpedance and PetersenCoil connect the same way as other devices using Terminal. The phases attribute on Terminal indicates the connection is at the neutral phase. The EarthFaultCompensator can have either one or two terminals modelled. 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.

If a PowerTransformer has a Y connection on one Terminal (secondary) and a PetersenCoil is connected to that Terminal, then the PowerTransformer's secondary Terminal should be specified with phases attribute equal to ABCN and the PetersenCoil's Terminal should be specified with phase N. This allows the ACLineSegment to connect with phases ABC (the default) and the PetersenCoil to connect to the same TransformerTerminal but only on the N phase. It is expected all PetersenCoil terminals to have only phase N.

If a normal modelling of a non-neutral network is done, then the Petersen coil model is added, which includes:

1) Adding the phasing of ABCN to the transformer secondary terminal so you have a place to connect neutral.
2) Adding the PetersenCoil object with its associated Terminal which is phase N, since only one Terminal is modelled the PetersenCoil is assumed solidly grounded.
3) Associating the PetersenCoil's single Terminal to the ConnectivityNode at transformer secondary.

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. Similar to PetersenCoils, it is expected that all GroundDisconnector terminals will have only phase N. For the data model refer to Figure 27.

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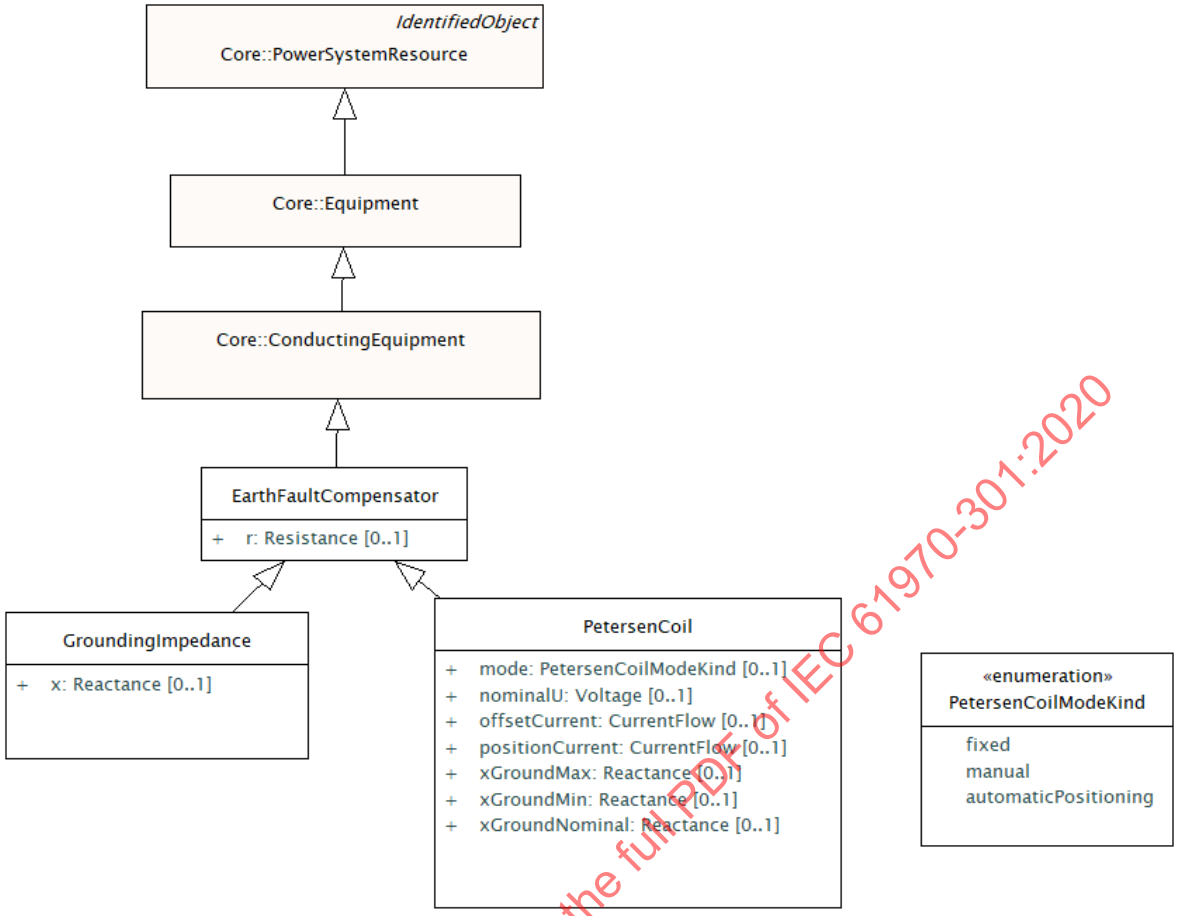


Figure 27 – Grounding device data model

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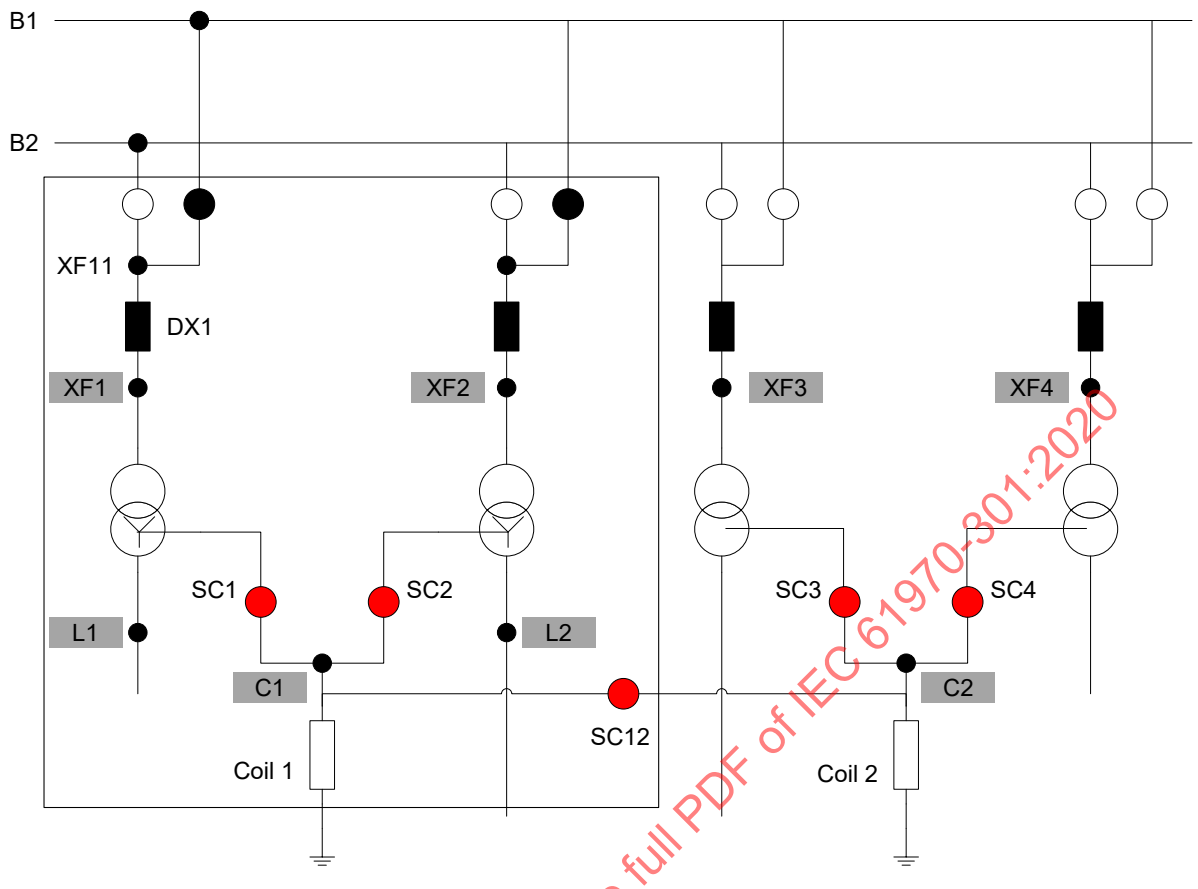


Figure 28 – Station including Petersen coils drawing example

In the example above, SC1, SC2, SC3, SC4 and SC12 are the ground circuit disconnectors. B1 and B2 are bus bar 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 28 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 CIM instance model example

The PetersenCoil that was depicted previously in Figure 28 is shown in Figure 29 modelled with only one terminal and implicit grounding.

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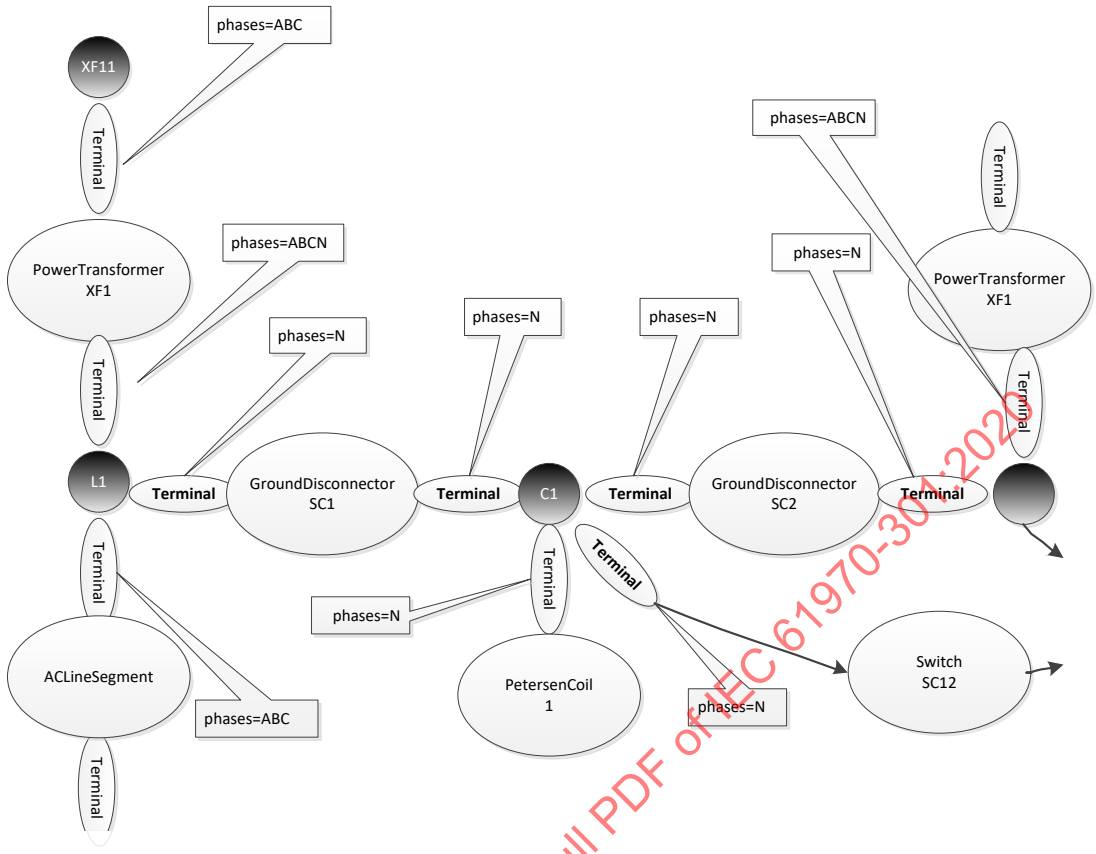


Figure 29 – Instance diagram objects with one terminal coil

Figure 29 shows how the ground disconnector 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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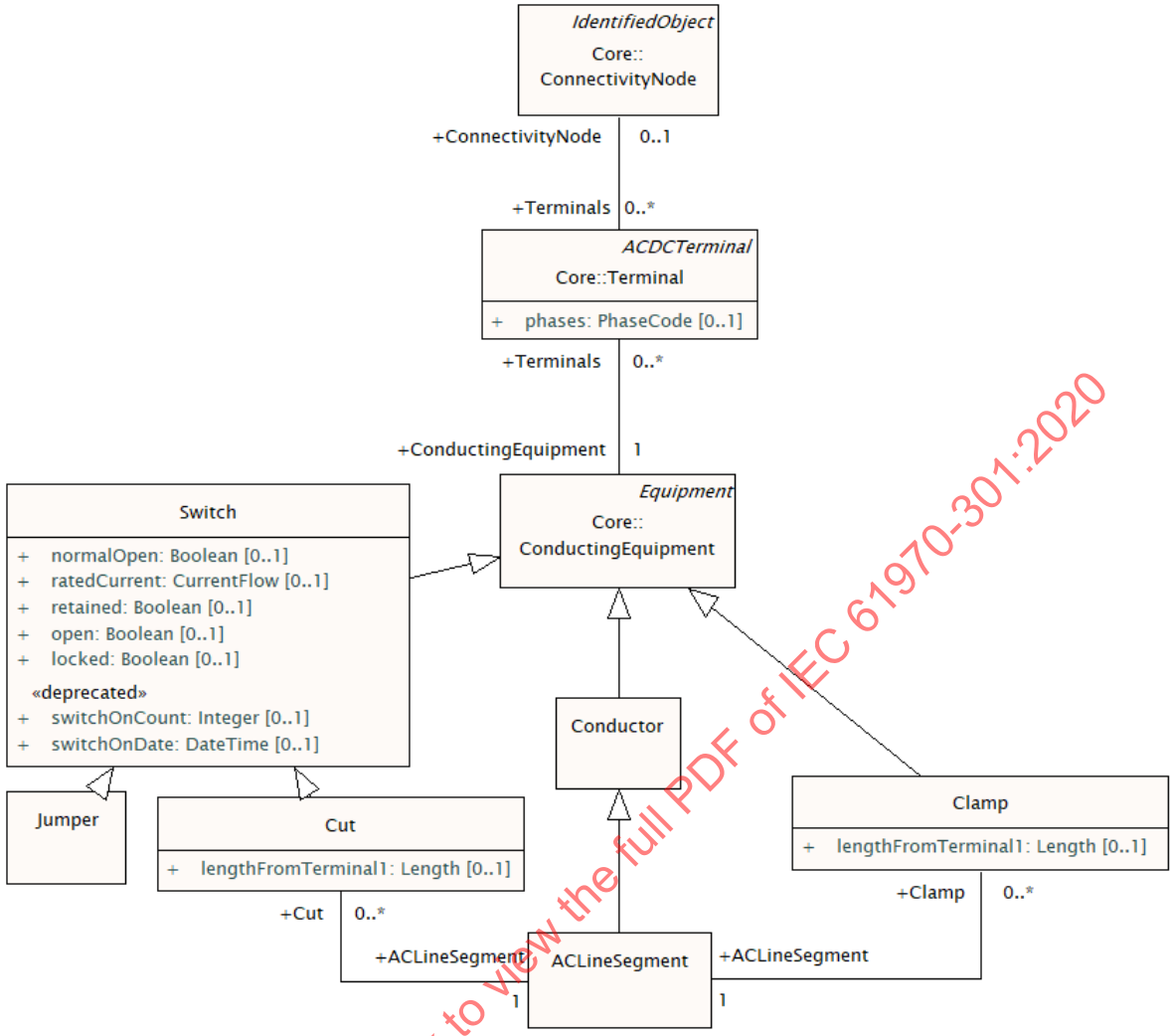


Figure 30 – Cuts, clamps, and jumpers UML model

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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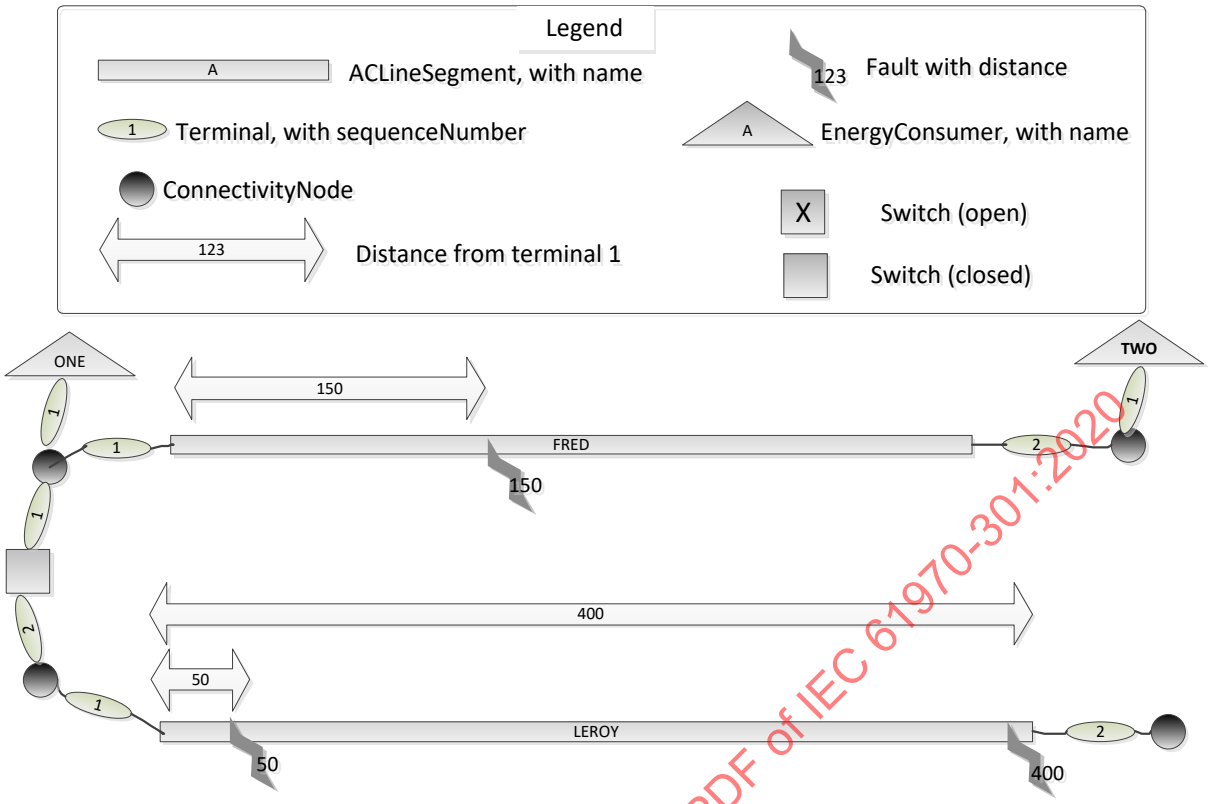


Figure 31 – Example before cuts and jumpers are applied

Figure 32 shows how the pure addition of Cut, ConnectivityNode, Jumper, Clamp and potentially other Conducting Equipment 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 remaining 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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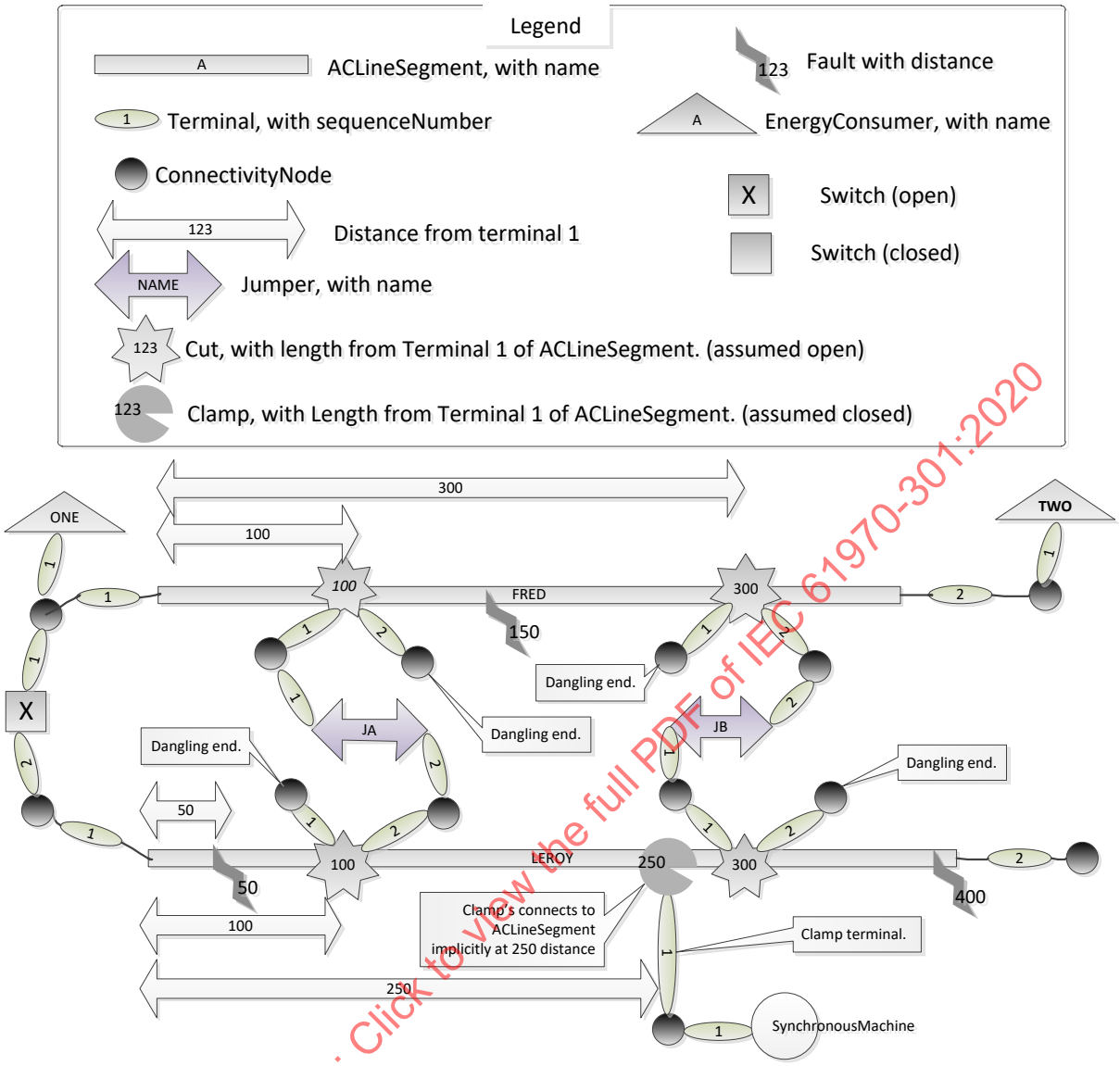


Figure 32 – Example after cuts and jumpers are applied

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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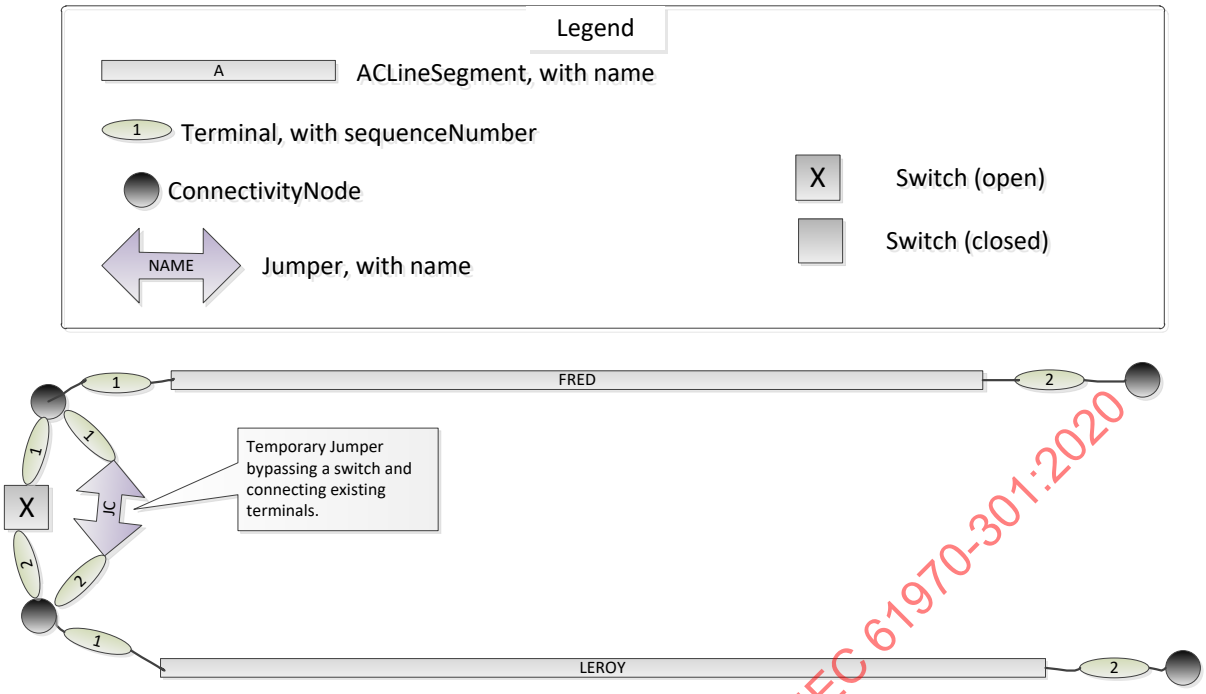


Figure 33 – Example of jumper without cut or clamp

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 several 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 StateVariables 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 6.

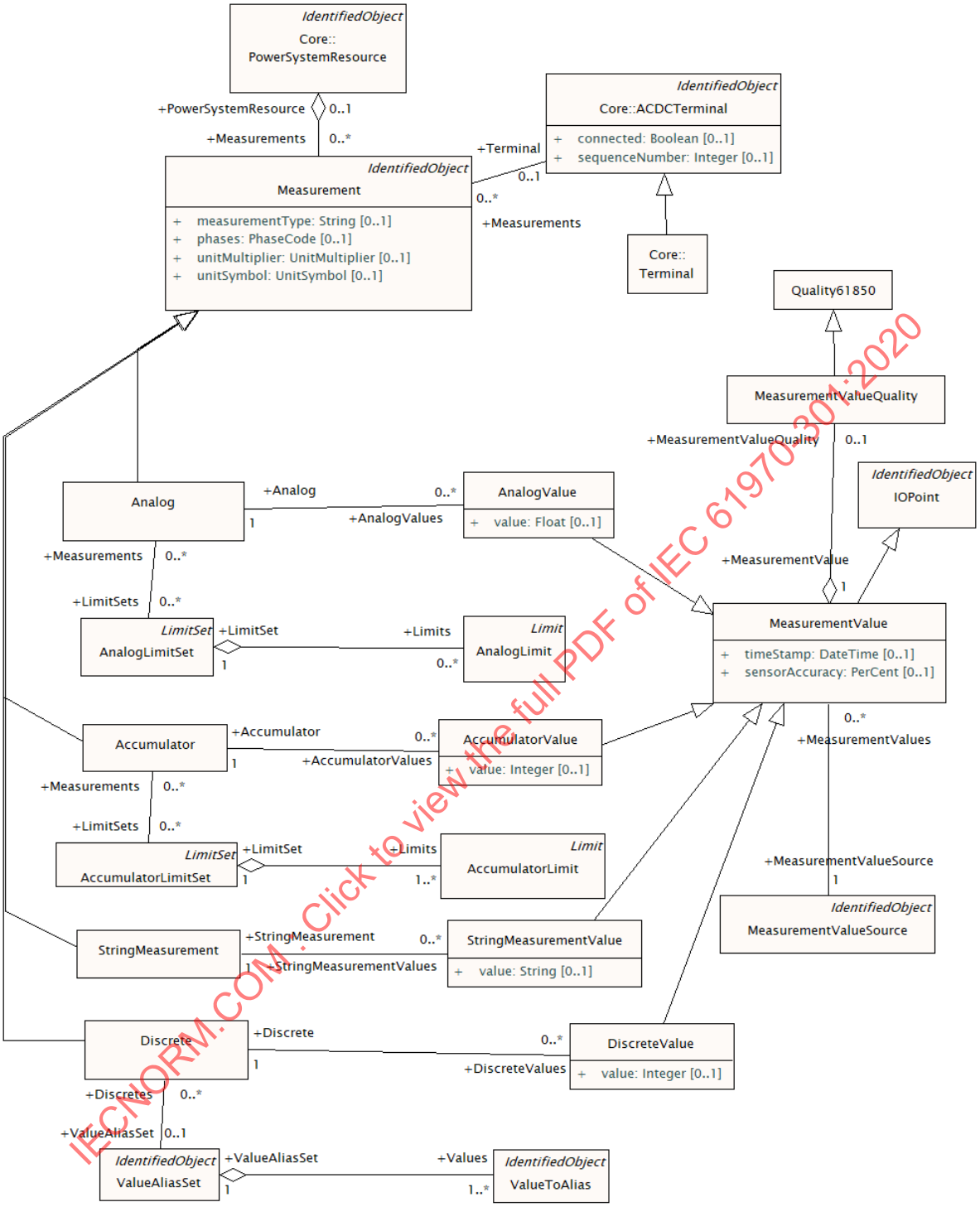
b) MeasurementValues of a Measurement are classified by MeasurementValueSource.

c) MeasurementValueSource inherits from IdentifiedObject. The values to be used for MeasurementValueSource.name are given in Table 7. This table provides several 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 6 – 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.
Specialization		Used when a specialization of the Analog class defines the type of measurement rather than the Measurement.measurementType attribute.

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Table 6 describes various types of measurements also defined in IEC 61850. The meanings of the columns in Table 6 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 6 is not an exhaustive list and that the mapping between measurements as defined in a control centre and a substation is non-trivial.

Table 7 – 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 apriori to exchange of measured values. The modelling 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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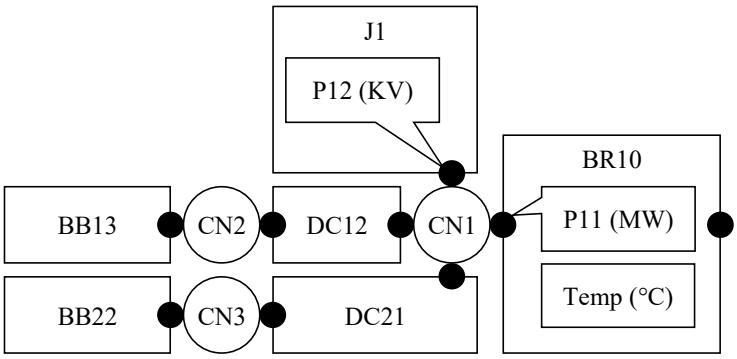


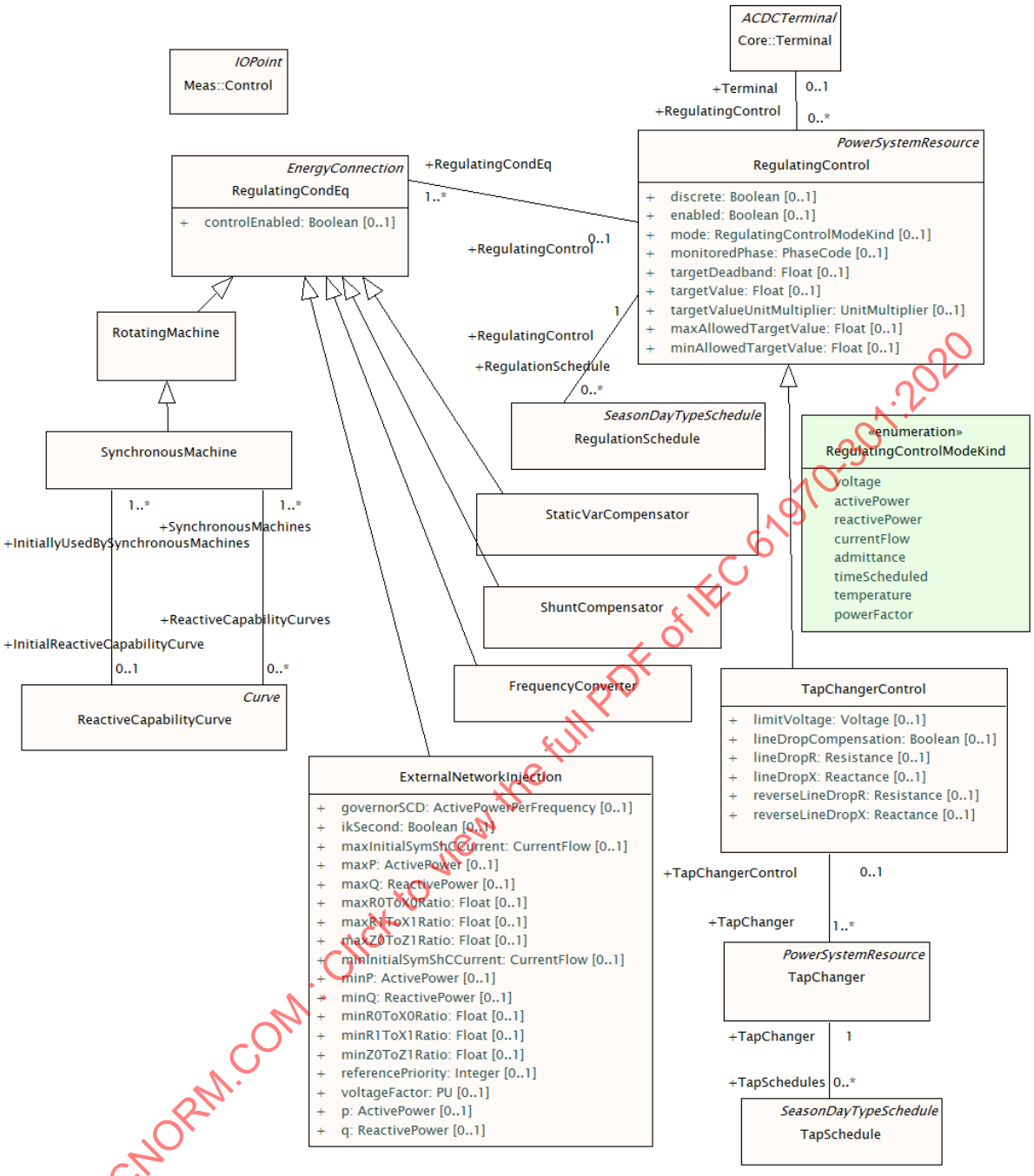
Figure 35 – Measurement placement

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.

4.5.12 Regulating control models

Regulation control, such as automatic voltage control at generators or voltage tap control at transformers is modelled 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 Introduction

4.5.13.1.1 General

Control systems modelling HVDC interconnection typically have three levels of detail in terms of modelling:

- Simplified injection model not using the CIM DC package.
- Detailed HVDC model using the CIM DC package and fictitious HVDC substations.
- Detailed HVDC model using the CIM DC package and no fictitious HVDC substations.

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.

The following general rules are defined:

- The flow through a DC pole relate to the Point of Common Coupling (PCC) at the ends of a pole. This means that PCC is always on the AC side.
- Detailed HVDC model using the CIM DC package and no fictitious HVDC substations is the preferred modelling as it corresponds to how substations are built, and equipment named
- Rules for switching of AC filters for LCCs are not supported by the standard.
- The converter transformer typically connects to switches located in a VoltageLevel where the AC network connects.
- The filters are typically located in the VoltageLevel where converter transformer connects.
- No TapChangerControl is used for the converter transformer, the control function is described in the ACDCConverter-s.
- The terminal at the HV side of the converter transformer, closest to the AC network, shall be associated with the Boundary Point/Connection point with the other MAS.
- The converter transformer and every ACDCConverter instance, belonging to the same substation pole, as well as all converter control equipment, essential protective and switching devices and auxiliaries, if any, used for conversion, shall be contained in the same cim:DCConverterUnit container instance. This also applies to shunts and series compensators at the LV side of the converter transformer and the DC smoothing reactors.
- In case of back-to-back installations two separate DCConverterUnit instances are used, each associated with one converter transformer.
- All HVDC overhead lines and cables, connecting two or more substations, shall be contained in the same DCLine container for every HVDC system pole.

4.5.13.1.2 Simplified Injection Model

The simplified injection model illustrated in Figure 37 connects the real substations at each ends of the DC pole with a Line that has two boundary ConnectivityNodes (CNs) or TopologicalNodes in case of bus-branch model representation, one for each DC pole end. The CNs are also the Point of Common Coupling (PCC) for each side. The real substations connect to the boundary CN/PCC with a ACLineSegment (ACLS) and an EquivalentInjection (EI).

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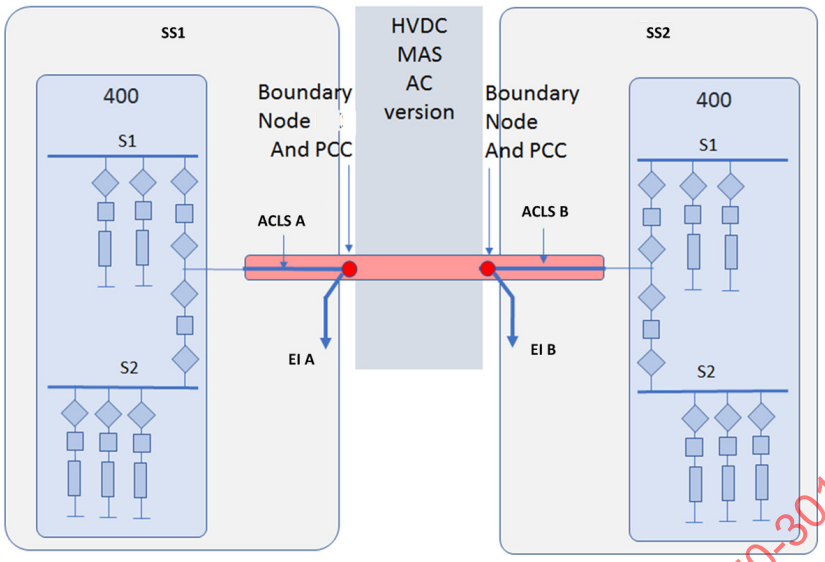


Figure 37 – Simplified example of HVDC model representation

Blue colours in Figure 37 represent objects in a regular MAS and red objects in a boundary MAS.

The ACLS "A", EI "A", ACLS "B" and EI "B" are at the PCCs at each side of the DC pole. The PCCs are the boundary nodes or connection points agreed between the parties responsible for the MAS of SS1 and SS2.

For a current source converter the reactive power is set to zero assuming that the AC filters keep the reactive consumption around zero. If the AC substation models the AC filters, then the reactive power consumption of the LCC shall be considered. The reactive consumption can normally be approximated by a reactive power demand equal to approx. 0.45-0.55 of the absolute value of the active power transfer. When substituting the HVDC poles by an internal representation featuring two "simplified HVDC injection models", and the power transfer is changed the reactive power may stay at the same value. This will ease power flow solution and not requiring switching of AC filters.

For voltage source converters reactive power control capabilities can be described by setting the attributes EquivalentInjection.regulationCapability and regulatingStatus to true. The limits minQ and maxQ or associated ReactiveCapabilityCurve shall reflect the reactive capability range if regulatingStatus is true.

4.5.13.1.3 Detailed HVDC model using the CIM DC package and fictitious HVDC substations

A detailed model contains the following parts:

- The real substations at each side of the connection.
- The same boundary as in the simplified model as in all cases the HVDC links have two boundary/connection points, see 4.5.13.1.2.
- For each real substation a fictitious substation that represents the HVDC part and connects to the boundary PCCs at each DC pole end.

Figure 38 shows a HVDC connection as a detailed model.

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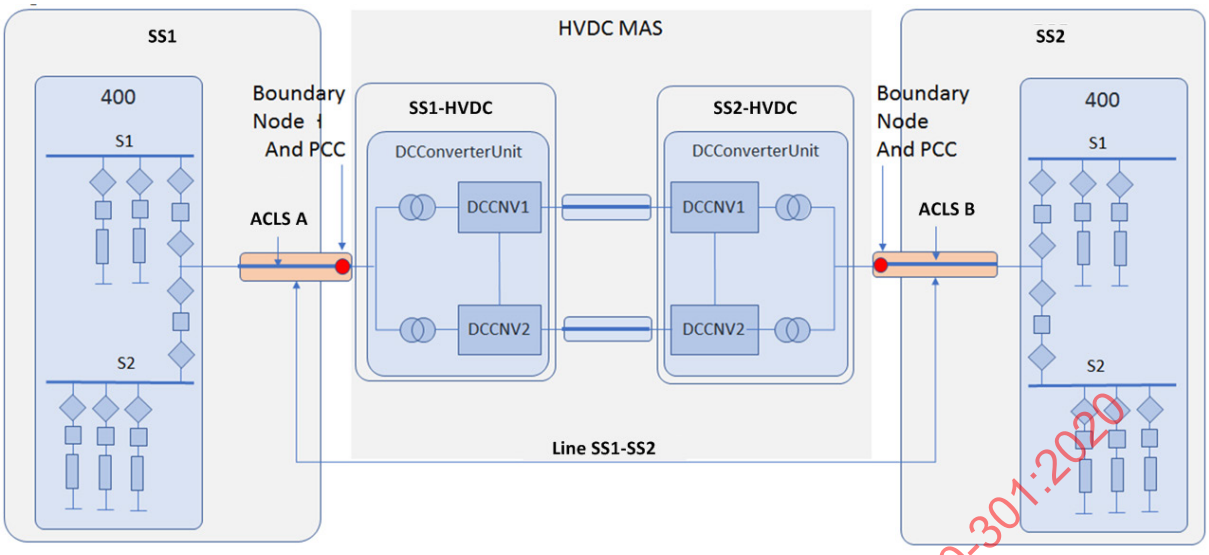


Figure 38 – Detailed example of HVDC model representation with fictitious HVDC substations

Blue colours in Figure 38 represent objects in a regular MAS and red objects in the boundary.

The SS1 and SS2 substations are the real ones, SS1-HVDC and SS2-HVDC are the fictitious with the HVDC equipment. “SS1-SS2” is the boundary Line with the two boundary CNs/PCCs that connect with the DC poles.

To convert a detailed model to simplified model the fictitious HVDC substations are removed and the EIs at the PCCs are inserted.

4.5.13.1.4 Detailed HVDC model using the CIM DC package and no fictitious HVDC substations

The preferred HVDC model is with all components in the real substation without fictitious substations or boundary Lines as shown in Figure 39.

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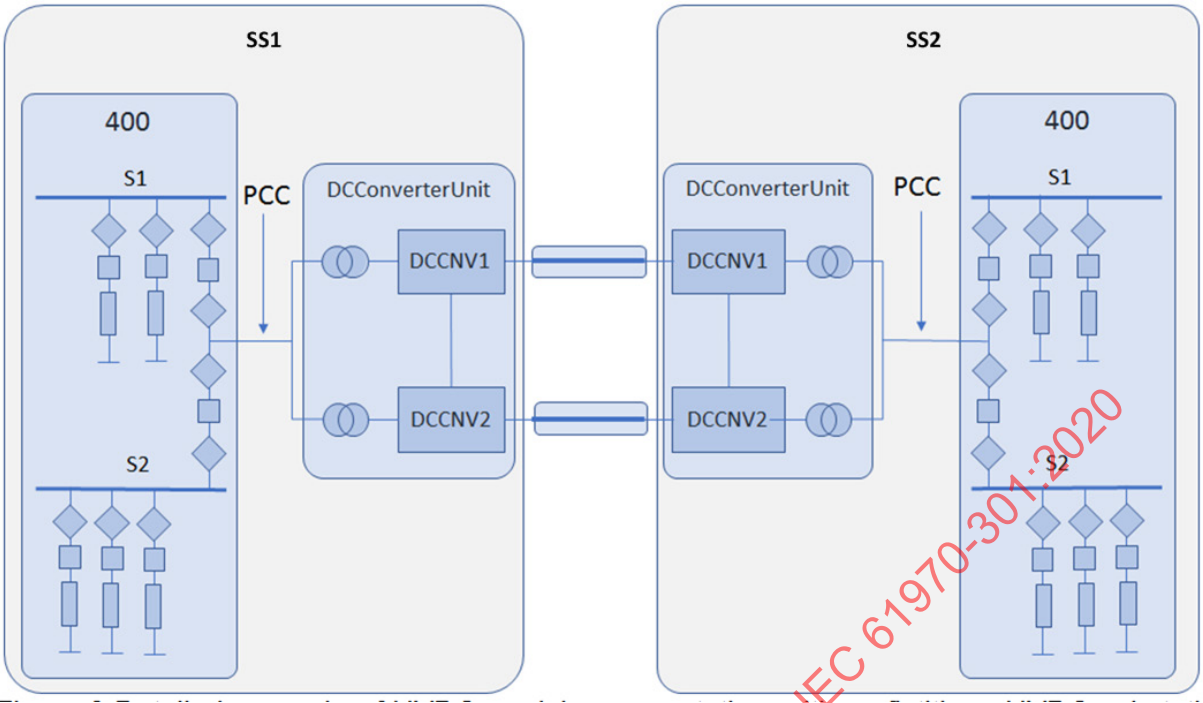


Figure 39 – Detailed example of HVDC model representation with no fictitious HVDC substations

A boundary point within a substation is defined at the PCC arrows in Figure 39.

A detailed HVDC model using the CIM DC package and no fictitious HVDC substations cannot easily be converted to a simplified model and must first be changed to a detailed HVDC model using the CIM DC package and fictitious HVDC substations model before it can be converted.

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 modelled as shown in Figure 40.

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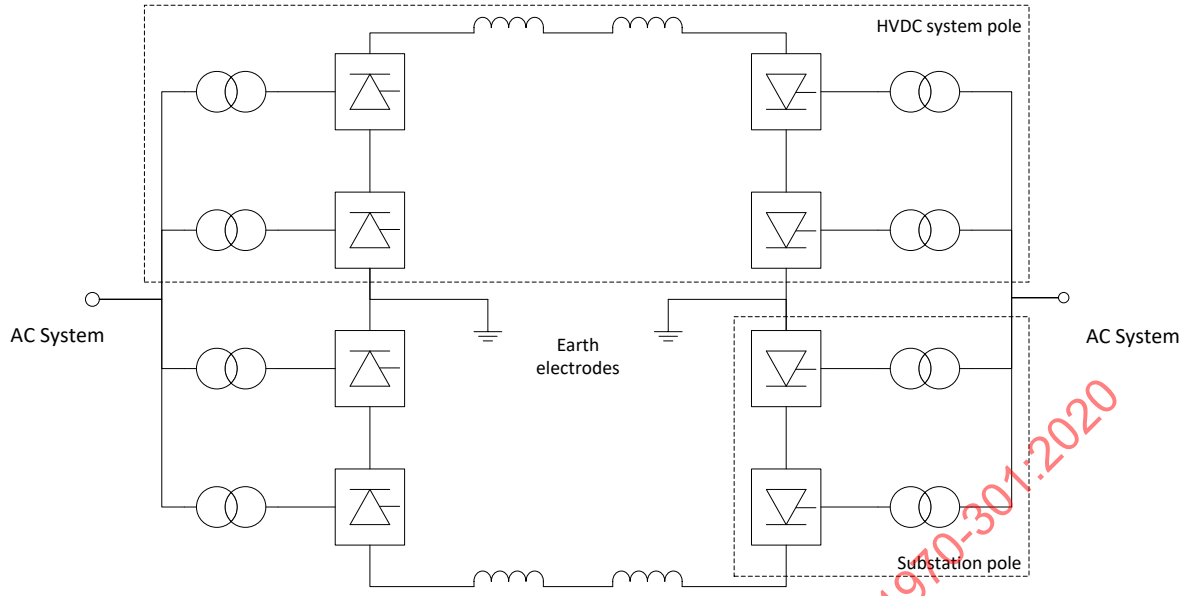


Figure 40 – HVDC bi-polar link from IEC 60633

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. For a CSC HVDC, the transformer shall be modelled explicitly.

4.5.13.2.3 VSC Topology

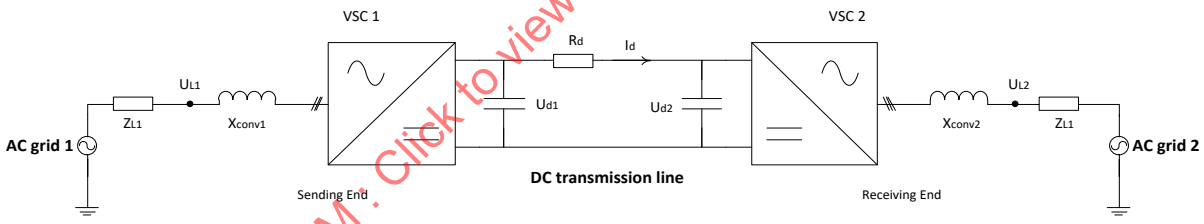


Figure 41 – A point-to-point VSC transmission scheme

The point-to-point VSC transmission scheme shown in Figure 41 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.

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4.5.13.3 HVDC power flow modelling

4.5.13.3.1 General

A power flow model derived from Figure 41 is shown in Figure 42.

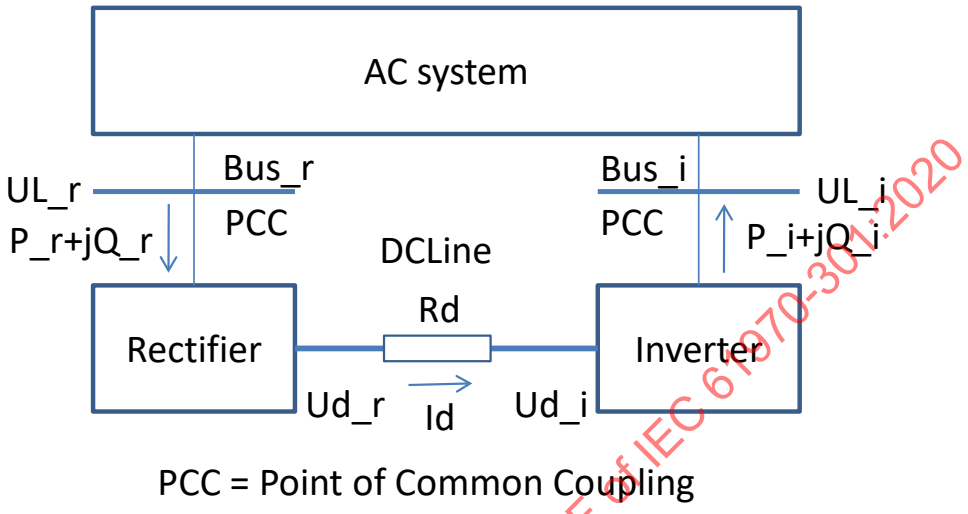


Figure 42 – HVDC power flow model

The AC side variables are as follows:

- P is the AC side active power injection at the rectifier (index r) and inverter (index i).
- 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 $U_{\mathrm{L_r}}$ and the voltage at Bus_i is $U_{\mathrm{L_i}}$. Power injected into the Rectifier from the AC system is $P_{\mathrm{r}} + jQ_{\mathrm{r}}$ and power injected into the Inverter is $P_i + jQ_{\mathrm{i}}$. 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 $P_{\mathrm{r}} + jQ_{\mathrm{r}}$ and $P_{\mathrm{i}} + jQ_{\mathrm{i}}$ and for PV nodes the active power injection and voltage $P_{\mathrm{r}}, UL_{\mathrm{r}}$ and $P_{\mathrm{i}}, UL_{\mathrm{i}}$ are computed from the HVDC link. Initial conditions for the HVDC link are given in two ways:

- P_{r} or P_{i}
- $U_{\mathrm{d_r}}$ or $U_{\mathrm{d_i}}$

The relation between the variables are $I_{\mathrm{d}} = P_{\mathrm{r}}/U_{\mathrm{d_r}} = P_{\mathrm{i}}/U_{\mathrm{d}_i}$.

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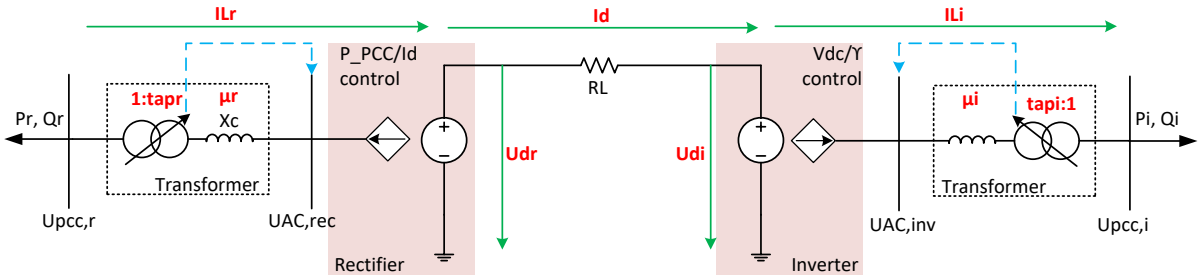


Figure 43 – Detailed HVDC power flow model

The active power and the reactive power at PCCs are derived, for lossless converters, via the following equations:

- $P_{\mathrm{r}} = U_{\mathrm{dr}} * I_{\mathrm{d}}$
- $Q_{\mathrm{r}} = U_{\mathrm{d0r}} * I_{\mathrm{d}} * \frac{\sin 2\alpha - \sin 2(\alpha - \mu_r) + 2\mu_r}{4 * (\cos\alpha - \cos(\alpha + \mu_r))}$
- $P_i = -U_{\mathrm{di}} * I_{\mathrm{d}}$
- $Q_i = U_{\mathrm{d0}i} * I_{\mathrm{d}} * \frac{\sin 2\gamma - \sin 2(\gamma - \mu_r) + 2\mu_r}{4 * (\cos\gamma - \cos(\gamma + \mu_r))}$

The power flow is illustrated in Figure 44 and Figure 45.

4.5.13.3.2 Current Source Converter (CSC)

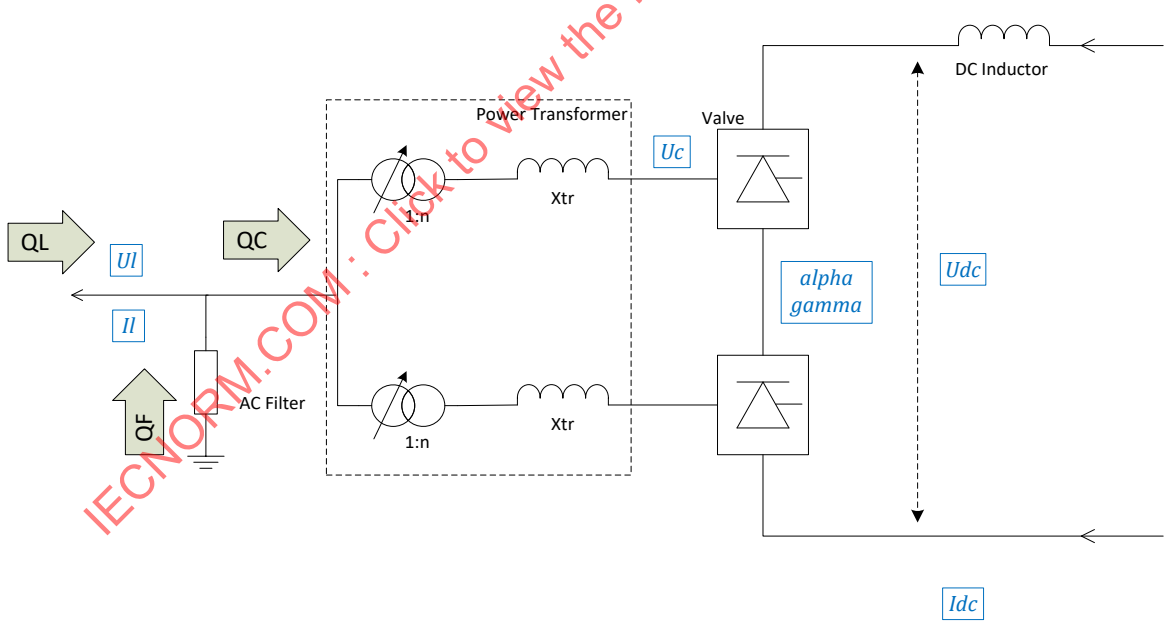


Figure 44 – Current Source Converter power flow

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. CSC equations require commutation reactance, tap changer and firing angle cascaded control. The commutation reactance for the CsConverters is based on the PowerTransformer which belongs to the DcConverterUnit, i.e. the impedance from converter transformer is used as Xc. The tap changer control for firing angle adjustment used also the tap changer data from the converter transformer. In case of shared tap changer in 2x6-pulse bridge configurations (3-winding converter transformer) the 6-pulse bridges shall be controlled in master/slave.

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The following equations shall be considered:

- $U_{\mathrm{d}} = U_{\mathrm{d0}} * \cos\alpha - \left(\frac{3}{\pi}\right) * X_{\mathrm{tr}} * I_{\mathrm{d}} * B$ or $U_{\mathrm{d}} = U_{\mathrm{d0}} * \cos\gamma - \left(\frac{3}{\pi}\right) * X_{\mathrm{tr}} * I_{\mathrm{d}} * B$
- $\varphi \approx cos^{-1}\left(\frac{V_d}{V_{d0}}\right)$
- $P = V_{\mathrm{d}} * I_{\mathrm{d}} = P_{\mathrm{ac}}$
- $Q = P * tan\varphi$
- the rated direct voltage: $U_{\mathrm{d0}} = ((3 * \sqrt{2})/\pi) * U_{\mathrm{C}} * B * T$
- $U_{\mathrm{t}} = U_{\mathrm{L}} * tapratio$

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

- $Q_{\mathrm{L}} = Q_{\mathrm{C}} - Q_{\mathrm{F}} = \left(\frac{P}{2}\right) - Q_{\mathrm{F}} \approx \frac{P}{2}$

where:

- α – firing angle
- B – number of bridges in series
- T – transformer turns ratio
- I_{d}, V_{d} – direct current and voltage per pole

4.5.13.3.3 Voltage Source Converter

The electrical components and their interconnections within a converter are shown in Figure 45. Figure 45 is the reference for the formulas in 4.5.13.3.

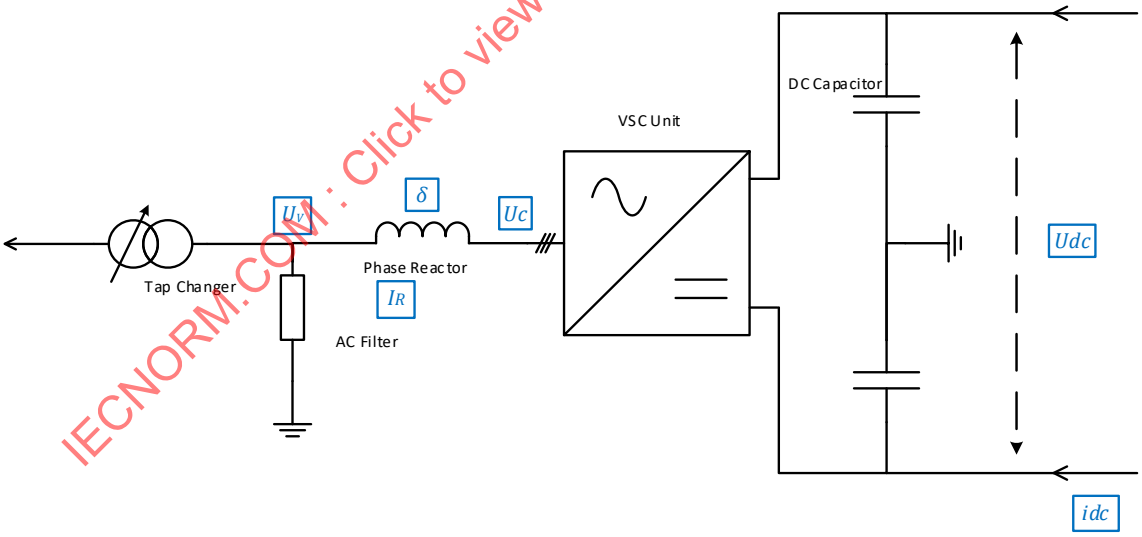


Figure 45 – Voltage Source Converter power flow

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.

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- 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 46 show the voltage vectors and the resulting power flow cases.

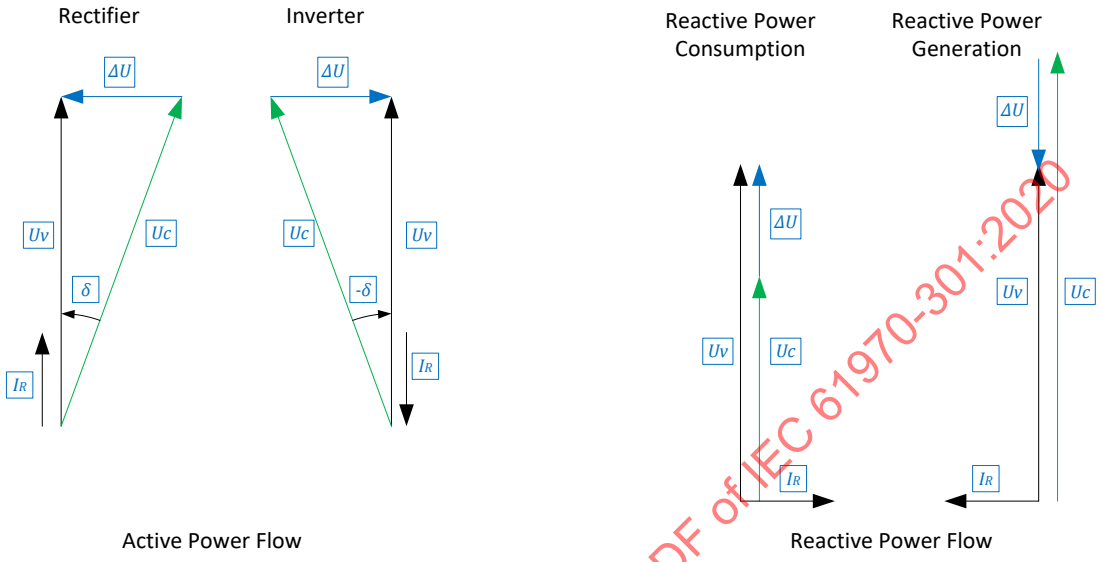


Figure 46 – Power flow cases

The behaviour of the Rectifier and Inverter can be described by a set of formulas having the following parameters, some of which are shown in Figure 42 and Figure 45.

- 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 46) are computed as $P = U_V * U_C * (\sin(\delta)/X_C)$
- $Q = U_V * (U_V - U_C) * (\cos(\delta)/X_C)$

The losses at a pole are described by the equation:

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

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 47 shows a diagram for a symmetric monopole Voltage Source Converter.

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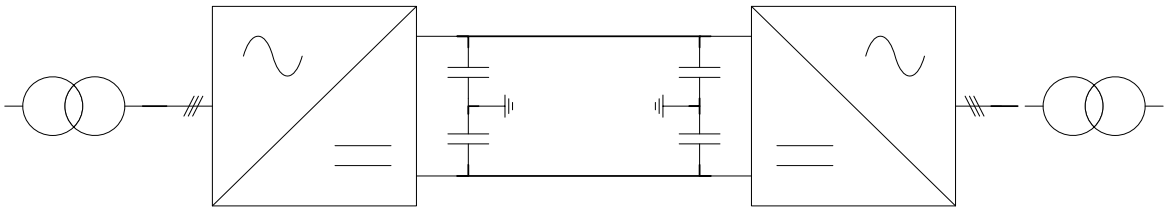


Figure 47 – VSC transmission with a symmetrical monopole illustrated with capacitive earthing on the DC side (IEC 62747)

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 48.

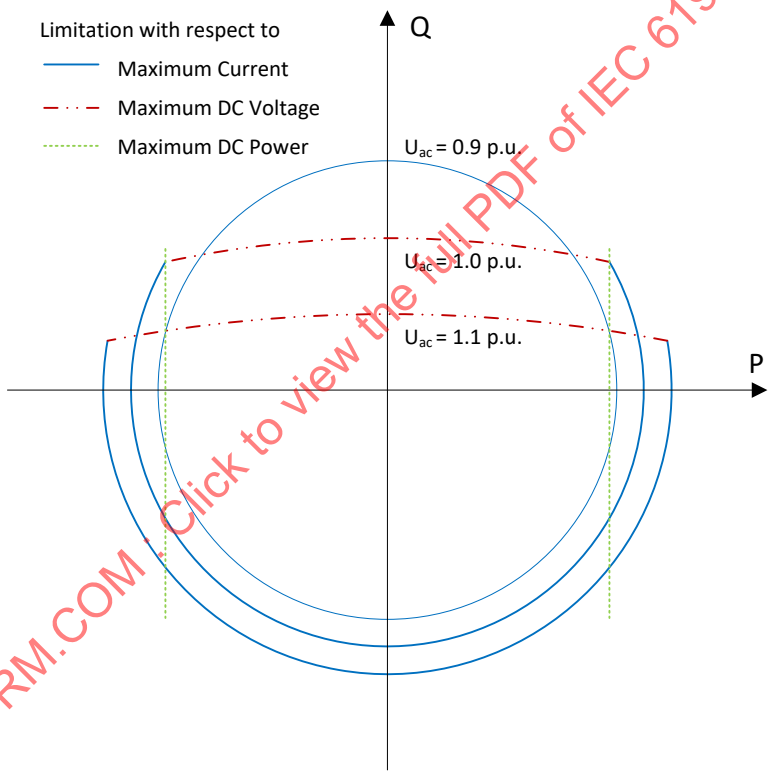


Figure 48 – VSC P-Q capability curve

It is also possible to use VSC in bipolar configurations as shown in Figure 49.

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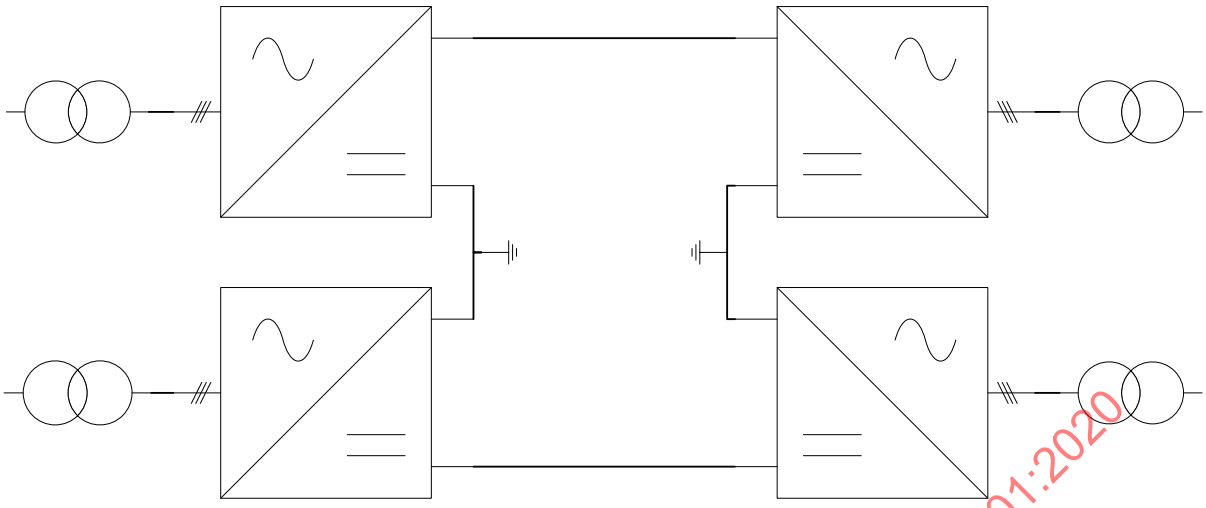


Figure 49 – Bipolar VSC transmission with earth return (IEC 62747)

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 IEC 60633 System Pole is not modelled 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 modelled 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 artefacts are used to describe AC and DC grids.

Figure 50 shows an example with the modelled objects of a bi-polar current source HVDC line.

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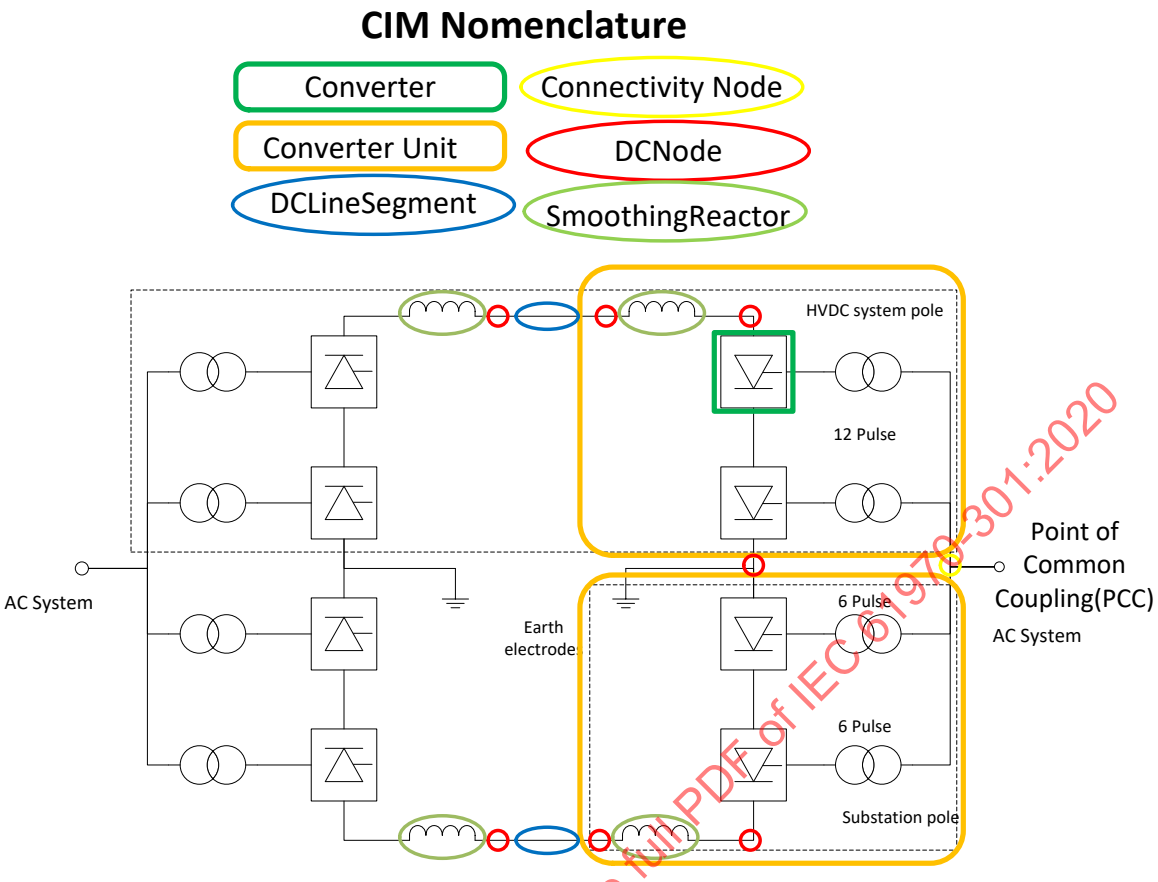


Figure 50 – Object instances for a bi-polar current source HVDC line

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

The corresponding diagram for VSC is shown in Figure 51.

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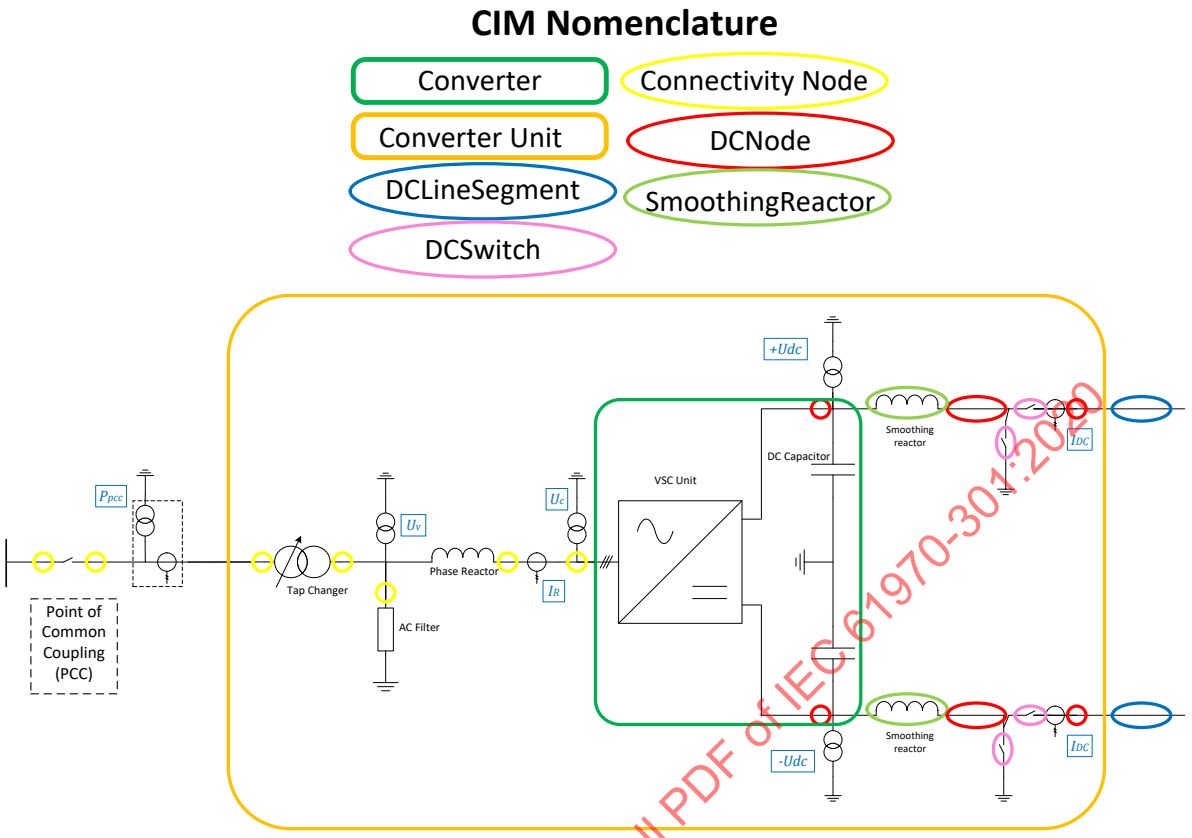


Figure 51 – Object instances for symmetric monopole VSC HVDC data model

As indicated in Figure 50 and Figure 51 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 51;
- breakers and disconnectors.

HVDC link can be operated in several ways:

- Bipolar, refer to Figure 49;
- Symmetrical monopole with capacitive earthing on the DC side – refer to Figure 47;
- 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.

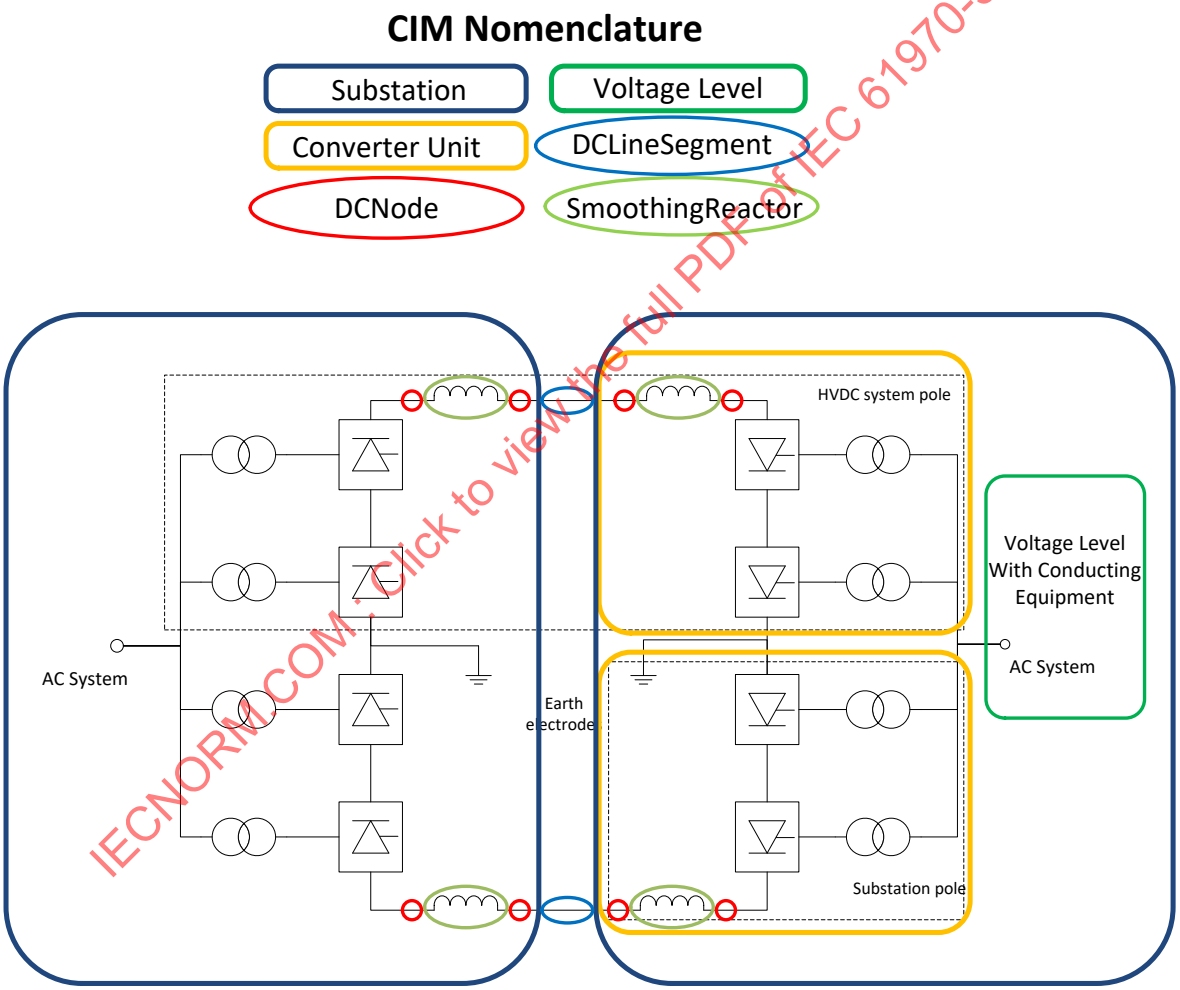
An HVDC substation sends operational status as SCADA signals to a superior SCADA. In bi-polar operation mode down rated Converter limits are typically sent to the superior SCADA.

The containment structures for two cases are shown in Figure 52 and Figure 53.

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 52 – 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.

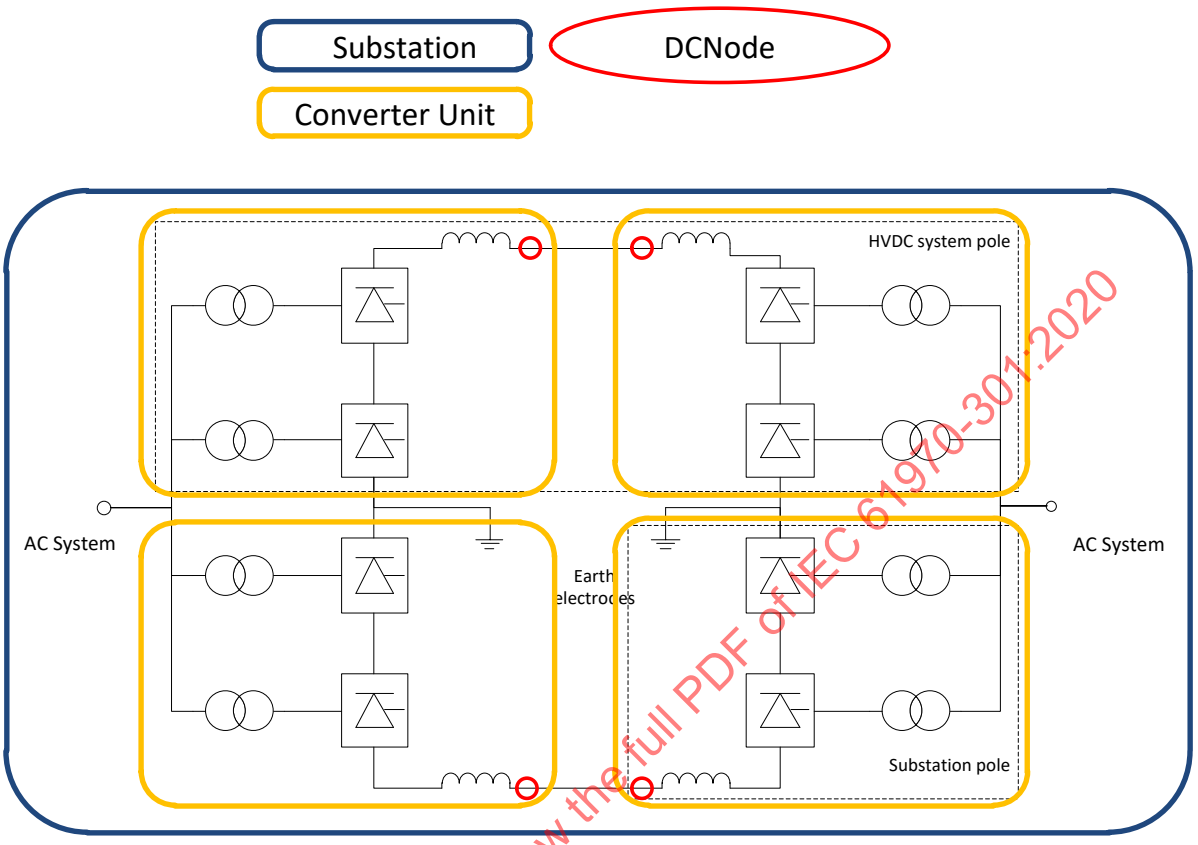


Figure 53 – Containment structure for a bipolar back-to-back HVDC station

4.5.13.4.2 DC Grids

DC grids will have switches that are used to reconfigure the DCLine-s 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 51 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 DC grid 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.

4.5.13.4.3 Topology

The basic AC system connectivity is shown in Figure 54.

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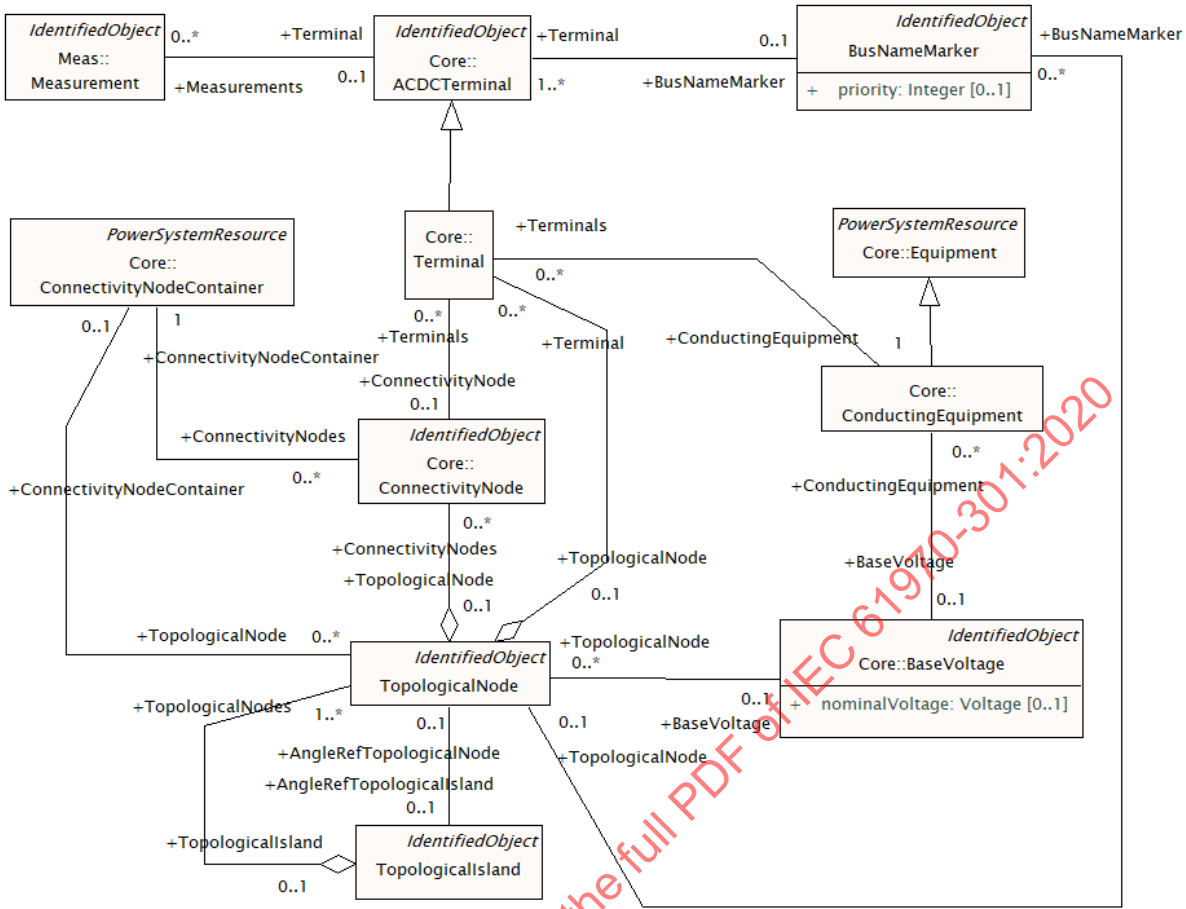


Figure 54 – The Basic topology in package Core

As shown in Figure 54, 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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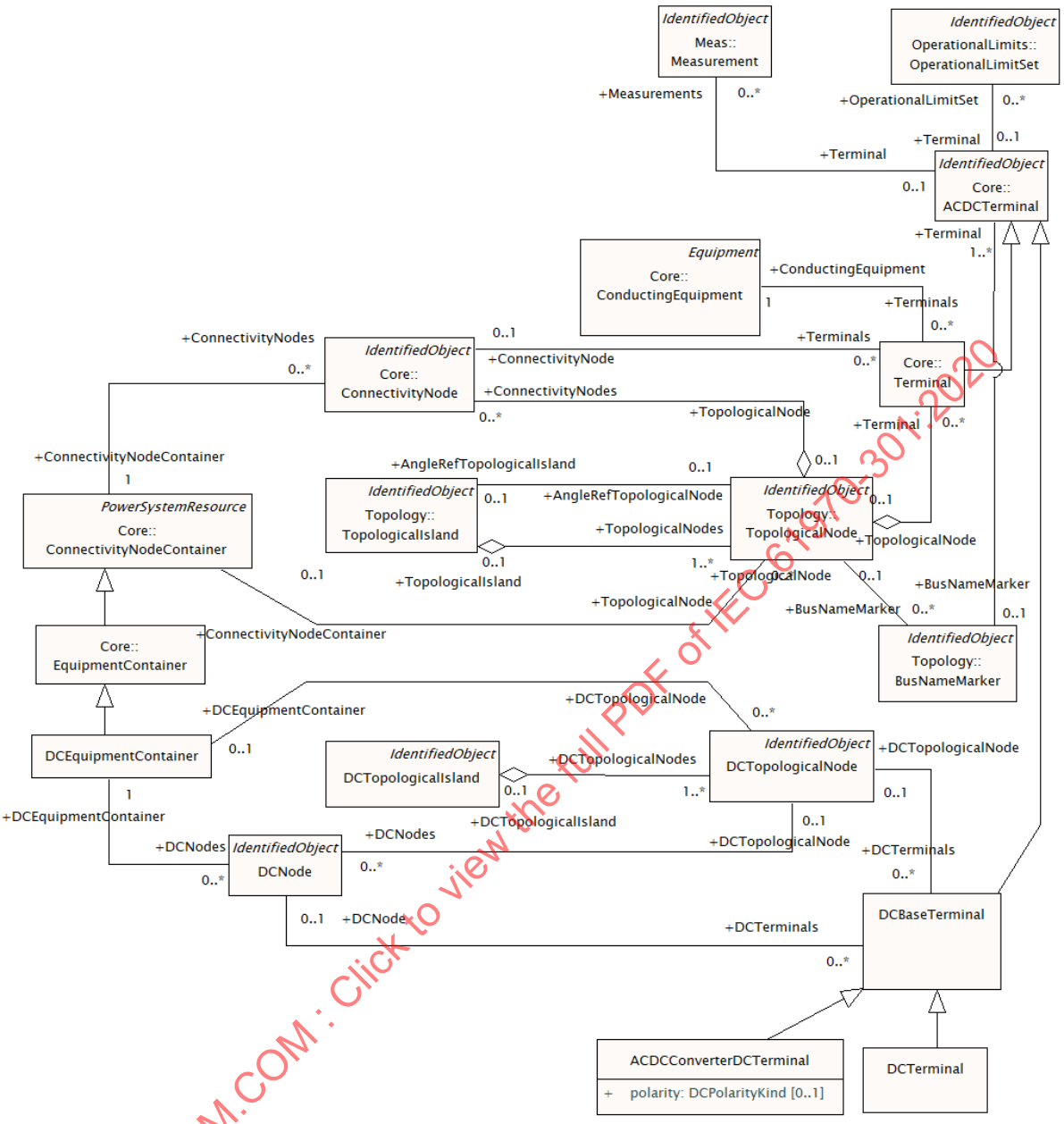


Figure 55 – DC and AC topology

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As shown in Figure 55, the ConductingEquipment-Terminal-ConnectivityNode pattern from the AC network is repeated for the DC network with the classes DCConductingEquipment-DCTerminal-DCNode.

4.5.13.4.4 Equipment

The DC equipment model is shown in Figure 56.

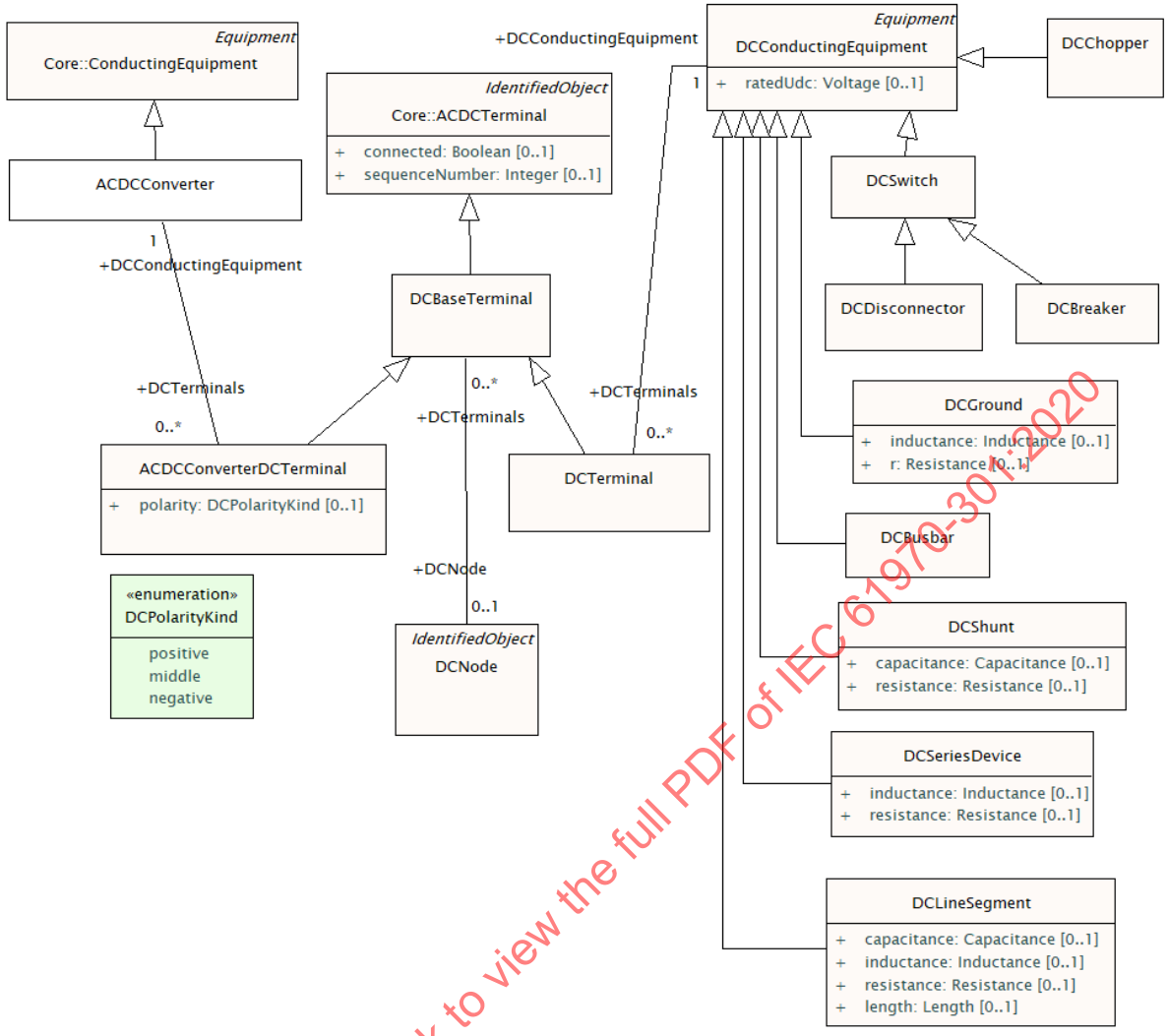


Figure 56 – Equipment model

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In order for the ACDCTerminal to feature both ACDCConverter and DCConductingEquipment, two types of DC terminals have been implemented as shown in Figure 56: 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 SvPowerFlow-s at the PCCTerminal-s hold the AC injections into the converter.

The DC line model is shown in Figure 57.

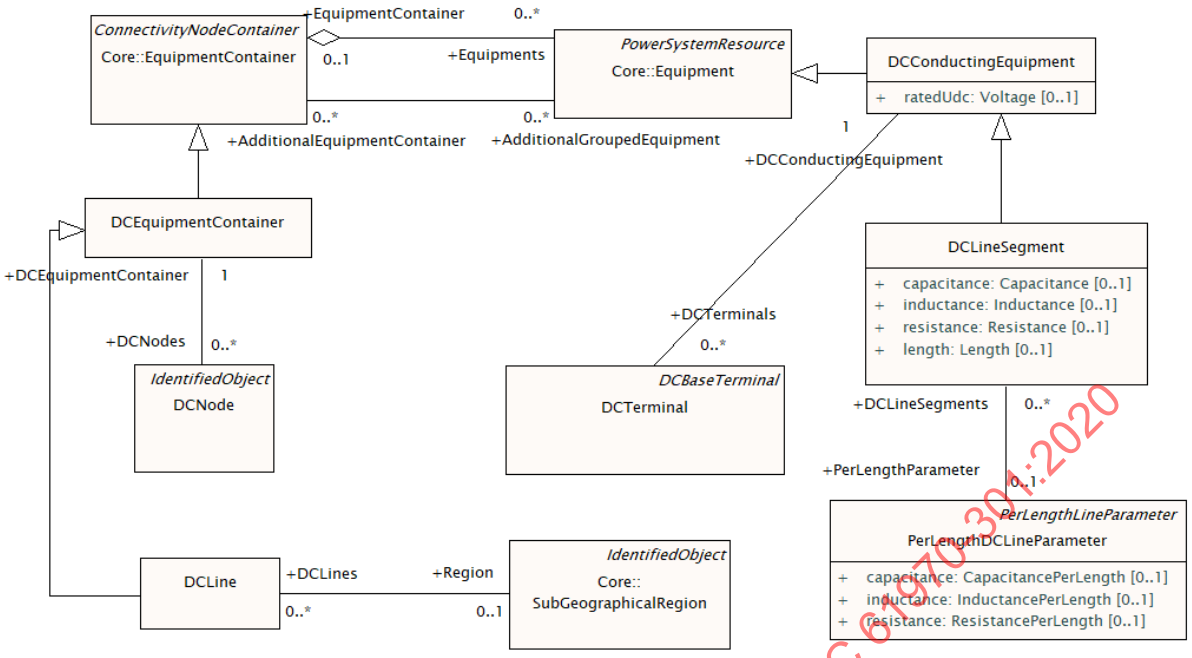


Figure 57 – HVDC line model

As shown in Figure 57 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.

4.5.13.5 Instance diagrams

Figure 58 is the legend for examples of DC equipment: a simple monopole, a simple bipolar and a detailed side of a monopole, shown in Figure 59, Figure 60 and Figure 61, respectively.

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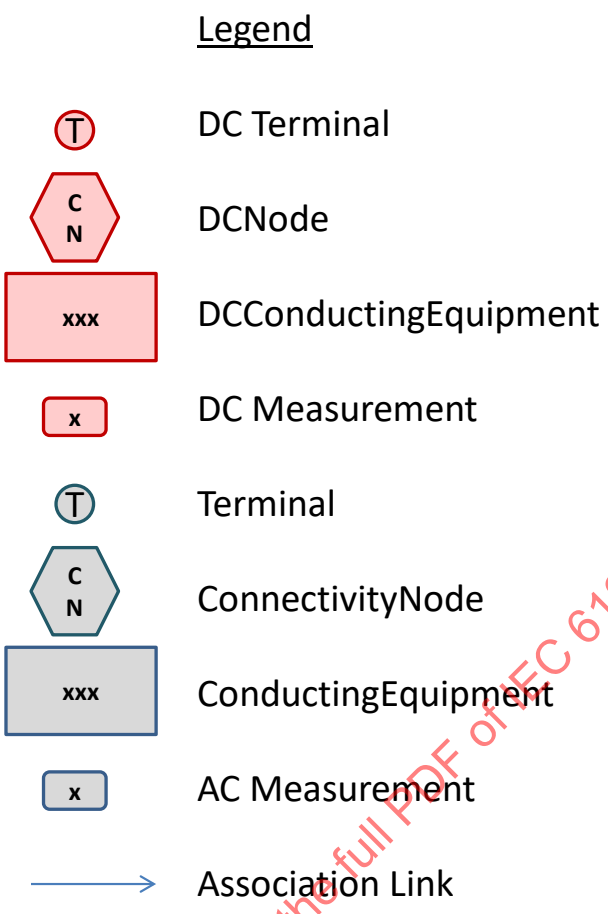


Figure 58 – Legend

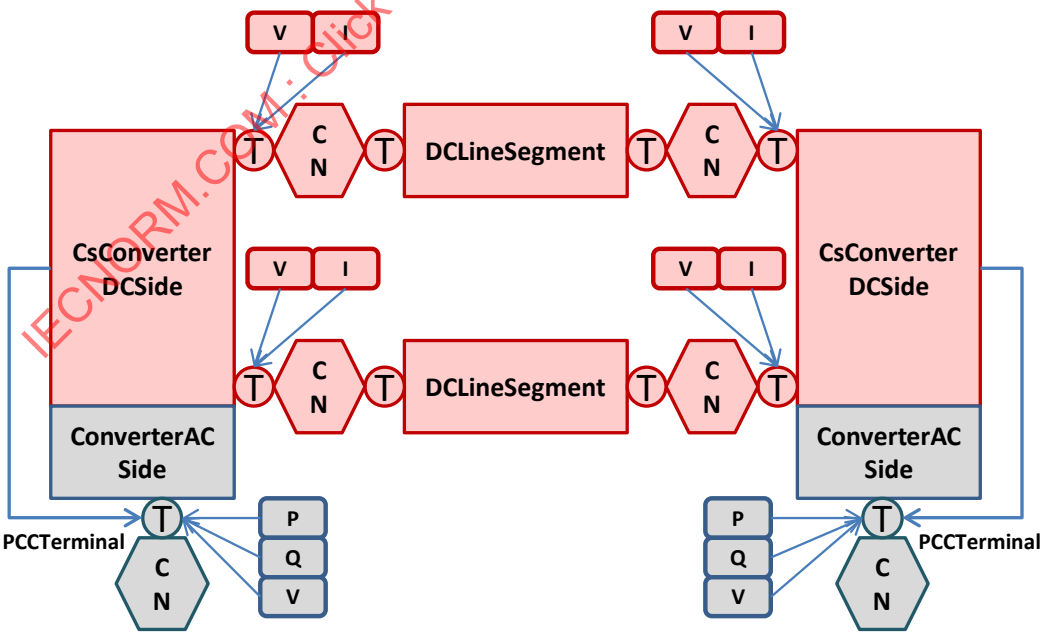


Figure 59 – Simple monopole with measurements

Refer to Figure 58 for an explanation of the symbols in Figure 59.

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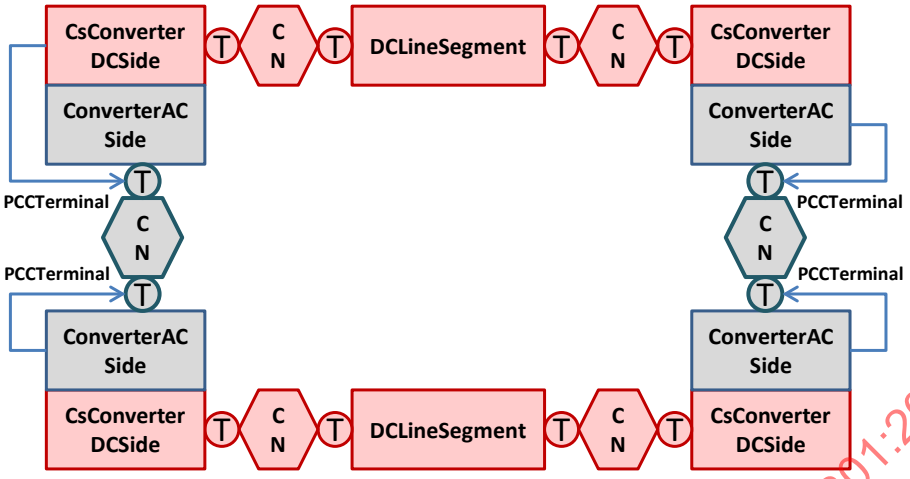


Figure 60 – Simple bipolar

Refer to Figure 58 for an explanation of the symbols in Figure 60.

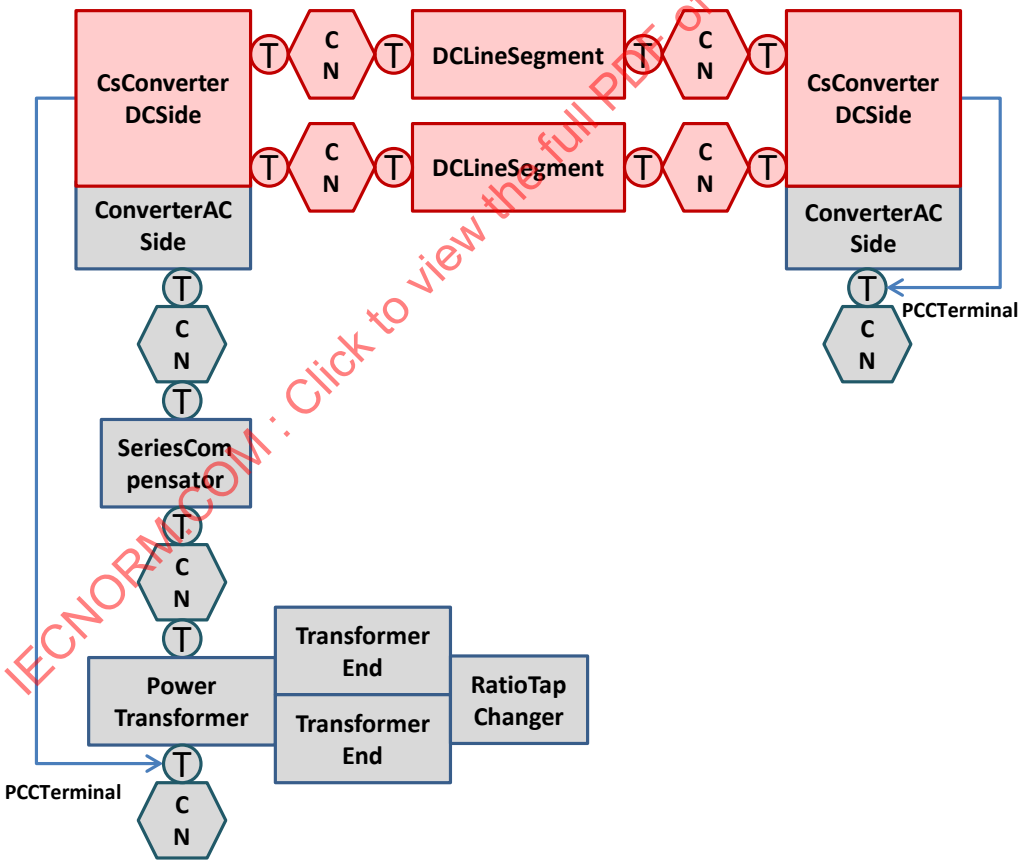


Figure 61 – Monopole one side with detailed model

Refer to Figure 58 for an explanation of the symbols in Figure 61.

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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 62.

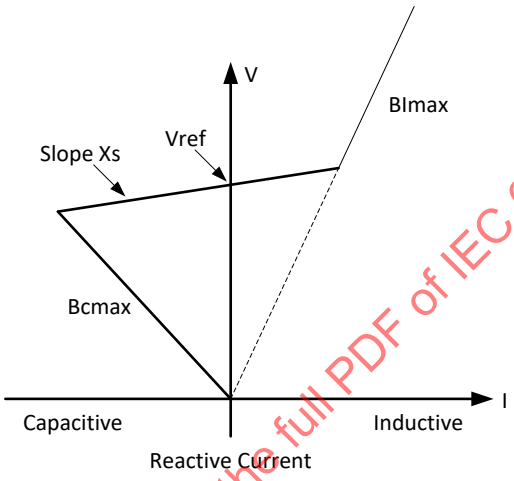


Figure 62 – V-I Characteristic of SVC

As long as the SVC susceptance B stays within the maximum and minimum susceptance values imposed by the total reactive power of capacitor banks (Bcmax) 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 the figure. The V-I characteristic is described by the following three equations:

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

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);

Bc_{max} is the maximum capacitive susceptance;

BI_{max} is the maximum inductive susceptance.

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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 CIM Model

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.

4.5.15 ICCP Configuration Model

4.5.15.1 Configuration use case

An ICCP configuration can be created in two ways:

1) The IO points (measurement values and controls) that will be exchanged over ICCP are known from an exchange of the equipment profile IEC 61970-452/EQ and the ICCP configuration relate directly to these IO points.
2) The IO points that will be exchanged over ICCP are not known from an exchange of the equipment profile and the ICCP configuration instead use an intermediate and commonly agreed name, the ICCP provided point name for the IO points to be exchanged over ICCP. This corresponds to the traditional ICCP configuration case.

The following example is for use case 1 above.

Two utilities, Utility A and B, may have overlapping network models see Figure 63 and exchange CIMXML EQ files with the connectivity node as border. Both Utility A and B want measurement values from each other. The description of the IO points in the network model are included in the exchanged CIMXML IEC 61970-452/EQ files. Both Utility A and B have a subset of the measurements in the CIMXML IEC 61970-452/EQ files available for ICCP exchange.

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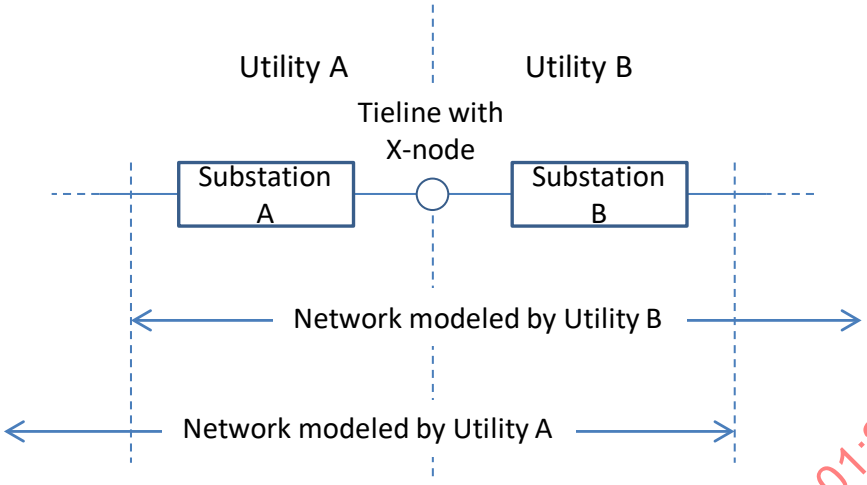


Figure 63 – ICCP measurements and network models

According to use case 2 above traditional way to configure ICCP is for the parties to agree on a common set of names for the exchanged measurements, the ICCP provided points. It is assumed that the two parties use different names for the same measurement and hence a third commonly agreed name is needed, the ICCP provided point names.

Based on this assumption Figure 64 shows a simplified sequence of configuring and starting ICCP.

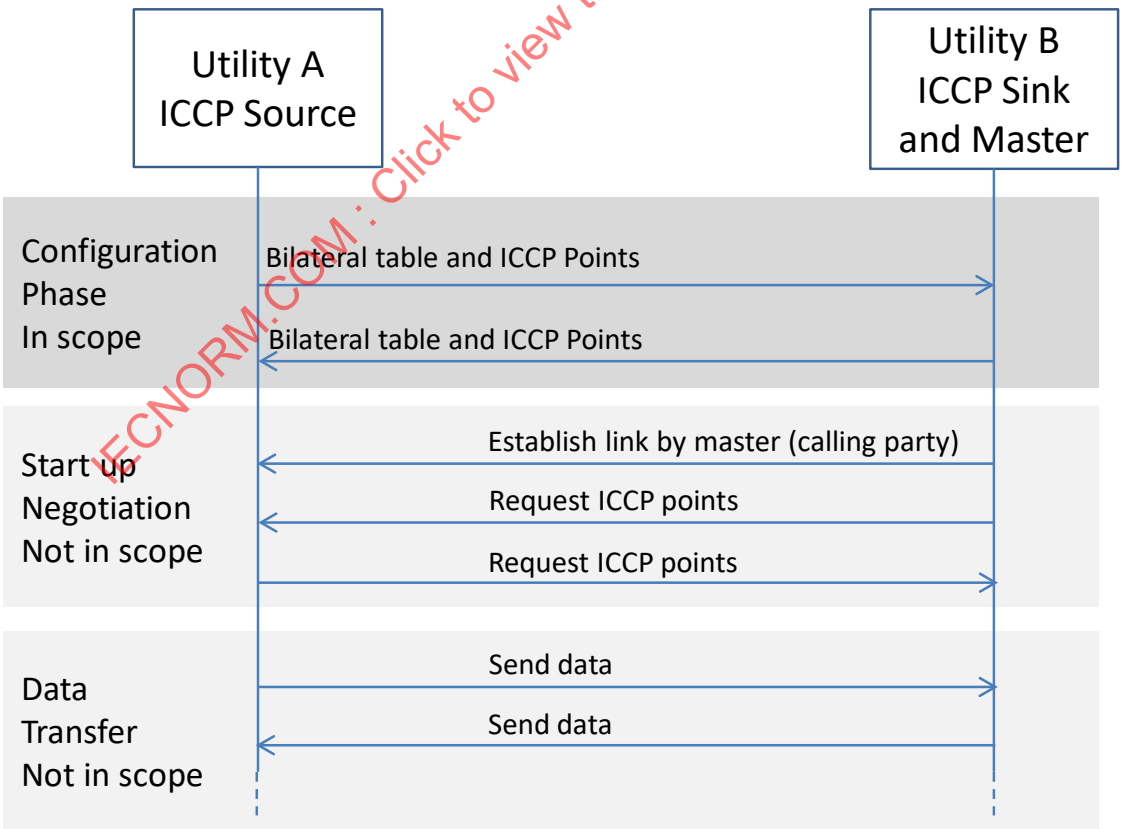


Figure 64 – ICCP configuration and start up

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In the configuration phase files describing the bilateral tables and ICCP point lists are exchanged, the dark grey shaded are in Figure 64. Configuring this exchange is in the scope of this document.

Setting up ICCP configuration means creating a cross reference for each measurement value between the parties. Creating the cross reference is tedious manual work.

When network models are exchanged as CIMXML data both the IEC 61970-452/EQ data and ICCP configuration data described in this document are exchanged. Given this the IO point identifiers and names are known by both parties. Hence the ICCP point mapping is already known and the manual cross referencing that is replaced by automatic linking.

Not all IO points defined in an IEC 61970-452/EQ file may be available over ICCP. Hence availability of a IO points over ICCP need to be described per IO point.

The ICCP protocol support providers of ICCP data to give different ICCP consumers different access rights, e.g. for the example in Figure 63 Utility A may want to allow access for the measurements in Substation A to Utility B but not to other utilities. Hence it must be possible for an ICCP provider to describe ICCP point availability per ICCP consumer. ICCP also support IO points that are globally available to all ICCP consumers.

Figure 65 shows an example ICCP configuration for one measurement value between different parties.

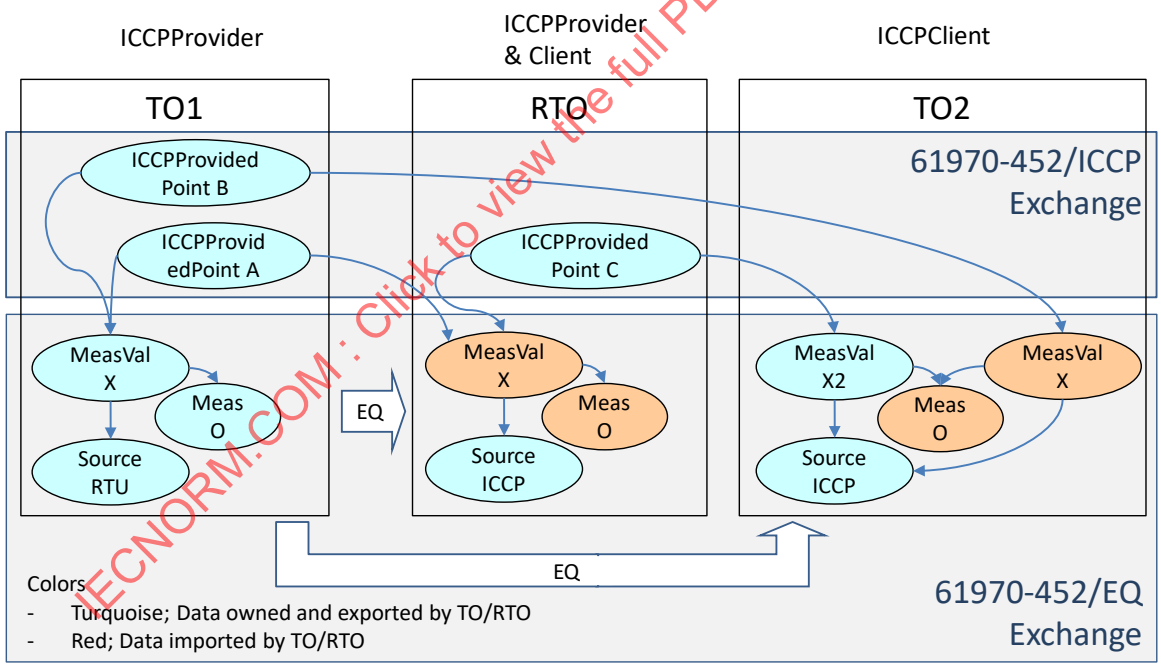


Figure 65 – Measurement value provider and consumer example

TO1 and RTO are control centres where TO1 provide the measurement value MeasVal X to an RTO and TO2. TO2 may get the measurement value MeasVal X directly from TO1 or indirectly from the RTO. Indirect exchange as between the RTO and TO2 may not be allowed even though it is technically possible.

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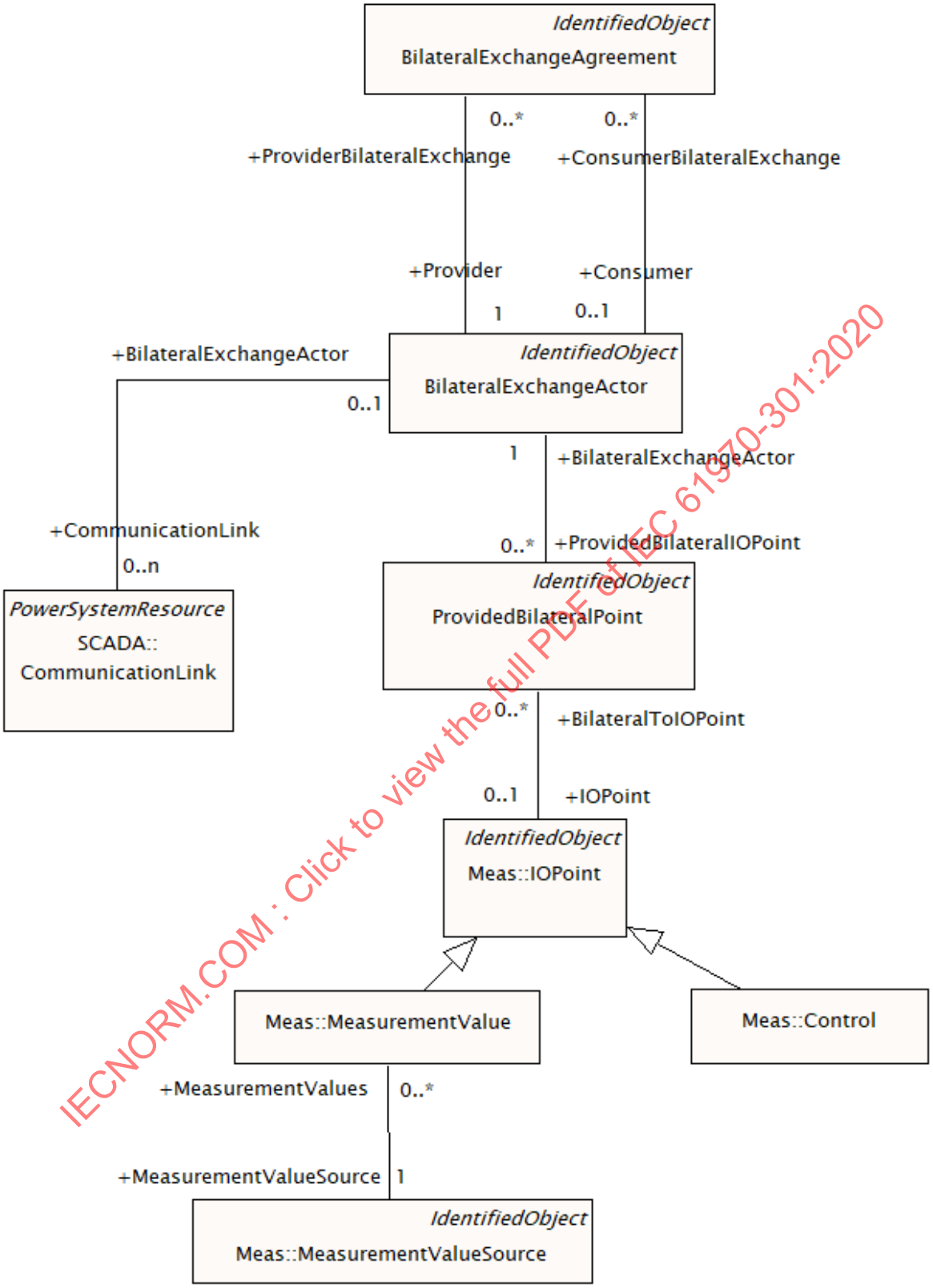
4.5.15.2 Information Model

ICCP (known officially as IEC 61870-6 TASE.2) data is exchanged using the Measurement classes (Analog, Discrete, and Accumulator), the MeasurementValue classes (AnalogValue, DiscreteValue, and AccumulatorValue), and the MeasurementValueSource class. The MeasurementValueSource class is used to define the control centre supplying the ICCP data. The MeasurementValueSource must 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 must have the NameType.name attribute set to “ICCP Provider ID”.

The MeasurementValue classes are used to specify the ICCP ID. The MeasurementValue must 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 must have the NameType.name attribute set to “ICCP ID”. The MeasurementValue.name attribute holds the SCADA point name. Each MeasurementValue will be associated with one Measurement.

Each MeasurementValue being supplied via ICCP must also have an association to a MeasurementValueSource.

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Figure 66 – Generalized bilateral exchange agreement data model

The data model in Figure 66 is generalized to any bilateral exchange. It describes the actors in such an exchange with BilateralExchangeActor. Two types of actors exist:

- Providers that may also be consumers
- Consumers only

Providers offer IOPoint-s that are available for exchange, currently MeasurementValue-s and Controls. The availability of data is described by BilateralExchangeAgreement. A BilateralExchangeAgreement has two BilateralExchangeActor-s referenced by BilateralExchangeAgreement.Provider and BilateralExchangeAgreement.Consumer. The actor referenced by BilateralExchangeAgreement.Provider is always a provider but may also be a consumer. The actor referenced by BilateralExchangeAgreement.Consumer is always a consumer but may also be a provider. In the case that the actor referenced by BilateralExchangeAgreement.Consumer is also a provider means that the actor referenced by BilateralExchangeAgreement.Provider is also a consumer such that the data exchange is bidirectional for this BilateralExchangeAgreement. A bidirectional exchange between two actors can also be achieved with two one way BilateralExchangeAgreement-s where one of the BilateralExchangeAgreement-s have one actor as provider only and the other as consumer only, this is reversed in the other BilateralExchangeAgreement.

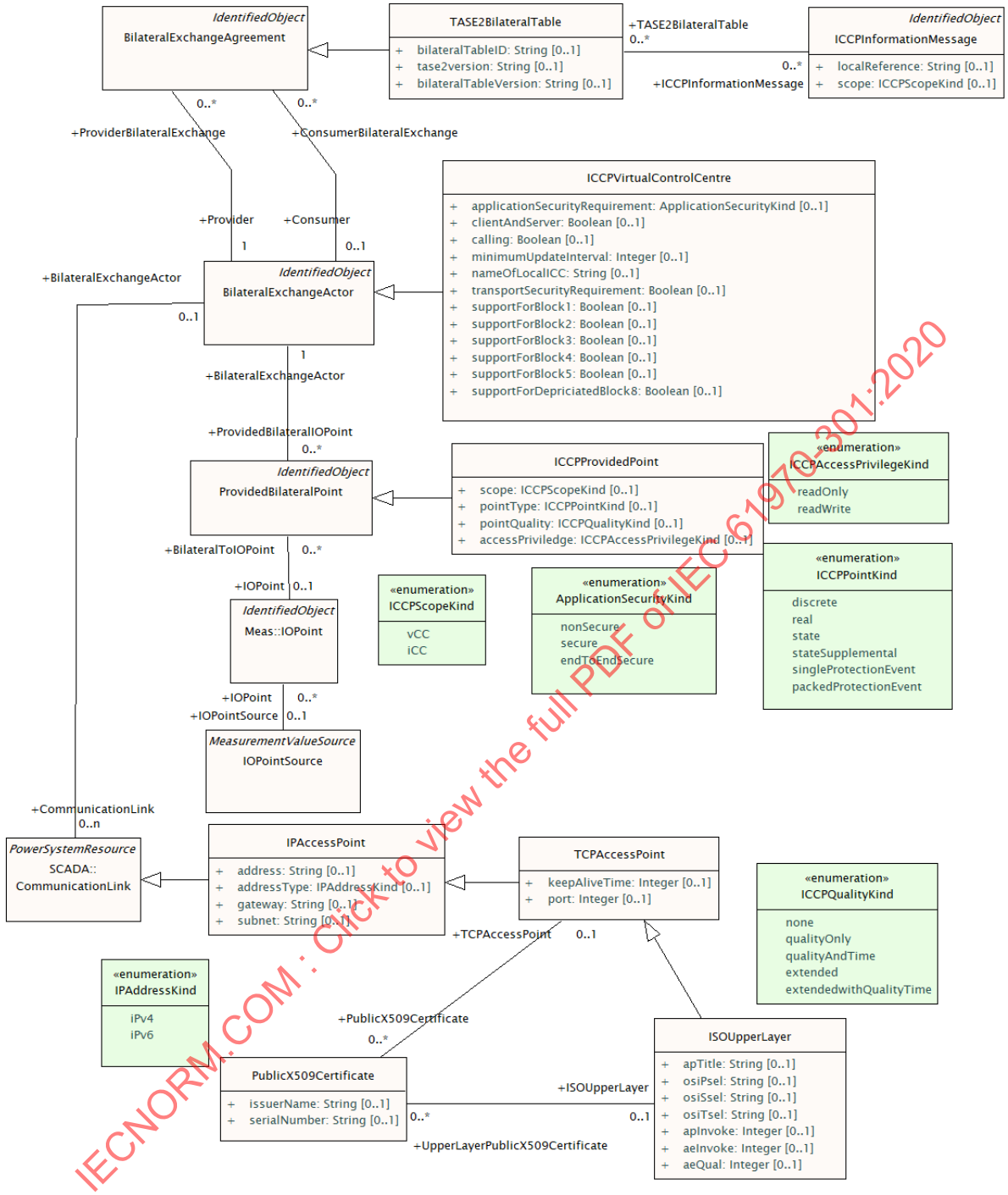
Data provided by a BilateralExchangeActor is described by ProvidedBilateralPoint that represents a many to many relation between the BilateralExchangeActor and IOPoint. IOPoint is a base class for MeasurementValue and Control and provides the association between measurements and ICCP points described by the class ProvidedBilateralPoint.

In the case where network models are exchanged as IEC 61970-452/EQ CIMXML files the ProvidedBilateralPoint.IOPont reference gives the IOPoint such that IOPoint identifiers (mRIDs) and names are known by a consumer. Based on this a consumer can select the whole or a subset of the provided IOPoint-s for exchange over ICCP. This is an internal decision on the consumer side and need not be exchanged as configuration data.

In the case where network models are not exchanged as IEC 61970-452/EQ CIMXML files the ProvidedBilateralPoint.IOPont reference is unspecified and the IOPoint identifiers (mRIDs) and names are unknown by a consumer. The ProvidedBilateralPoint name is then used as the commonly agreed ICCP name. The power industry has established rules for ICCP names that should be followed when used.

UML for ICCP bilateral exchange agreement is shown in Figure 67.

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Figure 67 – ICCP bilateral exchange agreement data model

The following subtypes from the generic data model are defined

- BilateralExchangeAgreement to TASE2BilateralTable.
- BilateralExchangeActor to ICCPVirtualControlCenter.
- ProvidedBilateralPoint to ICCPProvidedPoint.
- CommunicationLink to IPAccessPoint.

4.5.16 Feeder Model

The feeder model is used to represent “as built” feeders. Because Feeder is a type of ConductingEquipment, a Feeder can contain Equipment just as a Substation or VoltageLevel does. In addition to the containment association between EquipmentContainer and Equipment used for hierarchical naming purposes, there is a second association between these two classes to allow a piece of Equipment to be grouped with an additional EquipmentContainer. This modelling allows Equipment to be associated with more than one Feeder.

A Feeder can be contained by the Substation that nominally energized the feeder. One or more Terminals can also be associated with a Feeder to define the specific normal head feeding it. A Feeder can also contain a secondary distribution Substation. A secondary Substation can be associated with more than one Feeder to represent the Feeders that are normally energizing the Substation.

UML for the Feeder model is shown in Figure 68.

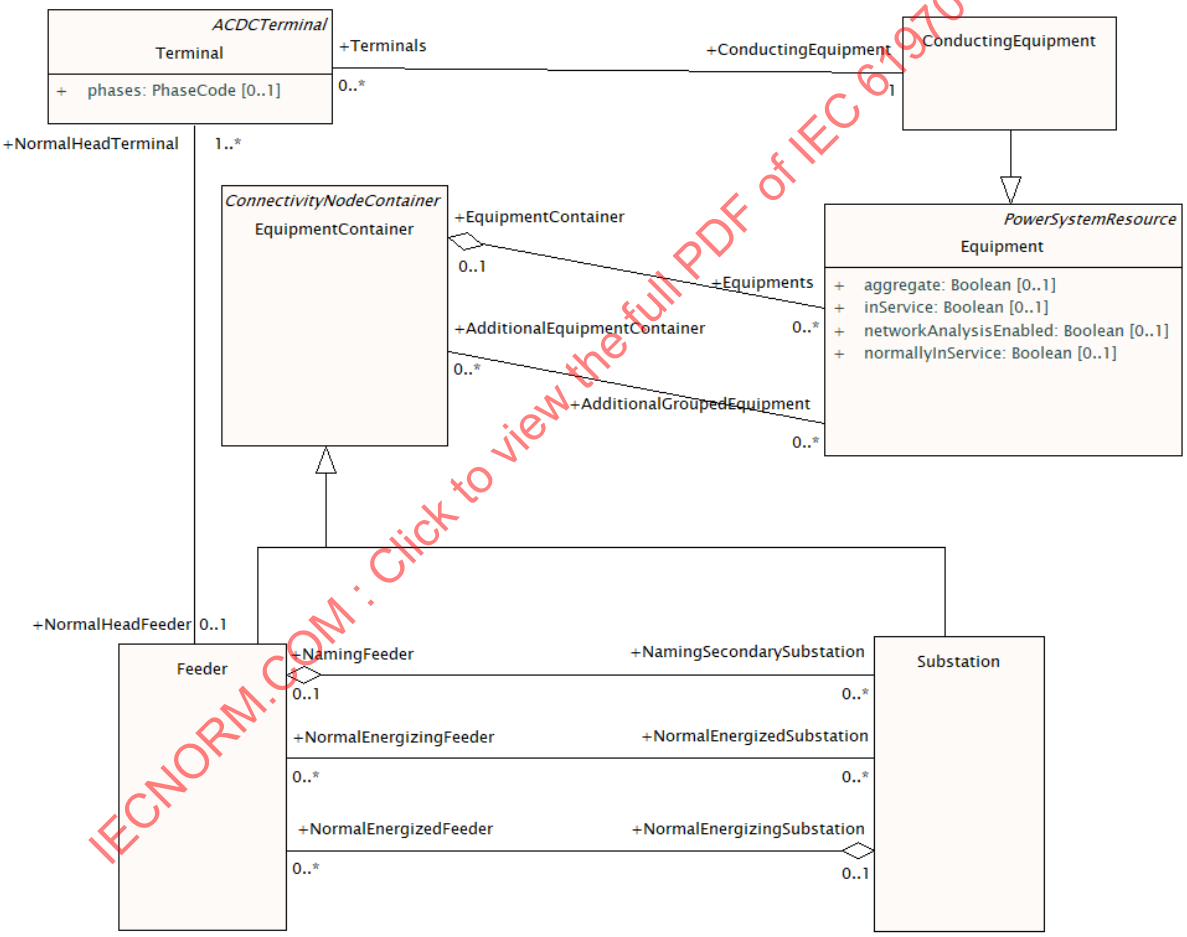


Figure 68 – Feeder data model

4.5.17 Control area modelling

Control area net interchange constraints are important for network analysis because when power flow cases are constructed, the situation to be studied almost always starts with a specification of the net load and net interchange for each control area. Control area constraints must be properly defined to correspond to the definitions for balancing authorities in the grid.Control area constraints in power flow are represented as a set of area control equality constraints of the form:

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Control Area Net Interchange = SUM (control area flow into the area on each tie)

Ties define control areas and ties must be defined such that every conducting element of the network is inside exactly one control area – in other words, control areas cover the network and do not overlap. This is also what happens in the real network, so it is natural and tie locations are usually well known. The control area net interchange is determined by summing flows in Terminals. The Terminals are identified by creating a set of TieFlow objects associated with a ControlArea object. Each TieFlow object is associated with one Terminal. An attribute of the ControlArea object specifies the net interchange (ControlArea.netInterchange).The control area orientation for net interchange is positive for an import, negative for an export. A tie between two control areas will appear in both control area specifications. It must be modelled in each such that the two representations of the tie flow sum to zero. The normal orientation of Terminal flow is positive for flow into the conducting equipment of the Terminal. (i.e. Flow from a bus into a device is positive.) However, the orientation of each flow in the control area specification must align with the control area convention, i.e. import is positive. If the orientation of the Terminal flow referenced by a TieFlow is positive into the control area, then this is confirmed by setting TieFlow.positiveFlowIn flag TRUE; if not, the orientation must be reversed by setting the TieFlow.positiveFlowIn flag FALSE.Figure 69 illustrates a simple tie, where the green arrows indicate the orientation of the Terminal flow (not the actual flow, but the direction of flow that will carry a plus sign):

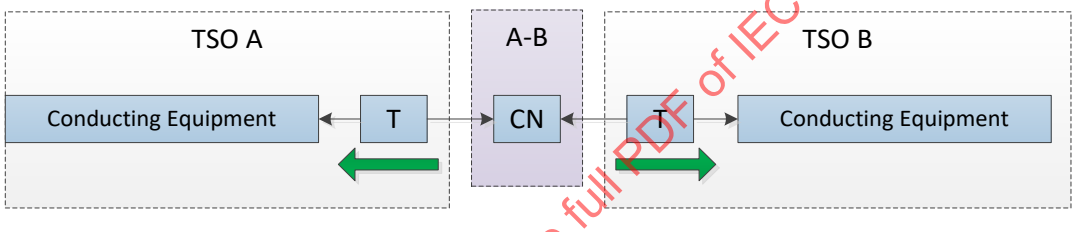


Figure 69 – Orientation of the Terminal flow

Figure 70 illustrates several ways that one can correctly describe the corresponding control area ties. The first two examples below agree on one single Terminal where both parties will measure flow. The third example chooses Terminals that are in the TSO network model so that the area control is always referencing its own network model.

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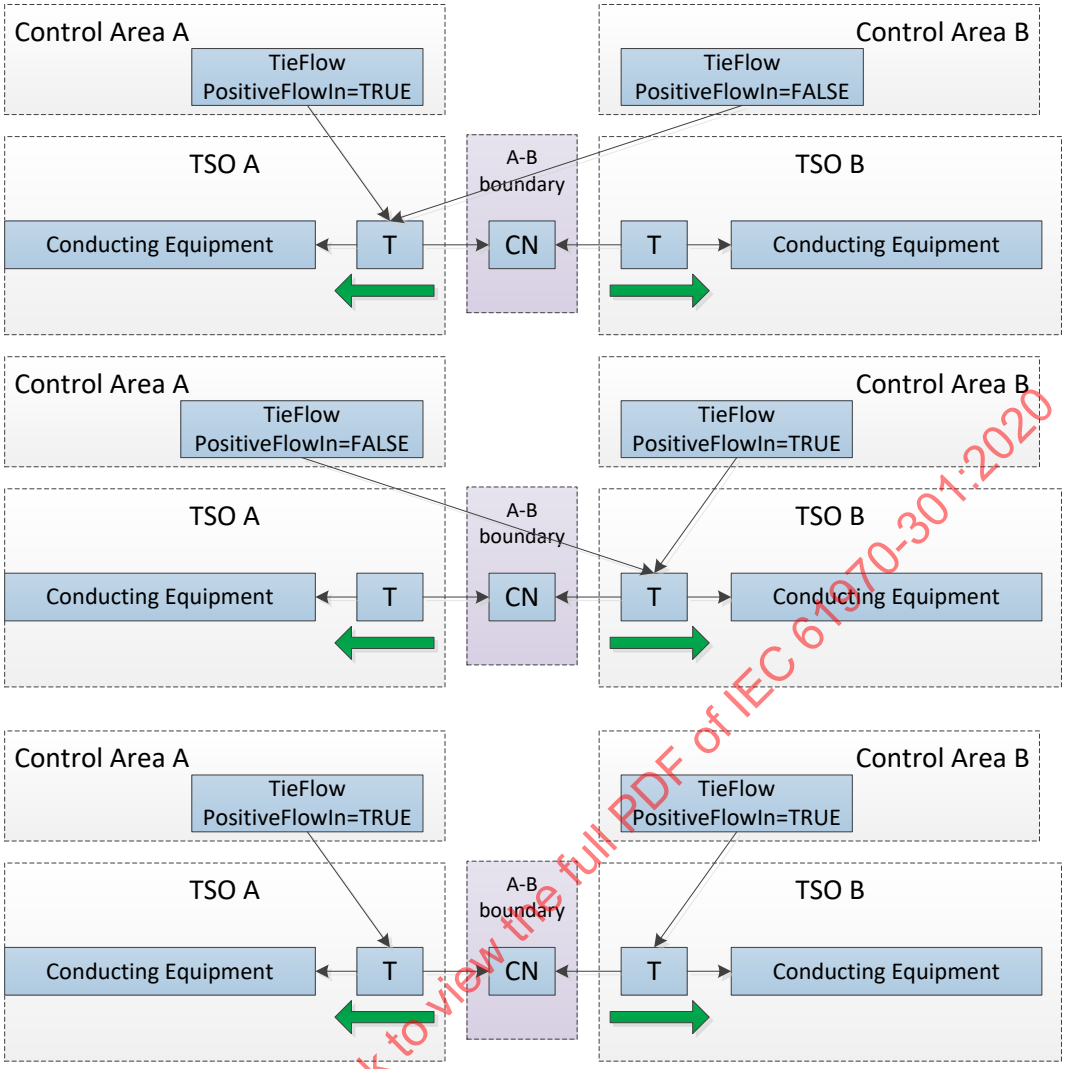


Figure 70 – Several ways to describe control area ties

4.6 Modelling guidelines

4.6.1 Modelling 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.

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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 modelling 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 start from 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 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 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 identified 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 of standards that use and extend the base CIM specified in this document.

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An example is IEC 61970-452, CIM static transmission network model profiles. 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 Modelling 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.

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 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, DCSeriesDevice, DCSwitch (and its specializations), DCChopper, 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) and DCConductingEquipment have a single terminal.

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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.

3 Available at <http://tanjakostic.org/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.

4.8.3 Nominal quantities

Many network model equipment attributes express nominal quantities. The following principles apply to those attributes.

- Nominal quantities are not related to the equipment but to the system nominal voltage in the grid.
- Rated quantities such as ratedU are related to the nameplate data.

4.8.4 Datatypes

W3C XML Schema Definition Language (XSD) 1.1 Part 2: Datatypes allows use of the following special values: INF, NaN to express quantities such as positive infinity, negative infinity, and not a number. CIM data types in general and the primitive Float are restricted not to use INF and NaN, if not explicitly allowed in a description of an attribute.

4.9 CIM modelling 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.

5 Detailed model

5.1 Overview

The part of the common information model (CIM) covered by IEC 61970-301 represents a comprehensive logical view of information exchanged between various 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 71 shows the top level packages included in this document.

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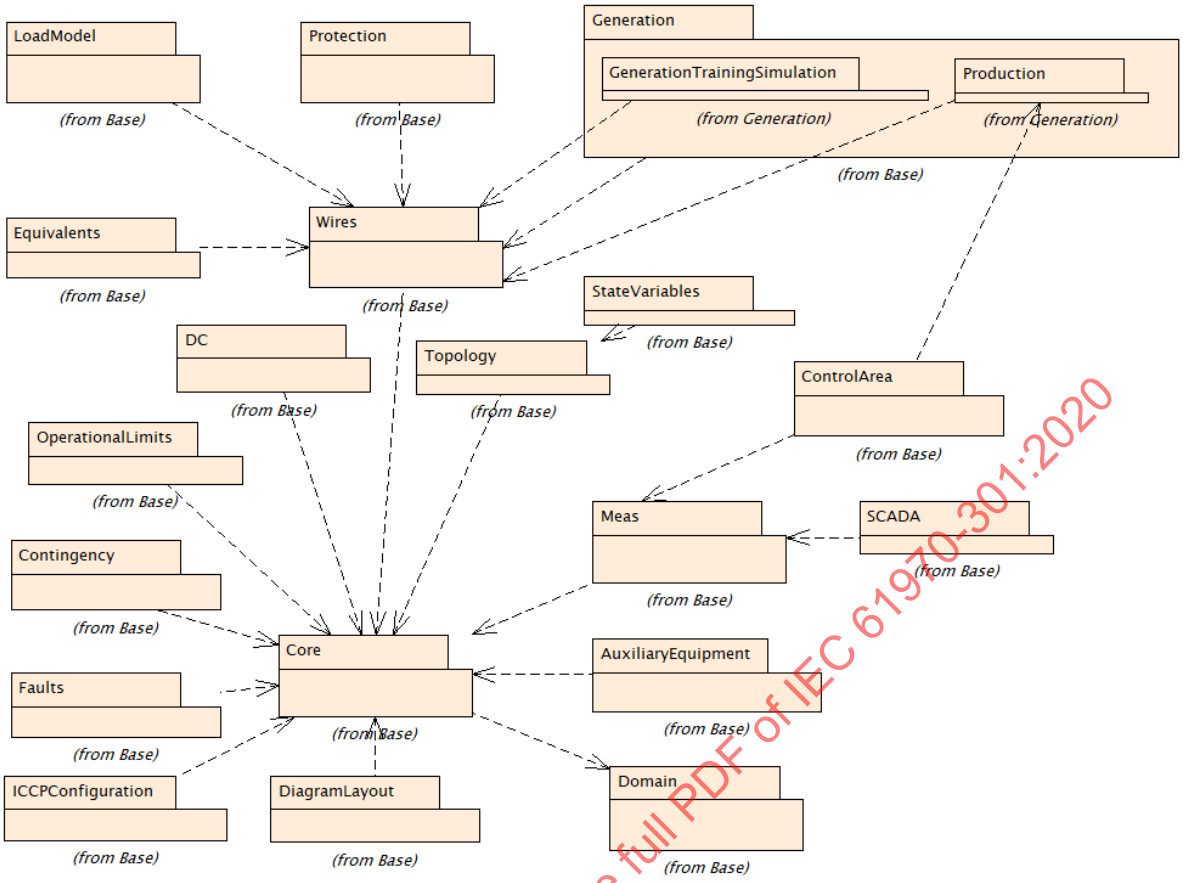


Figure 71 – CIM top level packages

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 8 and Table 9 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 is 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 8 – 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 8 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.

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Table 9 – 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 9, 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 10 since enumeration literals have no type. There are no inherited enumeration literals for an enumeration class.

Table 10 – 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 Package Base

6.1 General

[nsuri = http://iec.ch/TC57/CIM100#, nsprefix = cim]

Content of the base CIM published as IEC 61970-301.

6.2 Package Domain

6.2.1 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 other Compound classes, as long as the Compound classes do not recurse.

For all datatypes both positive and negative values are allowed unless stated otherwise for a particular datatype.

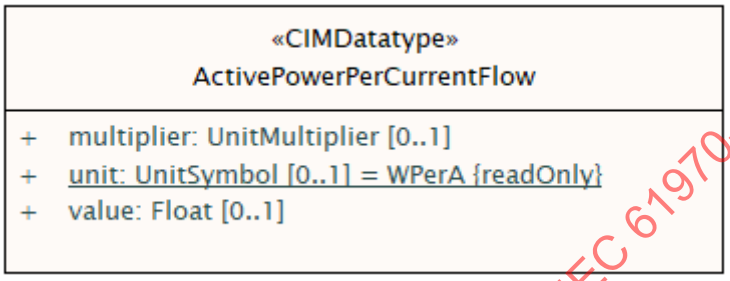


Figure 72 – Class diagram Domain::CombinedElectricalDatatypes

Figure 72: This diagram shows electrical datatypes that are combinations of other electrical datatypes.

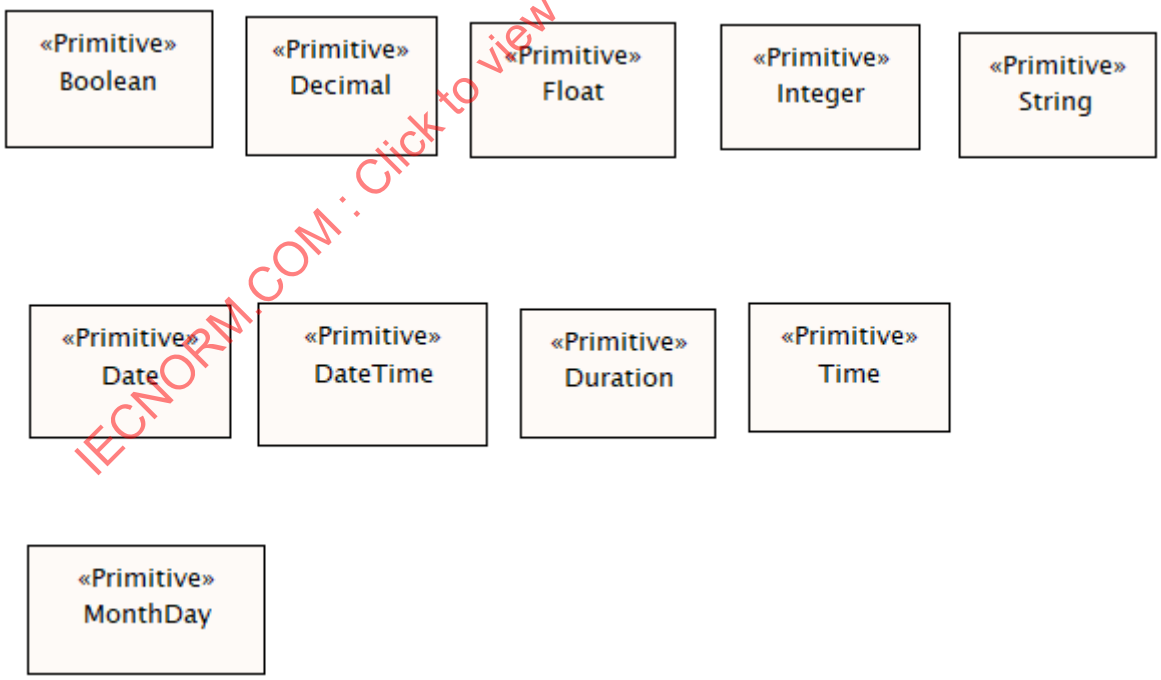
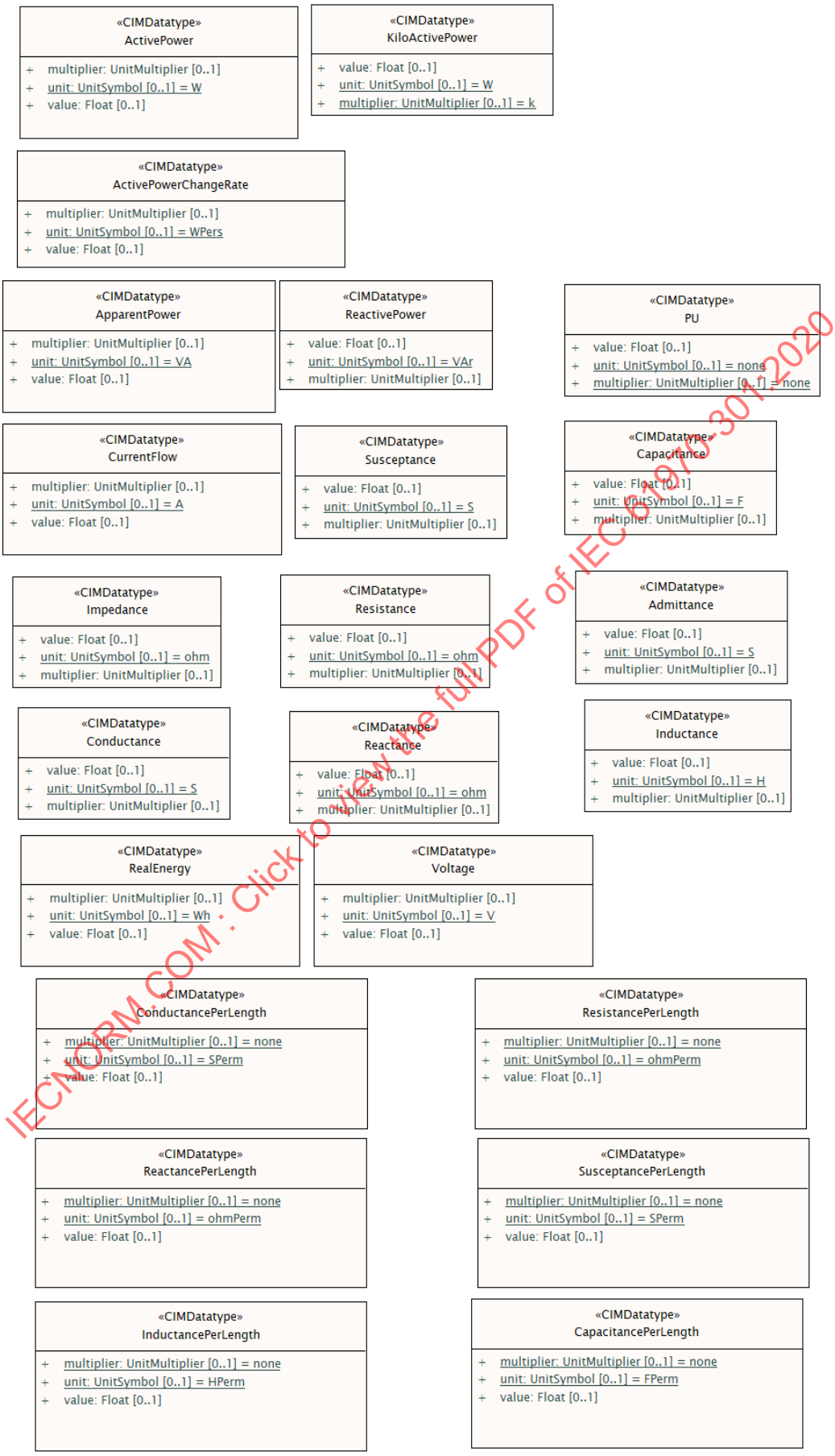


Figure 73 – Class diagram Domain::BasicDatatypes

Figure 73: This diagram shows basic datatypes that are the basis for all other datatypes.

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Figure 74 – Class diagram Domain::ElectricityDatatypes

Figure 74: This diagram shows electricity related data types.

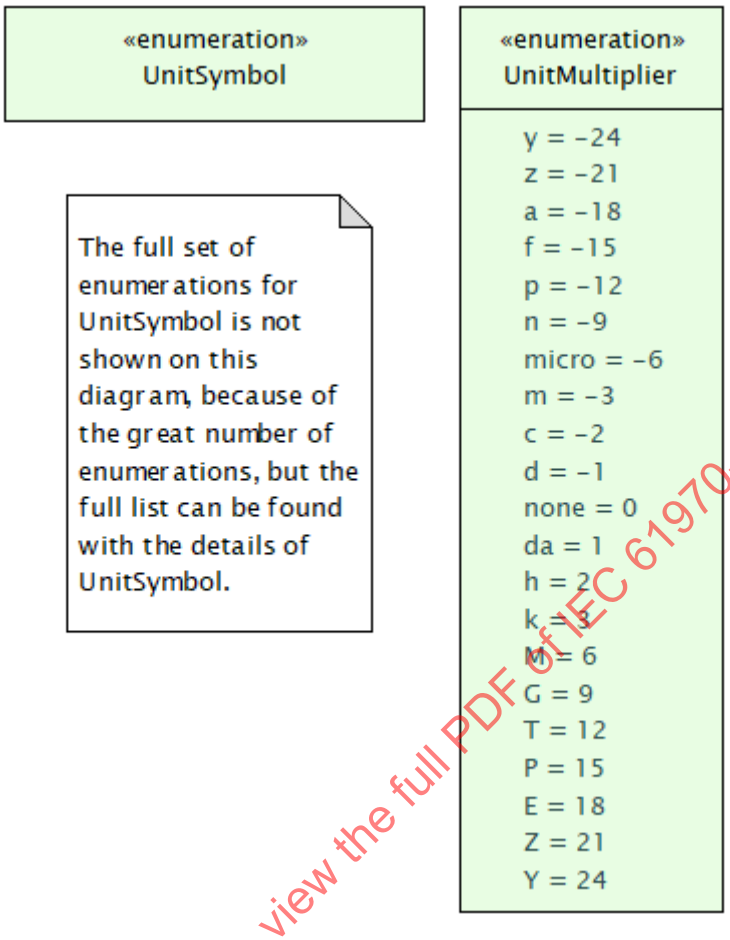
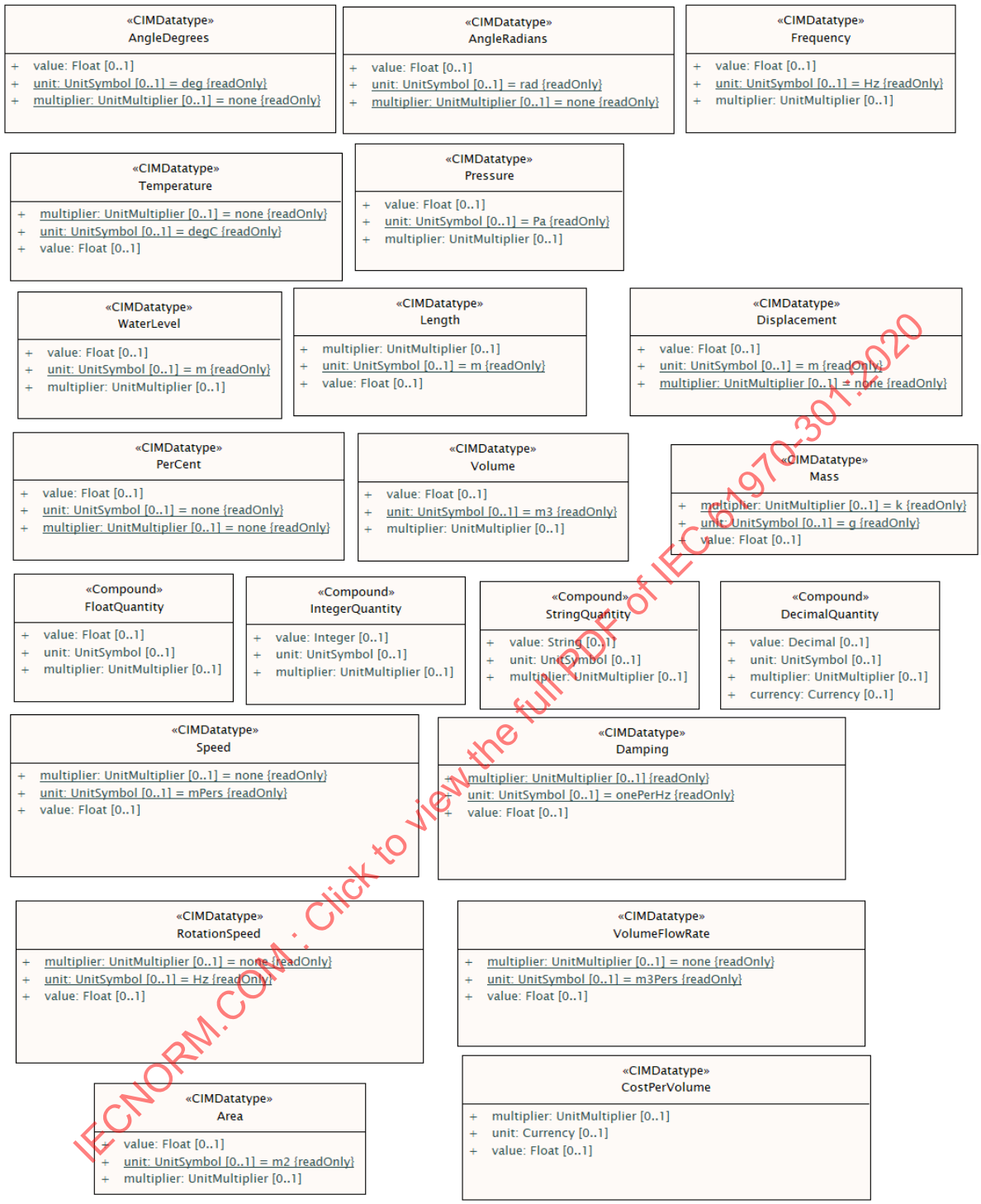


Figure 75 – Class diagram Domain::EnumeratedUnitDatatypes

Figure 75: This diagram shows enumerated data types related to the SI unit system.

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Figure 76 – Class diagram Domain::GeneralDatatypes

Figure 76: This diagram shows general data types.

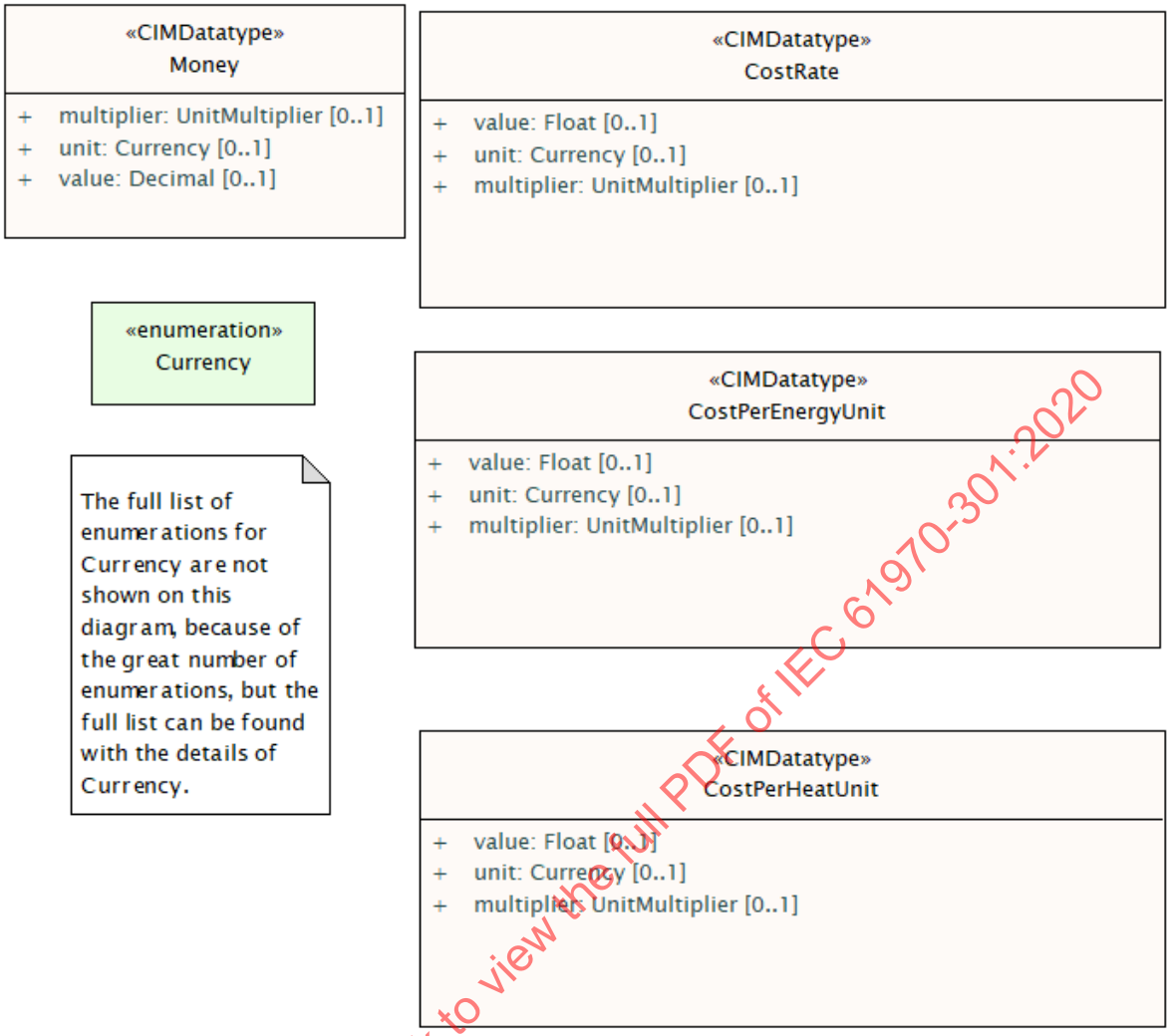


Figure 77 – Class diagram Domain::MonetaryDatatypes

Figure 77: This diagram shows monetary related data types.

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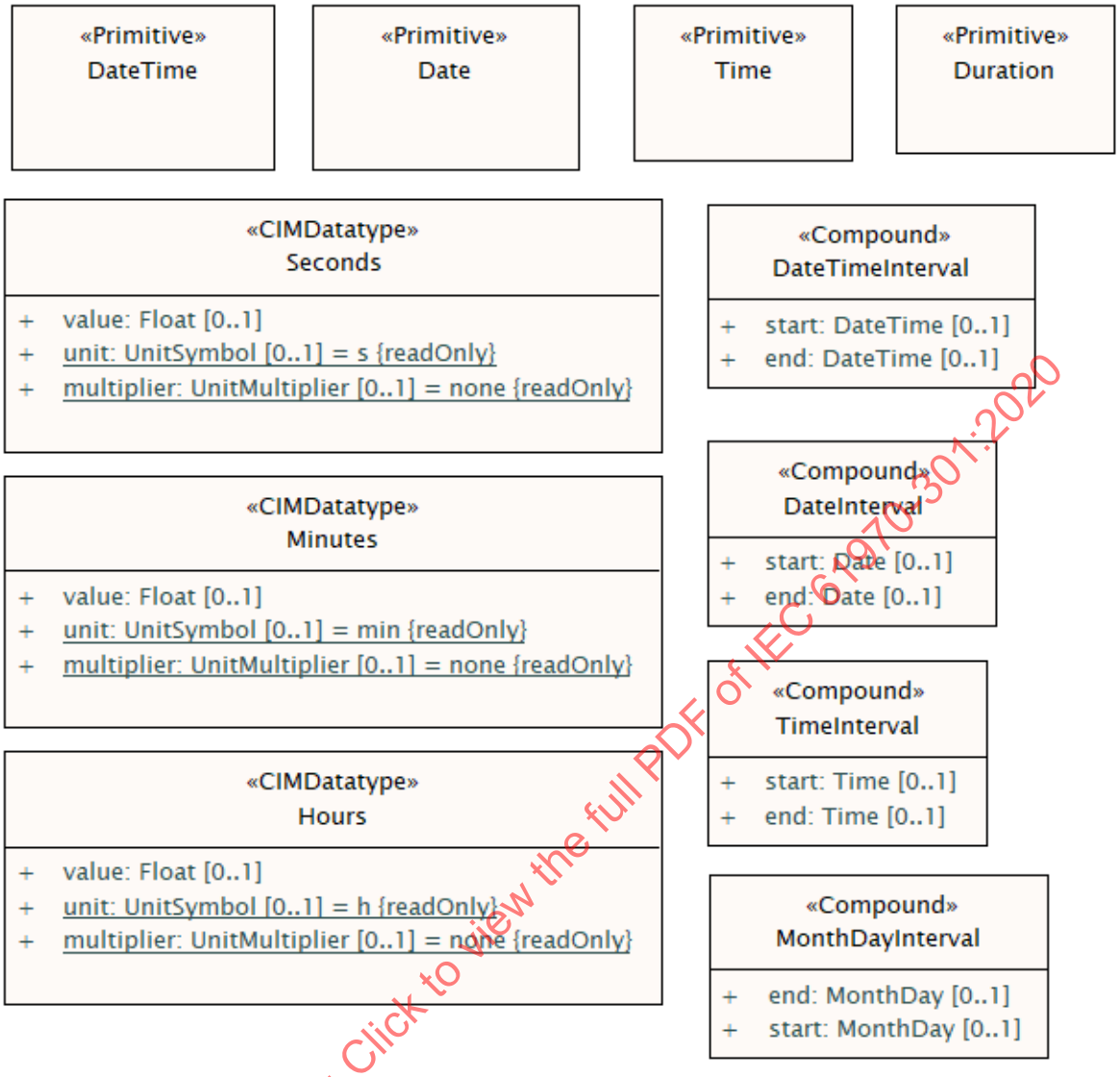


Figure 78 – Class diagram Domain::TimeDatatypes

Figure 78: This diagram shows time related data types.

6.2.2 ActivePower datatype

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

Table 11 shows all attributes of ActivePower.

Table 11 – Attributes of Domain::ActivePower

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

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6.2.3 ActivePowerChangeRate datatype

Rate of change of active power per time.

Table 12 shows all attributes of ActivePowerChangeRate.

Table 12 – Attributes of Domain::ActivePowerChangeRate

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

6.2.4 ActivePowerPerCurrentFlow datatype

Active power variation with current flow.

Table 13 shows all attributes of ActivePowerPerCurrentFlow.

Table 13 – Attributes of Domain::ActivePowerPerCurrentFlow

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

6.2.5 ActivePowerPerFrequency datatype

Active power variation with frequency.

Table 14 shows all attributes of ActivePowerPerFrequency.

Table 14 – Attributes of Domain::ActivePowerPerFrequency

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

6.2.6 Admittance datatype

Ratio of current to voltage.

Table 15 shows all attributes of Admittance.

Table 15 – 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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6.2.7 AngleDegrees datatype

Measurement of angle in degrees.

Table 16 shows all attributes of AngleDegrees.

Table 16 – Attributes of Domain::AngleDegrees

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

6.2.8 AngleRadians datatype

Phase angle in radians.

Table 17 shows all attributes of AngleRadians.

Table 17 – Attributes of Domain::AngleRadians

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

6.2.9 ApparentPower datatype

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

Table 18 shows all attributes of ApparentPower.

Table 18 – Attributes of Domain::ApparentPower

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

6.2.10 Area datatype

Area.

Table 19 shows all attributes of Area.

Table 19 – 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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6.2.11 Boolean primitive

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

6.2.12 Capacitance datatype

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

Table 20 shows all attributes of Capacitance.

Table 20 – Attributes of Domain::Capacitance

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

6.2.13 CapacitancePerLength datatype

Capacitance per unit of length.

Table 21 shows all attributes of CapacitancePerLength.

Table 21 – Attributes of Domain::CapacitancePerLength

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

6.2.14 Classification datatype

Classification of level. Specify as 1..n, with 1 being the most detailed, highest priority, etc as described on the attribute using this data type.

Table 22 shows all attributes of Classification.

Table 22 – Attributes of Domain::Classification

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

6.2.15 Conductance datatype

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

Table 23 shows all attributes of Conductance.

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Table 23 – Attributes of Domain::Conductance

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

6.2.16 ConductancePerLength datatype

Real part of admittance per unit of length.

Table 24 shows all attributes of ConductancePerLength.

Table 24 – Attributes of Domain::ConductancePerLength

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

6.2.17 CostPerEnergyUnit datatype

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

Table 25 shows all attributes of CostPerEnergyUnit.

Table 25 – Attributes of Domain::CostPerEnergyUnit

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

6.2.18 CostPerHeatUnit datatype

Cost, in units of currency, per quantity of heat generated.

Table 26 shows all attributes of CostPerHeatUnit.

Table 26 – Attributes of Domain::CostPerHeatUnit

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

6.2.19 CostPerVolume datatype

Cost per unit volume.

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Table 27 shows all attributes of CostPerVolume.

Table 27 – Attributes of Domain::CostPerVolume

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

6.2.20 CostRate datatype

Cost, in units of currency, per elapsed time.

Table 28 shows all attributes of CostRate.

Table 28 – Attributes of Domain::CostRate

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

6.2.21 Currency enumeration

Monetary currencies. ISO 4217 standard including 3-character currency code.

Table 29 shows all literals of Currency.

Table 29 – Literals of Domain::Currency

literal	value	description
AED	784	United Arab Emirates dirham.
AFN	971	Afghan afghani.
ALL	008	Albanian lek.
AMD	051	Armenian dram.
ANG	532	Netherlands Antillean guilder.
AOA	973	Angolan kwanza.
ARS	032	Argentine peso.
AUD	036	Australian dollar.
AWG	533	Aruban florin.
AZN	944	Azerbaijani manat.
BAM	977	Bosnia and Herzegovina convertible mark.
BBD	052	Barbados dollar.
BDT	050	Bangladeshi taka.
BGN	975	Bulgarian lev.
BHD	048	Bahraini dinar.
BIF	108	Burundian franc.
BMD	060	Bermudian dollar (customarily known as Bermuda dollar).

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literal	value	description
BND	096	Brunei dollar.
BOB	068	Boliviano.
BOV	984	Bolivian Mvdol (funds code).
BRL	986	Brazilian real.
BSD	044	Bahamian dollar.
BTN	064	Bhutanese ngultrum.
BWP	072	Botswana pula.
BYR	974	Belarusian ruble.
BZD	084	Belize dollar.
CAD	124	Canadian dollar.
CDF	976	Congolese franc.
CHF	756	Swiss franc.
CLF	990	Unidad de Fomento (funds code), Chile.
CLP	152	Chilean peso.
CNY	156	Chinese yuan.
COP	170	Colombian peso.
COU	970	Unidad de Valor Real.
CRC	188	Costa Rican colon.
CUC	931	Cuban convertible peso.
CUP	192	Cuban peso.
CVE	132	Cape Verde escudo.
CZK	203	Czech koruna.
DJF	262	Djiboutian franc.
DKK	208	Danish krone.
DOP	214	Dominican peso.
DZD	012	Algerian dinar.
EEK	233	Estonian kroon.
EGP	818	Egyptian pound.
ERN	232	Eritrean nakfa.
ETB	230	Ethiopian birr.
EUR	978	Euro.
FJD	242	Fiji dollar.
FKP	238	Falkland Islands pound.
GBP	826	Pound sterling.
GEL	981	Georgian lari.
GHS	936	Ghanaian cedi.
GIP	929	Gibraltar pound.
GMD	270	Gambian dalasi.
GNF	324	Guinean franc.
GTQ	320	Guatemalan quetzal.
GYD	328	Guyanese dollar.
HKD	344	Hong Kong dollar.
HNL	340	Honduran lempira.
HRK	191	Croatian kuna.

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literal	value	description
HTG	332	Haitian gourde.
HUF	348	Hungarian forint.
IDR	360	Indonesian rupiah.
ILS	376	Israeli new sheqel.
INR	356	Indian rupee.
IQD	368	Iraqi dinar.
IRR	364	Iranian rial.
ISK	352	Icelandic króna.
JMD	388	Jamaican dollar.
JOD	400	Jordanian dinar.
JPY	392	Japanese yen.
KES	404	Kenyan shilling.
KGS	417	Kyrgyzstani som.
KHR	116	Cambodian riel.
KMF	174	Comoro franc.
KPW	408	North Korean won.
KRW	410	South Korean won.
KWD	414	Kuwaiti dinar.
KYD	136	Cayman Islands dollar.
KZT	398	Kazakhstani tenge.
LAK	418	Lao kip.
LBP	422	Lebanese pound.
LKR	144	Sri Lanka rupee.
LRD	430	Liberian dollar.
LSL	426	Lesotho loti.
LTL	440	Lithuanian litas.
LVL	428	Latvian lats.
LYD	434	Libyan dinar.
MAD	504	Moroccan dirham.
MDL	498	Moldovan leu.
MGA	969	Malagasy ariary.
MKD	807	Macedonian denar.
MMK	104	Myanma kyat.
MNT	496	Mongolian tugrik.
MOP	446	Macanese pataca.
MRO	478	Mauritanian ouguiya.
MUR	480	Mauritian rupee.
MVR	462	Maldivian rufiyaa.
MWK	454	Malawian kwacha.
MXN	484	Mexican peso.
MYR	458	Malaysian ringgit.
MZN	943	Mozambican metical.
NAD	516	Namibian dollar.
NGN	566	Nigerian naira.

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literal	value	description
NIO	558	Cordoba oro.
NOK	578	Norwegian krone.
NPR	524	Nepalese rupee.
NZD	554	New Zealand dollar.
OMR	512	Omani rial.
PAB	590	Panamanian balboa.
PEN	604	Peruvian nuevo sol.
PGK	598	Papua New Guinean kina.
PHP	608	Philippine peso.
PKR	586	Pakistani rupee.
PLN	985	Polish zloty.
PYG	600	Paraguayan guaraní.
QAR	634	Qatari rial.
RON	946	Romanian new leu.
RSD	941	Serbian dinar.
RUB	643	Russian rouble.
RWF	646	Rwandan franc.
SAR	682	Saudi riyal.
SBD	090	Solomon Islands dollar.
SCR	690	Seychelles rupee.
SDG	938	Sudanese pound.
SEK	752	Swedish krona/kronor.
SGD	702	Singapore dollar.
SHP	654	Saint Helena pound.
SLL	694	Sierra Leonean leone.
SOS	706	Somali shilling.
SRD	968	Surinamese dollar.
STD	678	São Tomé and Príncipe dobra.
SYP	760	Syrian pound.
SZL	748	Lilangeni.
THB	764	Thai baht.
TJS	972	Tajikistani somoni.
TMT	934	Turkmenistani manat.
TND	788	Tunisian dinar.
TOP	776	Tongan pa'anga.
TRY	949	Turkish lira.
TTD	780	Trinidad and Tobago dollar.
TWD	901	New Taiwan dollar.
TZS	834	Tanzanian shilling.
UAH	980	Ukrainian hryvnia.
UGX	800	Ugandan shilling.
USD	840	United States dollar.
UYU	858	Uruguayan peso.
UZS	860	Uzbekistan som.

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literal	value	description
VEF	937	Venezuelan bolívar fuerte.
VND	704	Vietnamese Dong.
VUV	548	Vanuatu vatu.
WST	882	Samoan tala.
XAF	950	CFA franc BEAC.
XCD	951	East Caribbean dollar.
XOF	952	CFA Franc BCEAO.
XPF	953	CFP franc.
YER	886	Yemeni rial.
ZAR	710	South African rand.
ZMK	894	Zambian kwacha.
ZWL	932	Zimbabwe dollar.

6.2.22 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 30 shows all attributes of CurrentFlow.

Table 30 – Attributes of Domain::CurrentFlow

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

6.2.23 Damping datatype

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

Table 31 shows all attributes of Damping.

Table 31 – Attributes of Domain::Damping

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

6.2.24 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".

6.2.25 DateInterval compound

Interval between two dates.

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Table 32 shows all attributes of DateInterval.

Table 32 – 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.

6.2.26 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.

6.2.27 DateTimeInterval compound

Interval between two date and time points, where the interval includes the start time but excludes end time.

Table 33 shows all attributes of DateTimeInterval.

Table 33 – Attributes of Domain::DateTimeInterval

name	mult	type	description
start	0..1	DateTime	Start date and time of this interval. The start date and time is included in the defined interval.
end	0..1	DateTime	End date and time of this interval. The end date and time where the interval is defined up to, but excluded.

6.2.28 Decimal primitive

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

6.2.29 DecimalQuantity compound

Quantity with decimal value and associated unit or currency information.

Table 34 shows all attributes of DecimalQuantity.

Table 34 – Attributes of Domain::DecimalQuantity

name	mult	type	description
value	0..1	Decimal	Value of this quantity.
unit	0..1	UnitSymbol	Unit of this quantity.
multiplier	0..1	UnitMultiplier	Unit multiplier of this quantity.
currency	0..1	Currency	Currency of this quantity.

6.2.30 Displacement datatype

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

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Table 35 shows all attributes of Displacement.

Table 35 – Attributes of Domain::Displacement

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

6.2.31 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.

6.2.32 Emission datatype

Quantity of emission per fuel heat content.

Table 36 shows all attributes of Emission.

Table 36 – Attributes of Domain::Emission

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

6.2.33 Float primitive

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

6.2.34 FloatQuantity compound

Quantity with float value and associated unit information.

Table 37 shows all attributes of FloatQuantity.

Table 37 – Attributes of Domain::FloatQuantity

name	mult	type	description
value	0..1	Float	Value of this quantity.
unit	0..1	UnitSymbol	Unit of this quantity.
multiplier	0..1	UnitMultiplier	Unit multiplier of this quantity.

6.2.35 Frequency datatype

Cycles per second.

Table 38 shows all attributes of Frequency.

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Table 38 – Attributes of Domain::Frequency

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

6.2.36 HeatRate datatype

Heat generated, in energy per time unit of elapsed time.

Table 39 shows all attributes of HeatRate.

Table 39 – Attributes of Domain::HeatRate

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

6.2.37 Hours datatype

Time specified in hours.

Table 40 shows all attributes of Hours.

Table 40 – Attributes of Domain::Hours

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

6.2.38 Impedance datatype

Ratio of voltage to current.

Table 41 shows all attributes of Impedance.

Table 41 – Attributes of Domain::Impedance

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

6.2.39 Inductance datatype

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

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Table 42 shows all attributes of Inductance.

Table 42 – Attributes of Domain::Inductance

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

6.2.40 InductancePerLength datatype

Inductance per unit of length.

Table 43 shows all attributes of InductancePerLength.

Table 43 – Attributes of Domain::InductancePerLength

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

6.2.41 Integer primitive

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

6.2.42 IntegerQuantity compound

Quantity with integer value and associated unit information.

Table 44 shows all attributes of IntegerQuantity.

Table 44 – Attributes of Domain::IntegerQuantity

name	mult	type	description
value	0..1	Integer	Value of this quantity.
unit	0..1	UnitSymbol	Unit of this quantity.
multiplier	0..1	UnitMultiplier	Unit multiplier of this quantity.

6.2.43 KiloActivePower datatype

Active power in kilowatts.

Table 45 shows all attributes of KiloActivePower.

Table 45 – Attributes of Domain::KiloActivePower

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

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6.2.44 Length datatype

Unit of length. It shall be a positive value or zero.

Table 46 shows all attributes of Length.

Table 46 – Attributes of Domain::Length

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

6.2.45 Mass datatype

Mass.

Table 47 shows all attributes of Mass.

Table 47 – Attributes of Domain::Mass

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

6.2.46 Minutes datatype

Time in minutes.

Table 48 shows all attributes of Minutes.

Table 48 – Attributes of Domain::Minutes

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

6.2.47 Money datatype

Amount of money.

Table 49 shows all attributes of Money.

Table 49 – Attributes of Domain::Money

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

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6.2.48 MonthDay primitive

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

6.2.49 MonthDayInterval compound

Interval between two times specified as month and day.

Table 50 shows all attributes of MonthDayInterval.

Table 50 – 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.

6.2.50 PU datatype

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

Table 51 shows all attributes of PU.

Table 51 – Attributes of Domain::PU

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

6.2.51 PerCent datatype

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

Table 52 shows all attributes of PerCent.

Table 52 – 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)

6.2.52 Pressure datatype

Pressure in pascals.

Table 53 shows all attributes of Pressure.

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Table 53 – Attributes of Domain::Pressure

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

6.2.53 Reactance datatype

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

Table 54 shows all attributes of Reactance.

Table 54 – Attributes of Domain::Reactance

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

6.2.54 ReactancePerLength datatype

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

Table 55 shows all attributes of ReactancePerLength.

Table 55 – Attributes of Domain::ReactancePerLength

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

6.2.55 ReactivePower datatype

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

Table 56 shows all attributes of ReactivePower.

Table 56 – Attributes of Domain::ReactivePower

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

6.2.56 RealEnergy datatype

Real electrical energy.

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Table 57 shows all attributes of RealEnergy.

Table 57 – Attributes of Domain::RealEnergy

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

6.2.57 Resistance datatype

Resistance (real part of impedance).

Table 58 shows all attributes of Resistance.

Table 58 – Attributes of Domain::Resistance

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

6.2.58 ResistancePerLength datatype

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

Table 59 shows all attributes of ResistancePerLength.

Table 59 – Attributes of Domain::ResistancePerLength

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

6.2.59 RotationSpeed datatype

Number of revolutions per second.

Table 60 shows all attributes of RotationSpeed.

Table 60 – Attributes of Domain::RotationSpeed

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

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6.2.60 Seconds datatype

Time, in seconds.

Table 61 shows all attributes of Seconds.

Table 61 – 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)

6.2.61 Speed datatype

Distance per unit of time.

Table 62 shows all attributes of Speed.

Table 62 – Attributes of Domain::Speed

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

6.2.62 String primitive

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

6.2.63 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 63 shows all attributes of StringQuantity.

Table 63 – Attributes of Domain::StringQuantity

name	mult	type	description
value	0..1	String	Value of this quantity.
unit	0..1	UnitSymbol	Unit of this quantity.
multiplier	0..1	UnitMultiplier	Unit multiplier of this quantity.

6.2.64 Susceptance datatype

Imaginary part of admittance.

Table 64 shows all attributes of Susceptance.

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Table 64 – Attributes of Domain::Susceptance

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

6.2.65 SusceptancePerLength datatype

Imaginary part of admittance per unit of length.

Table 65 shows all attributes of SusceptancePerLength.

Table 65 – Attributes of Domain::SusceptancePerLength

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

6.2.66 Temperature datatype

Value of temperature in degrees Celsius.

Table 66 shows all attributes of Temperature.

Table 66 – Attributes of Domain::Temperature

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

6.2.67 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.

6.2.68 TimeInterval compound

Interval between two times.

Table 67 shows all attributes of TimeInterval.

Table 67 – 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.

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6.2.69 UnitMultiplier enumeration

The unit multipliers defined for the CIM. When applied to unit symbols, the unit symbol is treated as a derived unit. Regardless of the contents of the unit symbol text, the unit symbol shall be treated as if it were a single-character unit symbol. Unit symbols should not contain multipliers, and it should be left to the multiplier to define the multiple for an entire data type.

For example, if a unit symbol is "m2Pers" and the multiplier is "k", then the value is k(m**2/s), and the multiplier applies to the entire final value, not to any individual part of the value. This can be conceptualized by substituting a derived unit symbol for the unit type. If one imagines that the symbol "Þ" represents the derived unit "m2Pers", then applying the multiplier "k" can be conceptualized simply as "kÞ".

For example, the SI unit for mass is "kg" and not "g". If the unit symbol is defined as "kg", then the multiplier is applied to "kg" as a whole and does not replace the "k" in front of the "g". In this case, the multiplier of "m" would be used with the unit symbol of "kg" to represent one gram. As a text string, this violates the instructions in IEC 80000-1. However, because the unit symbol in CIM is treated as a derived unit instead of as an SI unit, it makes more sense to conceptualize the "kg" as if it were replaced by one of the proposed replacements for the SI mass symbol. If one imagines that the "kg" were replaced by a symbol "Þ", then it is easier to conceptualize the multiplier "m" as creating the proper unit "mÞ", and not the forbidden unit "mkg".

Table 68 shows all literals of UnitMultiplier.

Table 68 – Literals of Domain::UnitMultiplier

literal	value	description
y	-24	Yocto 10**-24.
z	-21	Zepto 10**-21.
a	-18	Atto 10**-18.
f	-15	Femto 10**-15.
p	-12	Pico 10**-12.
n	-9	Nano 10**-9.
micro	-6	Micro 10**-6.
m	-3	Milli 10**-3.
c	-2	Centi 10**-2.
d	-1	Deci 10**-1.
none	0	No multiplier or equivalently multiply by 1.
da	1	Deca 10**1.
h	2	Hecto 10**2.
k	3	Kilo 10**3.
M	6	Mega 10**6.
G	9	Giga 10**9.
T	12	Tera 10**12.
P	15	Peta 10**15.
E	18	Exa 10**18.
Z	21	Zetta 10**21.
Y	24	Yotta 10**24.

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6.2.70 UnitSymbol enumeration

The derived units defined for usage in the CIM. In some cases, the derived unit is equal to an SI unit. Whenever possible, the standard derived symbol is used instead of the formula for the derived unit. For example, the unit symbol Farad is defined as "F" instead of "CPerV". In cases where a standard symbol does not exist for a derived unit, the formula for the unit is used as the unit symbol. For example, density does not have a standard symbol and so it is represented as "kgPerm3". With the exception of the "kg", which is an SI unit, the unit symbols do not contain multipliers and therefore represent the base derived unit to which a multiplier can be applied as a whole.

Every unit symbol is treated as an unparseable text as if it were a single-letter symbol. The meaning of each unit symbol is defined by the accompanying descriptive text and not by the text contents of the unit symbol.

To allow the widest possible range of serializations without requiring special character handling, several substitutions are made which deviate from the format described in IEC 80000-1. The division symbol "/" is replaced by the letters "Per". Exponents are written in plain text after the unit as "m3" instead of being formatted as "m" with a superscript of 3 or introducing a symbol as in "m^3". The degree symbol "°" is replaced with the letters "deg". Any clarification of the meaning for a substitution is included in the description for the unit symbol.

Non-SI units are included in list of unit symbols to allow sources of data to be correctly labelled with their non-SI units (for example, a GPS sensor that is reporting numbers that represent feet instead of meters). This allows software to use the unit symbol information correctly convert and scale the raw data of those sources into SI-based units.

The integer values are used for harmonization with IEC 61850.

Table 69 shows all literals of UnitSymbol.

Table 69 – Literals of Domain::UnitSymbol

literal	value	description
none	0	Dimension less quantity, e.g. count, per unit, etc.
m	2	Length in metres.
kg	3	Mass in kilograms. Note: multiplier “k” is included in this unit symbol for compatibility with IEC 61850-7-3.
s	4	Time in seconds.
A	5	Current in amperes.
K	6	Temperature in kelvins.
mol	7	Amount of substance in moles.
cd	8	Luminous intensity in candelas.
deg	9	Plane angle in degrees.
rad	10	Plane angle in radians (m/m).
sr	11	Solid angle in steradians (m^2/m^2).
Gy	21	Absorbed dose in grays (J/kg).
Bq	22	Radioactivity in becquerels (1/s).
degC	23	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.

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literal	value	description
Sv	24	Dose equivalent in sieverts (J/kg).
F	25	Electric capacitance in farads (C/V).
C	26	Electric charge in coulombs (A·s).
S	27	Conductance in siemens.
H	28	Electric inductance in henrys (Wb/A).
V	29	Electric potential in volts (W/A).
ohm	30	Electric resistance in ohms (V/A).
J	31	Energy in joules (N·m = C·V = W·s).
N	32	Force in newtons (kg·m/s^2).
Hz	33	Frequency in hertz (1/s).
lx	34	Illuminance in lux (lm/m^2).
lm	35	Luminous flux in lumens (cd·sr).
Wb	36	Magnetic flux in webers (V·s).
T	37	Magnetic flux density in teslas (Wb/m^2).
W	38	Real power in watts (J/s). Electrical power may have real and reactive components. The real portion of electrical power (I^{2}R or VIcos(phi)), is expressed in Watts. See also apparent power and reactive power.
Pa	39	Pressure in pascals (N/m^2). Note: the absolute or relative measurement of pressure is implied with this entry. See below for more explicit forms.
m2	41	Area in square metres (m^2).
m3	42	Volume in cubic metres (m^3).
mPers	43	Velocity in metres per second (m/s).
mPers2	44	Acceleration in metres per second squared (m/s^2).
m3Pers	45	Volumetric flow rate in cubic metres per second (m^3/s).
mPerm3	46	Fuel efficiency in metres per cubic metres (m/m^3).
kgm	47	Moment of mass in kilogram metres (kg·m) (first moment of mass). Note: multiplier “k” is included in this unit symbol for compatibility with IEC 61850-7-3.
kgPerm3	48	Density in kilogram/cubic metres (kg/m^3). Note: multiplier “k” is included in this unit symbol for compatibility with IEC 61850-7-3.
m2Pers	49	Viscosity in square metres / second (m^2/s).
WPermK	50	Thermal conductivity in watt/metres kelvin.
JPerK	51	Heat capacity in joules/kelvin.
ppm	52	Concentration in parts per million.
rotPers	53	Rotations per second (1/s). See also Hz (1/s).
radPers	54	Angular velocity in radians per second (rad/s).
WPerm2	55	Heat flux density, irradiance, watts per square metre.
JPerm2	56	Insulation energy density, joules per square metre or watt second per square metre.
SPerm	57	Conductance per length (F/m).

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literal	value	description
KPers	58	Temperature change rate in kelvins per second.
PaPers	59	Pressure change rate in pascals per second.
JPerkgK	60	Specific heat capacity, specific entropy, joules per kilogram Kelvin.
VA	61	Apparent power in volt amperes. See also real power and reactive power.
VAr	63	Reactive power in volt amperes reactive. The “reactive” or “imaginary” component of electrical power (VIsin(phi)). (See also real power and apparent power). Note: Different meter designs use different methods to arrive at their results. Some meters may compute reactive power as an arithmetic value, while others compute the value vectorially. The data consumer should determine the method in use and the suitability of the measurement for the intended purpose.
cosPhi	65	Power factor, dimensionless. NOTE 1 This definition of power factor only holds for balanced systems. See the alternative definition under code 153. NOTE 2 Beware of differing sign conventions in use between the IEC and EEI. It is assumed that the data consumer understands the type of meter in use and the sign convention in use by the utility.
Vs	66	Volt seconds (Ws/A).
V2	67	Volt squared (W^2/A^2).
As	68	Ampere seconds (A·s).
A2	69	Amperes squared (A^2).
A2s	70	Ampere squared time in square amperes (A^2s).
VAh	71	Apparent energy in volt ampere hours.
Wh	72	Real energy in watt hours.
VArh	73	Reactive energy in volt ampere reactive hours.
VPerHz	74	Magnetic flux in volt per hertz.
HzPers	75	Rate of change of frequency in hertz per second.
character	76	Number of characters.
charPers	77	Data rate (baud) in characters per second.
kgm2	78	Moment of mass in kilogram square metres ($kg·m^2$) (Second moment of mass, commonly called the moment of inertia). Note: multiplier “k” is included in this unit symbol for compatibility with IEC 61850-7-3.
dB	79	Sound pressure level in decibels. Note: multiplier “d” is included in this unit symbol for compatibility with IEC 61850-7-3.
WPers	81	Ramp rate in watts per second.
lPers	82	Volumetric flow rate in litres per second.
dBm	83	Power level (logarithmic ratio of signal strength, Bel-mW), normalized to 1mW. Note: multiplier “d” is included in this unit symbol for compatibility with IEC 61850-7-3.
h	84	Time in hours, hour = 60 min = 3600 s.
min	85	Time in minutes, minute = 60 s.
Q	100	Quantity power, Q.

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literal	value	description
Qh	101	Quantity energy, Qh.
ohmm	102	Resistivity, ohm metres, (rho).
APerm	103	A/m, magnetic field strength, amperes per metre.
V2h	104	Volt-squared hour, volt-squared-hours.
A2h	105	Ampere-squared hour, ampere-squared hour.
Ah	106	Ampere-hours, ampere-hours.
count	111	Amount of substance, Counter value.
ft3	119	Volume, cubic feet.
m3Perh	125	Volumetric flow rate, cubic metres per hour.
gal	128	Volume in gallons, US gallon (1 gal = 231 in3 = 128 fl ounce).
Btu	132	Energy, British Thermal Units.
l	134	Volume in litres, litre = dm^3 = m^3/1 000.
lPerh	137	Volumetric flow rate, litres per hour.
lPerl	143	Concentration, The ratio of the volume of a solute divided by the volume of the solution. Note: Users may need use a prefix such a ‘µ’ to express a quantity such as ‘µL/L’.
gPerg	144	Concentration, The ratio of the mass of a solute divided by the mass of the solution. Note: Users may need use a prefix such a ‘µ’ to express a quantity such as ‘µg/g’.
molPerm3	145	Concentration, The amount of substance concentration, (c), the amount of solvent in moles divided by the volume of solution in m^3.
molPermol	146	Concentration, Molar fraction, the ratio of the molar amount of a solute divided by the molar amount of the solution.
molPerkg	147	Concentration, Molality, the amount of solute in moles and the amount of solvent in kilograms.
sPers	149	Time, Ratio of time. Note: Users may need to supply a prefix such as ‘µ’ to show rates such as ‘µs/s’.
HzPerHz	150	Frequency, rate of frequency change. Note: Users may need to supply a prefix such as ‘m’ to show rates such as ‘mHz/Hz’.
VPerV	151	Voltage, ratio of voltages. Note: Users may need to supply a prefix such as ‘m’ to show rates such as ‘mV/V’.
APerA	152	Current, ratio of amperages. Note: Users may need to supply a prefix such as ‘m’ to show rates such as ‘mA/A’.
VPerVA	153	Power factor, PF, the ratio of the active power to the apparent power. Note: The sign convention used for power factor will differ between IEC meters and EEI (ANSI) meters. It is assumed that the data consumers understand the type of meter being used and agree on the sign convention in use at any given utility.
rev	154	Amount of rotation, revolutions.
kat	158	Catalytic activity, katal = mol / s.
JPerkg	165	Specific energy, Joules / kg.
m3Uncompensated	166	Volume, cubic metres, with the value uncompensated for weather effects.

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literal	value	description
m3Compensated	167	Volume, cubic metres, with the value compensated for weather effects.
WPerW	168	Signal Strength, ratio of power. Note: Users may need to supply a prefix such as 'm' to show rates such as 'mW/W'.
therm	169	Energy, therms.
onePerm	173	Wavenumber, reciprocal metres, (1/m).
m3Perkg	174	Specific volume, cubic metres per kilogram, v.
Pas	175	Dynamic viscosity, pascal seconds.
Nm	176	Moment of force, newton metres.
NPerm	177	Surface tension, newton per metre.
radPers2	178	Angular acceleration, radians per second squared.
JPerm3	181	Energy density, joules per cubic metre.
VPerm	182	Electric field strength, volts per metre.
CPerm3	183	Electric charge density, coulombs per cubic metre.
CPerm2	184	Surface charge density, coulombs per square metre.
FPerm	185	Permittivity, farads per metre.
HPerm	186	Permeability, henrys per metre.
JPermol	187	Molar energy, joules per mole.
JPermolK	188	Molar entropy, molar heat capacity, joules per mole kelvin.
CPerkg	189	Exposure (x rays), coulombs per kilogram.
GyPers	190	Absorbed dose rate, grays per second.
WPersr	191	Radiant intensity, watts per steradian.
WPerm2sr	192	Radiance, watts per square metre steradian.
katPerm3	193	Catalytic activity concentration, katals per cubic metre.
d	195	Time in days, day = 24 h = 86 400 s.
anglemin	196	Plane angle, minutes.
anglesec	197	Plane angle, seconds.
ha	198	Area, hectares.
tonne	199	Mass in tons, "tonne" or "metric ton" (1000 kg = 1 Mg).
bar	214	Pressure in bars, (1 bar = 100 kPa).
mmHg	215	Pressure, millimetres of mercury (1 mmHg is approximately 133.3 Pa).
M	217	Length, nautical miles (1 M = 1 852 m).
kn	219	Speed, knots (1 kn = 1 852/3 600) m/s.
Mx	276	Magnetic flux, maxwells (1 Mx = 10-8 Wb).
G	277	Magnetic flux density, gausses (1 G = 10-4 T).
Oe	278	Magnetic field in oersteds, (1 Oe = (103/4p) A/m).
Vh	280	Volt-hour, Volt hours.
WPerA		Active power per current flow, watts per Ampere.
onePerHz		Reciprocal of frequency (1/Hz).

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literal	value	description
VPerVAr		Power factor, PF, the ratio of the active power to the apparent power. Note: The sign convention used for power factor will differ between IEC meters and EEI (ANSI) meters. It is assumed that the data consumers understand the type of meter being used and agree on the sign convention in use at any given utility.
ohmPerm	86	Electric resistance per length in ohms per metre ((V/A)/m).
kgPerJ		Weight per energy in kilograms per joule (kg/J). Note: multiplier “k” is included in this unit symbol for compatibility with IEC 61850-7-3.
JPers		Energy rate in joules per second (J/s).

6.2.71 Voltage datatype

Electrical voltage, can be both AC and DC.

Table 70 shows all attributes of Voltage.

Table 70 – Attributes of Domain::Voltage

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

6.2.72 VoltagePerReactivePower datatype

Voltage variation with reactive power.

Table 71 shows all attributes of VoltagePerReactivePower.

Table 71 – Attributes of Domain::VoltagePerReactivePower

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

6.2.73 Volume datatype

Volume.

Table 72 shows all attributes of Volume.

Table 72 – 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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6.2.74 VolumeFlowRate datatype

Volume per time.

Table 73 shows all attributes of VolumeFlowRate.

Table 73 – Attributes of Domain::VolumeFlowRate

name	mult	type	description
multiplier	0..1	UnitMultiplier	(const=none)
unit	0..1	UnitSymbol	(const=m3Pers)
value	0..1	Float	

6.2.75 WaterLevel datatype

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

Table 74 shows all attributes of WaterLevel.

Table 74 – Attributes of Domain::WaterLevel

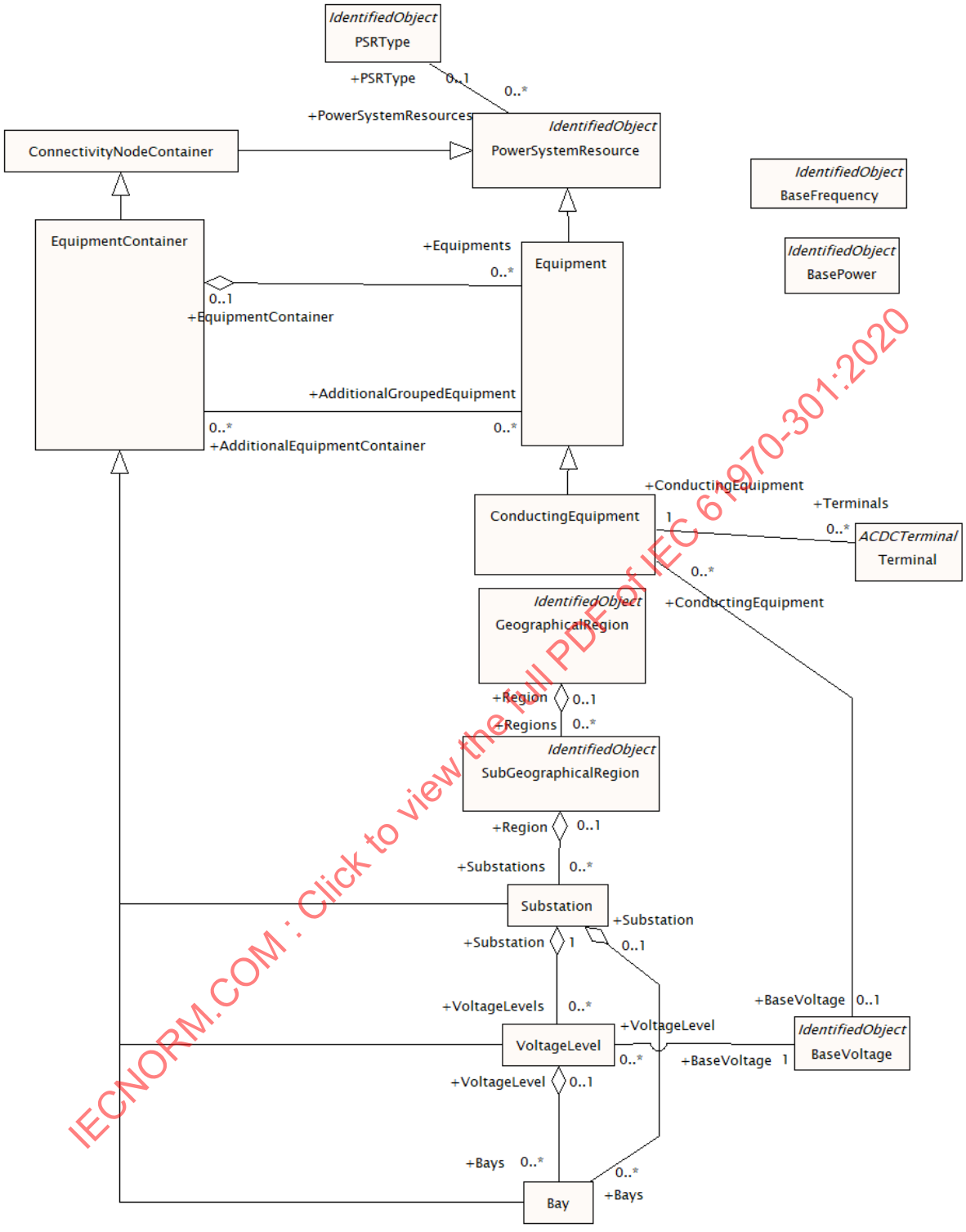
name	mult	type	description
value	0..1	Float	
unit	0..1	UnitSymbol	(const=m)
multiplier	0..1	UnitMultiplier	

6.3 Package Core

6.3.1 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 79 – Class diagram Core::Main

Figure 79: This diagram shows the main classes needed for any application of the CIM for modelling transmission and generation systems.

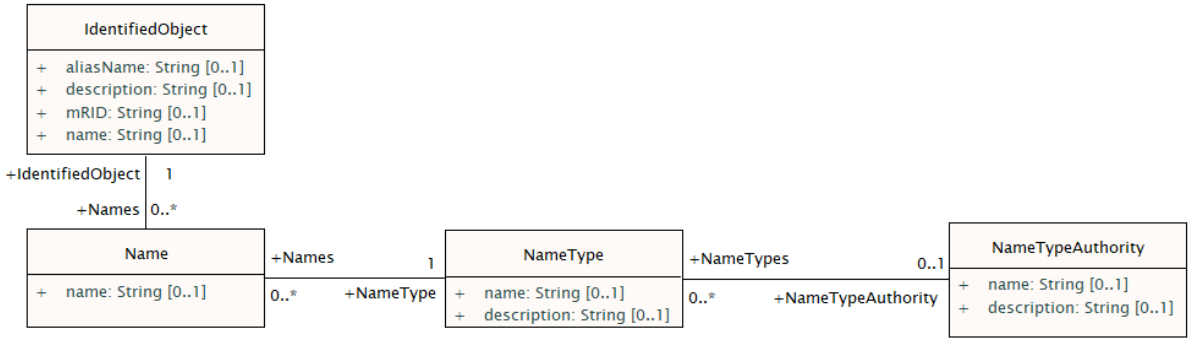
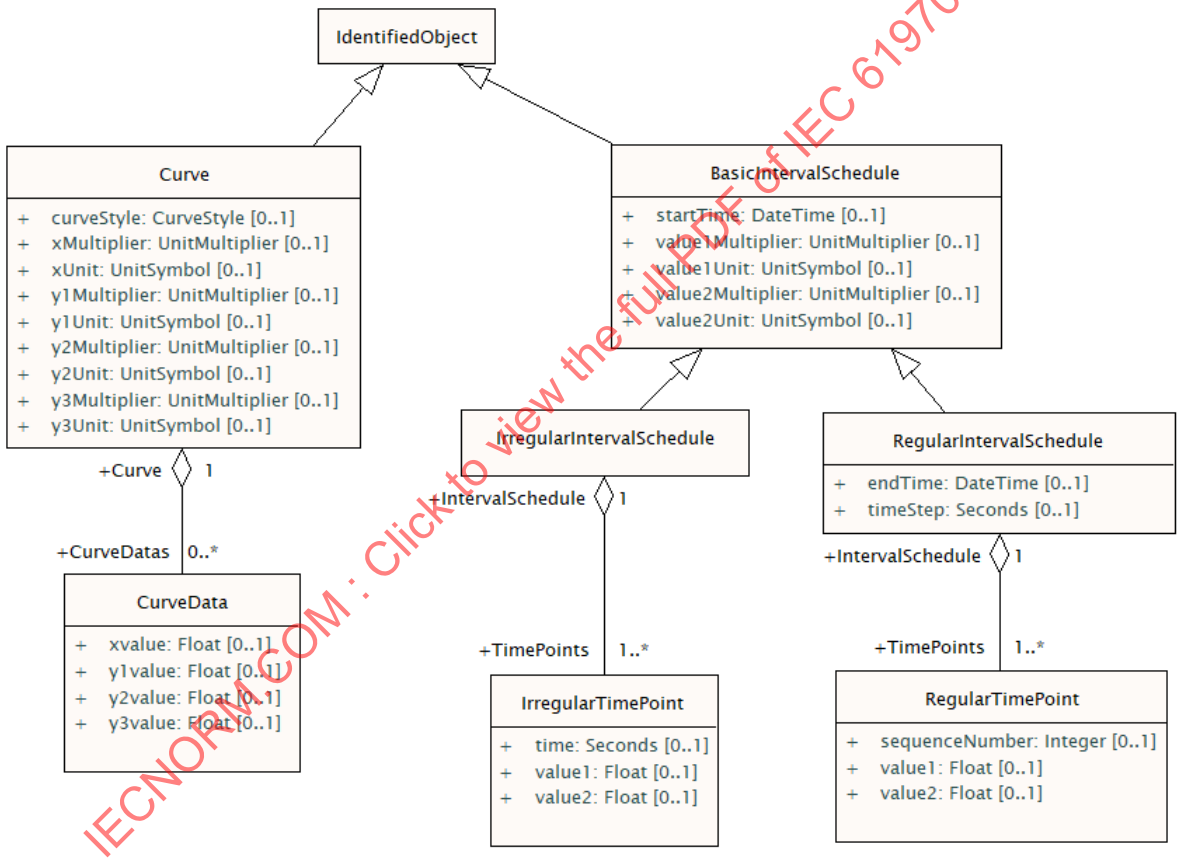


Figure 80 – Class diagram Core::Names

Figure 80: This diagram shows classes used to assign names to identified objects.



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Figure 81 – Class diagram Core::CurveSchedule

Figure 81: This diagram shows the common model for curves and time dependent schedules.

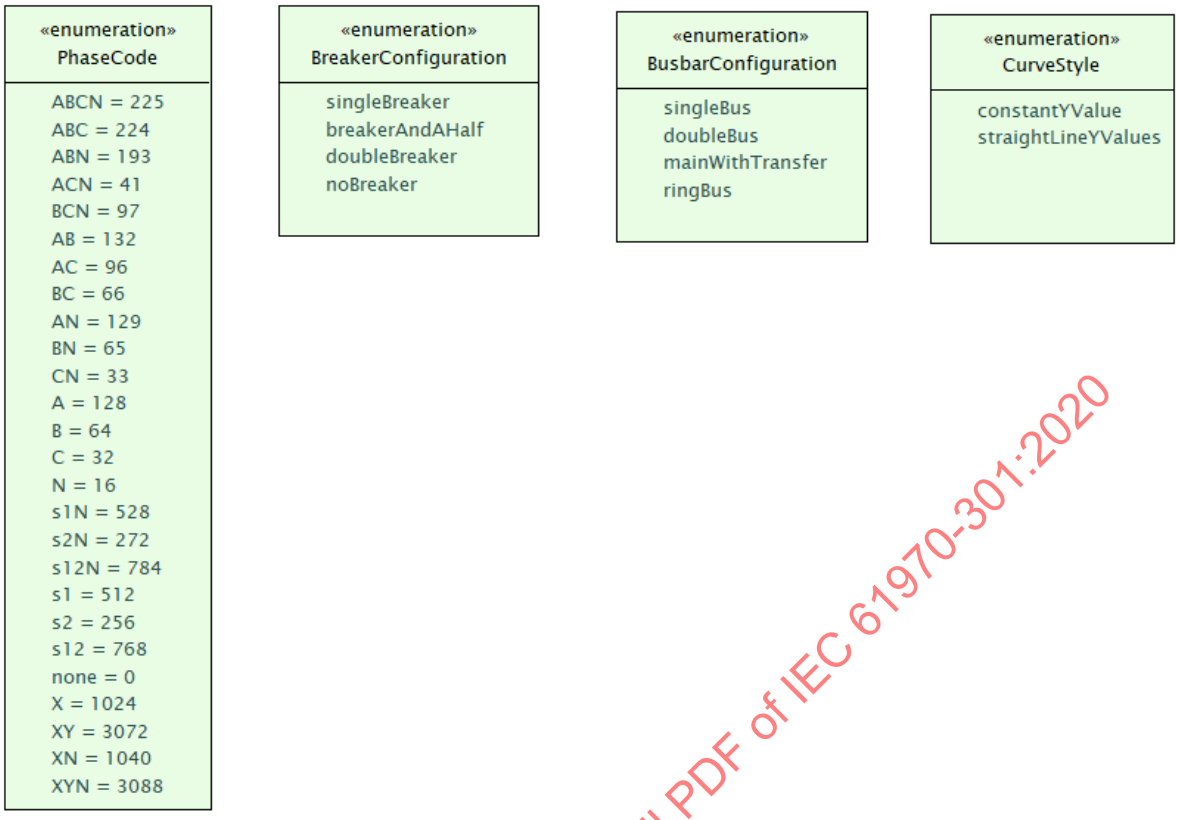


Figure 82 – Class diagram Core::Datatypes

Figure 82: This diagram shows the data types specific to the Core package.

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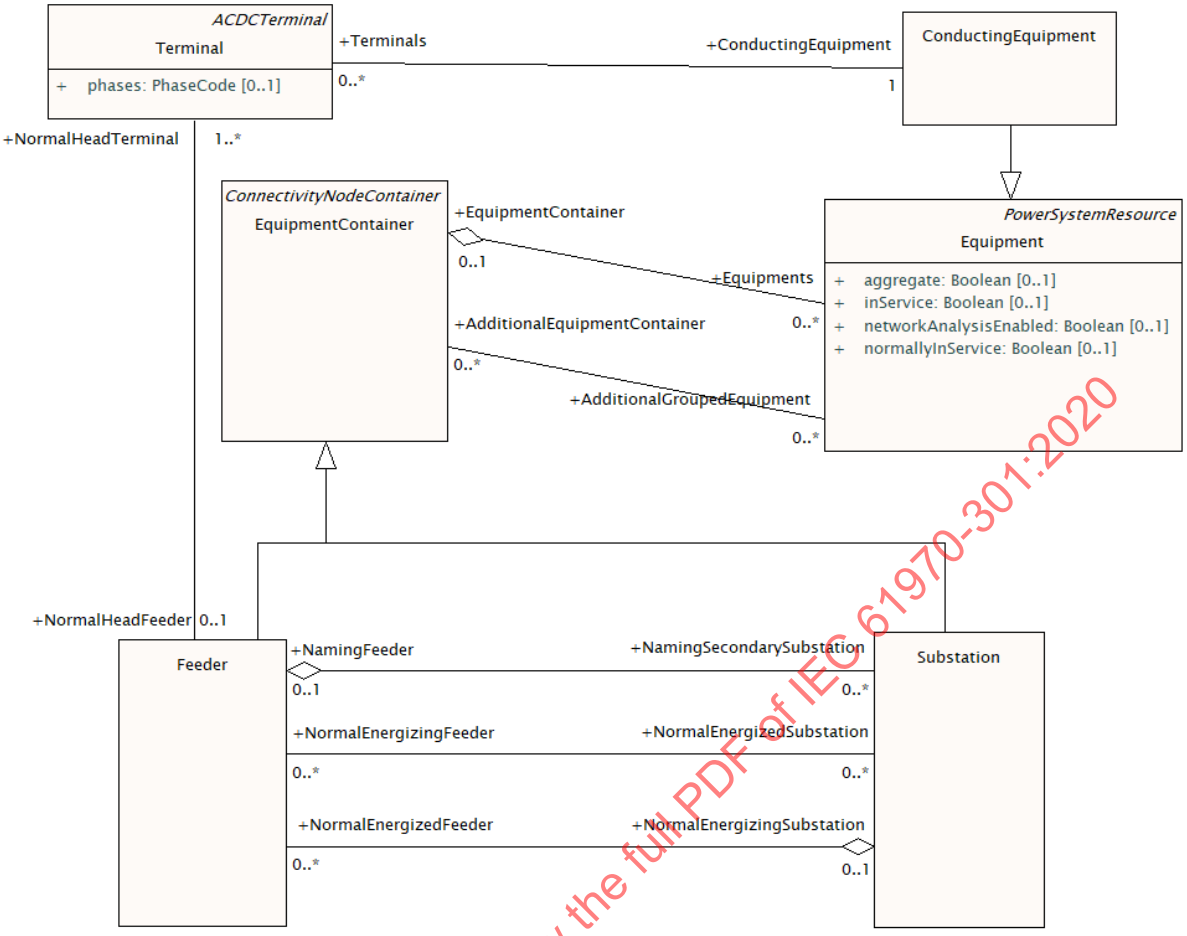


Figure 83 – Class diagram Core::FeederContainment

Figure 83: This diagram shows feeder containment.

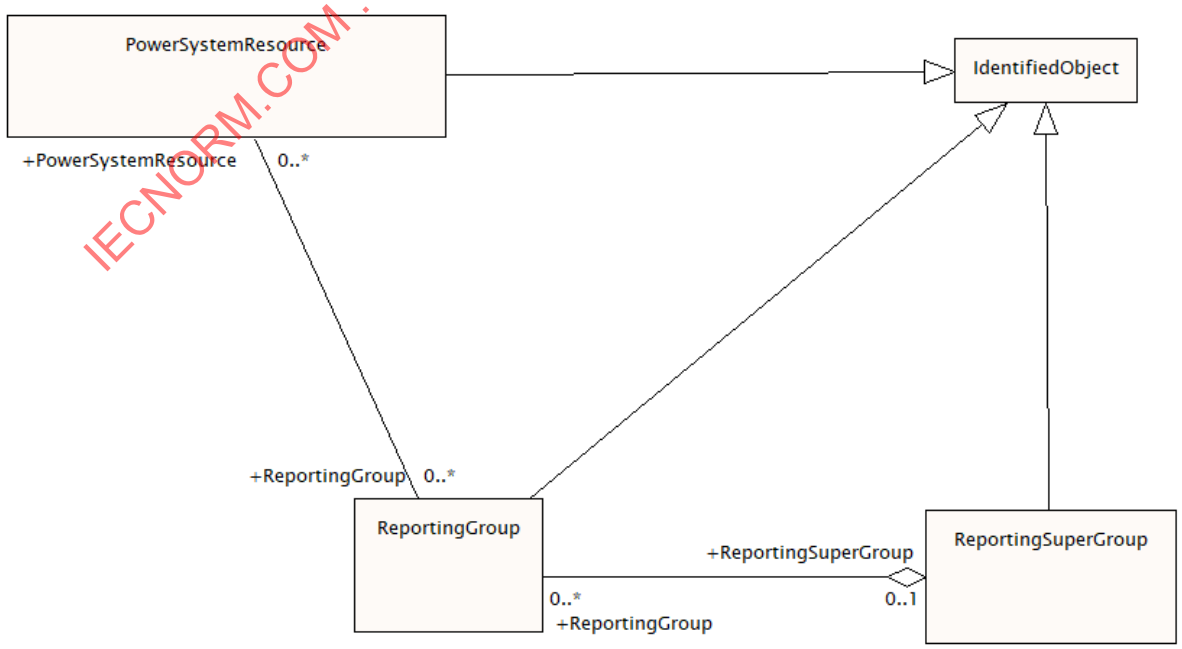


Figure 84 – Class diagram Core::Reporting

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Figure 84: This diagram shows the common model for ad-hoc reporting.

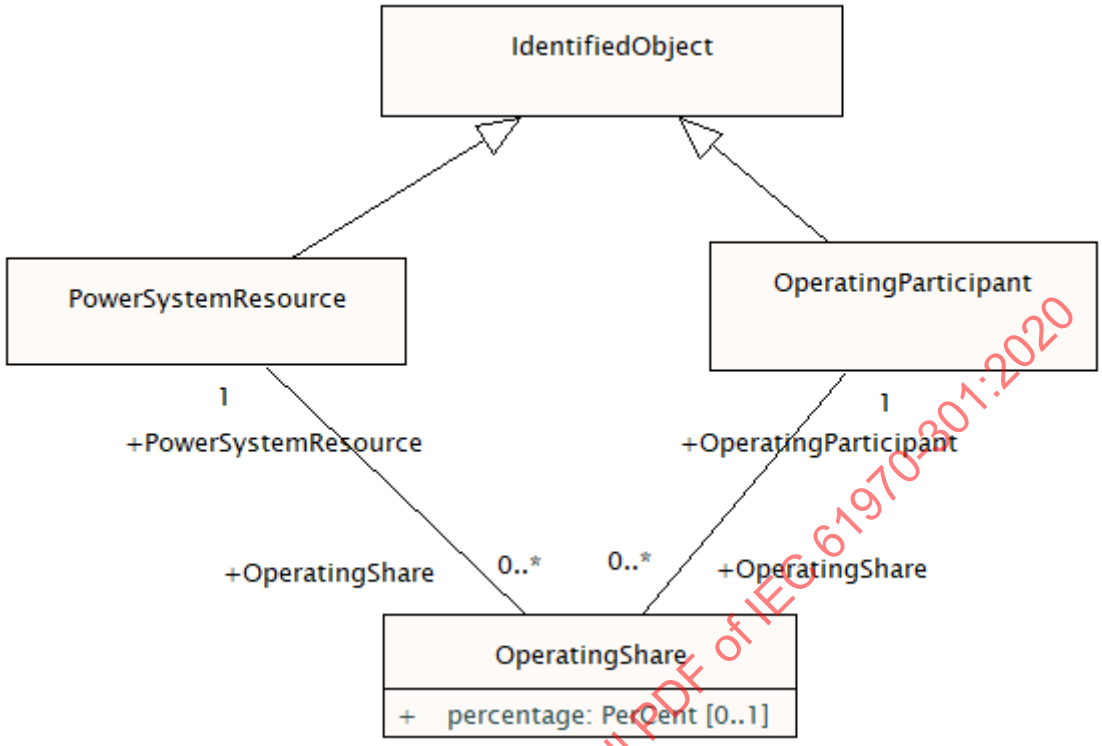


Figure 85 – Class diagram Core::OperatingShare

Figure 85: This diagram shows the common model for operating share.

6.3.2 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 75 shows all attributes of ACDCTerminal.

Table 75 – 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

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name	mult	type	description
			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

Table 76 shows all association ends of ACDCTerminal with other classes.

Table 76 – 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

6.3.3 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 its 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 77 shows all attributes of BaseFrequency.

Table 77 – 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 78 shows all association ends of BaseFrequency with other classes.

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Table 78 – 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

6.3.4 BasePower

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

Table 79 shows all attributes of BasePower.

Table 79 – 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 80 shows all association ends of BasePower with other classes.

Table 80 – 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

6.3.5 BaseVoltage

Defines a system base voltage which is referenced.

Table 81 shows all attributes of BaseVoltage.

Table 81 – Attributes of Core::BaseVoltage

name	mult	type	description
nominalVoltage	0..1	Voltage	The power system resource's base voltage. Shall be a positive value and not zero.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 82 shows all association ends of BaseVoltage with other classes.

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Table 82 – 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

6.3.6 BasicIntervalSchedule

Schedule of values at points in time.

Table 83 shows all attributes of BasicIntervalSchedule.

Table 83 – Attributes of Core::BasicIntervalSchedule

name	mult	type	description
startTime	0..1	DateTime	The time for the first time point. The value can be a time of day, not a specific date.
value1Multiplier	0..1	UnitMultiplier	Multiplier for value1.
value1Unit	0..1	UnitSymbol	Value1 units of measure.
value2Multiplier	0..1	UnitMultiplier	Multiplier for value2.
value2Unit	0..1	UnitSymbol	Value2 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 84 shows all association ends of BasicIntervalSchedule with other classes.

Table 84 – 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

6.3.7 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.

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Table 85 shows all attributes of Bay.

Table 85 – 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 86 shows all association ends of Bay with other classes.

Table 86 – 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
0..*	AdditionalGroupedEquipment	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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6.3.8 BreakerConfiguration enumeration

Switching arrangement for bay.

Table 87 shows all literals of BreakerConfiguration.

Table 87 – Literals of Core::BreakerConfiguration

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

6.3.9 BusbarConfiguration enumeration

Busbar layout for bay.

Table 88 shows all literals of BusbarConfiguration.

Table 88 – Literals of Core::BusbarConfiguration

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

6.3.10 ConductingEquipment

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

Table 89 shows all attributes of ConductingEquipment.

Table 89 – Attributes of Core::ConductingEquipment

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 90 shows all association ends of ConductingEquipment with other classes.

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Table 90 – 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..*	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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.3.11 ConnectivityNode

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

Table 91 shows all attributes of ConnectivityNode.

Table 91 – 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 92 shows all association ends of ConnectivityNode with other classes.

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Table 92 – 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 this connectivity node.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.3.12 ConnectivityNodeContainer

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

Table 93 shows all attributes of ConnectivityNodeContainer.

Table 93 – 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 94 shows all association ends of ConnectivityNodeContainer with other classes.

Table 94 – 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..*	ReportingGroup	0..*	ReportingGroup	inherited from: PowerSystemResource
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.3.13 Curve

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

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Table 95 shows all attributes of Curve.

Table 95 – 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 96 shows all association ends of Curve with other classes.

Table 96 – 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

6.3.14 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 97 shows all attributes of CurveData.

Table 97 – 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.

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Table 98 shows all association ends of CurveData with other classes.

Table 98 – 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.

6.3.15 CurveStyle enumeration

Style or shape of curve.

Table 99 shows all literals of CurveStyle.

Table 99 – 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.

6.3.16 Equipment

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

Table 100 shows all attributes of Equipment.

Table 100 – Attributes of Core::Equipment

name	mult	type	description
aggregate	0..1	Boolean	The aggregate flag provides an alternative way of representing an aggregated (equivalent) element. It is applicable in cases when the dedicated classes for equivalent equipment do not have all of the attributes necessary to represent the required level of detail. In case the flag is set to “true” the single instance of equipment represents multiple pieces of equipment that have been modelled together as an aggregate equivalent obtained by a network reduction procedure. Examples would be power transformers or synchronous machines operating in parallel modelled as a single aggregate power transformer or aggregate synchronous machine. The attribute is not used for EquivalentBranch, EquivalentShunt and EquivalentInjection.
inService	0..1	Boolean	Specifies the availability of the equipment. True means the equipment is available for topology processing, which determines if the equipment is energized or not. False means that the equipment is treated by network applications as if it is not in the model.
networkAnalysisEnabled	0..1	Boolean	The equipment is enabled to participate in network analysis. If unspecified, the value is assumed to be true.

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name	mult	type	description
normallyInService	0..1	Boolean	Specifies the availability of the equipment under normal operating conditions. True means the equipment is available for topology processing, which determines if the equipment is energized or not. False means that the equipment is treated by network applications as if it is not in the model.
aliasName	0..1	String	inherited 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 Equipment with other classes.

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

mult from	name	mult to	type	description
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..1	Faults	0..*	Fault	All faults on this equipment.
0..*	AdditionalEquipmentContainer	0..*	EquipmentContainer	Additional equipment container beyond the primary equipment container. The equipment is contained in another equipment container, but also grouped with this equipment 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..*	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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6.3.17 EquipmentContainer

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

Table 102 shows all attributes of EquipmentContainer.

Table 102 – 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 103 shows all association ends of EquipmentContainer with other classes.

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

mult from	name	mult to	type	description
0..1	Equipments	0..*	Equipment	Contained equipment.
0..*	AdditionalGroupedEquipment	0..*	Equipment	The additonal contained equipment. The equipment belong to the equipment container. The equipment is contained in another equipment container, but also grouped with this equipment container. Examples include when a switch contained in a substation is also desired to be grouped with a line container or when a switch is included in a secondary substation and also grouped in a feeder.
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

6.3.18 Feeder

A collection of equipment for organizational purposes, used for grouping distribution resources.

The organization a feeder does not necessarily reflect connectivity or current operation state.

Table 104 shows all attributes of Feeder.

Table 104 – Attributes of Core::Feeder

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 105 shows all association ends of Feeder with other classes.

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

mult from	name	mult to	type	description
0..*	NormalEnergizingSubstation	0..1	Substation	The substation that nominally energizes the feeder. Also used for naming purposes.
0..1	NamingSecondarySubstation	0..*	Substation	The secondary substations that are normally energized from the feeder. Used for naming purposes. Should be consistent with the other associations for energizing terminal specification and the feeder energization specification.
0..1	NormalHeadTerminal	1..*	Terminal	The normal head terminal or terminals of the feeder.
0..*	NormalEnergizedSubstation	0..*	Substation	The substations that are normally energized by the feeder.
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
0..*	AdditionalGroupedEquipment	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

6.3.19 GeographicalRegion

A geographical region of a power system network model.

Table 106 shows all attributes of GeographicalRegion.

Table 106 – 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 107 shows all association ends of GeographicalRegion with other classes.

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Table 107 – 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

6.3.20 IdentifiedObject root class

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

Table 108 shows all attributes of IdentifiedObject.

Table 108 – 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 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, 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.

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Table 109 shows all association ends of IdentifiedObject with other classes.

Table 109 – 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.

6.3.21 IrregularIntervalSchedule

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

Table 110 shows all attributes of IrregularIntervalSchedule.

Table 110 – Attributes of Core::IrregularIntervalSchedule

name	mult	type	description
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	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 111 shows all association ends of IrregularIntervalSchedule with other classes.

Table 111 – 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

6.3.22 IrregularTimePoint root class

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

Table 112 shows all attributes of IrregularTimePoint.

Table 112 – 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 113 shows all association ends of IrregularTimePoint with other classes.

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Table 113 – 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.

6.3.23 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 114 shows all attributes of Name.

Table 114 – Attributes of Core::Name

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

Table 115 shows all association ends of Name with other classes.

Table 115 – 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.

6.3.24 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 116 shows all attributes of NameType.

Table 116 – 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 117 shows all association ends of NameType with other classes.

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Table 117 – 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.

6.3.25 NameTypeAuthority root class

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

Table 118 shows all attributes of NameTypeAuthority.

Table 118 – 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 119 shows all association ends of NameTypeAuthority with other classes.

Table 119 – 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.

6.3.26 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 120 shows all attributes of OperatingParticipant.

Table 120 – 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 121 shows all association ends of OperatingParticipant with other classes.

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Table 121 – 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

6.3.27 OperatingShare root class

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

Table 122 shows all attributes of OperatingShare.

Table 122 – 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 123 shows all association ends of OperatingShare with other classes.

Table 123 – 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.

6.3.28 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 document, i.e. provide customisation that is non standard.

Table 124 shows all attributes of PSRType.

Table 124 – 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 125 shows all association ends of PSRType with other classes.

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Table 125 – 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

6.3.29 PhaseCode enumeration

An unordered enumeration of phase identifiers. Allows designation of phases for both transmission and distribution equipment, circuits and loads. The enumeration, by itself, does not describe how the phases are connected together or connected to ground. Ground is not explicitly denoted as a phase.

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.

The integer values are from IEC 61968-9 to support revenue metering applications.

Table 126 shows all literals of PhaseCode.

Table 126 – Literals of Core::PhaseCode

literal	value	description
ABCN	225	Phases A, B, C, and N.
ABC	224	Phases A, B, and C.
ABN	193	Phases A, B, and neutral.
ACN	41	Phases A, C and neutral.
BCN	97	Phases B, C, and neutral.
AB	132	Phases A and B.
AC	96	Phases A and C.
BC	66	Phases B and C.
AN	129	Phases A and neutral.
BN	65	Phases B and neutral.
CN	33	Phases C and neutral.
A	128	Phase A.
B	64	Phase B.
C	32	Phase C.
N	16	Neutral phase.
s1N	528	Secondary phase 1 and neutral.
s2N	272	Secondary phase 2 and neutral.
s12N	784	Secondary phases 1, 2, and neutral.
s1	512	Secondary phase 1.
s2	256	Secondary phase 2.
s12	768	Secondary phase 1 and 2.

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literal	value	description
none	0	No phases specified.
X	1024	Unknown non-neutral phase.
XY	3072	Two unknown non-neutral phases.
XN	1040	Unknown non-neutral phase plus neutral.
XYN	3088	Two unknown non-neutral phases plus neutral.

6.3.30 PowerSystemResource

A power system resource (PSR) 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 organisational entity such as sub-control area. Power system resources can have measurements associated.

Table 127 shows all attributes of PowerSystemResource.

Table 127 – 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 128 shows all association ends of PowerSystemResource with other classes.

Table 128 – 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

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6.3.31 RegularIntervalSchedule

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

Table 129 shows all attributes of RegularIntervalSchedule.

Table 129 – Attributes of Core::RegularIntervalSchedule

name	mult	type	description
endTime	0..1	DateTime	The time for the last time point. The value can be a time of day, not a specific date.
timeStep	0..1	Seconds	The time between each pair of subsequent regular time points in sequence order.
startTime	0..1	DateTime	inherited from: BasicIntervalSchedule
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	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 130 shows all association ends of RegularIntervalSchedule with other classes.

Table 130 – 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

6.3.32 RegularTimePoint root class

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

Table 131 shows all attributes of RegularTimePoint.

Table 131 – 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 schedules start time. To specify values for the start time, use sequence number 0. The sequence number cannot be negative.
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.

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Table 132 shows all association ends of RegularTimePoint with other classes.

Table 132 – 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.

6.3.33 ReportingGroup

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

Table 133 shows all attributes of ReportingGroup.

Table 133 – Attributes of Core::ReportingGroup

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 134 shows all association ends of ReportingGroup with other classes.

Table 134 – Association ends of Core::ReportingGroup with other classes

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

6.3.34 ReportingSuperGroup

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

Table 135 shows all attributes of ReportingSuperGroup.

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Table 135 – 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 136 shows all association ends of ReportingSuperGroup with other classes.

Table 136 – 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

6.3.35 SubGeographicalRegion

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

Table 137 shows all attributes of SubGeographicalRegion.

Table 137 – 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 138 shows all association ends of SubGeographicalRegion with other classes.

Table 138 – 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

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6.3.36 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 139 shows all attributes of Substation.

Table 139 – 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 140 shows all association ends of Substation with other classes.

Table 140 – 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..1	NormalEnergizedFeeder	0..*	Feeder	The normal energized feeders of the substation. Also used for naming purposes.
0..*	NamingFeeder	0..1	Feeder	The primary feeder that normally energizes the secondary substation. Used for naming purposes. Either this association or the substation to subgeographical region should be used for hierarchical containment specification.
0..*	NormalEnergizingFeeder	0..*	Feeder	The feeders that potentially energize the downstream substation. Should be consistent with the associations that describe the naming hierarchy.
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
0..*	AdditionalGroupedEquipment	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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6.3.37 Terminal

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

Table 141 shows all attributes of Terminal.

Table 141 – 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) shall be assumed, except for terminals of grounding classes (specializations of EarthFaultCompensator, GroundDisconnector, GroundSwitch, and Ground) which will be assumed to be N. Therefore, phase code ABCN is explicitly declared when needed, e.g. for star point grounding equipment. The phase code on terminals connecting same ConnectivityNode or same TopologicalNode as well as for equipment between two terminals shall be consistent.
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 142 shows all association ends of Terminal with other classes.

Table 142 – 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 unnecessary 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.
1..*	NormalHeadFeeder	0..1	Feeder	The feeder that this terminal normally feeds. Only specified for the terminals at head of feeders.
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.

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mult from	name	mult to	type	description
1..1	BranchGroupTerminal	0..*	BranchGroupTerminal	The directed branch group terminals for which this terminal is monitored.
1..1	SvPowerFlow	0..*	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	EquipmentFaults	0..*	EquipmentFault	The equipment faults at this terminal.
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

6.3.38 VoltageLevel

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

Table 143 shows all attributes of VoltageLevel.

Table 143 – Attributes of Core::VoltageLevel

name	mult	type	description
highVoltageLimit	0..1	Voltage	The bus bar's high voltage limit. The limit applies to all equipment and nodes contained in a given VoltageLevel. It is not required that it is exchanged in pair with lowVoltageLimit. It is preferable to use operational VoltageLimit, which prevails, if present.
lowVoltageLimit	0..1	Voltage	The bus bar's low voltage limit. The limit applies to all equipment and nodes contained in a given VoltageLevel. It is not required that it is exchanged in pair with highVoltageLimit. It is preferable to use operational VoltageLimit, which prevails, if present.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 144 shows all association ends of VoltageLevel with other classes.

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Table 144 – 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
0..*	AdditionalGroupedEquipment	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

6.4 Package Wires

6.4.1 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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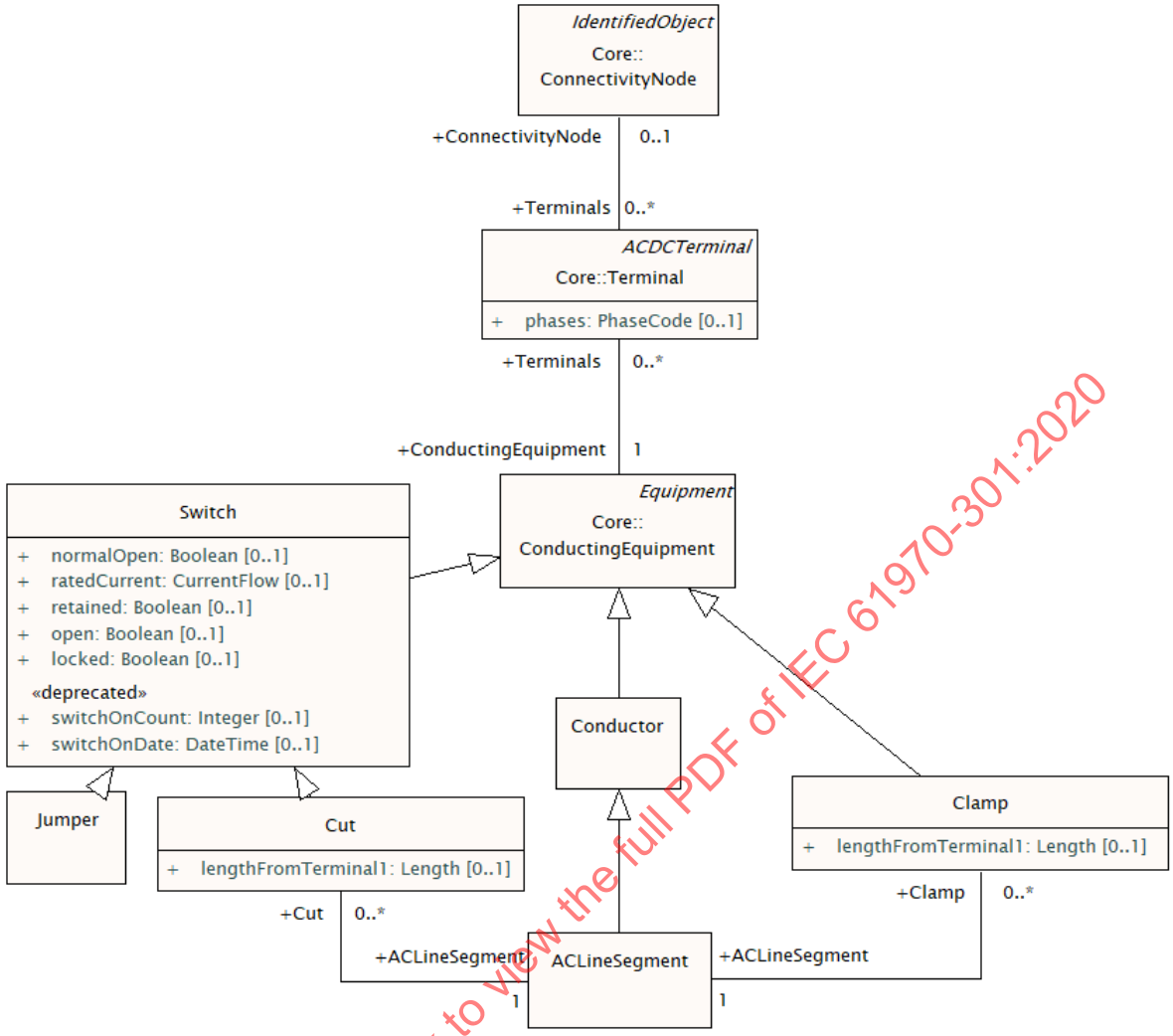


Figure 86 – Class diagram Wires::CutsAndJumpers

Figure 86: The diagram show the cuts and jumpers data model.

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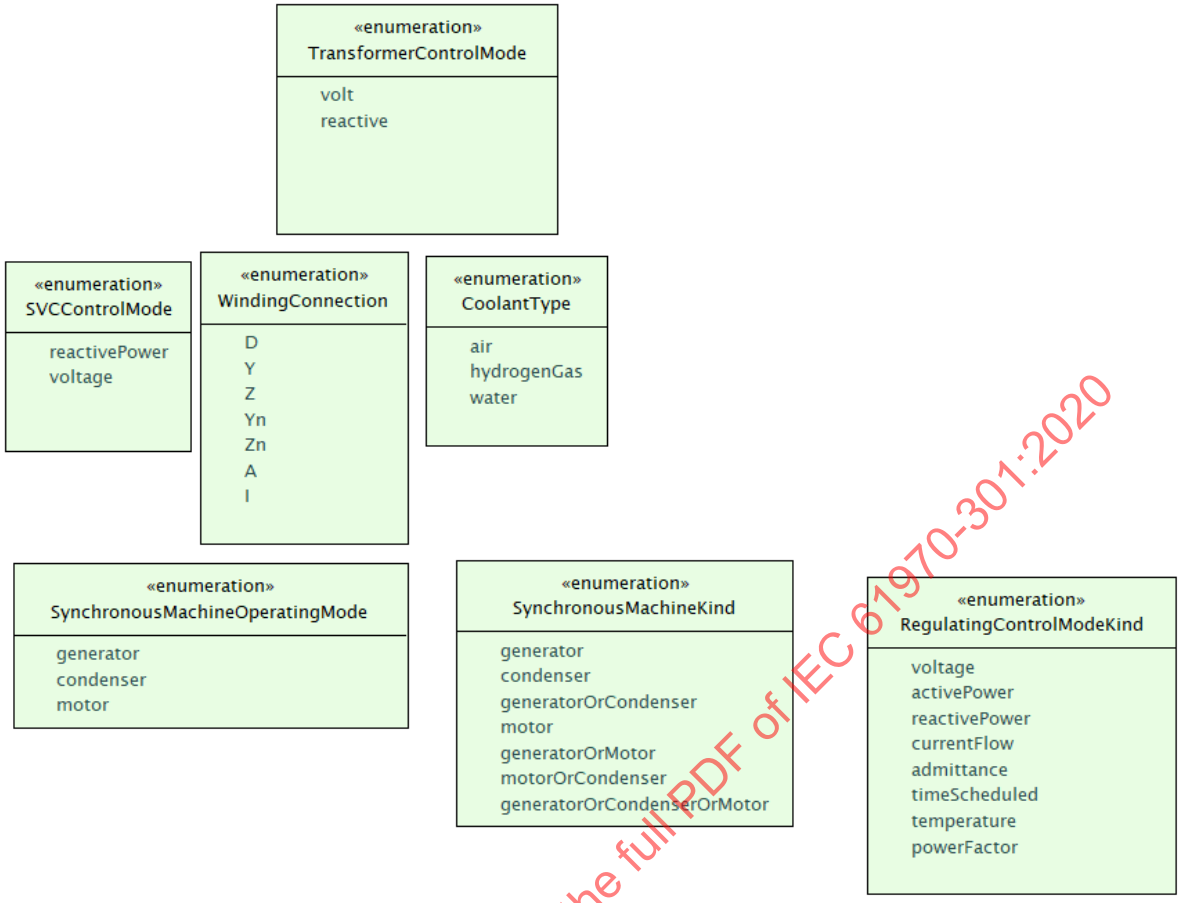


Figure 87 – Class diagram Wires::Datatypes

Figure 87: This diagram shows the data types specific to the Wires package.

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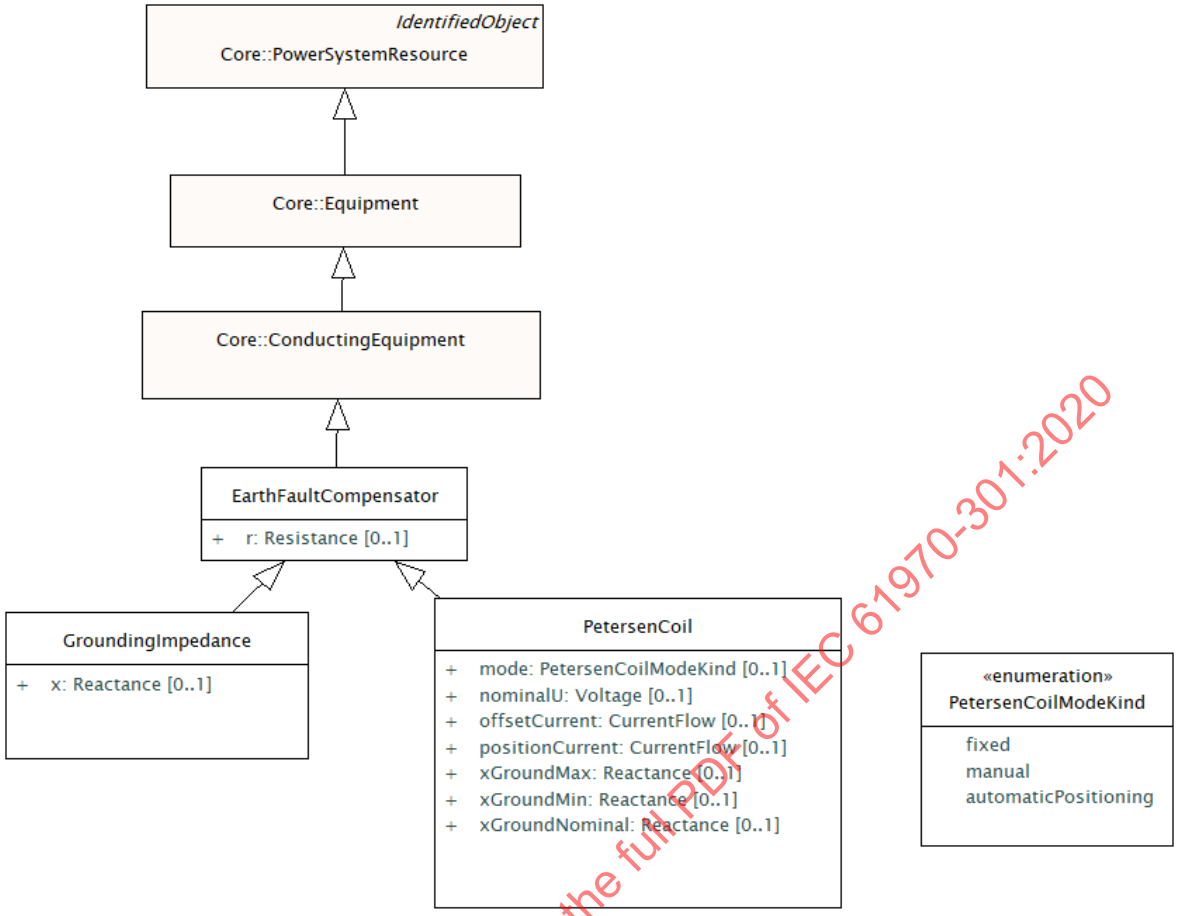
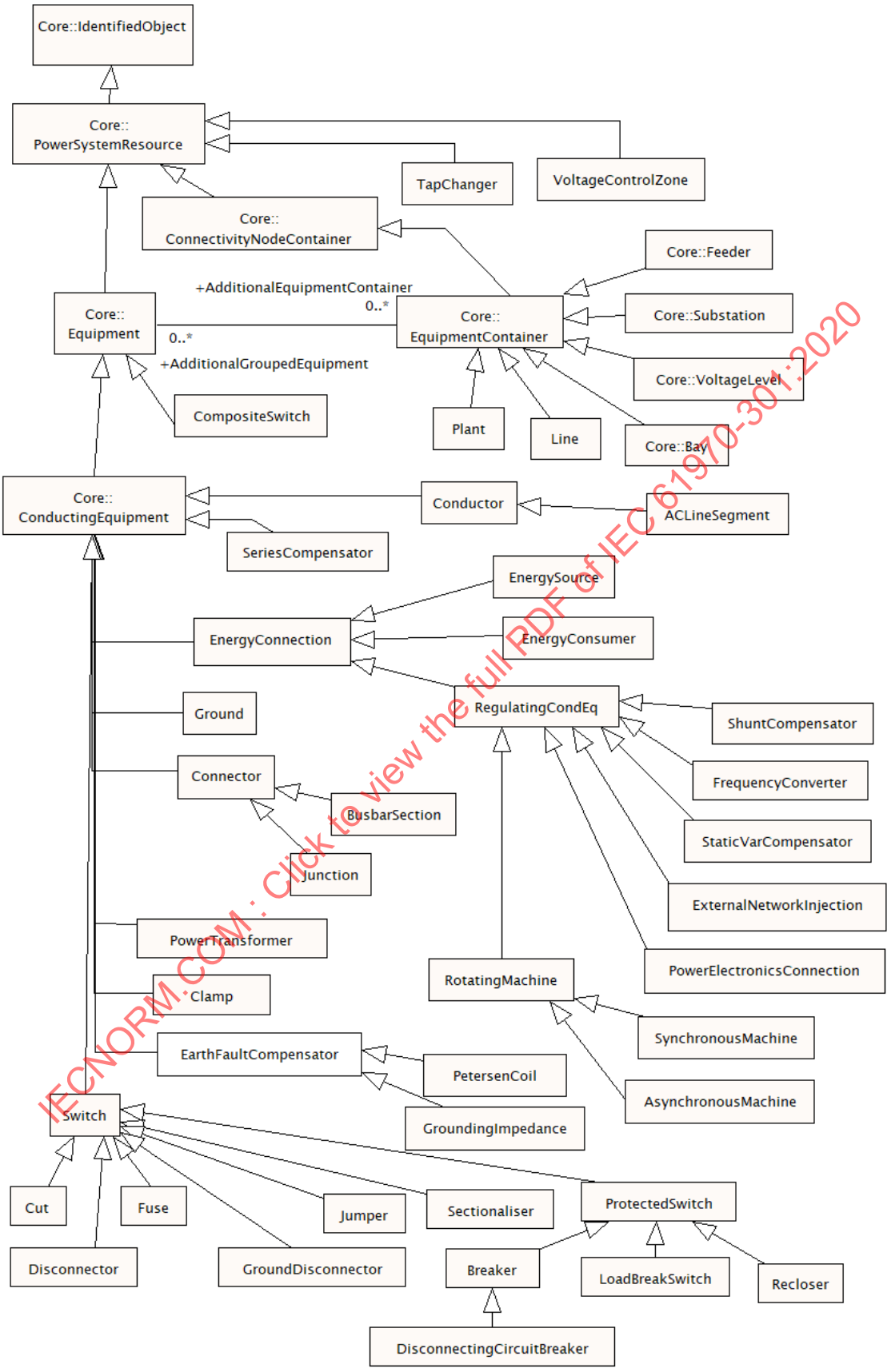


Figure 88 – Class diagram Wires::EarthFaultCompensator

Figure 88: Shows earth fault compensating devices.

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Figure 89 – Class diagram Wires::InheritanceHierarchy

Figure 89: This diagram describes inheritance between classes in and related to the Wires package.

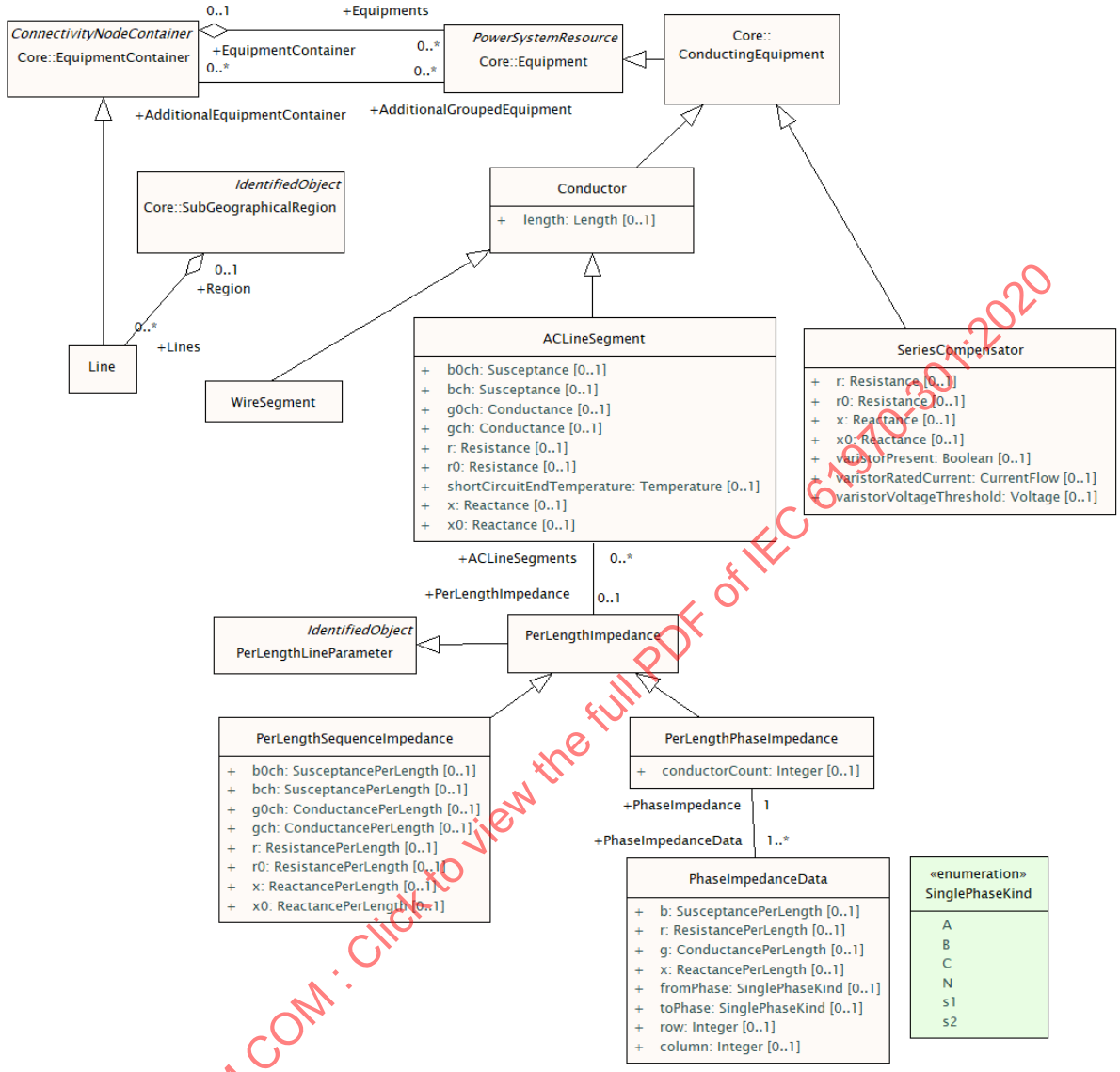


Figure 90 – Class diagram Wires::LineModel

Figure 90: This diagram shows all classes related to the transmission line model.

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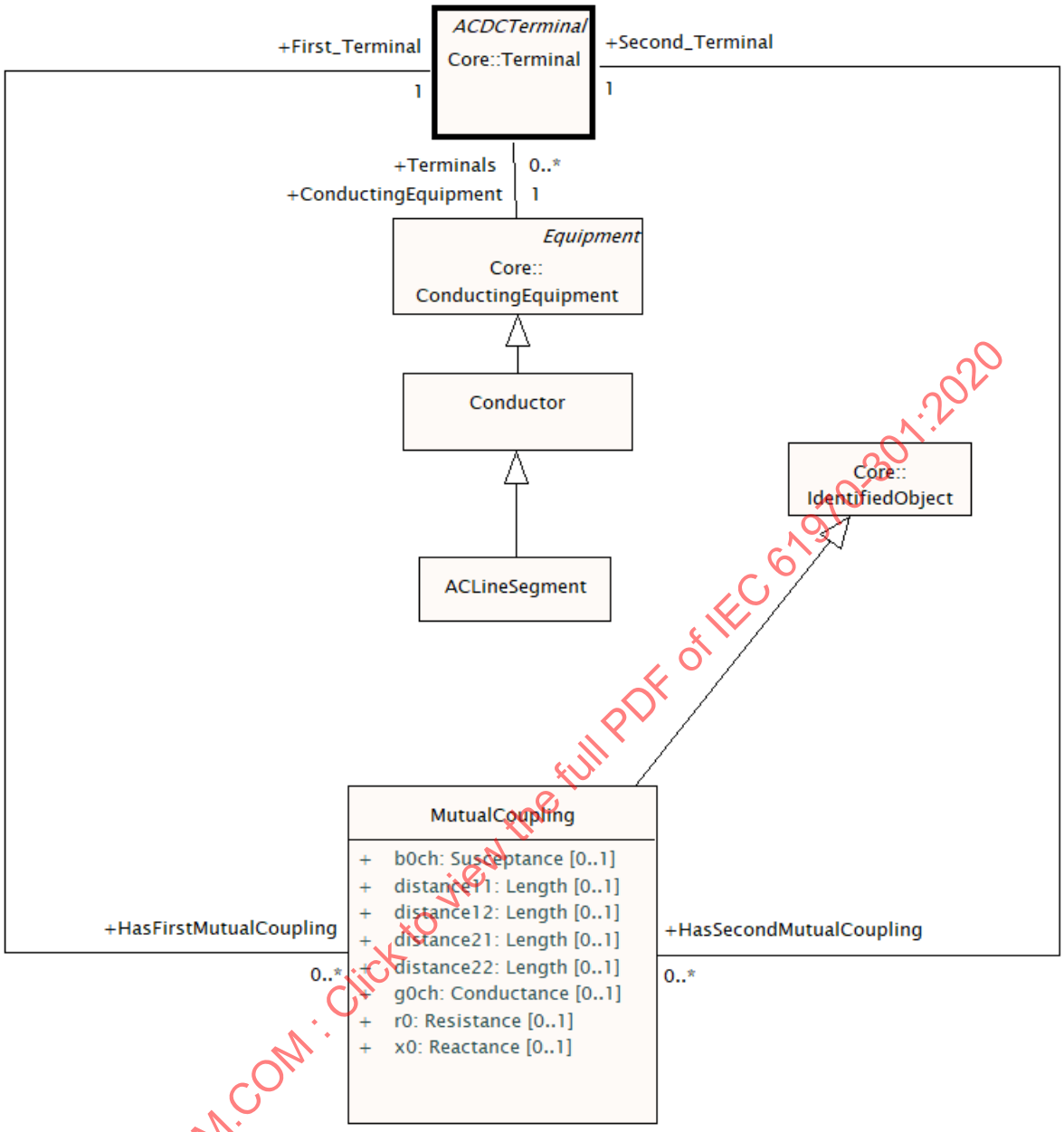
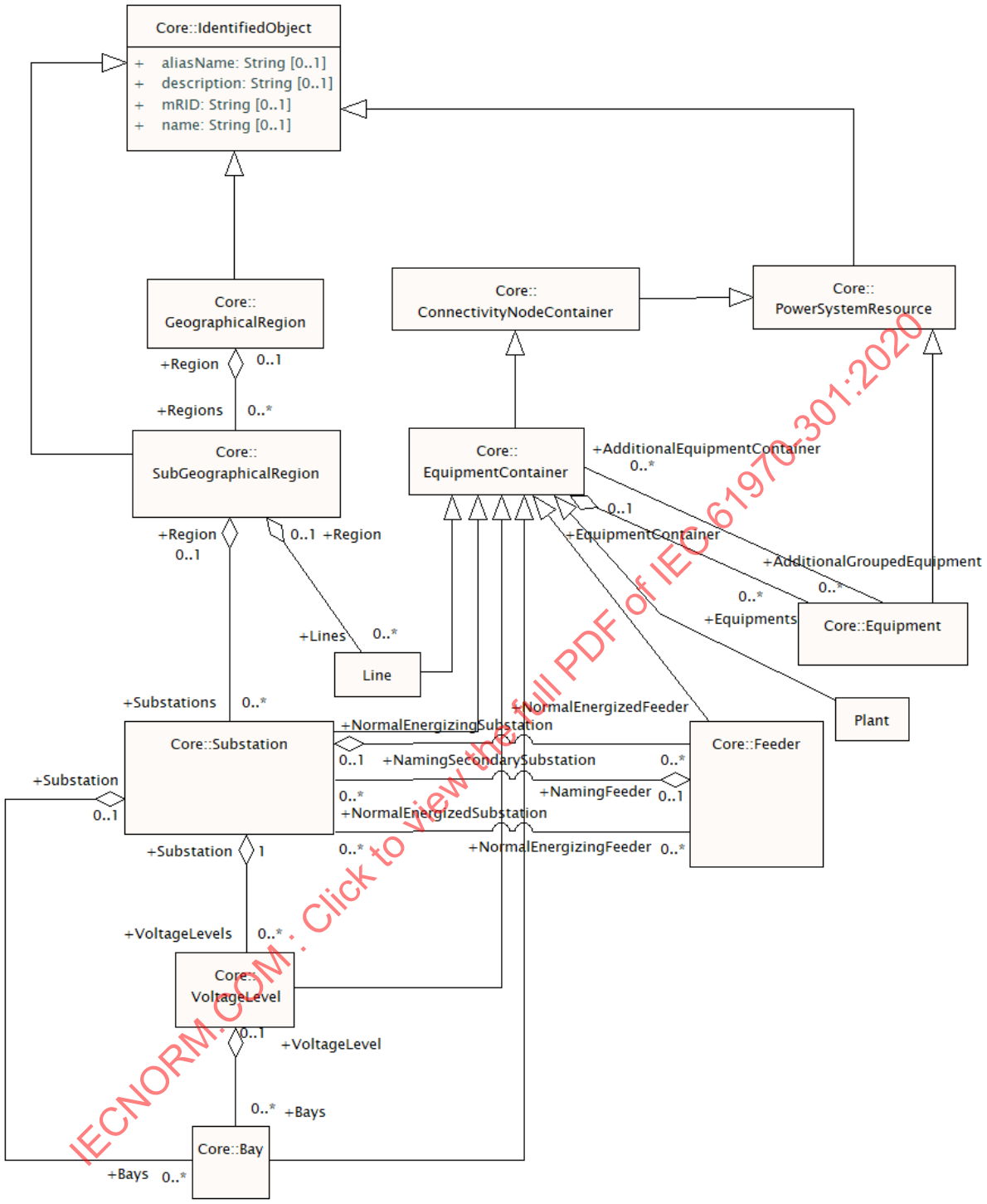


Figure 91 – Class diagram Wires::MutualCoupling

Figure 91: Shows mutual coupling models.

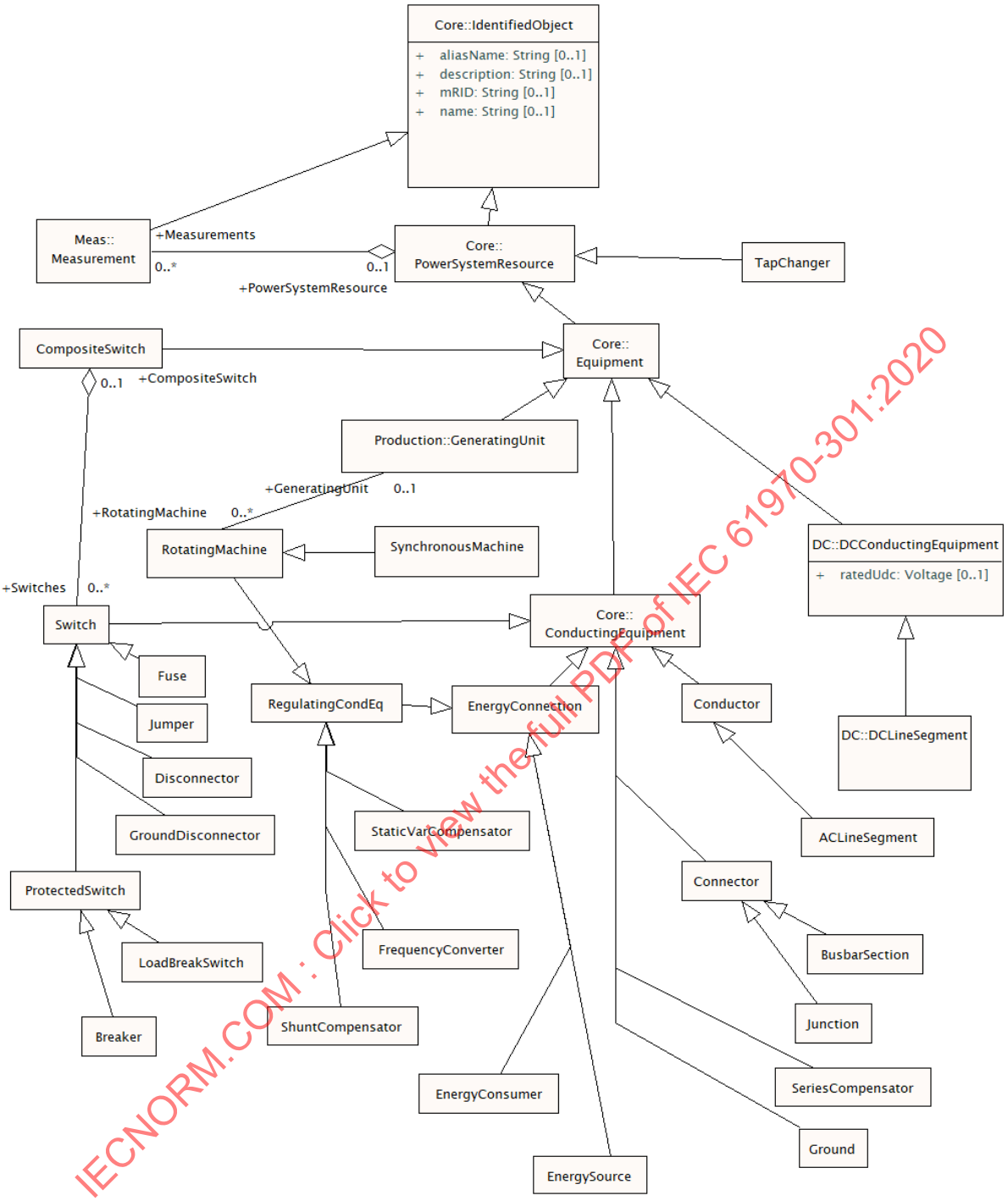
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Figure 92 – Class diagram Wires::NamingHierarchyPart1

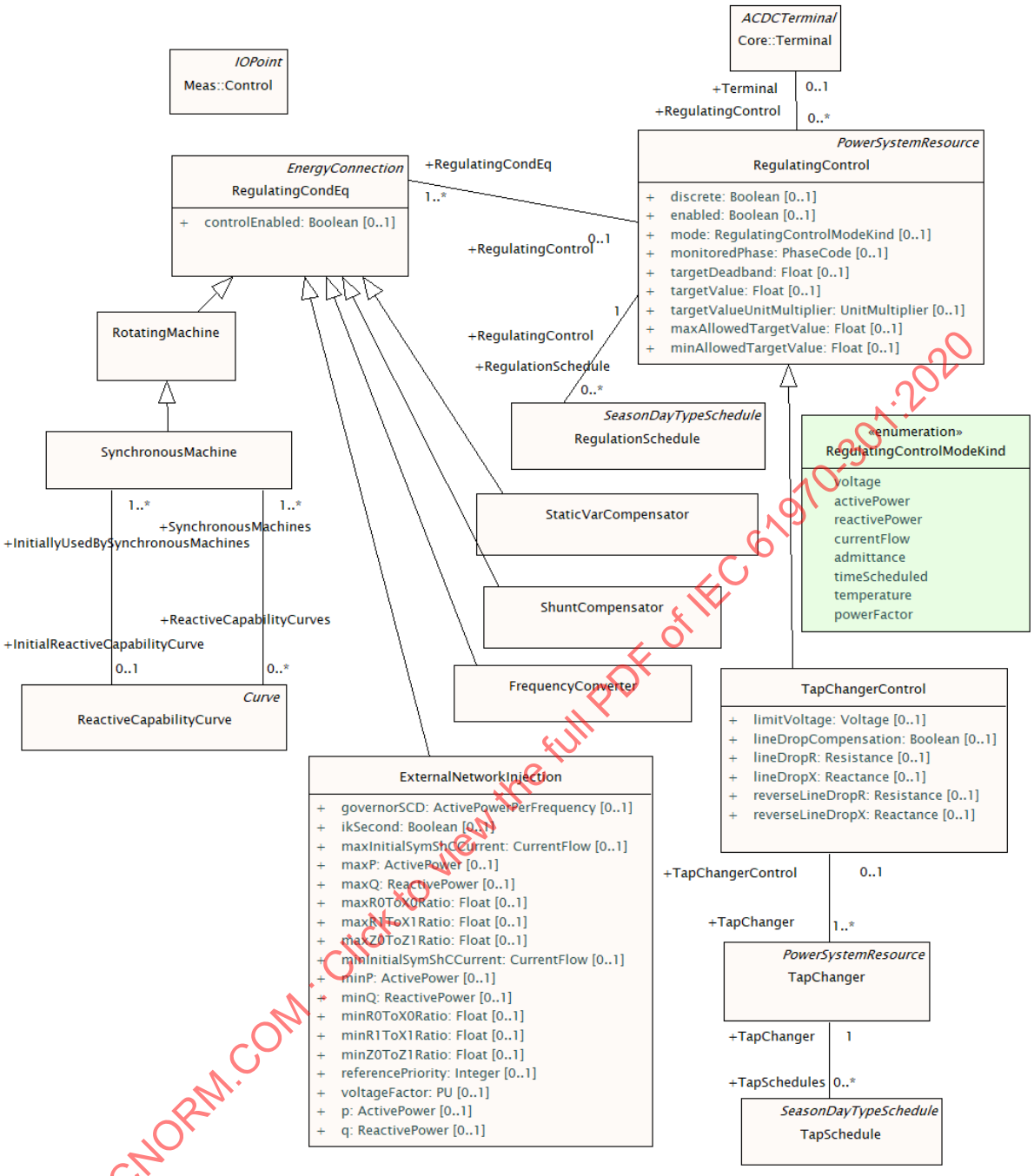
Figure 92: The diagram shows the upper part of the naming hierarchy. The hierarchy is a way to organize and name equipment. Hence it is tightly related to the IdentifiedObject and its attributes. The Equipment class is further specialized into many subtypes that are all contained by subclasses of the EquipmentContainer.



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Figure 93 – Class diagram Wires::NamingHierarchyPart2

Figure 93: 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 part 1 of the diagram.



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Figure 94 – Class diagram Wires::RegulatingEquipment

Figure 94: The diagram shows all classes related to equipment regulation and reactive power compensation.

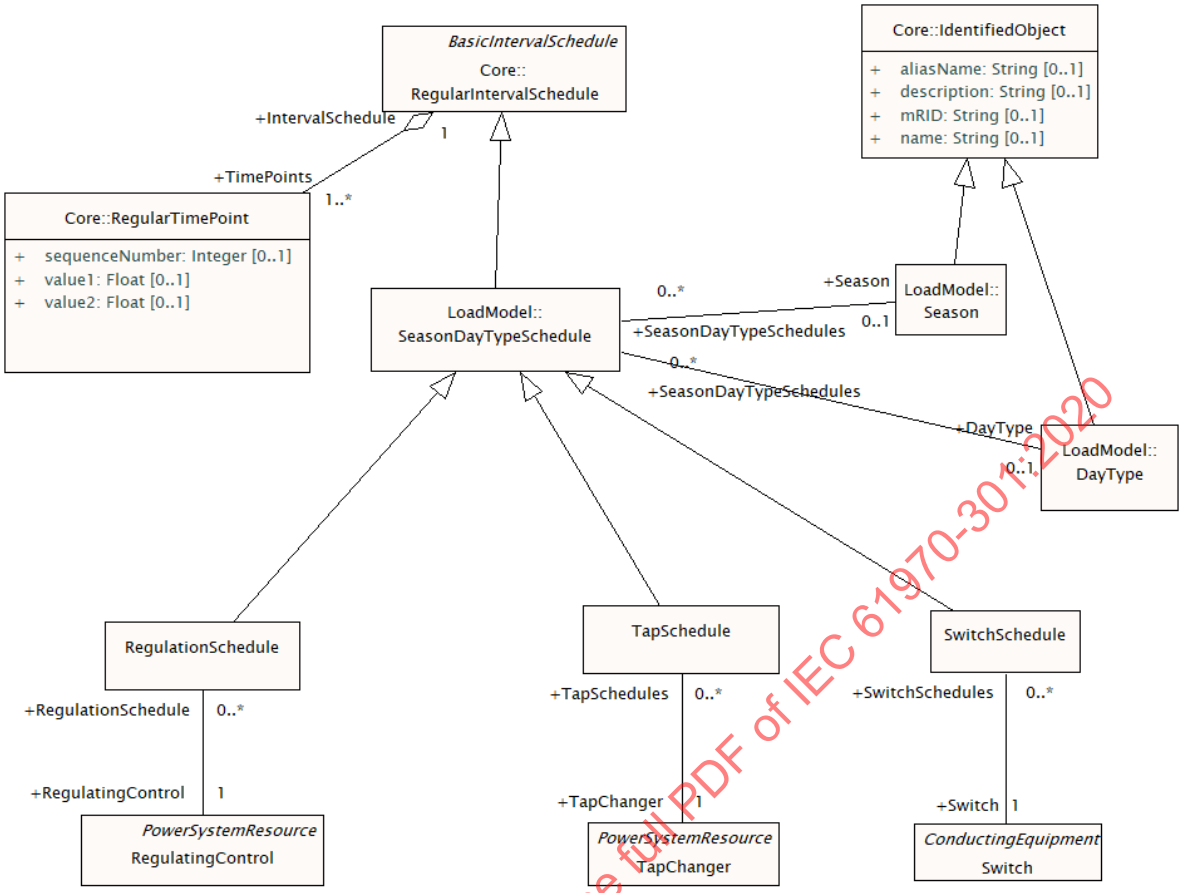


Figure 95 – Class diagram Wires::Schedules

Figure 95: Shows schedules of wires model.

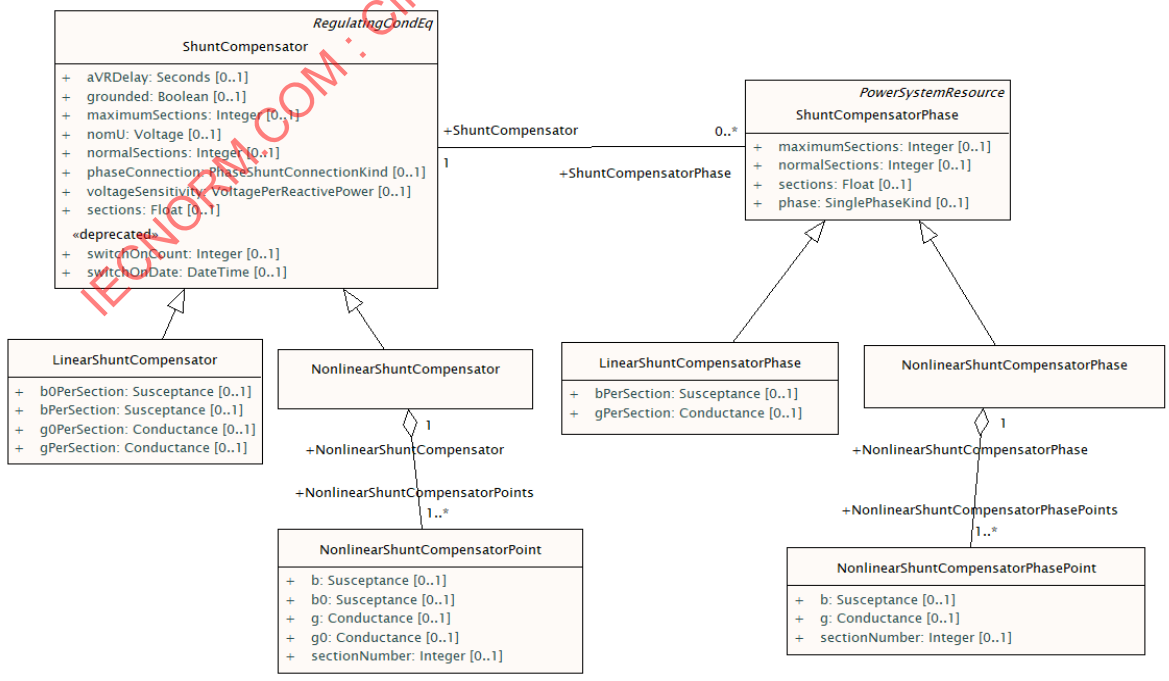


Figure 96 – Class diagram Wires::ShuntCompensator

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Figure 96: Shows shunt compensator inheritance structure.

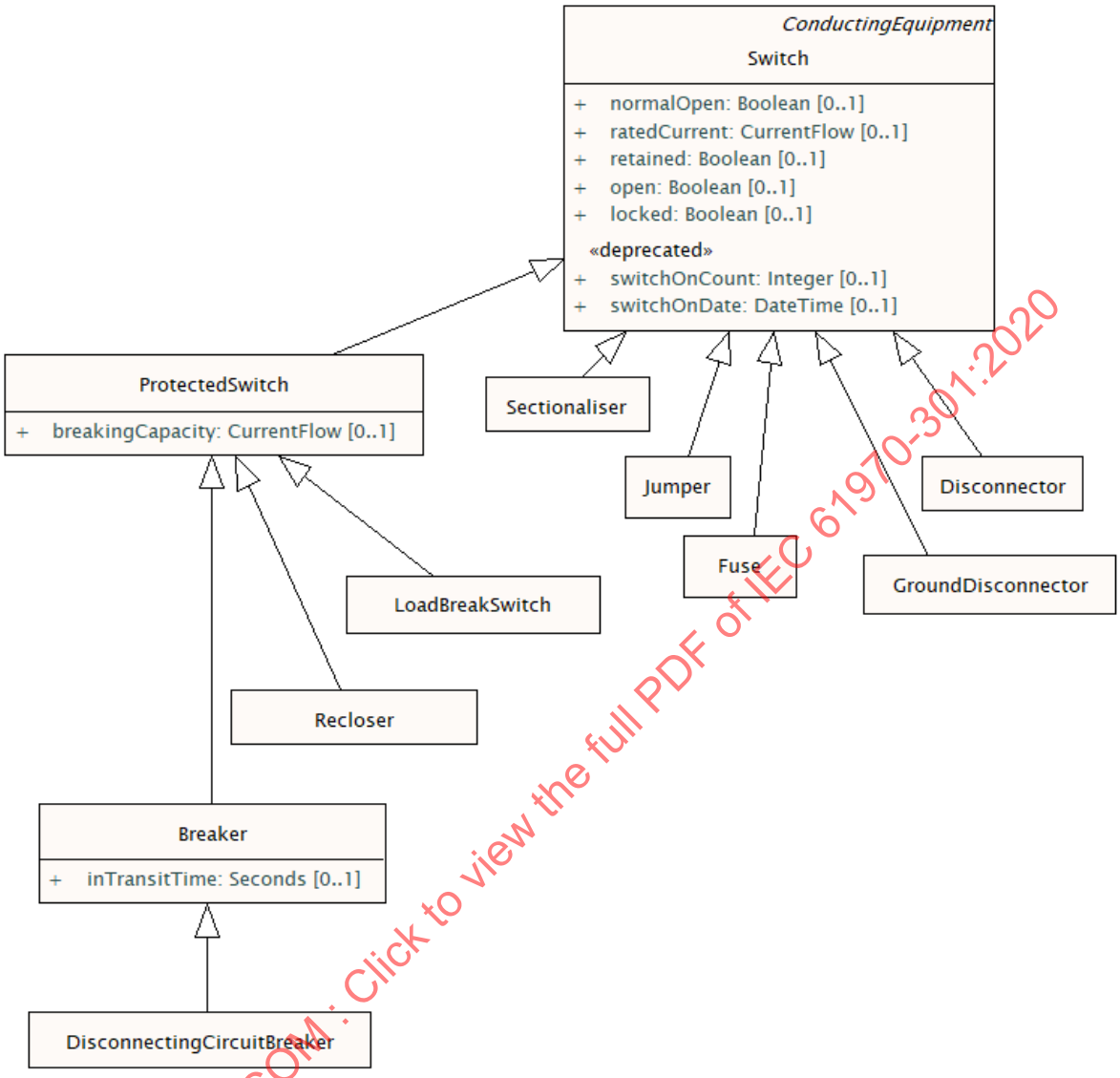
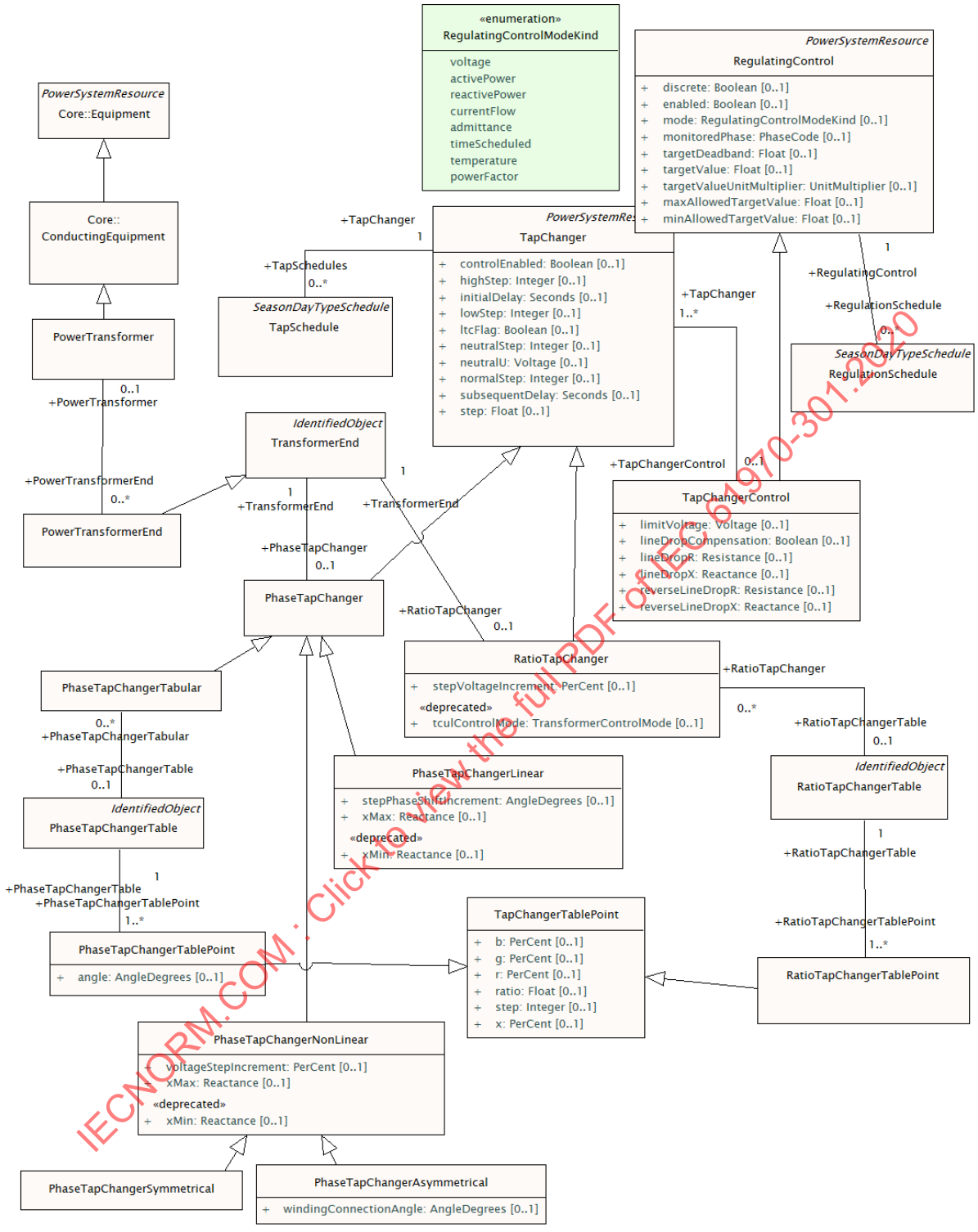


Figure 97 – Class diagram Wires::SwitchingEquipment

Figure 97: Shows switching equipment inheritance structure.

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Figure 98 – Class diagram Wires::TapChanger

Figure 98: This diagram shows all classes related to the transformer tap model.

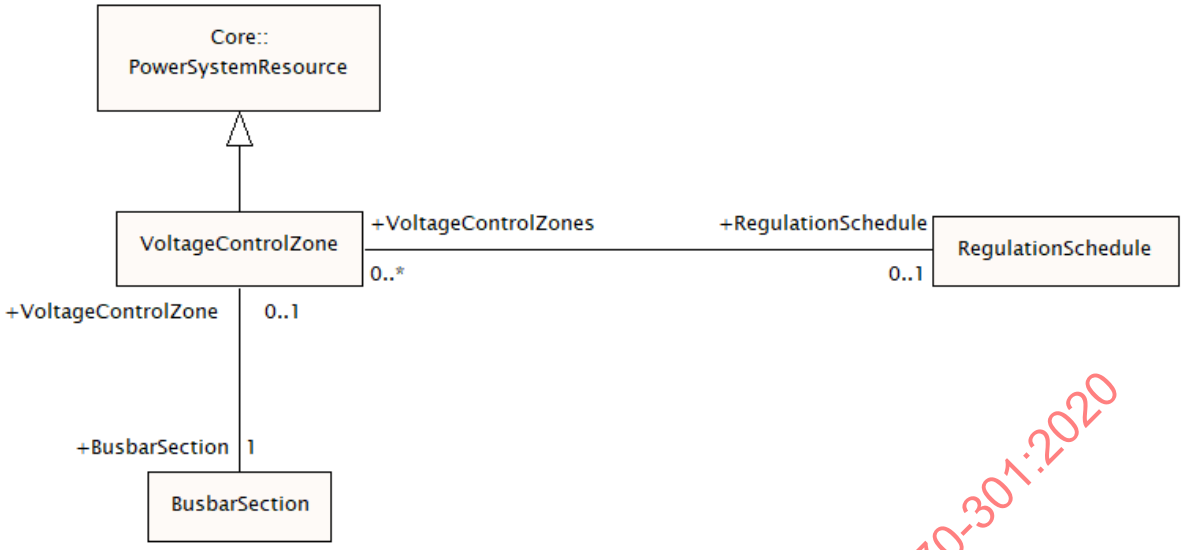
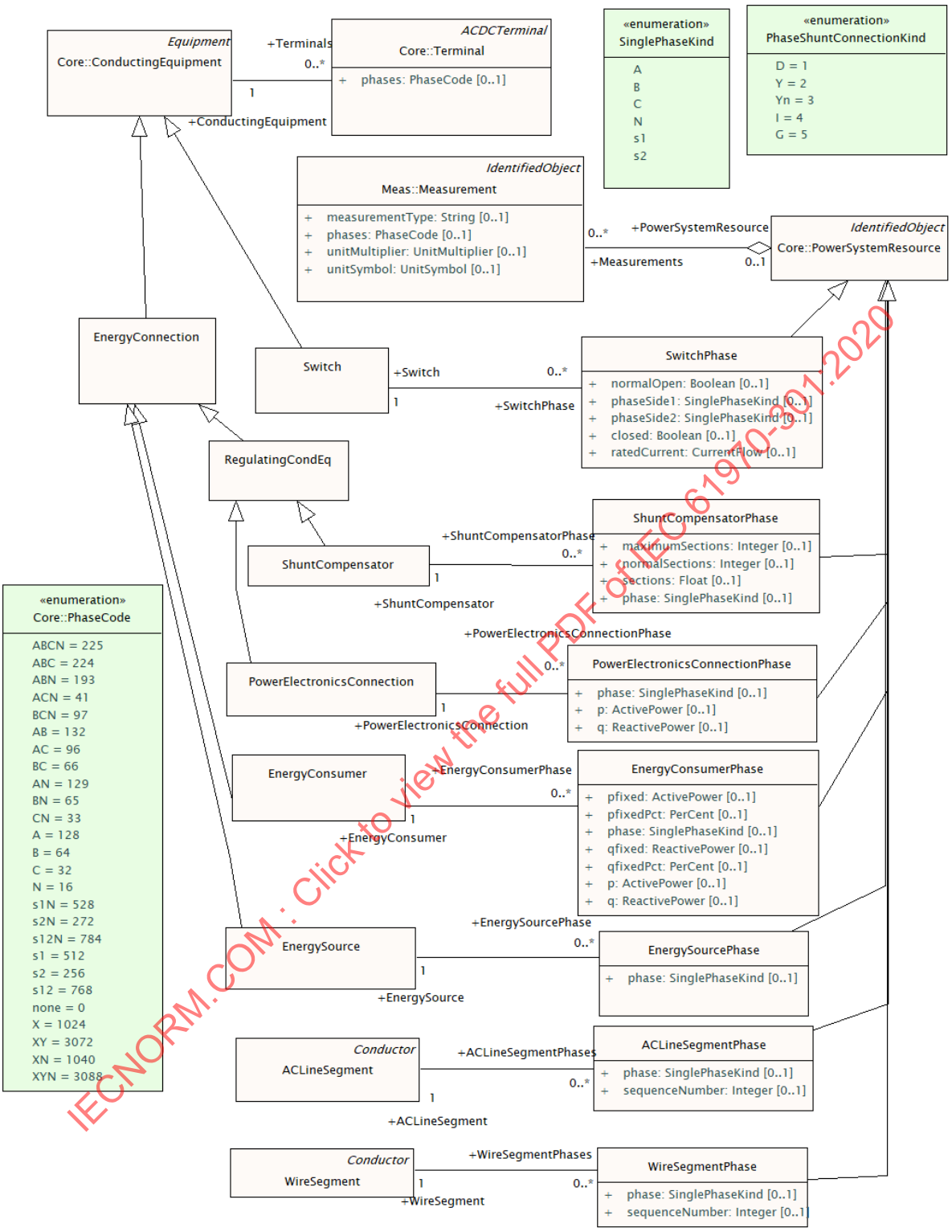


Figure 99 – Class diagram Wires::VoltageControl

Figure 99: This diagram shows all classes related to area voltage control.

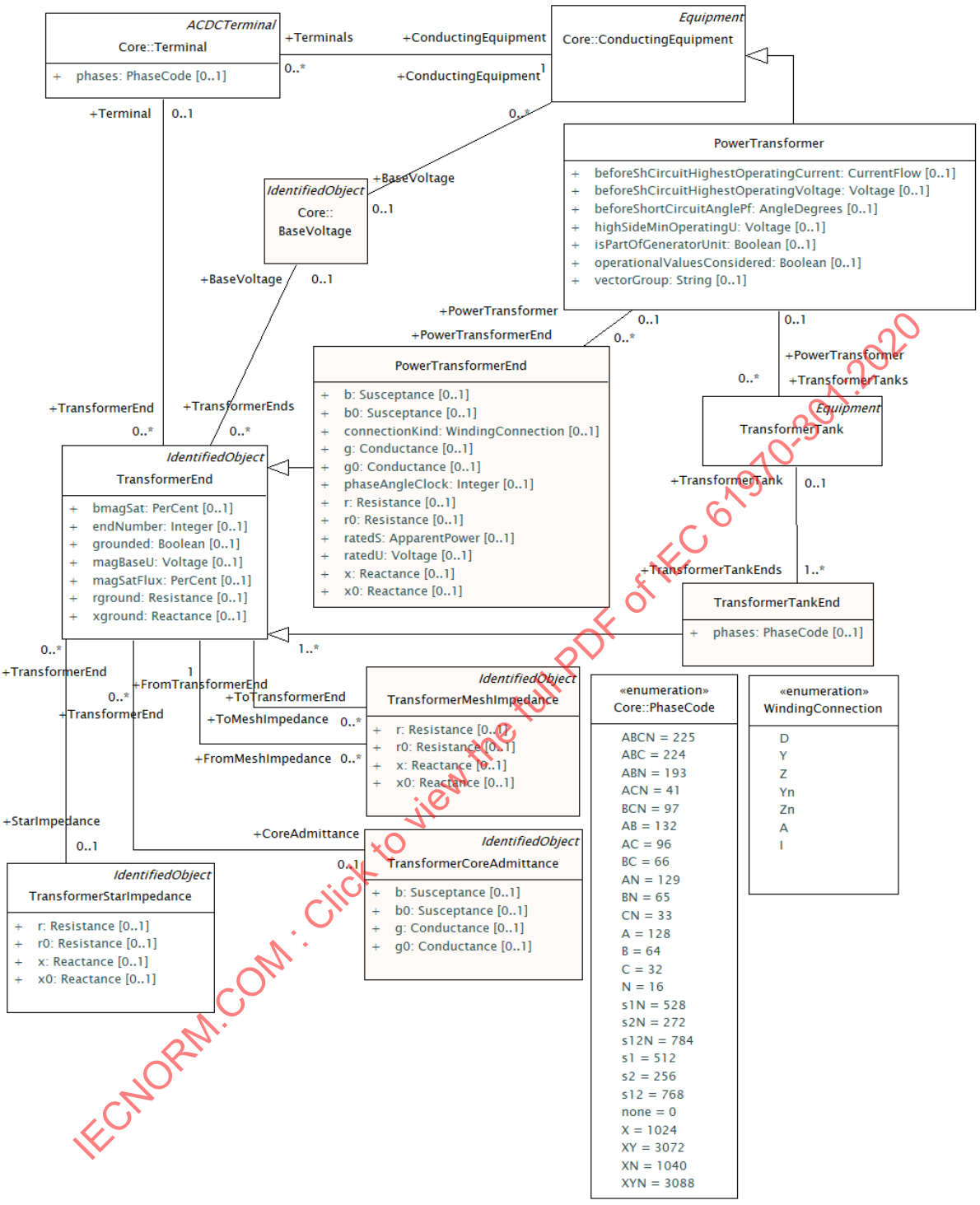
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Figure 100 – Class diagram Wires::WiresPhaseModel

Figure 100: Show the phase connection detail when modelling devices down to the phase components within a conducting equipment.



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Figure 101 – Class diagram Wires::Transformer

Figure 101: This diagram shows classes related to the core transformer model but does not show the tap changer details.

6.4.2 AsynchronousMachineKind enumeration

Kind of Asynchronous Machine.

Table 145 shows all literals of AsynchronousMachineKind.

Table 145 – Literals of Wires::AsynchronousMachineKind

literal	value	description
generator		The Asynchronous Machine is a generator.
motor		The Asynchronous Machine is a motor.

6.4.3 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 146 shows all attributes of ACLineSegment.

Table 146 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 147 shows all association ends of ACLineSegment with other classes.

Table 147 – 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..*	PerLengthImpedance	0..1	PerLengthImpedance	Per-length impedance of this line segment.
1..1	Cut	0..*	Cut	Cuts applied to the line segment.
0..1	LineFaults	0..*	LineFault	The line faults of 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.4.4 ACLineSegmentPhase

Represents a single wire of an alternating current line segment.

Table 148 shows all attributes of ACLineSegmentPhase.

Table 148 – Attributes of Wires::ACLineSegmentPhase

name	mult	type	description
phase	0..1	SinglePhaseKind	The phase connection of the wire at both ends.
sequenceNumber	0..1	Integer	Number designation for this line segment phase. Each line segment phase within a line segment should have a unique sequence number. This is useful for unbalanced modelling to bind the mathematical model (PhaseImpedanceData of PerLengthPhaseImpedance) with the connectivity model (this class) and the physical model (WirePosition) without tight coupling.
aliasName	0..1	String	inherited 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 ACLineSegmentPhase with other classes.

Table 149 – 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

6.4.5 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 150 shows all attributes of AsynchronousMachine.

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Table 150 – 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 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).
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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 151 shows all association ends of AsynchronousMachine with other classes.

Table 151 – 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 behaviour of this asynchronous machine.
1..1	HydroPump	0..1	HydroPump	inherited from: RotatingMachine
0..*	GeneratingUnit	0..1	GeneratingUnit	inherited from: RotatingMachine
1..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.4.6 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 152 shows all attributes of Breaker.

Table 152 – 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	(deprecated) inherited from: Switch
switchOnDate	0..1	DateTime	(deprecated) inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
locked	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 153 shows all association ends of Breaker with other classes.

Table 153 – 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	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
1..1	SvSwitch	0..*	SvSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.7 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 voltage transformers that are connected to busbar sections. A bus bar section may have many physical terminals but for analysis is modelled with exactly one logical terminal.

Table 154 shows all attributes of BusbarSection.

Table 154 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 155 shows all association ends of BusbarSection with other classes.

Table 155 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.8 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 156 shows all attributes of Clamp.

Table 156 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 157 shows all association ends of Clamp with other classes.

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Table 157 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.9 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 bus-bar 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 158 shows all attributes of CompositeSwitch.

Table 158 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 159 shows all association ends of CompositeSwitch with other classes.

Table 159 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.10 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 160 shows all attributes of Conductor.

Table 160 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 161 shows all association ends of Conductor with other classes.

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Table 161 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.11 Connector

A conductor, or group of conductors, with negligible impedance, that serve to connect other conducting equipment within a single substation and are modelled with a single logical terminal.

Table 162 shows all attributes of Connector.

Table 162 – Attributes of Wires::Connector

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 163 shows all association ends of Connector with other classes.

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Table 163 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.12 CoolantType enumeration

Method of cooling a machine.

Table 164 shows all literals of CoolantType.

Table 164 – Literals of Wires::CoolantType

literal	value	description
air		Air.
hydrogenGas		Hydrogen gas.
water		Water.

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6.4.13 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 165 shows all attributes of Cut.

Table 165 – 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	(deprecated) inherited from: Switch
switchOnDate	0..1	DateTime	(deprecated) inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
locked	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 166 shows all association ends of Cut with other classes.

Table 166 – 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	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
1..1	SvSwitch	0..*	SvSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.14 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 167 shows all attributes of Disconnector.

Table 167 – 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	(deprecated) inherited from: Switch
switchOnDate	0..1	DateTime	(deprecated) inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
locked	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 168 shows all association ends of Disconnector with other classes.

Table 168 – Association ends of Wires::Disconnector with other classes

mult from	name	mult to	type	description
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
1..1	SvSwitch	0..*	SvSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment

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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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.15 DisconnectingCircuitBreaker

A circuit breaking device including disconnecting function, eliminating the need for separate disconnectors.

Table 169 shows all attributes of DisconnectingCircuitBreaker.

Table 169 – Attributes of Wires::DisconnectingCircuitBreaker

name	mult	type	description
inTransitTime	0..1	Seconds	inherited from: Breaker
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	(deprecated) inherited from: Switch
switchOnDate	0..1	DateTime	(deprecated) inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
locked	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 170 shows all association ends of DisconnectingCircuitBreaker with other classes.

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Table 170 – Association ends of Wires::DisconnectingCircuitBreaker 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	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
1..1	SvSwitch	0..*	SvSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.16 EarthFaultCompensator

A conducting equipment used to represent a connection to ground which is typically used to compensate earth faults. An earth fault compensator device modelled with a single terminal implies a second terminal solidly connected to ground. If two terminals are modelled, the ground is not assumed and normal connection rules apply.

Table 171 shows all attributes of EarthFaultCompensator.

Table 171 – Attributes of Wires::EarthFaultCompensator

name	mult	type	description
r	0..1	Resistance	Nominal resistance of device.
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 172 shows all association ends of EarthFaultCompensator with other classes.

Table 172 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.17 EnergyConnection

A connection of energy generation or consumption on the power system model.

Table 173 shows all attributes of EnergyConnection.

Table 173 – Attributes of Wires::EnergyConnection

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 174 shows all association ends of EnergyConnection with other classes.

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Table 174 – Association ends of Wires::EnergyConnection with other classes

mult from	name	mult to	type	description
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.18 EnergyConsumer

Generic user of energy – a point of consumption on the power system model.

EnergyConsumer.pfixed, .qfixed, .pfixedPct and .qfixedPct have meaning only if there is no LoadResponseCharacteristic associated with EnergyConsumer or if LoadResponseCharacteristic.exponentModel is set to False.

Table 175 shows all attributes of EnergyConsumer.

Table 175 – 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 and does not vary as load group value varies. 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. Used to represent the time-varying components. 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 and does not vary as load group value varies. Load sign convention is used, i.e. positive sign means flow out from a node.

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name	mult	type	description
qfixedPct	0..1	PerCent	Fixed reactive power as a percentage of load group fixed reactive power. Used to represent the time-varying components. 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 176 shows all association ends of EnergyConsumer with other classes.

Table 176 – Association ends of Wires::EnergyConsumer with other classes

mult from	name	mult to	type	description
0..*	LoadResponse	0..1	LoadResponseCharacteristic	The load response characteristic of this load. If missing, this load is assumed to be constant power.
1..1	EnergyConsumerPhase	0..*	EnergyConsumerPhase	The individual phase models for this energy consumer.
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 behaviour of this energy consumer.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.19 EnergyConsumerPhase

A single phase of an energy consumer.

Table 177 shows all attributes of EnergyConsumerPhase.

Table 177 – 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.
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.
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 178 shows all association ends of EnergyConsumerPhase with other classes.

Table 178 – 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

6.4.20 EnergySchedulingType

Used to define the type of generation for scheduling purposes.

Table 179 shows all attributes of EnergySchedulingType.

Table 179 – Attributes of Wires::EnergySchedulingType

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 180 shows all association ends of EnergySchedulingType with other classes.

Table 180 – Association ends of Wires::EnergySchedulingType with other classes

mult from	name	mult to	type	description
0..1	EnergySource	0..*	EnergySource	Energy Source of a particular Energy Scheduling Type.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.4.21 EnergySource

A generic equivalent for an energy supplier on a transmission or distribution voltage level.

Table 181 shows all attributes of EnergySource.

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Table 181 – 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 used when voltage characteristics need to be imposed at the node associated with the terminal of the energy source, such as when voltages and angles from the transmission level are used as input to the distribution network. The attribute shall be a positive value or zero.
voltageMagnitude	0..1	Voltage	Phase-to-phase open circuit voltage magnitude used when voltage characteristics need to be imposed at the node associated with the terminal of the energy source, such as when voltages and angles from the transmission level are used as input to the distribution network. The attribute shall be a positive value or zero.
x	0..1	Reactance	Positive sequence Thevenin reactance.
x0	0..1	Reactance	Zero sequence Thevenin reactance.
xn	0..1	Reactance	Negative sequence Thevenin reactance.
pMin	0..1	ActivePower	This is the minimum active power that can be produced by the source. Load sign convention is used, i.e. positive sign means flow out from a TopologicalNode (bus) into the conducting equipment.
pMax	0..1	ActivePower	This is the maximum active power that can be produced by the source. Load sign convention is used, i.e. positive sign means flow out from a TopologicalNode (bus) into the conducting equipment.
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 182 shows all association ends of EnergySource with other classes.

Table 182 – Association ends of Wires::EnergySource with other classes

mult from	name	mult to	type	description
0..*	EnergySchedulingType	0..1	EnergySchedulingType	Energy Scheduling Type of an Energy Source.
1..1	EnergySourcePhase	0..*	EnergySourcePhase	The individual phase information of the energy source.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.22 EnergySourcePhase

Represents the single phase information of an unbalanced energy source.

Table 183 shows all attributes of EnergySourcePhase.

Table 183 – Attributes of Wires::EnergySourcePhase

name	mult	type	description
phase	0..1	SinglePhaseKind	Phase of this energy source component. If the energy source wye connected, the connection is from the indicated phase to the central ground or neutral point. If the energy source is delta connected, the phase indicates an energy source 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 184 shows all association ends of EnergySourcePhase with other classes.

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Table 184 – Association ends of Wires::EnergySourcePhase with other classes

mult from	name	mult to	type	description
0..*	EnergySource	1..1	EnergySource	The energy sourceto 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

6.4.23 ExternalNetworkInjection

This class represents the external network and it is used for IEC 60909 calculations.

Table 185 shows all attributes of ExternalNetworkInjection.

Table 185 – 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"). Used only if short circuit calculations are done according to superposition method.
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	Maximum reactive power limit. It is used for modelling of infeed for load flow exchange and not for short circuit modelling.
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.

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name	mult	type	description
minQ	0..1	ReactivePower	Minimum reactive power limit. It is used for modelling of infeed for load flow exchange and not for short circuit modelling.
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". Used only if short circuit calculations are done according to superposition method.
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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 186 shows all association ends of ExternalNetworkInjection with other classes.

Table 186 – Association ends of Wires::ExternalNetworkInjection with other classes

mult from	name	mult to	type	description
1..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
0..1	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment

mult from	name	mult to	type	description
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.24 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 187 shows all attributes of FrequencyConverter.

Table 187 – 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 frequency 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 frequency 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 188 shows all association ends of FrequencyConverter with other classes.

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Table 188 – Association ends of Wires::FrequencyConverter with other classes

mult from	name	mult to	type	description
1..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.25 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 189 shows all attributes of Fuse.

Table 189 – 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	(deprecated) inherited from: Switch
switchOnDate	0..1	DateTime	(deprecated) inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
locked	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 190 shows all association ends of Fuse with other classes.

Table 190 – Association ends of Wires::Fuse with other classes

mult from	name	mult to	type	description
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
1..1	SvSwitch	0..*	SvSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.4.26 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 191 shows all attributes of Ground.

Table 191 – Attributes of Wires::Ground

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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	mult	type	description
name	0..1	String	inherited from: IdentifiedObject

Table 192 shows all association ends of Ground with other classes.

Table 192 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.27 GroundingImpedance

A fixed impedance device used for grounding.

Table 193 shows all attributes of GroundingImpedance.

Table 193 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 194 shows all association ends of GroundingImpedance with other classes.

Table 194 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.28 GroundDisconnector

A manually operated or motor operated mechanical switching device used for isolating a circuit or equipment from ground.

Table 195 shows all attributes of GroundDisconnector.

Table 195 – 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	(deprecated) inherited from: Switch
switchOnDate	0..1	DateTime	(deprecated) inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
locked	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 196 shows all association ends of GroundDisconnector with other classes.

Table 196 – Association ends of Wires::GroundDisconnector with other classes

mult from	name	mult to	type	description
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
1..1	SvSwitch	0..*	SvSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.4.29 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 modelled by other equipment types.

Table 197 shows all attributes of Jumper.

Table 197 – 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	(deprecated) inherited from: Switch
switchOnDate	0..1	DateTime	(deprecated) inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
locked	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 198 shows all association ends of Jumper with other classes.

Table 198 – Association ends of Wires::Jumper with other classes

mult from	name	mult to	type	description
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
1..1	SvSwitch	0..*	SvSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.4.30 Junction

A point where one or more conducting equipments are connected with zero resistance.

Table 199 shows all attributes of Junction.

Table 199 – Attributes of Wires::Junction

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 Junction with other classes.

Table 200 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.4.31 Line

Contains equipment beyond a substation belonging to a power transmission line.

Table 201 shows all attributes of Line.

Table 201 – 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 202 shows all association ends of Line with other classes.

Table 202 – 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
0..*	AdditionalGroupedEquipment	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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6.4.32 LinearShuntCompensator

A linear shunt compensator has banks or sections with equal admittance values.

Table 203 shows all attributes of LinearShuntCompensator.

Table 203 – 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

name	mult	type	description
normalSections	0..1	Integer	inherited from: ShuntCompensator
phaseConnection	0..1	PhaseShuntConnectionKind	inherited from: ShuntCompensator
switchOnCount	0..1	Integer	(deprecated) inherited from: ShuntCompensator
switchOnDate	0..1	DateTime	(deprecated) 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 204 shows all association ends of LinearShuntCompensator with other classes.

Table 204 – 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..*	SvShuntCompensatorSections	inherited from: ShuntCompensator
1..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.4.33 LinearShuntCompensatorPhase

A per phase linear shunt compensator has banks or sections with equal admittance values.

Table 205 shows all attributes of LinearShuntCompensatorPhase.

Table 205 – 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
sections	0..1	Float	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 206 shows all association ends of LinearShuntCompensatorPhase with other classes.

Table 206 – 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

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6.4.34 LoadBreakSwitch

A mechanical switching device capable of making, carrying, and breaking currents under normal operating conditions.

Table 207 shows all attributes of LoadBreakSwitch.

Table 207 – 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	(deprecated) inherited from: Switch
switchOnDate	0..1	DateTime	(deprecated) inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
locked	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 208 shows all association ends of LoadBreakSwitch with other classes.

Table 208 – 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	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
1..1	SvSwitch	0..*	SvSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.35 MutualCoupling

This class represents the zero sequence line mutual coupling.

Table 209 shows all attributes of MutualCoupling.

Table 209 – 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
name	0..1	String	inherited from: IdentifiedObject

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Table 210 shows all association ends of MutualCoupling with other classes.

Table 210 – 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

6.4.36 NonlinearShuntCompensator

A non linear shunt compensator has bank or section admittance values that differ. The attributes g, b, g0 and b0 of the associated NonlinearShuntCompensatorPoint describe the total conductance and admittance of a NonlinearShuntCompensatorPoint at a section number specified by NonlinearShuntCompensatorPoint.sectionNumber.

Table 211 shows all attributes of NonlinearShuntCompensator.

Table 211 – 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	(deprecated) inherited from: ShuntCompensator
switchOnDate	0..1	DateTime	(deprecated) 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 212 shows all association ends of NonlinearShuntCompensator with other classes.

Table 212 – 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..*	SvShuntCompensatorSections	inherited from: ShuntCompensator
1..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.4.37 NonlinearShuntCompensatorPhase

A per phase non-linear shunt compensator has bank or section admittance values that differ. The attributes g and b of the associated NonlinearShuntCompensatorPhasePoint describe the total conductance and admittance of a NonlinearShuntCompensatorPhasePoint at a section number specified by NonlinearShuntCompensatorPhasePoint.sectionNumber.

Table 213 shows all attributes of NonlinearShuntCompensatorPhase.

Table 213 – Attributes of Wires::NonlinearShuntCompensatorPhase

name	mult	type	description
maximumSections	0..1	Integer	inherited from: ShuntCompensatorPhase
normalSections	0..1	Integer	inherited from: ShuntCompensatorPhase
sections	0..1	Float	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	mult	type	description
name	0..1	String	inherited from: IdentifiedObject

Table 214 shows all association ends of NonlinearShuntCompensatorPhase with other classes.

Table 214 – 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

6.4.38 NonlinearShuntCompensatorPhasePoint root class

A per phase non linear shunt compensator bank or section admittance value. The number of NonlinearShuntCompenstorPhasePoint instances associated with a NonlinearShuntCompensatorPhase shall be equal to ShuntCompensatorPhase.maximumSections. ShuntCompensator.sections shall only be set to one of the NonlinearShuntCompenstorPhasePoint.sectionNumber. There is no interpolation between NonlinearShuntCompenstorPhasePoint-s.

Table 215 shows all attributes of NonlinearShuntCompensatorPhasePoint.

Table 215 – 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 216 shows all association ends of NonlinearShuntCompensatorPhasePoint with other classes.

Table 216 – 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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6.4.39 NonlinearShuntCompensatorPoint root class

A non linear shunt compensator bank or section admittance value. The number of NonlinearShuntCompenstorPoint instances associated with a NonlinearShuntCompensator shall be equal to ShuntCompensator.maximumSections. ShuntCompensator.sections shall only be set to one of the NonlinearShuntCompenstorPoint.sectionNumber. There is no interpolation between NonlinearShuntCompenstorPoint-s.

Table 217 shows all attributes of NonlinearShuntCompensatorPoint.

Table 217 – 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 218 shows all association ends of NonlinearShuntCompensatorPoint with other classes.

Table 218 – 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.

6.4.40 PerLengthImpedance

Common type for per-length impedance electrical catalogues.

Table 219 shows all attributes of PerLengthImpedance.

Table 219 – 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 220 shows all association ends of PerLengthImpedance with other classes.

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Table 220 – 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

6.4.41 PerLengthLineParameter

Common type for per-length electrical catalogues describing line parameters.

Table 221 shows all attributes of PerLengthLineParameter.

Table 221 – 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 222 shows all association ends of PerLengthLineParameter with other classes.

Table 222 – 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

6.4.42 PerLengthPhaseImpedance

Impedance and admittance parameters per unit length for n-wire unbalanced lines, in matrix form.

Table 223 shows all attributes of PerLengthPhaseImpedance.

Table 223 – 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 224 shows all association ends of PerLengthPhaseImpedance with other classes.

Table 224 – 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

6.4.43 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 225 shows all attributes of PerLengthSequenceImpedance.

Table 225 – 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 226 shows all association ends of PerLengthSequenceImpedance with other classes.

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Table 226 – 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

6.4.44 PetersenCoil

A variable impedance device normally used to offset line charging during single line faults in an ungrounded section of network.

Table 227 shows all attributes of PetersenCoil.

Table 227 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 228 shows all association ends of PetersenCoil with other classes.

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Table 228 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.45 PetersenCoilModeKind enumeration

The mode of operation for a Petersen coil.

Table 229 shows all literals of PetersenCoilModeKind.

Table 229 – Literals of Wires::PetersenCoilModeKind

literal	value	description
fixed		Fixed position.
manual		Manual positioning.
automaticPositioning		Automatic positioning.

6.4.46 PhaseImpedanceData root class

Impedance and conductance matrix element values.

The diagonal elements are described by the elements having the same toPhase and fromPhase value and the off diagonal elements have different toPhase and fromPhase values. The matrix can also be stored in symmetric lower triangular format using the row and column attributes, which map to ACLineSegmentPhase.sequenceNumber.

Table 230 shows all attributes of PhaseImpedanceData.

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Table 230 – Attributes of Wires::PhaseImpedanceData

name	mult	type	description
b	0..1	SusceptancePerLength	Susceptance matrix element value, per length of unit.
r	0..1	ResistancePerLength	Resistance matrix element value, per length of unit.
g	0..1	ConductancePerLength	Conductance matrix element value, per length of unit.
x	0..1	ReactancePerLength	Reactance matrix element value, per length of unit.
fromPhase	0..1	SinglePhaseKind	Refer to the class description.
toPhase	0..1	SinglePhaseKind	Refer to the class description.
row	0..1	Integer	The matrix element's row number, in the range 1 to PerLengthPhaseImpedance.conductorCount. Only the lower triangle needs to be stored. This row number matches ACLineSegmentPhase.sequenceNumber.
column	0..1	Integer	The matrix element's column number, in the range 1 to row. Only the lower triangle needs to be stored. This column number matches ACLineSegmentPhase.sequenceNumber.

Table 231 shows all association ends of PhaseImpedanceData with other classes.

Table 231 – 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.

6.4.47 PhaseShuntConnectionKind enumeration

The configuration of phase connections for a single terminal device such as a load or capacitor.

Table 232 shows all literals of PhaseShuntConnectionKind.

Table 232 – Literals of Wires::PhaseShuntConnectionKind

literal	value	description
D	1	Delta connection.
Y	2	Wye connection.
Yn	3	Wye, with neutral brought out for grounding.
I	4	Independent winding, for single-phase connections.
G	5	Ground connection; use when explicit connection to ground needs to be expressed in combination with the phase code, such as for electrical wire/cable or for meters.

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6.4.48 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 233 shows all attributes of PhaseTapChanger.

Table 233 – 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 234 shows all association ends of PhaseTapChanger with other classes.

Table 234 – 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.
1..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	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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6.4.49 PhaseTapChangerAsymmetrical

Describes the tap model for an asymmetrical phase shifting transformer in which the difference voltage vector adds to the in-phase winding. The out-of-phase winding is the transformer end where the tap changer is located. The angle between the in-phase and out-of-phase windings is named the winding connection angle. The phase shift depends on both the difference voltage magnitude and the winding connection angle.

Table 235 shows all attributes of PhaseTapChangerAsymmetrical.

Table 235 – 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. The attribute can only be multiples of 30 degrees. The allowed range is -150 degrees to 150 degrees excluding 0.
voltageStepIncrement	0..1	PerCent	inherited from: PhaseTapChangerNonLinear
xMax	0..1	Reactance	inherited from: PhaseTapChangerNonLinear
xMin	0..1	Reactance	(deprecated) 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

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Table 236 shows all association ends of PhaseTapChangerAsymmetrical with other classes.

Table 236 – Association ends of Wires::PhaseTapChangerAsymmetrical with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
1..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	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

6.4.50 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 voltage magnitude of both sides is the same.

Table 237 shows all attributes of PhaseTapChangerLinear.

Table 237 – Attributes of Wires::PhaseTapChangerLinear

name	mult	type	description
stepPhaseShiftIncrement	0..1	AngleDegrees	Phase shift per step position. A positive value indicates a positive angle variation from the Terminal at the PowerTransformerEnd, where the TapChanger is located, into the 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. Depending on the “u” curve the attribute can be either higher or lower than PowerTransformerEnd.x.
xMin	0..1	Reactance	(deprecated) The reactance depends on the tap position according to a "u" shaped curve. The minimum reactance (xMin) appears at the mid tap position. PowerTransformerEnd.x shall be consistent with PhaseTapChangerLinear.xMin and PhaseTapChangerNonLinear.xMin. In case of inconsistency, PowerTransformerEnd.x shall be used.
controlEnabled	0..1	Boolean	inherited from: TapChanger
highStep	0..1	Integer	inherited from: TapChanger

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name	mult	type	description
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 238 shows all association ends of PhaseTapChangerLinear with other classes.

Table 238 – Association ends of Wires::PhaseTapChangerLinear with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
1..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	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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6.4.51 PhaseTapChangerNonLinear

The non-linear phase tap changer describes the non-linear behaviour 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 IEC 61970-301.

Table 239 shows all attributes of PhaseTapChangerNonLinear.

Table 239 – Attributes of Wires::PhaseTapChangerNonLinear

name	mult	type	description
voltageStepIncrement	0..1	PerCent	The voltage step increment on the out of phase winding (the PowerTransformerEnd where the TapChanger is located) specified in percent of rated voltage of the PowerTransformerEnd. A positive value means a positive voltage variation from the Terminal at the PowerTransformerEnd, where the TapChanger is located, into the transformer. When the increment is negative, the voltage decreases when the tap step increases.
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. Depending on the "u" curve the attribute can be either higher or lower than PowerTransformerEnd.x.
xMin	0..1	Reactance	(deprecated) The reactance depend on the tap position according to a "u" shaped curve. The minimum reactance (xMin) appear at the mid tap position. PowerTransformerEnd.x shall be consistent with PhaseTapChangerLinear.xMin and PhaseTapChangerNonLinear.xMin. In case of inconsistency, PowerTransformerEnd.x shall be used.
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

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Table 240 shows all association ends of PhaseTapChangerNonLinear with other classes.

Table 240 – Association ends of Wires::PhaseTapChangerNonLinear with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
1..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	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

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

6.4.52 PhaseTapChangerSymmetrical

Describes a symmetrical phase shifting transformer tap model in which the voltage magnitude of both sides is the same. 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 241 shows all attributes of PhaseTapChangerSymmetrical.

Table 241 – 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	(deprecated) 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 242 shows all association ends of PhaseTapChangerSymmetrical with other classes.

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Table 242 – Association ends of Wires::PhaseTapChangerSymmetrical with other classes

mult from	name	mult to	type	description
0..1	TransformerEnd	1..1	TransformerEnd	inherited from: PhaseTapChanger
1..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	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

6.4.53 PhaseTapChangerTable

Describes a tabular curve for how the phase angle difference and impedance varies with the tap step.

Table 243 shows all attributes of PhaseTapChangerTable.

Table 243 – 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 244 shows all association ends of PhaseTapChangerTable with other classes.

Table 244 – 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

6.4.54 PhaseTapChangerTablePoint

Describes each tap step in the phase tap changer tabular curve.

Table 245 shows all attributes of PhaseTapChangerTablePoint.

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Table 245 – Attributes of Wires::PhaseTapChangerTablePoint

name	mult	type	description
angle	0..1	AngleDegrees	The angle difference in degrees. A positive value indicates a positive angle variation from the Terminal at the PowerTransformerEnd, where the TapChanger is located, into the 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 246 shows all association ends of PhaseTapChangerTablePoint with other classes.

Table 246 – 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.

6.4.55 PhaseTapChangerTabular

Describes a tap changer with a table defining the relation between the tap step and the phase angle difference across the transformer.

Table 247 shows all attributes of PhaseTapChangerTabular.

Table 247 – 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 248 shows all association ends of PhaseTapChangerTabular with other classes.

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Table 248 – 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
1..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	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

6.4.56 Plant

A Plant is a collection of equipment for purposes of generation.

Table 249 shows all attributes of Plant.

Table 249 – 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 250 shows all association ends of Plant with other classes.

Table 250 – Association ends of Wires::Plant with other classes

mult from	name	mult to	type	description
0..1	Equipments	0..*	Equipment	inherited from: EquipmentContainer
0..*	AdditionalGroupedEquipment	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

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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

6.4.57 PowerElectronicsConnection

A connection to the AC network for energy production or consumption that uses power electronics rather than rotating machines.

Table 251 shows all attributes of PowerElectronicsConnection.

Table 251 – 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. The attribute shall be a positive value.
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	(deprecated) 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	(deprecated) Zero sequence resistance of the synchronous machine.
rn	0..1	Resistance	(deprecated) Negative sequence Thevenin resistance.
x	0..1	Reactance	(deprecated) Positive sequence Thevenin reactance.
x0	0..1	Reactance	(deprecated) Zero sequence Thevenin reactance.
xn	0..1	Reactance	(deprecated) Negative sequence Thevenin reactance.
maxIFault	0..1	PU	Maximum fault current this device will contribute, in per-unit of rated current, before the converter protection will trip or bypass.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 252 shows all association ends of PowerElectronicsConnection with other classes.

Table 252 – 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	PowerElectronicsConnectionPhase	0..*	PowerElectronicsConnectionPhase	The individual phases models for the power electronics connection.
1..1	WindTurbineType3or4Dynamics	0..1	WindTurbineType3or4Dynamics	The wind turbine type 3 or type 4 dynamics model associated with this power electronics connection.
1..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.4.58 PowerElectronicsConnectionPhase

A single phase of a power electronics connection.

Table 253 shows all attributes of PowerElectronicsConnectionPhase.

Table 253 – Attributes of Wires::PowerElectronicsConnectionPhase

name	mult	type	description
phase	0..1	SinglePhaseKind	Phase of this energy producer component. If the energy producer is wye connected, the connection is from the indicated phase to the central ground or neutral point. If the energy producer is delta connected, the phase indicates an energy producer connected from the indicated phase to the next logical non-neutral phase.
p	0..1	ActivePower	Active power injection. Load sign convention is used, i.e. positive sign means flow into the equipment from the network.
q	0..1	ReactivePower	Reactive power injection. Load sign convention is used, i.e. positive sign means flow into the equipment from the network.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 254 shows all association ends of PowerElectronicsConnectionPhase with other classes.

Table 254 – Association ends of Wires::PowerElectronicsConnectionPhase with other classes

mult from	name	mult to	type	description
0..*	PowerElectronicsConnection	1..1	PowerElectronicsConnection	Power electronics connection of this power electronics connection 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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6.4.59 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 modelled 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 255 shows all attributes of PowerTransformer.

Table 255 – Attributes of Wires::PowerTransformer

name	mult	type	description
beforeShCircuitHighestOperatingCurrent	0..1	CurrentFlow	The highest operating current (Ib in 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 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 (3.7.1 of IEC 60909:2001). 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 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. It has an impact on how the correction factors are calculated for transformers, since the transformer is not necessarily part of a synchronous machine and generating unit. It is not always possible to derive this information from the model. This is why the attribute is necessary.
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.
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 displacements. 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 position 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 voltage, wye with neutral mid voltage 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

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name	mult	type	description
			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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 256 shows all association ends of PowerTransformer with other classes.

Table 256 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.4.60 PowerTransformerEnd

A PowerTransformerEnd is associated with each Terminal of a PowerTransformer.

The impedance values r, r0, x, and x0 of a PowerTransformerEnd represents 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=2) PowerTransformerEnd has zero values for r, r0, x, and x0. Parameters are always provided, even if the PowerTransformerEnds have the same rated voltage. In this case, the parameters are provided at the PowerTransformerEnd which has TransformerEnd.endNumber equal to 1.
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. This 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.

Each PowerTransformerEnd must be contained by a PowerTransformer. Because a PowerTransformerEnd (or any other object) can not be contained by more than one parent, a PowerTransformerEnd can not have an association to an EquipmentContainer (Substation, VoltageLevel, etc).

Table 257 shows all attributes of PowerTransformerEnd.

Table 257 – 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.

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name	mult	type	description
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. The attribute shall be a positive value.
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 258 shows all association ends of PowerTransformerEnd with other classes.

Table 258 – 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	PhaseTapChanger	0..1	PhaseTapChanger	inherited from: TransformerEnd
1..1	RatioTapChanger	0..1	RatioTapChanger	inherited from: TransformerEnd
0..*	StarImpedance	0..1	TransformerStarImpedance	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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6.4.61 ProtectedSwitch

A ProtectedSwitch is a switching device that can be operated by ProtectionEquipment.

Table 259 shows all attributes of ProtectedSwitch.

Table 259 – 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	(deprecated) inherited from: Switch
switchOnDate	0..1	DateTime	(deprecated) inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
locked	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 260 shows all association ends of ProtectedSwitch with other classes.

Table 260 – 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	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
1..1	SvSwitch	0..*	SvSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.62 RatioTapChanger

A tap changer that changes the voltage ratio impacting the voltage magnitude but not the phase angle across the transformer.

Angle sign convention (general): Positive value indicates a positive phase shift from the winding where the tap is located to the other winding (for a two-winding transformer).

Table 261 shows all attributes of RatioTapChanger.

Table 261 – Attributes of Wires::RatioTapChanger

name	mult	type	description
stepVoltageIncrement	0..1	PerCent	Tap step increment, in per cent of rated voltage of the power transformer end, per step position. When the increment is negative, the voltage decreases when the tap step increases.
tculControlMode	0..1	TransformerControlMode	(deprecated) 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 262 shows all association ends of RatioTapChanger with other classes.

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Table 262 – 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.
1..*	TapChangerControl	0..1	TapChangerControl	inherited from: TapChanger
1..1	SvTapStep	0..1	SvTapStep	inherited from: TapChanger
1..1	TapSchedules	0..*	TapSchedule	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

6.4.63 RatioTapChangerTable

Describes a curve for how the voltage magnitude and impedance varies with the tap step.

Table 263 shows all attributes of RatioTapChangerTable.

Table 263 – 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 264 shows all association ends of RatioTapChangerTable with other classes.

Table 264 – 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

6.4.64 RatioTapChangerTablePoint

Describes each tap step in the ratio tap changer tabular curve.

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Table 265 shows all attributes of RatioTapChangerTablePoint.

Table 265 – 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 266 shows all association ends of RatioTapChangerTablePoint with other classes.

Table 266 – Association ends of Wires::RatioTapChangerTablePoint with other classes

mult from	name	mult to	type	description
1..*	RatioTapChangerTable	1..1	RatioTapChangerTable	Table of this point.

6.4.65 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 267 shows all attributes of ReactiveCapabilityCurve.

Table 267 – 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

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Table 268 shows all association ends of ReactiveCapabilityCurve with other classes.

Table 268 – Association ends of Wires::ReactiveCapabilityCurve with other classes

mult from	name	mult to	type	description
0..1	EquivalentInjection	0..*	EquivalentInjection	The equivalent injection using this reactive capability curve.
0..1	InitiallyUsedBySynchronousMachines	1..*	SynchronousMachine	Synchronous machines using this curve as default.
0..*	SynchronousMachines	1..*	SynchronousMachine	Synchronous machines using this 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

6.4.66 Recloser

Pole-mounted fault interrupter with built-in phase and ground relays, current transformer (CT), and supplemental controls.

Table 269 shows all attributes of Recloser.

Table 269 – 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	(deprecated) inherited from: Switch
switchOnDate	0..1	DateTime	(deprecated) inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
locked	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 270 shows all association ends of Recloser with other classes.

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Table 270 – 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	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
1..1	SvSwitch	0..*	SvSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.67 RegulatingCondEq

A type of conducting equipment that can regulate a quantity (i.e. voltage or flow) at a specific point in the network.

Table 271 shows all attributes of RegulatingCondEq.

Table 271 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 272 shows all association ends of RegulatingCondEq with other classes.

Table 272 – Association ends of Wires::RegulatingCondEq with other classes

mult from	name	mult to	type	description
1..*	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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.68 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.

The specified terminal shall be associated with the connectivity node of the controlled point. The most specific subtype of RegulatingControl shall be used in case such equipment 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.

The attribute minAllowedTargetValue and maxAllowedTargetValue are required in the following cases:

– For a power generating module operated in power factor control mode to specify maximum and minimum power factor values;

– Whenever it is necessary to have an off center target voltage for the tap changer regulator. For instance, due to long cables to off shore wind farms and the need to have a simpler setup at the off shore transformer platform, the voltage is controlled from the land at the connection point for the off shore wind farm. Since there usually is a voltage rise along the cable, there is typical and overvoltage of up 3-4 kV compared to the on shore station. Thus in normal operation the tap changer on the on shore station is operated with a target set point, which is in the lower parts of the dead band.

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The attributes minAllowedTargetValue and maxAllowedTargetValue are not related to the attribute targetDeadband and thus they are not treated as an alternative of the targetDeadband. They are needed due to limitations in the local substation controller. The attribute targetDeadband is used to prevent the power flow from move the tap position in circles (hunting) that is to be used regardless of the attributes minAllowedTargetValue and maxAllowedTargetValue.

Table 273 shows all attributes of RegulatingControl.

Table 273 – 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. The attribute shall be a positive value or zero. If RegulatingControl.discrete is set to "false", the RegulatingControl.targetDeadband is to be ignored. Note that for instance, if the targetValue is 100 kV and the targetDeadband is 2 kV the range is from 99 to 101 kV.
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.
maxAllowedTargetValue	0..1	Float	Maximum allowed target value (RegulatingControl.targetValue).
minAllowedTargetValue	0..1	Float	Minimum allowed target value (RegulatingControl.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 274 shows all association ends of RegulatingControl with other classes.

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Table 274 – 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 or a connectivity node. Sometimes it is useful to model regulation at a terminal of a bus bar object.
0..1	RegulatingCondEq	1..*	RegulatingCondEq	The equipment that participates in this regulating control scheme.
1..1	RegulationSchedule	0..*	RegulationSchedule	Schedule for this regulating control.
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

6.4.69 RegulatingControlModeKind enumeration

The kind of regulation model. For example regulating voltage, reactive power, active power, etc.

Table 275 shows all literals of RegulatingControlModeKind.

Table 275 – 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.
temperature		Control switches on/off based on the local temperature (i.e., a thermostat).
powerFactor		Power factor is specified.

6.4.70 RegulationSchedule

A pre-established pattern over time for a controlled variable, e.g., busbar voltage.

Table 276 shows all attributes of RegulationSchedule.

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Table 276 – 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
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	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 277 shows all association ends of RegulationSchedule with other classes.

Table 277 – 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

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6.4.71 RotatingMachine

A rotating machine which may be used as a generator or motor.

Table 278 shows all attributes of RotatingMachine.

Table 278 – 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. The attribute cannot be a negative value.
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.

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.
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. The attribute shall be a positive value.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 279 shows all association ends of RotatingMachine with other classes.

Table 279 – 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.
0..*	GeneratingUnit	0..1	GeneratingUnit	A synchronous machine may operate as a generator and as such becomes a member of a generating unit.
1..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.72 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 280 shows all attributes of Sectionaliser.

Table 280 – 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	(deprecated) inherited from: Switch
switchOnDate	0..1	DateTime	(deprecated) inherited from: Switch
retained	0..1	Boolean	inherited from: Switch
open	0..1	Boolean	inherited from: Switch
locked	0..1	Boolean	inherited from: Switch
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 281 shows all association ends of Sectionaliser with other classes.

Table 281 – Association ends of Wires::Sectionaliser with other classes

mult from	name	mult to	type	description
1..1	SwitchPhase	0..*	SwitchPhase	inherited from: Switch
1..1	SwitchSchedules	0..*	SwitchSchedule	inherited from: Switch
0..*	CompositeSwitch	0..1	CompositeSwitch	inherited from: Switch
1..1	SvSwitch	0..*	SvSwitch	inherited from: Switch
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.73 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 282 shows all attributes of SeriesCompensator.

Table 282 – 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 in parallel with the series compensator. It is used for short circuit calculations.
varistorRatedCurrent	0..1	CurrentFlow	The maximum current the varistor is designed to handle at specified duration. It is used for short circuit calculations and exchanged only if SeriesCompensator.varistorPresent is true. The attribute shall be a positive value.
varistorVoltageThreshold	0..1	Voltage	The DC voltage at which the varistor starts conducting. It is used for short circuit calculations and exchanged only if SeriesCompensator.varistorPresent is true.
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 283 shows all association ends of SeriesCompensator with other classes.

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Table 283 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.74 ShortCircuitRotorKind enumeration

Type of rotor, used by short circuit applications.

Table 284 shows all literals of ShortCircuitRotorKind.

Table 284 – Literals of Wires::ShortCircuitRotorKind

literal	value	description
salientPole1		Salient pole 1 in IEC 60909.
salientPole2		Salient pole 2 in IEC 60909.
turboSeries1		Turbo Series 1 in IEC 60909.
turboSeries2		Turbo series 2 in IEC 60909.

6.4.75 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 285 shows all attributes of ShuntCompensator.

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Table 285 – Attributes of Wires::ShuntCompensator

name	mult	type	description
aVRDelay	0..1	Seconds	An automatic voltage regulation delay (AVRDelay) which is the time delay from a change in voltage to when the capacitor is allowed to change state. This filters out temporary changes in voltage.
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. The value shall be between zero and ShuntCompensator.maximumSections.
phaseConnection	0..1	PhaseShuntConnectionKind	The type of phase connection, such as wye or delta.
switchOnCount	0..1	Integer	(deprecated) The switch on count since the capacitor count was last reset or initialized.
switchOnDate	0..1	DateTime	(deprecated) 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. The attribute shall be a positive value or zero. 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. For LinearShuntConpensator the value shall be between zero and ShuntCompensator.maximumSections. At value zero the shunt compensator conductance and admittance is zero. Linear interpolation of conductance and admittance between the previous and next integer section is applied in case of non-integer values. For NonlinearShuntCompensator-s shall only be set to one of the NonlinearShuntCompenstorPoint.sectionNumber. There is no interpolation between NonlinearShuntCompenstorPoint-s.
controlEnabled	0..1	Boolean	inherited from: RegulatingCondEq
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 286 shows all association ends of ShuntCompensator with other classes.

Table 286 – 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..*	SvShuntCompensatorSections	The state for the number of shunt compensator sections in service.
1..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.76 ShuntCompensatorPhase

Single phase of a multi-phase shunt compensator when its attributes might be different per phase.

Table 287 shows all attributes of ShuntCompensatorPhase.

Table 287 – 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. The value shall be between zero and ShuntCompensatorPhase.maximumSections.
sections	0..1	Float	Shunt compensator sections in use. Starting value for steady state solution. The attribute shall be a positive value or zero. 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.

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name	mult	type	description
			For LinearShuntConpensator the value shall be between zero and ShuntCompensatorPhase.maximumSections. At value zero the shunt compensator conductance and admittance is zero. Linear interpolation of conductance and admittance between the previous and next integer section is applied in case of non-integer values. For NonlinearShuntCompensator-s shall only be set to one of the NonlinearShuntCompenstorPhasePoint.sectionNumber. There is no interpolation between NonlinearShuntCompenstorPhasePoint-s.
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 288 shows all association ends of ShuntCompensatorPhase with other classes.

Table 288 – 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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6.4.77 SinglePhaseKind enumeration

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

Table 289 shows all literals of SinglePhaseKind.

Table 289 – 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.

6.4.78 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 290 shows all attributes of StaticVarCompensator.

Table 290 – Attributes of Wires::StaticVarCompensator

name	mult	type	description
capacitiveRating	0..1	Reactance	Capacitive reactance at maximum capacitive reactive power. Shall always be positive.
inductiveRating	0..1	Reactance	Inductive reactance at maximum inductive reactive power. Shall always be negative.
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. The attribute shall be a positive value or zero.
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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 291 shows all association ends of StaticVarCompensator with other classes.

Table 291 – Association ends of Wires::StaticVarCompensator with other classes

mult from	name	mult to	type	description
1..1	StaticVarCompensatorDynamics	0..1	StaticVarCompensatorDynamics	Static Var Compensator dynamics model used to describe dynamic behaviour of this Static Var Compensator.
1..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.4.79 SVCControlMode enumeration

Static VAr Compensator control mode.

Table 292 shows all literals of SVCControlMode.

Table 292 – Literals of Wires::SVCControlMode

literal	value	description
reactivePower		Reactive power control.
voltage		Voltage control.

6.4.80 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. The ACDCTerminal.connected at the two sides of the switch shall not be considered for assessing switch connectivity, i.e. only Switch.open, .normalOpen and .locked are relevant.

Table 293 shows all attributes of Switch.

Table 293 – 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. The attribute shall be a positive value.
switchOnCount	0..1	Integer	(deprecated) The switch on count since the switch was last reset or initialized.
switchOnDate	0..1	DateTime	(deprecated) The date and time when the switch was last switched on.
retained	0..1	Boolean	Branch is retained in the topological solution. 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.
locked	0..1	Boolean	If true, the switch is locked. The resulting switch state is a combination of locked and Switch.open attributes as follows: – locked=true and Switch.open=true. The resulting state is open and locked; – locked=false and Switch.open=true. The resulting state is open; – locked=false and Switch.open=false. The resulting state is closed.
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 294 shows all association ends of Switch with other classes.

Table 294 – Association ends of Wires::Switch with other classes

mult from	name	mult to	type	description
1..1	SwitchPhase	0..*	SwitchPhase	The individual switch phases for the switch.
1..1	SwitchSchedules	0..*	SwitchSchedule	A Switch can be associated with SwitchSchedules.
0..*	CompositeSwitch	0..1	CompositeSwitch	Composite switch to which this Switch belongs.
1..1	SvSwitch	0..*	SvSwitch	The switch state associated with the switch.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.81 SwitchPhase

Single phase of a multi-phase switch when its attributes might be different per phase.

Table 295 shows all attributes of SwitchPhase.

Table 295 – 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
ratedCurrent	0..1	CurrentFlow	The maximum continuous current carrying capacity in amps governed by the device material and construction. The attribute shall be a positive value.
aliasName	0..1	String	inherited 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 SwitchPhase with other classes.

Table 296 – 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

6.4.82 SwitchSchedule

A schedule of switch positions. If RegularTimePoint.value1 is 0, the switch is open. If 1, the switch is closed.

Table 297 shows all attributes of SwitchSchedule.

Table 297 – 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
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	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 298 shows all association ends of SwitchSchedule with other classes.

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Table 298 – 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

6.4.83 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 299 shows all attributes of SynchronousMachine.

Table 299 – 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. (4.6.1.2 in IEC 60909-0:2001). Used only for single fed short circuit on a generator. (4.3.4.2. in IEC 60909-0:2001).

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name	mult	type	description
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 IEC 60909-0). Used only for single fed short circuit on a generator (Section 4.3.4.2. in IEC 60909-0).
operatingMode	0..1	SynchronousMachineOperatingMode	Current mode of operation.
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 participating devices 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. (4.3.4.2. in IEC 60909-0:2001).
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 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

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name	mult	type	description
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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 300 shows all association ends of SynchronousMachine with other classes.

Table 300 – Association ends of Wires::SynchronousMachine with other classes

mult from	name	mult to	type	description
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.
0..*	PrimeMovers	0..*	PrimeMover	Prime movers that drive this SynchronousMachine.
1..1	SynchronousMachineDynamics	0..1	SynchronousMachineDynamics	Synchronous machine dynamics model used to describe dynamic behaviour of this synchronous machine.
1..1	HydroPump	0..1	HydroPump	inherited from: RotatingMachine
0..*	GeneratingUnit	0..1	GeneratingUnit	inherited from: RotatingMachine
1..*	RegulatingControl	0..1	RegulatingControl	inherited from: RegulatingCondEq
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.84 SynchronousMachineOperatingMode enumeration

Synchronous machine operating mode.

Table 301 shows all literals of SynchronousMachineOperatingMode.

Table 301 – Literals of Wires::SynchronousMachineOperatingMode

literal	value	description
generator		Operating as generator.
condenser		Operating as condenser.
motor		Operating as motor.

6.4.85 SynchronousMachineKind enumeration

Synchronous machine type.

Table 302 shows all literals of SynchronousMachineKind.

Table 302 – Literals of Wires::SynchronousMachineKind

literal	value	description
generator		Indicates the synchronous machine can operate as a generator.
condenser		Indicates the synchronous machine can operate as a condenser.
generatorOrCondenser		Indicates the synchronous machine can operate as a generator or as a condenser.
motor		Indicates the synchronous machine can operate as a motor.
generatorOrMotor		Indicates the synchronous machine can operate as a generator or as a motor.
motorOrCondenser		Indicates the synchronous machine can operate as a motor or as a condenser.
generatorOrCondenserOrMotor		Indicates the synchronous machine can operate as a generator or as a condenser or as a motor.

6.4.86 TapChanger

Mechanism for changing transformer winding tap positions.

Table 303 shows all attributes of TapChanger.

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Table 303 – 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 to or greater than lowStep and equal or less than highStep. It is the step position where the voltage is neutralU when the other terminals of the transformer are at the ratedU. If there are other tap changers on the transformer those taps are kept constant at their neutralStep.
neutralU	0..1	Voltage	Voltage at which the winding operates at the neutral tap setting. It is the voltage at the terminal of the PowerTransformerEnd associated with the tap changer when all tap changers on the transformer are at their neutralStep position. Normally neutralU of the tap changer is the same as ratedU of the PowerTransformerEnd, but it can differ in special cases such as when the tapping mechanism is separate from the winding more common on lower voltage transformers. This attribute is not relevant for PhaseTapChangerAsymmetrical, PhaseTapChangerSymmetrical and PhaseTapChangerLinear.
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 to 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

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Table 304 shows all association ends of TapChanger with other classes.

Table 304 – Association ends of Wires::TapChanger with other classes

mult from	name	mult to	type	description
1..*	TapChangerControl	0..1	TapChangerControl	The regulating control scheme in which this tap changer participates.
1..1	SvTapStep	0..1	SvTapStep	The tap step state associated with the tap changer.
1..1	TapSchedules	0..*	TapSchedule	A TapChanger can have TapSchedules.
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

6.4.87 TapChangerControl

Describes behaviour 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 305 shows all attributes of TapChangerControl.

Table 305 – 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
maxAllowedTargetValue	0..1	Float	inherited from: RegulatingControl

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name	mult	type	description
minAllowedTargetValue	0..1	Float	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 306 shows all association ends of TapChangerControl with other classes.

Table 306 – Association ends of Wires::TapChangerControl with other classes

mult from	name	mult to	type	description
0..1	TapChanger	1..*	TapChanger	The tap changers that participates in this regulating tap control scheme.
0..*	Terminal	0..1	Terminal	inherited from: RegulatingControl
0..1	RegulatingCondEq	1..*	RegulatingCondEq	inherited from: RegulatingControl
1..1	RegulationSchedule	0..*	RegulationSchedule	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

6.4.88 TapChangerTablePoint root class

Describes each tap step in the tabular curve.

Table 307 shows all attributes of TapChangerTablePoint.

Table 307 – 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.

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name	mult	type	description
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 at the tap step divided by rated voltage of the transformer end having the tap changer. Hence this is a value close to one. For example, if the ratio at step 1 is 1.01, and the rated voltage of the transformer end is 110kV, then the voltage obtained by setting the tap changer to step 1 to is 111.1kV.
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.

6.4.89 TapSchedule

A pre-established pattern over time for a tap step.

Table 308 shows all attributes of TapSchedule.

Table 308 – 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
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	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 309 shows all association ends of TapSchedule with other classes.

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Table 309 – 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

6.4.90 TransformerControlMode enumeration

Control modes for a transformer.

Table 310 shows all literals of TransformerControlMode.

Table 310 – Literals of Wires::TransformerControlMode

literal	value	description
volt		Voltage control.
reactive		Reactive power flow control.

6.4.91 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 311 shows all attributes of TransformerCoreAdmittance.

Table 311 – 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 312 shows all association ends of TransformerCoreAdmittance with other classes.

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Table 312 – 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

6.4.92 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 313 shows all attributes of TransformerEnd.

Table 313 – 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 314 shows all association ends of TransformerEnd with other classes.

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Table 314 – 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	PhaseTapChanger	0..1	PhaseTapChanger	Phase tap changer associated with this transformer end.
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).
0..*	CoreAdmittance	0..1	TransformerCoreAdmittance	Core admittance of this transformer end, representing magnetising 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

6.4.93 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 transformer end associations are 1. However, in cases where two or more transformer ends are modelled the cardinalities are larger than 1.

Table 315 shows all attributes of TransformerMeshImpedance.

Table 315 – 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

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Table 316 shows all association ends of TransformerMeshImpedance with other classes.

Table 316 – 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

6.4.94 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).

Table 317 shows all attributes of TransformerStarImpedance.

Table 317 – 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

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Table 318 shows all association ends of TransformerStarImpedance with other classes.

Table 318 – 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

6.4.95 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 placed in the same tank. Transformer tank can be used to model both single-phase and 3-phase transformers.

Table 319 shows all attributes of TransformerTank.

Table 319 – Attributes of Wires::TransformerTank

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 320 shows all association ends of TransformerTank with other classes.

Table 320 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.4.96 TransformerTankEnd

Transformer tank end represents an individual winding for unbalanced models or for transformer tanks connected into a bank (and bank is modelled with the PowerTransformer).

Table 321 shows all attributes of TransformerTankEnd.

Table 321 – 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 322 shows all association ends of TransformerTankEnd with other classes.

Table 322 – 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	PhaseTapChanger	0..1	PhaseTapChanger	inherited from: TransformerEnd
1..1	RatioTapChanger	0..1	RatioTapChanger	inherited from: TransformerEnd
0..*	StarImpedance	0..1	TransformerStarImpedance	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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6.4.97 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 bus bar section whose voltage will be controlled.

Table 323 shows all attributes of VoltageControlZone.

Table 323 – 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 324 shows all association ends of VoltageControlZone with other classes.

Table 324 – 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

6.4.98 WireSegment

A two terminal and power conducting device of negligible impedance and length represented as zero impedance device that can be used to connect auxiliary equipment to its terminals.

Table 325 shows all attributes of WireSegment.

Table 325 – Attributes of Wires::WireSegment

name	mult	type	description
length	0..1	Length	inherited from: Conductor
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 326 shows all association ends of WireSegment with other classes.

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Table 326 – Association ends of Wires::WireSegment with other classes

mult from	name	mult to	type	description
1..1	WireSegmentPhases	0..*	WireSegmentPhase	The wire segment phases which belong to the wire segment.
0..*	BaseVoltage	0..1	BaseVoltage	inherited from: ConductingEquipment
1..1	SvStatus	0..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.4.99 WireSegmentPhase

Represents a single wire of an alternating current wire segment.

Table 327 shows all attributes of WireSegmentPhase.

Table 327 – Attributes of Wires::WireSegmentPhase

name	mult	type	description
phase	0..1	SinglePhaseKind	The phase connection of the wire at both ends.
sequenceNumber	0..1	Integer	Number designation for this wire segment phase. Each wire segment phase within a wire segment should have a unique sequence number.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 328 shows all association ends of WireSegmentPhase with other classes.

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Table 328 – Association ends of Wires::WireSegmentPhase with other classes

mult from	name	mult to	type	description
0..*	WireSegment	1..1	WireSegment	The wire 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

6.4.100 WindingConnection enumeration

Winding connection type.

Table 329 shows all literals of WindingConnection.

Table 329 – 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.

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6.5 Package LoadModel

6.5.1 General

This package is responsible for modelling the energy consumers and the system load as curves and associated curve data. Special circumstances that may affect the load, such as seasons and day types, are also included here.

This information is used by Load Forecasting and Load Management.

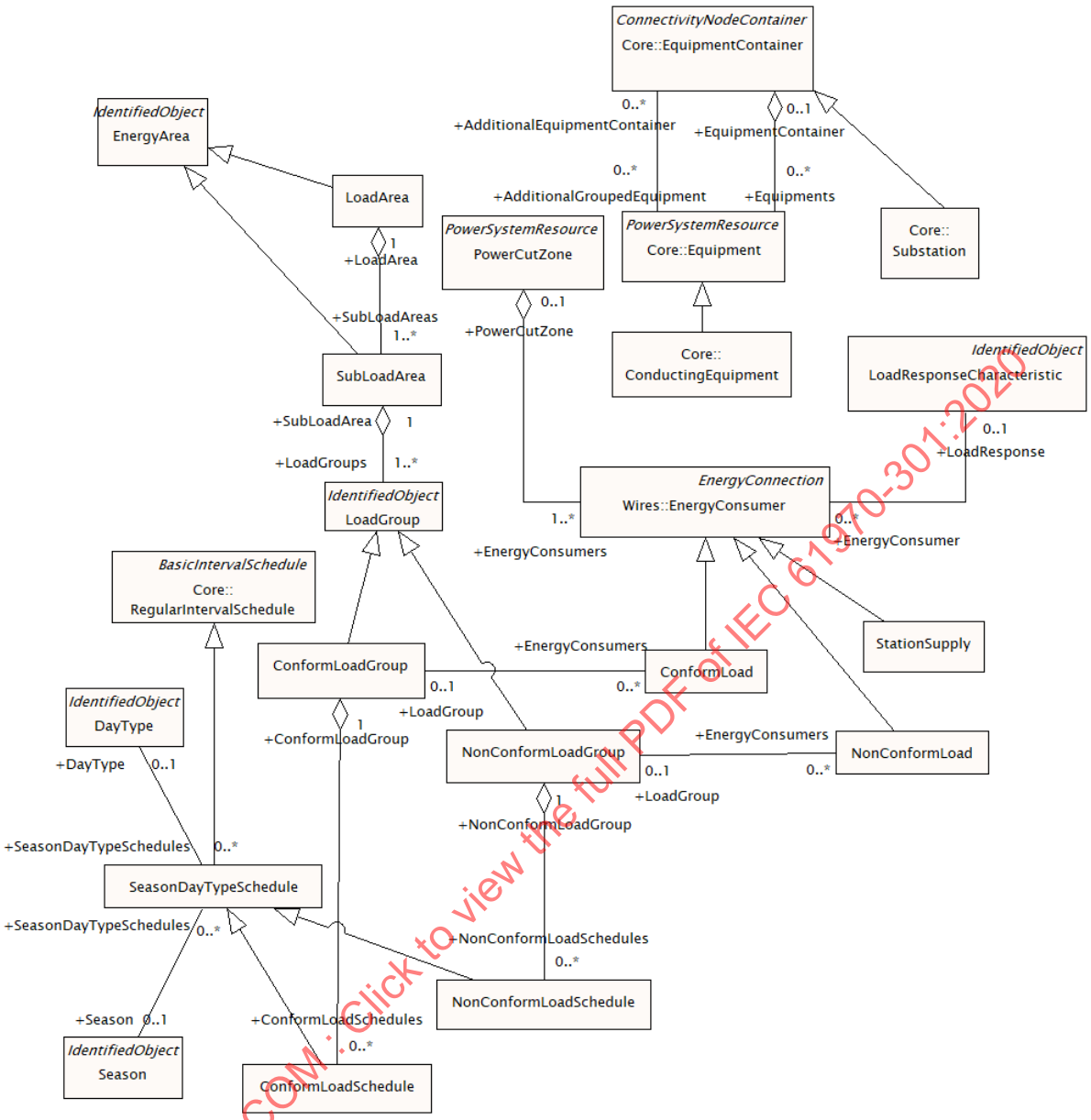


Figure 102 – Class diagram LoadModel::Main

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Figure 102: This diagram shows all classes included in the LoadModel package as well as the key external classes that have associations with LoadModel classes.

6.5.2 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 330 shows all attributes of ConformLoad.

Table 330 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 331 shows all association ends of ConformLoad with other classes.

Table 331 – Association ends of LoadModel::ConformLoad with other classes

mult from	name	mult to	type	description
0..*	LoadGroup	0..1	ConformLoadGroup	Group of this ConformLoad.
0..*	LoadResponse	0..1	LoadResponseCharacteristic	inherited from: EnergyConsumer
1..1	EnergyConsumerPhase	0..*	EnergyConsumerPhase	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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.5.3 ConformLoadGroup

A group of loads conforming to an allocation pattern.

Table 332 shows all attributes of ConformLoadGroup.

Table 332 – 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 333 shows all association ends of ConformLoadGroup with other classes.

Table 333 – 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	0..*	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

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6.5.4 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 334 shows all attributes of ConformLoadSchedule.

Table 334 – 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
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	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 335 shows all association ends of ConformLoadSchedule with other classes.

Table 335 – Association ends of LoadModel::ConformLoadSchedule with other classes

mult from	name	mult to	type	description
0..*	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

6.5.5 DayType

Group of similar days. For example it could be used to represent weekdays, weekend, or holidays.

Table 336 shows all attributes of DayType.

Table 336 – 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 337 shows all association ends of DayType with other classes.

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Table 337 – 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

6.5.6 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 338 shows all attributes of EnergyArea.

Table 338 – 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 339 shows all association ends of EnergyArea with other classes.

Table 339 – 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

6.5.7 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 340 shows all attributes of LoadArea.

Table 340 – 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 341 shows all association ends of LoadArea with other classes.

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Table 341 – 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

6.5.8 LoadGroup

The class is the third level in a hierarchical structure for grouping of loads for the purpose of load flow load scaling.

Table 342 shows all attributes of LoadGroup.

Table 342 – 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 343 shows all association ends of LoadGroup with other classes.

Table 343 – 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

6.5.9 LoadResponseCharacteristic

Models the characteristic response of the load demand due to changes in system conditions such as voltage and frequency. It is not related to demand response.

If LoadResponseCharacteristic.exponentModel is True, the exponential voltage or frequency dependent models are specified and used as to calculate active and reactive power components of the load model.

The equations to calculate active and reactive power components of the load model are internal to the power flow calculation, hence they use different quantities depending on the use case of the data exchange.

The equations for exponential voltage dependent load model injected power are:

pInjection= Pnominal* (Voltage/cim:BaseVoltage.nominalVoltage) ** cim:LoadResponseCharacteristic.pVoltageExponent

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qInjection= Qnominal* (Voltage/cim:BaseVoltage.nominalVoltage) ** cim:LoadResponseCharacteristic.qVoltageExponent

Where:

1) * means "multiply" and ** is "raised to power of";
2) Pnominal and Qnominal represent the active power and reactive power at nominal voltage as any load described by the voltage exponential model shall be given at nominal voltage. This means that EnergyConsumer.p and EnergyConsumer.q are at nominal voltage.
3) After power flow is solved:
   – pInjection and qInjection correspond to SvPowerflow.p and SvPowerflow.q respectively.
   – Voltage corresponds to SvVoltage.v at the TopologicalNode where the load is connected.

Table 344 shows all attributes of LoadResponseCharacteristic.

Table 344 – 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 consists of the attributes: – pVoltageExponent – qVoltageExponent – pFrequencyExponent – qFrequencyExponent. The coefficient model consists 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 modelled as constant current.
pConstantImpedance	0..1	Float	Portion of active power load modelled as constant impedance.
pConstantPower	0..1	Float	Portion of active power load modelled 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 modelled as constant current.
qConstantImpedance	0..1	Float	Portion of reactive power load modelled as constant impedance.

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name	mult	type	description
qConstantPower	0..1	Float	Portion of reactive power load modelled 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 345 shows all association ends of LoadResponseCharacteristic with other classes.

Table 345 – 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

6.5.10 NonConformLoad

NonConformLoad represents loads that do not follow a daily load change pattern and whose changes are not correlated with the daily load change pattern.

Table 346 shows all attributes of NonConformLoad.

Table 346 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 347 shows all association ends of NonConformLoad with other classes.

Table 347 – Association ends of LoadModel::NonConformLoad with other classes

mult from	name	mult to	type	description
0..*	LoadGroup	0..1	NonConformLoadGroup	Group of this ConformLoad.
0..*	LoadResponse	0..1	LoadResponseCharacteristic	inherited from: EnergyConsumer
1..1	EnergyConsumerPhase	0..*	EnergyConsumerPhase	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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.5.11 NonConformLoadGroup

Loads that do not follow a daily and seasonal load variation pattern.

Table 348 shows all attributes of NonConformLoadGroup.

Table 348 – 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 349 shows all association ends of NonConformLoadGroup with other classes.

Table 349 – 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	0..*	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

6.5.12 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 modelled).

Table 350 shows all attributes of NonConformLoadSchedule.

Table 350 – 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
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	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 351 shows all association ends of NonConformLoadSchedule with other classes.

Table 351 – Association ends of LoadModel::NonConformLoadSchedule with other classes

mult from	name	mult to	type	description
0..*	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

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6.5.13 PowerCutZone

An area or zone of the power system which is used for load shedding purposes.

Table 352 shows all attributes of PowerCutZone.

Table 352 – 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 353 shows all association ends of PowerCutZone with other classes.

Table 353 – 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

6.5.14 Season

A specified time period of the year.

Table 354 shows all attributes of Season.

Table 354 – 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

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Table 355 shows all association ends of Season with other classes.

Table 355 – 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

6.5.15 SeasonDayTypeSchedule

A time schedule covering a 24 hour period, with curve data for a specific type of season and day.

Table 356 shows all attributes of SeasonDayTypeSchedule.

Table 356 – 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
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	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 357 shows all association ends of SeasonDayTypeSchedule with other classes.

Table 357 – 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

6.5.16 StationSupply

Station supply with load derived from the station output.

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Table 358 shows all attributes of StationSupply.

Table 358 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 359 shows all association ends of StationSupply with other classes.

Table 359 – Association ends of LoadModel::StationSupply with other classes

mult from	name	mult to	type	description
0..*	LoadResponse	0..1	LoadResponseCharacteristic	inherited from: EnergyConsumer
1..1	EnergyConsumerPhase	0..*	EnergyConsumerPhase	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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.5.17 SubLoadArea

The class is the second level in a hierarchical structure for grouping of loads for the purpose of load flow load scaling.

Table 360 shows all attributes of SubLoadArea.

Table 360 – 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 361 shows all association ends of SubLoadArea with other classes.

Table 361 – 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

6.6 Package Generation

6.6.1 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 Training Simulation.

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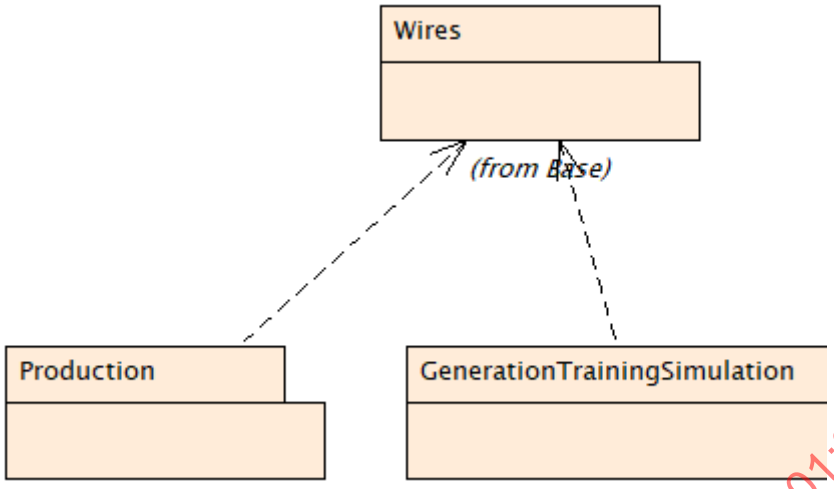


Figure 103 – Class diagram Generation::Main

Figure 103: This diagram shows the main generation packages and their dependency relationships to other packages.

6.6.2 Package GenerationTrainingSimulation

6.6.2.1 General

The GenerationTrainingSimululation package contains prime movers, such as turbines and boilers, which are needed for simulation and educational purposes.

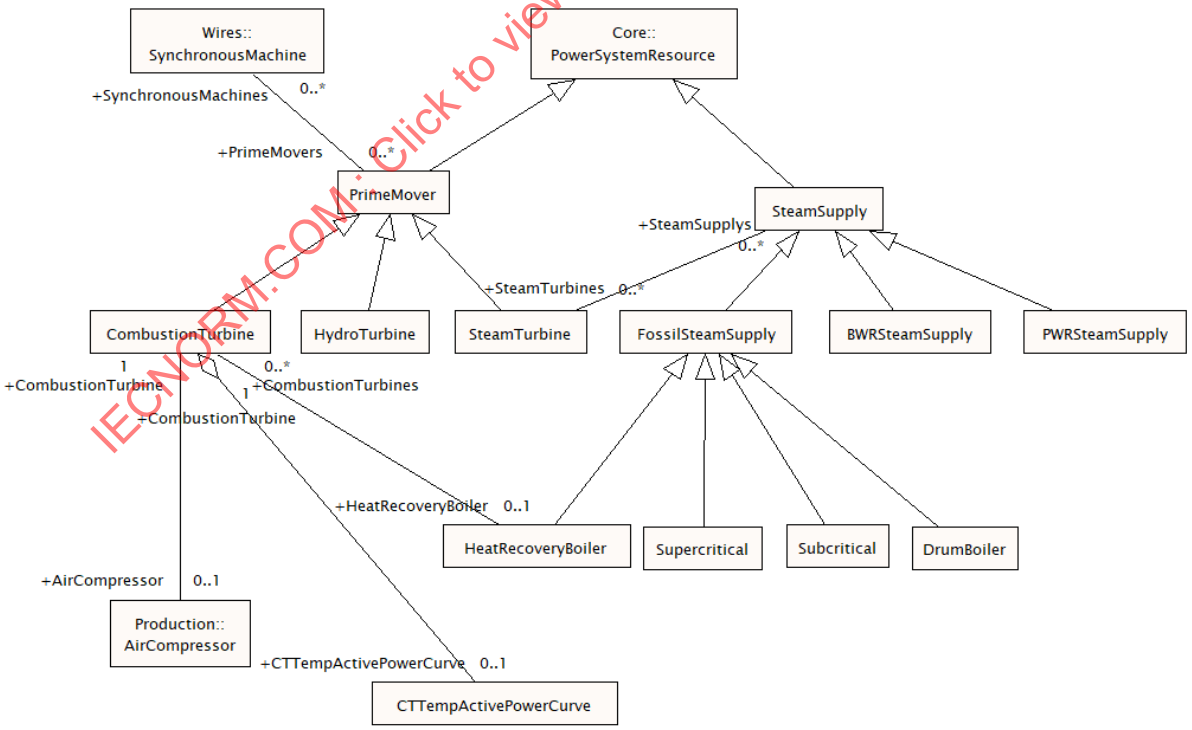


Figure 104 – Class diagram GenerationTrainingSimulation::Main

Figure 104: This diagram shows all classes included in the GenerationDynamics package as well as the key external classes that have associations with these classes.

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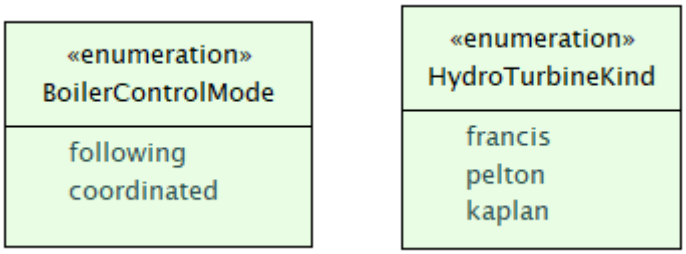


Figure 105 – Class diagram GenerationTrainingSimulation::Datatypes

Figure 105: This diagram shows the data types specific to the GenerationTrainingSimulation package.

6.6.2.2 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 modelling 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 modelling 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 modelling 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 modelling 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 modelling 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 modelling 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 modelling the effect of off-nominal frequency and voltage on recirculation and core flow, which affects the BWR power output.

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name	mult	type	description
rfAux8	0..1	PU	Coefficient for modelling 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.

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

6.6.2.3 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.

6.6.2.4 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.

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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

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

6.6.2.5 CombustionTurbine

A prime mover that is typically fuelled 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 modelling 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).

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name	mult	type	description
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.

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

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6.6.2.6 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
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.

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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

6.6.2.7 FossilSteamSupply

Fossil fuelled 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.
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.

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name	mult	type	description
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

6.6.2.8 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

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name	mult	type	description
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.

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

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6.6.2.9 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. The attribute shall be a positive value.
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. The attribute shall be a positive value.
turbineType	0..1	HydroTurbineKind	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.

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

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6.6.2.10 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.

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

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6.6.2.11 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

6.6.2.12 SteamSupply

Steam supply for steam turbine.

Table 381 shows all attributes of SteamSupply.

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.

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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

6.6.2.13 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.
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.

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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

6.6.2.14 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
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

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name	mult	type	description
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

6.6.2.15 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

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name	mult	type	description
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.

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

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6.6.2.16 HydroTurbineKind enumeration

Type of turbine.

Table 389 shows all literals of HydroTurbineKind.

Table 389 – Literals of GenerationTrainingSimulation::HydroTurbineKind

literal	value	description
francis		Francis.
pelton		Pelton.
kaplan		Kaplan.

6.6.3 Package Production

6.6.3.1 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.

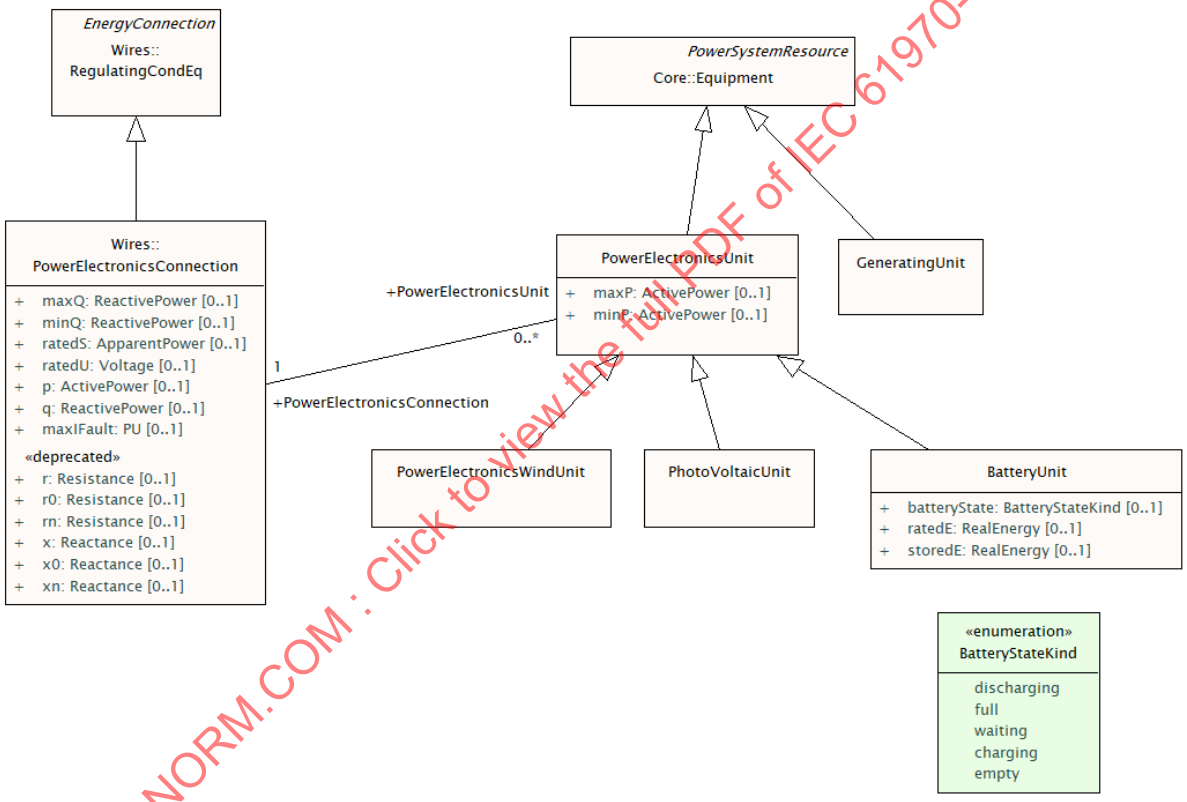


Figure 106 – Class diagram Production::PowerElectronics

Figure 106: This diagram shows power electronics classes and inheritance.

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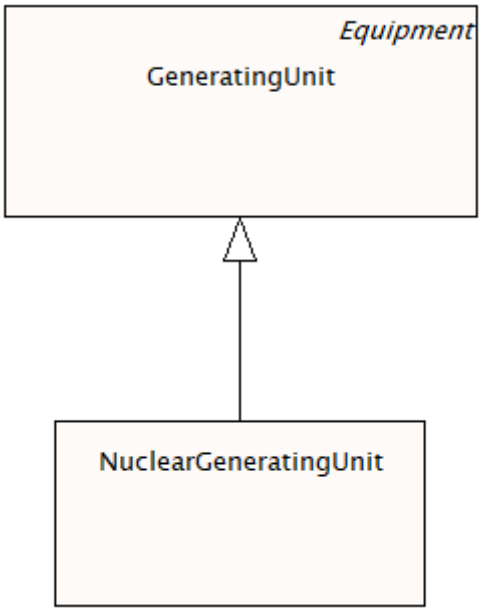


Figure 107 – Class diagram Production::Nuclear

Figure 107: This diagram shows nuclear generation inheritance.

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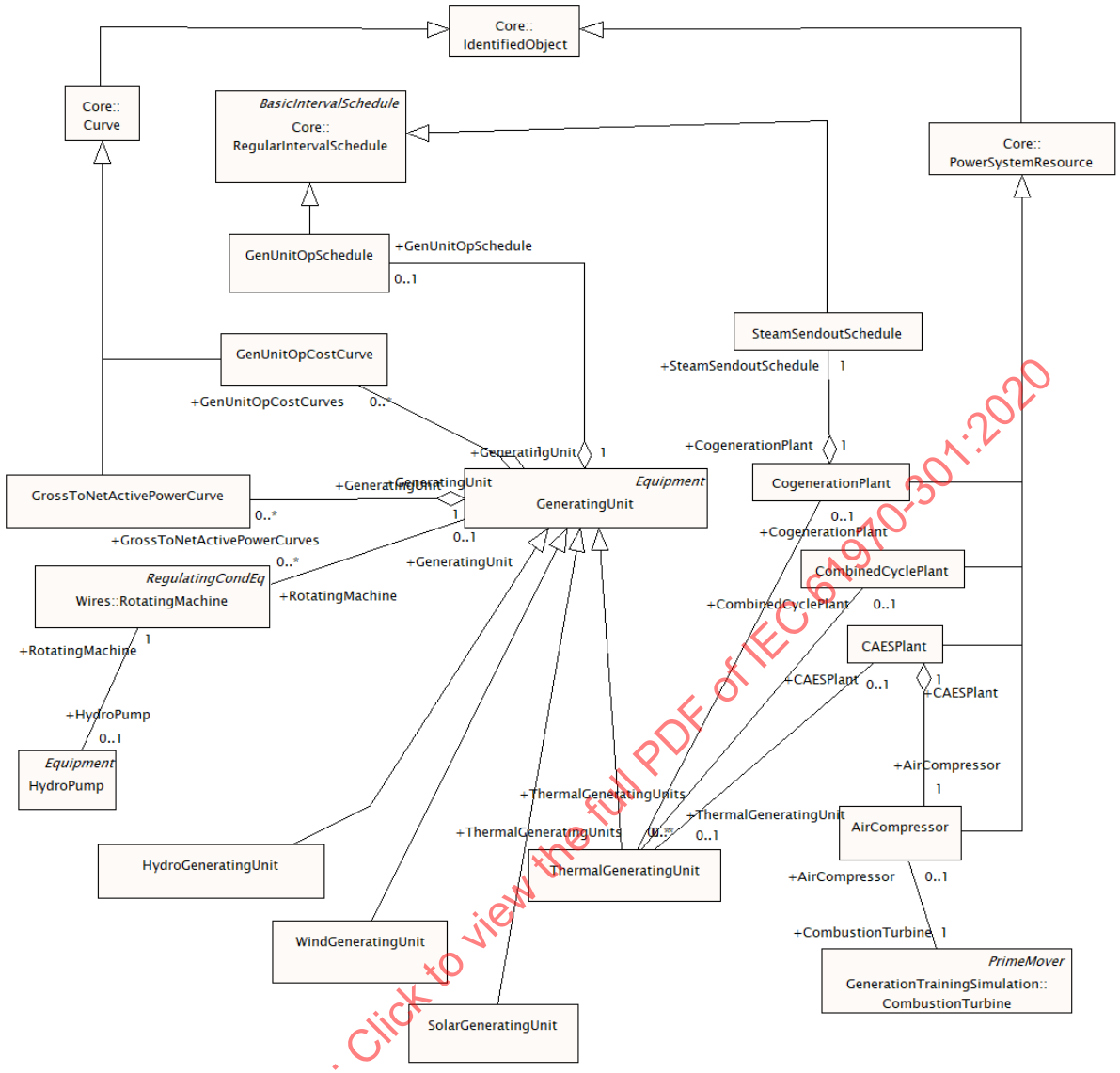


Figure 108 – Class diagram Production::Main

Figure 108: 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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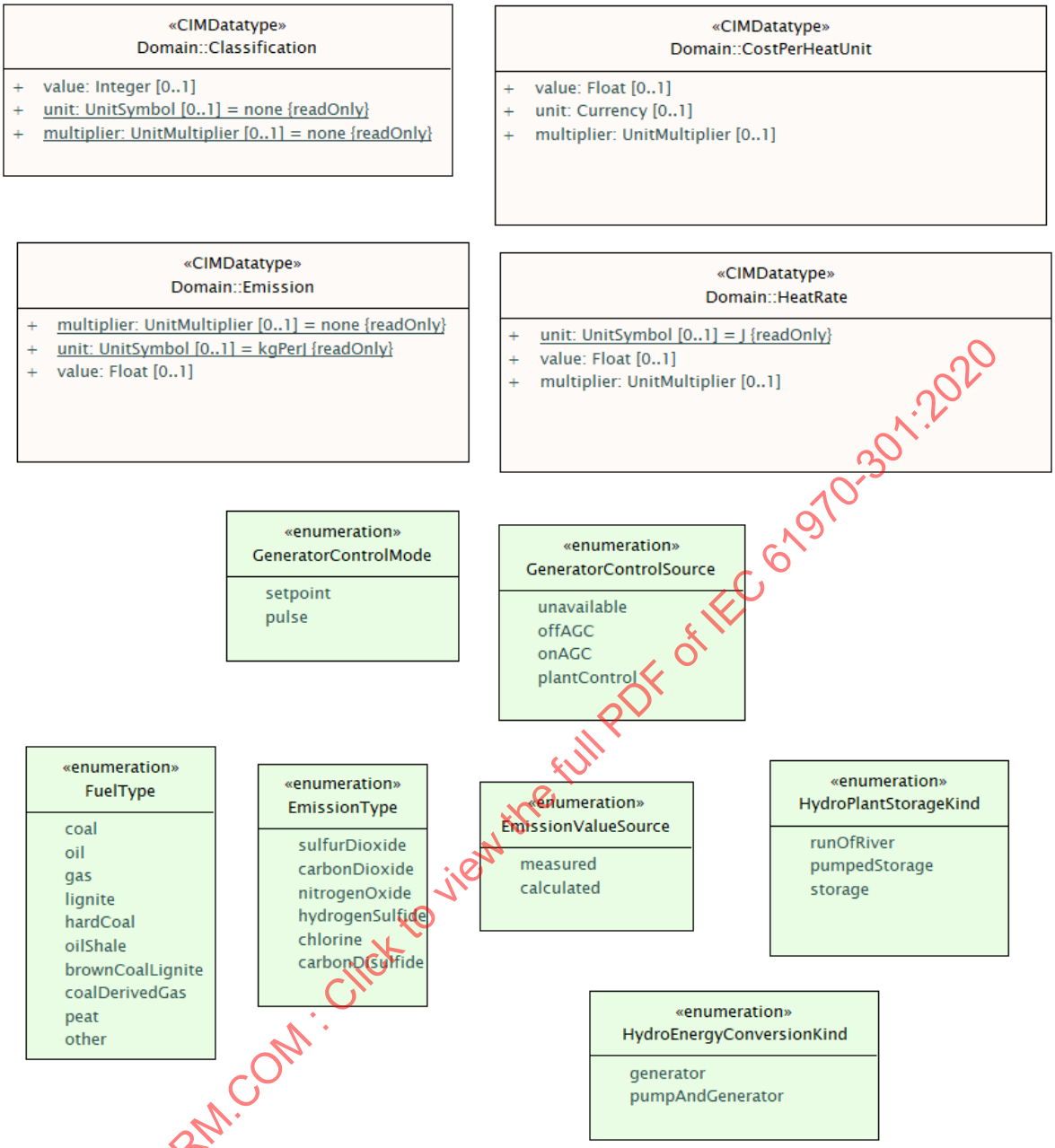


Figure 109 – Class diagram Production::Datatypes

Figure 109: This diagram show the data types specific to the Production package.

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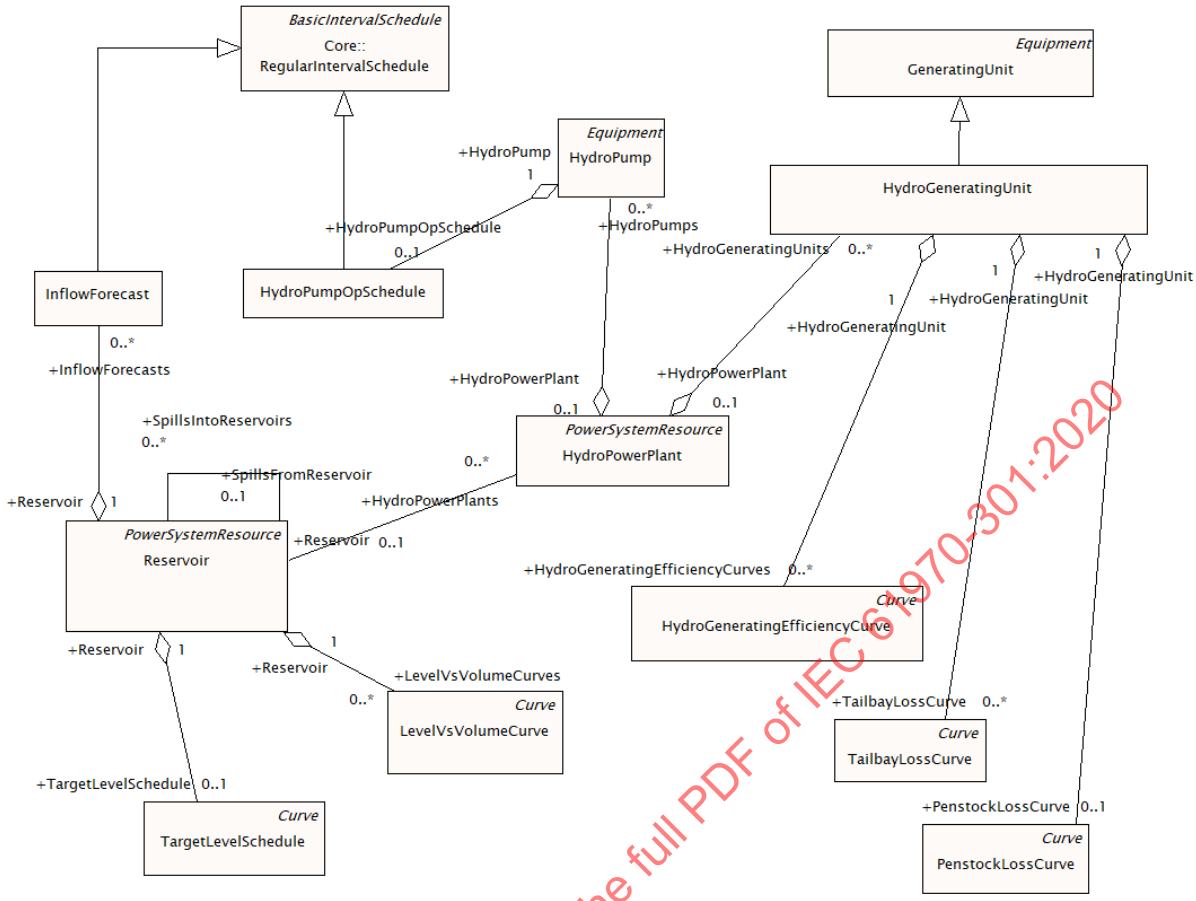


Figure 110 – Class diagram Production::Hydro

Figure 110: 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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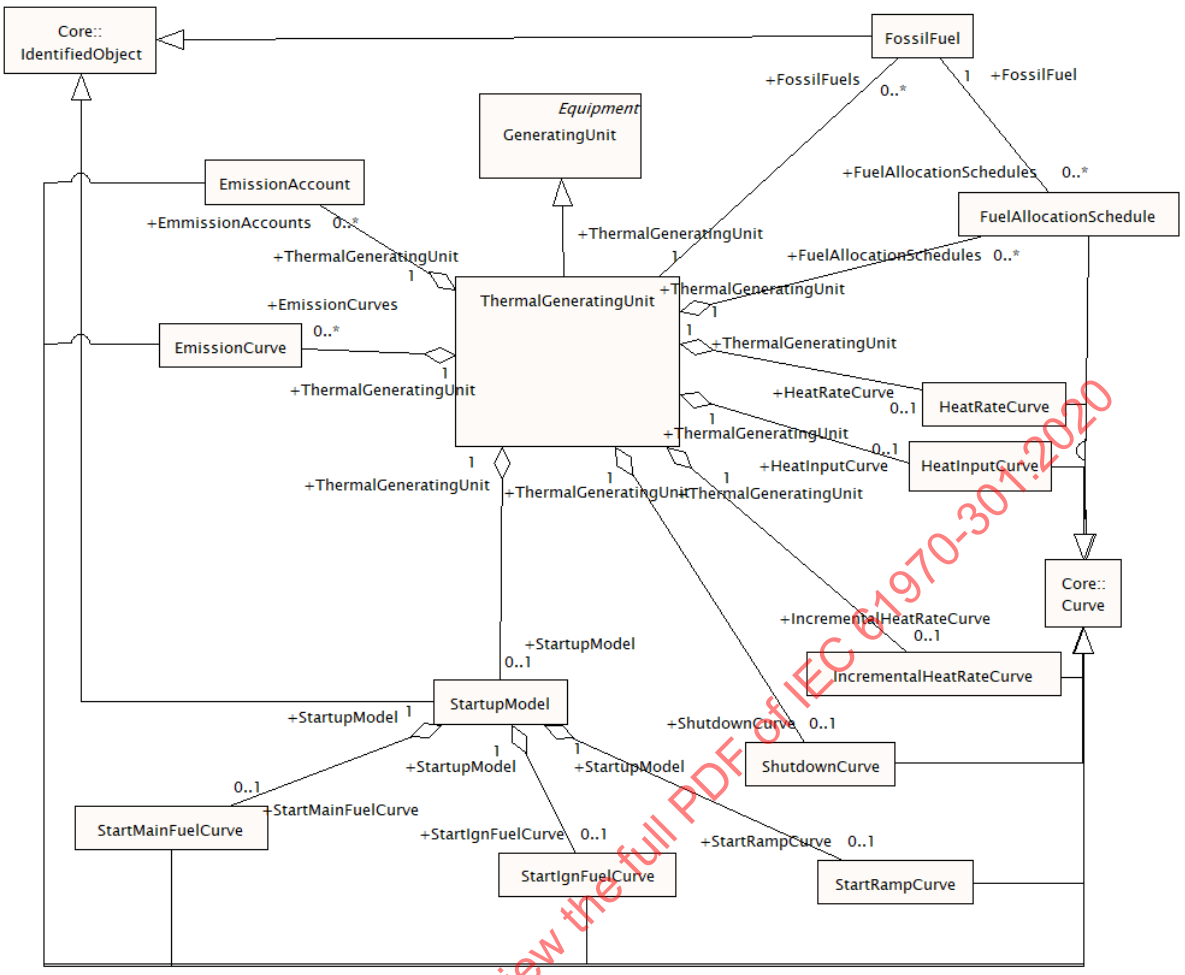


Figure 111 – Class diagram Production::Thermal

Figure 111: This diagram shows all classes included in the Thermal package as well as the key external classes that have associations with Thermal classes.

6.6.3.2 AirCompressor

Combustion turbine air compressor which is an integral part of a compressed air energy storage (CAES) plant.

Table 390 shows all attributes of AirCompressor.

Table 390 – 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 391 shows all association ends of AirCompressor with other classes.

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Table 391 – 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

6.6.3.3 BatteryStateKind enumeration

The state of the battery unit.

Table 392 shows all literals of BatteryStateKind.

Table 392 – Literals of Production::BatteryStateKind

literal	value	description
discharging		Stored energy is decreasing.
full		Unable to charge, and not discharging.
waiting		Neither charging nor discharging, but able to do so.
charging		Stored energy is increasing.
empty		Unable to discharge, and not charging.

6.6.3.4 BatteryUnit

An electrochemical energy storage device.

Table 393 shows all attributes of BatteryUnit.

Table 393 – Attributes of Production::BatteryUnit

name	mult	type	description
batteryState	0..1	BatteryStateKind	The current state of the battery (charging, full, etc.).
ratedE	0..1	RealEnergy	Full energy storage capacity of the battery. The attribute shall be a positive value.
storedE	0..1	RealEnergy	Amount of energy currently stored. The attribute shall be a positive value or zero and lower than BatteryUnit.ratedE.
maxP	0..1	ActivePower	inherited from: PowerElectronicsUnit
minP	0..1	ActivePower	inherited from: PowerElectronicsUnit
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment

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name	mult	type	description
networkAnalysisEnabled	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 394 shows all association ends of BatteryUnit with other classes.

Table 394 – Association ends of Production::BatteryUnit with other classes

mult from	name	mult to	type	description
0..*	PowerElectronicsConnection	1..1	PowerElectronicsConnection	inherited from: PowerElectronicsUnit
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.6.3.5 CAESPlant

Compressed air energy storage plant.

Table 395 shows all attributes of CAESPlant.

Table 395 – Attributes of Production::CAESPlant

name	mult	type	description
energyStorageCapacity	0..1	RealEnergy	The rated energy storage capacity. The attribute shall be a positive value.
ratedCapacityP	0..1	ActivePower	The CAES plant's gross rated generating capacity. The attribute shall be a positive value.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 396 shows all association ends of CAESPlant with other classes.

Table 396 – 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

6.6.3.6 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 397 shows all attributes of CogenerationPlant.

Table 397 – 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. The attribute shall be a positive value.
aliasName	0..1	String	inherited from: IdentifiedObject
description	0..1	String	inherited from: IdentifiedObject
mRID	0..1	String	inherited from: IdentifiedObject
name	0..1	String	inherited from: IdentifiedObject

Table 398 shows all association ends of CogenerationPlant with other classes.

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Table 398 – 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

6.6.3.7 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 399 shows all attributes of CombinedCyclePlant.

Table 399 – 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 400 shows all association ends of CombinedCyclePlant with other classes.

Table 400 – 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

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6.6.3.8 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 401 shows all attributes of EmissionAccount.

Table 401 – 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 402 shows all association ends of EmissionAccount with other classes.

Table 402 – 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

6.6.3.9 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 403 shows all attributes of EmissionCurve.

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Table 403 – 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 404 shows all association ends of EmissionCurve with other classes.

Table 404 – 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

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6.6.3.10 EmissionType enumeration

The type of emission.

Table 405 shows all literals of EmissionType.

Table 405 – Literals of Production::EmissionType

literal	value	description
sulfurDioxide		Sulfur dioxide.
carbonDioxide		Carbon dioxide.
nitrogenOxide		Nitrogen oxide.
hydrogenSulfide		Hydrogen sulfide.
chlorine		Chlorine.
carbonDisulfide		Carbon disulfide.

6.6.3.11 WindGenUnitKind enumeration

Kind of wind generating unit.

Table 406 shows all literals of WindGenUnitKind.

Table 406 – Literals of Production::WindGenUnitKind

literal	value	description
offshore		The wind generating unit is located offshore.
onshore		The wind generating unit is located onshore.

6.6.3.12 EmissionValueSource enumeration

The source of the emission value.

Table 407 shows all literals of EmissionValueSource.

Table 407 – Literals of Production::EmissionValueSource

literal	value	description
measured		Measured.
calculated		Calculated.

6.6.3.13 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 408 shows all attributes of FossilFuel.

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Table 408 – 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 409 shows all association ends of FossilFuel with other classes.

Table 409 – Association ends of Production::FossilFuel with other classes

mult from	name	mult to	type	description
1..1	FuelAllocationSchedules	0..*	FuelAllocationSchedule	A fuel allocation schedule shall have a fossil fuel.
0..*	ThermalGeneratingUnit	1..1	ThermalGeneratingUnit	A thermal generating unit may have one or more fossil fuels.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.6.3.14 FuelAllocationSchedule

The amount of fuel of a given type which is allocated for consumption over a specified period of time.

Table 410 shows all attributes of FuelAllocationSchedule.

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Table 410 – 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 411 shows all association ends of FuelAllocationSchedule with other classes.

Table 411 – 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

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6.6.3.15 FuelType enumeration

Type of fuel.

Table 412 shows all literals of FuelType.

Table 412 – 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.
brownCoalLignite		Brown coal lignite.
coalDerivedGas		Coal derived gas.
peat		Peat.
other		Any fuel type not included in the rest of the enumerated value.

6.6.3.16 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 413 shows all attributes of GenUnitOpCostCurve.

Table 413 – 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 414 shows all association ends of GenUnitOpCostCurve with other classes.

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Table 414 – 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

6.6.3.17 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 415 shows all attributes of GenUnitOpSchedule.

Table 415 – 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
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	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 416 shows all association ends of GenUnitOpSchedule with other classes.

Table 416 – 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

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6.6.3.18 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 417 shows all attributes of GeneratingUnit.

Table 417 – 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. Defines the control status of the 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.

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name	mult	type	description
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.
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. The sum of the participation factors across generating units does not have to sum to one. It is used for representing distributed slack participation factor. The attribute shall be a positive value or zero.
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). The attribute shall be a positive 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. The attribute shall be a positive value.
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. The attribute shall be a positive value.
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.

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name	mult	type	description
variableCost	0..1	Money	The variable cost component of production per unit of ActivePower.
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 418 shows all association ends of GeneratingUnit with other classes.

Table 418 – Association ends of Production::GeneratingUnit with other classes

mult from	name	mult to	type	description
0..1	RotatingMachine	0..*	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	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.
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.
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.6.3.19 GeneratorControlMode enumeration

Unit control modes.

Table 419 shows all literals of GeneratorControlMode.

Table 419 – Literals of Production::GeneratorControlMode

literal	value	description
setpoint		Setpoint control mode.
pulse		Pulse control mode.

6.6.3.20 GeneratorControlSource enumeration

The source of controls for a generating unit.

Table 420 shows all literals of GeneratorControlSource.

Table 420 – 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.

6.6.3.21 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 modelled, 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 421 shows all attributes of GrossToNetActivePowerCurve.

Table 421 – 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

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Table 422 shows all association ends of GrossToNetActivePowerCurve with other classes.

Table 422 – 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

6.6.3.22 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 423 shows all attributes of HeatInputCurve.

Table 423 – 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 424 shows all association ends of HeatInputCurve with other classes.

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Table 424 – 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

6.6.3.23 HeatRateCurve

Relationship between unit heat rate per active power (Y-axis) and unit output (X-axis). The heat input is from all fuels.

Table 425 shows all attributes of HeatRateCurve.

Table 425 – 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 426 shows all association ends of HeatRateCurve with other classes.

Table 426 – 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

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6.6.3.24 HydroEnergyConversionKind enumeration

Specifies the capability of the hydro generating unit to convert energy as a generator or pump.

Table 427 shows all literals of HydroEnergyConversionKind.

Table 427 – 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.

6.6.3.25 HydroGeneratingEfficiencyCurve

Relationship between unit efficiency as percentage and unit output active power for a given net head in meters. The relationship between efficiency, discharge, head, and power output is expressed as follows:

$$E = KP/HQ$$

where: E is the efficiency, as a percentage; P is the active power; H is the height; Q is the discharge, volume/time unit; K is a constant.

For example, a curve instance for a given net head could show efficiency (Y-axis) versus active power output (X-axis) or versus discharge on the X-axis.

Table 428 shows all attributes of HydroGeneratingEfficiencyCurve.

Table 428 – 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

Table 429 shows all association ends of HydroGeneratingEfficiencyCurve with other classes.

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Table 429 – 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

6.6.3.26 HydroGeneratingUnit

A generating unit whose prime mover is a hydraulic turbine (e.g., Francis, Pelton, Kaplan).

Table 430 shows all attributes of HydroGeneratingUnit.

Table 430 – 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.
dropHeight	0..1	Length	The height water drops from the reservoir mid-point to the turbine.
turbineType	0..1	HydroTurbineKind	Type of 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

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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
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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 431 shows all association ends of HydroGeneratingUnit with other classes.

Table 431 – Association ends of Production::HydroGeneratingUnit with other classes

mult from	name	mult to	type	description
1..1	HydroGeneratingEfficiencyCurves	0..*	HydroGeneratingEfficiencyCurve	A hydro generating unit has an efficiency 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	PenstockLossCurve	0..1	PenstockLossCurve	A hydro generating unit has a penstock loss curve.
0..1	RotatingMachine	0..*	RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.6.3.27 HydroPlantStorageKind enumeration

The type of hydro power plant.

Table 432 shows all literals of HydroPlantStorageKind.

Table 432 – Literals of Production::HydroPlantStorageKind

literal	value	description
runOfRiver		Run of river.
pumpedStorage		Pumped storage.
storage		Storage.

6.6.3.28 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 433 shows all attributes of HydroPowerPlant.

Table 433 – 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. The attribute shall be a positive value.
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. The attribute shall be a positive value.
pumpRatedP	0..1	ActivePower	The hydro plant's pumping rating active power for rated head conditions.

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name	mult	type	description
			The attribute shall be a positive value.
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 434 shows all association ends of HydroPowerPlant with other classes.

Table 434 – 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

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6.6.3.29 HydroPump

A synchronous motor-driven pump, typically associated with a pumped storage plant.

Table 435 shows all attributes of HydroPump.

Table 435 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 436 shows all association ends of HydroPump with other classes.

Table 436 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.6.3.30 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 437 shows all attributes of HydroPumpOpSchedule.

Table 437 – 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
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	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 438 shows all association ends of HydroPumpOpSchedule with other classes.

Table 438 – 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

6.6.3.31 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 439 shows all attributes of IncrementalHeatRateCurve.

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Table 439 – 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 440 shows all association ends of IncrementalHeatRateCurve with other classes.

Table 440 – 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

6.6.3.32 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 meters per second over the time increment.

Table 441 shows all attributes of InflowForecast.

Table 441 – 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
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule

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name	mult	type	description
value2Unit	0..1	UnitSymbol	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 442 shows all association ends of InflowForecast with other classes.

Table 442 – 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

6.6.3.33 LevelVsVolumeCurve

Relationship between reservoir volume and reservoir level. The volume is at the Y-axis and the reservoir level at the X-axis.

Table 443 shows all attributes of LevelVsVolumeCurve.

Table 443 – 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 444 shows all association ends of LevelVsVolumeCurve with other classes.

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Table 444 – 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

6.6.3.34 NuclearGeneratingUnit

A nuclear generating unit.

Table 445 shows all attributes of NuclearGeneratingUnit.

Table 445 – 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
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

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name	mult	type	description
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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 446 shows all association ends of NuclearGeneratingUnit with other classes.

Table 446 – Association ends of Production::NuclearGeneratingUnit with other classes

mult from	name	mult to	type	description
0..1	RotatingMachine	0..*	RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.6.3.35 PenstockLossCurve

Relationship between penstock head loss (in meters) and total discharge through the penstock (in cubic meters per second). One or more turbines may be connected to the same penstock.

Table 447 shows all attributes of PenstockLossCurve.

Table 447 – 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 448 shows all association ends of PenstockLossCurve with other classes.

Table 448 – 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

6.6.3.36 PhotoVoltaicUnit

A photovoltaic device or an aggregation of such devices.

Table 449 shows all attributes of PhotoVoltaicUnit.

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Table 449 – Attributes of Production::PhotoVoltaicUnit

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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 450 shows all association ends of PhotoVoltaicUnit with other classes.

Table 450 – Association ends of Production::PhotoVoltaicUnit with other classes

mult from	name	mult to	type	description
0..*	PowerElectronicsConnection	1..1	PowerElectronicsConnection	inherited from: PowerElectronicsUnit
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.6.3.37 PowerElectronicsUnit

A generating unit or battery or aggregation that connects to the AC network using power electronics rather than rotating machines.

Table 451 shows all attributes of PowerElectronicsUnit.

Table 451 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 452 shows all association ends of PowerElectronicsUnit with other classes.

Table 452 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.6.3.38 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 453 shows all attributes of PowerElectronicsWindUnit.

Table 453 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 454 shows all association ends of PowerElectronicsWindUnit with other classes.

Table 454 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.6.3.39 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 455 shows all attributes of Reservoir.

Table 455 – 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 meters 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 456 shows all association ends of Reservoir with other classes.

Table 456 – 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.
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.
1..1	TargetLevelSchedule	0..1	TargetLevelSchedule	A reservoir may have a water level target schedule.
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

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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

6.6.3.40 ShutdownCurve

Relationship between the rate in gross active power/minute (Y-axis) at which a unit should be shutdown and its present gross MW output (X-axis).

Table 457 shows all attributes of ShutdownCurve.

Table 457 – 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 458 shows all association ends of ShutdownCurve with other classes.

Table 458 – 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

6.6.3.41 SolarGeneratingUnit

A solar thermal generating unit, connected to the grid by means of a rotating machine. This class does not represent photovoltaic (PV) generation.

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Table 459 shows all attributes of SolarGeneratingUnit.

Table 459 – 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
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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 460 shows all association ends of SolarGeneratingUnit with other classes.

Table 460 – Association ends of Production::SolarGeneratingUnit with other classes

mult from	name	mult to	type	description
0..1	RotatingMachine	0..*	RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.6.3.42 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 461 shows all attributes of StartIgnFuelCurve.

Table 461 – 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 462 shows all association ends of StartIgnFuelCurve with other classes.

Table 462 – 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

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6.6.3.43 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 463 shows all attributes of StartMainFuelCurve.

Table 463 – 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

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 464 shows all association ends of StartMainFuelCurve with other classes.

Table 464 – 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

6.6.3.44 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 465 shows all attributes of StartRampCurve.

Table 465 – 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 466 shows all association ends of StartRampCurve with other classes.

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Table 466 – 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

6.6.3.45 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
name	0..1	String	inherited from: IdentifiedObject

Table 468 shows all association ends of StartupModel with other classes.

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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	StartIgnFuelCurve	0..1	StartIgnFuelCurve	The unit's startup model may have a startup ignition fuel curve.
1..1	StartMainFuelCurve	0..1	StartMainFuelCurve	The unit's startup model may have a startup main 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

6.6.3.46 SteamSendoutSchedule

The cogeneration plant's steam sendout schedule in volume per time unit.

Table 469 shows all attributes of SteamSendoutSchedule.

Table 469 – 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
value1Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value1Unit	0..1	UnitSymbol	inherited from: BasicIntervalSchedule
value2Multiplier	0..1	UnitMultiplier	inherited from: BasicIntervalSchedule
value2Unit	0..1	UnitSymbol	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 SteamSendoutSchedule with other classes.

Table 470 – 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

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6.6.3.47 TailbayLossCurve

Relationship between tailbay head loss height (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 471 shows all attributes of TailbayLossCurve.

Table 471 – 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 472 shows all association ends of TailbayLossCurve with other classes.

Table 472 – 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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6.6.3.48 TargetLevelSchedule

Reservoir water level targets from advanced studies or "rule curves". Typically in one hour increments for up to 10 days.

Table 473 shows all attributes of TargetLevelSchedule.

Table 473 – 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
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 474 shows all association ends of TargetLevelSchedule with other classes.

Table 474 – 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

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6.6.3.49 ThermalGeneratingUnit

A generating unit whose prime mover could be a steam turbine, combustion turbine, or diesel engine.

Table 475 shows all attributes of ThermalGeneratingUnit.

Table 475 – 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
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
inService	0..1	Boolean	inherited from: Equipment

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name	mult	type	description
networkAnalysisEnabled	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 476 shows all association ends of ThermalGeneratingUnit with other classes.

Table 476 – Association ends of Production::ThermalGeneratingUnit with other classes

mult from	name	mult to	type	description
0..1	CAESPlant	0..1	CAESPlant	A thermal generating unit may be a member of a compressed air energy storage plant.
0..*	CogenerationPlant	0..1	CogenerationPlant	A thermal generating unit may be a member of a cogeneration 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.
1..1	EmissionCurves	0..*	EmissionCurve	A thermal generating unit may have one or more emission curves.
1..1	FossilFuels	0..*	FossilFuel	A thermal generating unit may have one or more fossil fuels.
1..1	FuelAllocationSchedules	0..*	FuelAllocationSchedule	A thermal generating unit may have one or more fuel allocation schedules.
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.
1..1	IncrementalHeatRateCurve	0..1	IncrementalHeatRateCurve	A thermal generating unit may have an incremental heat rate curve.
1..1	ShutdownCurve	0..1	ShutdownCurve	A thermal generating unit may have a shutdown curve.
1..1	StartupModel	0..1	StartupModel	A thermal generating unit may have a startup model.
0..1	RotatingMachine	0..*	RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.6.3.50 WindGeneratingUnit

A wind driven generating unit, connected to the grid by means of a rotating machine. May be used to represent a single turbine or an aggregation.

Table 477 shows all attributes of WindGeneratingUnit.

Table 477 – 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
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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 478 shows all association ends of WindGeneratingUnit with other classes.

Table 478 – Association ends of Production::WindGeneratingUnit with other classes

mult from	name	mult to	type	description
0..1	RotatingMachine	0..*	RotatingMachine	inherited from: GeneratingUnit
1..1	GenUnitOpCostCurves	0..*	GenUnitOpCostCurve	inherited from: GeneratingUnit
1..1	GenUnitOpSchedule	0..1	GenUnitOpSchedule	inherited from: GeneratingUnit
1..1	ControlAreaGeneratingUnit	0..*	ControlAreaGeneratingUnit	inherited from: GeneratingUnit
1..1	GrossToNetActivePowerCurves	0..*	GrossToNetActivePowerCurve	inherited from: GeneratingUnit
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.7 Package DC

6.7.1 General

This package contains model for direct current equipment and controls.

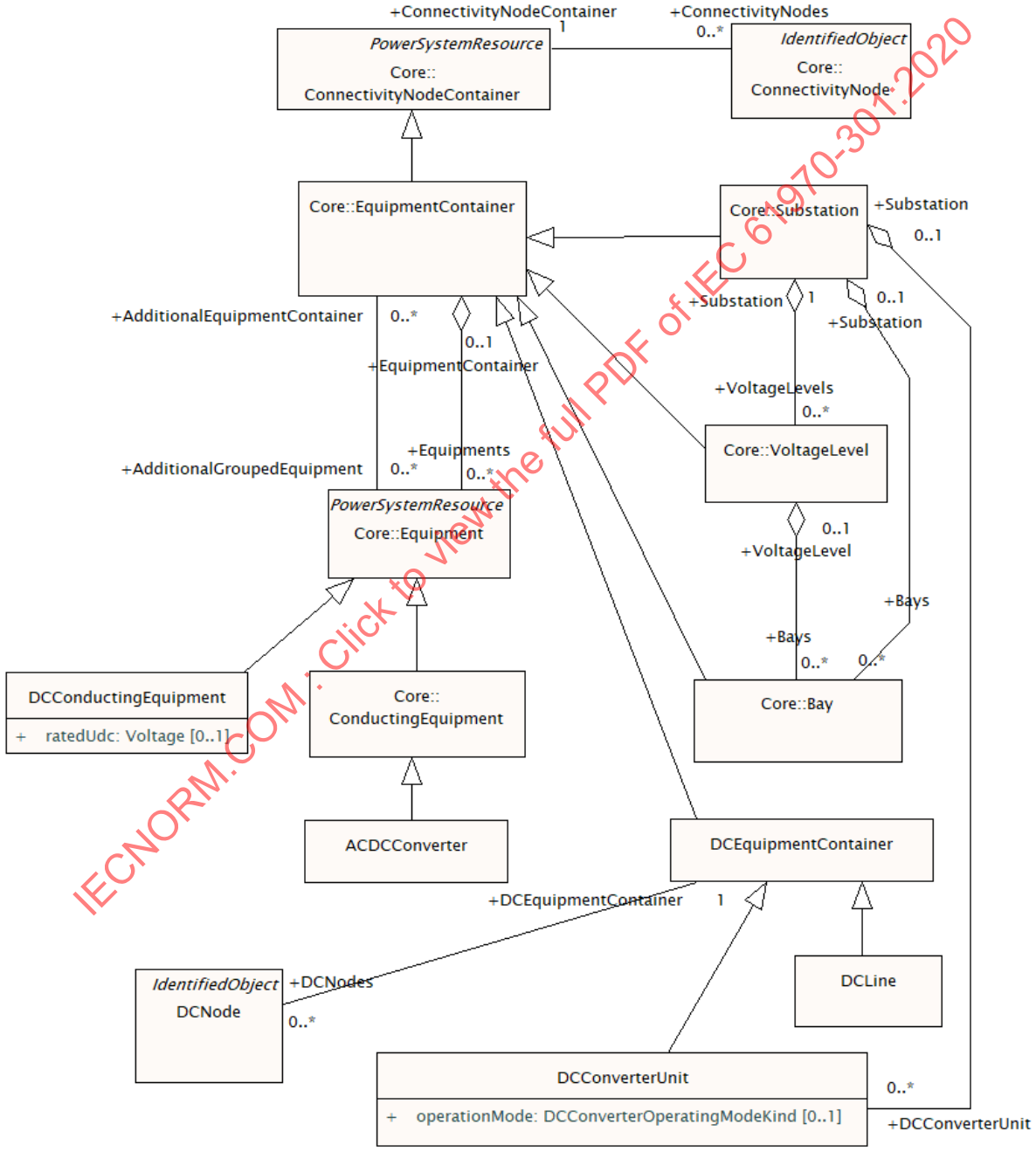


Figure 112 – Class diagram DC::DCContainment

Figure 112: The diagram show the DC containment model.

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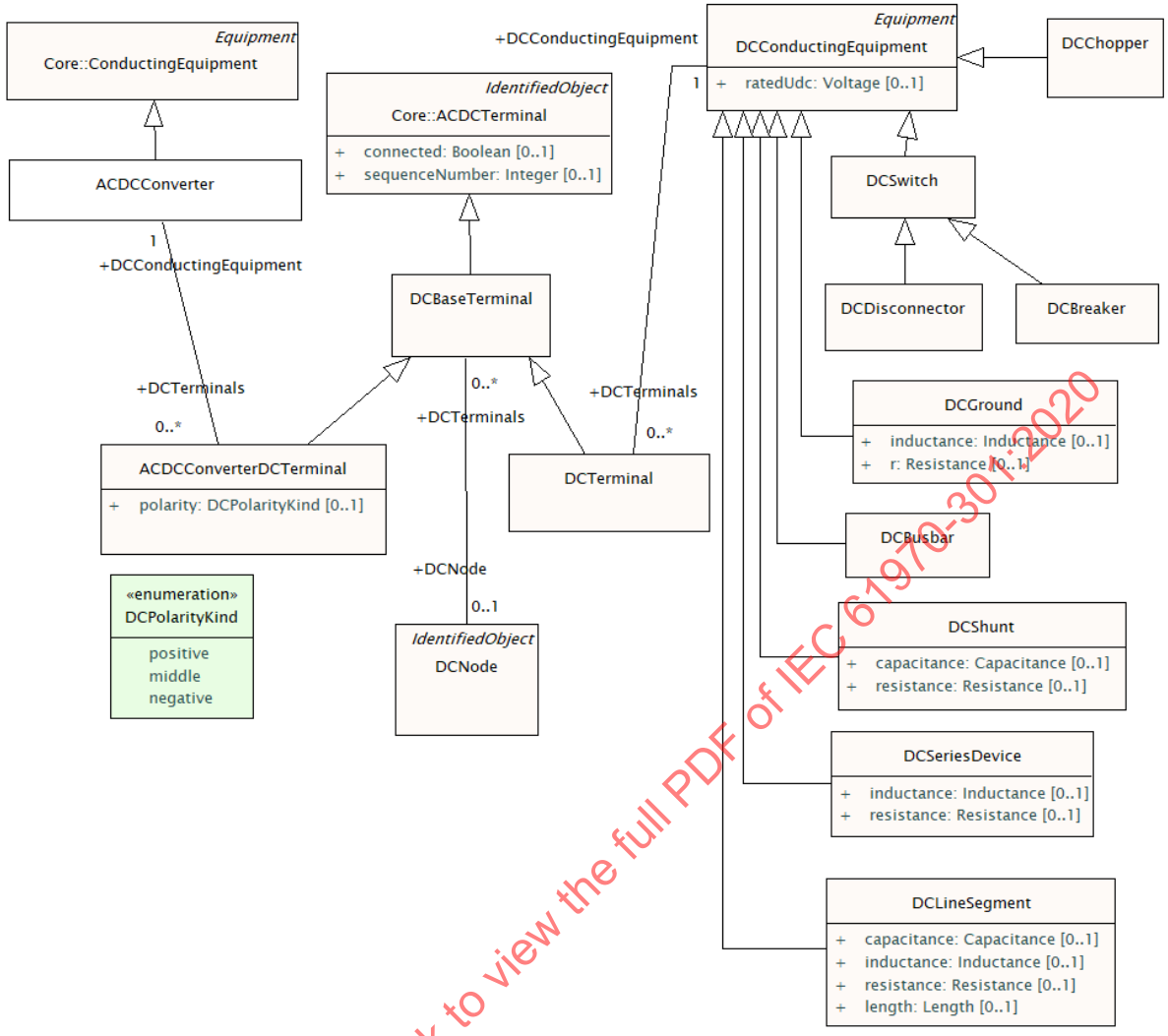


Figure 113 – Class diagram DC::DCEquipment

Figure 113: The diagram show the DC equipment model.

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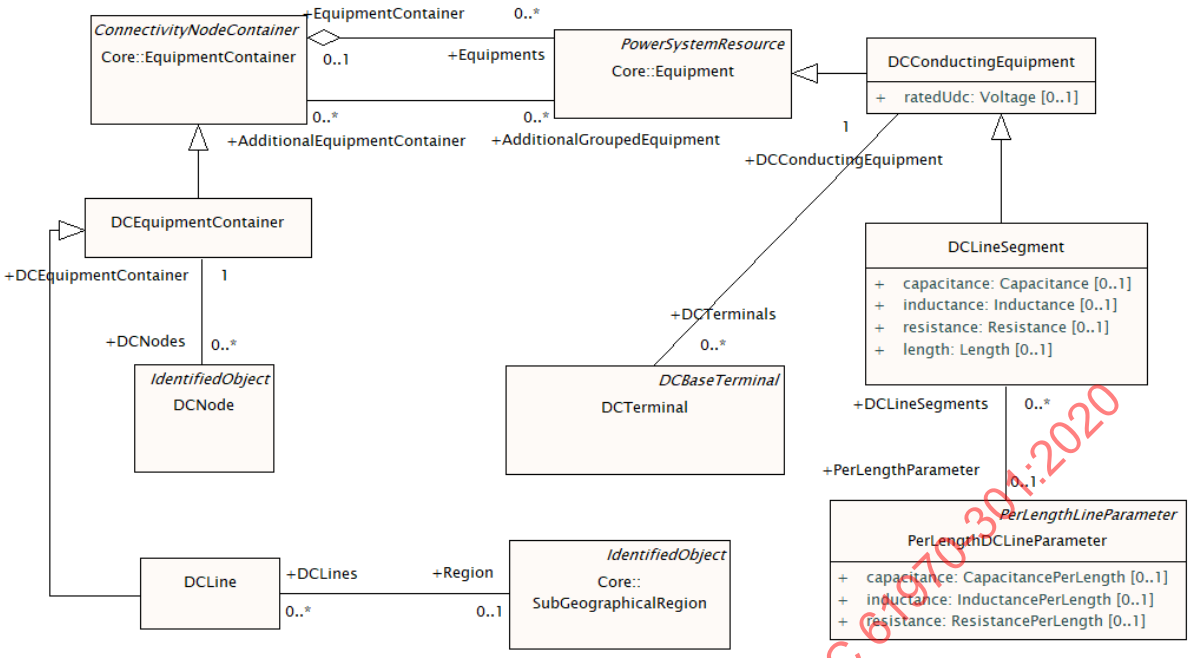
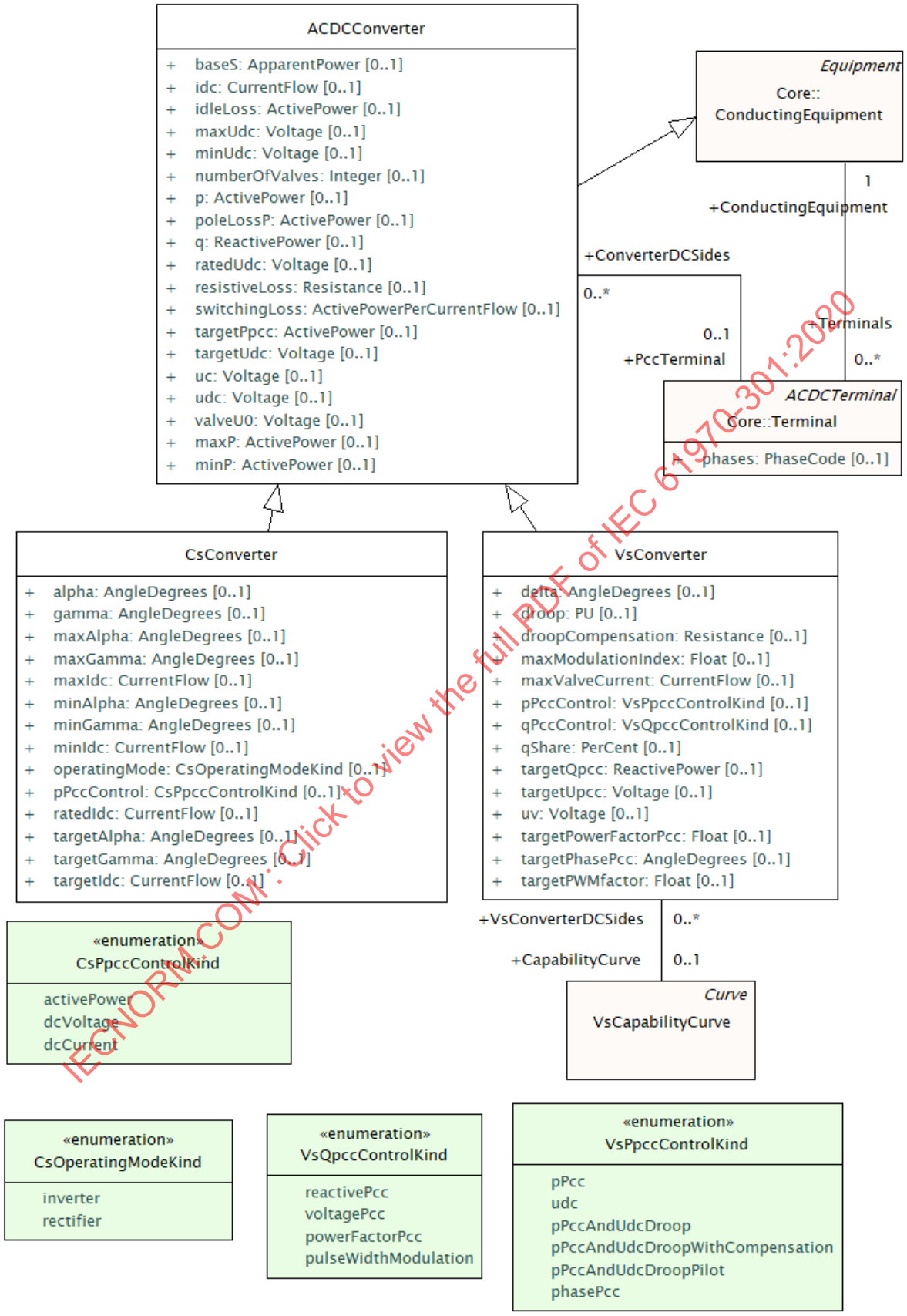


Figure 114 – Class diagram DC::DCLineModel

Figure 114: The diagram show the DC line model.

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Figure 115 – Class diagram DC::ACDCConverter

Figure 115: This diagram shows classes used to model DC converters.

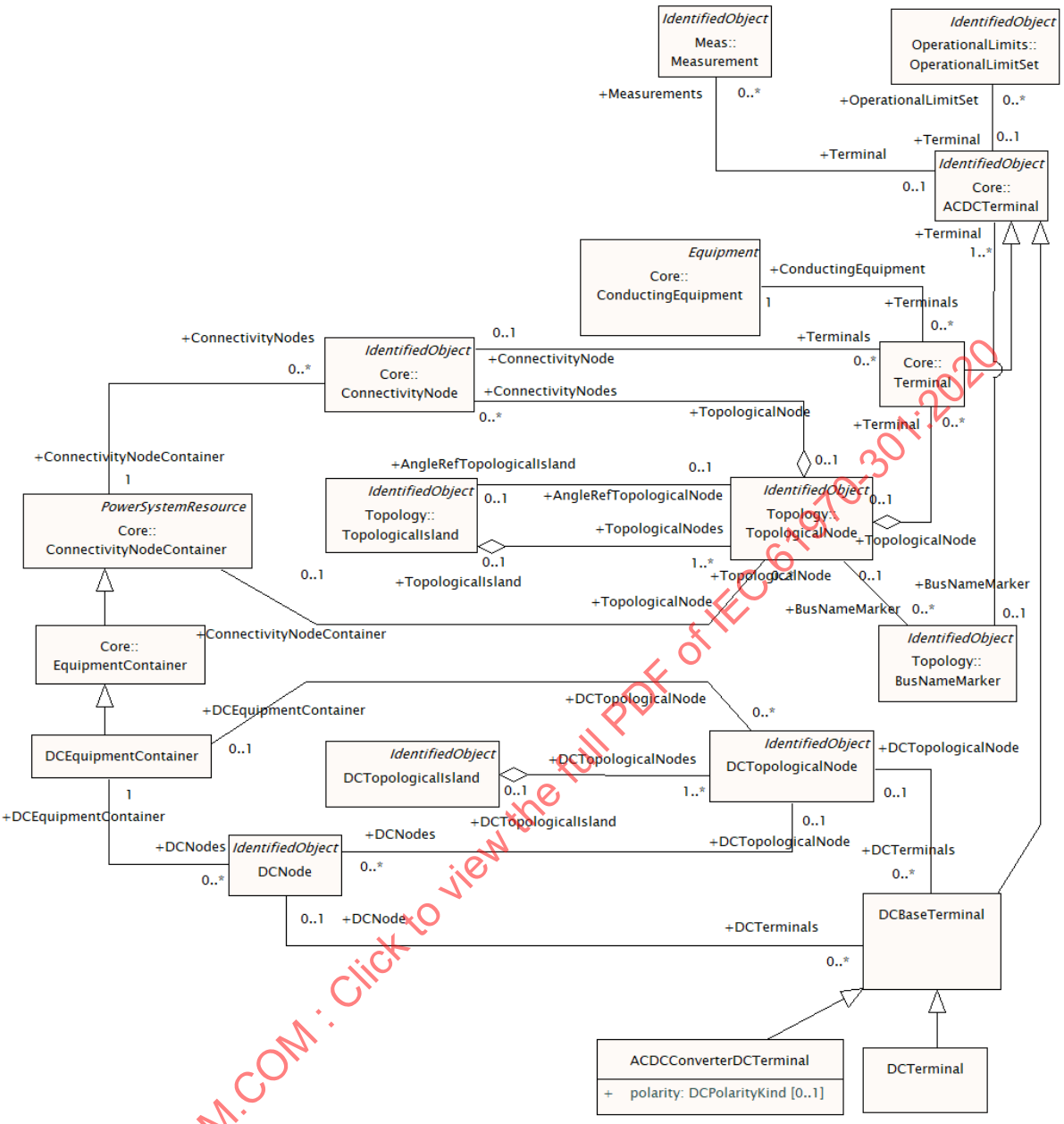


Figure 116 – Class diagram DC::ACDCConnectivityModel

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Figure 116: This diagram shows connectivity and topology model for both AC and DC networks.

6.7.2 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 479 shows all attributes of ACDCConverter.

Table 479 – Attributes of DC::ACDCConverter

name	mult	type	description
baseS	0..1	ApparentPower	Base apparent power of the converter pole. The attribute shall be a positive value.
idc	0..1	CurrentFlow	Converter DC current, also called Id. It is converter's state variable, result from power flow.
idleLoss	0..1	ActivePower	Active power loss in pole at no power transfer. It is converter's configuration data used in power flow. The attribute shall be a positive value.
maxUdc	0..1	Voltage	The maximum voltage on the DC side at which the converter should operate. It is converter's configuration data used in power flow. The attribute shall be a positive value.
minUdc	0..1	Voltage	The minimum voltage on the DC side at which the converter should operate. It is converter's configuration data used in power flow. The attribute shall be a positive value.
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. It is converter's state variable used in power flow. The attribute shall be a positive value.
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. The attribute shall be a positive value. It is converter's configuration data used in power flow. For instance a bipolar HVDC link with value 200 kV has a 400kV difference between the DC lines.
resistiveLoss	0..1	Resistance	It is converter's configuration data used in power flow. Refer to poleLossP. The attribute shall be a positive value.
switchingLoss	0..1	ActivePowerPerCurrentFlow	Switching losses, relative to the base apparent power 'baseS'. Refer to poleLossP. The attribute shall be a positive value.
targetPpcc	0..1	ActivePower	Real power injection target in AC grid, at point of common coupling. Load sign convention is used, i.e. positive sign means flow out from a node.
targetUdc	0..1	Voltage	Target value for DC voltage magnitude. The attribute shall be a positive value.

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name	mult	type	description
uc	0..1	Voltage	Line-to-line converter voltage, the voltage at the AC side of the valve. It is converter's state variable, result from power flow. The attribute shall be a positive value.
udc	0..1	Voltage	Converter voltage at the DC side, also called Ud. It is converter's state variable, result from power flow. The attribute shall be a positive value.
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 depend on numberOfValves * valveU0.
maxP	0..1	ActivePower	Maximum active power limit. The value is overwritten by values of VsCapabilityCurve, if present.
minP	0..1	ActivePower	Minimum active power limit. The value is overwritten by values of VsCapabilityCurve, if present.
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 480 shows all association ends of ACDCConverter with other classes.

Table 480 – 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.
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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.7.3 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 481 shows all attributes of ACDCConverterDCTerminal.

Table 481 – Attributes of DC::ACDCConverterDCTerminal

name	mult	type	description
polarity	0..1	DCPolarityKind	Represents the normal network polarity condition. Depending on the converter configuration the value shall be set as follows: - For a monopole with two converter terminals use DCPolarityKind “positive” and “negative”. - For a bi-pole or symmetric monopole with three converter terminals use DCPolarityKind “positive”, “middle” and “negative”.
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 482 shows all association ends of ACDCConverterDCTerminal with other classes.

Table 482 – 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

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6.7.4 CsConverter

DC side of the current source converter (CSC).

The firing angle controls the DC voltage at the converter, both for rectifier and inverter. The difference between the DC voltages of the rectifier and inverter determines the DC current. The extinction angle is used to limit the DC voltage at the inverter, if needed, and is not used in active power control. The firing angle, transformer tap position and number of connected filters are the primary means to control a current source DC line. Higher level controls are built on top, e.g. DC voltage, DC current and active power. From a steady state perspective it is sufficient to specify the wanted active power transfer (ACDCConverter.targetPpcc) and the control functions will set the DC voltage, DC current, firing angle, transformer tap position and number of connected filters to meet this. Therefore, attributes targetAlpha and targetGamma are not applicable in this case.

The reactive power consumed by the converter is a function of the firing angle, transformer tap position and number of connected filters, which can be approximated with half of the active power. The losses are a function of the DC voltage and DC current.

The attributes minAlpha and maxAlpha define the range of firing angles for rectifier operation between which no discrete tap changer action takes place. The range is typically 10 to 18 degrees.

The attributes minGamma and maxGamma define the range of extinction angles for inverter operation between which no discrete tap changer action takes place. The range is typically 17 to 20 degrees.

Table 483 shows all attributes of CsConverter.

Table 483 – Attributes of DC::CsConverter

name	mult	type	description
alpha	0..1	AngleDegrees	Firing angle that determines the DC voltage at the converter DC terminal. Typical value between 10 degrees and 18 degrees for a rectifier. It is converter's state variable, result from power flow. The attribute shall be a positive value.
gamma	0..1	AngleDegrees	Extinction angle. It is used to limit the DC voltage at the inverter if needed. Typical value between 17 degrees and 20 degrees for an inverter. It is converter's state variable, result from power flow. The attribute shall be a positive value.
maxAlpha	0..1	AngleDegrees	Maximum firing angle. It is converter's configuration data used in power flow. The attribute shall be a positive value.
maxGamma	0..1	AngleDegrees	Maximum extinction angle. It is converter's configuration data used in power flow. The attribute shall be a positive value.
maxIdc	0..1	CurrentFlow	The maximum direct current (Id) on the DC side at which the converter should operate. It is converter's configuration data use in power flow. The attribute shall be a positive value.
minAlpha	0..1	AngleDegrees	Minimum firing angle. It is converter's configuration data used in power flow. The attribute shall be a positive value.
minGamma	0..1	AngleDegrees	Minimum extinction angle. It is converter's configuration data used in power flow. The attribute shall be a positive value.

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name	mult	type	description
minIdc	0..1	CurrentFlow	The minimum direct current (Id) on the DC side at which the converter should operate. It is converter's configuration data used in power flow. The attribute shall be a positive value.
operatingMode	0..1	CsOperatingModeKind	Indicates whether the DC pole is operating as an inverter or as a rectifier. It is converter's 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. The attribute shall be a positive value. It is converter's configuration data used in power flow.
targetAlpha	0..1	AngleDegrees	Target firing angle. It is converter's control variable used in power flow. It is only applicable for rectifier if continuous tap changer control is used. Allowed values are within the range minAlpha<=targetAlpha<=maxAlpha. The attribute shall be a positive value.
targetGamma	0..1	AngleDegrees	Target extinction angle. It is converter's control variable used in power flow. It is only applicable for inverter if continuous tap changer control is used. Allowed values are within the range minGamma<=targetGamma<=maxGamma. The attribute shall be a positive value.
targetIdc	0..1	CurrentFlow	DC current target value. It is converter's control variable used in power flow. The attribute shall be a positive value.
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
maxP	0..1	ActivePower	inherited from: ACDCConverter
minP	0..1	ActivePower	inherited from: ACDCConverter
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 484 shows all association ends of CsConverter with other classes.

Table 484 – Association ends of DC::CsConverter with other classes

mult from	name	mult to	type	description
1..1	CSCDynamics	0..1	CSCDynamics	Current source converter dynamics model used to describe dynamic behaviour 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.7.5 DCTopologicalNode

DC bus.

Table 485 shows all attributes of DCTopologicalNode.

Table 485 – Attributes of DC::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 486 shows all association ends of DCTopologicalNode with other classes.

Table 486 – Association ends of DC::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	See association end TopologicalNode.Terminal.
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 topological node belongs.
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.7.6 CsOperatingModeKind enumeration

Operating mode for HVDC line operating as Current Source Converter.

Table 487 shows all literals of CsOperatingModeKind.

Table 487 – Literals of DC::CsOperatingModeKind

literal	value	description
inverter		Operating as inverter, which is the power receiving end.
rectifier		Operating as rectifier, which is the power sending end.

6.7.7 CsPpccControlKind enumeration

Active power control modes for HVDC line operating as Current Source Converter.

Table 488 shows all literals of CsPpccControlKind.

Table 488 – Literals of DC::CsPpccControlKind

literal	value	description
activePower		Control is active power control at AC side, at point of common coupling. Target is provided by ACDCConverter.targetPpcc.
dcVoltage		Control is DC voltage with target value provided by ACDCConverter.targetUdc.
dcCurrent		Control is DC current with target value provided by CsConverter.targetIdc.

6.7.8 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 requires that DC connections are distinct from AC connections.

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Table 489 shows all attributes of DCBaseTerminal.

Table 489 – 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 490 shows all association ends of DCBaseTerminal with other classes.

Table 490 – Association ends of DC::DCBaseTerminal with other classes

mult from	name	mult to	type	description
0..*	DCTopologicalNode	0..1	DCTopologicalNode	See association end Terminal.TopologicalNode.
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

6.7.9 DCBreaker

A breaker within a DC system.

Table 491 shows all attributes of DCBreaker.

Table 491 – Attributes of DC::DCBreaker

name	mult	type	description
ratedUdc	0..1	Voltage	inherited from: DCConductingEquipment
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 492 shows all association ends of DCBreaker with other classes.

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Table 492 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.7.10 DCBusbar

A busbar within a DC system.

Table 493 shows all attributes of DCBusbar.

Table 493 – Attributes of DC::DCBusbar

name	mult	type	description
ratedUdc	0..1	Voltage	inherited from: DCConductingEquipment
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 DCBusbar with other classes.

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Table 494 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.7.11 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 495 shows all attributes of DCChopper.

Table 495 – Attributes of DC::DCChopper

name	mult	type	description
ratedUdc	0..1	Voltage	inherited from: DCConductingEquipment
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 DCChopper with other classes.

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Table 496 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.7.12 DCConductingEquipment

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

Table 497 shows all attributes of DCConductingEquipment.

Table 497 – Attributes of DC::DCConductingEquipment

name	mult	type	description
ratedUdc	0..1	Voltage	Rated DC device voltage. The attribute shall be a positive value. It is configuration data used in power flow.
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 498 shows all association ends of DCConductingEquipment with other classes.

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Table 498 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.7.13 DCConverterOperatingModeKind enumeration

The operating mode of an HVDC bipole.

Table 499 shows all literals of DCConverterOperatingModeKind.

Table 499 – Literals of DC::DCConverterOperatingModeKind

literal	value	description
bipolar		Bipolar operation.
monopolarMetallicReturn		Monopolar operation with metallic return.
monopolarGroundReturn		Monopolar operation with ground return.

6.7.14 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 500 shows all attributes of DCConverterUnit.

Table 500 – Attributes of DC::DCConverterUnit

name	mult	type	description
operationMode	0..1	DCConverterOperatingModeKind	The operating mode of an HVDC bipole (bipolar, monopolar metallic return, etc).
aliasName	0..1	String	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 501 shows all association ends of DCConverterUnit with other classes.

Table 501 – 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
0..*	AdditionalGroupedEquipment	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

6.7.15 DCDisconnector

A disconnector within a DC system.

Table 502 shows all attributes of DCDisconnector.

Table 502 – Attributes of DC::DCDisconnector

name	mult	type	description
ratedUdc	0..1	Voltage	inherited from: DCConductingEquipment
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 DCDisconnector with other classes.

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Table 503 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.7.16 DCEquipmentContainer

A modelling construct to provide a root class for containment of DC as well as AC equipment. The class differ from the EquipmentContaner for AC in that it may also contain DCNode-s. Hence it can contain both AC and DC equipment.

Table 504 shows all attributes of DCEquipmentContainer.

Table 504 – 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 505 shows all association ends of DCEquipmentContainer with other classes.

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Table 505 – 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
0..*	AdditionalGroupedEquipment	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

6.7.17 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.
ratedUdc	0..1	Voltage	inherited from: DCConductingEquipment
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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.

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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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.7.18 DCLine

Overhead lines and/or cables connecting two or more HVDC substations.

Table 508 shows all attributes of DCLine.

Table 508 – 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 509 shows all association ends of DCLine with other classes.

Table 509 – 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
0..*	AdditionalGroupedEquipment	0..*	Equipment	inherited from: EquipmentContainer
1..1	ConnectivityNodes	0..*	ConnectivityNode	inherited from: ConnectivityNodeContainer
0..1	TopologicalNode	0..*	TopologicalNode	inherited from: ConnectivityNodeContainer

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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

6.7.19 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 510 shows all attributes of DCLineSegment.

Table 510 – 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.
ratedUdc	0..1	Voltage	inherited from: DCConductingEquipment
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 DCLineSegment with other classes.

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Table 511 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.7.20 DCNode

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

Table 512 shows all attributes of DCNode.

Table 512 – 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 513 shows all association ends of DCNode with other classes.

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Table 513 – 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 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

6.7.21 DCPolarityKind enumeration

Polarity for DC circuits.

Table 514 shows all literals of DCPolarityKind.

Table 514 – Literals of DC::DCPolarityKind

literal	value	description
positive		Positive pole. The converter terminal is intended to operate at a positive voltage relative the midpoint or negative terminal.
middle		Middle pole. The converter terminal is the midpoint in a bipolar or symmetric monopole configuration. The midpoint can be grounded and/or have a metallic return.
negative		Negative pole. The converter terminal is intended to operate at a negative voltage relative the midpoint or positive terminal.

6.7.22 DCSeriesDevice

A series device within the DC system, typically a reactor used for filtering or smoothing. Needed for transient and short circuit studies.

Table 515 shows all attributes of DCSeriesDevice.

Table 515 – 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	inherited from: DCConductingEquipment
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 516 shows all association ends of DCSeriesDevice with other classes.

Table 516 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.7.23 DCShunt

A shunt device within the DC system, typically used for filtering. Needed for transient and short circuit studies.

Table 517 shows all attributes of DCShunt.

Table 517 – 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	inherited from: DCConductingEquipment
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 518 shows all association ends of DCShunt with other classes.

Table 518 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.7.24 DCSwitch

A switch within the DC system.

Table 519 shows all attributes of DCSwitch.

Table 519 – Attributes of DC::DCSwitch

name	mult	type	description
ratedUdc	0..1	Voltage	inherited from: DCConductingEquipment
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 520 shows all association ends of DCSwitch with other classes.

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Table 520 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.7.25 DCTerminal

An electrical connection point to generic DC conducting equipment.

Table 521 shows all attributes of DCTerminal.

Table 521 – 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 522 shows all association ends of DCTerminal with other classes.

Table 522 – Association ends of DC::DCTerminal with other classes

mult from	name	mult to	type	description
0..*	DCConductingEquipment	1..1	DCConductingEquipment	An DC terminal belong 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

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6.7.26 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.

Only energised TopologicalNode-s shall be part of the topological island.

Table 523 shows all attributes of DCTopologicalIsland.

Table 523 – 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 524 shows all association ends of DCTopologicalIsland with other classes.

Table 524 – 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

6.7.27 PerLengthDCLineParameter

Common type for per-length electrical catalogues describing DC line parameters.

Table 525 shows all attributes of PerLengthDCLineParameter.

Table 525 – 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 526 shows all association ends of PerLengthDCLineParameter with other classes.

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Table 526 – 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

6.7.28 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 527 shows all attributes of VsCapabilityCurve.

Table 527 – 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 528 shows all association ends of VsCapabilityCurve with other classes.

Table 528 – 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

6.7.29 VsConverter

DC side of the voltage source converter (VSC).

Table 529 shows all attributes of VsConverter.

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Table 529 – Attributes of DC::VsConverter

name	mult	type	description
delta	0..1	AngleDegrees	Angle between VsConverter.uv and ACDCConverter.uc. It is converter's state variable used in power flow. The attribute shall be a positive value or zero.
droop	0..1	PU	Droop constant. The pu value is obtained as D [kV/MW] x Sb / Ubdc. The attribute shall be a positive value.
droopCompensation	0..1	Resistance	Compensation constant. Used to compensate for voltage drop when controlling voltage at a distant bus. The attribute shall be a positive value.
maxModulationIndex	0..1	Float	The maximum quotient between the AC converter voltage (Uc) and DC voltage (Ud). A factor typically less than 1. It is converter's configuration data used in power flow.
maxValveCurrent	0..1	CurrentFlow	The maximum current through a valve. It is converter's configuration data.
pPccControl	0..1	VsPpccControlKind	Kind of control of real power and/or DC voltage.
qPccControl	0..1	VsQpccControlKind	Kind of reactive power control.
qShare	0..1	PerCent	Reactive power sharing factor among parallel converters on Uac control. The attribute shall be a positive value or zero.
targetQpcc	0..1	ReactivePower	Reactive power injection target in AC grid, at point of common coupling. Load sign convention is used, i.e. positive sign means flow out from a node.
targetUpcc	0..1	Voltage	Voltage target in AC grid, at point of common coupling. The attribute shall be a positive value.
uv	0..1	Voltage	Line-to-line voltage on the valve side of the converter transformer. It is converter's state variable, result from power flow. The attribute shall be a positive value.
targetPowerFactorPcc	0..1	Float	Power factor target at the AC side, at point of common coupling. The attribute shall be a positive value.
targetPhasePcc	0..1	AngleDegrees	Phase target at AC side, at point of common coupling. The attribute shall be a positive value.
targetPWMfactor	0..1	Float	Magnitude of pulse-modulation factor. The attribute shall be a positive value.
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

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name	mult	type	description
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
maxP	0..1	ActivePower	inherited from: ACDCConverter
minP	0..1	ActivePower	inherited from: ACDCConverter
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 530 shows all association ends of VsConverter with other classes.

Table 530 – 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.
1..1	VSCDynamics	0..1	VSCDynamics	Voltage source converter dynamics model used to describe dynamic behaviour 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.7.30 VsPpccControlKind enumeration

Types applicable to the control of real power and/or DC voltage by voltage source converter.

Table 531 shows all literals of VsPpccControlKind.

Table 531 – Literals of DC::VsPpccControlKind

literal	value	description
pPcc		Control is real power at point of common coupling. The target value is provided by ACDCConverter.targetPpcc.
udc		Control is DC voltage with target value provided by ACDCConverter.targetUdc.
pPccAndUdcDroop		Control is active power at point of common coupling and local DC voltage, with the droop. Target values are provided by ACDCConverter.targetPpcc, ACDCConverter.targetUdc and VsConverter.droop.
pPccAndUdcDroopWithCompensation		Control is 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. Targets are provided by ACDCConverter.targetPpcc, ACDCConverter.targetUdc, VsConverter.droop and VsConverter.droopCompensation.
pPccAndUdcDroopPilot		Control is active power at point of common coupling and the pilot DC voltage, with the droop. The mode is used for Multi Terminal High Voltage DC (MTDC) systems where multiple HVDC Substations are connected to the HVDC transmission lines. The pilot voltage is then used to coordinate the control the DC voltage across the HVDC substations. Targets are provided by ACDCConverter.targetPpcc, ACDCConverter.targetUdc and VsConverter.droop.
phasePcc		Control is phase at point of common coupling. Target is provided by VsConverter.targetPhasePcc.

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6.7.31 VsQpccControlKind enumeration

Kind of reactive power control at point of common coupling for a voltage source converter.

Table 532 shows all literals of VsQpccControlKind.

Table 532 – Literals of DC::VsQpccControlKind

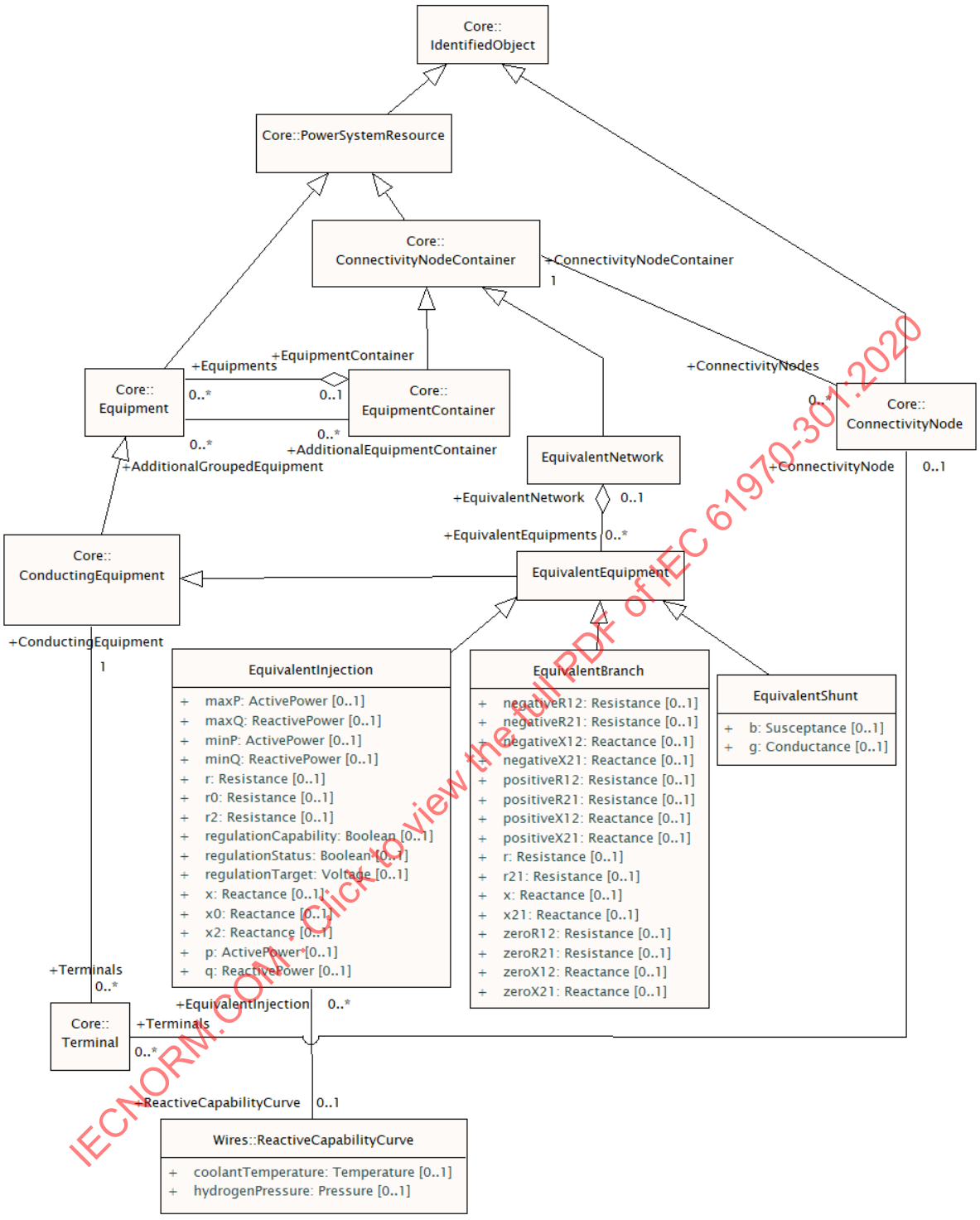
literal	value	description
reactivePcc		Control is reactive power at point of common coupling. Target is provided by VsConverter.targetQpcc.
voltagePcc		Control is voltage at point of common coupling. Target is provided by VsConverter.targetUpcc.
powerFactorPcc		Control is power factor at point of common coupling. Target is provided by VsConverter.targetPowerFactorPcc.
pulseWidthModulation		No explicit control. Pulse-modulation factor is directly set in magnitude (VsConverter.targetPWMfactor) and phase (VsConverter.targetPhasePcc).

6.8 Package Equivalents

6.8.1 General

The equivalents package models equivalent networks.

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Figure 117 – Class diagram Equivalents::Main

Figure 117: Shows model for equivalent networks.

6.8.2 EquivalentBranch

The class represents equivalent branches. In cases where a transformer phase shift is modelled and the EquivalentBranch is spanning the same nodes, the impedance quantities for the EquivalentBranch shall consider the needed phase shift.

Table 533 shows all attributes of EquivalentBranch.

Table 533 – 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.

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name	mult	type	description
r21	0..1	Resistance	Resistance from terminal sequence 2 to terminal sequence 1. Used for steady state power flow. This attribute is optional and represent 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.
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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 534 shows all association ends of EquivalentBranch with other classes.

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Table 534 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.8.3 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 535 shows all attributes of EquivalentEquipment.

Table 535 – Attributes of Equivalents::EquivalentEquipment

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 536 shows all association ends of EquivalentEquipment with other classes.

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Table 536 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.8.4 EquivalentInjection

This class represents equivalent injections (generation or load). Voltage regulation is allowed only at the point of connection.

Table 537 shows all attributes of EquivalentInjection.

Table 537 – Attributes of Equivalents::EquivalentInjection

name	mult	type	description
maxP	0..1	ActivePower	Maximum active power of the injection.
maxQ	0..1	ReactivePower	Maximum reactive power of the injection. Used for modelling of infeed for load flow exchange. Not used for short circuit modelling. 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	Minimum reactive power of the injection. Used for modelling of infeed for load flow exchange. Not used for short circuit modelling. 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.

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name	mult	type	description
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. If true the EquivalentInjection can regulate. If false the EquivalentInjection cannot regulate. ReactiveCapabilityCurve can only be associated with EquivalentInjection if the flag is true.
regulationStatus	0..1	Boolean	Specifies the regulation status of the EquivalentInjection. True is regulating. False is not regulating.
regulationTarget	0..1	Voltage	The target voltage for voltage regulation. The attribute shall be a positive value.
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.
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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 538 shows all association ends of EquivalentInjection with other classes.

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Table 538 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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

6.8.5 EquivalentNetwork

A class that groups electrical equivalents, including internal nodes, of a network that has been reduced. 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 539 shows all attributes of EquivalentNetwork.

Table 539 – 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 540 shows all association ends of EquivalentNetwork with other classes.

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Table 540 – 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

6.8.6 EquivalentShunt

The class represents equivalent shunts.

Table 541 shows all attributes of EquivalentShunt.

Table 541 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 542 shows all association ends of EquivalentShunt with other classes.

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Table 542 – 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..*	SvStatus	inherited from: ConductingEquipment
0..*	ProtectionEquipments	0..*	ProtectionEquipment	inherited from: ConductingEquipment
1..1	Terminals	0..*	Terminal	inherited from: ConductingEquipment
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..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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 Package AuxiliaryEquipment

6.9.1 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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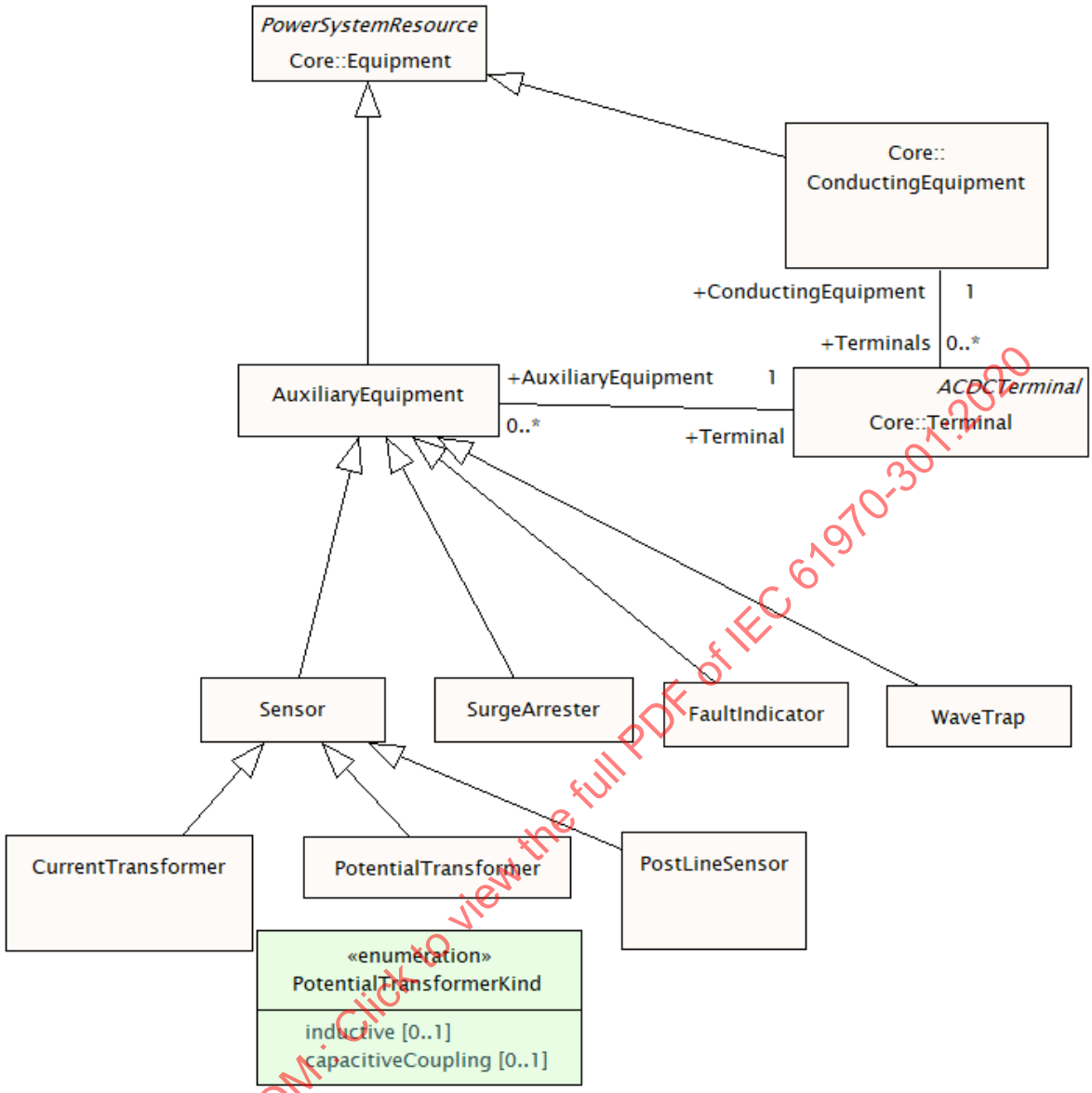


Figure 118 – Class diagram AuxiliaryEquipment::AuxiliaryEquipment

Figure 118: Inheritance and associations for auxiliary equipment.

6.9.2 AuxiliaryEquipment

AuxiliaryEquipment describe equipment that is not performing any primary functions but support for the equipment performing the primary function.

AuxiliaryEquipment is attached to primary equipment via an association with Terminal.

Table 543 shows all attributes of AuxiliaryEquipment.

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Table 543 – Attributes of AuxiliaryEquipment::AuxiliaryEquipment

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 544 shows all association ends of AuxiliaryEquipment with other classes.

Table 544 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.9.3 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 5A.

Table 545 shows all attributes of CurrentTransformer.

Table 545 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 546 shows all association ends of CurrentTransformer with other classes.

Table 546 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.9.4 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 547 shows all attributes of FaultIndicator.

Table 547 – Attributes of AuxiliaryEquipment::FaultIndicator

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 548 shows all association ends of FaultIndicator with other classes.

Table 548 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.9.5 PostLineSensor

A sensor used mainly in overhead distribution networks as the source of both current and voltage measurements.

Table 549 shows all attributes of PostLineSensor.

Table 549 – Attributes of AuxiliaryEquipment::PostLineSensor

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 550 shows all association ends of PostLineSensor with other classes.

Table 550 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.9.6 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 120V.

Table 551 shows all attributes of PotentialTransformer.

Table 551 – 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
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 552 shows all association ends of PotentialTransformer with other classes.

Table 552 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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 PotentialTransformerKind enumeration

The construction kind of the potential transformer.

Table 553 shows all literals of PotentialTransformerKind.

Table 553 – 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.

6.9.8 Sensor

This class describe devices that transform a measured quantity into signals that can be presented at displays, used in control or be recorded.

Table 554 shows all attributes of Sensor.

Table 554 – Attributes of AuxiliaryEquipment::Sensor

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 555 shows all association ends of Sensor with other classes.

Table 555 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.9.9 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 556 shows all attributes of SurgeArrester.

Table 556 – Attributes of AuxiliaryEquipment::SurgeArrester

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 557 shows all association ends of SurgeArrester with other classes.

Table 557 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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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6.9.10 WaveTrap

Line traps are devices that impede high frequency power line carrier signals yet present a negligible impedance at the main power frequency.

Table 558 shows all attributes of WaveTrap.

Table 558 – Attributes of AuxiliaryEquipment::WaveTrap

name	mult	type	description
aggregate	0..1	Boolean	inherited from: Equipment
inService	0..1	Boolean	inherited from: Equipment
networkAnalysisEnabled	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 559 shows all association ends of WaveTrap with other classes.

Table 559 – 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	OperationalLimitSet	0..*	OperationalLimitSet	inherited from: Equipment
1..1	ContingencyEquipment	0..*	ContingencyEquipment	inherited from: Equipment
0..*	EquipmentContainer	0..1	EquipmentContainer	inherited from: Equipment
0..1	Faults	0..*	Fault	inherited from: Equipment
0..*	AdditionalEquipmentContainer	0..*	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 Package Meas

6.10.1 General

Contains entities that describe dynamic measurement data exchanged between applications.

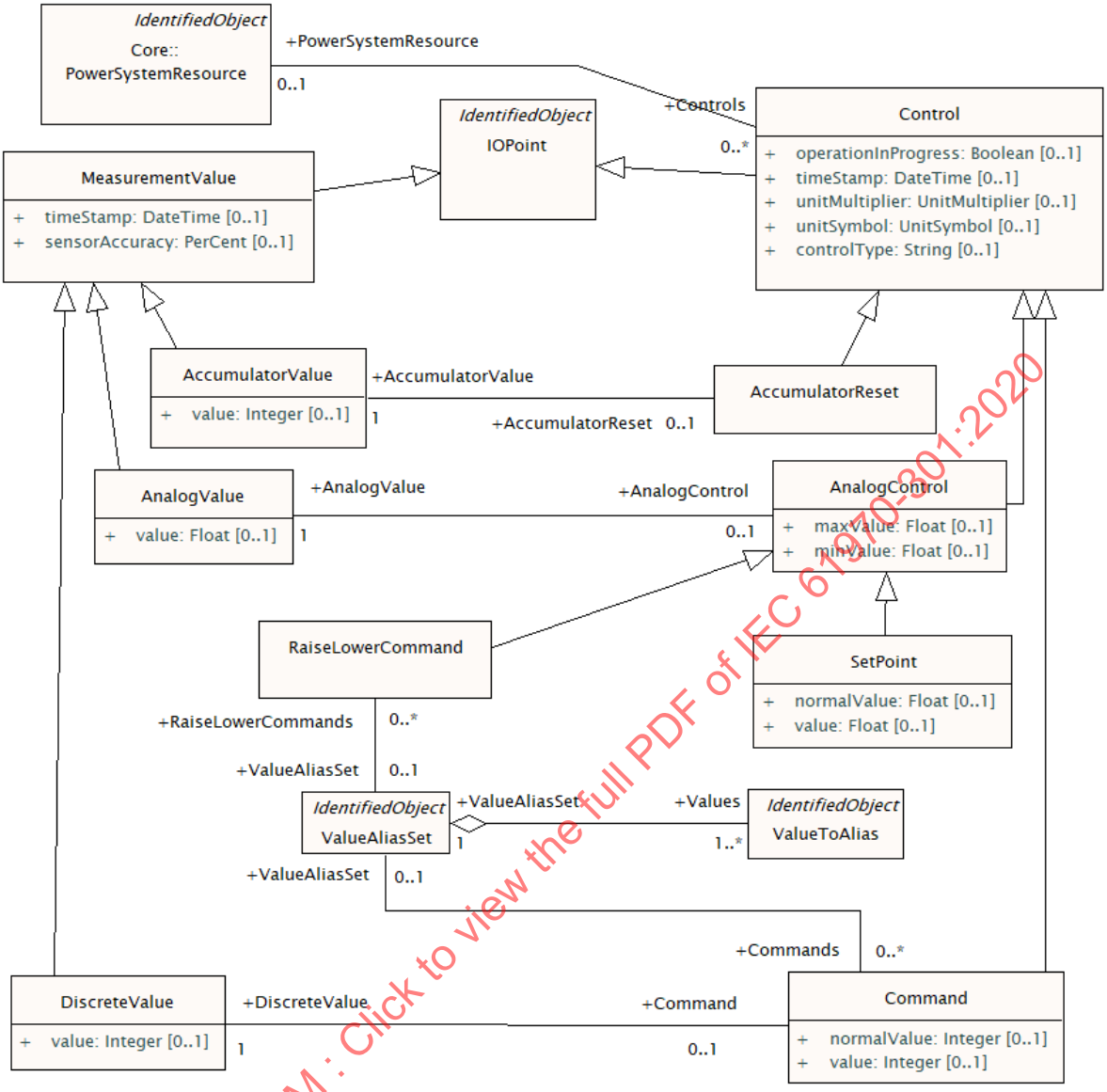


Figure 119 – Class diagram Meas::Control

Figure 119: This diagram shows all classes included in the Meas package.

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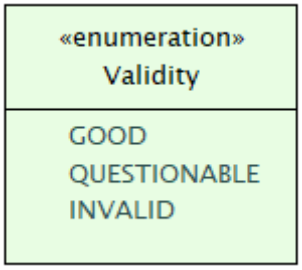
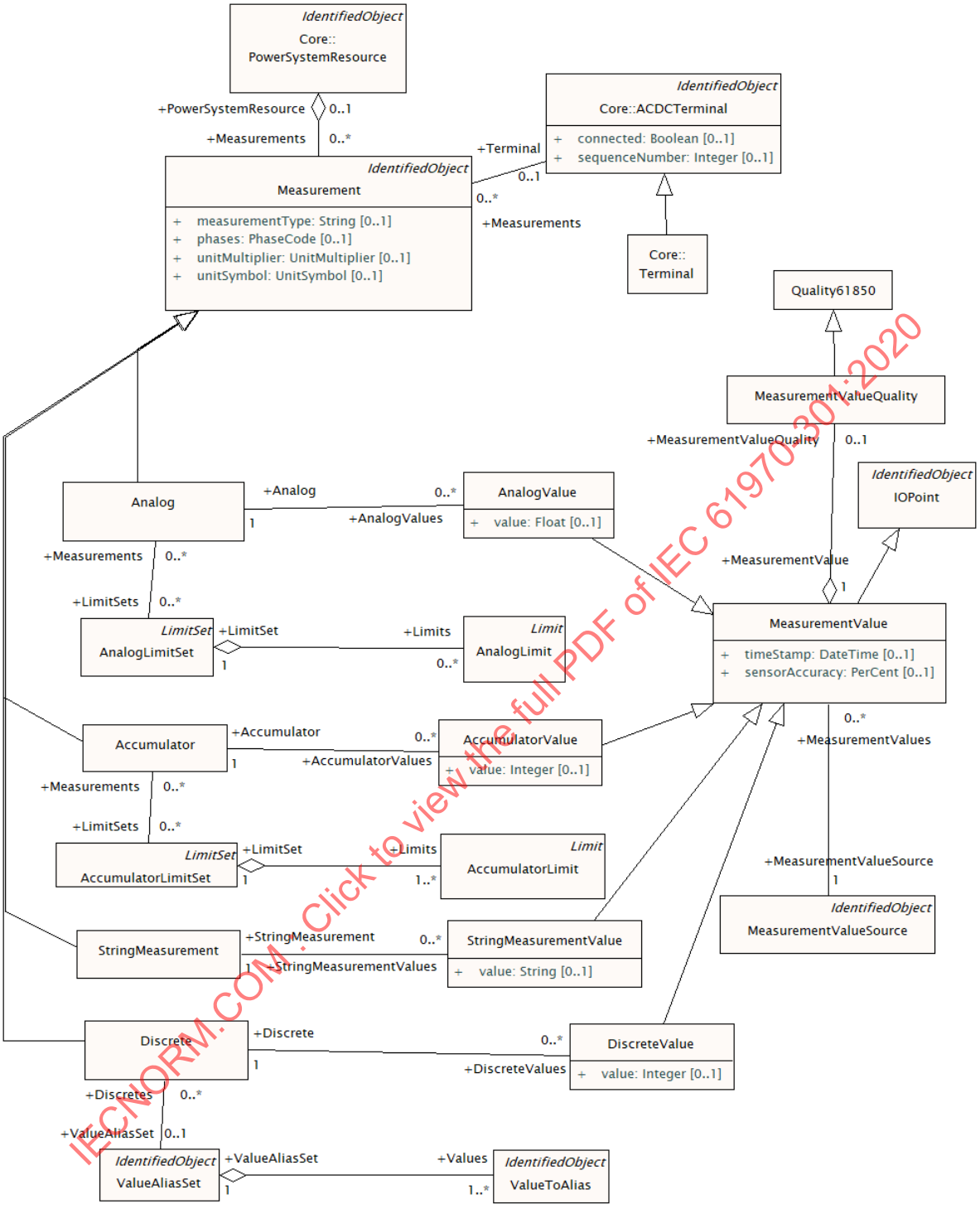


Figure 120 – Class diagram Meas::Datatypes

Figure 120: Shows datatypes for measurements.



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Figure 121 – Class diagram Meas::Measurement

Figure 121: This diagram shows classes central to the Measurement package and connections to some external classes.

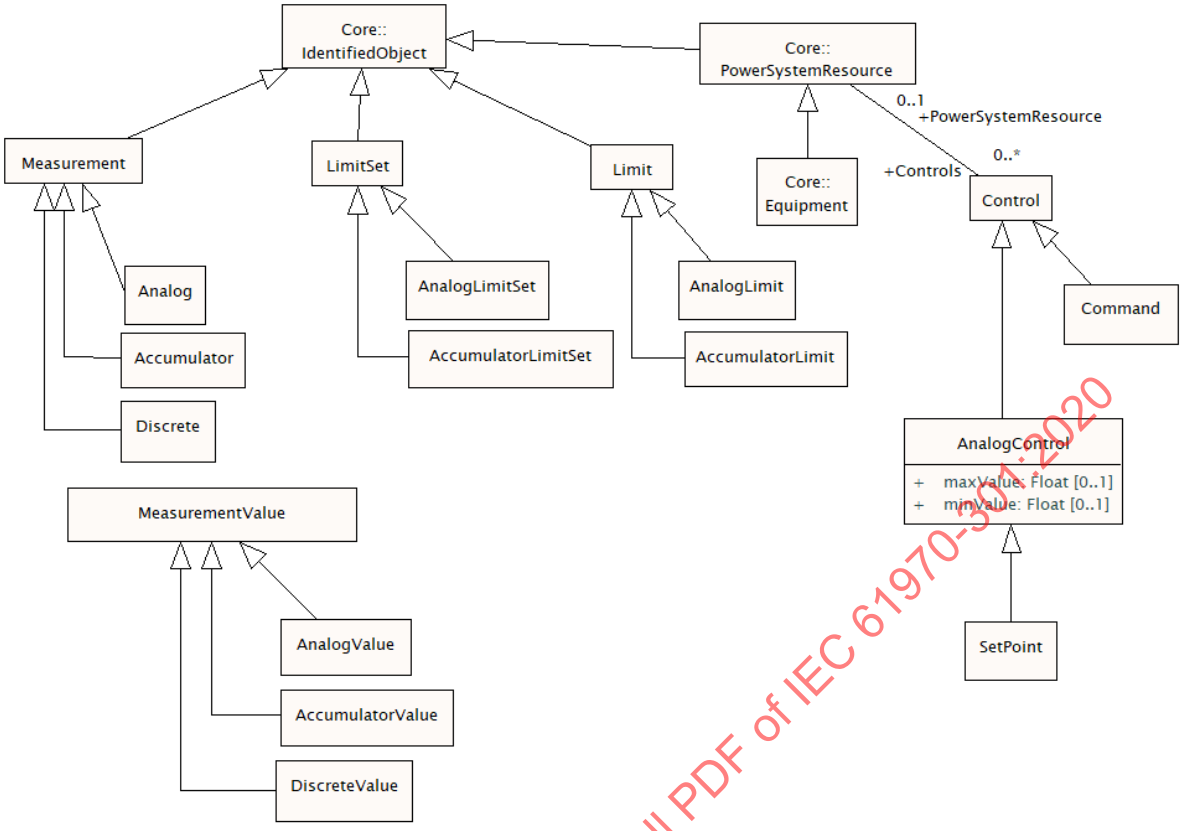


Figure 122 – Class diagram Meas::MeasurementInheritance

Figure 122: This diagram shows the measurement classes inheritance.

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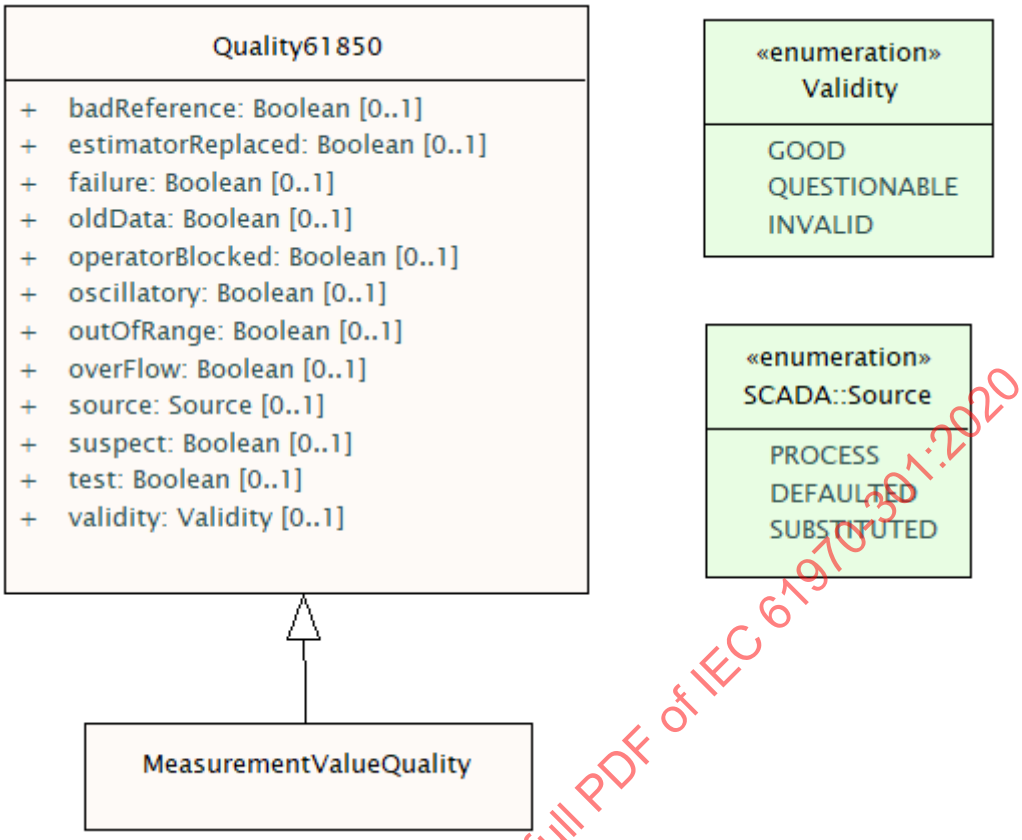


Figure 123 – Class diagram Meas::Quality

Figure 123: 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.

6.10.2 Accumulator

Accumulator represents an accumulated (counted) Measurement, e.g. an energy value.

Table 560 shows all attributes of Accumulator.

Table 560 – 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

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Table 561 shows all association ends of Accumulator with other classes.

Table 561 – 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

6.10.3 AccumulatorLimit

Limit values for Accumulator measurements.

Table 562 shows all attributes of AccumulatorLimit.

Table 562 – 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

Table 563 shows all association ends of AccumulatorLimit with other classes.

Table 563 – 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

6.10.4 AccumulatorLimitSet

An AccumulatorLimitSet specifies a set of Limits that are associated with an Accumulator measurement.

Table 564 shows all attributes of AccumulatorLimitSet.

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Table 564 – 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 565 shows all association ends of AccumulatorLimitSet with other classes.

Table 565 – 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

6.10.5 AccumulatorReset

This command resets the counter value to zero.

Table 566 shows all attributes of AccumulatorReset.

Table 566 – 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 567 shows all association ends of AccumulatorReset with other classes.

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Table 567 – 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	BilateralToIOPoint	0..*	ProvidedBilateralPoint	inherited from: IOPoint
0..*	IOPointSource	0..1	IOPointSource	inherited from: IOPoint
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

6.10.6 AccumulatorValue

AccumulatorValue represents an accumulated (counted) MeasurementValue.

Table 568 shows all attributes of AccumulatorValue.

Table 568 – 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 569 shows all association ends of AccumulatorValue with other classes.

Table 569 – 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	BilateralToIOPoint	0..*	ProvidedBilateralPoint	inherited from: IOPoint
0..*	IOPointSource	0..1	IOPointSource	inherited from: IOPoint
0..1	DiagramObjects	0..*	DiagramObject	inherited from: IdentifiedObject
1..1	Names	0..*	Name	inherited from: IdentifiedObject

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6.10.7 Analog

Analog represents an analog Measurement.

Table 570 shows all attributes of Analog.

Table 570 – 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 571 shows all association ends of Analog with other classes.

Table 571 – 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

6.10.8 AnalogControl

An analog control used for supervisory control.

Table 572 shows all attributes of AnalogControl.

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