# IEC 61970-457

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# INTERNATIONAL STANDARD

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## Energy management system application program interface (EMS-API) – Part 457: Dynamics profile

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

## Part 457: Dynamics profile

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International Standard IEC 61970-457 has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

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

| FDIS | Report on voting |
|---|---|
| 57/2331/FDIS | 57/2344/RVD |

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

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

It is based on the IEC 61970 UML version 'IEC61970CIM17v40', dated '2020-08-24'.

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 document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document 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- withdrawn,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

The IEC 61970-300 series of documents specify the common information model (CIM). The CIM is an abstract model that represents the objects in an electric utility enterprise typically needed to model the operational aspects of a utility.

This document is one of the IEC 61970-400 series of component interface standards that specify the semantic structure of data exchanged between components (or applications) and/or made publicly available data by a component. This document describes the payload that would be carried if applications are communicating via a messaging system, but the document does not include the method of exchange, and therefore is applicable to a variety of exchange implementations. All examples provided in this document are serialised according to in the IEC 61970-552:2016.

This document specifies the profile (or subset) of the CIM required to describe the exchanged dynamic model information needed to support the analysis of the steady state stability (small-signal stability) and/or transient stability of a power system or parts of it. The information is described with reference to a power system model that conforms to IEC 61970-452 and IEC 61970-456 in this series of related standards. Thus, equipment and other related power flow model data is not repeated in the information exchanged with this document. The schema(s) for expressing the dynamic model information are derived directly from the CIM, more specifically from IEC 61970-302.

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

# Part 457: Dynamics profile

## 1 Scope

This part of IEC 61970 specifies a standard interface for exchanging dynamic model information needed to support the analysis of the steady state stability (small-signal stability) and/or transient stability of a power system or parts of it. The schema(s) for expressing the dynamic model information are derived directly from the CIM, more specifically from IEC 61970-302.

The scope of this document includes only the dynamic model information that needs to be exchanged as part of a dynamic study, namely the type, description and parameters of each control equipment associated with a piece of power system equipment included in the steady state solution of a complete power system network model. Therefore, this profile is dependent upon other standard profiles for the equipment as specified in IEC 61970-452, CIM static transmission network model profiles, the topology, the steady state hypothesis and the steady-state solution (as specified in IEC 61970-456, *Solved power system state profiles*) of the power system, which bounds the scope of the exchange. The profile information described by this document needs to be exchanged in conjunction with IEC 61970-452 and IEC 61970-456 profiles' information to support the data requirements of transient analysis tools. IEC 61970-456 provides a detailed description of how different profile standards can be combined to form various types of power system network model exchanges.

This document supports the exchange of the following types of dynamic models:

- standard models: a simplified approach to exchange, where models are contained in predefined libraries of classes interconnected in a standard manner that represent dynamic behaviour of elements of the power system. The exchange only indicates the name of the model along with the attributes needed to describe its behaviour.
- proprietary user-defined models: an exchange that would provide users the ability to exchange the parameters of a model representing a vendor or user proprietary device where an explicit description of the model is not described in this document. The connections between the proprietary models and standard models are the same as described for the standard models exchange. Recipient of the data exchange will need to contact the sender for the behavioural details of the model.

This document builds on IEC 61970-302, CIM for dynamics which defines the descriptions of the standard dynamic models, their function block diagrams, and how they are interconnected and associated with the static network model. This type of model information is assumed to be pre-stored by all software applications hence it is not necessary to be exchanged in real-time or as part of a dynamics model exchange.

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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 61970-301:2020, *Energy management system application program interface (EMS-API) - Part 301: Common information model (CIM) base*

IEC 61970-302:2018, *Energy management system application program interface (EMS-API) - Part 302: Common information model (CIM) dynamics*

IEC 61970-452:2017, *Energy management system application program interface (EMS-API) - Part 452: CIM static transmission network model profiles*

IEC 61970-456:2018, *Energy management system application program interface (EMS-API) - Part 456: Solved power system state profiles*

## 3 Terms and definitions

No terms and definitions are listed in this document.

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

## 4 Profile specification

### 4.1 General

This document is applicable for both CIM16 and CIM17 base models; however, if exchanged with CIM16 related standards some types of wind models cannot be exchanged due to lack of power electronics related classes in IEC 61970-452:2017 and IEC 61970-456:2018.

The profile defined in this document has the following version related information:

- Title: Dynamics Vocabulary
- Keyword: DY
- Description: This vocabulary is describing the dynamics profile from IEC 61970-457.
- Version IRI: http://iec.ch/TC57/ns/CIM/Dynamic/1.0
- Version info: 1.0.0
- Prior version:
- Conforms to: urn:iso:std:iec:61970-457:ed-1|urn:iso:std:iec:61970-301:ed-7:amd1|urn:iso:std:iec:61970-301:ed-1|file://iec61970cim17v40_iec61968cim13v13a_iec62325cim03v17a.eap|urn:iso:std:iec:61970-401:draft:ed-1|urn:iso:std:iec:61970-501:draft:ed-2
- Identifier: urn:uuid:892c090f-a121-4e11-bede-e47a2be990ff

### 4.2 Requirements and constraints

This clause defines requirements and constraints that shall be fulfilled by applications that conform to this document. The naming of the rules shall not be used for the machine processing and for the moment it is just a string. The naming convention of the constraints is as follows.

“{rule.Type}:{rule.Standard}:{rule.Profile}:{rule.Property}:{rule.Name}”

where

rule.Type: C – for constraint; R – for requirement

rule.Standard: the number of the standard part, e.g. 452 for IEC 61970-452.

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rule.Profile: the abbreviation of the profile, e.g. TP for Topology profile. If set to “ALL” the constraint is applicable to all profiles.

rule.Property: for UML classes – the name of the class; for attributes and associations – the name of the class and attribute or association end, e.g. EnergyConsumer, IdentifiedObject.name, etc. If set to “NA” the property is not applicable to a specific UML element.

rule.Name: the name of the rule. It is unique for the same property

Example: C:452:EQ:IdentifiedObject.name:StringLength.

- C:457:DY:GovSteamSGO.pmin:datatype

There is a mistake in IEC 61970-302. The datatype of the attribute GovSteamSGO.pmin is given there as Seconds. The value exchanged with this attribute shall be PU as it is for GovSteamSGO.pmax.

- C:457:DY:mwbase:equation

The vast majority of turbine-governor models have mwbase as a parameter. The parameter is specified explicitly in the turbine-governor models to support use of a different value by transient analysis tools, if needed. If this parameter is present it shall correspond to RotatingMachine.ratedPowerFactor * RotatingMachine.ratedS.

- C:457:DY:IdentifiedObject.name:stringLength

The string IdentifiedObject.name has a maximum of 128 characters.

- C:457:DY:IdentifiedObject.description:stringLength

The string IdentifiedObject.description has a maximum of 256 characters.

- C:457:DY:ExcitationSystemDynamics.SynchronousMachineDynamics:reference

ExcitationSystemDynamics.SynchronousMachineDynamics cannot point to an object of type SynchronousMachineSimplified.

- C:457:DY:TurbineGovernorDynamics:deltaomega

Some turbine governors diagrams have deltaomega as an input others just omega. In cases where deltaomega is an input, the following relation with the speed is defined: deltaomega = (speed – 1) in pu.

- C:457:DY:RotatingMachineDynamics:modelType-SubtransientRoundRotorSimplified

Annex A specifies the usage of different attributes related to the model type.

If SynchronousMachineTimeConstantReactance.modelType is subtransientSimplified and .rotorType is roundRotor the following optional attributes are not exchanged or set to 0:

– SynchronousMachineDetailed.saturationFactorQAxis
– SynchronousMachineDetailed.saturationFactor120QAxis.

RotatingMachineDynamics.statorResistance is set to 0.

- C:457:DY:RotatingMachineDynamics:modelType-SubtransientSalientPole

Annex A specifies the usage of different attributes related to the model type.

If SynchronousMachineTimeConstantReactance.modelType is subtransient and .rotorType is salientPole the following optional attributes are not exchanged or set to 0:

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  - SynchronousMachineDetailed.saturationFactorQAxis
  - SynchronousMachineDetailed.saturationFactor120QAxis.
- C:457:DY:RotatingMachineDynamics:modelType-SubtransientRoundRotor

Annex A specifies the usage of different attributes related to the model type.

If SynchronousMachineTimeConstantReactance.modelType is subtransient and .rotorType is roundRotor the following optional attributes are required:

  - SynchronousMachineTimeConstantReactance.xQuadTrans
  - SynchronousMachineTimeConstantReactance.tpqo
  - SynchronousMachineDetailed.saturationFactorQAxis
  - SynchronousMachineDetailed.saturationFactor120QAxis
  - RotatingMachineDynamics.saturationFactor
  - RotatingMachineDynamics.saturationFactor120.
- R:457:NA:float

An attribute that is defined as float (e.g. has a type Float or a type which is a Datatype with .value attribute of type Float) shall support ISO/IEC 60559:2020 for floating-point arithmetic using single precision floating point. A single precision float supports 7 significant digits where the significant digits are described as an integer, or a decimal number with 6 decimal digits. Two float values are equal when the significant with 7 digits are identical, e.g. 1234567 is equal 1.234567E6 and so are 1.2345678 and 1.234567E0.

- R:457:DY:IdentifiedObject.name:rule

The attribute “name” inherited by many classes from the abstract class IdentifiedObject is not required to be unique. It must be a human readable identifier without additional embedded information that would need to be parsed. The attribute is used for purposes such as User Interface and data exchange debugging. The MRID defined in the data exchange format is the only unique and persistent identifier used for this data exchange.

- R:457:DY:IdentifiedObject.description:rule

The attribute “description” inherited by many classes from the abstract class IdentifiedObject must contain human readable text without additional embedded information that would need to be parsed.

- R:457:DY:NA:uniqueIdentifier

All IdentifiedObject-s shall have a persistent and globally unique identifier (Master Resource Identifier – mRID).

- R:457:DY:NA:exchange

Optional and required attributes and associations must be imported and exported if they are in the model file prior to import.

- R:457:DY:NA:exchange1

If an optional attribute does not exist in the imported file, it does not have to be exported in case exactly the same data set is exported, i.e. the tool is not obliged to automatically provide this attribute. If the export is resulting from an action by the user performed after the import, e.g. data processing or model update the export can contain optional attributes.

- R:457:DY:NA:exchange2

In most of the profiles the selection of optional and required attributes is made so as to ensure a minimum set of required attributes without which the exchange does not fulfil its basic

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purpose. Business processes governing different exchanges can require mandatory exchange of certain optional attributes or associations. Optional and required attributes and associations shall therefore be supported by applications which claim conformance with certain functionalities of IEC 61970-457. This provides flexibility for the business processes to adapt to different business requirements and base the exchanges on IEC 61970-457-compliant applications.

- R:457:DY:NA:exchange3

An exporter may, at his or her discretion, produce a serialization containing additional class data described by the CIM Schema but not required by this document provided these data adhere to the conventions established in Clause 8.

## 5 Overview

This document describes an interface standard in which payloads are used to exchange dynamic model information of prime mover response, controls and other data needed to support the analysis of the steady state stability (small-signal stability) and/or transient stability of a power system.

The primary objective is to enable interoperability among different software vendors used by utilities and regional or national reliability entities to help ensure bulk power system reliability and security of supply through the exchange of the dynamic models needed to conduct small signal stability and transient stability analysis studies. These studies are also utilized in system development processes where new interconnections or other grid reinforcements are studied.

IEC 61970-302 extends the CIM standard information model by adding new standard power system dynamic models to the static power system network model described by IEC 61970-301, IEC 61970-452 and IEC 61970-456. The scope of the standard models is defined to include the vast majority of models commonly implemented by vendors or commonly used by utilities today.

This document defines a standard model exchange format (a profile) based on the extended CIM information model to accommodate the data requirements that shall be exchanged to completely specify a particular dynamic case, including association of these dynamic models to static load flow model elements for some specific point in time. The current practice is to use vendor proprietary formats and a converter to transform from one proprietary format to another depending on the software products sending and receiving the dynamic case files.

The modelling approach sought to minimize the amount of information that had to be actually exchanged by leveraging commonly understood information about the individual dynamic model subsystems, such as the specific model behaviour, equations, interconnection patterns, input/output signals, and initialization procedures that can be pre-stored and thus do not need to be exchanged. The only information required in the exchange is the identity of the specific standard or user-defined (proprietary) models, an association to a specific equipment instance in the static network model, the parameter values that are dependent on the behavior of the physical equipment, the electromechanical and electronic controls, and the small signal behavioural aspects of the equipment.

In some cases, the purpose of the exchange is to include all data necessary to perform a small signal stability analysis of a specific scenario. In this case, the entire electrical model as defined in IEC 61970-452 and the data describing the solved state as defined in IEC 61970-456 will be required. The solved state will be based on the study conditions such as equipment outages and generator output levels.

How to read this document:

- The ‘Use cases’ clause (Clause 6) gives examples of business problems that this document is intended to address.

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- The ‘Architecture’ clause (Clause 7) summarizes how the models described in this document work with parts described in other IEC 61970 series standards.
- The ‘Detailed profile specification’ clause (Clause 8) defines the kinds of datasets controlled by this document.
- Annex A provides implementation clarifications related to the models inherited from RotatingMachineDynamics class.
- Annex B provides some examples when using IEC 61970-552 serialisation.

# 6 Use cases

## 6.1 General

The use case clause presents some of the business problems that were considered in the design of this document and discusses how the document is expected to provide value to the industry.

Dynamics models exchange supplies data for one of the most complex analyses of a power system. The requirements of the data exchanges are directly related to the level of detail of the power system modelling applied in a given area. This document (dynamics profile) supports the exchange of dynamic behaviour models used by software applications which perform analysis of the steady state stability (small-signal stability) and/or transient stability of a power system as defined by IEEE / CIGRE Standard Terms and Definitions for Power System Stability Analysis.

Dynamics models are typically described using both graphics and text. Therefore, there is a high level of complexity and room for interpretation, which this document is designed to minimize.

## 6.2 Dynamic assessment studies

Small signal stability and transient stability analysis studies are used by utilities and regional or national reliability entities to help ensure bulk power system reliability and security of supply. These studies are utilized in the scope of system development processes where new interconnections or other grid reinforcements are studied. Sharing of dynamics behaviour information is not just useful, but crucial, for grid operations entities (utilities, regional reliability organizations, transmission system operators) that need to do system-wide studies utilizing different applications. These studies are generally over very large portions of the network, if not the entire interconnection, and each entity studying the dynamic stability of its system needs to acquire dynamics data from each of its neighbouring systems.

The standard models library (see IEC 61970-302) is based on numerous common models (some IEEE standards, some IEC standards and some models widely used by the utilities or organizations), which have been defined for various components of the power system. Since dynamic stability studies performed at both utilities and reliability entities require model definitions of each component, exchange of dynamic models in a standardized format benefits overall grid reliability and grid planning by eliminating manual entry errors and facilitating timely data sharing.

Dynamic assessment studies require a full steady state electrical equipment model including topology and a solved state. The source of this data may vary.

- In the case of long-term studies, planning models are typically used. These models reflect the equipment in place at the time of the study. The steady state hypothesis, topology, and solution state reflect normal or adverse conditions based on the purpose of the study.
- Current conditions are usually studied by using an electrical model from a state estimator along with a topology based on current switch positions and a solved state reflecting current generation and load.

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- For historic events which warrant small signal analysis or reproduction of the behaviour of generators during the event, previous state estimator models and solutions are typically used in providing equipment, topology and state of the study period.
- New generation or area-to-area interconnections are mostly studied using small signal stability studies. In these cases, planning models are often used.

# 7 Architecture

## 7.1 General

The main architectural feature of this document is the reduction in complexity of how the different models connect to one another and to the electrical equipment they are related to. In order to study the dynamic behaviour of a generator, a model describing the transient behaviour of the generator, prime mover, governor, exciter, power system stabilizer, voltage regulator, and any other equipment must be defined. In addition, similar detail of all generators in the region shall be modelled in the same detail.

All of the models covered in IEC 61970-302 are included in this profile. The document lists all concrete and abstract classes used by the dynamics profile. However only concrete classes are present in the exchange of dynamics model data as they include all of the data inherited from the abstract classes. This document augments IEC 61970-302 with examples of how the dynamics data is organized and dependant on other profiles. Some examples of payload are included in this document.

Details of the descriptions of the individual models found in IEC 61970-302 are further amended in this document in order to describe the usage of the models. IEC 61970-302 lists typical values to assist understanding of the magnitude of the quantities used for each of the attributes. These values do not replace or reflect any real data, hence shall not be interpreted as default values and shall not be used in real data exchange as a substitute of unknown values for the parameters. The untended use of typical values is to indicate a potential set of parameters that can be used during development and testing of applications supporting the standard models defined in the standard. The attributes used in the payload of any CIM transfer shall normally reflect commissioning data or results from subsequent testing of the machines being studied in order to provide reliable results. This document specifies the required attributes for each class in the profile as well as the directions of the associations. Therefore, the profile is designed to augment the equipment model with additional transient model data. The associations between the classes in the equipment model and the classes covered under this profile shall be defined within the instances of the classes included in this profile. Persistence in identifiers shall be maintained for these types of exchanges.

Figure 1 gives an example of linkage between dynamics profile and a SynchronousMachine defined in equipment profile (IEC 61970-452).

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```
<cim:SynchronousMachineTimeConstantReactance rdf:ID="_99d08548-89cf-11e3-8aa9-2c44fd6790f2">
 <cim:IdentifiedObject.name>GENROU</cim:IdentifiedObject.name>
 <cim:DynamicsFunctionBlock.enabled>true</cim:DynamicsFunctionBlock.enabled>
...
<cim:SynchronousMachineDynamics.SynchronousMachine rdf:resource="#_caca0471-89ce-11e3-8aa9-
2c44fd6790f2" />
...
</cim:SynchronousMachineTimeConstantReactance>
```

**Figure 1 – SynchronousMachineDynamics association**

## 7.2 Profile architecture

Every generator in the equipment model shall have all of its dynamic components modelled. Some of the dynamic components feed signals to other components. Some generators share controls, which shall be modelled. Many of the component models are standardized throughout the industry. The standard component models are generally connected together in a standard way based on the type of generator. Several types of these standard model interconnections are outlined in IEC 61970-302. The diagram shown in Figure 2 is one of those and specifies how to trace signals through the different standard component models of a synchronous generator.

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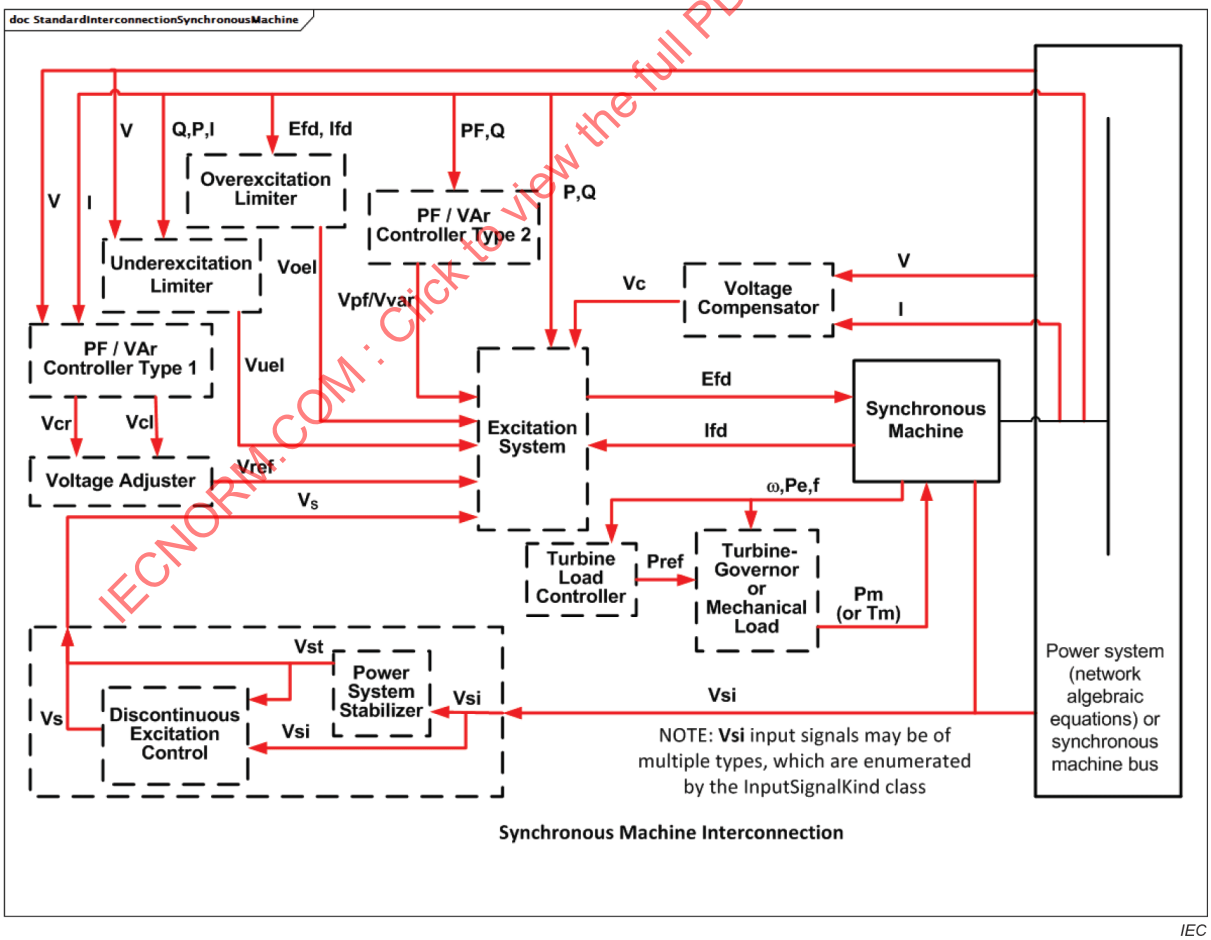


**Figure 2 – Interconnection diagram for a synchronous machine**

There are CIM classes representing each type of component and the associations between them reflect the possible combinations of components that can be used to represent a specific type of interconnection. For example, the synchronous machine, whose interconnection diagram is shown in Figure 3, is represented by the CIM classes and associations shown in Figure 2. The cardinality of the associations reflects how many of which components can be used in describing a given synchronous machine.

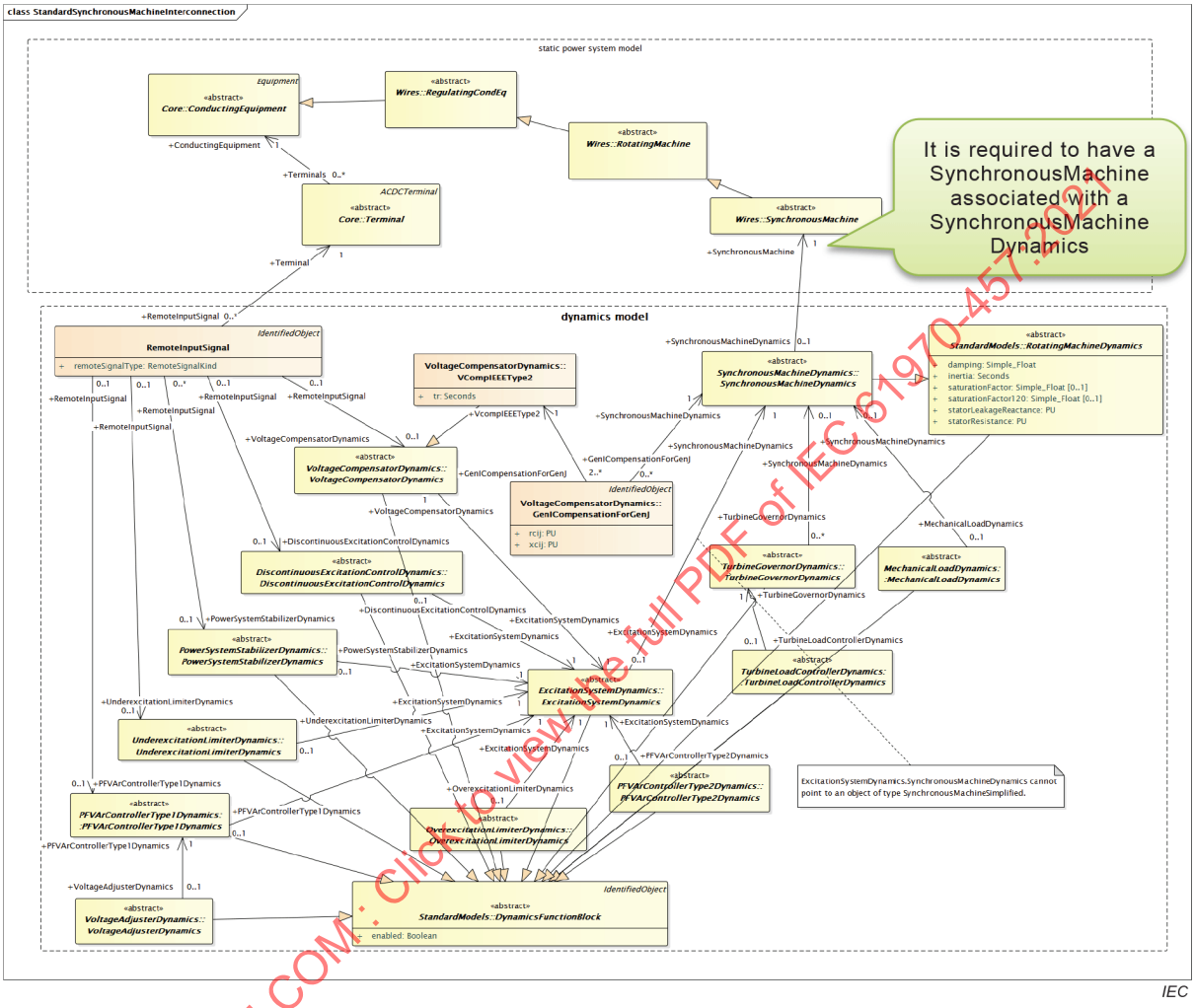


**Figure 3 – Standard connections for a synchronous machine**

Specifying the signal connectivity between models is not necessary for the standard models. A dynamic model for a specific generator shall include all of the components necessary to simulate its response to the electrical system. For example, if a generator does not have specific components installed such as limiters on the excitation controllers then the UnderexcitationLimiterDynamics and OverexcitationLimiterDynamics instances shall be excluded from the payload. The output signals from these components are not passed to the exciter component. In some cases, such as with a voltage adjuster, the input signal shall be passed through to the excitation system.

The exchange of dynamics data for use in simulations depends on data from other exchanges as defined in other IEC documentation and shown in the profile relationships in Figure 4.

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- Static network model profiles defined in IEC 61970-452 include the Equipment Model profile, which contains static modelling information describing power system physical elements and their electrical connections. Associations from Dynamics Models profile classes to equipment profile classes allow dynamic models to be associated with the specific equipment they represent. For example, there is an association from SynchronousMachineDynamics to SynchronousMachine which ties SynchronousMachineDynamics, along with all of its associated components, to the equipment model. This is illustrated in Figure 3.
- The steady-state solution profiles (Topology and State Variables) defined in IEC 61970-456 provide the topological connectivity of the model and the solved state of the model, which is used as a starting condition of the dynamics simulation. The steady-state solution information is accessible to the dynamics simulation because the classes of those profiles also refer to Equipment Model profile classes.
- The Schematic Layout profile defined in IEC 61970-453 describes the elements of schematic or geographic displays. Exchange of graphics data is not required to support dynamic simulation studies, but may be helpful in diagnosing or analyzing problem in the study.

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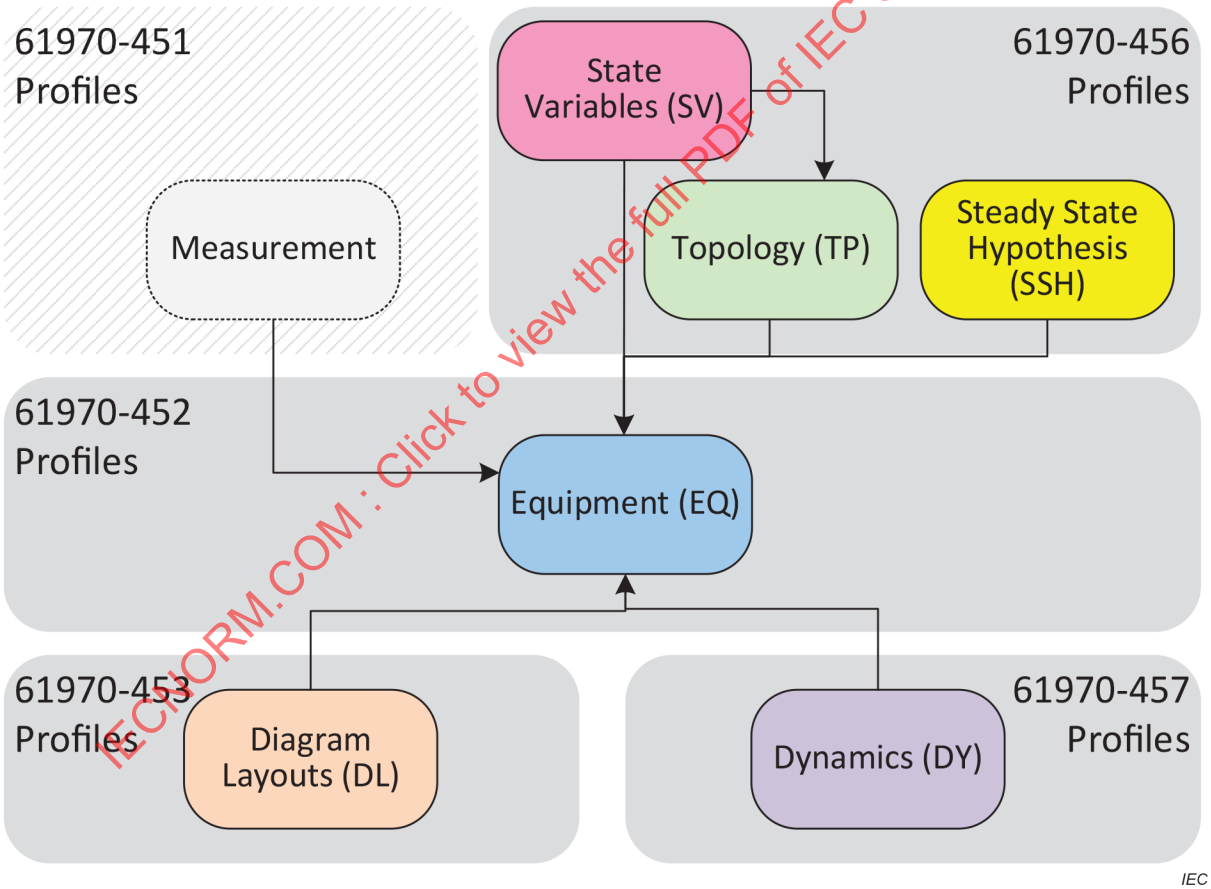


**Figure 4 – Profile relationships**

## 8 Detailed profile specification

### 8.1 General

This clause contains the detailed specification for the dynamics profile.

## 8.2 Package DynamicsProfile

### 8.2.1 General

This is the IEC 61970-457 profile.

### 8.2.2 (abstract) DynamicsProfileVersion root class

Version details.

Table 1 shows all attributes of DynamicsProfileVersion.

**Table 1 – Attributes of DynamicsProfile::DynamicsProfileVersion**

| name | mult | type | description |
|---|---|---|---|
| baseUML | 1..1 | String | (const=iec61970cim17v38_iec61968cim13v12_iec62325cim03v17a) Base UML provided by CIM model manager. |
| baseURI | 1..1 | String | (const=http://iec.ch/TC57/CIM/Dynamics/1/0) Profile URI used in the Model Exchange header and defined in IEC standards. It uniquely identifies the Profile and its version. The last two elements in the URI (e.g. http://iec.ch/TC57/61970-452/CoreEquipment/yy/zzz) indicate major and minor versions where:<br>– yy – indicates a major version;<br>– zzz – indicates a minor version. |
| date | 1..1 | Date | (const=2020-05-14) Profile creation date. The form is YYYY-MM-DD. For example, for 5 January 2009 it is 2009-01-05. |
| differenceModelURI | 1..1 | String | (const=http://iec.ch/TC57/61970-552/DifferenceModel/1#) Difference model URI defined by IEC 61970-552. |
| profileUML | 1..1 | String | (const=FDIS09-iec61970-600-CGMES-v3_0_0) UML which contains the profile. |
| modelDescriptionURI | 1..1 | String | (const=http://iec.ch/TC57/61970-552/ModelDescription/1#) Model Description URI defined by IEC 61970-552. |
| namespaceRDF | 1..1 | String | (const=http://www.w3.org/1999/02/22-rdf-syntax-ns#) RDF namespace. |
| namespaceUML | 1..1 | String | (const=http://iec.ch/TC57/CIM100#) CIM UML namespace. |
| shortName | 1..1 | String | (const=DY) The short name of the profile used in profile documentation. |

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### 8.2.3 Package Base

#### 8.2.3.1 General

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

#### 8.2.3.2 Package Domain

##### 8.2.3.2.1 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.

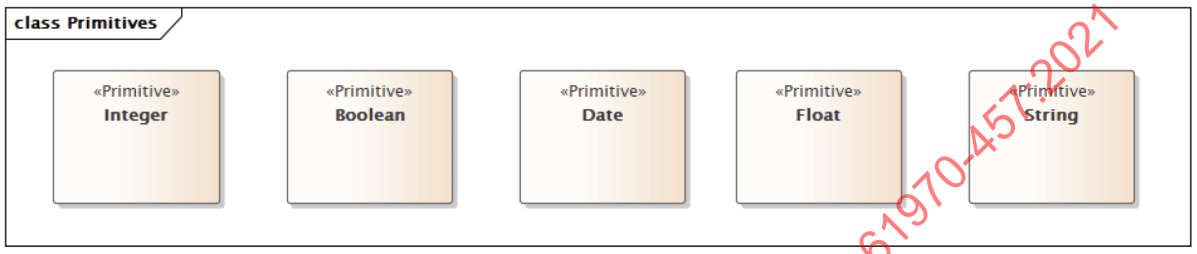


**Figure 5 – Class diagram Domain::Primitives**

Figure 5: This diagram lists the primitives defined in the CIM and used in this document.

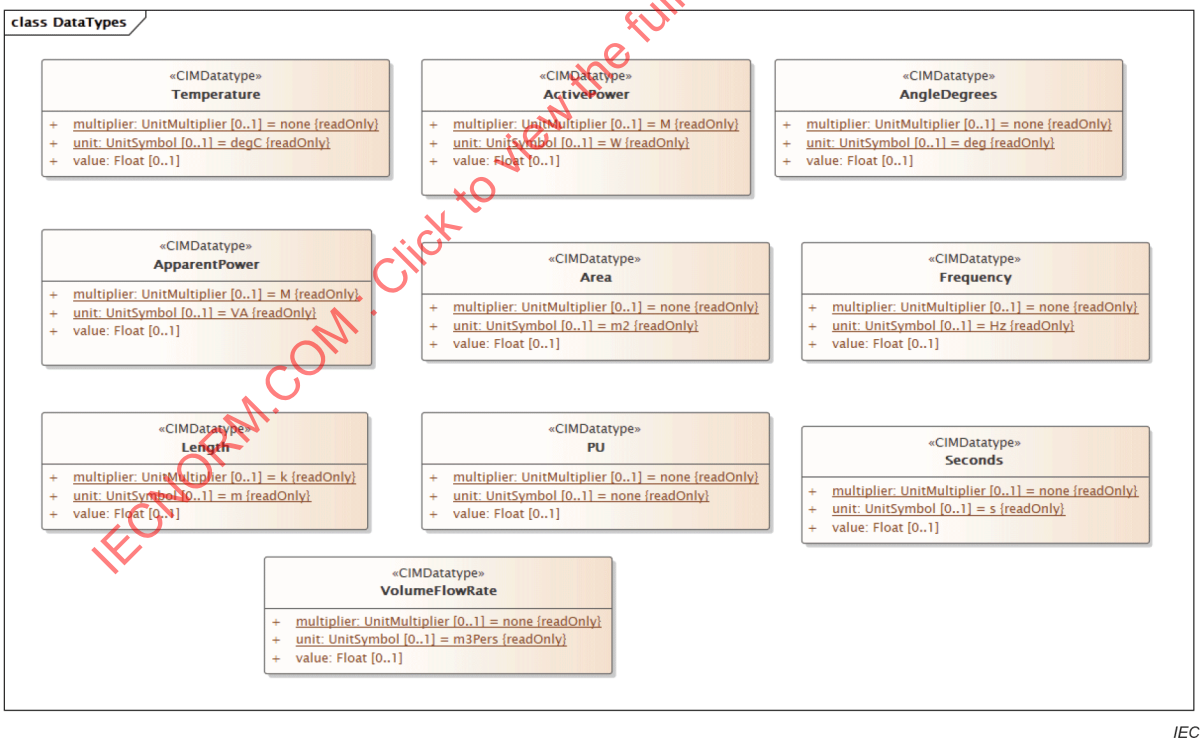


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**Figure 6 – Class diagram Domain::DataTypes**

Figure 6: This diagram illustrates the data types supported by the CIM and used in this document.

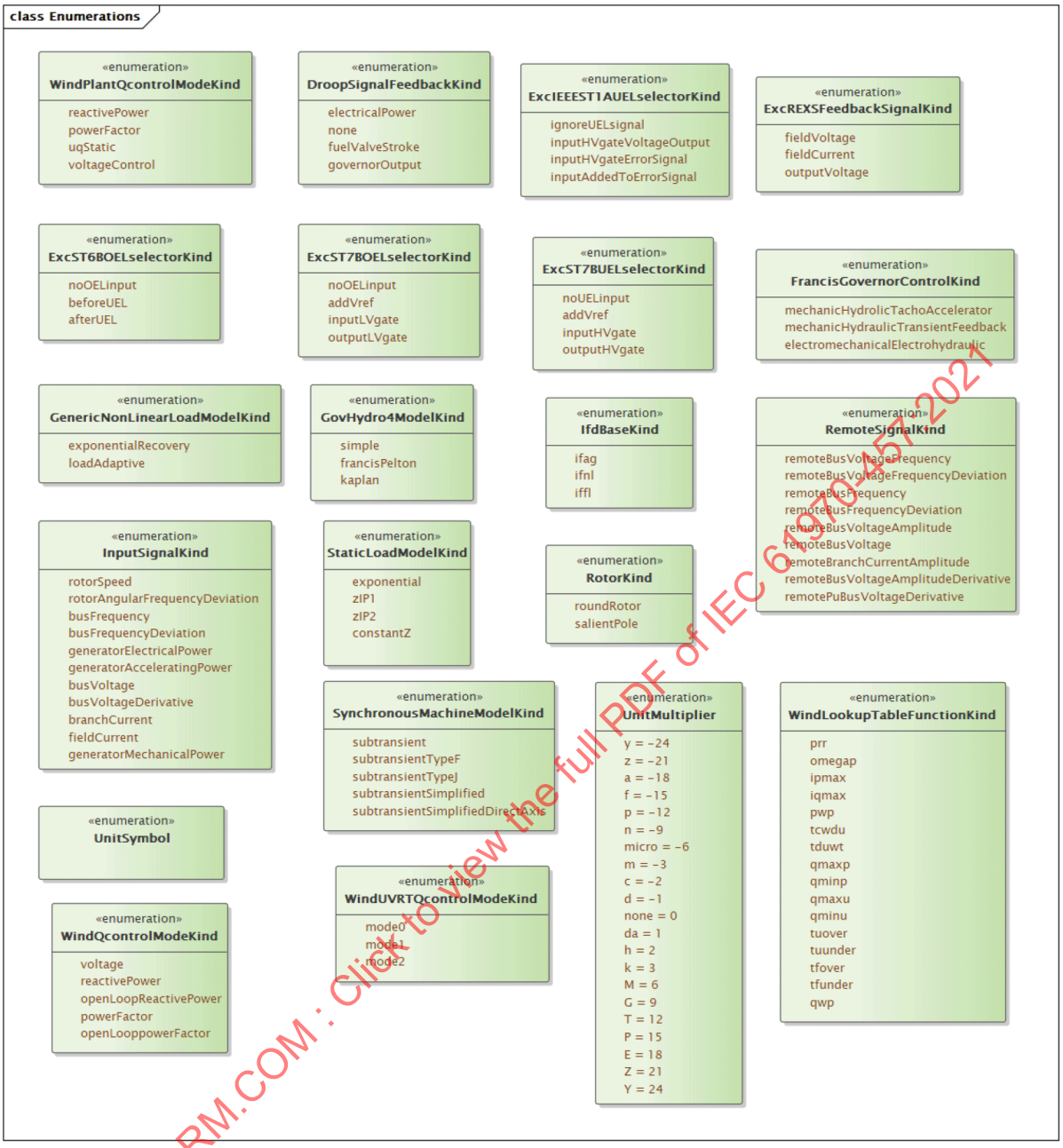


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**Figure 7 – Class diagram Domain::Enumerations**

Figure 7: This diagram provides information on the enumerations defined in the CIM and used in this document.

#### 8.2.3.2.2 ActivePower datatype

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

Table 2 shows all attributes of ActivePower.

**Table 2 – Attributes of Domain::ActivePower**

| name | mult | type | description |
|---|---|---|---|
| value | 0..1 | Float | |

| name | mult | type | description |
|---|---|---|---|
| multiplier | 0..1 | UnitMultiplier | (const=M) |
| unit | 0..1 | UnitSymbol | (const=W) |

#### 8.2.3.2.3 AngleDegrees datatype

Measurement of angle in degrees.

Table 3 shows all attributes of AngleDegrees.

**Table 3 – Attributes of Domain::AngleDegrees**

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

#### 8.2.3.2.4 ApparentPower datatype

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

Table 4 shows all attributes of ApparentPower.

**Table 4 – Attributes of Domain::ApparentPower**

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

#### 8.2.3.2.5 Area datatype

Area.

Table 5 shows all attributes of Area.

**Table 5 – Attributes of Domain::Area**

| name | mult | type | description |
|---|---|---|---|
| value | 0..1 | Float | |
| unit | 0..1 | UnitSymbol | (const=m2) |
| multiplier | 0..1 | UnitMultiplier | (const=none) |

#### 8.2.3.2.6 Frequency datatype

Cycles per second.

Table 6 shows all attributes of Frequency.

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**Table 6 – Attributes of Domain::Frequency**

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

#### 8.2.3.2.7 Length datatype

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

Table 7 shows all attributes of Length.

**Table 7 – Attributes of Domain::Length**

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

#### 8.2.3.2.8 PU datatype

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

Table 8 shows all attributes of PU.

**Table 8 – Attributes of Domain::PU**

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

#### 8.2.3.2.9 Seconds datatype

Time, in seconds.

Table 9 shows all attributes of Seconds.

**Table 9 – 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) |

#### 8.2.3.2.10 Temperature datatype

Value of temperature in degrees Celsius.

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Table 10 shows all attributes of Temperature.

**Table 10 – Attributes of Domain::Temperature**

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

#### 8.2.3.2.11 VolumeFlowRate datatype

Volume per time.

Table 11 shows all attributes of VolumeFlowRate.

**Table 11 – Attributes of Domain::VolumeFlowRate**

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

#### 8.2.3.2.12 Boolean primitive

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

#### 8.2.3.2.13 Float primitive

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

#### 8.2.3.2.14 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".

#### 8.2.3.2.15 Integer primitive

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

#### 8.2.3.2.16 String primitive

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

#### 8.2.3.2.17 DroopSignalFeedbackKind enumeration

Governor droop signal feedback source.

Table 12 shows all literals of DroopSignalFeedbackKind.

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**Table 12 – Literals of Domain::DroopSignalFeedbackKind**

| literal | value | description |
|---|---|---|
| electricalPower | | Electrical power feedback (connection indicated as 1 in the block diagrams of models, e.g. GovCT1, GovCT2). |
| none | | No droop signal feedback, is isochronous governor. |
| fuelValveStroke | | Fuel valve stroke feedback (true stroke) (connection indicated as 2 in the block diagrams of model, e.g. GovCT1, GovCT2). |
| governorOutput | | Governor output feedback (requested stroke) (connection indicated as 3 in the block diagrams of models, e.g. GovCT1, GovCT2). |

#### 8.2.3.2.18 ExcIEEEST1AUELselectorKind enumeration

Types of connections for the UEL input used in ExcIEEEST1A.

Table 13 shows all literals of ExcIEEEST1AUELselectorKind.

**Table 13 – Literals of Domain::ExcIEEEST1AUELselectorKind**

| literal | value | description |
|---|---|---|
| ignoreUELsignal | | Ignore UEL signal. |
| inputHVgateVoltageOutput | | UEL input HV gate with voltage regulator output. |
| inputHVgateErrorSignal | | UEL input HV gate with error signal. |
| inputAddedToErrorSignal | | UEL input added to error signal. |

#### 8.2.3.2.19 ExcREXSFeedbackSignalKind enumeration

Types of rate feedback signals.

Table 14 shows all literals of ExcREXSFeedbackSignalKind.

**Table 14 – Literals of Domain::ExcREXSFeedbackSignalKind**

| literal | value | description |
|---|---|---|
| fieldVoltage | | The voltage regulator output voltage is used. It is the same as exciter field voltage. |
| fieldCurrent | | The exciter field current is used. |
| outputVoltage | | The output voltage of the exciter is used. |

#### 8.2.3.2.20 ExcST6BOELselectorKind enumeration

Types of connections for the OEL input used for static excitation systems type 6B.

Table 15 shows all literals of ExcST6BOELselectorKind.

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**Table 15 – Literals of Domain::ExcST6BOELselectorKind**

| literal | value | description |
|---|---|---|
| noOELinput | | No OEL input is used. Corresponds to OELin not = 1 and not = 2 on the ExcST6B diagram. Original ExcST6B model would have called this OELin = 0. |
| beforeUEL | | The connection is before UEL. Corresponds to OELin = 1 on the ExcST6B diagram. |
| afterUEL | | The connection is after UEL. Corresponds to OELin = 2 on the ExcST6B diagram. |

#### 8.2.3.2.21 ExcST7BOELselectorKind enumeration

Types of connections for the OEL input used for static excitation systems type 7B.

Table 16 shows all literals of ExcST7BOELselectorKind.

**Table 16 – Literals of Domain::ExcST7BOELselectorKind**

| literal | value | description |
|---|---|---|
| noOELinput | | No OEL input is used. Corresponds to OELin not = 1 and not = 2 and not = 3 on the ExcST7B diagram. Original ExcST7B model would have called this OELin = 0. |
| addVref | | The signal is added to Vref. Corresponds to OELin = 1 on the ExcST7B diagram. |
| inputLVgate | | The signal is connected into the input LVGate. Corresponds to OELin = 2 on the ExcST7B diagram. |
| outputLVgate | | The signal is connected into the output LVGate. Corresponds to OELin = 3 on the ExcST7B diagram. |

#### 8.2.3.2.22 ExcST7BUELselectorKind enumeration

Types of connections for the UEL input used for static excitation systems type 7B.

Table 17 shows all literals of ExcST7BUELselectorKind.

**Table 17 – Literals of Domain::ExcST7BUELselectorKind**

| literal | value | description |
|---|---|---|
| noUELinput | | No UEL input is used. Corresponds to UELin not = 1 and not = 2 and not = 3 on the ExcST7B diagram. Original ExcST7B model would have called this UELin = 0. |
| addVref | | The signal is added to Vref. Corresponds to UELin = 1 on the ExcST7B diagram. |
| inputHVgate | | The signal is connected into the input HVGate. Corresponds to UELin = 2 on the ExcST7B diagram. |
| outputHVgate | | The signal is connected into the output HVGate. Corresponds to UELin = 3 on the ExcST7B diagram. |

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#### 8.2.3.2.23 FrancisGovernorControlKind enumeration

Governor control flag for Francis hydro model.

Table 18 shows all literals of FrancisGovernorControlKind.

**Table 18 – Literals of Domain::FrancisGovernorControlKind**

| literal | value | description |
|---|---|---|
| mechanicHydrolicTachoAccelerator | | Mechanic-hydraulic regulator with tacho-accelerometer (Cflag = 1). |
| mechanicHydraulicTransientFeedback | | Mechanic-hydraulic regulator with transient feedback (Cflag=2). |
| electromechanicalElectrohydraulic | | Electromechanical and electrohydraulic regulator (Cflag=3). |

#### 8.2.3.2.24 GenericNonLinearLoadModelKind enumeration

Type of generic non-linear load model.

Table 19 shows all literals of GenericNonLinearLoadModelKind.

**Table 19 – Literals of Domain::GenericNonLinearLoadModelKind**

| literal | value | description |
|---|---|---|
| exponentialRecovery | | Exponential recovery model. |
| loadAdaptive | | Load adaptive model. |

#### 8.2.3.2.25 GovHydro4ModelKind enumeration

Possible types of GovHydro4 models.

Table 20 shows all literals of GovHydro4ModelKind.

**Table 20 – Literals of Domain::GovHydro4ModelKind**

| literal | value | description |
|---|---|---|
| simple | | Simple model. |
| francisPelton | | Francis or Pelton model. |
| kaplan | | Kaplan model. |

#### 8.2.3.2.26 IfdBaseKind enumeration

Excitation base system mode.

Table 21 shows all literals of IfdBaseKind.

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**Table 21 – Literals of Domain::IfdBaseKind**

| literal | value | description |
|---|---|---|
| ifag | | Air gap line mode. |
| ifnl | | No load system with saturation mode. |
| iffl | | Full load system mode. |

#### 8.2.3.2.27 InputSignalKind enumeration

Types of input signals. In dynamics modelling, commonly represented by the j parameter.

Table 22 shows all literals of InputSignalKind.

**Table 22 – Literals of Domain::InputSignalKind**

| literal | value | description |
|---|---|---|
| rotorSpeed | | Input signal is rotor or shaft speed (angular frequency). |
| rotorAngularFrequencyDeviation | | Input signal is rotor or shaft angular frequency deviation. |
| busFrequency | | Input signal is bus voltage frequency. This could be a terminal frequency or remote frequency. |
| busFrequencyDeviation | | Input signal is deviation of bus voltage frequency. This could be a terminal frequency deviation or remote frequency deviation. |
| generatorElectricalPower | | Input signal is generator electrical power on rated S. |
| generatorAcceleratingPower | | Input signal is generator accelerating power. |
| busVoltage | | Input signal is bus voltage. This could be a terminal voltage or remote voltage. |
| busVoltageDerivative | | Input signal is derivative of bus voltage. This could be a terminal voltage derivative or remote voltage derivative. |
| branchCurrent | | Input signal is amplitude of remote branch current. |
| fieldCurrent | | Input signal is generator field current. |
| generatorMechanicalPower | | Input signal is generator mechanical power. |

#### 8.2.3.2.28 RemoteSignalKind enumeration

Type of input signal coming from remote bus.

Table 23 shows all literals of RemoteSignalKind.

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**Table 23 – Literals of Domain::RemoteSignalKind**

| literal | value | description |
|---|---|---|
| remoteBusVoltageFrequency | | Input is voltage frequency from remote terminal bus. |
| remoteBusVoltageFrequencyDeviation | | Input is voltage frequency deviation from remote terminal bus. |
| remoteBusFrequency | | Input is frequency from remote terminal bus. |
| remoteBusFrequencyDeviation | | Input is frequency deviation from remote terminal bus. |
| remoteBusVoltageAmplitude | | Input is voltage amplitude from remote terminal bus. |
| remoteBusVoltage | | Input is voltage from remote terminal bus. |
| remoteBranchCurrentAmplitude | | Input is branch current amplitude from remote terminal bus. |
| remoteBusVoltageAmplitudeDerivative | | Input is branch current amplitude derivative from remote terminal bus. |
| remotePuBusVoltageDerivative | | Input is PU voltage derivative from remote terminal bus. |

#### 8.2.3.2.29 RotorKind enumeration

Type of rotor on physical machine.

Table 24 shows all literals of RotorKind.

**Table 24 – Literals of Domain::RotorKind**

| literal | value | description |
|---|---|---|
| roundRotor | | Round rotor type of synchronous machine. |
| salientPole | | Salient pole type of synchronous machine. |

#### 8.2.3.2.30 StaticLoadModelKind enumeration

Type of static load model.

Table 25 shows all literals of StaticLoadModelKind.

**Table 25 – Literals of Domain::StaticLoadModelKind**

| literal | value | description |
|---|---|---|
| exponential | | This model is an exponential representation of the load. Exponential equations for active and reactive power are used and the following attributes are required:<br>kp1, kp2, kp3, kpf, ep1, ep2, ep3<br>kq1, kq2, kq3, kqf, eq1, eq2, eq3. |
| zIP1 | | This model integrates the frequency-dependent load (primarily motors). ZIP1 equations for active and reactive power are used and the following attributes are required:<br>kp1, kp2, kp3, kpf<br>kq1, kq2, kq3, kqf. |

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| literal | value | description |
|---|---|---|
| zIP2 | | This model separates the frequency-dependent load (primarily motors) from other load. ZIP2 equations for active and reactive power are used and the following attributes are required:<br>kp1, kp2, kp3, kq4, kpf<br>kq1, kq2, kq3, kq4, kqf. |
| constantZ | | The load is represented as a constant impedance. ConstantZ equations are used for active and reactive power and no attributes are required. |

#### 8.2.3.2.31 SynchronousMachineModelKind enumeration

Type of synchronous machine model used in dynamic simulation applications.

Table 26 shows all literals of SynchronousMachineModelKind.

**Table 26 – Literals of Domain::SynchronousMachineModelKind**

| literal | value | description |
|---|---|---|
| subtransient | | Subtransient synchronous machine model. |
| subtransientTypeF | | WECC type F variant of subtransient synchronous machine model. |
| subtransientTypeJ | | WECC type J variant of subtransient synchronous machine model. |
| subtransientSimplified | | Simplified version of subtransient synchronous machine model where magnetic coupling between the direct- and quadrature- axes is ignored. |
| subtransientSimplifiedDirectAxis | | Simplified version of a subtransient synchronous machine model with no damper circuit on the direct-axis. |

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#### 8.2.3.2.32 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 27 shows all literals of UnitMultiplier.

**Table 27 – 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. |

#### 8.2.3.2.33 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.

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The integer values are used for harmonization with IEC 61850.

Table 28 shows all literals of UnitSymbol.

**Table 28 – 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 (m2/m2). |
| Gy | 21 | Absorbed dose in grays (J/kg). |
| Bq | 22 | Radioactivity in becquerels (1/s). |
| degC | 23 | Relative temperature in degrees Celsius.<br>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. |
| 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/m2). |
| 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. |

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| literal | value | description |
|---|---|---|
| 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). |
| 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).<br>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.<br>NOTE 1 This definition of power factor only holds for balanced systems. See the alternative definition under code 153.<br>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 ($W^2/A^2$). |

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| literal | value | description |
|---|---|---|
| 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. |
| 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 = dm3 = m3/1000. |
| 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’. |

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| literal | value | description |
|---|---|---|
| molPerm3 | 145 | Concentration, The amount of substance concentration, (c), the amount of solvent in moles divided by the volume of solution in m³. |
| 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. |
| 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. |

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| literal | value | description |
|---|---|---|
| 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 = 86400 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 = 1852 m). |
| kn | 219 | Speed, knots (1 kn = 1852/3600) 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). |
| 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). |

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#### 8.2.3.2.34 WindLookupTableFunctionKind enumeration

Function of the lookup table.

Table 29 shows all literals of WindLookupTableFunctionKind.

**Table 29 – Literals of Domain::WindLookupTableFunctionKind**

| literal | value | description |
|---|---|---|
| prr | | Power versus speed change (negative slip) lookup table (prr(deltaomega)). It is used for the rotor resistance control model, IEC 61400-27-1:2015, 5.6.5.3. |
| omegap | | Power vs. speed lookup table (omega(p)). It is used for the P control model type 3, IEC 61400-27-1:2015, 5.6.5.4. |
| ipmax | | Lookup table for voltage dependency of active current limits (ipmax(uWT)). It is used for the current limitation model, IEC 61400-27-1:2015, 5.6.5.8. |
| iqmax | | Lookup table for voltage dependency of reactive current limits (iqmax(uWT)). It is used for the current limitation model, IEC 61400-27-1:2015, 5.6.5.8. |
| pwp | | Power vs. frequency lookup table (pWPbias(f)). It is used for the wind power plant frequency and active power control model, IEC 61400-27-1:2015, Annex D. |
| tcwdu | | Crowbar duration versus voltage variation look-up table (TCW(du)). It is a case-dependent parameter. It is used for the type 3B generator set model, IEC 61400-27-1:2015, 5.6.3.3. |
| tduwt | | Lookup table to determine the duration of the power reduction after a voltage dip, depending on the size of the voltage dip (Td(uWT)). It is a type-dependent parameter. It is used for the pitch control power model, IEC 61400-27-1:2015, 5.6.5.1. |
| qmaxp | | Lookup table for active power dependency of reactive power maximum limit (qmaxp(p)). It is used for the QP and QU limitation model, IEC 61400-27-1:2015, 5.6.5.10. |
| qminp | | Lookup table for active power dependency of reactive power minimum limit (qminp(p)). It is used for the QP and QU limitation model, IEC 61400-27-1:2015, 5.6.5.10. |
| qmaxu | | Lookup table for voltage dependency of reactive power maximum limit (qmaxu(p)). It is used for the QP and QU limitation model, IEC 61400-27-1:2015, 5.6.5.10. |
| qminu | | Lookup table for voltage dependency of reactive power minimum limit (qminu(p)). It is used for the QP and QU limitation model, IEC 61400-27-1:2015, 5.6.5.10. |
| tuover | | Disconnection time versus over-voltage lookup table (Tuover(uWT)). It is used for the grid protection model, IEC 61400-27-1:2015, 5.6.6. |
| tuunder | | Disconnection time versus under-voltage lookup table (Tuunder(uWT)). It is used for the grid protection model, IEC 61400-27-1:2015, 5.6.6. |
| tfover | | Disconnection time versus over-frequency lookup table (Tfover(fWT)). It is used for the grid protection model, IEC 61400-27-1:2015, 5.6.6. |
| tfunder | | Disconnection time versus under-frequency lookup table (Tfunder(fWT)). It is used for the grid protection model, IEC 61400-27-1:2015, 5.6.6. |
| qwp | | Look up table for the UQ static mode (qWP(uerr)). It is used for the voltage and reactive power control model, IEC 61400-27-1:2015, Annex D. |

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#### 8.2.3.2.35 WindPlantQcontrolModeKind enumeration

Reactive power/voltage controller mode.

Table 30 shows all literals of WindPlantQcontrolModeKind.

**Table 30 – Literals of Domain::WindPlantQcontrolModeKind**

| literal | value | description |
|---|---|---|
| reactivePower | | Reactive power reference. |
| powerFactor | | Power factor reference. |
| uqStatic | | UQ static. |
| voltageControl | | Voltage control. |

#### 8.2.3.2.36 WindQcontrolModeKind enumeration

General wind turbine Q control modes MqG.

Table 31 shows all literals of WindQcontrolModeKind.

**Table 31 – Literals of Domain::WindQcontrolModeKind**

| literal | value | description |
|---|---|---|
| voltage | | Voltage control (MqG equals 0). |
| reactivePower | | Reactive power control (MqG equals 1). |
| openLoopReactivePower | | Open loop reactive power control (only used with closed loop at plant level) (MqG equals 2). |
| powerFactor | | Power factor control (MqG equals 3). |
| openLooppowerFactor | | Open loop power factor control (MqG equals 4). |

#### 8.2.3.2.37 WindUVRTQcontrolModeKind enumeration

UVRT Q control modes MqUVRT.

Table 32 shows all literals of WindUVRTQcontrolModeKind.

**Table 32 – Literals of Domain::WindUVRTQcontrolModeKind**

| literal | value | description |
|---|---|---|
| mode0 | | Voltage-dependent reactive current injection (MqUVRT equals 0). |
| mode1 | | Reactive current injection controlled as the pre-fault value plus an additional voltage dependent reactive current injection (MqUVRT equals 1). |
| mode2 | | Reactive current injection controlled as the pre-fault value plus an additional voltage-dependent reactive current injection during fault, and as the pre-fault value plus an additional constant reactive current injection post fault (MqUVRT equals 2). |

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#### 8.2.3.3 Package Core

##### 8.2.3.3.1 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.

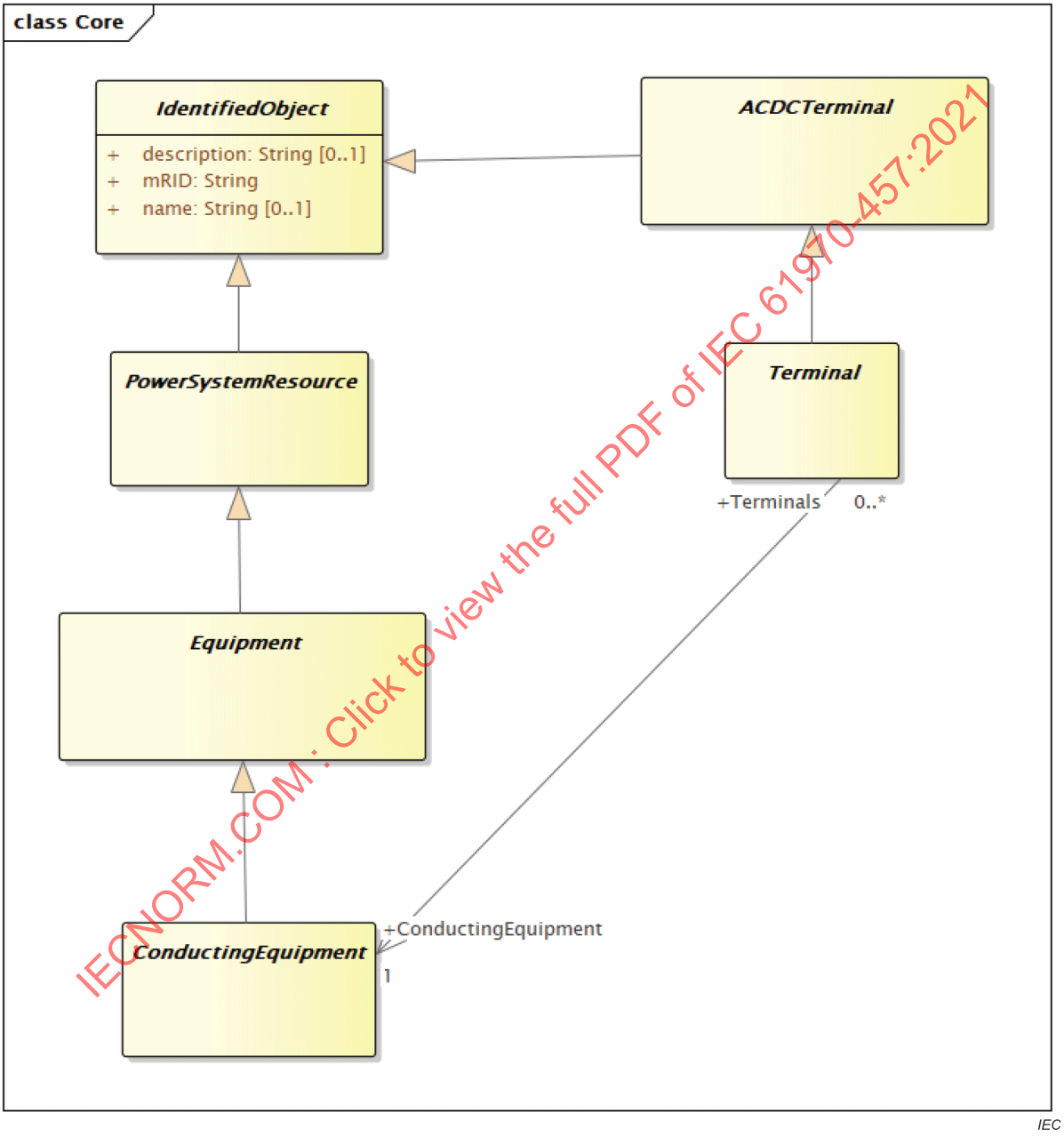


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**Figure 8 – Class diagram Core::Core**

Figure 8: This diagram shows the main classes which are exchanged in other profiles, but have connection with the dynamics profile.

##### 8.2.3.3.2 (abstract) 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 33 shows all attributes of ACDCTerminal.

**Table 33 – Attributes of Core::ACDCTerminal**

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

#### 8.2.3.3.3 (abstract) ConductingEquipment

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

Table 34 shows all attributes of ConductingEquipment.

**Table 34 – Attributes of Core::ConductingEquipment**

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

#### 8.2.3.3.4 (abstract) Equipment

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

Table 35 shows all attributes of Equipment.

**Table 35 – Attributes of Core::Equipment**

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

#### 8.2.3.3.5 (abstract) IdentifiedObject root class

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

Table 36 shows all attributes of IdentifiedObject.

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**Table 36 – Attributes of Core::IdentifiedObject**

| name | mult | type | description |
|---|---|---|---|
| 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 | 1..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.<br>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. |

#### 8.2.3.3.6 (abstract) 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 37 shows all attributes of PowerSystemResource.

**Table 37 – Attributes of Core::PowerSystemResource**

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

#### 8.2.3.3.7 (abstract) Terminal

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

Table 38 shows all attributes of Terminal.

**Table 38 – Attributes of Core::Terminal**

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

Table 39 shows all association ends of Terminal with other classes.

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**Table 39 – 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. |

#### 8.2.3.4 Package Wires

##### 8.2.3.4.1 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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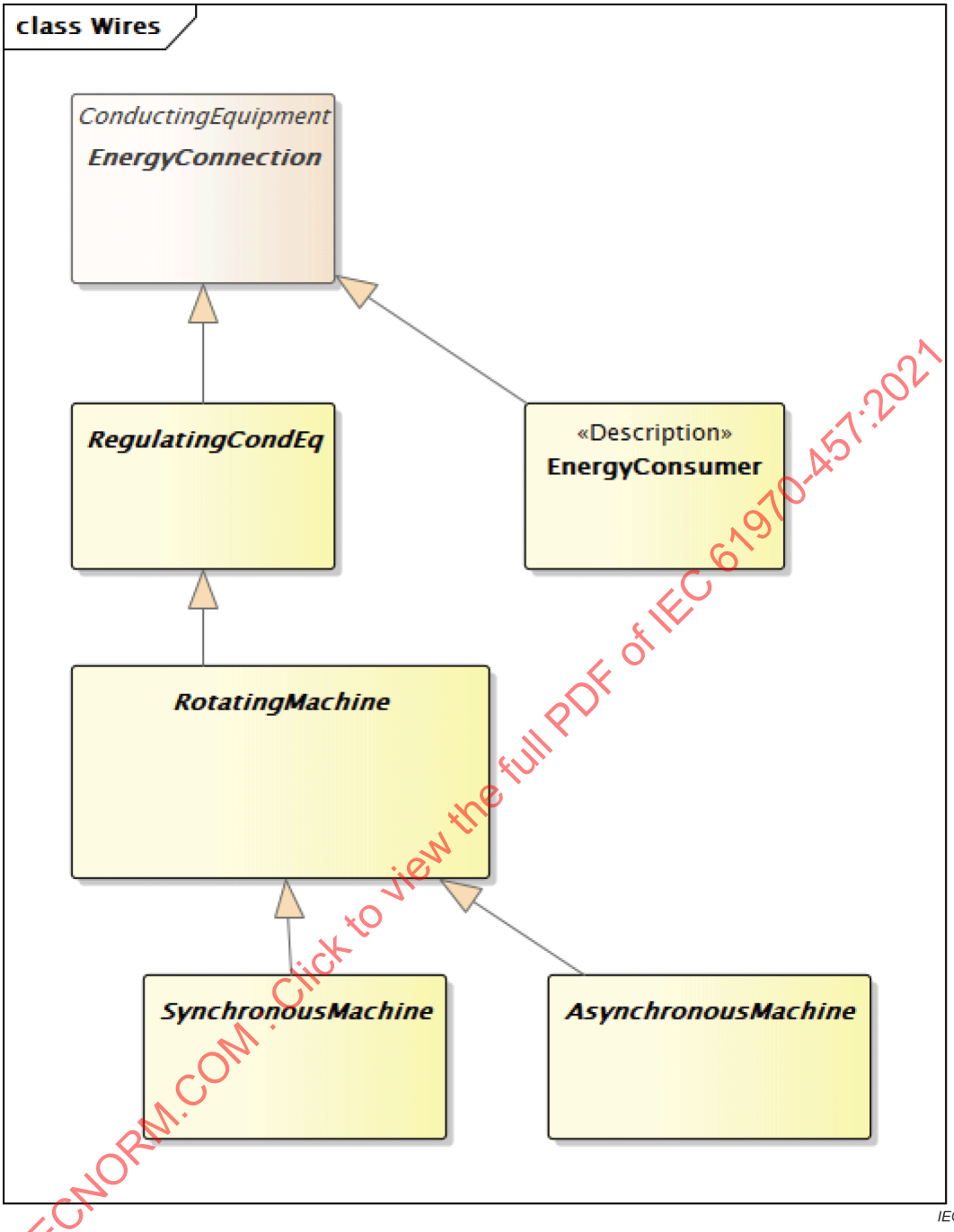


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**Figure 9 – Class diagram Wires::Wires**

Figure 9: This diagram shows the main classes which are exchanged in other profiles, but have connection with the dynamics profile.

#### 8.2.3.4.2 (abstract) 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 40 shows all attributes of AsynchronousMachine.

**Table 40 – Attributes of Wires::AsynchronousMachine**

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

#### 8.2.3.4.3 (abstract) EnergyConnection

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

Table 41 shows all attributes of EnergyConnection.

**Table 41 – Attributes of Wires::EnergyConnection**

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

#### 8.2.3.4.4 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 42 shows all attributes of EnergyConsumer.

**Table 42 – Attributes of Wires::EnergyConsumer**

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

Table 43 shows all association ends of EnergyConsumer with other classes.

**Table 43 – Association ends of Wires::EnergyConsumer with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | LoadDynamics | 0..1 | LoadDynamics | Load dynamics model used to describe dynamic behaviour of this energy consumer. |

#### 8.2.3.4.5 (abstract) PowerElectronicsConnection

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

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Table 44 shows all attributes of PowerElectronicsConnection.

**Table 44 – Attributes of Wires::PowerElectronicsConnection**

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

#### 8.2.3.4.6 (abstract) RegulatingCondEq

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

Table 45 shows all attributes of RegulatingCondEq.

**Table 45 – Attributes of Wires::RegulatingCondEq**

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

#### 8.2.3.4.7 (abstract) RotatingMachine

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

Table 46 shows all attributes of RotatingMachine.

**Table 46 – Attributes of Wires::RotatingMachine**

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

#### 8.2.3.4.8 (abstract) 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 47 shows all attributes of StaticVarCompensator.

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**Table 47 – Attributes of Wires::StaticVarCompensator**

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

#### 8.2.3.4.9 (abstract) 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 48 shows all attributes of SynchronousMachine.

**Table 48 – Attributes of Wires::SynchronousMachine**

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

### 8.2.3.5 Package DC

#### 8.2.3.5.1 General

This package contains model for direct current equipment and controls.

#### 8.2.3.5.2 (abstract) 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 49 shows all attributes of ACDCConverter.

**Table 49 – Attributes of DC::ACDCConverter**

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

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#### 8.2.3.5.3 (abstract) 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 filter, which can be approximated with half of the active power. The losses is 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 10-18 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 17-20 degrees.

Table 50 shows all attributes of CsConverter.

**Table 50 – Attributes of DC::CsConverter**

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

#### 8.2.3.5.4 (abstract) VsConverter

DC side of the voltage source converter (VSC).

Table 51 shows all attributes of VsConverter.

**Table 51 – Attributes of DC::VsConverter**

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

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### 8.2.4 Package Dynamics

#### 8.2.4.1 General

The CIM dynamic model definitions reflect the most common IEEE or, in the case of wind models, IEC, representations of models as well as models included in some of the transient stability software widely used by utilities.

These dynamic models are intended to ensure interoperability between different vendors' software products currently in use by electric utility energy companies, utilities, Transmission System Operators (TSOs), Regional Transmission Organizations (RTOs), and Independent System Operators (ISOs). It is important to note that each vendor is free to select its own internal implementation of these models. Differences in vendor results, as long as they are within accepted engineering practice, caused by different internal representations, are acceptable.

Unless explicitly stated otherwise, the following modelling conventions are followed:

- limited integrators are of the non-windup type;
- it shall be possible to enter a time constant of zero (where it makes sense).

#### 8.2.4.2 Package StandardInterconnections

##### 8.2.4.2.1 General

This subclause describes the standard interconnections for various types of equipment. These interconnections are understood by the application programs and can be identified based on the presence of one of the key classes with a relationship to the static power flow model: SynchronousMachineDynamics, AsynchronousMachineDynamics, EnergyConsumerDynamics or WindTurbineType3or4Dynamics.

The relationships between classes expressed in the interconnection diagrams are intended to support dynamic behaviour described by either standard models or user-defined models.

In the interconnection diagrams, boxes which are black in colour represent function blocks whose functionality can be provided by one of many standard models or by a user-defined model. Blue boxes represent specific standard models. A dashed box means that the function block or specific standard model is optional.

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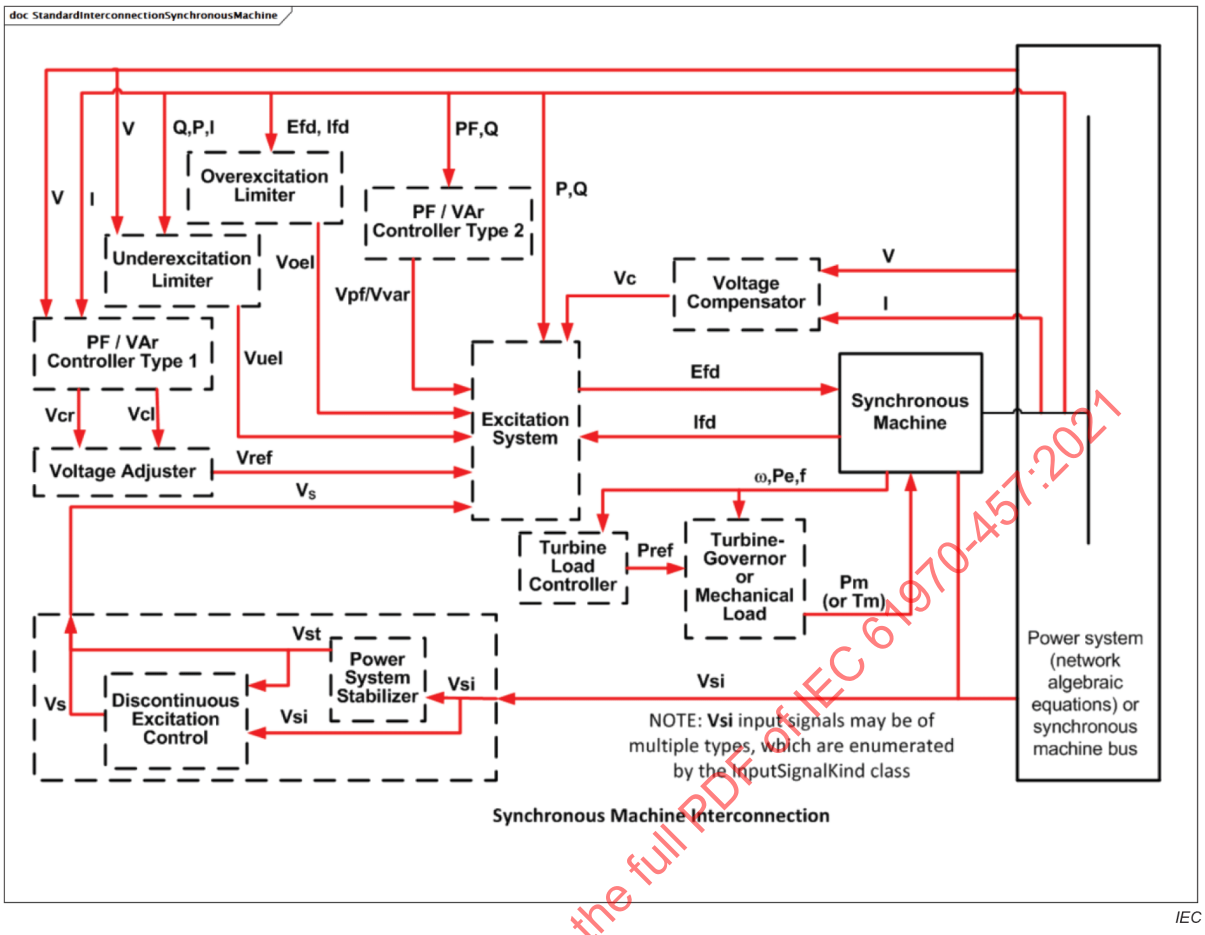


**Figure 10 – StandardInterconnectionSynchronousMachine**

Figure 10: A dynamic model that includes a single synchronous machine (generator, motor or condenser) and its related equipment models (function blocks) is associated with a synchronous machine in the static (power flow) model and has the standard interconnection shown above.

The interface between the dynamic synchronous machine and the network algebraic equations is application dependent. The variables used for this interface do not need to be identified since they are internal to the application program, well-defined and not necessary to be exchanged between applications.

The interfaces between different blocks in the above figure are indicative of the variety of input and output signals that are defined by the individual standard models. The figure provides information on most of the alternative interfaces, for instance, the turbine-governor (for generators) or the mechanical load (for motors) and the dynamic synchronous machine can be mechanical torque (Tm) or mechanical power (Pm).

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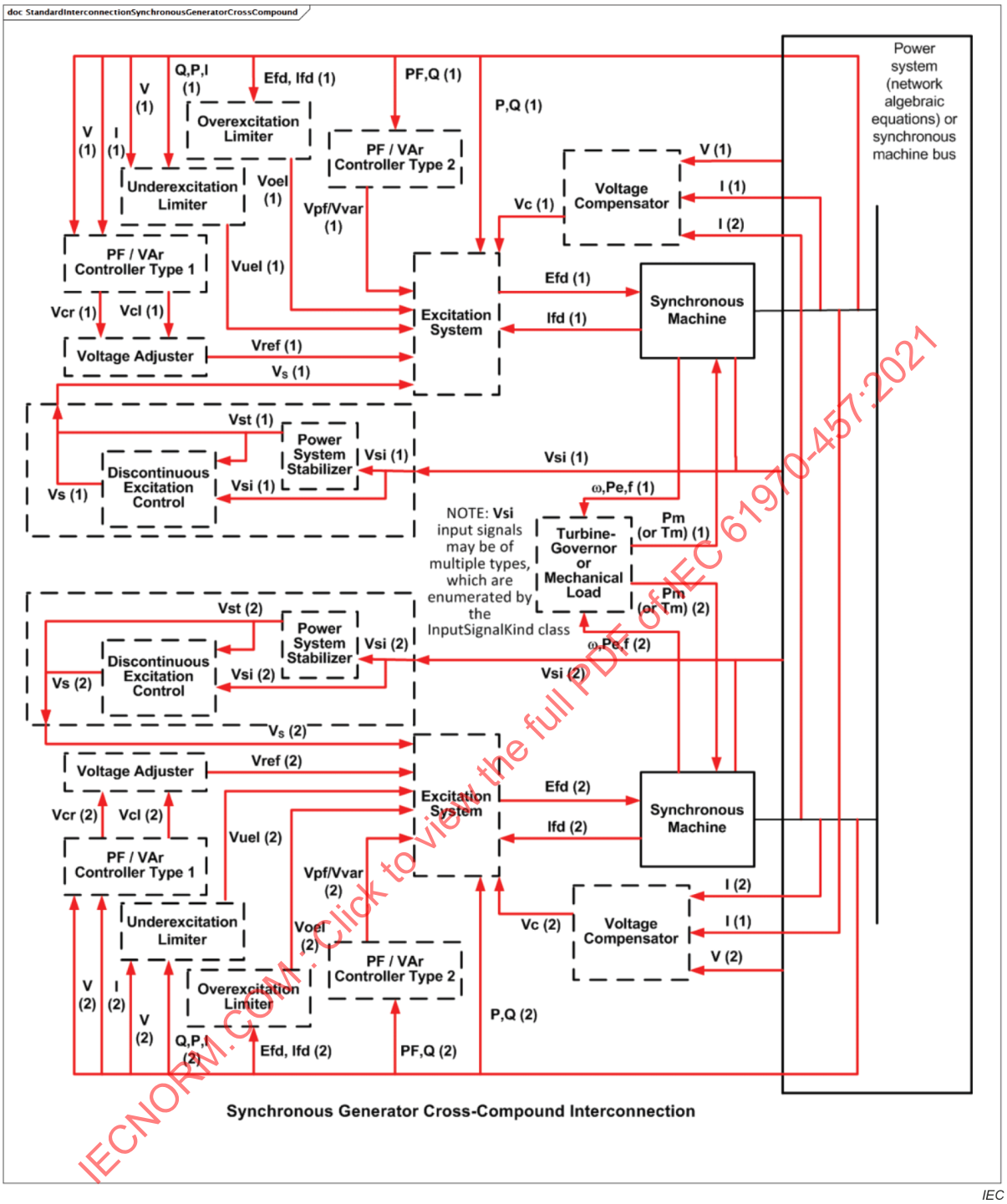


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**Figure 11 – StandardInterconnectionSynchronousGeneratorCrossCompound**

Figure 11: A cross-compound dynamic model that includes multiple synchronous generators and their related equipment models (function blocks), is associated with multiple synchronous machines in the static (power flow) model and has the standard interconnection shown above.

Generator 2 is the second unit of a cross-compound pair of generators and is usually connected to the same terminal bus. A single turbine-governor model determines the mechanical power for both units.

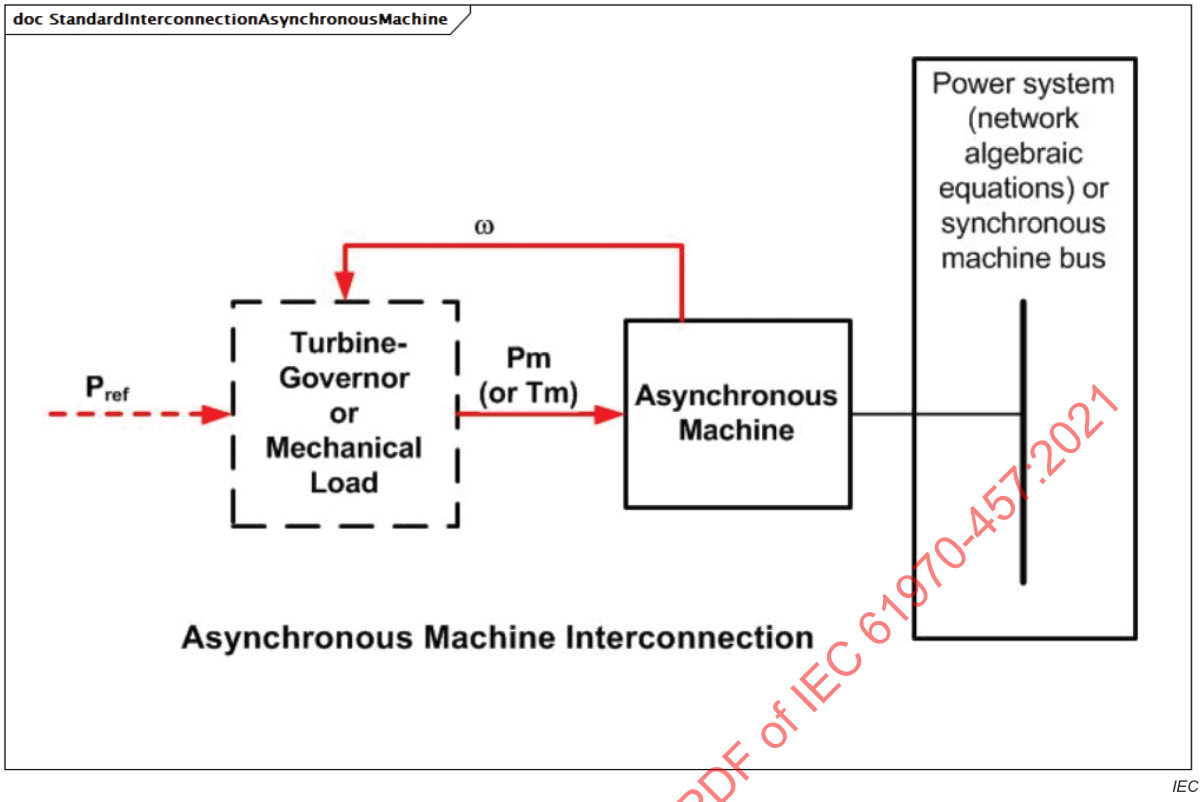


**Figure 12 – StandardInterconnectionAsynchronousMachine**

Figure 12: A dynamic model including an asynchronous machine (either a generator or motor) and its related equipment models (function blocks) is associated with an asynchronous machine in the static (power flow) model and has the standard interconnection shown above.

This interconnection is for a “squirrel-cage” induction machine or a wound-rotor induction machine with short-circuited field windings. Other models and a different interconnection are required for a wound-rotor machine with external connections to the field windings.

The interface between the dynamic asynchronous machine and the network algebraic equations is application-dependent.

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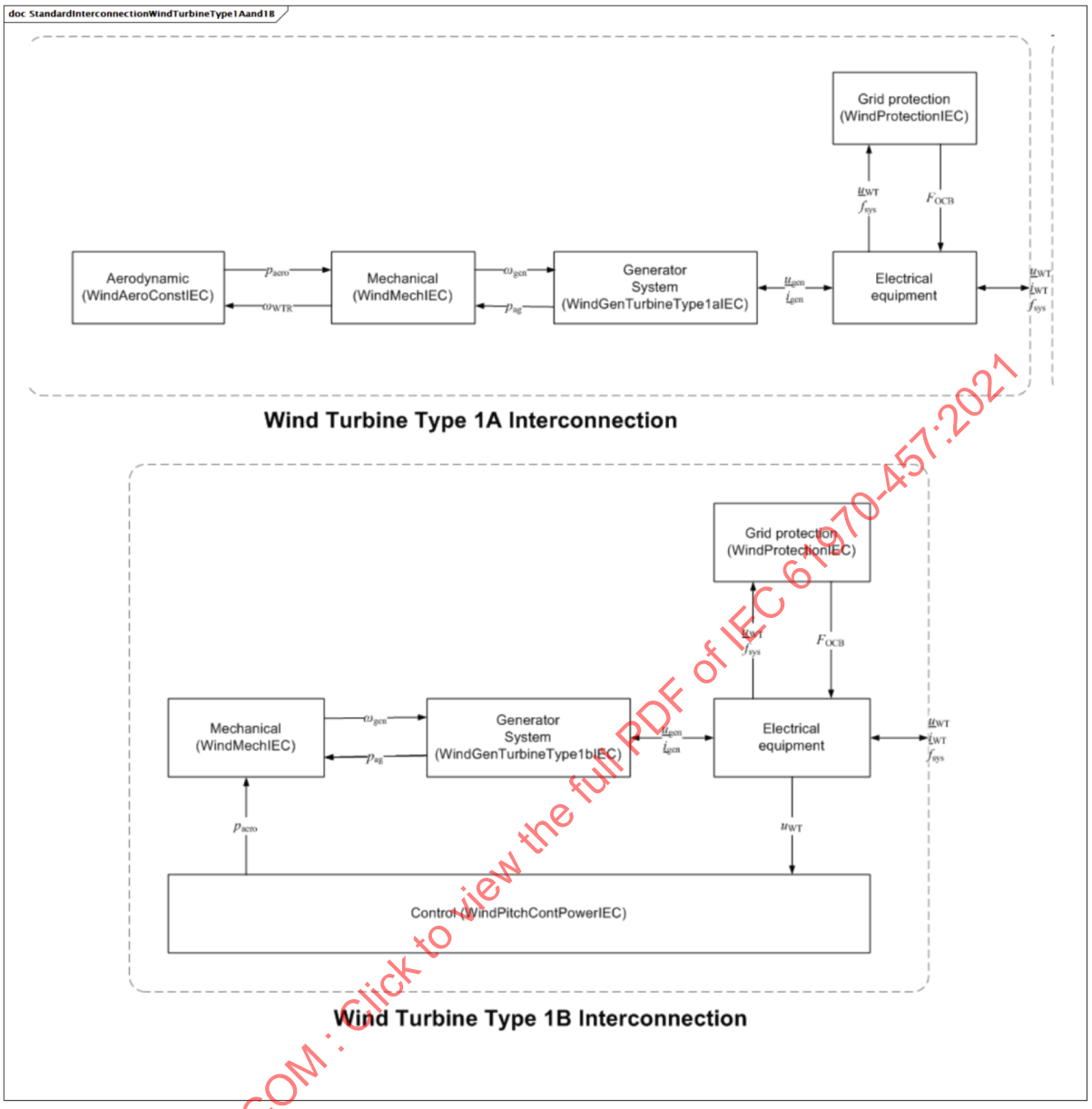


**Figure 13 – StandardInterconnectionWindTurbineType1Aand1B**

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Figure 13: A dynamic model representing a type 1 wind turbine model uses asynchronous generators directly connected to the grid, i.e. without power converters. Most type 1 wind turbines have a soft-starter, but this is only active during start-up. There are two type 1 models:

- type 1A: wind turbines with fixed pitch angle;
- type 1B: wind turbines with under voltage ride-through pitch angle control.

The two standard interconnections are shown in the figure.

Reference: IEC 61400-27-1:2015, 5.5.2.

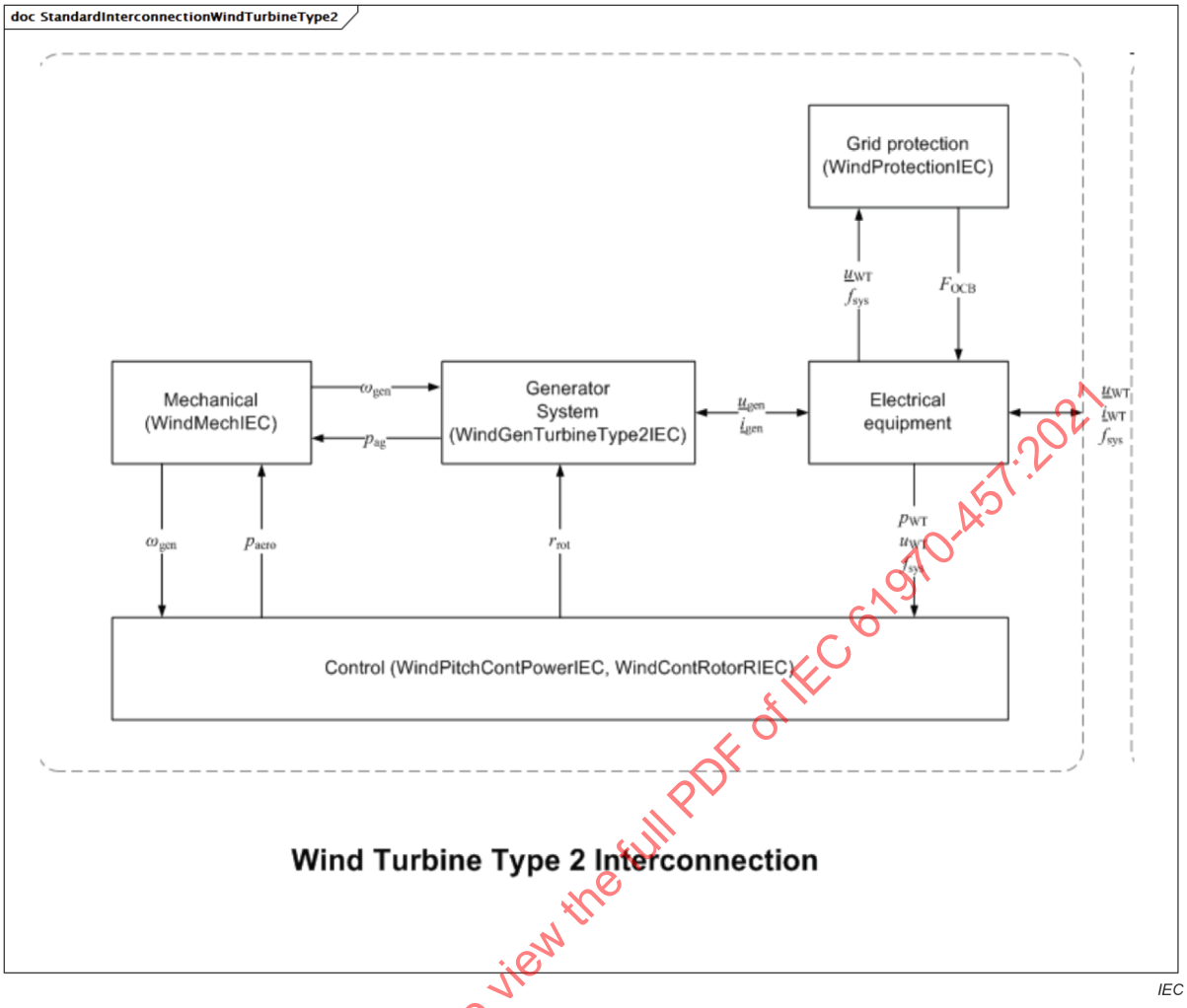


**Figure 14 – StandardInterconnectionWindTurbineType2**

Figure 14: A dynamic model representing a type 2 wind generator and its related standard equipment models is associated with an asynchronous machine in the static (power flow) model and has the standard interconnection shown in the figure.

The type 2 turbine is equipped with a variable rotor resistance (VRR) and therefore uses a variable rotor resistance asynchronous generator (VRRAG). Type 2 wind turbines are also normally equipped with blade angle control.

Reference: IEC 61400-27-1:2015, 5.5.3.

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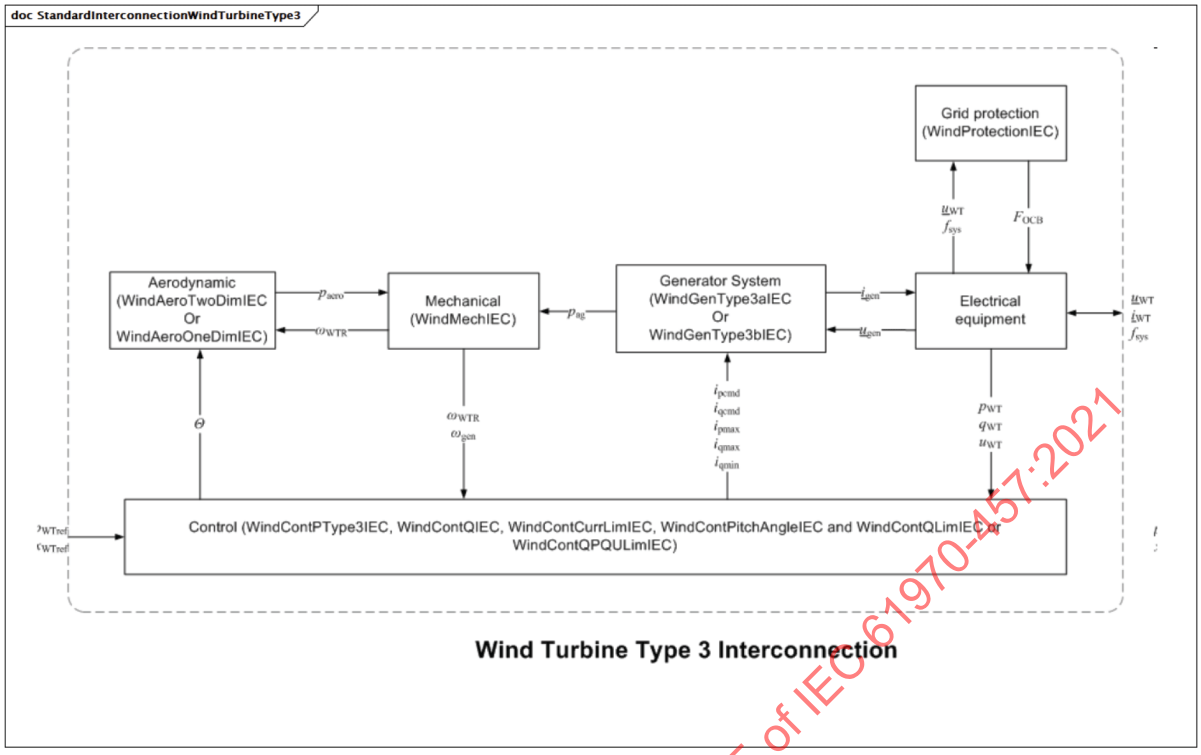


**Figure 15 – StandardInterconnectionWindTurbineType3**

Figure 15: A dynamic model representing a type 3 wind turbine which uses a doubly fed asynchronous generator (DFAG), where the stator is directly connected to the grid and the rotor is connected through a back-to-back power converter. It has the standard interconnection shown in the figure.

Reference: IEC 61400-27-1:2015, 5.5.4.

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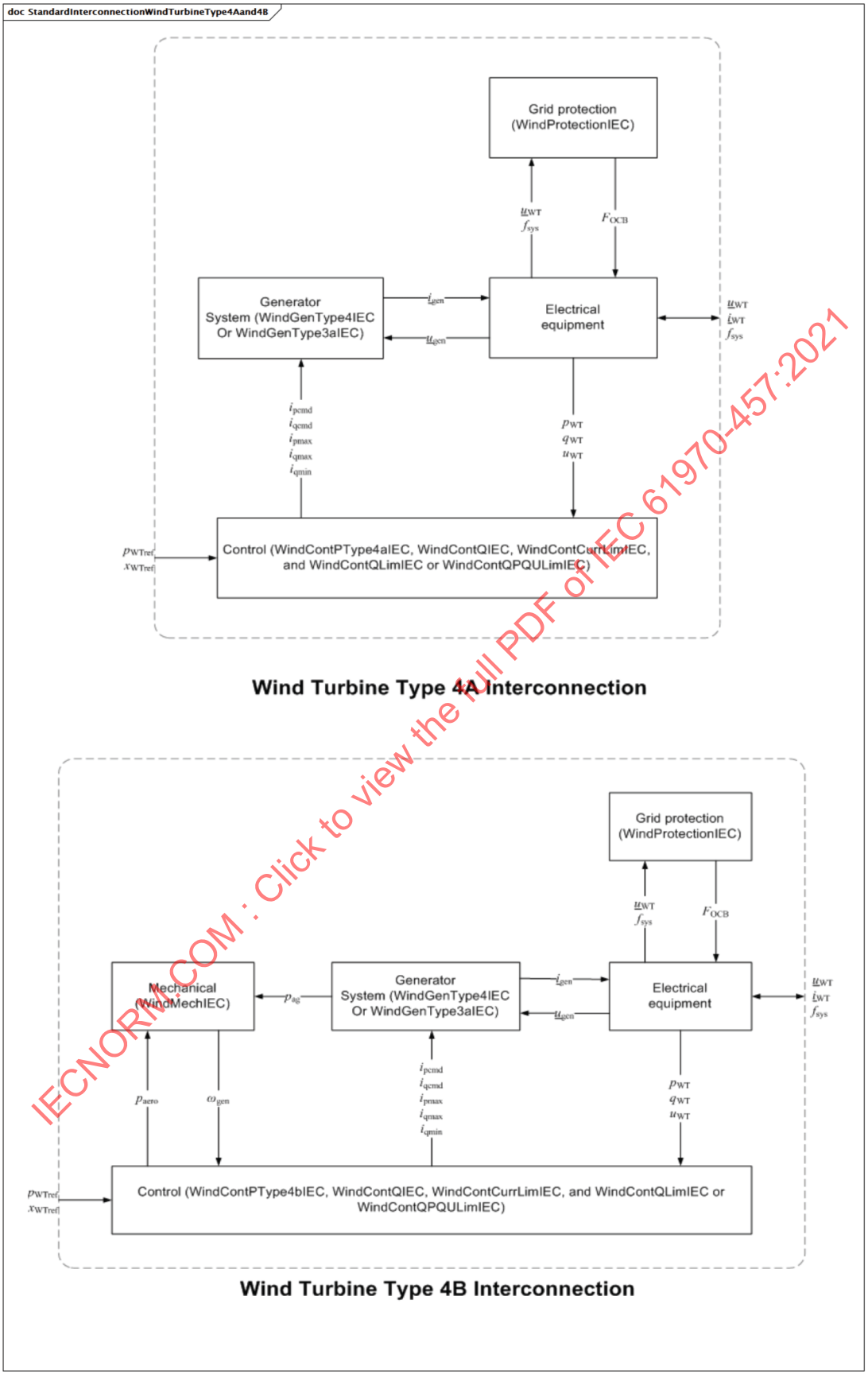


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**Figure 16 – StandardInterconnectionWindTurbineType4Aand4B**

Figure 16: A dynamic model representing a type 4 wind turbine which uses either synchronous generators (SG) or asynchronous generators (AG). Some type 4 wind turbines use direct drive synchronous generators, and therefore have no gearbox.

There are two type 4 models as follows:

- type 4A: a model neglecting the aerodynamic and mechanical parts and thus not simulating any power oscillations;
- type 4B: a model including a 2-mass mechanical model to replicate the power oscillations but assuming constant aerodynamic torque.

The standard interconnections for the two models are shown in the figure.

Reference: IEC 61400-27-1:2015, 5.5.5.

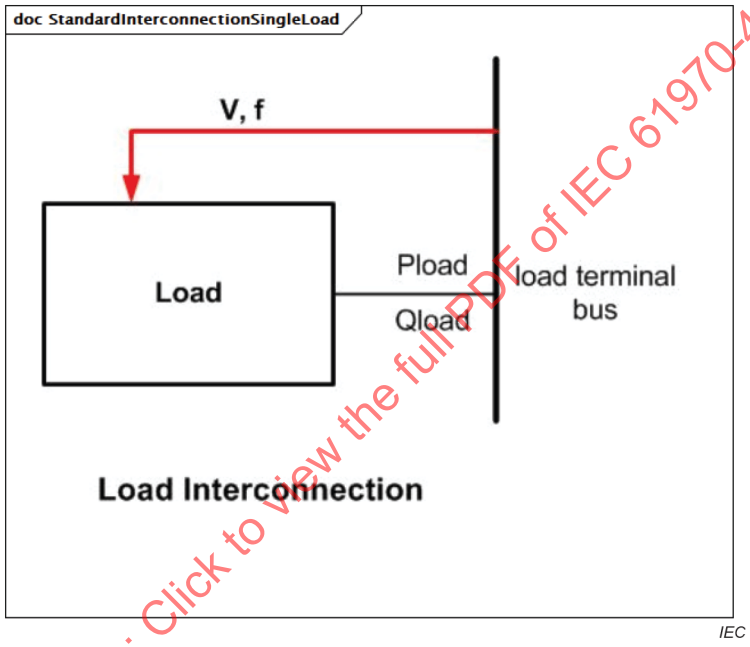


**Figure 17 – StandardInterconnectionSingleLoad**

Figure 17: A load model is associated with an energy consumer in the power flow data and has no standard interconnection with other models.

The P and Q consumption of the load are determined as a function of the magnitude and frequency of the voltage at the terminal bus as shown above.

The interface between the model and the network algebraic equations is application-dependent. Dynamic (motor) load models generally interface with the network equations in a similar manner to motor models.

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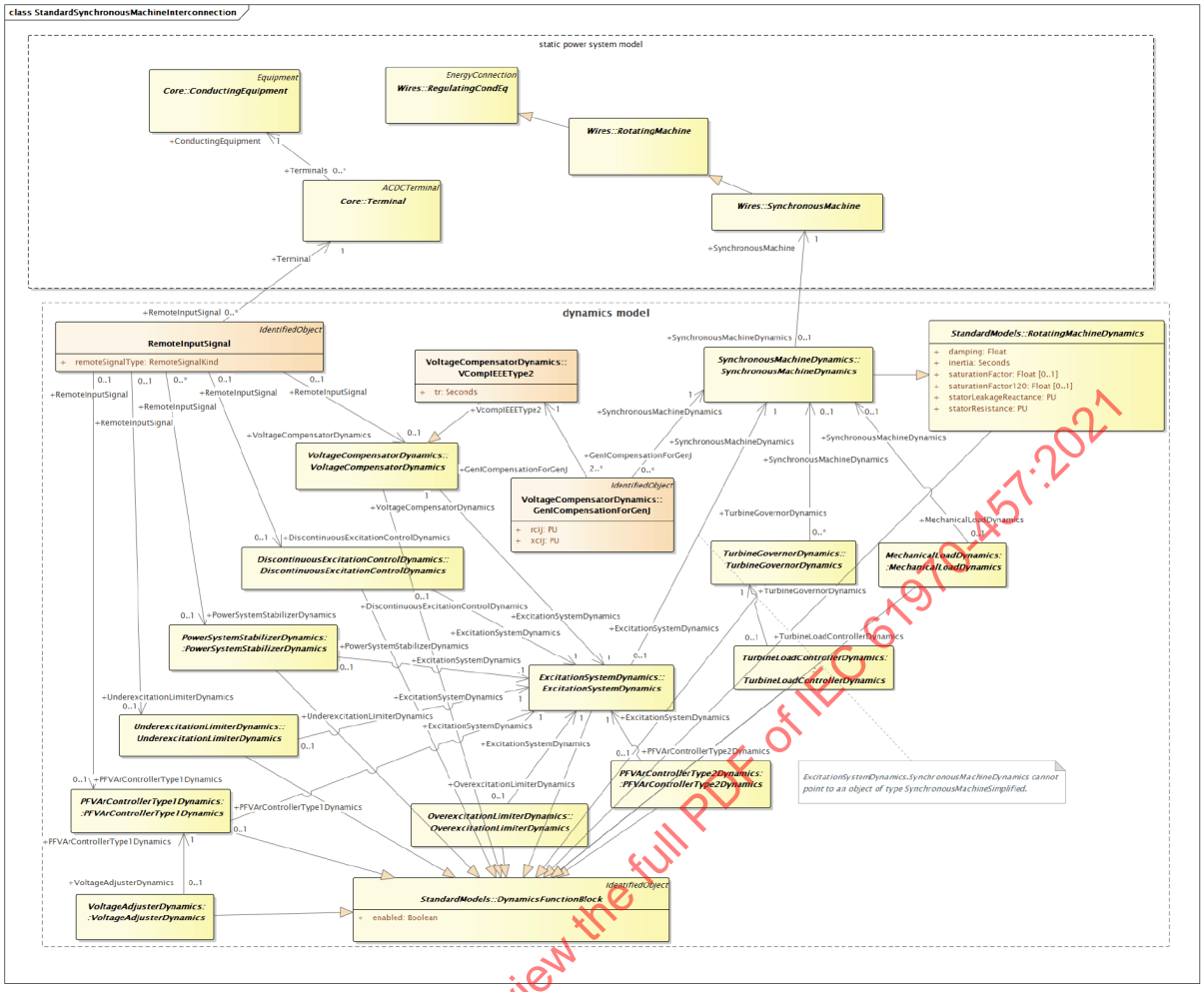


**Figure 18 – Class diagram StandardInterconnections:: StandardSynchronousMachineInterconnection**

Figure 18: This diagram shows the classes necessary for both of the two types of synchronous machine interconnection models: standard synchronous machine and standard synchronous generator cross-compound.

A standard synchronous machine interconnection has a single instance of a SynchronousMachineDynamics child class whereas a generator cross-compound connection has multiple instances of SynchronousMachineDynamics child classes related by a single instance of a TurbineGovernorDynamics child class.

A valid standard synchronous machine interconnection model reflects the following rules.

- It can have:
  - one instance of TurbineGovernorDynamics child class, but only if SynchronousMachine.operatingMode = generator;
  - one instance of MechanicalLoadDynamics child class, but only if SynchronousMachine.operatingMode = motor or SynchronousMachine.operatingMode = condenser.
- It cannot have any instance of GenICompensationForGenJ.

A generator cross-compound interconnection model reflects the following rules.

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- It can have:
  - multiple instances of SynchronousMachineDynamics child classes, each of which has its related SynchronousMachine.operatingMode = generator;
  - one instance of TurbineGovernorDynamics child class.
- It shall have two or more instances of GenICompensationForGenJ associated with each instance of a SynchronousMachineDynamics child class.

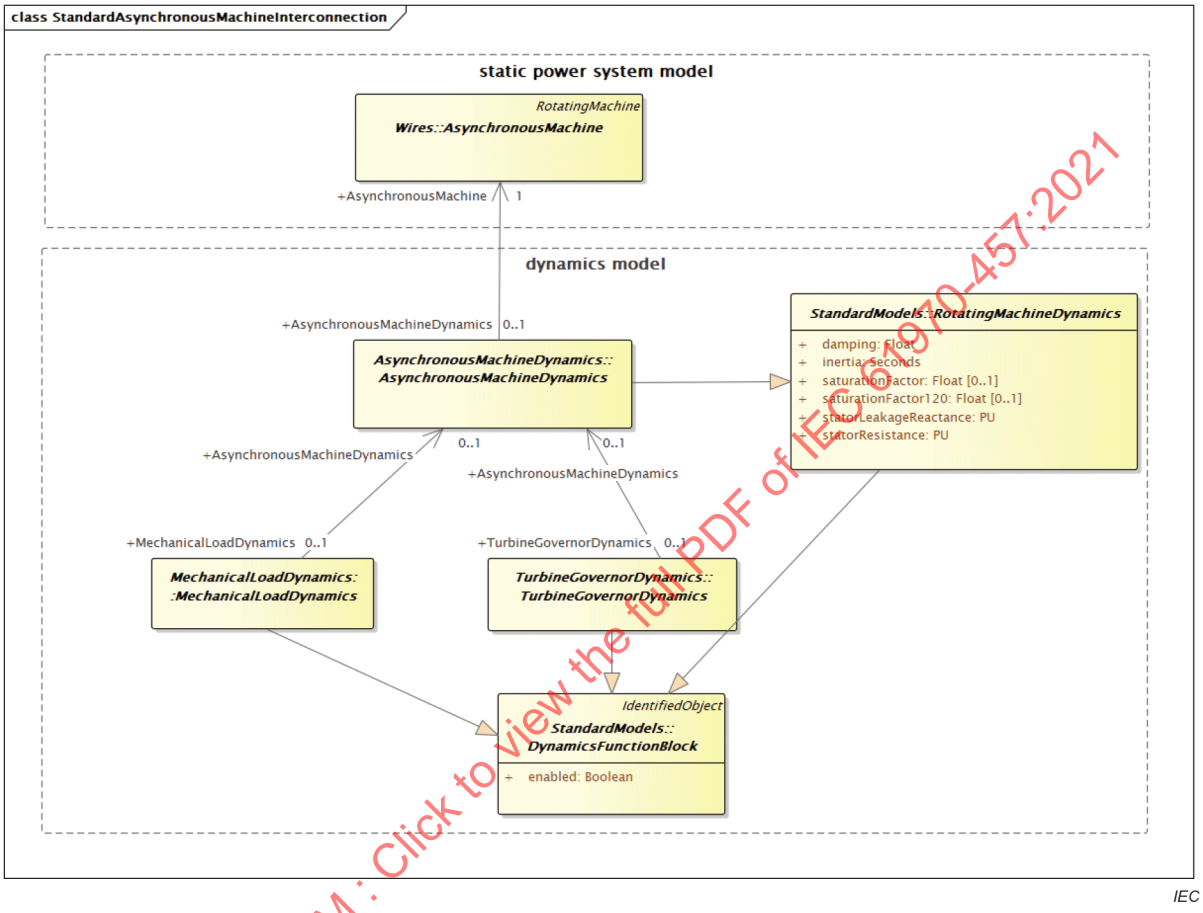


**Figure 19 – Class diagram StandardInterconnections:: StandardAsynchronousMachineInterconnection**

Figure 19: This diagram shows the classes necessary for the asynchronous machine interconnection model.

A standard asynchronous machine interconnection has a single instance of an AsynchronousMachineDynamics child class.

A valid standard asynchronous machine interconnection model also reflects the following rules. It can have:

- one instance of TurbineGovernorDynamics child class, but only if AsynchronousMachine.asynchronousMachineType = generator;
- one instance of MechanicalLoadDynamics child class, but only if AsynchronousMachine.asynchronousMachineType = motor.

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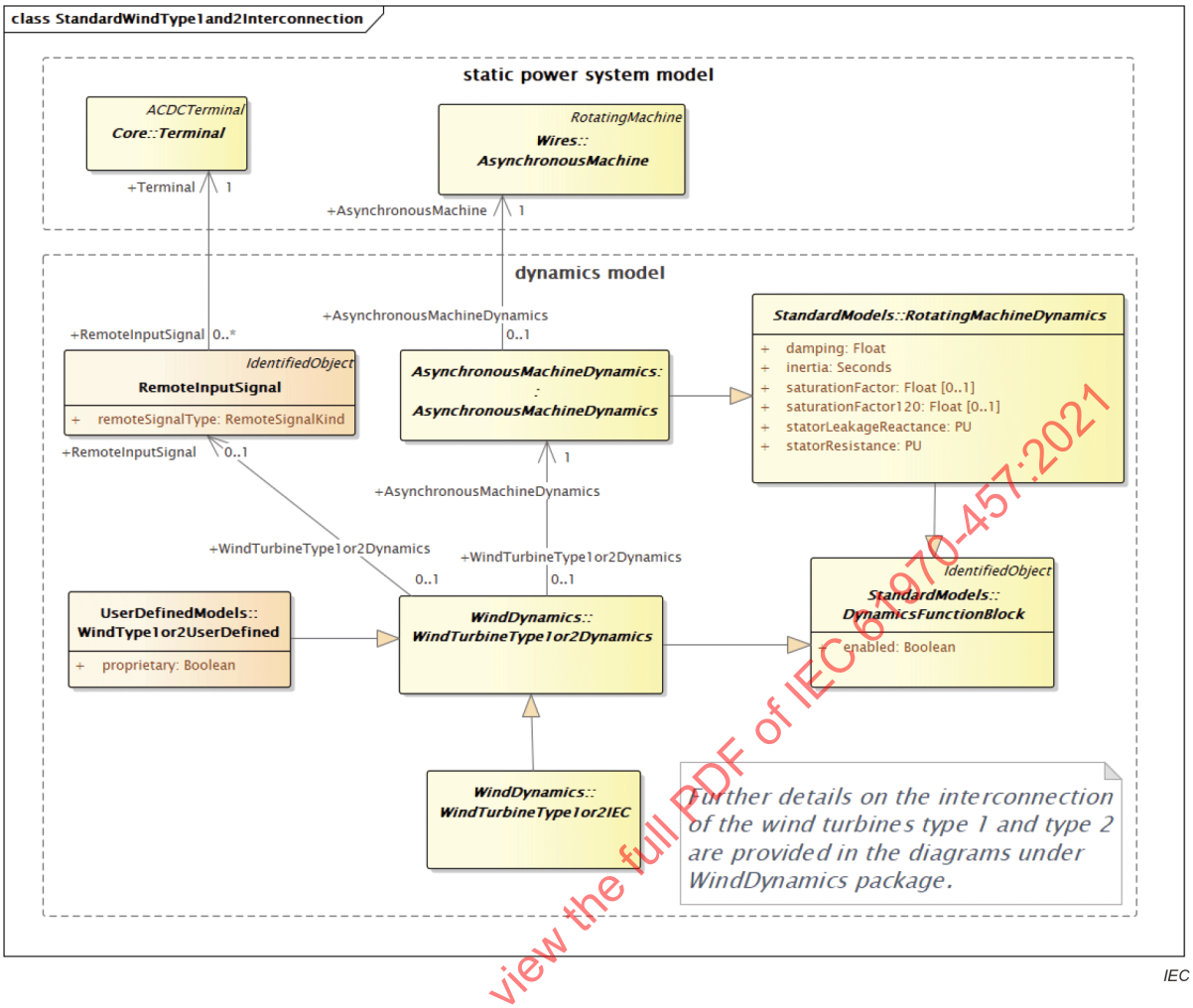


**Figure 20 – Class diagram StandardInterconnections:: StandardWindType1and2Interconnection**

Figure 20: This diagram shows the classes necessary for wind type 1 and type 2 interconnection models.

Standard IEC wind turbines type 1 and 2 interconnection models all have a single instance of an AsynchronousMachineDynamics child class and a single instance of the WindGenTurbineType1aIEC class, the WindGenTurbineType1bIEC class, or the WindGenTurbineType2IEC class as appropriate.

A valid IEC wind type 1A interconnection model also shall have one instance of each of the following classes (and no others):

- WindMechIEC;
- WindAeroConstIEC;
- WindProtectionIEC.

A valid IEC wind type 1B interconnection model also shall have one instance of each of the following classes (and no others):

- WindMechIEC;
- WindProtectionIEC;
- WindPitchContPowerIEC.

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A valid IEC wind type 2 interconnection model also shall have one instance of each of the following classes (and no others):

- WindMechIEC;
- WindContRotorRIEC;
- WindProtectionIEC;
- WindPitchContPowerIEC.

The WindProtectionIEC class and the WindContRotorRIEC class use the WindDynamicsLookupTable class.

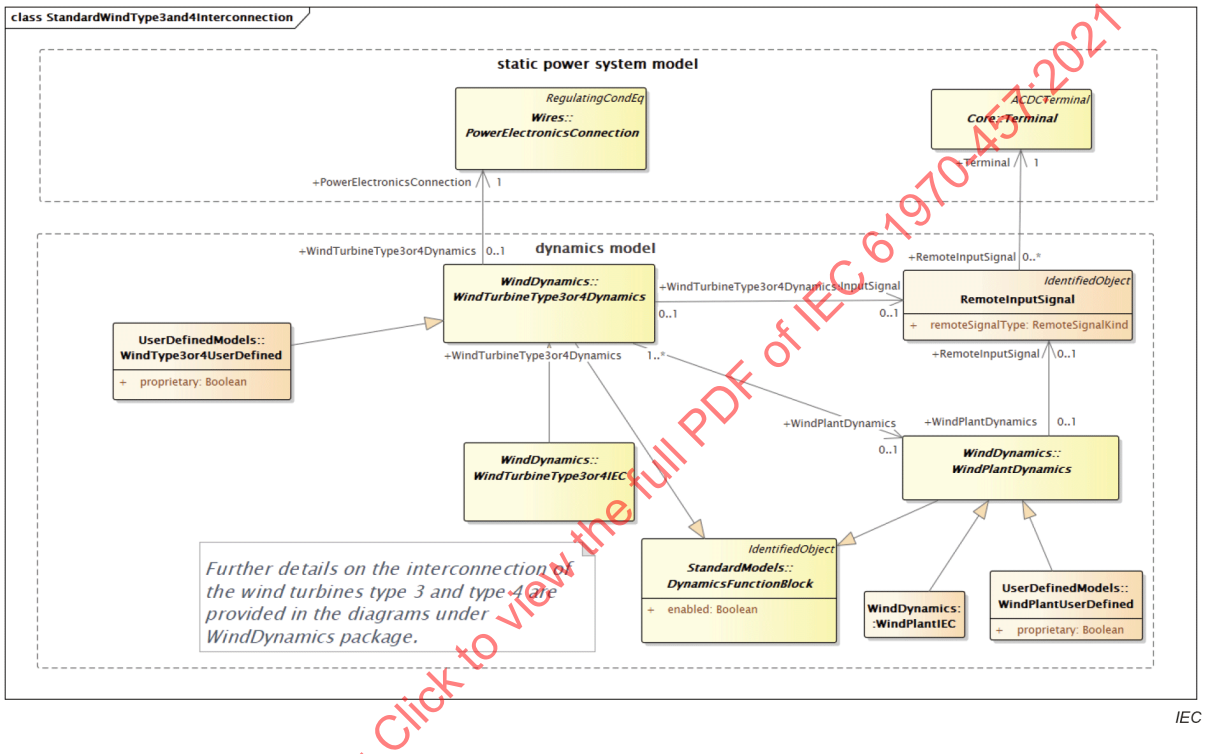


**Figure 21 – Class diagram StandardInterconnections:: StandardWindType3and4Interconnection**

Figure 21: This diagram shows the classes necessary for wind type 3 and type 4 interconnection models, including the wind plant model.

Standard IEC wind types 3, 4A, 4B and plant interconnection models all have a single instances as follows:

IEC wind type 3:

- WindTurbineType3IEC;
- WindAeroOneDimIEC or WindAeroTwoDimIEC;
- WindMechIEC;
- WindGenType3aIEC or WindGenType3bIEC;
- WindContPType3IEC;
- WindContQIEC;
- WindContCurrLimIEC;
- WindContQLimIEC or WindContQPQULimIEC;

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- WindContPitchAngleIEC;
- WindProtectionIEC.

IEC wind type 4A:

- WindTurbineType4aIEC;
- WindGenType4IEC or WindGenType3aIEC;
- WindContPType4aIEC;
- WindContQIEC;
- WindContCurrLimIEC;
- WindContQLimIEC or WindContQPQULimIEC;
- WindProtectionIEC.

IEC wind type 4B:

- WindTurbineType4bIEC;
- WindMechIEC;
- WindGenType4IEC or WindGenType3aIEC;
- WindContPType4bIEC;
- WindContQIEC;
- WindContCurrLimIEC;
- WindContQLimIEC or WindContQPQULimIEC;
- WindProtectionIEC.

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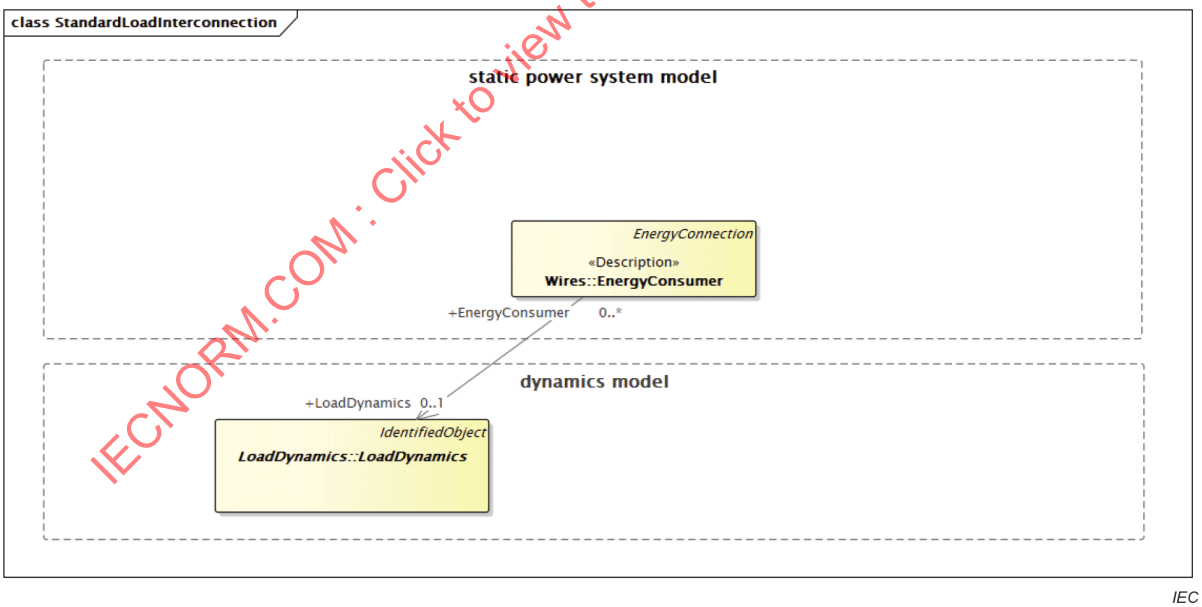


**Figure 22 – Class diagram StandardInterconnections::StandardLoadInterconnection**

Figure 22: This diagram shows the classes necessary for a load interconnection model.

A standard load interconnection model has a single instance of an EnergyConsumerDynamics child class plus a related instance of a LoadDynamics child class.

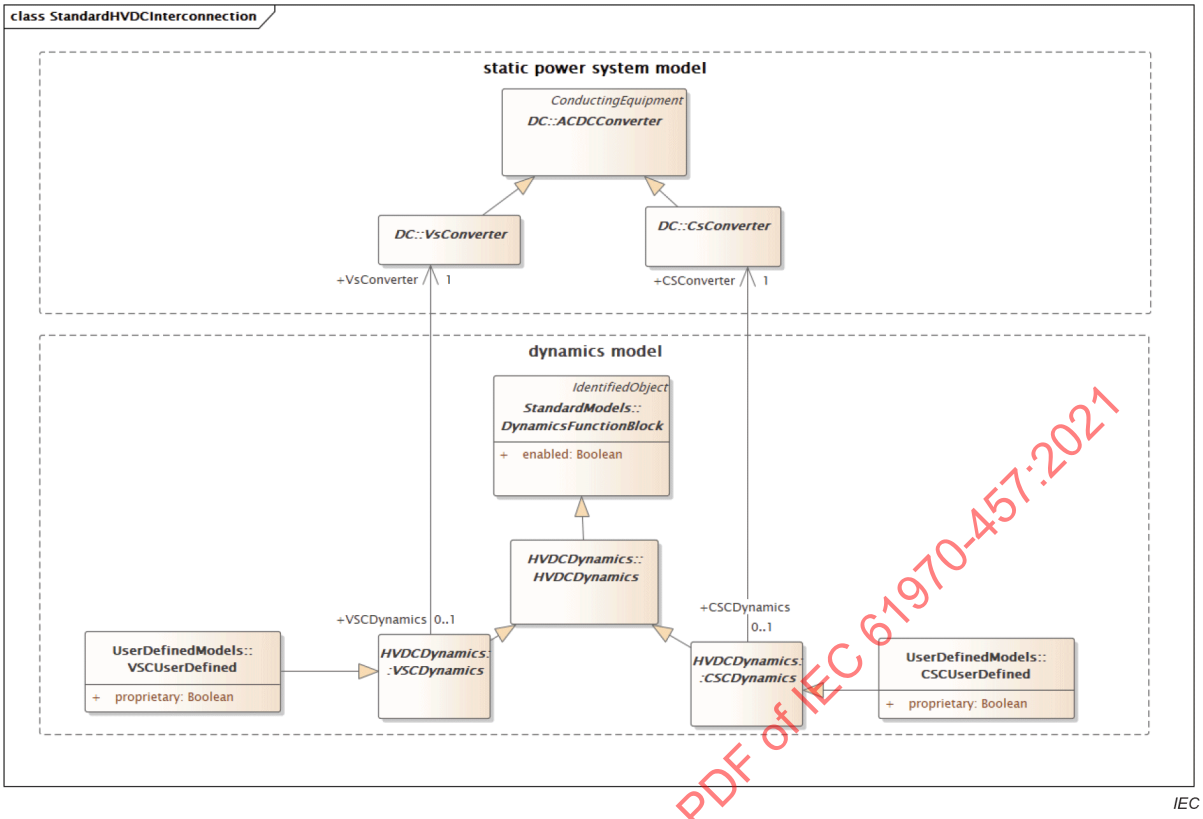


**Figure 23 – Class diagram StandardInterconnections::StandardHVDCInterconnection**

Figure 23: This diagram shows the classes necessary for a HVDC interconnection model.

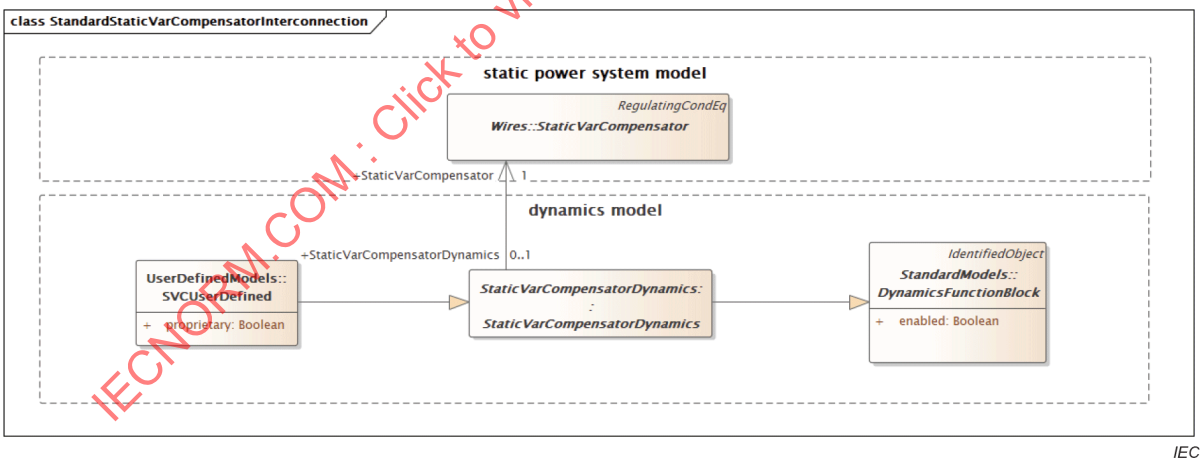


**Figure 24 – Class diagram StandardInterconnections::**
**StandardStaticVarCompensatorInterconnection**

Figure 24: This diagram shows the classes necessary for a static var compensator (SVC) interconnection model.

#### 8.2.4.2.2 RemoteInputSignal

Supports connection to a terminal associated with a remote bus from which an input signal of a specific type is coming.

Table 52 shows all attributes of RemoteInputSignal.

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**Table 52 – Attributes of StandardInterconnections::RemoteInputSignal**

| name | mult | type | description |
|---|---|---|---|
| remoteSignalType | 1..1 | RemoteSignalKind | Type of input signal. |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 53 shows all association ends of RemoteInputSignal with other classes.

**Table 53 – Association ends of StandardInterconnections:: RemoteInputSignal with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | Terminal | 1..1 | Terminal | Remote terminal with which this input signal is associated. |
| 0..1 | DiscontinuousExcitationControlDynamics | 0..1 | DiscontinuousExcitationControlDynamics | Discontinuous excitation control model using this remote input signal. |
| 0..* | PowerSystemStabilizerDynamics | 0..1 | PowerSystemStabilizerDynamics | Power system stabilizer model using this remote input signal. |
| 0..1 | UnderexcitationLimiterDynamics | 0..1 | UnderexcitationLimiterDynamics | Underexcitation limiter model using this remote input signal. |
| 0..1 | PFVArControllerType1Dynamics | 0..1 | PFVArControllerType1Dynamics | Power factor or VAr controller type 1 model using this remote input signal. |
| 0..1 | VoltageCompensatorDynamics | 0..1 | VoltageCompensatorDynamics | Voltage compensator model using this remote input signal. |

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#### 8.2.4.3 Package StandardModels

##### 8.2.4.3.1 General

This subclause contains standard dynamic model specifications grouped into packages by standard function block (type of equipment being modelled).

In the CIM, standard dynamic models are expressed by means of a class named with the standard model name and attributes reflecting each of the parameters necessary to describe the behaviour of an instance of the standard model.

##### 8.2.4.3.2 (abstract) DynamicsFunctionBlock

Abstract parent class for all Dynamics function blocks.

Table 54 shows all attributes of DynamicsFunctionBlock.

**Table 54 – Attributes of StandardModels::DynamicsFunctionBlock**

| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | Function block used indicator.<br>true = use of function block is enabled<br>false = use of function block is disabled. |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

#### 8.2.4.3.3 (abstract) RotatingMachineDynamics

Abstract parent class for all synchronous and asynchronous machine standard models.

Table 55 shows all attributes of RotatingMachineDynamics.

**Table 55 – Attributes of StandardModels::RotatingMachineDynamics**

| name | mult | type | description |
|---|---|---|---|
| damping | 1..1 | Float | Damping torque coefficient (D) (>= 0). A proportionality constant that, when multiplied by the angular velocity of the rotor poles with respect to the magnetic field (frequency), results in the damping torque. This value is often zero when the sources of damping torques (generator damper windings, load damping effects, etc.) are modelled in detail. Typical value = 0. |
| inertia | 1..1 | Seconds | Inertia constant of generator or motor and mechanical load (H) (> 0). This is the specification for the stored energy in the rotating mass when operating at rated speed. For a generator, this includes the generator plus all other elements (turbine, exciter) on the same shaft and has units of MW x s. For a motor, it includes the motor plus its mechanical load. Conventional units are PU on the generator MVA base, usually expressed as MW x s / MVA or just s. This value is used in the accelerating power reference frame for operator training simulator solutions. Typical value = 3. |
| saturationFactor | 0..1 | Float | Saturation factor at rated terminal voltage (S1) (>= 0). Not used by simplified model. Defined by defined by S(E1) in the SynchronousMachineSaturationParameters diagram. Typical value = 0,02. |
| saturationFactor120 | 0..1 | Float | Saturation factor at 120 % of rated terminal voltage (S12) (>= RotatingMachineDynamics.saturationFactor). Not used by the simplified model, defined by S(E2) in the SynchronousMachineSaturationParameters diagram. Typical value = 0,12. |
| statorLeakageReactance | 1..1 | PU | Stator leakage reactance (Xl) (>= 0). Typical value = 0,15. |
| statorResistance | 1..1 | PU | Stator (armature) resistance (Rs) (>= 0). Typical value = 0,005. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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#### 8.2.4.3.4 Package SynchronousMachineDynamics

##### 8.2.4.3.4.1 General

For conventional power generating units (e.g., thermal, hydro, combustion turbine), a synchronous machine model represents the electrical characteristics of the generator and the mechanical characteristics of the turbine-generator rotational inertia. Large industrial motors or groups of similar motors can be represented by individual motor models which are represented as generators with negative active power in the static (power flow) data.

The interconnection with the electrical network equations can differ among simulation tools. The tool only needs to know the synchronous machine to establish the correct interconnection. The interconnection with the motor's equipment could also differ due to input and output signals required by standard models.

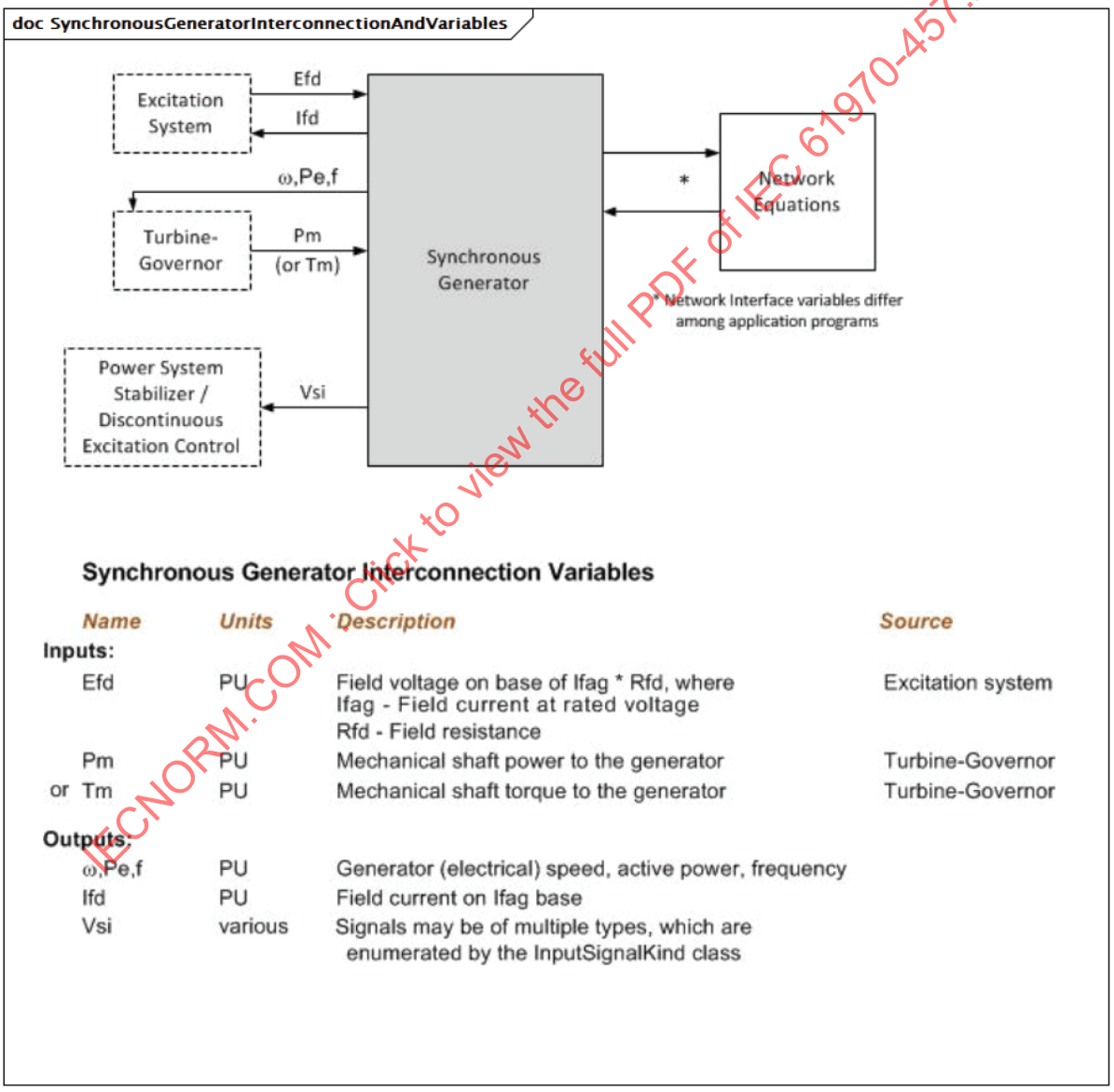


**Figure 25 – SynchronousGeneratorInterconnectionAndVariables**

Figure 25: This diagram illustrates the inputs and outputs for a synchronous generator.

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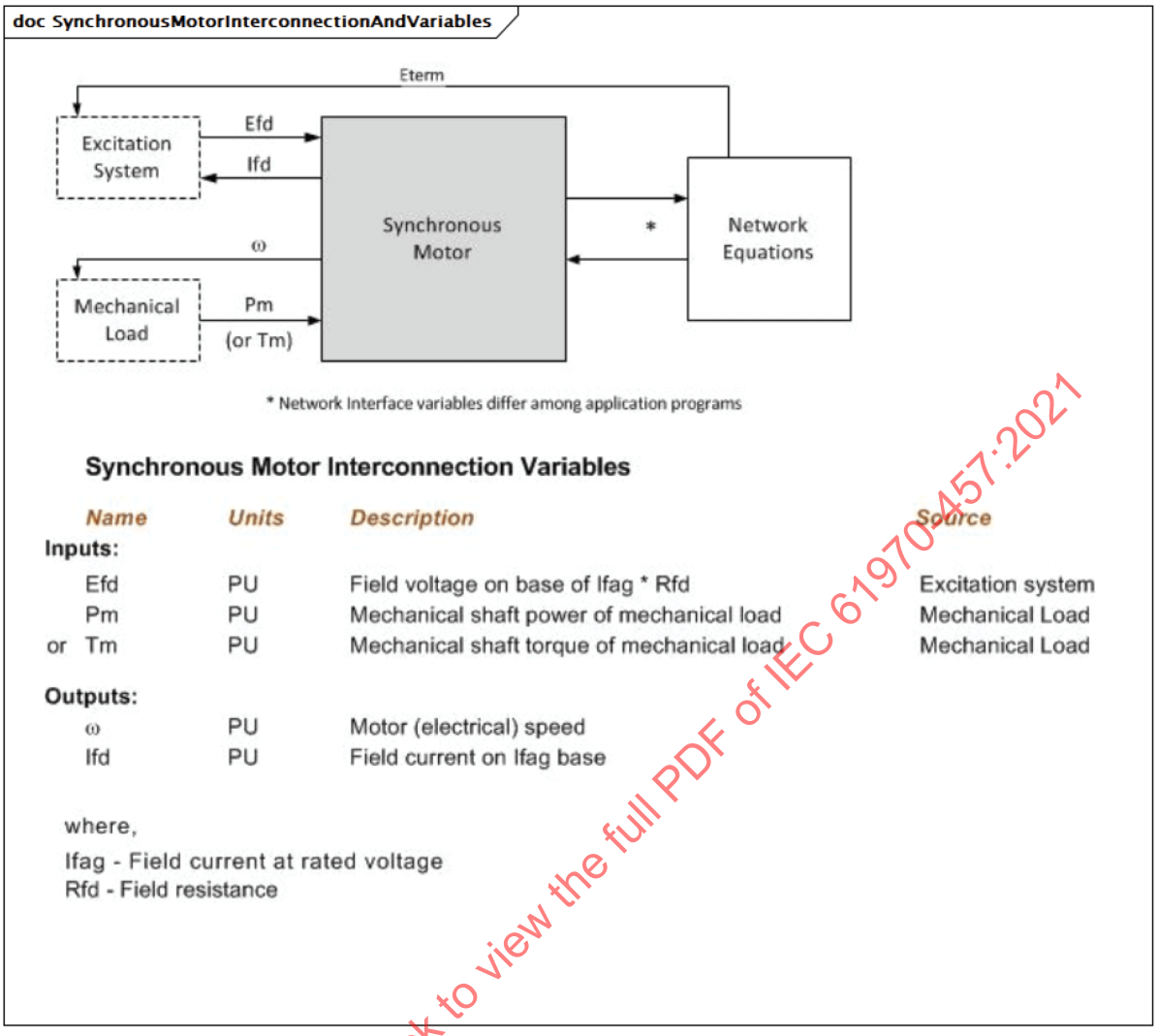


**Figure 26 – SynchronousMotorInterconnectionAndVariables**

Figure 26: This diagram illustrates the inputs and outputs for a synchronous motor.

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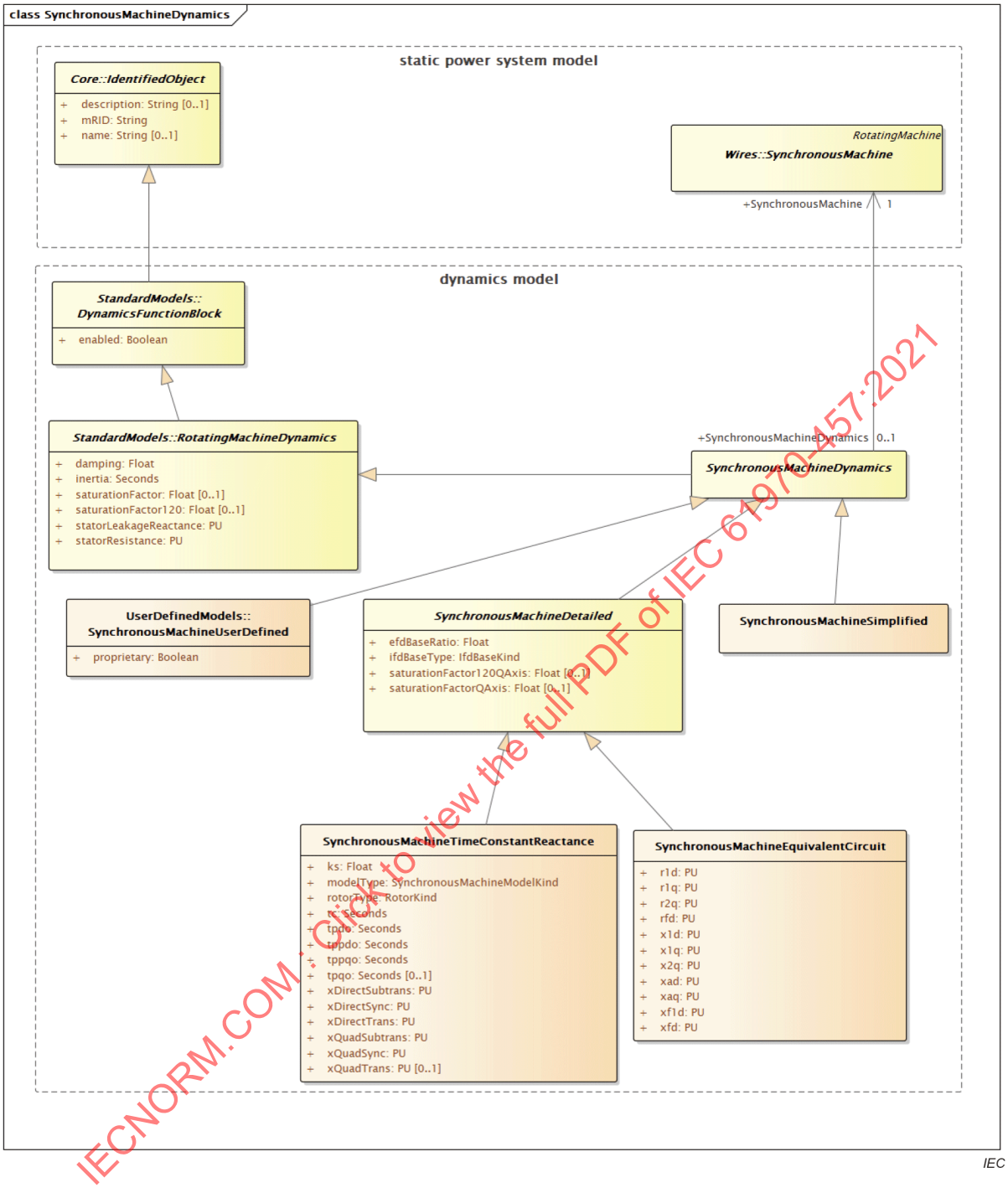


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**Figure 27 – Class diagram SynchronousMachineDynamics:: SynchronousMachineDynamics**

Figure 27: This diagram shows static power system model classes and dynamics model classes related to the synchronous machine dynamics model. An association between the SynchronousMachineDynamics class and the SynchronousMachine class provides a means for relating the dynamics model to the static model.

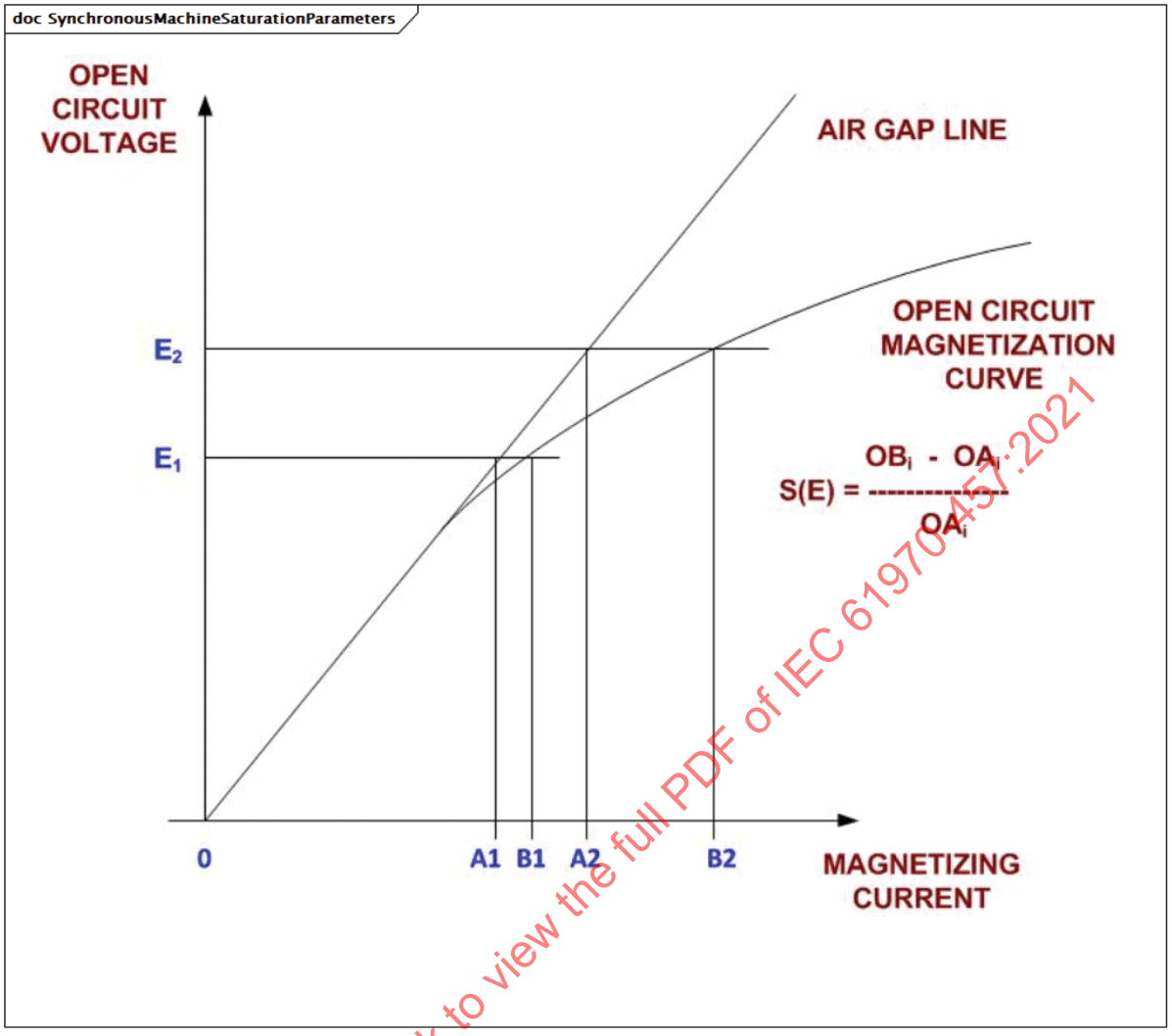


**Figure 28 – SynchronousMachineSaturationParameters**

Figure 28: This diagram shows the synchronous machine saturation parameters.

Parameter details:

1) The quantity OAi in amperes is normally called Ifag (which means field current at rated voltage, open circuit on the air gap (no saturation) line). OBi in amperes isnormally called Ifn (which means field current at rated voltage with no load on the machine).
2) Saturation factors for generators are given by RotatingMachineDynamics.saturationFactor and RotatingMachineDynamics.saturationFactor120.
3) For exciters, the values are given in the attributes for each standard excitation system model.

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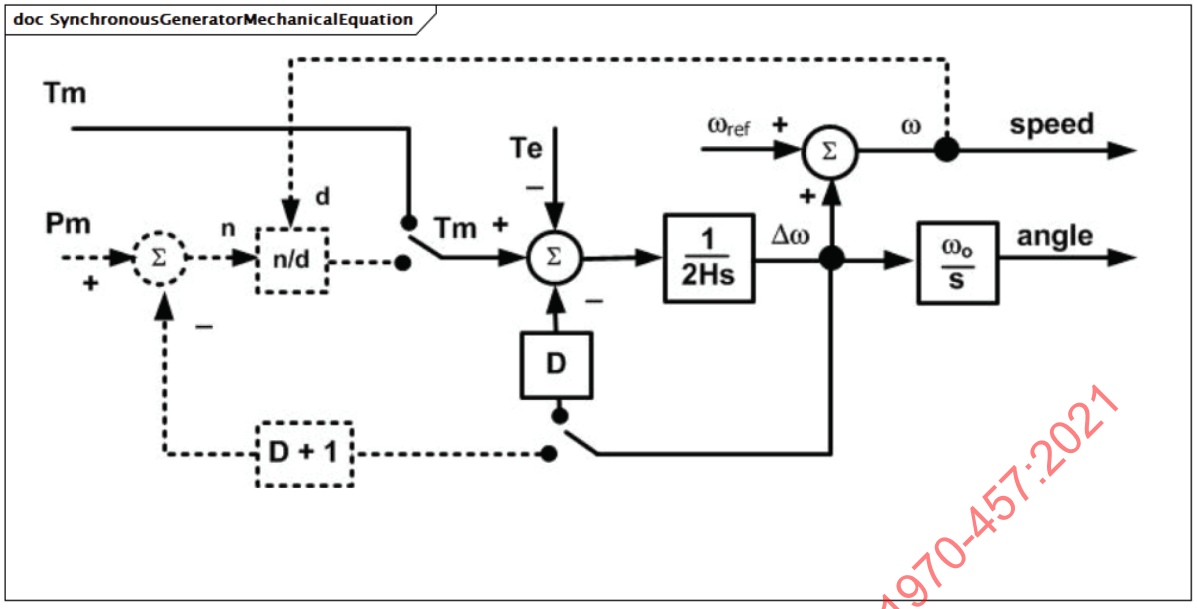


**Figure 29 – SynchronousGeneratorMechanicalEquation**

Figure 29: The mechanical equations for all the variations of the synchronous generator model are the same and can be represented by the SynchronousGeneratorMechanicalEquation block diagram.

Parameter details:

1) All variables are PU on generator MVA base except angle, which is in radians.
2) omega0 is the system synchronous frequency in radians per s. omegaref is the PU system frequency (or isolated area frequency), which can be constant at the initial frequency or vary during a simulation depending on the application program.
3) The input to the mechanical equations can be either Pm or Tm depending on the application program. Application programs using Pm as the input with the damping feedback subtracted from Pm will need to increase D by 1 as shown. In that case, the damping feedback to the torque summing point is not used.

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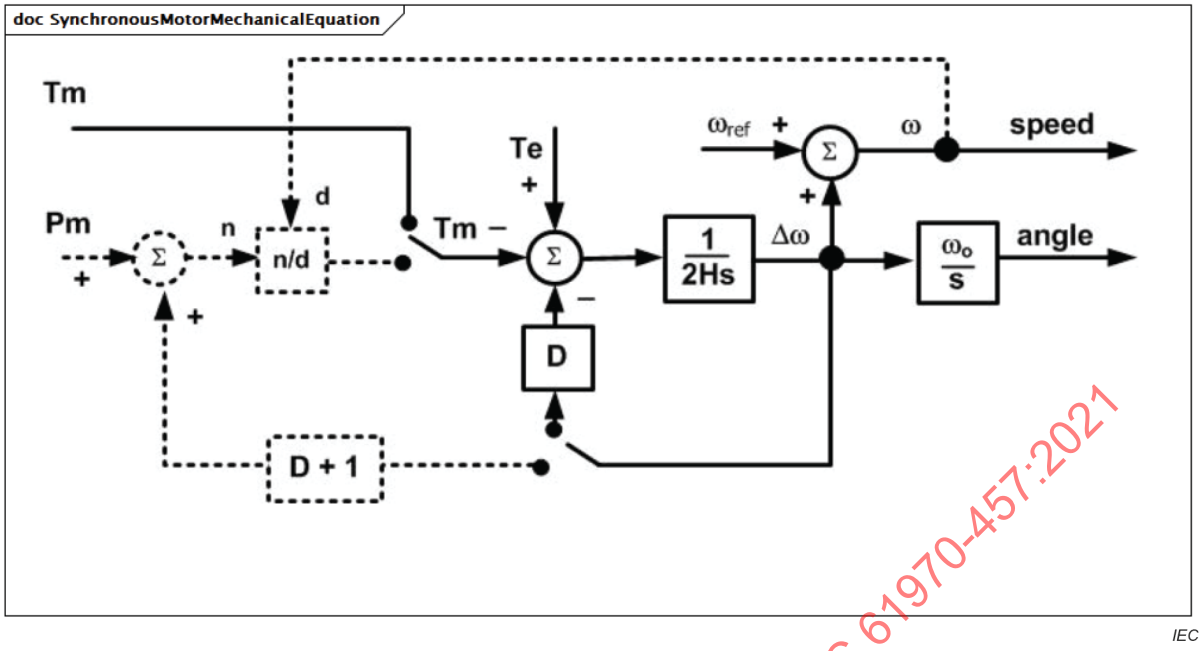


**Figure 30 – SynchronousMotorMechanicalEquation**

Figure 30: The mechanical equations for all variations of the synchronous motor model are the same and can be represented by the SynchronousMotorMechanicalEquation diagram.

Parameter details:

1) All variables are PU on motor MVA base except angle, which is in radians.
2) omega0 is the system synchronous frequency in radians per s. omegaref is the PU system frequency (or isolated area frequency), which can be constant at the initial frequency or vary during a simulation depending on the application program.

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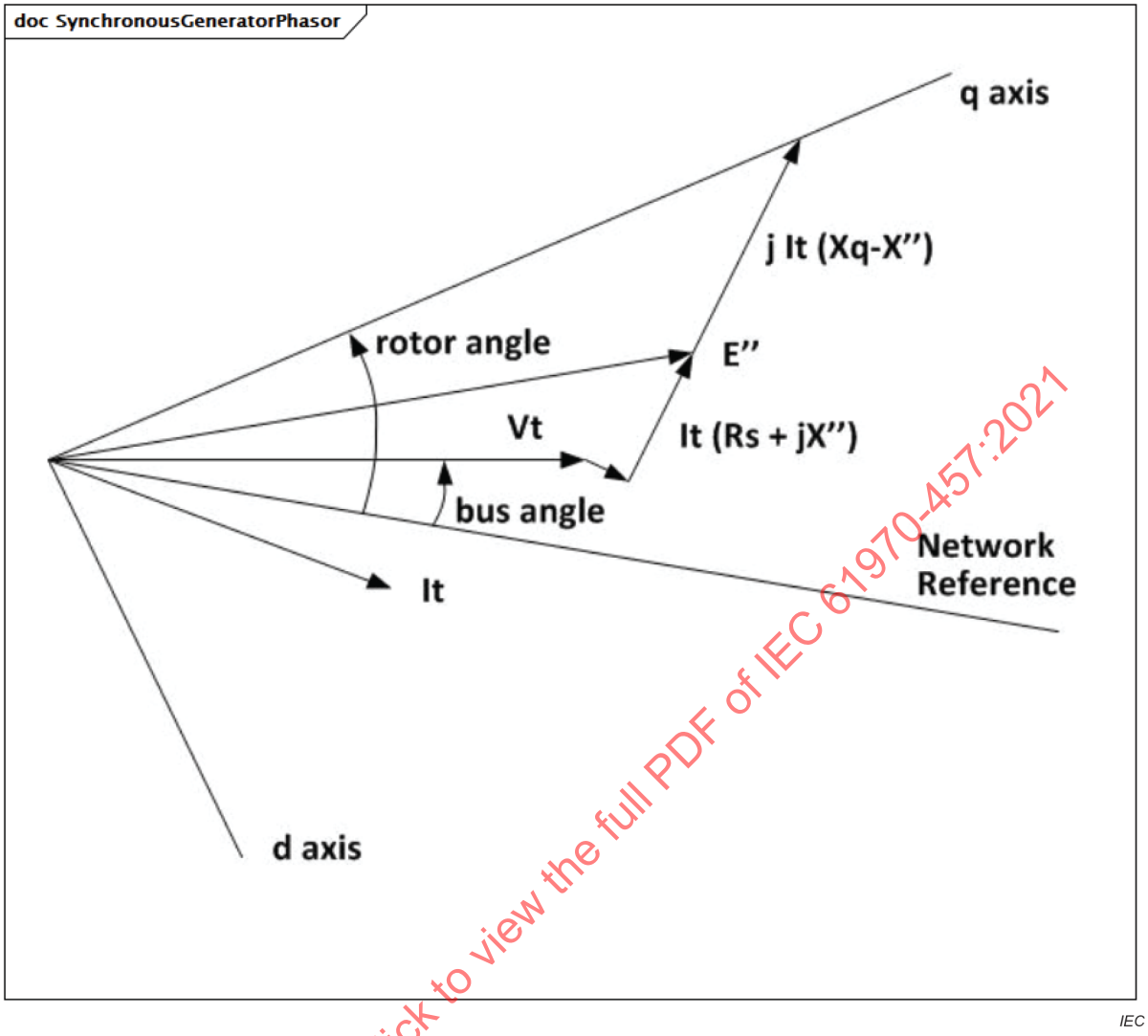


**Figure 31 – SynchronousGeneratorPhasor**

Figure 31: Diagram details:

1) The definition of d- and q-axis variables is based on the SynchronousGeneratorPhasor diagram (counter-clockwise rotation) for the case of an overexcited generator (generating reactive power).

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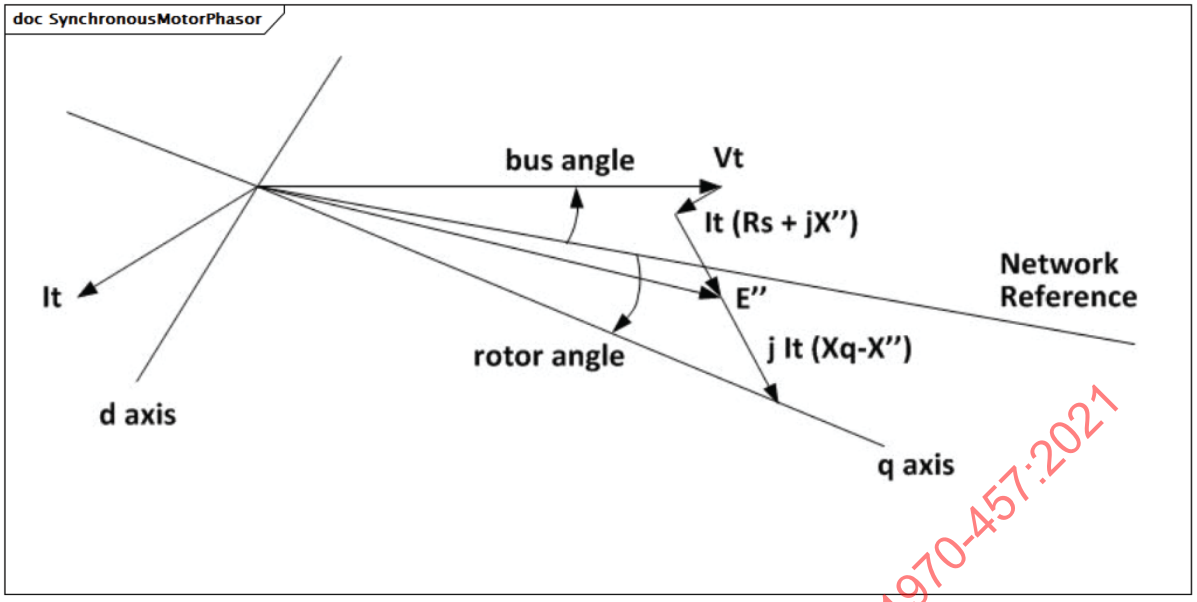


**Figure 32 – SynchronousMotorPhasor**

Figure 32: Diagram details:

1) The definition of d- and q-axis variables is based on the SynchronousMotorPhasor diagram (counter-clockwise rotation) for the case of a motor consuming active power and overexcited (generating reactive power).

#### 8.2.4.3.4.2 SynchronousMachineSimplified

The simplified model represents a synchronous generator as a constant internal voltage behind an impedance (Rs + jXp) as shown in the Simplified diagram.

Since internal voltage is held constant, there is no Efd input and any excitation system model will be ignored. There is also no Ifd output.

This model should not be used for representing a real generator except, perhaps, small generators whose response is insignificant.

The parameters used for the simplified model include:

- RotatingMachineDynamics.damping (D);
- RotatingMachineDynamics.inertia (H);
- RotatingMachineDynamics.statorLeakageReactance (used to exchange jXp for SynchronousMachineSimplified);
- RotatingMachineDynamics.statorResistance (Rs).

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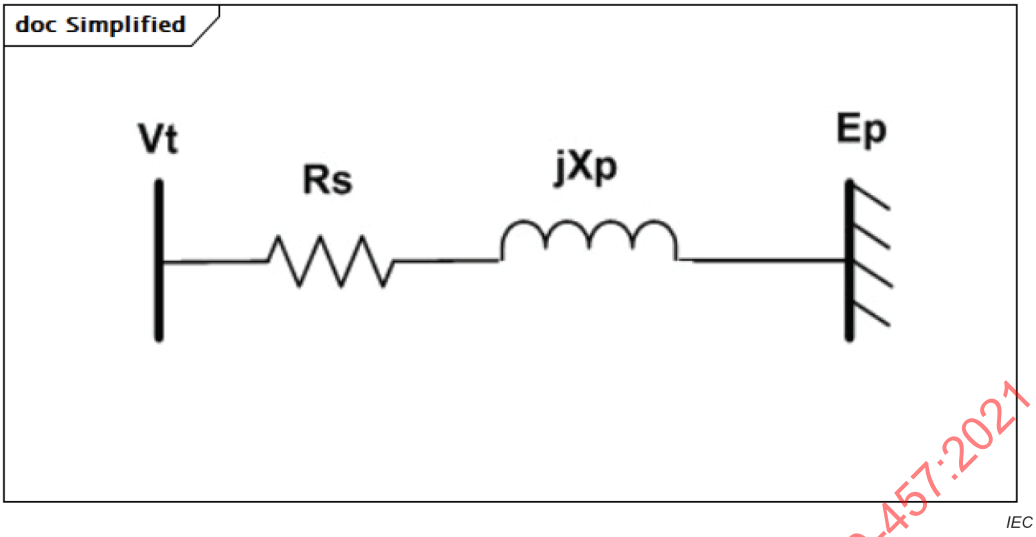


**Figure 33 – Simplified**

Figure 33: This diagram describes the simplified synchronous generator model.

Parameter details:

1) The model is often used for gross equivalents of parts of a system that are not represented in detail. In this case the MVA rating would be the combined rating of all generators in the equivalenced area.
2) Rs + jXp would be the short-circuit equivalent impedance at the location of the equivalent generator on the generator MVA rating base. Inertia constant (H) would be typical or average values for the generators in the equivalenced area.
3) The internal reactance (Xp) can be labelled in different ways (X?, X?, X?d, X?d) by different simulation tools.

Table 56 shows all attributes of SynchronousMachineSimplified.

**Table 56 – Attributes of SynchronousMachineDynamics:: SynchronousMachineSimplified**

| name | mult | type | description |
|---|---|---|---|
| damping | 1..1 | Float | inherited from: RotatingMachineDynamics |
| inertia | 1..1 | Seconds | inherited from: RotatingMachineDynamics |
| saturationFactor | 0..1 | Float | inherited from: RotatingMachineDynamics |
| saturationFactor120 | 0..1 | Float | inherited from: RotatingMachineDynamics |
| statorLeakageReactance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| statorResistance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 57 shows all association ends of SynchronousMachineSimplified with other classes.

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**Table 57 – Association ends of SynchronousMachineDynamics:: SynchronousMachineSimplified with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachine | 1..1 | SynchronousMachine | inherited from: SynchronousMachineDynamics |

#### 8.2.4.3.4.3 (abstract) SynchronousMachineDynamics

Synchronous machine whose behaviour is described by reference to a standard model expressed in one of the following forms:

- simplified (or classical), where a group of generators or motors is not modelled in detail;
- detailed, in equivalent circuit form;
- detailed, in time constant reactance form; or
- by definition of a user-defined model.

It is a common practice to represent small generators by a negative load rather than by a dynamic generator model when performing dynamics simulations. In this case, a SynchronousMachine in the static model is not represented by anything in the dynamics model, instead it is treated as an ordinary load.

Parameter details:

1) Synchronous machine parameters such as Xl, Xd, Xp etc. are actually used as inductances in the models, but are commonly referred to as reactances since, at nominal frequency, the PU values are the same. However, some references use the symbol L instead of X.

Table 58 shows all attributes of SynchronousMachineDynamics.

**Table 58 – Attributes of SynchronousMachineDynamics:: SynchronousMachineDynamics**

| name | mult | type | description |
|---|---|---|---|
| damping | 1..1 | Float | inherited from: RotatingMachineDynamics |
| inertia | 1..1 | Seconds | inherited from: RotatingMachineDynamics |
| saturationFactor | 0..1 | Float | inherited from: RotatingMachineDynamics |
| saturationFactor120 | 0..1 | Float | inherited from: RotatingMachineDynamics |
| statorLeakageReactance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| statorResistance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 59 shows all association ends of SynchronousMachineDynamics with other classes.

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**Table 59 – Association ends of SynchronousMachineDynamics:: SynchronousMachineDynamics with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachine | 1..1 | SynchronousMachine | Synchronous machine to which synchronous machine dynamics model applies. |

#### 8.2.4.3.4.4 (abstract) SynchronousMachineDetailed

All synchronous machine detailed types use a subset of the same data parameters and input/output variables.

The several variations differ in the following ways:

- the number of equivalent windings that are included;
- the way in which saturation is incorporated into the model;
- whether or not “subtransient saliency” (X''q not = X''d) is represented.

It is not necessary for each simulation tool to have separate models for each of the model types. The same model can often be used for several types by alternative logic within the model. Also, differences in saturation representation might not result in significant model performance differences so model substitutions are often acceptable.

Table 60 shows all attributes of SynchronousMachineDetailed.

**Table 60 – Attributes of SynchronousMachineDynamics::SynchronousMachineDetailed**

| name | mult | type | description |
|---|---|---|---|
| saturationFactorQAxis | 0..1 | Float | Quadrature-axis saturation factor at rated terminal voltage (S1q) (>= 0). Typical value = 0,02. |
| saturationFactor120QAxis | 0..1 | Float | Quadrature-axis saturation factor at 120% of rated terminal voltage (S12q) (>= SynchonousMachineDetailed.saturationFactorQAxis). Typical value = 0,12. |
| efdBaseRatio | 1..1 | Float | Ratio (exciter voltage/generator voltage) of Efd bases of exciter and generator models (> 0). Typical value = 1. |
| ifdBaseType | 1..1 | IfdBaseKind | Excitation base system mode. It should be equal to the value of WLMDV given by the user. WLMDV is the PU ratio between the field voltage and the excitation current: Efd = WLMDV x Ifd. Typical value = ifag. |
| damping | 1..1 | Float | inherited from: RotatingMachineDynamics |
| inertia | 1..1 | Seconds | inherited from: RotatingMachineDynamics |
| saturationFactor | 0..1 | Float | inherited from: RotatingMachineDynamics |
| saturationFactor120 | 0..1 | Float | inherited from: RotatingMachineDynamics |
| statorLeakageReactance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| statorResistance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 61 shows all association ends of SynchronousMachineDetailed with other classes.

**Table 61 – Association ends of SynchronousMachineDynamics:: SynchronousMachineDetailed with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachine | 1..1 | SynchronousMachine | inherited from: SynchronousMachineDynamics |

#### 8.2.4.3.4.5 SynchronousMachineTimeConstantReactance

Synchronous machine detailed modelling types are defined by the combination of the attributes SynchronousMachineTimeConstantReactance.modelType and SynchronousMachineTimeConstantReactance.rotorType.

Parameter details:

1) The “p” in the time-related attribute names is a substitution for a “prime” in the usual parameter notation, e.g. tpdo refers to T'do.
2) The parameters used for models expressed in time constant reactance form include:
   - RotatingMachine.ratedS (MVAbase);
   - RotatingMachineDynamics.damping (D);
   - RotatingMachineDynamics.inertia (H);
   - RotatingMachineDynamics.saturationFactor (S1);
   - RotatingMachineDynamics.saturationFactor120 (S12);
   - RotatingMachineDynamics.statorLeakageReactance (Xl);
   - RotatingMachineDynamics.statorResistance (Rs);
   - SynchronousMachineTimeConstantReactance.ks (Ks);
   - SynchronousMachineDetailed.saturationFactorQAxis (S1q);
   - SynchronousMachineDetailed.saturationFactor120QAxis (S12q);
   - SynchronousMachineDetailed.efdBaseRatio;
   - SynchronousMachineDetailed.ifdBaseType;
   - .xDirectSync (Xd);
   - .xDirectTrans (X'd);
   - .xDirectSubtrans (X''d);
   - .xQuadSync (Xq);
   - .xQuadTrans (X'q);
   - .xQuadSubtrans (X''q);
   - .tpdo (T'do);
   - .tppdo (T''do);
   - .tpqo (T'qo);
   - .tppqo (T''qo);
   - .tc.

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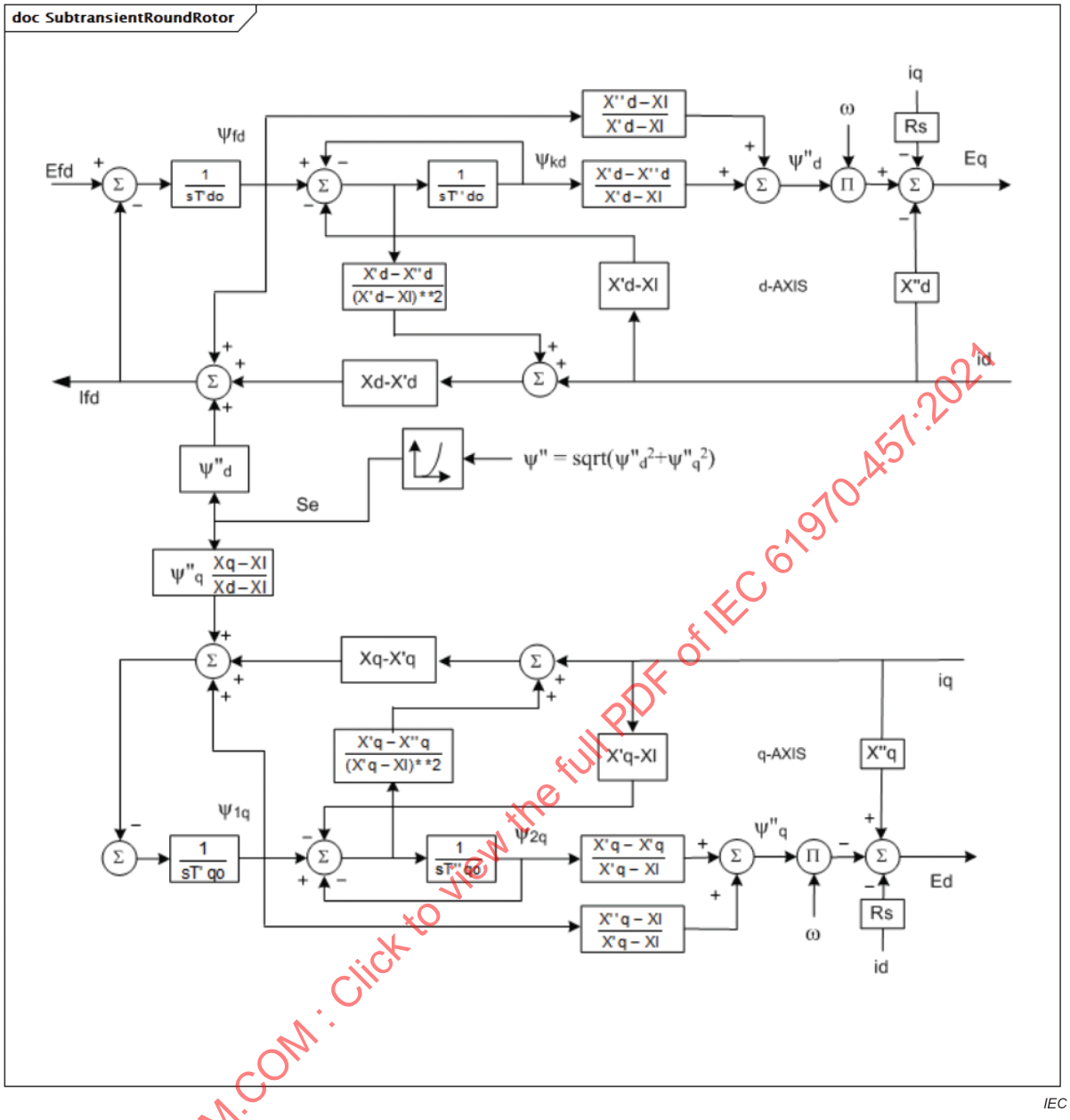


**Figure 34 – SubtransientRoundRotor**

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Figure 34: The subtransient round rotor type is modelled using one of the concrete child classes of the SynchronousMachineDetailed class. If the SynchronousMachineTimeConstantReactance class is used, .modelType = subtransient and .rotorType = roundRotor.

The complete equivalent circuit is used with two rotor windings in each axis.

Ifd represents LadIfd (XadIfd) and is a voltage proportional to field current in PU (IEEE 421.5-2005, Annex B). It is equal to Efd in steady-state.

Parameter details:

1) X''q can be assumed to be equal to X''d (no subtransient saliency).
2) Saturation is modelled in both the direct- and quadrature- axes.
3) For generators, the following parameters can be omitted with defaults shown: X''q (= X''d), Ks (= 0), S1q (= S1), S12q (= S12), Tc (= 0).

4) For motors, the following parameter is not used: X''q.

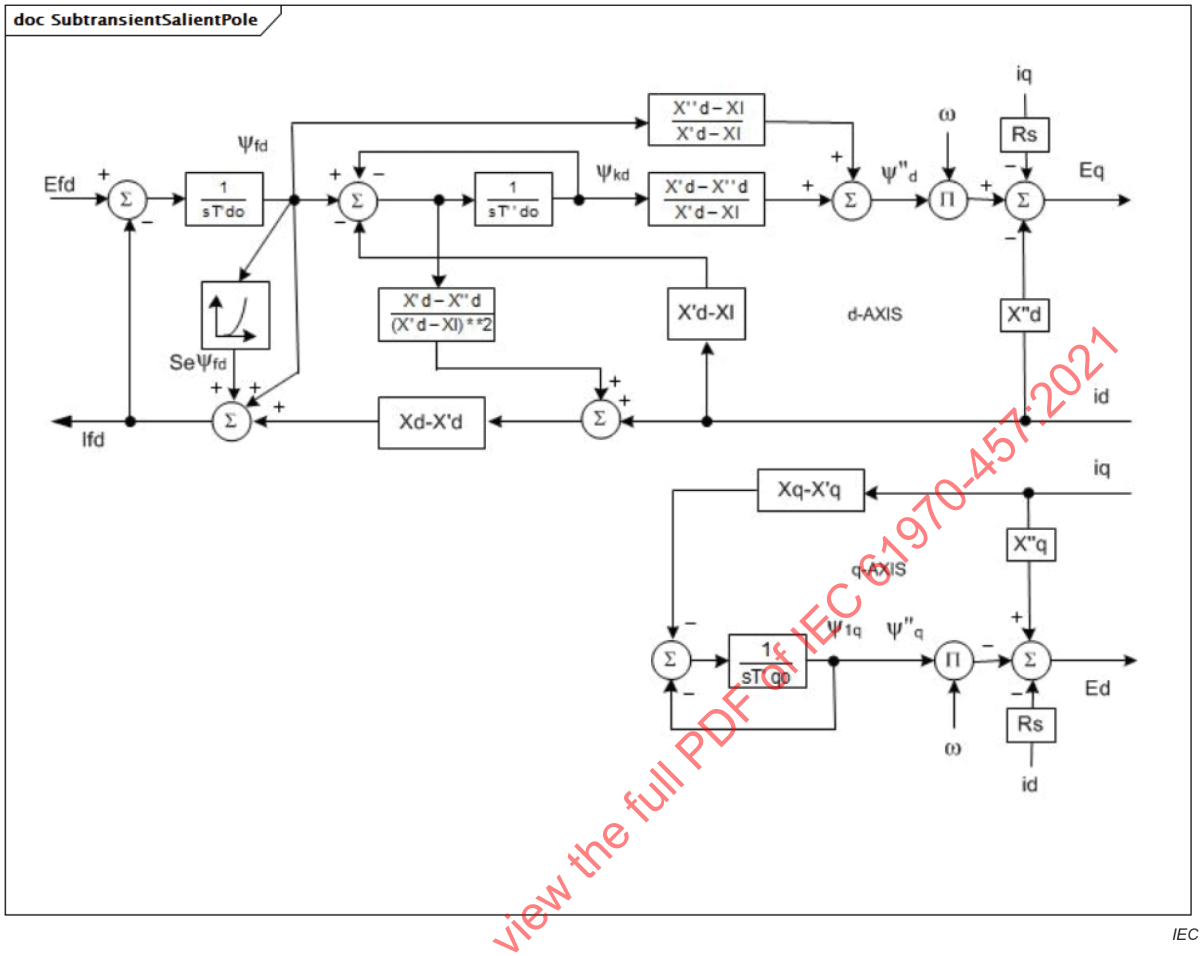


**Figure 35 – SubtransientSalientPole**

Figure 35: The subtransient salient pole type is modelled using one of the concrete child classes of the SynchronousMachineDetailed class. If the SynchronousMachineTimeConstantReactance class is used, .modelType = subtransient and .rotorKind = salientPole.

The d-axis equivalent circuit is the same as for the subtransient round rotor type. The q-axis has only one equivalent rotor winding, which can be labelled as transient (X'q) or subtransient (X''q); X'q is used for the CIM description.

Ifd represents LadIfd (XadIfd) and is a voltage proportional to field current in PU (IEEE 421.5-2005, Annex B). It is equal to Efd in steady-state.

Parameter details:

1) X''q (=X'q) is assumed to be equal to X''d (no subtransient saliency).
2) Saturation is modelled in the d-axis only.
3) For generators, the following input parameters can be omitted with default shown: X'q (=X''d), X''q (=X''d), T''qo, Ks (=0), S1q (=0), S12q (=0), Tc (=0).
4) For motors, the following input parameters are not used: X'q, X''q, T''qo.

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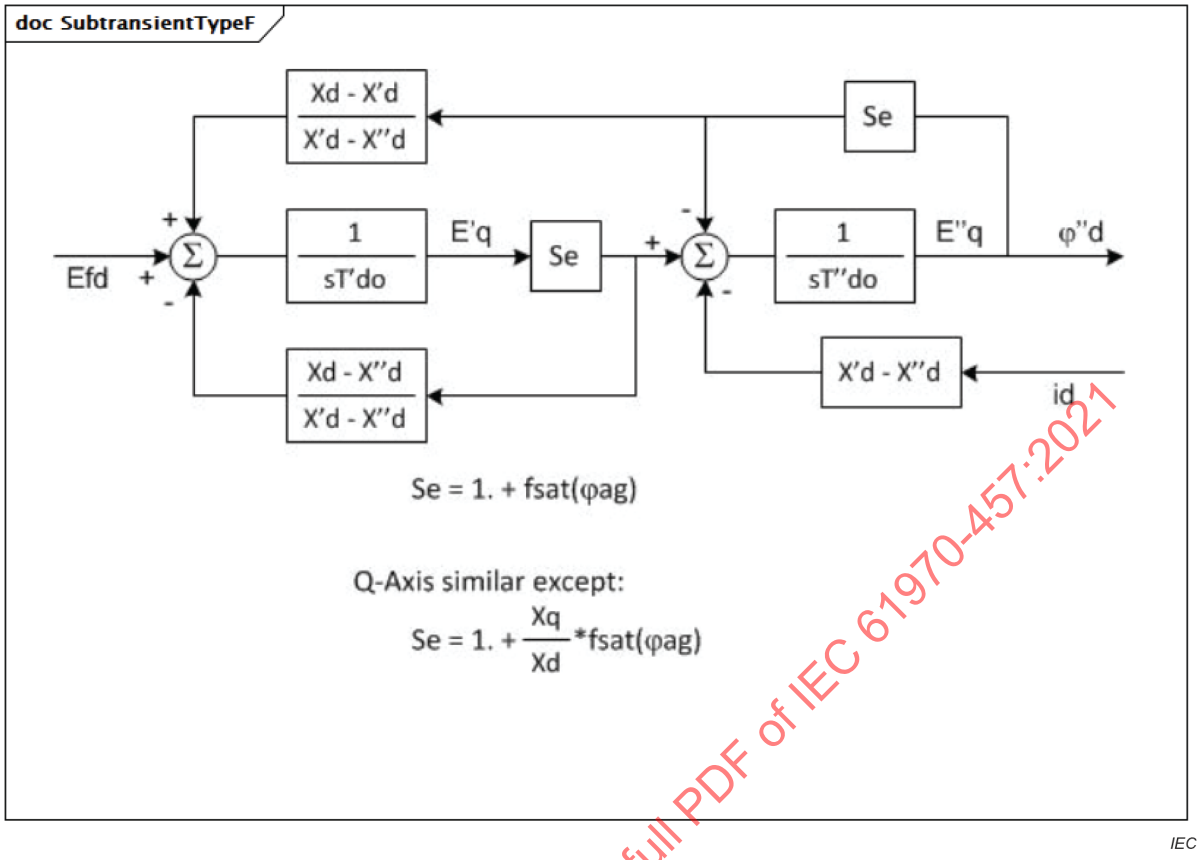


**Figure 36 – SubtransientTypeF**

Figure 36: The subtransient type F is modelled using one of the concrete child classes of the SynchronousMachineDetailed class. If the SynchronousMachineTimeConstantReactance class is used, .modelType = subtransientTypeF.

This model is the WECC type F model with uniform inductance rotor modelling; shaft speed effects are neglected. It has a similar level of detail to the subtransient round rotor type but permits subtransient saliency (X''q not = X''d) and models saturation differently. The subtransient round rotor type can usually be substituted without significant loss of accuracy.

Saturation is modelled in both the direct- and quadrature-axes.

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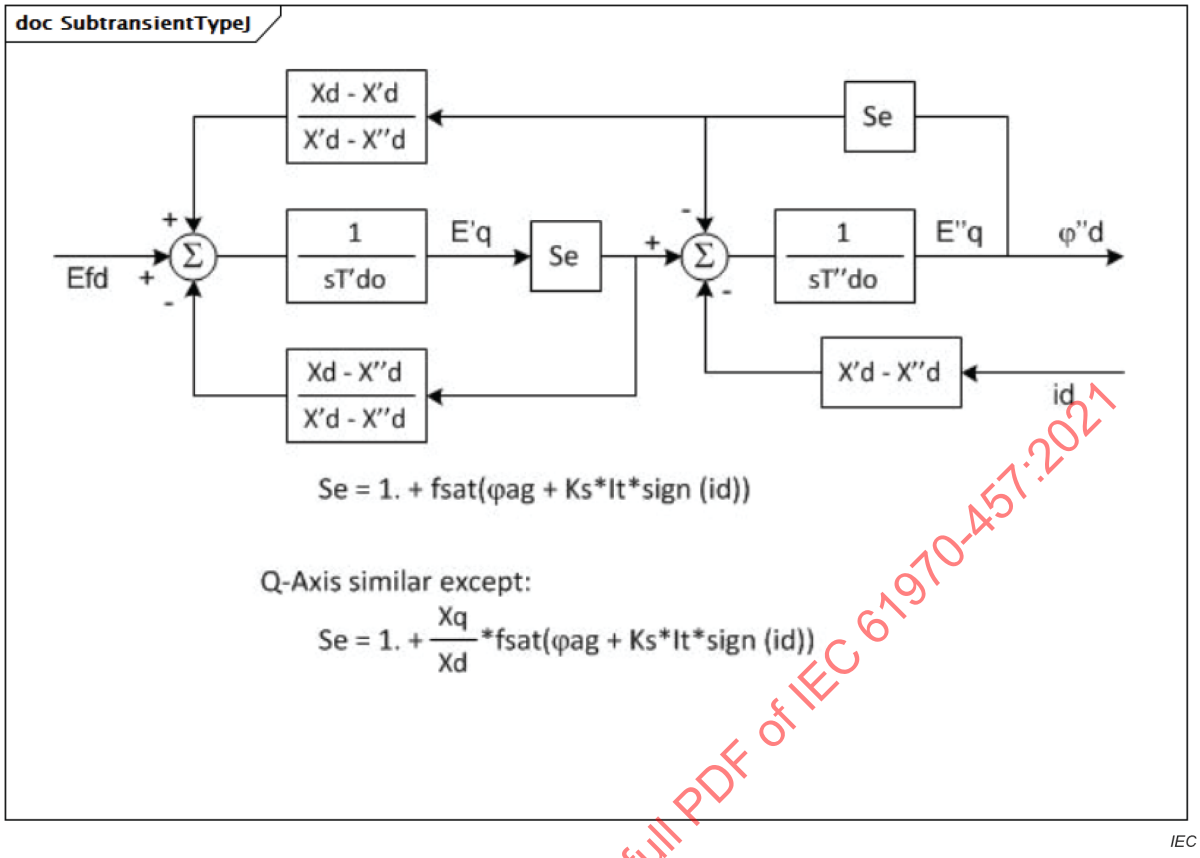


**Figure 37 – SubtransientTypeJ**

Figure 37: The subtransient type J is modelled using one of the concrete child classes of the SynchronousMachineDetailed class. If the SynchronousMachineTimeConstantReactance class is used, .modelType = subtransientTypeJ.

This model is the WECC type J model with uniform inductance ratios rotor modelling with modified saturation model; shaft speed effects are neglected. This model is the same as subtransient type F but includes the effect of generator loading on saturation. With the usage of the saturation constant (Ks) parameter, it allows reproduction of the measured "V curves" over the whole range of reactive power, particularly on some hydro (salient pole) machines.

Saturation is modelled in both the direct- and quadrature-axes.

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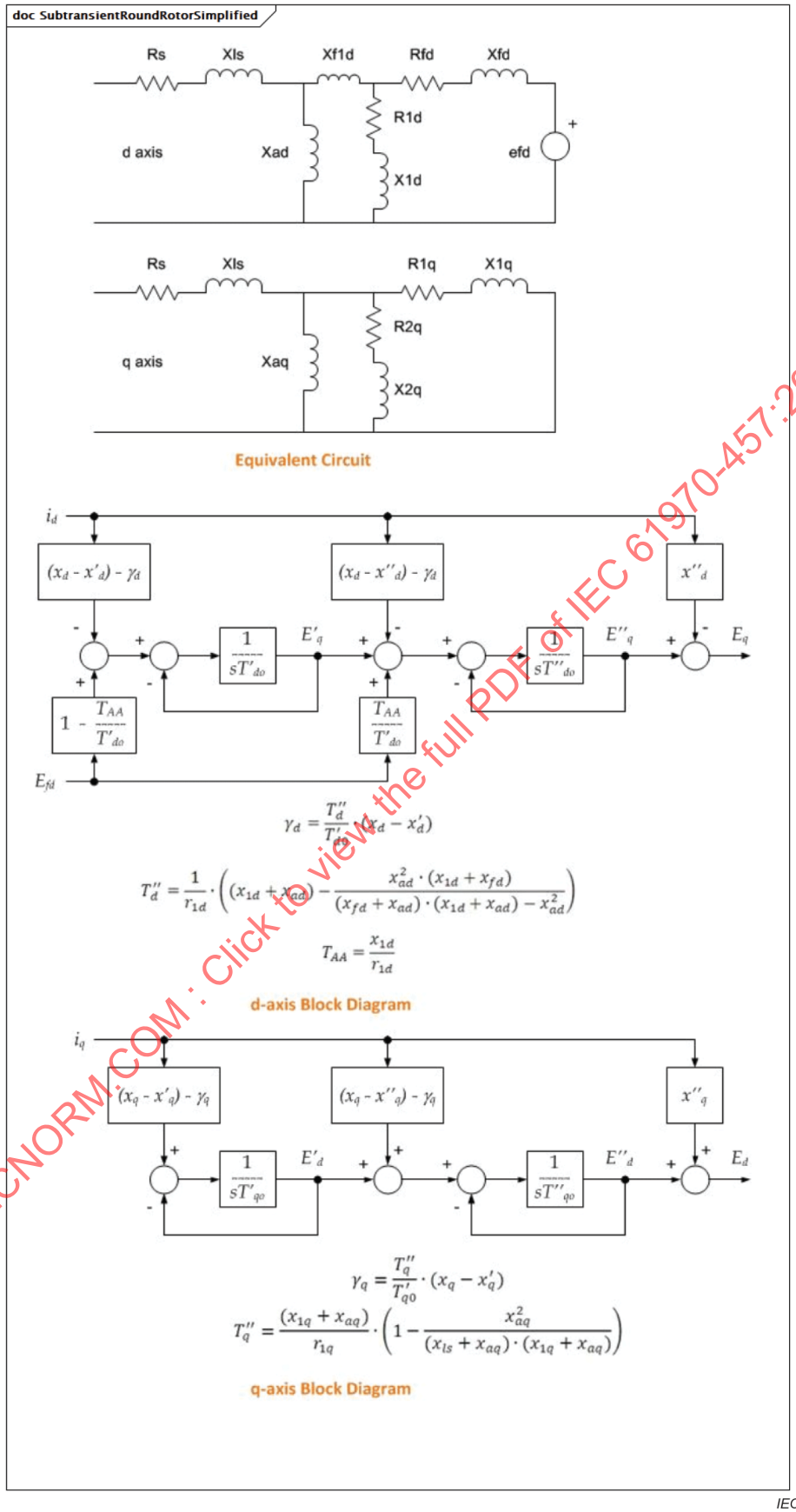


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**Figure 38 – SubtransientRoundRotorSimplified**

Figure 38: The subtransient round rotor simplified type is modelled using one of the concrete child classes of the SynchronousMachineDetailed class. If the SynchronousMachineTimeConstantReactance class is used, .modelType = subtransientSimplified and .rotorKind = roundRotor.

It is a simplified version of subtransient round rotor type, magnetic coupling between the direct- and quadrature- axes is ignored.

Parameter details:

1) The effects of speed variation are neglected.
2) No armature resistance.
3) No saturation effects.
4) No subtransient saliency.
5) Direct-axis with field circuit and one equivalent damper circuit, X'd not = X''d.
6) Quadrature-axis with two equivalent damper circuit, X''q not = X'q.
7) For generators and motors the following input parameters are needed: Xd, X'd, X''d, T'do, T''do and Xq, X'q, X''q, T'qo, T''qo.

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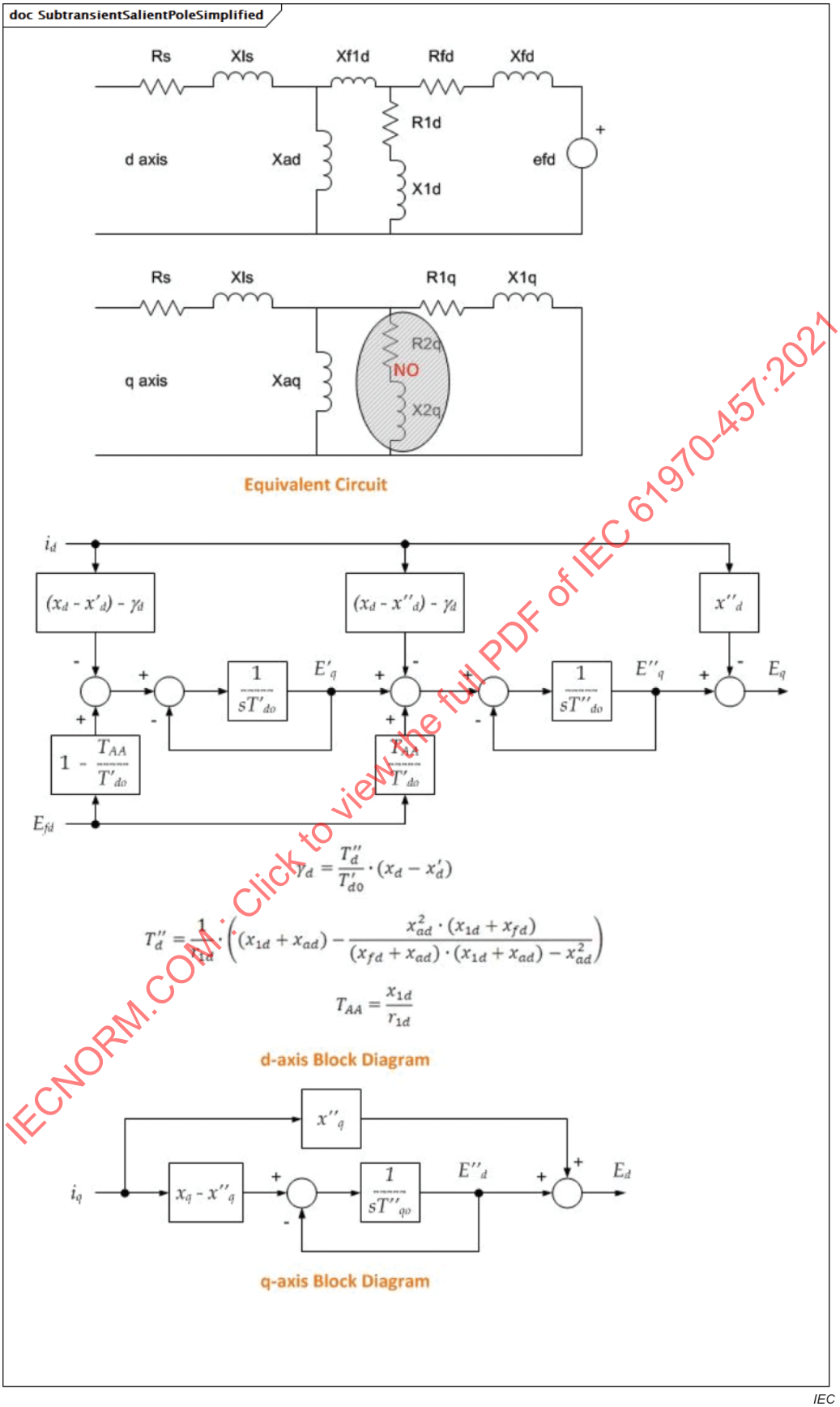


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**Figure 39 – SubtransientSalientPoleSimplified**

Figure 39: The subtransient salient pole simplified type is modelled using one of the concrete child classes of the SynchronousMachineDetailed class. If the SynchronousMachineTimeConstantReactance class is used, .modelType = subtransientSimplified and .rotorKind = salientPole.

It is a simplified version of subtransient salient pole type, magnetic coupling between the direct- and quadrature- axes is ignored.

Parameter details:

1) The effects of speed variation are neglected.
2) No armature resistance.
3) No saturation effects.
4) No subtransient saliency.
5) Direct-axis with field circuit and one equivalent damper circuit, X'd not = X''d.
6) Quadrature-axis with only one equivalent damper circuit, which is labeled as subtransient (X''q), X''q =X'q.
7) For generators and motors the following input parameters are needed: Xd, X'd, X''d, T'do, T''do and Xq, X''q, T''qo.

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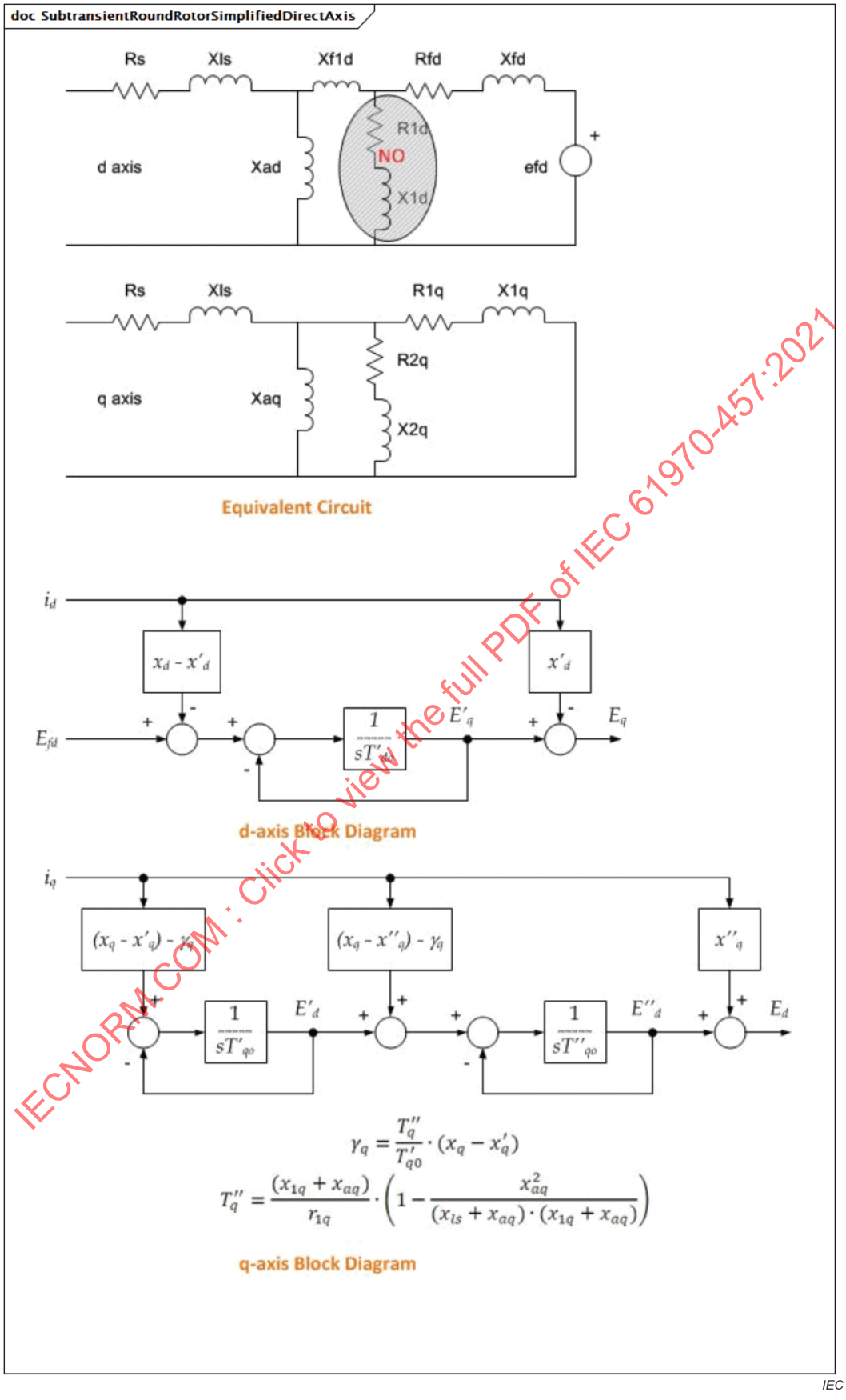


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**Figure 40 – SubtransientRoundRotorSimplifiedDirectAxis**

Figure 40: The subtransient round rotor simplified direct-axis type is modelled using one of the concrete child classes of the SynchronousMachineDetailed class. If the SynchronousMachineTimeConstantReactance class is used, .modelType = subtransientSimplifiedDirectAxis and .rotorKind = roundRotor.

It is a simplified version of a subtransient round rotor type with no damper circuit on the d-axis. This simplification contributes to a reduction in computational effort by reducing the order of the differential equation system. The q-axis has two equivalent rotor windings. Magnetic coupling between the direct- and quadrature- axes is ignored.

Parameter details:

1) The effects of speed variation are neglected.
2) No armature resistance.
3) No saturation effects.
4) No subtransient saliency.
5) Direct-axis with field circuit only, no equivalent damper circuit. Approximation: X'd = X''d.
6) Quadrature-axis with two equivalent damper circuit, X''q not = X'q.
7) For generators and motors the following input parameters are needed: Xd, X'd, T'do and Xq, X'q, X''q, T'qo, T''qo.

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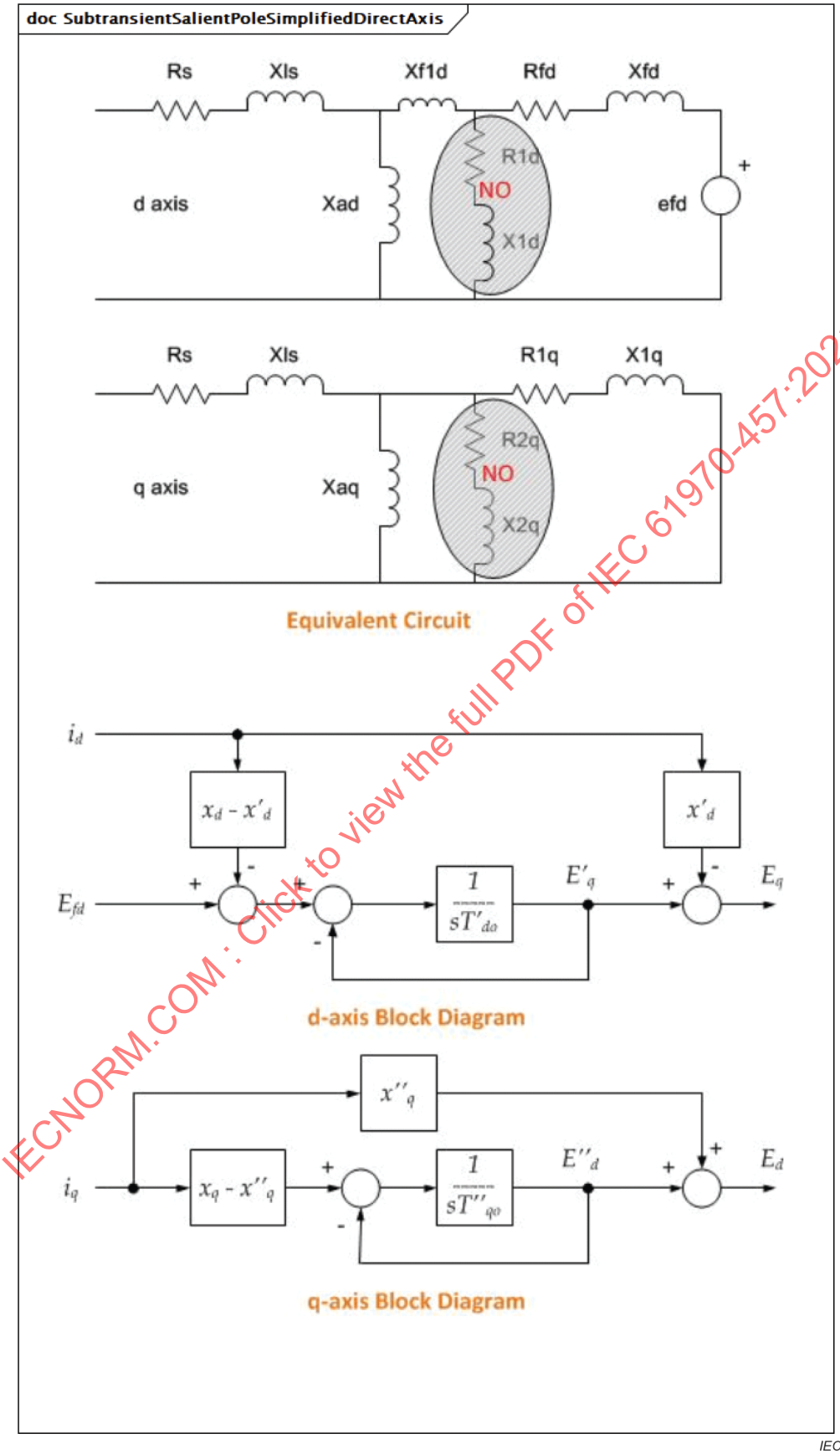


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**Figure 41 – SubtransientSalientPoleSimplifiedDirectAxis**

Figure 41: The subtransient salient pole simplified direct-axis type is modelled using one of the concrete child classes of the SynchronousMachineDetailed class. If the SynchronousMachineTimeConstantReactance class is used, .modelType = subtransientSimplifiedDirectAxis and .rotorKind = salientPole. It is a simplified version of a subtransient salient pole type with no damper circuit on the d-axis. This simplification contributes to a reduction in computational effort by reducing the order of the differential equation system. The q-axis has only one equivalent rotor winding. Magnetic coupling between the direct- and quadrature-axes is ignored.

Parameter details:

1) The effects of speed variation are neglected.
2) No armature resistance.
3) No saturation effects.
4) No subtransient saliency.
5) Direct-axis with field circuit only, no equivalent damper circuit. Approximation: X'd = X''d.
6) Quadrature-axis with only one equivalent damper circuit, which is labelled as subtransient (X''q), X''q =X'q.
7) For generators and motors the following input parameters are needed: Xd, X'd, T'do and Xq, X''q, T''qo.

Table 62 shows all attributes of SynchronousMachineTimeConstantReactance.

**Table 62 – Attributes of SynchronousMachineDynamics:: SynchronousMachineTimeConstantReactance**

| name | mult | type | description |
|---|---|---|---|
| rotorType | 0..1 | RotorKind | Type of rotor on physical machine. |
| modelType | 1..1 | SynchronousMachineModelKind | Type of synchronous machine model used in dynamic simulation applications. |
| ks | 1..1 | Float | Saturation loading correction factor (Ks) (>= 0). Used only by type J model. Typical value = 0. |
| xDirectSync | 1..1 | PU | Direct-axis synchronous reactance (Xd) (>= SynchronousMachineTimeConstantReactance.xDirectTrans). The quotient of a sustained value of that AC component of armature voltage that is produced by the total direct-axis flux due to direct-axis armature current and the value of the AC component of this current, the machine running at rated speed. Typical value = 1,8. |
| xDirectTrans | 1..1 | PU | Direct-axis transient reactance (unsaturated) (X'd) (>= SynchronousMachineTimeConstantReactance.xDirectSubtrans). Typical value = 0,5. |
| xDirectSubtrans | 1..1 | PU | Direct-axis subtransient reactance (unsaturated) (X''d) (> RotatingMachineDynamics.statorLeakageReactance). Typical value = 0,2. |
| xQuadSync | 1..1 | PU | Quadrature-axis synchronous reactance (Xq) (>= SynchronousMachineTimeConstantReactance.xQuadTrans).<br><br>The ratio of the component of reactive armature voltage, due to the quadrature-axis component of armature current, to this component of current, under steady state conditions and at rated frequency. Typical value = 1,6. |
| xQuadTrans | 0..1 | PU | Quadrature-axis transient reactance (X'q) (>= SynchronousMachineTimeConstantReactance.xQuadSubtrans). Typical value = 0,3. |

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| name | mult | type | description |
|---|---|---|---|
| xQuadSubtrans | 1..1 | PU | Quadrature-axis subtransient reactance (X''q) (> RotatingMachineDynamics.statorLeakageReactance). Typical value = 0,2. |
| tpdo | 1..1 | Seconds | Direct-axis transient rotor time constant (T'do) (> SynchronousMachineTimeConstantReactance.tppdo). Typical value = 5. |
| tppdo | 1..1 | Seconds | Direct-axis subtransient rotor time constant (T''do) (> 0). Typical value = 0,03. |
| tpqo | 0..1 | Seconds | Quadrature-axis transient rotor time constant (T'qo) (> SynchronousMachineTimeConstantReactance.tppqo). Typical value = 0,5. |
| tppqo | 1..1 | Seconds | Quadrature-axis subtransient rotor time constant (T''qo) (> 0). Typical value = 0,03. |
| tc | 1..1 | Seconds | Damping time constant for "Canay" reactance (>= 0). Typical value = 0. |
| saturationFactorQAxis | 0..1 | Float | inherited from: SynchronousMachineDetailed |
| saturationFactor120QAxis | 0..1 | Float | inherited from: SynchronousMachineDetailed |
| efdBaseRatio | 1..1 | Float | inherited from: SynchronousMachineDetailed |
| ifdBaseType | 1..1 | IfdBaseKind | inherited from: SynchronousMachineDetailed |
| damping | 1..1 | Float | inherited from: RotatingMachineDynamics |
| inertia | 1..1 | Seconds | inherited from: RotatingMachineDynamics |
| saturationFactor | 0..1 | Float | inherited from: RotatingMachineDynamics |
| saturationFactor120 | 0..1 | Float | inherited from: RotatingMachineDynamics |
| statorLeakageReactance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| statorResistance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 63 shows all association ends of SynchronousMachineTimeConstantReactance with other classes.

**Table 63 – Association ends of SynchronousMachineDynamics:: SynchronousMachineTimeConstantReactance with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachine | 1..1 | SynchronousMachine | inherited from: SynchronousMachineDynamics |

#### 8.2.4.3.4.6 SynchronousMachineEquivalentCircuit

The electrical equations for all variations of the synchronous models are based on the SynchronousEquivalentCircuit diagram for the direct- and quadrature- axes.

Equations for conversion between equivalent circuit and time constant reactance forms:

Xd = Xad + Xl

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X’d = Xl + Xad x Xfd / (Xad + Xfd)

X”d = Xl + Xad x Xfd x X1d / (Xad x Xfd + Xad x X1d + Xfd x X1d)

Xq = Xaq + Xl

X’q = Xl + Xaq x X1q / (Xaq + X1q)

X”q = Xl + Xaq x X1q x X2q / (Xaq x X1q + Xaq x X2q + X1q x X2q)

T’do = (Xad + Xfd) / (omega0 x Rfd)

T”do = (Xad x Xfd + Xad x X1d + Xfd x X1d) / (omega0 x R1d x (Xad + Xfd)

T’qo = (Xaq + X1q) / (omega0 x R1q)

T”qo = (Xaq x X1q + Xaq x X2q + X1q x X2q) / (omega0 x R2q x (Xaq + X1q)

Same equations using CIM attributes from SynchronousMachineTimeConstantReactance class on left of "=" and SynchronousMachineEquivalentCircuit class on right (except as noted):

xDirectSync = xad + RotatingMachineDynamics.statorLeakageReactance

xDirectTrans = RotatingMachineDynamics.statorLeakageReactance + xad x xfd / (xad + xfd)

xDirectSubtrans = RotatingMachineDynamics.statorLeakageReactance + xad x xfd x x1d / (xad x xfd + xad x x1d + xfd x x1d)

xQuadSync = xaq + RotatingMachineDynamics.statorLeakageReactance

xQuadTrans = RotatingMachineDynamics.statorLeakageReactance + xaq x x1q / (xaq+ x1q)

xQuadSubtrans = RotatingMachineDynamics.statorLeakageReactance + xaq x x1q x x2q / (xaq x x1q + xaq x x2q + x1q x x2q)

tpdo = (xad + xfd) / (2 x pi x nominal frequency x rfd)

tppdo = (xad x xfd + xad x x1d + xfd x x1d) / (2 x pi x nominal frequency x r1d x (xad + xfd)

tpqo = (xaq + x1q) / (2 x pi x nominal frequency x r1q)

tppqo = (xaq x x1q + xaq x x2q + x1q x x2q) / (2 x pi x nominal frequency x r2q x (xaq + x1q)

These are only valid for a simplified model where "Canay" reactance is zero.

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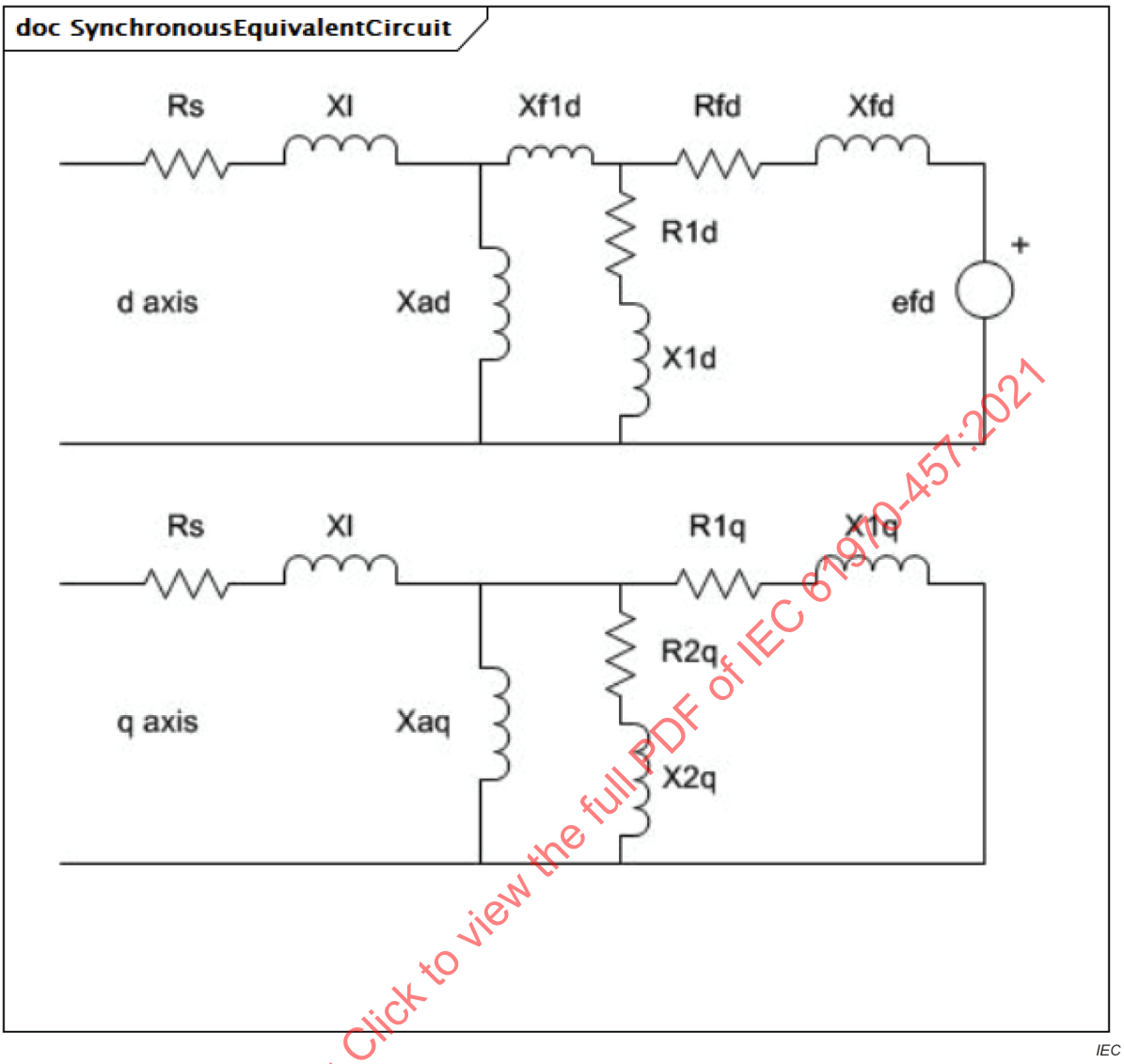


**Figure 42 – SynchronousEquivalentCircuit**

Figure 42: In each axis, the branches represent the stator leakage reactance (Xl) and resistance (Rs), the magnetizing reactance (Xad, Xaq), the physical field winding (Rfd, Xfd) on the rotor, and equivalent windings for eddy current flow in the rotor iron.

Table 64 shows all attributes of SynchronousMachineEquivalentCircuit.

**Table 64 – Attributes of SynchronousMachineDynamics:: SynchronousMachineEquivalentCircuit**

| name | mult | type | description |
|---|---|---|---|
| xad | 1..1 | PU | Direct-axis mutual reactance. |
| rfd | 1..1 | PU | Field winding resistance. |
| xfd | 1..1 | PU | Field winding leakage reactance. |
| r1d | 1..1 | PU | Direct-axis damper 1 winding resistance. |
| x1d | 1..1 | PU | Direct-axis damper 1 winding leakage reactance. |
| xf1d | 1..1 | PU | Differential mutual (“Canay”) reactance. |
| xaq | 1..1 | PU | Quadrature-axis mutual reactance. |

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| name | mult | type | description |
|---|---|---|---|
| r1q | 1..1 | PU | Quadrature-axis damper 1 winding resistance. |
| x1q | 1..1 | PU | Quadrature-axis damper 1 winding leakage reactance. |
| r2q | 1..1 | PU | Quadrature-axis damper 2 winding resistance. |
| x2q | 1..1 | PU | Quadrature-axis damper 2 winding leakage reactance. |
| saturationFactorQAxis | 0..1 | Float | inherited from: SynchronousMachineDetailed |
| saturationFactor120QAxis | 0..1 | Float | inherited from: SynchronousMachineDetailed |
| efdBaseRatio | 1..1 | Float | inherited from: SynchronousMachineDetailed |
| ifdBaseType | 1..1 | IfdBaseKind | inherited from: SynchronousMachineDetailed |
| damping | 1..1 | Float | inherited from: RotatingMachineDynamics |
| inertia | 1..1 | Seconds | inherited from: RotatingMachineDynamics |
| saturationFactor | 0..1 | Float | inherited from: RotatingMachineDynamics |
| saturationFactor120 | 0..1 | Float | inherited from: RotatingMachineDynamics |
| statorLeakageReactance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| statorResistance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 65 shows all association ends of SynchronousMachineEquivalentCircuit with other classes.

**Table 65 – Association ends of SynchronousMachineDynamics:: SynchronousMachineEquivalentCircuit with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachine | 1..1 | SynchronousMachine | inherited from: SynchronousMachineDynamics |

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#### 8.2.4.3.5 Package AsynchronousMachineDynamics

##### 8.2.4.3.5.1 General

An asynchronous machine model represents a (induction) generator or motor with no external connection to the rotor windings, e.g. a squirrel-cage induction machine.

The interconnection with the electrical network equations can differ among simulation tools. The program only needs to know the terminal to which this asynchronous machine is connected in order to establish the correct interconnection. The interconnection with the motor's equipment could also differ due to input and output signals required by standard models.

The asynchronous machine model is used to model wind generators type 1 and type 2. For these, normal practice is to include the rotor flux transients and neglect the stator flux transients.

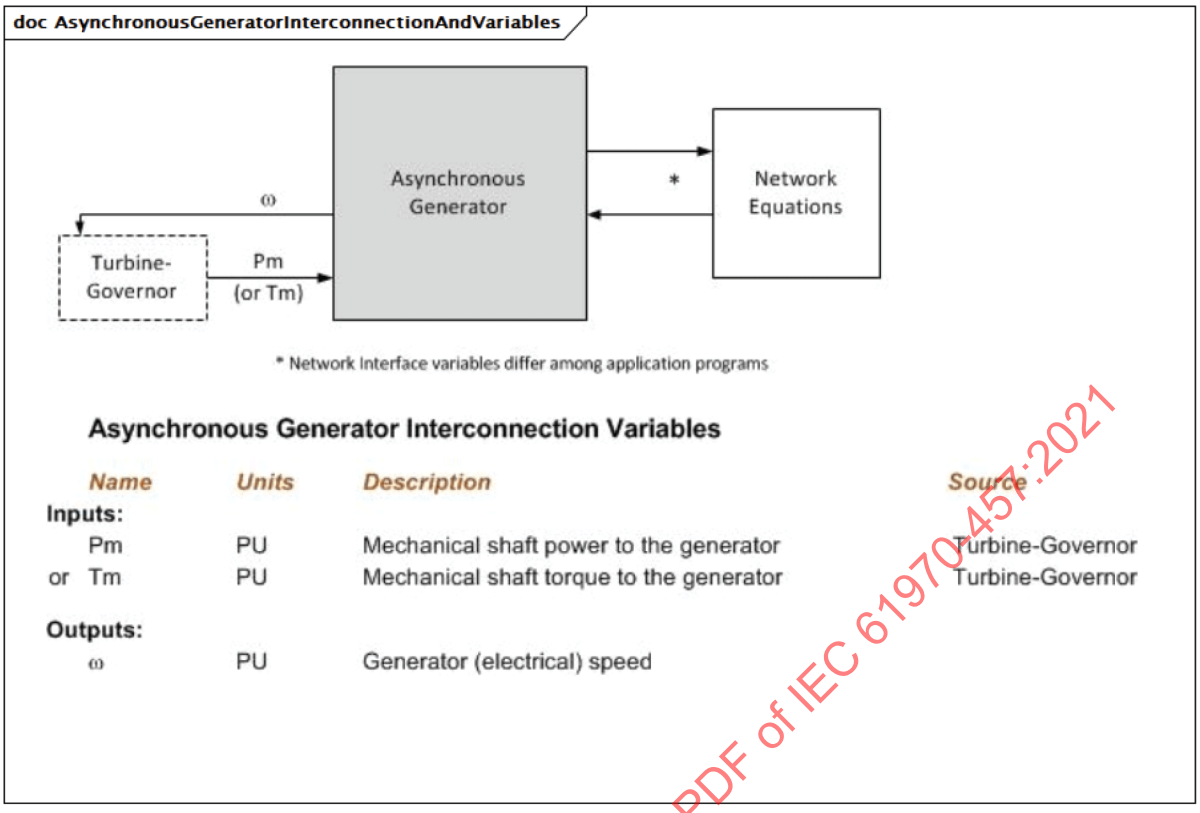


**Figure 43 – AsynchronousGeneratorInterconnectionAndVariables**

Figure 43: This diagram illustrates the inputs and outputs for an asynchronous generator.

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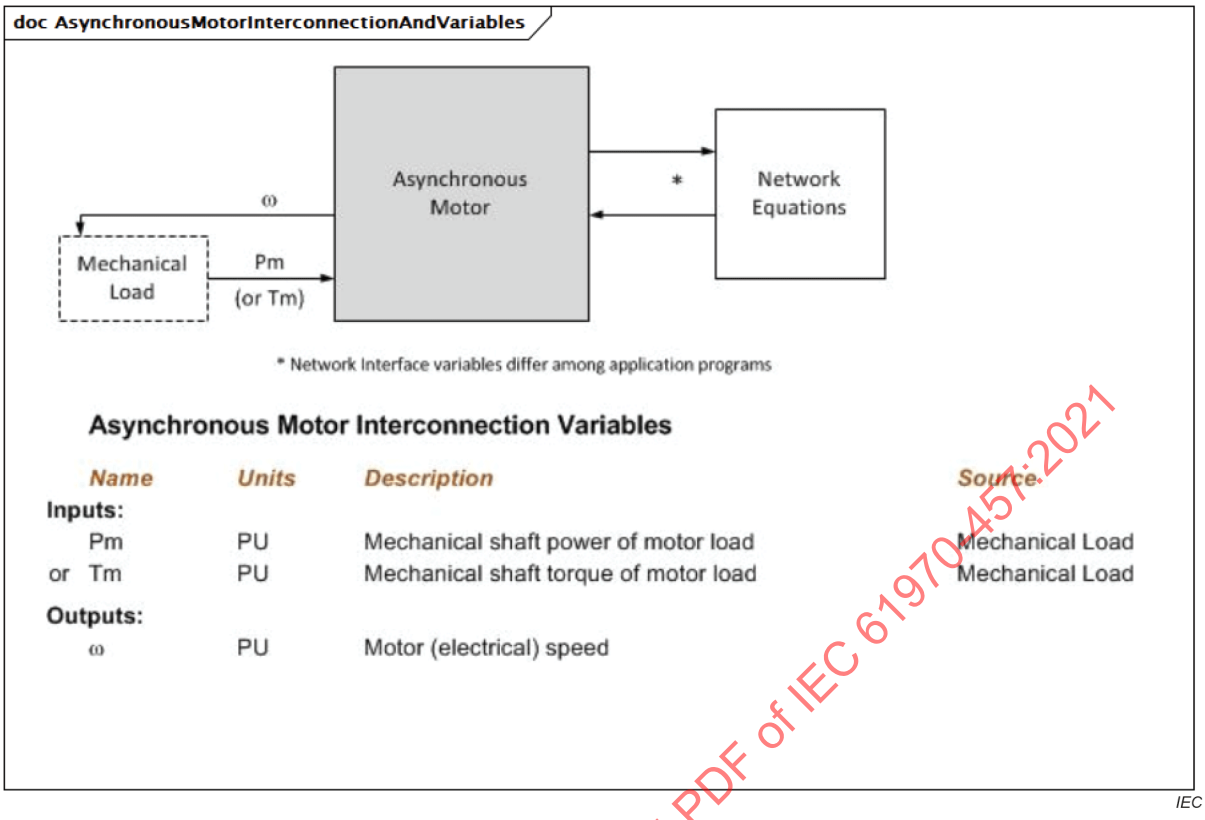


**Figure 44 – AsynchronousMotorInterconnectionAndVariables**

Figure 44: This diagram illustrates the inputs and outputs for an asynchronous motor.

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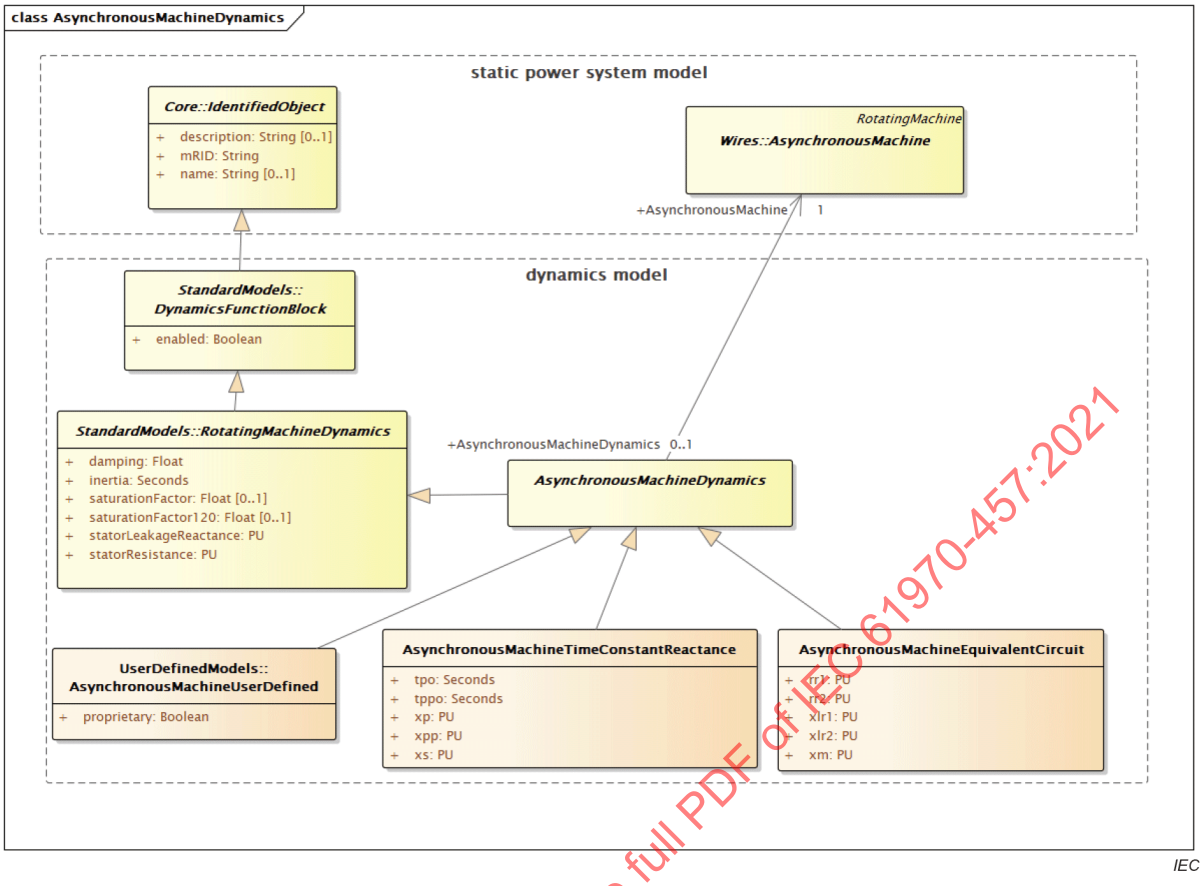


**Figure 45 – Class diagram AsynchronousMachineDynamics:: AsynchronousMachineDynamics**

Figure 45: This diagram shows static power system model classes and dynamics model classes related to the asynchronous machine dynamics model. An association between the AsynchronousMachineDynamics class and the AsynchronousMachine class provides a means for relating the dynamics model to the static model.

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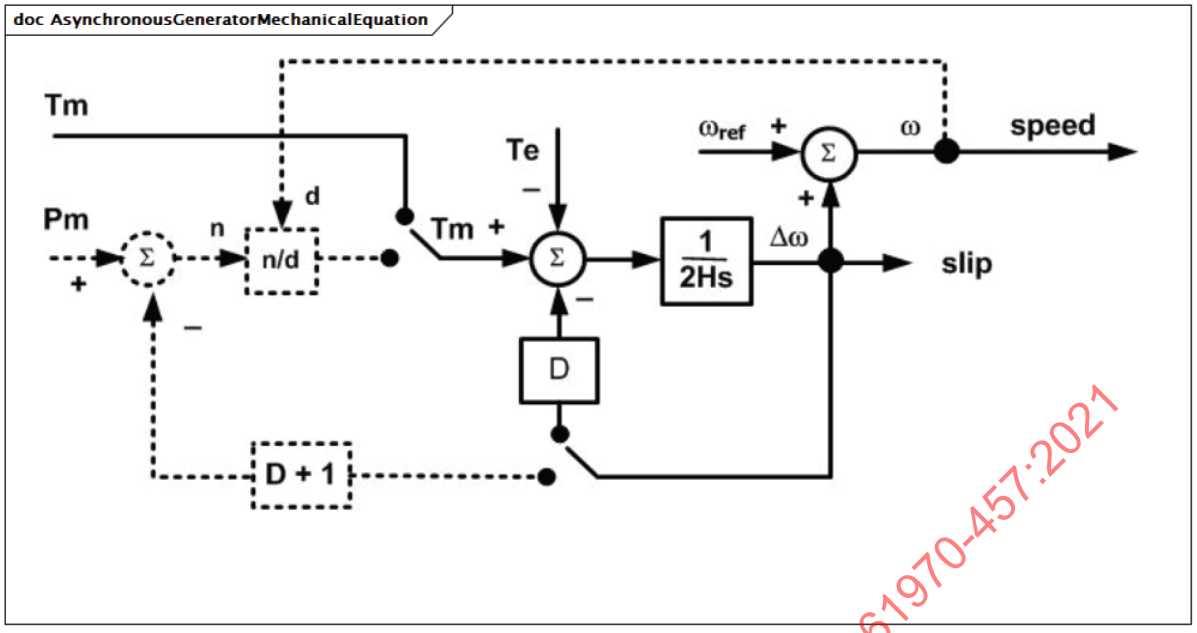


**Figure 46 – AsynchronousGeneratorMechanicalEquation**

Figure 46: The mechanical equations for all the variations of the asynchronous generator model are the same and can be represented by the AsynchronousGeneratorMechanicalEquation block diagram.

Parameter details:

1) All variables are PU on motor MVA base except angle, which is in radians.
2) omega0 is the system synchronous frequency in radians per s. omegaref is the PU system frequency (or isolated area frequency), which can be constant at the initial frequency or vary during a simulation depending on the application program.

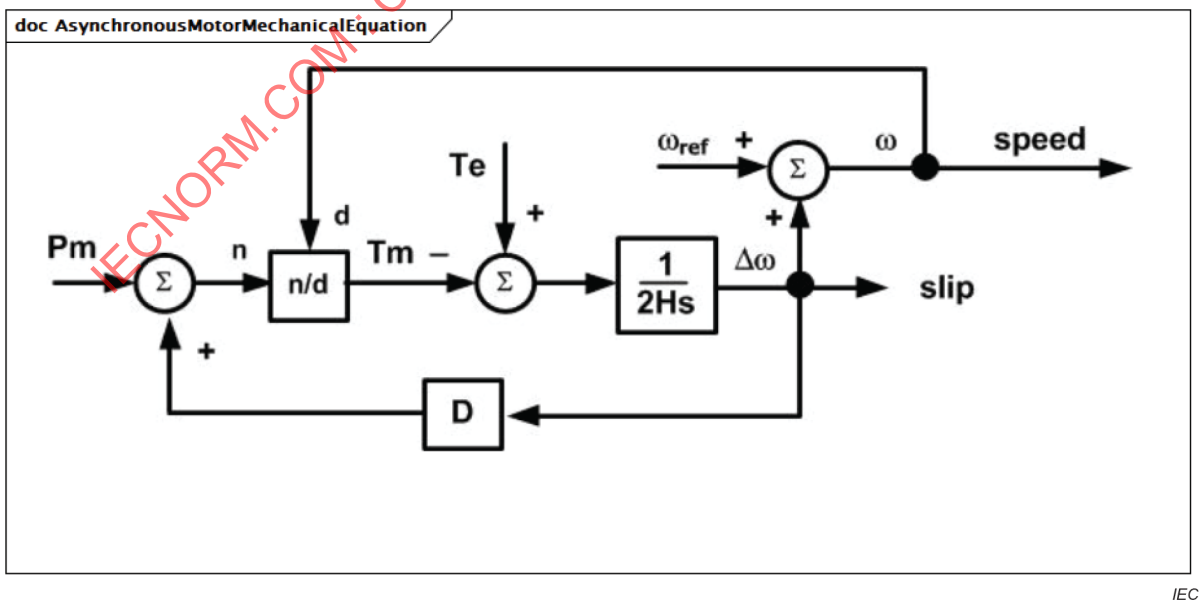


**Figure 47 – AsynchronousMotorMechanicalEquation**

Figure 47: The mechanical equations for all variations of the asynchronous motor model are the same and can be represented by the AsynchronousMotorMechanicalEquation diagram.

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Parameter details:

1) All variables are PU on motor MVA base except angle, which is in radians.
2) omega0 is the system synchronous frequency in radians per s. omegaref is the PU system frequency (or isolated area frequency), which can be constant at the initial frequency or vary during a simulation depending on the application program.

#### 8.2.4.3.5.2 (abstract) AsynchronousMachineDynamics

Asynchronous machine whose behaviour is described by reference to a standard model expressed in either time constant reactance form or equivalent circuit form or by definition of a user-defined model.

Parameter details:

1) Asynchronous machine parameters such as Xl, Xs, etc. are actually used as inductances in the model, but are commonly referred to as reactances since, at nominal frequency, the PU values are the same. However, some references use the symbol L instead of X.

Table 66 shows all attributes of AsynchronousMachineDynamics.

**Table 66 – Attributes of AsynchronousMachineDynamics:: AsynchronousMachineDynamics**

| name | mult | type | description |
|---|---|---|---|
| damping | 1..1 | Float | inherited from: RotatingMachineDynamics |
| inertia | 1..1 | Seconds | inherited from: RotatingMachineDynamics |
| saturationFactor | 0..1 | Float | inherited from: RotatingMachineDynamics |
| saturationFactor120 | 0..1 | Float | inherited from: RotatingMachineDynamics |
| statorLeakageReactance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| statorResistance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 67 shows all association ends of AsynchronousMachineDynamics with other classes.

**Table 67 – Association ends of AsynchronousMachineDynamics:: AsynchronousMachineDynamics with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | AsynchronousMachine | 1..1 | AsynchronousMachine | Asynchronous machine to which this asynchronous machine dynamics model applies. |

#### 8.2.4.3.5.3 AsynchronousMachineTimeConstantReactance

Parameter details:

1) If X'' = X', a single cage (one equivalent rotor winding per axis) is modelled.
2) The “p” in the attribute names is a substitution for a “prime” in the usual parameter notation, e.g. tpo refers to T'o.

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The parameters used for models expressed in time constant reactance form include:

RotatingMachine.ratedS (MVAbase);

RotatingMachineDynamics.damping (D);

RotatingMachineDynamics.inertia (H);

RotatingMachineDynamics.saturationFactor (S1);

RotatingMachineDynamics.saturationFactor120 (S12);

RotatingMachineDynamics.statorLeakageReactance (Xl);

RotatingMachineDynamics.statorResistance (Rs);

.xs (Xs);

.xp (X');

.xpp (X'');

.tpo (T'o);

.tppo (T''o).

Table 68 shows all attributes of AsynchronousMachineTimeConstantReactance.

**Table 68 – Attributes of AsynchronousMachineDynamics:: AsynchronousMachineTimeConstantReactance**

| name | mult | type | description |
|---|---|---|---|
| xs | 1..1 | PU | Synchronous reactance (Xs) (>= AsynchronousMachineTimeConstantReactance.xp). Typical value = 1,8. |
| xp | 1..1 | PU | Transient reactance (unsaturated) (X') (>= AsynchronousMachineTimeConstantReactance.xpp). Typical value = 0,5. |
| xpp | 1..1 | PU | Subtransient reactance (unsaturated) (X'') (> RotatingMachineDynamics.statorLeakageReactance). Typical value = 0,2. |
| tpo | 1..1 | Seconds | Transient rotor time constant (T'o) (> AsynchronousMachineTimeConstantReactance.tppo). Typical value = 5. |
| tppo | 1..1 | Seconds | Subtransient rotor time constant (T''o) (> 0). Typical value = 0,03. |
| damping | 1..1 | Float | inherited from: RotatingMachineDynamics |
| inertia | 1..1 | Seconds | inherited from: RotatingMachineDynamics |
| saturationFactor | 0..1 | Float | inherited from: RotatingMachineDynamics |
| saturationFactor120 | 0..1 | Float | inherited from: RotatingMachineDynamics |
| statorLeakageReactance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| statorResistance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 69 shows all association ends of AsynchronousMachineTimeConstantReactance with other classes.

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**Table 69 – Association ends of AsynchronousMachineDynamics:: AsynchronousMachineTimeConstantReactance with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | AsynchronousMachine | 1..1 | AsynchronousMachine | inherited from: AsynchronousMachineDynamics |

#### 8.2.4.3.5.4 AsynchronousMachineEquivalentCircuit

The electrical equations of all variations of the asynchronous model are based on the AsynchronousEquivalentCircuit diagram for the direct- and quadrature-axes, with two equivalent rotor windings in each axis.

Equations for conversion between equivalent circuit and time constant reactance forms:

Xs = Xm + Xl

X' = Xl + Xm x Xlr1 / (Xm + Xlr1)

X'' = Xl + Xm x Xlr1 x Xlr2 / (Xm x Xlr1 + Xm x Xlr2 + Xlr1 x Xlr2)

T'o = (Xm + Xlr1) / (omega0 x Rr1)

T''o = (Xm x Xlr1 + Xm x Xlr2 + Xlr1 x Xlr2) / (omega0 x Rr2 x (Xm + Xlr1)

Same equations using CIM attributes from AsynchronousMachineTimeConstantReactance class on left of "=" and AsynchronousMachineEquivalentCircuit class on right (except as noted):

xs = xm + RotatingMachineDynamics.statorLeakageReactance

xp = RotatingMachineDynamics.statorLeakageReactance + xm x xlr1 / (xm + xlr1)

xpp = RotatingMachineDynamics.statorLeakageReactance + xm x xlr1 x xlr2 / (xm x xlr1 + xm x xlr2 + xlr1 x xlr2)

tpo = (xm + xlr1) / (2 x pi x nominal frequency x rr1)

tppo = (xm x xlr1 + xm x xlr2 + xlr1 x xlr2) / (2 x pi x nominal frequency x rr2 x (xm + xlr1).

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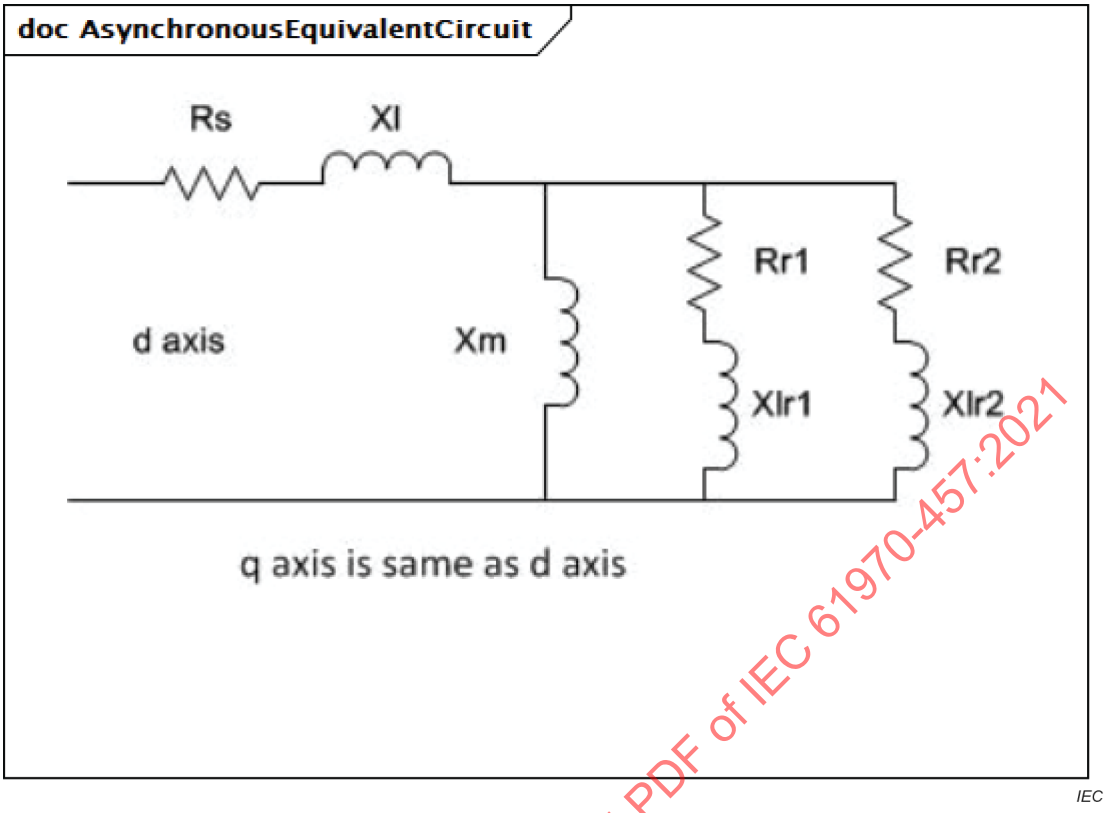


**Figure 48 – AsynchronousEquivalentCircuit**

Figure 48: In each axis, the branches represent the stator leakage reactance (Xl) and resistance (Rs), the magnetizing reactance (Xm), and the resistance and leakage reactance of equivalent windings (Rr1, Xlr1, etc.) on the rotor.

Table 70 shows all attributes of AsynchronousMachineEquivalentCircuit.

**Table 70 – Attributes of AsynchronousMachineDynamics:: AsynchronousMachineEquivalentCircuit**

| name | mult | type | description |
|---|---|---|---|
| xm | 1..1 | PU | Magnetizing reactance. |
| rr1 | 1..1 | PU | Damper 1 winding resistance. |
| xlr1 | 1..1 | PU | Damper 1 winding leakage reactance. |
| rr2 | 1..1 | PU | Damper 2 winding resistance. |
| xlr2 | 1..1 | PU | Damper 2 winding leakage reactance. |
| damping | 1..1 | Float | inherited from: RotatingMachineDynamics |
| inertia | 1..1 | Seconds | inherited from: RotatingMachineDynamics |
| saturationFactor | 0..1 | Float | inherited from: RotatingMachineDynamics |
| saturationFactor120 | 0..1 | Float | inherited from: RotatingMachineDynamics |
| statorLeakageReactance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| statorResistance | 1..1 | PU | inherited from: RotatingMachineDynamics |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 71 shows all association ends of AsynchronousMachineEquivalentCircuit with other classes.

**Table 71 – Association ends of AsynchronousMachineDynamics:: AsynchronousMachineEquivalentCircuit with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | AsynchronousMachine | 1..1 | AsynchronousMachine | inherited from: AsynchronousMachineDynamics |

#### 8.2.4.3.6 Package TurbineGovernorDynamics

##### 8.2.4.3.6.1 General

The turbine-governor model is linked to one or two synchronous generators and determines the shaft mechanical power (Pm) or torque (Tm) for the generator model.

Unlike IEEE standard models for other function blocks, the three IEEE turbine-governor standard models (GovHydroIEEE0, GovHydroIEEE2, and GovSteamIEEE1) are documented in IEEE Transactions, not in IEEE standards. For that reason, diagrams are supplied for those models.

A 2012 IEEE report, Dynamic Models for Turbine-Governors in Power System Studies, provides updated information on a variety of models including IEEE, vendor and reliability authority models. Fully incorporating the results of that report into the CIM dynamics model is a future effort.

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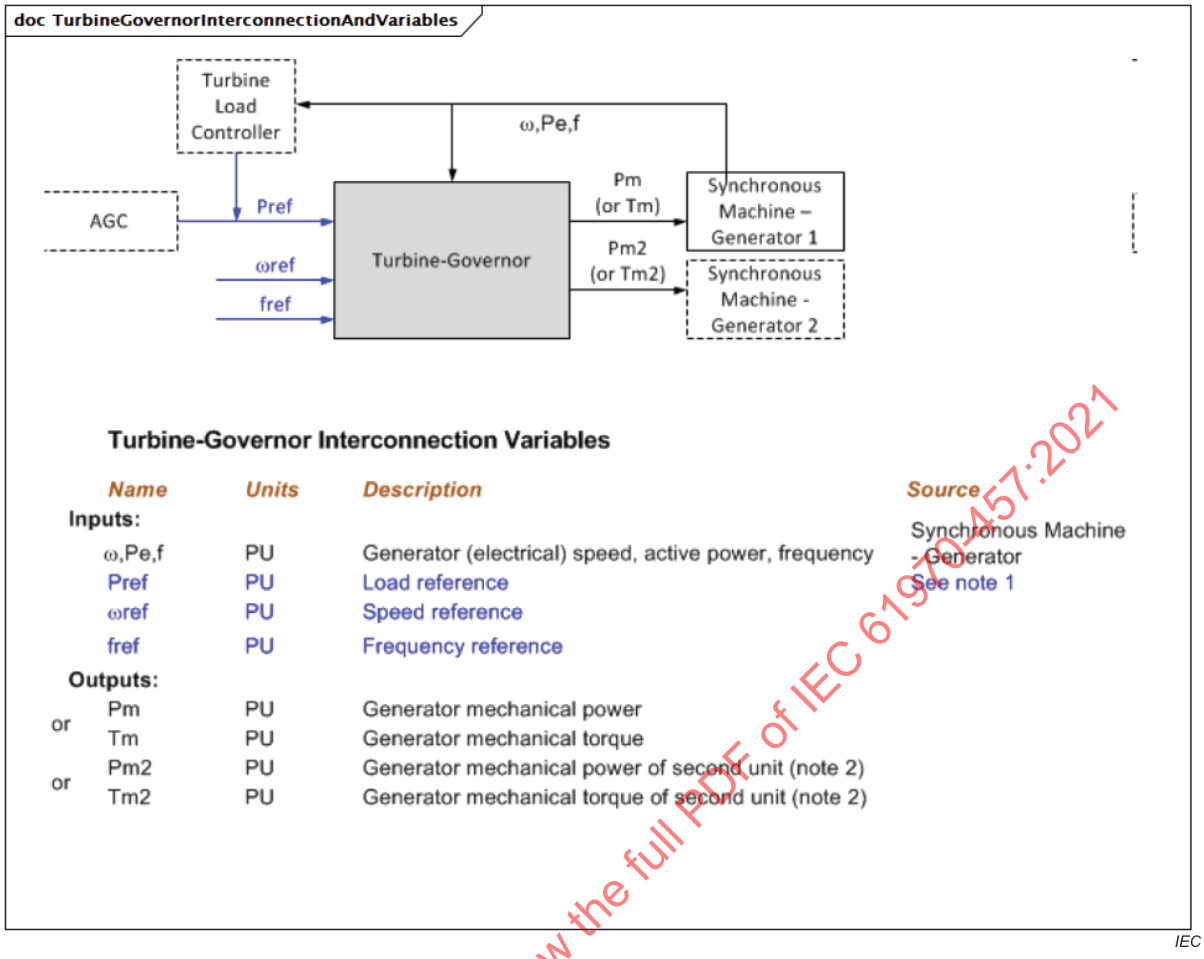


**Figure 49 – TurbineGovernorInterconnectionAndVariables**

Figure 49: This diagram illustrates the inputs and outputs for a turbine-governor. Some turbine-governor models are used in cross-compound interconnections, e.g. GovSteam1, where they are connected to two generators (synchronous machines).

Diagram details:

1) Pref is usually held constant for stability analysis, but can be determined by a user-defined model or, for long-term dynamics, an area-wide automatic generation control (AGC) model. For some models, Pref has units of PU speed instead of PU power.
2) The vast majority of turbine-governor models have MWbase as a parameter. This parameter corresponds to GeneratingUnit.ratedGrossMaxP from the Production package, but is specified explicitly in the Dynamics package to support use of a different value by transient analysis tools, if needed.

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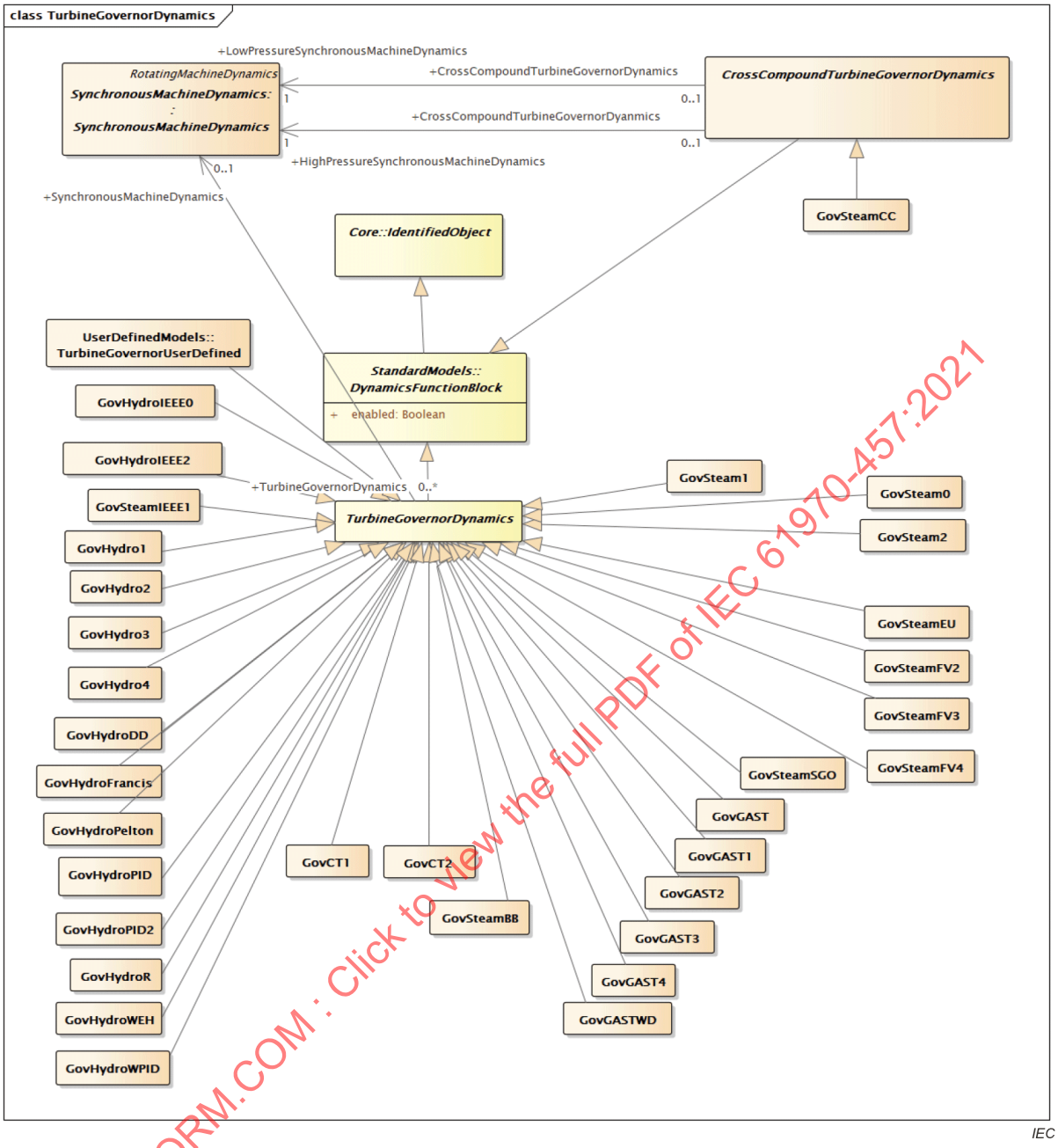


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**Figure 50 – Class diagram TurbineGovernorDynamics::TurbineGovernorDynamics**

Figure 50: This diagram shows dynamic standard model turbine-governor classes and their inheritance from the TurbineGovernorDynamics class.

#### 8.2.4.3.6.2 (abstract) CrossCompoundTurbineGovernorDynamics

Turbine-governor cross-compound function block whose behaviour is described by reference to a standard model or by definition of a user-defined model.

Table 72 shows all attributes of CrossCompoundTurbineGovernorDynamics.

**Table 72 – Attributes of TurbineGovernorDynamics:: CrossCompoundTurbineGovernorDynamics**

| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 73 shows all association ends of CrossCompoundTurbineGovernorDynamics with other classes.

**Table 73 – Association ends of TurbineGovernorDynamics:: CrossCompoundTurbineGovernorDynamics with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | HighPressureSynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | High-pressure synchronous machine with which this cross-compound turbine governor is associated. |
| 0..1 | LowPressureSynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | Low-pressure synchronous machine with which this cross-compound turbine governor is associated. |

#### 8.2.4.3.6.3 (abstract) TurbineGovernorDynamics

Turbine-governor function block whose behaviour is described by reference to a standard model or by definition of a user-defined model.

Table 74 shows all attributes of TurbineGovernorDynamics.

**Table 74 – Attributes of TurbineGovernorDynamics::TurbineGovernorDynamics**

| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 75 shows all association ends of TurbineGovernorDynamics with other classes.

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**Table 75 – Association ends of TurbineGovernorDynamics:: TurbineGovernorDynamics with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | Synchronous machine model with which this turbine-governor model is associated. TurbineGovernorDynamics shall have either an association to SynchronousMachineDynamics or to AsynchronousMachineDynamics. |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | Asynchronous machine model with which this turbine-governor model is associated. TurbineGovernorDynamics shall have either an association to SynchronousMachineDynamics or to AsynchronousMachineDynamics. |

#### 8.2.4.3.6.4 GovHydroIEEE0

IEEE simplified hydro governor-turbine model. Used for mechanical-hydraulic and electro-hydraulic turbine governors, with or without steam feedback. Typical values given are for mechanical-hydraulic turbine-governor.

Reference: IEEE Transactions on Power Apparatus and Systems, November/December 1973, Volume PAS-92, Number 6, Dynamic Models for Steam and Hydro Turbines in Power System Studies, page 1904.

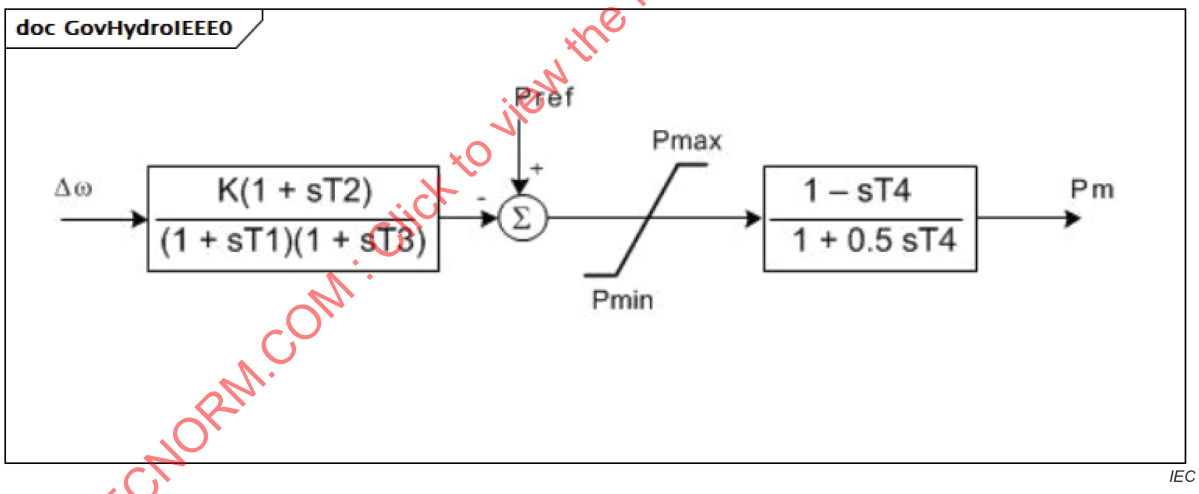


**Figure 51 – GovHydroIEEE0**

Figure 51: This diagram describes the CIM model interpretation of the IEEE simplified hydro governor-turbine model.

Table 76 shows all attributes of GovHydroIEEE0.

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**Table 76 – Attributes of TurbineGovernorDynamics::GovHydroIEEE0**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| k | 1..1 | PU | Governor gain (K). |
| t1 | 1..1 | Seconds | Governor lag time constant (T1) (>= 0). Typical value = 0,25. |
| t2 | 1..1 | Seconds | Governor lead time constant (T2) (>= 0). Typical value = 0. |
| t3 | 1..1 | Seconds | Gate actuator time constant (T3) (>= 0). Typical value = 0,1. |
| t4 | 1..1 | Seconds | Water starting time (T4) (>= 0). |
| pmax | 1..1 | PU | Gate maximum (Pmax) (> GovHydroIEEE0.pmin). |
| pmin | 1..1 | PU | Gate minimum (Pmin) (< GovHydroIEEE.pmax). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 77 shows all association ends of GovHydroIEEE0 with other classes.

**Table 77 – Association ends of TurbineGovernorDynamics:: GovHydroIEEE0 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.5 GovHydroIEEE2

IEEE hydro turbine governor model represents plants with straightforward penstock configurations and hydraulic-dashpot governors.

Reference: IEEE Transactions on Power Apparatus and Systems, November/December 1973, Volume PAS-92, Number 6, Dynamic Models for Steam and Hydro Turbines in Power System Studies, page 1904.

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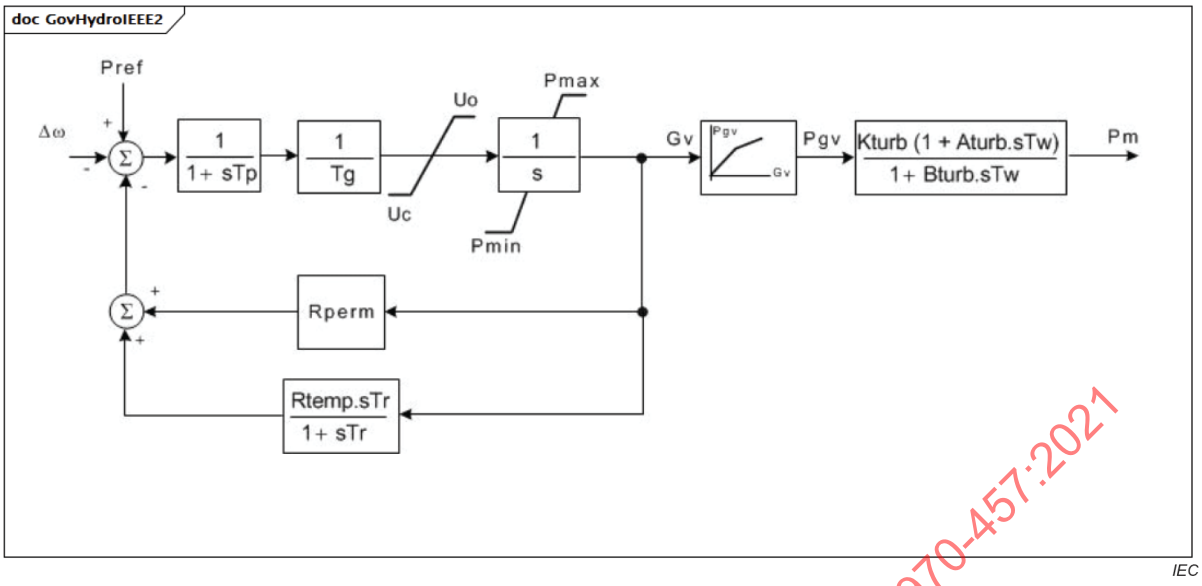


**Figure 52 – GovHydroIEEE2**

Figure 52: This diagram describes the CIM model interpretation of the IEEE hydro turbine governor model representing plants with straightforward penstock configurations and hydraulic-dashpot governors.

Parameter details:

1) PU parameters are on base of MWbase, which is normally the MW capability of the turbine.
2) This turbine governor model is a reasonable approximation to the performance of simple hydro plants for small motions of the gates about a given load, but it represents the variation of water inertia effect with load only if the values of the turbine parameters are properly adjusted by the user as load is varied. For idealized turbine model, set Kturb = 1, Aturb = -1, Bturb = 0,5.
3) The nonlinear gain between gate position and power can be input with up to 6 points. The (0,0, 0,0) and (1,0, 1,0) points can be assumed. The output is not allowed to go beyond 0,0 and 1,0. However, if Pmax > 1,0, the input and output are scaled by Pmax. If Gv1 is a negative number or zero values, the default hydro curve (between 0,0, 0,0 and 1,0, 1,0) will be used.

Table 78 shows all attributes of GovHydroIEEE2.

**Table 78 – Attributes of TurbineGovernorDynamics::GovHydroIEEE2**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| tg | 1..1 | Seconds | Gate servo time constant (Tg) (>= 0). Typical value = 0,5. |
| tp | 1..1 | Seconds | Pilot servo valve time constant (Tp) (>= 0). Typical value = 0,03. |
| uo | 1..1 | Float | Maximum gate opening velocity (Uo). Unit = PU / s. Typical value = 0,1. |
| uc | 1..1 | Float | Maximum gate closing velocity (Uc) (<0). Typical value = -0,1. |
| pmax | 1..1 | PU | Maximum gate opening (Pmax) (> GovHydroIEEE2.pmin). Typical value = 1. |

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| name | mult | type | description |
|---|---|---|---|
| pmin | 1..1 | PU | Minimum gate opening (Pmin) (<GovHydroIEEE2.pmax). Typical value = 0. |
| rperm | 1..1 | PU | Permanent droop (Rperm). Typical value = 0,05. |
| rtemp | 1..1 | PU | Temporary droop (Rtemp). Typical value = 0,5. |
| tr | 1..1 | Seconds | Dashpot time constant (Tr) (>= 0). Typical value = 12. |
| tw | 1..1 | Seconds | Water inertia time constant (Tw) (>= 0). Typical value = 2. |
| kturb | 1..1 | PU | Turbine gain (Kturb). Typical value = 1. |
| aturb | 1..1 | PU | Turbine numerator multiplier (Aturb). Typical value = -1. |
| bturb | 1..1 | PU | Turbine denominator multiplier (Bturb) (> 0). Typical value = 0,5. |
| gv1 | 1..1 | PU | Nonlinear gain point 1, PU gv (Gv1). Typical value = 0. |
| pgv1 | 1..1 | PU | Nonlinear gain point 1, PU power (Pgv1). Typical value = 0. |
| gv2 | 1..1 | PU | Nonlinear gain point 2, PU gv (Gv2). Typical value = 0. |
| pgv2 | 1..1 | PU | Nonlinear gain point 2, PU power (Pgv2). Typical value = 0. |
| gv3 | 1..1 | PU | Nonlinear gain point 3, PU gv (Gv3). Typical value = 0. |
| pgv3 | 1..1 | PU | Nonlinear gain point 3, PU power (Pgv3). Typical value = 0. |
| gv4 | 1..1 | PU | Nonlinear gain point 4, PU gv (Gv4). Typical value = 0. |
| pgv4 | 1..1 | PU | Nonlinear gain point 4, PU power (Pgv4). Typical value = 0. |
| gv5 | 1..1 | PU | Nonlinear gain point 5, PU gv (Gv5). Typical value = 0. |
| pgv5 | 1..1 | PU | Nonlinear gain point 5, PU power (Pgv5). Typical value = 0. |
| gv6 | 1..1 | PU | Nonlinear gain point 6, PU gv (Gv6). Typical value = 0. |
| pgv6 | 1..1 | PU | Nonlinear gain point 6, PU power (Pgv6). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 79 shows all association ends of GovHydroIEEE2 with other classes.

**Table 79 – Association ends of TurbineGovernorDynamics:: GovHydroIEEE2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.6 GovSteamIEEE1

IEEE steam turbine governor model.

Reference: IEEE Transactions on Power Apparatus and Systems, November/December 1973, Volume PAS-92, Number 6, Dynamic Models for Steam and Hydro Turbines in Power System Studies, page 1904.

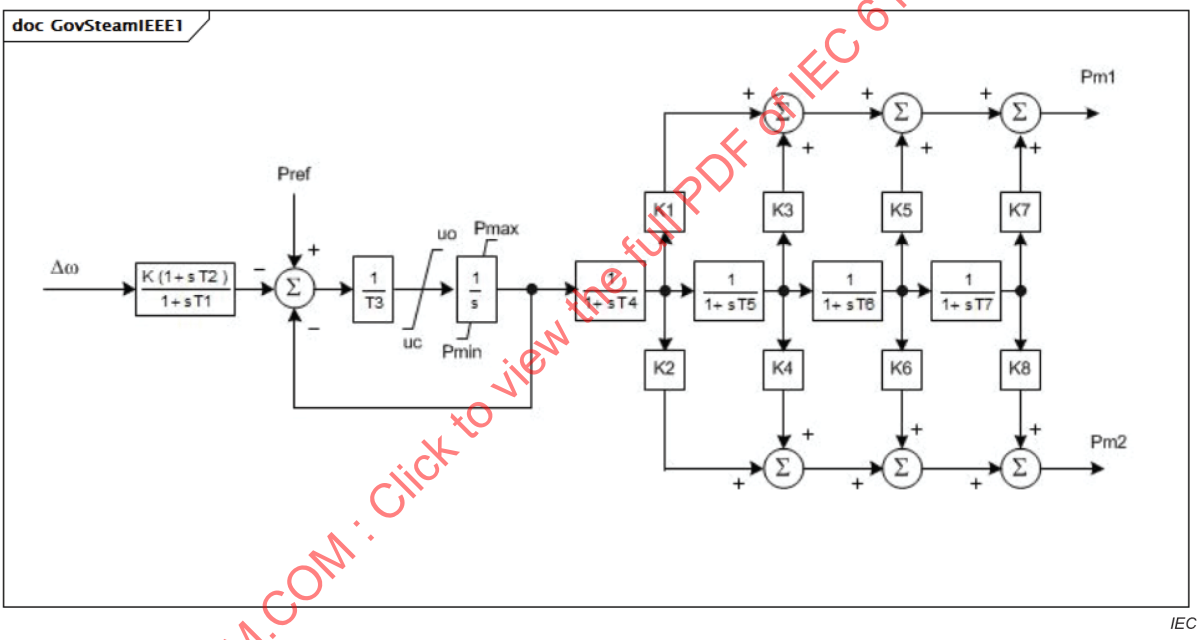


**Figure 53 – GovSteamIEEE1**

Figure 53: This diagram describes the CIM model interpretation of the IEEE steam turbine governor model.

Parameter details:

1) PU parameters are on base of MWbase, which is normally the MW capability of the turbine.
2) For a tandem-compound turbine the parameters K2, K4, K6, and K8 are ignored. For a cross-compound turbine, two generators are connected to this turbine-governor model.
3) Each generator shall be represented in the load flow by data on its own MVA base. The values of K1, K3, K5, and K7 shall be specified to describe the proportionate development of power on the first turbine shaft. K2, K4, K6, and K8 shall describe the second turbine shaft. Normally K1 + K3 + K5 + K7 = 1,0 and K2 + K4 + K6 + K8 = 1,0 (if second generator is present).
4) The division of power between the two shafts is in proportion to the values of MVA bases of the two generators. The initial condition load flow should, therefore, have the two generators loaded to the same fraction of each one's MVA base.

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Table 80 shows all attributes of GovSteamIEEE1.

**Table 80 – Attributes of TurbineGovernorDynamics::GovSteamIEEE1**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| k | 1..1 | PU | Governor gain (reciprocal of droop) (K) (> 0). Typical value = 25. |
| t1 | 1..1 | Seconds | Governor lag time constant (T1) (>= 0). Typical value = 0. |
| t2 | 1..1 | Seconds | Governor lead time constant (T2) (>= 0). Typical value = 0. |
| t3 | 1..1 | Seconds | Valve positioner time constant (T3) (> 0). Typical value = 0,1. |
| uo | 1..1 | Float | Maximum valve opening velocity (Uo) (> 0). Unit = PU / s. Typical value = 1. |
| uc | 1..1 | Float | Maximum valve closing velocity (Uc) (< 0). Unit = PU / s. Typical value = -10. |
| pmax | 1..1 | PU | Maximum valve opening (Pmax) (> GovSteamIEEE1.pmin). Typical value = 1. |
| pmin | 1..1 | PU | Minimum valve opening (Pmin) (>= 0 and < GovSteamIEEE1.pmax). Typical value = 0. |
| t4 | 1..1 | Seconds | Inlet piping/steam bowl time constant (T4) (>= 0). Typical value = 0,3. |
| k1 | 1..1 | Float | Fraction of HP shaft power after first boiler pass (K1). Typical value = 0,2. |
| k2 | 1..1 | Float | Fraction of LP shaft power after first boiler pass (K2). Typical value = 0. |
| t5 | 1..1 | Seconds | Time constant of second boiler pass (T5) (>= 0). Typical value = 5. |
| k3 | 1..1 | Float | Fraction of HP shaft power after second boiler pass (K3). Typical value = 0,3. |
| k4 | 1..1 | Float | Fraction of LP shaft power after second boiler pass (K4). Typical value = 0. |
| t6 | 1..1 | Seconds | Time constant of third boiler pass (T6) (>= 0). Typical value = 0,5. |
| k5 | 1..1 | Float | Fraction of HP shaft power after third boiler pass (K5). Typical value = 0,5. |
| k6 | 1..1 | Float | Fraction of LP shaft power after third boiler pass (K6). Typical value = 0. |
| t7 | 1..1 | Seconds | Time constant of fourth boiler pass (T7) (>= 0). Typical value = 0. |
| k7 | 1..1 | Float | Fraction of HP shaft power after fourth boiler pass (K7). Typical value = 0. |
| k8 | 1..1 | Float | Fraction of LP shaft power after fourth boiler pass (K8). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 81 shows all association ends of GovSteamIEEE1 with other classes.

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**Table 81 – Association ends of TurbineGovernorDynamics:: GovSteamIEEE1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.7 GovCT1

General model for any prime mover with a PID governor, used primarily for combustion turbine and combined cycle units.

This model can be used to represent a variety of prime movers controlled by PID governors. It is suitable, for example, for the representation of:

- gas turbine and single shaft combined cycle turbines
- diesel engines with modern electronic or digital governors
- steam turbines where steam is supplied from a large boiler drum or a large header whose pressure is substantially constant over the period under study
- simple hydro turbines in dam configurations where the water column length is short and water inertia effects are minimal.

Additional information on this model is available in the 2012 IEEE report, Dynamic Models for Turbine-Governors in Power System Studies, 3.1.2.3, pages 3-4 (GGOV1).

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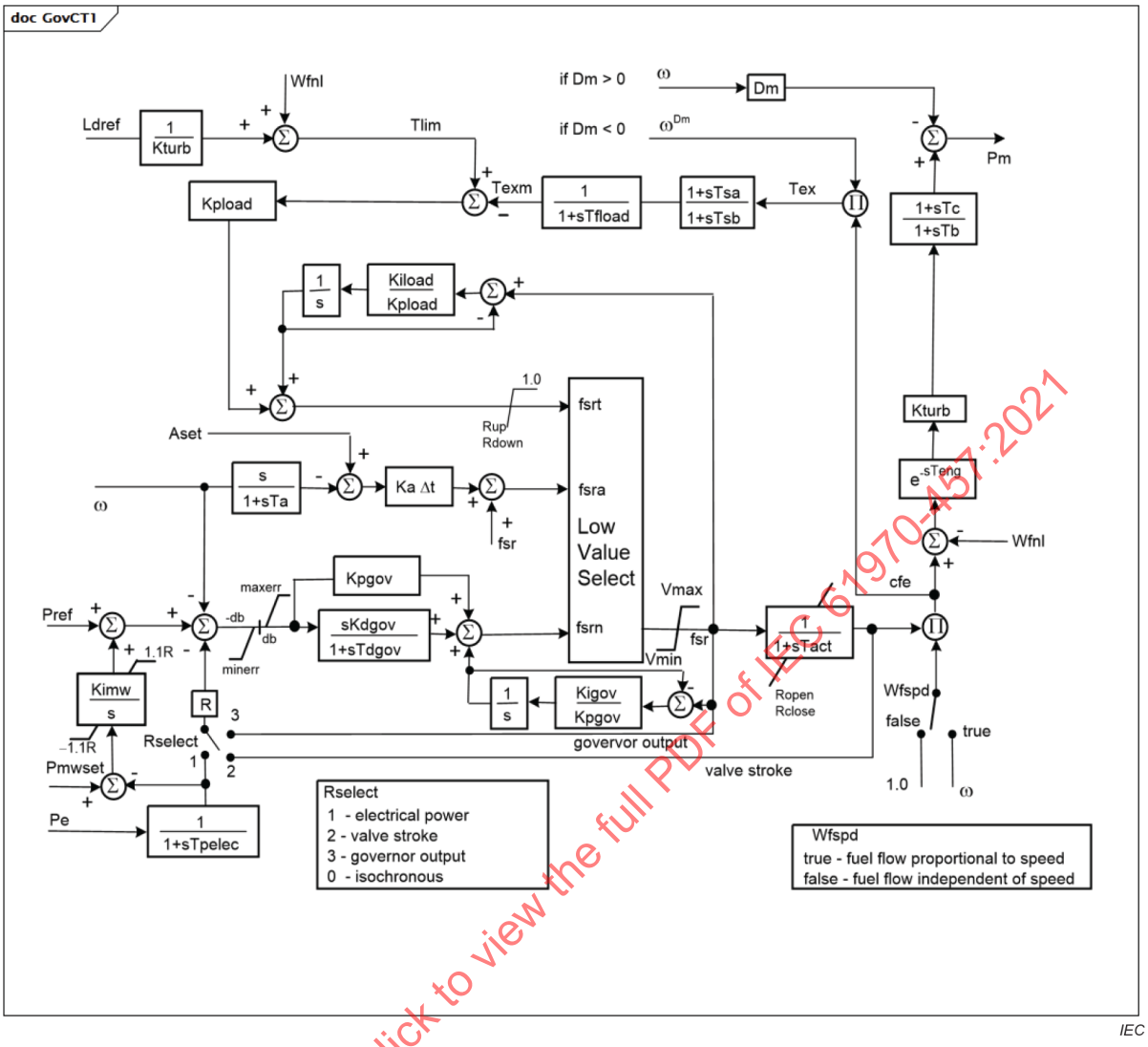


**Figure 54 – GovCT1**

Figure 54: This diagram describes the GovCT1 turbine governor model.

Parameter details:

1) PU parameters are on base of MWbase, which is normally the MW capability of the turbine.
2) The range of fuel valve travel and of fuel flow is unity. Thus the largest possible value of Vmax is 1,0 and the smallest possible value of Vmin is zero. Vmax can, however, be reduced below unity to represent a loading limit imposed by the operator or a supervisory control system. For gas turbines Vmin should normally be greater than zero and less than Wfnl to represent a minimum firing limit. The value of the fuel flow at maximum output shall be less than, or equal to unity, depending on the value of Kturb.
3) The load limiter module can be used to impose a maximum output limit such as an exhaust temperature limit. To do this the time constant Tfload should be set to represent the time constant in the measurement of temperature (or other signal), and the gains of the limiter, Kpload and Kiload, should be set to give prompt stable control when on limit. The load limit can be deactivated by setting the parameter Ldref to a high value.

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4) This model includes a simple representation of a supervisory load controller. This controller is active if the parameter Kimw is non-zero. The load controller is a slow acting reset loop that adjusts the speed/load reference of the turbine governor to hold the electrical power output of the unit at its initial condition value. This value is stored in the parameter Pmwset (which equals Pe, initial generated power) when the model is initialized, and can be changed thereafter. The load controller shall be adjusted to respond gently relative to the speed governor.

5) The parameters Aset, Ka, and Ta describe an acceleration limiter. Ta shall be non-zero, but the acceleration limiter can be disabled by setting Aset to a large value, such as 1.

6) The parameters Tsa and Tsb are provided to augment the exhaust gas temperature measurement subsystem in gas turbines. For example, they can be set to values such as 4,0 and 5,0, to represent the “radiation shield” element of large gas turbines.

7) The parameters Rup and Rdown specify the maximum rate of increase and decrease of the output of the load limit controller (Kpload / Kiload). These parameters should normally be set, or defaulted to 99 / -99, but can be given particular values to represent the temperature limit controls of some General ElectricTM heavy-duty engine controls.

NOTE GE heavy-duty engine controls are an example of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of these products.

8) The fuel flow command fsr is determined by whichever is lowest of fsrt, fsra, and fsrn. Although not explicitly shown in the GovCT1 diagram, the signals that are not in control track fsr so that they do not “windup“ beyond that value. This represents GE gas turbine control practice but might not be true for other controller designs.

9) As shown in the GovCT1 diagram, when Kpgov is non-zero, the governor PI control is implemented to “track“ fsr to prevent windup when fsr is limited by another signal (fsrt, fsra) or Vmax/Vmin. If Kpgov is zero, the integral path is implemented directly. The same applies to the load limiter PI control with regard to Kpload.

10) The parameter delta t in the block diagram is the simulation time step. It is not exchanged with the dataset. In cases where applications are using variable time step the results of the simulations could be different. In such situations the application applies a default value which is 0,001.

Table 82 shows all attributes of GovCT1.

**Table 82 – Attributes of TurbineGovernorDynamics::GovCT1**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| r | 1..1 | PU | Permanent droop (R). Typical value = 0,04. |
| rselect | 1..1 | DroopSignalFeedbackKind | Feedback signal for droop (Rselect). Typical value = electricalPower. |
| tpelec | 1..1 | Seconds | Electrical power transducer time constant (Tpelec) (> 0). Typical value = 1. |
| maxerr | 1..1 | PU | Maximum value for speed error signal (maxerr) (> GovCT1.minerr). Typical value = 0,05. |
| minerr | 1..1 | PU | Minimum value for speed error signal (minerr) (< GovCT1.maxerr). Typical value = -0,05. |
| kpgov | 1..1 | PU | Governor proportional gain (Kpgov). Typical value = 10. |
| kigov | 1..1 | PU | Governor integral gain (Kigov). Typical value = 2. |
| kdgov | 1..1 | PU | Governor derivative gain (Kdgov). Typical value = 0. |
| tdgov | 1..1 | Seconds | Governor derivative controller time constant (Tdgov) (>= 0). Typical value = 1. |

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| name | mult | type | description |
|---|---|---|---|
| vmax | 1..1 | PU | Maximum valve position limit (Vmax) (> GovCT1.vmin). Typical value = 1. |
| vmin | 1..1 | PU | Minimum valve position limit (Vmin) (< GovCT1.vmax). Typical value = 0,15. |
| tact | 1..1 | Seconds | Actuator time constant (Tact) (>= 0). Typical value = 0,5. |
| kturb | 1..1 | PU | Turbine gain (Kturb) (> 0). Typical value = 1,5. |
| wfnl | 1..1 | PU | No load fuel flow (Wfnl). Typical value = 0,2. |
| tb | 1..1 | Seconds | Turbine lag time constant (Tb) (> 0). Typical value = 0,5. |
| tc | 1..1 | Seconds | Turbine lead time constant (Tc) (>= 0). Typical value = 0. |
| wfspd | 1..1 | Boolean | Switch for fuel source characteristic to recognize that fuel flow, for a given fuel valve stroke, can be proportional to engine speed (Wfspd).<br>true = fuel flow proportional to speed (for some gas turbines and diesel engines with positive displacement fuel injectors)<br>false = fuel control system keeps fuel flow independent of engine speed.<br>Typical value = true. |
| teng | 1..1 | Seconds | Transport time delay for diesel engine used in representing diesel engines where there is a small but measurable transport delay between a change in fuel flow setting and the development of torque (Teng) (>= 0). Teng should be zero in all but special cases where this transport delay is of particular concern. Typical value = 0. |
| tfload | 1..1 | Seconds | Load-limiter time constant (Tfload) (> 0). Typical value = 3. |
| kpload | 1..1 | PU | Load limiter proportional gain for PI controller (Kpload). Typical value = 2. |
| kiload | 1..1 | PU | Load limiter integral gain for PI controller (Kiload). Typical value = 0,67. |
| ldref | 1..1 | PU | Load limiter reference value (Ldref). Typical value = 1. |
| dm | 1..1 | PU | Speed sensitivity coefficient (Dm). Dm can represent either the variation of the engine power with the shaft speed or the variation of maximum power capability with shaft speed. If it is positive it describes the falling slope of the engine speed verses power characteristic as speed increases. A slightly falling characteristic is typical for reciprocating engines and some aero-derivative turbines. If it is negative the engine power is assumed to be unaffected by the shaft speed, but the maximum permissible fuel flow is taken to fall with falling shaft speed. This is characteristic of single-shaft industrial turbines due to exhaust temperature limits. Typical value = 0. |
| ropen | 1..1 | Float | Maximum valve opening rate (Ropen). Unit = PU / s. Typical value = 0.10. |
| rclose | 1..1 | Float | Minimum valve closing rate (Rclose). Unit = PU / s. Typical value = -0,1. |
| kimw | 1..1 | PU | Power controller (reset) gain (Kimw). The default value of 0,01 corresponds to a reset time of 100 s. A value of 0,001 corresponds |

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| name | mult | type | description |
|---|---|---|---|
| | | | to a relatively slow-acting load controller. Typical value = 0,01. |
| aset | 1..1 | Float | Acceleration limiter setpoint (Aset). Unit = PU / s. Typical value = 0,01. |
| ka | 1..1 | PU | Acceleration limiter gain (Ka). Typical value = 10. |
| ta | 1..1 | Seconds | Acceleration limiter time constant (Ta) (> 0). Typical value = 0,1. |
| db | 1..1 | PU | Speed governor deadband in PU speed (db). In the majority of applications, it is recommended that this value be set to zero. Typical value = 0. |
| tsa | 1..1 | Seconds | Temperature detection lead time constant (Tsa) (>= 0). Typical value = 4. |
| tsb | 1..1 | Seconds | Temperature detection lag time constant (Tsb) (>= 0). Typical value = 5. |
| rup | 1..1 | PU | Maximum rate of load limit increase (Rup). Typical value = 99. |
| rdown | 1..1 | PU | Maximum rate of load limit decrease (Rdown). Typical value = -99. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 83 shows all association ends of GovCT1 with other classes.

**Table 83 – Association ends of TurbineGovernorDynamics::GovCT1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.8 GovCT2

General governor with frequency-dependent fuel flow limit. This model is a modification of the GovCT1 model in order to represent the frequency-dependent fuel flow limit of a specific gas turbine manufacturer.

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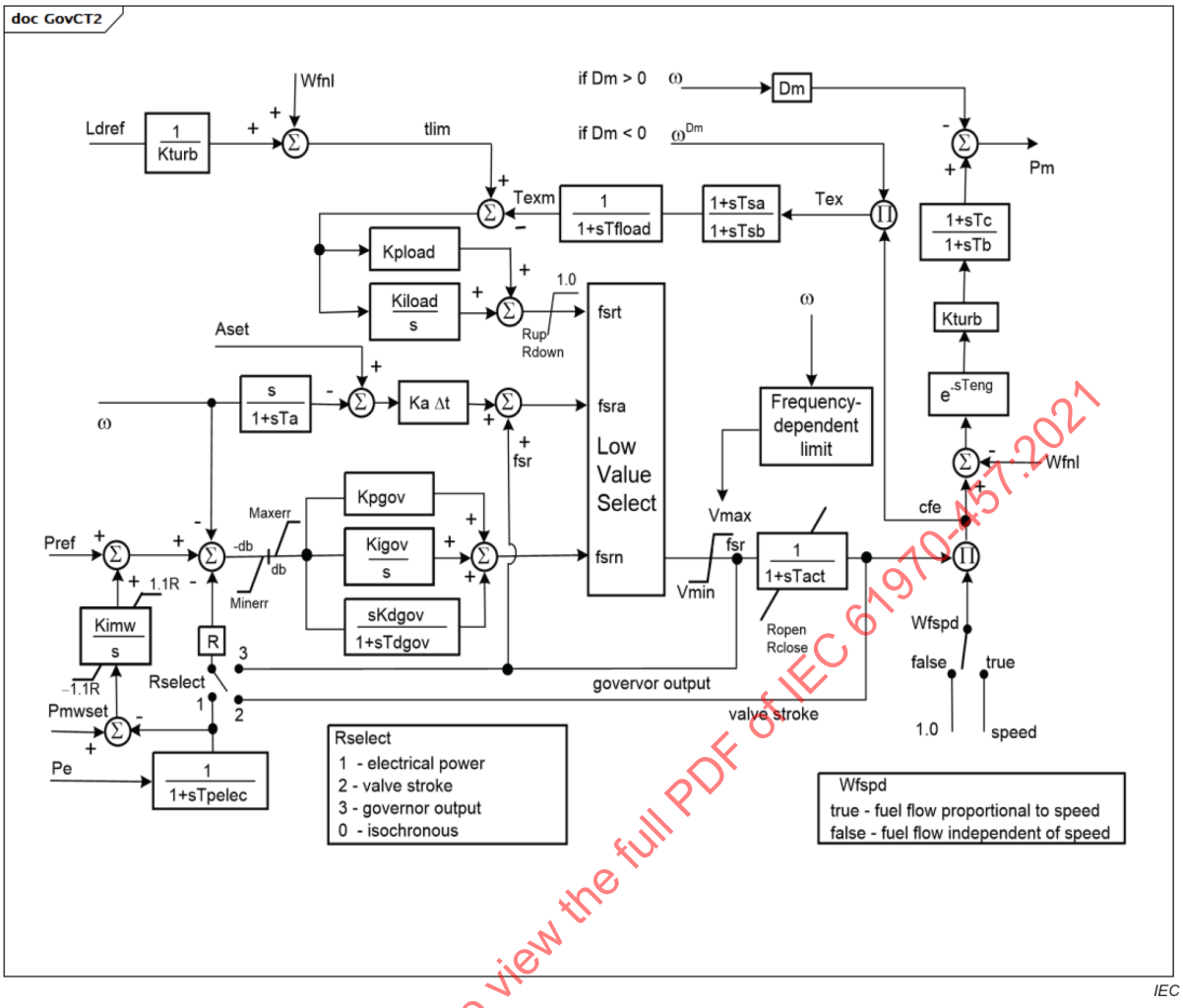


**Figure 55 – GovCT2**

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Figure 55: This diagram describes the GovCT2 turbine governor model.

Parameter Details:

1) The frequency-dependent limit reduces the Vmax limit on fuel flow signal (fsr). For normal operation, the limiter performs no action. When frequency (generator speed) drops below Flim1, the highest frequency data point, the desired value for the power limit (Plim) is determined by linear interpolation between associated data pairs. The maximum value of the limiter (Vmax) will ramp to the fsr value corresponding to Plim (Plim / Kturb + Wfnl) at the Prate ramp rate. Plim will be updated as the frequency changes. If the frequency subsequently rises back above Flim1, the value of the limit will ramp up at the rate Prate back to the normal value of Vmax.

2) The frequency-dependent limit is defined by a set of up to 10 pairs of points relating frequency (generator speed in Hz) and power. The points shall be monotonically decreasing in both the magnitude of frequency and power. If fewer than 10 points are needed to define the relationship, values of zero shall be entered for the remaining frequencies and power limits. The value of the last non-zero data pair is used as a lower limit, that is, the last two values are not extrapolated to calculate lower power limits. If there is only one set of frequency and power limits, those values will be used as a single limit of power applied at that frequency and below.

3) Refer to the GovCT1 model for other parameter details. Aside from the frequency-dependent limit, GovCT2 is identical to GovCT1, except that the temperature fuel command fsrt does not track fsr when it is not in control. Instead, it stays at its upper limit (1).

4) The Kpgov/Kigov and Kpload/Kiload controllers include tracking logic to ensure smooth transfer between active controllers. This logic is not shown on the GovCT2 diagram.

5) Pmwset equals Pe, initial generated power.

6) The parameter delta t in the block diagram is the simulation time step. It is not exchanged with the dataset. In cases where applications are using variable time step the results of the simulations could be different. In such situations the application applies a default value which is 0,001.

Table 84 shows all attributes of GovCT2.

**Table 84 – Attributes of TurbineGovernorDynamics::GovCT2**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| r | 1..1 | PU | Permanent droop (R). Typical value = 0,05. |
| rselect | 1..1 | DroopSignalFeedbackKind | Feedback signal for droop (Rselect). Typical value = electricalPower. |
| tpelec | 1..1 | Seconds | Electrical power transducer time constant (Tpelec) (>= 0). Typical value = 2,5. |
| maxerr | 1..1 | PU | Maximum value for speed error signal (Maxerr) (> GovCT2.minerr). Typical value = 1. |
| minerr | 1..1 | PU | Minimum value for speed error signal (Minerr) (< GovCT2.maxerr). Typical value = -1. |
| kpgov | 1..1 | PU | Governor proportional gain (Kpgov). Typical value = 4. |
| kigov | 1..1 | PU | Governor integral gain (Kigov). Typical value = 0,45. |
| kdgov | 1..1 | PU | Governor derivative gain (Kdgov). Typical value = 0. |
| tdgov | 1..1 | Seconds | Governor derivative controller time constant (Tdgov) (>= 0). Typical value = 1. |
| vmax | 1..1 | PU | Maximum valve position limit (Vmax) (> GovCT2.vmin). Typical value = 1. |
| vmin | 1..1 | PU | Minimum valve position limit (Vmin) (< GovCT2.vmax). Typical value = 0,175. |
| tact | 1..1 | Seconds | Actuator time constant (Tact) (>= 0). Typical value = 0,4. |
| kturb | 1..1 | PU | Turbine gain (Kturb). Typical value = 1,9168. |
| wfnl | 1..1 | PU | No load fuel flow (Wfnl). Typical value = 0,187. |
| tb | 1..1 | Seconds | Turbine lag time constant (Tb) (>= 0). Typical value = 0,1. |
| tc | 1..1 | Seconds | Turbine lead time constant (Tc) (>= 0). Typical value = 0. |
| wfspd | 1..1 | Boolean | Switch for fuel source characteristic to recognize that fuel flow, for a given fuel valve stroke, can be proportional to engine speed (Wfspd).<br>true = fuel flow proportional to speed (for some gas turbines and diesel engines with positive displacement fuel injectors)<br>false = fuel control system keeps fuel flow independent of engine speed.<br>Typical value = false. |

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| name | mult | type | description |
|---|---|---|---|
| teng | 1..1 | Seconds | Transport time delay for diesel engine used in representing diesel engines where there is a small but measurable transport delay between a change in fuel flow setting and the development of torque (Teng) (>= 0). Teng should be zero in all but special cases where this transport delay is of particular concern. Typical value = 0. |
| tfload | 1..1 | Seconds | Load limiter time constant (Tfload) (>= 0). Typical value = 3. |
| kpload | 1..1 | PU | Load limiter proportional gain for PI controller (Kpload). Typical value = 1. |
| kiload | 1..1 | PU | Load limiter integral gain for PI controller (Kiload). Typical value = 1. |
| ldref | 1..1 | PU | Load limiter reference value (Ldref). Typical value = 1. |
| dm | 1..1 | PU | Speed sensitivity coefficient (Dm). Dm can represent either the variation of the engine power with the shaft speed or the variation of maximum power capability with shaft speed. If it is positive it describes the falling slope of the engine speed verses power characteristic as speed increases. A slightly falling characteristic is typical for reciprocating engines and some aero-derivative turbines. If it is negative the engine power is assumed to be unaffected by the shaft speed, but the maximum permissible fuel flow is taken to fall with falling shaft speed. This is characteristic of single-shaft industrial turbines due to exhaust temperature limits. Typical value = 0. |
| ropen | 1..1 | Float | Maximum valve opening rate (Ropen). Unit = PU / s. Typical value = 99. |
| rclose | 1..1 | Float | Minimum valve closing rate (Rclose). Unit = PU / s. Typical value = -99. |
| kimw | 1..1 | PU | Power controller (reset) gain (Kimw). The default value of 0,01 corresponds to a reset time of 100 seconds. A value of 0,001 corresponds to a relatively slow-acting load controller. Typical value = 0. |
| aset | 1..1 | Float | Acceleration limiter setpoint (Aset). Unit = PU / s. Typical value = 10. |
| ka | 1..1 | PU | Acceleration limiter gain (Ka). Typical value = 10. |
| ta | 1..1 | Seconds | Acceleration limiter time constant (Ta) (>= 0). Typical value = 1. |
| db | 1..1 | PU | Speed governor deadband in PU speed (db). In the majority of applications, it is recommended that this value be set to zero. Typical value = 0. |
| tsa | 1..1 | Seconds | Temperature detection lead time constant (Tsa) (>= 0). Typical value = 0. |
| tsb | 1..1 | Seconds | Temperature detection lag time constant (Tsb) (>= 0). Typical value = 50. |
| rup | 1..1 | PU | Maximum rate of load limit increase (Rup). Typical value = 99. |
| rdown | 1..1 | PU | Maximum rate of load limit decrease (Rdown). Typical value = -99. |
| prate | 1..1 | PU | Ramp rate for frequency-dependent power limit (Prate). Typical value = 0,017. |
| flim1 | 1..1 | Frequency | Frequency threshold 1 (Flim1). Unit = Hz. Typical value = 59. |
| plim1 | 1..1 | PU | Power limit 1 (Plim1). Typical value = 0,8 325. |

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| name | mult | type | description |
|---|---|---|---|
| flim2 | 1..1 | Frequency | Frequency threshold 2 (Flim2). Unit = Hz. Typical value = 0. |
| plim2 | 1..1 | PU | Power limit 2 (Plim2). Typical value = 0. |
| flim3 | 1..1 | Frequency | Frequency threshold 3 (Flim3). Unit = Hz. Typical value = 0. |
| plim3 | 1..1 | PU | Power limit 3 (Plim3). Typical value = 0. |
| flim4 | 1..1 | Frequency | Frequency threshold 4 (Flim4). Unit = Hz. Typical value = 0. |
| plim4 | 1..1 | PU | Power limit 4 (Plim4). Typical value = 0. |
| flim5 | 1..1 | Frequency | Frequency threshold 5 (Flim5). Unit = Hz. Typical value = 0. |
| plim5 | 1..1 | PU | Power limit 5 (Plim5). Typical value = 0. |
| flim6 | 1..1 | Frequency | Frequency threshold 6 (Flim6). Unit = Hz. Typical value = 0. |
| plim6 | 1..1 | PU | Power limit 6 (Plim6). Typical value = 0. |
| flim7 | 1..1 | Frequency | Frequency threshold 7 (Flim7). Unit = Hz. Typical value = 0. |
| plim7 | 1..1 | PU | Power limit 7 (Plim7). Typical value = 0. |
| flim8 | 1..1 | Frequency | Frequency threshold 8 (Flim8). Unit = Hz. Typical value = 0. |
| plim8 | 1..1 | PU | Power limit 8 (Plim8). Typical value = 0. |
| flim9 | 1..1 | Frequency | Frequency threshold 9 (Flim9). Unit = Hz. Typical value = 0. |
| plim9 | 1..1 | PU | Power Limit 9 (Plim9). Typical value = 0. |
| flim10 | 1..1 | Frequency | Frequency threshold 10 (Flim10). Unit = Hz. Typical value = 0. |
| plim10 | 1..1 | PU | Power limit 10 (Plim10). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 85 shows all association ends of GovCT2 with other classes.

**Table 85 – Association ends of TurbineGovernorDynamics::GovCT2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.9 GovGAST

Single shaft gas turbine.

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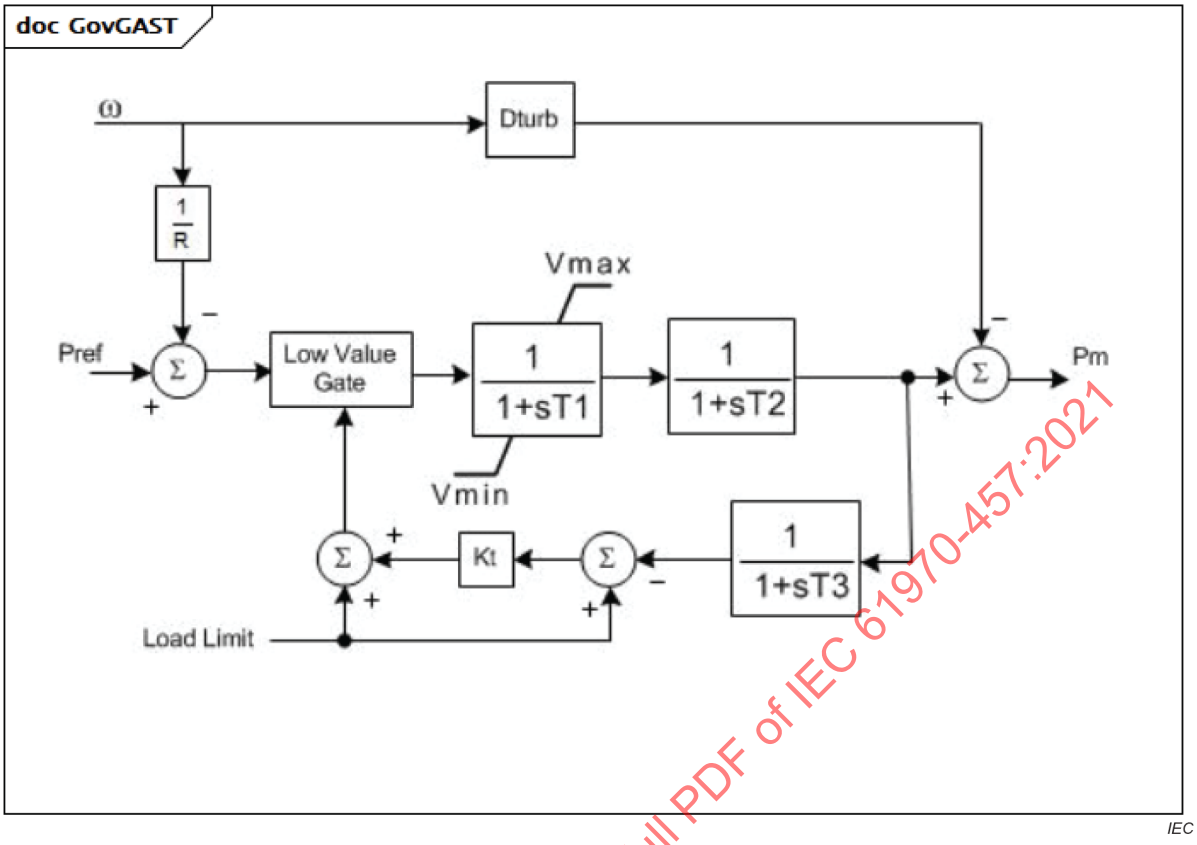


**Figure 56 – GovGAST**

Figure 56: This diagram describes the GovGAST turbine governor model.

Table 86 shows all attributes of GovGAST.

**Table 86 – Attributes of TurbineGovernorDynamics::GovGAST**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| r | 1..1 | PU | Permanent droop (R) (>0). Typical value = 0,04. |
| t1 | 1..1 | Seconds | Governor mechanism time constant (T1) (>= 0). T1 represents the natural valve positioning time constant of the governor for small disturbances, as seen when rate limiting is not in effect. Typical value = 0,5. |
| t2 | 1..1 | Seconds | Turbine power time constant (T2) (>= 0). T2 represents delay due to internal energy storage of the gas turbine engine. T2 can be used to give a rough approximation to the delay associated with acceleration of the compressor spool of a multi-shaft engine, or with the compressibility of gas in the plenum of a free power turbine of an aero-derivative unit, for example. Typical value = 0,5. |
| t3 | 1..1 | Seconds | Turbine exhaust temperature time constant (T3) (>= 0). Typical value = 3. |
| at | 1..1 | PU | Ambient temperature load limit (Load Limit). Typical value = 1. |
| kt | 1..1 | PU | Temperature limiter gain (Kt). Typical value = 3. |

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| name | mult | type | description |
|---|---|---|---|
| vmax | 1..1 | PU | Maximum turbine power, PU of MWbase (Vmax) (> GovGAST.vmin). Typical value = 1. |
| vmin | 1..1 | PU | Minimum turbine power, PU of MWbase (Vmin) (< GovGAST.vmax). Typical value = 0. |
| dturb | 1..1 | PU | Turbine damping factor (Dturb). Typical value = 0,18. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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

**Table 87 – Association ends of TurbineGovernorDynamics:: GovGAST with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

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### 8.2.4.3.6.10 GovGAST1

Modified single shaft gas turbine.

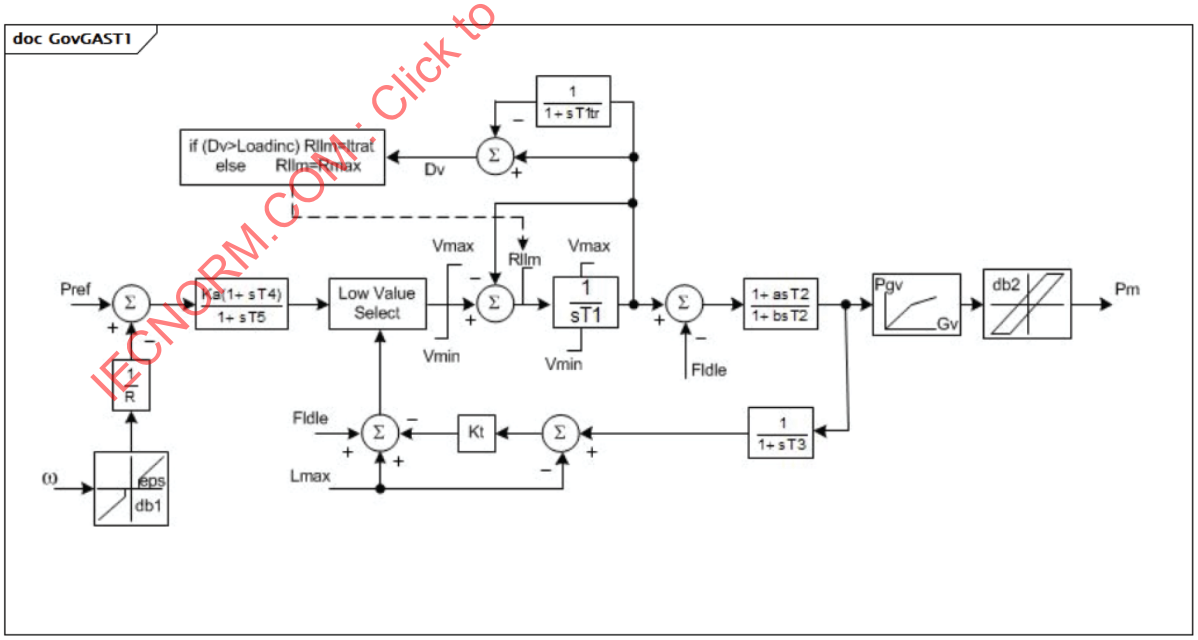


**Figure 57 – GovGAST1**

Figure 57: This diagram describes the GovGAST1 turbine governor model.

Parameter details:

1) Rmax, Linc, Tltr, Ltrate represent a loading rate limit subsystem. For small excursions about a steady load, the fuel valve can open at a rate of Rmax PU / s. The time constant, Tltr, is used to obtain a long term average valve position. When a large output increase is called for, the fuel valve is allowed to open at the full rate only until the valve opening has moved ahead of the long term average position by Linc PU. After this the valve is permitted to open only at the rate, Ltrat, until the long term average position catches up.
2) The nonlinear gain between gate position and power can be input with up to 6 points. The (0,0, 0,0) and (1,0, 1,0) points can be assumed. The output is not allowed to go beyond 0,0 and 1,0. However, if Vmax > 1,0, the input and output are scaled by Vmax. If Gv1 is a negative number or zero values, the default curve (between 0,0, 0,0 and 1,0, 1,0) will be used.

Table 88 shows all attributes of GovGAST1.

**Table 88 – Attributes of TurbineGovernorDynamics::GovGAST1**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| r | 1..1 | PU | Permanent droop (R) (>0). Typical value = 0,04. |
| t1 | 1..1 | Seconds | Governor mechanism time constant (T1) (>= 0). T1 represents the natural valve positioning time constant of the governor for small disturbances, as seen when rate limiting is not in effect. Typical value = 0,5. |
| t2 | 1..1 | Seconds | Turbine power time constant (T2) (>= 0). T2 represents delay due to internal energy storage of the gas turbine engine. T2 can be used to give a rough approximation to the delay associated with acceleration of the compressor spool of a multi-shaft engine, or with the compressibility of gas in the plenum of the free power turbine of an aero-derivative unit, for example. Typical value = 0,5. |
| t3 | 1..1 | Seconds | Turbine exhaust temperature time constant (T3) (>= 0). T3 represents delay in the exhaust temperature and load limiting system. Typical value = 3. |
| lmax | 1..1 | PU | Ambient temperature load limit (Lmax). Lmax is the turbine power output corresponding to the limiting exhaust gas temperature. Typical value = 1. |
| kt | 1..1 | PU | Temperature limiter gain (Kt). Typical value = 3. |
| vmax | 1..1 | PU | Maximum turbine power, PU of MWbase (Vmax) (> GovGAST1.vmin). Typical value = 1. |
| vmin | 1..1 | PU | Minimum turbine power, PU of MWbase (Vmin) (< GovGAST1.vmax). Typical value = 0. |
| fidle | 1..1 | PU | Fuel flow at zero power output (Fidle). Typical value = 0,18. |
| rmax | 1..1 | Float | Maximum fuel valve opening rate (Rmax). Unit = PU / s. Typical value = 1. |
| loadinc | 1..1 | PU | Valve position change allowed at fast rate (Loadinc). Typical value = 0,05. |
| tltr | 1..1 | Seconds | Valve position averaging time constant (Tltr) (>= 0). Typical value = 10. |
| ltrate | 1..1 | Float | Maximum long term fuel valve opening rate (Ltrate). Typical value = 0,02. |
| a | 1..1 | Float | Turbine power time constant numerator scale factor (a). Typical value = 0,8. |

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| name | mult | type | description |
|---|---|---|---|
| b | 1..1 | Float | Turbine power time constant denominator scale factor (b) (>0). Typical value = 1. |
| db1 | 1..1 | Frequency | Intentional dead-band width (db1). Unit = Hz. Typical value = 0. |
| eps | 1..1 | Frequency | Intentional db hysteresis (eps). Unit = Hz. Typical value = 0. |
| db2 | 1..1 | ActivePower | Unintentional dead-band (db2). Unit = MW. Typical value = 0. |
| gv1 | 1..1 | PU | Nonlinear gain point 1, PU gv (Gv1). Typical value = 0. |
| pgv1 | 1..1 | PU | Nonlinear gain point 1, PU power (Pgv1). Typical value = 0. |
| gv2 | 1..1 | PU | Nonlinear gain point 2,PU gv (Gv2). Typical value = 0. |
| pgv2 | 1..1 | PU | Nonlinear gain point 2, PU power (Pgv2). Typical value = 0. |
| gv3 | 1..1 | PU | Nonlinear gain point 3, PU gv (Gv3). Typical value = 0. |
| pgv3 | 1..1 | PU | Nonlinear gain point 3, PU power (Pgv3). Typical value = 0. |
| gv4 | 1..1 | PU | Nonlinear gain point 4, PU gv (Gv4). Typical value = 0. |
| pgv4 | 1..1 | PU | Nonlinear gain point 4, PU power (Pgv4). Typical value = 0. |
| gv5 | 1..1 | PU | Nonlinear gain point 5, PU gv (Gv5). Typical value = 0. |
| pgv5 | 1..1 | PU | Nonlinear gain point 5, PU power (Pgv5). Typical value = 0. |
| gv6 | 1..1 | PU | Nonlinear gain point 6, PU gv (Gv6). Typical value = 0. |
| pgv6 | 1..1 | PU | Nonlinear gain point 6, PU power (Pgv6). Typical value = 0. |
| ka | 1..1 | PU | Governor gain (Ka). Typical value = 0. |
| t4 | 1..1 | Seconds | Governor lead time constant (T4) (>= 0). Typical value = 0. |
| t5 | 1..1 | Seconds | Governor lag time constant (T5) (>= 0). If = 0, entire gain and lead-lag block is bypassed. Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 89 shows all association ends of GovGAST1 with other classes.

**Table 89 – Association ends of TurbineGovernorDynamics:: GovGAST1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.11 GovGAST2

Gas turbine.

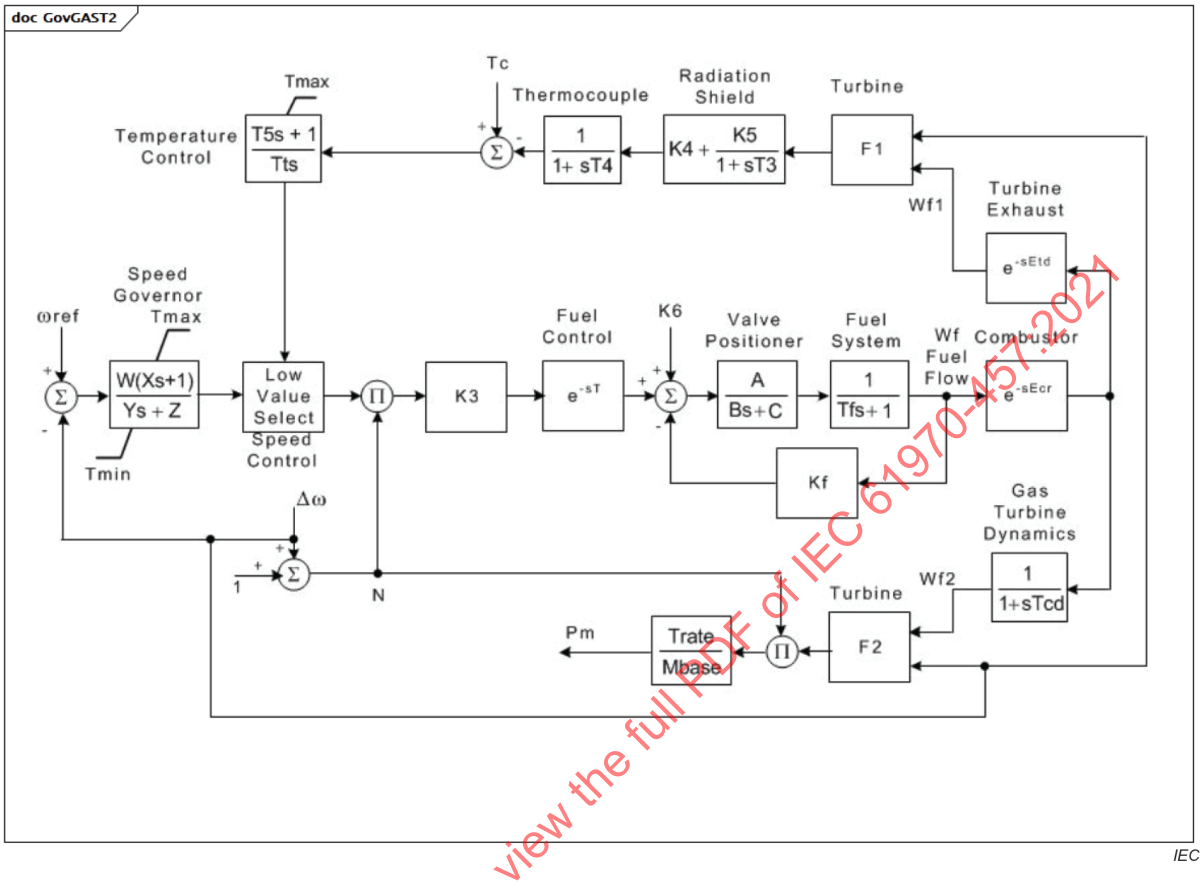


**Figure 58 – GovGAST2**

Figure 58: This diagram describes the GovGAST2 turbine governor model.

Parameter details:

1) Temperature control output is set to output of speed governor when temperature control input changes from positive to negative.
2) F1 = Tr – Af1(1 – Wf1) – Bf1(delta omega).
3) F2 = Af2 + Bf2(Wf2) – Cf2(delta omega).

Table 90 shows all attributes of GovGAST2.

**Table 90 – Attributes of TurbineGovernorDynamics::GovGAST2**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| w | 1..1 | PU | Governor gain (1/droop) on turbine rating (W). |
| x | 1..1 | Seconds | Governor lead time constant (X) (>= 0). |
| y | 1..1 | Seconds | Governor lag time constant (Y) (> 0). |
| z | 1..1 | Integer | Governor mode (Z).<br>1 = droop<br>0 = isochronous. |

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| name | mult | type | description |
|---|---|---|---|
| etd | 1..1 | Seconds | Turbine and exhaust delay (Etd) (>= 0). |
| tcd | 1..1 | Seconds | Compressor discharge time constant (Tcd) (>= 0). |
| trate | 1..1 | ActivePower | Turbine rating (Trate). Unit = MW. |
| t | 1..1 | Seconds | Fuel control time constant (T) (>= 0). |
| tmax | 1..1 | PU | Maximum turbine limit (Tmax) (> GovGAST2.tmin). |
| tmin | 1..1 | PU | Minimum turbine limit (Tmin) (< GovGAST2.tmax). |
| ecr | 1..1 | Seconds | Combustion reaction time delay (Ecr) (>= 0). |
| k3 | 1..1 | PU | Ratio of fuel adjustment (K3). |
| a | 1..1 | Float | Valve positioner (A). |
| b | 1..1 | Float | Valve positioner (B). |
| c | 1..1 | Float | Valve positioner (C). |
| tf | 1..1 | Seconds | Fuel system time constant (Tf) (>= 0). |
| kf | 1..1 | PU | Fuel system feedback (Kf). |
| k5 | 1..1 | PU | Gain of radiation shield (K5). |
| k4 | 1..1 | PU | Gain of radiation shield (K4). |
| t3 | 1..1 | Seconds | Radiation shield time constant (T3) (>= 0). |
| t4 | 1..1 | Seconds | Thermocouple time constant (T4) (>= 0). |
| tt | 1..1 | Seconds | Temperature controller integration rate (Tt) (>= 0). |
| t5 | 1..1 | Seconds | Temperature control time constant (T5) (>= 0). |
| af1 | 1..1 | PU | Exhaust temperature parameter (Af1). Unit = PU temperature. Based on temperature in degrees C. |
| bf1 | 1..1 | PU | (Bf1). Bf1 = E(1 – W) where E (speed sensitivity coefficient) is 0,55 to 0,65 x Tr. Unit = PU temperature. Based on temperature in degrees C. |
| af2 | 1..1 | PU | Coefficient equal to 0,5(1-speed) (Af2). |
| bf2 | 1..1 | PU | Turbine torque coefficient Khhv (depends on heating value of fuel stream in combustion chamber) (Bf2). |
| cf2 | 1..1 | PU | Coefficient defining fuel flow where power output is 0 % (Cf2). Synchronous but no output. Typically 0,23 x Khhv (23 % fuel flow). |
| tr | 1..1 | Temperature | Rated temperature (Tr). Unit = °C depending on parameters Af1 and Bf1. |
| k6 | 1..1 | PU | Minimum fuel flow (K6). |
| tc | 1..1 | Temperature | Temperature control (Tc). Unit = °F or °C depending on parameters Af1 and Bf1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 91 shows all association ends of GovGAST2 with other classes.

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**Table 91 – Association ends of TurbineGovernorDynamics:: GovGAST2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

### 8.2.4.3.6.12 GovGAST3

Generic turbogas with acceleration and temperature controller.

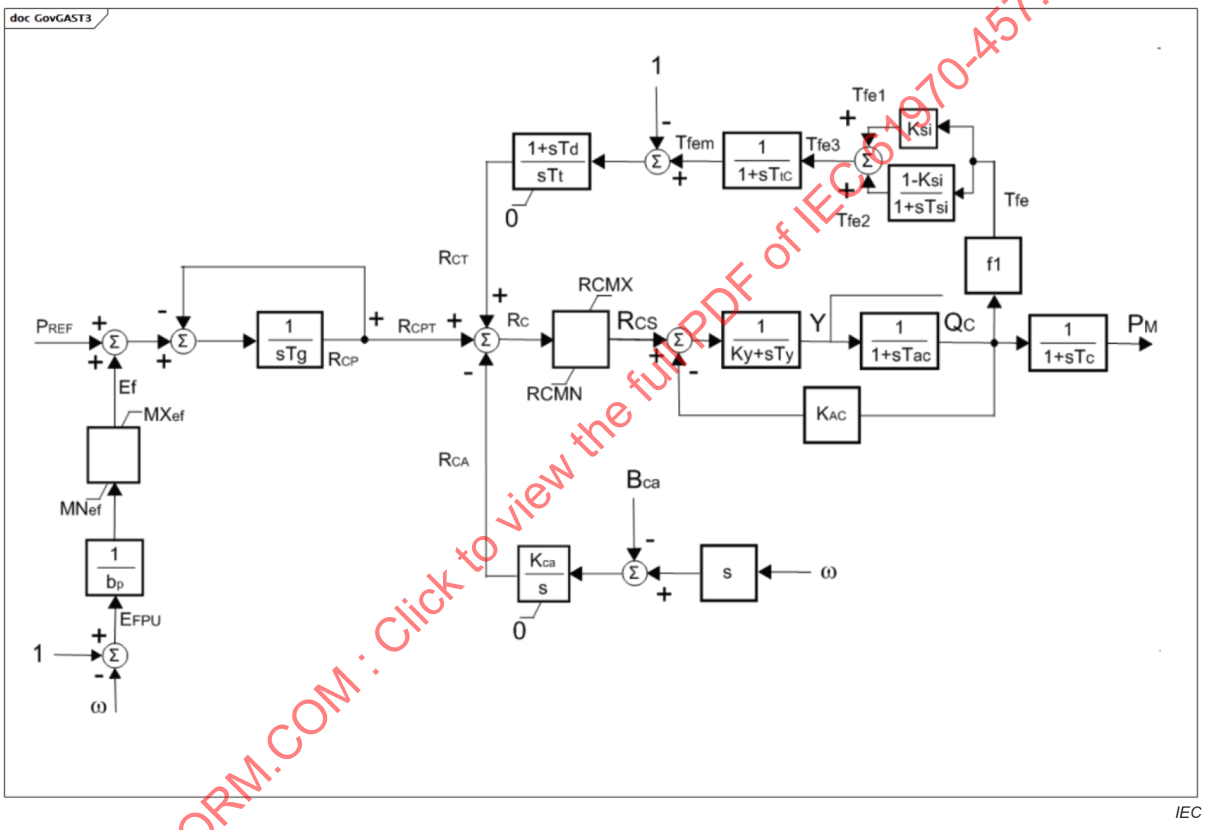


**Figure 59 – GovGAST3**

Figure 59: This diagram describes the GovGAST3 turbine governor model.

Parameter details:

1) PU parameters are on base of MW capability of the turbine.
2) omega has units of PU speed.
3) Function for exhaust temperature calculation shown in GovGAST3ExhaustTemperature diagram.

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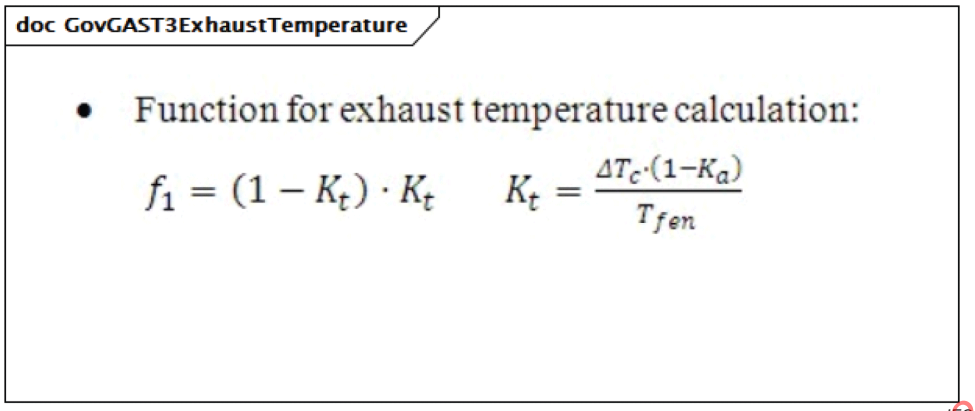


**Figure 60 – GovGAST3ExhaustTemperature**

Figure 60: This diagram illustrates the function for exhaust temperature calculation.

Table 92 shows all attributes of GovGAST3.

**Table 92 – Attributes of TurbineGovernorDynamics::GovGAST3**

| name | mult | type | description |
|---|---|---|---|
| bp | 1..1 | PU | Droop (bp). Typical value = 0,05. |
| tg | 1..1 | Seconds | Time constant of speed governor (Tg) (>= 0). Typical value = 0,05. |
| rcmx | 1..1 | PU | Maximum fuel flow (RCMX). Typical value = 1. |
| rcmn | 1..1 | PU | Minimum fuel flow (RCMN). Typical value = -0,1. |
| ky | 1..1 | Float | Coefficient of transfer function of fuel valve positioner (Ky). Typical value = 1. |
| ty | 1..1 | Seconds | Time constant of fuel valve positioner (Ty) (>= 0). Typical value = 0,2. |
| tac | 1..1 | Seconds | Fuel control time constant (Tac) (>= 0). Typical value = 0,1. |
| kac | 1..1 | Float | Fuel system feedback (KAC). Typical value = 0. |
| tc | 1..1 | Seconds | Compressor discharge volume time constant (Tc) (>= 0). Typical value = 0,2. |
| bca | 1..1 | Float | Acceleration limit set-point (Bca). Unit = 1/s. Typical value = 0,01. |
| kca | 1..1 | Float | Acceleration control integral gain (Kca). Unit = 1/s. Typical value = 100. |
| dtc | 1..1 | Temperature | Exhaust temperature variation due to fuel flow increasing from 0 to 1 PU (deltaTc). Typical value = 390. |
| ka | 1..1 | PU | Minimum fuel flow (Ka). Typical value = 0,23. |
| tsi | 1..1 | Seconds | Time constant of radiation shield (Tsi) (>= 0). Typical value = 15. |
| ksi | 1..1 | Float | Gain of radiation shield (Ksi). Typical value = 0,8. |
| ttc | 1..1 | Seconds | Time constant of thermocouple (Ttc) (>= 0). Typical value = 2,5. |
| tfen | 1..1 | Temperature | Turbine rated exhaust temperature correspondent to Pm=1 PU (Tfen). Typical value = 540. |

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| name | mult | type | description |
|---|---|---|---|
| td | 1..1 | Seconds | Temperature controller derivative gain (Td) (>= 0). Typical value = 3,3. |
| tt | 1..1 | Temperature | Temperature controller integration rate (Tt). Typical value = 250. |
| mxef | 1..1 | PU | Fuel flow maximum positive error value (MXef). Typical value = 0,05. |
| mnef | 1..1 | PU | Fuel flow maximum negative error value (MNef). Typical value = -0,05. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 93 shows all association ends of GovGAST3 with other classes.

**Table 93 – Association ends of TurbineGovernorDynamics::GovGAST3 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.13 GovGAST4

Generic turbogas.

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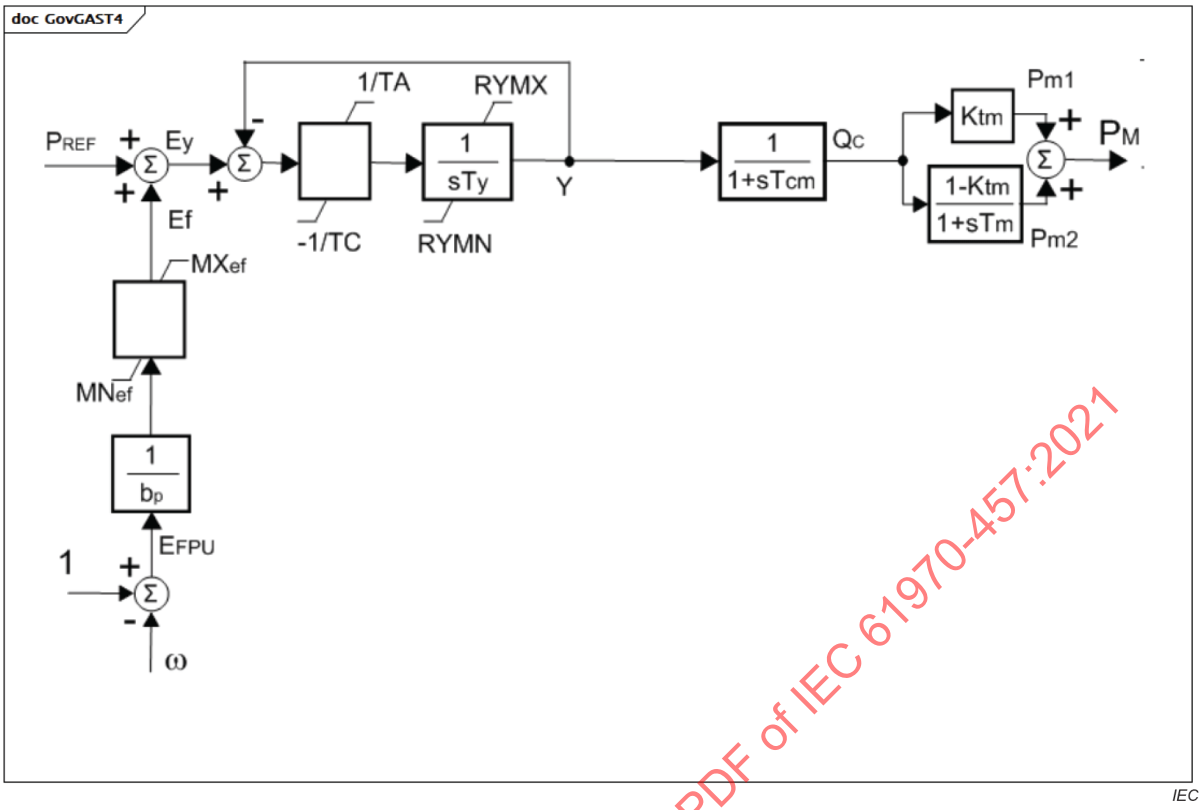


**Figure 61 – GovGAST4**

Figure 61: This diagram describes the GovGAST4 turbine governor model.

Parameter details:

1) PU parameters are on base of MW capability of the turbine.
2) omega has units of PU speed.

Table 94 shows all attributes of GovGAST4.

**Table 94 – Attributes of TurbineGovernorDynamics::GovGAST4**

| name | mult | type | description |
|---|---|---|---|
| bp | 1..1 | PU | Droop (bp). Typical value = 0,05. |
| ty | 1..1 | Seconds | Time constant of fuel valve positioner (Ty) (>= 0). Typical value = 0,1. |
| ta | 1..1 | Seconds | Maximum gate opening velocity (TA) (>= 0). Typical value = 3. |
| tc | 1..1 | Seconds | Maximum gate closing velocity (TC) (>= 0). Typical value = 0,5. |
| tcm | 1..1 | Seconds | Fuel control time constant (Tcm) (>= 0). Typical value = 0,1. |
| ktm | 1..1 | PU | Compressor gain (Ktm). Typical value = 0. |
| tm | 1..1 | Seconds | Compressor discharge volume time constant (Tm) (>= 0). Typical value = 0,2. |
| rymx | 1..1 | PU | Maximum valve opening (RYMX). Typical value = 1,1. |
| rymn | 1..1 | PU | Minimum valve opening (RYMN). Typical value = 0. |

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| name | mult | type | description |
|---|---|---|---|
| mxef | 1..1 | PU | Fuel flow maximum positive error value (MXef). Typical value = 0,05. |
| mnef | 1..1 | PU | Fuel flow maximum negative error value (MNef). Typical value = -0,05. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 95 shows all association ends of GovGAST4 with other classes.

**Table 95 – Association ends of TurbineGovernorDynamics:: GovGAST4 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.14 GovGASTWD

Woodward™ [1] gas turbine governor.

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[1] Woodward gas turbines are an example of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of these products.

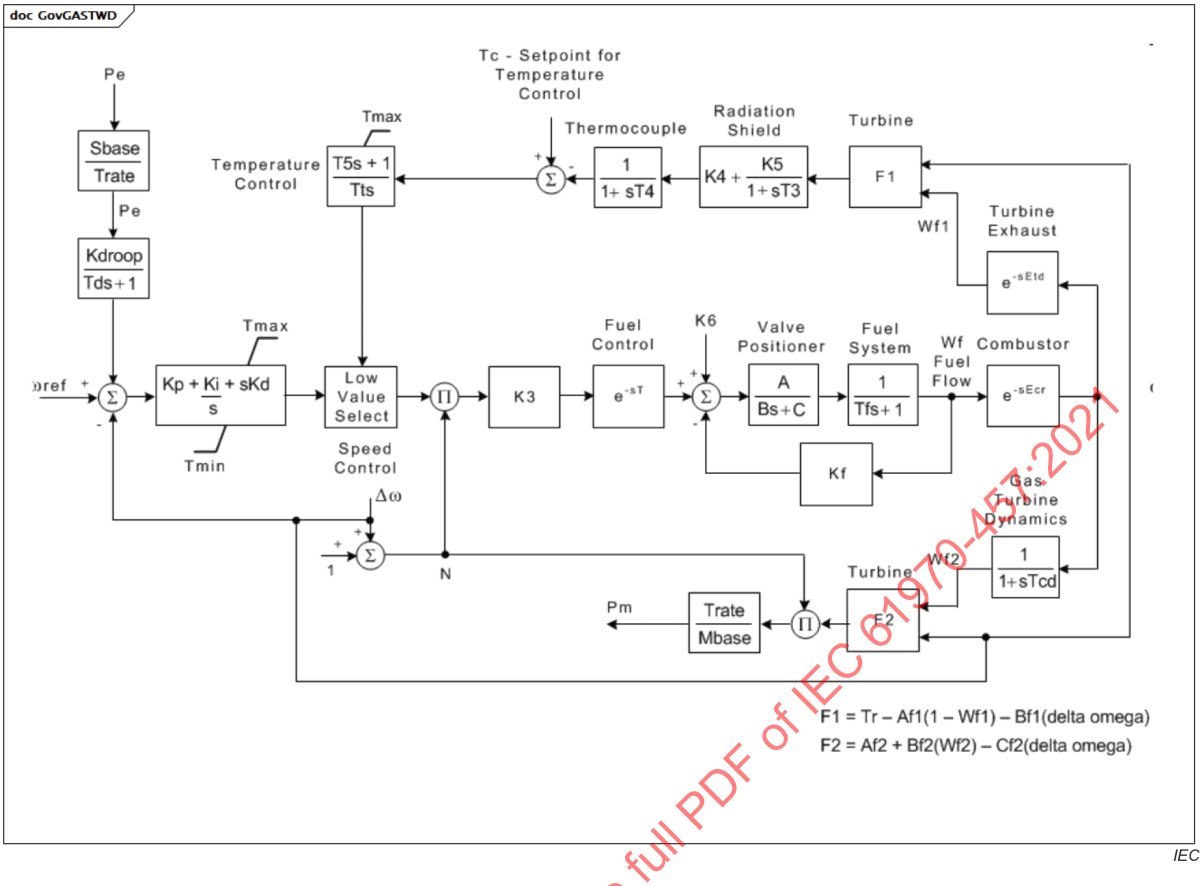


**Figure 62 – GovGASTWD**

Figure 62: This diagram describes the GovGASTWD turbine governor model.

Parameter details:

1) Temperature control output is set to output of speed governor when temperature control input changes from positive to negative.
2) F1 = Tr – Af1(1 – Wf1) – Bf1(delta omega)
3) F2 = Af2 + Bf2(Wf2) – Cf2(delta omega).

Table 96 shows all attributes of GovGASTWD.

**Table 96 – Attributes of TurbineGovernorDynamics::GovGASTWD**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| kdroop | 1..1 | PU | (Kdroop) (>= 0). |
| kp | 1..1 | PU | PID proportional gain (Kp). |
| ki | 1..1 | PU | Isochronous Governor Gain (Ki). |
| kd | 1..1 | PU | Drop governor gain (Kd). |
| etd | 1..1 | Seconds | Turbine and exhaust delay (Etd) (>= 0). |
| tcd | 1..1 | Seconds | Compressor discharge time constant (Tcd) (>= 0). |
| trate | 1..1 | ActivePower | Turbine rating (Trate). Unit = MW. |
| t | 1..1 | Seconds | Fuel control time constant (T) (>= 0). |

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| name | mult | type | description |
|---|---|---|---|
| tmax | 1..1 | PU | Maximum Turbine limit (Tmax) (> GovGASTWD.tmin). |
| tmin | 1..1 | PU | Minimum turbine limit (Tmin) (< GovGASTWD.tmax). |
| ecr | 1..1 | Seconds | Combustion reaction time delay (Ecr) (>= 0). |
| k3 | 1..1 | PU | Ratio of fuel adjustment (K3). |
| a | 1..1 | Float | Valve positioner (A). |
| b | 1..1 | Float | Valve positioner (B). |
| c | 1..1 | Float | Valve positioner (C). |
| tf | 1..1 | Seconds | Fuel system time constant (Tf) (>= 0). |
| kf | 1..1 | PU | Fuel system feedback (Kf). |
| k5 | 1..1 | PU | Gain of radiation shield (K5). |
| k4 | 1..1 | PU | Gain of radiation shield (K4). |
| t3 | 1..1 | Seconds | Radiation shield time constant (T3) (>= 0). |
| t4 | 1..1 | Seconds | Thermocouple time constant (T4) (>= 0). |
| tt | 1..1 | Seconds | Temperature controller integration rate (Tt) (>= 0). |
| t5 | 1..1 | Seconds | Temperature control time constant (T5) (>= 0). |
| af1 | 1..1 | PU | Exhaust temperature parameter (Af1). |
| bf1 | 1..1 | PU | (Bf1). Bf1 = E(1-w) where E (speed sensitivity coefficient) is 0,55 to 0,65 x Tr. |
| af2 | 1..1 | PU | Coefficient equal to 0,5(1-speed) (Af2). |
| bf2 | 1..1 | PU | Turbine torque coefficient Khhv (depends on heating value of fuel stream in combustion chamber) (Bf2). |
| cf2 | 1..1 | PU | Coefficient defining fuel flow where power output is 0 % (Cf2). Synchronous but no output. Typically 0,23 x Khhv (23 % fuel flow). |
| tr | 1..1 | Temperature | Rated temperature (Tr). |
| k6 | 1..1 | PU | Minimum fuel flow (K6). |
| tc | 1..1 | Temperature | Temperature control (Tc). |
| td | 1..1 | Seconds | Power transducer time constant (Td) (>= 0). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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

**Table 97 – Association ends of TurbineGovernorDynamics:: GovGASTWD with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.15 GovHydro1

Basic hydro turbine governor.

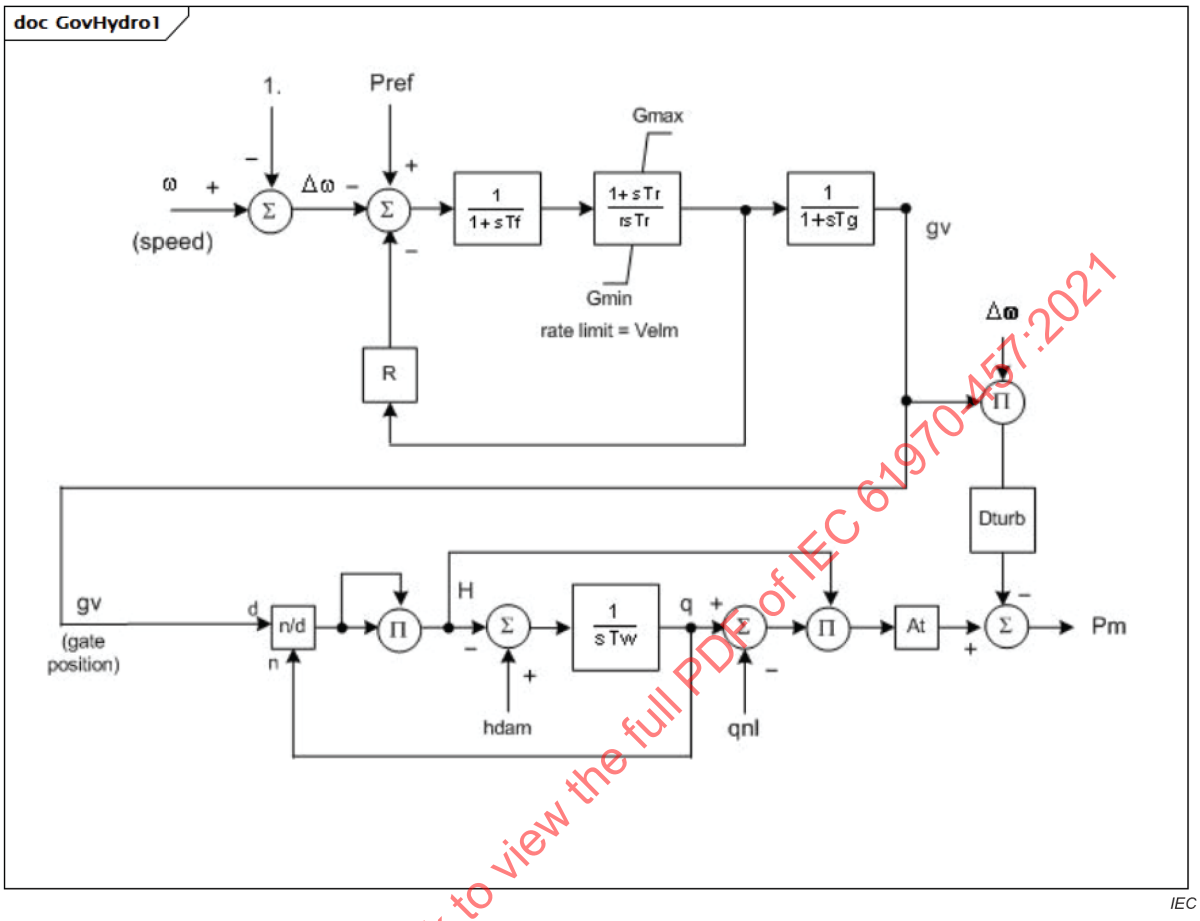


**Figure 63 – GovHydro1**

Figure 63: This diagram describes the GovHydro1 turbine governor model.

Parameter details:

1) PU parameters are on base of MWbase, which is normally the MW capability of the turbine.
2) The gates travel over a range of 1,0 PU from fully closed to fully opened. The gate position is normally greater than zero at zero power and normally less than 1,0 when power is 1,0 PU. Gmax and Gmin are operating limits.
3) Dturb has units of delta P (PU of mwcap) /delta speed (PU).

Table 98 shows all attributes of GovHydro1.

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**Table 98 – Attributes of TurbineGovernorDynamics::GovHydro1**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| rperm | 1..1 | PU | Permanent droop (R) (> 0). Typical value = 0,04. |
| rtemp | 1..1 | PU | Temporary droop (r) (> GovHydro1.rperm). Typical value = 0,3. |
| tr | 1..1 | Seconds | Washout time constant (Tr) (> 0). Typical value = 5. |
| tf | 1..1 | Seconds | Filter time constant (Tf) (> 0). Typical value = 0,05. |
| tg | 1..1 | Seconds | Gate servo time constant (Tg) (> 0). Typical value = 0,5. |
| velm | 1..1 | Float | Maximum gate velocity (Vlem) (> 0). Typical value = 0,2. |
| gmax | 1..1 | PU | Maximum gate opening (Gmax) (> 0 and > GovHydro.gmin). Typical value = 1. |
| gmin | 1..1 | PU | Minimum gate opening (Gmin) (>= 0 and < GovHydro1.gmax). Typical value = 0. |
| tw | 1..1 | Seconds | Water inertia time constant (Tw) (> 0). Typical value = 1. |
| at | 1..1 | PU | Turbine gain (At) (> 0). Typical value = 1,2. |
| dturb | 1..1 | PU | Turbine damping factor (Dturb) (>= 0). Typical value = 0,5. |
| qnl | 1..1 | PU | No-load flow at nominal head (qnl) (>= 0). Typical value = 0,08. |
| hdam | 1..1 | PU | Turbine nominal head (hdam). Typical value = 1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 99 shows all association ends of GovHydro1 with other classes.

**Table 99 – Association ends of TurbineGovernorDynamics:: GovHydro1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.16 GovHydro2

IEEE hydro turbine governor with straightforward penstock configuration and hydraulic-dashpot governor.

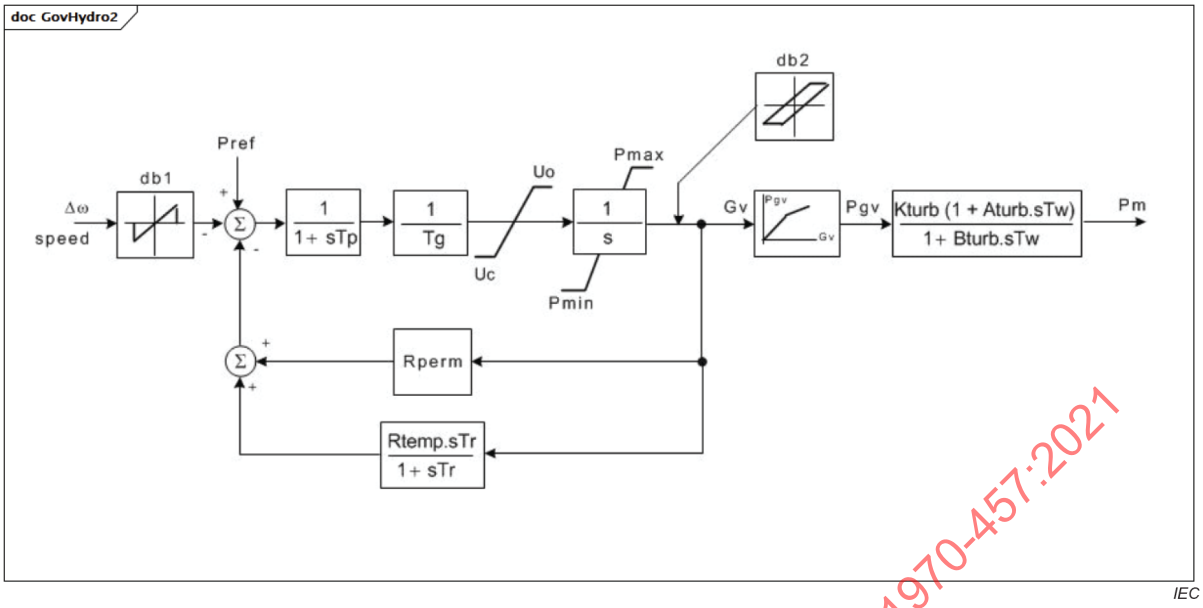


**Figure 64 – GovHydro2**

Figure 64: This diagram describes the GovHydro2 turbine governor model.

Parameter details:

1) PU parameters are on base of MWbase, which is normally the MW capability of the turbine.
2) This turbine governor model is a reasonable approximation to the performance of simple hydro plants for small motions of the gates about a given load, but it represents the variation of water inertia effect with load only if the values of the turbine parameters are properly adjusted by the user as load is varied. For idealized turbine model, set Kturb = 1,0, Aturb = -1,0, Bturb = 0,5.
3) The nonlinear gain between gate position and power can be input with up to 6 points. The (0,0, 0,0) and (1,0, 1,0.) points can be assumed. The output is not allowed to go beyond 0,0 and 1,0. However, if Pmax > 1,0, the input and output are scaled by Pmax. If Gv1 is a negative number or zero, the default hydro curve (between (0,0, 0,0) and (1,0, 1,0)) will be used.
4) For compatibility with older versions of this model: Kturb = a23, Aturb = a11 – a13 x a21/a23, Bturb = a11.

Table 100 shows all attributes of GovHydro2.

**Table 100 – Attributes of TurbineGovernorDynamics::GovHydro2**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| tg | 1..1 | Seconds | Gate servo time constant (Tg) (> 0). Typical value = 0,5. |
| tp | 1..1 | Seconds | Pilot servo valve time constant (Tp) (>= 0). Typical value = 0,03. |
| uo | 1..1 | Float | Maximum gate opening velocity (Uo). Unit = PU / s. Typical value = 0,1. |
| uc | 1..1 | Float | Maximum gate closing velocity (Uc) (< 0). Unit = PU / s. Typical value = -0,1. |
| pmax | 1..1 | PU | Maximum gate opening (Pmax) (> GovHydro2.pmin). Typical value = 1. |

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| name | mult | type | description |
|---|---|---|---|
| pmin | 1..1 | PU | Minimum gate opening (Pmin) (< GovHydro2.pmax). Typical value = 0. |
| rperm | 1..1 | PU | Permanent droop (Rperm). Typical value = 0,05. |
| rtemp | 1..1 | PU | Temporary droop (Rtemp). Typical value = 0,5. |
| tr | 1..1 | Seconds | Dashpot time constant (Tr) (>= 0). Typical value = 12. |
| tw | 1..1 | Seconds | Water inertia time constant (Tw) (>= 0). Typical value = 2. |
| kturb | 1..1 | PU | Turbine gain (Kturb). Typical value = 1. |
| aturb | 1..1 | PU | Turbine numerator multiplier (Aturb). Typical value = -1. |
| bturb | 1..1 | PU | Turbine denominator multiplier (Bturb) (> 0). Typical value = 0,5. |
| db1 | 1..1 | Frequency | Intentional deadband width (db1). Unit = Hz. Typical value = 0. |
| eps | 1..1 | Frequency | Intentional db hysteresis (eps). Unit = Hz. Typical value = 0. |
| db2 | 1..1 | ActivePower | Unintentional deadband (db2). Unit = MW. Typical value = 0. |
| gv1 | 1..1 | PU | Nonlinear gain point 1, PU gv (Gv1). Typical value = 0. |
| pgv1 | 1..1 | PU | Nonlinear gain point 1, PU power (Pgv1). Typical value = 0. |
| gv2 | 1..1 | PU | Nonlinear gain point 2, PU gv (Gv2). Typical value = 0. |
| pgv2 | 1..1 | PU | Nonlinear gain point 2, PU power (Pgv2). Typical value = 0. |
| gv3 | 1..1 | PU | Nonlinear gain point 3, PU gv (Gv3). Typical value = 0. |
| pgv3 | 1..1 | PU | Nonlinear gain point 3, PU power (Pgv3). Typical value = 0. |
| gv4 | 1..1 | PU | Nonlinear gain point 4, PU gv (Gv4). Typical value = 0. |
| pgv4 | 1..1 | PU | Nonlinear gain point 4, PU power (Pgv4). Typical value = 0. |
| gv5 | 1..1 | PU | Nonlinear gain point 5, PU gv (Gv5). Typical value = 0. |
| pgv5 | 1..1 | PU | Nonlinear gain point 5, PU power (Pgv5). Typical value = 0. |
| gv6 | 1..1 | PU | Nonlinear gain point 6, PU gv (Gv6). Typical value = 0. |
| pgv6 | 1..1 | PU | Nonlinear gain point 6, PU power (Pgv6). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 101 shows all association ends of GovHydro2 with other classes.

**Table 101 – Association ends of TurbineGovernorDynamics:: GovHydro2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.17 GovHydro3

Modified IEEE hydro governor-turbine. This model differs from that defined in the IEEE modelling guideline paper in that the limits on gate position and velocity do not permit "wind up" of the upstream signals.

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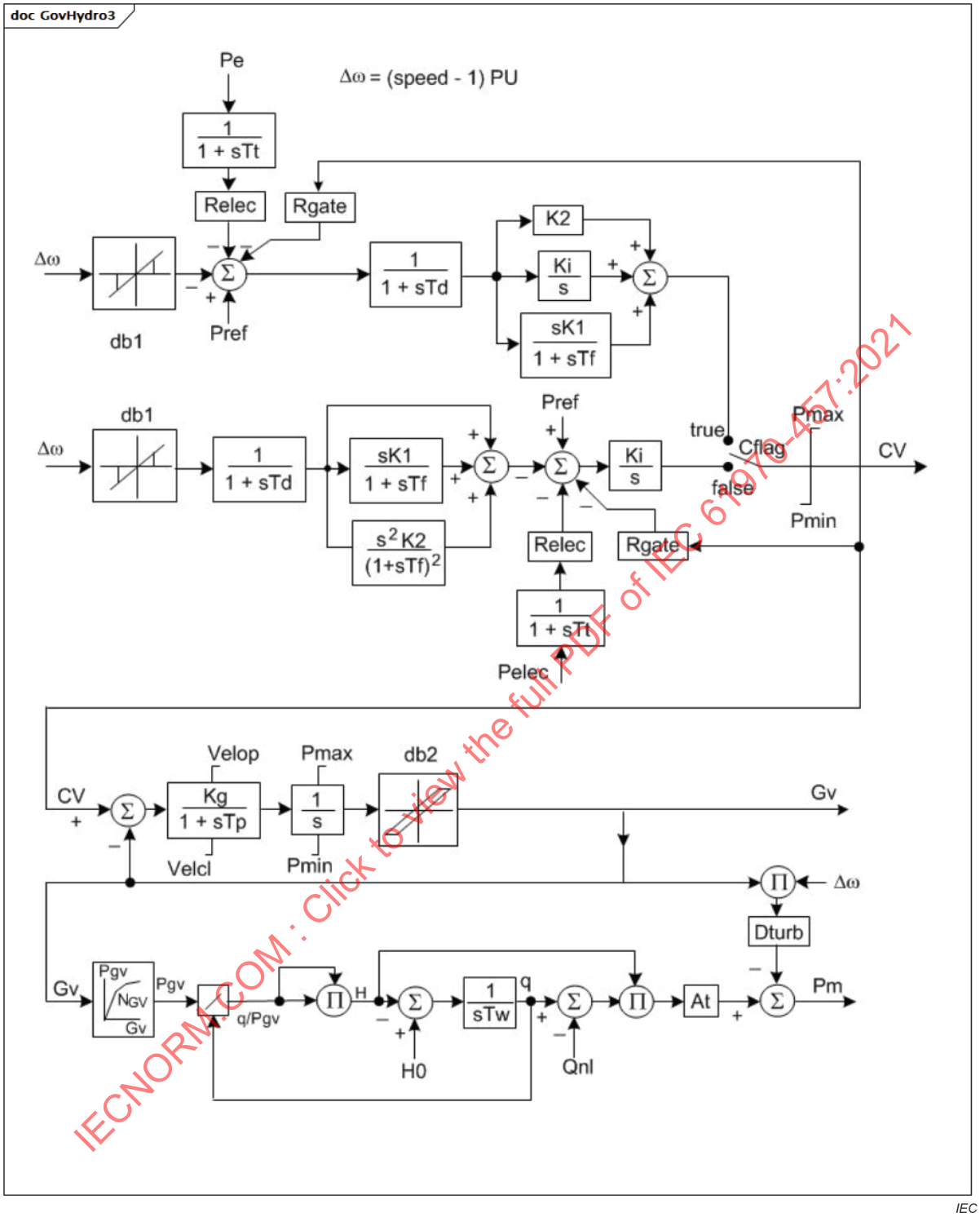


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**Figure 65 – GovHydro3**

Figure 65: This diagram describes the GovHydro3 turbine governor model.

Parameter details:

1) The nonlinear gain between gate position and power can be input with up to 6 points. The (0,0, 0,0) and (1,0, 1,0) points can be assumed. The output is not allowed to go beyond 0,0 and 1,0. However, if Pmax > 1,0, the input and output are scaled by Pmax. If Gv1 is a negative number or zero, the default hydro curve (between (0,0, 0,0) and (1,0, 1,0)) will be used.

Table 102 shows all attributes of GovHydro3.

**Table 102 – Attributes of TurbineGovernorDynamics::GovHydro3**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| pmax | 1..1 | PU | Maximum gate opening, PU of MWbase (Pmax) (> GovHydro3.pmin). Typical value = 1. |
| pmin | 1..1 | PU | Minimum gate opening, PU of MWbase (Pmin) (< GovHydro3.pmax). Typical value = 0. |
| governorControl | 1..1 | Boolean | Governor control flag (Cflag).<br>true = PID control is active<br>false = double derivative control is active.<br>Typical value = true. |
| rgate | 1..1 | PU | Steady-state droop, PU, for governor output feedback (Rgate). Typical value = 0. |
| relec | 1..1 | PU | Steady-state droop, PU, for electrical power feedback (Relec). Typical value = 0,05. |
| td | 1..1 | Seconds | Input filter time constant (Td) (>= 0). Typical value = 0,05. |
| tf | 1..1 | Seconds | Washout time constant (Tf) (>= 0). Typical value = 0,1. |
| tp | 1..1 | Seconds | Gate servo time constant (Tp) (>= 0). Typical value = 0,05. |
| velop | 1..1 | Float | Maximum gate opening velocity (Velop). Unit = PU / s. Typical value = 0,2. |
| velcl | 1..1 | Float | Maximum gate closing velocity (Velcl). Unit = PU / s. Typical value = -0,2. |
| k1 | 1..1 | PU | Derivative gain (K1). Typical value = 0,01. |
| k2 | 1..1 | PU | Double derivative gain, if Cflag = -1 (K2). Typical value = 2,5. |
| ki | 1..1 | PU | Integral gain (Ki). Typical value = 0,5. |
| kg | 1..1 | PU | Gate servo gain (Kg). Typical value = 2. |
| tt | 1..1 | Seconds | Power feedback time constant (Tt) (>= 0). Typical value = 0,2. |
| db1 | 1..1 | Frequency | Intentional dead-band width (db1). Unit = Hz. Typical value = 0. |
| eps | 1..1 | Frequency | Intentional db hysteresis (eps). Unit = Hz. Typical value = 0. |
| db2 | 1..1 | ActivePower | Unintentional dead-band (db2). Unit = MW. Typical value = 0. |
| tw | 1..1 | Seconds | Water inertia time constant (Tw) (>= 0). If = 0, block is bypassed. Typical value = 1. |
| at | 1..1 | PU | Turbine gain (At) (>0). Typical value = 1,2. |
| dturb | 1..1 | PU | Turbine damping factor (Dturb). Typical value = 0,2. |
| qnl | 1..1 | PU | No-load turbine flow at nominal head (Qnl). Typical value = 0,08. |
| h0 | 1..1 | PU | Turbine nominal head (H0). Typical value = 1. |
| gv1 | 1..1 | PU | Nonlinear gain point 1, PU gv (Gv1). Typical value = 0. |
| pgv1 | 1..1 | PU | Nonlinear gain point 1, PU power (Pgv1). Typical value = 0. |

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| name | mult | type | description |
|---|---|---|---|
| gv2 | 1..1 | PU | Nonlinear gain point 2, PU gv (Gv2). Typical value = 0. |
| pgv2 | 1..1 | PU | Nonlinear gain point 2, PU power (Pgv2). Typical value = 0. |
| gv3 | 1..1 | PU | Nonlinear gain point 3, PU gv (Gv3). Typical value = 0. |
| pgv3 | 1..1 | PU | Nonlinear gain point 3, PU power (Pgv3). Typical value = 0. |
| gv4 | 1..1 | PU | Nonlinear gain point 4, PU gv (Gv4). Typical value = 0. |
| pgv4 | 1..1 | PU | Nonlinear gain point 4, PU power (Pgv4). Typical value = 0. |
| gv5 | 1..1 | PU | Nonlinear gain point 5, PU gv (Gv5). Typical value = 0. |
| pgv5 | 1..1 | PU | Nonlinear gain point 5, PU power (Pgv5). Typical value = 0. |
| gv6 | 1..1 | PU | Nonlinear gain point 6, PU gv (Gv6). Typical value = 0. |
| pgv6 | 1..1 | PU | Nonlinear gain point 6, PU power (Pgv6). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 103 shows all association ends of GovHydro3 with other classes.

**Table 103 – Association ends of TurbineGovernorDynamics:: GovHydro3 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

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#### 8.2.4.3.6.18 GovHydro4

Hydro turbine and governor. Represents plants with straight-forward penstock configurations and hydraulic governors of the traditional 'dashpot' type. This model can be used to represent simple, Francis/Pelton or Kaplan turbines.

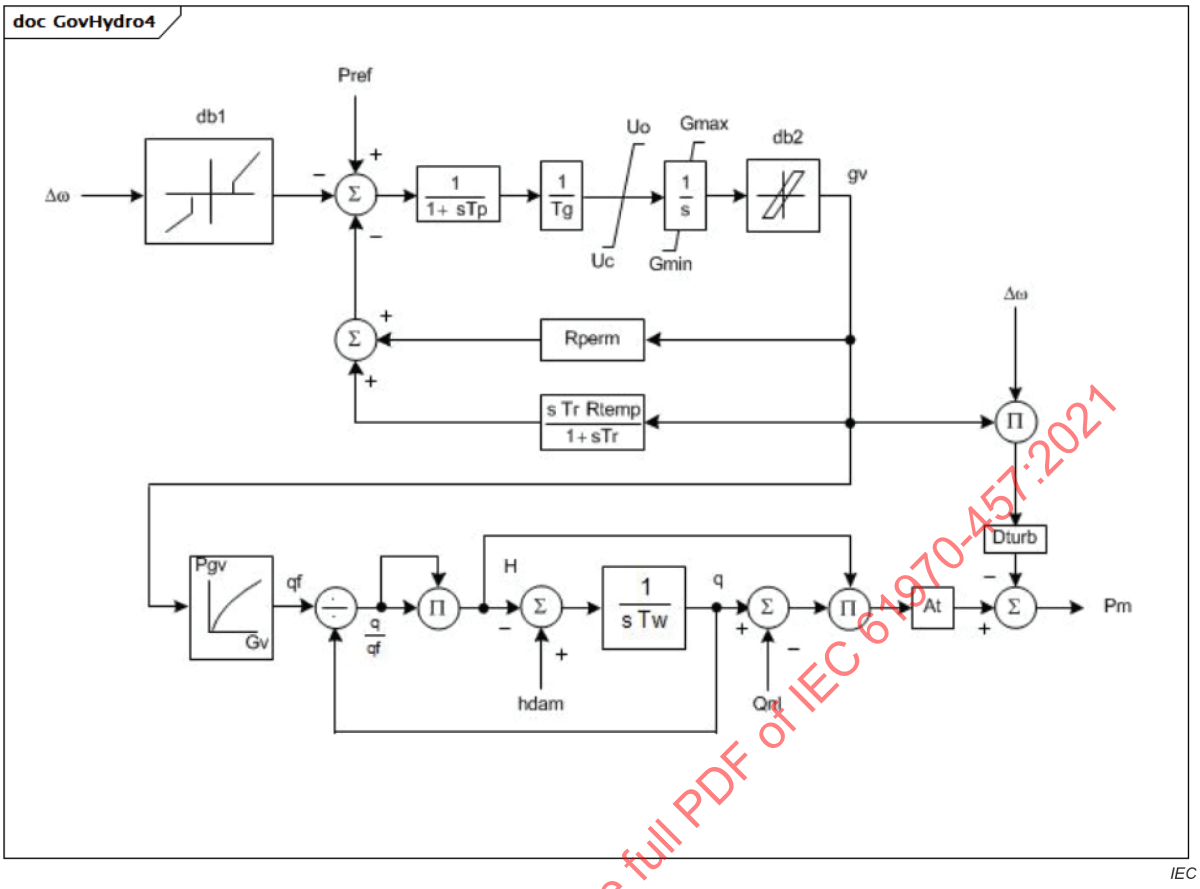


**Figure 66 – GovHydro4**

Figure 66: This diagram describes the GovHydro4 turbine governor model.

Parameter details:

1) The GovHydro4 model can be used to represent three different standard model variants: simple, Francis/Pelton and Kaplan.
2) The gates travel over a range of 1 to 0 PU from fully closed to fully opened. The gates are at a position greater than zero at zero power and, normally, less than 1 PU when power is 1 PU. Gmax and Gmin are operating limits.
3) The following parameter combinations are used by the variants to represent gate-head-flow power characteristics:
   - Simple: the line with slope At and intercept Qnl describes the gate opening-to-turbine power characteristic (as shown in the GovHydro4SimpleHydroTurbine diagram). This curve is proportional to turbine power, with the constant of proportionality being a function of available head. This constant is specified by the turbine gain, At. Parameters Gv0 to Gv5, Pgv0 to Pgv5, and Bgv0 to Bgv5 are not considered.
   - Francis/Pelton turbine model: (Gv0, Pgv0) thru (Gv5, Pgv5) are used to describe the non-linear gate opening-to-turbine power characteristic (as shown in the GovHydro4FrancisPeltonTurbine diagram). Bgv0 to Bgv5 are not considered.
   - Kaplan turbine model: (Gv0, Pgv0) thru (Gv5, Pgv5) and (Gv0, Bv0) thru (Gv5, Bgv5) are used to describe the non-linear characteristics of gate opening-to-turbine power and gate opening-to-blade angle (as shown in the GovHydro4KaplanTurbine diagram).

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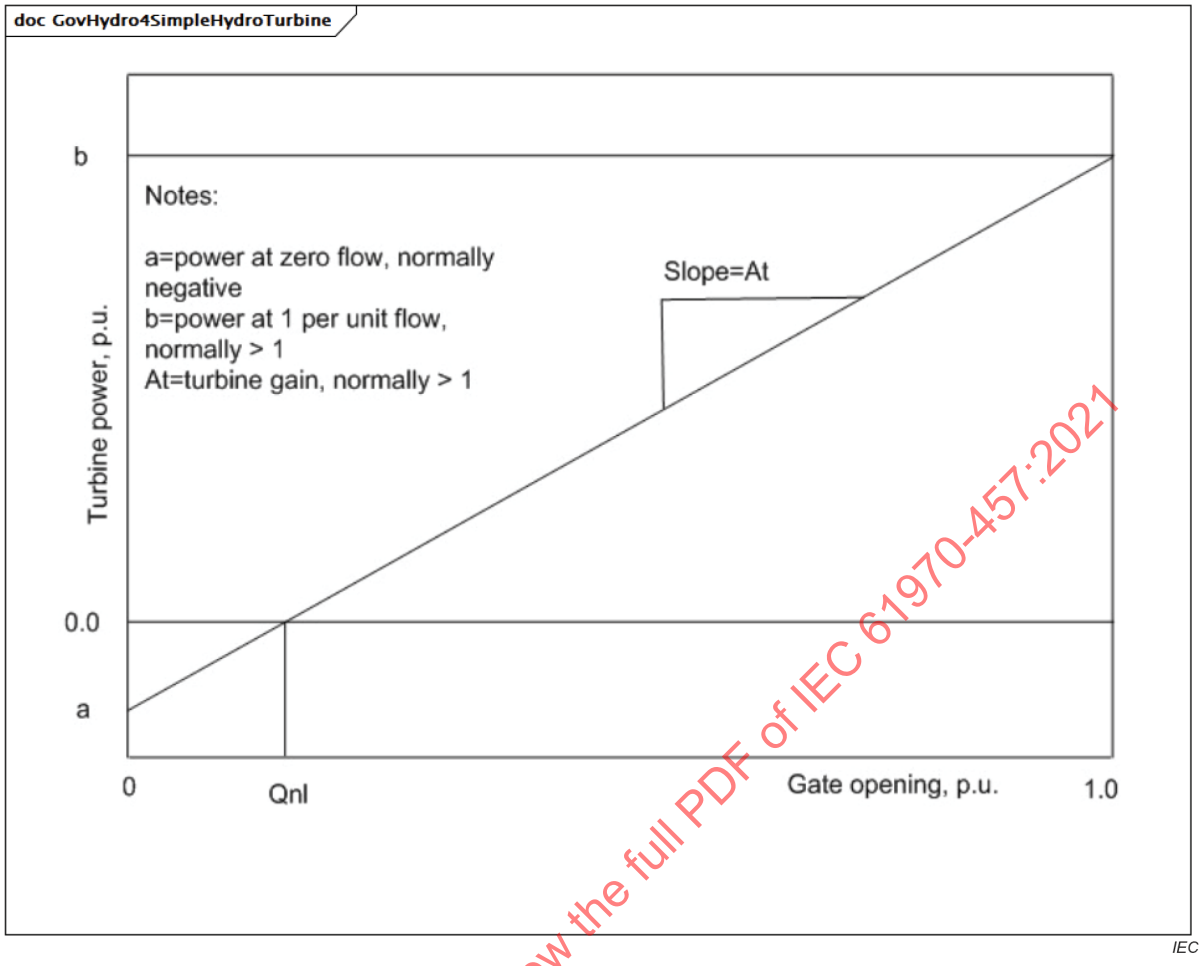


**Figure 67 – GovHydro4SimpleHydroTurbine**

Figure 67: This diagram illustrates the gate-head-flow-power characteristics for a simple general purpose model.

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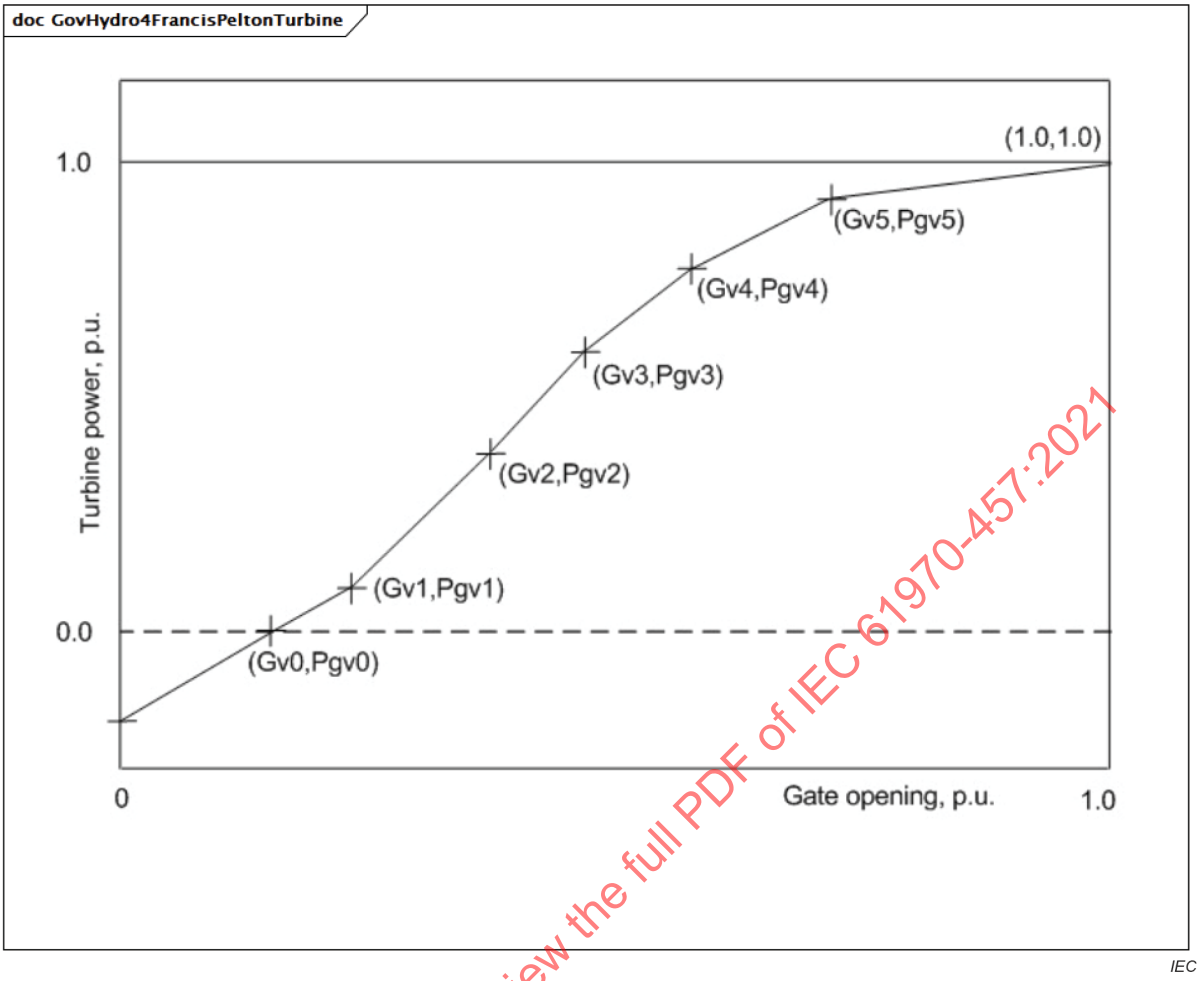


**Figure 68 – GovHydro4FrancisPeltonTurbine**

Figure 68: This diagram illustrates the gate-head-flow-power characteristics for a Francis/Pelton turbine model.

Parameter details:

1) The curve described by (Gv0, Pgv0) to (Gv5, Pgv5) describes the relationship of flow through the turbine to stroke of the gate actuating servomotor.
2) If Gv0 is greater than 0, the first two data points will be used to extrapolate downward for gate positions less than Gv0 If Gv0 is a negative number or zero, the default hydro curve (between (0,0, 0,0) and (1,0, 1,0)) will be used.

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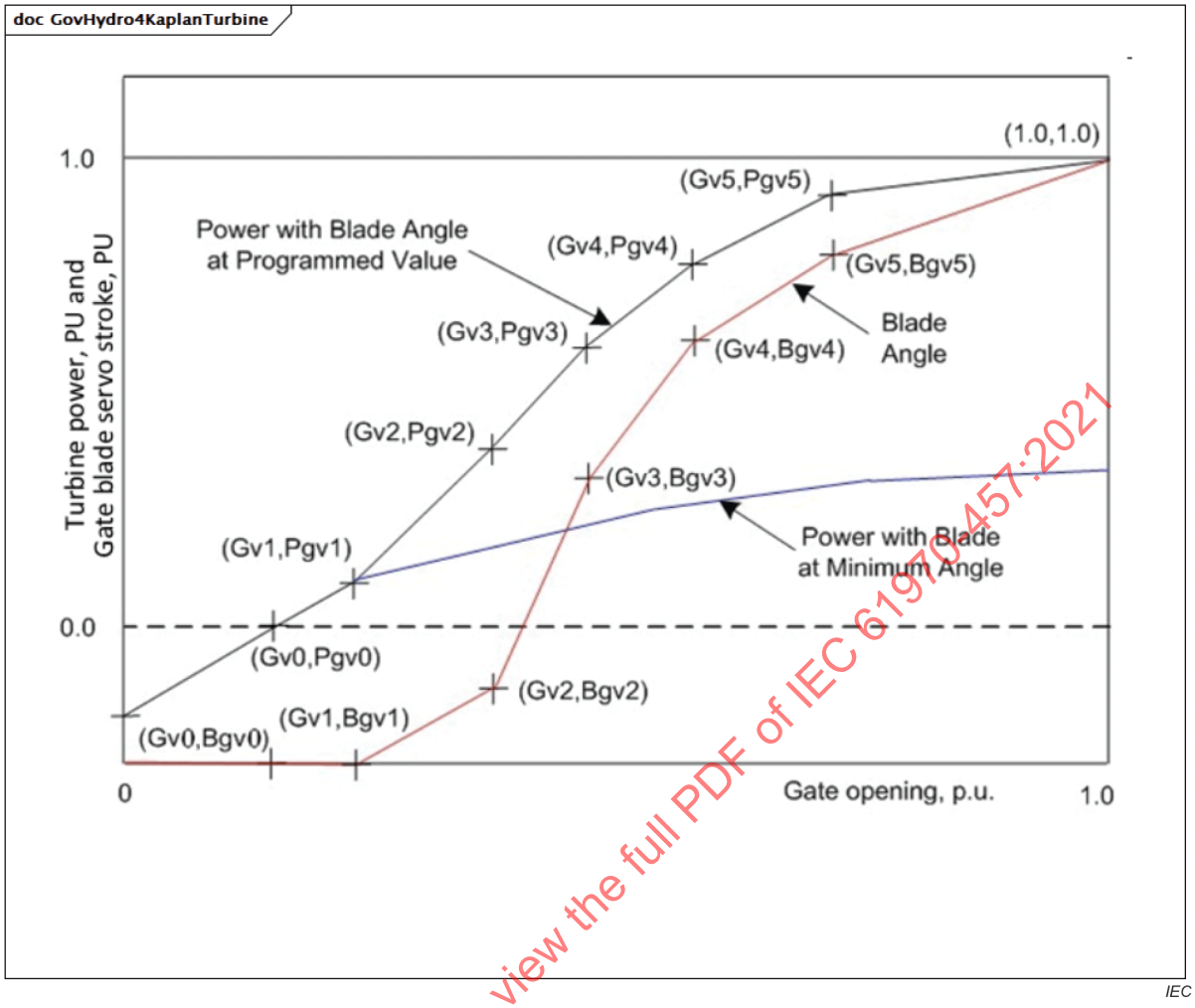


**Figure 69 – GovHydro4KaplanTurbine**

Figure 69: This diagram illustrates the non-linear characteristics of gate opening-to-turbine power and gate opening-to-blade angle for a Kaplan turbine model.

Parameter details:

1) The curve described by (Gv0, Pgv0) to (Gv5, Pgv5) describes the relationship of flow through the turbine to stroke of the gate actuating servomotor.
2) If Gv0 is greater than 0, the first two data points will be used to extrapolate downward for gate positions less than Gv0 If Gv0 is a negative number or zero, the default hydro curve (between (0,0, 0,0) and (1,0, 1,0)) will be used.

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Table 104 shows all attributes of GovHydro4.

**Table 104 – Attributes of TurbineGovernorDynamics::GovHydro4**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| tg | 1..1 | Seconds | Gate servo time constant (Tg) (> 0). Typical value = 0,5. |
| tp | 1..1 | Seconds | Pilot servo time constant (Tp) (>= 0). Typical value = 0,1. |
| uo | 1..1 | Float | Max gate opening velocity (Uo). Typical value = 0,2. |
| uc | 1..1 | Float | Max gate closing velocity (Uc). Typical value = 0,2. |
| gmax | 1..1 | PU | Maximum gate opening, PU of MWbase (Gmax) (> GovHydro4.gmin). Typical value = 1. |
| gmin | 1..1 | PU | Minimum gate opening, PU of MWbase (Gmin) (< GovHydro4.gmax). Typical value = 0. |
| rperm | 1..1 | Seconds | Permanent droop (Rperm) (>= 0). Typical value = 0,05. |
| rtemp | 1..1 | Seconds | Temporary droop (Rtemp) (>= 0). Typical value = 0,3. |
| tr | 1..1 | Seconds | Dashpot time constant (Tr) (>= 0). Typical value = 5. |
| tw | 1..1 | Seconds | Water inertia time constant (Tw) (> 0). Typical value = 1. |
| at | 1..1 | PU | Turbine gain (At). Typical value = 1,2. |
| dturb | 1..1 | PU | Turbine damping factor (Dturb). Unit = delta P (PU of MWbase) / delta speed (PU). Typical value for simple = 0,5, Francis/Pelton = 1,1, Kaplan = 1,1. |
| hdam | 1..1 | PU | Head available at dam (hdam). Typical value = 1. |
| qnl | 1..1 | PU | No-load flow at nominal head (Qnl).<br>Typical value for simple = 0,08, Francis/Pelton = 0, Kaplan = 0. |
| db1 | 1..1 | Frequency | Intentional deadband width (db1). Unit = Hz. Typical value = 0. |
| eps | 1..1 | Frequency | Intentional db hysteresis (eps). Unit = Hz. Typical value = 0. |
| db2 | 1..1 | ActivePower | Unintentional dead-band (db2). Unit = MW. Typical value = 0. |
| gv0 | 1..1 | PU | Nonlinear gain point 0, PU gv (Gv0) (= 0 for simple). Typical for Francis/Pelton = 0,1, Kaplan = 0,1. |
| pgv0 | 1..1 | PU | Nonlinear gain point 0, PU power (Pgv0) (= 0 for simple). Typical value = 0. |
| gv1 | 1..1 | PU | Nonlinear gain point 1, PU gv (Gv1) (= 0 for simple, > GovHydro4.gv0 for Francis/Pelton and Kaplan). Typical value for Francis/Pelton = 0,4, Kaplan = 0,4. |
| pgv1 | 1..1 | PU | Nonlinear gain point 1, PU power (Pgv1) (= 0 for simple).<br>Typical value for Francis/Pelton = 0,42, Kaplan = 0,35. |

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| name | mult | type | description |
|---|---|---|---|
| gv2 | 1..1 | PU | Nonlinear gain point 2, PU gv (Gv2) (= 0 for simple, > GovHydro4.gv1 for Francis/Pelton and Kaplan). Typical value for Francis/Pelton = 0,5, Kaplan = 0,5. |
| pgv2 | 1..1 | PU | Nonlinear gain point 2, PU power (Pgv2) (= 0 for simple).<br>Typical value for Francis/Pelton = 0,56, Kaplan = 0,468. |
| gv3 | 1..1 | PU | Nonlinear gain point 3, PU gv (Gv3) (= 0 for simple, > GovHydro4.gv2 for Francis/Pelton and Kaplan). Typical value for Francis/Pelton = 0,7, Kaplan = 0,7. |
| pgv3 | 1..1 | PU | Nonlinear gain point 3, PU power (Pgv3) (= 0 for simple).<br>Typical value for Francis/Pelton = 0,8, Kaplan = 0,796. |
| gv4 | 1..1 | PU | Nonlinear gain point 4, PU gv (Gv4) (= 0 for simple, > GovHydro4.gv3 for Francis/Pelton and Kaplan). Typical value for Francis/Pelton = 0,8, Kaplan = 0,8. |
| pgv4 | 1..1 | PU | Nonlinear gain point 4, PU power (Pgv4) (= 0 for simple).<br>Typical value for Francis/Pelton = 0,9, Kaplan = 0,917. |
| gv5 | 1..1 | PU | Nonlinear gain point 5, PU gv (Gv5) (= 0 for simple, < 1 and > GovHydro4.gv4 for Francis/Pelton and Kaplan). Typical value for Francis/Pelton = 0,9, Kaplan = 0,9. |
| pgv5 | 1..1 | PU | Nonlinear gain point 5, PU power (Pgv5) (= 0 for simple).<br>Typical value for Francis/Pelton = 0,97, Kaplan = 0,99. |
| bgv0 | 1..1 | PU | Kaplan blade servo point 0 (Bgv0) (= 0 for simple, = 0 for Francis/Pelton). Typical value for Kaplan = 0. |
| bgv1 | 1..1 | PU | Kaplan blade servo point 1 (Bgv1) (= 0 for simple, = 0 for Francis/Pelton). Typical value for Kaplan = 0. |
| bgv2 | 1..1 | PU | Kaplan blade servo point 2 (Bgv2) (= 0 for simple, = 0 for Francis/Pelton). Typical value for Kaplan = 0,1. |
| bgv3 | 1..1 | PU | Kaplan blade servo point 3 (Bgv3) (= 0 for simple, = 0 for Francis/Pelton). Typical value for Kaplan = 0,667. |
| bgv4 | 1..1 | PU | Kaplan blade servo point 4 (Bgv4) (= 0 for simple, = 0 for Francis/Pelton). Typical value for Kaplan = 0,9. |
| bgv5 | 1..1 | PU | Kaplan blade servo point 5 (Bgv5) (= 0 for simple, = 0 for Francis/Pelton). Typical value for Kaplan = 1. |
| bmax | 1..1 | Float | Maximum blade adjustment factor (Bmax) (= 0 for simple, = 0 for Francis/Pelton). Typical value for Kaplan = 1,1276. |
| tblade | 1..1 | Seconds | Blade servo time constant (Tblade) (>= 0). Typical value = 100. |
| model | 1..1 | GovHydro4ModelKind | The kind of model being represented (simple, Francis/Pelton or Kaplan). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |

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

Table 105 shows all association ends of GovHydro4 with other classes.

**Table 105 – Association ends of TurbineGovernorDynamics:: GovHydro4 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

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#### 8.2.4.3.6.19 GovHydroDD

Double derivative hydro governor and turbine.

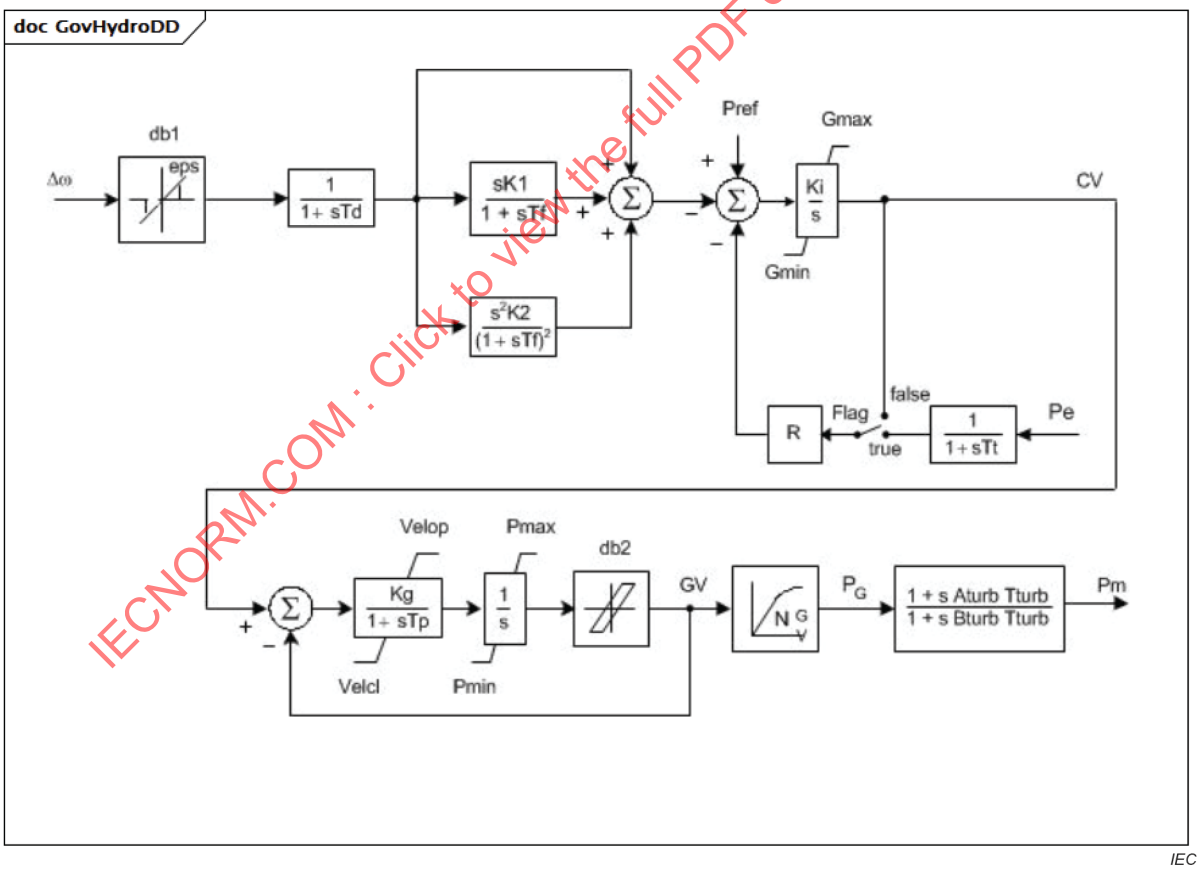


**Figure 70 – GovHydroDD**

Figure 70: This diagram describes the GovHydroDD turbine governor model.

Parameter details:

1) If Tf is input as zero, but K1 or K2 is not zero, Tf is set to a small value (4 times integration time step). If Bturb x Tturb is less than 4 times integration time step, Tturb is set to zero to bypass the block.
2) The nonlinear gain between gate position and power can be input with up to 6 points. The (0,0, 0,0) and (1,0, 1,0) points can be assumed. The output is not allowed to go beyond 0,0 and 1,0. However, if Pmax > 1,0, the input and output are scaled by Pmax. If Gv1 is a negative number or zero values, the default hydro curve (between (0,0, 0,0) and (1,0, 1,0)) will be used.
3) For a hydro turbine, set Tturb = Tw (water starting time), set Aturb = -1,0 and Bturb = 0,5. For a diesel engine or two-shaft gas turbine, set Aturb = 0,8 and Bturb = 1,0 and Tturb = 1 s. For a small steam turbine with a non-reheat steam supply or a single- shaft gas turbine, set Aturb = 0,0 and Bturb = 1,0 and Tturb = 0,2 s.

Table 106 shows all attributes of GovHydroDD.

**Table 106 – Attributes of TurbineGovernorDynamics::GovHydroDD**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (>0). Unit = MW. |
| pmax | 1..1 | PU | Maximum gate opening, PU of MWbase (Pmax) (> GovHydroDD.pmin). Typical value = 1. |
| pmin | 1..1 | PU | Minimum gate opening, PU of MWbase (Pmin) (> GovHydroDD.pmax). Typical value = 0. |
| r | 1..1 | PU | Steady state droop (R). Typical value = 0,05. |
| td | 1..1 | Seconds | Input filter time constant (Td) (>= 0). If = 0, block is bypassed. Typical value = 0. |
| tf | 1..1 | Seconds | Washout time constant (Tf) (>= 0). Typical value = 0,1. |
| tp | 1..1 | Seconds | Gate servo time constant (Tp) (>= 0). If = 0, block is bypassed. Typical value = 0,35. |
| velop | 1..1 | Float | Maximum gate opening velocity (Velop). Unit = PU / s. Typical value = 0,09. |
| velcl | 1..1 | Float | Maximum gate closing velocity (Velcl). Unit = PU / s. Typical value = -0,14. |
| k1 | 1..1 | PU | Single derivative gain (K1). Typical value = 3,6. |
| k2 | 1..1 | PU | Double derivative gain (K2). Typical value = 0,2. |
| ki | 1..1 | PU | Integral gain (Ki). Typical value = 1. |
| kg | 1..1 | PU | Gate servo gain (Kg). Typical value = 3. |
| tturb | 1..1 | Seconds | Turbine time constant (Tturb) (>= 0). See parameter detail 3. Typical value = 0,8. |
| aturb | 1..1 | PU | Turbine numerator multiplier (Aturb) (see parameter detail 3). Typical value = -1. |
| bturb | 1..1 | PU | Turbine denominator multiplier (Bturb) (see parameter detail 3). Typical value = 0,5. |
| tt | 1..1 | Seconds | Power feedback time constant (Tt) (>= 0). If = 0, block is bypassed. Typical value = 0,02. |
| db1 | 1..1 | Frequency | Intentional dead-band width (db1). Unit = Hz. Typical value = 0. |
| eps | 1..1 | Frequency | Intentional db hysteresis (eps). Unit = Hz. Typical value = 0. |
| db2 | 1..1 | ActivePower | Unintentional dead-band (db2). Unit = MW. Typical value = 0. |

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| name | mult | type | description |
|---|---|---|---|
| gv1 | 1..1 | PU | Nonlinear gain point 1, PU gv (Gv1). Typical value = 0. |
| pgv1 | 1..1 | PU | Nonlinear gain point 1, PU power (Pgv1). Typical value = 0. |
| gv2 | 1..1 | PU | Nonlinear gain point 2, PU gv (Gv2). Typical value = 0. |
| pgv2 | 1..1 | PU | Nonlinear gain point 2, PU power (Pgv2). Typical value = 0. |
| gv3 | 1..1 | PU | Nonlinear gain point 3, PU gv (Gv3). Typical value = 0. |
| pgv3 | 1..1 | PU | Nonlinear gain point 3, PU power (Pgv3). Typical value = 0. |
| gv4 | 1..1 | PU | Nonlinear gain point 4, PU gv (Gv4). Typical value = 0. |
| pgv4 | 1..1 | PU | Nonlinear gain point 4, PU power (Pgv4). Typical value = 0. |
| gv5 | 1..1 | PU | Nonlinear gain point 5, PU gv (Gv5). Typical value = 0. |
| pgv5 | 1..1 | PU | Nonlinear gain point 5, PU power (Pgv5). Typical value = 0. |
| gv6 | 1..1 | PU | Nonlinear gain point 6, PU gv (Gv6). Typical value = 0. |
| pgv6 | 1..1 | PU | Nonlinear gain point 6, PU power (Pgv6). Typical value = 0. |
| gmax | 1..1 | PU | Maximum gate opening (Gmax) (> GovHydroDD.gmin). Typical value = 0. |
| gmin | 1..1 | PU | Minimum gate opening (Gmin) (< GovHydroDD.gmax). Typical value = 0. |
| inputSignal | 1..1 | Boolean | Input signal switch (Flag).<br>true = Pe input is used<br>false = feedback is received from CV.<br>Flag is normally dependent on Tt. If Tt is zero, Flag is set to false. If Tt is not zero, Flag is set to true.<br>Typical value = true. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 107 shows all association ends of GovHydroDD with other classes.

**Table 107 – Association ends of TurbineGovernorDynamics:: GovHydroDD with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.20 GovHydroFrancis

Detailed hydro unit – Francis model. This model can be used to represent three types of governors.

A schematic of the hydraulic system of detailed hydro unit models, such as Francis and Pelton, is provided in the DetailedHydroModelHydraulicSystem diagram (Figure 73).

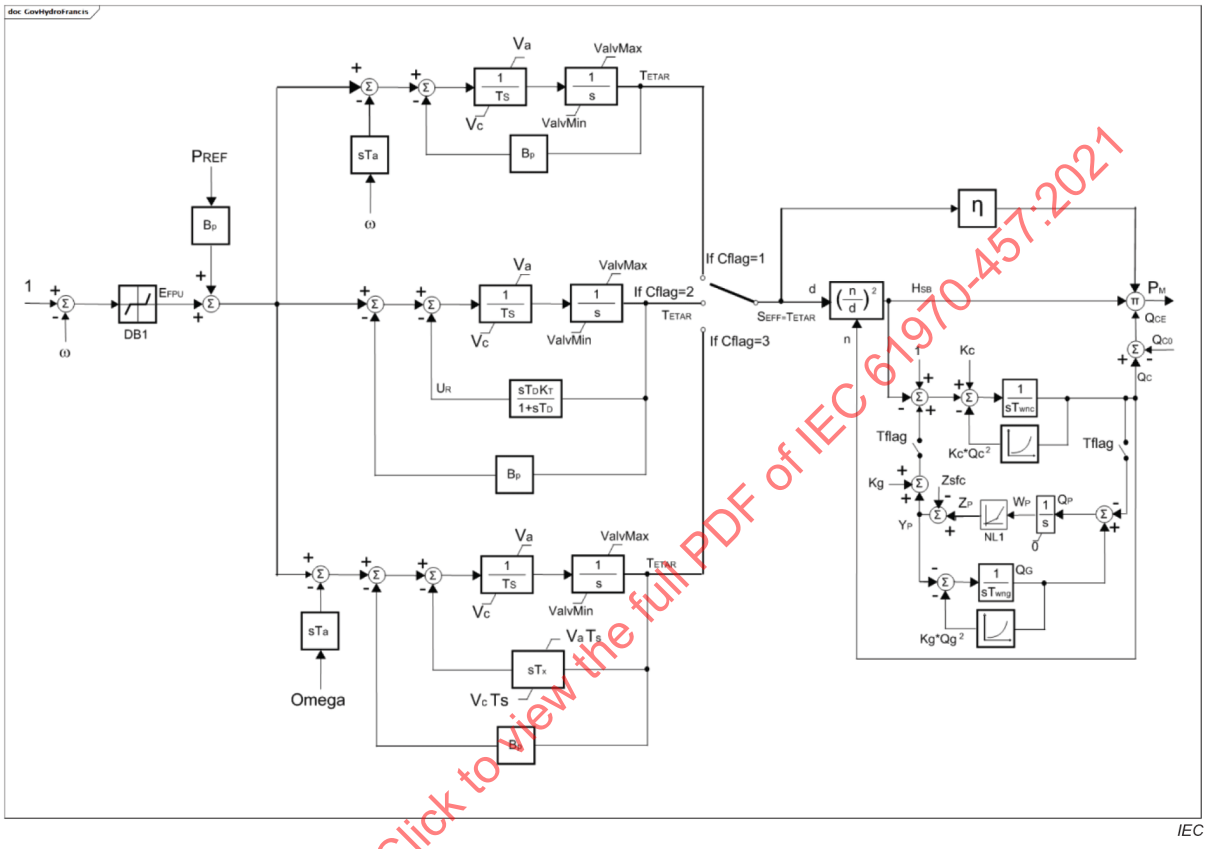


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**Figure 71 – GovHydroFrancis**

Figure 71: This diagram describes the GovHydroFrancis turbine governor model.

Parameter details:

1) PU parameters are on base of MW capability of the turbine.
2) Rated hydraulic head, Hn in metres, and rated flow, Qn in cubic metres per s, are the design parameters of the hydraulic system capability.
3) Hydraulic system head attributes (Zsfc, H1, H2) are in metres but in the block diagram are in PU on base of Hn in metres.
4) Hydraulic area attributes (Av0, Av1) are in square metres but in the block diagram are in PU on base of Qn / Hn in square metres per s.
5) omega has units of PU speed.
6) Non-linear gain and efficiency equations are shown in GovHydroFrancisNonLinearGainAndEfficiency diagram (Figure 73).

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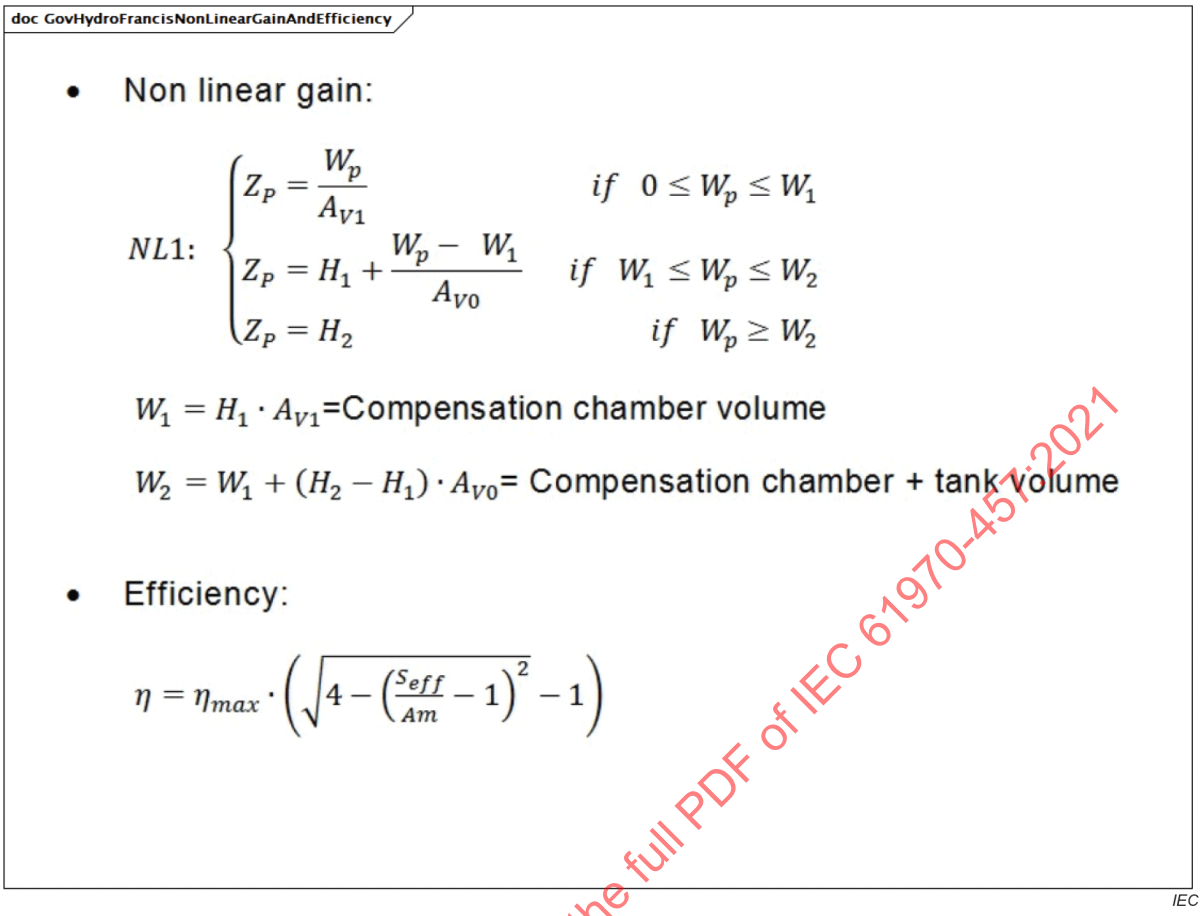


**Figure 72 – GovHydroFrancisNonLinearGainAndEfficiency**

Figure 72: This diagram illustrates the non-linear gain and efficiency equations.

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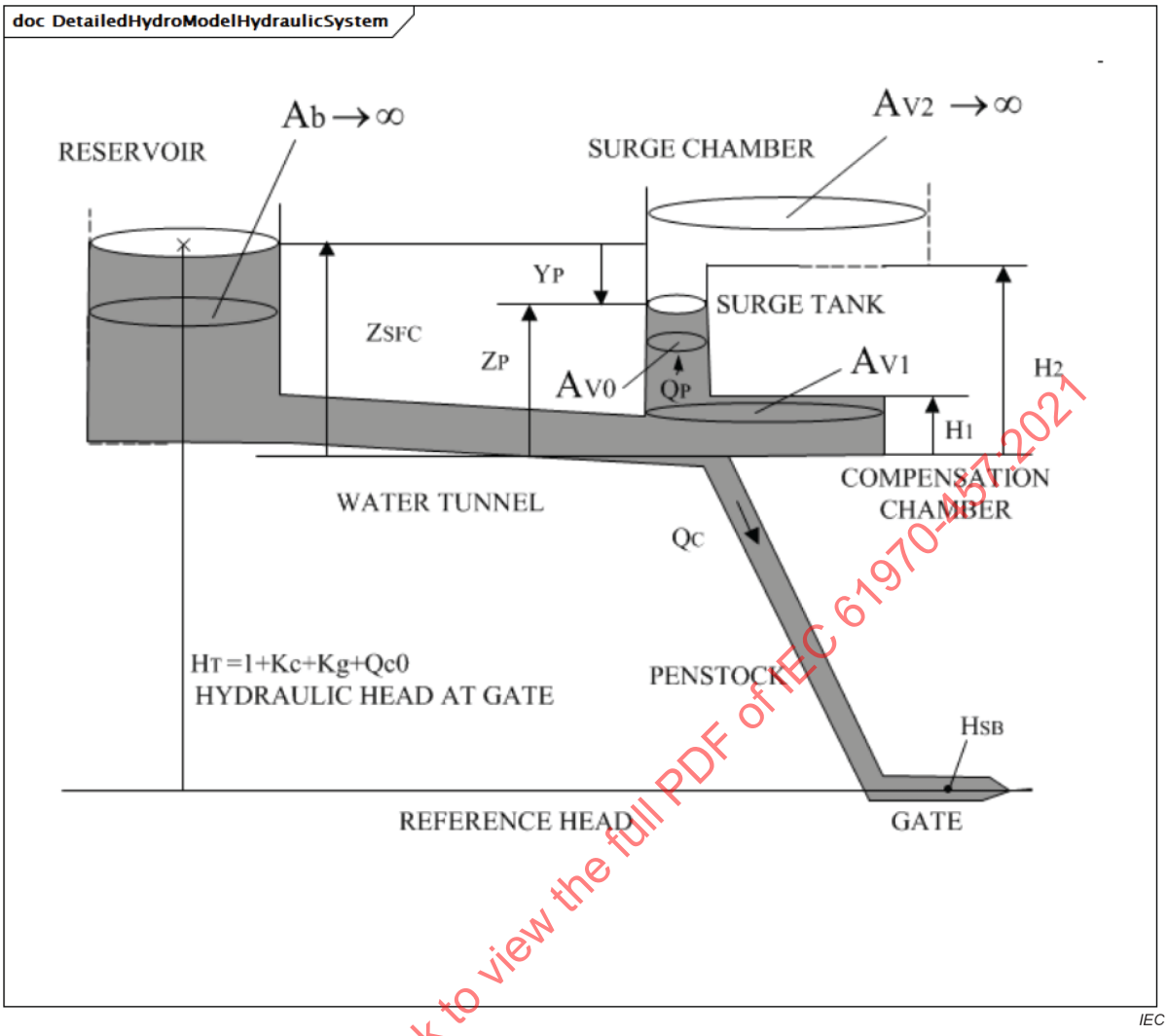


**Figure 73 – DetailedHydroModelHydraulicSystem**

Figure 73: This diagram illustrates the detailed hydro model of a hydraulic system.

Table 108 shows all attributes of GovHydroFrancis.

**Table 108 – Attributes of TurbineGovernorDynamics::GovHydroFrancis**

| name | mult | type | description |
|---|---|---|---|
| am | 1..1 | PU | Opening section SEFF at the maximum efficiency (Am). Typical value = 0,7. |
| av0 | 1..1 | Area | Area of the surge tank (AV0). Unit = m2. Typical value = 30. |
| av1 | 1..1 | Area | Area of the compensation tank (AV1). Unit = m2. Typical value = 700. |
| bp | 1..1 | PU | Droop (Bp). Typical value = 0,05. |
| db1 | 1..1 | Frequency | Intentional dead-band width (DB1). Unit = Hz. Typical value = 0. |
| etamax | 1..1 | PU | Maximum efficiency (EtaMax). Typical value = 1,05. |
| governorControl | 1..1 | FrancisGovernorControlKind | Governor control flag (Cflag). Typical value = mechanicHydrolicTachoAccelerator. |

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| name | mult | type | description |
|---|---|---|---|
| h1 | 1..1 | Length | Head of compensation chamber water level with respect to the level of penstock (H1). Unit = km. Typical value = 0,004. |
| h2 | 1..1 | Length | Head of surge tank water level with respect to the level of penstock (H2). Unit = km. Typical value = 0,040. |
| hn | 1..1 | Length | Rated hydraulic head (Hn). Unit = km. Typical value = 0,250. |
| kc | 1..1 | PU | Penstock loss coefficient (due to friction) (Kc). Typical value = 0,025. |
| kg | 1..1 | PU | Water tunnel and surge chamber loss coefficient (due to friction) (Kg). Typical value = 0,025. |
| kt | 1..1 | PU | Washout gain (Kt). Typical value = 0,25. |
| qc0 | 1..1 | PU | No-load turbine flow at nominal head (Qc0). Typical value = 0,1. |
| qn | 1..1 | VolumeFlowRate | Rated flow (Qn). Unit = m3/s. Typical value = 250. |
| ta | 1..1 | Seconds | Derivative gain (Ta) (>= 0). Typical value = 3. |
| td | 1..1 | Seconds | Washout time constant (Td) (>= 0). Typical value = 6. |
| ts | 1..1 | Seconds | Gate servo time constant (Ts) (>= 0). Typical value = 0,5. |
| twnc | 1..1 | Seconds | Water inertia time constant (Twnc) (>= 0). Typical value = 1. |
| twng | 1..1 | Seconds | Water tunnel and surge chamber inertia time constant (Twng) (>= 0). Typical value = 3. |
| tx | 1..1 | Seconds | Derivative feedback gain (Tx) (>= 0). Typical value = 1. |
| va | 1..1 | Float | Maximum gate opening velocity (Va). Unit = PU / s. Typical value = 0,06. |
| valvmax | 1..1 | PU | Maximum gate opening (ValvMax) (> GovHydroFrancis.valvmin). Typical value = 1,1. |
| valvmin | 1..1 | PU | Minimum gate opening (ValvMin) (< GovHydroFrancis.valvmax). Typical value = 0. |
| vc | 1..1 | Float | Maximum gate closing velocity (Vc). Unit = PU / s. Typical value = -0,06. |
| waterTunnelSurgeChamberSimulation | 1..1 | Boolean | Water tunnel and surge chamber simulation (Tflag).<br>true = enable of water tunnel and surge chamber simulation<br>false = inhibit of water tunnel and surge chamber simulation.<br>Typical value = false. |
| zsfc | 1..1 | Length | Head of upper water level with respect to the level of penstock (Zsfc). Unit = km. Typical value = 0,025. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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

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**Table 109 – Association ends of TurbineGovernorDynamics:: GovHydroFrancis with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

### 8.2.4.3.6.21 GovHydroPelton

Detailed hydro unit – Pelton model. This model can be used to represent the dynamic related to water tunnel and surge chamber.

The DetailedHydroModelHydraulicSystem diagram (Figure 73), located under the GovHydroFrancis class, provides a schematic of the hydraulic system of detailed hydro unit models, such as Francis and Pelton.

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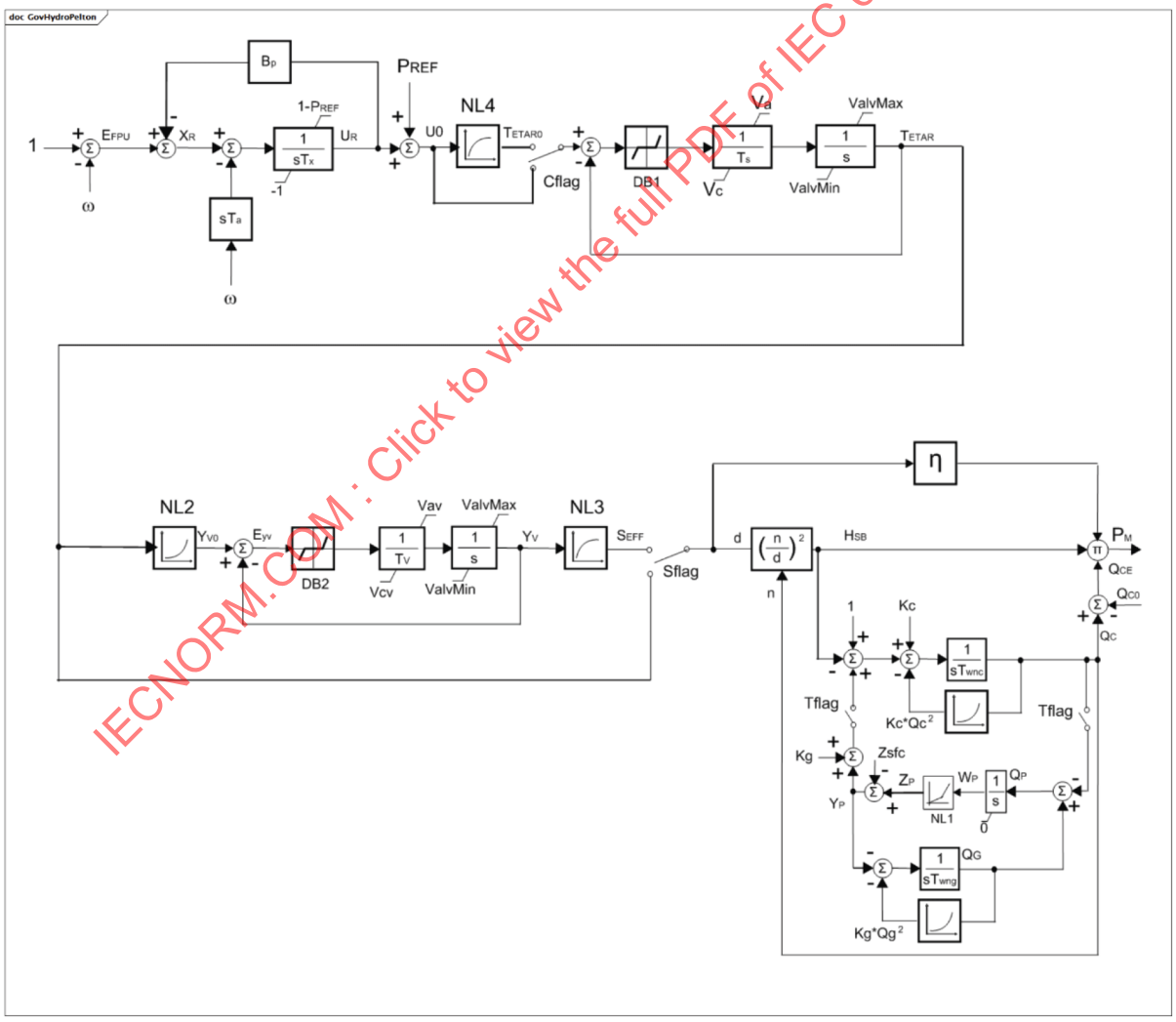


**Figure 74 – GovHydroPelton**

Figure 74: This diagram describes the GovHydroPelton turbine governor model.

Parameter details:

1) PU parameters are on base of MW capability of the turbine.
2) Rated hydraulic head, Hn, in metres, and rated flow, Qn, in cubic metres per s, are the design parameters of the hydraulic system capability.
3) Hydraulic system head attributes (Zsfc, H1, H2) are in metres but in the block diagram are in PU on base of Hn in metres.
4) Hydraulic area attributes (Av0, Av1) are in square metres but in the block diagram are in PU on base of Qn / Hn in square metres per s.
5) omega has units of PU speed.
6) Non-linear gains and efficiency shown in GovHydroPeltonNonLinearGainAndEfficiency diagram (Figure 75).

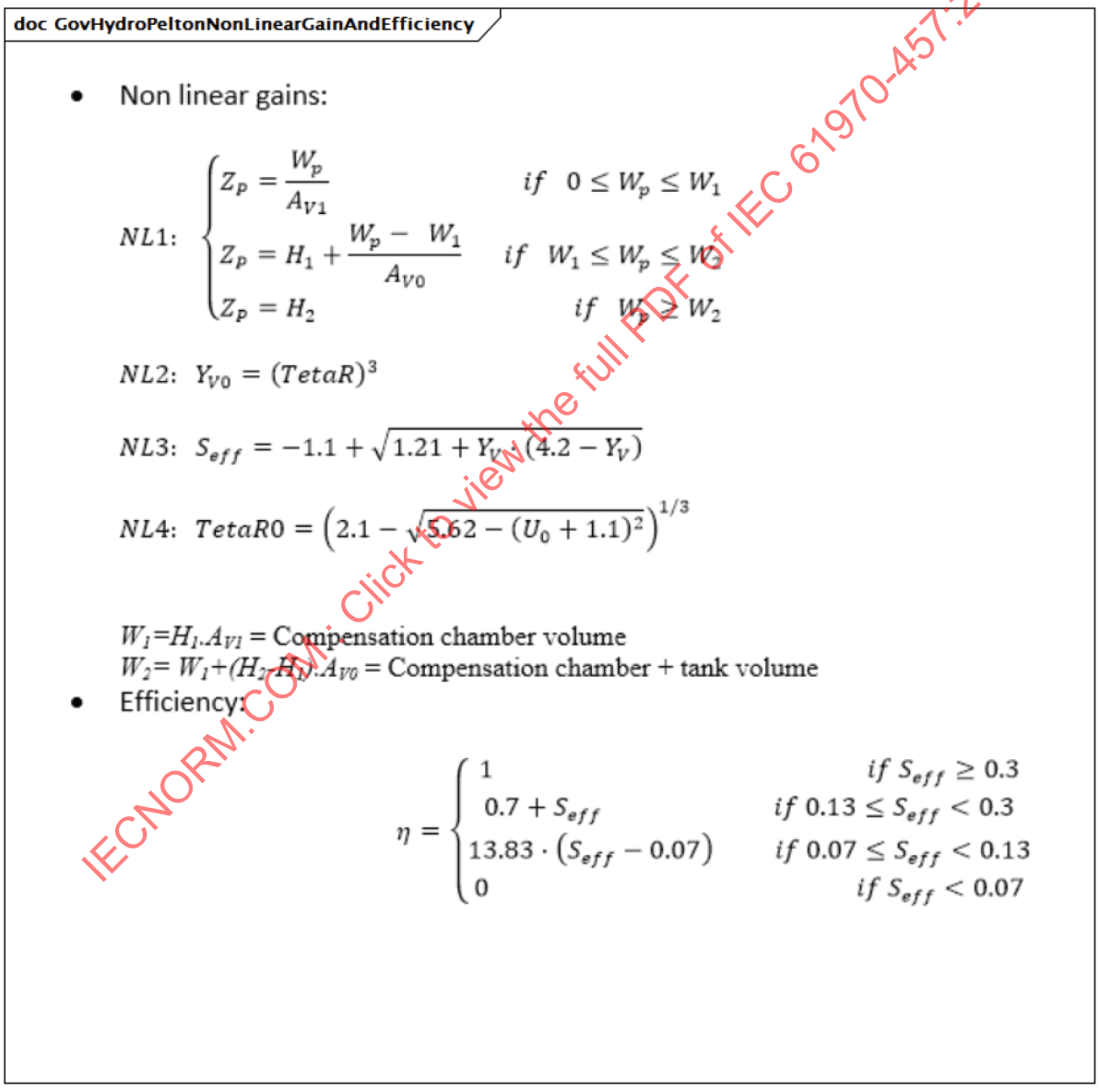


**Figure 75 – GovHydroPeltonNonLinearGainAndEfficiency**

Figure 75: This diagram illustrates the non-linear gain and efficiency equations.

Table 110 shows all attributes of GovHydroPelton.

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**Table 110 – Attributes of TurbineGovernorDynamics::GovHydroPelton**

| name | mult | type | description |
|---|---|---|---|
| av0 | 1..1 | Area | Area of the surge tank (AV0). Unit = m2. Typical value = 30. |
| av1 | 1..1 | Area | Area of the compensation tank (AV1). Unit = m2. Typical value = 700. |
| bp | 1..1 | PU | Droop (bp). Typical value = 0,05. |
| db1 | 1..1 | Frequency | Intentional dead-band width (DB1). Unit = Hz. Typical value = 0. |
| db2 | 1..1 | Frequency | Intentional dead-band width of valve opening error (DB2). Unit = Hz. Typical value = 0,01. |
| h1 | 1..1 | Length | Head of compensation chamber water level with respect to the level of penstock (H1). Unit = km. Typical value = 0,004. |
| h2 | 1..1 | Length | Head of surge tank water level with respect to the level of penstock (H2). Unit = km. Typical value = 0,040. |
| hn | 1..1 | Length | Rated hydraulic head (Hn). Unit = km. Typical value = 0,250. |
| kc | 1..1 | PU | Penstock loss coefficient (due to friction) (Kc). Typical value = 0,025. |
| kg | 1..1 | PU | Water tunnel and surge chamber loss coefficient (due to friction) (Kg). Typical value = 0,025. |
| qc0 | 1..1 | PU | No-load turbine flow at nominal head (Qc0). Typical value = 0,05. |
| qn | 1..1 | VolumeFlowRate | Rated flow (Qn). Unit = m3/s. Typical value = 250. |
| simplifiedPelton | 1..1 | Boolean | Simplified Pelton model simulation (Sflag).<br>true = enable of simplified Pelton model simulation<br>false = enable of complete Pelton model simulation (non-linear gain).<br>Typical value = true. |
| staticCompensating | 1..1 | Boolean | Static compensating characteristic (Cflag). It should be true if simplifiedPelton = false.<br>true = enable of static compensating characteristic<br>false = inhibit of static compensating characteristic.<br>Typical value = false. |
| ta | 1..1 | Seconds | Derivative gain (accelerometer time constant) (Ta) (>= 0). Typical value = 3. |
| ts | 1..1 | Seconds | Gate servo time constant (Ts) (>= 0). Typical value = 0,15. |
| tv | 1..1 | Seconds | Servomotor integrator time constant (Tv) (>= 0). Typical value = 0,3. |
| twnc | 1..1 | Seconds | Water inertia time constant (Twnc) (>= 0). Typical value = 1. |
| twng | 1..1 | Seconds | Water tunnel and surge chamber inertia time constant (Twng) (>= 0). Typical value = 3. |
| tx | 1..1 | Seconds | Electronic integrator time constant (Tx) (>= 0). Typical value = 0,5. |
| va | 1..1 | Float | Maximum gate opening velocity (Va). Unit = PU / s. Typical value = 0,06. |
| valvmax | 1..1 | PU | Maximum gate opening (ValvMax) (> GovHydroPelton.valvmin). Typical value = 1,1. |

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| name | mult | type | description |
|---|---|---|---|
| valvmin | 1..1 | PU | Minimum gate opening (ValvMin) (< GovHydroPelton.valvmax). Typical value = 0. |
| vav | 1..1 | PU | Maximum servomotor valve opening velocity (Vav). Typical value = 0,1. |
| vc | 1..1 | Float | Maximum gate closing velocity (Vc). Unit = PU / s. Typical value = -0,06. |
| vcv | 1..1 | PU | Maximum servomotor valve closing velocity (Vcv). Typical value = -0,1. |
| waterTunnelSurgeChamberSimulation | 1..1 | Boolean | Water tunnel and surge chamber simulation (Tflag).<br>true = enable of water tunnel and surge chamber simulation<br>false = inhibit of water tunnel and surge chamber simulation.<br>Typical value = false. |
| zsfc | 1..1 | Length | Head of upper water level with respect to the level of penstock (Zsfc). Unit = km. Typical value = 0,025. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 111 shows all association ends of GovHydroPelton with other classes.

**Table 111 – Association ends of TurbineGovernorDynamics:: GovHydroPelton with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.22 GovHydroPID

PID governor and turbine.

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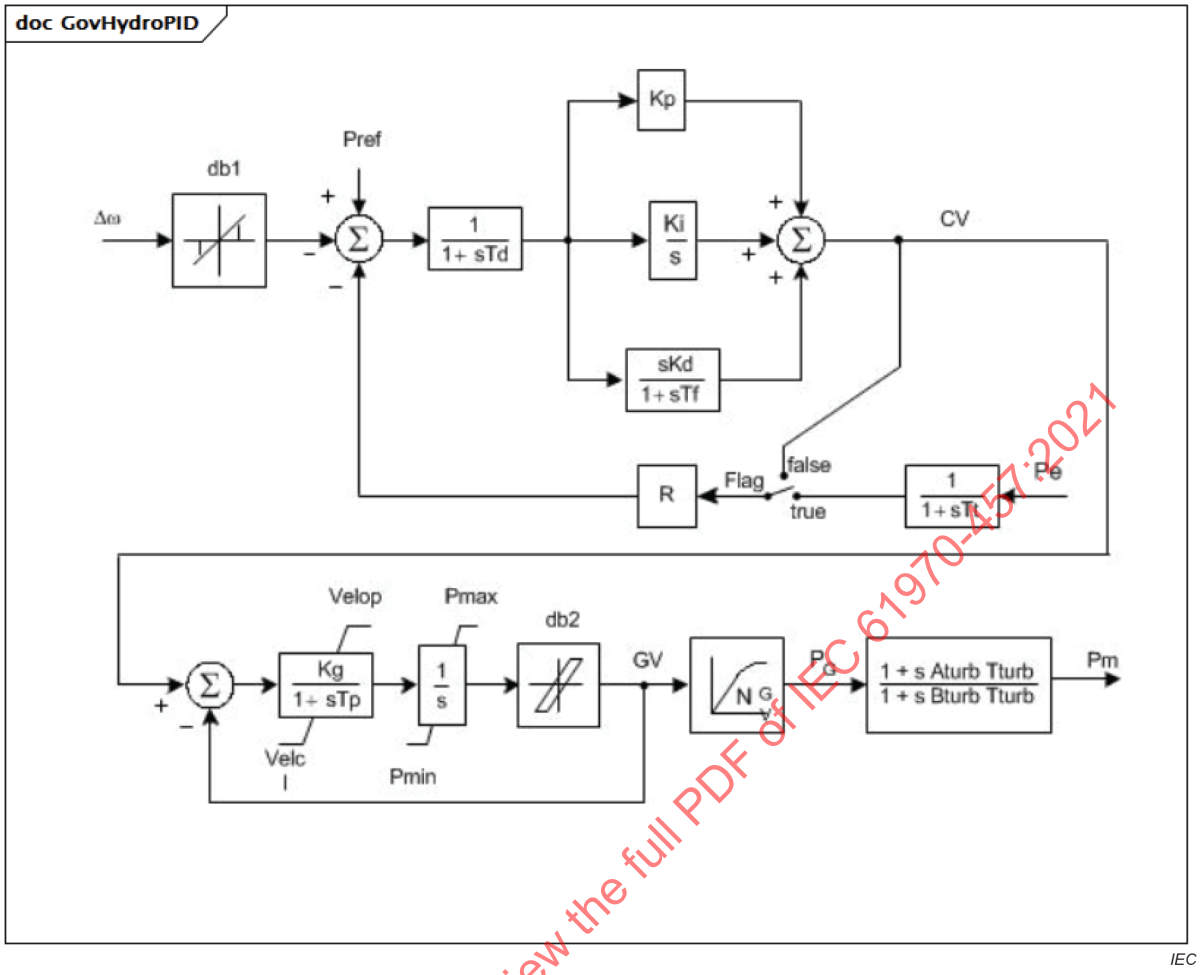


**Figure 76 – GovHydroPID**

Figure 76: This diagram describes the GovHydroPID turbine governor model.

Parameter details:

1) If Tf is zero, but Kd is not zero, Tf is set to a small value (4 times integration time step).
2) The nonlinear gain between gate position and power can be input with up to 6 points. The (0,0 , 0,0) and (1,0 , 1,0) points can be assumed. The output is not allowed to go beyond 0,0 and 1,0. However, if Pmax > 1, the input and output are scaled by Pmax. If Gv1 is a negative number or zero, the default hydro curve (between (0,0 , 0,0) and (1,0 , 1,0)) will be used.
3) For a hydro turbine, set Tturb = Tw (water starting time), set Aturb = -1 and Bturb = 0,5. For a diesel engine or two-shaft gas turbine, set Aturb = 0,8 and Bturb = 1 and Tturb = 1 s. For a small steam turbine with a non-reheat steam supply or a single- shaft gas turbine, set Aturb = 0 and Bturb = 1 and Tturb = 0 s.

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Table 112 shows all attributes of GovHydroPID.

**Table 112 – Attributes of TurbineGovernorDynamics::GovHydroPID**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| pmax | 1..1 | PU | Maximum gate opening, PU of MWbase (Pmax) (> GovHydroPID.pmin). Typical value = 1. |
| pmin | 1..1 | PU | Minimum gate opening, PU of MWbase (Pmin) (< GovHydroPID.pmax). Typical value = 0. |
| r | 1..1 | PU | Steady state droop (R). Typical value = 0,05. |
| td | 1..1 | Seconds | Input filter time constant (Td) (>= 0). If = 0, block is bypassed. Typical value = 0. |
| tf | 1..1 | Seconds | Washout time constant (Tf) (>= 0). Typical value = 0,1. |
| tp | 1..1 | Seconds | Gate servo time constant (Tp) (>= 0). If = 0, block is bypassed. Typical value = 0,35. |
| velop | 1..1 | Float | Maximum gate opening velocity (Velop). Unit = PU / s. Typical value = 0,09. |
| velcl | 1..1 | Float | Maximum gate closing velocity (Velcl). Unit = PU / s. Typical value = -0,14. |
| kd | 1..1 | PU | Derivative gain (Kd). Typical value = 1,11. |
| kp | 1..1 | PU | Proportional gain (Kp). Typical value = 0,1. |
| ki | 1..1 | PU | Integral gain (Ki). Typical value = 0,36. |
| kg | 1..1 | PU | Gate servo gain (Kg). Typical value = 2,5. |
| tturb | 1..1 | Seconds | Turbine time constant (Tturb) (>= 0). See Parameter detail 3. Typical value = 0,8. |
| aturb | 1..1 | PU | Turbine numerator multiplier (Aturb) (see parameter detail 3). Typical value -1. |
| bturb | 1..1 | PU | Turbine denominator multiplier (Bturb) (see parameter detail 3). Typical value = 0,5. |
| tt | 1..1 | Seconds | Power feedback time constant (Tt) (>= 0). If = 0, block is bypassed. Typical value = 0,02. |
| db1 | 1..1 | Frequency | Intentional dead-band width (db1). Unit = Hz. Typical value = 0. |
| inputSignal | 1..1 | Boolean | Input signal switch (Flag).<br>true = Pe input is used<br>false = feedback is received from CV.<br>Flag is normally dependent on Tt. If Tt is zero, Flag is set to false. If Tt is not zero, Flag is set to true.<br>Typical value = true. |
| eps | 1..1 | Frequency | Intentional db hysteresis (eps). Unit = Hz. Typical value = 0. |
| db2 | 1..1 | ActivePower | Unintentional dead-band (db2). Unit = MW. Typical value = 0. |
| gv1 | 1..1 | PU | Nonlinear gain point 1, PU gv (Gv1). Typical value = 0. |
| pgv1 | 1..1 | PU | Nonlinear gain point 1, PU power (Pgv1). Typical value = 0. |
| gv2 | 1..1 | PU | Nonlinear gain point 2, PU gv (Gv2). Typical value = 0. |
| pgv2 | 1..1 | PU | Nonlinear gain point 2, PU power (Pgv2). Typical value = 0. |

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| name | mult | type | description |
|---|---|---|---|
| gv3 | 1..1 | PU | Nonlinear gain point 3, PU gv (Gv3). Typical value = 0. |
| pgv3 | 1..1 | PU | Nonlinear gain point 3, PU power (Pgv3). Typical value = 0. |
| gv4 | 1..1 | PU | Nonlinear gain point 4, PU gv (Gv4). Typical value = 0. |
| pgv4 | 1..1 | PU | Nonlinear gain point 4, PU power (Pgv4). Typical value = 0. |
| gv5 | 1..1 | PU | Nonlinear gain point 5, PU gv (Gv5). Typical value = 0. |
| pgv5 | 1..1 | PU | Nonlinear gain point 5, PU power (Pgv5). Typical value = 0. |
| gv6 | 1..1 | PU | Nonlinear gain point 6, PU gv (Gv6). Typical value = 0. |
| pgv6 | 1..1 | PU | Nonlinear gain point 6, PU power (Pgv6). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 113 shows all association ends of GovHydroPID with other classes.

**Table 113 – Association ends of TurbineGovernorDynamics:: GovHydroPID with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.23 GovHydroPID2

Hydro turbine and governor. Represents plants with straightforward penstock configurations and "three term" electro-hydraulic governors (i.e. Woodward™[2] electronic).

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2 Woodward electronic governors are an example of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of these products.

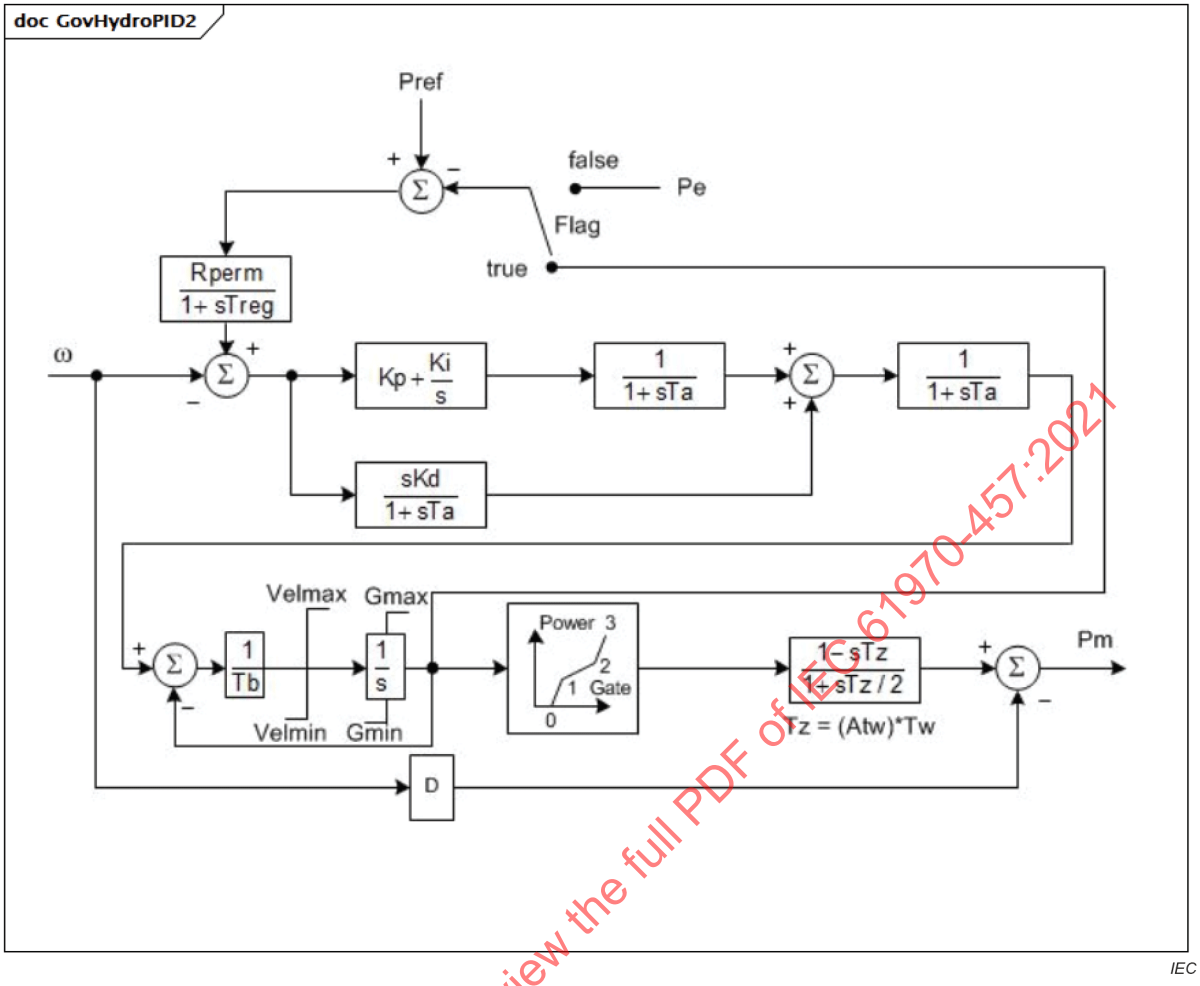


**Figure 77 – GovHydroPID2**

Figure 77: This diagram describes the GovHydroPID2 turbine governor model.

Parameter details:

1) The gates travel over a range of 1,0 PU from fully closed to fully opened. The gates are at a position greater than zero at zero power and, normally, less than 1,0 when power is 1,0 PU.
2) G0, G1, P1, G2, P2, and P3 specify the variation of power with gate G2 > G1 > G0.
3) This model uses a simplified turbine-penstock model that does not account for the variation of the water inertia effect with gate opening. To make this model correspond to other models using the "classical" turbine-penstock model, set Atw to unity. To approximate water inertia effects at part load, Atw can be set to the PU gate opening about which perturbations are centred.

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Table 114 shows all attributes of GovHydroPID2.

**Table 114 – Attributes of TurbineGovernorDynamics::GovHydroPID2**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (>0). Unit = MW. |
| treg | 1..1 | Seconds | Speed detector time constant (Treg) (>= 0). Typical value = 0. |
| rperm | 1..1 | PU | Permanent drop (Rperm). Typical value = 0. |
| kp | 1..1 | PU | Proportional gain (Kp). Typical value = 0. |
| ki | 1..1 | Float | Reset gain (Ki). Unit = PU/s. Typical value = 0. |
| kd | 1..1 | PU | Derivative gain (Kd). Typical value = 0. |
| ta | 1..1 | Seconds | Controller time constant (Ta) (>= 0). Typical value = 0. |
| tb | 1..1 | Seconds | Gate servo time constant (Tb) (> 0). |
| velmax | 1..1 | Float | Maximum gate opening velocity (Velmax) (< GovHydroPID2.velmin). Unit = PU / s. Typical value = 0. |
| velmin | 1..1 | Float | Maximum gate closing velocity (Velmin) (> GovHydroPID2.velmax). Unit = PU / s. Typical value = 0. |
| gmax | 1..1 | PU | Maximum gate opening (Gmax) (> GovHydroPID2.gmin). Typical value = 0. |
| gmin | 1..1 | PU | Minimum gate opening (Gmin) (> GovHydroPID2.gmax). Typical value = 0. |
| tw | 1..1 | Seconds | Water inertia time constant (Tw) (>= 0). Typical value = 0. |
| d | 1..1 | PU | Turbine damping factor (D). Unit = delta P / delta speed. Typical value = 0. |
| g0 | 1..1 | PU | Gate opening at speed no load (G0). Typical value = 0. |
| g1 | 1..1 | PU | Intermediate gate opening (G1). Typical value = 0. |
| p1 | 1..1 | PU | Power at gate opening G1 (P1). Typical value = 0. |
| g2 | 1..1 | PU | Intermediate gate opening (G2). Typical value = 0. |
| p2 | 1..1 | PU | Power at gate opening G2 (P2). Typical value = 0. |
| p3 | 1..1 | PU | Power at full opened gate (P3). Typical value = 0. |
| atw | 1..1 | PU | Factor multiplying Tw (Atw). Typical value = 0. |
| feedbackSignal | 1..1 | Boolean | Feedback signal type flag (Flag).<br>true = use gate position feedback signal<br>false = use Pe. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 115 shows all association ends of GovHydroPID2 with other classes.

**Table 115 – Association ends of TurbineGovernorDynamics:: GovHydroPID2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.24 GovHydroR

Fourth order lead-lag governor and hydro turbine.

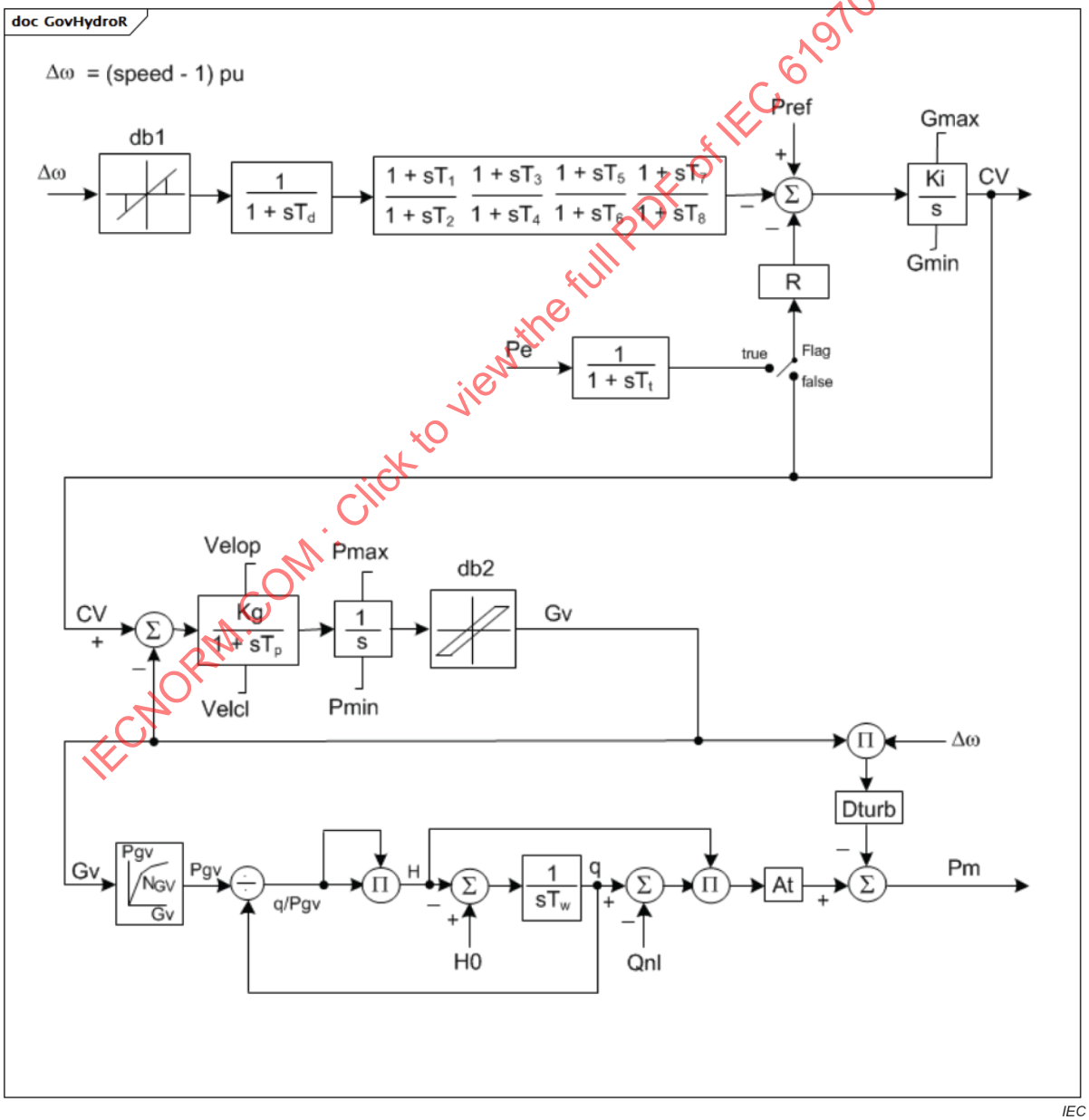


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**Figure 78 – GovHydroR**

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Figure 78: This diagram describes the GovHydroR turbine governor model.

Parameter details:

1) The nonlinear gain between gate position and power can be input with up to 6 points. The (0,0 , 0,0) and (1,0 , 1,0) points can be assumed. The output is not allowed to go beyond 0,0 and 1,0. However, if Pmax > 1,0, the input and output are scaled by Pmax. If Gv1 is a negative number or zero, the default hydro curve (between (0,0 , 0,0) and (1,0 , 1,0)) will be used.

Table 116 shows all attributes of GovHydroR.

**Table 116 – Attributes of TurbineGovernorDynamics::GovHydroR**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| pmax | 1..1 | PU | Maximum gate opening, PU of MWbase (Pmax) (> GovHydroR.pmin). Typical value = 1. |
| pmin | 1..1 | PU | Minimum gate opening, PU of MWbase (Pmin) (< GovHydroR.pmax). Typical value = 0. |
| r | 1..1 | PU | Steady-state droop (R). Typical value = 0,05. |
| td | 1..1 | Seconds | Input filter time constant (Td) (>= 0). Typical value = 0,05. |
| t1 | 1..1 | Seconds | Lead time constant 1 (T1) (>= 0). Typical value = 1,5. |
| t2 | 1..1 | Seconds | Lag time constant 1 (T2) (>= 0). Typical value = 0,1. |
| t3 | 1..1 | Seconds | Lead time constant 2 (T3) (>= 0). Typical value = 1,5. |
| t4 | 1..1 | Seconds | Lag time constant 2 (T4) (>= 0). Typical value = 0,1. |
| t5 | 1..1 | Seconds | Lead time constant 3 (T5) (>= 0). Typical value = 0. |
| t6 | 1..1 | Seconds | Lag time constant 3 (T6) (>= 0). Typical value = 0,05. |
| t7 | 1..1 | Seconds | Lead time constant 4 (T7) (>= 0). Typical value = 0. |
| t8 | 1..1 | Seconds | Lag time constant 4 (T8) (>= 0). Typical value = 0,05. |
| tp | 1..1 | Seconds | Gate servo time constant (Tp) (>= 0). Typical value = 0,05. |
| velop | 1..1 | Float | Maximum gate opening velocity (Velop). Unit = PU / s. Typical value = 0,2. |
| velcl | 1..1 | Float | Maximum gate closing velocity (Velcl). Unit = PU / s. Typical value = -0,2. |
| ki | 1..1 | PU | Integral gain (Ki). Typical value = 0,5. |
| kg | 1..1 | PU | Gate servo gain (Kg). Typical value = 2. |
| gmax | 1..1 | PU | Maximum governor output (Gmax) (> GovHydroR.gmin). Typical value = 1,05. |
| gmin | 1..1 | PU | Minimum governor output (Gmin) (< GovHydroR.gmax). Typical value = -0,05. |
| tt | 1..1 | Seconds | Power feedback time constant (Tt) (>= 0). Typical value = 0. |

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| name | mult | type | description |
|---|---|---|---|
| inputSignal | 1..1 | Boolean | Input signal switch (Flag).<br>true = Pe input is used<br>false = feedback is received from CV.<br>Flag is normally dependent on Tt. If Tt is zero, Flag is set to false. If Tt is not zero, Flag is set to true.<br>Typical value = true. |
| db1 | 1..1 | Frequency | Intentional dead-band width (db1). Unit = Hz. Typical value = 0. |
| eps | 1..1 | Frequency | Intentional db hysteresis (eps). Unit = Hz. Typical value = 0. |
| db2 | 1..1 | ActivePower | Unintentional dead-band (db2). Unit = MW. Typical value = 0. |
| tw | 1..1 | Seconds | Water inertia time constant (Tw) (> 0). Typical value = 1. |
| at | 1..1 | PU | Turbine gain (At). Typical value = 1,2. |
| dturb | 1..1 | PU | Turbine damping factor (Dturb). Typical value = 0,2. |
| qnl | 1..1 | PU | No-load turbine flow at nominal head (Qnl). Typical value = 0,08. |
| h0 | 1..1 | PU | Turbine nominal head (H0). Typical value = 1. |
| gv1 | 1..1 | PU | Nonlinear gain point 1, PU gv (Gv1). Typical value = 0. |
| pgv1 | 1..1 | PU | Nonlinear gain point 1, PU power (Pgv1). Typical value = 0. |
| gv2 | 1..1 | PU | Nonlinear gain point 2, PU gv (Gv2). Typical value = 0. |
| pgv2 | 1..1 | PU | Nonlinear gain point 2, PU power (Pgv2). Typical value = 0. |
| gv3 | 1..1 | PU | Nonlinear gain point 3, PU gv (Gv3). Typical value = 0. |
| pgv3 | 1..1 | PU | Nonlinear gain point 3, PU power (Pgv3). Typical value = 0. |
| gv4 | 1..1 | PU | Nonlinear gain point 4, PU gv (Gv4). Typical value = 0. |
| pgv4 | 1..1 | PU | Nonlinear gain point 4, PU power (Pgv4). Typical value = 0. |
| gv5 | 1..1 | PU | Nonlinear gain point 5, PU gv (Gv5). Typical value = 0. |
| pgv5 | 1..1 | PU | Nonlinear gain point 5, PU power (Pgv5). Typical value = 0. |
| gv6 | 1..1 | PU | Nonlinear gain point 6, PU gv (Gv6). Typical value = 0. |
| pgv6 | 1..1 | PU | Nonlinear gain point 6, PU power (Pgv6). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 117 shows all association ends of GovHydroR with other classes.

**Table 117 – Association ends of TurbineGovernorDynamics:: GovHydroR with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.25 GovHydroWEH

Woodward™[3] electric hydro governor.

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3 Woodward electric hydro governors are an example of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of these products.

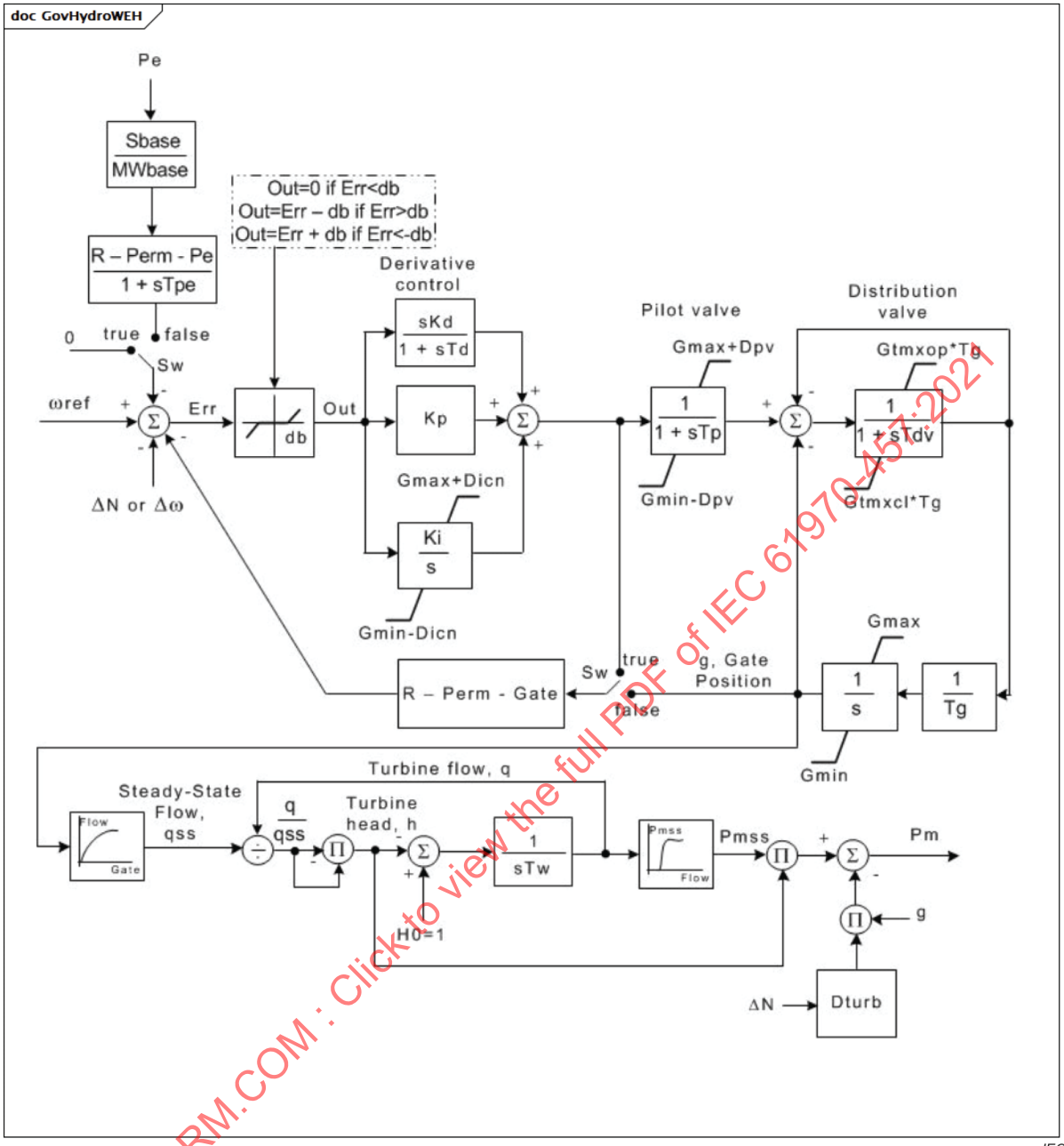


**Figure 79 – GovHydroWEH**

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Figure 79: This diagram describes the GovHydroWEH turbine governor model.

Parameter details:

1) The nonlinear relationship between gate position and water flow can be input with up to 5 points specified by pairs of .gvn and .fln attributes.
2) The nonlinear relationship between turbine flow and mechanical power output (on machine MVA rating) can be input with up to 10 points specified by pairs of .fpn and .pmssn attributes.

Table 118 shows all attributes of GovHydroWEH.

**Table 118 – Attributes of TurbineGovernorDynamics::GovHydroWEH**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| rpg | 1..1 | Float | Permanent droop for governor output feedback (R-Perm-Gate). |
| rpp | 1..1 | Float | Permanent droop for electrical power feedback (R-Perm-Pe). |
| tpe | 1..1 | Seconds | Electrical power droop time constant (Tpe) (>= 0). |
| kp | 1..1 | PU | Derivative control gain (Kp). |
| ki | 1..1 | PU | Derivative controller Integral gain (Ki). |
| kd | 1..1 | PU | Derivative controller derivative gain (Kd). |
| td | 1..1 | Seconds | Derivative controller time constant (Td) (>= 0). Limits the derivative characteristic beyond a breakdown frequency to avoid amplification of high-frequency noise. |
| tp | 1..1 | Seconds | Pilot valve time lag time constant (Tp) (>= 0). |
| tdv | 1..1 | Seconds | Distributive valve time lag time constant (Tdv) (>= 0). |
| tg | 1..1 | Seconds | Value to allow the distribution valve controller to advance beyond the gate movement rate limit (Tg) (>= 0). |
| gtmxop | 1..1 | PU | Maximum gate opening rate (Gtmxop). |
| gtmxcl | 1..1 | PU | Maximum gate closing rate (Gtmxcl). |
| gmax | 1..1 | PU | Maximum gate position (Gmax) (> GovHydroWEH.gmin). |
| gmin | 1..1 | PU | Minimum gate position (Gmin) (< GovHydroWEH.gmax). |
| dturb | 1..1 | PU | Turbine damping factor (Dturb). Unit = delta P (PU of MWbase) / delta speed (PU). |
| tw | 1..1 | Seconds | Water inertia time constant (Tw) (> 0). |
| db | 1..1 | PU | Speed deadband (db). |
| dpv | 1..1 | PU | Value to allow the pilot valve controller to advance beyond the gate limits (Dpv). |
| dicn | 1..1 | PU | Value to allow the integral controller to advance beyond the gate limits (Dicn). |
| feedbackSignal | 1..1 | Boolean | Feedback signal selection (Sw).<br>true = PID output (if R-Perm-Gate = droop and R-Perm-Pe = 0)<br>false = electrical power (if R-Perm-Gate = 0 and R-Perm-Pe = droop) or<br>false = gate position (if R-Perm-Gate = droop and R-Perm-Pe = 0).<br>Typical value = false. |
| gv1 | 1..1 | PU | Gate 1 (Gv1). Gate Position value for point 1 for lookup table representing water flow through the turbine as a function of gate position to produce steady state flow. |
| gv2 | 1..1 | PU | Gate 2 (Gv2). Gate Position value for point 2 for lookup table representing water flow through the turbine as a function of gate position to produce steady state flow. |

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| name | mult | type | description |
|---|---|---|---|
| gv3 | 1..1 | PU | Gate 3 (Gv3). Gate Position value for point 3 for lookup table representing water flow through the turbine as a function of gate position to produce steady state flow. |
| gv4 | 1..1 | PU | Gate 4 (Gv4). Gate Position value for point 4 for lookup table representing water flow through the turbine as a function of gate position to produce steady state flow. |
| gv5 | 1..1 | PU | Gate 5 (Gv5). Gate Position value for point 5 for lookup table representing water flow through the turbine as a function of gate position to produce steady state flow. |
| fl1 | 1..1 | PU | Flowgate 1 (Fl1). Flow value for gate position point 1 for lookup table representing water flow through the turbine as a function of gate position to produce steady state flow. |
| fl2 | 1..1 | PU | Flowgate 2 (Fl2). Flow value for gate position point 2 for lookup table representing water flow through the turbine as a function of gate position to produce steady state flow. |
| fl3 | 1..1 | PU | Flowgate 3 (Fl3). Flow value for gate position point 3 for lookup table representing water flow through the turbine as a function of gate position to produce steady state flow. |
| fl4 | 1..1 | PU | Flowgate 4 (Fl4). Flow value for gate position point 4 for lookup table representing water flow through the turbine as a function of gate position to produce steady state flow. |
| fl5 | 1..1 | PU | Flowgate 5 (Fl5). Flow value for gate position point 5 for lookup table representing water flow through the turbine as a function of gate position to produce steady state flow. |
| fp1 | 1..1 | PU | Flow P1 (Fp1). Turbine flow value for point 1 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| fp2 | 1..1 | PU | Flow P2 (Fp2). Turbine flow value for point 2 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| fp3 | 1..1 | PU | Flow P3 (Fp3). Turbine flow value for point 3 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| fp4 | 1..1 | PU | Flow P4 (Fp4). Turbine flow value for point 4 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| fp5 | 1..1 | PU | Flow P5 (Fp5). Turbine flow value for point 5 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| fp6 | 1..1 | PU | Flow P6 (Fp6). Turbine flow value for point 6 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| fp7 | 1..1 | PU | Flow P7 (Fp7). Turbine flow value for point 7 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| fp8 | 1..1 | PU | Flow P8 (Fp8). Turbine flow value for point 8 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |

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| name | mult | type | description |
|---|---|---|---|
| fp9 | 1..1 | PU | Flow P9 (Fp9). Turbine flow value for point 9 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| fp10 | 1..1 | PU | Flow P10 (Fp10). Turbine flow value for point 10 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| pmss1 | 1..1 | PU | Pmss flow P1 (Pmss1). Mechanical power output for turbine flow point 1 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| pmss2 | 1..1 | PU | Pmss flow P2 (Pmss2). Mechanical power output for turbine flow point 2 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| pmss3 | 1..1 | PU | Pmss flow P3 (Pmss3). Mechanical power output for turbine flow point 3 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| pmss4 | 1..1 | PU | Pmss flow P4 (Pmss4). Mechanical power output for turbine flow point 4 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| pmss5 | 1..1 | PU | Pmss flow P5 (Pmss5). Mechanical power output for turbine flow point 5 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| pmss6 | 1..1 | PU | Pmss flow P6 (Pmss6). Mechanical power output for turbine flow point 6 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| pmss7 | 1..1 | PU | Pmss flow P7 (Pmss7). Mechanical power output for turbine flow point 7 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| pmss8 | 1..1 | PU | Pmss flow P8 (Pmss8). Mechanical power output for turbine flow point 8 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| pmss9 | 1..1 | PU | Pmss flow P9 (Pmss9). Mechanical power output for turbine flow point 9 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| pmss10 | 1..1 | PU | Pmss flow P10 (Pmss10). Mechanical power output for turbine flow point 10 for lookup table representing PU mechanical power on machine MVA rating as a function of turbine flow. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 119 shows all association ends of GovHydroWEH with other classes.

**Table 119 – Association ends of TurbineGovernorDynamics:: GovHydroWEH with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.26 GovHydroWPID

Woodward™[4] PID hydro governor.

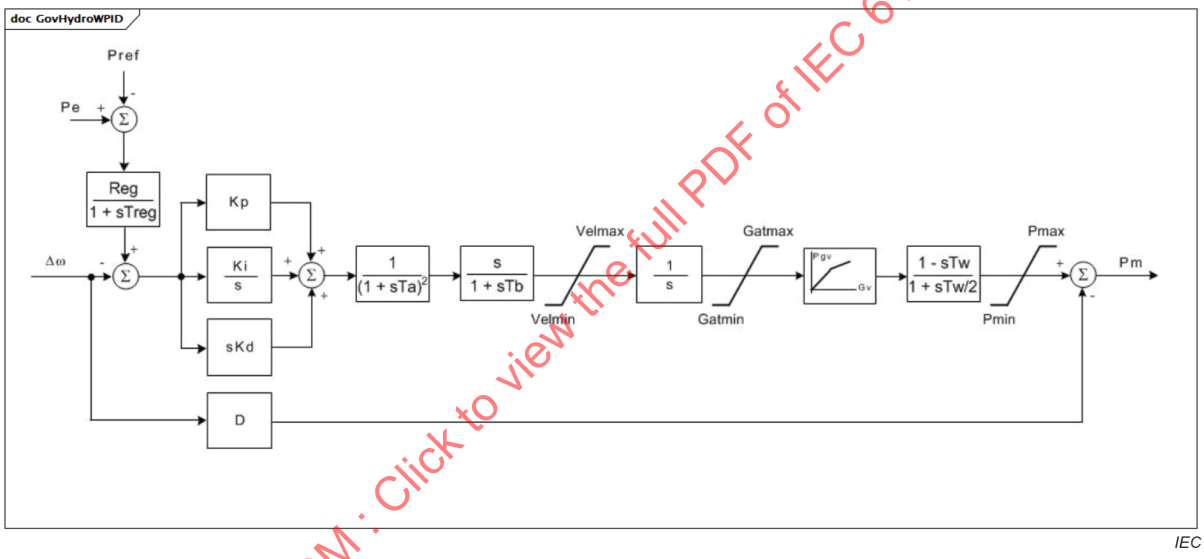


**Figure 80 – GovHydroWPID**

Figure 80: This diagram describes the GovHydroWPID turbine governor model.

Parameter details:

1) The nonlinear gain between gate position and power can be input with up to 3 points. The (0,0, 0,0) point can be assumed. In this model, Gv3 = 1,0 and the output is not allowed to go above 1,0. However, if Pmax > 1,0, the input and output are scaled by Pmax. If Gv1 is a negative number or zero, the default hydro curve (between (0,0, 0,0) and (1,0, 1,0)) will be used.

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4 Woodward electric hydro governors are an example of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of these products.

Table 120 shows all attributes of GovHydroWPID.

**Table 120 – Attributes of TurbineGovernorDynamics::GovHydroWPID**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| treg | 1..1 | Seconds | Speed detector time constant (Treg) (>= 0). |
| reg | 1..1 | PU | Permanent drop (Reg). |
| kp | 1..1 | PU | Proportional gain (Kp). Typical value = 0,1. |
| ki | 1..1 | PU | Reset gain (Ki). Typical value = 0,36. |
| kd | 1..1 | PU | Derivative gain (Kd). Typical value = 1,11. |
| ta | 1..1 | Seconds | Controller time constant (Ta) (>= 0). Typical value = 0. |
| tb | 1..1 | Seconds | Gate servo time constant (Tb) (>= 0). Typical value = 0. |
| velmax | 1..1 | PU | Maximum gate opening velocity (Velmax) (> GovHydroWPID.velmin). Unit = PU / s. Typical value = 0. |
| velmin | 1..1 | PU | Maximum gate closing velocity (Velmin) (< GovHydroWPID.velmax). Unit = PU / s. Typical value = 0. |
| gatmax | 1..1 | PU | Gate opening limit maximum (Gatmax) (> GovHydroWPID.gatmin). |
| gatmin | 1..1 | PU | Gate opening limit minimum (Gatmin) (< GovHydroWPID.gatmax). |
| tw | 1..1 | Seconds | Water inertia time constant (Tw) (>= 0). Typical value = 0. |
| pmax | 1..1 | PU | Maximum power output (Pmax) (> GovHydroWPID.pmin). |
| pmin | 1..1 | PU | Minimum power output (Pmin) (< GovHydroWPID.pmax). |
| d | 1..1 | PU | Turbine damping factor (D). Unit = delta P / delta speed. |
| gv3 | 1..1 | PU | Gate position 3 (Gv3) (= 1,0). |
| gv1 | 1..1 | PU | Gate position 1 (Gv1). |
| pgv1 | 1..1 | PU | Output at Gv1 PU of MWbase (Pgv1). |
| gv2 | 1..1 | PU | Gate position 2 (Gv2). |
| pgv2 | 1..1 | PU | Output at Gv2 PU of MWbase (Pgv2). |
| pgv3 | 1..1 | PU | Output at Gv3 PU of MWbase (Pgv3). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 121 shows all association ends of GovHydroWPID with other classes.

**Table 121 – Association ends of TurbineGovernorDynamics:: GovHydroWPID with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.27 GovSteam0

A simplified steam turbine governor.

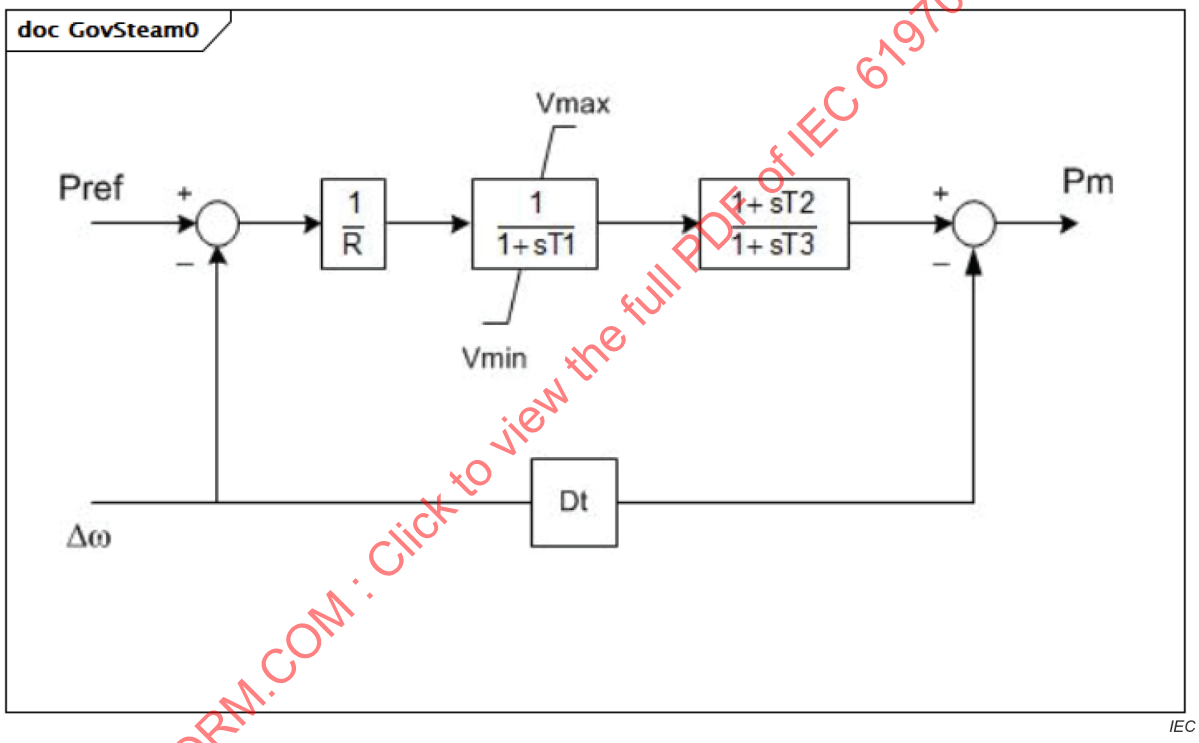


**Figure 81 – GovSteam0**

Figure 81: This diagram describes the GovSteam0 turbine governor model.

Parameter details:

1) To represent a non-reheat turbine set T2= 0 and T3 to about 0,5 s. For reheat turbine, set T2 = T3 x (HP turbine fraction).

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Table 122 shows all attributes of GovSteam0.

**Table 122 – Attributes of TurbineGovernorDynamics::GovSteam0**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| r | 1..1 | PU | Permanent droop (R). Typical value = 0,05. |
| t1 | 1..1 | Seconds | Steam bowl time constant (T1) (> 0). Typical value = 0,5. |
| vmax | 1..1 | PU | Maximum valve position, PU of mwcap (Vmax) (> GovSteam0.vmin). Typical value = 1. |
| vmin | 1..1 | PU | Minimum valve position, PU of mwcap (Vmin) (< GovSteam0.vmax). Typical value = 0. |
| t2 | 1..1 | Seconds | Numerator time constant of T2/T3 block (T2) (>= 0). Typical value = 3. |
| t3 | 1..1 | Seconds | Reheater time constant (T3) (> 0). Typical value = 10. |
| dt | 1..1 | PU | Turbine damping coefficient (Dt). Unit = delta P / delta speed. Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 123 shows all association ends of GovSteam0 with other classes.

**Table 123 – Association ends of TurbineGovernorDynamics:: GovSteam0 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.28 GovSteam1

Steam turbine governor, based on the GovSteamIEEE1 (with optional deadband and nonlinear valve gain added).

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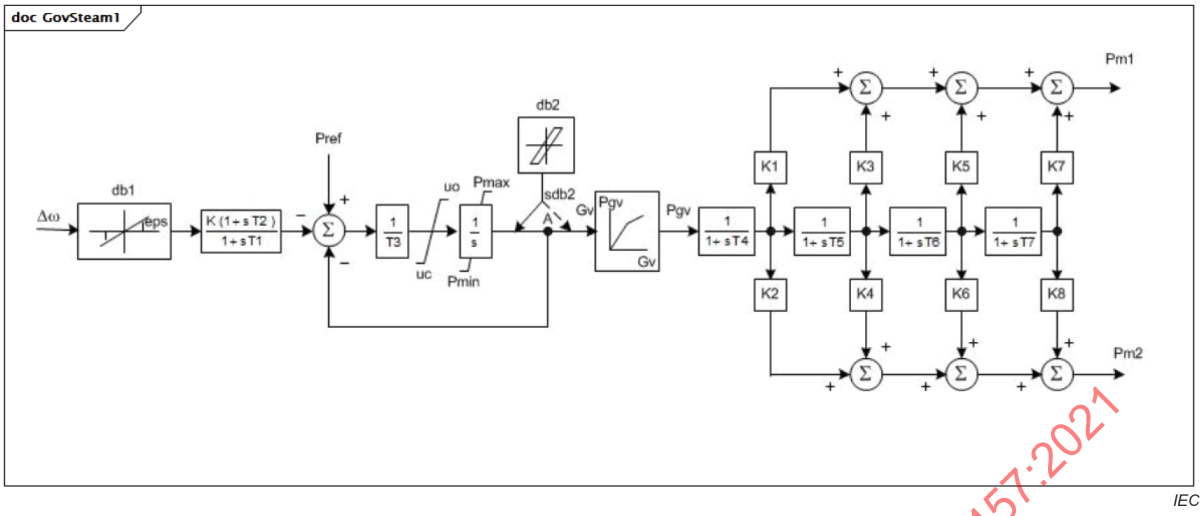


**Figure 82 – GovSteam1**

Figure 82: This diagram describes the GovSteam1 turbine governor model.

Parameter details:

1) PU parameters are on base of MWbase, which is normally the MW capability of the turbine.
2) For a tandem-compound turbine, the parameters K2, K4, K6, and K8 are ignored. For a cross-compound turbine, two generators are connected to this turbine-governor model.
3) Each generator shall be represented in the load flow by data on its own MVA base. The values of K1, K3, K5, and K7 shall be specified to describe the proportionate development of power on the first turbine shaft. K2, K4, K6, and K8 shall describe the second turbine shaft. Normally K1 + K3 + K5 + K7 = 1,0 and K2 + K4 + K6 + K8 = 1,0 (if second generator is present).
4) The division of power between the two shafts is in proportion to the values of MVA bases of the two generators. The initial condition load flow should, therefore, have the two generators loaded to the same fraction of each one's MVA base.
5) The intentional input speed deadband follows the relationship shown in the GovSteamIEEE1InputSpeedDeadband diagram.
6) The unintentional deadband can be used to represent backlash hysteresis in the control components by the relationship shown in the GovSteamIEEE1BacklashHysteresis diagram.
7) The nonlinear gain between gate position and power can be input with up to 6 points. The (0,0, 0,0) and (1,0, 1,0) points can be assumed. The output is not allowed to go beyond 0,0 and 1,0. However, if Pmax > 1,0, the input and output are scaled by Pmax. If Gv1 is a negative number or zero, the default curve (between (0,0, 0,0) and (1,0, 1,0)) will be used.

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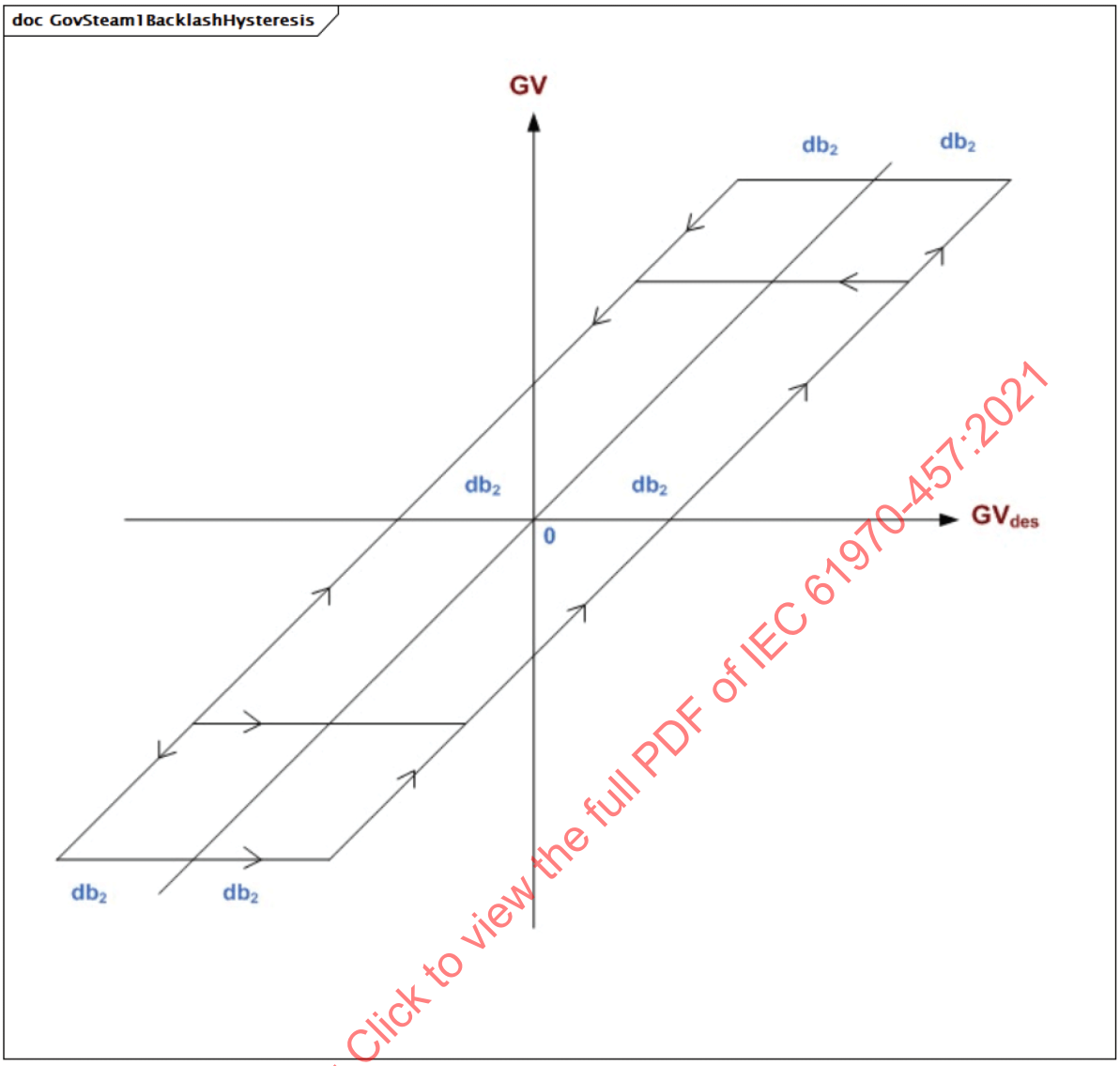


**Figure 83 – GovSteam1BacklashHysteresis**

Figure 83: This diagram illustrates the backlash hysteresis.

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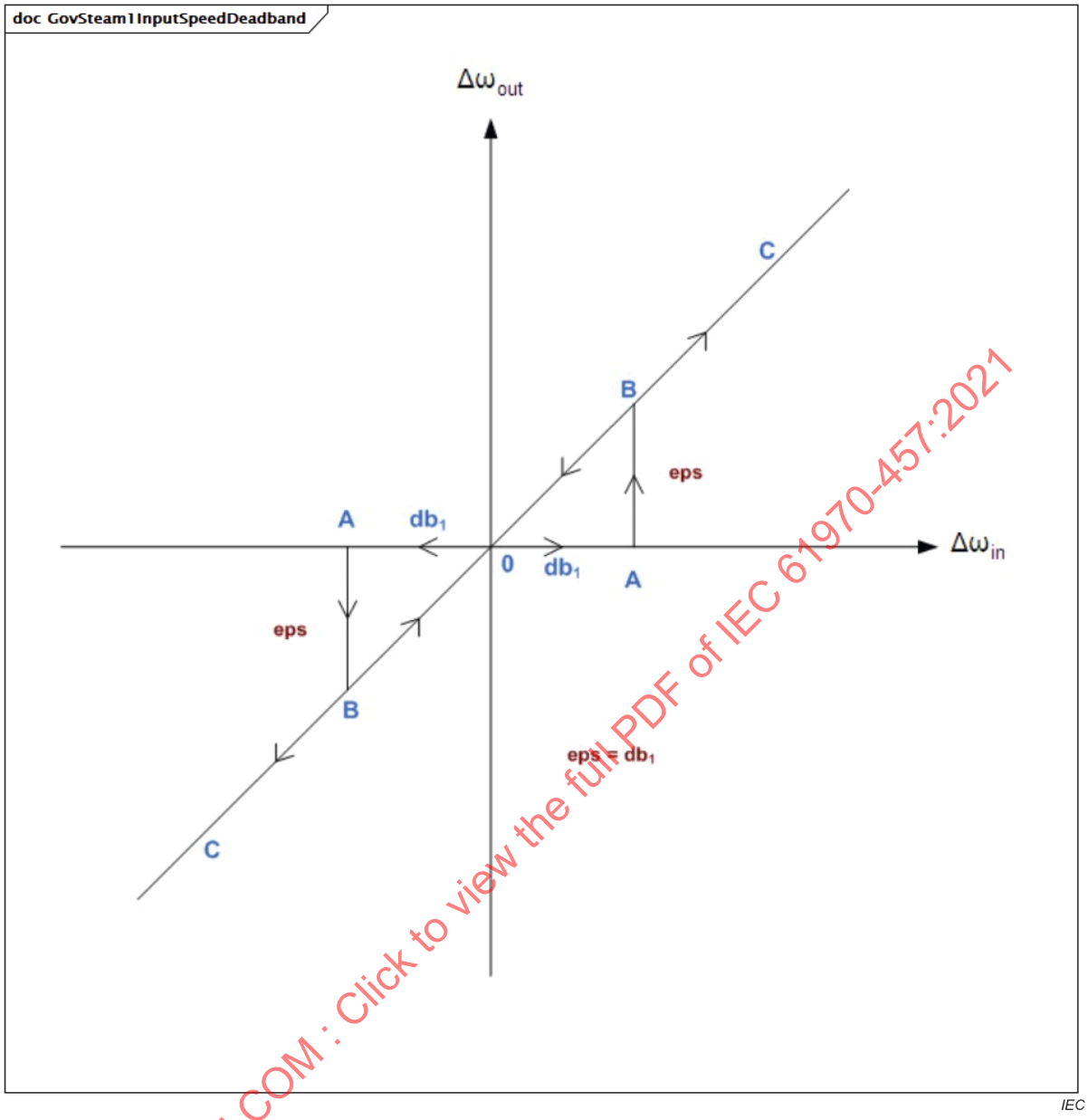


**Figure 84 – GovSteam1InputSpeedDeadband**

Figure 84: This diagram illustrates the input speed deadband.

Table 124 shows all attributes of GovSteam1.

**Table 124 – Attributes of TurbineGovernorDynamics::GovSteam1**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| k | 1..1 | PU | Governor gain (reciprocal of droop) (K) (> 0). Typical value = 25. |
| t1 | 1..1 | Seconds | Governor lag time constant (T1) (>= 0). Typical value = 0. |
| t2 | 1..1 | Seconds | Governor lead time constant (T2) (>= 0). Typical value = 0. |

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| name | mult | type | description |
|---|---|---|---|
| t3 | 1..1 | Seconds | Valve positioner time constant (T3) (> 0). Typical value = 0,1. |
| uo | 1..1 | Float | Maximum valve opening velocity (Uo) (> 0). Unit = PU / s. Typical value = 1. |
| uc | 1..1 | Float | Maximum valve closing velocity (Uc) (< 0). Unit = PU / s. Typical value = -10. |
| pmax | 1..1 | PU | Maximum valve opening (Pmax) (> GovSteam1.pmin). Typical value = 1. |
| pmin | 1..1 | PU | Minimum valve opening (Pmin) (>= 0 and < GovSteam1.pmax). Typical value = 0. |
| t4 | 1..1 | Seconds | Inlet piping/steam bowl time constant (T4) (>= 0). Typical value = 0,3. |
| k1 | 1..1 | Float | Fraction of HP shaft power after first boiler pass (K1). Typical value = 0,2. |
| k2 | 1..1 | Float | Fraction of LP shaft power after first boiler pass (K2). Typical value = 0. |
| t5 | 1..1 | Seconds | Time constant of second boiler pass (T5) (>= 0). Typical value = 5. |
| k3 | 1..1 | Float | Fraction of HP shaft power after second boiler pass (K3). Typical value = 0,3. |
| k4 | 1..1 | Float | Fraction of LP shaft power after second boiler pass (K4). Typical value = 0. |
| t6 | 1..1 | Seconds | Time constant of third boiler pass (T6) (>= 0). Typical value = 0,5. |
| k5 | 1..1 | Float | Fraction of HP shaft power after third boiler pass (K5). Typical value = 0,5. |
| k6 | 1..1 | Float | Fraction of LP shaft power after third boiler pass (K6). Typical value = 0. |
| t7 | 1..1 | Seconds | Time constant of fourth boiler pass (T7) (>= 0). Typical value = 0. |
| k7 | 1..1 | Float | Fraction of HP shaft power after fourth boiler pass (K7). Typical value = 0. |
| k8 | 1..1 | Float | Fraction of LP shaft power after fourth boiler pass (K8). Typical value = 0. |
| db1 | 1..1 | Frequency | Intentional deadband width (db1). Unit = Hz. Typical value = 0. |
| eps | 1..1 | Frequency | Intentional db hysteresis (eps). Unit = Hz. Typical value = 0. |
| sdb1 | 1..1 | Boolean | Intentional deadband indicator.<br>true = intentional deadband is applied<br>false = intentional deadband is not applied.<br>Typical value = true. |
| sdb2 | 1..1 | Boolean | Unintentional deadband location.<br>true = intentional deadband is applied before point "A"<br>false = intentional deadband is applied after point "A".<br>Typical value = true. |
| db2 | 1..1 | ActivePower | Unintentional deadband (db2). Unit = MW. Typical value = 0. |

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| name | mult | type | description |
|---|---|---|---|
| valve | 1..1 | Boolean | Nonlinear valve characteristic.<br>true = nonlinear valve characteristic is used<br>false = nonlinear valve characteristic is not used.<br>Typical value = true. |
| gv1 | 1..1 | PU | Nonlinear gain valve position point 1 (GV1).<br>Typical value = 0. |
| pgv1 | 1..1 | PU | Nonlinear gain power value point 1 (Pgv1).<br>Typical value = 0. |
| gv2 | 1..1 | PU | Nonlinear gain valve position point 2 (GV2).<br>Typical value = 0,4. |
| pgv2 | 1..1 | PU | Nonlinear gain power value point 2 (Pgv2).<br>Typical value = 0,75. |
| gv3 | 1..1 | PU | Nonlinear gain valve position point 3 (GV3).<br>Typical value = 0,5. |
| pgv3 | 1..1 | PU | Nonlinear gain power value point 3 (Pgv3).<br>Typical value = 0,91. |
| gv4 | 1..1 | PU | Nonlinear gain valve position point 4 (GV4).<br>Typical value = 0,6. |
| pgv4 | 1..1 | PU | Nonlinear gain power value point 4 (Pgv4).<br>Typical value = 0,98. |
| gv5 | 1..1 | PU | Nonlinear gain valve position point 5 (GV5).<br>Typical value = 1. |
| pgv5 | 1..1 | PU | Nonlinear gain power value point 5 (Pgv5).<br>Typical value = 1. |
| gv6 | 1..1 | PU | Nonlinear gain valve position point 6 (GV6).<br>Typical value = 0. |
| pgv6 | 1..1 | PU | Nonlinear gain power value point 6 (Pgv6).<br>Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 125 shows all association ends of GovSteam1 with other classes.

**Table 125 – Association ends of TurbineGovernorDynamics:: GovSteam1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.29 GovSteam2

Simplified governor.

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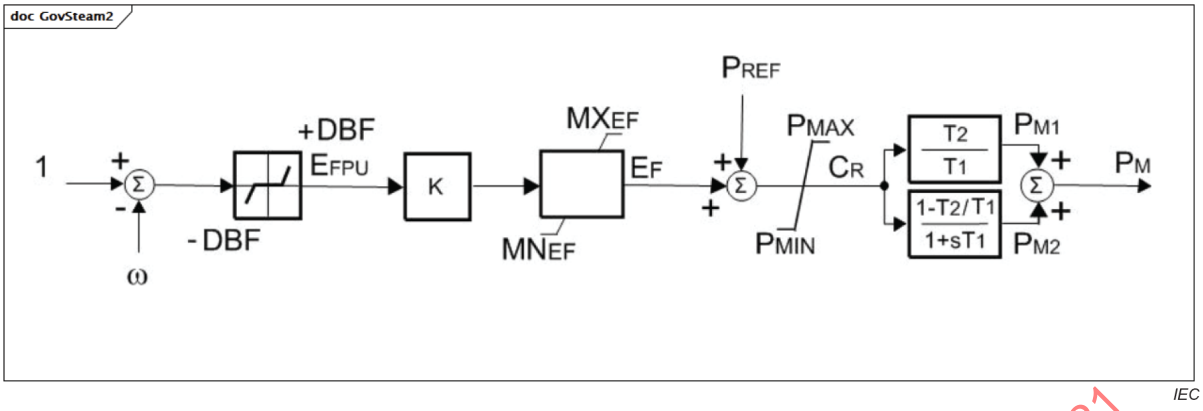


**Figure 85 – GovSteam2**

Figure 85: This diagram describes the GovSteam2 turbine governor model.

Parameter details:

1) PU parameters are on base of MW capability of the turbine.
2) This model can be used for both thermal and hydro power plants.
3) omega has units of per unit speed.

Table 126 shows all attributes of GovSteam2.

**Table 126 – Attributes of TurbineGovernorDynamics::GovSteam2**

| name | mult | type | description |
|---|---|---|---|
| k | 1..1 | Float | Governor gain (reciprocal of droop) (K). Typical value = 20. |
| dbf | 1..1 | PU | Frequency deadband (DBF). Typical value = 0. |
| t1 | 1..1 | Seconds | Governor lag time constant (T1) (> 0). Typical value = 0,45. |
| t2 | 1..1 | Seconds | Governor lead time constant (T2) (>= 0). Typical value = 0. |
| pmax | 1..1 | PU | Maximum fuel flow (PMAX) (> GovSteam2.pmin). Typical value = 1. |
| pmin | 1..1 | PU | Minimum fuel flow (PMIN) (< GovSteam2.pmax). Typical value = 0. |
| mxef | 1..1 | PU | Fuel flow maximum positive error value (MXEF). Typical value = 1. |
| mnef | 1..1 | PU | Fuel flow maximum negative error value (MNEF). Typical value = -1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 127 shows all association ends of GovSteam2 with other classes.

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**Table 127 – Association ends of TurbineGovernorDynamics:: GovSteam2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.30 GovSteamBB

European governor model.

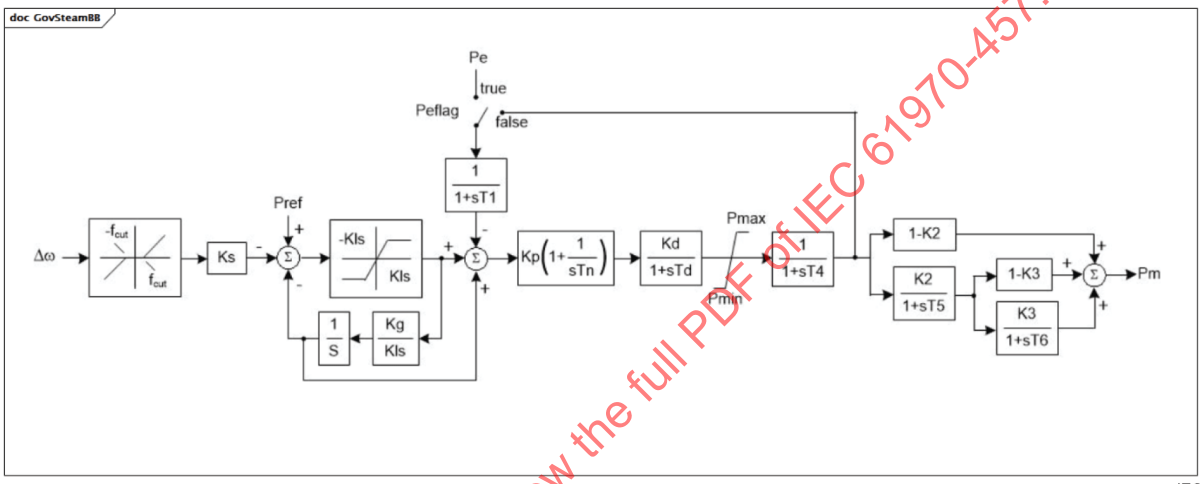


**Figure 86 – GovSteamBB**

Figure 86: This diagram describes the GovSteamBB turbine governor model.

Table 128 shows all attributes of GovSteamBB.

**Table 128 – Attributes of TurbineGovernorDynamics::GovSteamBB**

| name | mult | type | description |
|---|---|---|---|
| fcut | 1..1 | PU | Frequency deadband (fcut) (>= 0). Typical value = 0,002. |
| ks | 1..1 | PU | Gain (Ks). Typical value = 21,0. |
| kls | 1..1 | PU | Gain (Kls) (> 0). Typical value = 0,1. |
| kg | 1..1 | PU | Gain (Kg). Typical value = 1,0. |
| t1 | 1..1 | Seconds | Time constant (T1). Typical value = 0,05. |
| kp | 1..1 | PU | Gain (Kp). Typical value = 1,0. |
| tn | 1..1 | Seconds | Time constant (Tn) (> 0). Typical value = 1,0. |
| kd | 1..1 | PU | Gain (Kd). Typical value = 1,0. |
| td | 1..1 | Seconds | Time constant (Td) (> 0). Typical value = 1,0. |
| pmax | 1..1 | PU | High power limit (Pmax) (> GovSteamBB.pmin). Typical value = 1,0. |
| pmin | 1..1 | PU | Low power limit (Pmin) (< GovSteamBB.pmax). Typical value = 0. |

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| name | mult | type | description |
|---|---|---|---|
| t4 | 1..1 | Seconds | Time constant (T4). Typical value = 0,15. |
| k2 | 1..1 | PU | Gain (K2). Typical value = 0,75. |
| t5 | 1..1 | Seconds | Time constant (T5). Typical value = 12,0. |
| k3 | 1..1 | PU | Gain (K3). Typical value = 0,5. |
| t6 | 1..1 | Seconds | Time constant (T6). Typical value = 0,75. |
| peflag | 1..1 | Boolean | Electric power input selection (Peflag).<br>true = electric power input<br>false = feedback signal.<br>Typical value = false. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 129 shows all association ends of GovSteamBB with other classes.

**Table 129 – Association ends of TurbineGovernorDynamics:: GovSteamBB with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.31 GovSteamCC

Cross compound turbine governor. Unlike tandem compound units, cross compound units are not on the same shaft.

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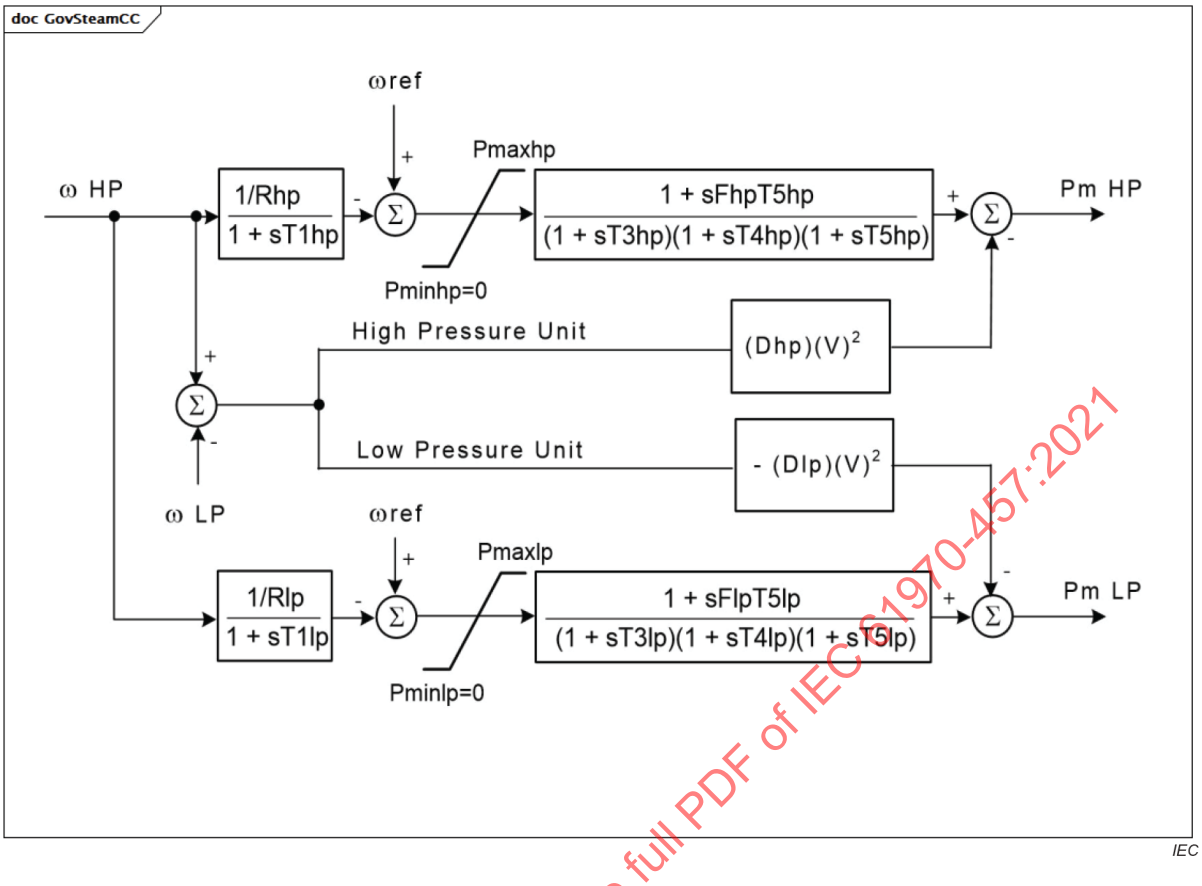


**Figure 87 – GovSteamCC**

Figure 87: This diagram describes the GovSteamCC turbine governor model.

Parameter details:

1) Both generators shall be present and in service.
2) Each generator shall be represented in the load flow by data stated on its own MVA base. The division of power between the two turbines is determined by the values of MWbase of the two generators, not by the values of Fhp and Flp.
3) The rotor speed reference values (omegaref) are the respective reference values of the units, each of which has its own separate shaft with each its own generator and exciter.
4) V is the terminal voltage.
5) Fhp and Flp can be used to represent the presence of dual reheat stages for a single turbine. If there is only one reheat stage, between the HP and LP turbines, Fhp and Flp should normally be unity and zero, respectively, and T5lp should be set to the reheater time constant.
6) Dhp and Dlp give a rough approximation of the damping of intermachine speed oscillations by electromagnetic effects. When the generators are represented by the round rotor model with proper values for subtransient time constants, this damping is represented accurately in the generator electrical torques and Dhp and Dlp should be set to zero.
7) If any of the time constants are zero, they are bypassed.

Table 130 shows all attributes of GovSteamCC.

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**Table 130 – Attributes of TurbineGovernorDynamics::GovSteamCC**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| pmaxhp | 1..1 | PU | Maximum HP value position (Pmaxhp). Typical value = 1. |
| rhp | 1..1 | PU | HP governor droop (Rhp) (> 0). Typical value = 0,05. |
| t1hp | 1..1 | Seconds | HP governor time constant (T1hp) (>= 0). Typical value = 0,1. |
| t3hp | 1..1 | Seconds | HP turbine time constant (T3hp) (>= 0). Typical value = 0,1. |
| t4hp | 1..1 | Seconds | HP turbine time constant (T4hp) (>= 0). Typical value = 0,1. |
| t5hp | 1..1 | Seconds | HP reheater time constant (T5hp) (>= 0). Typical value = 10. |
| fhp | 1..1 | PU | Fraction of HP power ahead of reheater (Fhp). Typical value = 0,3. |
| dhp | 1..1 | PU | HP damping factor (Dhp). Typical value = 0. |
| pmaxlp | 1..1 | PU | Maximum LP value position (Pmaxlp). Typical value = 1. |
| rlp | 1..1 | PU | LP governor droop (Rlp) (> 0). Typical value = 0,05. |
| t1lp | 1..1 | Seconds | LP governor time constant (T1lp) (>= 0). Typical value = 0,1. |
| t3lp | 1..1 | Seconds | LP turbine time constant (T3lp) (>= 0). Typical value = 0,1. |
| t4lp | 1..1 | Seconds | LP turbine time constant (T4lp) (>= 0). Typical value = 0,1. |
| t5lp | 1..1 | Seconds | LP reheater time constant (T5lp) (>= 0). Typical value = 10. |
| flp | 1..1 | PU | Fraction of LP power ahead of reheater (Flp). Typical value = 0,7. |
| dlp | 1..1 | PU | LP damping factor (Dlp). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 131 shows all association ends of GovSteamCC with other classes.

**Table 131 – Association ends of TurbineGovernorDynamics:: GovSteamCC with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | HighPressureSynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: CrossCompoundTurbineGovernorDynamics |
| 0..1 | LowPressureSynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: CrossCompoundTurbineGovernorDynamics |

#### 8.2.4.3.6.32 GovSteamEU

Simplified boiler and steam turbine with PID governor.

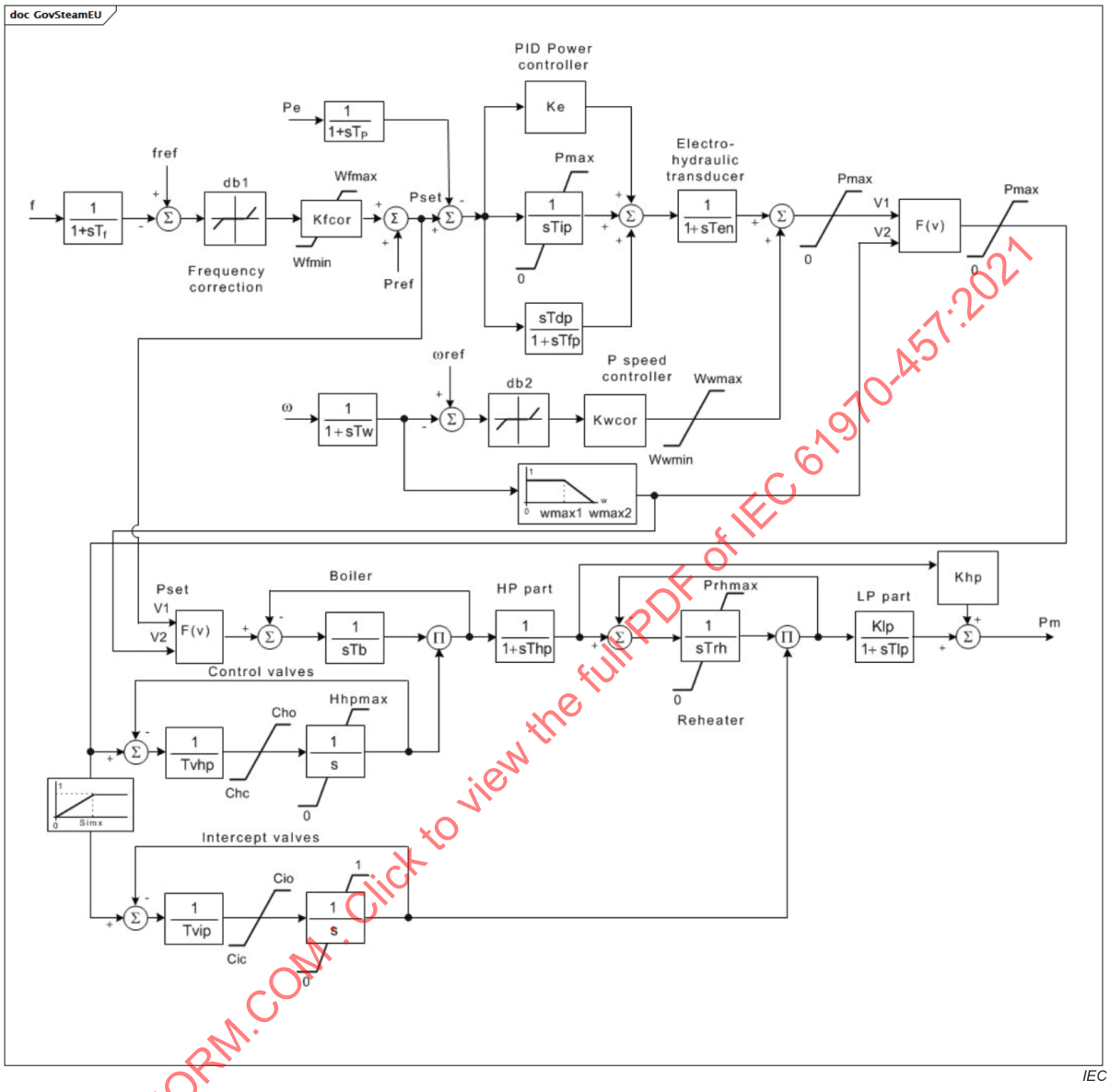


**Figure 88 – GovSteamEU**

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Figure 88: This diagram describes the GovSteamEU turbine governor model.

Parameter details:

1) PU parameters are on base of turbine MW capability MWbase.
2) To represent a non-reheat turbine, set Trh = 0 and Tlp to about 0,5 s.
3) F(v) is minimum value selection.
4) Frequency (f) is local (nodal) frequency.

Table 132 shows all attributes of GovSteamEU.

**Table 132 – Attributes of TurbineGovernorDynamics::GovSteamEU**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| tp | 1..1 | Seconds | Power transducer time constant (Tp) (>= 0). Typical value = 0,07. |
| ke | 1..1 | PU | Gain of the power controller (Ke). Typical value = 0,65. |
| tip | 1..1 | Seconds | Integral time constant of the power controller (Tip) (>= 0). Typical value = 2. |
| tdp | 1..1 | Seconds | Derivative time constant of the power controller (Tdp) (>= 0). Typical value = 0. |
| tfp | 1..1 | Seconds | Time constant of the power controller (Tfp) (>= 0). Typical value = 0. |
| tf | 1..1 | Seconds | Frequency transducer time constant (Tf) (>= 0). Typical value = 0. |
| kfcor | 1..1 | PU | Gain of the frequency corrector (Kfcor). Typical value = 20. |
| db1 | 1..1 | PU | Deadband of the frequency corrector (db1). Typical value = 0. |
| wfmax | 1..1 | PU | Upper limit for frequency correction (Wfmax) (> GovSteamEU.wfmin). Typical value = 0,05. |
| wfmin | 1..1 | PU | Lower limit for frequency correction (Wfmin) (< GovSteamEU.wfmax). Typical value = -0,05. |
| pmax | 1..1 | PU | Maximal active power of the turbine (Pmax). Typical value = 1. |
| ten | 1..1 | Seconds | Electro hydraulic transducer (Ten) (>= 0). Typical value = 0,1. |
| tw | 1..1 | Seconds | Speed transducer time constant (Tw) (>= 0). Typical value = 0,02. |
| komegacor | 1..1 | PU | Gain of the speed governor (Kwcor). Typical value = 20. |
| db2 | 1..1 | PU | Deadband of the speed governor (db2). Typical value = 0,0004. |
| wwmax | 1..1 | PU | Upper limit for the speed governor (Wwmax) (> GovSteamEU.wwmin). Typical value = 0,1. |
| wwmin | 1..1 | PU | Lower limit for the speed governor frequency correction (Wwmin) (< GovSteamEU.wwmax). Typical value = -1. |
| wmax1 | 1..1 | PU | Emergency speed control lower limit (wmax1). Typical value = 1,025. |
| wmax2 | 1..1 | PU | Emergency speed control upper limit (wmax2). Typical value = 1,05. |
| tvhp | 1..1 | Seconds | Control valves servo time constant (Tvhp) (>= 0). Typical value = 0,1. |
| cho | 1..1 | Float | Control valves rate opening limit (Cho). Unit = PU / s. Typical value = 0,17. |
| chc | 1..1 | Float | Control valves rate closing limit (Chc). Unit = PU / s. Typical value = -3,3. |
| hhpmax | 1..1 | PU | Maximum control valve position (Hhpmax). Typical value = 1. |
| tvip | 1..1 | Seconds | Intercept valves servo time constant (Tvip) (>= 0). Typical value = 0,15. |
| cio | 1..1 | PU | Intercept valves rate opening limit (Cio). Typical value = 0,123. |

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| name | mult | type | description |
|---|---|---|---|
| cic | 1..1 | PU | Intercept valves rate closing limit (Cic). Typical value = -2,2. |
| simx | 1..1 | PU | Intercept valves transfer limit (Simx). Typical value = 0,425. |
| thp | 1..1 | Seconds | High pressure (HP) time constant of the turbine (Thp) (>= 0). Typical value = 0,31. |
| trh | 1..1 | Seconds | Reheater time constant of the turbine (Trh) (>= 0). Typical value = 8. |
| tlp | 1..1 | Seconds | Low pressure (LP) time constant of the turbine (Tlp) (>= 0). Typical value = 0,45. |
| prhmax | 1..1 | PU | Maximum low pressure limit (Prhmax). Typical value = 1,4. |
| khp | 1..1 | PU | Fraction of total turbine output generated by HP part (Khp). Typical value = 0,277. |
| klp | 1..1 | PU | Fraction of total turbine output generated by HP part (Klp). Typical value = 0,723. |
| tb | 1..1 | Seconds | Boiler time constant (Tb) (>= 0). Typical value = 100. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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

**Table 133 – Association ends of TurbineGovernorDynamics:: GovSteamEU with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.33 GovSteamFV2

Steam turbine governor with reheat time constants and modelling of the effects of fast valve closing to reduce mechanical power.

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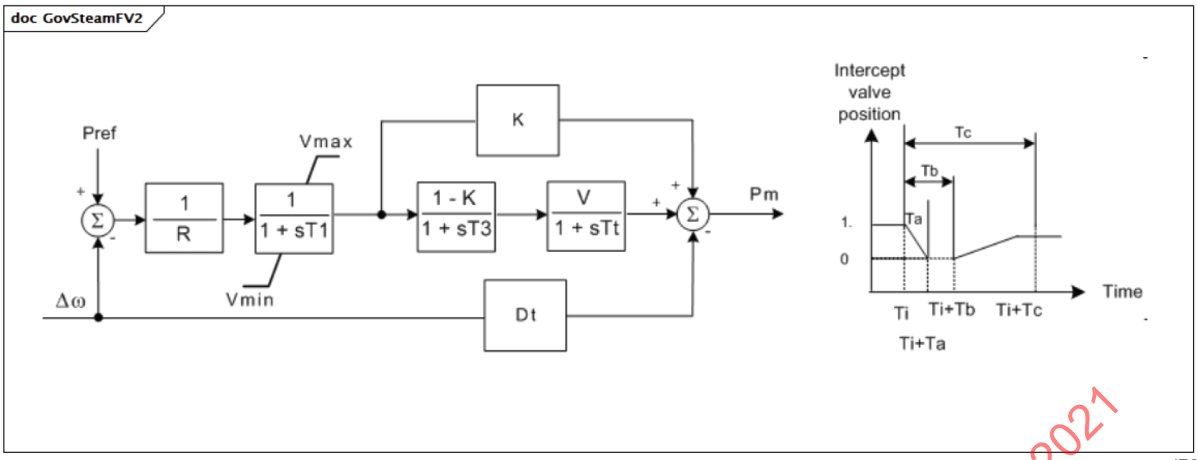


**Figure 89 – GovSteamFV2**

Figure 89: This diagram describes the GovSteamFV2 turbine governor model.

Parameter details:

1) Valve position is determined by the time curve. The valve position is either 1 or 0.
2) Ti (Initial time to begin fast valving) is a user-defined parameter at the time of the simulation and is not exchanged. Ti is assumed to be 0,1 s. It is used to review the effect of the fast valving.

Table 134 shows all attributes of GovSteamFV2.

**Table 134 – Attributes of TurbineGovernorDynamics::GovSteamFV2**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Alternate base used instead of machine base in equipment model if necessary (MWbase) (> 0). Unit = MW. |
| t1 | 1..1 | Seconds | Governor time constant (T1) (>= 0). |
| vmax | 1..1 | PU | (Vmax) (> GovSteamFV2.vmin). |
| vmin | 1..1 | PU | (Vmin) (< GovSteamFV2.vmax). |
| k | 1..1 | PU | Fraction of the turbine power developed by turbine sections not involved in fast valving (K). |
| t3 | 1..1 | Seconds | Reheater time constant (T3) (>= 0). |
| dt | 1..1 | PU | (Dt). |
| tt | 1..1 | Seconds | Time constant with which power falls off after intercept valve closure (Tt) (>= 0). |
| r | 1..1 | PU | (R). |
| ta | 1..1 | Seconds | Time after initial time for valve to close (Ta) (>= 0). |
| tb | 1..1 | Seconds | Time after initial time for valve to begin opening (Tb) (>= 0). |
| tc | 1..1 | Seconds | Time after initial time for valve to become fully open (Tc) (>= 0). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 135 shows all association ends of GovSteamFV2 with other classes.

**Table 135 – Association ends of TurbineGovernorDynamics:: GovSteamFV2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

### 8.2.4.3.6.34 GovSteamFV3

Simplified GovSteamIEEE1 steam turbine governor with Prmax limit and fast valving.

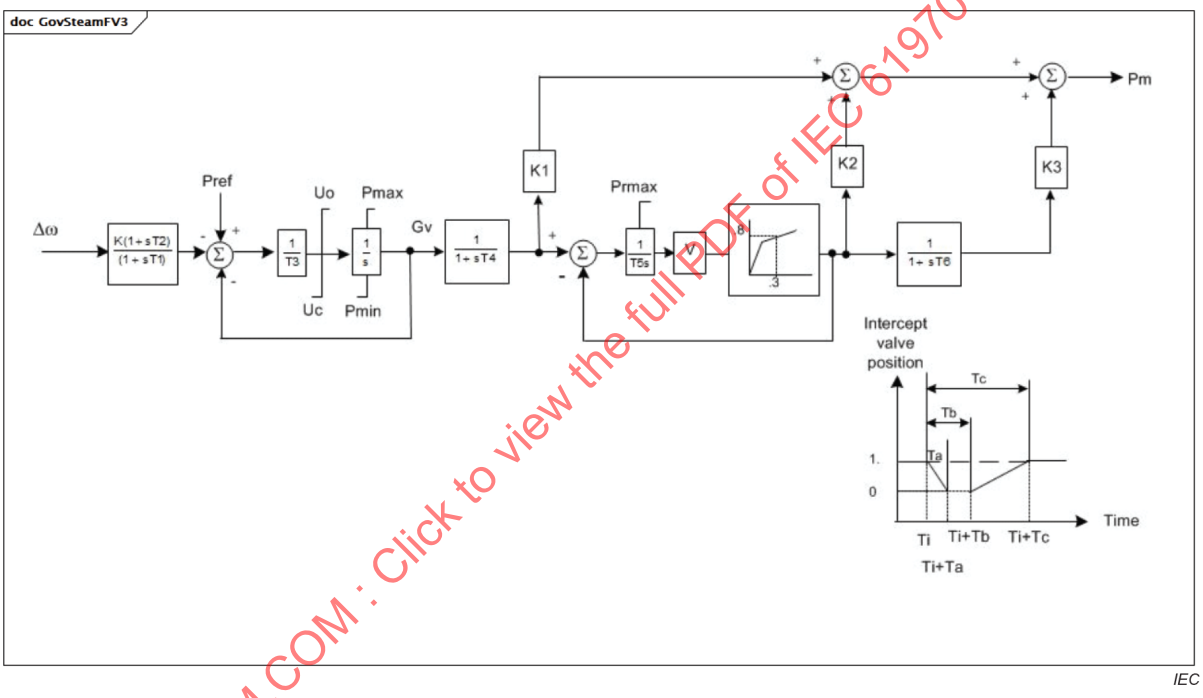


**Figure 90 – GovSteamFV3**

Figure 90: This diagram describes the GovSteamFV3 turbine governor model.

Parameter details:

1) The gains K1, K2, K3 describe the division of power output among turbine stages. Normally, K1 + K2 + K3 = 1.
2) The times Ta, Tb, and Tc are all with respect to the initiation time.
3) The value Prmax is a limit on the pressure in the reheater. Normally, this value should be about 1,10 PU.
4) The nonlinear gain between gate position and power can be input with up to 6 points. The (0,0, 0,0) and (1,0, 1,0) points can be assumed. The output is not allowed to go beyond 0,0 and 1,0. However, if Pmax > 1,0, the input and output are scaled by Pmax. If Gv1 is a negative number or zero values, the default curve (between 0,0, 0,0 and 1,0, 1,0) will be used.

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5) Ti (initial time to begin fast valving) is a user-defined parameter at the time of the simulation and it is not exchanged. Ti is assumed to be 0,1 s. It is used to review the effect of the fast valving.

Table 136 shows all attributes of GovSteamFV3.

**Table 136 – Attributes of TurbineGovernorDynamics::GovSteamFV3**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| k | 1..1 | PU | Governor gain, (reciprocal of droop) (K). Typical value = 20. |
| t1 | 1..1 | Seconds | Governor lead time constant (T1) (>= 0). Typical value = 0. |
| t2 | 1..1 | Seconds | Governor lag time constant (T2) (>= 0). Typical value = 0. |
| t3 | 1..1 | Seconds | Valve positioner time constant (T3) (> 0). Typical value = 0. |
| uo | 1..1 | Float | Maximum valve opening velocity (Uo). Unit = PU / s. Typical value = 0,1. |
| uc | 1..1 | Float | Maximum valve closing velocity (Uc). Unit = PU / s. Typical value = -1. |
| pmax | 1..1 | PU | Maximum valve opening, PU of MWbase (Pmax) (> GovSteamFV3.pmin). Typical value = 1. |
| pmin | 1..1 | PU | Minimum valve opening, PU of MWbase (Pmin) (< GovSteamFV3.pmax). Typical value = 0. |
| t4 | 1..1 | Seconds | Inlet piping/steam bowl time constant (T4) (>= 0). Typical value = 0,2. |
| k1 | 1..1 | PU | Fraction of turbine power developed after first boiler pass (K1). Typical value = 0,2. |
| t5 | 1..1 | Seconds | Time constant of second boiler pass (i.e. reheater) (T5) (> 0 if fast valving is used, otherwise >= 0). Typical value = 0,5. |
| k2 | 1..1 | PU | Fraction of turbine power developed after second boiler pass (K2). Typical value = 0,2. |
| t6 | 1..1 | Seconds | Time constant of crossover or third boiler pass (T6) (>= 0). Typical value = 10. |
| k3 | 1..1 | PU | Fraction of hp turbine power developed after crossover or third boiler pass (K3). Typical value = 0,6. |
| ta | 1..1 | Seconds | Time to close intercept valve (IV) (Ta) (>= 0). Typical value = 0,97. |
| tb | 1..1 | Seconds | Time until IV starts to reopen (Tb) (>= 0). Typical value = 0,98. |
| tc | 1..1 | Seconds | Time until IV is fully open (Tc) (>= 0). Typical value = 0,99. |
| prmax | 1..1 | PU | Max. pressure in reheater (Prmax). Typical value = 1. |
| gv1 | 1..1 | PU | Nonlinear gain valve position point 1 (GV1). Typical value = 0. |
| pgv1 | 1..1 | PU | Nonlinear gain power value point 1 (Pgv1). Typical value = 0. |
| gv2 | 1..1 | PU | Nonlinear gain valve position point 2 (GV2). Typical value = 0,4. |
| pgv2 | 1..1 | PU | Nonlinear gain power value point 2 (Pgv2). Typical value = 0,75. |

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| name | mult | type | description |
|---|---|---|---|
| gv3 | 1..1 | PU | Nonlinear gain valve position point 3 (GV3). Typical value = 0,5. |
| pgv3 | 1..1 | PU | Nonlinear gain power value point 3 (Pgv3). Typical value = 0,91. |
| gv4 | 1..1 | PU | Nonlinear gain valve position point 4 (GV4). Typical value = 0,6. |
| pgv4 | 1..1 | PU | Nonlinear gain power value point 4 (Pgv4). Typical value = 0,98. |
| gv5 | 1..1 | PU | Nonlinear gain valve position point 5 (GV5). Typical value = 1. |
| pgv5 | 1..1 | PU | Nonlinear gain power value point 5 (Pgv5). Typical value = 1. |
| gv6 | 1..1 | PU | Nonlinear gain valve position point 6 (GV6). Typical value = 0. |
| pgv6 | 1..1 | PU | Nonlinear gain power value point 6 (Pgv6). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 137 shows all association ends of GovSteamFV3 with other classes.

**Table 137 – Association ends of TurbineGovernorDynamics:: GovSteamFV3 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.35 GovSteamFV4

Detailed electro-hydraulic governor for steam unit.

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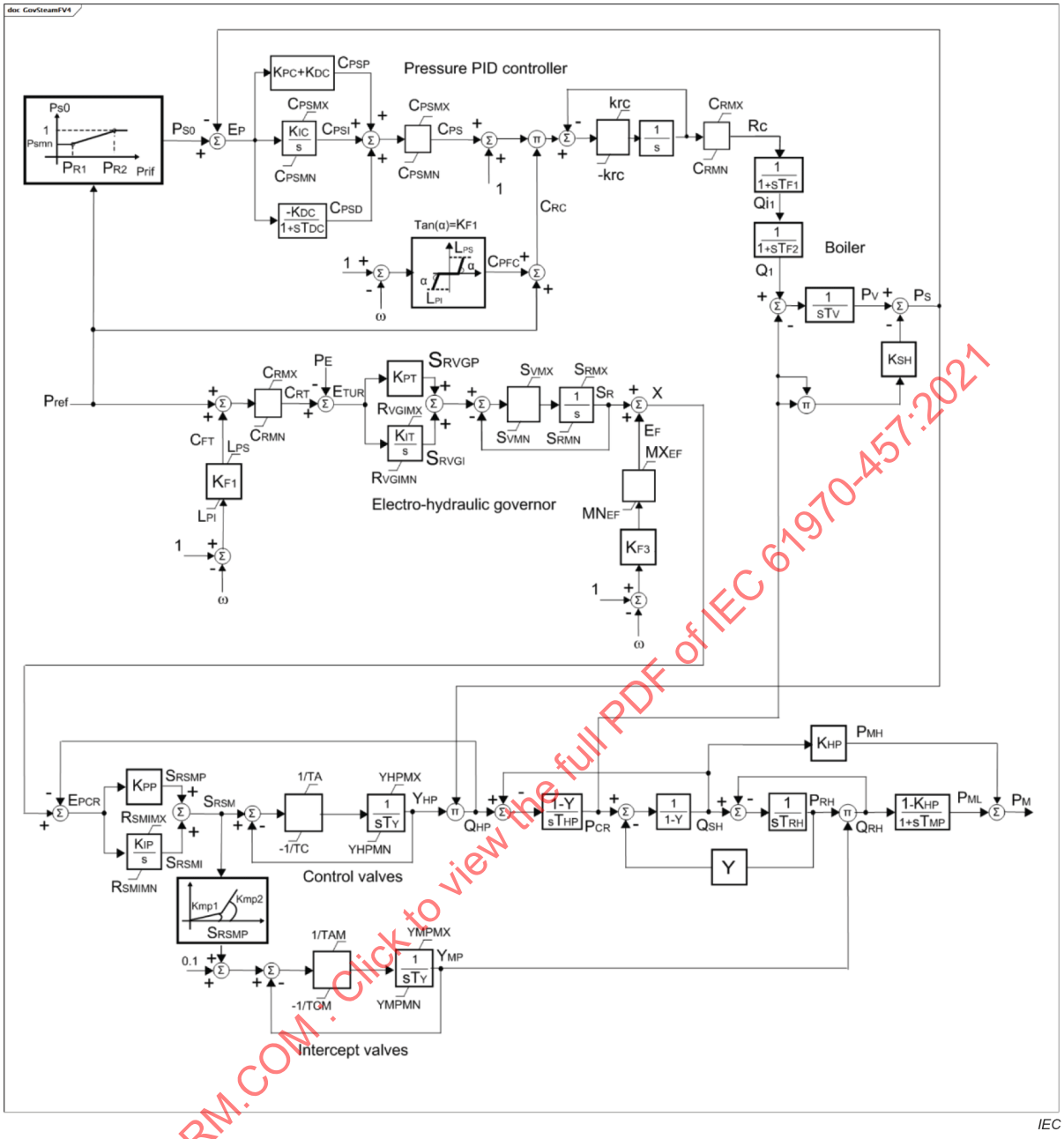


**Figure 91 – GovSteamFV4**

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Figure 91: This diagram describes the GovSteamFV4 turbine governor model.

Parameter details:

1) PU parameters are on base of MW capability of the turbine.
2) This model can be used for steam units in coordinated control, not belonging to a combined-cycle power plant.
3) omega has units of per unit speed.

Table 138 shows all attributes of GovSteamFV4.

**Table 138 – Attributes of TurbineGovernorDynamics::GovSteamFV4**

| name | mult | type | description |
|---|---|---|---|
| kf1 | 1..1 | PU | Frequency bias (reciprocal of droop) (Kf1). Typical value = 20. |
| kf3 | 1..1 | PU | Frequency control (reciprocal of droop) (Kf3). Typical value = 20. |
| lps | 1..1 | PU | Maximum positive power error (Lps). Typical value = 0,03. |
| lpi | 1..1 | PU | Maximum negative power error (Lpi). Typical value = -0,15. |
| mxef | 1..1 | PU | Upper limit for frequency correction (MXEF). Typical value = 0,05. |
| mnef | 1..1 | PU | Lower limit for frequency correction (MNEF). Typical value = -0,05. |
| crmx | 1..1 | PU | Maximum value of regulator set-point (Crmx). Typical value = 1,2. |
| crmn | 1..1 | PU | Minimum value of regulator set-point (Crmn). Typical value = 0. |
| kpt | 1..1 | PU | Proportional gain of electro-hydraulic regulator (Kpt). Typical value = 0,3. |
| kit | 1..1 | PU | Integral gain of electro-hydraulic regulator (Kit). Typical value = 0,04. |
| rvgmx | 1..1 | PU | Maximum value of integral regulator (Rvgmx). Typical value = 1,2. |
| rvgmn | 1..1 | PU | Minimum value of integral regulator (Rvgmn). Typical value = 0. |
| svmx | 1..1 | Float | Maximum regulator gate opening velocity (Svmx). Typical value = 0,0333. |
| svmn | 1..1 | Float | Maximum regulator gate closing velocity (Svmn). Typical value = -0,0333. |
| srmx | 1..1 | PU | Maximum valve opening (Srmx). Typical value = 1,1. |
| srmn | 1..1 | PU | Minimum valve opening (Srmn). Typical value = 0. |
| kpp | 1..1 | PU | Proportional gain of pressure feedback regulator (Kpp). Typical value = 1. |
| kip | 1..1 | PU | Integral gain of pressure feedback regulator (Kip). Typical value = 0,5. |
| rsmimx | 1..1 | PU | Maximum value of integral regulator (Rsmimx). Typical value = 1,1. |
| rsmimn | 1..1 | PU | Minimum value of integral regulator (Rsmimn). Typical value = 0. |
| kmp1 | 1..1 | PU | First gain coefficient of intercept valves characteristic (Kmp1). Typical value = 0,5. |
| kmp2 | 1..1 | PU | Second gain coefficient of intercept valves characteristic (Kmp2). Typical value = 3,5. |
| srsmp | 1..1 | PU | Intercept valves characteristic discontinuity point (Srsmp). Typical value = 0,43. |
| ta | 1..1 | Seconds | Control valves rate opening time (Ta) (>= 0). Typical value = 0,8. |
| tc | 1..1 | Seconds | Control valves rate closing time (Tc) (>= 0). Typical value = 0,5. |
| ty | 1..1 | Seconds | Control valves servo time constant (Ty) (>= 0). Typical value = 0,1. |
| yhpmx | 1..1 | PU | Maximum control valve position (Yhpmx). Typical value = 1,1. |

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| name | mult | type | description |
|---|---|---|---|
| yhpmn | 1..1 | PU | Minimum control valve position (Yhpmn). Typical value = 0. |
| tam | 1..1 | Seconds | Intercept valves rate opening time (Tam) (>= 0). Typical value = 0,8. |
| tcm | 1..1 | Seconds | Intercept valves rate closing time (Tcm) (>= 0). Typical value = 0,5. |
| ympmx | 1..1 | PU | Maximum intercept valve position (Ympmx). Typical value = 1,1. |
| ympmn | 1..1 | PU | Minimum intercept valve position (Ympmn). Typical value = 0. |
| y | 1..1 | PU | Coefficient of linearized equations of turbine (Stodola formulation) (Y). Typical value = 0,13. |
| thp | 1..1 | Seconds | High pressure (HP) time constant of the turbine (Thp) (>= 0). Typical value = 0,15. |
| trh | 1..1 | Seconds | Reheater time constant of the turbine (Trh) (>= 0). Typical value = 10. |
| tmp | 1..1 | Seconds | Low pressure (LP) time constant of the turbine (Tmp) (>= 0). Typical value = 0,4. |
| khp | 1..1 | PU | Fraction of total turbine output generated by HP part (Khp). Typical value = 0,35. |
| pr1 | 1..1 | PU | First value of pressure set point static characteristic (Pr1). Typical value = 0,2. |
| pr2 | 1..1 | PU | Second value of pressure set point static characteristic, corresponding to Ps0 = 1,0 PU (Pr2). Typical value = 0,75. |
| psmn | 1..1 | PU | Minimum value of pressure set point static characteristic (Psmn). Typical value = 1. |
| kpc | 1..1 | PU | Proportional gain of pressure regulator (Kpc). Typical value = 0,5. |
| kic | 1..1 | PU | Integral gain of pressure regulator (Kic). Typical value = 0,0033. |
| kdc | 1..1 | PU | Derivative gain of pressure regulator (Kdc). Typical value = 1. |
| tdc | 1..1 | Seconds | Derivative time constant of pressure regulator (Tdc) (>= 0). Typical value = 90. |
| cpsmx | 1..1 | PU | Maximum value of pressure regulator output (Cpsmx). Typical value = 1. |
| cpsmn | 1..1 | PU | Minimum value of pressure regulator output (Cpsmn). Typical value = -1. |
| krc | 1..1 | PU | Maximum variation of fuel flow (Krc). Typical value = 0,05. |
| tf1 | 1..1 | Seconds | Time constant of fuel regulation (Tf1) (>= 0). Typical value = 10. |
| tf2 | 1..1 | Seconds | Time constant of steam chest (Tf2) (>= 0). Typical value = 10. |
| tv | 1..1 | Seconds | Boiler time constant (Tv) (>= 0). Typical value = 60. |
| ksh | 1..1 | PU | Pressure loss due to flow friction in the boiler tubes (Ksh). Typical value = 0,08. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 139 shows all association ends of GovSteamFV4 with other classes.

**Table 139 – Association ends of TurbineGovernorDynamics:: GovSteamFV4 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.6.36 GovSteamSGO

Simplified steam turbine governor.

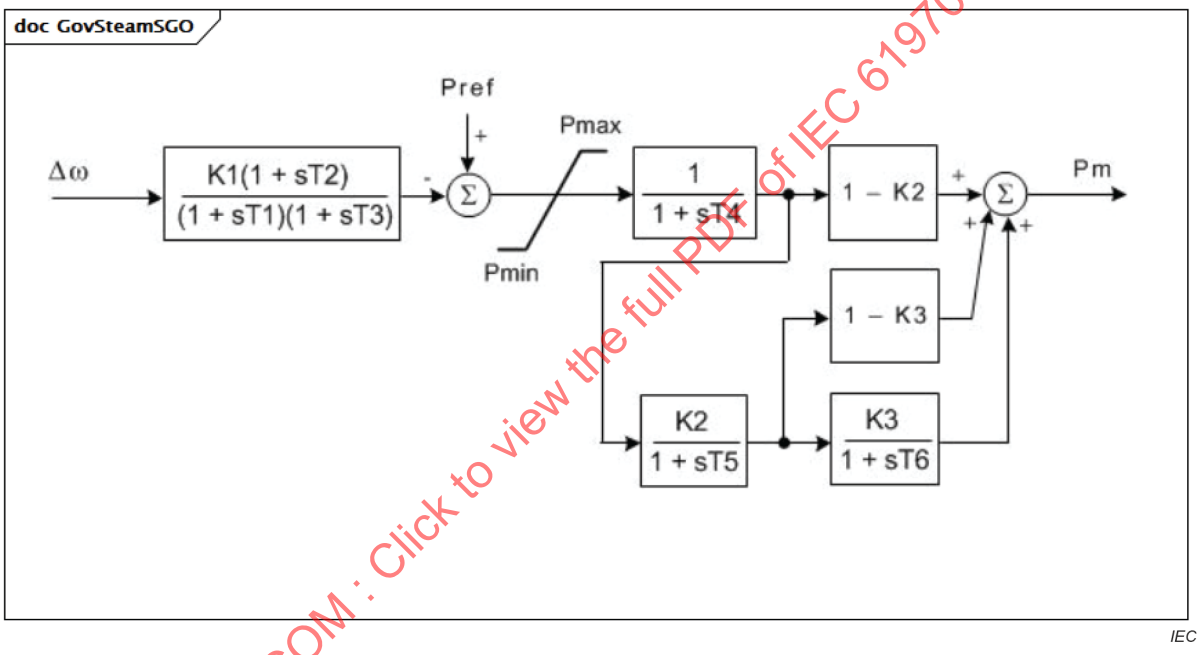


**Figure 92 – GovSteamSGO**

Figure 92: This diagram describes the GovSteamSGO turbine governor model.

Table 140 shows all attributes of GovSteamSGO.

**Table 140 – Attributes of TurbineGovernorDynamics::GovSteamSGO**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| t1 | 1..1 | Seconds | Controller lag (T1) (>= 0). |
| t2 | 1..1 | Seconds | Controller lead compensation (T2) (>= 0). |
| t3 | 1..1 | Seconds | Governor lag (T3) (> 0). |
| t4 | 1..1 | Seconds | Delay due to steam inlet volumes associated with steam chest and inlet piping (T4) (>= 0). |
| t5 | 1..1 | Seconds | Reheater delay including hot and cold leads (T5) (>= 0). |

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| name | mult | type | description |
|---|---|---|---|
| t6 | 1..1 | Seconds | Delay due to IP-LP turbine, crossover pipes and LP end hoods (T6) (>= 0). |
| k1 | 1..1 | PU | One / PU regulation (K1). |
| k2 | 1..1 | PU | Fraction (K2). |
| k3 | 1..1 | PU | Fraction (K3). |
| pmax | 1..1 | PU | Upper power limit (Pmax) (> GovSteamSGO.pmin). |
| pmin | 1..1 | Seconds | Lower power limit (Pmin) (>= 0 and < GovSteamSGO.pmax). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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

**Table 141 – Association ends of TurbineGovernorDynamics:: GovSteamSGO with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..* | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: TurbineGovernorDynamics |

#### 8.2.4.3.7 Package TurbineLoadControllerDynamics

##### 8.2.4.3.7.1 General

A turbine load controller acts to maintain turbine power at a set value by continuous adjustment of the turbine governor speed-load reference.

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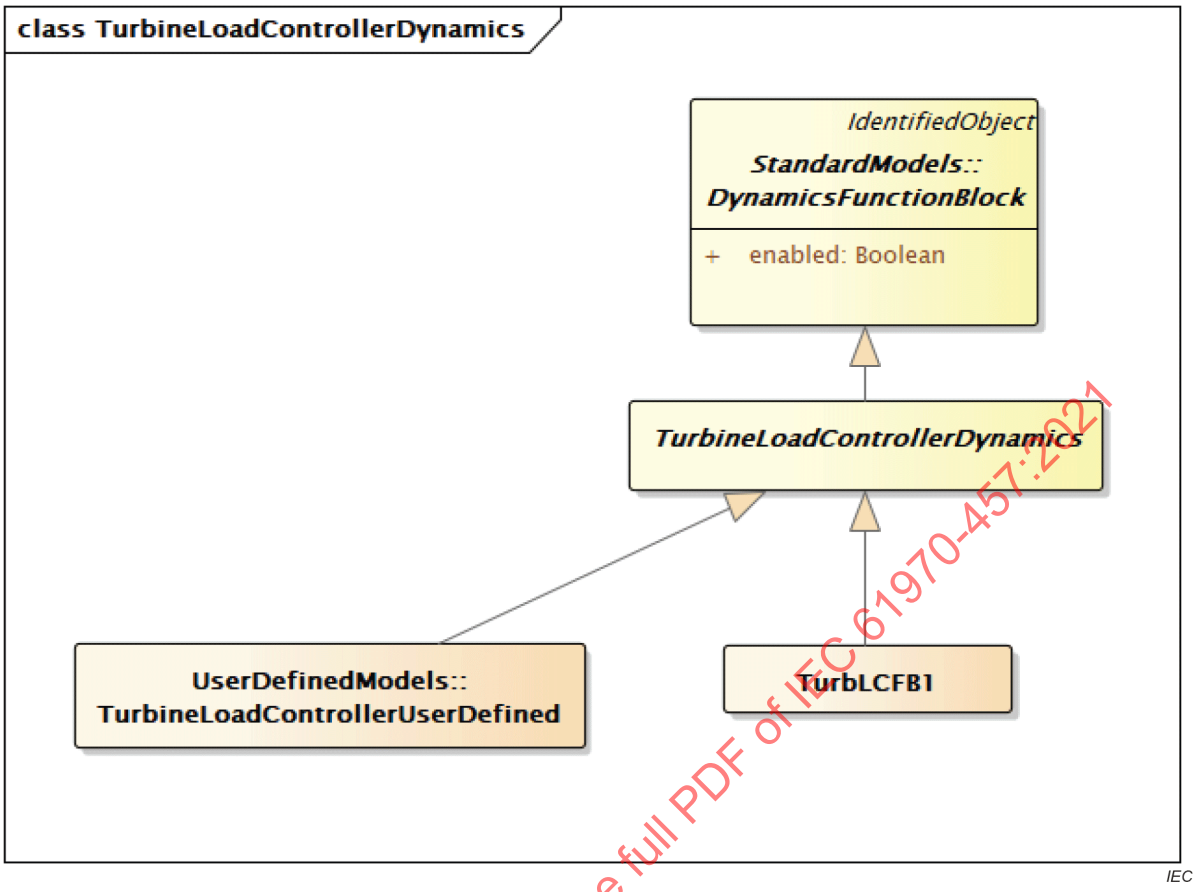


**Figure 93 – Class diagram TurbineLoadControllerDynamics::TurbineLoadControllerDynamics**

Figure 93: This diagram shows dynamic standard model turbine load controller classes and their inheritance from the TurbineLoadControllerDynamics class.

#### 8.2.4.3.7.2 (abstract) TurbineLoadControllerDynamics

Turbine load controller function block whose behaviour is described by reference to a standard model or by definition of a user-defined model.

Table 142 shows all attributes of TurbineLoadControllerDynamics.

**Table 142 – Attributes of TurbineLoadControllerDynamics:: TurbineLoadControllerDynamics**

| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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

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**Table 143 – Association ends of TurbineLoadControllerDynamics:: TurbineLoadControllerDynamics with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | TurbineGovernorDynamics | 1..1 | TurbineGovernorDynamics | Turbine-governor controlled by this turbine load controller. |

#### 8.2.4.3.7.3 TurbLCFB1

Turbine load controller model developed by WECC. This model represents a supervisory turbine load controller that acts to maintain turbine power at a set value by continuous adjustment of the turbine governor speed-load reference. This model is intended to represent slow-reset 'outer loop' controllers managing the action of the turbine governor.

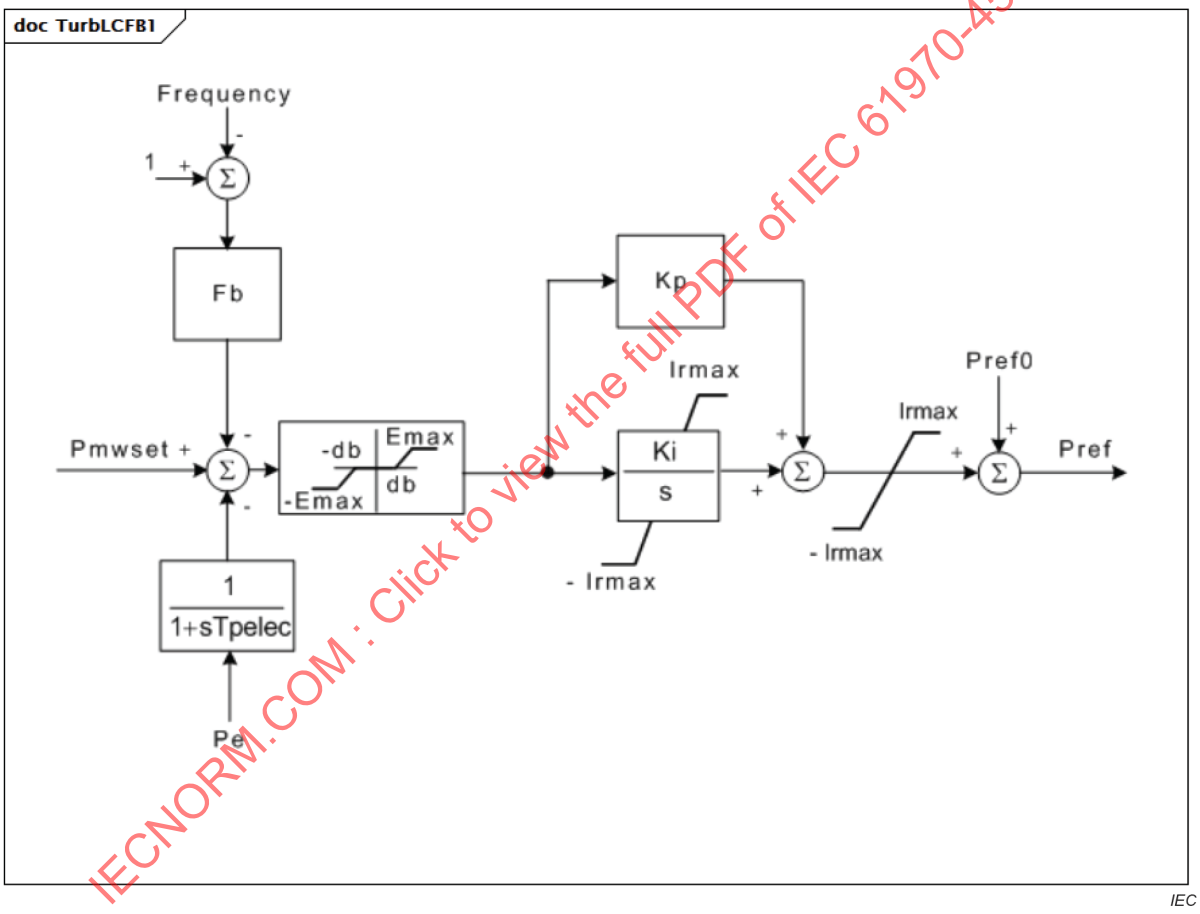


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**Figure 94 – TurbLCFB1**

Figure 94: This diagram describes the TurbLCFB1 turbine load controller model.

Parameter details:

1) The load reference of this supervisory load control loop is accessible as the parameter, Pmwset. Pmwset is given a value automatically when the model is initialized. This value overwrites any value entered prior to initialization.
2) The controller acts by applying a bias to the turbine-governor speed load reference, Pref. This reference is initialized in the normal manner by the turbine-governor model.

3) The output of the controller is limited to plus or minus Irmax. To prevent the controller from adjusting the turbine power excessively, Irmax should not exceed approximately one half of the governor droop or approximately 0,025 PU.

4) The error limit, Emax, is intended to set a maximum rate of change of turbine power. If limitation of load change rate is desired, Emax should be set such that Emax = (max rate, PU / s) x (droop of governor in PU) / Ki. Note that governor droop used in this calculation shall be in PU relative to the base power, MWbase, of the turbine. Note, also, that some governor models (such as GovSteamIEEE1) have their droop specified by the value of a gain whose value is the reciprocal of the droop. For example, in GovSteamIEEE1 the droop is specified by the gain, K, whose typical value is 1 / 0,04 = 25.

5) This model recognizes the two alternative ways of specifying the turbine-governor load reference. In models such as GovCT1 and GovHydro1, the reference is a speed setpoint. In other models such as GovSteamIEEE1, the reference is a PU load value. The references are generally as follows: 1) speed reference (1 + (initial power or valve position) x (droop)), 2) load reference (0 + (initial power or valve position)). The parameters of TurbLCFB1 shall always be set on the basis of a governor speed reference.

Table 144 shows all attributes of TurbLCFB1.

**Table 144 – Attributes of TurbineLoadControllerDynamics::TurbLCFB1**

| name | mult | type | description |
|---|---|---|---|
| mwbase | 1..1 | ActivePower | Base for power values (MWbase) (> 0). Unit = MW. |
| speedReferenceGovernor | 1..1 | Boolean | Type of turbine governor reference (Type).<br>true = speed reference governor<br>false = load reference governor.<br>Typical value = true. |
| db | 1..1 | PU | Controller deadband (db). Typical value = 0. |
| emax | 1..1 | PU | Maximum control error (Emax) (see parameter detail 4). Typical value = 0,02. |
| fb | 1..1 | PU | Frequency bias gain (Fb). Typical value = 0. |
| kp | 1..1 | PU | Proportional gain (Kp). Typical value = 0. |
| ki | 1..1 | PU | Integral gain (Ki). Typical value = 0. |
| fbf | 1..1 | Boolean | Frequency bias flag (Fbf).<br>true = enable frequency bias<br>false = disable frequency bias.<br>Typical value = false. |
| pbf | 1..1 | Boolean | Power controller flag (Pbf).<br>true = enable load controller<br>false = disable load controller.<br>Typical value = false. |
| tpelec | 1..1 | Seconds | Power transducer time constant (Tpelec) (>= 0). Typical value = 0. |
| irmax | 1..1 | PU | Maximum turbine speed/load reference bias (Irmax) (see parameter detail 3). Typical value = 0. |
| pmwset | 1..1 | ActivePower | Power controller setpoint (Pmwset) (see parameter detail 1). Unit = MW. Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 145 shows all association ends of TurbLCFB1 with other classes.

**Table 145 – Association ends of TurbineLoadControllerDynamics:: TurbLCFB1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | TurbineGovernorDynamics | 1..1 | TurbineGovernorDynamics | inherited from: TurbineLoadControllerDynamics |

#### 8.2.4.3.8 Package MechanicalLoadDynamics

##### 8.2.4.3.8.1 General

A mechanical load represents the variation in a motor's shaft torque or power as a function of shaft speed.

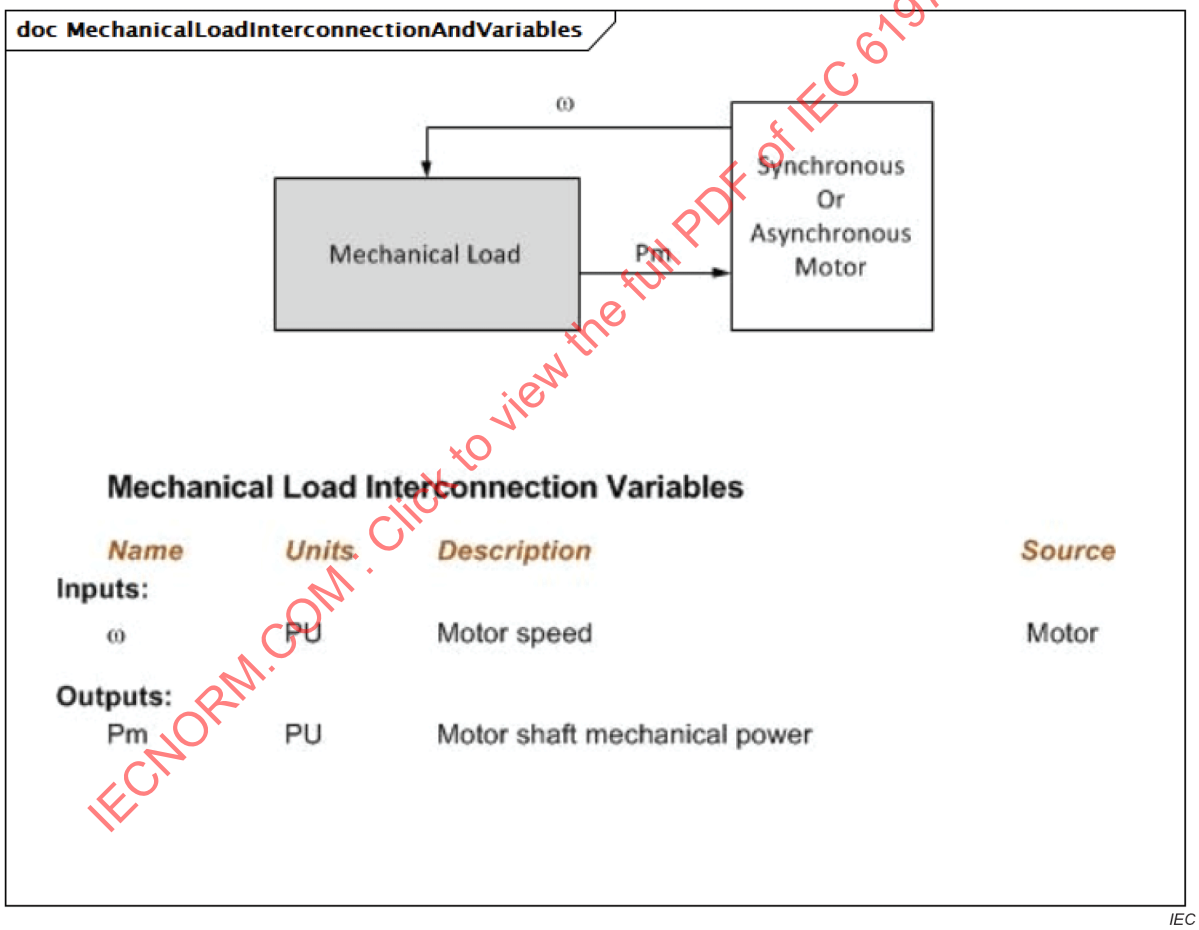


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**Figure 95 – MechanicalLoadInterconnectionAndVariables**

Figure 95: This diagram illustrates the inputs and outputs for a mechanical load.

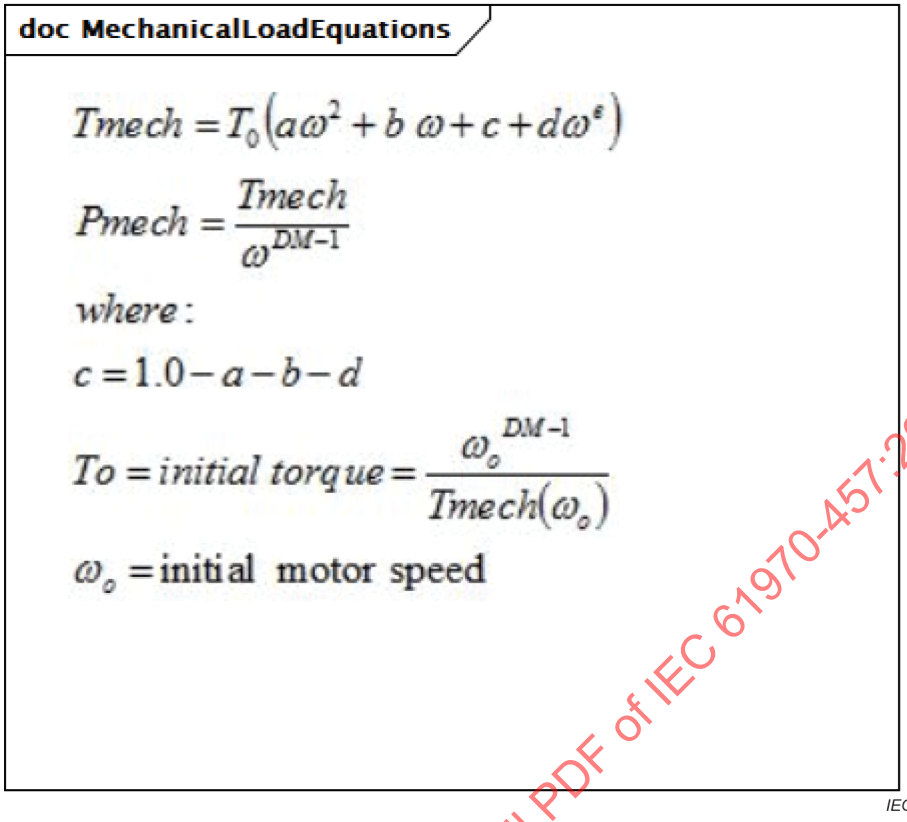


**Figure 96 – MechanicalLoadEquations**

Figure 96: This diagram illustrates the equations for a mechanical load.

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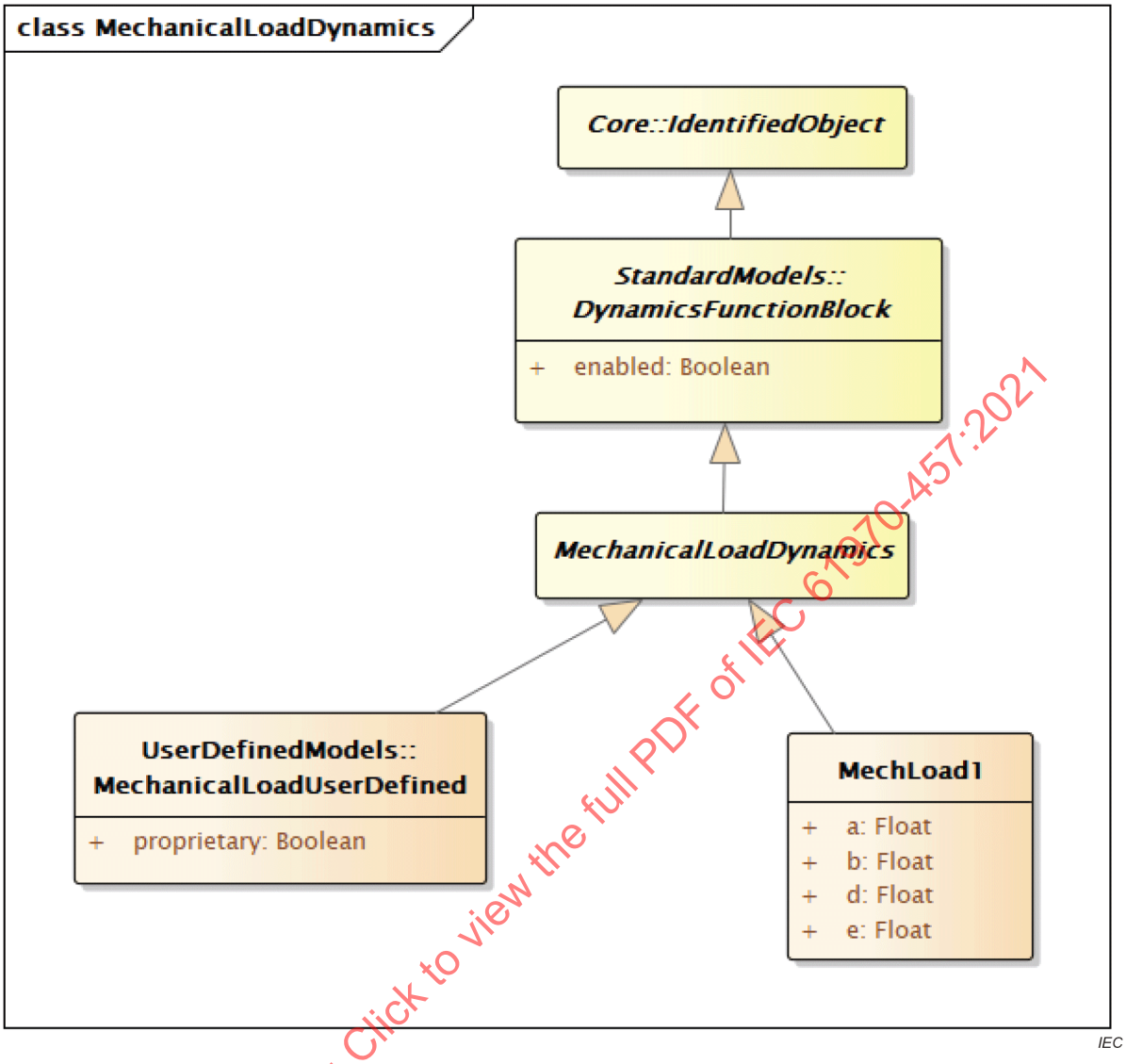


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**Figure 97 – Class diagram MechanicalLoadDynamics::MechanicalLoadDynamics**

Figure 97: This diagram shows dynamic standard model mechanical load classes and their inheritance from the MechanicalLoadDynamics class.

#### 8.2.4.3.8.2 (abstract) MechanicalLoadDynamics

Mechanical load function block whose behaviour is described by reference to a standard model or by definition of a user-defined model.

Table 146 shows all attributes of MechanicalLoadDynamics.

**Table 146 – Attributes of MechanicalLoadDynamics::MechanicalLoadDynamics**

| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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

**Table 147 – Association ends of MechanicalLoadDynamics:: MechanicalLoadDynamics with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | Synchronous machine model with which this mechanical load model is associated. MechanicalLoadDynamics shall have either an association to SynchronousMachineDynamics or AsynchronousMachineDyanmics. |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | Asynchronous machine model with which this mechanical load model is associated. MechanicalLoadDynamics shall have either an association to SynchronousMachineDynamics or to AsynchronousMachineDynamics. |

#### 8.2.4.3.8.3 MechLoad1

Mechanical load model type 1.

Table 148 shows all attributes of MechLoad1.

**Table 148 – Attributes of MechanicalLoadDynamics::MechLoad1**

| name | mult | type | description |
|---|---|---|---|
| a | 1..1 | Float | Speed squared coefficient (a). |
| b | 1..1 | Float | Speed coefficient (b). |
| d | 1..1 | Float | Speed to the exponent coefficient (d). |
| e | 1..1 | Float | Exponent (e). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 149 shows all association ends of MechLoad1 with other classes.

**Table 149 – Association ends of MechanicalLoadDynamics:: MechLoad1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 0..1 | SynchronousMachineDynamics | inherited from: MechanicalLoadDynamics |
| 0..1 | AsynchronousMachineDynamics | 0..1 | AsynchronousMachineDynamics | inherited from: MechanicalLoadDynamics |

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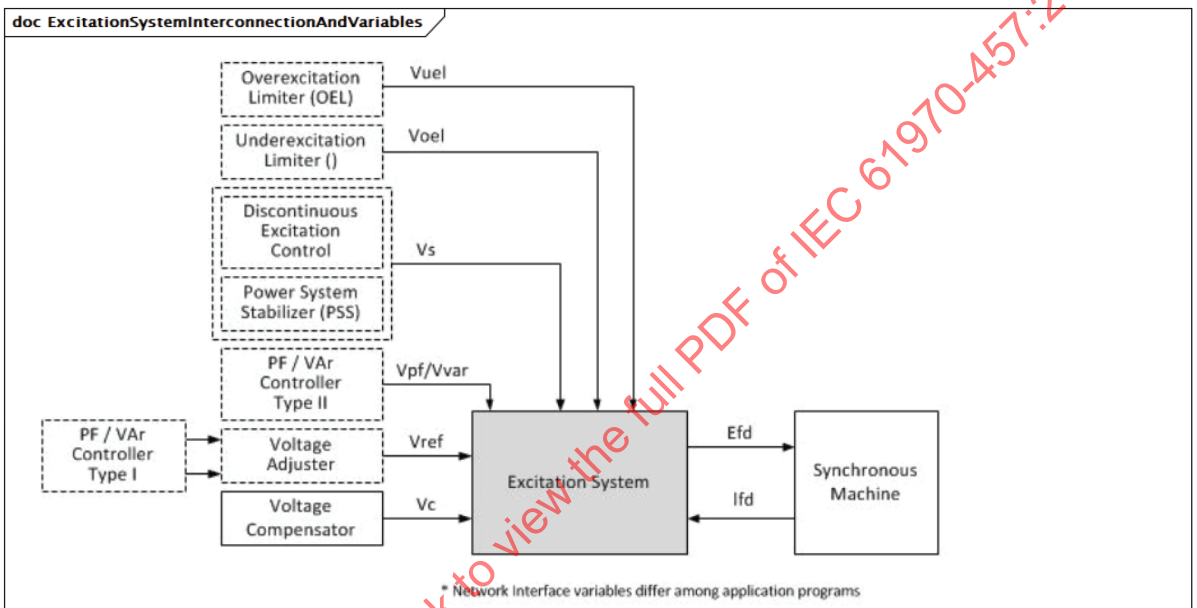
#### 8.2.4.3.9 Package ExcitationSystemDynamics

##### 8.2.4.3.9.1 General

The excitation system model provides the field voltage (Efd) for a synchronous machine model. It is linked to a specific generator (synchronous machine).

The representation of all limits used by the models (not including IEEE standard models) shall comply with the representation defined in the Annex E of the IEEE 421.5-2005, unless specified differently in the documentation of the model.

The parameters are different for each excitation system model; the same parameter name can have different meaning in different models.




**Excitation System Interconnection Variables**

| Name | Units | Description | Source |
|---|---|---|---|
| **Inputs:** | | | |
| Vc | PU | Compensated generator terminal voltage | Voltage Compensator, if present. If not, terminal voltage ($V_T$) is used. |
| Vref | PU | Voltage reference | Voltage Adjuster |
| Ifd | PU | Generator field current | Synchronous machine |
| Vs | PU | Power system stabilizer (PSS) output | PSS / Discontinuous Excitation Control |
| Voel | PU | Overexcitation limiter output | OEL |
| Vuel | PU | Underexcitation limiter output | UEL |
| Vpf | PU | PF Controller Type II output | PF / VAr Controller Type II |
| Vvar | PU | Var Controller Type II output | PF / VAr Controller Type II |
| **Outputs:** | | | |
| Efd | PU | Generator field voltage | |

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**Figure 98 – ExcitationSystemInterconnectionAndVariables**

Figure 98: This diagram illustrates the inputs and outputs for an excitation system model.

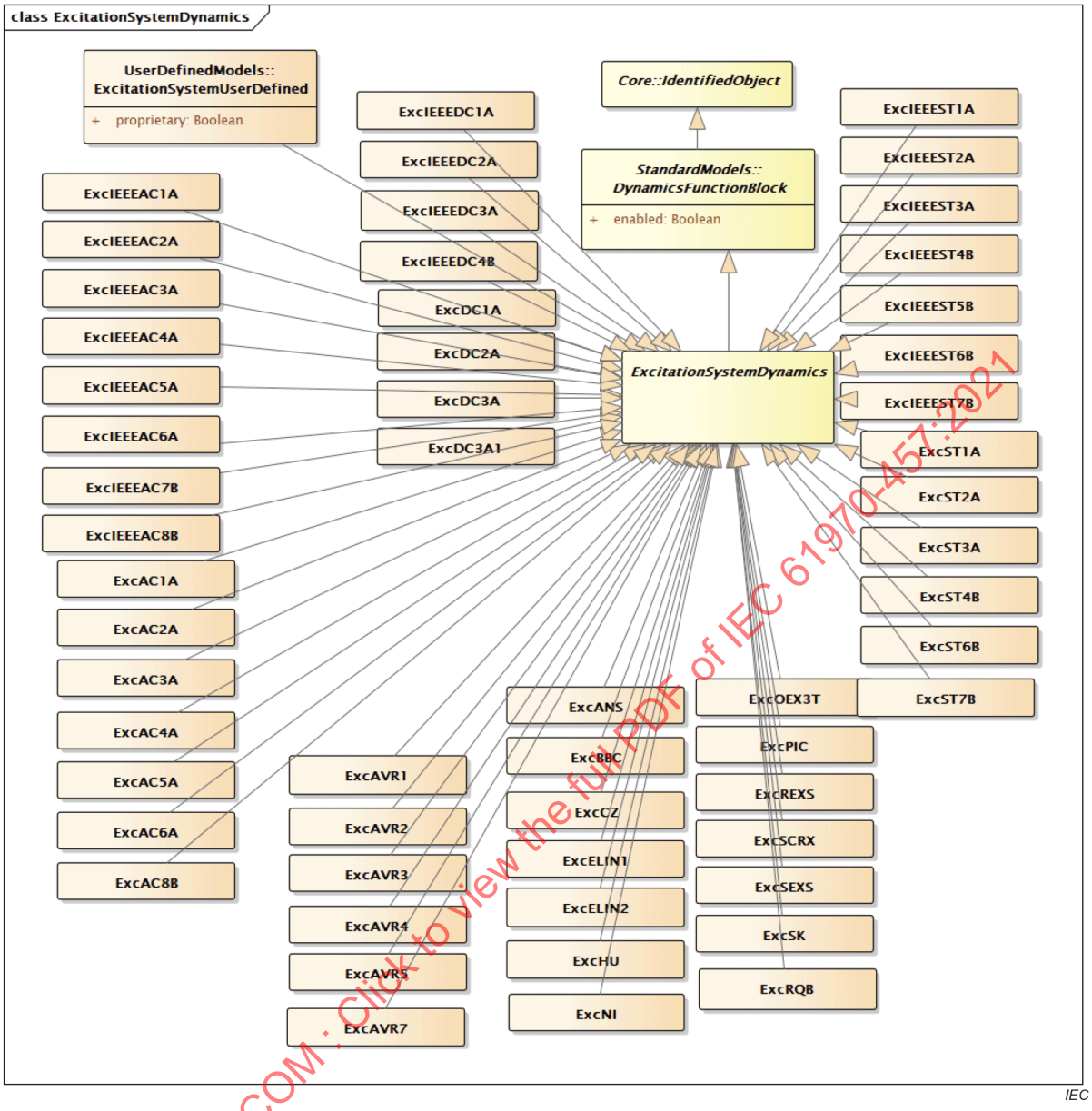


**Figure 99 – Class diagram ExcitationSystemDynamics::ExcitationSystemDynamics**

Figure 99: This diagram shows dynamic standard model excitation system classes and their inheritance from the ExcitationSystemDynamics class.

#### 8.2.4.3.9.2 (abstract) ExcitationSystemDynamics

Excitation system function block whose behaviour is described by reference to a standard model or by definition of a user-defined model.

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Table 150 shows all attributes of ExcitationSystemDynamics.

**Table 150 – Attributes of ExcitationSystemDynamics::ExcitationSystemDynamics**

| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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

**Table 151 – Association ends of ExcitationSystemDynamics:: ExcitationSystemDynamics with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | Synchronous machine model with which this excitation system model is associated. |

#### 8.2.4.3.9.3 ExcIEEEAC1A

IEEE 421.5-2005 type AC1A model. The model represents the field-controlled alternator-rectifier excitation systems designated type AC1A. These excitation systems consist of an alternator main exciter with non-controlled rectifiers.

Reference: IEEE 421.5-2005, 6.1.

Table 152 shows all attributes of ExcIEEEAC1A.

**Table 152 – Attributes of ExcitationSystemDynamics::ExcIEEEAC1A**

| name | mult | type | description |
|---|---|---|---|
| tb | 1..1 | Seconds | Voltage regulator time constant (TB) (>= 0). Typical value = 0. |
| tc | 1..1 | Seconds | Voltage regulator time constant (TC) (>= 0). Typical value = 0. |
| ka | 1..1 | PU | Voltage regulator gain (KA) (> 0). Typical value = 400. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (> 0). Typical value = 0,02. |
| vamax | 1..1 | PU | Maximum voltage regulator output (VAMAX) (> 0). Typical value = 14,5. |
| vamin | 1..1 | PU | Minimum voltage regulator output (VAMIN) (< 0). Typical value = -14,5. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (TE) (> 0). Typical value = 0,8. |
| kf | 1..1 | PU | Excitation control system stabilizer gains (KF) (>= 0). Typical value = 0,03. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (TF) (> 0). Typical value = 1. |

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| name | mult | type | description |
|---|---|---|---|
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (KC) (>= 0). Typical value = 0,2. |
| kd | 1..1 | PU | Demagnetizing factor, a function of exciter alternator reactances (KD) (>= 0). Typical value = 0,38. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (KE). Typical value = 1. |
| ve1 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (VE1) (> 0). Typical value = 4,18. |
| seve1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, VE1, back of commutating reactance (SE[VE1]) (>= 0). Typical value = 0,1. |
| ve2 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (VE2) (> 0). Typical value = 3,14. |
| seve2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, VE2, back of commutating reactance (SE[VE2]) (>= 0). Typical value = 0,03. |
| vrmax | 1..1 | PU | Maximum voltage regulator outputs (VRMAX) (> 0). Typical value = 6,03. |
| vrmin | 1..1 | PU | Minimum voltage regulator outputs (VRMIN) (< 0). Typical value = -5,43. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 153 shows all association ends of ExcIEEEAC1A with other classes.

**Table 153 – Association ends of ExcitationSystemDynamics:: ExcIEEEAC1A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.4 ExcIEEEAC2A

IEEE 421.5-2005 type AC2A model. The model represents a high initial response field-controlled alternator-rectifier excitation system. The alternator main exciter is used with non-controlled rectifiers. The type AC2A model is similar to that of type AC1A except for the inclusion of exciter time constant compensation and exciter field current limiting elements.

Reference: IEEE 421.5-2005, 6.2.

Table 154 shows all attributes of ExcIEEEAC2A.

**Table 154 – Attributes of ExcitationSystemDynamics::ExcIEEEAC2A**

| name | mult | type | description |
|---|---|---|---|
| tb | 1..1 | Seconds | Voltage regulator time constant (TB) (>= 0). Typical value = 0. |
| tc | 1..1 | Seconds | Voltage regulator time constant (TC) (>= 0). Typical value = 0. |
| ka | 1..1 | PU | Voltage regulator gain (KA) (> 0). Typical value = 400. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (> 0). Typical value = 0,02. |
| vamax | 1..1 | PU | Maximum voltage regulator output (VAMAX) (> 0). Typical value = 8. |
| vamin | 1..1 | PU | Minimum voltage regulator output (VAMIN) (< 0). Typical value = -8. |
| kb | 1..1 | PU | Second stage regulator gain (KB) (> 0). Typical value = 25. |
| vrmax | 1..1 | PU | Maximum voltage regulator outputs (VRMAX) (> 0). Typical value = 105. |
| vrmin | 1..1 | PU | Minimum voltage regulator outputs (VRMIN) (< 0). Typical value = -95. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (TE) (> 0). Typical value = 0,6. |
| vfemax | 1..1 | PU | Exciter field current limit reference (VFEMAX) (> 0). Typical value = 4,4. |
| kh | 1..1 | PU | Exciter field current feedback gain (KH) (>= 0). Typical value = 1. |
| kf | 1..1 | PU | Excitation control system stabilizer gains (KF) (>= 0). Typical value = 0,03. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (TF) (> 0). Typical value = 1. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (KC) (>= 0). Typical value = 0,28. |
| kd | 1..1 | PU | Demagnetizing factor, a function of exciter alternator reactances (KD) (>= 0). Typical value = 0,35. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (KE) (>= 0). Typical value = 1. |
| ve1 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (VE1) (> 0). Typical value = 4,4. |
| seve1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, VE1, back of commutating reactance (SE[VE1]) (>= 0). Typical value = 0,037. |
| ve2 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (VE2) (> 0). Typical value = 3,3. |
| seve2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, VE2, back of commutating reactance (SE[VE2]) (>= 0). Typical value = 0,012. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 155 shows all association ends of ExcIEEEAC2A with other classes.

**Table 155 – Association ends of ExcitationSystemDynamics:: ExcIEEEAC2A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.5 ExcIEEEAC3A

IEEE 421.5-2005 type AC3A model. The model represents the field-controlled alternator-rectifier excitation systems designated type AC3A. These excitation systems include an alternator main exciter with non-controlled rectifiers. The exciter employs self-excitation, and the voltage regulator power is derived from the exciter output voltage. Therefore, this system has an additional nonlinearity, simulated by the use of a multiplier whose inputs are the voltage regulator command signal, Va, and the exciter output voltage, Efd, times KR. This model is applicable to excitation systems employing static voltage regulators.

Reference: IEEE 421.5-2005, 6.3.

Table 156 shows all attributes of ExcIEEEAC3A.

**Table 156 – Attributes of ExcitationSystemDynamics::ExcIEEEAC3A**

| name | mult | type | description |
|---|---|---|---|
| tb | 1..1 | Seconds | Voltage regulator time constant (TB) (>= 0). Typical value = 0. |
| tc | 1..1 | Seconds | Voltage regulator time constant (TC) (>= 0). Typical value = 0. |
| ka | 1..1 | PU | Voltage regulator gain (KA) (> 0). Typical value = 45,62. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (> 0). Typical value = 0,013. |
| vamax | 1..1 | PU | Maximum voltage regulator output (VAMAX) (> 0). Typical value = 1. |
| vamin | 1..1 | PU | Minimum voltage regulator output (VAMIN) (< 0). Typical value = -0,95. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (TE) (> 0). Typical value = 1,17. |
| vemin | 1..1 | PU | Minimum exciter voltage output (VEMIN) (<= 0). Typical value = 0. |
| kr | 1..1 | PU | Constant associated with regulator and alternator field power supply (KR) (> 0). Typical value = 3,77. |
| kf | 1..1 | PU | Excitation control system stabilizer gains (KF) (>= 0). Typical value = 0,143. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (TF) (> 0). Typical value = 1. |
| kn | 1..1 | PU | Excitation control system stabilizer gain (KN) (>= 0). Typical value = 0,05. |
| efdn | 1..1 | PU | Value of Efd at which feedback gain changes (EFDN) (> 0). Typical value = 2,36. |

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| name | mult | type | description |
|---|---|---|---|
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (KC) (>= 0). Typical value = 0,104. |
| kd | 1..1 | PU | Demagnetizing factor, a function of exciter alternator reactances (KD) (>= 0). Typical value = 0,499. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (KE). Typical value = 1. |
| vfemax | 1..1 | PU | Exciter field current limit reference (VFEMAX) (>= 0). Typical value = 16. |
| ve1 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (VE1) (> 0). Typical value = 6,24. |
| seve1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, VE1, back of commutating reactance (SE[VE1]) (>= 0). Typical value = 1,143. |
| ve2 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (VE2) (> 0). Typical value = 4,68. |
| seve2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, VE2, back of commutating reactance (SE[VE2]) (>= 0). Typical value = 0,1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 157 shows all association ends of ExcIEEEAC3A with other classes.

**Table 157 – Association ends of ExcitationSystemDynamics:: ExcIEEEAC3A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.6 ExcIEEEAC4A

IEEE 421.5-2005 type AC4A model. The model represents type AC4A alternator-supplied controlled-rectifier excitation system which is quite different from the other types of AC systems. This high initial response excitation system utilizes a full thyristor bridge in the exciter output circuit. The voltage regulator controls the firing of the thyristor bridges. The exciter alternator uses an independent voltage regulator to control its output voltage to a constant value. These effects are not modelled; however, transient loading effects on the exciter alternator are included.

Reference: IEEE 421.5-2005, 6.4.

Table 158 shows all attributes of ExcIEEEAC4A.

**Table 158 – Attributes of ExcitationSystemDynamics::ExcIEEEAC4A**

| name | mult | type | description |
|---|---|---|---|
| vimax | 1..1 | PU | Maximum voltage regulator input limit (VIMAX) (> 0). Typical value = 10. |
| vimin | 1..1 | PU | Minimum voltage regulator input limit (VIMIN) (< 0). Typical value = -10. |
| tc | 1..1 | Seconds | Voltage regulator time constant (TC) (>= 0). Typical value = 1. |
| tb | 1..1 | Seconds | Voltage regulator time constant (TB) (>= 0). Typical value = 10. |
| ka | 1..1 | PU | Voltage regulator gain (KA) (> 0). Typical value = 200. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (> 0). Typical value = 0,015. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX) (> 0). Typical value = 5,64. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (< 0). Typical value = -4,53. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (KC) (>= 0). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 159 shows all association ends of ExcIEEEAC4A with other classes.

**Table 159 – Association ends of ExcitationSystemDynamics:: ExcIEEEAC4A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.7 ExcIEEEAC5A

IEEE 421.5-2005 type AC5A model. The model represents a simplified model for brushless excitation systems. The regulator is supplied from a source, such as a permanent magnet generator, which is not affected by system disturbances. Unlike other AC models, this model uses loaded rather than open circuit exciter saturation data in the same way as it is used for the DC models. Because the model has been widely implemented by the industry, it is sometimes used to represent other types of systems when either detailed data for them are not available or simplified models are required.

Reference: IEEE 421.5-2005, 6.5.

Table 160 shows all attributes of ExcIEEEAC5A.

**Table 160 – Attributes of ExcitationSystemDynamics::ExcIEEEAC5A**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | PU | Voltage regulator gain (KA) (> 0). Typical value = 400. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (> 0). Typical value = 0,02. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX) (> 0). Typical value = 7,3. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (< 0). Typical value = -7,3. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (KE). Typical value = 1. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (TE) (> 0). Typical value = 0,8. |
| kf | 1..1 | PU | Excitation control system stabilizer gains (KF) (>= 0). Typical value = 0,03. |
| tf1 | 1..1 | Seconds | Excitation control system stabilizer time constant (TF1) (> 0). Typical value = 1. |
| tf2 | 1..1 | Seconds | Excitation control system stabilizer time constant (TF2) (>= 0). Typical value = 1. |
| tf3 | 1..1 | Seconds | Excitation control system stabilizer time constant (TF3) (>= 0). Typical value = 1. |
| efd1 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (EFD1) (> 0). Typical value = 5,6. |
| seefd1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, EFD1 (SE[EFD1]) (>= 0). Typical value = 0,86. |
| efd2 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (EFD2) (> 0). Typical value = 4,2. |
| seefd2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, EFD2 (SE[EFD2]) (>= 0). Typical value = 0,5. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 161 shows all association ends of ExcIEEEAC5A with other classes.

**Table 161 – Association ends of ExcitationSystemDynamics:: ExcIEEEAC5A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.8 ExcIEEEAC6A

IEEE 421.5-2005 type AC6A model. The model represents field-controlled alternator-rectifier excitation systems with system-supplied electronic voltage regulators. The maximum output of the regulator, VR, is a function of terminal voltage, VT. The field current limiter included in the original model AC6A remains in the 2005 update.

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Reference: IEEE 421.5-2005, 6.6.

Table 162 shows all attributes of ExcIEEEAC6A.

**Table 162 – Attributes of ExcitationSystemDynamics::ExcIEEEAC6A**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | PU | Voltage regulator gain (KA) (> 0). Typical value = 536. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (>= 0). Typical value = 0,086. |
| tk | 1..1 | Seconds | Voltage regulator time constant (TK) (>= 0). Typical value = 0,18. |
| tb | 1..1 | Seconds | Voltage regulator time constant (TB) (>= 0). Typical value = 9. |
| tc | 1..1 | Seconds | Voltage regulator time constant (TC) (>= 0). Typical value = 3. |
| vamax | 1..1 | PU | Maximum voltage regulator output (VAMAX) (> 0). Typical value = 75. |
| vamin | 1..1 | PU | Minimum voltage regulator output (VAMIN) (< 0). Typical value = -75. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX) (> 0). Typical value = 44. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (< 0). Typical value = -36. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (TE) (> 0). Typical value = 1. |
| kh | 1..1 | PU | Exciter field current limiter gain (KH) (>= 0). Typical value = 92. |
| tj | 1..1 | Seconds | Exciter field current limiter time constant (TJ) (>= 0). Typical value = 0,02. |
| th | 1..1 | Seconds | Exciter field current limiter time constant (TH) (> 0). Typical value = 0,08. |
| vfelim | 1..1 | PU | Exciter field current limit reference (VFELIM) (> 0). Typical value = 19. |
| vhmax | 1..1 | PU | Maximum field current limiter signal reference (VHMAX) (> 0). Typical value = 75. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (KC) (>= 0). Typical value = 0,173. |
| kd | 1..1 | PU | Demagnetizing factor, a function of exciter alternator reactances (KD) (>= 0). Typical value = 1,91. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (KE). Typical value = 1,6. |
| ve1 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (VE1) (> 0). Typical value = 7,4. |
| seve1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, VE1, back of commutating reactance (SE[VE1]) (>= 0). Typical value = 0,214. |
| ve2 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (VE2) (> 0). Typical value = 5,55. |
| seve2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, VE2, back of commutating reactance (SE[VE2]) (>= 0). Typical value = 0,044. |

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| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 163 shows all association ends of ExcIEEEAC6A with other classes.

**Table 163 – Association ends of ExcitationSystemDynamics:: ExcIEEEAC6A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.9 ExcIEEEAC7B

IEEE 421.5-2005 type AC7B model. The model represents excitation systems which consist of an AC alternator with either stationary or rotating rectifiers to produce the DC field requirements. It is an upgrade to earlier AC excitation systems, which replace only the controls but retain the AC alternator and diode rectifier bridge.

Reference: IEEE 421.5-2005, 6.7. Note, however, that in IEEE 421.5-2005, the [1 / sTE] block is shown as [1 / (1 + sTE)], which is incorrect.

Table 164 shows all attributes of ExcIEEEAC7B.

**Table 164 – Attributes of ExcitationSystemDynamics::ExcIEEEAC7B**

| name | mult | type | description |
|---|---|---|---|
| kpr | 1..1 | PU | Voltage regulator proportional gain (KPR) (> 0 if ExcIEEEAC7B.kir = 0). Typical value = 4,24. |
| kir | 1..1 | PU | Voltage regulator integral gain (KIR) (>= 0). Typical value = 4,24. |
| kdr | 1..1 | PU | Voltage regulator derivative gain (KDR) (>= 0). Typical value = 0. |
| tdr | 1..1 | Seconds | Lag time constant (TDR) (>= 0). Typical value = 0. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX) (> 0). Typical value = 5,79. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (< 0). Typical value = -5,79. |
| kpa | 1..1 | PU | Voltage regulator proportional gain (KPA) (> 0 if ExcIEEEAC7B.kia = 0). Typical value = 65,36. |
| kia | 1..1 | PU | Voltage regulator integral gain (KIA) (>= 0). Typical value = 59,69. |
| vamax | 1..1 | PU | Maximum voltage regulator output (VAMAX) (> 0). Typical value = 1. |
| vamin | 1..1 | PU | Minimum voltage regulator output (VAMIN) (< 0). Typical value = -0,95. |
| kp | 1..1 | PU | Potential circuit gain coefficient (KP) (> 0). Typical value = 4,96. |

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| name | mult | type | description |
|---|---|---|---|
| kl | 1..1 | PU | Exciter field voltage lower limit parameter (KL). Typical value = 10. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (TE) (> 0). Typical value = 1,1. |
| vfemax | 1..1 | PU | Exciter field current limit reference (VFEMAX). Typical value = 6,9. |
| vemin | 1..1 | PU | Minimum exciter voltage output (VEMIN) (<= 0). Typical value = 0. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (KE). Typical value = 1. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (KC) (>= 0). Typical value = 0,18. |
| kd | 1..1 | PU | Demagnetizing factor, a function of exciter alternator reactances (KD) (>= 0). Typical value = 0,02. |
| kf1 | 1..1 | PU | Excitation control system stabilizer gain (KF1) (>= 0). Typical value = 0,212. |
| kf2 | 1..1 | PU | Excitation control system stabilizer gain (KF2) (>= 0). Typical value = 0. |
| kf3 | 1..1 | PU | Excitation control system stabilizer gain (KF3) (>= 0). Typical value = 0. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (TF) (> 0). Typical value = 1. |
| ve1 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (VE1) (> 0). Typical value = 6,3. |
| seve1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, VE1, back of commutating reactance (SE[VE1]) (>= 0). Typical value = 0,44. |
| ve2 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (VE2) (> 0). Typical value = 3,02. |
| seve2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, VE2, back of commutating reactance (SE[VE2]) (>= 0). Typical value = 0,075. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 165 shows all association ends of ExcIEEEAC7B with other classes.

**Table 165 – Association ends of ExcitationSystemDynamics:: ExcIEEEAC7B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.10 ExcIEEEAC8B

IEEE 421.5-2005 type AC8B model. This model represents a PID voltage regulator with either a brushless exciter or DC exciter. The AVR in this model consists of PID control, with separate constants for the proportional (KPR), integral (KIR), and derivative (KDR) gains. The representation of the brushless exciter (TE, KE, SE, KC, KD) is similar to the model type AC2A. The type AC8B model can be used to represent static voltage regulators applied to brushless excitation systems. Digitally based voltage regulators feeding DC rotating main exciters can be represented with the AC type AC8B model with the parameters KC and KD set to 0. For thyristor power stages fed from the generator terminals, the limits VRMAX and VRMIN should be a function of terminal voltage: VT x VRMAX and VT x VRMIN.

Reference: IEEE 421.5-2005, 6.8.

Table 166 shows all attributes of ExcIEEEAC8B.

**Table 166 – Attributes of ExcitationSystemDynamics::ExcIEEEAC8B**

| name | mult | type | description |
|---|---|---|---|
| kpr | 1..1 | PU | Voltage regulator proportional gain (KPR) (> 0 if ExcIEEEAC8B.kir = 0). Typical value = 80. |
| kir | 1..1 | PU | Voltage regulator integral gain (KIR) (>= 0). Typical value = 5. |
| kdr | 1..1 | PU | Voltage regulator derivative gain (KDR) (>= 0). Typical value = 10. |
| tdr | 1..1 | Seconds | Lag time constant (TDR) (> 0). Typical value = 0,1. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX) (> 0). Typical value = 35. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (<= 0). Typical value = 0. |
| ka | 1..1 | PU | Voltage regulator gain (KA) (> 0). Typical value = 1. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (>= 0). Typical value = 0. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (TE) (> 0). Typical value = 1,2. |
| vfemax | 1..1 | PU | Exciter field current limit reference (VFEMAX). Typical value = 6. |
| vemin | 1..1 | PU | Minimum exciter voltage output (VEMIN) (<= 0). Typical value = 0. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (KE). Typical value = 1. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (KC) (>= 0). Typical value = 0,55. |
| kd | 1..1 | PU | Demagnetizing factor, a function of exciter alternator reactances (KD) (>= 0). Typical value = 1,1. |
| ve1 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (VE1) (> 0). Typical value = 6,5. |
| seve1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, VE1, back of commutating reactance (SE[VE1]) (>= 0). Typical value = 0,3. |

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| name | mult | type | description |
|---|---|---|---|
| ve2 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (VE2) (> 0). Typical value = 9. |
| seve2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, VE2, back of commutating reactance (SE[VE2]) (>= 0). Typical value = 3. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 167 shows all association ends of ExcIEEEAC8B with other classes.

**Table 167 – Association ends of ExcitationSystemDynamics:: ExcIEEEAC8B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.11 ExcIEEEDC1A

IEEE 421.5-2005 type DC1A model. This model represents field-controlled DC commutator exciters with continuously acting voltage regulators (especially the direct-acting rheostatic, rotating amplifier, and magnetic amplifier types). Because this model has been widely implemented by the industry, it is sometimes used to represent other types of systems when detailed data for them are not available or when a simplified model is required.

Reference: IEEE 421.5-2005, 5.1.

Table 168 shows all attributes of ExcIEEEDC1A.

**Table 168 – Attributes of ExcitationSystemDynamics::ExcIEEEDC1A**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | PU | Voltage regulator gain (KA) (> 0). Typical value = 46. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (> 0). Typical value = 0,06. |
| tb | 1..1 | Seconds | Voltage regulator time constant (TB) (>= 0). Typical value = 0. |
| tc | 1..1 | Seconds | Voltage regulator time constant (TC) (>= 0). Typical value = 0. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX) (> ExcIEEEDC1A.vrmin). Typical value = 1. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (< 0 and < ExcIEEEDC1A.vrmax). Typical value = -0,9. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (KE). Typical value = 0. |

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| name | mult | type | description |
|---|---|---|---|
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (TE) (> 0). Typical value = 0,46. |
| kf | 1..1 | PU | Excitation control system stabilizer gain (KF) (>= 0). Typical value = 0.1. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (TF) (> 0). Typical value = 1. |
| efd1 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (EFD1) (> 0). Typical value = 3,1. |
| seefd1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, EFD1 (SE[EFD1]) (>= 0). Typical value = 0.33. |
| efd2 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (EFD2) (> 0). Typical value = 2,3. |
| seefd2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, EFD2 (SE[EFD2]) (>= 0). Typical value = 0,1. |
| uelin | 1..1 | Boolean | UEL input (uelin).<br>true = input is connected to the HV gate<br>false = input connects to the error signal.<br>Typical value = true. |
| exclim | 1..1 | Boolean | (exclim). IEEE standard is ambiguous about lower limit on exciter output.<br>true = a lower limit of zero is applied to integrator output<br>false = a lower limit of zero is not applied to integrator output.<br>Typical value = true. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 169 shows all association ends of ExcIEEEDC1A with other classes.

**Table 169 – Association ends of ExcitationSystemDynamics:: ExcIEEEDC1A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.12 ExcIEEEDC2A

IEEE 421.5-2005 type DC2A model. This model represents field-controlled DC commutator exciters with continuously acting voltage regulators having supplies obtained from the generator or auxiliary bus. It differs from the type DC1A model only in the voltage regulator output limits, which are now proportional to terminal voltage VT.

It is representative of solid-state replacements for various forms of older mechanical and rotating amplifier regulating equipment connected to DC commutator exciters.

Reference: IEEE 421.5-2005, 5.2.

Table 170 shows all attributes of ExcIEEEDC2A.

**Table 170 – Attributes of ExcitationSystemDynamics::ExcIEEEDC2A**

| name | mult | type | description |
|---|---|---|---|
| efd1 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (EFD1) (> 0). Typical value = 3,05. |
| efd2 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (EFD2) (> 0). Typical value = 2,29. |
| exclim | 1..1 | PU | (exclim). IEEE standard is ambiguous about lower limit on exciter output. Typical value = –999 which means that there is no limit applied. |
| ka | 1..1 | PU | Voltage regulator gain (KA) (> 0). Typical value = 300. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (KE). Typical value = 1. |
| kf | 1..1 | PU | Excitation control system stabilizer gain (KF) (>= 0). Typical value = 0,1. |
| seefd1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, EFD1 (SE[EFD1]) (>= 0). Typical value = 0,279. |
| seefd2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, EFD2 (SE[EFD2]) (>= 0). Typical value = 0,117. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (> 0). Typical value = 0,01. |
| tb | 1..1 | Seconds | Voltage regulator time constant (TB) (>= 0). Typical value = 0. |
| tc | 1..1 | Seconds | Voltage regulator time constant (TC) (>= 0). Typical value = 0. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (TE) (> 0). Typical value = 1,33. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (TF) (> 0). Typical value = 0,675. |
| uelin | 1..1 | Boolean | UEL input (uelin).<br>true = input is connected to the HV gate<br>false = input connects to the error signal.<br>Typical value = true. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX)(> ExcIEEEDC2A.vrmin). Typical value = 4,95. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (< 0 and < ExcIEEEDC2A.vrmax). Typical value = -4,9. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 171 shows all association ends of ExcIEEEDC2A with other classes.

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**Table 171 – Association ends of ExcitationSystemDynamics:: ExcIEEEDC2A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.13 ExcIEEEDC3A

IEEE 421.5-2005 type DC3A model. This model represents older systems, in particular those DC commutator exciters with non-continuously acting regulators that were commonly used before the development of the continuously acting varieties. These systems respond at basically two different rates, depending upon the magnitude of voltage error. For small errors, adjustment is made periodically with a signal to a motor-operated rheostat. Larger errors cause resistors to be quickly shorted or inserted and a strong forcing signal applied to the exciter. Continuous motion of the motor-operated rheostat occurs for these larger error signals, even though it is bypassed by contactor action.

Reference: IEEE 421.5-2005, 5.3.

Table 172 shows all attributes of ExcIEEEDC3A.

**Table 172 – Attributes of ExcitationSystemDynamics::ExcIEEEDC3A**

| name | mult | type | description |
|---|---|---|---|
| trh | 1..1 | Seconds | Rheostat travel time (TRH) (> 0). Typical value = 20. |
| kv | 1..1 | PU | Fast raise/lower contact setting (KV) (> 0). Typical value = 0,05. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX) (> 0). Typical value = 1. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (<= 0). Typical value = 0. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (TE) (> 0). Typical value = 0,5. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (KE). Typical value = 0,05. |
| efd1 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (EFD1) (> 0). Typical value = 3,375. |
| seefd1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, EFD1 (SE[EFD1]) (>= 0). Typical value = 0,267. |
| efd2 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (EFD2) (> 0). Typical value = 3,15. |
| seefd2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, EFD2 (SE[EFD2]) (>= 0). Typical value = 0,068. |
| exclim | 1..1 | Boolean | (exclim). IEEE standard is ambiguous about lower limit on exciter output.<br>true = a lower limit of zero is applied to integrator output<br>false = a lower limit of zero is not applied to integrator output.<br>Typical value = true. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |

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

Table 173 shows all association ends of ExcIEEEDC3A with other classes.

**Table 173 – Association ends of ExcitationSystemDynamics:: ExcIEEEDC3A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.14 ExcIEEEDC4B

IEEE 421.5-2005 type DC4B model. These excitation systems utilize a field-controlled DC commutator exciter with a continuously acting voltage regulator having supplies obtained from the generator or auxiliary bus.

Reference: IEEE 421.5-2005, 5.4.

Table 174 shows all attributes of ExcIEEEDC4B.

**Table 174 – Attributes of ExcitationSystemDynamics::ExcIEEEDC4B**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | PU | Voltage regulator gain (KA) (> 0). Typical value = 1. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (> 0). Typical value = 0,2. |
| kp | 1..1 | PU | Regulator proportional gain (KP) (>= 0). Typical value = 20. |
| ki | 1..1 | PU | Regulator integral gain (KI) (>= 0). Typical value = 20. |
| kd | 1..1 | PU | Regulator derivative gain (KD) (>= 0). Typical value = 20. |
| td | 1..1 | Seconds | Regulator derivative filter time constant (TD) (> 0 if ExcIEEEDC4B.kd > 0). Typical value = 0,01. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX) (> ExcIEEEDC4B.vrmin). Typical value = 2,7. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (<= 0 and < ExcIEEEDC4B.vrmax). Typical value = -0,9. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (KE). Typical value = 1. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (TE) (> 0). Typical value = 0,8. |
| kf | 1..1 | PU | Excitation control system stabilizer gain (KF) (>= 0). Typical value = 0. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (TF) (>= 0). Typical value = 1. |

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| name | mult | type | description |
|---|---|---|---|
| efd1 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (EFD1) (> 0). Typical value = 1,75. |
| seefd1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, EFD1 (SE[EFD1]) (>= 0). Typical value = 0,08. |
| efd2 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (EFD2) (> 0). Typical value = 2,33. |
| seefd2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, EFD2 (SE[EFD2]) (>= 0). Typical value = 0,27. |
| vemin | 1..1 | PU | Minimum exciter voltage output (VEMIN) (<= 0). Typical value = 0. |
| oelin | 1..1 | Boolean | OEL input (OELin).<br>true = LV gate<br>false = subtract from error signal.<br>Typical value = true. |
| uelin | 1..1 | Boolean | UEL input (UELin).<br>true = HV gate<br>false = add to error signal.<br>Typical value = true. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 175 shows all association ends of ExcIEEEDC4B with other classes.

**Table 175 – Association ends of ExcitationSystemDynamics:: ExcIEEEDC4B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.15 ExcIEEEST1A

IEEE 421.5-2005 type ST1A model. This model represents systems in which excitation power is supplied through a transformer from the generator terminals (or the unit's auxiliary bus) and is regulated by a controlled rectifier. The maximum exciter voltage available from such systems is directly related to the generator terminal voltage.

Reference: IEEE 421.5-2005, 7.1.

Table 176 shows all attributes of ExcIEEEST1A.

**Table 176 – Attributes of ExcitationSystemDynamics::ExcIEEEST1A**

| name | mult | type | description |
|---|---|---|---|
| ilr | 1..1 | PU | Exciter output current limit reference (ILR). Typical value = 0. |
| ka | 1..1 | PU | Voltage regulator gain (KA) (> 0). Typical value = 190. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (KC) (>= 0). Typical value = 0,08. |
| kf | 1..1 | PU | Excitation control system stabilizer gains (KF) (>= 0). Typical value = 0. |
| klr | 1..1 | PU | Exciter output current limiter gain (KLR). Typical value = 0. |
| pssin | 1..1 | Boolean | Selector of the Power System Stabilizer (PSS) input (PSSin).<br>true = PSS input (Vs) added to error signal<br>false = PSS input (Vs) added to voltage regulator output.<br>Typical value = true. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (>= 0). Typical value = 0. |
| tb | 1..1 | Seconds | Voltage regulator time constant (TB) (>= 0). Typical value = 10. |
| tb1 | 1..1 | Seconds | Voltage regulator time constant (TB1) (>= 0). Typical value = 0. |
| tc | 1..1 | Seconds | Voltage regulator time constant (TC) (>= 0). Typical value = 1. |
| tc1 | 1..1 | Seconds | Voltage regulator time constant (TC1) (>= 0). Typical value = 0. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (TF) (>= 0). Typical value = 1. |
| uelin | 1..1 | ExcIEEEST1AUELselectorKind | Selector of the connection of the UEL input (UELin). Typical value = ignoreUELsignal. |
| vamax | 1..1 | PU | Maximum voltage regulator output (VAMAX) (> 0). Typical value = 14,5. |
| vamin | 1..1 | PU | Minimum voltage regulator output (VAMIN) (< 0). Typical value = -14,5. |
| vimax | 1..1 | PU | Maximum voltage regulator input limit (VIMAX) (> 0). Typical value = 999. |
| vimin | 1..1 | PU | Minimum voltage regulator input limit (VIMIN) (< 0). Typical value = -999. |
| vrmax | 1..1 | PU | Maximum voltage regulator outputs (VRMAX) (> 0). Typical value = 7,8. |
| vrmin | 1..1 | PU | Minimum voltage regulator outputs (VRMIN) (< 0). Typical value = -6,7. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 177 shows all association ends of ExcIEEEST1A with other classes.

**Table 177 – Association ends of ExcitationSystemDynamics:: ExcIEEEST1A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.16 ExcIEEEST2A

IEEE 421.5-2005 type ST2A model. Some static systems use both current and voltage sources (generator terminal quantities) to comprise the power source. The regulator controls the exciter output through controlled saturation of the power transformer components. These compound-source rectifier excitation systems are designated type ST2A and are represented by ExcIEEEST2A.

Reference: IEEE 421.5-2005, 7.2.

Table 178 shows all attributes of ExcIEEEST2A.

**Table 178 – Attributes of ExcitationSystemDynamics::ExcIEEEST2A**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | PU | Voltage regulator gain (KA) (> 0). Typical value = 120. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (> 0). Typical value = 0,15. |
| vrmax | 1..1 | PU | Maximum voltage regulator outputs (VRMAX) (> 0). Typical value = 1. |
| vrmin | 1..1 | PU | Minimum voltage regulator outputs (VRMIN) (<= 0). Typical value = 0. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (KE). Typical value = 1. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (TE) (> 0). Typical value = 0,5. |
| kf | 1..1 | PU | Excitation control system stabilizer gains (KF) (>= 0). Typical value = 0,05. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (TF) (>= 0). Typical value = 1. |
| kp | 1..1 | PU | Potential circuit gain coefficient (KP) (>= 0). Typical value = 4,88. |
| ki | 1..1 | PU | Potential circuit gain coefficient (KI) (>= 0). Typical value = 8. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (KC) (>= 0). Typical value = 1,82. |
| efdmax | 1..1 | PU | Maximum field voltage (EFDMax) (>= 0). Typical value = 99. |
| uelin | 1..1 | Boolean | UEL input (UELin).<br>true = HV gate<br>false = add to error signal.<br>Typical value = true. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |

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

Table 179 shows all association ends of ExcIEEEST2A with other classes.

**Table 179 – Association ends of ExcitationSystemDynamics:: ExcIEEEST2A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.17 ExcIEEEST3A

IEEE 421.5-2005 type ST3A model. Some static systems utilize a field voltage control loop to linearize the exciter control characteristic. This also makes the output independent of supply source variations until supply limitations are reached. These systems utilize a variety of controlled-rectifier designs: full thyristor complements or hybrid bridges in either series or shunt configurations. The power source can consist of only a potential source, either fed from the machine terminals or from internal windings. Some designs can have compound power sources utilizing both machine potential and current. These power sources are represented as phasor combinations of machine terminal current and voltage and are accommodated by suitable parameters in model type ST3A which is represented by ExcIEEEST3A.

Reference: IEEE 421.5-2005, 7.3.

Table 180 shows all attributes of ExcIEEEST3A.

**Table 180 – Attributes of ExcitationSystemDynamics::ExcIEEEST3A**

| name | mult | type | description |
|---|---|---|---|
| vimax | 1..1 | PU | Maximum voltage regulator input limit (VIMAX) (> 0). Typical value = 0,2. |
| vimin | 1..1 | PU | Minimum voltage regulator input limit (VIMIN) (< 0). Typical value = -0,2. |
| ka | 1..1 | PU | Voltage regulator gain (KA) (> 0). This is parameter K in the IEEE standard. Typical value = 200. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (>= 0). Typical value = 0. |
| tb | 1..1 | Seconds | Voltage regulator time constant (TB) (>= 0). Typical value = 10. |
| tc | 1..1 | Seconds | Voltage regulator time constant (TC) (>= 0). Typical value = 1. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX) (> 0). Typical value = 10. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (< 0). Typical value = -10. |
| km | 1..1 | PU | Forward gain constant of the inner loop field regulator (KM) (> 0). Typical value = 7,93. |
| tm | 1..1 | Seconds | Forward time constant of inner loop field regulator (TM) (> 0). Typical value = 0,4. |

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| name | mult | type | description |
|---|---|---|---|
| vmmax | 1..1 | PU | Maximum inner loop output (VMMax) (> 0). Typical value = 1. |
| vmmin | 1..1 | PU | Minimum inner loop output (VMMin) (<= 0). Typical value = 0. |
| kg | 1..1 | PU | Feedback gain constant of the inner loop field regulator (KG) (>= 0). Typical value = 1. |
| kp | 1..1 | PU | Potential circuit gain coefficient (KP) (> 0). Typical value = 6,15. |
| thetap | 1..1 | AngleDegrees | Potential circuit phase angle (thetap). Typical value = 0. |
| ki | 1..1 | PU | Potential circuit gain coefficient (KI) (>= 0). Typical value = 0. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (KC) (>= 0). Typical value = 0,2. |
| xl | 1..1 | PU | Reactance associated with potential source (XL) (>= 0). Typical value = 0,081. |
| vbmax | 1..1 | PU | Maximum excitation voltage (VBMax) (> 0). Typical value = 6,9. |
| vgmax | 1..1 | PU | Maximum inner loop feedback voltage (VGMax) (>= 0). Typical value = 5,8. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 181 shows all association ends of ExcIEEEST3A with other classes.

**Table 181 – Association ends of ExcitationSystemDynamics:: ExcIEEEST3A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.18 ExcIEEEST4B

IEEE 421.5-2005 type ST4B model. This model is a variation of the type ST3A model, with a proportional plus integral (PI) regulator block replacing the lag-lead regulator characteristic that is in the ST3A model. Both potential and compound source rectifier excitation systems are modelled. The PI regulator blocks have non-windup limits that are represented. The voltage regulator of this model is typically implemented digitally.

Reference: IEEE 421.5-2005, 7.4.

Table 182 shows all attributes of ExcIEEEST4B.

**Table 182 – Attributes of ExcitationSystemDynamics::ExcIEEEST4B**

| name | mult | type | description |
|---|---|---|---|
| kpr | 1..1 | PU | Voltage regulator proportional gain (KPR). Typical value = 10,75. |
| kir | 1..1 | PU | Voltage regulator integral gain (KIR). Typical value = 10,75. |
| ta | 1..1 | Seconds | Voltage regulator time constant (TA) (>= 0). Typical value = 0,02. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX) (> 0). Typical value = 1. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (< 0). Typical value = -0,87. |
| kpm | 1..1 | PU | Voltage regulator proportional gain output (KPM). Typical value = 1. |
| kim | 1..1 | PU | Voltage regulator integral gain output (KIM). Typical value = 0. |
| vmmax | 1..1 | PU | Maximum inner loop output (VMMax) (> ExcIEEEST4B.vmmin). Typical value = 99. |
| vmmin | 1..1 | PU | Minimum inner loop output (VMMin) (< ExcIEEEST4B.vmmax). Typical value = -99. |
| kg | 1..1 | PU | Feedback gain constant of the inner loop field regulator (KG) (>= 0). Typical value = 0. |
| kp | 1..1 | PU | Potential circuit gain coefficient (KP) (> 0). Typical value = 9,3. |
| thetap | 1..1 | AngleDegrees | Potential circuit phase angle (thetap). Typical value = 0. |
| ki | 1..1 | PU | Potential circuit gain coefficient (KI) (>= 0). Typical value = 0. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (KC) (>= 0). Typical value = 0,113. |
| xl | 1..1 | PU | Reactance associated with potential source (XL) (>= 0). Typical value = 0,124. |
| vbmax | 1..1 | PU | Maximum excitation voltage (VBMax) (> 0). Typical value = 11,63. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 183 shows all association ends of ExcIEEEST4B with other classes.

**Table 183 – Association ends of ExcitationSystemDynamics:: ExcIEEEST4B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.19 ExcIEEEST5B

IEEE 421.5-2005 type ST5B model. The type ST5B excitation system is a variation of the type ST1A model, with alternative overexcitation and underexcitation inputs and additional limits.

The block diagram in the IEEE 421.5 standard has input signal Vc and does not indicate the summation point with Vref. The implementation of the ExcIEEEST5B shall consider summation point with Vref.

Reference: IEEE 421.5-2005, 7.5.

Table 184 shows all attributes of ExcIEEEST5B.

**Table 184 – Attributes of ExcitationSystemDynamics::ExcIEEEST5B**

| name | mult | type | description |
|---|---|---|---|
| kr | 1..1 | PU | Regulator gain (KR) (> 0). Typical value = 200. |
| t1 | 1..1 | Seconds | Firing circuit time constant (T1) (>= 0). Typical value = 0,004. |
| kc | 1..1 | PU | Rectifier regulation factor (KC) (>= 0). Typical value = 0,004. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX) (> 0). Typical value = 5. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (< 0). Typical value = -4. |
| tc1 | 1..1 | Seconds | Regulator lead time constant (TC1) (>= 0). Typical value = 0,8. |
| tb1 | 1..1 | Seconds | Regulator lag time constant (TB1) (>= 0). Typical value = 6. |
| tc2 | 1..1 | Seconds | Regulator lead time constant (TC2) (>= 0). Typical value = 0,08. |
| tb2 | 1..1 | Seconds | Regulator lag time constant (TB2) (>= 0). Typical value = 0,01. |
| toc1 | 1..1 | Seconds | OEL lead time constant (TOC1) (>= 0). Typical value = 0,1. |
| tob1 | 1..1 | Seconds | OEL lag time constant (TOB1) (>= 0). Typical value = 2. |
| toc2 | 1..1 | Seconds | OEL lead time constant (TOC2) (>= 0). Typical value = 0,08. |
| tob2 | 1..1 | Seconds | OEL lag time constant (TOB2) (>= 0). Typical value = 0,08. |
| tuc1 | 1..1 | Seconds | UEL lead time constant (TUC1) (>= 0). Typical value = 2. |
| tub1 | 1..1 | Seconds | UEL lag time constant (TUB1) (>= 0). Typical value = 10. |
| tuc2 | 1..1 | Seconds | UEL lead time constant (TUC2) (>= 0). Typical value = 0,1. |
| tub2 | 1..1 | Seconds | UEL lag time constant (TUB2) (>= 0). Typical value = 0,05. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 185 shows all association ends of ExcIEEEST5B with other classes.

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**Table 185 – Association ends of ExcitationSystemDynamics:: ExcIEEEST5B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.20 ExcIEEEST6B

IEEE 421.5-2005 type ST6B model. This model consists of a PI voltage regulator with an inner loop field voltage regulator and pre-control. The field voltage regulator implements a proportional control. The pre-control and the delay in the feedback circuit increase the dynamic response.

Reference: IEEE 421.5-2005, 7.6.

Table 186 shows all attributes of ExcIEEEST6B.

**Table 186 – Attributes of ExcitationSystemDynamics::ExcIEEEST6B**

| name | mult | type | description |
|---|---|---|---|
| ilr | 1..1 | PU | Exciter output current limit reference (ILR) (> 0). Typical value = 4,164. |
| kci | 1..1 | PU | Exciter output current limit adjustment (KCI) (> 0). Typical value = 1,0577. |
| kff | 1..1 | PU | Pre-control gain constant of the inner loop field regulator (KFF). Typical value = 1. |
| kg | 1..1 | PU | Feedback gain constant of the inner loop field regulator (KG) (>= 0). Typical value = 1. |
| kia | 1..1 | PU | Voltage regulator integral gain (KIA) (> 0). Typical value = 45,094. |
| klr | 1..1 | PU | Exciter output current limiter gain (KLR) (> 0). Typical value = 17,33. |
| km | 1..1 | PU | Forward gain constant of the inner loop field regulator (KM). Typical value = 1. |
| kpa | 1..1 | PU | Voltage regulator proportional gain (KPA) (> 0). Typical value = 18,038. |
| oelin | 1..1 | ExcST6BOELselectorKind | OEL input selector (OELin). Typical value = noOELinput. |
| tg | 1..1 | Seconds | Feedback time constant of inner loop field voltage regulator (TG) (>= 0). Typical value = 0,02. |
| vamax | 1..1 | PU | Maximum voltage regulator output (VAMAX) (> 0). Typical value = 4,81. |
| vamin | 1..1 | PU | Minimum voltage regulator output (VAMIN) (< 0). Typical value = -3,85. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX) (> 0). Typical value = 4,81. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (< 0). Typical value = -3,85. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 187 shows all association ends of ExcIEEEST6B with other classes.

**Table 187 – Association ends of ExcitationSystemDynamics:: ExcIEEEST6B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.21 ExcIEEEST7B

IEEE 421.5-2005 type ST7B model. This model is representative of static potential-source excitation systems. In this system, the AVR consists of a PI voltage regulator. A phase lead-lag filter in series allows the introduction of a derivative function, typically used with brushless excitation systems. In that case, the regulator is of the PID type. In addition, the terminal voltage channel includes a phase lead-lag filter. The AVR includes the appropriate inputs on its reference for overexcitation limiter (OEL1), underexcitation limiter (UEL), stator current limiter (SCL), and current compensator (DROOP). All these limitations, when they work at voltage reference level, keep the PSS (VS signal from PSS) in operation. However, the UEL limitation can also be transferred to the high value (HV) gate acting on the output signal. In addition, the output signal passes through a low value (LV) gate for a ceiling overexcitation limiter (OEL2).

Reference: IEEE 421.5-2005, 7.7.

Table 188 shows all attributes of ExcIEEEST7B.

**Table 188 – Attributes of ExcitationSystemDynamics::ExcIEEEST7B**

| name | mult | type | description |
|---|---|---|---|
| kh | 1..1 | PU | High-value gate feedback gain (KH) (>= 0). Typical value = 1. |
| kia | 1..1 | PU | Voltage regulator integral gain (KIA) (>= 0). Typical value = 1. |
| kl | 1..1 | PU | Low-value gate feedback gain (KL) (>= 0). Typical value = 1. |
| kpa | 1..1 | PU | Voltage regulator proportional gain (KPA) (> 0). Typical value = 40. |
| oelin | 1..1 | ExcST7BOELselectorKind | OEL input selector (OELin). Typical value = noOELinput. |
| tb | 1..1 | Seconds | Regulator lag time constant (TB) (>= 0). Typical value = 1. |
| tc | 1..1 | Seconds | Regulator lead time constant (TC) (>= 0). Typical value = 1. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (TF) (>= 0). Typical value = 1. |
| tg | 1..1 | Seconds | Feedback time constant of inner loop field voltage regulator (TG) (>= 0). Typical value = 1. |
| tia | 1..1 | Seconds | Feedback time constant (TIA) (>= 0). Typical value = 3. |
| uelin | 1..1 | ExcST7BUELselectorKind | UEL input selector (UELin). Typical value = noUELinput. |
| vmax | 1..1 | PU | Maximum voltage reference signal (VMAX) (> 0 and > ExcIEEEST7B.vmin). Typical value = 1,1. |
| vmin | 1..1 | PU | Minimum voltage reference signal (VMIN) (> 0 and < ExcIEEEST7B.vmax). Typical value = 0,9. |

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| name | mult | type | description |
|---|---|---|---|
| vrmax | 1..1 | PU | Maximum voltage regulator output (VRMAX) (> 0). Typical value = 5. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (VRMIN) (< 0). Typical value = -4,5. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 189 shows all association ends of ExcIEEEST7B with other classes.

**Table 189 – Association ends of ExcitationSystemDynamics:: ExcIEEEST7B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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### 8.2.4.3.9.22 ExcAC1A

Modified IEEE AC1A alternator-supplied rectifier excitation system with different rate feedback source.

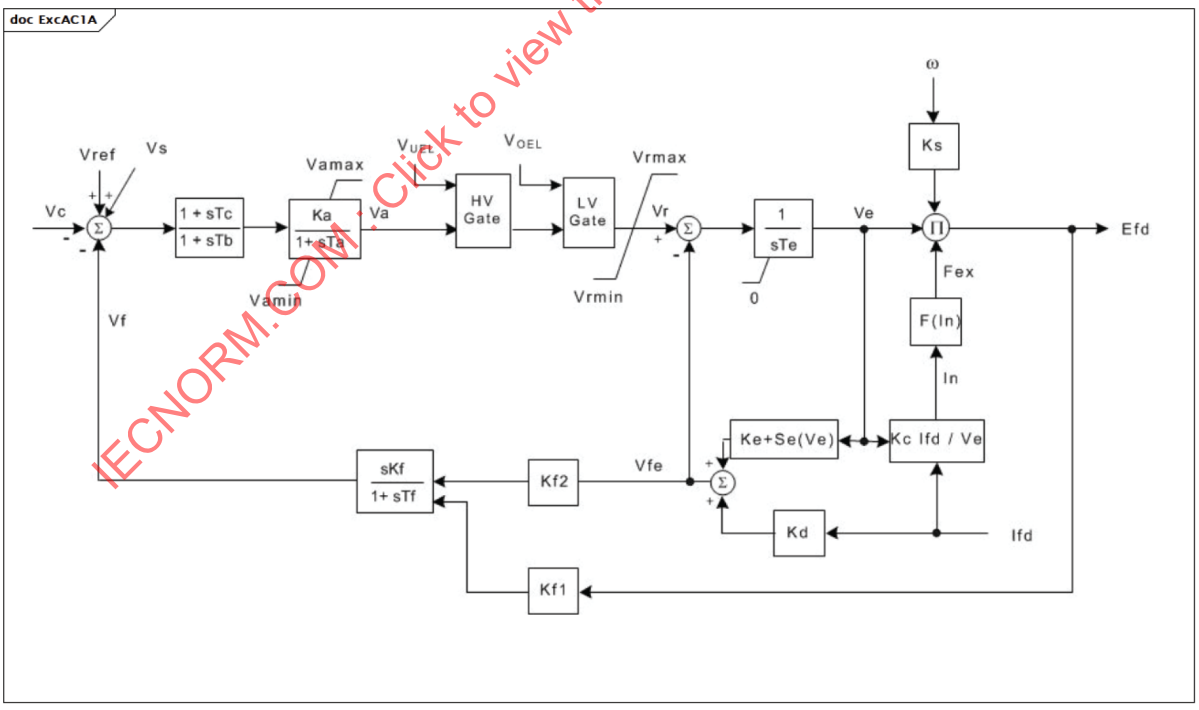


**Figure 100 – ExcAC1A**

Figure 100: This diagram describes the ExcAC1A excitation system model.

Parameter details:

1) If Ks is set to 1 the output (Efd) is multiplied by generator speed.

Table 190 shows all attributes of ExcAC1A.

**Table 190 – Attributes of ExcitationSystemDynamics::ExcAC1A**

| name | mult | type | description |
|---|---|---|---|
| tb | 1..1 | Seconds | Voltage regulator time constant (Tb) (>= 0). Typical value = 0. |
| tc | 1..1 | Seconds | Voltage regulator time constant (Tc) (>= 0). Typical value = 0. |
| ka | 1..1 | PU | Voltage regulator gain (Ka) (> 0). Typical value = 400. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (> 0). Typical value = 0,02. |
| vamax | 1..1 | PU | Maximum voltage regulator output (Vamax) (> 0). Typical value = 14,5. |
| vamin | 1..1 | PU | Minimum voltage regulator output (Vamin) (< 0). Typical value = -14,5. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (Te) (> 0). Typical value = 0,8. |
| kf | 1..1 | PU | Excitation control system stabilizer gains (Kf) (>= 0). Typical value = 0,03. |
| kf1 | 1..1 | PU | Coefficient to allow different usage of the model (Kf1) (>= 0). Typical value = 0. |
| kf2 | 1..1 | PU | Coefficient to allow different usage of the model (Kf2) (>= 0). Typical value = 1. |
| ks | 1..1 | PU | Coefficient to allow different usage of the model-speed coefficient (Ks) (>= 0). Typical value = 0. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf) (> 0). Typical value = 1. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (Kc) (>= 0). Typical value = 0,2. |
| kd | 1..1 | PU | Demagnetizing factor, a function of exciter alternator reactances (Kd) (>= 0). Typical value = 0,38. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (Ke). Typical value = 1. |
| ve1 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (Ve1) (> 0). Typical value = 4,18. |
| seve1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Ve1, back of commutating reactance (Se[Ve1]) (>= 0). Typical value = 0,1. |
| ve2 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (Ve2) (> 0). Typical value = 3,14. |
| seve2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Ve2, back of commutating reactance (Se[Ve2]) (>= 0). Typical value = 0,03. |
| vrmax | 1..1 | PU | Maximum voltage regulator outputs (Vrmax) (> 0). Typical value = 6,03. |
| vrmin | 1..1 | PU | Minimum voltage regulator outputs (Vrmin) (< 0). Typical value = -5,43. |

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| name | mult | type | description |
|---|---|---|---|
| hvlvgates | 1..1 | Boolean | Indicates if both HV gate and LV gate are active (HVLVgates).<br>true = gates are used<br>false = gates are not used.<br>Typical value = true. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 191 shows all association ends of ExcAC1A with other classes.

**Table 191 – Association ends of ExcitationSystemDynamics:: ExcAC1A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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### 8.2.4.3.9.23 ExcAC2A

Modified IEEE AC2A alternator-supplied rectifier excitation system with different field current limit.

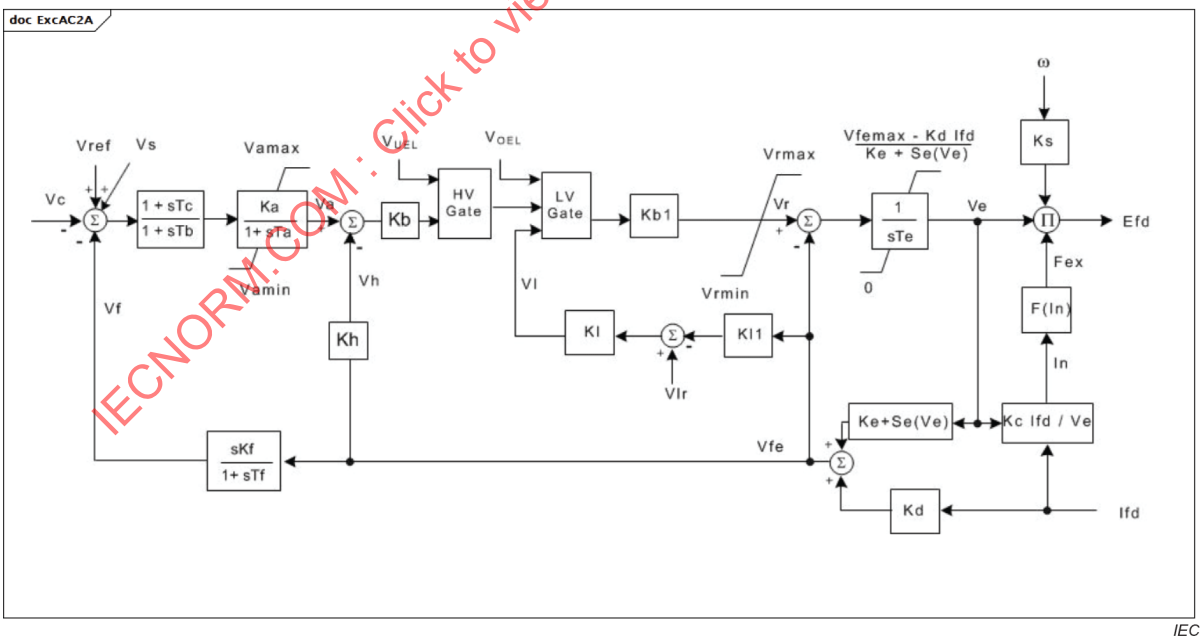


**Figure 101 – ExcAC2A**

Figure 101: This diagram describes the ExcAC2A excitation system model.

Parameter details:

1) If Ks is set to 1 the output (Efd) is multiplied by generator speed;

2) The upper limit on Ve represents the effect of the field current limiter. If Vfemax is zero, this limit will not be enforced. In the real system, the limiter is implemented by a low value gate just before Kb. The input to this LV gate is Kl x (Vlr – Vfe). If the values of Kl and Vlr are given, Vfemax can be calculated as Vlr x Kl x Kb / (1 + Kl x Kb).

Table 192 shows all attributes of ExcAC2A.

**Table 192 – Attributes of ExcitationSystemDynamics::ExcAC2A**

| name | mult | type | description |
|---|---|---|---|
| tb | 1..1 | Seconds | Voltage regulator time constant (Tb) (>= 0). Typical value = 0. |
| tc | 1..1 | Seconds | Voltage regulator time constant (Tc) (>= 0). Typical value = 0. |
| ka | 1..1 | PU | Voltage regulator gain (Ka) (> 0). Typical value = 400. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (> 0). Typical value = 0,02. |
| vamax | 1..1 | PU | Maximum voltage regulator output (Vamax) (> 0). Typical value = 8. |
| vamin | 1..1 | PU | Minimum voltage regulator output (Vamin) (< 0). Typical value = -8. |
| kb | 1..1 | PU | Second stage regulator gain (Kb) (> 0). Exciter field current controller gain. Typical value = 25. |
| kb1 | 1..1 | PU | Second stage regulator gain (Kb1). It is exciter field current controller gain used as alternative to Kb to represent a variant of the ExcAC2A model. Typical value = 25. |
| vrmax | 1..1 | PU | Maximum voltage regulator outputs (Vrmax) (> 0). Typical value = 105. |
| vrmin | 1..1 | PU | Minimum voltage regulator outputs (Vrmin) (< 0). Typical value = -95. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (Te) (> 0). Typical value = 0,6. |
| vfemax | 1..1 | PU | Exciter field current limit reference (Vfemax) (>= 0). Typical value = 4,4. |
| kh | 1..1 | PU | Exciter field current feedback gain (Kh) (>= 0). Typical value = 1. |
| kf | 1..1 | PU | Excitation control system stabilizer gains (Kf) (>= 0). Typical value = 0,03. |
| kl | 1..1 | PU | Exciter field current limiter gain (Kl). Typical value = 10. |
| vlr | 1..1 | PU | Maximum exciter field current (Vlr) (> 0). Typical value = 4,4. |
| kl1 | 1..1 | PU | Coefficient to allow different usage of the model (Kl1). Typical value = 1. |
| ks | 1..1 | PU | Coefficient to allow different usage of the model-speed coefficient (Ks) (>= 0). Typical value = 0. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf) (> 0). Typical value = 1. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (Kc) (>= 0). Typical value = 0,28. |
| kd | 1..1 | PU | Demagnetizing factor, a function of exciter alternator reactances (Kd) (>= 0). Typical value = 0,35. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (Ke). Typical value = 1. |

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| name | mult | type | description |
|---|---|---|---|
| ve1 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (Ve1) (> 0). Typical value = 4,4. |
| seve1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Ve1, back of commutating reactance (Se[Ve1]) (>= 0). Typical value = 0,037. |
| ve2 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (Ve2) (> 0). Typical value = 3,3. |
| seve2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Ve2, back of commutating reactance (Se[Ve2]) (>= 0). Typical value = 0,012. |
| hvgate | 1..1 | Boolean | Indicates if HV gate is active (HVgate).<br>true = gate is used<br>false = gate is not used.<br>Typical value = true. |
| lvgate | 1..1 | Boolean | Indicates if LV gate is active (LVgate).<br>true = gate is used<br>false = gate is not used.<br>Typical value = true. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 193 shows all association ends of ExcAC2A with other classes.

**Table 193 – Association ends of ExcitationSystemDynamics:: ExcAC2A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.24 ExcAC3A

Modified IEEE AC3A alternator-supplied rectifier excitation system with different field current limit.

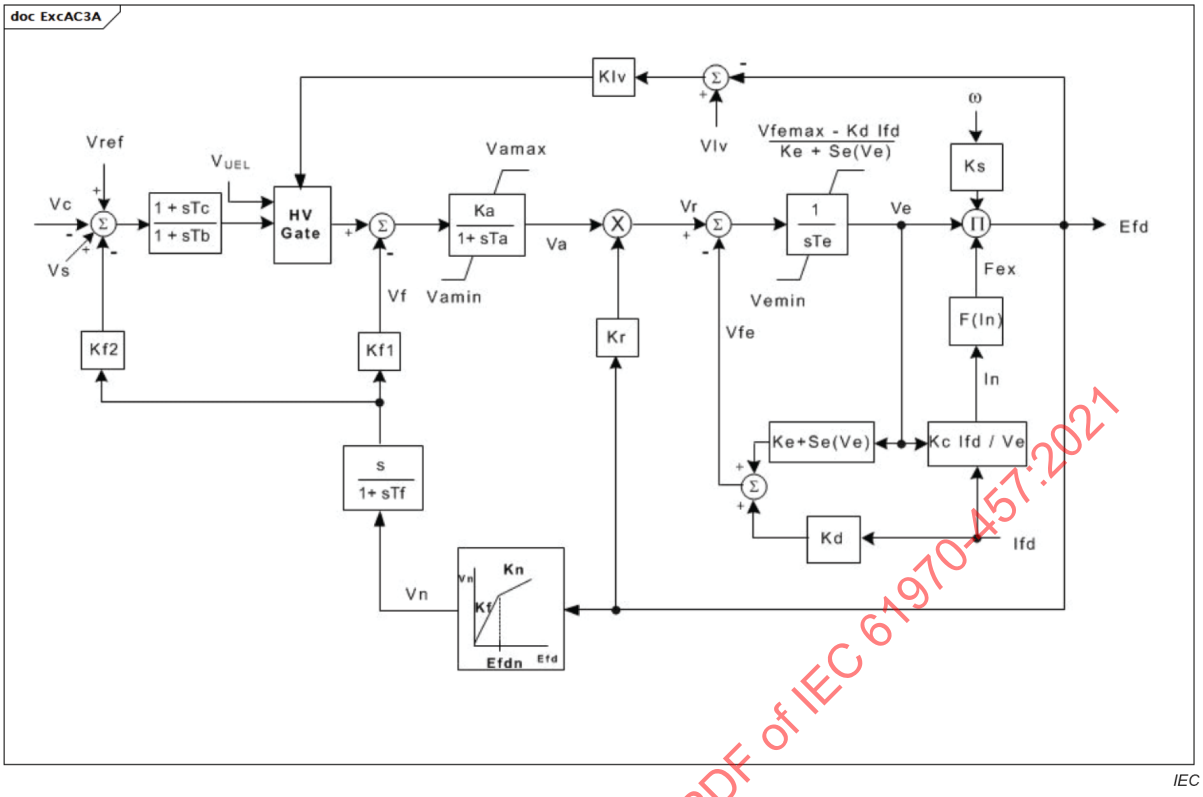


**Figure 102 – ExcAC3A**

Figure 102: This diagram describes the ExcAC3A excitation system model.

Parameter details:

1) If Ks is set to 1, the output (Efd) is multiplied by generator speed.
2) The upper limit on Ve is an approximate representation of the effect of the maximum field current limiter. If Vfemax is zero, this limit will not be enforced. The lower limit (Vemin) on Ve is an approximate representation of the minimum field voltage limiter.

Table 194 shows all attributes of ExcAC3A.

**Table 194 – Attributes of ExcitationSystemDynamics::ExcAC3A**

| name | mult | type | description |
|---|---|---|---|
| tb | 1..1 | Seconds | Voltage regulator time constant (Tb) (>= 0). Typical value = 0. |
| tc | 1..1 | Seconds | Voltage regulator time constant (Tc) (>= 0). Typical value = 0. |
| ka | 1..1 | Seconds | Voltage regulator gain (Ka) (> 0). Typical value = 45,62. |
| ta | 1..1 | PU | Voltage regulator time constant (Ta) (> 0). Typical value = 0,013. |
| vamax | 1..1 | PU | Maximum voltage regulator output (Vamax) (> 0). Typical value = 1. |
| vamin | 1..1 | PU | Minimum voltage regulator output (Vamin) (< 0). Typical value = -0,95. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (Te) (> 0). Typical value = 1,17. |

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| name | mult | type | description |
|---|---|---|---|
| vemin | 1..1 | PU | Minimum exciter voltage output (Vemin) (<= 0). Typical value = 0. |
| kr | 1..1 | PU | Constant associated with regulator and alternator field power supply (Kr) (> 0). Typical value =3,77. |
| kf | 1..1 | PU | Excitation control system stabilizer gains (Kf) (>= 0). Typical value = 0,143. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf) (> 0). Typical value = 1. |
| kn | 1..1 | PU | Excitation control system stabilizer gain (Kn) (>= 0). Typical value =0,05. |
| efdn | 1..1 | PU | Value of Efd at which feedback gain changes (Efdn) (> 0). Typical value = 2,36. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (Kc) (>= 0). Typical value = 0,104. |
| kd | 1..1 | PU | Demagnetizing factor, a function of exciter alternator reactances (Kd) (>= 0). Typical value = 0,499. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (Ke). Typical value = 1. |
| klv | 1..1 | PU | Gain used in the minimum field voltage limiter loop (Klv). Typical value = 0,194. |
| kf1 | 1..1 | PU | Coefficient to allow different usage of the model (Kf1). Typical value = 1. |
| kf2 | 1..1 | PU | Coefficient to allow different usage of the model (Kf2). Typical value = 0. |
| ks | 1..1 | PU | Coefficient to allow different usage of the model-speed coefficient (Ks). Typical value = 0. |
| vfemax | 1..1 | PU | Exciter field current limit reference (Vfemax) (>= 0). Typical value = 16. |
| ve1 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (Ve1) (> 0). Typical value = 6.24. |
| seve1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Ve1, back of commutating reactance (Se[Ve1]) (>= 0). Typical value = 1,143. |
| ve2 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (Ve2) (> 0). Typical value = 4,68. |
| seve2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Ve2, back of commutating reactance (Se[Ve2]) (>= 0). Typical value = 0,1. |
| vlv | 1..1 | PU | Field voltage used in the minimum field voltage limiter loop (Vlv). Typical value = 0,79. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 195 shows all association ends of ExcAC3A with other classes.

**Table 195 – Association ends of ExcitationSystemDynamics:: ExcAC3A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

### 8.2.4.3.9.25 ExcAC4A

Modified IEEE AC4A alternator-supplied rectifier excitation system with different minimum controller output.

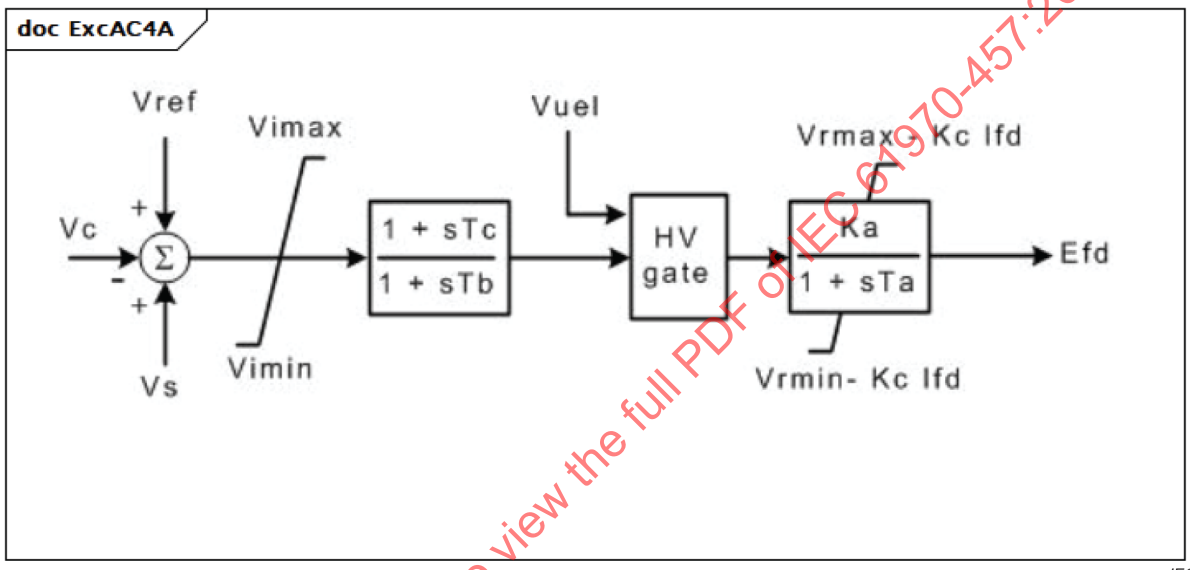


**Figure 103 – ExcAC4A**

Figure 103: This diagram describes the ExcAC4A excitation system model.

Table 196 shows all attributes of ExcAC4A.

**Table 196 – Attributes of ExcitationSystemDynamics::ExcAC4A**

| name | mult | type | description |
|---|---|---|---|
| vimax | 1..1 | PU | Maximum voltage regulator input limit (Vimax) (> 0). Typical value = 10. |
| vimin | 1..1 | PU | Minimum voltage regulator input limit (Vimin) (< 0). Typical value = -10. |
| tc | 1..1 | Seconds | Voltage regulator time constant (Tc) (>= 0). Typical value = 1. |
| tb | 1..1 | Seconds | Voltage regulator time constant (Tb) (>= 0). Typical value = 10. |
| ka | 1..1 | PU | Voltage regulator gain (Ka) (> 0). Typical value = 200. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (> 0). Typical value = 0,015. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (Vrmax) (> 0). Typical value = 5,64. |

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| name | mult | type | description |
|---|---|---|---|
| vrmin | 1..1 | PU | Minimum voltage regulator output (Vrmin) (< 0). Typical value = -4,53. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (Kc) (>= 0). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 197 shows all association ends of ExcAC4A with other classes.

**Table 197 – Association ends of ExcitationSystemDynamics::ExcAC4A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.26 ExcAC5A

Modified IEEE AC5A alternator-supplied rectifier excitation system with different minimum controller output.

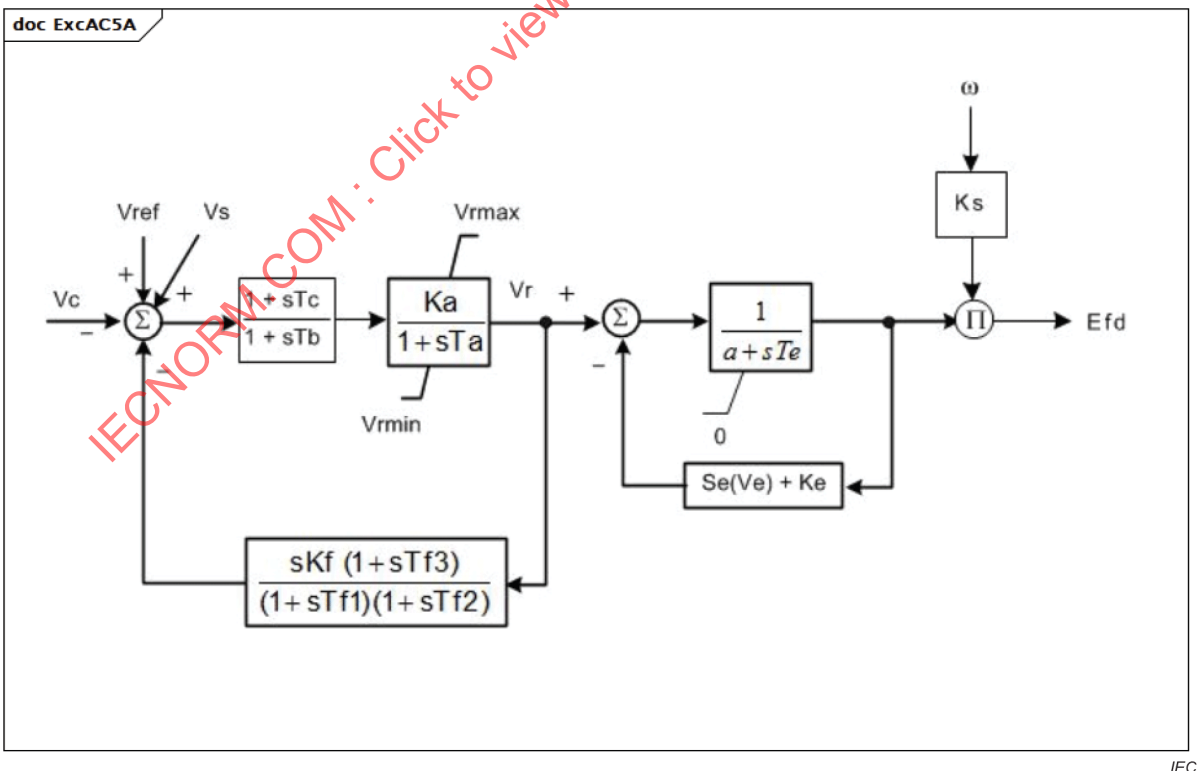


**Figure 104 – ExcAC5A**

Figure 104: This diagram describes the ExcAC5A excitation system model.

Parameter details:

1) If Ks is set to 1, the output (Efd) is multiplied by generator speed.

Table 198 shows all attributes of ExcAC5A.

**Table 198 – Attributes of ExcitationSystemDynamics::ExcAC5A**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | PU | Voltage regulator gain (Ka) (> 0). Typical value = 400. |
| ks | 1..1 | PU | Coefficient to allow different usage of the model-speed coefficient (Ks). Typical value = 0. |
| tb | 1..1 | Seconds | Voltage regulator time constant (Tb) (>= 0). Typical value = 0. |
| tc | 1..1 | Seconds | Voltage regulator time constant (Tc) (>= 0). Typical value = 0. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (> 0). Typical value = 0,02. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (Vrmax) (> 0). Typical value = 7,3. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (Vrmin) (< 0). Typical value =-7,3. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (Ke). Typical value = 1. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (Te) (> 0). Typical value = 0,8. |
| kf | 1..1 | PU | Excitation control system stabilizer gains (Kf) (>= 0). Typical value = 0,03. |
| tf1 | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf1) (> 0). Typical value = 1. |
| tf2 | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf2) (>= 0). Typical value = 0,8. |
| tf3 | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf3) (>= 0). Typical value = 0. |
| efd1 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (Efd1) (> 0). Typical value = 5,6. |
| seefd1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Efd1 (Se[Efd1]) (>= 0). Typical value = 0,86. |
| efd2 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (Efd2) (> 0). Typical value = 4,2. |
| seefd2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Efd2 (Se[Efd2]) (>= 0). Typical value = 0,5. |
| a | 1..1 | Float | Coefficient to allow different usage of the model (a). Typical value = 1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 199 shows all association ends of ExcAC5A with other classes.

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**Table 199 – Association ends of ExcitationSystemDynamics:: ExcAC5A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

### 8.2.4.3.9.27 ExcAC6A

Modified IEEE AC6A alternator-supplied rectifier excitation system with speed input.

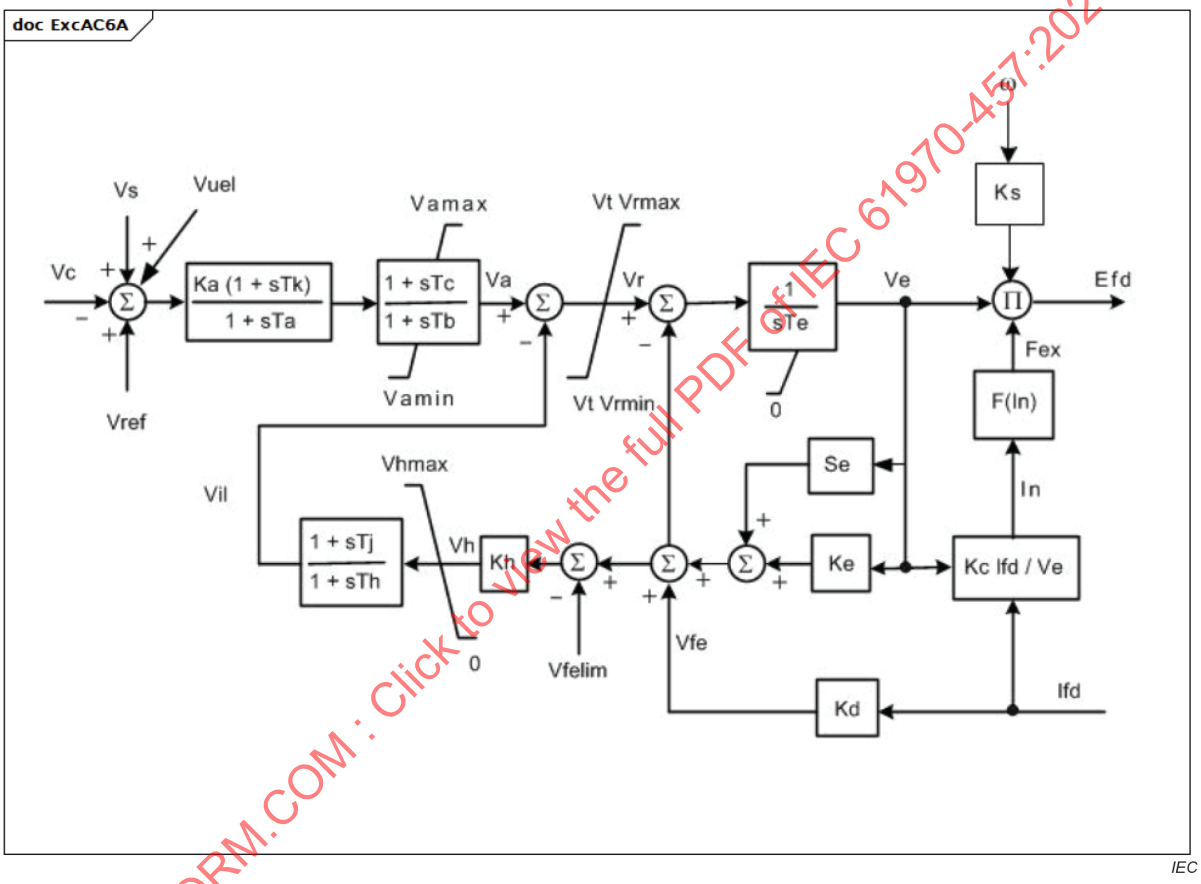


**Figure 105 – ExcAC6A**

Figure 105: This diagram describes the ExcAC6A excitation system model.

Parameter details:

1) If Ks is set to 1 the output (Efd) is multiplied by generator speed.

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Table 200 shows all attributes of ExcAC6A.

**Table 200 – Attributes of ExcitationSystemDynamics::ExcAC6A**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | PU | Voltage regulator gain (Ka) (> 0). Typical value = 536. |
| ks | 1..1 | PU | Coefficient to allow different usage of the model-speed coefficient (Ks). Typical value = 0. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (>= 0). Typical value = 0,086. |
| tk | 1..1 | Seconds | Voltage regulator time constant (Tk) (>= 0). Typical value = 0,18. |
| tb | 1..1 | Seconds | Voltage regulator time constant (Tb) (>= 0). Typical value = 9. |
| tc | 1..1 | Seconds | Voltage regulator time constant (Tc) (>= 0). Typical value = 3. |
| vamax | 1..1 | PU | Maximum voltage regulator output (Vamax) (> 0). Typical value = 75. |
| vamin | 1..1 | PU | Minimum voltage regulator output (Vamin) (< 0). Typical value = -75. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (Vrmax) (> 0). Typical value = 44. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (Vrmin) (< 0). Typical value = -36. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (Te) (> 0). Typical value = 1. |
| kh | 1..1 | PU | Exciter field current limiter gain (Kh) (>= 0). Typical value = 92. |
| tj | 1..1 | Seconds | Exciter field current limiter time constant (Tj) (>= 0). Typical value = 0,02. |
| th | 1..1 | Seconds | Exciter field current limiter time constant (Th) (> 0). Typical value = 0,08. |
| vfelim | 1..1 | PU | Exciter field current limit reference (Vfelim) (> 0). Typical value = 19. |
| vhmax | 1..1 | PU | Maximum field current limiter signal reference (Vhmax) (> 0). Typical value = 75. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (Kc) (>= 0). Typical value = 0,173. |
| kd | 1..1 | PU | Demagnetizing factor, a function of exciter alternator reactances (Kd) (>= 0). Typical value = 1,91. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (Ke). Typical value = 1,6. |
| ve1 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (Ve1) (> 0). Typical value = 7,4. |
| seve1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Ve1, back of commutating reactance (Se[Ve1]) (>= 0). Typical value = 0,214. |
| ve2 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (Ve2) (> 0). Typical value = 5,55. |
| seve2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Ve2, back of commutating reactance (Se[Ve2]) (>= 0). Typical value = 0,044. |

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| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 201 shows all association ends of ExcAC6A with other classes.

**Table 201 – Association ends of ExcitationSystemDynamics:: ExcAC6A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.28 ExcAC8B

Modified IEEE AC8B alternator-supplied rectifier excitation system with speed input and input limiter.

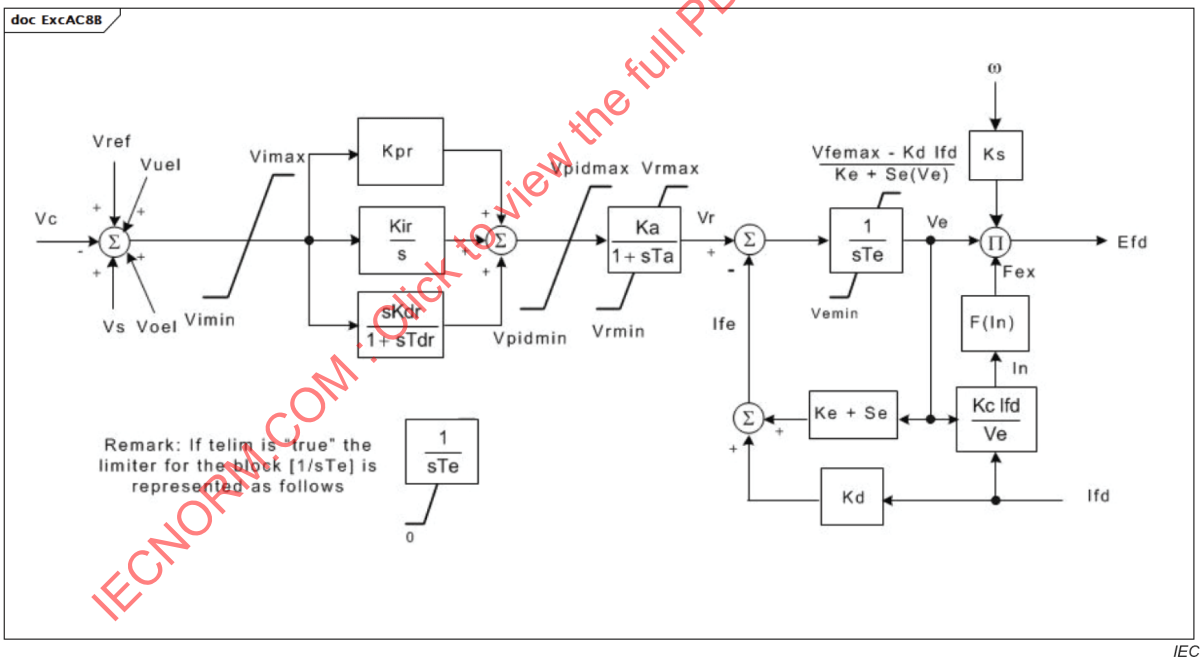


**Figure 106 – ExcAC8B**

Figure 106: This diagram describes the ExcAC8A excitation system model.

Parameter details:

1) The upper limit on Ve represents the effect of the field current limiter. If Vfemax is zero, this limit will not be enforced.
2) The non-windup limits are defined as in Annex E of IEEE 421.5-2005.
3) If Ks is set to 1, the output (Efd) is multiplied by generator speed.

Table 202 shows all attributes of ExcAC8B.

**Table 202 – Attributes of ExcitationSystemDynamics::ExcAC8B**

| name | mult | type | description |
|---|---|---|---|
| inlim | 1..1 | Boolean | Input limiter indicator.<br>true = input limiter Vimax and Vimin is considered<br>false = input limiter Vimax and Vimin is not considered.<br>Typical value = true. |
| ka | 1..1 | PU | Voltage regulator gain (Ka) (> 0). Typical value = 1. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (Kc) (>= 0). Typical value = 0,55. |
| kd | 1..1 | PU | Demagnetizing factor, a function of exciter alternator reactances (Kd) (>= 0). Typical value = 1,1. |
| kdr | 1..1 | PU | Voltage regulator derivative gain (Kdr) (>= 0). Typical value = 10. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (Ke). Typical value = 1. |
| kir | 1..1 | PU | Voltage regulator integral gain (Kir) (>= 0). Typical value = 5. |
| kpr | 1..1 | PU | Voltage regulator proportional gain (Kpr) (> 0 if ExcAC8B.kir = 0). Typical value = 80. |
| ks | 1..1 | PU | Coefficient to allow different usage of the model-speed coefficient (Ks). Typical value = 0. |
| pidlim | 1..1 | Boolean | PID limiter indicator.<br>true = input limiter Vpidmax and Vpidmin is considered<br>false = input limiter Vpidmax and Vpidmin is not considered.<br>Typical value = true. |
| seve1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Ve1, back of commutating reactance (Se[Ve1]) (>= 0). Typical value = 0,3. |
| seve2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Ve2, back of commutating reactance (Se[Ve2]) (>= 0). Typical value = 3. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (>= 0). Typical value = 0. |
| tdr | 1..1 | Seconds | Lag time constant (Tdr) (> 0 if ExcAC8B.kdr > 0). Typical value = 0,1. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (Te) (> 0). Typical value = 1,2. |
| telim | 1..1 | Boolean | Selector for the limiter on the block (1/sTe).<br>See diagram for meaning of true and false.<br>Typical value = false. |
| ve1 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (Ve1) (> 0). Typical value = 6,5. |

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| name | mult | type | description |
|---|---|---|---|
| ve2 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (Ve2) (> 0). Typical value = 9. |
| vemin | 1..1 | PU | Minimum exciter voltage output (Vemin) (<= 0). Typical value = 0. |
| vfemax | 1..1 | PU | Exciter field current limit reference (Vfemax). Typical value = 6. |
| vimax | 1..1 | PU | Input signal maximum (Vimax) (> ExcAC8B.vimin). Typical value = 35. |
| vimin | 1..1 | PU | Input signal minimum (Vimin) (< ExcAC8B.vimax). Typical value = -10. |
| vpidmax | 1..1 | PU | PID maximum controller output (Vpidmax) (> ExcAC8B.vpidmin). Typical value = 35. |
| vpidmin | 1..1 | PU | PID minimum controller output (Vpidmin) (< ExcAC8B.vpidmax). Typical value = -10. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (Vrmax) (> 0). Typical value = 35. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (Vrmin) (< 0). Typical value = 0. |
| vtmult | 1..1 | Boolean | Multiply by generator's terminal voltage indicator.<br><br>true = the limits Vrmax and Vrmin are multiplied by the generator's terminal voltage to represent a thyristor power stage fed from the generator terminals<br><br>false = limits are not multiplied by generator's terminal voltage.<br><br>Typical value = false. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 203 shows all association ends of ExcAC8B with other classes.

**Table 203 – Association ends of ExcitationSystemDynamics:: ExcAC8B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.29 ExcANS

Italian excitation system. It represents static field voltage or excitation current feedback excitation system.

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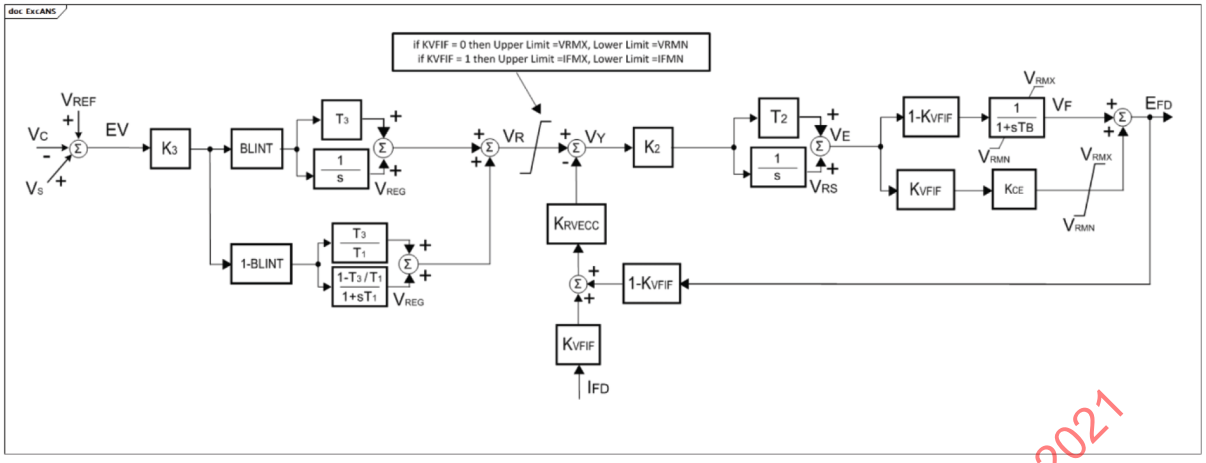


**Figure 107 – ExcANS**

Figure 107: This diagram describes the ExcANS excitation system model.

Parameter details:

1) Limits on VR signal are modelled as follows:
   – If KVFIF = 0, then upper limit = VRMX and lower limit = VRMN;
   – If KVFIF = 1, then upper limit = IFMX and lower limit = IFMN.

Table 204 shows all attributes of ExcANS.

**Table 204 – Attributes of ExcitationSystemDynamics::ExcANS**

| name | mult | type | description |
|---|---|---|---|
| k3 | 1..1 | Float | AVR gain (K3). Typical value = 1 000. |
| k2 | 1..1 | Float | Exciter gain (K2). Typical value = 20. |
| kce | 1..1 | Float | Ceiling factor (KCE). Typical value = 1. |
| t3 | 1..1 | Seconds | Time constant (T3) (>= 0). Typical value = 1,6. |
| t2 | 1..1 | Seconds | Time constant (T2) (>= 0). Typical value = 0,05. |
| t1 | 1..1 | Seconds | Time constant (T1) (>= 0). Typical value = 20. |
| blint | 1..1 | Integer | Governor control flag (BLINT).<br>0 = lead-lag regulator<br>1 = proportional integral regulator.<br>Typical value = 0. |
| kvfif | 1..1 | Integer | Rate feedback signal flag (KVFIF).<br>0 = output voltage of the exciter<br>1 = exciter field current.<br>Typical value = 0. |
| ifmn | 1..1 | PU | Minimum exciter current (IFMN). Typical value = -5,2. |
| ifmx | 1..1 | PU | Maximum exciter current (IFMX). Typical value = 6,5. |
| vrmn | 1..1 | PU | Minimum AVR output (VRMN). Typical value = -5,2. |
| vrmx | 1..1 | PU | Maximum AVR output (VRMX). Typical value = 6,5. |

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| name | mult | type | description |
|---|---|---|---|
| krvecc | 1..1 | Integer | Feedback enabling (KRVECC).<br>0 = open loop control<br>1 = closed loop control.<br>Typical value = 1. |
| tb | 1..1 | Seconds | Exciter time constant (TB) (>= 0). Typical value = 0,04. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 205 shows all association ends of ExcANS with other classes.

**Table 205 – Association ends of ExcitationSystemDynamics::ExcANS with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.30 ExcAVR1

Italian excitation system corresponding to IEEE (1968) type 1 model. It represents an exciter dynamo and electromechanical regulator.

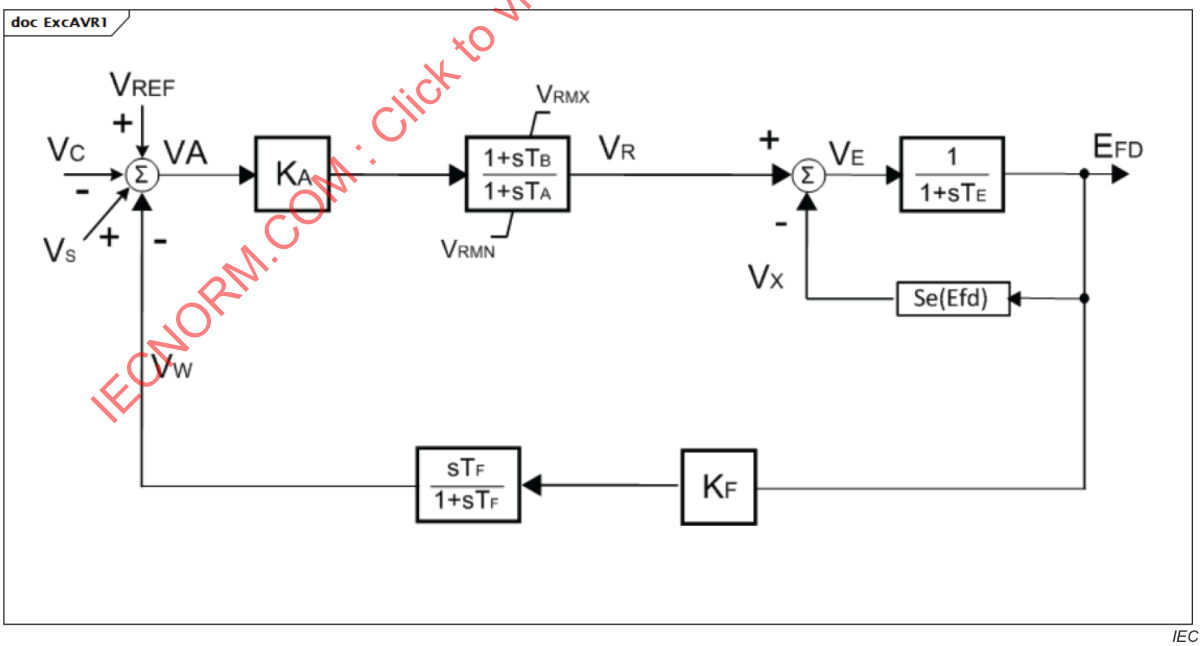


**Figure 108 – ExcAVR1**

Figure 108: This diagram describes the ExcAVR1 excitation system model.

Table 206 shows all attributes of ExcAVR1.

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**Table 206 – Attributes of ExcitationSystemDynamics::ExcAVR1**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | Float | AVR gain (KA). Typical value = 500. |
| vrmn | 1..1 | PU | Minimum AVR output (VRMN). Typical value = -6. |
| vrmx | 1..1 | PU | Maximum AVR output (VRMX). Typical value = 7. |
| ta | 1..1 | Seconds | AVR time constant (TA) (>= 0). Typical value = 0,2. |
| tb | 1..1 | Seconds | AVR time constant (TB) (>= 0). Typical value = 0. |
| te | 1..1 | Seconds | Exciter time constant (TE) (>= 0). Typical value = 1. |
| e1 | 1..1 | PU | Field voltage value 1 (E1). Typical value = 4.18. |
| se1 | 1..1 | Float | Saturation factor at E1 (S[E1]). Typical value = 0,1. |
| e2 | 1..1 | PU | Field voltage value 2 (E2). Typical value = 3,14. |
| se2 | 1..1 | Float | Saturation factor at E2 (S[E2]). Typical value = 0,03. |
| kf | 1..1 | Float | Rate feedback gain (KF). Typical value = 0,12. |
| tf | 1..1 | Seconds | Rate feedback time constant (TF) (>= 0). Typical value = 1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 207 shows all association ends of ExcAVR1 with other classes.

**Table 207 – Association ends of ExcitationSystemDynamics:: ExcAVR1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.31 ExcAVR2

Italian excitation system corresponding to IEEE (1968) type 2 model. It represents an alternator and rotating diodes and electromechanic voltage regulators.

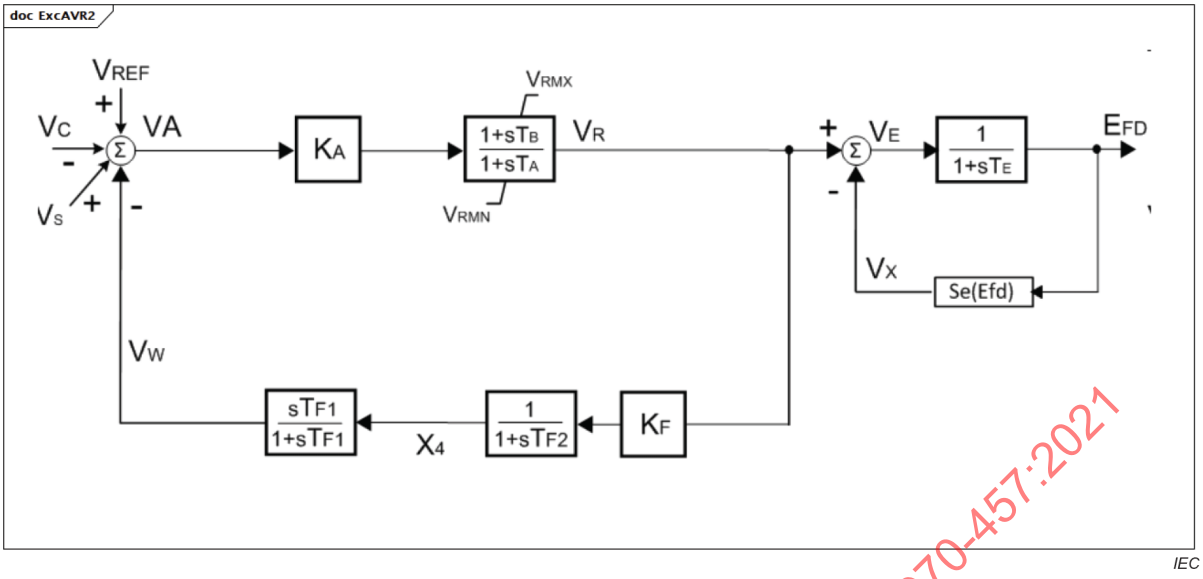


**Figure 109 – ExcAVR2**

Figure 109: This diagram describes the ExcAVR2 excitation system model.

Table 208 shows all attributes of ExcAVR2.

**Table 208 – Attributes of ExcitationSystemDynamics::ExcAVR2**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | Float | AVR gain (KA). Typical value = 500. |
| vrmn | 1..1 | PU | Minimum AVR output (VRMN). Typical value = -6. |
| vrmx | 1..1 | PU | Maximum AVR output (VRMX). Typical value = 7. |
| ta | 1..1 | Seconds | AVR time constant (TA) (>= 0). Typical value = 0,02. |
| tb | 1..1 | Seconds | AVR time constant (TB) (>= 0). Typical value = 0. |
| te | 1..1 | Seconds | Exciter time constant (TE) (>= 0). Typical value = 1. |
| e1 | 1..1 | PU | Field voltage value 1 (E1). Typical value = 4,18. |
| se1 | 1..1 | Float | Saturation factor at E1 (S[E1]). Typical value = 0.1. |
| e2 | 1..1 | PU | Field voltage value 2 (E2). Typical value = 3,14. |
| se2 | 1..1 | Float | Saturation factor at E2 (S[E2]). Typical value = 0,03. |
| kf | 1..1 | Float | Rate feedback gain (KF). Typical value = 0,12. |
| tf1 | 1..1 | Seconds | Rate feedback time constant (TF1) (>= 0). Typical value = 1. |
| tf2 | 1..1 | Seconds | Rate feedback time constant (TF2) (>= 0). Typical value = 1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 209 shows all association ends of ExcAVR2 with other classes.

**Table 209 – Association ends of ExcitationSystemDynamics:: ExcAVR2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.32 ExcAVR3

Italian excitation system. It represents an exciter dynamo and electric regulator.

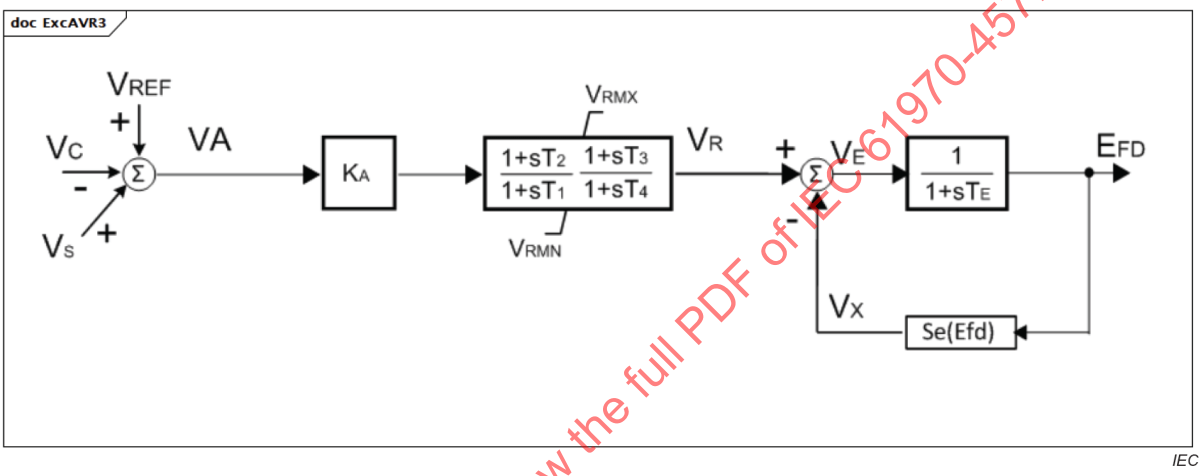


**Figure 110 – ExcAVR3**

Figure 110: This diagram describes the ExcAVR3 excitation system model.

Parameter details:

1) The non-windup limit is defined as in Annex E of the IEEE 421.5-2005.

Table 210 shows all attributes of ExcAVR3.

**Table 210 – Attributes of ExcitationSystemDynamics::ExcAVR3**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | Float | AVR gain (KA). Typical value = 100. |
| vrmn | 1..1 | PU | Minimum AVR output (VRMN). Typical value = -7,5. |
| vrmx | 1..1 | PU | Maximum AVR output (VRMX). Typical value = 7,5. |
| t1 | 1..1 | Seconds | AVR time constant (T1) (>= 0). Typical value = 20. |
| t2 | 1..1 | Seconds | AVR time constant (T2) (>= 0). Typical value = 1,6. |
| t3 | 1..1 | Seconds | AVR time constant (T3) (>= 0). Typical value = 0,66. |
| t4 | 1..1 | Seconds | AVR time constant (T4) (>= 0). Typical value = 0,07. |

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| name | mult | type | description |
|---|---|---|---|
| te | 1..1 | Seconds | Exciter time constant (TE) (>= 0). Typical value = 1. |
| e1 | 1..1 | PU | Field voltage value 1 (E1). Typical value = 4,18. |
| se1 | 1..1 | Float | Saturation factor at E1 (S[E1]). Typical value = 0,1. |
| e2 | 1..1 | PU | Field voltage value 2 (E2). Typical value = 3,14. |
| se2 | 1..1 | Float | Saturation factor at E2 (S[E2]). Typical value = 0,03. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 211 shows all association ends of ExcAVR3 with other classes.

**Table 211 – Association ends of ExcitationSystemDynamics:: ExcAVR3 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.33 ExcAVR4

Italian excitation system. It represents a static exciter and electric voltage regulator.

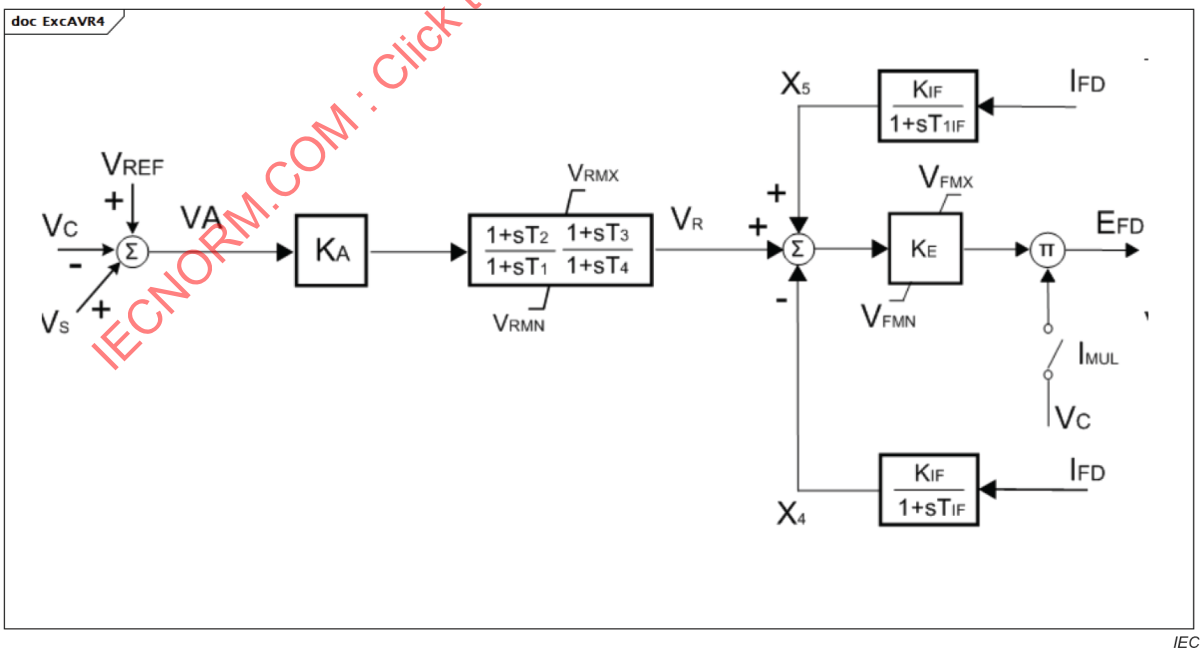


**Figure 111 – ExcAVR4**

Figure 111: This diagram describes the ExcAVR4 excitation system model.

Table 212 shows all attributes of ExcAVR4.

**Table 212 – Attributes of ExcitationSystemDynamics::ExcAVR4**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | Float | AVR gain (KA). Typical value = 300. |
| vrmn | 1..1 | PU | Minimum AVR output (VRMN). Typical value = 0. |
| vrmx | 1..1 | PU | Maximum AVR output (VRMX). Typical value = 5. |
| t1 | 1..1 | Seconds | AVR time constant (T1) (>= 0). Typical value = 4,8. |
| t2 | 1..1 | Seconds | AVR time constant (T2) (>= 0). Typical value = 1,5. |
| t3 | 1..1 | Seconds | AVR time constant (T3) (>= 0). Typical value = 0. |
| t4 | 1..1 | Seconds | AVR time constant (T4) (>= 0). Typical value = 0. |
| ke | 1..1 | Float | Exciter gain (KE). Typical value = 1. |
| vfmx | 1..1 | PU | Maximum exciter output (VFMX). Typical value = 5. |
| vfmn | 1..1 | PU | Minimum exciter output (VFMN). Typical value = 0. |
| kif | 1..1 | Float | Exciter internal reactance (KIF). Typical value = 0. |
| tif | 1..1 | Seconds | Exciter current feedback time constant (TIF) (>= 0). Typical value = 0. |
| t1if | 1..1 | Seconds | Exciter current feedback time constant (T1IF) (>= 0). Typical value = 60. |
| imul | 1..1 | Boolean | AVR output voltage dependency selector (IMUL).<br>true = selector is connected<br>false = selector is not connected.<br>Typical value = true. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 213 shows all association ends of ExcAVR4 with other classes.

**Table 213 – Association ends of ExcitationSystemDynamics:: ExcAVR4 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.34 ExcAVR5

Manual excitation control with field circuit resistance. This model can be used as a very simple representation of manual voltage control.

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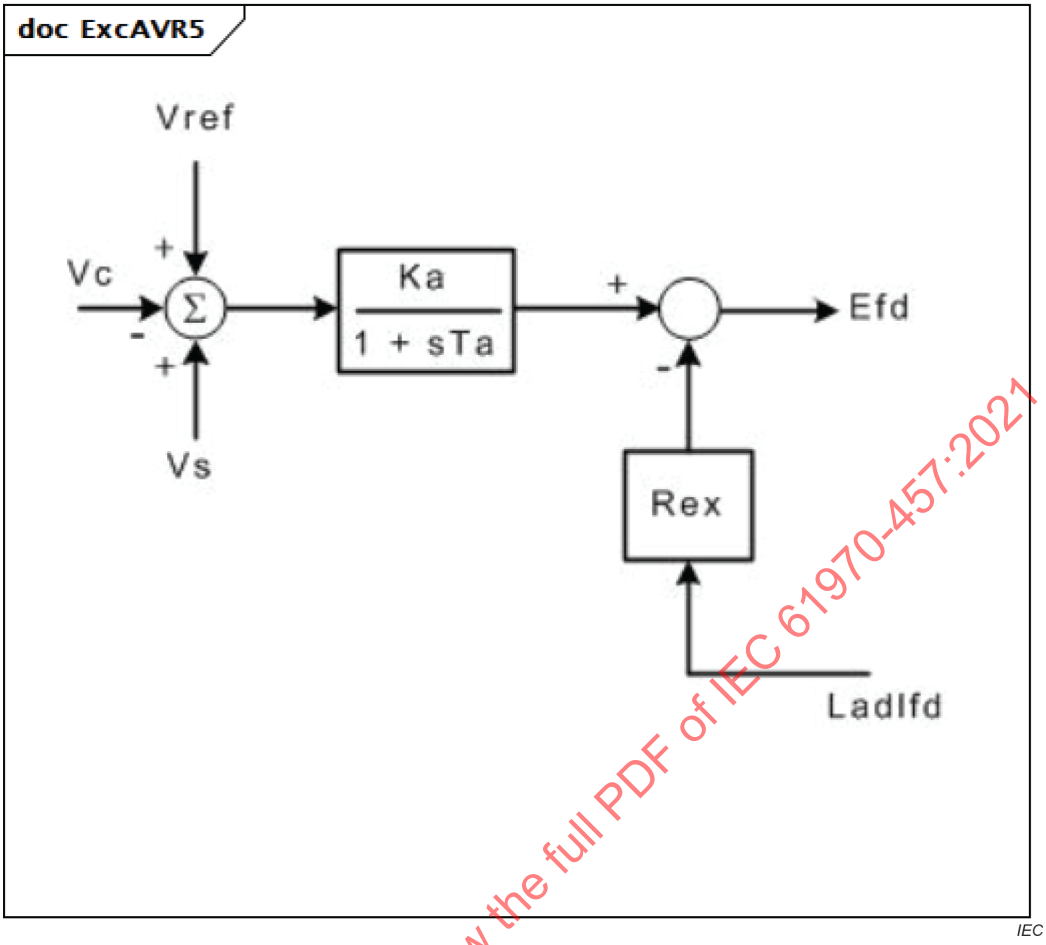


**Figure 112 – ExcAVR5**

Figure 112: This diagram describes the ExcAVR5 excitation system model.

Table 214 shows all attributes of ExcAVR5.

**Table 214 – Attributes of ExcitationSystemDynamics::ExcAVR5**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | PU | Gain (Ka). |
| ta | 1..1 | Seconds | Time constant (Ta) (>= 0). |
| rex | 1..1 | PU | Effective output resistance (Rex). Rex represents the effective output resistance seen by the excitation system. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 215 shows all association ends of ExcAVR5 with other classes.

**Table 215 – Association ends of ExcitationSystemDynamics:: ExcAVR5 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.35 ExcAVR7

IVO excitation system.

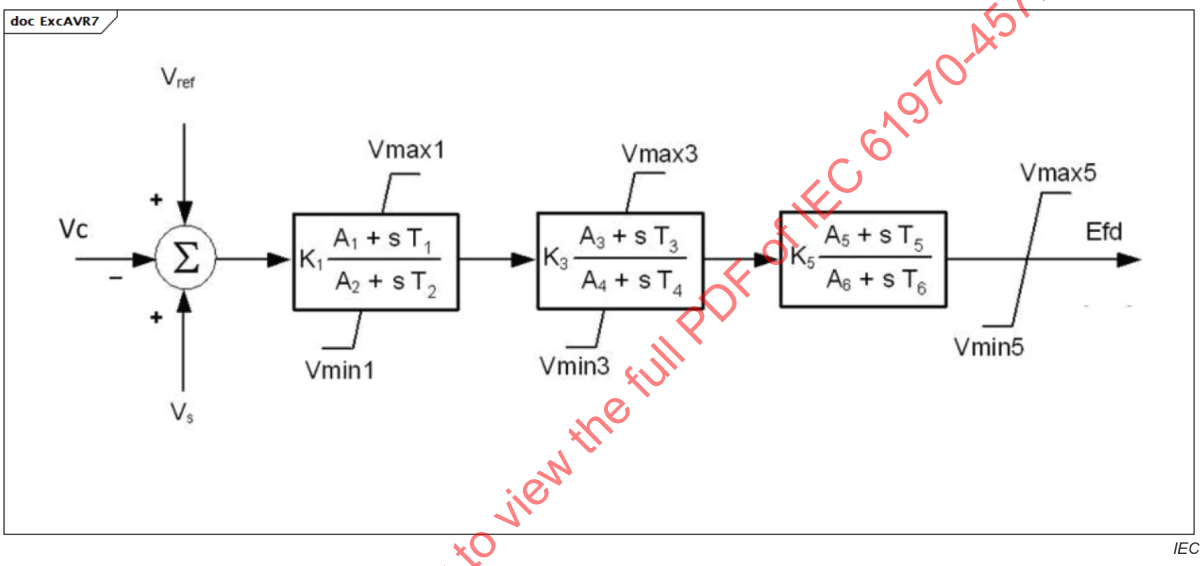


**Figure 113 – ExcAVR7**

Figure 113: This diagram describes the ExcAVR7 excitation system model.

Table 216 shows all attributes of ExcAVR7.

**Table 216 – Attributes of ExcitationSystemDynamics::ExcAVR7**

| name | mult | type | description |
|---|---|---|---|
| k1 | 1..1 | PU | Gain (K1). Typical value = 1. |
| a1 | 1..1 | PU | Lead coefficient (A1). Typical value = 0,5. |
| a2 | 1..1 | PU | Lag coefficient (A2). Typical value = 0,5. |
| t1 | 1..1 | Seconds | Lead time constant (T1) (>= 0). Typical value = 0,05. |
| t2 | 1..1 | Seconds | Lag time constant (T2) (>= 0). Typical value = 0,1. |
| vmax1 | 1..1 | PU | Lead-lag maximum limit (Vmax1) (> ExcAVR7.vmin1). Typical value = 5. |
| vmin1 | 1..1 | PU | Lead-lag minimum limit (Vmin1) (< ExcAVR7.vmax1). Typical value = -5. |
| k3 | 1..1 | PU | Gain (K3). Typical value = 3. |
| a3 | 1..1 | PU | Lead coefficient (A3). Typical value = 0,5. |

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| name | mult | type | description |
|---|---|---|---|
| a4 | 1..1 | PU | Lag coefficient (A4). Typical value = 0,5. |
| t3 | 1..1 | Seconds | Lead time constant (T3) (>= 0). Typical value = 0,1. |
| t4 | 1..1 | Seconds | Lag time constant (T4) (>= 0). Typical value = 0,1. |
| vmax3 | 1..1 | PU | Lead-lag maximum limit (Vmax3) (> ExcAVR7.vmin3). Typical value = 5. |
| vmin3 | 1..1 | PU | Lead-lag minimum limit (Vmin3) (< ExcAVR7.vmax3). Typical value = -5. |
| k5 | 1..1 | PU | Gain (K5). Typical value = 1. |
| a5 | 1..1 | PU | Lead coefficient (A5). Typical value = 0,5. |
| a6 | 1..1 | PU | Lag coefficient (A6). Typical value = 0,5. |
| t5 | 1..1 | Seconds | Lead time constant (T5) (>= 0). Typical value = 0,1. |
| t6 | 1..1 | Seconds | Lag time constant (T6) (>= 0). Typical value = 0,1. |
| vmax5 | 1..1 | PU | Lead-lag maximum limit (Vmax5) (> ExcAVR7.vmin5). Typical value = 5. |
| vmin5 | 1..1 | PU | Lead-lag minimum limit (Vmin5) (< ExcAVR7.vmax5). Typical value = -2. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 217 shows all association ends of ExcAVR7 with other classes.

**Table 217 – Association ends of ExcitationSystemDynamics:: ExcAVR7 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.36 ExcBBC

Transformer fed static excitation system (static with ABB regulator). This model represents a static excitation system in which a gated thyristor bridge fed by a transformer at the main generator terminals feeds the main generator directly.

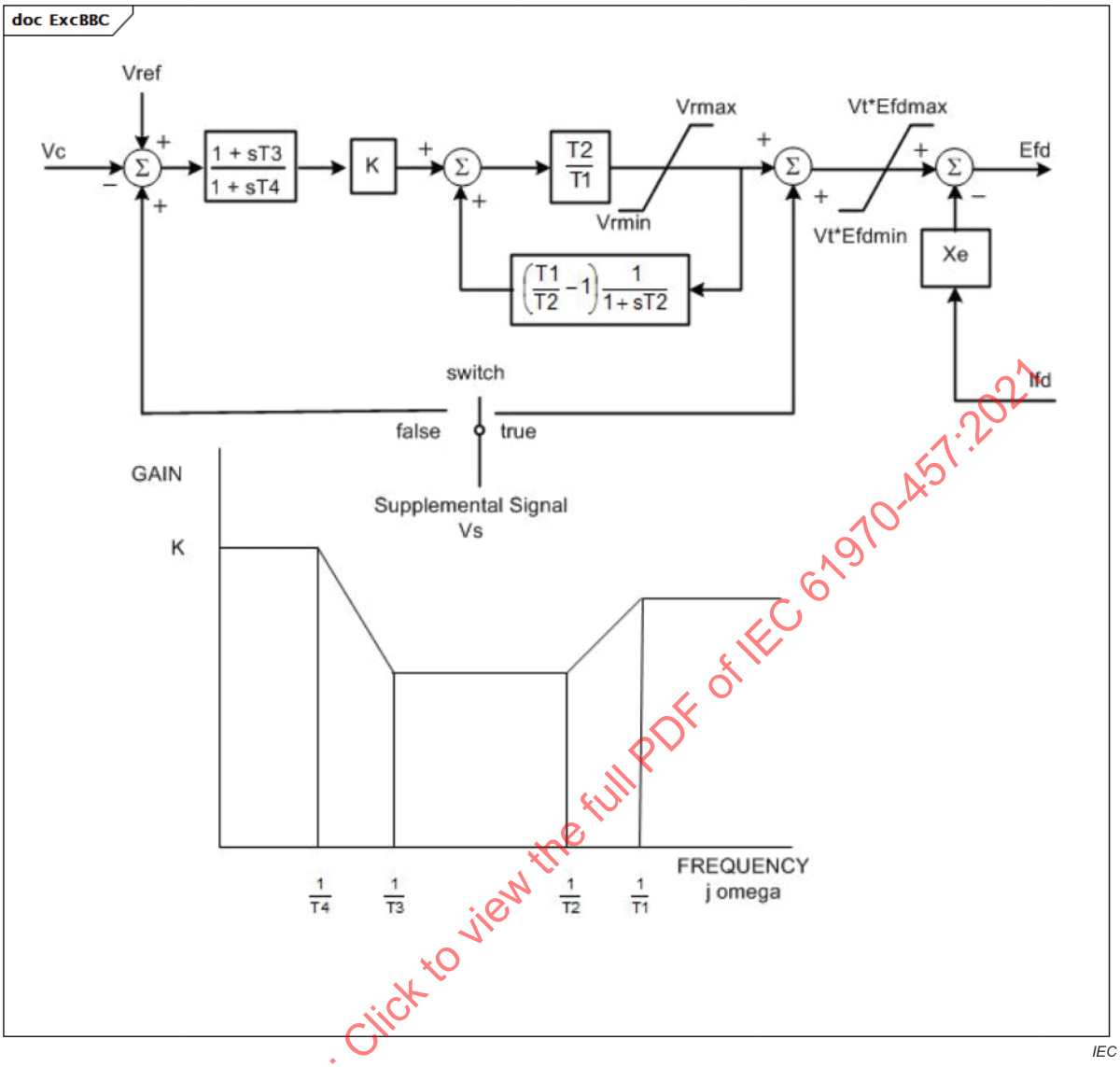


**Figure 114 – ExcBBC**

Figure 114: This diagram describes the ExcBBC excitation system model.

Table 218 shows all attributes of ExcBBC.

**Table 218 – Attributes of ExcitationSystemDynamics::ExcBBC**

| name | mult | type | description |
|---|---|---|---|
| t1 | 1..1 | Seconds | Controller time constant (T1) (>= 0). Typical value = 6. |
| t2 | 1..1 | Seconds | Controller time constant (T2) (>= 0). Typical value = 1. |
| t3 | 1..1 | Seconds | Lead/lag time constant (T3) (>= 0). If = 0, block is bypassed. Typical value = 0,05. |
| t4 | 1..1 | Seconds | Lead/lag time constant (T4) (>= 0). If = 0, block is bypassed. Typical value = 0,01. |
| k | 1..1 | PU | Steady state gain (K) (not = 0). Typical value = 300. |
| vrmin | 1..1 | PU | Minimum control element output (Vrmin) (< ExcBBC.vrmax). Typical value = -5. |

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| name | mult | type | description |
|---|---|---|---|
| vrmax | 1..1 | PU | Maximum control element output (Vrmax) (> ExcBBC.vrmin). Typical value = 5. |
| efdmin | 1..1 | PU | Minimum open circuit exciter voltage (Efdmin) (< ExcBBC.efdmax). Typical value = -5. |
| efdmax | 1..1 | PU | Maximum open circuit exciter voltage (Efdmax) (> ExcBBC.efdmin). Typical value = 5. |
| xe | 1..1 | PU | Effective excitation transformer reactance (Xe) (>= 0). Xe models the regulation of the transformer/rectifier unit. Typical value = 0,05. |
| switch | 1..1 | Boolean | Supplementary signal routing selector (switch).<br>true = Vs connected to 3rd summing point<br>false = Vs connected to 1st summing point (see diagram).<br>Typical value = false. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 219 shows all association ends of ExcBBC with other classes.

**Table 219 – Association ends of ExcitationSystemDynamics:: ExcBBC with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.37 ExcCZ

Czech proportion/integral exciter.

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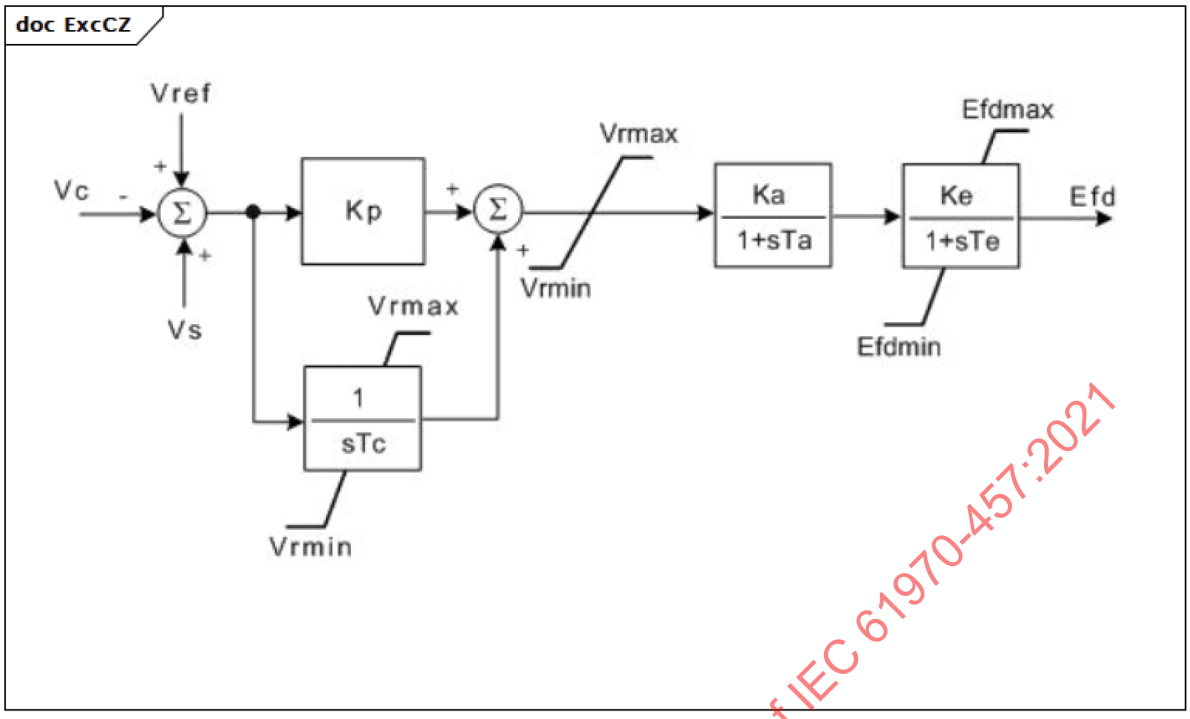


**Figure 115 – ExcCZ**

Figure 115: This diagram describes the ExcCZ excitation system model.

Table 220 shows all attributes of ExcCZ.

**Table 220 – Attributes of ExcitationSystemDynamics::ExcCZ**

| name | mult | type | description |
|---|---|---|---|
| kp | 1..1 | PU | Regulator proportional gain (Kp). |
| tc | 1..1 | Seconds | Regulator integral time constant (Tc) (>= 0). |
| vrmax | 1..1 | PU | Voltage regulator maximum limit (Vrmax) (> ExcCZ.vrmin). |
| vrmin | 1..1 | PU | Voltage regulator minimum limit (Vrmin) (< ExcCZ.vrmax). |
| ka | 1..1 | PU | Regulator gain (Ka). |
| ta | 1..1 | Seconds | Regulator time constant (Ta) (>= 0). |
| ke | 1..1 | PU | Exciter constant related to self-excited field (Ke). |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (Te) (>= 0). |
| efdmax | 1..1 | PU | Exciter output maximum limit (Efdmax) (> ExcCZ.efdmin). |
| efdmin | 1..1 | PU | Exciter output minimum limit (Efdmin) (< ExcCZ.efdmax). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 221 shows all association ends of ExcCZ with other classes.

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**Table 221 – Association ends of ExcitationSystemDynamics::ExcCZ with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.38 ExcDC1A

Modified IEEE DC1A direct current commutator exciter with speed input and without underexcitation limiters (UEL) inputs.

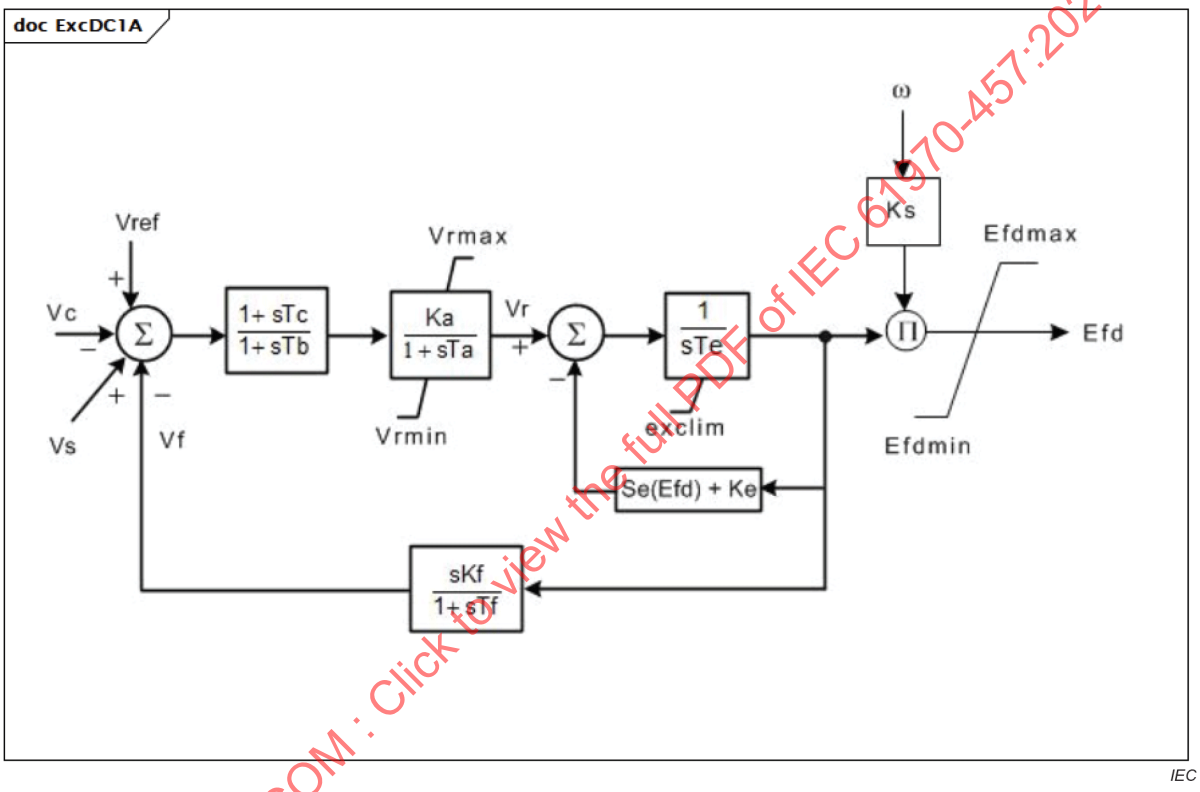


**Figure 116 – ExcDC1A**

Figure 116: This diagram describes the ExcDC1A excitation system model.

Parameter details:

1) If Ks is set to 1, the output (Efd) is multiplied by generator speed.

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Table 222 shows all attributes of ExcDC1A.

**Table 222 – Attributes of ExcitationSystemDynamics::ExcDC1A**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | PU | Voltage regulator gain (Ka) (> 0). Typical value = 46. |
| ks | 1..1 | PU | Coefficient to allow different usage of the model-speed coefficient (Ks). Typical value = 0. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (> 0). Typical value = 0,06. |
| tb | 1..1 | Seconds | Voltage regulator time constant (Tb) (>= 0). Typical value = 0. |
| tc | 1..1 | Seconds | Voltage regulator time constant (Tc) (>= 0). Typical value = 0. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (Vrmax) (> ExcDC1A.vrmin). Typical value = 1. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (Vrmin) (< 0 and < ExcDC1A.vrmax). Typical value = -0,9. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (Ke). Typical value = 0. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (Te) (> 0). Typical value = 0,46. |
| kf | 1..1 | PU | Excitation control system stabilizer gain (Kf) (>= 0). Typical value = 0,1. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf) (> 0). Typical value = 1. |
| efd1 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (Efd1) (> 0). Typical value = 3,1. |
| seefd1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Efd1 (Se[Eefd1]) (>= 0). Typical value = 0,33. |
| efd2 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (Efd2) (> 0). Typical value = 2,3. |
| seefd2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Efd2 (Se[Eefd2]) (>= 0). Typical value = 0,1. |
| exclim | 1..1 | Boolean | (exclim). IEEE standard is ambiguous about lower limit on exciter output.<br>true = a lower limit of zero is applied to integrator output<br>false = a lower limit of zero is not applied to integrator output.<br>Typical value = true. |
| efdmin | 1..1 | PU | Minimum voltage exciter output limiter (Efdmin) (< ExcDC1A.edfmax). Typical value = -99. |
| efdmax | 1..1 | PU | Maximum voltage exciter output limiter (Efdmax) (> ExcDC1A.efdmin). Typical value = 99. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 223 shows all association ends of ExcDC1A with other classes.

**Table 223 – Association ends of ExcitationSystemDynamics:: ExcDC1A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

### 8.2.4.3.9.39 ExcDC2A

Modified IEEE DC2A direct current commutator exciter with speed input, one more lag block in feedback loop and without underexcitation limiters (UEL) inputs. DC type 2 excitation system model with added speed multiplier, added lead-lag, and voltage-dependent limits.

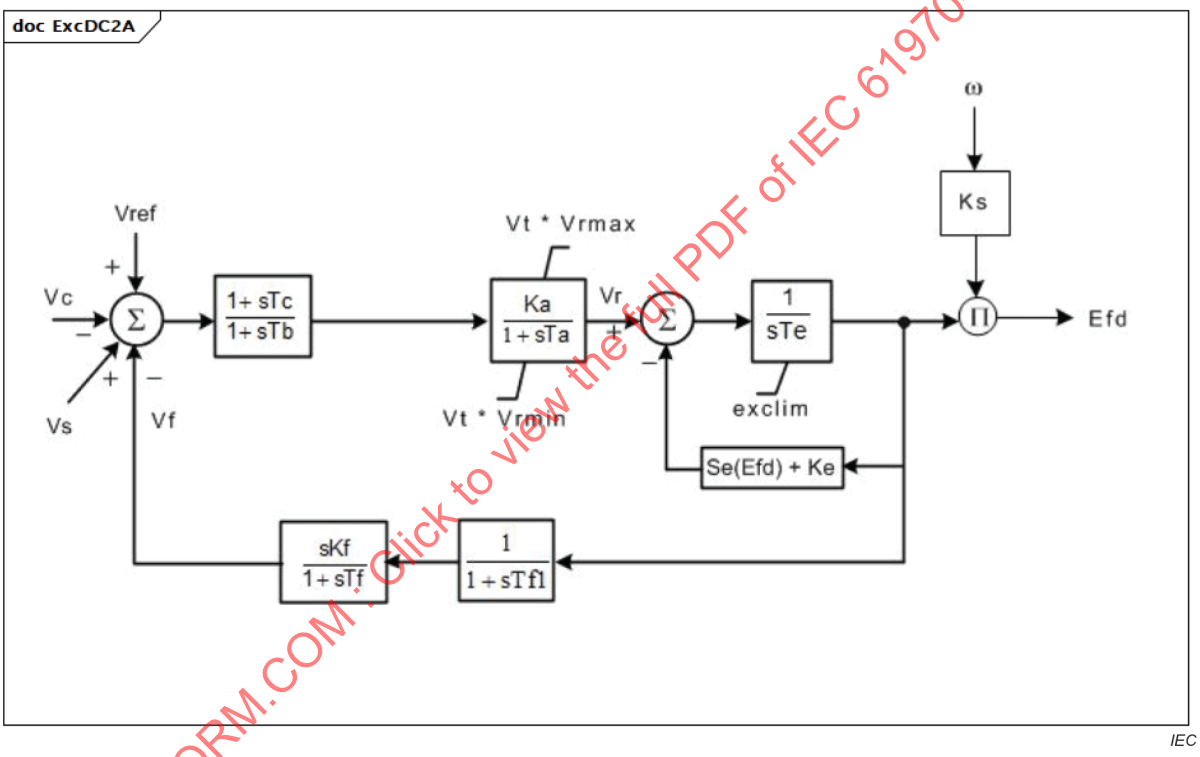


**Figure 117 – ExcDC2A**

Figure 117: This diagram describes the ExcDC2A excitation system model.

Parameter details:

1) If Ks is set to 1, the output (Efd) is multiplied by generator speed.

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Table 224 shows all attributes of ExcDC2A.

**Table 224 – Attributes of ExcitationSystemDynamics::ExcDC2A**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | PU | Voltage regulator gain (Ka) (> 0). Typical value = 300. |
| ks | 1..1 | PU | Coefficient to allow different usage of the model-speed coefficient (Ks). Typical value = 0. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (> 0). Typical value = 0,01. |
| tb | 1..1 | Seconds | Voltage regulator time constant (Tb) (>= 0). Typical value = 0. |
| tc | 1..1 | Seconds | Voltage regulator time constant (Tc) (>= 0). Typical value = 0. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (Vrmax) (> ExcDC2A.vrmin). Typical value = 4,95. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (Vrmin) (< 0 and < ExcDC2A.vrmax). Typical value = -4,9. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (Ke). If Ke is entered as zero, the model calculates an effective value of Ke such that the initial condition value of Vr is zero. The zero value of Ke is not changed. If Ke is entered as non-zero, its value is used directly, without change. Typical value = 1. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (Te) (> 0). Typical value = 1,33. |
| kf | 1..1 | PU | Excitation control system stabilizer gain (Kf) (>= 0). Typical value = 0,1. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf) (> 0). Typical value = 0,675. |
| tf1 | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf1) (>= 0). Typical value = 0. |
| efd1 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (Efd1) (> 0). Typical value = 3,05. |
| seefd1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Efd1 (Se[Efd1]) (>= 0). Typical value = 0,279. |
| efd2 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (Efd2) (> 0). Typical value = 2,29. |
| seefd2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Efd2 (Se[Efd2]) (>= 0). Typical value = 0,117. |
| exclim | 1..1 | Boolean | (exclim). IEEE standard is ambiguous about lower limit on exciter output.<br>true = a lower limit of zero is applied to integrator output<br>false = a lower limit of zero is not applied to integrator output.<br>Typical value = true. |
| vtlim | 1..1 | Boolean | (Vtlim).<br>true = limiter at the block (Ka / [1 + sTa]) is dependent on Vt<br>false = limiter at the block is not dependent on Vt.<br>Typical value = true. |

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| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 225 shows all association ends of ExcDC2A with other classes.

**Table 225 – Association ends of ExcitationSystemDynamics:: ExcDC2A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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### 8.2.4.3.9.40 ExcDC3A

Modified IEEE DC3A direct current commutator exciter with speed input, and deadband. DC old type 4.

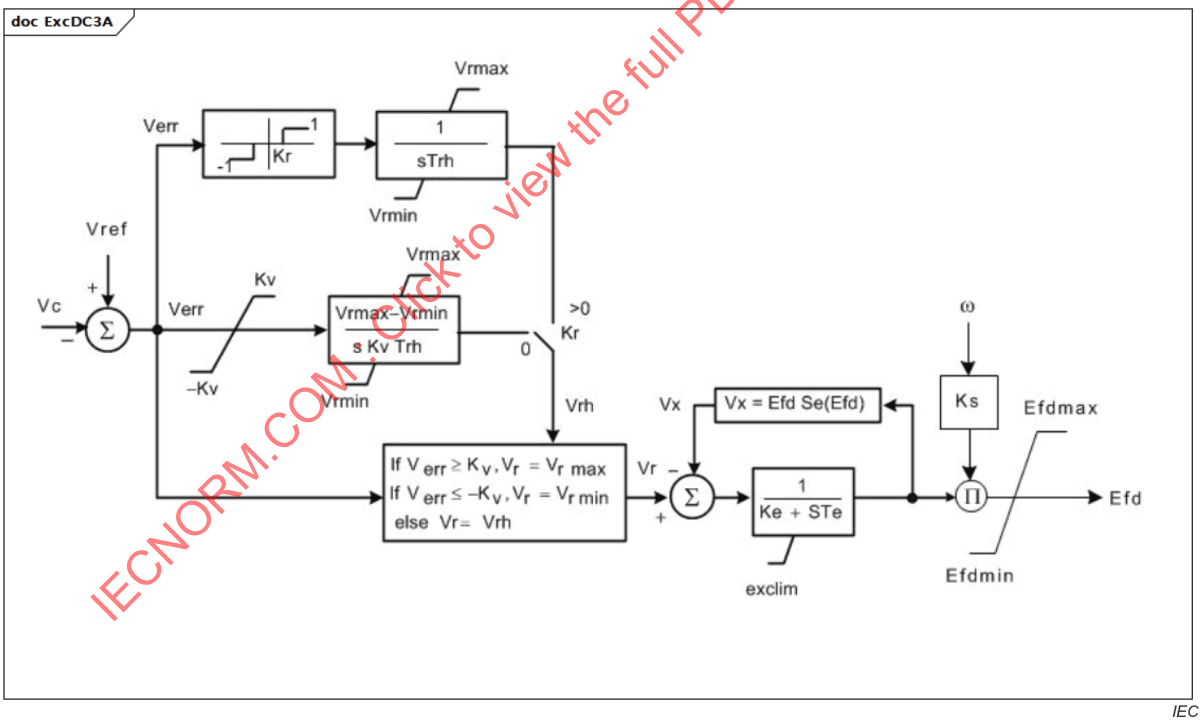


**Figure 118 – ExcDC3A**

Figure 118: This diagram describes the ExcDC3A excitation system model.

Parameter details:

1) If Ks is set to 1, the output (Efd) is multiplied by generator speed.
2) If Kr is not zero, the voltage regulator input changes at a constant rate if Verr > Kr or Verr < -Kr as per the IEEE (1968) type 4 model. If Kr is zero, the error signal drives the voltage regulator continuously as per the IEEE (1980) DC3 and IEEE (1992, 2005) DC3A models.

Table 226 shows all attributes of ExcDC3A.

**Table 226 – Attributes of ExcitationSystemDynamics::ExcDC3A**

| name | mult | type | description |
|---|---|---|---|
| trh | 1..1 | Seconds | Rheostat travel time (Trh) (> 0). Typical value = 20. |
| ks | 1..1 | PU | Coefficient to allow different usage of the model-speed coefficient (Ks). Typical value = 0. |
| kr | 1..1 | PU | Deadband (Kr). Typical value = 0. |
| kv | 1..1 | PU | Fast raise/lower contact setting (Kv) (> 0). Typical value = 0,05. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (Vrmax) (> 0). Typical value = 5. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (Vrmin) (<= 0). Typical value = 0. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (Te) (> 0). Typical value = 1,83. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (Ke). Typical value = 1. |
| efd1 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (Efd1) (> 0). Typical value = 2,6. |
| seefd1 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Efd1 (Se[Efd1]) (>= 0). Typical value = 0,1. |
| efd2 | 1..1 | PU | Exciter voltage at which exciter saturation is defined (Efd2) (> 0). Typical value = 3,45. |
| seefd2 | 1..1 | Float | Exciter saturation function value at the corresponding exciter voltage, Efd2 (Se[Efd2]) (>= 0). Typical value = 0,35. |
| exclim | 1..1 | Boolean | (exclim). IEEE standard is ambiguous about lower limit on exciter output.<br>true = a lower limit of zero is applied to integrator output<br>false = a lower limit of zero not applied to integrator output.<br>Typical value = true. |
| efdmax | 1..1 | PU | Maximum voltage exciter output limiter (Efdmax) (> ExcDC3A.efdmin). Typical value = 99. |
| efdmin | 1..1 | PU | Minimum voltage exciter output limiter (Efdmin) (< ExcDC3A.efdmax). Typical value = -99. |
| efdlim | 1..1 | Boolean | (Efdlim).<br>true = exciter output limiter is active<br>false = exciter output limiter not active.<br>Typical value = true. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 227 shows all association ends of ExcDC3A with other classes.

**Table 227 – Association ends of ExcitationSystemDynamics:: ExcDC3A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.41 ExcDC3A1

Modified old IEEE type 3 excitation system.

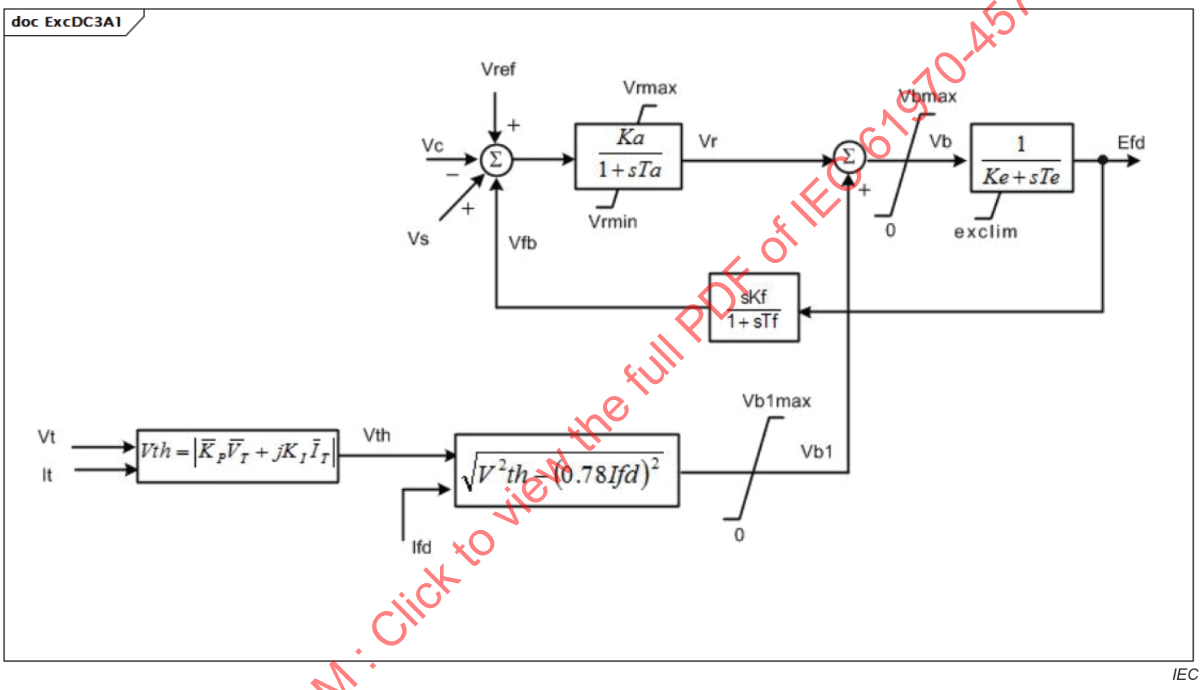


**Figure 119 – ExcDC3A1**

Figure 119: This diagram describes the ExcDC3A1 excitation system model.

Parameter details:

1) Ifd represents LadIfd (XadIfd) and is a voltage proportional to field current in PU (IEEE 421.5-2005, Annex B). It is equal to Efd in steady-state.

Table 228 shows all attributes of ExcDC3A1.

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**Table 228 – Attributes of ExcitationSystemDynamics::ExcDC3A1**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | PU | Voltage regulator gain (Ka) (> 0). Typical value = 300. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (> 0). Typical value = 0,01. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (Vrmax) (> ExcDC3A1.vrmin). Typical value = 5. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (Vrmin) (< 0 and < ExcDC3A1.vrmax). Typical value = 0. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (Te) (> 0). Typical value = 1,83. |
| kf | 1..1 | PU | Excitation control system stabilizer gain (Kf) (>= 0). Typical value = 0,1. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf) (>= 0). Typical value = 0,675. |
| kp | 1..1 | PU | Potential circuit gain coefficient (Kp) (>= 0). Typical value = 4,37. |
| ki | 1..1 | PU | Potential circuit gain coefficient (Ki) (>= 0). Typical value = 4,83. |
| vbmax | 1..1 | PU | Available exciter voltage limiter (Vbmax) (> 0). Typical value = 11,63. |
| exclim | 1..1 | Boolean | (exclim).<br>true = lower limit of zero is applied to integrator output<br>false = lower limit of zero not applied to integrator output.<br>Typical value = true. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (Ke). Typical value = 1. |
| vb1max | 1..1 | PU | Available exciter voltage limiter (Vb1max) (> 0). Typical value = 11,63. |
| vblim | 1..1 | Boolean | Vb limiter indicator.<br>true = exciter Vbmax limiter is active<br>false = Vb1max is active.<br>Typical value = true. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 229 shows all association ends of ExcDC3A1 with other classes.

**Table 229 – Association ends of ExcitationSystemDynamics:: ExcDC3A1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.42 ExcELIN1

Static PI transformer fed excitation system ELIN (VATECH) – simplified model. This model represents an all-static excitation system. A PI voltage controller establishes a desired field current set point for a proportional current controller. The integrator of the PI controller has a follow-up input to match its signal to the present field current. A power system stabilizer with power input is included in the model.

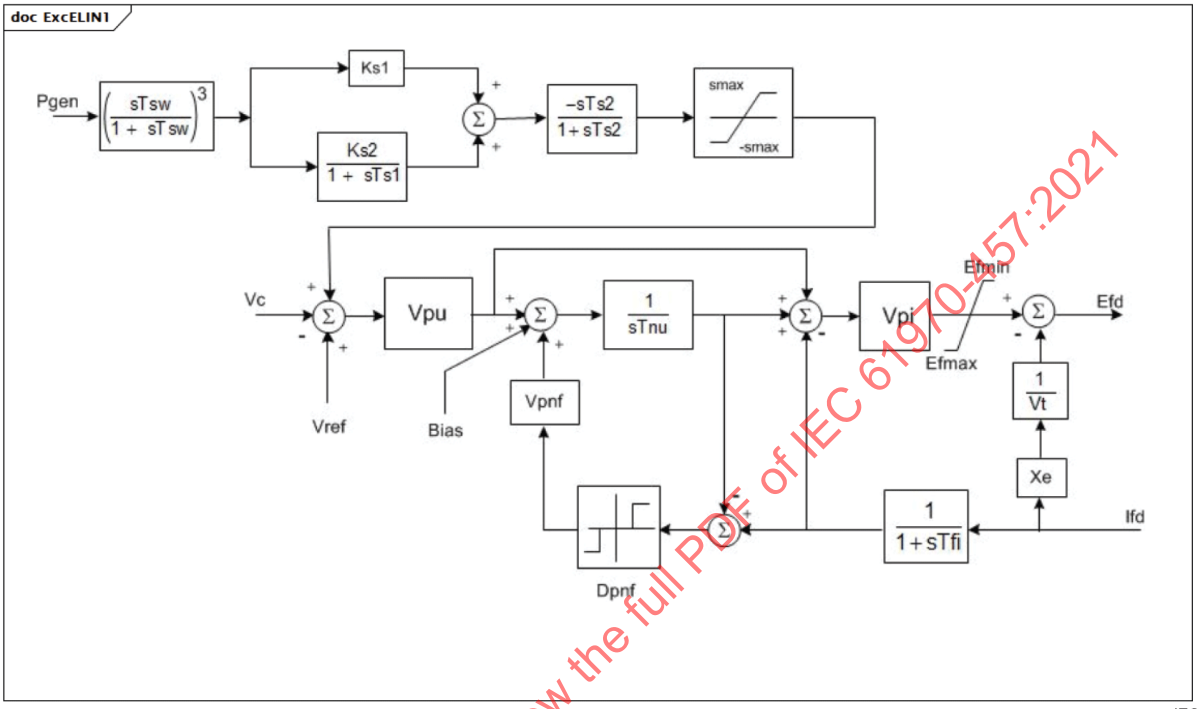


**Figure 120 – ExcELIN1**

Figure 120: This diagram describes the ExcELIN1 excitation system model.

Table 230 shows all attributes of ExcELIN1.

**Table 230 – Attributes of ExcitationSystemDynamics::ExcELIN1**

| name | mult | type | description |
|---|---|---|---|
| tfi | 1..1 | Seconds | Current transducer time constant (Tfi) (>= 0). Typical value = 0. |
| tnu | 1..1 | Seconds | Controller reset time constant (Tnu) (>= 0). Typical value = 2. |
| vpu | 1..1 | PU | Voltage controller proportional gain (Vpu). Typical value = 34,5. |
| vpi | 1..1 | PU | Current controller gain (Vpi). Typical value = 12,45. |
| vpnf | 1..1 | PU | Controller follow up gain (Vpnf). Typical value = 2. |
| dpnf | 1..1 | PU | Controller follow up deadband (Dpnf). Typical value = 0. |
| tsw | 1..1 | Seconds | Stabilizer parameters (Tsw) (>= 0). Typical value = 3. |
| efmin | 1..1 | PU | Minimum open circuit excitation voltage (Efmin) (< ExcELIN1.efmax). Typical value = -5. |

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| name | mult | type | description |
|---|---|---|---|
| efmax | 1..1 | PU | Maximum open circuit excitation voltage (Efmax) (> ExcELIN1.efmin). Typical value = 5. |
| xe | 1..1 | PU | Excitation transformer effective reactance (Xe) (>= 0). Xe represents the regulation of the transformer/rectifier unit. Typical value = 0,06. |
| ks1 | 1..1 | PU | Stabilizer gain 1 (Ks1). Typical value = 0. |
| ks2 | 1..1 | PU | Stabilizer gain 2 (Ks2). Typical value = 0. |
| ts1 | 1..1 | Seconds | Stabilizer phase lag time constant (Ts1) (>= 0). Typical value = 1. |
| ts2 | 1..1 | Seconds | Stabilizer filter time constant (Ts2) (>= 0). Typical value = 1. |
| smax | 1..1 | PU | Stabilizer limit output (smax). Typical value = 0,1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 231 shows all association ends of ExcELIN1 with other classes.

**Table 231 – Association ends of ExcitationSystemDynamics:: ExcELIN1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.43 ExcELIN2

Detailed excitation system ELIN (VATECH). This model represents an all-static excitation system. A PI voltage controller establishes a desired field current set point for a proportional current controller. The integrator of the PI controller has a follow-up input to match its signal to the present field current. Power system stabilizer models used in conjunction with this excitation system model: PssELIN2, PssIEEE2B, Pss2B.

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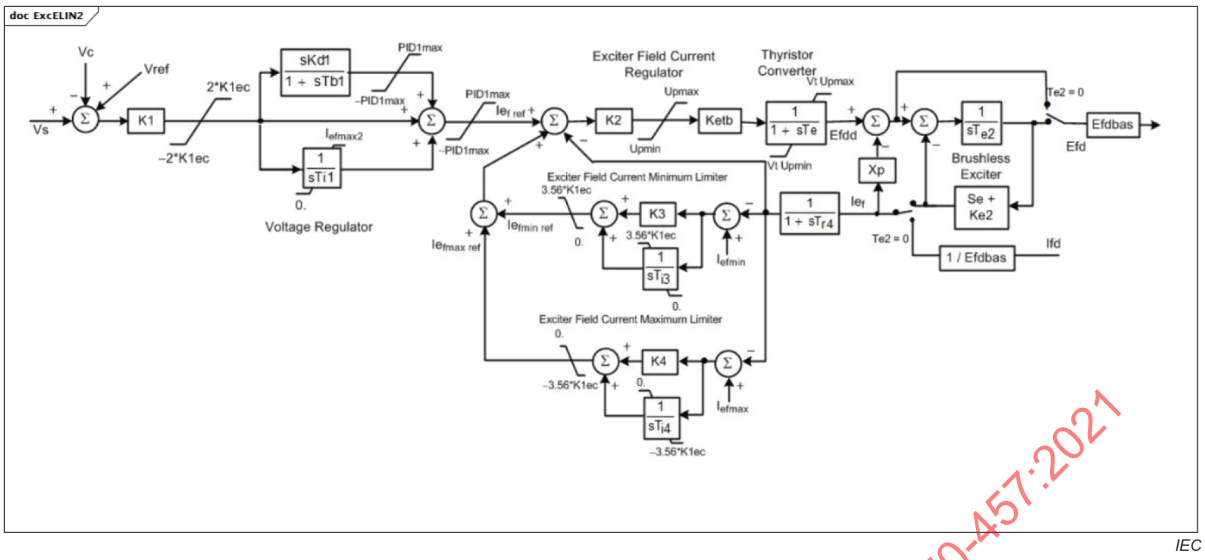


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**Figure 121 – ExcELIN2**

Figure 121: This diagram describes the ExcELIN2 excitation system model.

Table 232 shows all attributes of ExcELIN2.

**Table 232 – Attributes of ExcitationSystemDynamics::ExcELIN2**

| name | mult | type | description |
|---|---|---|---|
| k1 | 1..1 | PU | Voltage regulator input gain (K1). Typical value = 0. |
| k1ec | 1..1 | PU | Voltage regulator input limit (K1ec). Typical value = 2. |
| kd1 | 1..1 | PU | Voltage controller derivative gain (Kd1). Typical value = 34,5. |
| tb1 | 1..1 | Seconds | Voltage controller derivative washout time constant (Tb1) (>= 0). Typical value = 12,45. |
| pid1max | 1..1 | PU | Controller follow up gain (PID1max). Typical value = 2. |
| ti1 | 1..1 | PU | Controller follow up deadband (Ti1). Typical value = 0. |
| iefmax2 | 1..1 | PU | Minimum open circuit excitation voltage (Iefmax2). Typical value = -5. |
| k2 | 1..1 | PU | Gain (K2). Typical value = 5. |
| ketb | 1..1 | PU | Gain (Ketb). Typical value = 0,06. |
| upmax | 1..1 | PU | Limiter (Upmax) (> ExcELIN2.upmin). Typical value = 3. |
| upmin | 1..1 | PU | Limiter (Upmin) (< ExcELIN2.upmax). Typical value = 0. |
| te | 1..1 | Seconds | Time constant (Te) (>= 0). Typical value = 0. |
| xp | 1..1 | PU | Excitation transformer effective reactance (Xp). Typical value = 1. |
| te2 | 1..1 | Seconds | Time Constant (Te2) (>= 0). Typical value = 1. |
| ke2 | 1..1 | PU | Gain (Ke2). Typical value = 0,1. |
| ve1 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (Ve1) (> 0). Typical value = 3. |

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| name | mult | type | description |
|---|---|---|---|
| seve1 | 1..1 | PU | Exciter saturation function value at the corresponding exciter voltage, Ve1, back of commutating reactance (Se[Ve1]) (>= 0). Typical value = 0. |
| ve2 | 1..1 | PU | Exciter alternator output voltages back of commutating reactance at which saturation is defined (Ve2) (> 0). Typical value = 0. |
| seve2 | 1..1 | PU | Exciter saturation function value at the corresponding exciter voltage, Ve2, back of commutating reactance (Se[Ve2]) (>= 0). Typical value = 1. |
| tr4 | 1..1 | Seconds | Time constant (Tr4) (>= 0). Typical value = 1. |
| k3 | 1..1 | PU | Gain (K3). Typical value = 0,1. |
| ti3 | 1..1 | Seconds | Time constant (Ti3) (>= 0). Typical value = 3. |
| k4 | 1..1 | PU | Gain (K4). Typical value = 0. |
| ti4 | 1..1 | Seconds | Time constant (Ti4) (>= 0). Typical value = 0. |
| iefmax | 1..1 | PU | Limiter (Iefmax) (> ExcELIN2.iefmin). Typical value = 1. |
| iefmin | 1..1 | PU | Limiter (Iefmin) (< ExcELIN2.iefmax). Typical value = 1. |
| efdbas | 1..1 | PU | Gain (Efdbas). Typical value = 0,1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 233 shows all association ends of ExcELIN2 with other classes.

**Table 233 – Association ends of ExcitationSystemDynamics:: ExcELIN2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.44 ExcHU

Hungarian excitation system, with built-in voltage transducer.

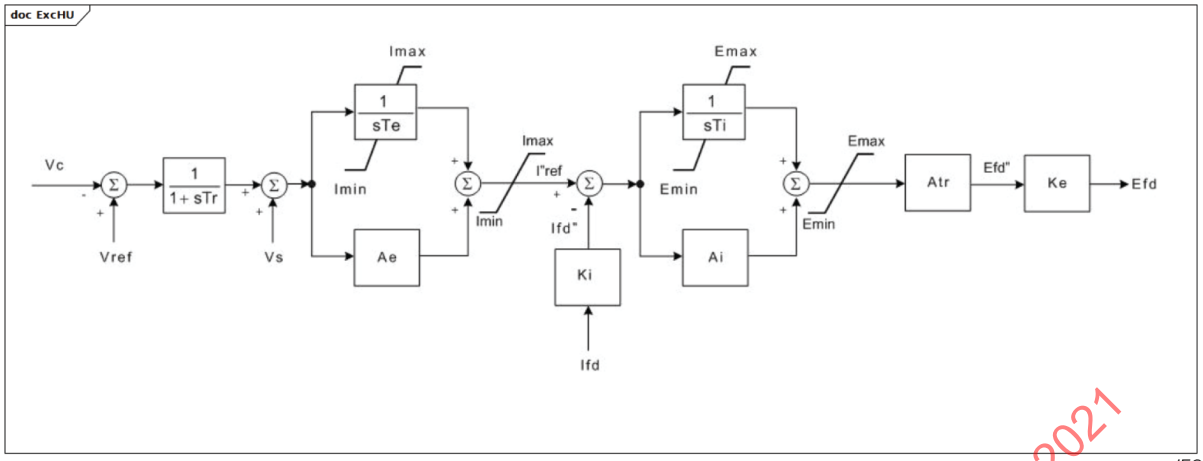


**Figure 122 – ExcHU**

Figure 122: This diagram describes the ExcHU excitation system model.

Table 234 shows all attributes of ExcHU.

**Table 234 – Attributes of ExcitationSystemDynamics::ExcHU**

| name | mult | type | description |
|---|---|---|---|
| tr | 1..1 | Seconds | Filter time constant (Tr) (>= 0). If a voltage compensator is used in conjunction with this excitation system model, Tr should be set to 0. Typical value = 0,01. |
| te | 1..1 | Seconds | Major loop PI tag integration time constant (Te) (>= 0). Typical value = 0,154. |
| imin | 1..1 | PU | Major loop PI tag output signal lower limit (Imin) (< ExcHU.imax). Typical value = 0,1. |
| imax | 1..1 | PU | Major loop PI tag output signal upper limit (Imax) (> ExcHU.imin). Typical value = 2,19. |
| ae | 1..1 | PU | Major loop PI tag gain factor (Ae). Typical value = 3. |
| emin | 1..1 | PU | Field voltage control signal lower limit on AVR base (Emin) (< ExcHU.emax). Typical value = -0,866. |
| emax | 1..1 | PU | Field voltage control signal upper limit on AVR base (Emax) (> ExcHU.emin). Typical value = 0,996. |
| ki | 1..1 | Float | Current base conversion constant (Ki). Typical value = 0,2 142 8. |
| ai | 1..1 | PU | Minor loop PI tag gain factor (Ai). Typical value = 22. |
| ti | 1..1 | Seconds | Minor loop PI control tag integration time constant (Ti) (>= 0). Typical value = 0,0 133 3. |
| atr | 1..1 | PU | AVR constant (Atr). Typical value = 2,19. |
| ke | 1..1 | Float | Voltage base conversion constant (Ke). Typical value = 4,666. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 235 shows all association ends of ExcHU with other classes.

**Table 235 – Association ends of ExcitationSystemDynamics::ExcHU with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.45 ExcNI

Bus or solid fed SCR (silicon-controlled rectifier) bridge excitation system model type NI (NVE).

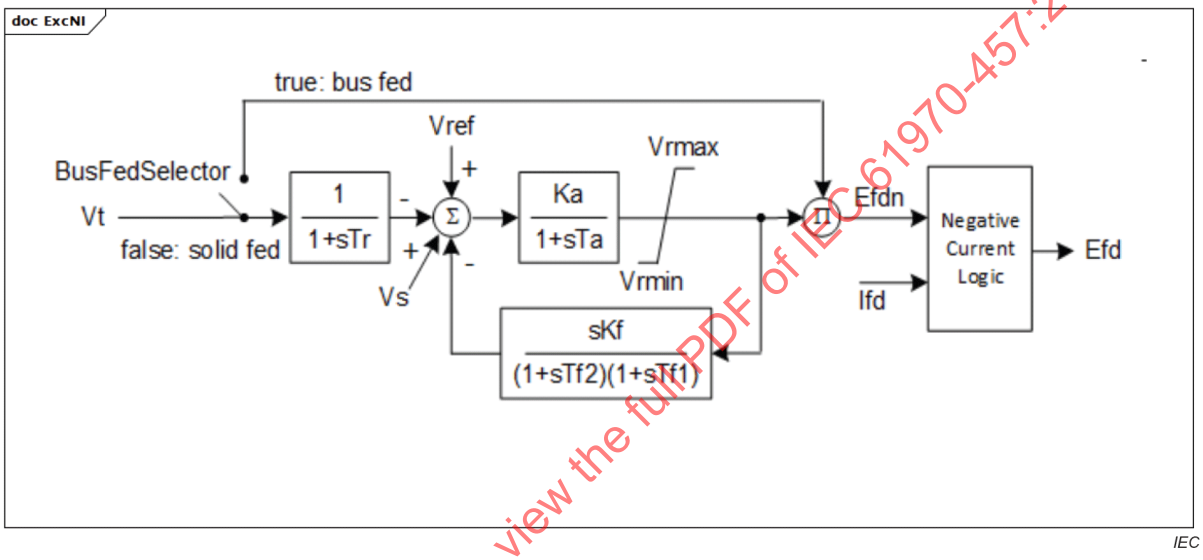


**Figure 123 – ExcNI**

Figure 123: This diagram describes the ExcNI excitation system model.

Parameter details:

1) R shall either be = 0 (meaning the exciter has negative current capability) or > 0 (meaning the exciter has no negative current capability).
2) The 'Negative Current Logic' block logic uses the R parameter and the Efdn and Ifd inputs. The output Efd is set equal to the input Efdn unless R x Ifd > 0 and R x Ifd > Efdn, in which case Efd is set equal to R x Ifd. This means that the negative current logic is active (R and Ifd are used to calculate Efd) only when the current is positive and the exciter does not have current capability (i.e. when ExcNi.r is greater than 0).

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Table 236 shows all attributes of ExcNI.

**Table 236 – Attributes of ExcitationSystemDynamics::ExcNI**

| name | mult | type | description |
|---|---|---|---|
| busFedSelector | 1..1 | Boolean | Fed by selector (BusFedSelector).<br>true = bus fed (switch is closed)<br>false = solid fed (switch is open).<br>Typical value = true. |
| tr | 1..1 | Seconds | Time constant (Tr) (>= 0). Typical value = 0,02. |
| ka | 1..1 | PU | Voltage regulator gain (Ka) (> 0). Typical value = 210. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (> 0). Typical value = 0,02. |
| vrmax | 1..1 | PU | Maximum voltage regulator ouput (Vrmax) (> ExcNI.vrmin). Typical value = 5,0. |
| vrmin | 1..1 | PU | Minimum voltage regulator ouput (Vrmin) (< ExcNI.vrmax). Typical value = -2,0. |
| kf | 1..1 | PU | Excitation control system stabilizer gain (Kf) (> 0). Typical value 0,01. |
| tf2 | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf2) (> 0). Typical value = 0,1. |
| tf1 | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf1) (> 0). Typical value = 1,0. |
| r | 1..1 | PU | rc / rfd (R) (>= 0).<br>0 means exciter has negative current capability<br>> 0 means exciter does not have negative current capability.<br>Typical value = 5. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 237 shows all association ends of ExcNI with other classes.

**Table 237 – Association ends of ExcitationSystemDynamics::ExcNI with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.46 ExcOEX3T

Modified IEEE type ST1 excitation system with semi-continuous and acting terminal voltage limiter.

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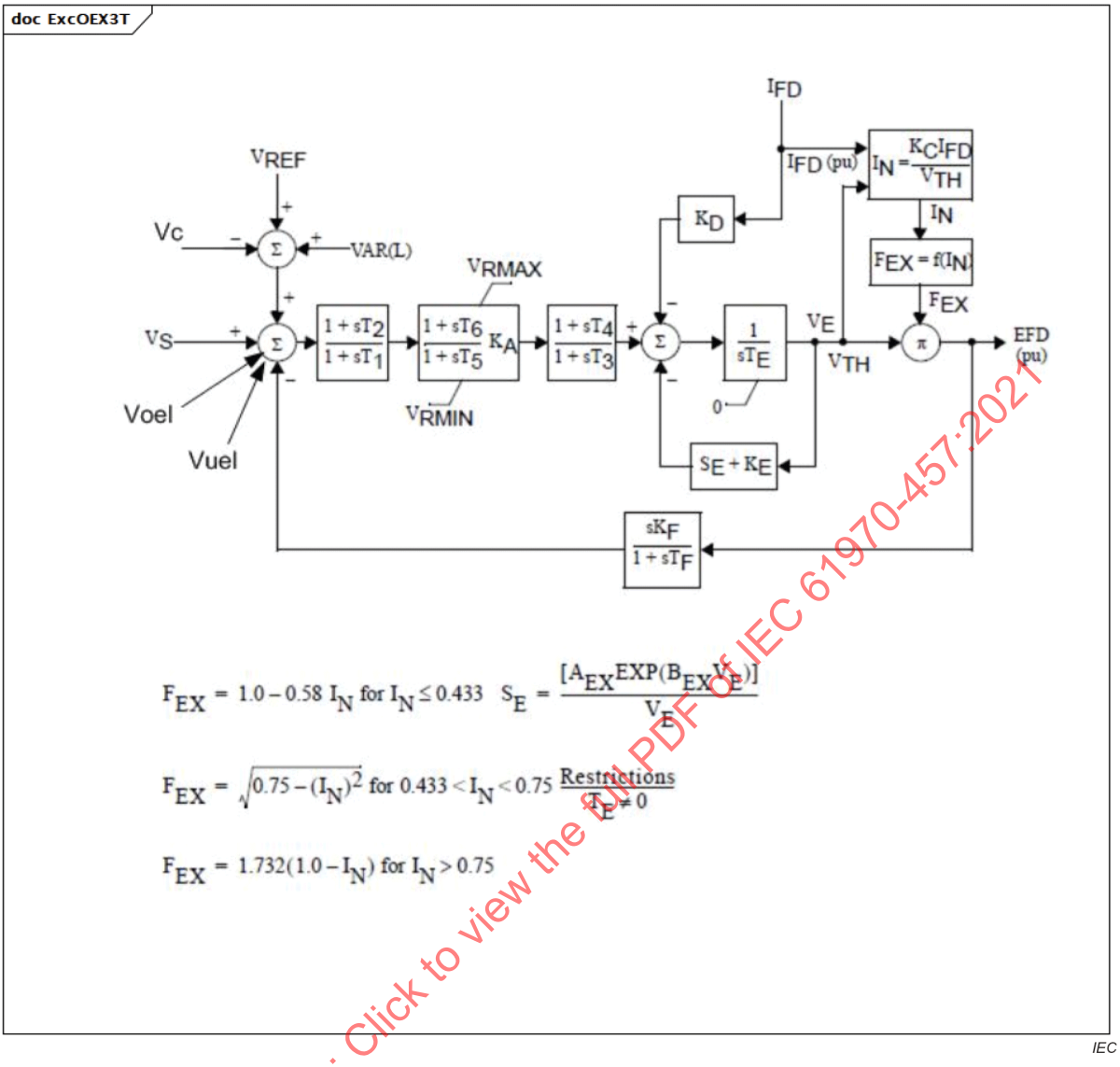


$$F_{EX} = 1.0 - 0.58\ I_N \text{ for } I_N \le 0.433 \quad S_E = \frac{[A_{EX}\mathrm{EXP}(B_{EX}V_E)]}{V_E}$$

$$F_{EX} = \sqrt{0.75 - (I_N)^2} \text{ for } 0.433 < I_N < 0.75 \quad \frac{\text{Restrictions}}{T_E \neq 0}$$

$$F_{EX} = 1.732(1.0 - I_N) \text{ for } I_N > 0.75$$

**Figure 124 – ExcOEX3T**

Figure 124: This diagram describes the ExcOEX3T excitation system model.

Table 238 shows all attributes of ExcOEX3T.

**Table 238 – Attributes of ExcitationSystemDynamics::ExcOEX3T**

| name | mult | type | description |
|---|---|---|---|
| t1 | 1..1 | Seconds | Time constant (T1) (>= 0). |
| t2 | 1..1 | Seconds | Time constant (T2) (>= 0). |
| t3 | 1..1 | Seconds | Time constant (T3) (>= 0). |
| t4 | 1..1 | Seconds | Time constant (T4) (>= 0). |
| ka | 1..1 | PU | Gain (KA). |
| t5 | 1..1 | Seconds | Time constant (T5) (>= 0). |
| t6 | 1..1 | Seconds | Time constant (T6) (>= 0). |
| vrmax | 1..1 | PU | Limiter (VRMAX) (> ExcOEX3T.vrmin). |
| vrmin | 1..1 | PU | Limiter (VRMIN) (< ExcOEX3T.vrmax). |

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| name | mult | type | description |
|---|---|---|---|
| te | 1..1 | Seconds | Time constant (TE) (>= 0). |
| kf | 1..1 | PU | Gain (KF). |
| tf | 1..1 | Seconds | Time constant (TF) (>= 0). |
| kc | 1..1 | PU | Gain (KC). |
| kd | 1..1 | PU | Gain (KD). |
| ke | 1..1 | PU | Gain (KE). |
| e1 | 1..1 | PU | Saturation parameter (E1). |
| see1 | 1..1 | PU | Saturation parameter (SE[E1]). |
| e2 | 1..1 | PU | Saturation parameter (E2). |
| see2 | 1..1 | PU | Saturation parameter (SE[E2]). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 239 shows all association ends of ExcOEX3T with other classes.

**Table 239 – Association ends of ExcitationSystemDynamics:: ExcOEX3T with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.47 ExcPIC

Proportional/integral regulator excitation system. This model can be used to represent excitation systems with a proportional-integral (PI) voltage regulator controller.

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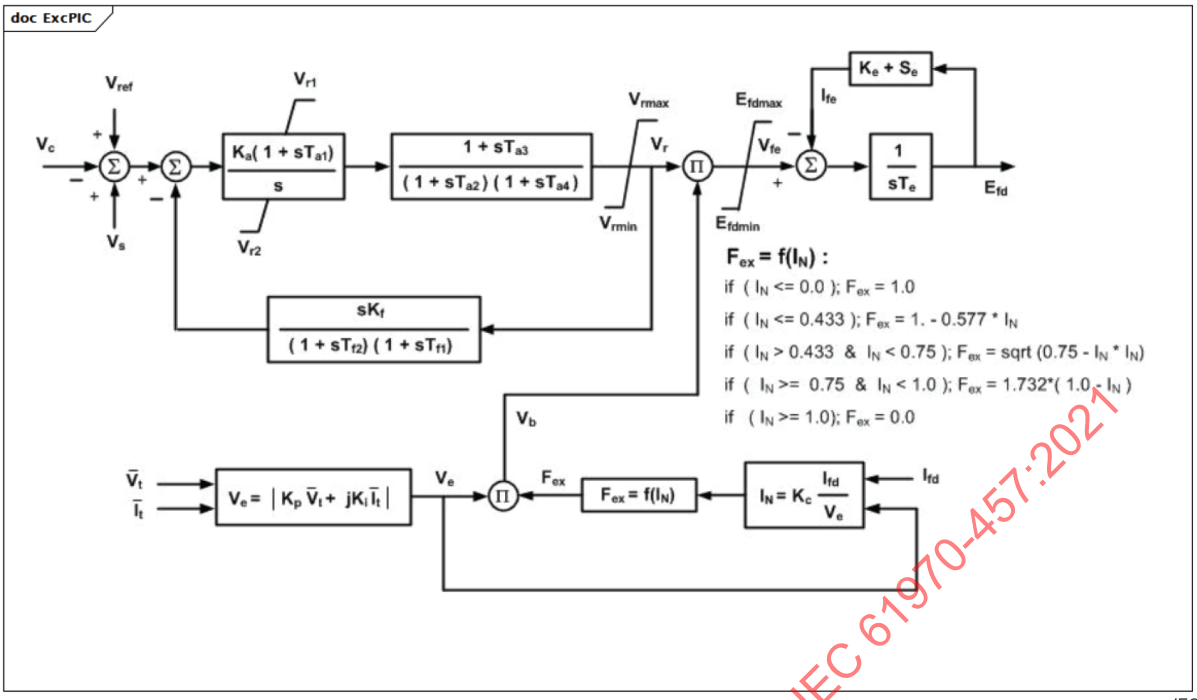


**Figure 125 – ExcPIC**

Figure 125: This diagram describes the ExcPIC excitation system model.

Table 240 shows all attributes of ExcPIC.

**Table 240 – Attributes of ExcitationSystemDynamics::ExcPIC**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | PU | PI controller gain (Ka). Typical value = 3,15. |
| ta1 | 1..1 | Seconds | PI controller time constant (Ta1) (>= 0). Typical value = 1. |
| vr1 | 1..1 | PU | PI maximum limit (Vr1). Typical value = 1. |
| vr2 | 1..1 | PU | PI minimum limit (Vr2). Typical value = -0,87. |
| ta2 | 1..1 | Seconds | Voltage regulator time constant (Ta2) (>= 0). Typical value = 0,01. |
| ta3 | 1..1 | Seconds | Lead time constant (Ta3) (>= 0). Typical value = 0. |
| ta4 | 1..1 | Seconds | Lag time constant (Ta4) (>= 0). Typical value = 0. |
| vrmax | 1..1 | PU | Voltage regulator maximum limit (Vrmax) (> ExcPIC.vrmin). Typical value = 1. |
| vrmin | 1..1 | PU | Voltage regulator minimum limit (Vrmin) (< ExcPIC.vrmax). Typical value = -0,87. |
| kf | 1..1 | PU | Rate feedback gain (Kf). Typical value = 0. |
| tf1 | 1..1 | Seconds | Rate feedback time constant (Tf1) (>= 0). Typical value = 0. |
| tf2 | 1..1 | Seconds | Rate feedback lag time constant (Tf2) (>= 0). Typical value = 0. |
| efdmax | 1..1 | PU | Exciter maximum limit (Efdmax) (> ExcPIC.efdmin). Typical value = 8. |
| efdmin | 1..1 | PU | Exciter minimum limit (Efdmin) (< ExcPIC.efdmax). Typical value = -0,87. |

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| name | mult | type | description |
|---|---|---|---|
| ke | 1..1 | PU | Exciter constant (Ke). Typical value = 0. |
| te | 1..1 | Seconds | Exciter time constant (Te) (>= 0). Typical value = 0. |
| e1 | 1..1 | PU | Field voltage value 1 (E1). Typical value = 0. |
| se1 | 1..1 | PU | Saturation factor at E1 (Se1). Typical value = 0. |
| e2 | 1..1 | PU | Field voltage value 2 (E2). Typical value = 0. |
| se2 | 1..1 | PU | Saturation factor at E2 (Se2). Typical value = 0. |
| kp | 1..1 | PU | Potential source gain (Kp). Typical value = 6,5. |
| ki | 1..1 | PU | Current source gain (Ki). Typical value = 0. |
| kc | 1..1 | PU | Exciter regulation factor (Kc). Typical value = 0,08. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 241 shows all association ends of ExcPIC with other classes.

**Table 241 – Association ends of ExcitationSystemDynamics::ExcPIC with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.48 ExcREXS

General purpose rotating excitation system. This model can be used to represent a wide range of excitation systems whose DC power source is an AC or DC generator. It encompasses IEEE type AC1, AC2, DC1, and DC2 excitation system models.

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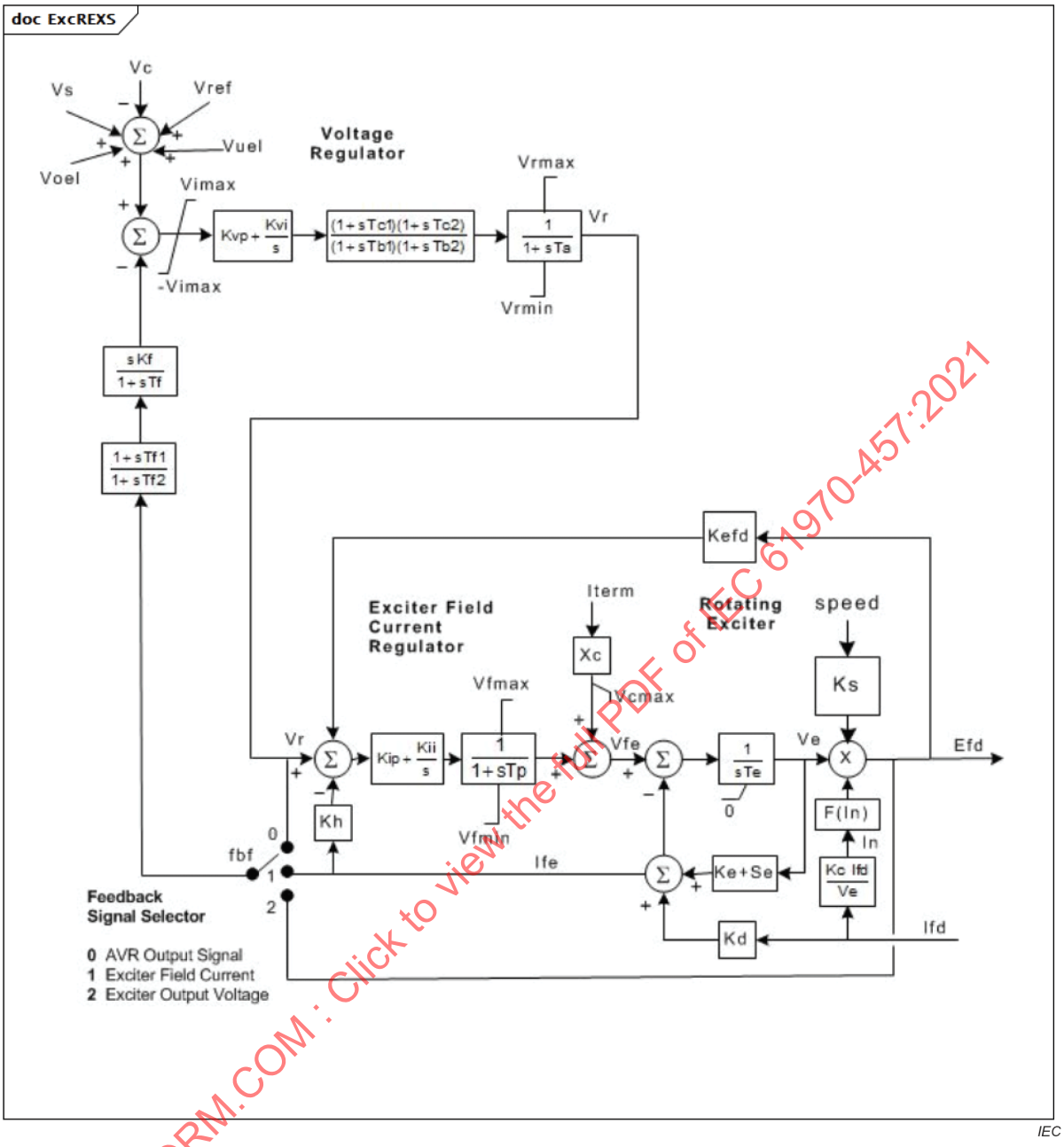


**Figure 126 – ExcREXS**

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Figure 126: This diagram describes the ExcREXS excitation system model.

Parameter details:

1) The rotating exciter can be of either DC or brushless AC type. To model a DC exciter, set Kc = Kd = 0.
2) An AC exciter can be modelled either by setting Kc and Kd to non- zero values to represent the armature reaction of the exciter and the regulation of the rotating rectifier, respectively, or by specifying the saturation factors, Se1 and Se2, to represent the excitation-output-voltage curve of the exciter as loaded by the field resistance of the main generator. It is preferable to use the first approach (Kd = 0) since the later approach does not represent the effect of armature reaction in the exciter on its field current and hence invalidates the model when field current is sensed by the voltage regulator.

3) When this model is used to represent a separately-excited exciter, the value of Ke should normally be close to unity. A shunt-excited DC exciter can be modelled by setting Ke to the appropriate small negative value needed to represent the relationship between the exciter's air gap line and field resistance line. Note, though, that this model does not determine the value of Ke automatically when a shunt field DC exciter is being represented
4) The voltage regulator can be of proportional or proportional-plus-integral form. Either Kvp or Kvi, but not both, can be zero.
5) The voltage regulator output can be either the field voltage applied directly to the exciter or the input to an exciter field current regulator by choice of values of Kip, Kii, and Kh. Either or both of Kip and Kii shall be non-zero. If Kii is non-zero, Kh should normally be non-zero.
6) The voltage regulator reference is modified by a volts-per-hertz limiter when shaft speed falls below Nvphz. When the shaft speed is below Nvphz the regulator reference is reduced as follows: effective Vref = Vref (1,0 – Kvphz (speed – Nvphz)) The volts-per-hertz limiter can be disabled by setting Nvphz = 0 or Kvphz = 0.
7) Saturation parameters are given by the IEEE saturation factor definition using the open circuit magnetization of the exciter. Either point [E1, S(E1) or E2, S(E2)] can be the higher value and the other the lower.
8) If Ks is set to 1, the output (Efd) is multiplied by generator speed.
9) The voltage regulator output limits, Vrmax and Vrmin, shall be stated as multiples of the value of exciter field current needed to maintain the exciter output at its base value. The field current limit, Vlr, shall be stated as a multiple of the exciter field current needed to maintain the exciter output at its base value. That is, Vrmax and Vrmin shall be stated in terms of the PU exciter output voltage to which they correspond in the steady state.
10) The regulator output limit flag indicates whether the control power supply for the voltage regulator is a transformer at the generator terminals or an independent source such as a permanent magnet generator. Set Flimf as follows:
    – Flimf = 0 the limits on regulator output are Vrmax, Vrmin, Vfmax and Vfmin;
    – Flimf = 1 the limits on regulator output are (Vrmax × Vterm), (Vrmin × Vterm), (Vfmax × Vterm), and (Vfmin × Vterm).
11) Feedback signal selector uses ExcREXSFeedbackSignalKind, where:
    – 0 (AVR output signal) = ExcREXSFeedbackSignalKind.fieldVoltage;
    – 1 (exciter field current) = ExcREXSFeedbackSignalKind.fieldCurent;
    – 2 (exciter output voltage) = ExcREXSFeedbackSignalKind.outputVoltage.

Table 242 shows all attributes of ExcREXS.

**Table 242 – Attributes of ExcitationSystemDynamics::ExcREXS**

| name | mult | type | description |
|---|---|---|---|
| e1 | 1..1 | PU | Field voltage value 1 (E1). Typical value = 3. |
| e2 | 1..1 | PU | Field voltage value 2 (E2). Typical value = 4. |
| fbf | 1..1 | ExcREXSFeedbackSignalKind | Rate feedback signal flag (fbf). Typical value = fieldCurrent. |
| flimf | 1..1 | PU | Limit type flag (Flimf). Typical value = 0. |
| kc | 1..1 | PU | Rectifier regulation factor (Kc). Typical value = 0,05. |
| kd | 1..1 | PU | Exciter regulation factor (Kd). Typical value = 2. |
| ke | 1..1 | PU | Exciter field proportional constant (Ke). Typical value = 1. |
| kefd | 1..1 | PU | Field voltage feedback gain (Kefd). Typical value = 0. |
| kf | 1..1 | Seconds | Rate feedback gain (Kf) (>= 0). Typical value = 0,05. |

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| name | mult | type | description |
|---|---|---|---|
| kh | 1..1 | PU | Field voltage controller feedback gain (Kh). Typical value = 0. |
| kii | 1..1 | PU | Field current regulator integral gain (Kii). Typical value = 0. |
| kip | 1..1 | PU | Field current regulator proportional gain (Kip). Typical value = 1. |
| ks | 1..1 | PU | Coefficient to allow different usage of the model-speed coefficient (Ks). Typical value = 0. |
| kvi | 1..1 | PU | Voltage regulator integral gain (Kvi). Typical value = 0. |
| kvp | 1..1 | PU | Voltage regulator proportional gain (Kvp). Typical value = 2800. |
| kvphz | 1..1 | PU | V/Hz limiter gain (Kvphz). Typical value = 0. |
| nvphz | 1..1 | PU | Pickup speed of V/Hz limiter (Nvphz). Typical value = 0. |
| se1 | 1..1 | PU | Saturation factor at E1 (Se1). Typical value = 0,0001. |
| se2 | 1..1 | PU | Saturation factor at E2 (Se2). Typical value = 0,001. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (>= 0). If = 0, block is bypassed. Typical value = 0,01. |
| tb1 | 1..1 | Seconds | Lag time constant (Tb1) (>= 0). If = 0, block is bypassed. Typical value = 0. |
| tb2 | 1..1 | Seconds | Lag time constant (Tb2) (>= 0). If = 0, block is bypassed. Typical value = 0. |
| tc1 | 1..1 | Seconds | Lead time constant (Tc1) (>= 0). Typical value = 0. |
| tc2 | 1..1 | Seconds | Lead time constant (Tc2) (>= 0). Typical value = 0. |
| te | 1..1 | Seconds | Exciter field time constant (Te) (> 0). Typical value = 1,2. |
| tf | 1..1 | Seconds | Rate feedback time constant (Tf) (>= 0). If = 0, the feedback path is not used. Typical value = 1. |
| tf1 | 1..1 | Seconds | Feedback lead time constant (Tf1) (>= 0). Typical value = 0. |
| tf2 | 1..1 | Seconds | Feedback lag time constant (Tf2) (>= 0). If = 0, block is bypassed. Typical value = 0. |
| tp | 1..1 | Seconds | Field current bridge time constant (Tp) (>= 0). Typical value = 0. |
| vcmax | 1..1 | PU | Maximum compounding voltage (Vcmax). Typical value = 0. |
| vfmax | 1..1 | PU | Maximum exciter field current (Vfmax) (> ExcREXS.vfmin). Typical value = 47. |
| vfmin | 1..1 | PU | Minimum exciter field current (Vfmin) (< ExcREXS.vfmax). Typical value = -20. |
| vimax | 1..1 | PU | Voltage regulator input limit (Vimax). Typical value = 0,1. |
| vrmax | 1..1 | PU | Maximum controller output (Vrmax) (> ExcREXS.vrmin). Typical value = 47. |
| vrmin | 1..1 | PU | Minimum controller output (Vrmin) (< ExcREXS.vrmax). Typical value = -20. |
| xc | 1..1 | PU | Exciter compounding reactance (Xc). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |

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

Table 243 shows all association ends of ExcREXS with other classes.

**Table 243 – Association ends of ExcitationSystemDynamics:: ExcREXS with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

### 8.2.4.3.9.49 ExcRQB

Excitation system type RQB (four-loop regulator, régulateur quatre boucles, developed in France) primarily used in nuclear or thermal generating units. This excitation system shall be always used together with power system stabilizer type PssRQB.

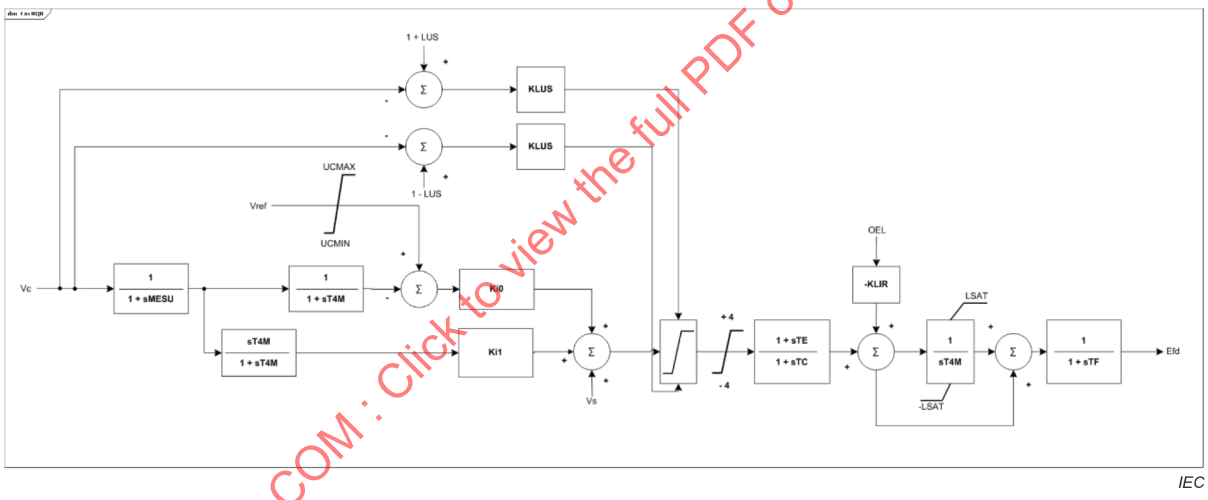


**Figure 127 – ExcRQB**

Figure 127: This diagram describes the ExcRQB excitation system model.

Table 244 shows all attributes of ExcRQB.

**Table 244 – Attributes of ExcitationSystemDynamics::ExcRQB**

| name | mult | type | description |
|---|---|---|---|
| ki0 | 1..1 | Float | Voltage reference input gain (Ki0). Typical value = 12,7. |
| ki1 | 1..1 | Float | Voltage input gain (Ki1). Typical value = -16,8. |
| te | 1..1 | Seconds | Lead lag time constant (TE) (>= 0). Typical value = 0,22. |
| tc | 1..1 | Seconds | Lead lag time constant (TC) (>= 0). Typical value = 0,02. |
| klir | 1..1 | Float | OEL input gain (KLIR). Typical value = 12,13. |

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| name | mult | type | description |
|---|---|---|---|
| ucmin | 1..1 | PU | Minimum voltage reference limit (UCMIN) (< ExcRQB.ucmax). Typical value = 0,9. |
| ucmax | 1..1 | PU | Maximum voltage reference limit (UCMAX) (> ExcRQB.ucmin). Typical value = 1,1. |
| lus | 1..1 | PU | Setpoint (LUS). Typical value = 0,12. |
| klus | 1..1 | Float | Limiter gain (KLUS). Typical value = 50. |
| mesu | 1..1 | Seconds | Voltage input time constant (MESU) (>= 0). Typical value = 0,02. |
| t4m | 1..1 | Seconds | Input time constant (T4M) (>= 0). Typical value = 5. |
| lsat | 1..1 | PU | Integrator limiter (LSAT). Typical value = 5,73. |
| tf | 1..1 | Seconds | Exciter time constant (TF) (>= 0). Typical value = 0,01. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 245 shows all association ends of ExcRQB with other classes.

**Table 245 – Association ends of ExcitationSystemDynamics:: ExcRQB with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.50 ExcSCRX

Simple excitation system with generic characteristics typical of many excitation systems; intended for use where negative field current could be a problem.

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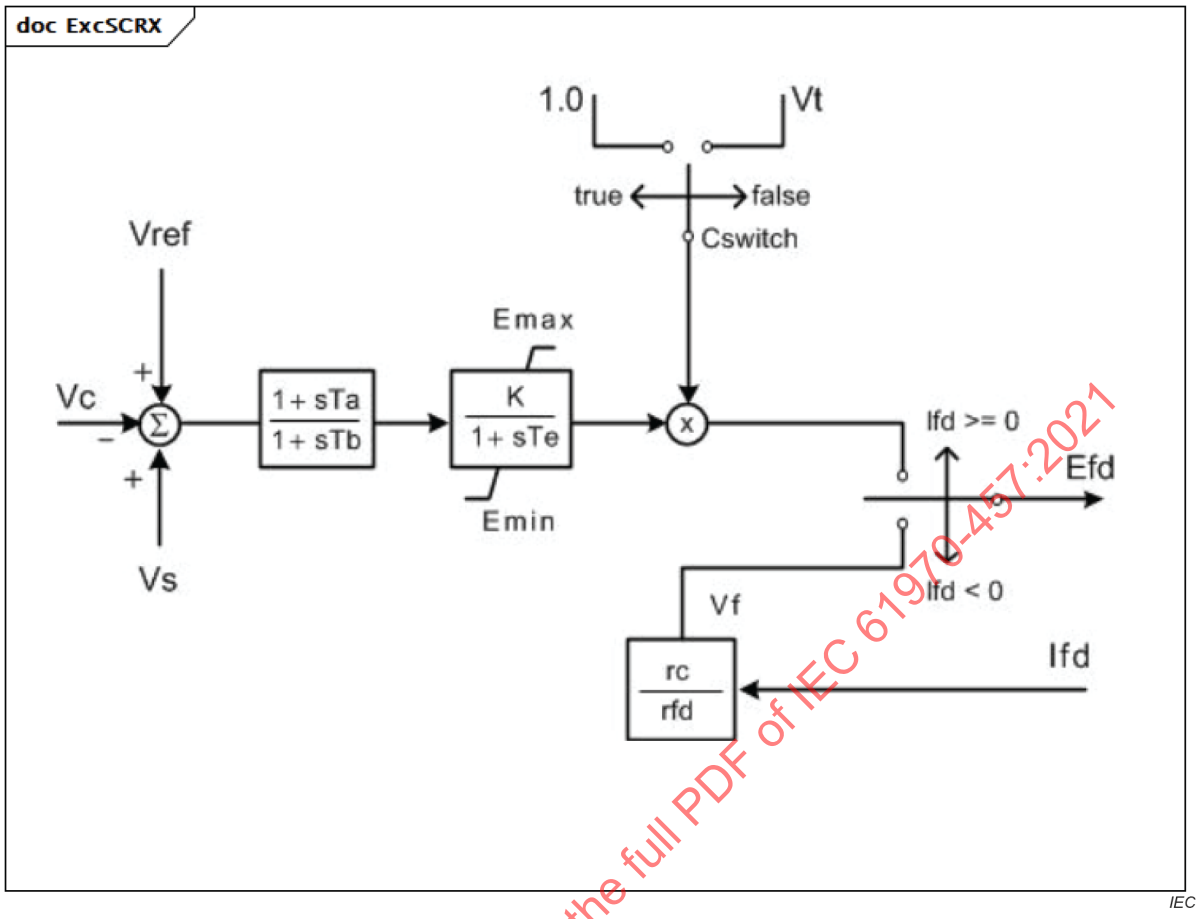


**Figure 128 – ExcSCRX**

Figure 128: This diagram describes the ExcSCRX excitation system model.

Table 246 shows all attributes of ExcSCRX.

**Table 246 – Attributes of ExcitationSystemDynamics::ExcSCRX**

| name | mult | type | description |
|---|---|---|---|
| tatb | 1..1 | Float | Gain reduction ratio of lag-lead element ([Ta / Tb]). The parameter Ta is not defined explicitly. Typical value = 0.1. |
| tb | 1..1 | Seconds | Denominator time constant of lag-lead block (Tb) (>= 0). Typical value = 10. |
| k | 1..1 | PU | Gain (K) (> 0). Typical value = 200. |
| te | 1..1 | Seconds | Time constant of gain block (Te) (> 0). Typical value = 0,02. |
| emin | 1..1 | PU | Minimum field voltage output (Emin) (< ExcSCRX.emax). Typical value = 0. |
| emax | 1..1 | PU | Maximum field voltage output (Emax) (> ExcSCRX.emin). Typical value = 5. |
| cswitch | 1..1 | Boolean | Power source switch (Cswitch).<br>true = fixed voltage of 1,0 PU<br>false = generator terminal voltage. |
| rcrfd | 1..1 | Float | Ratio of field discharge resistance to field winding resistance ([rc / rfd]). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |

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

Table 247 shows all association ends of ExcSCRX with other classes.

**Table 247 – Association ends of ExcitationSystemDynamics:: ExcSCRX with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.51 ExcSEXS

Simplified excitation system.

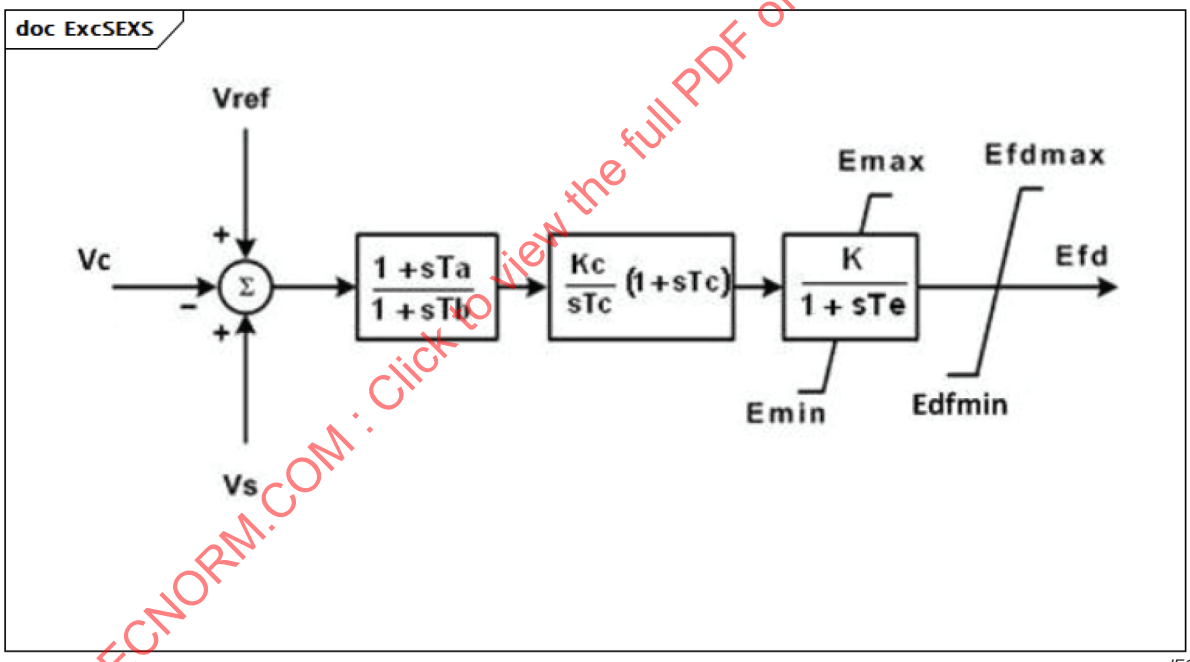


**Figure 129 – ExcSEXS**

Figure 129: This diagram describes the ExcSEXS excitation system model.

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Table 248 shows all attributes of ExcSEXS.

**Table 248 – Attributes of ExcitationSystemDynamics::ExcSEXS**

| name | mult | type | description |
|---|---|---|---|
| tatb | 1..1 | Float | Gain reduction ratio of lag-lead element ([Ta / Tb]). Typical value = 0,1. |
| tb | 1..1 | Seconds | Denominator time constant of lag-lead block (Tb) (>= 0). Typical value = 10. |
| k | 1..1 | PU | Gain (K) (> 0). Typical value = 100. |
| te | 1..1 | Seconds | Time constant of gain block (Te) (> 0). Typical value = 0,05. |
| emin | 1..1 | PU | Minimum field voltage output (Emin) (< ExcSEXS.emax). Typical value = -5. |
| emax | 1..1 | PU | Maximum field voltage output (Emax) (> ExcSEXS.emin). Typical value = 5. |
| kc | 1..1 | PU | PI controller gain (Kc) (> 0 if ExcSEXS.tc > 0). Typical value = 0,08. |
| tc | 1..1 | Seconds | PI controller phase lead time constant (Tc) (>= 0). Typical value = 0. |
| efdmin | 1..1 | PU | Field voltage clipping minimum limit (Efdmin) (< ExcSEXS.efdmax). Typical value = -5. |
| efdmax | 1..1 | PU | Field voltage clipping maximum limit (Efdmax) (> ExcSEXS.efdmin). Typical value = 5. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 249 shows all association ends of ExcSEXS with other classes.

**Table 249 – Association ends of ExcitationSystemDynamics:: ExcSEXS with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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### 8.2.4.3.9.52 ExcSK

Slovakian excitation system. UEL and secondary voltage control are included in this model. When this model is used, there cannot be a separate underexcitation limiter or VAr controller model.

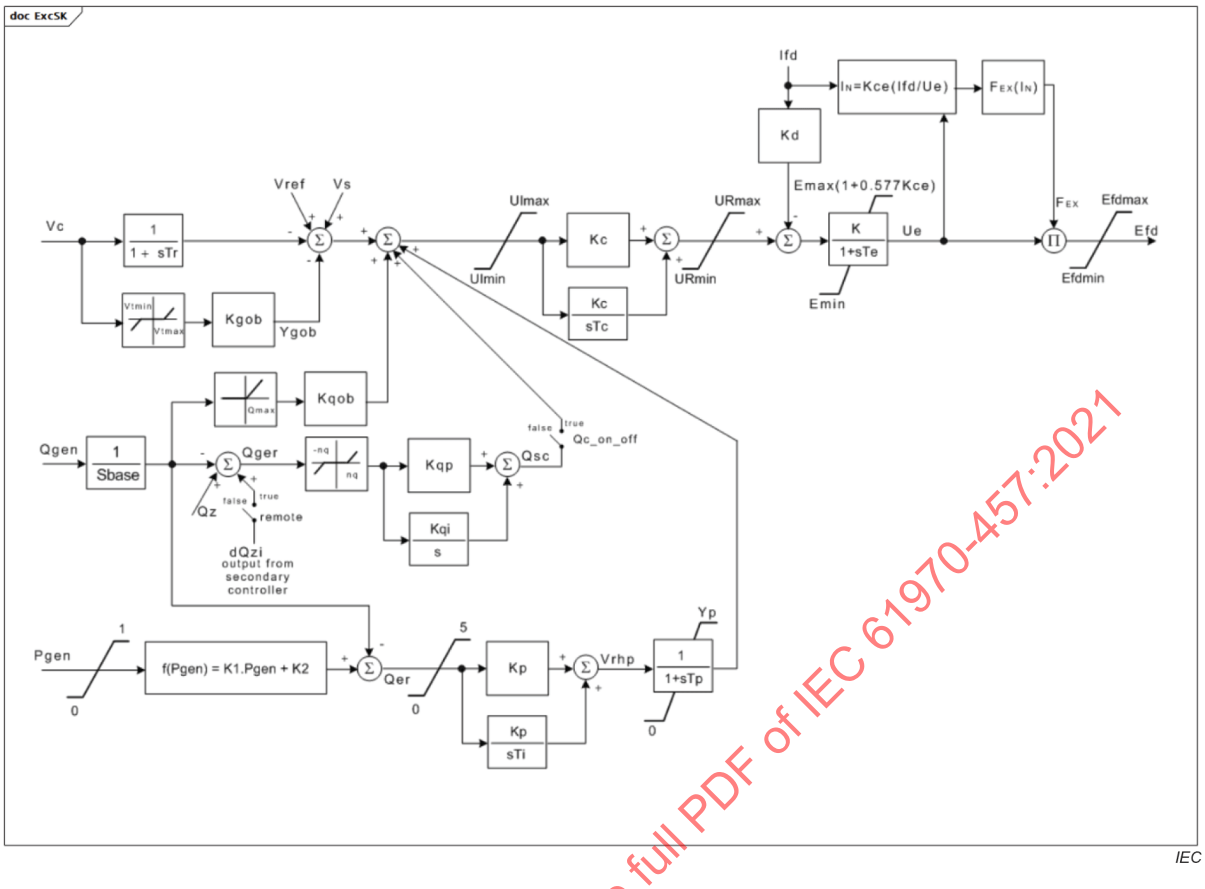


**Figure 130 – ExcSK**

Figure 130: This diagram describes the ExcSK excitation system model.

Parameter details:

1) Qmax is calculated using this equation: Qmax = K1 x Pgen + K2.
2) Pgen and Qgen are in PU.
3) The part of the model which includes Qmax and Kqob represents back-coupling from the reactive power with statics. It is used for parallel co-operation with other generators to share the reactive power demand. This can be neglected if the configuration is a single generating unit.
4) The block Fex (In) is modelled as described in IEEE 421.5 – part on rectifier regulation equations.

Table 250 shows all attributes of ExcSK.

**Table 250 – Attributes of ExcitationSystemDynamics::ExcSK**

| name | mult | type | description |
|---|---|---|---|
| efdmax | 1..1 | PU | Field voltage clipping upper level limit (Efdmax) (> ExcSK.efdmin). |
| efdmin | 1..1 | PU | Field voltage clipping lower level limit (Efdmin) (< ExcSK.efdmax). |
| emax | 1..1 | PU | Maximum field voltage output (Emax) (> ExcSK.emin). Typical value = 20. |
| emin | 1..1 | PU | Minimum field voltage output (Emin) (< ExcSK.emax). Typical value = -20. |
| k | 1..1 | PU | Gain (K). Typical value = 1. |

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| name | mult | type | description |
|---|---|---|---|
| k1 | 1..1 | PU | Parameter of underexcitation limit (K1). Typical value = 0,1 364. |
| k2 | 1..1 | PU | Parameter of underexcitation limit (K2). Typical value = -0,3 861. |
| kc | 1..1 | PU | PI controller gain (Kc). Typical value = 70. |
| kce | 1..1 | PU | Rectifier regulation factor (Kce). Typical value = 0. |
| kd | 1..1 | PU | Exciter internal reactance (Kd). Typical value = 0. |
| kgob | 1..1 | PU | P controller gain (Kgob). Typical value = 10. |
| kp | 1..1 | PU | PI controller gain (Kp). Typical value = 1. |
| kqi | 1..1 | PU | PI controller gain of integral component (Kqi). Typical value = 0. |
| kqob | 1..1 | PU | Rate of rise of the reactive power (Kqob). |
| kqp | 1..1 | PU | PI controller gain (Kqp). Typical value = 0. |
| nq | 1..1 | PU | Deadband of reactive power (nq). Determines the range of sensitivity. Typical value = 0,001. |
| qconoff | 1..1 | Boolean | Secondary voltage control state (Qc_on_off).<br>true = secondary voltage control is on<br>false = secondary voltage control is off.<br>Typical value = false. |
| qz | 1..1 | PU | Desired value (setpoint) of reactive power, manual setting (Qz). |
| remote | 1..1 | Boolean | Selector to apply automatic calculation in secondary controller model (remote).<br>true = automatic calculation is activated<br>false = manual set is active; the use of desired value of reactive power (Qz) is required.<br>Typical value = true. |
| sbase | 1..1 | ApparentPower | Apparent power of the unit (Sbase) (> 0). Unit = MVA. Typical value = 259. |
| tc | 1..1 | Seconds | PI controller phase lead time constant (Tc) (>= 0). Typical value = 8. |
| te | 1..1 | Seconds | Time constant of gain block (Te) (>= 0). Typical value = 0,1. |
| ti | 1..1 | Seconds | PI controller phase lead time constant (Ti) (>= 0). Typical value = 2. |
| tp | 1..1 | Seconds | Time constant (Tp) (>= 0). Typical value = 0,1. |
| tr | 1..1 | Seconds | Voltage transducer time constant (Tr) (>= 0). Typical value = 0,01. |
| uimax | 1..1 | PU | Maximum error (UImax) (> ExcSK.uimin). Typical value = 10. |
| uimin | 1..1 | PU | Minimum error (UImin) (< ExcSK.uimax). Typical value = -10. |
| urmax | 1..1 | PU | Maximum controller output (URmax) (> ExcSK.urmin). Typical value = 10. |
| urmin | 1..1 | PU | Minimum controller output (URmin) (< ExcSK.urmax). Typical value = -10. |
| vtmax | 1..1 | PU | Maximum terminal voltage input (Vtmax) (> ExcSK.vtmin). Determines the range of voltage deadband. Typical value = 1,05. |

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| name | mult | type | description |
|---|---|---|---|
| vtmin | 1..1 | PU | Minimum terminal voltage input (Vtmin) (< ExcSK.vtmax). Determines the range of voltage deadband. Typical value = 0,95. |
| yp | 1..1 | PU | Maximum output (Yp). Typical value = 1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 251 shows all association ends of ExcSK with other classes.

**Table 251 – Association ends of ExcitationSystemDynamics::ExcSK with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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### 8.2.4.3.9.53 ExcST1A

Modification of an old IEEE ST1A static excitation system without overexcitation limiter (OEL) and underexcitation limiter (UEL).

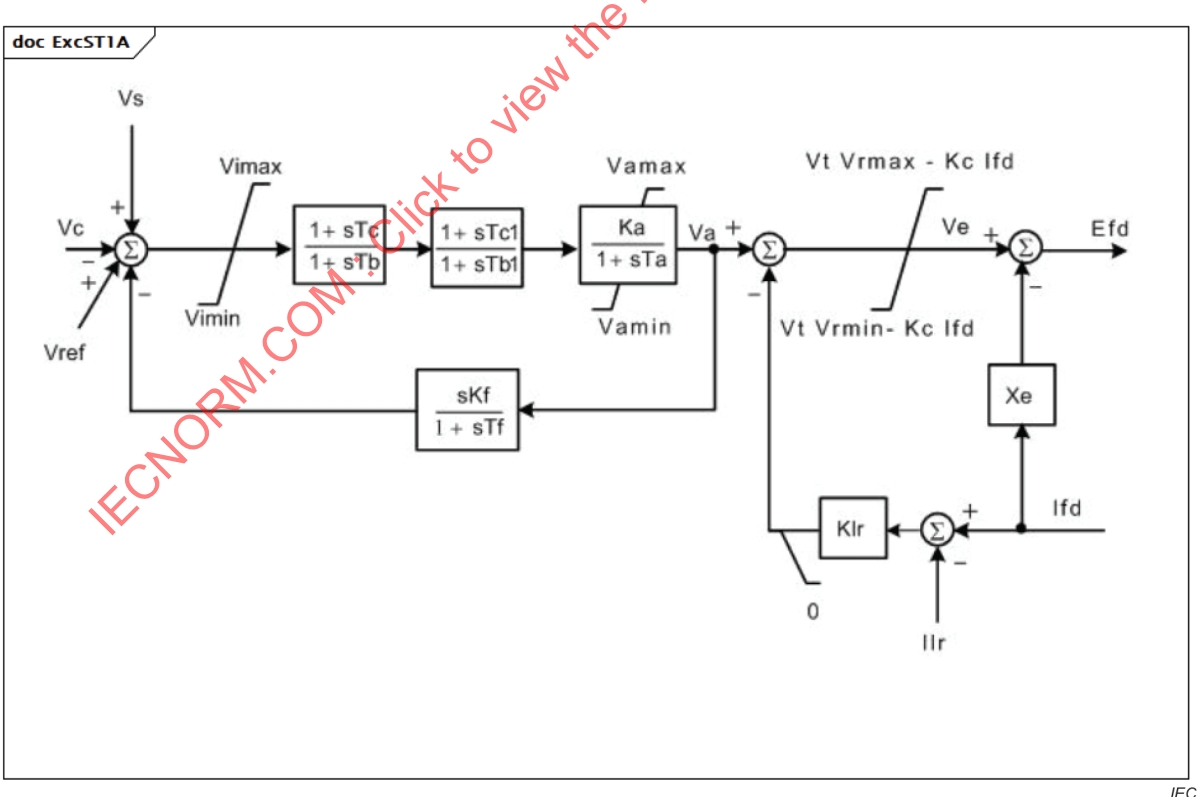


**Figure 131 – ExcST1A**

Figure 131: This diagram describes the ExcST1A excitation system model.

Table 252 shows all attributes of ExcST1A.

**Table 252 – Attributes of ExcitationSystemDynamics::ExcST1A**

| name | mult | type | description |
|---|---|---|---|
| vimax | 1..1 | PU | Maximum voltage regulator input limit (Vimax) (> 0). Typical value = 999. |
| vimin | 1..1 | PU | Minimum voltage regulator input limit (Vimin) (< 0). Typical value = -999. |
| tc | 1..1 | Seconds | Voltage regulator time constant (Tc) (>= 0). Typical value = 1. |
| tb | 1..1 | Seconds | Voltage regulator time constant (Tb) (>= 0). Typical value = 10. |
| ka | 1..1 | PU | Voltage regulator gain (Ka) (> 0). Typical value = 190. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (>= 0). Typical value = 0,02. |
| vrmax | 1..1 | PU | Maximum voltage regulator outputs (Vrmax) (> 0). Typical value = 7,8. |
| vrmin | 1..1 | PU | Minimum voltage regulator outputs (Vrmin) (< 0). Typical value = -6,7. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (Kc) (>= 0). Typical value = 0,05. |
| kf | 1..1 | PU | Excitation control system stabilizer gains (Kf) (>= 0). Typical value = 0. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf) (>= 0). Typical value = 1. |
| tc1 | 1..1 | Seconds | Voltage regulator time constant (Tc1) (>= 0). Typical value = 0. |
| tb1 | 1..1 | Seconds | Voltage regulator time constant (Tb1) (>= 0). Typical value = 0. |
| vamax | 1..1 | PU | Maximum voltage regulator output (Vamax) (> 0). Typical value = 999. |
| vamin | 1..1 | PU | Minimum voltage regulator output (Vamin) (< 0). Typical value = -999. |
| ilr | 1..1 | PU | Exciter output current limit reference (Ilr). Typical value = 0. |
| klr | 1..1 | PU | Exciter output current limiter gain (Klr). Typical value = 0. |
| xe | 1..1 | PU | Excitation xfmr effective reactance (Xe). Typical value = 0,04. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 253 shows all association ends of ExcST1A with other classes.

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**Table 253 – Association ends of ExcitationSystemDynamics:: ExcST1A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

### 8.2.4.3.9.54 ExcST2A

Modified IEEE ST2A static excitation system with another lead-lag block added to match the model defined by WECC.

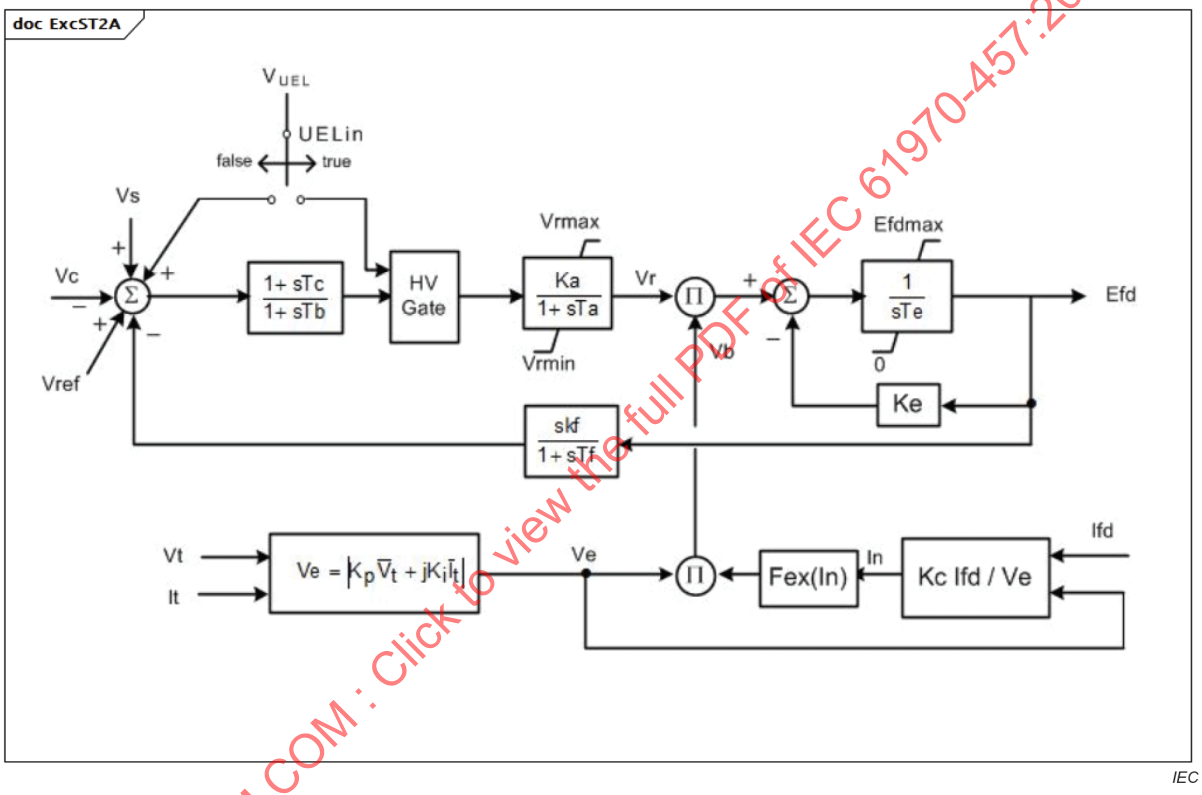


**Figure 132 – ExcST2A**

Figure 132: This diagram describes the ExcST2A excitation system model.

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Table 254 shows all attributes of ExcST2A.

**Table 254 – Attributes of ExcitationSystemDynamics::ExcST2A**

| name | mult | type | description |
|---|---|---|---|
| ka | 1..1 | PU | Voltage regulator gain (Ka) (> 0). Typical value = 120. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (> 0). Typical value = 0,15. |
| vrmax | 1..1 | PU | Maximum voltage regulator outputs (Vrmax) (> 0). Typical value = 1. |
| vrmin | 1..1 | PU | Minimum voltage regulator outputs (Vrmin) (< 0). Typical value = -1. |
| ke | 1..1 | PU | Exciter constant related to self-excited field (Ke). Typical value = 1. |
| te | 1..1 | Seconds | Exciter time constant, integration rate associated with exciter control (Te) (> 0). Typical value = 0,5. |
| kf | 1..1 | PU | Excitation control system stabilizer gains (kf) (>= 0). Typical value = 0,05. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf) (>= 0). Typical value = 0,7. |
| kp | 1..1 | PU | Potential circuit gain coefficient (Kp) (>= 0). Typical value = 4,88. |
| ki | 1..1 | PU | Potential circuit gain coefficient (Ki) (>= 0). Typical value = 8. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (Kc) (>= 0). Typical value = 1,82. |
| efdmax | 1..1 | PU | Maximum field voltage (Efdmax) (>= 0). Typical value = 99. |
| uelin | 1..1 | Boolean | UEL input (UELin).<br>true = HV gate<br>false = add to error signal.<br>Typical value = false. |
| tb | 1..1 | Seconds | Voltage regulator time constant (Tb) (>= 0). Typical value = 0. |
| tc | 1..1 | Seconds | Voltage regulator time constant (Tc) (>= 0). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 255 shows all association ends of ExcST2A with other classes.

**Table 255 – Association ends of ExcitationSystemDynamics:: ExcST2A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.55 ExcST3A

Modified IEEE ST3A static excitation system with added speed multiplier.

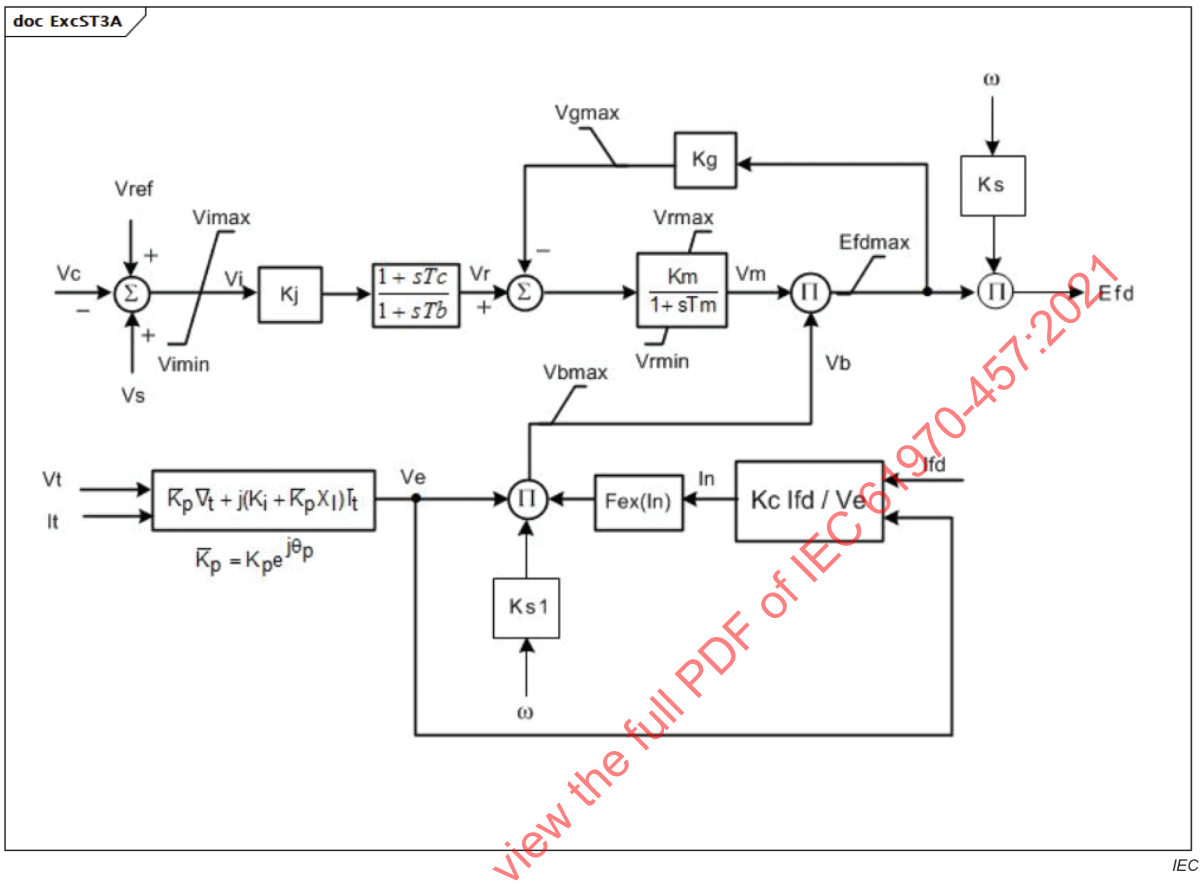


**Figure 133 – ExcST3A**

Figure 133: This diagram describes the ExcST3A excitation system model.

Parameter details:

1) If Ks or Ks1 is set to 1, the output (Efd) is multiplied by generator speed.

Table 256 shows all attributes of ExcST3A.

**Table 256 – Attributes of ExcitationSystemDynamics::ExcST3A**

| name | mult | type | description |
|---|---|---|---|
| vimax | 1..1 | PU | Maximum voltage regulator input limit (Vimax) (> 0). Typical value = 0,2. |
| vimin | 1..1 | PU | Minimum voltage regulator input limit (Vimin) (< 0). Typical value = -0,2. |
| kj | 1..1 | PU | AVR gain (Kj) (> 0). Typical value = 200. |
| tb | 1..1 | Seconds | Voltage regulator time constant (Tb) (>= 0). Typical value = 6,67. |
| tc | 1..1 | Seconds | Voltage regulator time constant (Tc) (>= 0). Typical value = 1. |
| efdmax | 1..1 | PU | Maximum AVR output (Efdmax) (>= 0). Typical value = 6,9. |

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| name | mult | type | description |
|---|---|---|---|
| km | 1..1 | PU | Forward gain constant of the inner loop field regulator (Km) (> 0). Typical value = 7,04. |
| tm | 1..1 | Seconds | Forward time constant of inner loop field regulator (Tm) (> 0). Typical value = 1. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (Vrmax) (> 0). Typical value = 1. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (Vrmin) (< 0). Typical value = -1. |
| kg | 1..1 | PU | Feedback gain constant of the inner loop field regulator (Kg) (>= 0). Typical value = 1. |
| kp | 1..1 | PU | Potential source gain (Kp) (> 0). Typical value = 4,37. |
| thetap | 1..1 | AngleDegrees | Potential circuit phase angle (thetap). Typical value = 20. |
| ki | 1..1 | PU | Potential circuit gain coefficient (Ki) (>= 0). Typical value = 4,83. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (Kc) (>= 0). Typical value = 1,1. |
| xl | 1..1 | PU | Reactance associated with potential source (Xl) (>= 0). Typical value = 0,09. |
| vbmax | 1..1 | PU | Maximum excitation voltage (Vbmax) (> 0). Typical value = 8,63. |
| vgmax | 1..1 | PU | Maximum inner loop feedback voltage (Vgmax) (>= 0). Typical value = 6,53. |
| ks | 1..1 | PU | Coefficient to allow different usage of the model-speed coefficient (Ks). Typical value = 0. |
| ks1 | 1..1 | PU | Coefficient to allow different usage of the model-speed coefficient (Ks1). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 257 shows all association ends of ExcST3A with other classes.

**Table 257 – Association ends of ExcitationSystemDynamics:: ExcST3A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.9.56 ExcST4B

Modified IEEE ST4B static excitation system with maximum inner loop feedback gain Vgmax.

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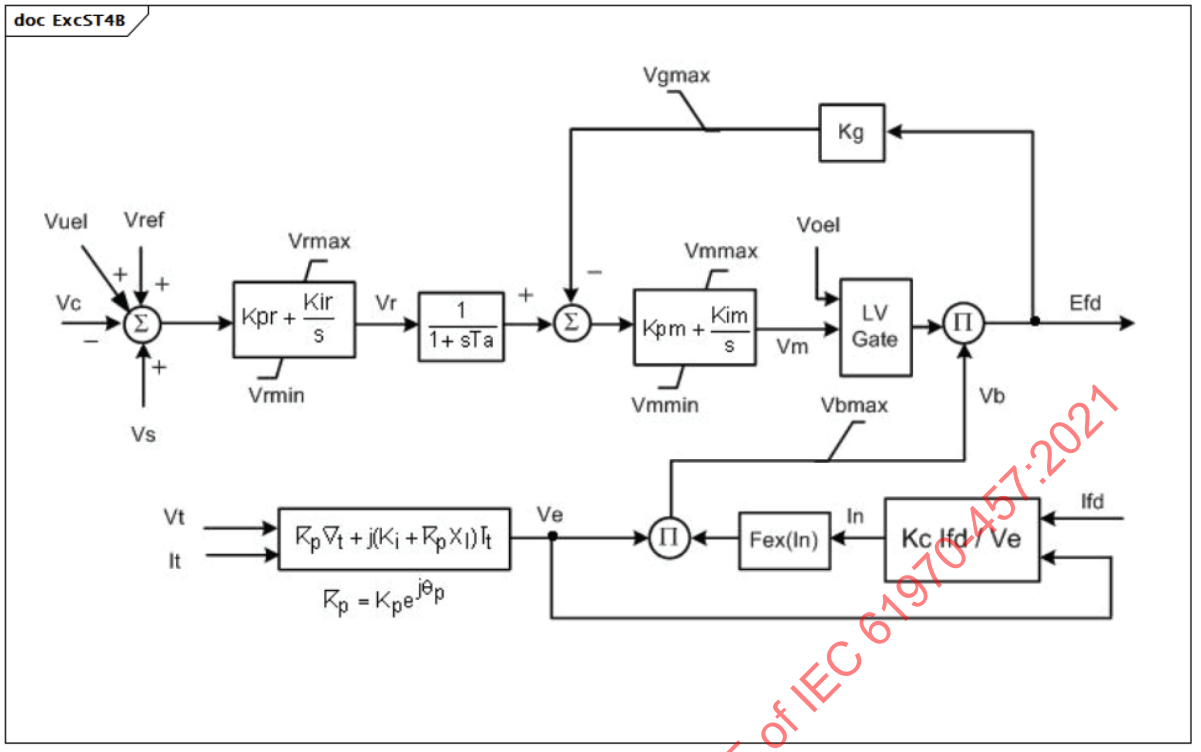


**Figure 134 – ExcST4B**

Figure 134: This diagram describes the ExcST4B excitation system model.

Table 258 shows all attributes of ExcST4B.

**Table 258 – Attributes of ExcitationSystemDynamics::ExcST4B**

| name | mult | type | description |
|---|---|---|---|
| kpr | 1..1 | PU | Voltage regulator proportional gain (Kpr). Typical value = 10,75. |
| kir | 1..1 | PU | Voltage regulator integral gain (Kir). Typical value = 10,75. |
| ta | 1..1 | Seconds | Voltage regulator time constant (Ta) (>= 0). Typical value = 0,02. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (Vrmax) (> 0). Typical value = 1. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (Vrmin) (< 0). Typical value = -0,87. |
| kpm | 1..1 | PU | Voltage regulator proportional gain output (Kpm). Typical value = 1. |
| kim | 1..1 | PU | Voltage regulator integral gain output (Kim). Typical value = 0. |
| vmmax | 1..1 | PU | Maximum inner loop output (Vmmax) (> ExcST4B.vmmin). Typical value = 99. |
| vmmin | 1..1 | PU | Minimum inner loop output (Vmmin) (< ExcST4B.vmmax). Typical value = -99. |
| kg | 1..1 | PU | Feedback gain constant of the inner loop field regulator (Kg) (>= 0). Typical value = 0. |
| kp | 1..1 | PU | Potential circuit gain coefficient (Kp) (> 0). Typical value = 9,3. |

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| name | mult | type | description |
|---|---|---|---|
| thetap | 1..1 | AngleDegrees | Potential circuit phase angle (thetap). Typical value = 0. |
| ki | 1..1 | PU | Potential circuit gain coefficient (Ki) (>= 0). Typical value = 0. |
| kc | 1..1 | PU | Rectifier loading factor proportional to commutating reactance (Kc) (>= 0). Typical value = 0,113. |
| xl | 1..1 | PU | Reactance associated with potential source (Xl) (>= 0). Typical value = 0,124. |
| vbmax | 1..1 | PU | Maximum excitation voltage (Vbmax) (> 0). Typical value = 11,63. |
| vgmax | 1..1 | PU | Maximum inner loop feedback voltage (Vgmax) (>= 0). Typical value = 5,8. |
| uel | 1..1 | Boolean | Selector (UEL).<br>true = UEL is part of block diagram<br>false = UEL is not part of block diagram.<br>Typical value = false. |
| lvgate | 1..1 | Boolean | Selector (LVGate).<br>true = LVGate is part of the block diagram<br>false = LVGate is not part of the block diagram.<br>Typical value = false. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 259 shows all association ends of ExcST4B with other classes.

**Table 259 – Association ends of ExcitationSystemDynamics:: ExcST4B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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#### 8.2.4.3.9.57 ExcST6B

Modified IEEE ST6B static excitation system with PID controller and optional inner feedback loop.

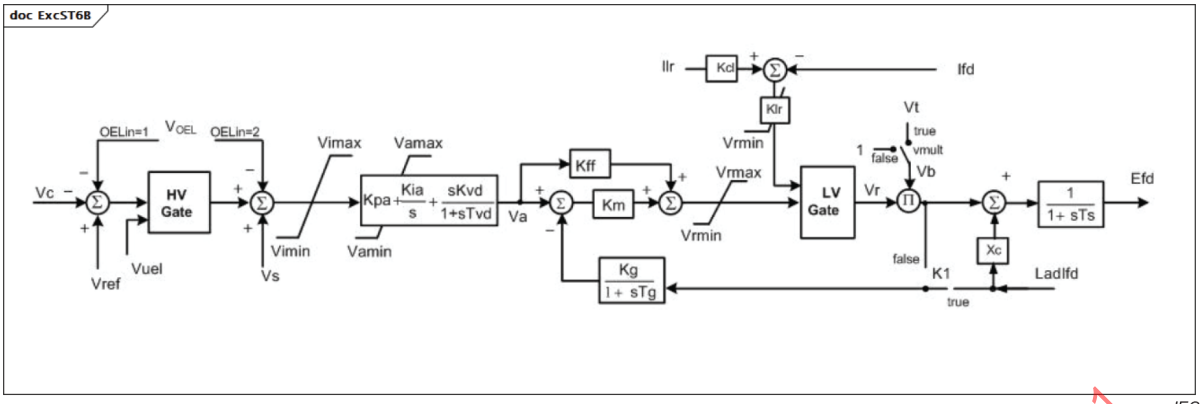


**Figure 135 – ExcST6B**

Figure 135: This diagram describes the ExcST6B excitation system model.

Table 260 shows all attributes of ExcST6B.

**Table 260 – Attributes of ExcitationSystemDynamics::ExcST6B**

| name | mult | type | description |
|---|---|---|---|
| ilr | 1..1 | PU | Exciter output current limit reference (Ilr) (> 0). Typical value = 4,164. |
| k1 | 1..1 | Boolean | Selector (K1).<br>true = feedback is from Ifd<br>false = feedback is not from Ifd.<br>Typical value = true. |
| kcl | 1..1 | PU | Exciter output current limit adjustment (Kcl) (> 0). Typical value = 1,0577. |
| kff | 1..1 | PU | Pre-control gain constant of the inner loop field regulator (Kff). Typical value = 1. |
| kg | 1..1 | PU | Feedback gain constant of the inner loop field regulator (Kg) (>= 0). Typical value = 1. |
| kia | 1..1 | PU | Voltage regulator integral gain (Kia) (> 0). Typical value = 45,094. |
| klr | 1..1 | PU | Exciter output current limit adjustment (Kcl) (> 0). Typical value = 17,33. |
| km | 1..1 | PU | Forward gain constant of the inner loop field regulator (Km). Typical value = 1. |
| kpa | 1..1 | PU | Voltage regulator proportional gain (Kpa) (> 0). Typical value = 18,038. |
| kvd | 1..1 | PU | Voltage regulator derivative gain (Kvd). Typical value = 0. |
| oelin | 1..1 | ExcST6BOELselectorKind | OEL input selector (OELin). Typical value = noOELinput (corresponds to OELin = 0 on diagram). |
| tg | 1..1 | Seconds | Feedback time constant of inner loop field voltage regulator (Tg) (>= 0). Typical value = 0,02. |
| ts | 1..1 | Seconds | Rectifier firing time constant (Ts) (>= 0). Typical value = 0. |
| tvd | 1..1 | Seconds | Voltage regulator derivative gain (Tvd) (>= 0). Typical value = 0. |

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| name | mult | type | description |
|---|---|---|---|
| vamax | 1..1 | PU | Maximum voltage regulator output (Vamax) (> 0). Typical value = 4,81. |
| vamin | 1..1 | PU | Minimum voltage regulator output (Vamin) (< 0). Typical value = -3,85. |
| vilim | 1..1 | Boolean | Selector (Vilim).<br>true = Vimin-Vimax limiter is active<br>false = Vimin-Vimax limiter is not active.<br>Typical value = true. |
| vimax | 1..1 | PU | Maximum voltage regulator input limit (Vimax) (> ExcST6B.vimin). Typical value = 10. |
| vimin | 1..1 | PU | Minimum voltage regulator input limit (Vimin) (< ExcST6B.vimax). Typical value = -10. |
| vmult | 1..1 | Boolean | Selector (vmult).<br>true = multiply regulator output by terminal voltage<br>false = do not multiply regulator output by terminal voltage.<br>Typical value = true. |
| vrmax | 1..1 | PU | Maximum voltage regulator output (Vrmax) (> 0). Typical value = 4,81. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (Vrmin) (< 0). Typical value = -3,85. |
| xc | 1..1 | PU | Excitation source reactance (Xc). Typical value = 0,05. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 261 shows all association ends of ExcST6B with other classes.

**Table 261 – Association ends of ExcitationSystemDynamics:: ExcST6B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

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### 8.2.4.3.9.58 ExcST7B

Modified IEEE ST7B static excitation system without stator current limiter (SCL) and current compensator (DROOP) inputs.

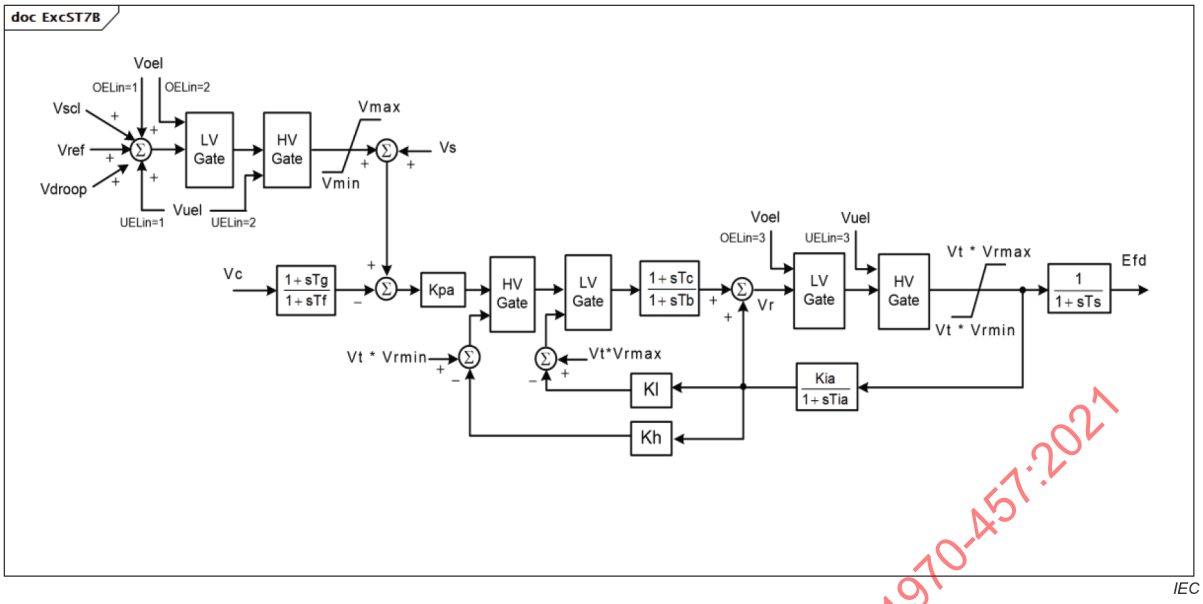


**Figure 136 – ExcST7B**

Figure 136: This diagram describes the ExcST7B excitation system model.

Table 262 shows all attributes of ExcST7B.

**Table 262 – Attributes of ExcitationSystemDynamics::ExcST7B**

| name | mult | type | description |
|---|---|---|---|
| kh | 1..1 | PU | High-value gate feedback gain (Kh) (>= 0). Typical value = 1. |
| kia | 1..1 | PU | Voltage regulator integral gain (Kia) (>= 0). Typical value = 1. |
| kl | 1..1 | PU | Low-value gate feedback gain (Kl) (>= 0). Typical value = 1. |
| kpa | 1..1 | PU | Voltage regulator proportional gain (Kpa) (> 0). Typical value = 40. |
| oelin | 1..1 | ExcST7BOELselectorKind | OEL input selector (OELin). Typical value = noOELinput. |
| tb | 1..1 | Seconds | Regulator lag time constant (Tb) (>= 0). Typical value = 1. |
| tc | 1..1 | Seconds | Regulator lead time constant (Tc) (>= 0). Typical value = 1. |
| tf | 1..1 | Seconds | Excitation control system stabilizer time constant (Tf) (>= 0). Typical value = 1. |
| tg | 1..1 | Seconds | Feedback time constant of inner loop field voltage regulator (Tg) (>= 0). Typical value = 1. |
| tia | 1..1 | Seconds | Feedback time constant (Tia) (>= 0). Typical value = 3. |
| ts | 1..1 | Seconds | Rectifier firing time constant (Ts) (>= 0). Typical value = 0. |
| uelin | 1..1 | ExcST7BUELselectorKind | UEL input selector (UELin). Typical value = noUELinput. |
| vmax | 1..1 | PU | Maximum voltage reference signal (Vmax) (> 0 and > ExcST7B.vmin)). Typical value = 1,1. |
| vmin | 1..1 | PU | Minimum voltage reference signal (Vmin) (> 0 and < ExcST7B.vmax). Typical value = 0,9. |

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| name | mult | type | description |
|---|---|---|---|
| vrmax | 1..1 | PU | Maximum voltage regulator output (Vrmax) (> 0). Typical value = 5. |
| vrmin | 1..1 | PU | Minimum voltage regulator output (Vrmin) (< 0). Typical value = -4,5. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 263 shows all association ends of ExcST7B with other classes.

**Table 263 – Association ends of ExcitationSystemDynamics:: ExcST7B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | SynchronousMachineDynamics | 1..1 | SynchronousMachineDynamics | inherited from: ExcitationSystemDynamics |

#### 8.2.4.3.10 Package OverexcitationLimiterDynamics

##### 8.2.4.3.10.1 General

Overexcitation limiters (OELs) are also referred to as maximum excitation limiters and field current limiters. The possibility of voltage collapse in stressed power systems increases the importance of modelling these limiters in studies of system conditions that cause machines to operate at high levels of excitation for a sustained period, such as voltage collapse or system-islanding. Such events typically occur over a long time frame compared with transient or small-signal stability simulations.

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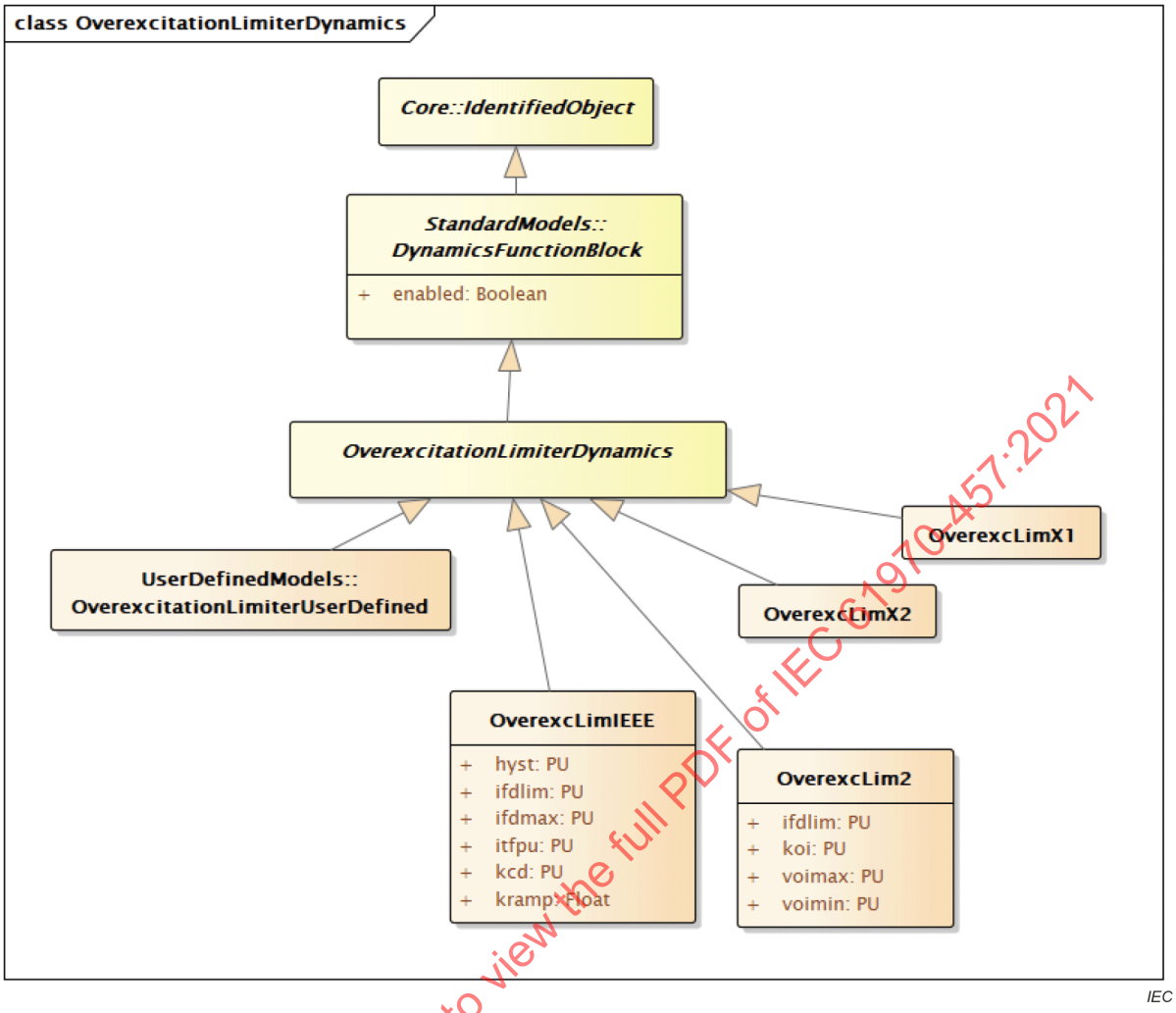


**Figure 137 – Class diagram OverexcitationLimiterDynamics::
OverexcitationLimiterDynamics**

Figure 137: This diagram shows dynamic standard model overexcitation limiter classes and their inheritance from the OverexcitationLimiterDynamics class.

#### 8.2.4.3.10.2 (abstract) OverexcitationLimiterDynamics

Overexcitation limiter function block whose behaviour is described by reference to a standard model or by definition of a user-defined model.

Table 264 shows all attributes of OverexcitationLimiterDynamics.

**Table 264 – Attributes of OverexcitationLimiterDynamics::
OverexcitationLimiterDynamics**

| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 265 shows all association ends of OverexcitationLimiterDynamics with other classes.

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**Table 265 – Association ends of OverexcitationLimiterDynamics:: OverexcitationLimiterDynamics with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | Excitation system model with which this overexcitation limiter model is associated. |

#### 8.2.4.3.10.3 OverexcLimIEEE

The over excitation limiter model is intended to represent the significant features of OELs necessary for some large-scale system studies. It is the result of a pragmatic approach to obtain a model that can be widely applied with attainable data from generator owners. An attempt to include all variations in the functionality of OELs and duplicate how they interact with the rest of the excitation systems would likely result in a level of application insufficient for the studies for which they are intended.

Reference: IEEE OEL 421.5-2005, 9.

Table 266 shows all attributes of OverexcLimIEEE.

**Table 266 – Attributes of OverexcitationLimiterDynamics::OverexcLimIEEE**

| name | mult | type | description |
|---|---|---|---|
| itfpu | 1..1 | PU | OEL timed field current limiter pickup level (ITFPU). Typical value = 1,05. |
| ifdmax | 1..1 | PU | OEL instantaneous field current limit (IFDMAX). Typical value = 1,5. |
| ifdlim | 1..1 | PU | OEL timed field current limit (IFDLIM). Typical value = 1,05. |
| hyst | 1..1 | PU | OEL pickup/drop-out hysteresis (HYST). Typical value = 0,03. |
| kcd | 1..1 | PU | OEL cooldown gain (KCD). Typical value = 1. |
| kramp | 1..1 | Float | OEL ramped limit rate (KRAMP). Unit = PU / s. Typical value = 10. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 267 shows all association ends of OverexcLimIEEE with other classes.

**Table 267 – Association ends of OverexcitationLimiterDynamics:: OverexcLimIEEE with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: OverexcitationLimiterDynamics |

#### 8.2.4.3.10.4 OverexcLim2

Different from LimIEEEOEL, LimOEL2 has a fixed pickup threshold and reduces the excitation set-point by means of a non-windup integral regulator.

Irated is the rated machine excitation current (calculated from nameplate conditions: Vnom, Pnom, CosPhinom).

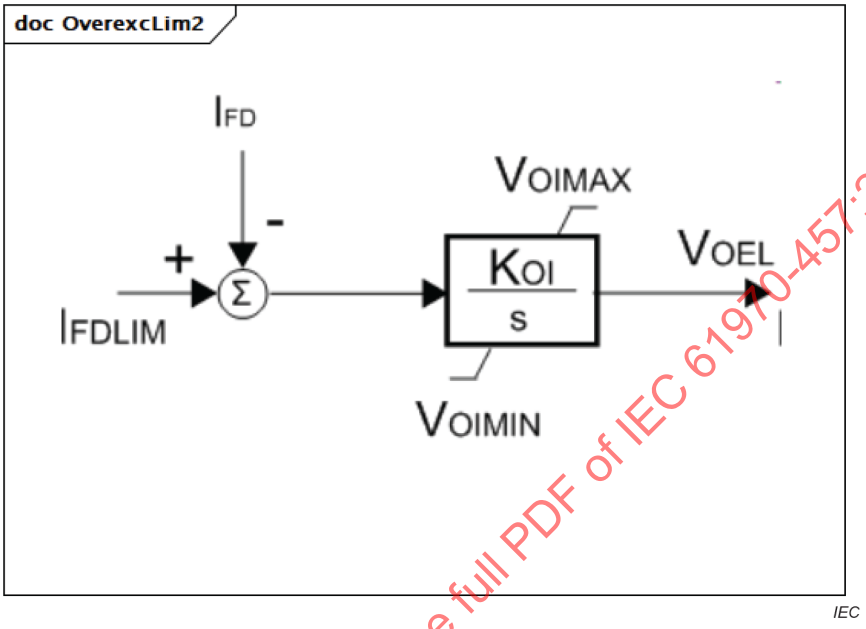


**Figure 138 – OverexcLim2**

Figure 138: This diagram describes the OverexcLim2 overexcitation limiter model.

Table 268 shows all attributes of OverexcLim2.

**Table 268 – Attributes of OverexcitationLimiterDynamics::OverexcLim2**

| name | mult | type | description |
|---|---|---|---|
| koi | 1..1 | PU | Gain Over excitation limiter (KOI). Typical value = 0,1. |
| voimax | 1..1 | PU | Maximum error signal (VOIMAX) (> OverexcLim2.voimin). Typical value = 0. |
| voimin | 1..1 | PU | Minimum error signal (VOIMIN) (< OverexcLim2.voimax). Typical value = -9999. |
| ifdlim | 1..1 | PU | Limit value of rated field current (IFDLIM). Typical value = 1,05. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 269 shows all association ends of OverexcLim2 with other classes.

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**Table 269 – Association ends of OverexcitationLimiterDynamics:: OverexcLim2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: OverexcitationLimiterDynamics |

#### 8.2.4.3.10.5 OverexcLimX1

Field voltage over excitation limiter.

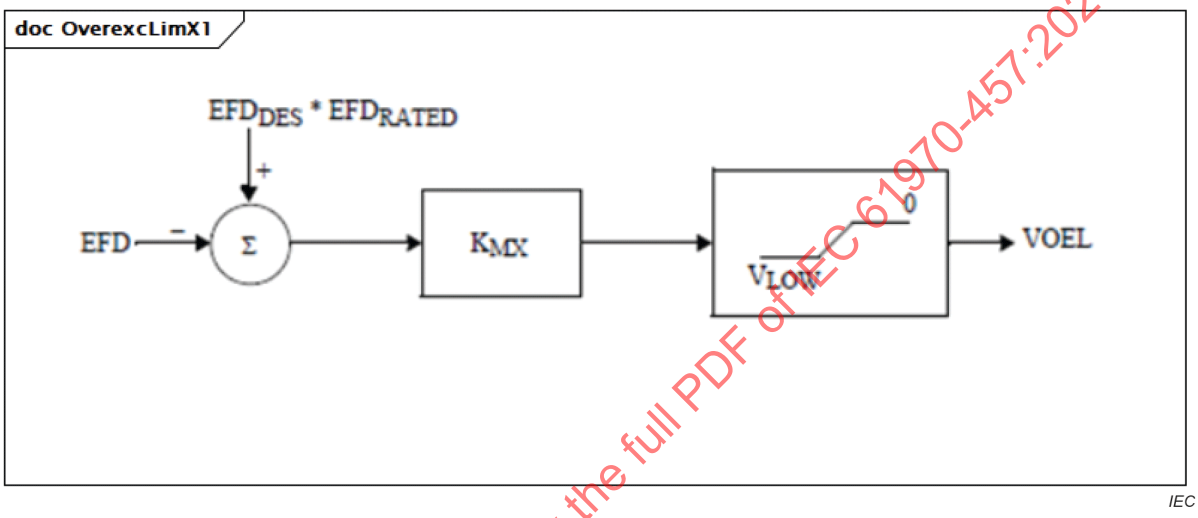


**Figure 139 – OverexcLimX1**

Figure 139: This diagram describes the OverexcLimX1 overexcitation limiter model.

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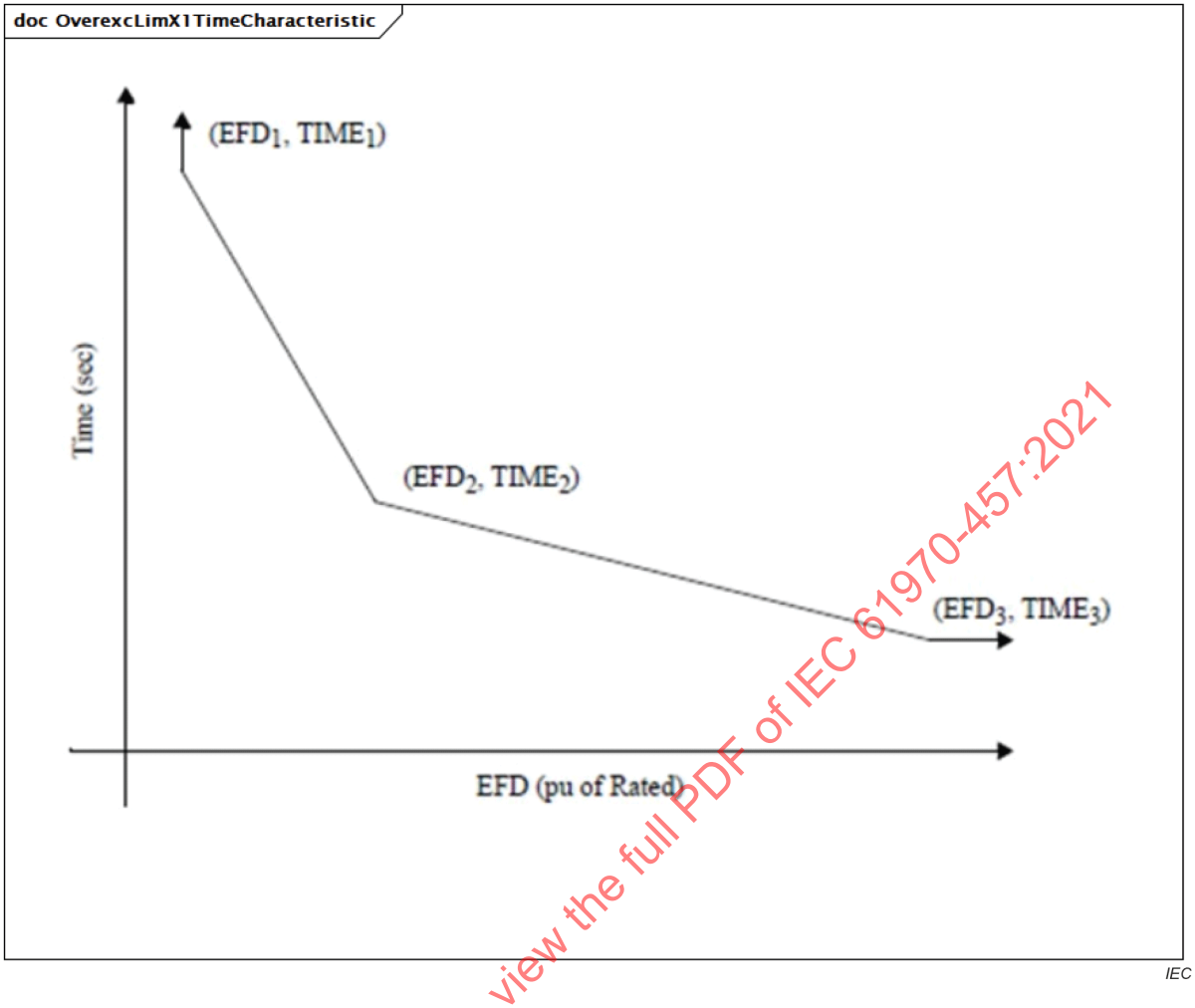


**Figure 140 – OverexcLimX1TimeCharacteristic**

Figure 140: This model assumes an inverse time characteristic, where operating time is a function of the magnitude of the overvoltage.

Table 270 shows all attributes of OverexcLimX1.

**Table 270 – Attributes of OverexcitationLimiterDynamics::OverexcLimX1**

| name | mult | type | description |
|---|---|---|---|
| efdrated | 1..1 | PU | Rated field voltage (EFDRATED). Typical value = 1,05. |
| efd1 | 1..1 | PU | Low voltage point on the inverse time characteristic (EFD1). Typical value = 1,1. |
| t1 | 1..1 | Seconds | Time to trip the exciter at the low voltage point on the inverse time characteristic (TIME1) (>= 0). Typical value = 120. |
| efd2 | 1..1 | PU | Mid voltage point on the inverse time characteristic (EFD2). Typical value = 1,2. |
| t2 | 1..1 | Seconds | Time to trip the exciter at the mid voltage point on the inverse time characteristic (TIME2) (>= 0). Typical value = 40. |
| efd3 | 1..1 | PU | High voltage point on the inverse time characteristic (EFD3). Typical value = 1,5. |

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| name | mult | type | description |
|---|---|---|---|
| t3 | 1..1 | Seconds | Time to trip the exciter at the high voltage point on the inverse time characteristic (TIME3) (>= 0). Typical value = 15. |
| efddes | 1..1 | PU | Desired field voltage (EFDDES). Typical value = 0,9. |
| kmx | 1..1 | PU | Gain (KMX). Typical value = 0,01. |
| vlow | 1..1 | PU | Low voltage limit (VLOW) (> 0). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 271 shows all association ends of OverexcLimX1 with other classes.

**Table 271 – Association ends of OverexcitationLimiterDynamics:: OverexcLimX1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: OverexcitationLimiterDynamics |

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#### 8.2.4.3.10.6 OverexcLimX2

Field voltage or current overexcitation limiter designed to protect the generator field of an AC machine with automatic excitation control from overheating due to prolonged overexcitation.

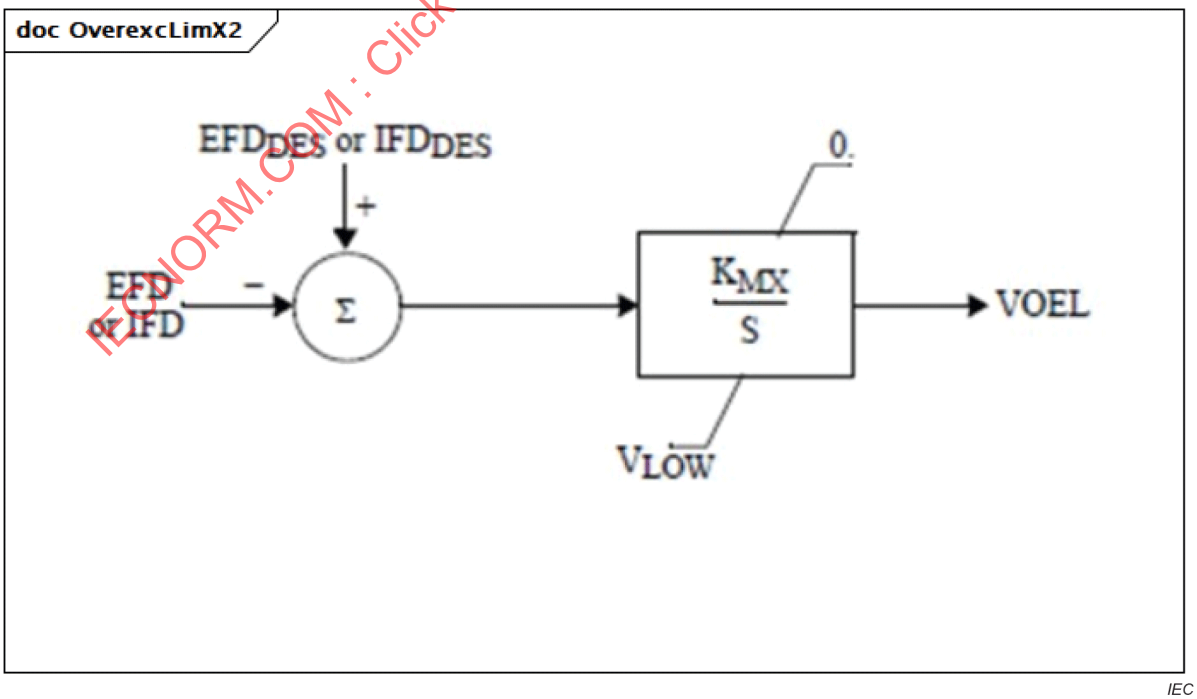


**Figure 141 – OverexcLimX2**

Figure 141: This diagram describes the OverexcLimX2 overexcitation limiter model.

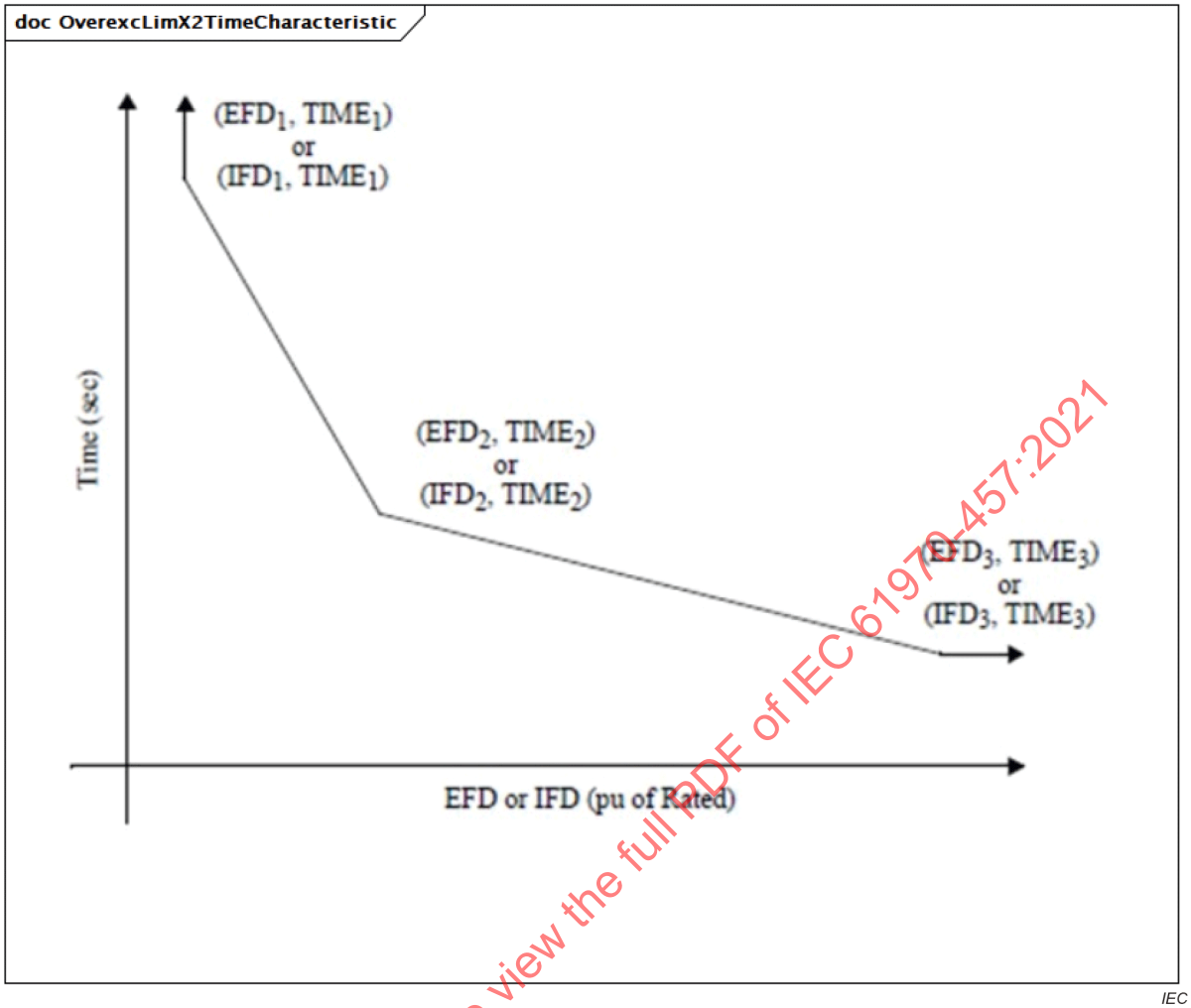


**Figure 142 – OverexcLimX2TimeCharacteristic**

Figure 142: This model assumes an inverse time characteristic, where operating time is a function of the magnitude of the overvoltage.

Table 272 shows all attributes of OverexcLimX2.

**Table 272 – Attributes of OverexcitationLimiterDynamics::OverexcLimX2**

| name | mult | type | description |
|---|---|---|---|
| m | 1..1 | Boolean | (m).<br>true = IFD limiting<br>false = EFD limiting. |
| efdrated | 1..1 | PU | Rated field voltage if m = false or rated field current if m = true (EFDRATED). Typical value = 1,05. |
| efd1 | 1..1 | PU | Low voltage or current point on the inverse time characteristic (EFD1). Typical value = 1,1. |
| t1 | 1..1 | Seconds | Time to trip the exciter at the low voltage or current point on the inverse time characteristic (TIME1) (>= 0). Typical value = 120. |
| efd2 | 1..1 | PU | Mid voltage or current point on the inverse time characteristic (EFD2). Typical value = 1,2. |

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| name | mult | type | description |
|---|---|---|---|
| t2 | 1..1 | Seconds | Time to trip the exciter at the mid voltage or current point on the inverse time characteristic (TIME2) (>= 0). Typical value = 40. |
| efd3 | 1..1 | PU | High voltage or current point on the inverse time characteristic (EFD3). Typical value = 1,5. |
| t3 | 1..1 | Seconds | Time to trip the exciter at the high voltage or current point on the inverse time characteristic (TIME3) (>= 0). Typical value = 15. |
| efddes | 1..1 | PU | Desired field voltage if m = false or desired field current if m = true (EFDDES). Typical value = 1. |
| kmx | 1..1 | PU | Gain (KMX). Typical value = 0,002. |
| vlow | 1..1 | PU | Low voltage limit (VLOW) (> 0). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 273 shows all association ends of OverexcLimX2 with other classes.

**Table 273 – Association ends of OverexcitationLimiterDynamics:: OverexcLimX2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: OverexcitationLimiterDynamics |

#### 8.2.4.3.11 Package UnderexcitationLimiterDynamics

##### 8.2.4.3.11.1 General

Underexcitation limiters (UELs) act to boost excitation. The UEL typically senses either a combination of voltage and current of the synchronous machine or a combination of real and reactive power. Some UELs utilize a temperature or pressure recalibration feature, in which the UEL characteristic is shifted depending upon the generator cooling gas temperature or pressure.

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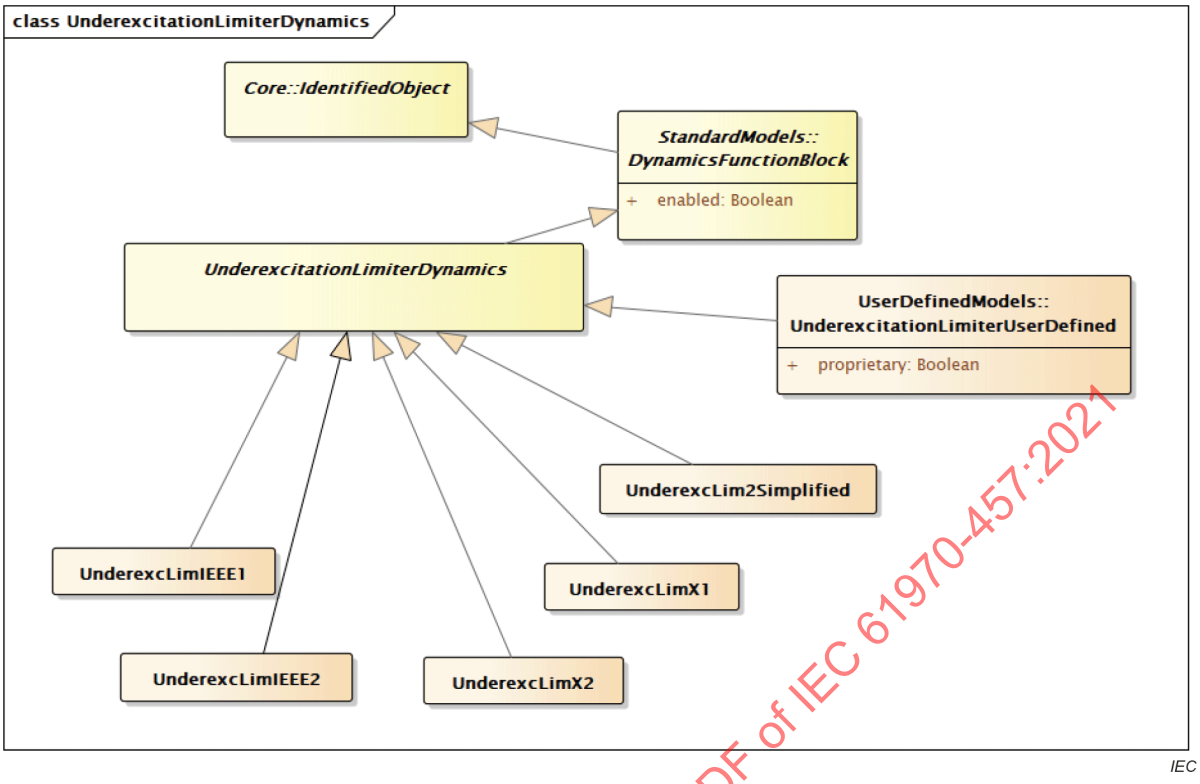


**Figure 143 – Class diagram UnderexcitationLimiterDynamics::UnderexcitationLimiterDynamics**

Figure 143: This diagram shows dynamic standard model underexcitation limiter classes and their inheritance from the UnderexcitationLimiterDynamics class.

#### 8.2.4.3.11.2 (abstract) UnderexcitationLimiterDynamics

Underexcitation limiter function block whose behaviour is described by reference to a standard model or by definition of a user-defined model.

Table 274 shows all attributes of UnderexcitationLimiterDynamics.

**Table 274 – Attributes of UnderexcitationLimiterDynamics:: UnderexcitationLimiterDynamics**

| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 275 shows all association ends of UnderexcitationLimiterDynamics with other classes.

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**Table 275 – Association ends of UnderexcitationLimiterDynamics:: UnderexcitationLimiterDynamics with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | Excitation system model with which this underexcitation limiter model is associated. |

#### 8.2.4.3.11.3 UnderexcLimIEEE1

Type UEL1 model which has a circular limit boundary when plotted in terms of machine reactive power vs. real power output.

Reference: IEEE UEL1 421.5-2005, 10.1.

Table 276 shows all attributes of UnderexcLimIEEE1.

**Table 276 – Attributes of UnderexcitationLimiterDynamics::UnderexcLimIEEE1**

| name | mult | type | description |
|---|---|---|---|
| kur | 1..1 | PU | UEL radius setting (KUR). Typical value = 1,95. |
| kuc | 1..1 | PU | UEL centre setting (KUC). Typical value = 1,38. |
| kuf | 1..1 | PU | UEL excitation system stabilizer gain (KUF). Typical value = 3,3. |
| vurmax | 1..1 | PU | UEL maximum limit for radius phasor magnitude (VURMAX). Typical value = 5,8. |
| vucmax | 1..1 | PU | UEL maximum limit for operating point phasor magnitude (VUCMAX). Typical value = 5,8. |
| kui | 1..1 | PU | UEL integral gain (KUI). Typical value = 0. |
| kul | 1..1 | PU | UEL proportional gain (KUL). Typical value = 100. |
| vuimax | 1..1 | PU | UEL integrator output maximum limit (VUIMAX) (> UnderexcLimIEEE1.vuimin). |
| vuimin | 1..1 | PU | UEL integrator output minimum limit (VUIMIN) (< UnderexcLimIEEE1.vuimax). |
| tu1 | 1..1 | Seconds | UEL lead time constant (TU1) (>= 0). Typical value = 0. |
| tu2 | 1..1 | Seconds | UEL lag time constant (TU2) (>= 0). Typical value = 0,05. |
| tu3 | 1..1 | Seconds | UEL lead time constant (TU3) (>= 0). Typical value = 0. |
| tu4 | 1..1 | Seconds | UEL lag time constant (TU4) (>= 0). Typical value = 0. |
| vulmax | 1..1 | PU | UEL output maximum limit (VULMAX) (> UnderexcLimIEEE1.vulmin). Typical value = 18. |
| vulmin | 1..1 | PU | UEL output minimum limit (VULMIN) (< UnderexcLimIEEE1.vulmax). Typical value = -18. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 277 shows all association ends of UnderexcLimIEEE1 with other classes.

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**Table 277 – Association ends of UnderexcitationLimiterDynamics:: UnderexcLimIEEE1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: UnderexcitationLimiterDynamics |

#### 8.2.4.3.11.4 UnderexcLimIEEE2

Type UEL2 underexcitation limiter which has either a straight-line or multi-segment characteristic when plotted in terms of machine reactive power output vs. real power output.

Reference: IEEE UEL2 421.5-2005, 10.2 (limit characteristic lookup table shown in Figure 10.4).

Table 278 shows all attributes of UnderexcLimIEEE2.

**Table 278 – Attributes of UnderexcitationLimiterDynamics::UnderexcLimIEEE2**

| name | mult | type | description |
|---|---|---|---|
| tuv | 1..1 | Seconds | Voltage filter time constant (TUV) (>= 0). Typical value = 5. |
| tup | 1..1 | Seconds | Real power filter time constant (TUP) (>= 0). Typical value = 5. |
| tuq | 1..1 | Seconds | Reactive power filter time constant (TUQ) (>= 0). Typical value = 0. |
| kui | 1..1 | PU | UEL integral gain (KUI). Typical value = 0,5. |
| kul | 1..1 | PU | UEL proportional gain (KUL). Typical value = 0,8. |
| vuimax | 1..1 | PU | UEL integrator output maximum limit (VUIMAX) (> UnderexcLimIEEE2.vuimin). Typical value = 0,25. |
| vuimin | 1..1 | PU | UEL integrator output minimum limit (VUIMIN) (< UnderexcLimIEEE2.vuimax). Typical value = 0. |
| kuf | 1..1 | PU | UEL excitation system stabilizer gain (KUF). Typical value = 0. |
| kfb | 1..1 | PU | Gain associated with optional integrator feedback input signal to UEL (KFB). Typical value = 0. |
| tul | 1..1 | Seconds | Time constant associated with optional integrator feedback input signal to UEL (TUL) (>= 0). Typical value = 0. |
| tu1 | 1..1 | Seconds | UEL lead time constant (TU1) (>= 0). Typical value = 0. |
| tu2 | 1..1 | Seconds | UEL lag time constant (TU2) (>= 0). Typical value = 0. |
| tu3 | 1..1 | Seconds | UEL lead time constant (TU3) (>= 0). Typical value = 0. |
| tu4 | 1..1 | Seconds | UEL lag time constant (TU4) (>= 0). Typical value = 0. |
| vulmax | 1..1 | PU | UEL output maximum limit (VULMAX) (> UnderexcLimIEEE2.vulmin). Typical value = 0,25. |
| vulmin | 1..1 | PU | UEL output minimum limit (VULMIN) (< UnderexcLimIEEE2.vulmax). Typical value = 0. |
| p0 | 1..1 | PU | Real power values for endpoints (P0). Typical value = 0. |

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| name | mult | type | description |
|---|---|---|---|
| q0 | 1..1 | PU | Reactive power values for endpoints (Q0). Typical value = -0,31. |
| p1 | 1..1 | PU | Real power values for endpoints (P1). Typical value = 0,3. |
| q1 | 1..1 | PU | Reactive power values for endpoints (Q1). Typical value = -0,31. |
| p2 | 1..1 | PU | Real power values for endpoints (P2). Typical value = 0,6. |
| q2 | 1..1 | PU | Reactive power values for endpoints (Q2). Typical value = -0,28. |
| p3 | 1..1 | PU | Real power values for endpoints (P3). Typical value = 0,9. |
| q3 | 1..1 | PU | Reactive power values for endpoints (Q3). Typical value = -0,21. |
| p4 | 1..1 | PU | Real power values for endpoints (P4). Typical value = 1,02. |
| q4 | 1..1 | PU | Reactive power values for endpoints (Q4). Typical value = 0. |
| p5 | 1..1 | PU | Real power values for endpoints (P5). |
| q5 | 1..1 | PU | Reactive power values for endpoints (Q5). |
| p6 | 1..1 | PU | Real power values for endpoints (P6). |
| q6 | 1..1 | PU | Reactive power values for endpoints (Q6). |
| p7 | 1..1 | PU | Real power values for endpoints (P7). |
| q7 | 1..1 | PU | Reactive power values for endpoints (Q7). |
| p8 | 1..1 | PU | Real power values for endpoints (P8). |
| q8 | 1..1 | PU | Reactive power values for endpoints (Q8). |
| p9 | 1..1 | PU | Real power values for endpoints (P9). |
| q9 | 1..1 | PU | Reactive power values for endpoints (Q9). |
| p10 | 1..1 | PU | Real power values for endpoints (P10). |
| q10 | 1..1 | PU | Reactive power values for endpoints (Q10). |
| k1 | 1..1 | Float | UEL terminal voltage exponent applied to real power input to UEL limit look-up table (k1). Typical value = 2. |
| k2 | 1..1 | Float | UEL terminal voltage exponent applied to reactive power output from UEL limit look-up table (k2). Typical value = 2. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 279 shows all association ends of UnderexcLimIEEE2 with other classes.

**Table 279 – Association ends of UnderexcitationLimiterDynamics:: UnderexcLimIEEE2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: UnderexcitationLimiterDynamics |

#### 8.2.4.3.11.5 UnderexcLim2Simplified

Simplified type UEL2 underexcitation limiter. This model can be derived from UnderexcLimIEEE2. The limit characteristic (look –up table) is a single straight-line, the same as UnderexcLimIEEE2 (see Figure 10.4, IEEE 421.5-2005 Section 10.2).

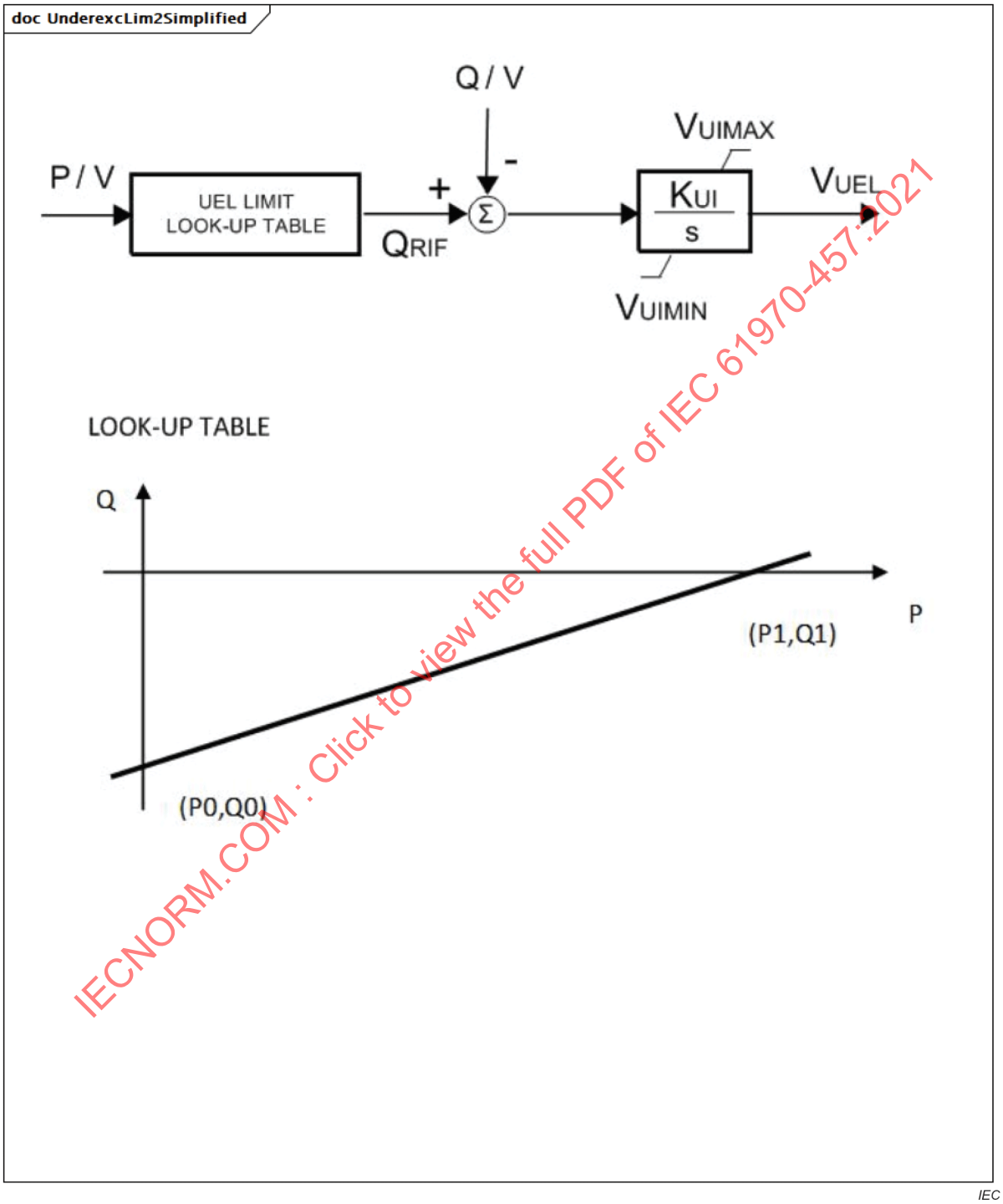


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**Figure 144 – UnderexcLim2Simplified**

Figure 144: This diagram describes the UnderexcLim2Simplified underexcitation limiter model.

Table 280 shows all attributes of UnderexcLim2Simplified.

**Table 280 – Attributes of UnderexcitationLimiterDynamics::UnderexcLim2Simplified**

| name | mult | type | description |
|---|---|---|---|
| q0 | 1..1 | PU | Segment Q initial point (Q0). Typical value = -0,31. |
| q1 | 1..1 | PU | Segment Q end point (Q1). Typical value = -0,1. |
| p0 | 1..1 | PU | Segment P initial point (P0). Typical value = 0. |
| p1 | 1..1 | PU | Segment P end point (P1). Typical value = 1. |
| kui | 1..1 | PU | Gain Under excitation limiter (KUI). Typical value = 0,1. |
| vuimin | 1..1 | PU | Minimum error signal (VUIMIN) (< UnderexcLim2Simplified.vuimax). Typical value = 0. |
| vuimax | 1..1 | PU | Maximum error signal (VUIMAX) (> UnderexcLim2Simplified.vuimin). Typical value = 1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 281 shows all association ends of UnderexcLim2Simplified with other classes.

**Table 281 – Association ends of UnderexcitationLimiterDynamics:: UnderexcLim2Simplified with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: UnderexcitationLimiterDynamics |

#### 8.2.4.3.11.6 UnderexcLimX1

Allis-Chalmers minimum excitation limiter.

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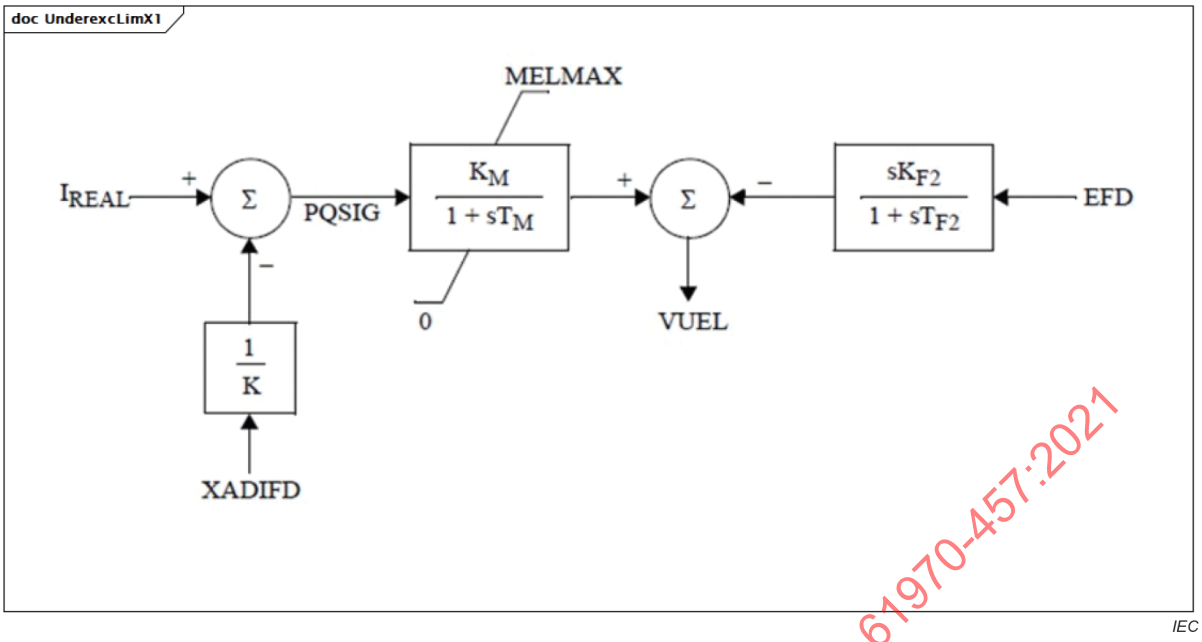


**Figure 145 – UnderexcLimX1**

Figure 145: This diagram describes the UnderexcLimX1 underexcitation limiter model.

Parameter details:

1) IREAL is the real part of stator current.
2) XADIFD is the signal Ifd as shown in the diagram of the SubtransientRoundRotor model, i.e. the XADIFD = E'q + [(E'q – psid) x (Xd – X'd) x (X'd – X"d) + Id x (Xd – X'd) x (X"d – Xl) x (X'd – Xl)] / (X'd – Xl) ** 2, where the psi in psid is the Greek symbol psi.

Table 282 shows all attributes of UnderexcLimX1.

**Table 282 – Attributes of UnderexcitationLimiterDynamics::UnderexcLimX1**

| name | mult | type | description |
|---|---|---|---|
| kf2 | 1..1 | PU | Differential gain (KF2). |
| tf2 | 1..1 | Seconds | Differential time constant (TF2) (>= 0). |
| km | 1..1 | PU | Minimum excitation limit gain (KM). |
| tm | 1..1 | Seconds | Minimum excitation limit time constant (TM) (>= 0). |
| melmax | 1..1 | PU | Minimum excitation limit value (MELMAX). |
| k | 1..1 | PU | Minimum excitation limit slope (K) (> 0). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 283 shows all association ends of UnderexcLimX1 with other classes.

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**Table 283 – Association ends of UnderexcitationLimiterDynamics:: UnderexcLimX1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: UnderexcitationLimiterDynamics |

#### 8.2.4.3.11.7 UnderexcLimX2

Westinghouse minimum excitation limiter.

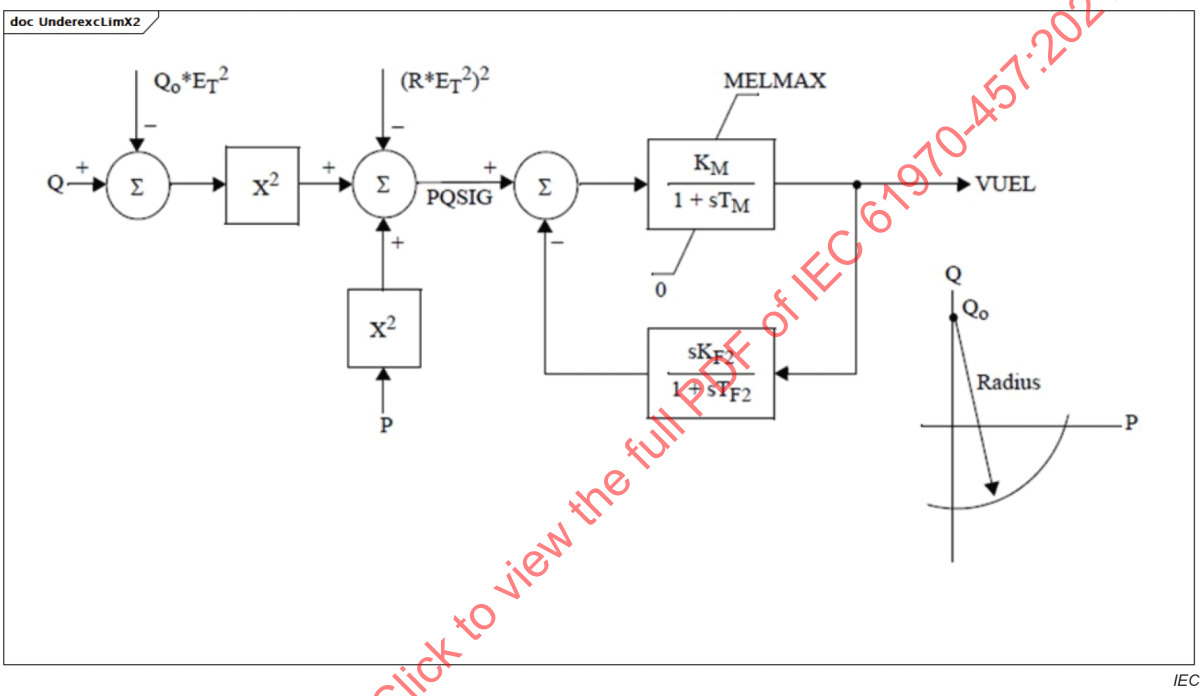


**Figure 146 – UnderexcLimX2**

Figure 146: This diagram describes the UnderexcLimX2 underexcitation limiter model.

Table 284 shows all attributes of UnderexcLimX2.

**Table 284 – Attributes of UnderexcitationLimiterDynamics::UnderexcLimX2**

| name | mult | type | description |
|---|---|---|---|
| kf2 | 1..1 | PU | Differential gain (KF2). |
| tf2 | 1..1 | Seconds | Differential time constant (TF2) (>= 0). |
| km | 1..1 | PU | Minimum excitation limit gain (KM). |
| tm | 1..1 | Seconds | Minimum excitation limit time constant (TM) (>= 0). |
| melmax | 1..1 | PU | Minimum excitation limit value (MELMAX). |
| qo | 1..1 | PU | Excitation centre setting (QO). |
| r | 1..1 | PU | Excitation radius (R). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |

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

Table 285 shows all association ends of UnderexcLimX2 with other classes.

**Table 285 – Association ends of UnderexcitationLimiterDynamics:: UnderexcLimX2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: UnderexcitationLimiterDynamics |

#### 8.2.4.3.12 Package PowerSystemStabilizerDynamics

##### 8.2.4.3.12.1 General

The power system stabilizer (PSS) model provides an input (Vs) to the excitation system model to improve damping of system oscillations. A variety of input signals can be used depending on the particular design.

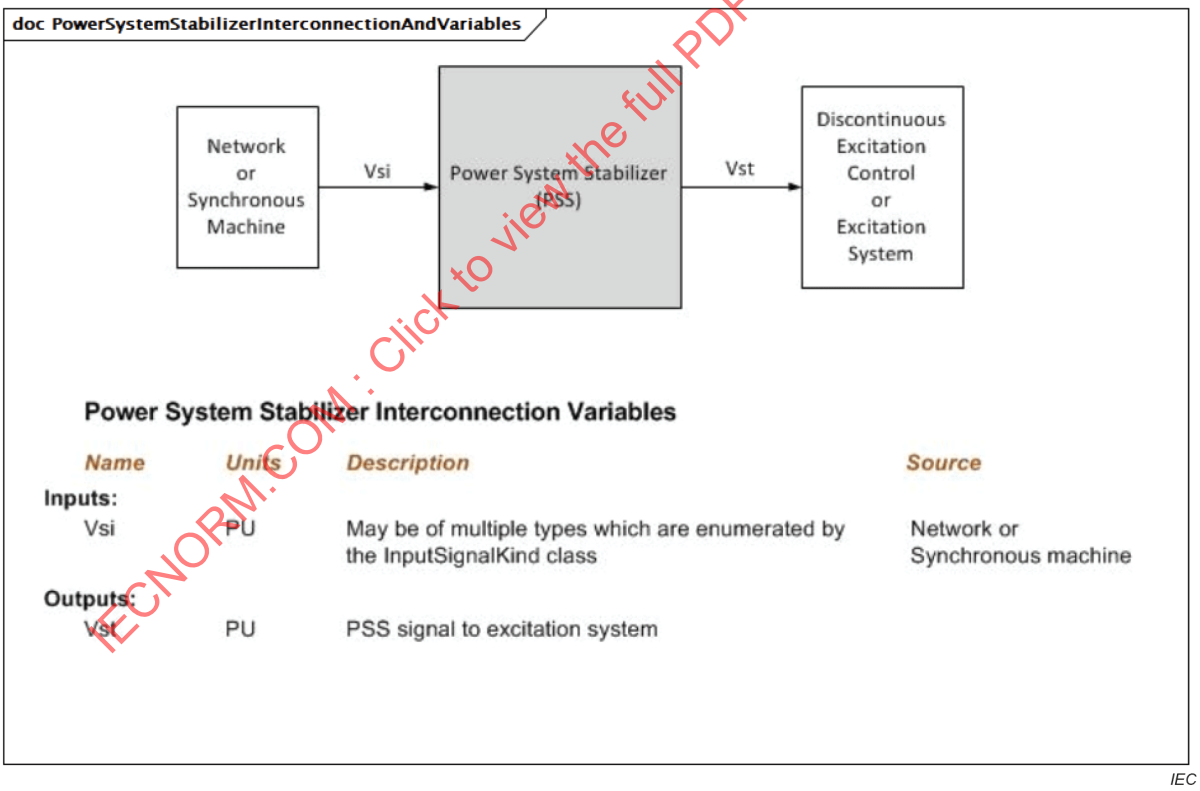


**Figure 147 – PowerSystemStabilizerInterconnectionAndVariables**

Figure 147: This diagram illustrates the inputs and outputs for a power system stabilizer.

Diagram details:

1) If there is no discontinuous excitation control function block present, then output is Vs, not Vst
2) Vs is always initialized to zero by the excitation system model.

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3) If bus voltage frequency is not available from network, the model can calculate it as derivative of the bus voltage angle.

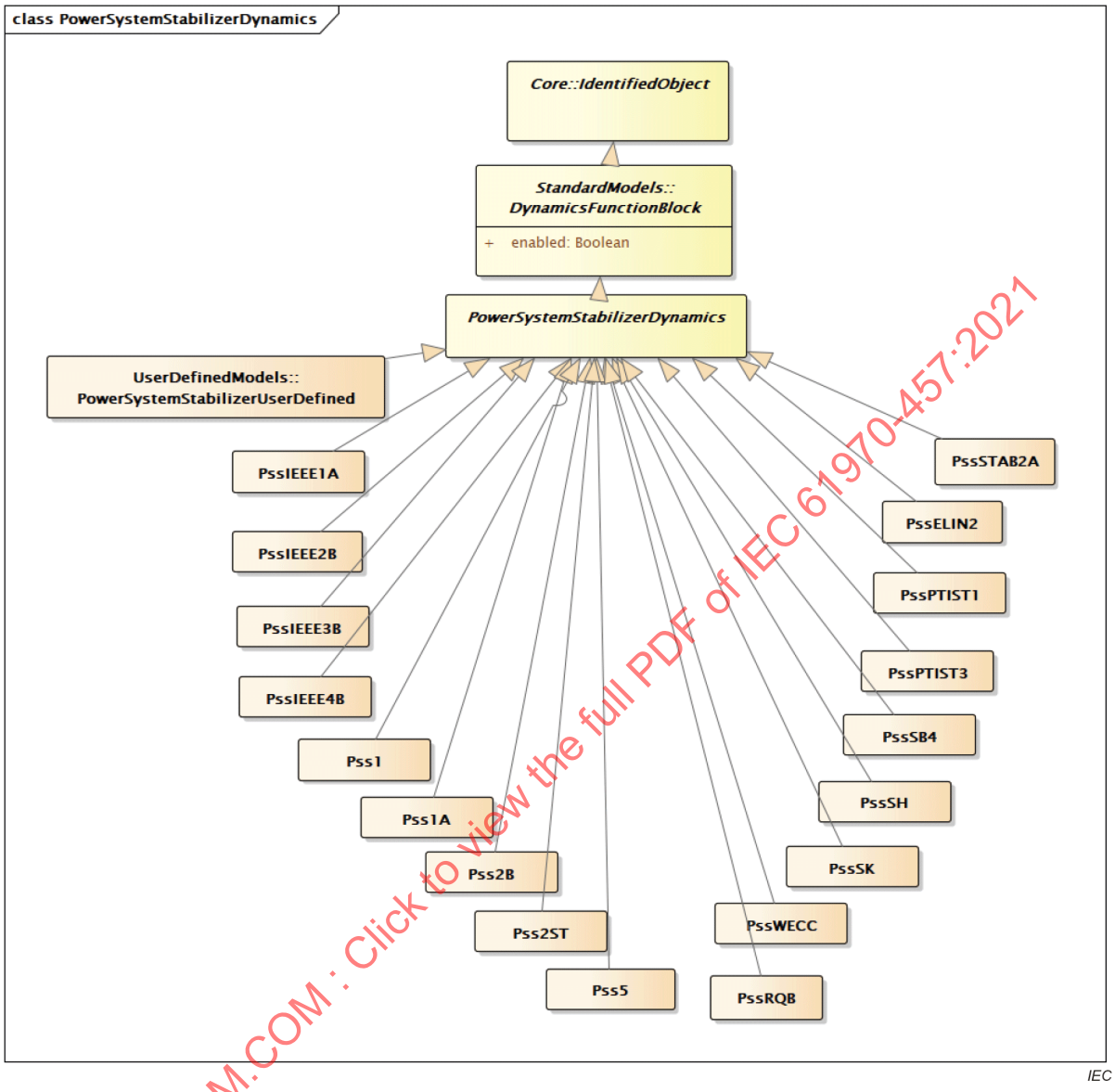


**Figure 148 – Class diagram PowerSystemStabilizerDynamics:: PowerSystemStabilizerDynamics**

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Figure 148: This diagram shows dynamic standard model power system stabilizer classes and their inheritance from the PowerSystemStabilizerDynamics class.

#### 8.2.4.3.12.2 (abstract) PowerSystemStabilizerDynamics

Power system stabilizer function block whose behaviour is described by reference to a standard model or by definition of a user-defined model.

Table 286 shows all attributes of PowerSystemStabilizerDynamics.

**Table 286 – Attributes of PowerSystemStabilizerDynamics:: PowerSystemStabilizerDynamics**

| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 287 shows all association ends of PowerSystemStabilizerDynamics with other classes.

**Table 287 – Association ends of PowerSystemStabilizerDynamics:: PowerSystemStabilizerDynamics with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | Excitation system model with which this power system stabilizer model is associated. |

#### 8.2.4.3.12.3 PssIEEE1A

IEEE 421.5-2005 type PSS1A power system stabilizer model. PSS1A is the generalized form of a PSS with a single input signal.

Reference: IEEE 1A 421.5-2005, 8.1.

Table 288 shows all attributes of PssIEEE1A.

**Table 288 – Attributes of PowerSystemStabilizerDynamics::PssIEEE1A**

| name | mult | type | description |
|---|---|---|---|
| inputSignalType | 1..1 | InputSignalKind | Type of input signal (rotorAngularFrequencyDeviation, generatorElectricalPower, or busFrequencyDeviation). Typical value = rotorAngularFrequencyDeviation. |
| a1 | 1..1 | PU | PSS signal conditioning frequency filter constant (A1). Typical value = 0,061. |
| a2 | 1..1 | PU | PSS signal conditioning frequency filter constant (A2). Typical value = 0,0017. |
| t1 | 1..1 | Seconds | Lead/lag time constant (T1) (>= 0). Typical value = 0,3. |
| t2 | 1..1 | Seconds | Lead/lag time constant (T2) (>= 0). Typical value = 0,03. |
| t3 | 1..1 | Seconds | Lead/lag time constant (T3) (>= 0). Typical value = 0,3. |
| t4 | 1..1 | Seconds | Lead/lag time constant (T4) (>= 0). Typical value = 0,03. |
| t5 | 1..1 | Seconds | Washout time constant (T5) (>= 0). Typical value = 10. |
| t6 | 1..1 | Seconds | Transducer time constant (T6) (>= 0). Typical value = 0,01. |
| ks | 1..1 | PU | Stabilizer gain (Ks). Typical value = 5. |

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| name | mult | type | description |
|---|---|---|---|
| vrmax | 1..1 | PU | Maximum stabilizer output (Vrmax) (> PssIEEE1A.vrmin). Typical value = 0,05. |
| vrmin | 1..1 | PU | Minimum stabilizer output (Vrmin) (< PssIEEE1A.vrmax). Typical value = -0,05. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 289 shows all association ends of PssIEEE1A with other classes.

**Table 289 – Association ends of PowerSystemStabilizerDynamics:: PssIEEE1A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

#### 8.2.4.3.12.4 PssIEEE2B

IEEE 421.5-2005 type PSS2B power system stabilizer model. This stabilizer model is designed to represent a variety of dual-input stabilizers, which normally use combinations of power and speed or frequency to derive the stabilizing signal.

Reference: IEEE 2B 421.5-2005, 8.2.

Table 290 shows all attributes of PssIEEE2B.

**Table 290 – Attributes of PowerSystemStabilizerDynamics::PssIEEE2B**

| name | mult | type | description |
|---|---|---|---|
| inputSignal1Type | 1..1 | InputSignalKind | Type of input signal #1 (rotorAngularFrequencyDeviation, busFrequencyDeviation). Typical value = rotorAngularFrequencyDeviation. |
| inputSignal2Type | 1..1 | InputSignalKind | Type of input signal #2 (generatorElectricalPower). Typical value = generatorElectricalPower. |
| vsi1max | 1..1 | PU | Input signal #1 maximum limit (Vsi1max) (> PssIEEE2B.vsi1min). Typical value = 2. |
| vsi1min | 1..1 | PU | Input signal #1 minimum limit (Vsi1min) (< PssIEEE2B.vsi1max). Typical value = -2. |
| tw1 | 1..1 | Seconds | First washout on signal #1 (Tw1) (>= 0). Typical value = 2. |
| tw2 | 1..1 | Seconds | Second washout on signal #1 (Tw2) (>= 0). Typical value = 2. |
| vsi2max | 1..1 | PU | Input signal #2 maximum limit (Vsi2max) (> PssIEEE2B.vsi2min). Typical value = 2. |
| vsi2min | 1..1 | PU | Input signal #2 minimum limit (Vsi2min) (< PssIEEE2B.vsi2max). Typical value = -2. |
| tw3 | 1..1 | Seconds | First washout on signal #2 (Tw3) (>= 0). Typical value = 2. |

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| name | mult | type | description |
|---|---|---|---|
| tw4 | 1..1 | Seconds | Second washout on signal #2 (Tw4) (>= 0). Typical value = 0. |
| t1 | 1..1 | Seconds | Lead/lag time constant (T1) (>= 0). Typical value = 0,12. |
| t2 | 1..1 | Seconds | Lead/lag time constant (T2) (>= 0). Typical value = 0,02. |
| t3 | 1..1 | Seconds | Lead/lag time constant (T3) (>= 0). Typical value = 0,3. |
| t4 | 1..1 | Seconds | Lead/lag time constant (T4) (>= 0). Typical value = 0,02. |
| t6 | 1..1 | Seconds | Time constant on signal #1 (T6) (>= 0). Typical value = 0. |
| t7 | 1..1 | Seconds | Time constant on signal #2 (T7) (>= 0). Typical value = 2. |
| t8 | 1..1 | Seconds | Lead of ramp tracking filter (T8) (>= 0). Typical value = 0,2. |
| t9 | 1..1 | Seconds | Lag of ramp tracking filter (T9) (>= 0). Typical value = 0,1. |
| t10 | 1..1 | Seconds | Lead/lag time constant (T10) (>= 0). Typical value = 0. |
| t11 | 1..1 | Seconds | Lead/lag time constant (T11) (>= 0). Typical value = 0. |
| ks1 | 1..1 | PU | Stabilizer gain (Ks1). Typical value = 12. |
| ks2 | 1..1 | PU | Gain on signal #2 (Ks2). Typical value = 0,2. |
| ks3 | 1..1 | PU | Gain on signal #2 input before ramp-tracking filter (Ks3). Typical value = 1. |
| n | 1..1 | Integer | Order of ramp tracking filter (N). Typical value = 1. |
| m | 1..1 | Integer | Denominator order of ramp tracking filter (M). Typical value = 5. |
| vstmax | 1..1 | PU | Stabilizer output maximum limit (Vstmax) (> PssIEEE2B.vstmin). Typical value = 0,1. |
| vstmin | 1..1 | PU | Stabilizer output minimum limit (Vstmin) (< PssIEEE2B.vstmax). Typical value = -0,1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 291 shows all association ends of PssIEEE2B with other classes.

**Table 291 – Association ends of PowerSystemStabilizerDynamics:: PssIEEE2B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

#### 8.2.4.3.12.5 PssIEEE3B

IEEE 421.5-2005 type PSS3B power system stabilizer model. The PSS model PSS3B has dual inputs of electrical power and rotor angular frequency deviation. The signals are used to derive an equivalent mechanical power signal.

This model has 2 input signals. They have the following fixed types (expressed in terms of InputSignalKind values): the first one is of rotorAngleFrequencyDeviation type and the second one is of generatorElectricalPower type.

Reference: IEEE 3B 421.5-2005, 8.3.

Table 292 shows all attributes of PssIEEE3B.

**Table 292 – Attributes of PowerSystemStabilizerDynamics::PssIEEE3B**

| name | mult | type | description |
|---|---|---|---|
| t1 | 1..1 | Seconds | Transducer time constant (T1) (>= 0). Typical value = 0,012. |
| t2 | 1..1 | Seconds | Transducer time constant (T2) (>= 0). Typical value = 0,012. |
| tw1 | 1..1 | Seconds | Washout time constant (Tw1) (>= 0). Typical value = 0,3. |
| tw2 | 1..1 | Seconds | Washout time constant (Tw2) (>= 0). Typical value = 0,3. |
| tw3 | 1..1 | Seconds | Washout time constant (Tw3) (>= 0). Typical value = 0,6. |
| ks1 | 1..1 | PU | Gain on signal # 1 (Ks1). Typical value = -0,602. |
| ks2 | 1..1 | PU | Gain on signal # 2 (Ks2). Typical value = 30,12. |
| a1 | 1..1 | PU | Notch filter parameter (A1). Typical value = 0,359. |
| a2 | 1..1 | PU | Notch filter parameter (A2). Typical value = 0,586. |
| a3 | 1..1 | PU | Notch filter parameter (A3). Typical value = 0,429. |
| a4 | 1..1 | PU | Notch filter parameter (A4). Typical value = 0,564. |
| a5 | 1..1 | PU | Notch filter parameter (A5). Typical value = 0,001. |
| a6 | 1..1 | PU | Notch filter parameter (A6). Typical value = 0. |
| a7 | 1..1 | PU | Notch filter parameter (A7). Typical value = 0,031. |
| a8 | 1..1 | PU | Notch filter parameter (A8). Typical value = 0. |
| vstmax | 1..1 | PU | Stabilizer output maximum limit (Vstmax) (> PssIEEE3B.vstmin). Typical value = 0,1. |
| vstmin | 1..1 | PU | Stabilizer output minimum limit (Vstmin) (< PssIEEE3B.vstmax). Typical value = -0,1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 293 shows all association ends of PssIEEE3B with other classes.

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**Table 293 – Association ends of PowerSystemStabilizerDynamics:: PssIEEE3B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

#### 8.2.4.3.12.6 PssIEEE4B

IEEE 421.5-2005 type PSS4B power system stabilizer. The PSS4B model represents a structure based on multiple working frequency bands. Three separate bands, respectively dedicated to the low-, intermediate- and high-frequency modes of oscillations, are used in this delta omega (speed input) PSS.

There is an error in the in IEEE 421.5-2005 PSS4B model: the Pe input should read –Pe. This implies that the input Pe needs to be multiplied by -1.

Reference: IEEE 4B 421.5-2005, 8.4.

Parameter details:

This model has 2 input signals. They have the following fixed types (expressed in terms of InputSignalKind values): the first one is of rotorAngleFrequencyDeviation type and the second one is of generatorElectricalPower type.

Table 294 shows all attributes of PssIEEE4B.

**Table 294 – Attributes of PowerSystemStabilizerDynamics::PssIEEE4B**

| name | mult | type | description |
|---|---|---|---|
| bwh1 | 1..1 | Float | Notch filter 1 (high-frequency band): three dB bandwidth (Bwi). |
| bwh2 | 1..1 | Float | Notch filter 2 (high-frequency band): three dB bandwidth (Bwi). |
| bwl1 | 1..1 | Float | Notch filter 1 (low-frequency band): three dB bandwidth (Bwi). |
| bwl2 | 1..1 | Float | Notch filter 2 (low-frequency band): three dB bandwidth (Bwi). |
| kh | 1..1 | PU | High band gain (KH). Typical value = 120. |
| kh1 | 1..1 | PU | High band differential filter gain (KH1). Typical value = 66. |
| kh11 | 1..1 | PU | High band first lead-lag blocks coefficient (KH11). Typical value = 1. |
| kh17 | 1..1 | PU | High band first lead-lag blocks coefficient (KH17). Typical value = 1. |
| kh2 | 1..1 | PU | High band differential filter gain (KH2). Typical value = 66. |
| ki | 1..1 | PU | Intermediate band gain (KI). Typical value = 30. |
| ki1 | 1..1 | PU | Intermediate band differential filter gain (KI1). Typical value = 66. |
| ki11 | 1..1 | PU | Intermediate band first lead-lag blocks coefficient (KI11). Typical value = 1. |
| ki17 | 1..1 | PU | Intermediate band first lead-lag blocks coefficient (KI17). Typical value = 1. |

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| name | mult | type | description |
|---|---|---|---|
| ki2 | 1..1 | PU | Intermediate band differential filter gain (KI2). Typical value = 66. |
| kl | 1..1 | PU | Low band gain (KL). Typical value = 7.5. |
| kl1 | 1..1 | PU | Low band differential filter gain (KL1). Typical value = 66. |
| kl11 | 1..1 | PU | Low band first lead-lag blocks coefficient (KL11). Typical value = 1. |
| kl17 | 1..1 | PU | Low band first lead-lag blocks coefficient (KL17). Typical value = 1. |
| kl2 | 1..1 | PU | Low band differential filter gain (KL2). Typical value = 66. |
| omeganh1 | 1..1 | Float | Notch filter 1 (high-frequency band): filter frequency (omegani). |
| omeganh2 | 1..1 | Float | Notch filter 2 (high-frequency band): filter frequency (omegani). |
| omeganl1 | 1..1 | Float | Notch filter 1 (low-frequency band): filter frequency (omegani). |
| omeganl2 | 1..1 | Float | Notch filter 2 (low-frequency band): filter frequency (omegani). |
| th1 | 1..1 | Seconds | High band time constant (TH1) (>= 0). Typical value = 0,01513. |
| th10 | 1..1 | Seconds | High band time constant (TH10) (>= 0). Typical value = 0. |
| th11 | 1..1 | Seconds | High band time constant (TH11) (>= 0). Typical value = 0. |
| th12 | 1..1 | Seconds | High band time constant (TH12) (>= 0). Typical value = 0. |
| th2 | 1..1 | Seconds | High band time constant (TH2) (>= 0). Typical value = 0,01816. |
| th3 | 1..1 | Seconds | High band time constant (TH3) (>= 0). Typical value = 0. |
| th4 | 1..1 | Seconds | High band time constant (TH4) (>= 0). Typical value = 0. |
| th5 | 1..1 | Seconds | High band time constant (TH5) (>= 0). Typical value = 0. |
| th6 | 1..1 | Seconds | High band time constant (TH6) (>= 0). Typical value = 0. |
| th7 | 1..1 | Seconds | High band time constant (TH7) (>= 0). Typical value = 0,01816. |
| th8 | 1..1 | Seconds | High band time constant (TH8) (>= 0). Typical value = 0,02179. |
| th9 | 1..1 | Seconds | High band time constant (TH9) (>= 0). Typical value = 0. |
| ti1 | 1..1 | Seconds | Intermediate band time constant (TI1) (>= 0). Typical value = 0,173. |
| ti10 | 1..1 | Seconds | Intermediate band time constant (TI10) (>= 0). Typical value = 0. |
| ti11 | 1..1 | Seconds | Intermediate band time constant (TI11) (>= 0). Typical value = 0. |
| ti12 | 1..1 | Seconds | Intermediate band time constant (TI12) (>= 0). Typical value = 0. |
| ti2 | 1..1 | Seconds | Intermediate band time constant (TI2) (>= 0). Typical value = 0,2075. |
| ti3 | 1..1 | Seconds | Intermediate band time constant (TI3) (>= 0). Typical value = 0. |

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| name | mult | type | description |
|---|---|---|---|
| ti4 | 1..1 | Seconds | Intermediate band time constant (TI4) (>= 0). Typical value = 0. |
| ti5 | 1..1 | Seconds | Intermediate band time constant (TI5) (>= 0). Typical value = 0. |
| ti6 | 1..1 | Seconds | Intermediate band time constant (TI6) (>= 0). Typical value = 0. |
| ti7 | 1..1 | Seconds | Intermediate band time constant (TI7) (>= 0). Typical value = 0,2075. |
| ti8 | 1..1 | Seconds | Intermediate band time constant (TI8) (>= 0). Typical value = 0,2491. |
| ti9 | 1..1 | Seconds | Intermediate band time constant (TI9) (>= 0). Typical value = 0. |
| tl1 | 1..1 | Seconds | Low band time constant (TL1) (>= 0). Typical value = 1,73. |
| tl10 | 1..1 | Seconds | Low band time constant (TL10) (>= 0). Typical value = 0. |
| tl11 | 1..1 | Seconds | Low band time constant (TL11) (>= 0). Typical value = 0. |
| tl12 | 1..1 | Seconds | Low band time constant (TL12) (>= 0). Typical value = 0. |
| tl2 | 1..1 | Seconds | Low band time constant (TL2) (>= 0). Typical value = 2,075. |
| tl3 | 1..1 | Seconds | Low band time constant (TL3) (>= 0). Typical value = 0. |
| tl4 | 1..1 | Seconds | Low band time constant (TL4) (>= 0). Typical value = 0. |
| tl5 | 1..1 | Seconds | Low band time constant (TL5) (>= 0). Typical value = 0. |
| tl6 | 1..1 | Seconds | Low band time constant (TL6) (>= 0). Typical value = 0. |
| tl7 | 1..1 | Seconds | Low band time constant (TL7) (>= 0). Typical value = 2,075. |
| tl8 | 1..1 | Seconds | Low band time constant (TL8) (>= 0). Typical value = 2,491. |
| tl9 | 1..1 | Seconds | Low band time constant (TL9) (>= 0). Typical value = 0. |
| vhmax | 1..1 | PU | High band output maximum limit (VHmax) (> PssIEEE4B.vhmin). Typical value = 0,6. |
| vhmin | 1..1 | PU | High band output minimum limit (VHmin) (< PssIEEE4V.vhmax). Typical value = -0,6. |
| vimax | 1..1 | PU | Intermediate band output maximum limit (VImax) (> PssIEEE4B.vimin). Typical value = 0,6. |
| vimin | 1..1 | PU | Intermediate band output minimum limit (VImin) (< PssIEEE4B.vimax). Typical value = -0,6. |
| vlmax | 1..1 | PU | Low band output maximum limit (VLmax) (> PssIEEE4B.vlmin). Typical value = 0,075. |
| vlmin | 1..1 | PU | Low band output minimum limit (VLmin) (< PssIEEE4B.vlmax). Typical value = -0,075. |
| vstmax | 1..1 | PU | PSS output maximum limit (VSTmax) (> PssIEEE4B.vstmin). Typical value = 0,15. |
| vstmin | 1..1 | PU | PSS output minimum limit (VSTmin) (< PssIEEE4B.vstmax). Typical value = -0,15. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |

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

Table 295 shows all association ends of PssIEEE4B with other classes.

**Table 295 – Association ends of PowerSystemStabilizerDynamics:: PssIEEE4B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

#### 8.2.4.3.12.7 Pss1

Italian PSS with three inputs (speed, frequency, power).

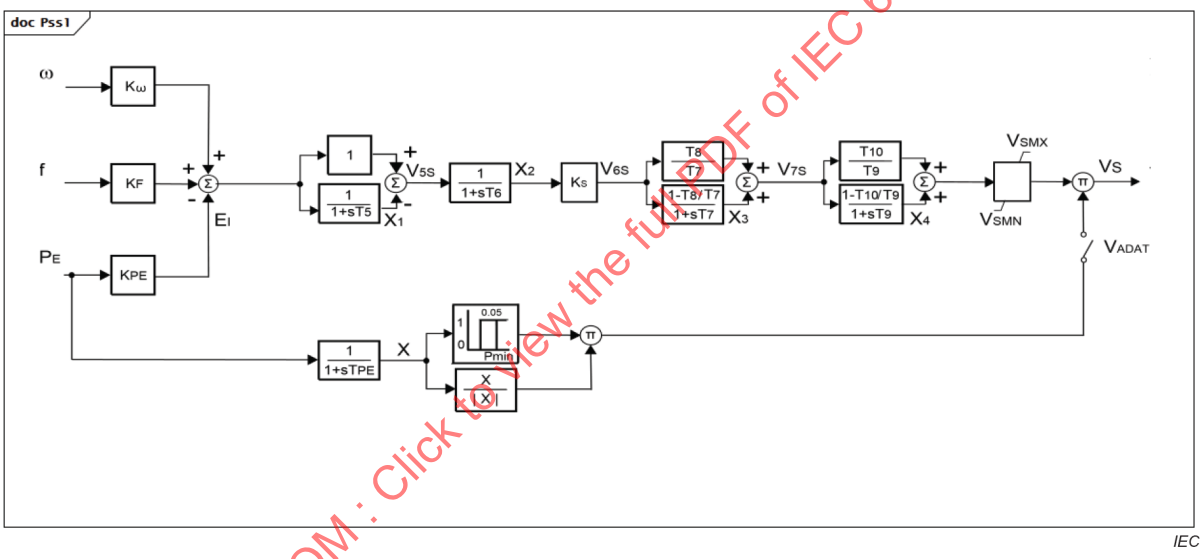


**Figure 149 – Pss1**

Figure 149: This diagram describes the Pss1 power system stabilizer model.

Parameter details:

1) This model has 3 input signals. They have the following fixed types (expressed in terms of InputSignalKind values): omega is of rotorSpeed type, f is of busFrequency type, and PE is of generatorElectricalPower type.
2) X is not a parameter, but rather an input signal to the block [X /|X|]. The block reflects the sign of Pe. When Pe is negative (for example, for a unit in pumping mode), the output of the block [X /|X|] is negative. When Pe is positive, the output of the block is positive.

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Table 296 shows all attributes of Pss1.

**Table 296 – Attributes of PowerSystemStabilizerDynamics::Pss1**

| name | mult | type | description |
|---|---|---|---|
| komega | 1..1 | Float | Shaft speed power input gain (Komega). Typical value = 0. |
| kf | 1..1 | Float | Frequency power input gain (KF). Typical value = 5. |
| kpe | 1..1 | Float | Electric power input gain (KPE). Typical value = 0,3. |
| pmin | 1..1 | PU | Minimum power PSS enabling (Pmin). Typical value = 0,25. |
| ks | 1..1 | Float | PSS gain (Ks). Typical value = 1. |
| vsmn | 1..1 | PU | Stabilizer output maximum limit (VSMN). Typical value = -0,06. |
| vsmx | 1..1 | PU | Stabilizer output minimum limit (VSMX). Typical value = 0,06. |
| tpe | 1..1 | Seconds | Electric power filter time constant (TPE) (>= 0). Typical value = 0,05. |
| t5 | 1..1 | Seconds | Washout (T5) (>= 0). Typical value = 3,5. |
| t6 | 1..1 | Seconds | Filter time constant (T6) (>= 0). Typical value = 0. |
| t7 | 1..1 | Seconds | Lead/lag time constant (T7) (>= 0). If = 0, both blocks are bypassed. Typical value = 0. |
| t8 | 1..1 | Seconds | Lead/lag time constant (T8) (>= 0). Typical value = 0. |
| t9 | 1..1 | Seconds | Lead/lag time constant (T9) (>= 0). If = 0, both blocks are bypassed. Typical value = 0. |
| t10 | 1..1 | Seconds | Lead/lag time constant (T10) (>= 0). Typical value = 0. |
| vadat | 1..1 | Boolean | Signal selector (VADAT).<br>true = closed (generator power is greater than Pmin)<br>false = open (Pe is smaller than Pmin).<br>Typical value = true. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 297 shows all association ends of Pss1 with other classes.

**Table 297 – Association ends of PowerSystemStabilizerDynamics:: Pss1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

#### 8.2.4.3.12.8 Pss1A

Single input power system stabilizer. It is a modified version in order to allow representation of various vendors' implementations on PSS type 1A.

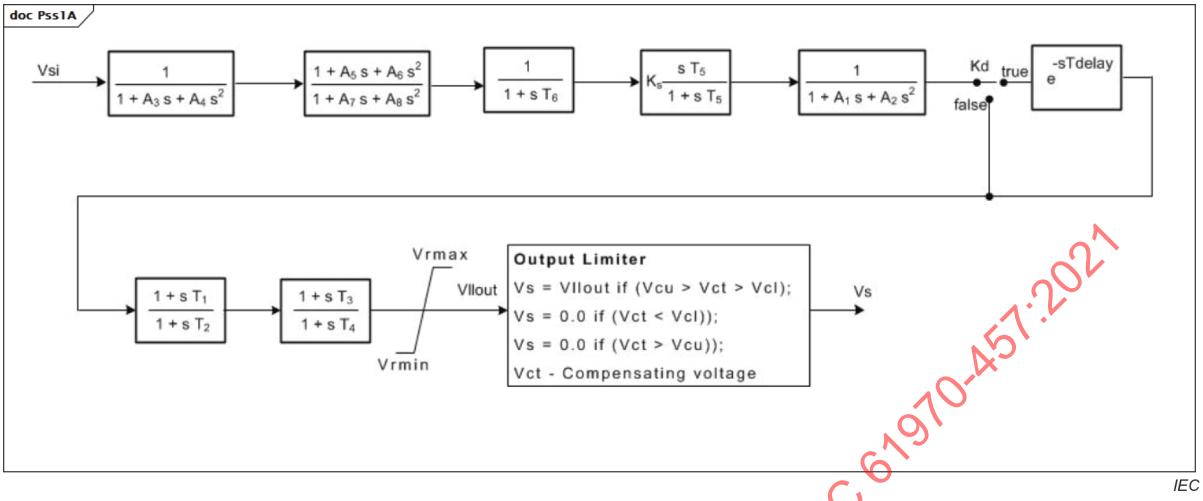


**Figure 150 – Pss1A**

Figure 150: This diagram describes the Pss1A power system stabilizer model.

Table 298 shows all attributes of Pss1A.

**Table 298 – Attributes of PowerSystemStabilizerDynamics::Pss1A**

| name | mult | type | description |
|---|---|---|---|
| inputSignalType | 1..1 | InputSignalKind | Type of input signal (rotorAngularFrequencyDeviation, busFrequencyDeviation, generatorElectricalPower, generatorAcceleratingPower, busVoltage, or busVoltageDerivative). |
| a1 | 1..1 | PU | Notch filter parameter (A1). |
| a2 | 1..1 | PU | Notch filter parameter (A2). |
| t1 | 1..1 | Seconds | Lead/lag time constant (T1) (>= 0). |
| t2 | 1..1 | Seconds | Lead/lag time constant (T2) (>= 0). |
| t3 | 1..1 | Seconds | Lead/lag time constant (T3) (>= 0). |
| t4 | 1..1 | Seconds | Lead/lag time constant (T4) (>= 0). |
| t5 | 1..1 | Seconds | Washout time constant (T5) (>= 0). |
| t6 | 1..1 | Seconds | Transducer time constant (T6) (>= 0). |
| ks | 1..1 | PU | Stabilizer gain (Ks). |
| vrmax | 1..1 | PU | Maximum stabilizer output (Vrmax) (> Pss1A.vrmin). |
| vrmin | 1..1 | PU | Minimum stabilizer output (Vrmin) (< Pss1A.vrmax). |
| vcu | 1..1 | PU | Stabilizer input cutoff threshold (Vcu). |
| vcl | 1..1 | PU | Stabilizer input cutoff threshold (Vcl). |
| a3 | 1..1 | PU | Notch filter parameter (A3). |
| a4 | 1..1 | PU | Notch filter parameter (A4). |
| a5 | 1..1 | PU | Notch filter parameter (A5). |

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| name | mult | type | description |
|---|---|---|---|
| a6 | 1..1 | PU | Notch filter parameter (A6). |
| a7 | 1..1 | PU | Notch filter parameter (A7). |
| a8 | 1..1 | PU | Notch filter parameter (A8). |
| kd | 1..1 | Boolean | Selector (Kd).<br>true = e-sTdelay used<br>false = e-sTdelay not used. |
| tdelay | 1..1 | Seconds | Time constant (Tdelay) (>= 0). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 299 shows all association ends of Pss1A with other classes.

**Table 299 – Association ends of PowerSystemStabilizerDynamics:: Pss1A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

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### 8.2.4.3.12.9 Pss2B

Modified IEEE PSS2B. Extra lead/lag (or rate) block added at end (up to 4 lead/lags total).

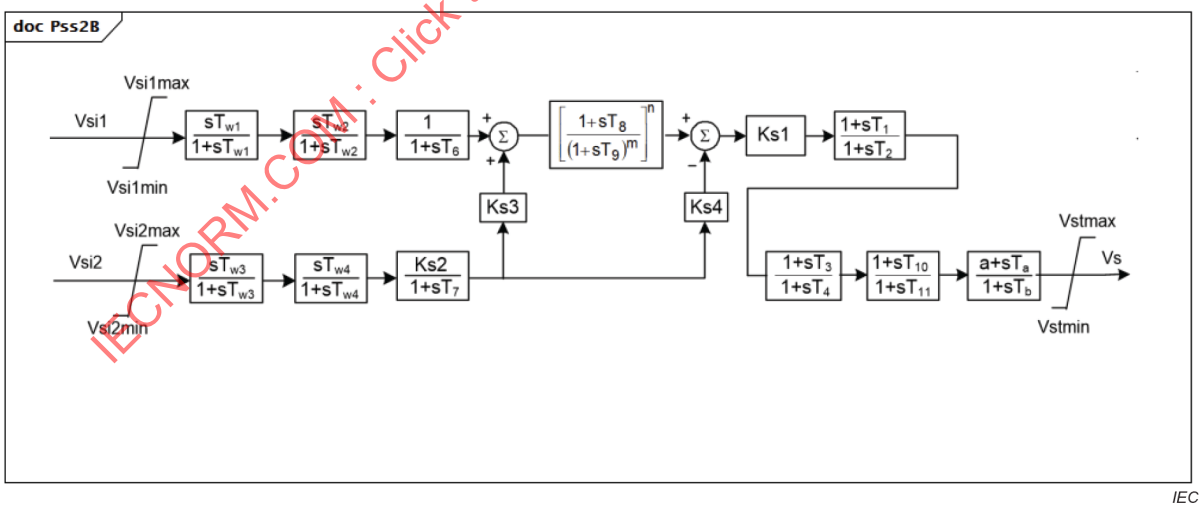


**Figure 151 – Pss2B**

Figure 151: This diagram describes the Pss2B power system stabilizer model.

Parameter details:

1) This model has 2 input signals. They have the following fixed types (expressed in terms of InputSignalKind values): Vsi1 is of rotorSpeed type and Vsi2 is of generatorElectricalPower type.

Table 300 shows all attributes of Pss2B.

**Table 300 – Attributes of PowerSystemStabilizerDynamics::Pss2B**

| name | mult | type | description |
|---|---|---|---|
| vsi1max | 1..1 | PU | Input signal #1 maximum limit (Vsi1max) (> Pss2B.vsi1min). Typical value = 2. |
| vsi1min | 1..1 | PU | Input signal #1 minimum limit (Vsi1min) (< Pss2B.vsi1max). Typical value = -2. |
| tw1 | 1..1 | Seconds | First washout on signal #1 (Tw1) (>= 0). Typical value = 2. |
| tw2 | 1..1 | Seconds | Second washout on signal #1 (Tw2) (>= 0). Typical value = 2. |
| vsi2max | 1..1 | PU | Input signal #2 maximum limit (Vsi2max) (> Pss2B.vsi2min). Typical value = 2. |
| vsi2min | 1..1 | PU | Input signal #2 minimum limit (Vsi2min) (< Pss2B.vsi2max). Typical value = -2. |
| tw3 | 1..1 | Seconds | First washout on signal #2 (Tw3) (>= 0). Typical value = 2. |
| tw4 | 1..1 | Seconds | Second washout on signal #2 (Tw4) (>= 0). Typical value = 0. |
| t1 | 1..1 | Seconds | Lead/lag time constant (T1) (>= 0). Typical value = 0,12. |
| t2 | 1..1 | Seconds | Lead/lag time constant (T2) (>= 0). Typical value = 0,02. |
| t3 | 1..1 | Seconds | Lead/lag time constant (T3) (>= 0). Typical value = 0,3. |
| t4 | 1..1 | Seconds | Lead/lag time constant (T4) (>= 0). Typical value = 0,02. |
| t6 | 1..1 | Seconds | Time constant on signal #1 (T6) (>= 0). Typical value = 0. |
| t7 | 1..1 | Seconds | Time constant on signal #2 (T7) (>= 0). Typical value = 2. |
| t8 | 1..1 | Seconds | Lead of ramp tracking filter (T8) (>= 0). Typical value = 0,2. |
| t9 | 1..1 | Seconds | Lag of ramp tracking filter (T9) (>= 0). Typical value = 0,1. |
| t10 | 1..1 | Seconds | Lead/lag time constant (T10) (>= 0). Typical value = 0. |
| t11 | 1..1 | Seconds | Lead/lag time constant (T11) (>= 0). Typical value = 0. |
| ks1 | 1..1 | PU | Stabilizer gain (Ks1). Typical value = 12. |
| ks2 | 1..1 | PU | Gain on signal #2 (Ks2). Typical value = 0,2. |
| ks3 | 1..1 | PU | Gain on signal #2 input before ramp-tracking filter (Ks3). Typical value = 1. |
| ks4 | 1..1 | PU | Gain on signal #2 input after ramp-tracking filter (Ks4). Typical value = 1. |
| n | 1..1 | Integer | Order of ramp tracking filter (n). Typical value = 1. |
| m | 1..1 | Integer | Denominator order of ramp tracking filter (m). Typical value = 5. |
| vstmax | 1..1 | PU | Stabilizer output maximum limit (Vstmax) (> Pss2B.vstmin). Typical value = 0,1. |
| vstmin | 1..1 | PU | Stabilizer output minimum limit (Vstmin) (< Pss2B.vstmax). Typical value = -0,1. |
| a | 1..1 | Float | Numerator constant (a). Typical value = 1. |

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| name | mult | type | description |
|---|---|---|---|
| ta | 1..1 | Seconds | Lead constant (Ta) (>= 0). Typical value = 0. |
| tb | 1..1 | Seconds | Lag time constant (Tb) (>= 0). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 301 shows all association ends of Pss2B with other classes.

**Table 301 – Association ends of PowerSystemStabilizerDynamics::Pss2B with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

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### 8.2.4.3.12.10 Pss2ST

PTI microprocessor-based stabilizer type 1.

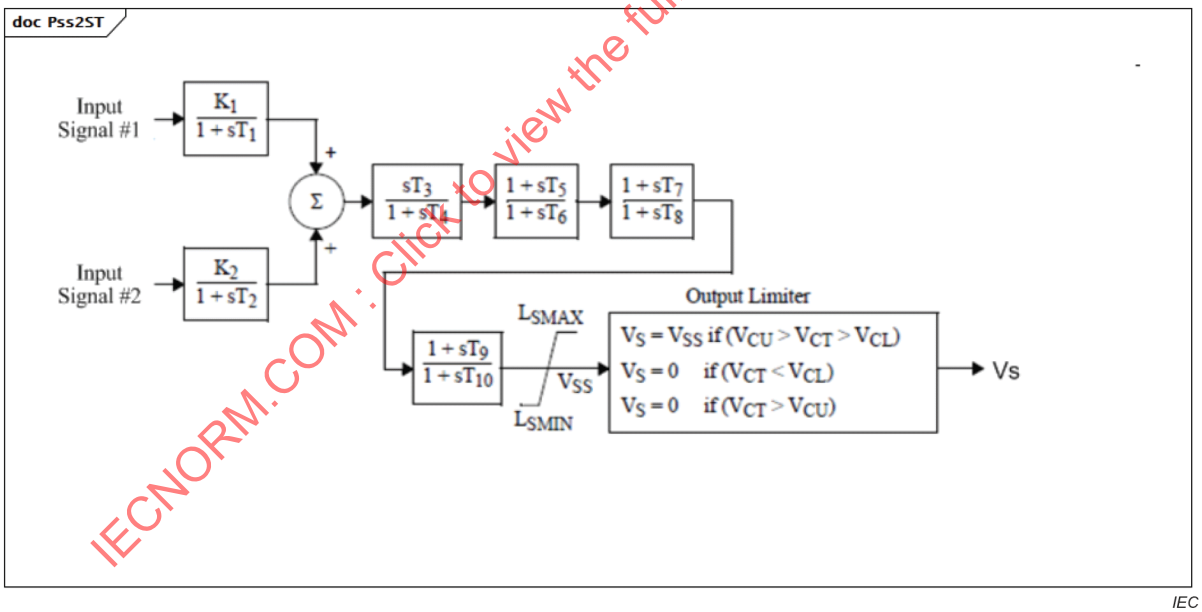


**Figure 152 – Pss2ST**

Figure 152: This diagram describes the Pss2ST power system stabilizer model.

Table 302 shows all attributes of Pss2ST.

**Table 302 – Attributes of PowerSystemStabilizerDynamics::Pss2ST**

| name | mult | type | description |
|---|---|---|---|
| inputSignal1Type | 1..1 | InputSignalKind | Type of input signal #1 (rotorAngularFrequencyDeviation, busFrequencyDeviation, generatorElectricalPower, generatorAcceleratingPower, busVoltage, or busVoltageDerivative – shall be different than Pss2ST.inputSignal2Type). Typical value = rotorAngularFrequencyDeviation. |
| inputSignal2Type | 1..1 | InputSignalKind | Type of input signal #2 (rotorAngularFrequencyDeviation, busFrequencyDeviation, generatorElectricalPower, generatorAcceleratingPower, busVoltage, or busVoltageDerivative – shall be different than Pss2ST.inputSignal1Type). Typical value = busVoltageDerivative. |
| k1 | 1..1 | PU | Gain (K1). |
| k2 | 1..1 | PU | Gain (K2). |
| t1 | 1..1 | Seconds | Time constant (T1) (>= 0). |
| t2 | 1..1 | Seconds | Time constant (T2) (>= 0). |
| t3 | 1..1 | Seconds | Time constant (T3) (>= 0). |
| t4 | 1..1 | Seconds | Time constant (T4) (>= 0). |
| t5 | 1..1 | Seconds | Time constant (T5) (>= 0). |
| t6 | 1..1 | Seconds | Time constant (T6) (>= 0). |
| t7 | 1..1 | Seconds | Time constant (T7) (>= 0). |
| t8 | 1..1 | Seconds | Time constant (T8) (>= 0). |
| t9 | 1..1 | Seconds | Time constant (T9) (>= 0). |
| t10 | 1..1 | Seconds | Time constant (T10) (>= 0). |
| lsmax | 1..1 | PU | Limiter (LSMAX) (> Pss2ST.lsmin). |
| lsmin | 1..1 | PU | Limiter (LSMIN) (< Pss2ST.lsmax). |
| vcu | 1..1 | PU | Cutoff limiter (VCU). |
| vcl | 1..1 | PU | Cutoff limiter (VCL). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 303 shows all association ends of Pss2ST with other classes.

**Table 303 – Association ends of PowerSystemStabilizerDynamics:: Pss2ST with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

#### 8.2.4.3.12.11 Pss5

Detailed Italian PSS.

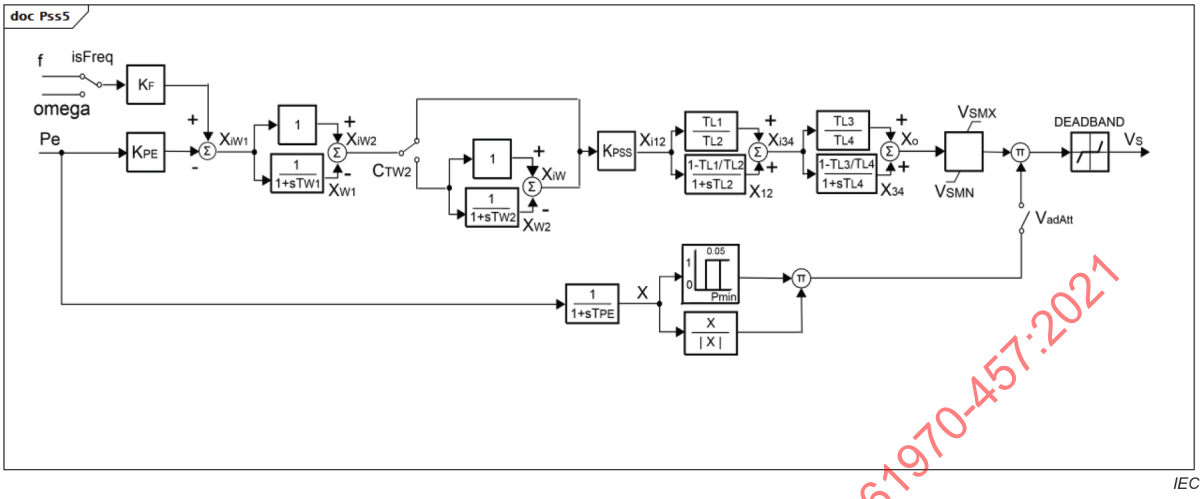


**Figure 153 – Pss5**

Figure 153: This diagram describes the Pss5 power system stabilizer model.

Parameter Details:

1) This model has 2 input signals. The type of first input signal is controlled by the isFreq switch (allowing the input to be either f with a type of busFrequency or omega with a type of rotorSpeed). The type of the second one, Pe, is generatorElectricalPower. (Types are described here as they are defined by InputSignalKind values).
2) X is not a parameter, but rather an input signal to the block [X /|X|]. The block reflects the sign of Pe. When Pe is negative (for example, for a unit in pumping mode), the output of the block [X /|X|] is negative. When Pe is positive, the output of the block is positive.

Table 304 shows all attributes of Pss5.

**Table 304 – Attributes of PowerSystemStabilizerDynamics::Pss5**

| name | mult | type | description |
|---|---|---|---|
| kpe | 1..1 | Float | Electric power input gain (KPE). Typical value = 0,3. |
| kf | 1..1 | Float | Frequency/shaft speed input gain (KF). Typical value = 5. |
| isfreq | 1..1 | Boolean | Selector for frequency/shaft speed input (isFreq).<br>true = speed (same meaning as InputSignaKind.rotorSpeed)<br>false = frequency (same meaning as InputSignalKind.busFrequency).<br>Typical value = true (same meaning as InputSignalKind.rotorSpeed). |
| kpss | 1..1 | Float | PSS gain (KPSS). Typical value = 1. |
| ctw2 | 1..1 | Boolean | Selector for second washout enabling (CTW2).<br>true = second washout filter is bypassed<br>false = second washout filter in use.<br>Typical value = true. |

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| name | mult | type | description |
|---|---|---|---|
| tw1 | 1..1 | Seconds | First washout (TW1) (>= 0). Typical value = 3,5. |
| tw2 | 1..1 | Seconds | Second washout (TW2) (>= 0). Typical value = 0. |
| tl1 | 1..1 | Seconds | Lead/lag time constant (TL1) (>= 0). Typical value = 0. |
| tl2 | 1..1 | Seconds | Lead/lag time constant (TL2) (>= 0). If = 0, both blocks are bypassed. Typical value = 0. |
| tl3 | 1..1 | Seconds | Lead/lag time constant (TL3) (>= 0). Typical value = 0. |
| tl4 | 1..1 | Seconds | Lead/lag time constant (TL4) (>= 0). If = 0, both blocks are bypassed. Typical value = 0. |
| vsmn | 1..1 | PU | Stabilizer output maximum limit (VSMN). Typical value = -0,1. |
| vsmx | 1..1 | PU | Stabilizer output minimum limit (VSMX). Typical value = 0,1. |
| tpe | 1..1 | Seconds | Electric power filter time constant (TPE) (>= 0). Typical value = 0,05. |
| pmin | 1..1 | PU | Minimum power PSS enabling (Pmin). Typical value = 0,25. |
| deadband | 1..1 | PU | Stabilizer output deadband (DEADBAND). Typical value = 0. |
| vadat | 1..1 | Boolean | Signal selector (VadAtt).<br>true = closed (generator power is greater than Pmin)<br>false = open (Pe is smaller than Pmin).<br>Typical value = true. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 305 shows all association ends of Pss5 with other classes.

**Table 305 – Association ends of PowerSystemStabilizerDynamics:: Pss5 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

#### 8.2.4.3.12.12 PssELIN2

Power system stabilizer typically associated with ExcELIN2 (though PssIEEE2B or Pss2B can also be used).

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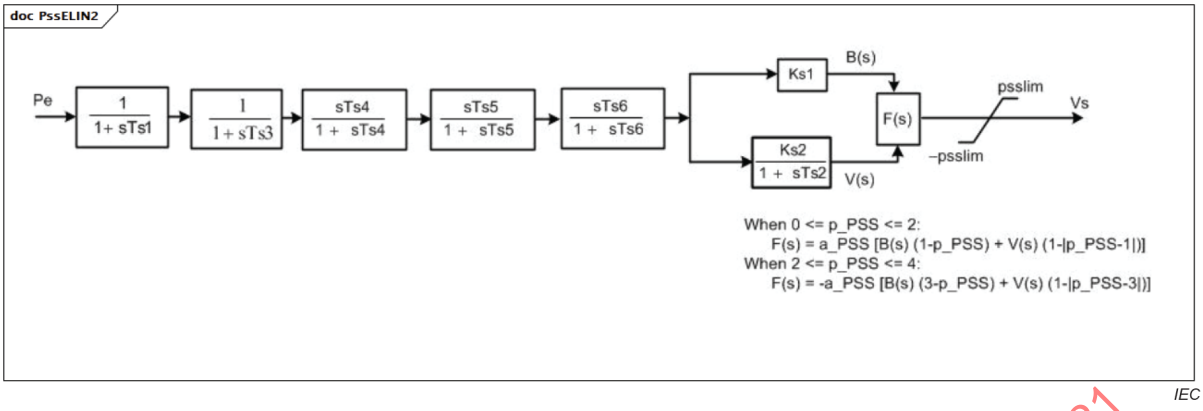


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**Figure 154 – PssELIN2**

Figure 154: This diagram describes the PssELIN2 power system stabilizer model.

Parameter details:

1) The input Pe has the fixed type (expressed in terms of inputSignalKind value) of generatorElectricalPower.

Table 306 shows all attributes of PssELIN2.

**Table 306 – Attributes of PowerSystemStabilizerDynamics::PssELIN2**

| name | mult | type | description |
|---|---|---|---|
| ts1 | 1..1 | Seconds | Time constant (Ts1) (>= 0). Typical value = 0. |
| ts2 | 1..1 | Seconds | Time constant (Ts2) (>= 0). Typical value = 1. |
| ts3 | 1..1 | Seconds | Time constant (Ts3) (>= 0). Typical value = 1. |
| ts4 | 1..1 | Seconds | Time constant (Ts4) (>= 0). Typical value = 0,1. |
| ts5 | 1..1 | Seconds | Time constant (Ts5) (>= 0). Typical value = 0. |
| ts6 | 1..1 | Seconds | Time constant (Ts6) (>= 0). Typical value = 1. |
| ks1 | 1..1 | PU | Gain (Ks1). Typical value = 1. |
| ks2 | 1..1 | PU | Gain (Ks2). Typical value = 0,1. |
| ppss | 1..1 | PU | Coefficient (p_PSS) (>= 0 and <= 4). Typical value = 0,1. |
| apss | 1..1 | PU | Coefficient (a_PSS). Typical value = 0,1. |
| psslim | 1..1 | PU | PSS limiter (psslim). Typical value = 0,1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 307 shows all association ends of PssELIN2 with other classes.

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**Table 307 – Association ends of PowerSystemStabilizerDynamics:: PssELIN2 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

### 8.2.4.3.12.13 PssPTIST1

PTI microprocessor-based stabilizer type 1.

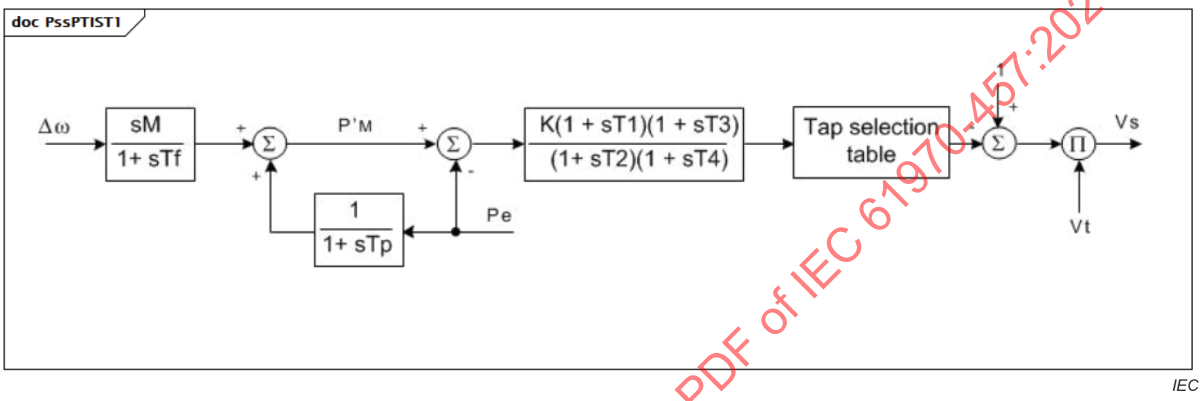


**Figure 155 – PssPTIST1**

Figure 155: This diagram describes the PssPTIST1 power system stabilizer model.

Parameter details:

1) Tap selection table enables the output control signal to be used to select an autotransformer tap position, which, in turn, modulates the feedback terminal voltage (digital output option).
2) This model has 2 input signals. The type (expressed in terms of InputSignalKind values) of the first signal (delta omega) is rotorAngularFrequency and the type of the second one, Pe, is generatorElectricalPower.

Table 308 shows all attributes of PssPTIST1.

**Table 308 – Attributes of PowerSystemStabilizerDynamics::PssPTIST1**

| name | mult | type | description |
|---|---|---|---|
| m | 1..1 | PU | (M). M = 2 x H. Typical value = 5. |
| tf | 1..1 | Seconds | Time constant (Tf) (>= 0). Typical value = 0,2. |
| tp | 1..1 | Seconds | Time constant (Tp) (>= 0). Typical value = 0,2. |
| t1 | 1..1 | Seconds | Time constant (T1) (>= 0). Typical value = 0,3. |
| t2 | 1..1 | Seconds | Time constant (T2) (>= 0). Typical value = 1. |
| t3 | 1..1 | Seconds | Time constant (T3) (>= 0). Typical value = 0,2. |
| t4 | 1..1 | Seconds | Time constant (T4) (>= 0). Typical value = 0,05. |
| k | 1..1 | PU | Gain (K). Typical value = 9. |
| dtf | 1..1 | Seconds | Time step frequency calculation (deltatf) (>= 0). Typical value = 0,025. |
| dtc | 1..1 | Seconds | Time step related to activation of controls (deltatc) (>= 0). Typical value = 0,025. |

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| name | mult | type | description |
|---|---|---|---|
| dtp | 1..1 | Seconds | Time step active power calculation (deltatp) (>= 0). Typical value = 0,0125. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 309 shows all association ends of PssPTIST1 with other classes.

**Table 309 – Association ends of PowerSystemStabilizerDynamics:: PssPTIST1 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

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### 8.2.4.3.12.14 PssPTIST3

PTI microprocessor-based stabilizer type 3.

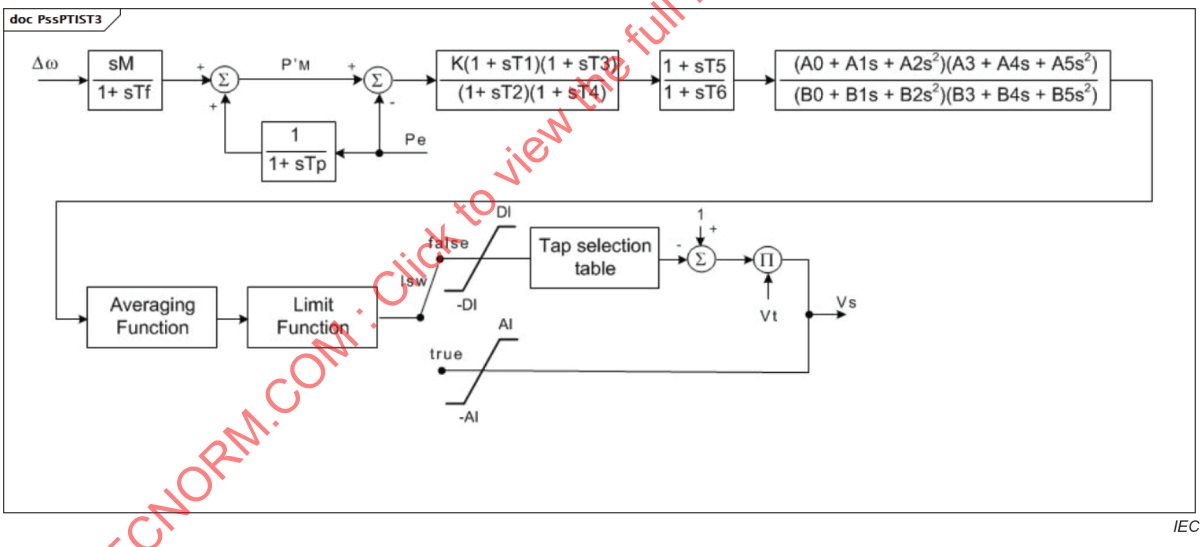


**Figure 156 – PssPTIST3**

Figure 156: This diagram describes the PssPTIST3 power system stabilizer model.

Parameter details:

1) This model has 2 input signals. The type (expressed in terms of InputSignalKind values) of the first signal (delta omega) is rotorAngularFrequency and the type of the second one, Pe, is generatorElectricalPower.
2) 'Tap selection table' enables the output control signal to be used to select an autotransformer tap position, which, in turn, modulates the feedback terminal voltage (digital output option).

3) 'Averaging Function' keeps a running average of the last NAV control outputs (clicks) up to a maximum of 16. This feature can be disabled by setting NAV equal to 1 (i.e., average 1 output). The last NAV outputs are stored in the output averaging table, VAR(1) to VAR(16). The sum of the last outputs is stored in the output accumulator. The averaging feature was added to reduce tap chattering under steady-state conditions. If the control output at any given click exceeds the threshold specified in Athres, the 'Averaging Function' will be automatically bypassed and that output signal will be passed directly to the 'Limit Function'. This feature has been added such that under transient conditions the stabilizer reverts to normal operation. When the absolute value of output signal is beyond the threshold, the output averaging table entries and accumulator are zeroed out. When the signal falls below the threshold, the table is rebuilt starting with the first signal within the threshold. If the output averaging is enabled, then the threshold value would probably be specified in the range from 0,002 to 0,02.

4) 'Limit Function' counts the number of control outputs that the output signal continuously exceeds a user-defined threshold as set in Lthres and, after the output signal has continuously exceeded the threshold for a number of user-defined counts as specified by NCL, the function ramps the tap position to nominal or the analogue output to zero over a user-specified number of counts as defined in NCR.

Table 310 shows all attributes of PssPTIST3.

**Table 310 – Attributes of PowerSystemStabilizerDynamics::PssPTIST3**

| name | mult | type | description |
|---|---|---|---|
| m | 1..1 | PU | (M). M = 2 x H. Typical value = 5. |
| tf | 1..1 | Seconds | Time constant (Tf) (>= 0). Typical value = 0,2. |
| tp | 1..1 | Seconds | Time constant (Tp) (>= 0). Typical value = 0,2. |
| t1 | 1..1 | Seconds | Time constant (T1) (>= 0). Typical value = 0,3. |
| t2 | 1..1 | Seconds | Time constant (T2) (>= 0). Typical value = 1. |
| t3 | 1..1 | Seconds | Time constant (T3) (>= 0). Typical value = 0,2. |
| t4 | 1..1 | Seconds | Time constant (T4) (>= 0). Typical value = 0,05. |
| k | 1..1 | PU | Gain (K). Typical value = 9. |
| dtf | 1..1 | Seconds | Time step frequency calculation (deltatf) (>= 0). Typical value = 0,025 (0,03 for 50 Hz). |
| dtc | 1..1 | Seconds | Time step related to activation of controls (deltatc) (>= 0). Typical value = 0,025 (0,03 for 50 Hz). |
| dtp | 1..1 | Seconds | Time step active power calculation (deltatp) (>= 0). Typical value = 0,0125 (0,015 for 50 Hz). |
| t5 | 1..1 | Seconds | Time constant (T5) (>= 0). |
| t6 | 1..1 | Seconds | Time constant (T6) (>= 0). |
| a0 | 1..1 | PU | Filter coefficient (A0). |
| a1 | 1..1 | PU | Limiter (Al). |
| a2 | 1..1 | PU | Filter coefficient (A2). |
| b0 | 1..1 | PU | Filter coefficient (B0). |
| b1 | 1..1 | PU | Filter coefficient (B1). |
| b2 | 1..1 | PU | Filter coefficient (B2). |
| a3 | 1..1 | PU | Filter coefficient (A3). |
| a4 | 1..1 | PU | Filter coefficient (A4). |
| a5 | 1..1 | PU | Filter coefficient (A5). |
| b3 | 1..1 | PU | Filter coefficient (B3). |
| b4 | 1..1 | PU | Filter coefficient (B4). |

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| name | mult | type | description |
|---|---|---|---|
| b5 | 1..1 | PU | Filter coefficient (B5). |
| athres | 1..1 | PU | Threshold value above which output averaging will be bypassed (Athres). Typical value = 0,005. |
| dl | 1..1 | PU | Limiter (Dl). |
| al | 1..1 | PU | Limiter (Al). |
| lthres | 1..1 | PU | Threshold value (Lthres). |
| pmin | 1..1 | PU | (Pmin). |
| isw | 1..1 | Boolean | Digital/analogue output switch (Isw).<br>true = produce analogue output<br>false = convert to digital output, using tap selection table. |
| nav | 1..1 | Float | Number of control outputs to average (NAV) (1 <= NAV <= 16). Typical value = 4. |
| ncl | 1..1 | Float | Number of counts at limit to active limit function (NCL) (> 0). |
| ncr | 1..1 | Float | Number of counts until reset after limit function is triggered (NCR). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 311 shows all association ends of PssPTIST3 with other classes.

**Table 311 – Association ends of PowerSystemStabilizerDynamics:: PssPTIST3 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

#### 8.2.4.3.12.15 PssRQB

Power system stabilizer type RQB. This power system stabilizer is intended to be used together with excitation system type ExcRQB, which is primarily used in nuclear or thermal generating units.

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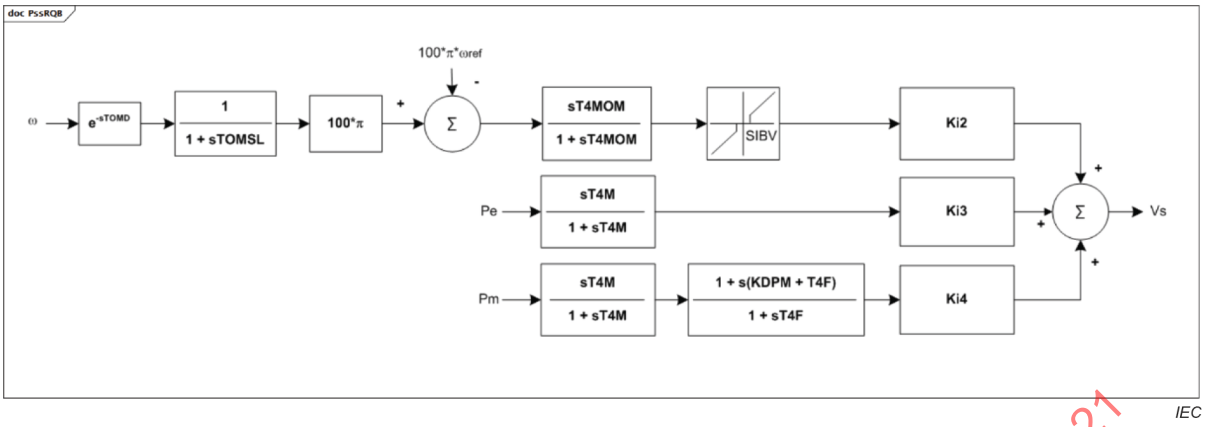


**Figure 157 – PssRQB**

Figure 157: This diagram describes the PssRQB power system stabilizer model.

Parameter details:

1) This model has 3 input signals. They have the following fixed types (expressed in terms of InputSignalKind values): omega is of rotorSpeed type, Pe is of generatorElectricalPower type, and Pm is of generatorMechanicalPower type.
2) The block containing SIBV describes the following behaviour:
   – if input signal value < -SIBV, output signal = input + SIBV;
   – if input signal value is between -SIBV and SIBV, output signal = 0;
   – if input signal value > SIBV, output signal = input – SIBV.

Table 312 shows all attributes of PssRQB.

**Table 312 – Attributes of PowerSystemStabilizerDynamics::PssRQB**

| name | mult | type | description |
|---|---|---|---|
| ki2 | 1..1 | Float | Speed input gain (Ki2). Typical value = 3,43. |
| ki3 | 1..1 | Float | Electrical power input gain (Ki3). Typical value = -11,45. |
| ki4 | 1..1 | Float | Mechanical power input gain (Ki4). Typical value = 11,86. |
| t4m | 1..1 | Seconds | Input time constant (T4M) (>= 0). Typical value = 5. |
| tomd | 1..1 | Seconds | Speed delay (TOMD) (>= 0). Typical value = 0,02. |
| tomsl | 1..1 | Seconds | Speed time constant (TOMSL) (>= 0). Typical value = 0,04. |
| t4mom | 1..1 | Seconds | Speed time constant (T4MOM) (>= 0). Typical value = 1,27. |
| sibv | 1..1 | PU | Speed deadband (SIBV). Typical value = 0,006. |
| kdpm | 1..1 | Float | Lead lag gain (KDPM). Typical value = 0,185. |
| t4f | 1..1 | Seconds | Lead lag time constant (T4F) (>= 0). Typical value = 0,045. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 313 shows all association ends of PssRQB with other classes.

**Table 313 – Association ends of PowerSystemStabilizerDynamics:: PssRQB with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

### 8.2.4.3.12.16 PssSB4

Power sensitive stabilizer model.

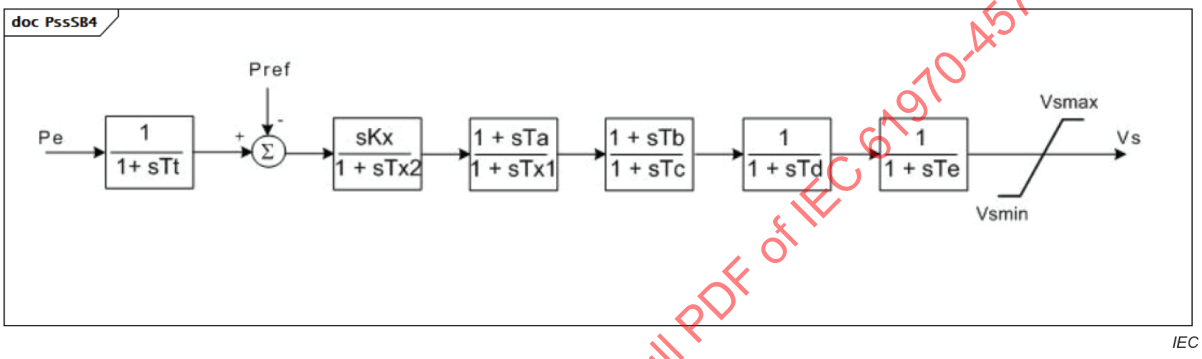


**Figure 158 – PssSB4**

Figure 158: This diagram describes the PssSB4 power system stabilizer model.

Parameter details:

1) The input Pe has the fixed type (expressed in terms of inputSignalKind value) of generatorElectricalPower.

Table 314 shows all attributes of PssSB4.

**Table 314 – Attributes of PowerSystemStabilizerDynamics::PssSB4**

| name | mult | type | description |
|---|---|---|---|
| tt | 1..1 | Seconds | Time constant (Tt) (>= 0). Typical value = 0,18. |
| kx | 1..1 | PU | Gain (Kx). Typical value = 2,7. |
| tx2 | 1..1 | Seconds | Time constant (Tx2) (>= 0). Typical value = 5,0. |
| ta | 1..1 | Seconds | Time constant (Ta) (>= 0). Typical value = 0,37. |
| tx1 | 1..1 | Seconds | Reset time constant (Tx1) (>= 0). Typical value = 0,035. |
| tb | 1..1 | Seconds | Time constant (Tb) (>= 0). Typical value = 0,37. |
| tc | 1..1 | Seconds | Time constant (Tc) (>= 0). Typical value = 0,035. |
| td | 1..1 | Seconds | Time constant (Td) (>= 0). Typical value = 0,0. |
| te | 1..1 | Seconds | Time constant (Te) (>= 0). Typical value = 0,0169. |
| vsmax | 1..1 | PU | Limiter (Vsmax) (> PssSB4.vsmin). Typical value = 0,062. |
| vsmin | 1..1 | PU | Limiter (Vsmin) (< PssSB4.vsmax). Typical value = -0,062. |

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| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 315 shows all association ends of PssSB4 with other classes.

**Table 315 – Association ends of PowerSystemStabilizerDynamics:: PssSB4 with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

### 8.2.4.3.12.17 PssSH

Siemens™ "H infinity" power system stabilizer[5] with generator electrical power input.

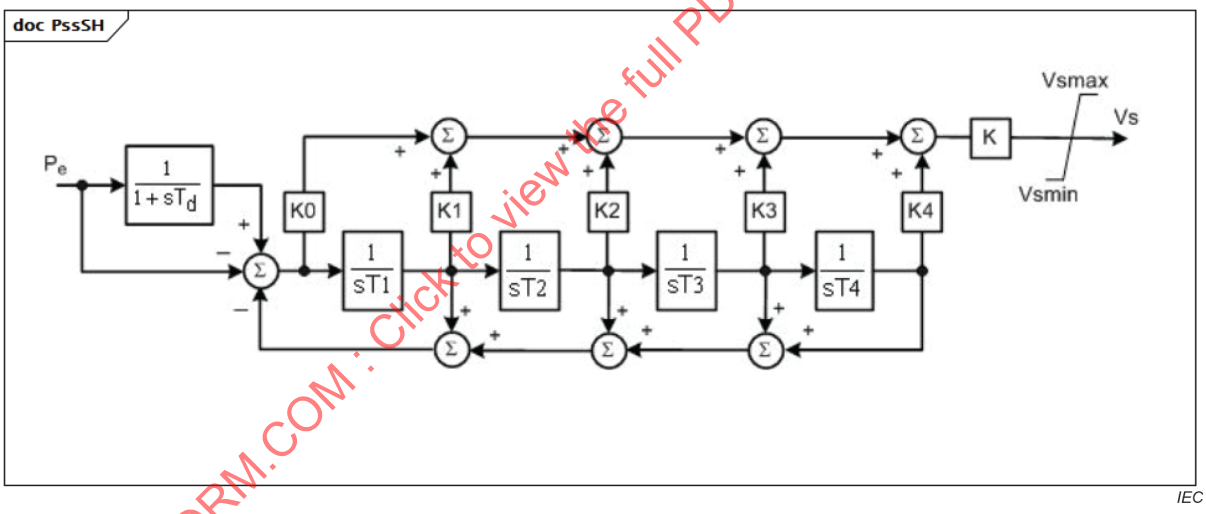


**Figure 159 – PssSH**

Figure 159: This diagram describes the PssSH power system stabilizer model.

Parameter details:

1) The input Pe has the fixed type (expressed in terms of inputSignalKind value) of generatorElectricalPower.

5 Siemens "H infinity" power system stabilizers are an example of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of these products.

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Table 316 shows all attributes of PssSH.

**Table 316 – Attributes of PowerSystemStabilizerDynamics::PssSH**

| name | mult | type | description |
|---|---|---|---|
| k | 1..1 | PU | Main gain (K). Typical value = 1. |
| k0 | 1..1 | PU | Gain 0 (K0). Typical value = 0,012. |
| k1 | 1..1 | PU | Gain 1 (K1). Typical value = 0,488. |
| k2 | 1..1 | PU | Gain 2 (K2). Typical value = 0,064. |
| k3 | 1..1 | PU | Gain 3 (K3). Typical value = 0,224. |
| k4 | 1..1 | PU | Gain 4 (K4). Typical value = 0,1. |
| td | 1..1 | Seconds | Input time constant (Td) (>= 0). Typical value = 10. |
| t1 | 1..1 | Seconds | Time constant 1 (T1) (> 0). Typical value = 0,076. |
| t2 | 1..1 | Seconds | Time constant 2 (T2) (> 0). Typical value = 0,086. |
| t3 | 1..1 | Seconds | Time constant 3 (T3) (> 0). Typical value = 1,068. |
| t4 | 1..1 | Seconds | Time constant 4 (T4) (> 0). Typical value = 1,913. |
| vsmax | 1..1 | PU | Output maximum limit (Vsmax) (> PssSH.vsmin). Typical value = 0,1. |
| vsmin | 1..1 | PU | Output minimum limit (Vsmin) (< PssSH.vsmax). Typical value = -0,1. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 317 shows all association ends of PssSH with other classes.

**Table 317 – Association ends of PowerSystemStabilizerDynamics:: PssSH with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

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#### 8.2.4.3.12.18 PssSK

Slovakian PSS with three inputs.

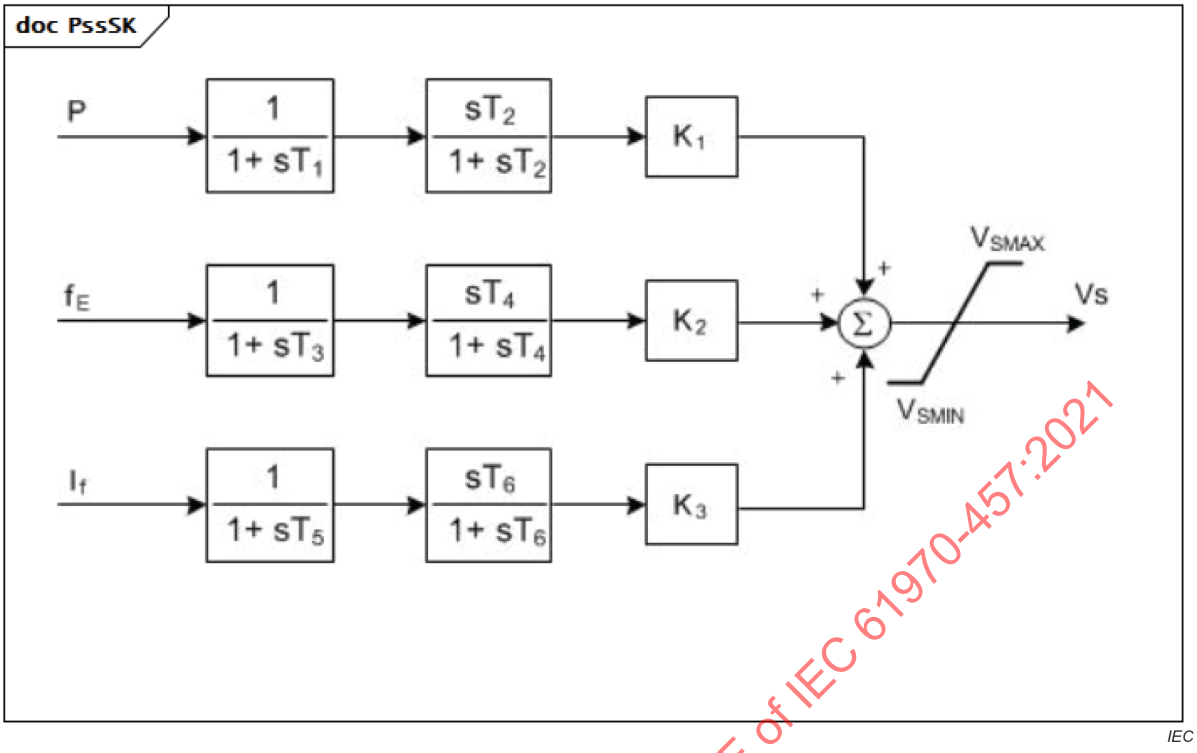


**Figure 160 – PssSK**

Figure 160: This diagram describes the PssSK power system stabilizer model.

Parameter details:

1) This model has 3 input signals. They have the following fixed types (expressed in terms of InputSignalKind values): P is of generatorElectricalPower type, fE is of busFrequency type, and If is of fieldCurrent type.

Table 318 shows all attributes of PssSK.

**Table 318 – Attributes of PowerSystemStabilizerDynamics::PssSK**

| name | mult | type | description |
|---|---|---|---|
| k1 | 1..1 | PU | Gain P (K1). Typical value = -0,3. |
| k2 | 1..1 | PU | Gain fE (K2). Typical value = -0,15. |
| k3 | 1..1 | PU | Gain If (K3). Typical value = 10. |
| t1 | 1..1 | Seconds | Denominator time constant (T1) (> 0,005). Typical value = 0,3. |
| t2 | 1..1 | Seconds | Filter time constant (T2) (> 0,005). Typical value = 0,35. |
| t3 | 1..1 | Seconds | Denominator time constant (T3) (> 0,005). Typical value = 0,22. |
| t4 | 1..1 | Seconds | Filter time constant (T4) (> 0,005). Typical value = 0,02. |
| t5 | 1..1 | Seconds | Denominator time constant (T5) (> 0,005). Typical value = 0,02. |
| t6 | 1..1 | Seconds | Filter time constant (T6) (> 0,005). Typical value = 0,02. |
| vsmax | 1..1 | PU | Stabilizer output maximum limit (VSMAX) (> PssSK.vsmin). Typical value = 0,4. |

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| name | mult | type | description |
|---|---|---|---|
| vsmin | 1..1 | PU | Stabilizer output minimum limit (VSMIN) (< PssSK.vsmax). Typical value = -0.4. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 319 shows all association ends of PssSK with other classes.

**Table 319 – Association ends of PowerSystemStabilizerDynamics::PssSK with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

#### 8.2.4.3.12.19 PssSTAB2A

Power system stabilizer part of an ABB excitation system[6].

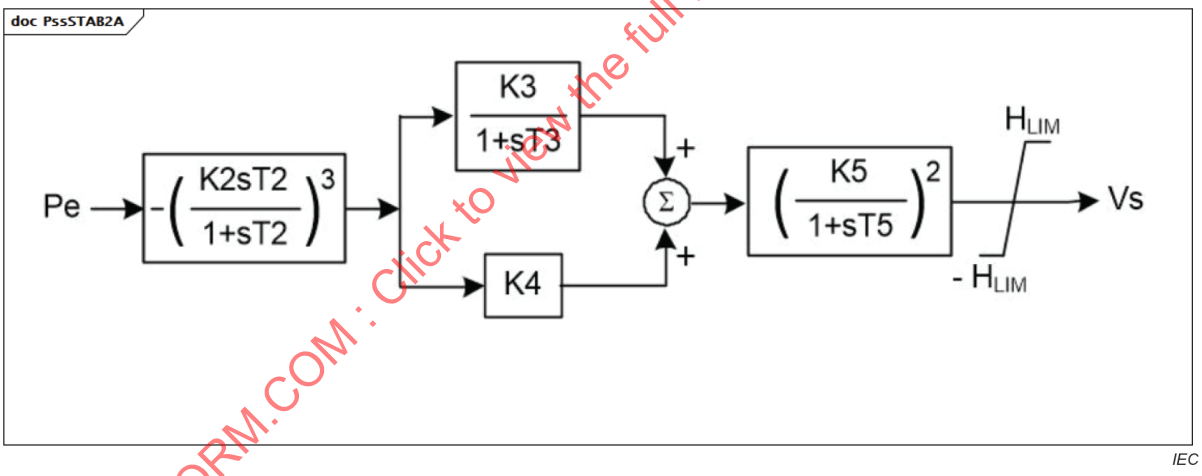


**Figure 161 – PssSTAB2A**

Figure 161: This diagram describes the PssSTAB2A power system stabilizer model.

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6 ABB excitation systems are an example of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of these products.

Table 320 shows all attributes of PssSTAB2A.

**Table 320 – Attributes of PowerSystemStabilizerDynamics::PssSTAB2A**

| name | mult | type | description |
|---|---|---|---|
| k2 | 1..1 | PU | Gain (K2). Typical value = 1,0. |
| k3 | 1..1 | PU | Gain (K3). Typical value = 0,25. |
| k4 | 1..1 | PU | Gain (K4). Typical value = 0,075. |
| k5 | 1..1 | PU | Gain (K5). Typical value = 2,5. |
| t2 | 1..1 | Seconds | Time constant (T2). Typical value = 4,0. |
| t3 | 1..1 | Seconds | Time constant (T3). Typical value = 2,0. |
| t5 | 1..1 | Seconds | Time constant (T5). Typical value = 4,5. |
| hlim | 1..1 | PU | Stabilizer output limiter (HLIM). Typical value = 0,5. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 321 shows all association ends of PssSTAB2A with other classes.

**Table 321 – Association ends of PowerSystemStabilizerDynamics:: PssSTAB2A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

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### 8.2.4.3.12.20 PssWECC

Dual input power system stabilizer, based on IEEE type 2, with modified output limiter defined by WECC (Western Electricity Coordinating Council, USA).

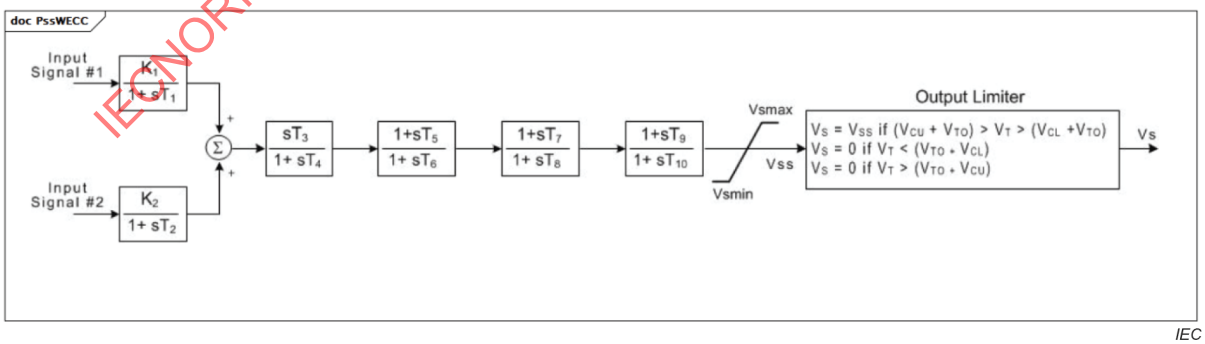


**Figure 162 – PssWECC**

Figure 162: This diagram describes the PssWECC power system stabilizer model.

Parameter details:

1) VT is the terminal voltage.
2) VTO is the initial terminal voltage.

Table 322 shows all attributes of PssWECC.

**Table 322 – Attributes of PowerSystemStabilizerDynamics::PssWECC**

| name | mult | type | description |
|---|---|---|---|
| inputSignal1Type | 1..1 | InputSignalKind | Type of input signal #1 (rotorAngularFrequencyDeviation, busFrequencyDeviation, generatorElectricalPower, generatorAcceleratingPower, busVoltage, or busVoltageDerivative – shall be different than PssWECC.inputSignal2Type). Typical value = rotorAngularFrequencyDeviation. |
| inputSignal2Type | 1..1 | InputSignalKind | Type of input signal #2 (rotorAngularFrequencyDeviation, busFrequencyDeviation, generatorElectricalPower, generatorAcceleratingPower, busVoltage, busVoltageDerivative – shall be different than PssWECC.inputSignal1Type). Typical value = busVoltageDerivative. |
| k1 | 1..1 | PU | Input signal 1 gain (K1). Typical value = 1,13. |
| t1 | 1..1 | Seconds | Input signal 1 transducer time constant (T1) (>= 0). Typical value = 0,037. |
| k2 | 1..1 | PU | Input signal 2 gain (K2). Typical value = 0,0. |
| t2 | 1..1 | Seconds | Input signal 2 transducer time constant (T2) (>= 0). Typical value = 0,0. |
| t3 | 1..1 | Seconds | Stabilizer washout time constant (T3) (>= 0). Typical value = 9,5. |
| t4 | 1..1 | Seconds | Stabilizer washout time lag constant (T4) (>= 0). Typical value = 9,5. |
| t5 | 1..1 | Seconds | Lead time constant (T5) (>= 0). Typical value = 1,7. |
| t6 | 1..1 | Seconds | Lag time constant (T6) (>= 0). Typical value = 1,5. |
| t7 | 1..1 | Seconds | Lead time constant (T7) (>= 0). Typical value = 1,7. |
| t8 | 1..1 | Seconds | Lag time constant (T8) (>= 0). Typical value = 1,5. |
| t10 | 1..1 | Seconds | Lag time constant (T10) (>= 0). Typical value = 0. |
| t9 | 1..1 | Seconds | Lead time constant (T9) (>= 0). Typical value = 0. |
| vsmax | 1..1 | PU | Maximum output signal (Vsmax) (> PssWECC.vsmin). Typical value = 0,05. |
| vsmin | 1..1 | PU | Minimum output signal (Vsmin) (< PssWECC.vsmax). Typical value = -0,05. |
| vcu | 1..1 | PU | Maximum value for voltage compensator output (VCU). Typical value = 0. |
| vcl | 1..1 | PU | Minimum value for voltage compensator output (VCL). Typical value = 0. |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |

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

Table 323 shows all association ends of PssWECC with other classes.

**Table 323 – Association ends of PowerSystemStabilizerDynamics:: PssWECC with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: PowerSystemStabilizerDynamics |

#### 8.2.4.3.13 Package DiscontinuousExcitationControlDynamics

##### 8.2.4.3.13.1 General

In certain system configurations, continuous excitation control with terminal voltage and power system stabilizing regulator input signals does not ensure that the potential of the excitation system for improving system stability is fully exploited. For these situations, discontinuous excitation control signals can be employed to enhance stability following large transient disturbances.

For additional information please refer to IEEE 421.5-2005, 12.

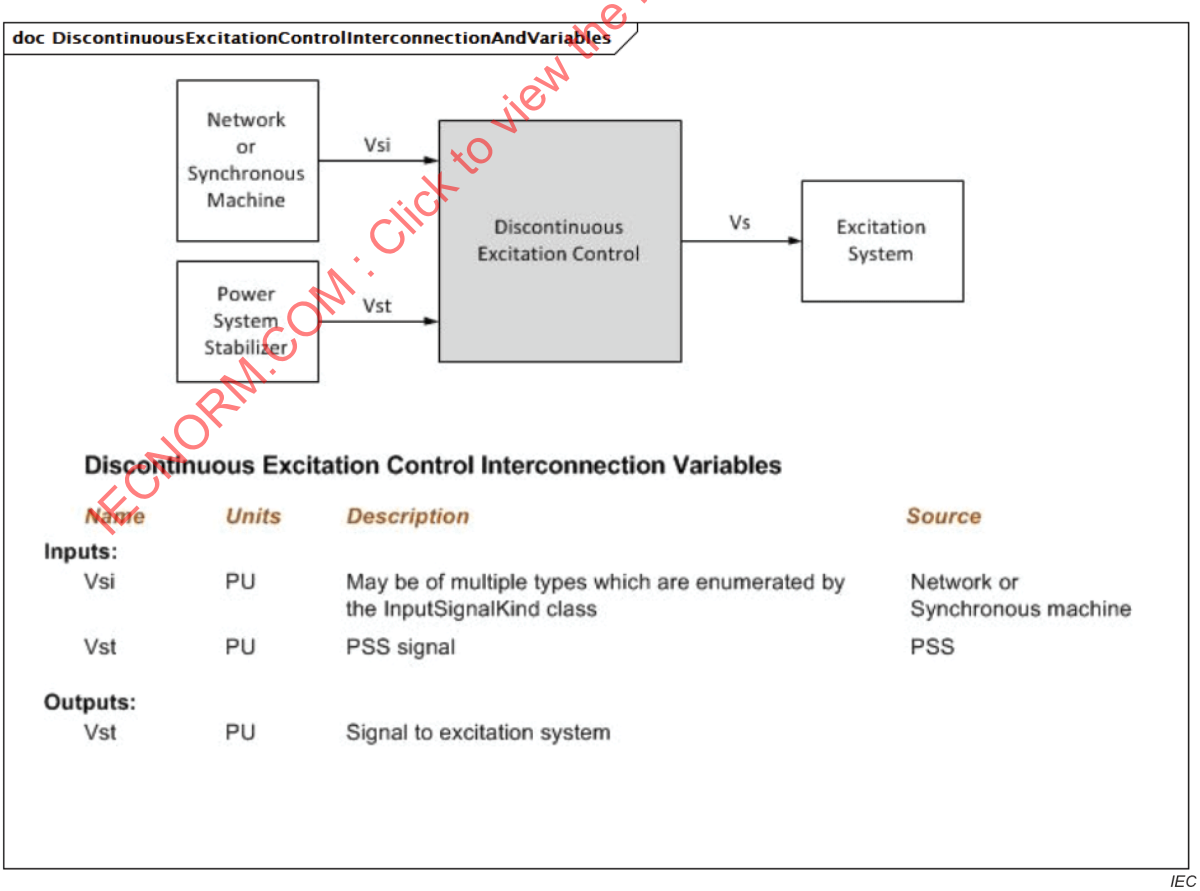


**Figure 163 – DiscontinuousExcitationControlInterconnectionAndVariables**

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Figure 163: This diagram illustrates the inputs and outputs for a discontinuous excitation control.

Diagram details:

1) Vs is always initialized to zero by the excitation system model.
2) If bus voltage frequency is not available from network, the model can calculate it as derivative of the bus voltage angle.

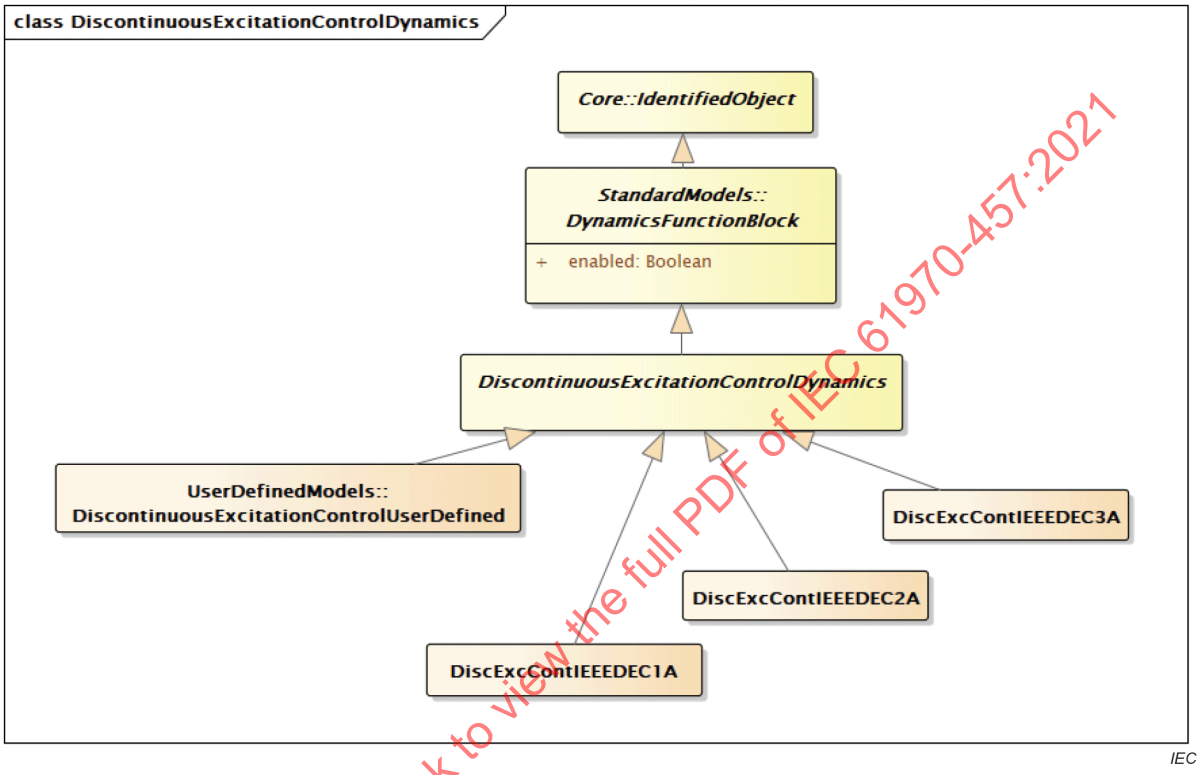


**Figure 164 – Class diagram DiscontinuousExcitationControlDynamics:: DiscontinuousExcitationControlDynamics**

Figure 164: This diagram shows dynamic standard model discontinuous excitation control classes and their inheritance from the DiscontinuousExcitationControlDynamics class.

#### 8.2.4.3.13.2 (abstract) DiscontinuousExcitationControlDynamics

Discontinuous excitation control function block whose behaviour is described by reference to a standard model or by definition of a user-defined model.

Table 324 shows all attributes of DiscontinuousExcitationControlDynamics.

**Table 324 – Attributes of DiscontinuousExcitationControlDynamics:: DiscontinuousExcitationControlDynamics**

| name | mult | type | description |
|---|---|---|---|
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

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Table 325 shows all association ends of DiscontinuousExcitationControlDynamics with other classes.

**Table 325 – Association ends of DiscontinuousExcitationControlDynamics:: DiscontinuousExcitationControlDynamics with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | Excitation system model with which this discontinuous excitation control model is associated. |

#### 8.2.4.3.13.3 DiscExcContIEEEDEC1A

IEEE type DEC1A discontinuous excitation control model that boosts generator excitation to a level higher than that demanded by the voltage regulator and stabilizer immediately following a system fault.

Reference: IEEE 421.5-2005, 12.2.

Table 326 shows all attributes of DiscExcContIEEEDEC1A.

**Table 326 – Attributes of DiscontinuousExcitationControlDynamics:: DiscExcContIEEEDEC1A**

| name | mult | type | description |
|---|---|---|---|
| vtlmt | 1..1 | PU | Voltage reference (VTLMT). Typical value = 1,1. |
| vomax | 1..1 | PU | Limiter (VOMAX) (> DiscExcContIEEEDEC1A.vomin). Typical value = 0,3. |
| vomin | 1..1 | PU | Limiter (VOMIN) (< DiscExcContIEEEDEC1A.vomax). Typical value = 0,1. |
| ketl | 1..1 | PU | Terminal voltage limiter gain (KETL). Typical value = 47. |
| vtc | 1..1 | PU | Terminal voltage level reference (VTC). Typical value = 0,95. |
| val | 1..1 | PU | Regulator voltage reference (VAL). Typical value = 5,5. |
| esc | 1..1 | PU | Speed change reference (ESC). Typical value = 0,0015. |
| kan | 1..1 | PU | Discontinuous controller gain (KAN). Typical value = 400. |
| tan | 1..1 | Seconds | Discontinuous controller time constant (TAN) (>= 0). Typical value = 0,08. |
| tw5 | 1..1 | Seconds | DEC washout time constant (TW5) (>= 0). Typical value = 5. |
| vsmax | 1..1 | PU | Limiter (VSMAX)(> DiscExcContIEEEDEC1A.vsmin). Typical value = 0,2. |
| vsmin | 1..1 | PU | Limiter (VSMIN) (< DiscExcContIEEEDEC1A.vsmax). Typical value = -0,066. |
| td | 1..1 | Seconds | Time constant (TD) (>= 0). Typical value = 0,03. |
| tl1 | 1..1 | Seconds | Time constant (TL1) (>= 0). Typical value = 0,025. |
| tl2 | 1..1 | Seconds | Time constant (TL2) (>= 0). Typical value = 1,25. |

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| name | mult | type | description |
|---|---|---|---|
| vtm | 1..1 | PU | Voltage limits (VTM). Typical value = 1,13. |
| vtn | 1..1 | PU | Voltage limits (VTN). Typical value = 1,12. |
| vanmax | 1..1 | PU | Limiter for Van (VANMAX). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 327 shows all association ends of DiscExcContIEEEDEC1A with other classes.

**Table 327 – Association ends of DiscontinuousExcitationControlDynamics:: DiscExcContIEEEDEC1A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: DiscontinuousExcitationControlDynamics |

#### 8.2.4.3.13.4 DiscExcContIEEEDEC2A

IEEE type DEC2A model for discontinuous excitation control. This system provides transient excitation boosting via an open-loop control as initiated by a trigger signal generated remotely.

Reference: IEEE 421.5-2005, 12.3.

Table 328 shows all attributes of DiscExcContIEEEDEC2A.

**Table 328 – Attributes of DiscontinuousExcitationControlDynamics:: DiscExcContIEEEDEC2A**

| name | mult | type | description |
|---|---|---|---|
| vk | 1..1 | PU | Discontinuous controller input reference (VK). |
| td1 | 1..1 | Seconds | Discontinuous controller time constant (TD1) (>= 0). |
| td2 | 1..1 | Seconds | Discontinuous controller washout time constant (TD2) (>= 0). |
| vdmin | 1..1 | PU | Limiter (VDMIN) (< DiscExcContIEEEDEC2A.vdmax). |
| vdmax | 1..1 | PU | Limiter (VDMAX) (> DiscExcContIEEEDEC2A.vdmin). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 329 shows all association ends of DiscExcContIEEEDEC2A with other classes.

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**Table 329 – Association ends of DiscontinuousExcitationControlDynamics:: DiscExcContIEEEDEC2A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: DiscontinuousExcitationControlDynamics |

#### 8.2.4.3.13.5 DiscExcContIEEEDEC3A

IEEE type DEC3A model. In some systems, the stabilizer output is disconnected from the regulator immediately following a severe fault to prevent the stabilizer from competing with action of voltage regulator during the first swing.

Reference: IEEE 421.5-2005, 12.4.

Table 330 shows all attributes of DiscExcContIEEEDEC3A.

**Table 330 – Attributes of DiscontinuousExcitationControlDynamics:: DiscExcContIEEEDEC3A**

| name | mult | type | description |
|---|---|---|---|
| vtmin | 1..1 | PU | Terminal undervoltage comparison level (VTMIN). |
| tdr | 1..1 | Seconds | Reset time delay (TDR) (>= 0). |
| enabled | 1..1 | Boolean | inherited from: DynamicsFunctionBlock |
| description | 0..1 | String | inherited from: IdentifiedObject |
| mRID | 1..1 | String | inherited from: IdentifiedObject |
| name | 0..1 | String | inherited from: IdentifiedObject |

Table 331 shows all association ends of DiscExcContIEEEDEC3A with other classes.

**Table 331 – Association ends of DiscontinuousExcitationControlDynamics:: DiscExcContIEEEDEC3A with other classes**

| mult from | name | mult to | type | description |
|---|---|---|---|---|
| 0..1 | ExcitationSystemDynamics | 1..1 | ExcitationSystemDynamics | inherited from: DiscontinuousExcitationControlDynamics |

#### 8.2.4.3.14 Package PFVArControllerType1Dynamics

##### 8.2.4.3.14.1 General

Excitation systems for synchronous machines are sometimes supplied with an optional means of automatically adjusting generator output reactive power (VAr) or power factor (PF) to a user-specified value. This can be accomplished with either a reactive power or power factor controller or regulator. A reactive power or power factor controller is defined as a PF/VAr controller in IEEE 421.1 as "a control function that acts through the reference adjuster to modify the voltage regulator set point to maintain the synchronous machine steady-state power factor or reactive power at a predetermined value."

For additional information please refer to IEEE 421.5-2005, 11.

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