ORGANON

Dynamic Models Reference

Version 1.2

17/04/06

Table of Contents

Introduction

Organon contains tools designed to perform power system static and dynamic analysis, such as conventional and continuation power flow computation, contingency analysis and time domain simulation.

The conventional power flow solution is based on Newton-Raphson's method, with all controls (HVDC, OLTC, phase shifters, remote voltage control, etc.) embedded in the Jacobian matrix. The continuation power flow is based on the tangent vector method. Time domain simulation is implemented with Variable-Step-Variable-Order algorithms. The integration of differential equations is based on the ABM method.

The program can read and write network data files in different formats, like PSSE/PTI raw files (release 26), IEEE Common Format files and ANAREDE/CEPEL data files. The program also reads and writes in binary format, which allows for data migration without the loss of precision.

The capacity of the program is 99999 buses.

The MS Windows based GUI has facilities to select input and output data files, edit data, run conventional and/or continuation power flow and contingency analysis and generate reports.

Report can include results of: voltage modules and angles, active and reactive generations, active and reactive flows, branch loading, violations (voltage, reactive generation and overload), area summary, link cc summary, deviation of voltage, reactive generation and flow of one contingency with respect to the base case and contingencies ranking based on the tangent vector norm.

This volume (II) presents the models for dynamic simulation.

Time Domain Simulation Methods

Organon uses a variable-step-variable-order integration algorithm and the simultaneous solution of algebraic and differential equations. These algorithms are suitable for efficient simulation of short and long-term dynamics.

The time step is controlled by the accuracy of the simulation. The 'local truncation error' at every step is used to measure the accuracy. For example, if high frequency oscillations are present in the simulation trajectory, the time step will be forced to a small value. On the other hand, if the trajectories become smother the time step is allowed to increase. Also, in case of system instability the step will be forced to very small values. Typically the time step varies from 0.001s to 40s.

The main advantages of a variable time step are:

- More accurate simulation.

- More robustness.

- Simulations are usually faster.

- The same models can be used for fast and slow dynamic phenomena.

Organon also has Energy Function algorithms embedded. This allows for early termination facilities and calculation of energy margins.

Data Files

Time domain simulation requires a network model and a dynamic model.

The initialisation of dynamic models in Organon is based on the load flow case (network model) loaded in memory. Therefore, it is important to make sure that the current loaded case is converged to run a time domain simulation. Otherwise, the simulation will not start at stead-state condition. Also, every time a new network model is loaded into memory the dynamic models, if any, are discarded. This is necessary to make sure that the dynamic models matches the network model. Therefore, it is necessary to re-enter dynamic model if needed.

The dynamic model required to run Organon is entered in an ASCII file of *.dyn type, which contains a set of parameters for built in models. This file includes the parameters for the power system components (e.g., generators, loads, static var compensators, etc.). Two additional files can be entered. One containing simulation parameters (simulation time and set of events), which must have extension *.evt, and another one (*.plv) with predefined plotting specifications (variables to be stored during simulation and graphic definitions).

The data is input in the following sequence:

- Dynamic models (synchronous generators; DC Links, SVCs, etc.);

- Static load models;

- Criteria parameters;

Note: The dynamic data file can only be loaded if there is load flow data loaded. Whenever a load flow data file is loaded, the dynamic data is lost.

The general structure of the file is:

.

.

Dynamic models

.

.

-999

.

.

Static load models

.

.

-999

Criteria parameters

-999

Output File

Organon currently does not generate any output file. All the results are directed to the Message Window.

The following chapters specify the data input format for all of the built in models, events and plotting.

AvailableModels

The general format to enter data is as follows:

Model Name

BusNumber Parameters BusName

Parameters (optional)

The parameters may require more than one record of data. For example, a synchronous machine model typically requires one additional record to enter all the parameters.

The bus, to which the equipment is connected, can be identified either by its number or its name. The program uses the name whenever the bus number is zero.

Voltage Regulator, PSS, OEL, UEL and Governors are 'dependent' models, as they cannot exist without the machine model. The parameters for those models are entered as a sequence of the synchronous machine parameters.

List of Built in Models:

Synchronous Machine Models

Five synchronous machine models are available. Some are more appropriate to round rotor machines an others to salient pole machines. An infinite bus model is also available. The block diagrams for the models are shown below. The details of the equations can be seen in [1]. The models are identified by their respective name.

The machine controls (Voltage Regulator, PSS, OEL, UEL and Governors) cannot exist without the machine model. The parameters for those models are entered following the synchronous machine parameters. On the other hand, the specification of these controls is optional. For example, if a voltage regulator is not specified for a particular machine, constant field voltage is assumed. On the other hand, if a model number is specified for the machine, then the respective data has to be provided. The data for the machine control models has to be entered in the following sequence: Voltage Regulator, PSS, UEL, OEL and Governor. In other words, if a voltage regulator model and PSS model are specified, then the Voltage Regulator data has to be entered before the PSS data. It is also important to note that PSS, UEL and OEL data can only be entered if the Voltage Regulator is specified and the respective data is entered first.

Available Synchronous Machine Models:

Infinite Bus

Synchronous Machine 1

Synchronous Machine 2

Synchronous Machine 3

Synchronous Machine 4

Synchronous Machine 5

Synchronous Machine 6

Plotting Variables for Synchronous Machines

The following variables from a synchronous machine model can be selected for plotting:

Var No.	Definition
1	P_m - Mechanical Power (MW)
2	P - Active power output (pu)
3	Q - Reactive power output (pu)
4	δ - Rotor angle (degrees)
5	ω - Rotor speed (Hz)
6	Ei - Voltage proportional to the field current (pu)#
7	$E'q$ - Voltage behind d axis transient reactance (pu)
8	$E''q$ - Voltage behind d axis sub-transient reactance (pu) #
9	$E'd$ - Voltage behind q axis transient reactance (pu) #
10	$E''d$ - Voltage behind q axis sub-transient reactance (pu) #
11	E_{fd} - Field Voltage (pu) #
12	I - Stator current (pu)
13	Id - d axis stator current (pu)
14	Iq - q axis stator current (pu)
15	Vd - d axis terminal voltage (pu)
16	Vq - q axis terminal voltage (pu)
17	$\Psi''q$ - q axis sub-transient flux (pu) #
18	V - Terminal voltage (pu)

- available only for some models.

Example: (stator current of machine #1 at bus 100) - See Chapter 4.

Object Code	Var Code	Bus	Object ID
SM	11	100	1

Infinite Bus

The Infinite Bus model requires two records of data whereas the synchronous machine models require two records. The following tables show the required data for each model.

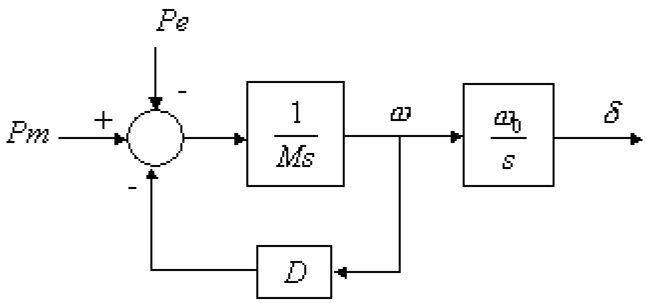
First Record:

Type	Parameter	Description	Default
Integer	Bus No.	Number of terminal bus	
Integer	10	Model Number	
Char(12)	BName	Terminal Bus Name	

Second Record:

Type	Parameter	Description	Default
Real	*X*	Reactance (pu)	
Real	Base	MVA Base for *X* (MVA)	

SM01 - Classical synchronous machine



First Record:

Type	Parameter	Description	Default
Integer	Bus No.	Number of terminal bus	
Integer	GOV	Governor Model No.	
Integer	ID	Unit ID[1]	
Char(12)	BName	Terminal Bus Name	

Notes:

The ID number is necessary when there is more than one machine connected to the same bus. With the identification number it is possible to identify events and specify plotting variables for each machine connected to the same bus.

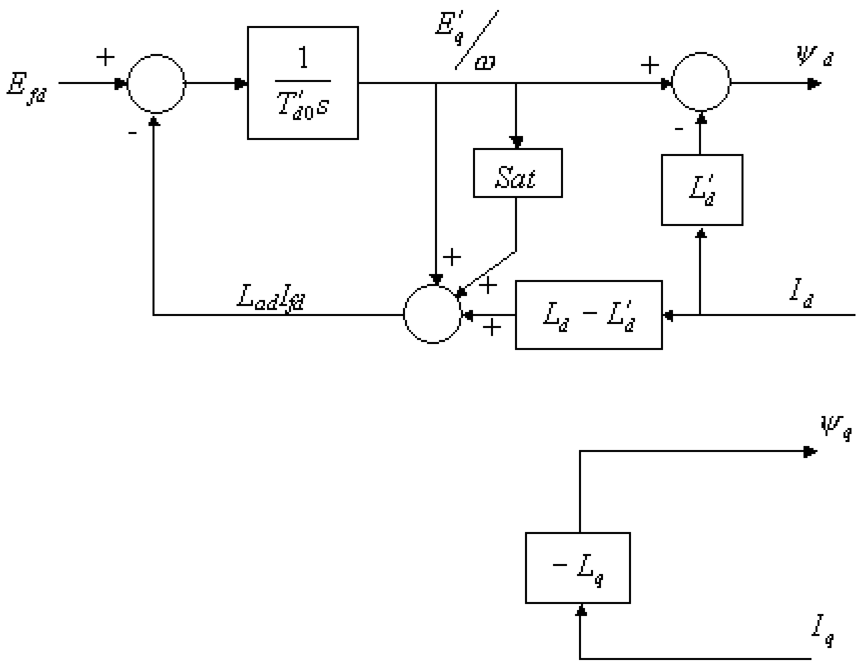
Second Record:

Type	Parameter	Description	Default
Real	X'_d	D axis transient reactance (pu)	
Real	R_a	Stator resistance (pu)	
Real	Base	MVA Base	
Real	X_t	Step-up transformer reactance (optional)[1]	
Real	*H*	Inertia constant (MW/MVA.s)	
Real	*D*	Damping (pu/pu)	

Notes:

If *Xt* is provided the step-up transformer is modelled as part of the synchronous machine. This is useful when the load-flow base case includes the data only for the high voltage side of the step-up transformer.

SM02 - Salient pole - one d axis rotor winding



First Record:

Type	Parameter	Description	Default
Integer	Bus No.	Number of terminal bus	
Integer	VR	Volt Reg. Model No.	
Integer	PSS	PSS Model No.	
Integer	GOV	Governor Model No.	
Integer	RB	Controlled bus No.[1]	
Real	R_c	Compensated Resistance[2]	
Real	X_c	Compensated Inductance[2]	
Real	T_r	Transducer time constant	
Integer	UEL	UEL Model No.	
Integer	OEL	OEL Model No.	
Integer	ID	Unit ID[4]	
Char(12)	BName	Terminal Bus Name	
Char(12)	BName CB	Controlled Bus Name	

Notes:

The default controlled bus is the bus the machine is connected to.

Impedance compensation is implemented by $Vc = \left|Vt + (Rc + jXc)I\right|$, where *Vc* is the controlled voltage, *Vt* is the terminal voltage and *I* is the machine terminal current.

Similar machines connected in parallel can be represented by single aggregated machine. In this case, the user enters the parameters of one machine and uses NE to inform the number of machines in parallel. Then the parameters of the equivalent machine are automatically recalculated.

The ID number is necessary when there is more than one machine connected to the same bus. With the identification number it is possible to identify events and specify plotting variables for each machine connected to the same bus.

For the case where generators are aggregated in the load flow case and the user wants to represent them individually in the time domain simulation, the factors F_p and F_q provide the participation of each unit in the total generation. If no participation is informed, the generation is evenly shared among all units.

Second Record.

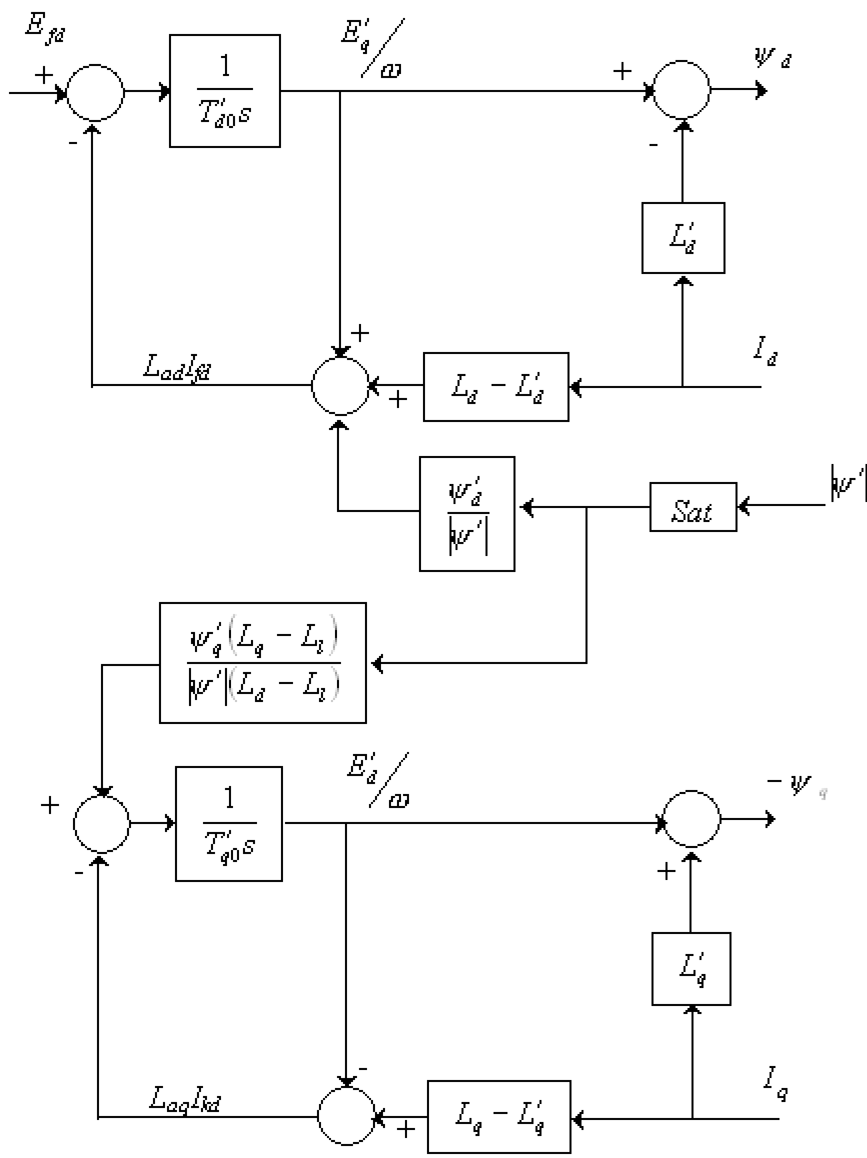
Type	Parameter	Description	Default
Real	X_d	D axis reactance (pu)	
Real	X'_d	D axis transient reactance (pu)	
Real	X_q	Q axis reactance (pu)	
Real	R_a	Stator resistance (pu)	
Real	Base	MVA base	
Real	X_l	Leakage reactance (pu)	
Real	X_t	Step-up transformer reactance (optional)[1]	
Real	T'_d	D axis transient time constant (s)	
Real	H	Inertia constant (MW/MVA.s)	
Real	D	Damping (pu/pu)	
Real	A_g	Saturation proportional coefficient[#]	
Real	B_g	Saturation proportional coefficient[#]	

Sat = $A_g.\exp(B_g.(E_{fd} - 0.8))$

Notes:

If Xt is provided the step-up transformer is modelled as part of the synchronous machine. This is useful when the load-flow base case includes the data only for the high voltage side of the step-up transformer.

SM03 - Round rotor - one d-axis and one q-axis windings



First Record:

Type	Parameter	Description	Default
Integer	Bus No.	Number of terminal bus	
Integer	VR	Volt Reg. Model No.	
Integer	PSS	PSS Model No.	
Integer	GOV	Governor Model No.	
Integer	RB	Controlled bus No.[1]	
Real	R_c	Compensated Resistance[2]	
Real	X_c	Compensated Inductance[2]	
Real	T_r	Transducer time constant	
Integer	UEL	UEL Model No.	
Integer	OEL	OEL Model No.	
Integer	ID	Unit ID[4]	
Char(12)	BName	Terminal Bus Name	
Char(12)	BName CB	Controlled Bus Name	

Notes:

The default controlled bus is the bus the machine is connected to.

Impedance compensation is implemented by $Vc = \left|Vt + (Rc + jXc)I\right|$, where *Vc* is the controlled voltage, *Vt* is the terminal voltage and *I* is the machine terminal current.

Similar machines connected in parallel can be represented by single aggregated machine. In this case, the user enters the parameters of one machine and uses NE to inform the number of machines in parallel. Then the parameters of the equivalent machine are automatically recalculated.

The ID number is necessary when there is more than one machine connected to the same bus. With the identification number it is possible to identify events and specify plotting variables for each machine connected to the same bus.

For the case where generators are aggregated in the load flow case and the user wants to represent them individually in the time domain simulation, the factors Fp and Fq provide the participation of each unit in the total generation. If no participation is informed, the generation is evenly shared among all units.

Second Record:

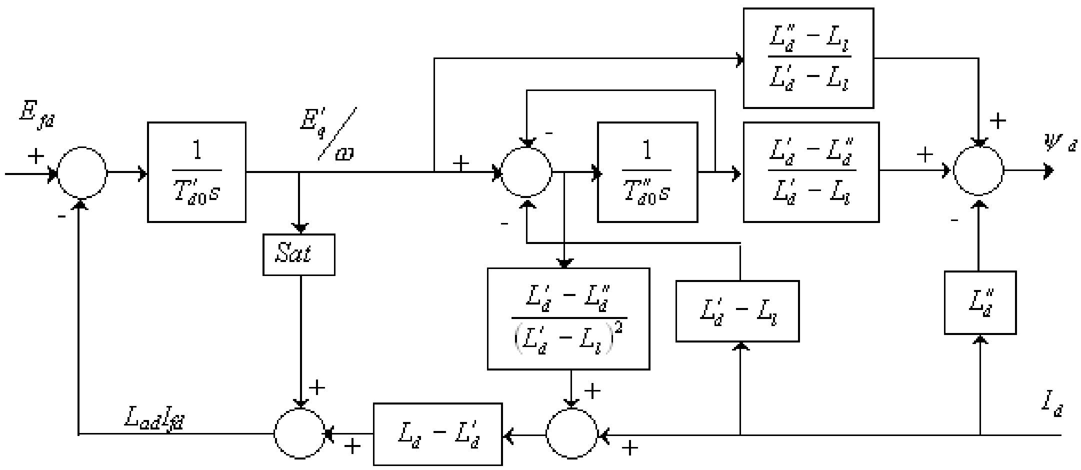
Type	Parameter	Description	Default
Real	X_d	D axis reactance (pu)	
Real	X'_d	D axis transient reactance (pu)	
Real	X_q	Q axis reactance (pu)	
Real	X'_q	Q axis transient reactance (pu)	
Real	R_a	Stator resistance (pu)	
Real	Base	MVA base	
Real	X_l	Leakage reactance (pu)	
Real	X_t	Step-up transformer reactance (optional)[1]	
Real	T'_d	D axis transient time constant (s)	
Real	T'_q	Q axis transient time constant (s)	
Real	*H*	Inertia constant (MW/MVA.s)	
Real	*D*	Damping (pu/pu)	
Real	A_g	Saturation proportional coefficient[#]	
Real	B_g	Saturation proportional coefficient[#]	

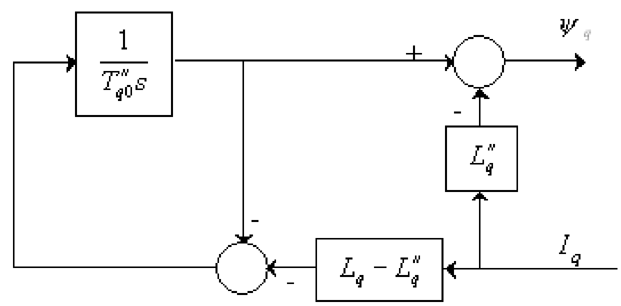
Sat = $A_g.\exp(B_g.(E_{fd} - 0.8))$

Notes:

If Xt is provided the step-up transformer is modelled as part of the synchronous machine. This is useful when the load-flow base case includes the data only for the high voltage side of the step-up transformer.

SM04 - Salient Pole - two d-axes and one q-axis windings





First Record:

Type	Parameter	Description	Default
Integer	Bus No.	Number of terminal bus	
Integer	VR	Volt Reg. Model No.	
Integer	PSS	PSS Model No.	
Integer	GOV	Governor Model No.	
Integer	RB	Controlled bus No.[1]	
Real	R_c	Compensated Resistance[2]	
Real	X_c	Compensated Inductance[2]	
Real	T_r	Transducer time constant	
Integer	UEL	UEL Model No.	
Integer	OEL	OEL Model No.	

Integer	ID	Unit ID[4]	
Char(12)	BName	Terminal Bus Name	
Char(12)	BName CB	Controlled Bus Name	

Notes:

The default controlled bus is the bus the machine is connected to.

Impedance compensation is implemented by $Vc = \left|Vt + (Rc + jXc)I\right|$, where *Vc* is the controlled voltage, *Vt* is the terminal voltage and *I* is the machine terminal current.

Similar machines connected in parallel can be represented by single aggregated machine. In this case, the user enters the parameters of one machine and uses NE to inform the number of machines in parallel. Then the parameters of the equivalent machine are automatically recalculated.

The ID number is necessary when there is more than one machine connected to the same bus. With the identification number it is possible to identify events and specify plotting variables for each machine connected to the same bus.

For the case where generators are aggregated in the load flow case and the user wants to represent them individually in the time domain simulation, the factors F_p and F_q provide the participation of each unit in the total generation. If no participation is informed, the generation is evenly shared among all units.

Second Record:

Type	Parameter	Description	Default
Real	X_d	D axis reactance (pu)	
Real	X'_d	D axis transient reactance (pu)	
Real	X''_d	D axis sub-transient reactance (pu)	
Real	X_q	Q axis reactance (pu)	
Real	0.	Q axis transient reactance (pu)	
Real	X''_q	Q axis sub-transient reactance (pu)	
Real	R_a	Stator resistance (pu)	
Real	Base	MVA base	
Real	X_l	Leakage reactance (pu)	
Real	X_t	Step-up transformer reactance (optional)[1]	
Real	T'_d	D axis transient time constant (s)	
Real	T''_d	D axis sub-transient time constant (s)	
Real	0.	Q axis transient time constant (s)	
Real	*H*	Inertia constant (MW/MVA.s)	
Real	*D*	Damping (pu/pu)	

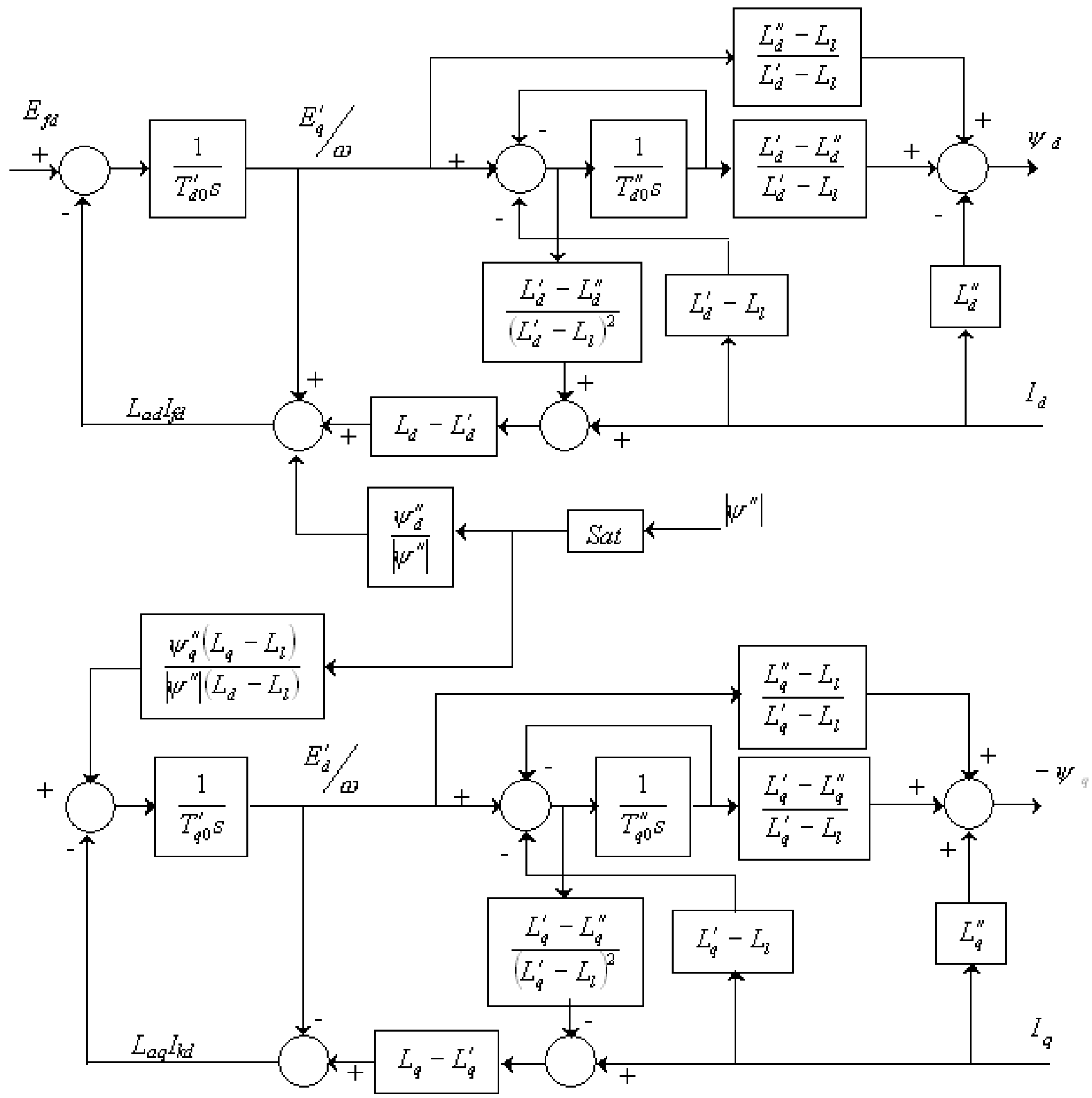
Real	T''_q	Q axis sub-transient time constant	
Real	A_g	Saturation proportional coefficient#	
Real	B_g	Saturation proportional coefficient#	

Sat = $A_g.\exp(B_g.(E_{fd} - 0.8))$

Notes:

If Xt is provided the step-up transformer is modelled as part of the synchronous machine. This is useful when the load-flow base case includes the data only for the high voltage side of the step-up transformer.

SM05 - Round rotor - two d-axis and two q-axis windings



First Record:

Type	Parameter	Description	Default
Integer	Bus No.	Number of terminal bus	
Integer	VR	Volt Reg. Model No.	
Integer	PSS	PSS Model No.	
Integer	GOV	Governor Model No.	
Integer	RB	Controlled bus No.[1]	
Real	R_c	Compensated Resistance[2]	
Real	X_c	Compensated Inductance[2]	
Real	T_r	Transducer time constant	
Integer	UEL	UEL Model No.	
Integer	OEL	OEL Model No.	
Integer	ID	Unit ID[4]	
Char(12)	BName	Terminal Bus Name	
Char(12)	BName CB	Controlled Bus Name	

Notes:

- The default controlled bus is the bus the machine is connected to.

- Impedance compensation is implemented by $Vc = \left|Vt + (Rc + jXc)I\right|$, where *Vc* is the controlled voltage, *Vt* is the terminal voltage and *I* is the machine terminal current.

- Similar machines connected in parallel can be represented by single aggregated machine. In this case, the user enters the parameters of one machine and uses NE to inform the number of machines in parallel. Then the parameters of the equivalent machine are automatically recalculated.

- The ID number is necessary when there is more than one machine connected to the same bus. With the identification number it is possible to identify events and specify plotting variables for each machine connected to the same bus.

- For the case where generators are aggregated in the load flow case and the user wants to represent them individually in the time domain simulation, the factors F_p and F_q provide the participation of each unit in the total generation. If no participation is informed, the generation is evenly shared among all units.

Second Record:

Type	Parameter	Description	Default
Real	X_d	D axis reactance (pu)	
Real	X'_d	D axis transient reactance (pu)	
Real	X''_d	D axis sub-transient reactance (pu)	
Real	X_q	Q axis reactance (pu)	
Real	X'_q	Q axis transient reactance (pu)	
Real	X''_q	Q axis sub-transient reactance (pu)	
Real	R_a	Stator resistance (pu)	
Real	Base	MVA base	
Real	X_l	Leakage reactance (pu)	
Real	X_t	Step-up transformer reactance (optional)[1]	
Real	T'_d	D axis transient time constant (s)	
Real	T''_d	D axis sub-transient time constant (s)	
Real	T'_q	Q axis transient time constant (s)	
Real	H	Inertia constant (MW/MVA.s)	
Real	D	Damping (pu/pu)	
Real	T''_q	Q axis sub-transient time constant	
Real	$S_{1.0}$	Saturation at 1.0 pu field current[#]	
Real	$S_{1.2}$	Saturation at 1.2 pu field current[#]	

Saturation model => Sat = $A.\exp(B.E_{fd})/E_{fd}$

Notes:

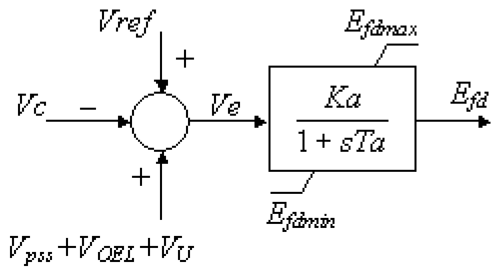
If Xt is provided the step-up transformer is modelled as part of the synchronous machine. This is useful when the load-flow base case includes the data only for the high voltage side of the step-up transformer.

Automatic Voltage Regulator Models

Models Available:

AVR01- Alternator Supplied Controlled-Rectifier Exciter

Model Number - 1



Data format

Type	Parameter	Default
Real	K_a	50.
Real	T_a>0*	0.02
Real	E_{fdmin}	-5.
Real	E_{fdmax}	5.

- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting Variables:

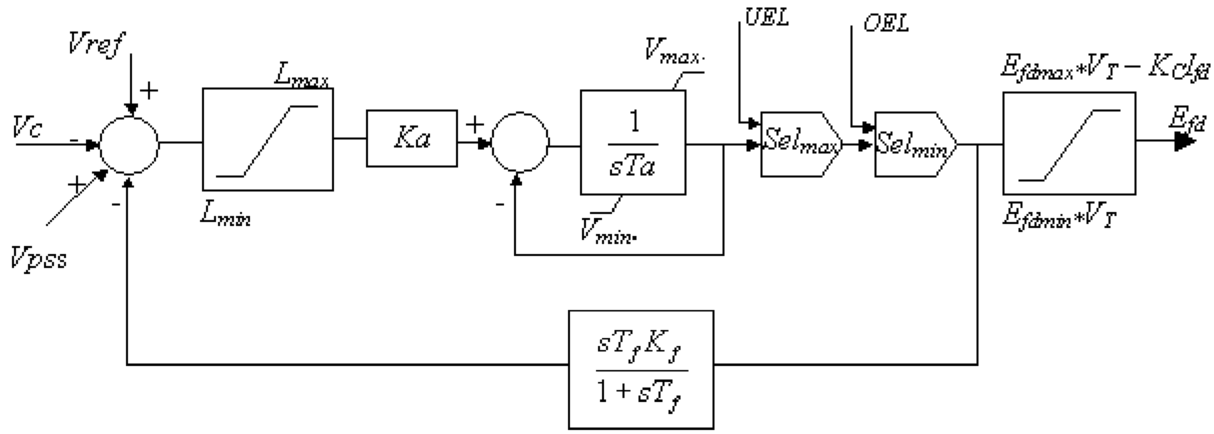
Var No.	Definition
1	V_{ref} - Reference voltage (pu)
2	E_{fd} - Field voltage (pu)
3	V_c - Controlled Voltage (pu)
4	V_e - Control Error (pu)

Example: (field voltage of machine #1 at bus 100) - See Chapter 4.

Object Code	Var Code	Bus	Object ID
AVR	2	100	1

AVR02 - Potential-Source Controlled-Rectifier Exciter (based on ST1A)

Model Number - 2



Data format.

Type	Parameter	Default
Real	K_a	200.
Real	T_a>0	0.02
Real	K_f	0.015
Real	T_f	1.
Real	L_{min}	-1.
Real	L_{max}	1.
Real	V_{min}	-5.
Real	V_{max}	5.
Real	E_{fdmin}	-5.
Real	E_{fdmax}	5.
Real	K_c	0.038

- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting variables:

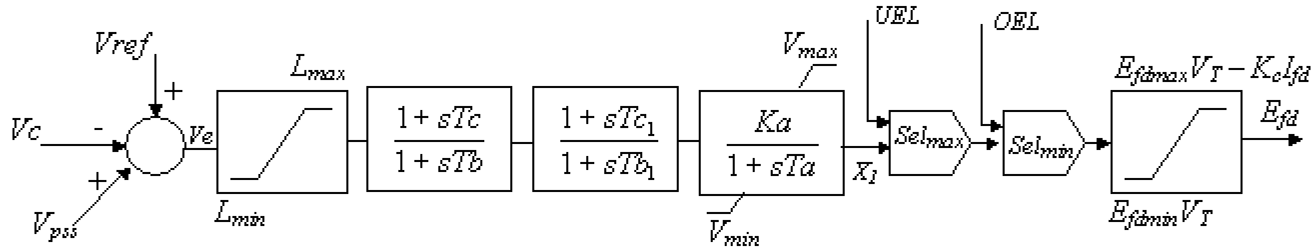
Var No.	Definition
1	V_{ref} – Reference Voltage (pu)
2	E_{fd} – Field Voltage (pu)
3	X_1 – Regulator output – before UEL selector (pu)
4	X_2 – Feedback compensation – derivative block (pu)

Example: (stator current of machine #1 at bus 100) – See Chapter 4.

Object Code	Var Code	Bus	Object ID
AVR	2	100	1

AVR03 - Potential-Source Controlled-Rectifier Exciter (based on ST1A)

Model Number – 3



Data format:

Type	Parameter	Default
Real	K_a	200.
Real	T_a>0	0.02
Real	T_c	1.
Real	T_b	4.
Real	T_{c1}	1.
Real	T_{b1}	1.
Real	L_{min}	-1.
Real	L_{max}	1.
Real	V_{min}	-5.
Real	V_{max}	5.
Real	E_{fdmin}	-5.
Real	E_{fdmax}	5.
Real	K_c	0.038

Plotting variables:

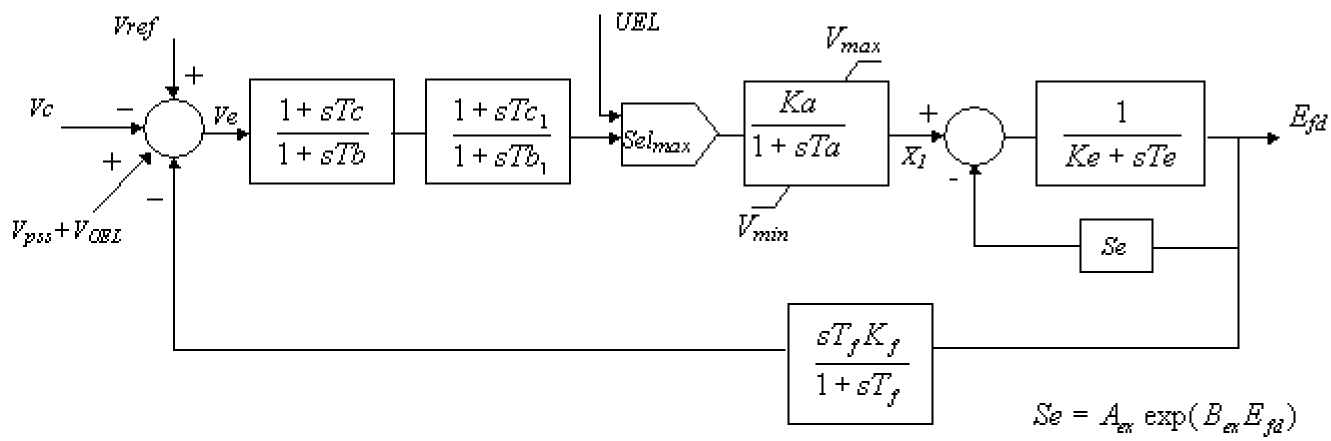
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1 - Regulator output - before the two lead-lag blocks (pu)
4	V_c - Controlled Voltage (pu)
5	V_e - Control Error (pu)

Example: (stator current of machine #1 at bus 100)

Object Code	Var Code	Bus	Object ID
AVR	2	100	1

AVR04 - DC Commutator Exciter (Based on DC1A)

Model Number - 4



Data format:

Type	Parameter	Default
Real	K_a	50.
Real	T_a>0[*]	0.06
Real	K_e[#]	0.
Real	T_e	0.5
Real	T_c	1.
Real	T_b(>0)	1.
Real	K_f	0.1
Real	T_f	1.
Real	V_{min}	-1.
Real	V_{max}	1.
Real	E_1	4.75
Real	$S(E_1)$	0.1
Real	E_2	6.24
Real	$S(E_2)$	1.14
Real	T_{c1}	1.
Real	T_{b1}	1.

- If K_e = 0, it is computed internally as $K_e = -S_e$

- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting variables:

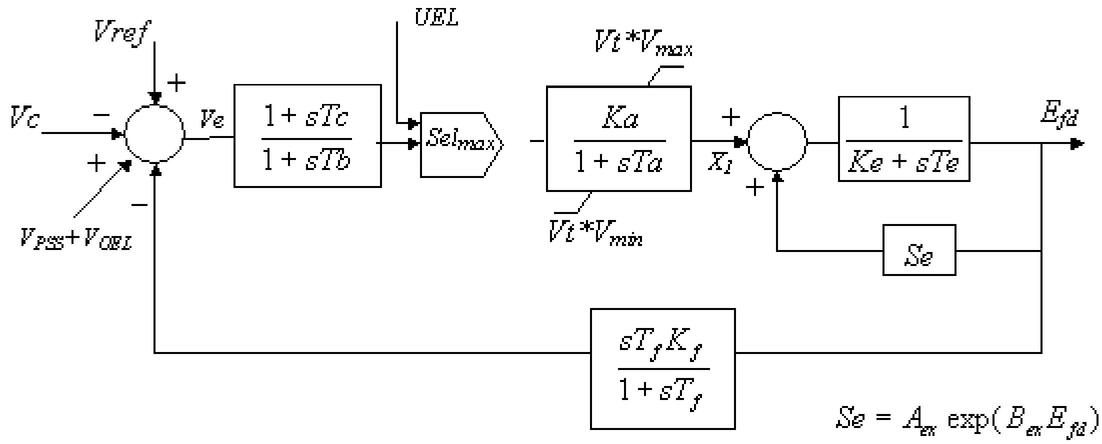
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1 - Regulator output (pu)

Example: (stator current of machine #1 at bus 100)

Object Code	Var Code	Bus	Object ID
AVR	2	100	1

AVR05 - DC Commutator Exciter (Based on DC2A)

Model Number - 5



Data format:

Type	Parameter	Default
Real	K_a	200.
Real	T_a>0*	0.01
Real	K_e	1.
Real	T_e	1.3
Real	T_c	1.
Real	T_b(>0)	1.
Real	K_f	0.148
Real	T_f	0.675
Real	A_{ex}	0.012
Real	B_{ex}	1.
Real	V_{min}	-5.
Real	V_{max}	5.

- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting variables:

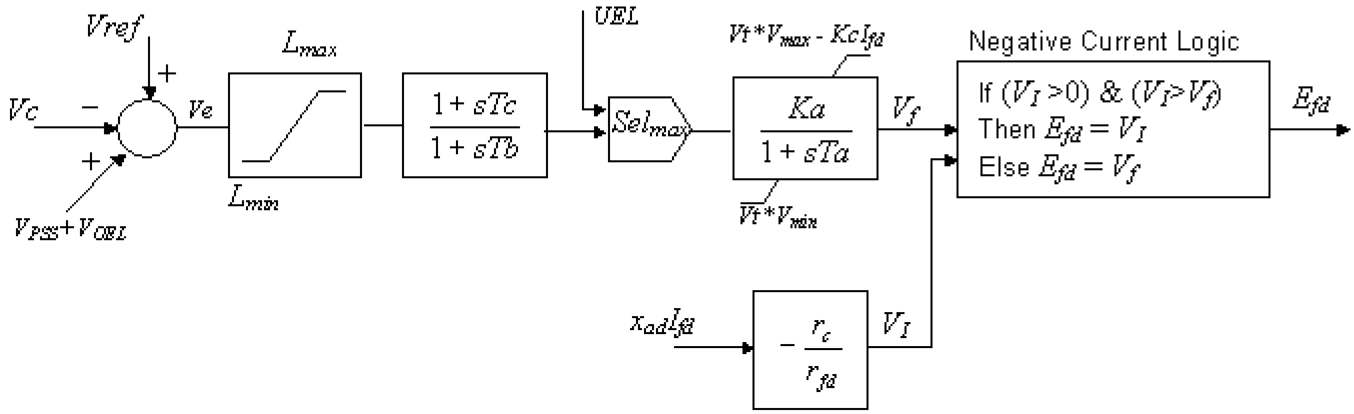
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1 - Regulator output (pu)

Example: (stator current of machine #1 at bus 100)

Object Code	Var Code	Bus	Object ID
AVR	2	100	1

AVR06 - Potential-Source Controlled-Rectifier Exciter (based on ST1A)

Model Number - 6



Data format:

Type	Parameter	Default
Real	K_a	200.
Real	T_a>0*	0.015
Real	T_c	1.
Real	T_b	10.
Real	L_{min}	-2.
Real	Lmax	2.
Real	V_{min}	-5.
Real	V_{max}	6.
Real	K_c	0.02
Real	r_c/r_{fd}[1]	0.

1 - r_c/r_{fd} is the ratio between the field discharge resistor and field winding resistance. If the excitation system does not allow negative current, this ratio has to be set to zero. For excitation systems with negative current capacity the ratio should be set to zero. For excitation systems without discharge resistor and without negative bridge, the ration should be set to a high value.

- If *Ta* = 0 the program will set it to the default smallest time constant value.

Plotting variables:

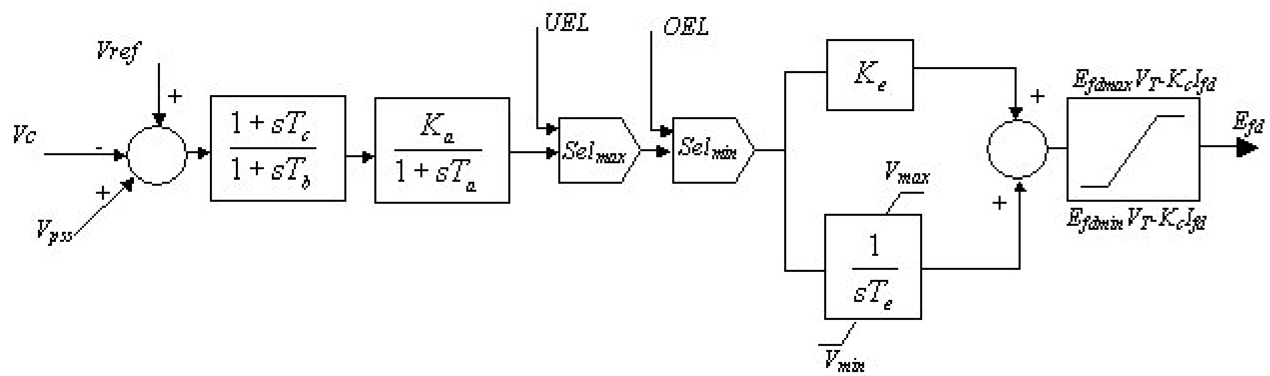
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1 - Output of lead/lag block T_c/T_b (pu)
4	V_I - (pu)
5	V_f - (pu)

Example: (stator current of machine #1 at bus 100)

Object Code	Var Code	Bus	Object ID
AVR	2	100	1

AVR07 - Potential-Source Controlled-Rectifier Exciter (PI control)

Model Number - 7



Data format:

Type	Parameter	Default
Real	K_a	100.
Real	T_a	0.01
Real	K_e	1.
Real	T_e>0	2.
Real	V_{min}	-5.
Real	V_{max}	6.
Real	E_{fdmin}	-5.
Real	E_{fdmax}	6.
Real	T_c	1.
Real	T_b	1.
Real	K_c	0.2

- If Te = 0 the program will set it to the default smallest time constant value. < /FONT >

Plotting variables:

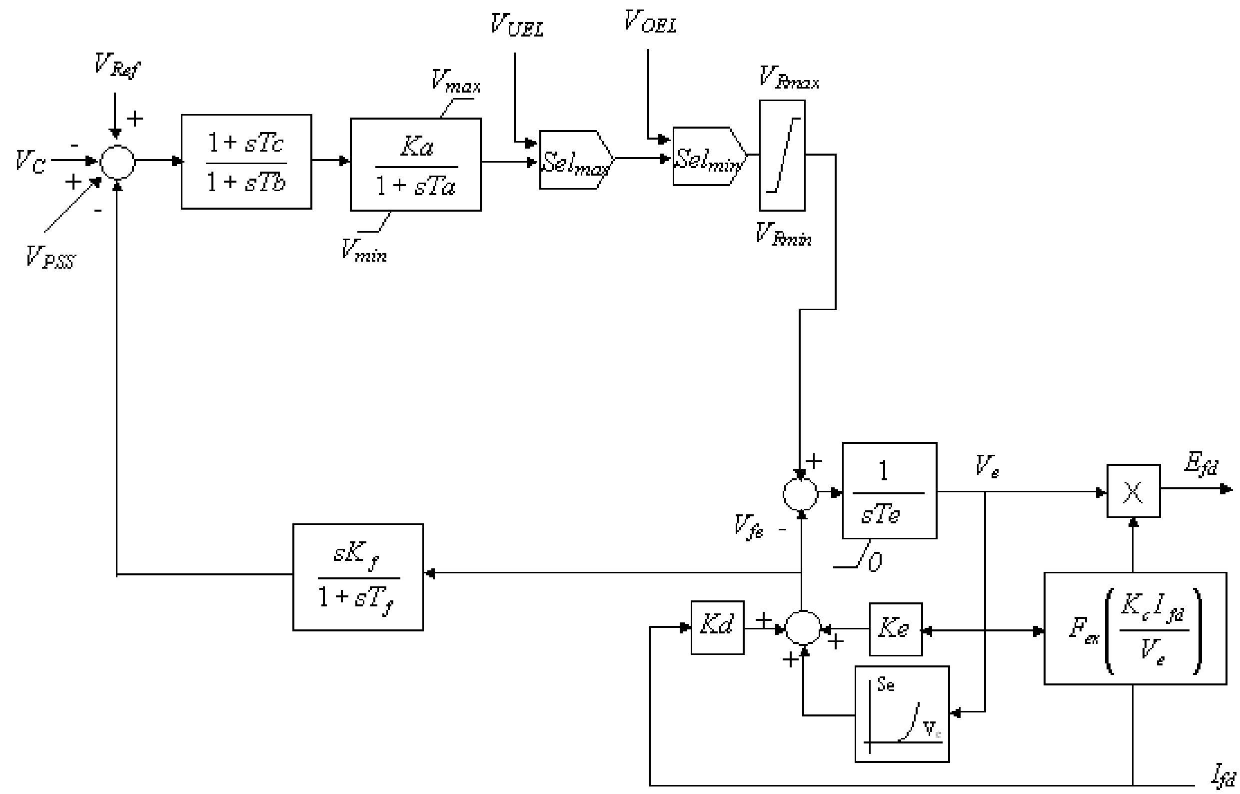
Var No.	Definition
1	V_{ref} – Reference Voltage (pu)
2	E_{fd} – Field Voltage (pu)
3	X_1 – Integrator output (pu)
4	X_2 – Amplifier output – before UEL selector (pu)

Example: (stator current of machine #1 at bus 100)

Object Code	Var Code	Bus	Object ID
AVR	2	100	1

AVR08 - Alternator-Rectifier Exciter with Noncontrolled Rectifiers and Feedback From Exciter Field Current (AC1A)

Model Number - 8



Data format:

Type	Parameter	Default
Real	T_b	1.
Real	T_c	1.
Real	K_a	200.
Real	$T_a>0^*$	0.02
Real	V_{max}	15.
Real	V_{min}	-15/
Real	T_e	0.8
Real	K_f	0.03
Real	T_f	1.
Real	K_c	0.2
Real	K_d	0.38
Real	K_e	1.
Real	E_1	4.18
Real	$Sat(E_1)$	0.1
Real	E_2	3.14
Real	$Sat(E_2)$	0.03
Real	VR_{max}	6.
Real	VR_{min}	-5.

- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting variables:

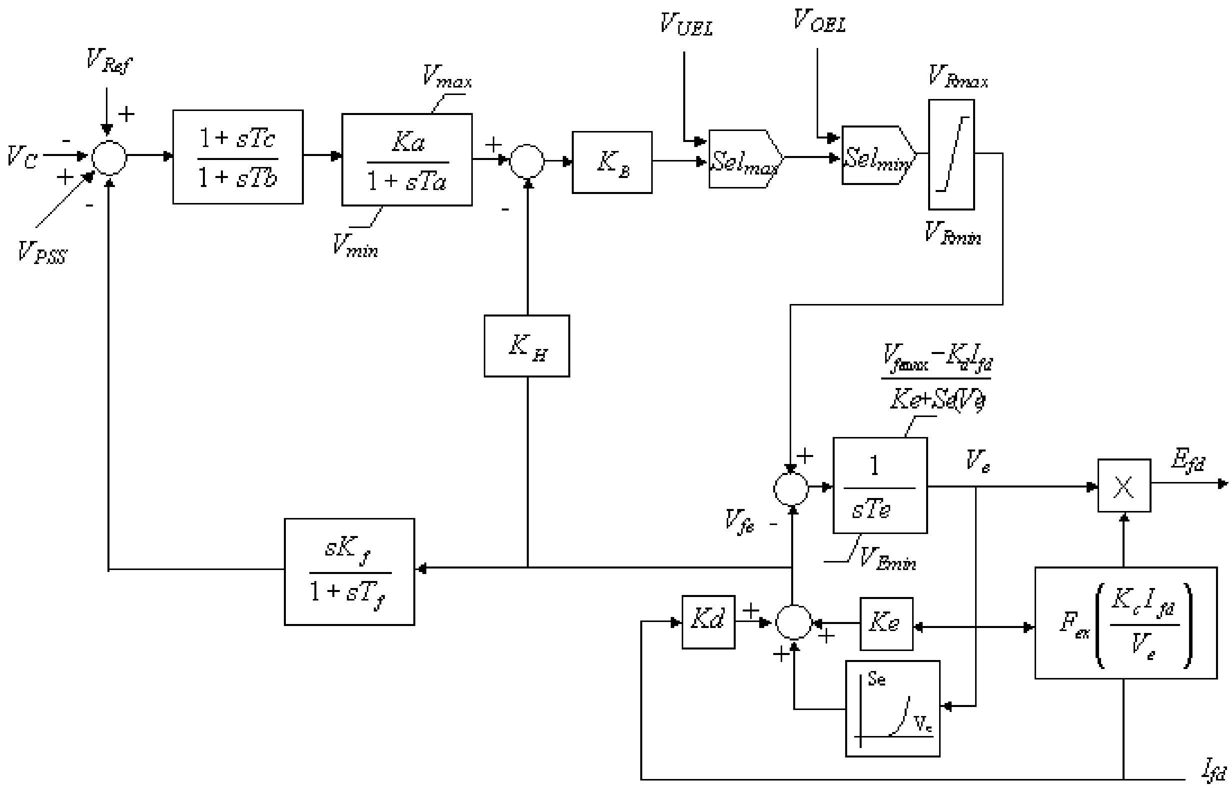
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_2 - Amplifier output before UEL selector (pu)
4	X_4
5	I_{fd}

Example: (stator current of machine #1 at bus 100)

Object Code	Var Code	Bus	Object ID
AVR	2	100	1

AVR09 - High Initial Response Alternator-Rectifier Exciter with Noncontrolled Rectifiers and Feedback From Exciter Field Current

Model Number - 9



Data format:

Type	Parameter	Default
Real	T_b	1.
Real	T_c	1.
Real	K_a	200.
Real	$T_a>0$	0.02
Real	V_{max}	8.
Real	V_{min}	-8.
Real	K_b	25.
Real	VR_{max}	100.
Real	VR_{min}	-100.
Real	$T_e>0$	0.6
Real	Vfe_{max}	4.4
Real	K_h	1.
Real	K_f	0.03
Real	T_f	1.
Real	K_c	0.28
Real	K_d	0.35
Real	K_e	1.
Real	E_1	4.4
Real	$Sat(E_1)$	0.037
Real	E_2	3.3
Real	$Sat(E_2)$	0.012

- If T_a = 0 the program will set it to the default smallest time constant value. The same applies to T_e.

Plotting variables:

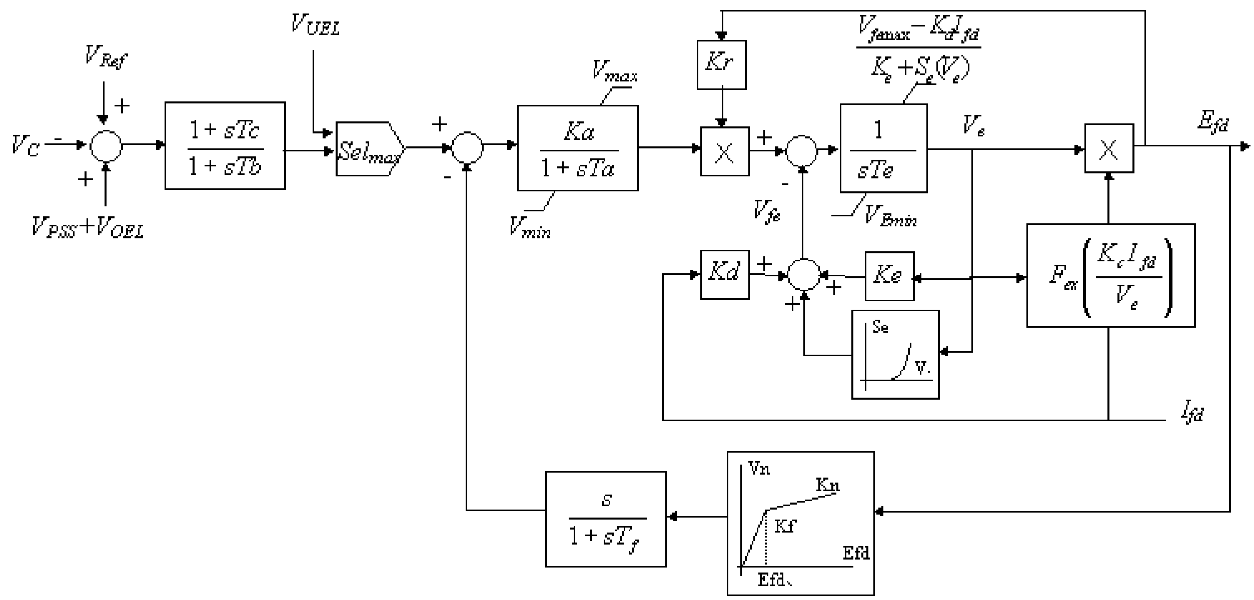
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1
4	X_2 - Amplifier output before UEL selector (pu)
5	X_3 - Feedback compensation - derivative block (pu)
6	X_4
7	X_5

Example: (stator current of machine #1 at bus 100)

Object Code	Var Code	Bus	Object ID
AVR	2	100	1

AVR10 - Alternator-Rectifier Exciter with Noncontrolled Rectifiers and Feedback From Exciter Field Current (AC3A)

Model Number - 10



Data format:

Type	Parameter	Default
Real	T_b	1.
Real	T_c	1.
Real	K_a	50.
Real	$T_a>0^*$	0.02
Real	V_{max}	1.
Real	V_{min}	-1.
Real	$T_e>0^*$	1.2
Real	VE_{min}	0.8
Real	K_r	3.77
Real	K_f	0.14
Real	T_f	1.
Real	K_n	0.05
Real	E_{fdN}	2.36
Real	K_c	0.1
Real	K_d	0.5
Real	K_e	1.
Real	V_{femax}	16.
Real	E_1	6.24
Real	$Sat(E_1)$	1.14
Real	E_2	0.75*E1
Real	$Sat(E_2)$	0.1

Plotting variables:

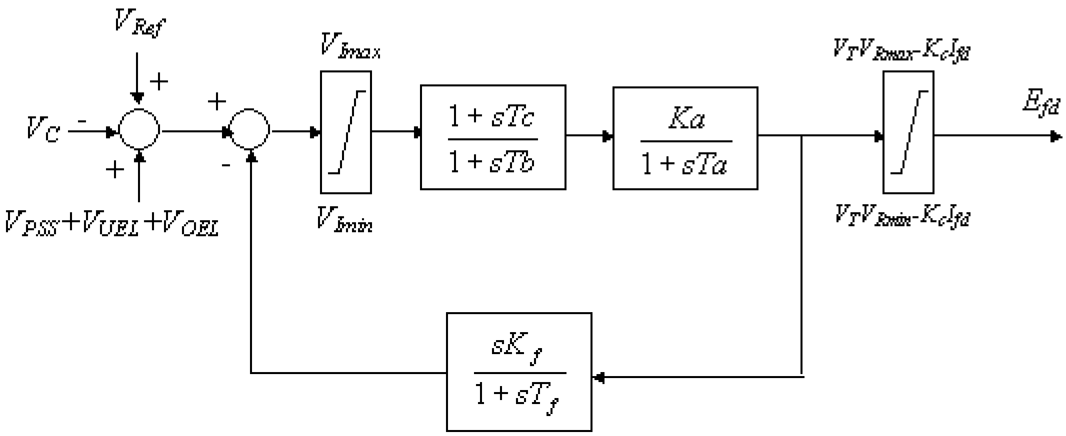
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1
4	X_2 - Amplifier output (pu)
5	X_3 - Feedback compensation - derivative block (pu)
6	X_4
7	X_5

Example: (stator current of machine #1 at bus 100)

Object Code	Var Code	Bus	Object ID
AVR	2	100	1

AVR11 - Potential-Source Controlled-Rectifier Exciter (based on ST1A)

Model Number - 11



Data format:

Type	Parameter	Default
Real	VI_{max}	100.
Real	VI_{min}	-100.
Real	T_c	1.
Real	T_b	1.
Real	K_a	200.
Real	T_a	0.02
Real	VR_{max}	6.
Real	VR_{min}	-6.
Real	K_c	0.038
Real	K_f	0.
Real	T_f	1.

Plotting variables:

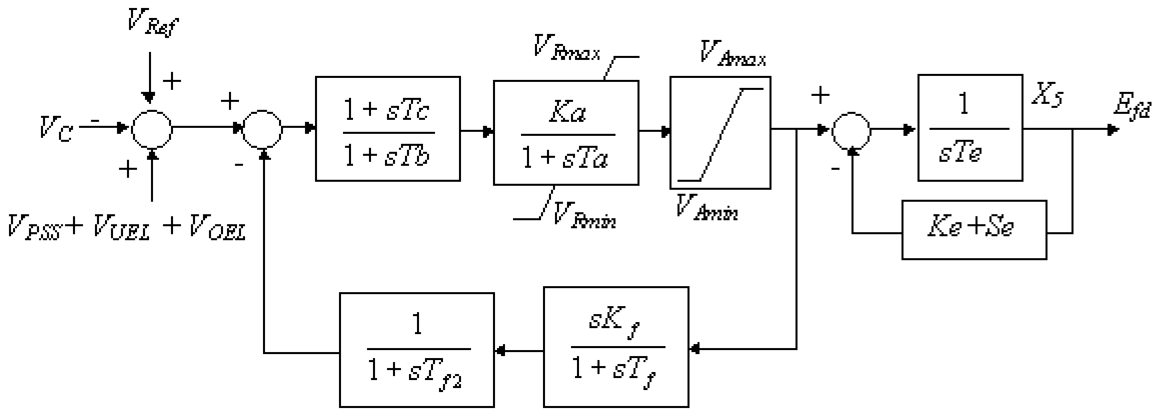
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1
4	X_2 - Feedback compensation - derivative block (pu)
5	X_3 - Amplifier output before the limiter block (pu)

Example: (stator current of machine #1 at bus 100)

Object Code	Var Code	Bus	Object ID
AVR	2	100	1

AVR13 - DC Commutator Exciter

Model Number - 13



Data format:

Type	Parameter	Default
Real	K_a	100.
Real	T_a>0*	0.02
Real	T_b	1.
Real	T_c	1.
Real	VR_{max}	14.
Real	VR_{min}	-14.
Real	K_e	1.
Real	T_e	1.3
Real	K_f	0.02
Real	T_{f1}	0.6
Real	T_{f2}	1.2
Real	E_1	2.3
Real	Sat(E_1)	0.1
Real	E_2	3.1
Real	Sat(E_2)	0.33
Real	V_{Amax}	1000
Real	V_{Amin}	-1000

- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting variables:

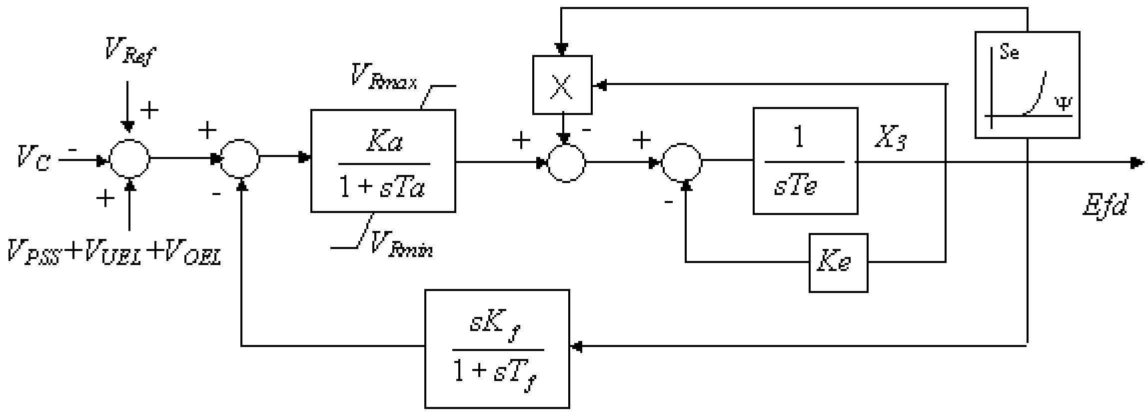
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1
4	X_2
5	X_3
6	X_4 - Amplifier output (pu)
7	X_5

Example: (stator current of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
AVR	2	100	1

AVR12 - DC Commutator Exciter (Based on DC1A)

Model Number - 12



Data format:

Type	Parameter	Default
Real	K_a	50.
Real	$T_a>0^*$	0.06
Real	V_{Rmax}	1.
Real	V_{Rmin}	-1.
Real	K_e	0.
Real	T_e	0.5
Real	K_f	0.1
Real	T_f	1.
Real	E_1	3.1
Real	$Sat(E_1)$	0.33
Real	E_2	2.3
Real	$Sat(E_2)$	0.1

- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting variables:

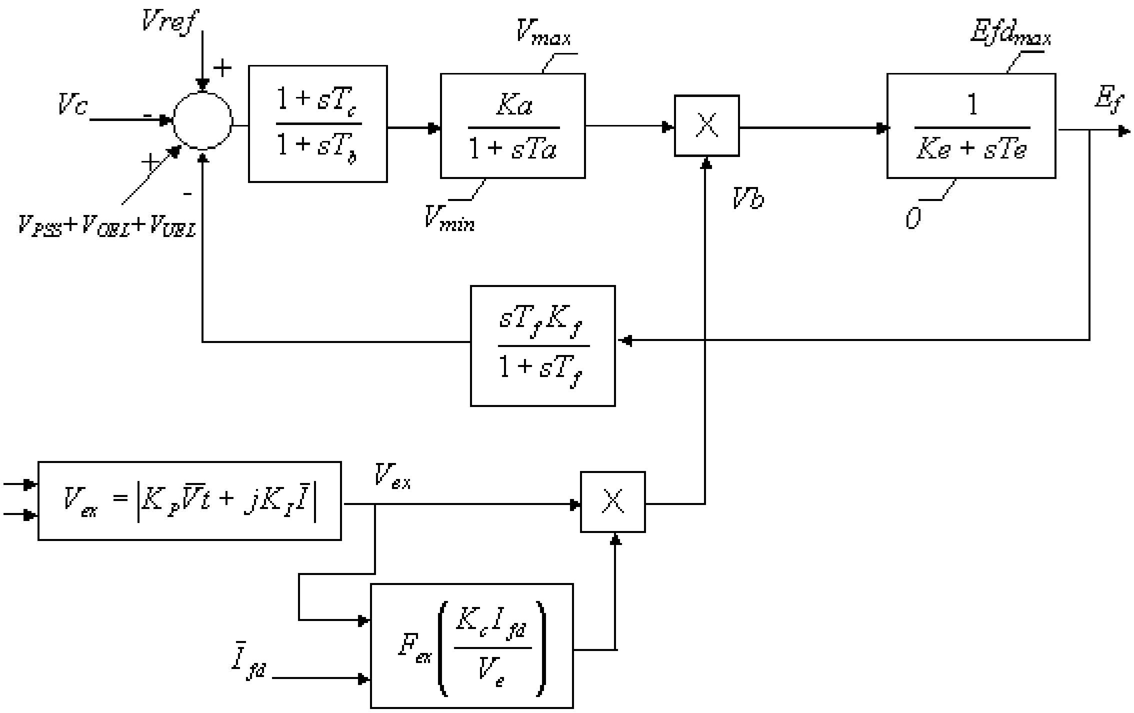
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1 - Amplifier output
4	X_2 - Feedback compensation - derivative block (pu)
5	X_3

Example: (stator current of machine #1 at bus 100)

Object Code	Var Code	Bus	Object ID
AVR	2	100	1

AVR14 - Compound-Source Rectifier Exciter (Based on ST2A)

Model Number - 14



Data format:

Type	Parameter	Default
Real	K_a	120.
Real	$T_a>0^*$	0.15
Real	V_{max}	1.
Real	V_{min}	0.
Real	K_e	1.
Real	$T_e>0*$	0.5
Real	K_f	0.05
Real	T_f	1.
Real	K_p	4.88
Real	K_i	8.
Real	K_c	1.82
Real	E_{fdmax}	3.
Real	T_c	1.
Real	T_b	1.

- If T_a = 0 the program will set it to the default smallest time constant value. The same applies to *Te*.

Plotting variables:

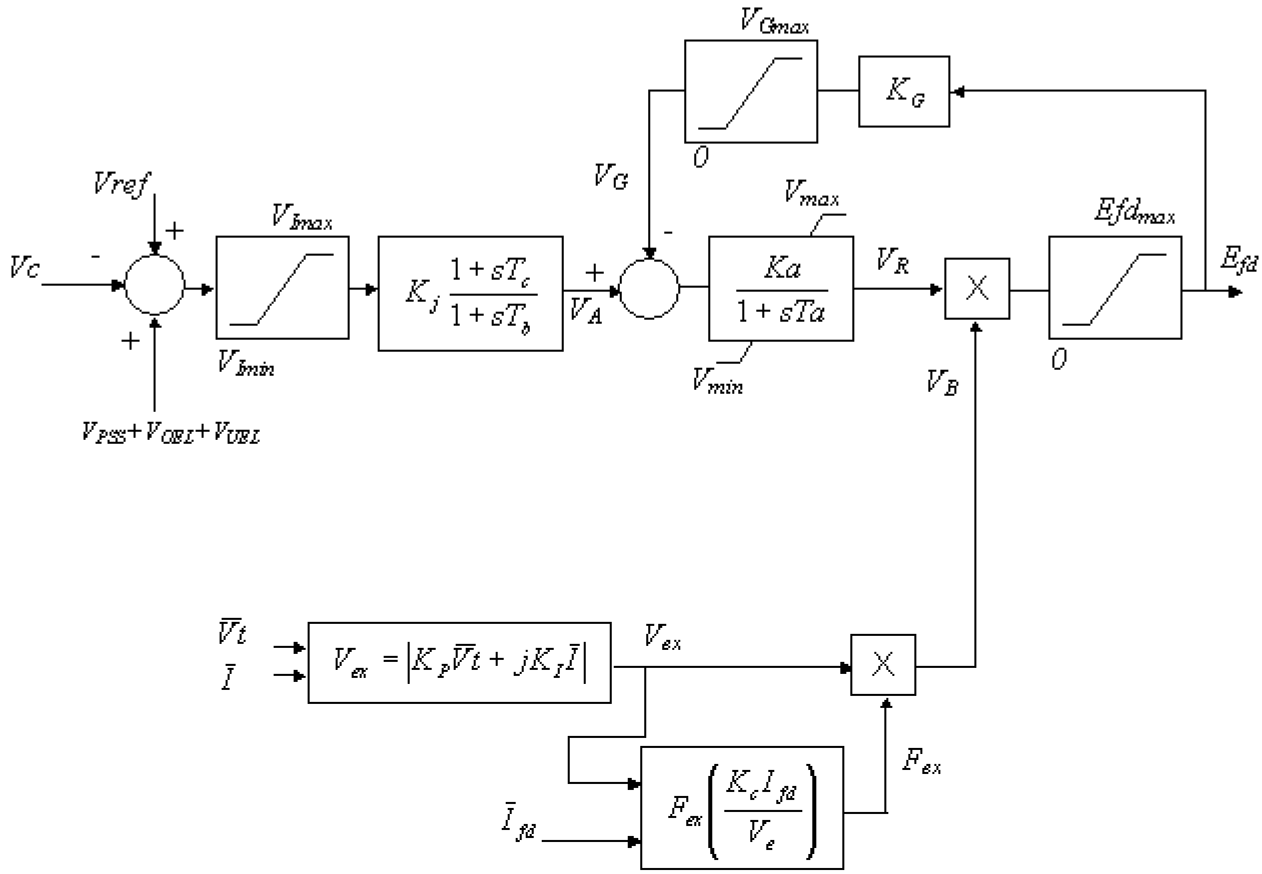
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1
4	X_2
5	X_3
6	X_4 - Amplifier output (pu)
7	X_5

Example: (stator current of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
AVR	2	100	1

AVR15 - Potential or Compound-Source Controlled-Rectifier Exciter With Field Voltage Control Loop (Based on ST3A)

Model Number - 15



Data format:

Type	Parameter	Default
Real	VI_{max}	0.2
Real	VI_{min}	-0.2
Real	K_j	200.
Real	T_c	1.
Real	T_b	10.
Real	K_a	8.
Real	$T_a>0^*$	0.4
Real	V_{max}	1.
Real	V_{min}	0.
Real	K_g	1.
Real	K_p	6.
Real	K_i	1.
Real	Efd_{max}	7.
Real	K_c	0.2
Real	V_{Gmax}	6.

- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting variables:

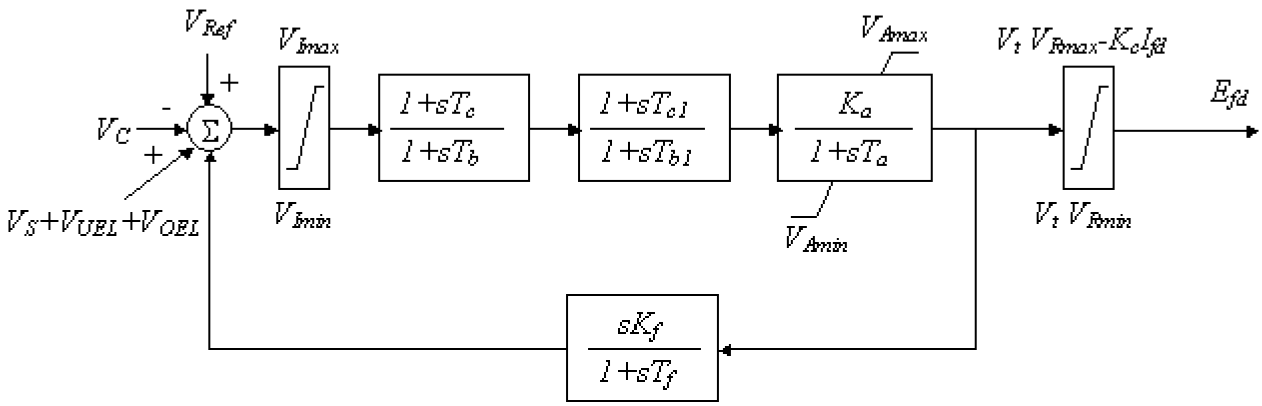
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	V_r
4	X_3
5	V_b
6	V_{ex}
7	F_{ex}
8	I_{fd}

Example: (stator current of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
AVR	2	100	1

AVR16 - Potential-Source Controlled-Rectifier Exciter (Based on ST1A)

Model Number - 16



Data format:

Type	Parameter	Default
Real	V_{Imax}	10.
Real	V_{Imin}	-10.
Real	T_c	1.
Real	T_b	1.
Real	T_{c1}	1.
Real	T_{b1}	1.
Real	K_a	200.
Real	$T_a>0^*$	0.02
Real	V_{Amax}	6.
Real	V_{Amin}	-5.
Real	V_{Rmax}	6.
Real	V_{Rmin}	-5.
Real	K_C	0.038
Real	K_f	0.
Real	T_f	1.

- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting variables:

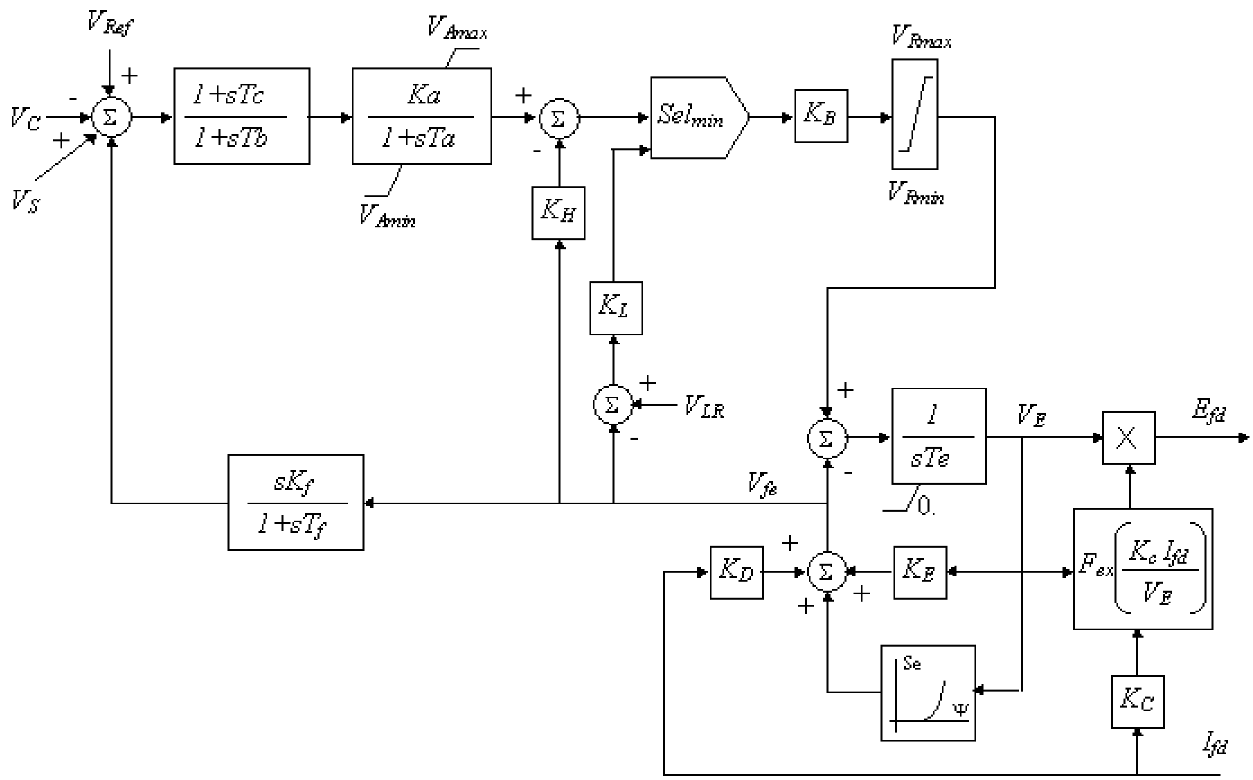
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1
4	X_2
5	X_3 - Feedback compensation - derivative block (pu)
6	X_4 - Amplifier output before limiter (pu)

Example: (stator current of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
AVR	2	100	1

AVR17 - High Initial Response Alternator-Rectifier Excitation System With Noncontrolled Rectifiers and Feedback From Exciter Fie

Model Number - 17



Note: This model is obsolete. AVR09 should be used instead. To do that what is required is to make V_{femax} = V_{LR} and disregard K_L.

Data format:

Type	Parameter	Default
Real	T_b	1.
Real	T_c	1.
Real	K_a	200.
Real	$T_a>0^*$	0.02
Real	V_{Amax}	8.
Real	V_{Amin}	-8.
Real	K_B	25.
Real	V_{Rmax}	100.
Real	V_{Rmin}	-100.
Real	$T_e>0^*$	0.6
Real	K_L	20.
Real	K_H	1.
Real	K_f	0.03
Real	T_f	1.
Real	K_C	0.28
Real	K_D	0.35
Real	K_E	1.
Real	V_{LR}	4.4
Real	E_1	4.4
Real	$Sat(E_1)$	0.037
Real	E_2	3.3
Real	$Sat(E_2)$	0.012

- If T_a = 0 the program will set it to the default smallest time constant value. The same applies to T_e.

Plotting variables:

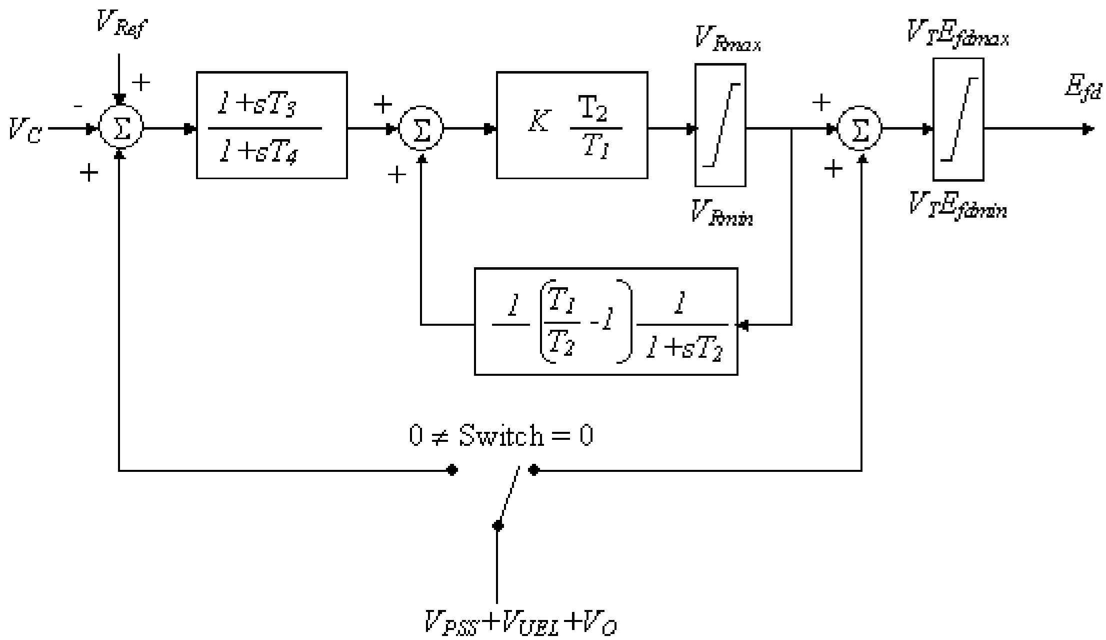
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1
4	X_2 - Amplifier output before selector (pu)
5	X_3 - Feedback compensation - derivative block (pu)
6	X_4
7	X_5

Example: (stator current of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
AVR	2	100	1

AVR18 - Brown Boveri Static Exciter

Model Number - 18



Data format:

Type	Parameter	Default
Real	*K*	100.
Real	T_1	1.
Real	T_2	1.
Real	T_3	1.
Real	T_4	1.
Real	V_{Rmax}	6.
Real	V_{Rmin}	-6.
Real	E_{fdmax}	6.
Real	E_{fdmin}	-6.
Integer	Switch	--

Plotting variables:

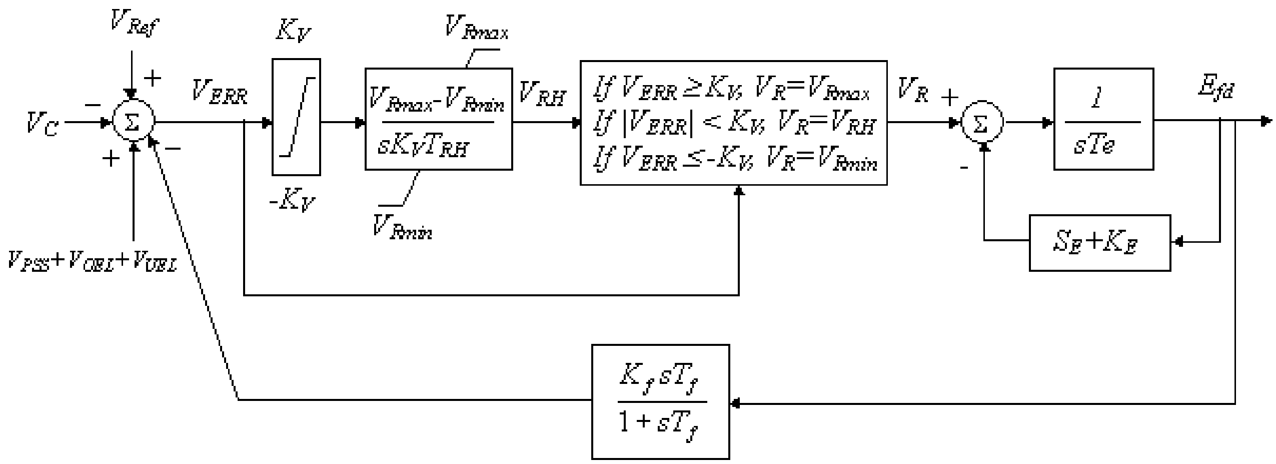
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1
4	X_2
5	X_3

Example: (stator current of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
AVR	2	100	1

AVR19 - DC Commutator Exciter With Noncontinuous Acting Regulator (DC3A)

Model Number - 19



Data format:

Type	Parameter	Default
Real	$T_{RH}>0$*	20.
Real	$K_{V>0}$	0.05
Real	V_{Rmax}	5.
Real	V_{Rmin}	-1.
Real	T_e	1.4
Real	K_e	1.
Real	E_1	4.5
Real	Sat(E_1)	0.27
Real	E_2	3.
Real	Sat(E_2)	0.07
Real	Kf	0.
Real	Tf	0.

* - If T_{RH} = 0 the program will set it to the default smallest time constant value.

Plotting variables:

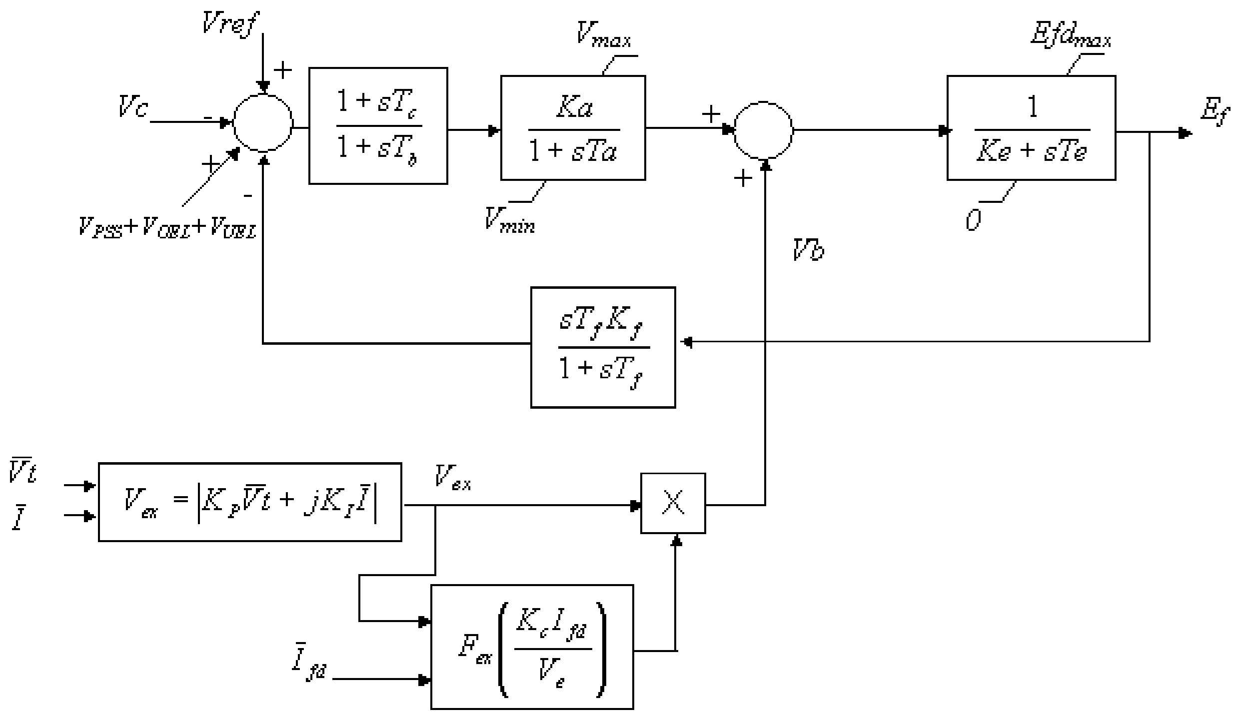
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	V_{RH}
4	X_2

Example: (stator current of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
AVR	2	100	1

AVR20 - Compound-Source Rectifier Exciter (ST2A)

Model Number - 14



Data format:

Type	Parameter	Default
Real	K_a	120.
Real	T_a>0*	0.15
Real	Vmax	1.
Real	Vmin	0.
Real	K_e	1.
Real	T_e>0*	0.5
Real	K_f	0.05
Real	T_f	1.
Real	K_p	4.88
Real	K_i	8.
Real	K_c	1.82
Real	E_{fdmax}	3.
Real	T_c	1.
Real	T_b	1.

- If T_a = 0 the program will set it to the default smallest time constant value. The same applies to T_e.

Plotting variables:

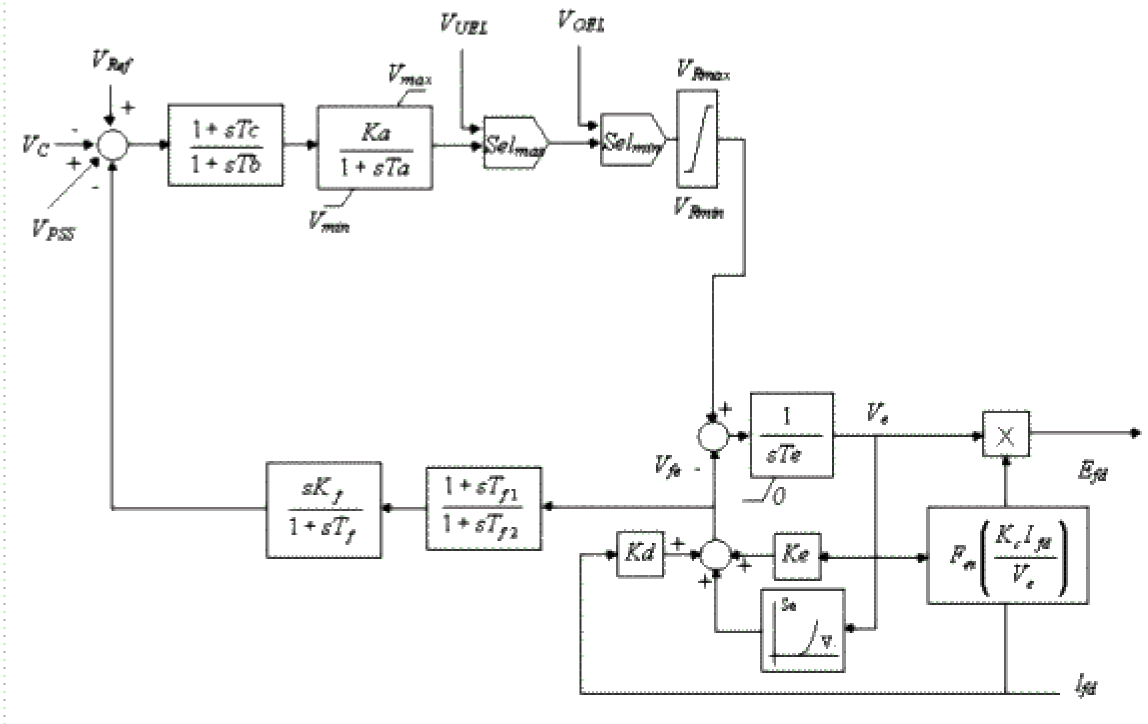
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_1
4	X_2
5	X_3
6	X_4 - Amplifier output (pu)
7	X_5

Example: (stator current of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
AVR	2	100	1

AVR21 - Alternator-Rectifier Exciter with Noncontrolled Rectifiers and Feedback From Exciter Field Current (AC1A)

Model Number - 21



Data format:

Type	Parameter	Default
Real	T_b	1.
Real	T_c	1.
Real	K_a	200.
Real	T_a>0*	0.02
Real	V_{max}	15.
Real	V_{min}	-15/
Real	T_e	0.8
Real	K_f	0.03
Real	T_f	1.
Real	K_c	0.2
Real	K_d	0.38
Real	K_e	1.
Real	E_1	4.18
Real	Sat(E_1)	0.1
Real	E_2	3.14
Real	Sat(E_2)	0.03
Real	VR_{max}	6.
Real	VR_{min}	-5.
Real	T_{f1}	1.
Real	T_{f2}	1.

- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting variables:

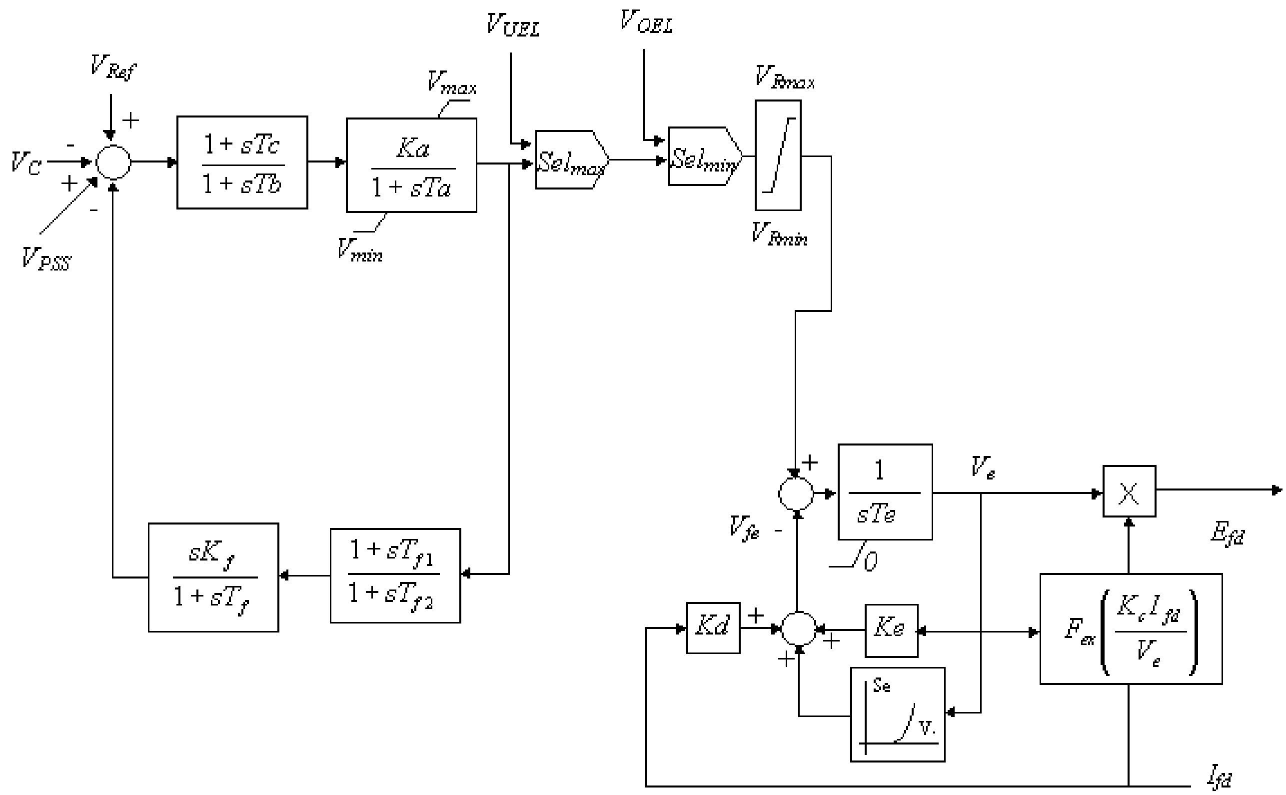
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_2 - Amplifier output before UEL selector (pu)
4	X_4
5	I_{fd}

Example: (stator current of machine #1 at bus 100)

Object Code	Var Code	Bus	Object ID
AVR	2	100	1

AVR22 - Alternator-Rectifier Exciter with Noncontrolled Rectifiers and Feedback From Amplifier

Model Number - 22



Data format:

Type	Parameter	Default
Real	T_b	1.
Real	T_c	1.
Real	K_a	200.
Real	$T_a>0^*$	0.02
Real	V_{max}	15.
Real	V_{min}	-15/
Real	T_e	0.8
Real	K_f	0.03
Real	T_f	1.
Real	K_c	0.2
Real	K_d	0.38
Real	K_e	1.
Real	E_1	4.18
Real	$Sat(E_1)$	0.1
Real	E_2	3.14
Real	$Sat(E_2)$	0.03
Real	VR_{max}	6.
Real	VR_{min}	-5.
Real	T_{f1}	1.
Real	T_{f2}	1.

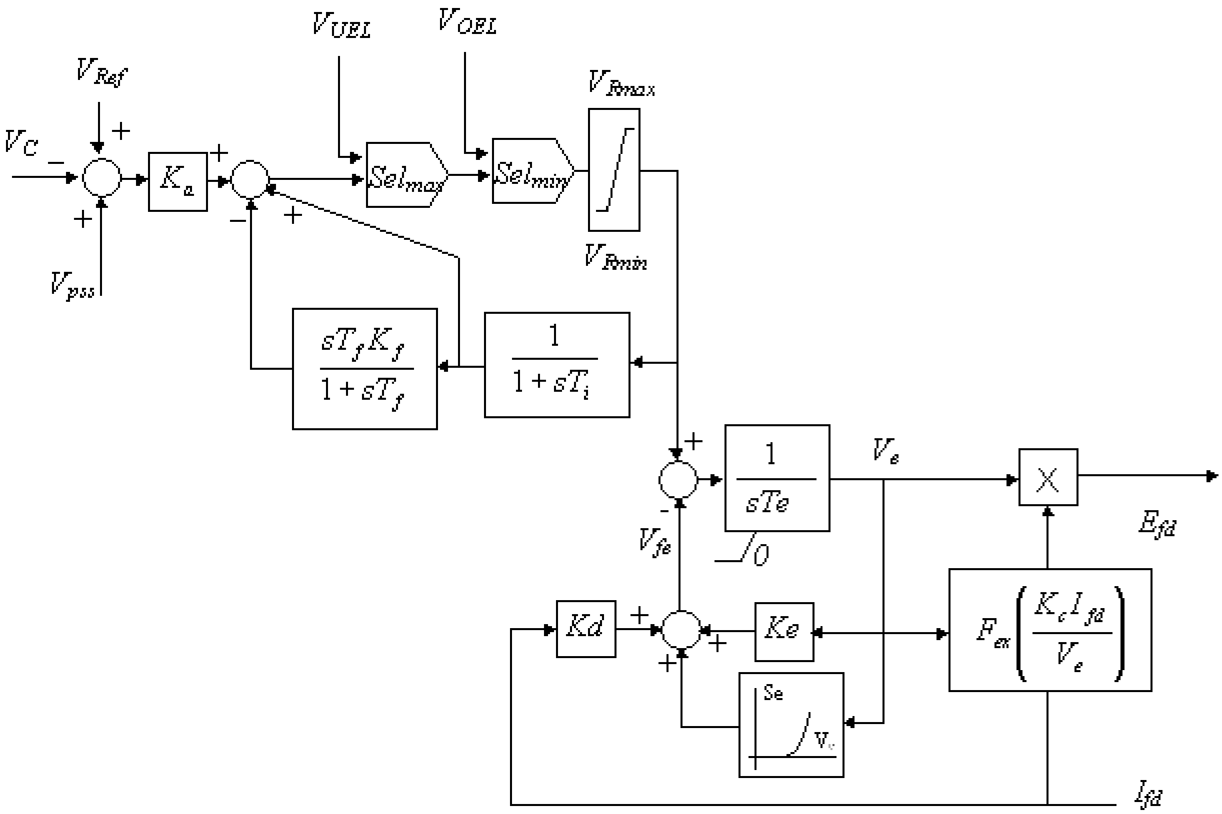
- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting variables:

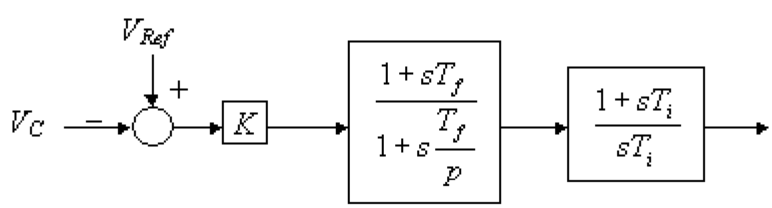
Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_2 - Amplifier output before UEL selector (pu)
4	X_4
5	I_{fd}

AVR23 - Alternator-Rectifier Exciter with Noncontrolled Rectifiers and PI Control

Model Number - 23



The control of this excitation system is a implementation of the following transfer function (neglecting nonlinearities).



This requires the following relationship.

$$K_f = (p-1)\frac{T_i}{T_f}$$

$$K_a = K.p$$

Data format:

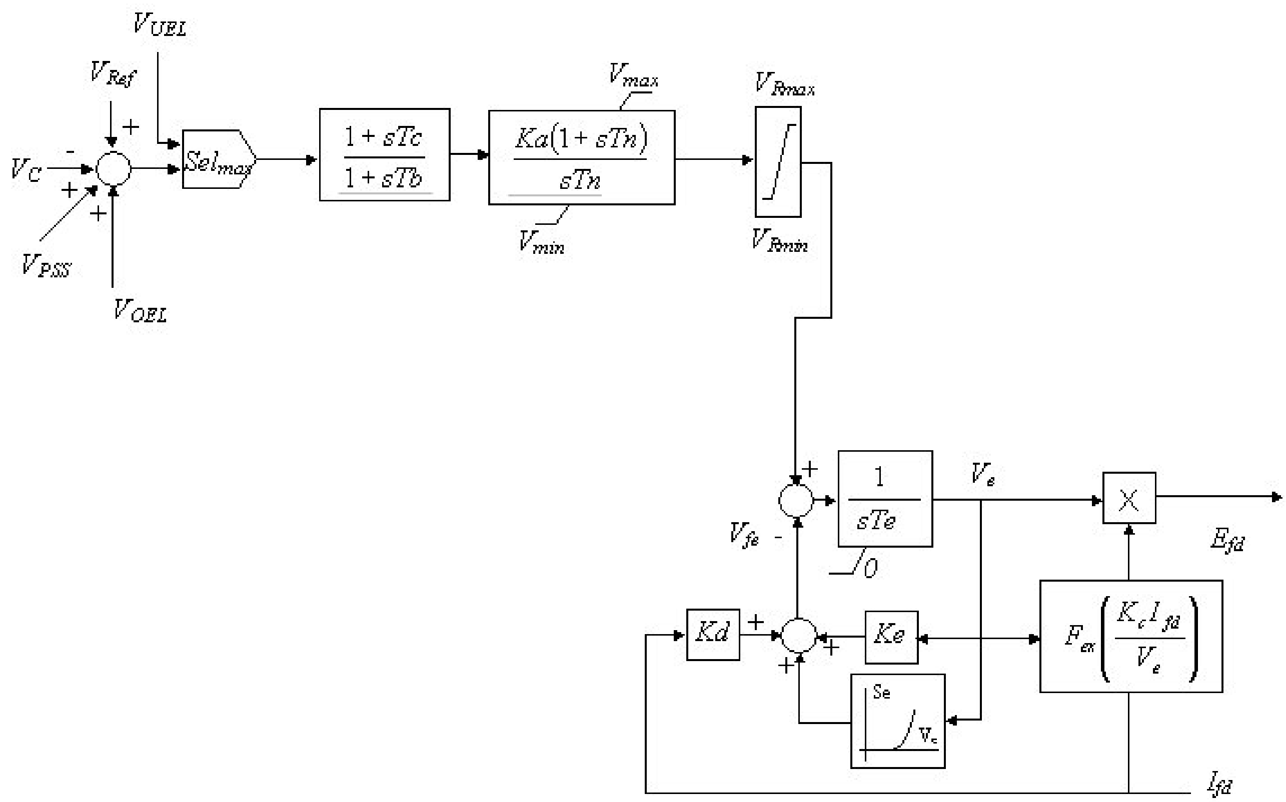
Type	Parameter	Default *(p=3)*
Real	K_a	102.
Real	T_i	5.
Real	T_e	0.8
Real	K_f(>0)	100.
Real	T_f	0.1
Real	K_c	0.2
Real	K_d	0.38
Real	K_e	1.
Real	E_1	4.18
Real	Sat(E_1)	0.1
Real	E_2	3.14
Real	Sat(E_2)	0.03
Real	VR_{max}	9.
Real	VR_{min}	-8.

Plotting variables:

Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_2 - Amplifier output before UEL selector (pu)
4	X_4
5	I_{fd}

AVR24 - Alternator-Rectifier Exciter with Noncontrolled Rectifiers and PI Control + Lead-Lag Compensation

Model Number - 24



Data format:

Type	Parameter	Default
Real	T_b	1.
Real	T_c	1.
Real	K_a	200.
Real	T_n>0*	0.02
Real	V_{max}	15.
Real	V_{min}	-15/
Real	T_e	0.8
Real	K_c	0.2
Real	K_d	0.38
Real	K_e	1.
Real	E_1	4.18
Real	Sat(E_1)	0.1
Real	E_2	3.14
Real	Sat(E_2)	0.03
Real	VR_{max}	6.
Real	VR_{min}	-5.

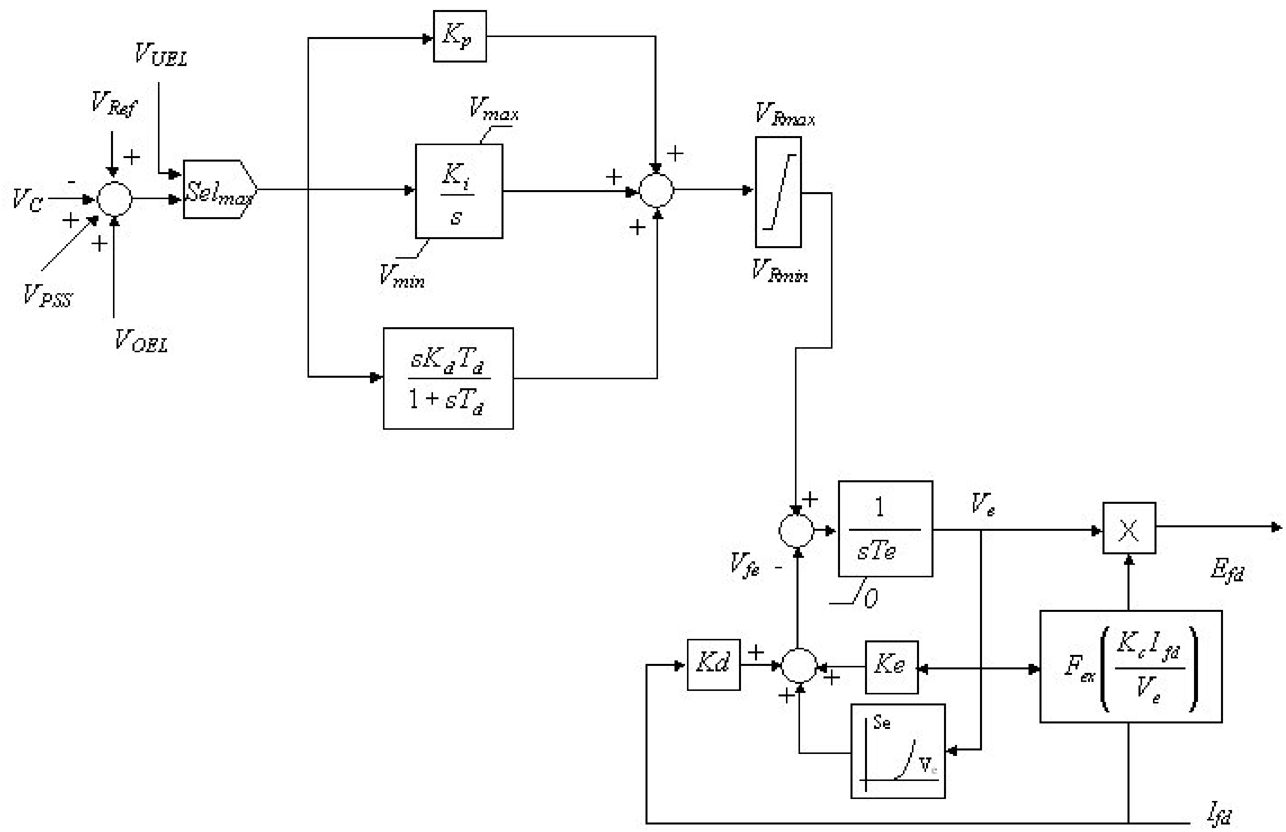
- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting variables:

Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_2 - Amplifier output before UEL selector (pu)
4	X_4
5	I_{fd}

AVR25 - Alternator-Rectifier Exciter with Noncontrolled Rectifiers and PID Control

Model Number - 25



Data format:

Type	Parameter	Default
Real	K_d	0.003
Real	T_d	0.1
Real	K_i	2.
Real	K_p	42.
Real	V_{max}	15.
Real	V_{min}	-15/
Real	T_e	0.8
Real	K_c	0.2
Real	K_d	0.38
Real	K_e	1.
Real	E_1	4.18
Real	$Sat(E_1)$	0.1
Real	E_2	3.14
Real	$Sat(E_2)$	0.03
Real	VR_{max}	6.
Real	VR_{min}	-5.

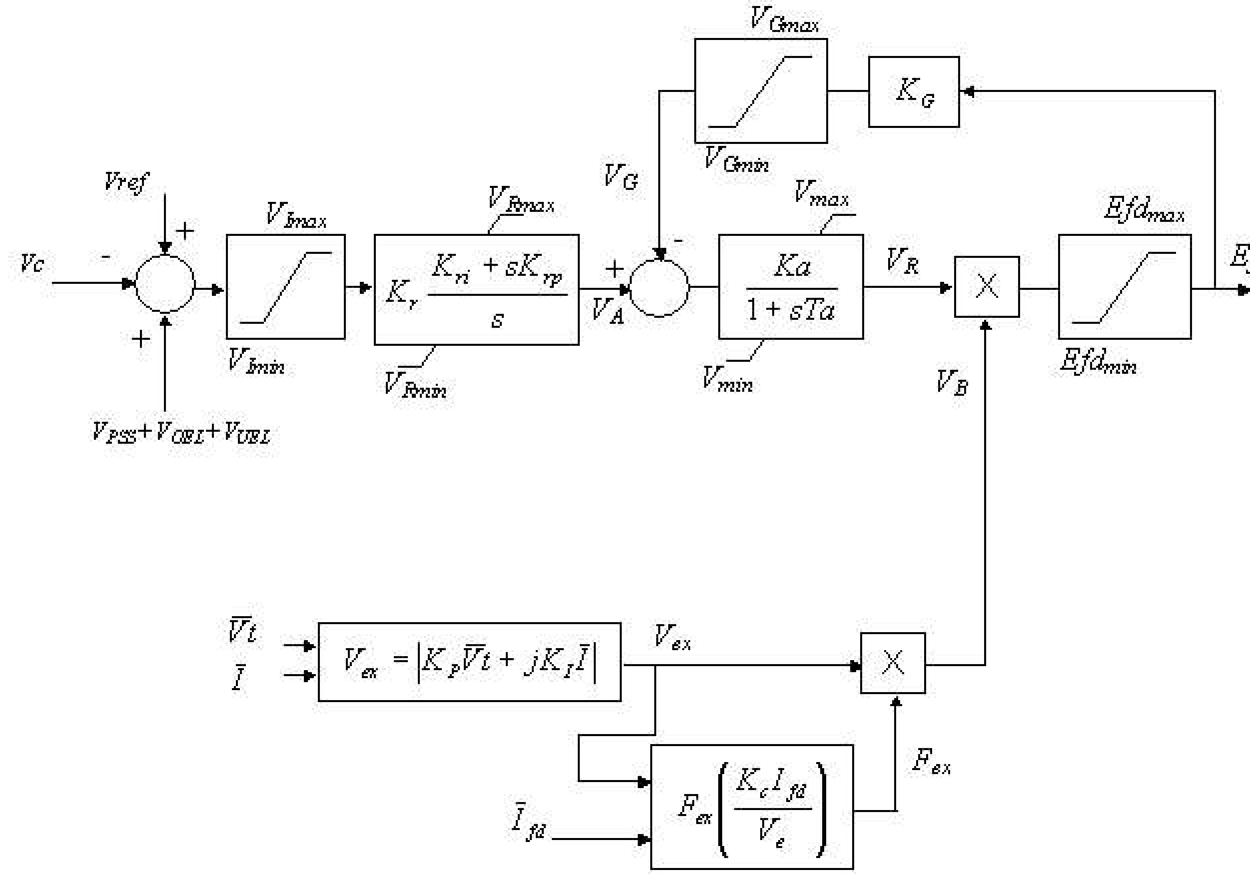
- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting variables:

Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	X_2 - Amplifier output before UEL selector (pu)
4	X_4
5	I_{fd}

AVR26 - Potential or Compound-Source Controlled-Rectifier Exciter With Field Voltage Control Loop (Based on ST3A)

Model Number - 26



Data format:

Type	Parameter	Default
Real	VI_{max}	0.2
Real	VI_{min}	-0.2
Real	K_r	20.
Real	K_{rp}	1.
Real	K_{ri}	1.
Real	K_a	8.
Real	$T_a>0^*$	0.4
Real	V_{max}	1.
Real	V_{min}	0.
Real	K_g	1.
Real	K_p	6.
Real	K_i	1.
Real	Efd_{max}	7.
Real	Efd_{min}	0.
Real	K_c	0.2
Real	V_{Gmax}	6.
Real	V_{Gmin}	0.
Real	V_{Rmax}	10.
Real	V_{Rmin}	-10.

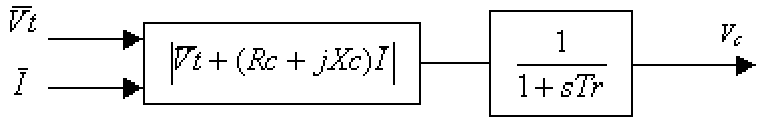
- If T_a = 0 the program will set it to the default smallest time constant value.

Plotting variables:

Var No.	Definition
1	V_{ref} - Reference Voltage (pu)
2	E_{fd} - Field Voltage (pu)
3	V_r
4	X_3
5	V_b
6	V_{ex}
7	F_{ex}
8	I_{fd}

Voltage Transducer Model

Model Transducer01



The data for the transducer is entered in the first record of Synchronous Machine data.

Power System Stabiliser - PSS Models

Models Available:

PSS01

PSS02

PSS03

PSS04

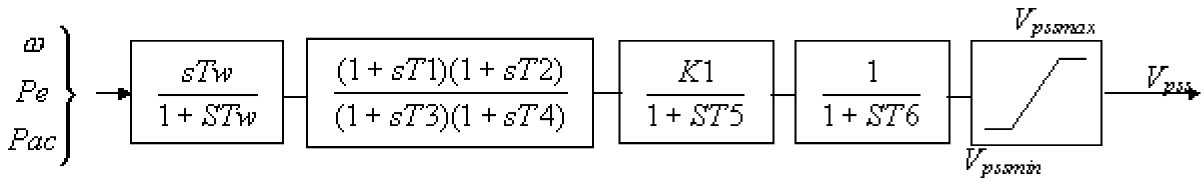
PSS05

PSS06

PSS07

PSS01 - Single Input Stabiliser

Model Number - 1



Data format:

Type	Parameter	Default
Real	T_1	
Real	T_2	
Real	T_3	
Real	T_4	
Real	T_5	
Real	T_6	
Real	T_w	
Real	K_1	
Real	V_{pssmin}	
Real	V_{pssmax}	
Integer	Type[#]	

PSS Type:

1 = rotor angular speed

2 = acelerating power

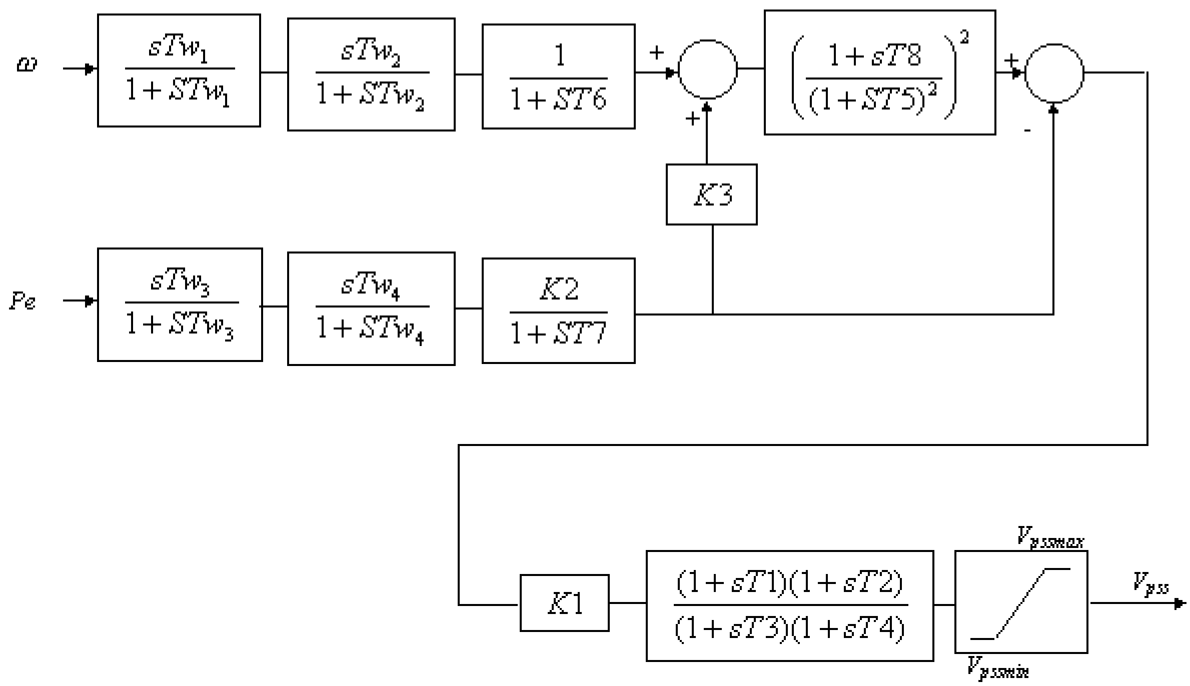
3 = electric power

Plotting variables:

Var No.	Definition
1	Pss output (pu)
2	
3	
4	

PSS02 - Dual Input Stabiliser (Based on PSS2A)

Model Number - 2



Data format:

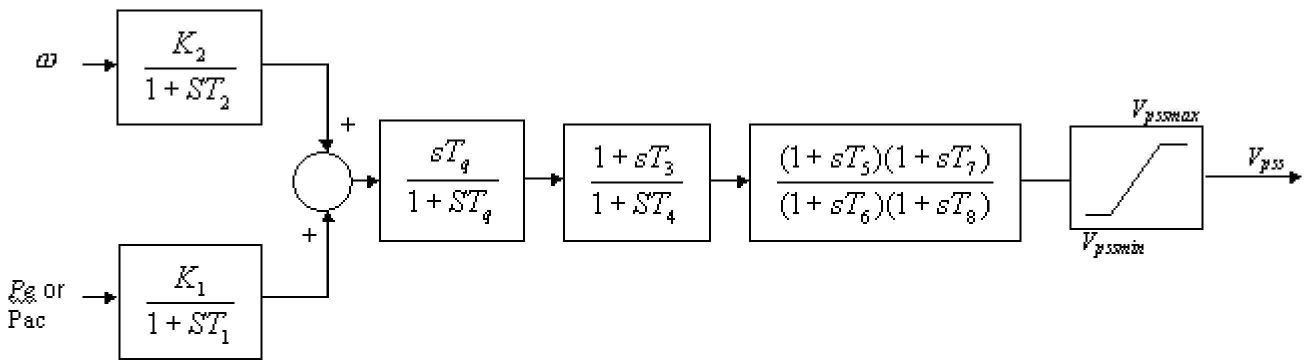
Type	Parameter	Default
Real	T_1	0.31
Real	T_2	0.01
Real	T_3	0.31
Real	T_4	0.31
Real	T_5	*0*
Real	T_6	0.01
Real	T_7	1.
Real	T_8	*0*
Real	T_{w1}	2.5
Real	T_{w2}	2.5
Real	T_{w3}	3.0
Real	T_{w4}	3.0
Real	K_1	8.
Real	K_2	*0*
Real	K_3	*0*
Real	V_{pssmin}	-0.1
Real	V_{pssmax}	0.1

Plotting variables:

Var No.	Definition
1	PSS output (pu)
2	
3	
4	

PSS03 - Dual Input Stabiliser

Model Number - 3



Data format:

Type	Parameter	Default
Real	T_1	
Real	T_2	
Real	T_3	
Real	T_4	
Real	T_5	
Real	T_6	
Real	T_7	
Real	T_8	
Real	T_w	
Real	K_1	
Real	K_2	
Real	V_{pssmin}	
Real	V_{pssmax}	
Integer	Type#	

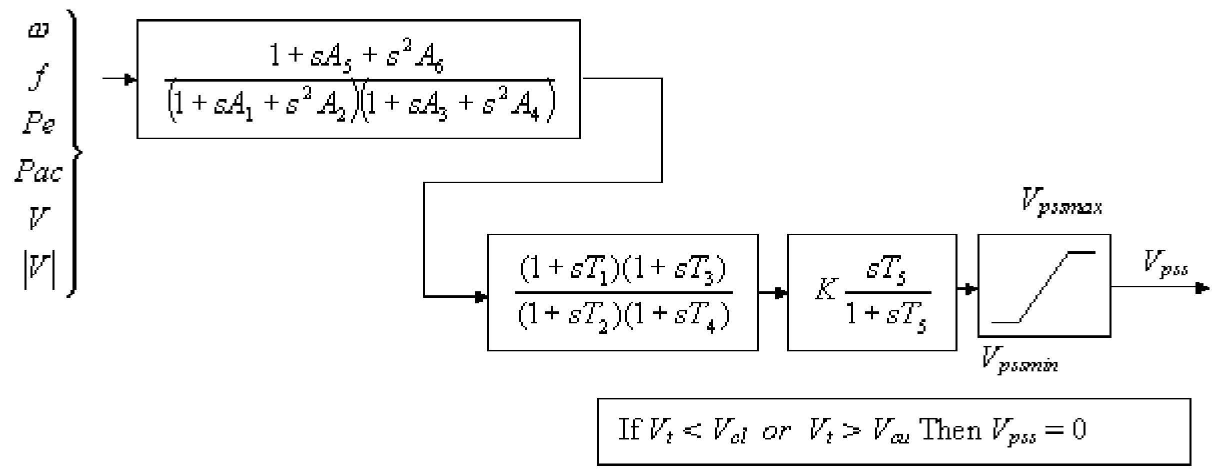
- Type 0 is for accelerating power in the first input; Type 1 is for electrical power in the first input.

Plotting variables:

Var No.	Definition
1	PSS output (pu)
2	Output of filter block K_1/T_1
3	Output of filter block K_2/T_2
4	Input of washout block T_q
5	Output of washout block T_q
6	Output of lead/lag block T_3/T_4
7	Output of lead/lag block T_5/T_6
8	Output of lead/lag block T_7/T_8

PSS04 - Single Input Stabiliser (Based on PSS1A)

Model Number – 4



Data format:

Type	Parameter	Default
Real	A_1	0.
Real	A_2	0.
Real	A_3	0.01
Real	A_4	0.
Real	A_5	0.
Real	A_6	0.
Real	T_1	0.31
Real	T_2	0.01
Real	T_3	0.31
Real	T_4	0.31
Real	T_5	2.1
Real	K	8.
Real	V_{pssmin}	-0.1
Real	V_{pssmax}	0.1
Real	V_{cu}^*	0.
Real	V_{cl}^*	0.

Integer	Type#	*1*

\# - Types available:

1 - rotor speed deviation (pu)

2 - bus frequency deviation (pu)

3 - generator electrical power on Machine Base (pu)

4 - generator accelerating power (pu)

5 - bus voltage (pu)

6 - derivative of pu bus voltage

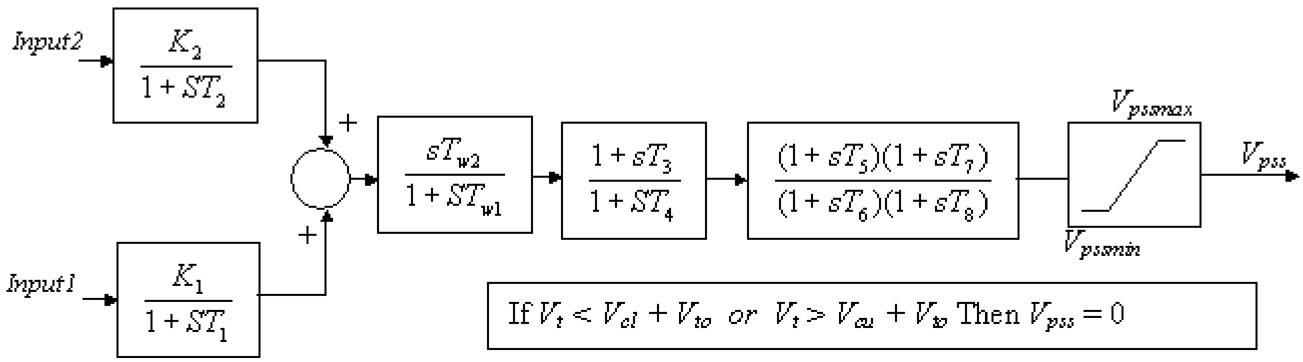
* - If equal zero, ignored

Plotting variables:

Var No.	Definition
1	PSS output (pu)

PSS05 - Dual Input Stabiliser

Model Number – 5



Data format:

Type	Parameter	Default
Integer	Type1#	*4*
Integer	Bus1	terminal
Integer	Type2#	*0*
Integer	Bus2	-
Real	T_1	0.8
Real	T_2	0.8
Real	T_{w2}	2.5
Real	T_{w1}	2.5
Real	T_3	*0*
Real	T_4	0.01
Real	T_5	1.0
Real	T_6	1.0
Real	T_7	0.4
Real	T_8	0.2
Real	K_1	8.
Real	K_2	0.
Real	V_{pssmax}	0.1
Real	V_{pssmin}	-0.1
Real	V_{cu}	*4*
Real	V_{cl}	*0*

- Types available:

1 - rotor speed deviation (pu)

2 - bus frequency deviation (pu)

3 - generator electrical power on Machine Base (pu)

4 - generator accelerating power (pu)

5 - bus voltage (pu)

6 - derivative of pu bus voltage

* - If equal zero, ignored

Plotting variables:

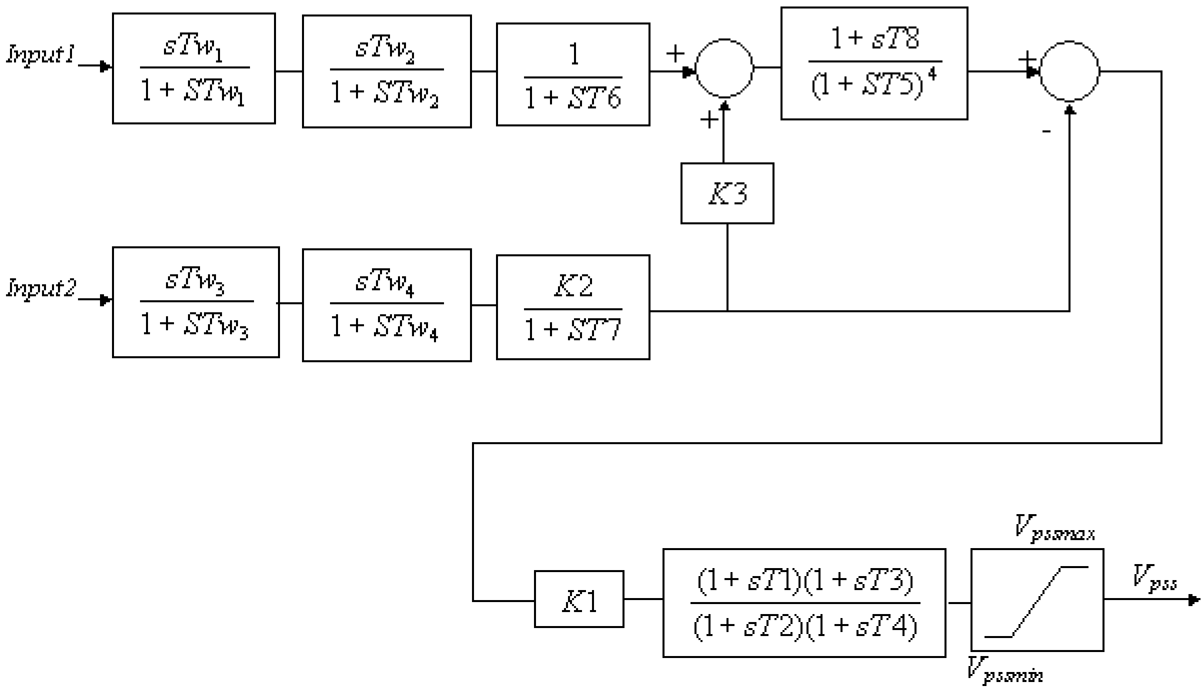
Var No.	Definition
1	PSS output (pu)
2	Output of filter block K_1/T_1
3	Output of filter block K_2/T_2
4	Input of washout block T_q
5	Output of washout block T_q
6	Output of lead/lag block T_3/T_4
7	Output of lead/lag block T_5/T_6
8	Output of lead/lag block T_7/T_8

Example: (PSS output of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
PSS	1	100	1

PSS06 - Dual Input Stabiliser (Based on PSS2A)

Model Number - 6



Data format:

Type	Parameter	Default
Real	T_1	0.31
Real	T_2	0.01
Real	T_3	0.31
Real	T_4	0.31
Real	T_5	*0*
Real	T_6	0.01
Real	T_7	1.
Real	T_8	0.
Real	T_{w1}	2.5
Real	T_{w2}	2.5
Real	T_{w3}	3.
Real	T_{w4}	3.
Real	K_1	*8*
Real	K_2	*0*
Real	K_3	*0*
Real	V_{min}	-0.1
Real	V_{max}	0.1
Integer	Type Input1#	*1*
Integer	Type Input2#	*3*

- Types available:

1 - rotor speed deviation (pu)

2 - bus frequency deviation (pu)

3 - generator electrical power on Machine Base (pu)

4 - generator accelerating power (pu)

5 - bus voltage (pu)

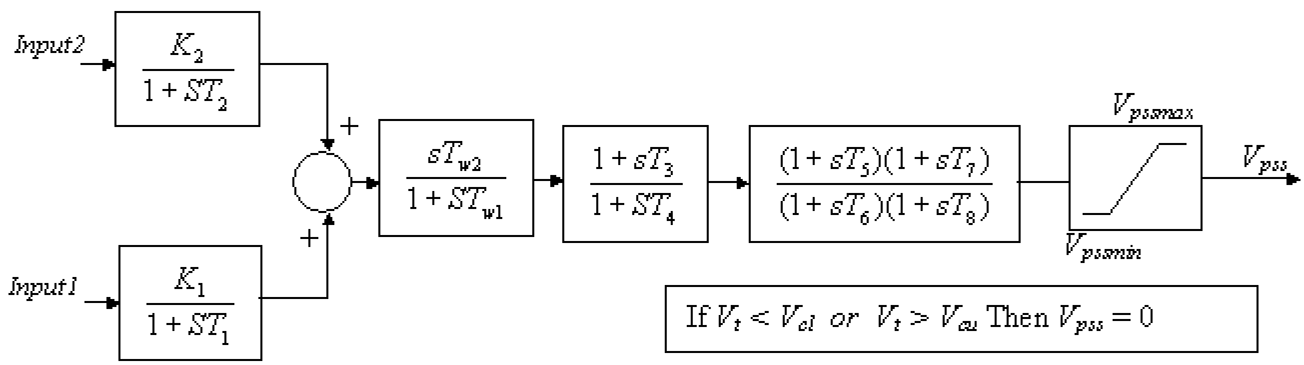
6 - derivative of pu bus voltage

Plotting variables:

Var No.	Definition
1	PSS output (pu)
2	
3	
4	

PSS07 - Single Input Stabiliser

Model Number - 5



Data format:

Type	Parameter	Default
Integer	Type1#	*4*
Integer	Bus1	terminal
Integer	Type2#	*0*
Integer	Bus2	-
Real	T_1	0.8
Real	T_2	0.8
Real	T_{w2}	2.5
Real	T_{w1}	2.5
Real	T_3	*0*
Real	T_4	0.01
Real	T_5	1.
Real	T_6	1.
Real	T_7	0.4
Real	T_8	0.2
Real	K_1	8.
Real	K_2	0.
Real	V_{max}	0.1
Real	V_{min}	-0.1
Real	V_{cu} (pu)*	4.
Real	V_{cl} (pu)*	*0*

- Types available:

1 - rotor speed deviation (pu)

2 - bus frequency deviation (pu)

3 - generator electrical power on Machine Base (pu)

4 - generator accelerating power (pu)

5 - bus voltage (pu)

6 - derivative of pu bus voltage

*- If equal zero, ignored.

Plotting variables:

Var No.	Definition
1	PSS output (pu)
2	Output of filter block K_1/T_1
3	Output of filter block K_2/T_2
4	Input of washout block T_q
5	Output of washout block T_q
6	Output of lead/lag block T_3/T_4
7	Output of lead/lag block T_5/T_6
8	Output of lead/lag block T_7/T_8

Overexcitation Limiter - OEL Models

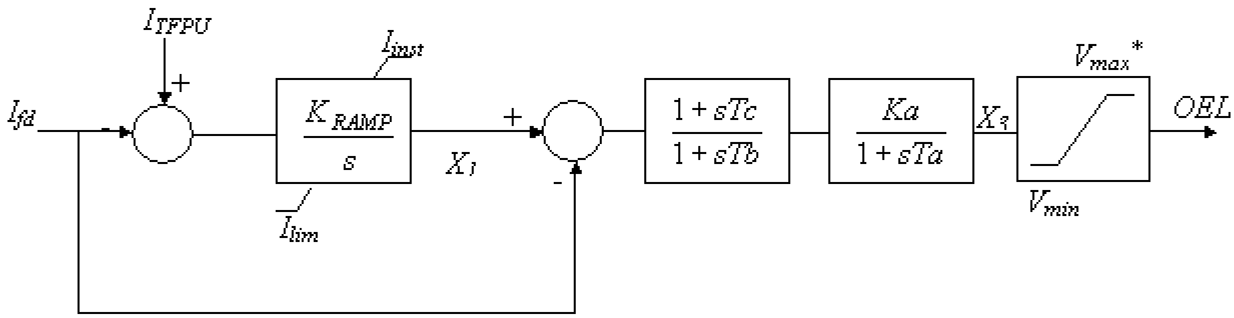
Models Available:

OEL01

OEL02

OEL01

Model Number - 1



Data format:

Type	Parameter	Default
Real	I_{TFPU}	
Real	I_{inst}	
Real	I_{lim}	
Real	K_{ramp}	
Real	K_a	
Real	T_a	
Real	T_b	
Real	T_c	
Real	V_{min}	

* Note: V_{max} is calculated according to the type of connection to the AVR. If it is a LV gate selector, V_{max} is set to 10^{10}. If it is a summing connection, V_{max} is set to 0.

Plotting variables:

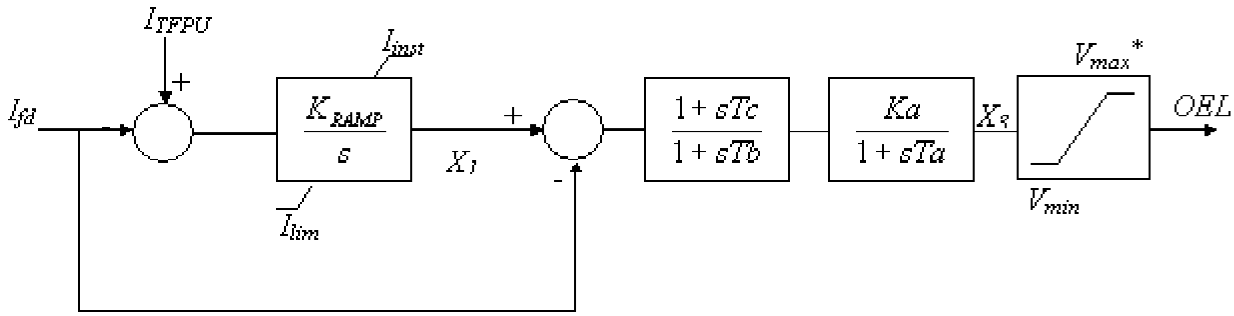
Var No.	Definition
1	OEL output (pu)
2	Input of Lead/Lag block *Tc/Tb*
3	Output of Lead/Lag block *Tc/Tb*

Example: (OEL output of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
OEL	1	100	1

OEL02

Model Number - 2



Data format:

Type	Parameter	Default
Real	P_{max}#	0.8*Base
Real	Q_{max}#	0.6*Base
Real	α #	1.05
Real	β #	1.6
Real	K_{ramp}	0.02
Real	K_a	20.
Real	T_a	0.1
Real	T_b	1.
Real	T_c	1.
Real	V_{min}	-10.

#Note: In this model I_{TFPU} is calculated based on the values of *Pmax*, and *Qmax*. I_{lim} and I_{inst} are determined by

$I_{lim} = \alpha I_{TFPU}$; $I_{inst} = \beta I_{TFPU}$

* Note: V_{max} is calculated according to the type of connection to the AVR. If it is a LV gate selector, V_{max} is set to 10^{10}. If it is a summing connection, V_{max} is set to 0.

Plotting variables:

Var No.	Definition
1	OEL output (pu)
2	Input of Lead/Lag block *Tc/Tb*
3	Output of Lead/Lag block *Tc/Tb*

Underexcitation Limiter Models

Models Available

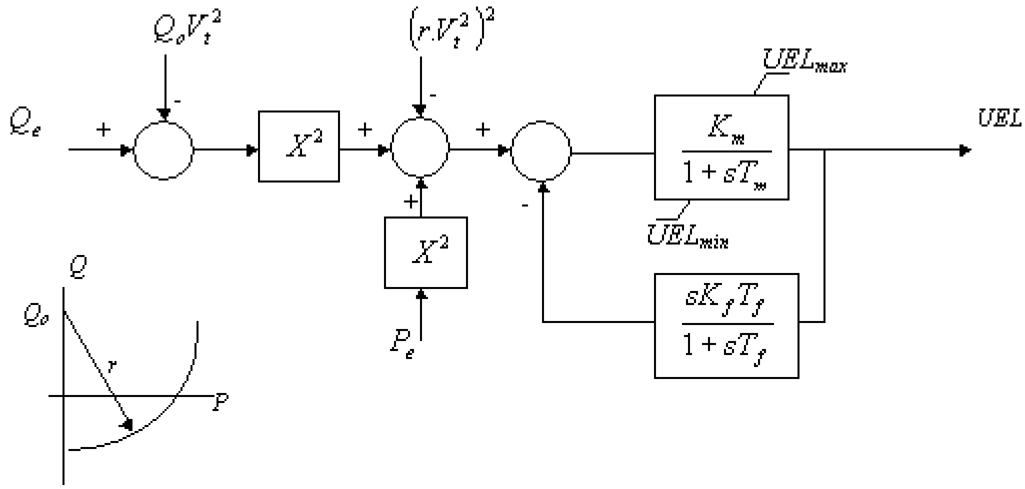
UEL01

UEL02

UEL03

UEL01

Model Number - 1



Data format:

Type	Parameter
Real	K_f
Real	T_f
Real	K_m
Real	T_m
Real	UEL_{min}*
Real	UEL_{max}
Real	Q_o
Real	*r*

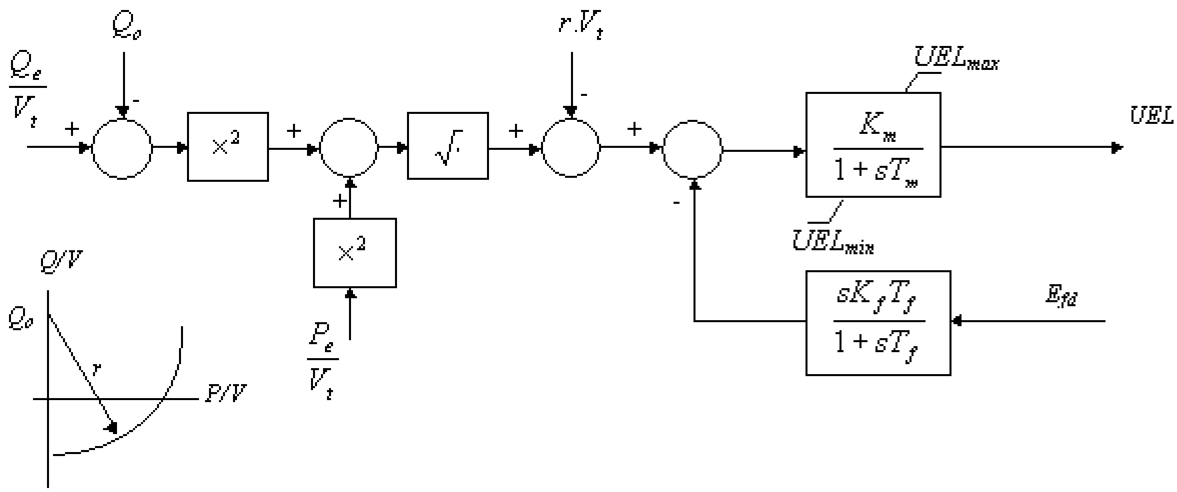
* - If the UEL output is connected to a summing junction instead of a maximum selector, the UELmin limit must be 0. Otherwise, the UEL would affect the voltage control when it should not.

Plotting variables:

Var No.	Definition
1	UEL output (pu)
2	Output of feedback block K_f/T_f
3	$(Q - Qo.V^2)^2 + P^2 - (rV^2)^2$
4	$(Q - Qo.V^2)^2$

UEL03

Model Number - 3



Data format:

Type	Parameter
Real	K_f
Real	T_f
Real	K_m
Real	T_m
Real	UEL_{min} *
Real	UEL_{max}
Real	Q_o (center of curve for 1 pu voltage)
Real	*r*

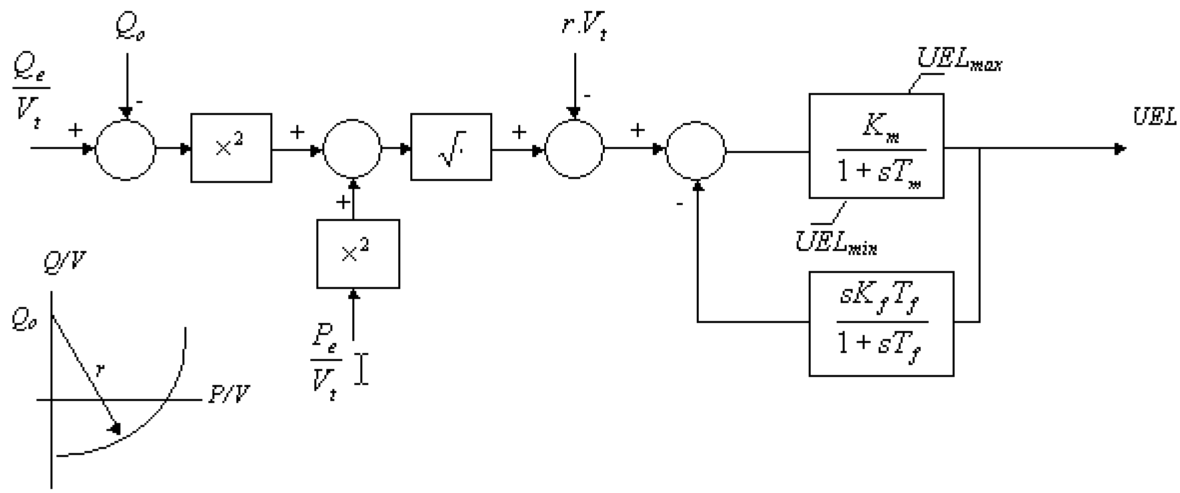
* - If the UEL output is connected to a summing junction instead of a maximum selector, the UELmin limit must be 0. Otherwise, the UEL would affect the voltage control when it should not.

Plotting variables:

Var No.	Definition
1	UEL output (pu)
2	Output of feedback block K_f/T_f
3	$(Q - Qo.V^2)^2 + P^2 - (rV^2)^2$
4	$(Q - Qo.V^2)^2$

UEL02

Model Number - 2



Data format:

Type	Parameter
Real	K_f
Real	T_f
Real	K_m
Real	T_m
Real	UEL_{min} *
Real	UEL_{max}
Real	Q_o (center of curve for 1 pu voltage)
Real	r

* - If the UEL output is connected to a summing junction instead of a maximum selector, the UELmin limit must be 0. Otherwise, the UEL would affect the voltage control when it should not.

Plotting variables:

Var No.	Definition
1	UEL output (pu)
2	Output of feedback block K_f/T_f
3	Sqrt($(Q - Qo.V^2)^2 + P^2 - (rV^2)^2$)
4	$(Q - Qo.V^2)^2$

Example: (UEL output of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
UEL	1	100	1

Governor Models

Models Available:

GOV01

GOV02

GOV03

GOV04

GOV05

GOV06

GOV07

GOV08

GOV09

GOV10

GOV11

GOV12

GOV13

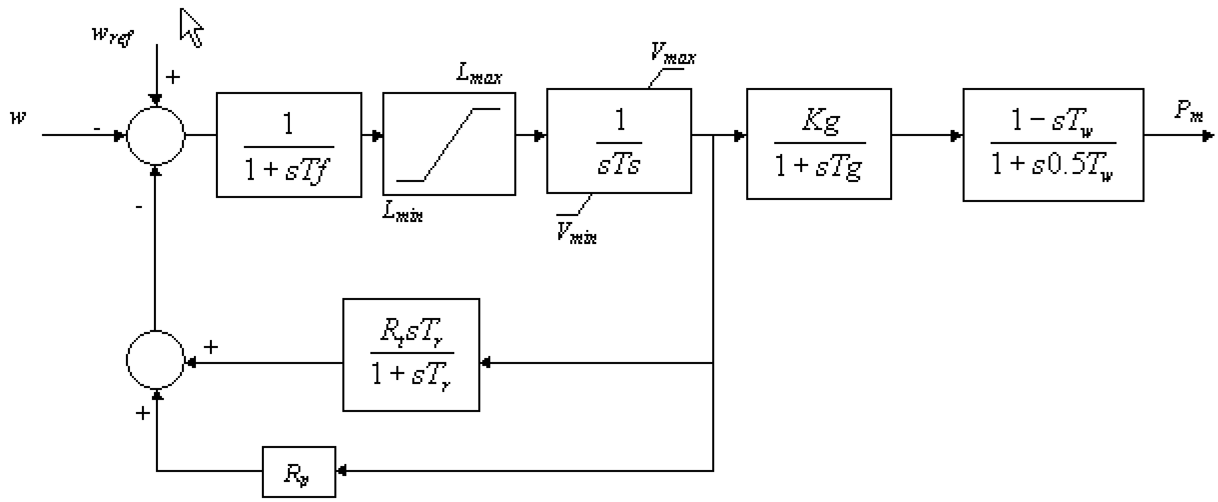
GOV14

GOV15

GOV16

GOV01 - Hydro Governor with Linear Turbine

Model Number - 1



Data format:

Type	Parameter	Default
Real	K_g	1.
Real	T_g	0.5
Real	T_w	2.8
Real	R_t	Formulae 1
Real	T_r	Formulae 2
Real	R_p	0.05
Real	T_s(>0)	0.2
Real	T_f	0.05
Real	L_{min}	-0.15
Real	L_{max}	0.15
Real	V_{min}	0.01
Real	V_{max}	3.0

Formulae 1 : $(2.3-(T_w-1.)*0.15)*T_w/H$ Formulae 2: $(5-(T_w-1.)*0.5)*T_w$

Plotting variables:

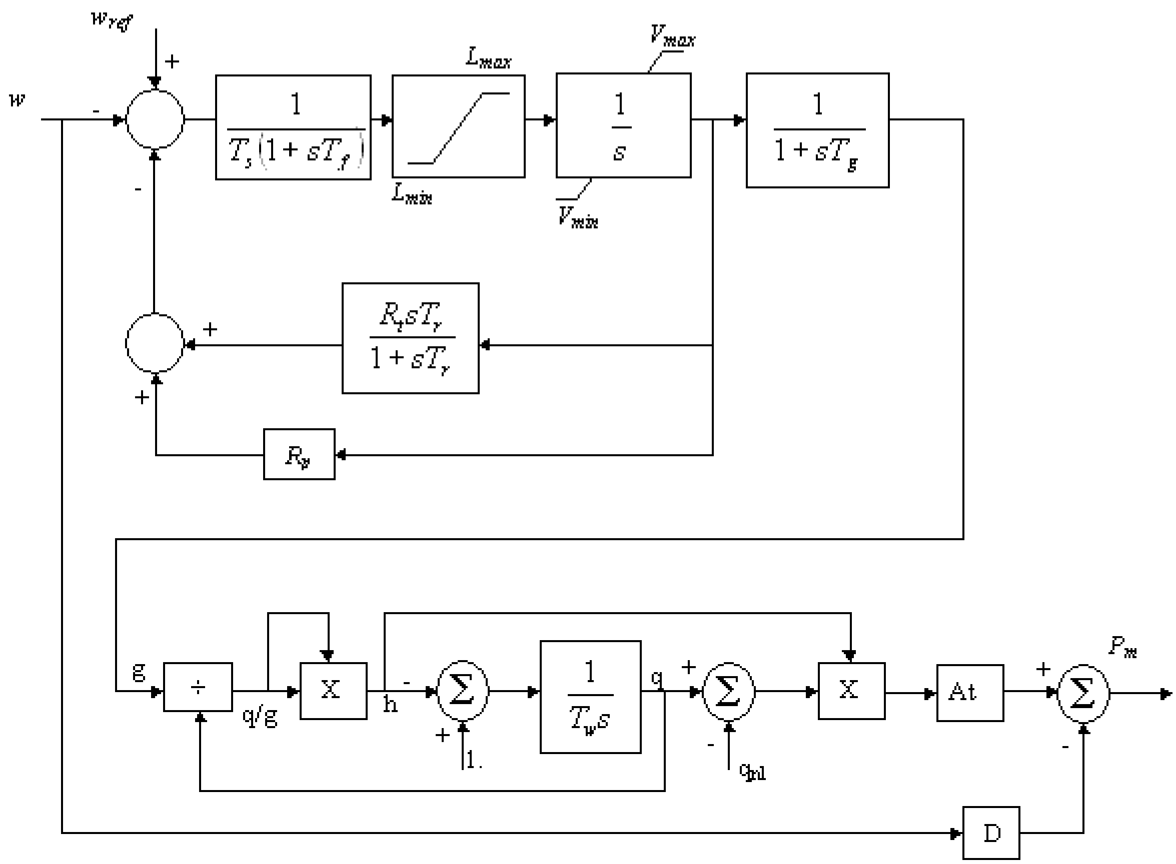
Var No.	Definition
1	Reference speed
2	P_m - Mechanical power
3	Output of integrator (pilot valve)
4	Output of block K_g/T_g (gate position)

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV02 - Hydro Governor with Non-linear Turbine

Model Number - 2



Data format

Type	Parameter	Default
Real	A_t	1.
Real	T_g	0.5
Real	T_w	2.8
Real	R_t	Formulae 1
Real	T_r	Formulae 2
Real	R_p	0.05
Real	T_s(>0)	0.2
Real	T_f	0.05
Real	L_{min}	-0.15
Real	L_{max}	0.15
Real	V_{min}	0.01
Real	V_{max}	1.
Real	q_{nl}	0.05
Real	*D*	0.

Formulae 1 : $(2.3-(T_w-1.)*0.15)*T_w/H$ Formulae 2: $(5-(T_w-1.)*0.5)*T_w$

Plotting variables:

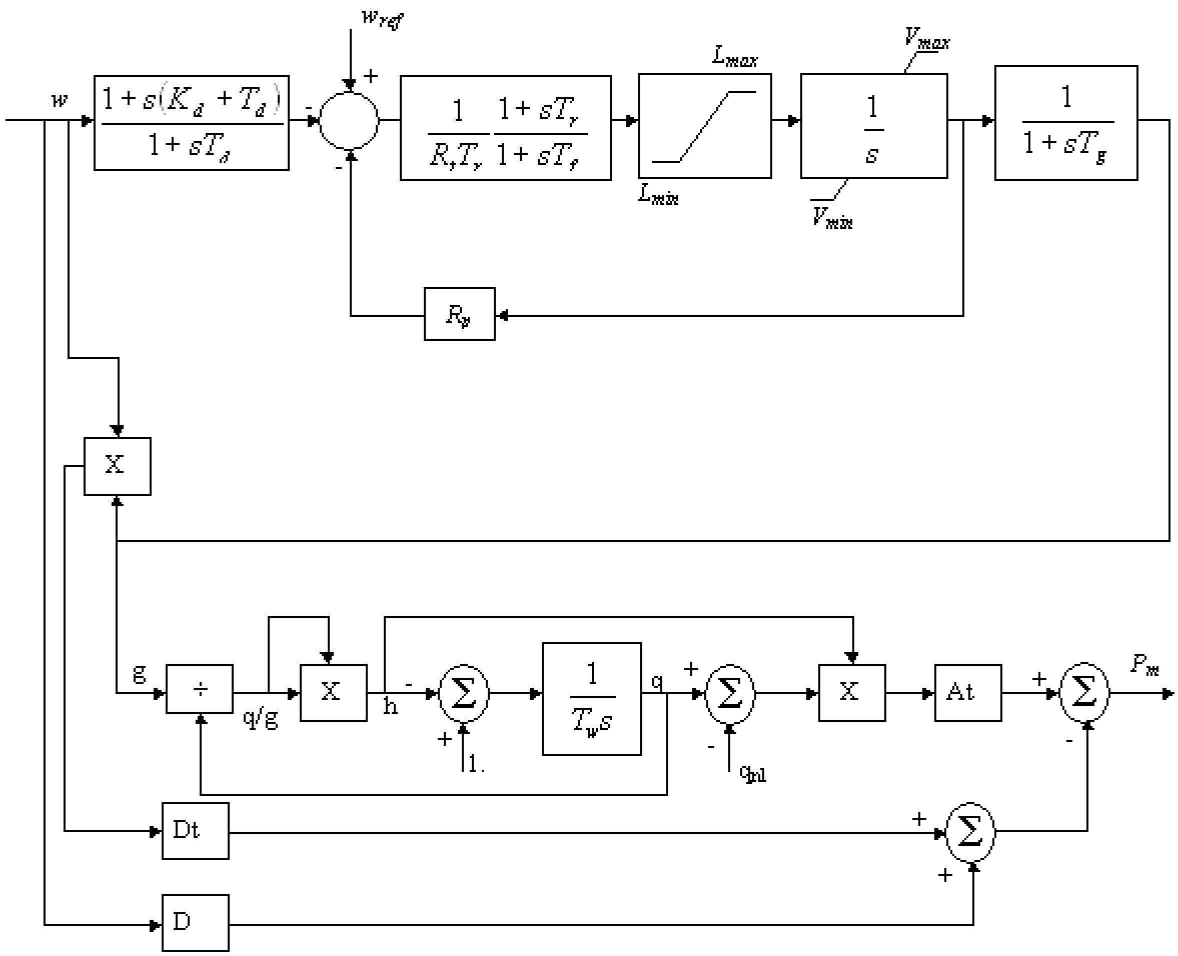
Var No.	Definition
1	Reference speed
2	P_m - Mechanical power
3	Output of integrator (pilot valve)
4	Output of block K_g/T_g (gate position)

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV03 - Hydro Governor with Non-Linear Turbine

Model Number - 3



Models that represent the temporary droop compensation as a feedback (Figure below) instead of cascade can be converted to the above representation using the following relationship.

$T_f = \dfrac{T_r T_s}{T_s + r T_r}$, and

$R_t = \dfrac{T_s}{T_r} + r$

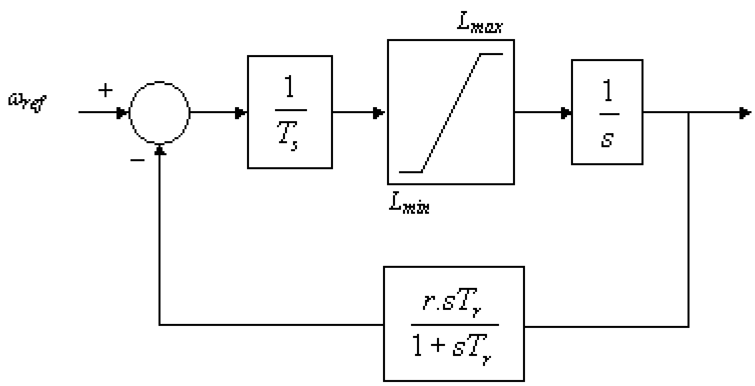


Figure – Feedback droop compensation.

Data format:

Type	Parameter	Default
Real	A_t	1.
Real	T_g	0.5
Real	T_w	2.8
Real	R_t(>0)	Formulae 1
Real	T_r(>0)	Formulae 2
Real	R_p	0.05
Real	T_f	0.2
Real	L_{min}	-0.15
Real	L_{max}	0.15
Real	V_{min}	0.01
Real	V_{max}	1.
Real	q_{nl}	0.05
Real	K_d	*0*
Real	T_d	1.
Real	D_t	0.
Real	*D*	0.

Formulae 1 : $(2.3-(T_w-1.)*0.15)*T_w/H$; Formulae 2: $(5-(T_w-1.)*0.5)*T_w$

Plotting variables:

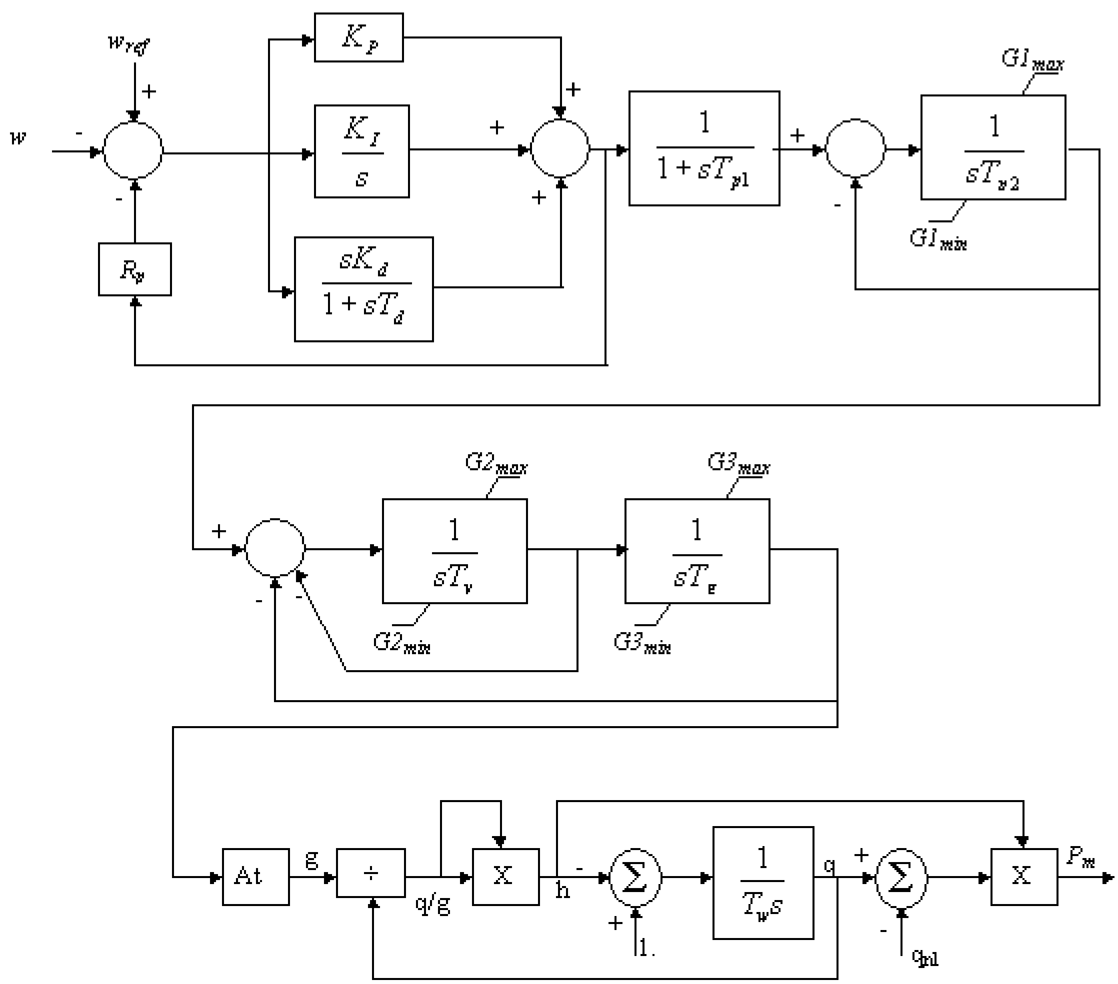
Var No.	Definition
1	Reference speed
2	Pm - Mechanical power
3	Output of integrator (pilot valve)
4	Output of block K_g/T_g (gate position)

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV04 - PID Hydro Governor with Position Feedback – Non-Linear Turbine

Model Number - 4



Data format:

Type	Parameter	Default
Real	R_p	0.05
Real	K_p	Formulae 1
Real	K_i	Formulae 2
Real	K_d	*0*
Real	T_d	0.5
Real	T_{p1}	0.2
Real	T_{p2} (>0)	0.1
Real	G_{1min}	-1.
Real	G_{1max}	1.
Real	T_v (>0)	0.2
Real	G_{2min}	-0.2
Real	G_{2max}	0.2.
Real	T_q (>0)	1.
Real	G_{3min}	0.01
Real	G_{3max}	1.
Real	T_w	2.8
Real	A_t	1.1
Real	q_{nl}	0.05

Formulae 1 : H/(2.3-(T_w-1.)*0.15)*T_w; Formulae 2: H/((2.3-(T_w-1.)*0.15)*(5-(T_w-1.)*0.5)*T_w**2)

Plotting variables:

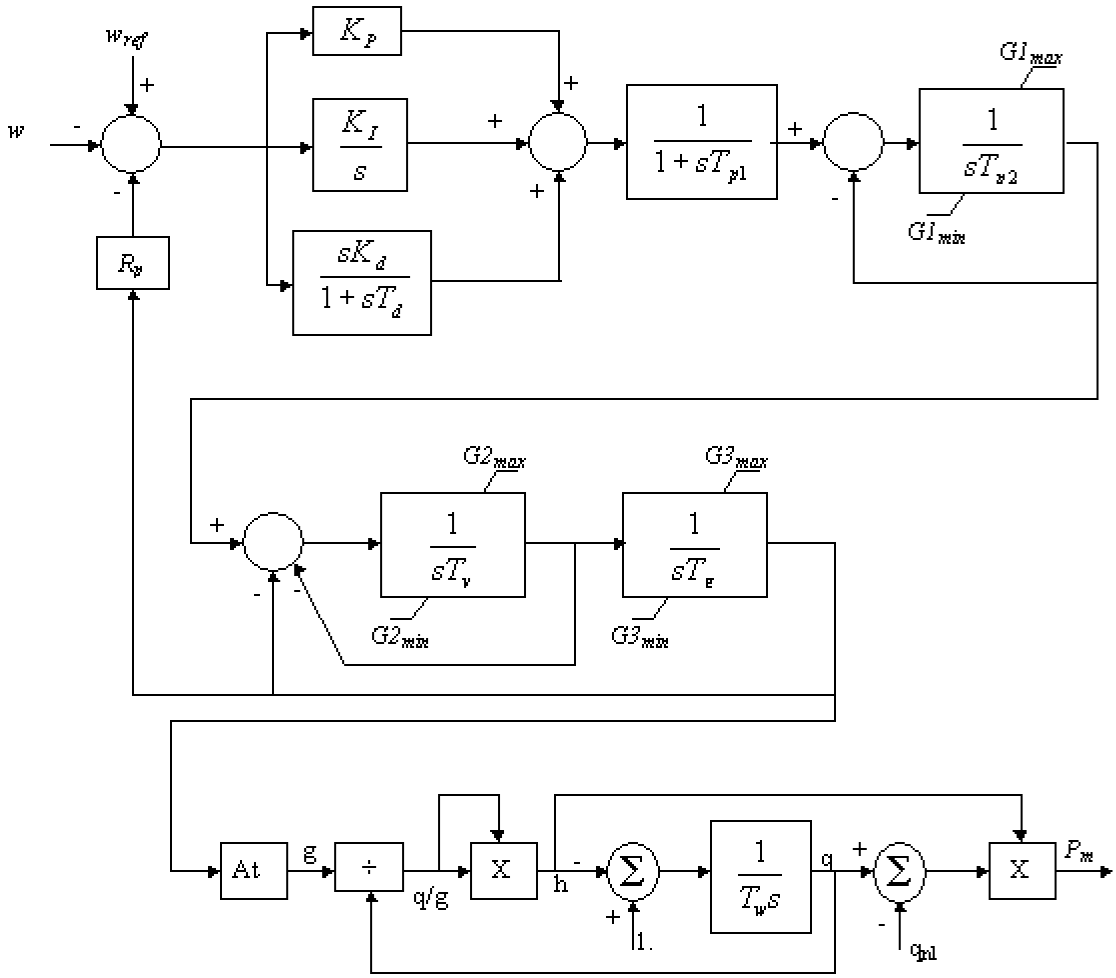
Var No.	Definition
1	Reference speed
2	P_m - Mechanical power
3	Output of block $1/sT_{p2}$ (pilot valve)
4	Output of block $1/sT_g$ (gate position)

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV05 - PID Hydro Governor with Gate Feedback - Non-Linear Turbine

Model Number - 5



Data format:

Type	Parameter	Default
Real	R_p	0.05
Real	K_p	Formulae 1
Real	K_i	Formulae 2
Real	K_d	*0*
Real	T_d	0.5
Real	T_{p1}	0.2
Real	T_{p2} (>0)	0.1
Real	G_{1min}	-1.
Real	G_{1max}	1.
Real	T_v (>0)	0.2
Real	G_{2min}	-0.2
Real	G_{2max}	0.2
Real	T_q (>0)	1.
Real	G_{3min}	0.01
Real	G_{3max}	1.
Real	T_w	2.8
Real	A_t	1.1
Real	q_{nl}	0.05

Formulae 1 : H/(2.3-(T_w-1.)*0.15)*T_w; Formulae 2: H/((2.3-(T_w-1.)*0.15)*(5-(T_w-1.)*0.5)*T_w**2)

Plotting variables:

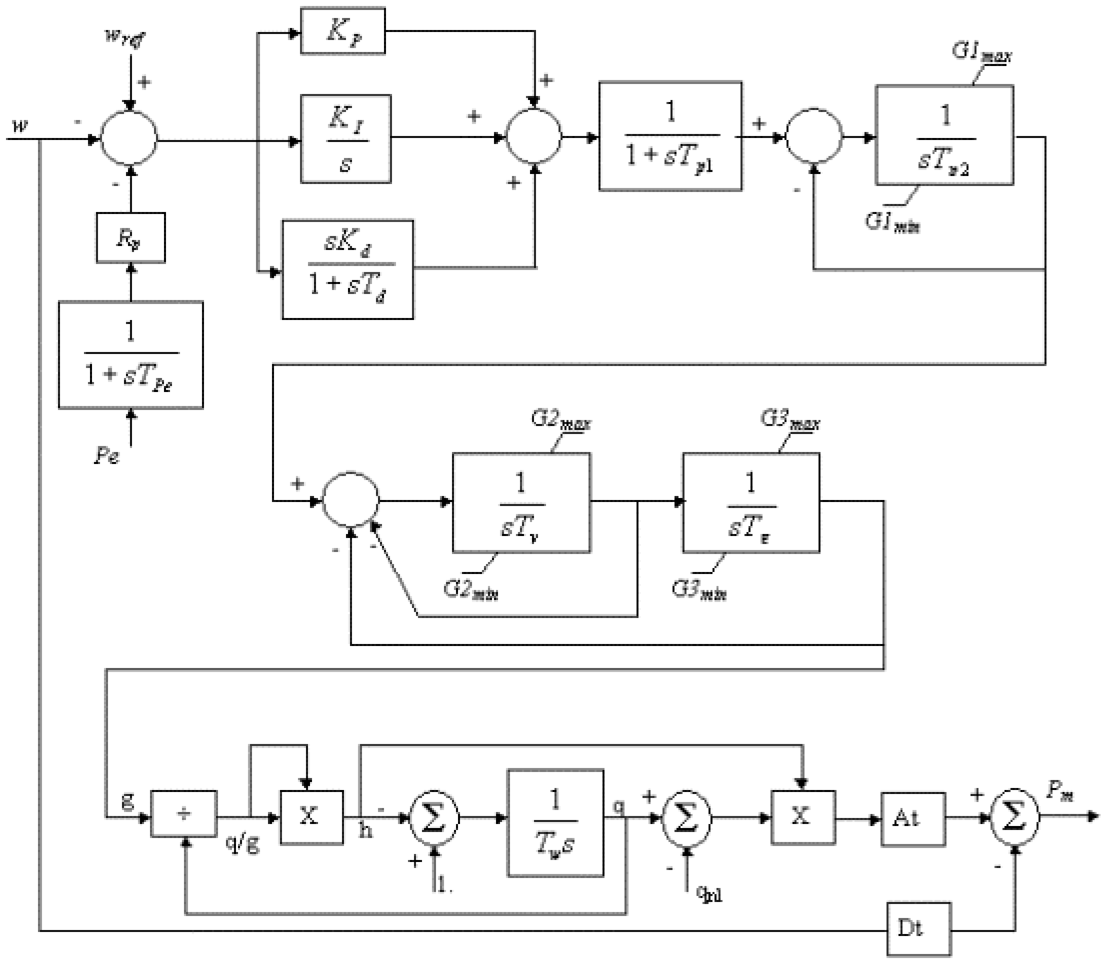
Var No.	Definition
1	Reference speed
2	P_m - Mechanical power
3	Output of block $1/sT_{p2}$ (pilot valve)
4	Output of block $1/sT_g$ (gate position)

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV06 - PID Hydro Governor with Electric Power Feedback - Non-Linear Turbine

Model Number - 6



Data format:

Type	Parameter	Default
Real	R_p	0.05
Real	T_e	1.
Real	K_p	Formulae 1
Real	K_i	Formulae 2
Real	K_d	*0*
Real	T_d	0.5
Real	T_{p1}	0.2
Real	T_{p2} (>0)	0.1
Real	G_{1min}	-1.0
Real	G_{1max}	1.0
Real	T_v (>0)	0.2
Real	G_{2min}	-0.2
Real	G_{2max}	0.2
Real	T_q (>0)	1.
Real	G_{3min}	0.01
Real	G_{3max}	1.
Real	T_w	2.8
Real	A_t	1.1
Real	q_{nl}	0.05
Real	D_t	0.

Formulae 1 : H/(2.3-(T_w-1.)*0.15)*T_w; Formulae 2: H/((2.3-(T_w-1.)*0.15)*(5-(T_w-1.)*0.5)*T_w**2)

Plotting variables:

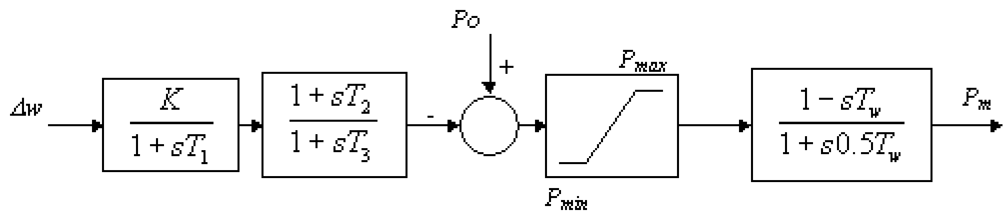
Var No.	Definition
1	Reference speed
2	P_m - Mechanical power
3	Output of block $1/sT_{p2}$ (pilot valve)
4	Output of block $1/sT_g$ (gate position)

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV07 - Simplified Hydro Governor - Linear Turbine

Model Number - 7



Data format:

Type	Parameter	Default
Real	*K*	20.
Real	T_1 (sec)	0.5
Real	T_2(sec)	Formulae 2
Real	T_3 (>0) (sec)	Formulae 1
Real	P_{max} (pu on machine MVA rating)	*0*
Real	P_{min} (pu on machine MVA rating)	*1*
Real	T_w (>0) (sec), water starting time	2.8

Formulae 1 : ((5-(T_w-1.)*0.5)*(2.3-(T_w-1.)*0.15)*T_w**2)/H; Formulae 2: (5-(T_w-1.)*0.5)*T_w

Plotting variables:

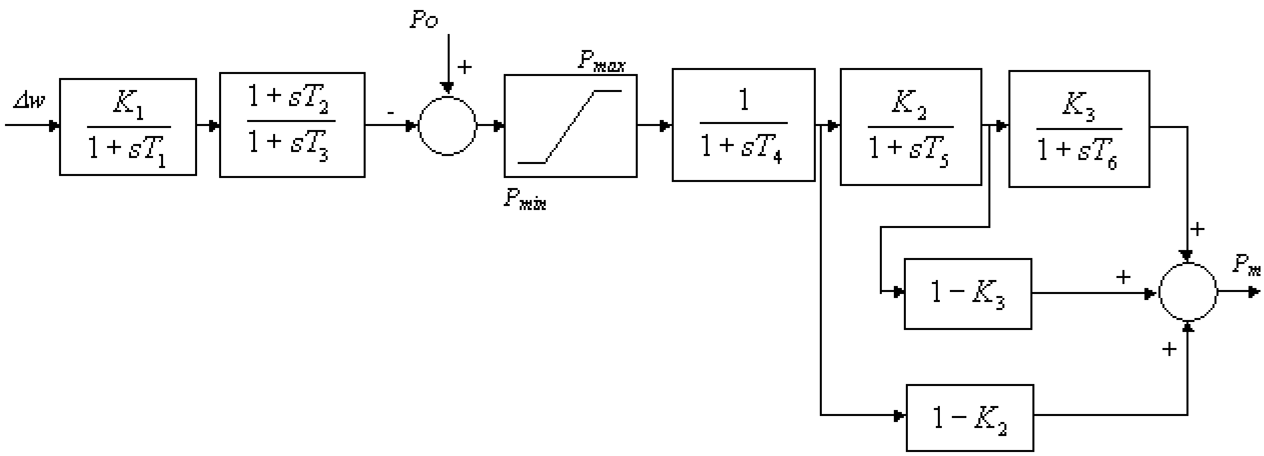
Var No.	Definition
1	Reference speed
2	P_m - Mechanical power
3	Output of limiting block (gate position)

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV08 - Steam Governor and Turbine

Model Number - 8



Data format:

Type	Parameter	Default
Real	T_1 (sec)	0.2
Real	T_2(sec)	*0*
Real	T_3 (>0) (sec)	0.3
Real	T_4 (sec)	0.4
Real	T_5 (sec)	*4*
Real	T_6 (sec)	0.7
Real	K_1 (1/pu)	20
Real	K_2, fraction	0.25
Real	K_3, fraction	0.5
Real	P_{max} (pu on machine MVA rating)	*1*
Real	P_{min} (pu on machine MVA rating)	*0*

Plotting variables:

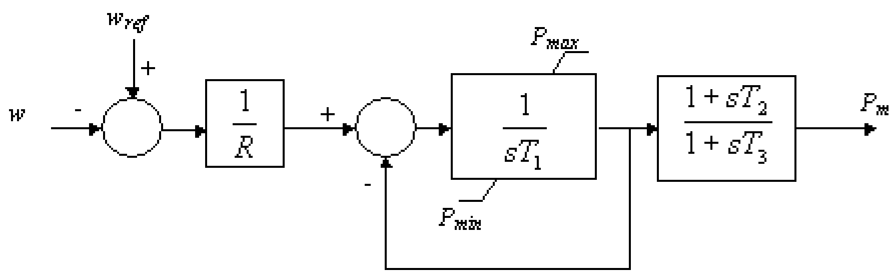
Var No.	Definition
1	Reference speed
2	Pm - Mechanical power
3	Output of limiting block (gate position)
4	Turbine power, output of block $1/T_4$ (pu)
5	Turbine power, output of block K_2/T_5 (pu)
6	Turbine power, output of block K_3/T_6 (pu)

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV09 - Simplified Steam Governor and Turbine

Model Number - 9



Data format:

Type	Parameter	Default
Real	R (>0)	0.05
Real	T_1 (>0) (sec)	0.5
Real	P_{max} (pu on machine MVA rating)	*1*
Real	P_{min} (pu on machine MVA rating)	*0*
Real	T_2 (sec)	*2*
Real	T_3 (>0) (sec)	*6*

Plotting variables:

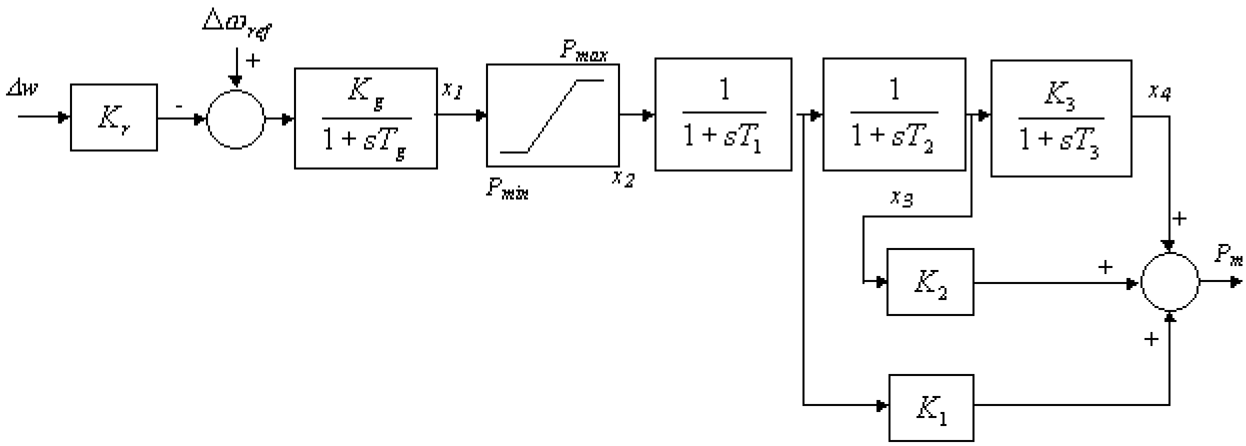
Var No.	Definition
1	Reference speed
2	P_m - Mechanical power
3	Output of block $1/T_1$ (gate position)

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV10 - Generic Steam Turbine

Model Number - 10



Data format:

Type	Parameter	Default
Real	K_g	20
Real	T_g(sec)	0.5
Real	K_r	*1*
Real	K_1	0.25
Real	T_1 (sec)	0.4
Real	K_2	0.5
Real	T_2 (sec)	*4*
Real	K_3	0.25
Real	T_3 (sec)	0.7
Real	P_{min} (pu on machine MVA rating)	*0*
Real	P_{max} (pu on machine MVA rating)	*1*

Plotting variables:

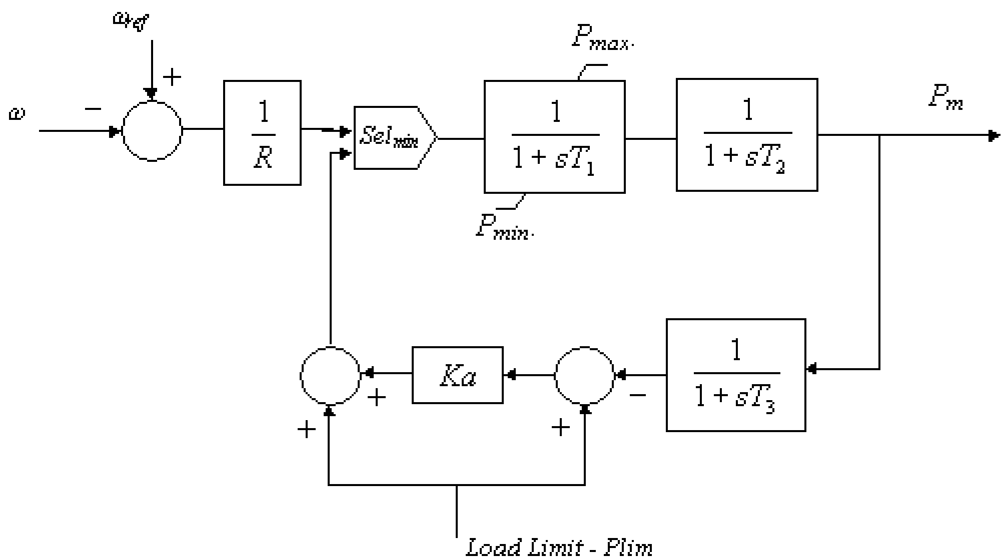
Var No.	Definition
1	Reference speed
2	Pm - Mechanical power
3	Output of the governor (state variable x_1)
4	State variable x_2
5	State variable x_3
6	State variable x_4

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV11 - Gas Turbine-Governor

Model Number - 11



Data format:

Type	Parameter	Default
Real	R (permanent speed droop) (>0)	0.05
Real	T_1(sec) (>0)	0.5
Real	T_2 (sec)	2.0
Real	T_3 (sec)	10.
Real	P_{lim} (Ambient Temperature Load Limit)	1.
Real	K_a	50
Real	P_{max} (pu on machine MVA rating)	*1*
Real	P_{min} (pu on machine MVA rating)	*0*

Plotting variables:

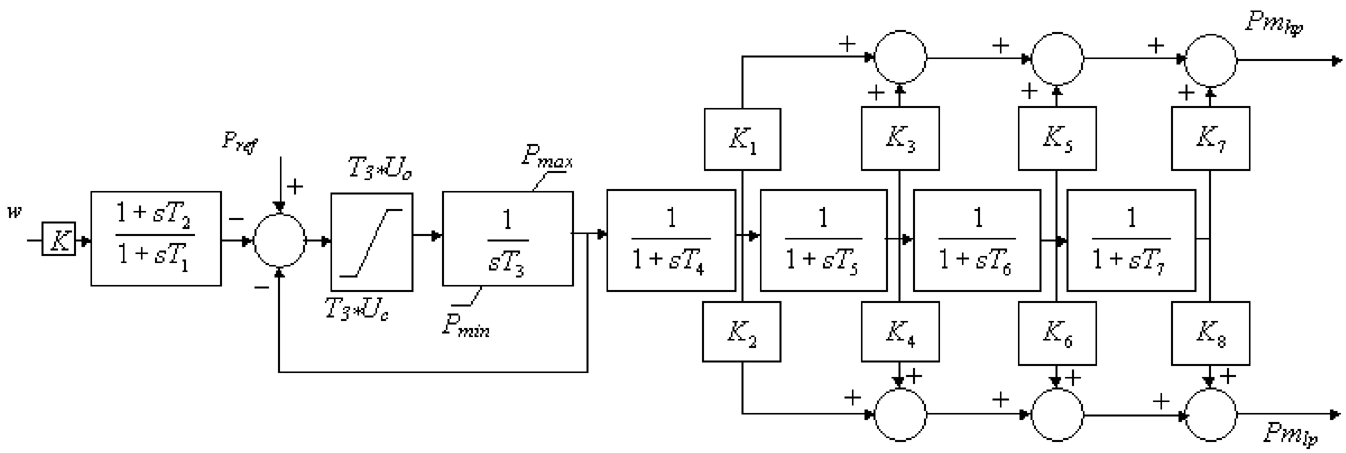
Var No.	Definition
1	Reference speed
2	P_m - Mechanical power
3	Output of the governor (state variable x_1)
4	State variable x_2
5	State variable x_3

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV12 - IEEE Type 1 Speed-Governing Model

Model Number - 12



Note: This model can only be used with synchronous machine models SM01, SM03, SM05. These are acceptable models to represent a round rotor machine. Models SM02 and SM04 (suitable for salient pole machines) are not prepared to accept mechanical power input from high and low pressure shafts.

The frequency input for this model is taken from the high-pressure shaft. Therefore, disturbances that electrically separate the two generators have to be carefully implemented because the results may not correctly represent what users wish to see. For example, if the HP generator is shut down the mechanical power for the LP generator will be reduced to almost zero. On the other hand, if the breakers of the LP generator are opened, the governor will not see the rotor speeding up and the mechanical power will remain the same. Consequently the rotor will be subject to a very high acceleration. Although this may not cause a additional problems to the system, as the machine is isolated, any output from the LP generator will be misleading.

Important: The data of a synchronous machine connected to the Low Pressure shaft has to be entered just after the data of the synchronous machine connected to the High Pressure shaft. The number of the governor model for the Low Pressure machine is -1, which means that this machine is going to use the governor of the preceding machine.

Data format:

Type	Parameter	Default
Real	*K*	20
Real	T_1(sec)	*1*
Real	T_2 (sec)	*1*
Real	T_3 (>0) (sec)	0.1
Real	U_o (>0.) (pu/sec)	0.1
Real	U_c (<0.) (pu/sec)	-0.1
Real	P_{max} (pu on machine MVA rating)	*1*
Real	P_{min} (pu on machine MVA rating)	*0*
Real	T_4 (sec)	0.25
Real	K_1	0.22
Real	K_2	*0*
Real	T_5 (sec)	*5*
Real	K_3	*0*
Real	K_4	0.22
Real	T_6 (sec)	*5*
Real	K_5	0.14
Real	K_6	0.14
Real	T_7 (sec)	0.4
Real	K_7	0.14
Real	K_8	0.14

Plotting variables:

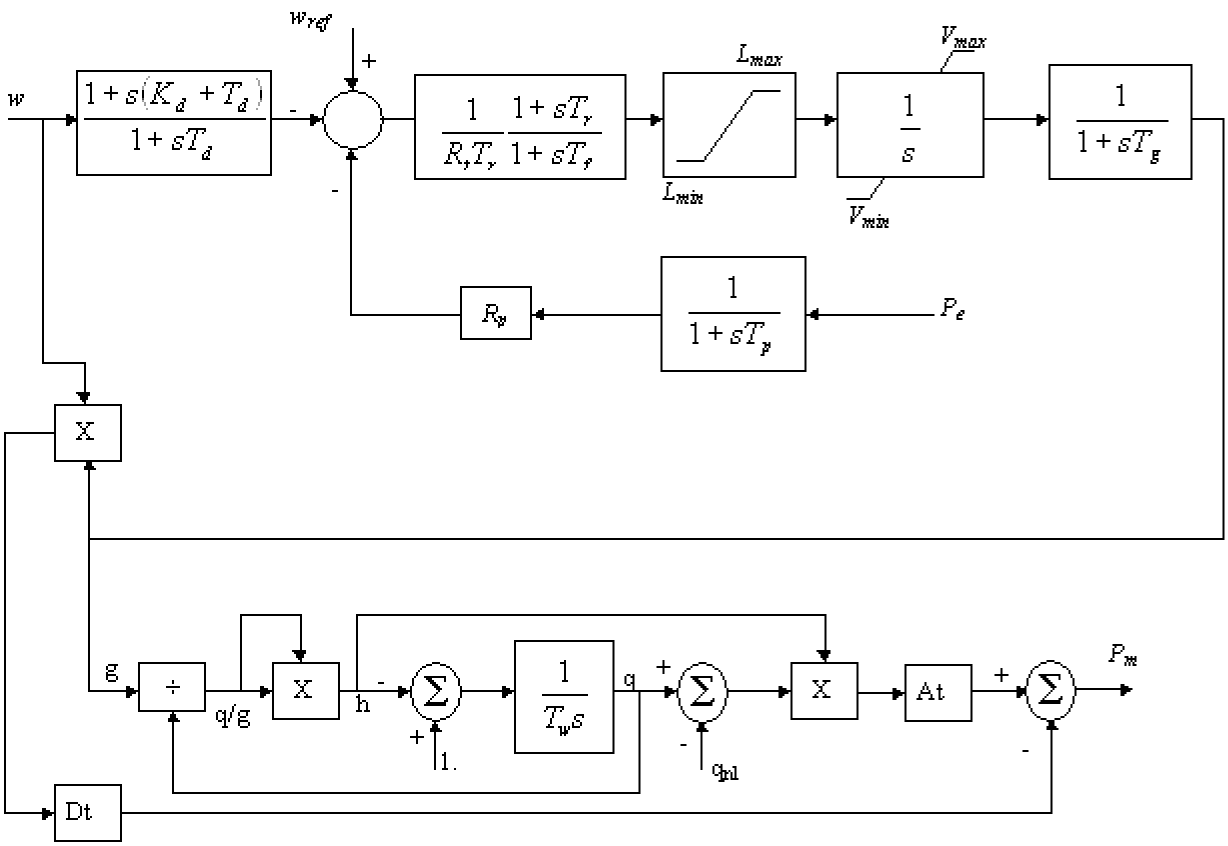
Var No.	Definition
1	Reference power (pu)
2	Pm_{hp}- Mechanical power on the high presure shaft
3	Pm_{lp} – Mechanical power on the low presure shaft
4	Output of lead-leg block T_2/T_1 (pu)
5	Output of integer block $1/T_3$ (pu)
6	Output of lag block $1/T_4$ (pu)
7	Output of lag block $1/T_5$ (pu)
8	Output of lag block $1/T_6$ (pu)
9	Output of lag block $1/T_7$ (pu)

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV13 - Hydro Governor - Non-Linear Turbine

Model Number - 13



Models that represent the temporary droop compensation as a feedback (Figure below) instead of cascade can be converted to the above representation using the following relationship.

$$T_f = \frac{T_r T_s}{T_s + rT_r}$$, and

$$R_t = \frac{T_s}{T_r} + r$$

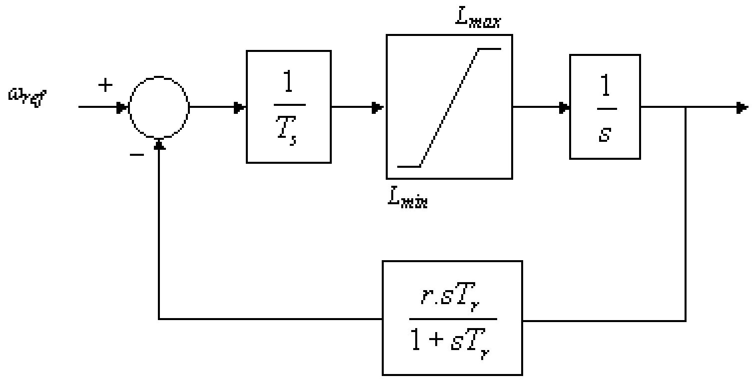


Figure – Feedback droop compensation.

Data format:

Type	Parameter	Default
Real	A_t	1.
Real	T_g	0.5
Real	T_w	2.8
Real	R_t(>0)	Formulae 1
Real	T_r(>0)	Formulae 2
Real	R_p	0.05
Real	T_f	0.2
Real	L_{min}	-0.15
Real	L_{max}	0.15
Real	V_{min}	0.01
Real	V_{max}	1.
Real	q_{nl}	0.05
Real	K_d	*0*
Real	T_d	1.
Real	T_p	1.
Real	D_t	0.

Formulae 1 : (2.3-(T_w-1.)*0.15)*T_w/H; Formulae 2: (5-(T_w-1.)*0.5)*T_w

Plotting variables:

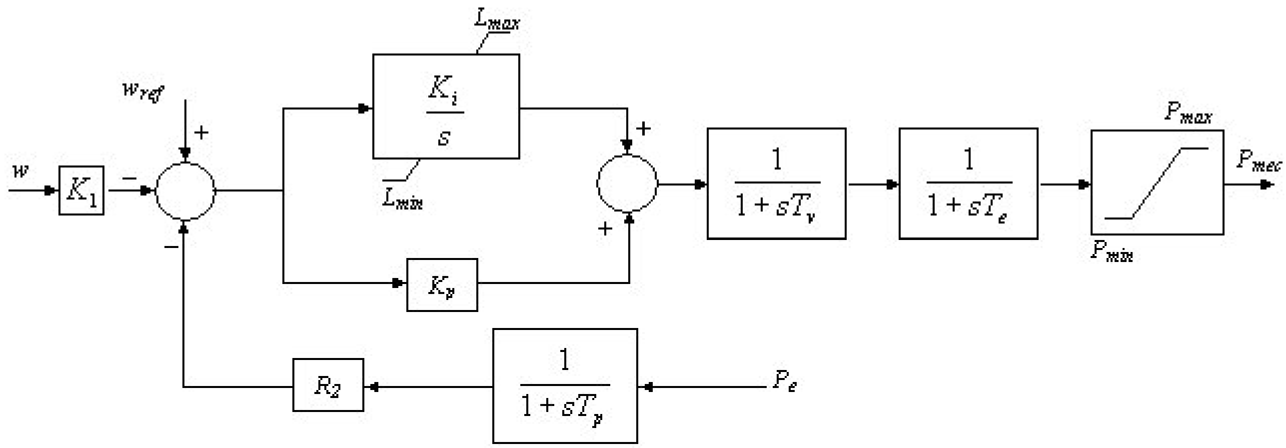
Var No.	Definition
1	Reference speed
2	Pm - Mechanical power
3	Output of integrator (pilot valve)
4	Output of block K_g/T_g (gate position)

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV14 - Gas Turbine

Model Number - 14



Data format:

Type	Parameter	Default
Real	K_1	1.
Real	R_2	0.05
Real	T_p	2.0
Real	K_p	0.5
Real	K_i	0.1
Real	T_v	0.1
Real	T_e	0.6
Real	L_{min}	-0.5
Real	L_{max}	1.15
Real	P_{min}	0.0
Real	P_{max}	1.

Plotting variables:

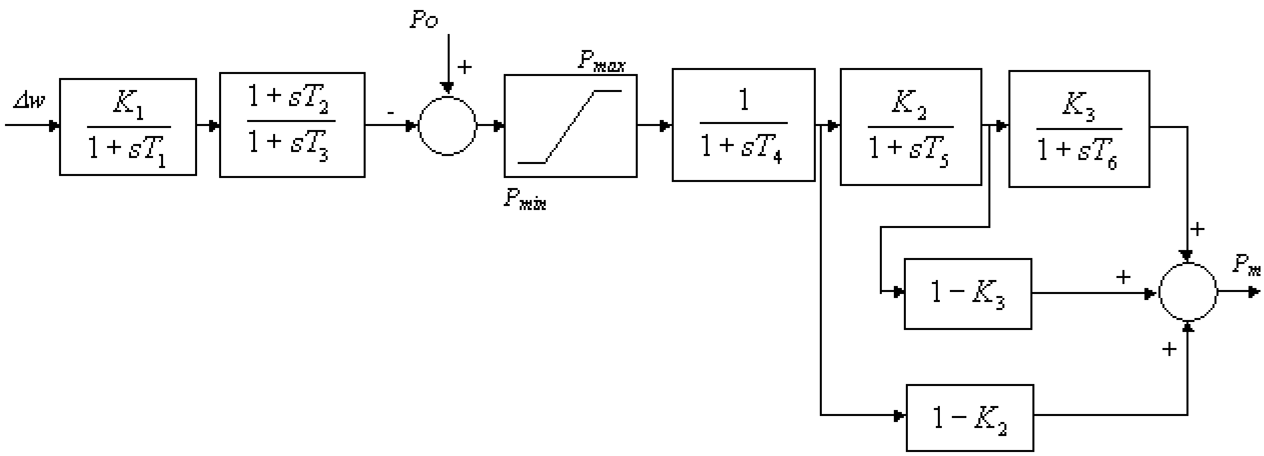
Var No.	Definition
1	Reference speed
2	Pm - Mechanical power
3	Output of integrator
4	Output of proportional gain K_p

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV15 - Steam Governor and Turbine

Model Number - 15



Note: This model is similar to GOV08, but the implementation of the lead-lag compensation is exactly as shown in the above diagram.

Data format:

Type	Parameter	Default
Real	T_1 (sec)	0.2
Real	T_2(sec)	*0*
Real	T_3 (>0) (sec)	0.3
Real	T_4 (sec)	0.4
Real	T_5 (sec)	*4*
Real	T_6 (sec)	0.7
Real	K_1 (1/pu)	20
Real	K_2, fraction	0.25
Real	K_3, fraction	0.5
Real	P_{max} (pu on machine MVA rating)	*1*
Real	P_{min} (pu on machine MVA rating)	*0*

Plotting variables:

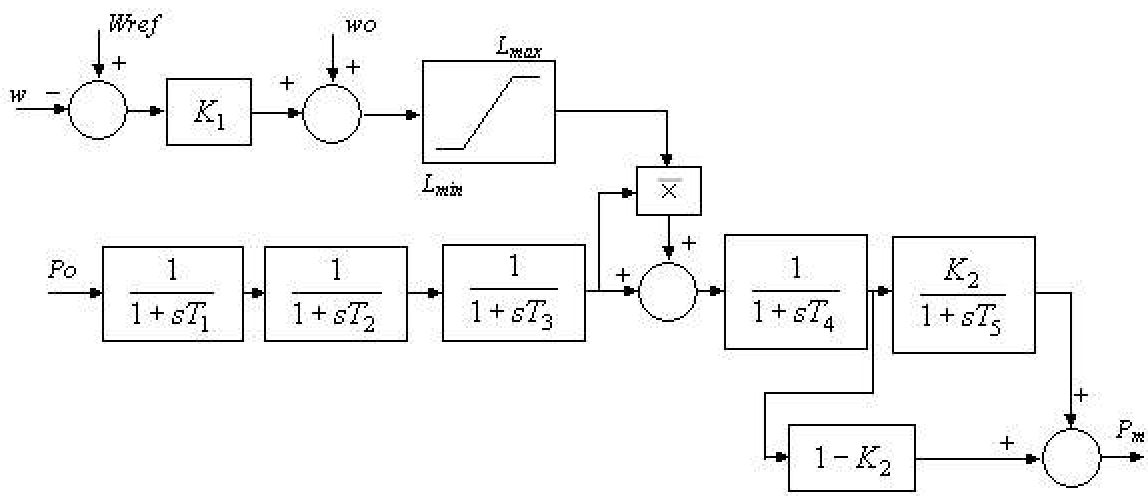
Var No.	Definition
1	Reference speed
2	Pm - Mechanical power
3	Output of limiting block (gate position)
4	Turbine power, output of block $1/T_4$ (pu)
5	Turbine power, output of block K_2/T_5 (pu)
6	Turbine power, output of block K_3/T_6 (pu)

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

GOV16 - Steam Governor and Turbine for Combined Cycle Plants

Model Number - 16



Notes:

1) *Po* is the normalized output power of the combined Gas Turbine.

2) The parameters of the combined gas turbine MUST be entered before the parameters of the steam turbine.

Data format:

Type	Parameter	Default
Integer	Combined Gas Turbine Bus	-
Integer	Combined Gas Turbine Group	-
Real	T_1 (sec)	72.
Real	T_2(sec)	85.
Real	T_3 (sec)	70.
Real	T_4 (sec)	1.5
Real	T_5 (sec)	10.
Real	K_1 (1/pu)	20
Real	K_2, fraction	0.8
Real	wo	0.01
Real	L_{max}	1.
Real	L_{min}	-1.

Plotting variables:

Var No.	Definition
1	Reference speed
2	Pm - Mechanical power
3	Boiler power (pu). Output of block $1/(1+ sT_3)$
4	High pressure output (pu). Output of block $1/(1+sT_4)$
5	Low pressure output. Output of block $K_2/(1+sT_5)$
6	Output of Limiter (L_{min}, L_{max})

Example: (mechanical power of machine #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
GOV	2	100	1

Static VAR Compensator – SVC Models

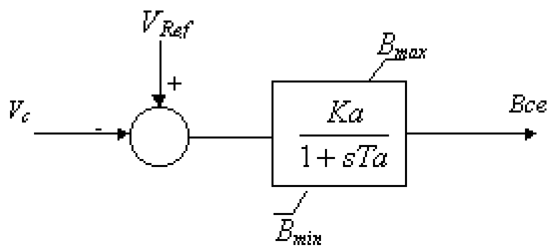
Models Available:

SVC01

SVC02

SVC01

Model Number - 11



Data format:

First record

Type	Parameter	Description	Default
Integer	Bus No.	Number of terminal bus	
Integer	RB	Controlled bus No.[1]	
Integer	NE	Number of units in parallel[3]	
Integer	EQ	Unit ID[4]	
Char(12)	BName	Terminal Bus Name	
Char(12)	Bname2	Controlled Bus Name	
Integer	F_q	Reactive Power Partic. Factor[5]	

Second record:

Type	Parameter	Default
Real	K_a	
Real	T_a	
Real	B_{min} (MVA)	
Real	B_{max} (MVA)	
Real	*Base* (MVA)	

Plotting variables:

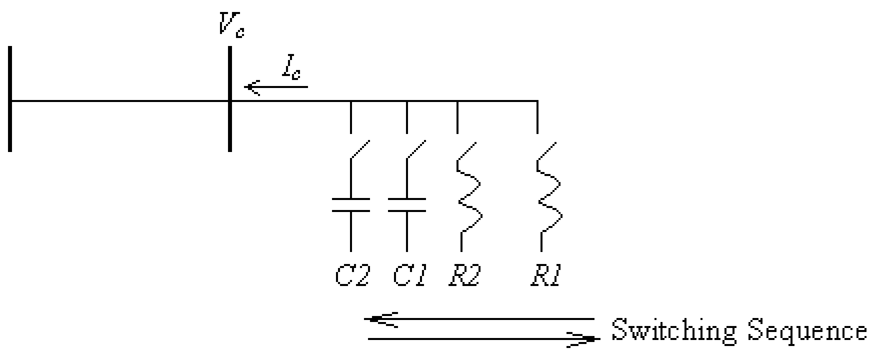
Var No.	Definition
1	Qsvc – Total Mvar output
2	-

Example: (reactive power of SVC #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
SVC	1	100	1

SVC02 - Discrete Shunt Model

Model Number - 12



SVC02 is a model to be used with the discrete shunt device data imported from the load-flow database. It is similar to the SWSHN1 model from PSSE.

This model does not contain any differential equation. The shunt admittance is placed directly into the Ybus matrix.

Model Functionality:

The objective is to control the voltage between the specified values V_{max} and V_{min}.

If the controlled voltage moves above V_{max}, the High-Voltage-Timer is triggered (the Low-Voltage-Timer is reset).

If the controlled voltage moves below V_{min} the Low-Voltage-Timer is triggered (the High-Voltage-Timer is reset).

If the controlled voltage is between V_{max} and V_{min}, both High and Low Voltage-Timers are reset.

If either the Hi or Low Voltage-Timers reach pickup time, a control action takes place, i.e., a trigger is sent to a breaker of one of the switchable block.

For high voltage situations the control action is either a switching of a capacitor bank or insertion of a reactor.

For low voltage situations the control action is either a switching of a reactor or insertion of a capacitor bank.

The timers (High and Low) are blocked after the trigger signal is sent to the breaker. They are unblocked just after the breaker status change.

Time to close and open the breakers can be specified separately.

The switching sequence is the same as the load-flow.

Note:

A combination of a relatively small short circuit ratio at the shunt device bus with narrow dead-band (V_{max}-V_{min} small) and large step sizes (large Mvar blocks) can lead to limit cycle phenomenon for this model.

Data Format

First Record:

Type	Parameter	Description	Default
Integer	Bus No.	Number of terminal bus	
Char(12)	BName	Terminal Bus Name	
Integer	F_q	Reactive Power Partic. Factor[5]	

Second Record:

Type	Parameter	Description	Default
Real	V_{max}	0, absolute value or relative value	
Real	V_{min}	0, absolute value or relative value	
Real	PT_{hi}	Pickup Timer High Voltage	
Real	PT_{lo}	Pickup Timer Low Voltage	
Real	BT_{cl}	Breaker Closing Time	
Real	BT_{op}	Breaker Open Time	

Plotting variables:

Var No.	Definition
1	Qsvc - Total Mvar output
2	Shunt susceptance, (pu)
3	Voltage Deviation - (pu). Vc-Vmax (if Vc>Vmas) or Vc-Vmin (if Vc<Vmin) or 0

Example: (reactive power of SVC #1 at bus 100)

Object Code	Var. No.	Bus	Object ID
SVC	1	100	1

High Voltage Direct Current Links - HVDC - Models

Models Available:

HVDC01

HVDC01

Model Number = 21

Data format:

Type	Parameter	Default
Integer	Rectifier Bus Number	
Integer	Inverter Bus Number	
Integer	Pole Number	
Integer	Rectifier Model	
Integer	Inverter Model	
Real	DC Line Inductance (H)	
Real	DC Line Resistance (Ω)	
Real	DC Voltage Base (kV)	
Char(12)	Rectifier Bus Number	
Char(12)	Inverter Bus Number	
Integer	-	
Integer	-	

Plotting variables:

Var No.	Definition
1	I_d - Direct current on the transmission line (pu)
2	P_r - AC active power output of the Rectifier (pu)
3	Q_r - AC reactive power output of the Rectifier (pu)
4	P_i - AC active power output of the Inverter (pu)
5	Q_i - AC reactive power output of the Inverter (pu)
6	V_{dr} - DC voltage on the Rectifier bus (pu)
7	V_{di} - DC voltage on the Inverter bus (pu)
8	Alfa - Firing angle at the Rectifier (rad)
9	Gama - Extinction angle at the Inverter (rad)

Example: (DC current of Pole #1 at bus 100)

Object Code	Var. No.	Bus	Pole No.
DC	0	100	1

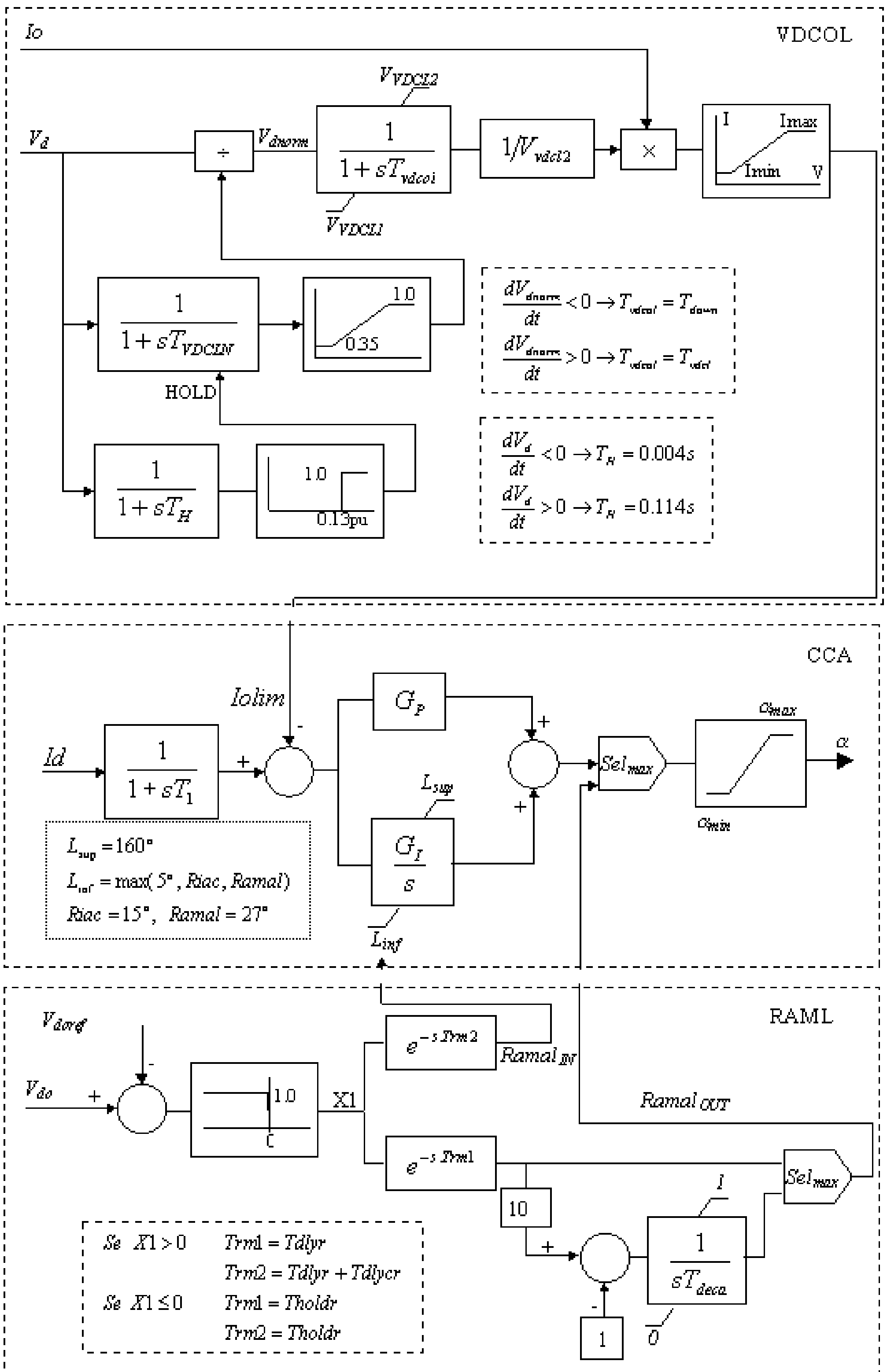
Rectifier Control Models

Models Available:

RET01

RET01

Model Number = 1



Data Format

CCA - Current Control Amplifier

Type	Parameter	Default
Real	K_i	
Real	K_p	
Real	Alf_{min} (degrees)	
Real	Alf_{max} (degrees)	
Real	T_1 (sec)	

VDCOL – Voltage Dependent Current Order Limit

Type	Parameter	Default
Real	T_2 (sec)	
Real	T_3 (sec)	
Real	Tv_{dcln} (sec)	
Real	T_{down} (sec)	
Real	T_{vdcl} (sec)	
Real	V_{vdcl1}	
Real	V_{vdcl2}	
Real	I_{mim}	
Real	I_{max}	

Note: The RAMAL control is not implemented yet in this model.

Plotting variables:

Var No.	Definition
1	CCA - Output of block $1/T_1$ (pu)
2	CCA - Output of the integrator (pu)
3	VDCOL - Output of block $1/T_h$ (pu)
4	VDCOL - Output of block $1/T_{vdcln}$ (pu)
5	VDCOL - Vdnorm (pu)
6	VDCOL - Output of block $1/T_{vdcoi}$ (pu)
7	Io - Current order (pu)
8	Gama - Extinction angle at the Inverter (rad)

Example: (rectifier current order of Pole #1 at bus 100)

Object Code	Var. No.	Bus	Pole No.
RECT	7	100	1

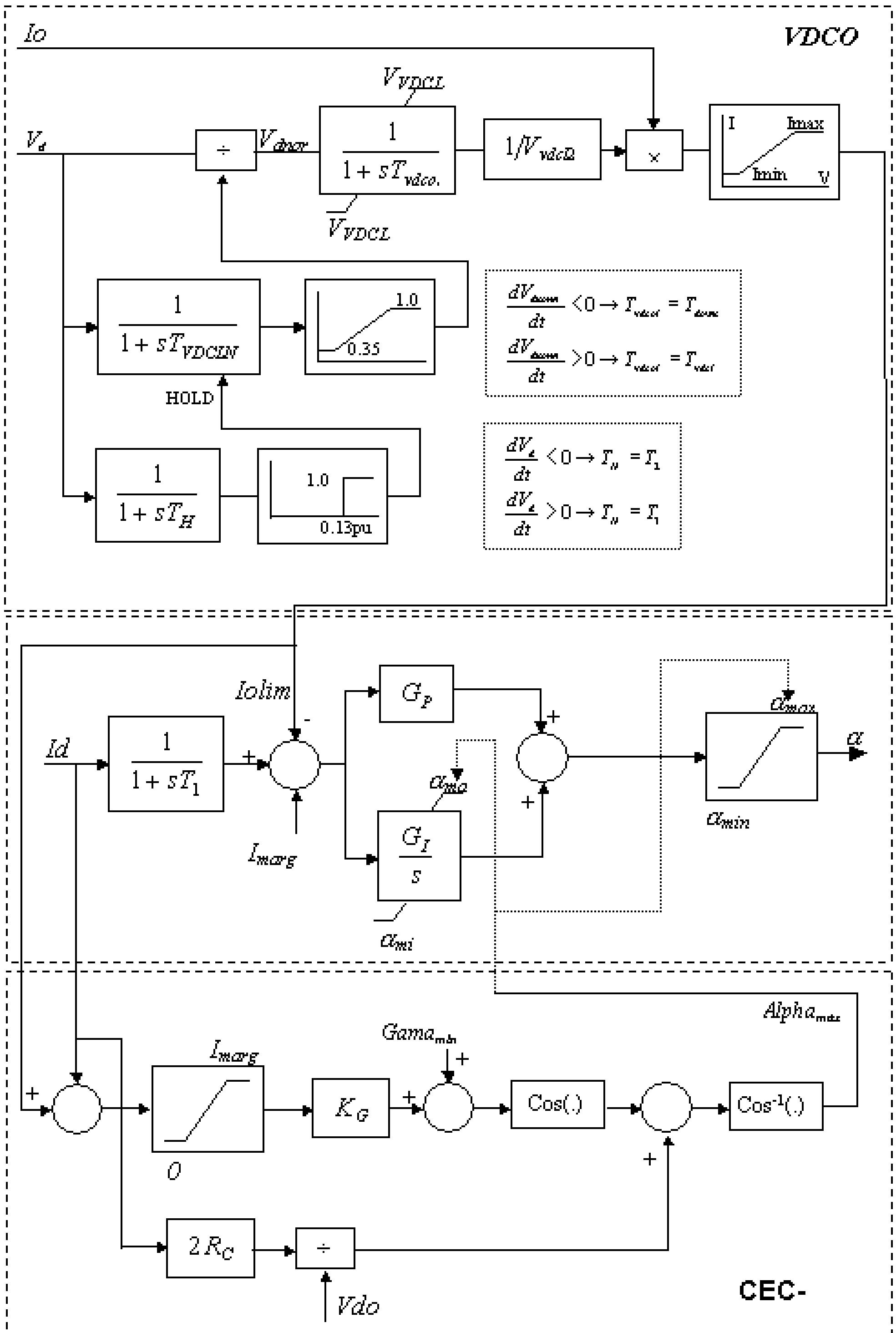
Inverter Control Models

Models Available:

[INV01]

INV01

Model Number = 1



Data format

CCA/CEC - Current Control Amplifier

Type	Parameter	Default
Real	K_i	
Real	K_p	
Real	$Alfa_{min}$	
Real	$Gama_{min}$	
Real	T_1	
Real	K_G	
Real	I_{marg}	

VDCOL – Voltage Dependent Current Order Limit

Type	Parameter	Default
Real	T_2 (sec)	
Real	T_3 (sec)	
Real	Tv_{dcln} (sec)	
Real	T_{down} (sec)	
Real	T_{vdcl} (sec)	
Real	V_{vdcl1}	
Real	V_{vdcl2}	
Real	I_{mim}	
Real	I_{max}	

Plotting variables:

Var No.	Definition
1	CCA X1 - Output of block $1/T_1$ (pu)
2	CCA X2 - Output of the integrator (pu)
3	VDCOL X3 - Output of block $1/T_h$ (pu)
4	VDCOL X4 - Output of block $1/T_{vdcln}$ (pu)
5	VDCOL X5 - Vdnorm (pu)
6	VDCOL X6 - Output of block $1/T_{vdcoi}$ (pu)
7	Io - Current order (pu)
8	Gama - Extinction angle at the Inverter (deg)

Example: (inverter current order of Pole #1 at bus 100)

Object Code	Var. No.	Bus	Pole No.
INV	7	100	1

Static Load Model

Models Available

LOAD01

LOAD02

LOAD01

$S = P + jQ$ where

$P = P_0(K_Z V^2 + K_I V + K_P)$

$Q = Q_0(L_Z V^2 + L_I V + L_P)$

$K_Z = 1 - (K_I + K_P)$

$L_Z = 1 - (L_I + L_P)$

Static Load Model input format:

Type	Parameter	Default
Integer	Bus or Area Number	
Char(1)	S (for system), A (for Area) or B (for Bus)	
Integer	1 (model number)	
Real	K_P (%)	
Real	L_P (%)	
Real	K_I (%)	
Real	L_I (%)	

Plotting variables:

Var No.	Definition
1	P - Total active load on the bus
2	Q - Total reactive load on the bus

Example: (active power at bus 100)

Object Code	Var. No.	Bus	Code No.
BUS	3	100	-

LOAD02

S = P + jQ where

$P = P_0(Kp_1V\alpha^{1} + Kp_2V\alpha^{2} + Kp_3V\alpha^{3})(1 + Kp_{f\Delta} f)$

$Q = Q_0(Kq_1V\beta^{1} + Kq_2V\beta^{2} + Kq_3V\beta^{3})(1 + Kq_{f\Delta} f)$

Static Load Model input format:

Type	Parameter	Default
Integer	Bus or Area Number	
Char(1)	S (for system), A (for Area) or B (for Bus)	
Integer	2 (model number)	
Real	K_{P1}	
Real	K_{P2}	
Real	K_{P3}	
Real	K_{q1}	
Real	K_{q2}	
Real	K_{q3}	
Real	K_{pf}	
Real	K_{qf}	
Real	α_1	
Real	α_2	
Real	α_3	
Real	β_1	
Real	β_2	
Real	β_3	

Plotting variables:

Var No.	Definition
1	P - Total active load on the bus
2	Q - Total reactive load on the bus

Example: (active power at bus 100)

Object Code	Var. No.	Bus	Code No.
BUS	3	100	-

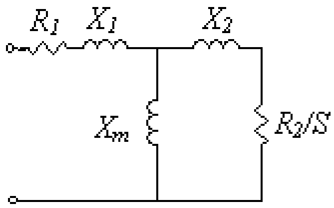
Induction Motor Models

Models available:

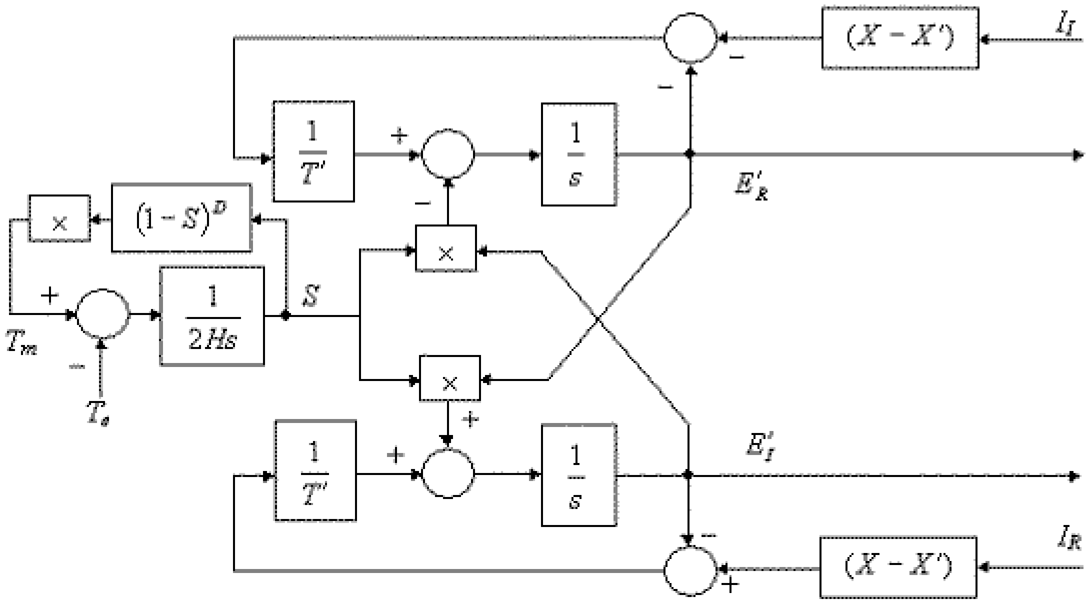
IM01

IM01 - Single Cage Induction Motor

Model number - 51



Induction Motor Equivalent Circuit



Induction Motor Block Diagram

Data format:

First Record

Type	Parameter	Description	Default
Integer	Bus No.	Number of terminal bus	-
Integer	ID	Unit Identification Number[1]	-
Char(12)	BName	Terminal Bus Name	-
Integer	F_p	Active Power Partic. Factor[2]	-

Notes:

The ID number is useful when there are more than one motor connected to the same bus. With the identification number it is possible to identify events and specify plotting variables for each motor connected to the same bus.

F_p is the motor participation factor for the load of the bus. If no participation is informed, then 100% will be assumed.

Second Record

Type	Parameter	Default
Real	*R*	0.013
Real	*X*	3.867
Real	X'	0.23
Real	T'	1.17
Real	*H*	1.5
Real	*D*	2.
Real	MVA *Base*	10.[1]

Note:

The MVA Base has to be compatible with the induction motor load. Otherwise, there may be initialisation or stability problems.

Plotting variables:

Var No.	Definition
1	T_m - Mechanical Torque
2	*P* - Electrical Power
3	*Q* - Reactive Power
4	*S* - Rotor Slip
5	E'_R - Real component of transient voltage
6	E'_I - Imaginary component of transient voltage
7	I_R - Real component of terminal current
8	I_I - Imaginary component of terminal current

Example: (active power of motor #1 at bus 100)

Object Code	Var. No.	Bus	Code No.
IM	1	100	1

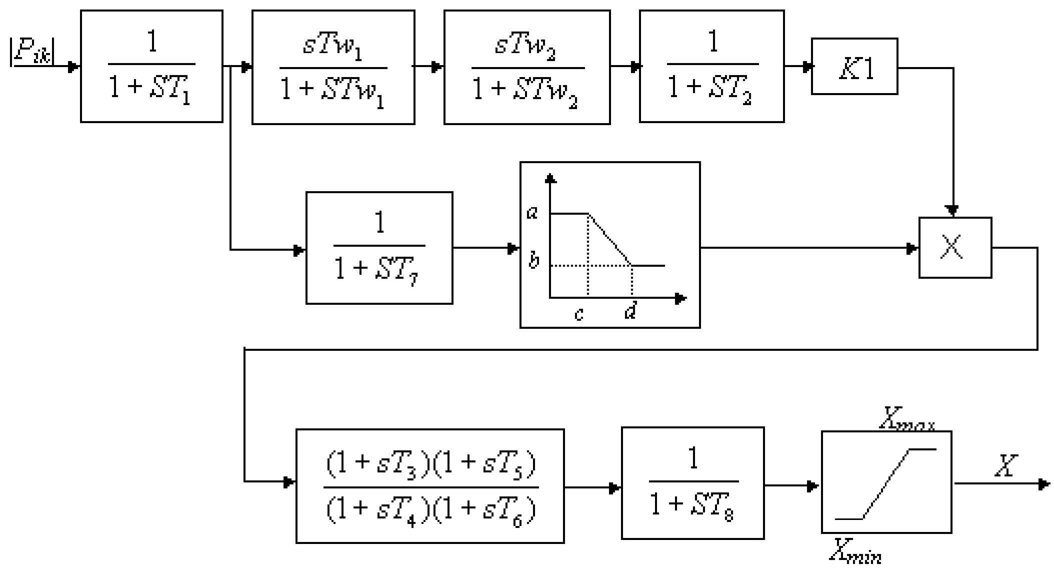
TCSC Models

Models Available

CSC01

CSC01 Model - (Controllable Series Capacitor - Stabiliser Control)

Model number - 41



Data format:

First Record

Type	Description	Default
Integer	Number of the bus From of the capacitor branch	
Integer	Number of the bus To of the capacitor branch	
Integer	Circuit ID number of the capacitor branch	
Integer	Number of bus From for Pik measurement branch	
Integer	Number of bus To for Pik measurement branch	
Integer	Circuit ID number of Pik measurement branch	
Char(12)	Name of the bus From of the capacitor branch	
Char(12)	Name of the bus To of the capacitor branch	

Second Record

Type	Parameter	Default
Real	T_1 (sec)	
Real	T_2 (sec)	
Real	T_3 (sec)	
Real	T_4 (>0) (sec)	
Real	T_5 (sec)	
Real	T_6 (>0) (sec)	
Real	T_7 (sec)	
Real	T_8 (sec)	
Real	T_{w1} (sec)	
Real	T_{w2} (sec)	
Real	K_1	
Real	X_{min}	
Real	X_{max}	
Real	*c*	
Real	*b*	
Real	*d*	
Real	*a*	

Plotting variables:

Var No.	Definition
1	*X* - Variable series impedance
2	Output of filter $1/T_1$ (pu)
3	Output of washout T_{w1} (pu)
4	Output of filter $1/T_2$ (pu)
5	Output of filter $1/T_7$ (pu)
6	Output of multiplier (pu)
7	|*Pik*| - Module of measured flow (pu)

Example: (variable impedance of TCSC #1 connected to bus 100)

Object Code	Var. No.	Bus	Code No.
TCSC	0	100	1

On Load Tap Changer - OLTC - Models

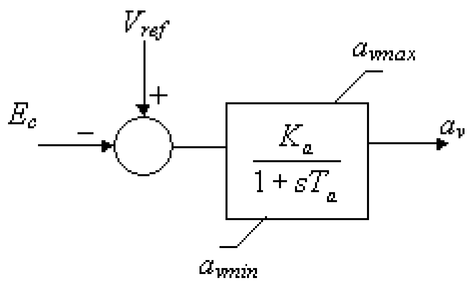
Models Available

[OLTC1]

[OLTC2]

OLTC1

Model number - 31



The transformer Tap ratio *a* is defined as:

$$a = 1/Tap = a_0 + a_v$$

where a_0 is the initial value of the tap (modelled as part of the network) and a_v is the variable part (modelled as a state variable).

Data format:

Type	Parameter	Default	Typical Range
Integer	Number of Bus From	-	-
Integer	Number of Bus To	-	-
Integer	Trafo Identification Number	-	-
Real	K_a (pu/pu)	50.	
Real	T_a (sec)	30.	
Char(12)	Name of Bus From	-	-
Char(12)	Name of Bus To	-	-

Notes: a_{vmax} is automatically calculated based on the minimum Tap value taken from the load-flow data. a_{vmin} is similarly calculated based on maximum Tap.

Plotting variables:

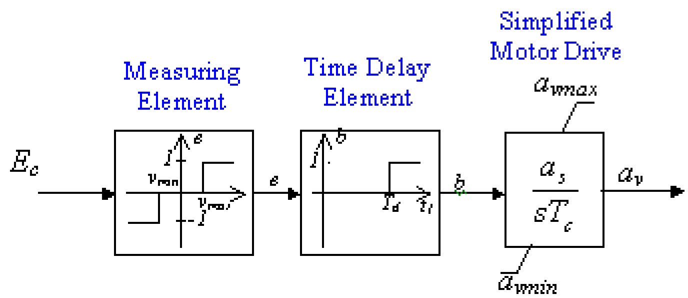
Var No.	Definition
1	*a* - Tap ratio
2	V_{ref} (pu)

Example: (Tap ratio of OLTC #1 connected to bus 100)

Object Code	Var. No.	Bus	Code No.
OLTC	0	100	1

OLTC2

Model number - 32



The transformer Tap ratio *a* is defined as:

$$a = 1/Tap = a_0 + a_v$$

where a_0 is the initial value of the tap (modelled as part of the network) and a_v is the variable part (modelled as a state variable). The gain of the integrator (a_s) is the Tap step size, which is imported from the load-flow data.

Data format:

Type	Parameter	Default	Typical Range
Integer	Number of Bus From	-	-
Integer	Number of Bus To	-	-
Real	T_d (sec) (>0)	30.	
Real	*Tc* (sec) (>0)	5.	
Integer	Trafo ID Number (circuit No.)	-	-
Char(12)	Name of Bus From	-	-
Char(12)	Name of Bus To	-	-

Notes: a_{vmax} is automatically calculated based on the minimum a_{vmin} is similarly calculated based on maximum Tap. a_{vmax}, a_{vmin} , V_{max} and V_{min} are imported from load-flow data.

Plotting variables:

Var No.	Definition
1	*a* - Tap ratio
2	V_{ref} (pu)

Example: (Tap ratio of OLTC #1 connected to bus 100)

Object Code	Var. No.	Bus	Code No.
OLTC	0	100	1

Wind Power Generator Models

Models Available

WGEN01

WGEN01

Model number - 61

Data format:

First record:

Type	Parameter	Default	Typical Range
Integer	Bus Number	-	-
Integer	Group ID	-	-
Char(12)	Bus Name	-	-

Second record:

Type	Parameter	Default	Typical Range
Real	MVA Base	40	-
Real	X" (pu)	0.55	-
Real	Tc (s)	0.02	-
Real	K_{vi} (pu/pu)	30.	
Real	XIQ_{max} (pu)	0.3	
Real	XIQ_{min} (pu)	-0.35	
Real	K_{qi} (pu/pu)	0.05	
Real	IP_{max} (pu)	1.1	
Real	T_5 (s)	5.	
Real	T_{pc} (s)	0.05	
Real	P_{max} (pu)	1.12	
Real	P_{min} (pu)	0.1	
Real	dP_{max} (pu)	0.45	
Real	dP_{min} (pu)	-0.45	
Real	K_{pt} (pu/pu)	3.	
Real	K_{it} (pu/pu)	0.6	
Real	K_{pc} (pu/pu)	30.	
Real	K_{vi} (pu/pu)	3.	
Real	K_{ic} (pu/pu)	30.	
Real	K_{pp} (pu/pu)	150.	
Real	K_{ip} (pu/pu)	25.	
Real	T_p (s)	0.3	
Real	$Teta_{max}$ (degree)	27.	
Real	$Teta_{min}$ (degree)	0.	
Real	$dTeta_{max}$ (degree)	10.	
Real	$dTeta_{min}$ (degree)	-10.	
Real	H_t (1/s)	1.94	
Real	H_g (1/s)	1.11	

Real	D_{tg} (pu/pu)	3.	
Real	K_{tg} (pu/rad)	5.75	
Real	W_b (rad/s)	125.66	
Real	K_{ar} (pu/pu)	0.00145	
Real	K_b (pu)	69.5	

Notes:

Plotting variables:

Var No.	Definition
1	Pele (pu)
2	Qele (pu)
3	E´´qcmd (pu)
4	Pord (pu)
5	Wref (pu)
6	Teta (pu)
7	wt (pu)
8	wg (pu)
9	Delta (pu)
10	Lambda (pu)
11	Vref (pu)

Example: (Pele of WGEN01#1 connected to bus 100)

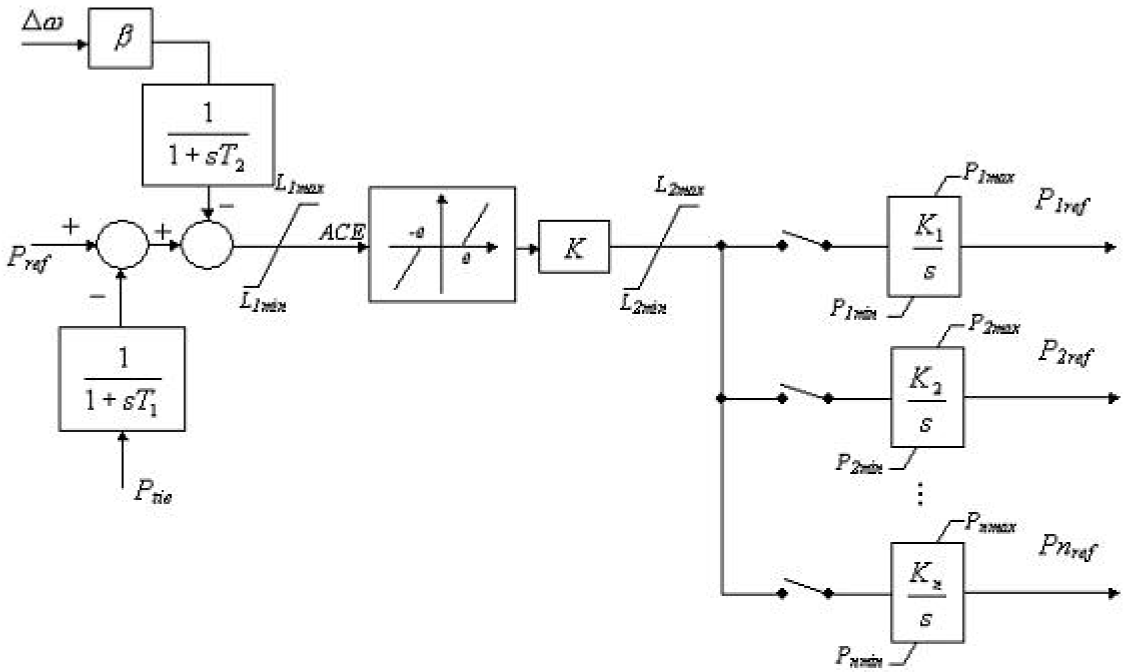
Object Code	Var. No.	Bus	Code No.
WG	1	100	1

Automatic Generation Control - AGC - Models

Models Available:

AGC01

Model number - 201



Data format:

The AGC data is input using two records for the central control and one record for each controlled unit. The first record contains the central control parameters. Each subsequent record informs the data for each generating unit under AGC control (bus number, ID, status, etc.). The list of generators is ended by a record containing a bus number = 0. < /FONT >

First Record:

Type	Parameter	Typical Value
Integer	Area Number	-
Integer	Number of Bus for Frequency Measurement	-
Real	Frequency Control Bias	20
Real	*K*	0.0005
Real	T_1 (sec)	10.
Real	T_2 (sec) > 0.0	10.
Real	Dead band magnitude (e)	0.01
Real	L_{1min}	-0.5
Real	L_{1max}	0.5
Real	L_{2min}	1.
Real	L_{2max}	-1.
Char(12)	Name of Bus for Frequency Measurement (optional)	-

Subsequent records (one per generating unit under control):

Type	Parameter	Typical Values
Integer	Generator Bus Number	-
Integer	Generator Identification Number	-
Real	K_I - Integrator Gain	1.
Integer	Unit Status (1 = on AGC control; 0 = off AGC control) < /FONT >	1
Char(12)	Name of Generator Bus (optional)	-

Plotting variables:

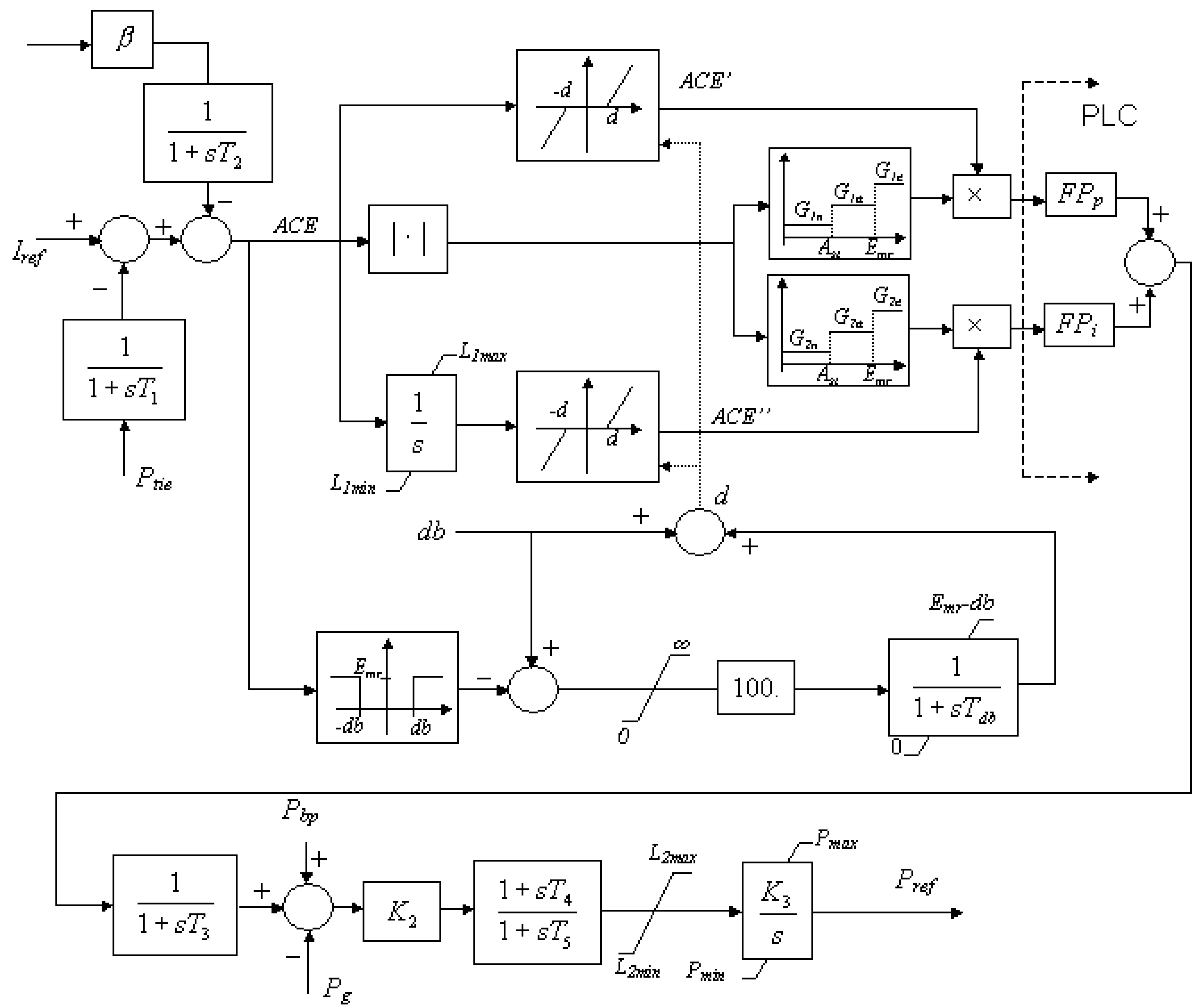
Var No.	Definition
1	*Freq* - Measured frequency
2	*Pintchg* - Measured power interchange (pu)
3	ACE - Area Control Error
4	Output - Signal sent to each unit

Example: (ACE of AGC for area 3)

Object Code	Var. No.	Area	Code No.
AGC	2	3	-

AGC02

Model number - 202



Data format:

The AGC data is entered in three groups. The first contains the AGC control parameters. The second group informs the tie lines. The third enter the control parameters for each power plant.

Header:

Type	Parameter
Integer	Model Number
Integer	Model Number

AGC control parameters:

Type	Parameter	Typical Value
Integer	Area Number	-
Integer	Number of Bus for Frequency Measurement	-
Real	Frequency Control Bias	
Real	db – static deadband	
Real	E_{mr} – Emergency level	
Real	A_{st} – Assistance level	
Real	T_{db} – Dynamic deadband time constant	
Real	T_1 (sec)	
Real	T_2 (sec)	
Real	L_{1min}	
Real	L_{1max}	
Real	G_{1n}	
Real	G_{1a}	
Real	G_{1e}	
Real	G_{2n}	
Real	G_{2a}	
Real	G_{2e}	
Char(12)	Name of Bus for Frequency Measurement (optional)	-

Tie line information (termination with –999 / code):

Type	Parameter	Typical Values
Integer	Measurement Bus of tie branch (positive or negative) §	-
Integer	Other bus of tie branch	-
Integer	Circuit ID of tie branch	

§ - If the number of measurement bus is positive the MW flow is considered as entering the branch. In other words, the flow is from measurement bus to the other branch bus. If it is negative, the flow is considered as leaving the branch, i.e., the negative of flow from measurement bus to the other branch bus. The branches interconnecting two areas are entered in the Tie Line information fields of both AGCs, but if in one of them the measurement bus is positive, in the other it must be negative, and vice-versa. By definition a positive flow is leaving the control area.

PLC information (one per generating unit under control):

Type	Parameter	Typical Values
Integer	Generator Bus Number	-
Integer	Generator Id	-
Real	P_{max} – Maximum power capability	
Real	P_{min} – Minimum power capability	
Real	PF_p – Proportional participation factor	
Real	Pf_i – Integral participation factor	
Real	T_3	
Real	T_4	
Real	T_5	
Real	L_{2max}	
Real	L_{2min}	
Real	K_2	
Real	K_3 – Pulse rate	
Char(12)	Name of Generator Bus (optional)	-

Plotting variables:

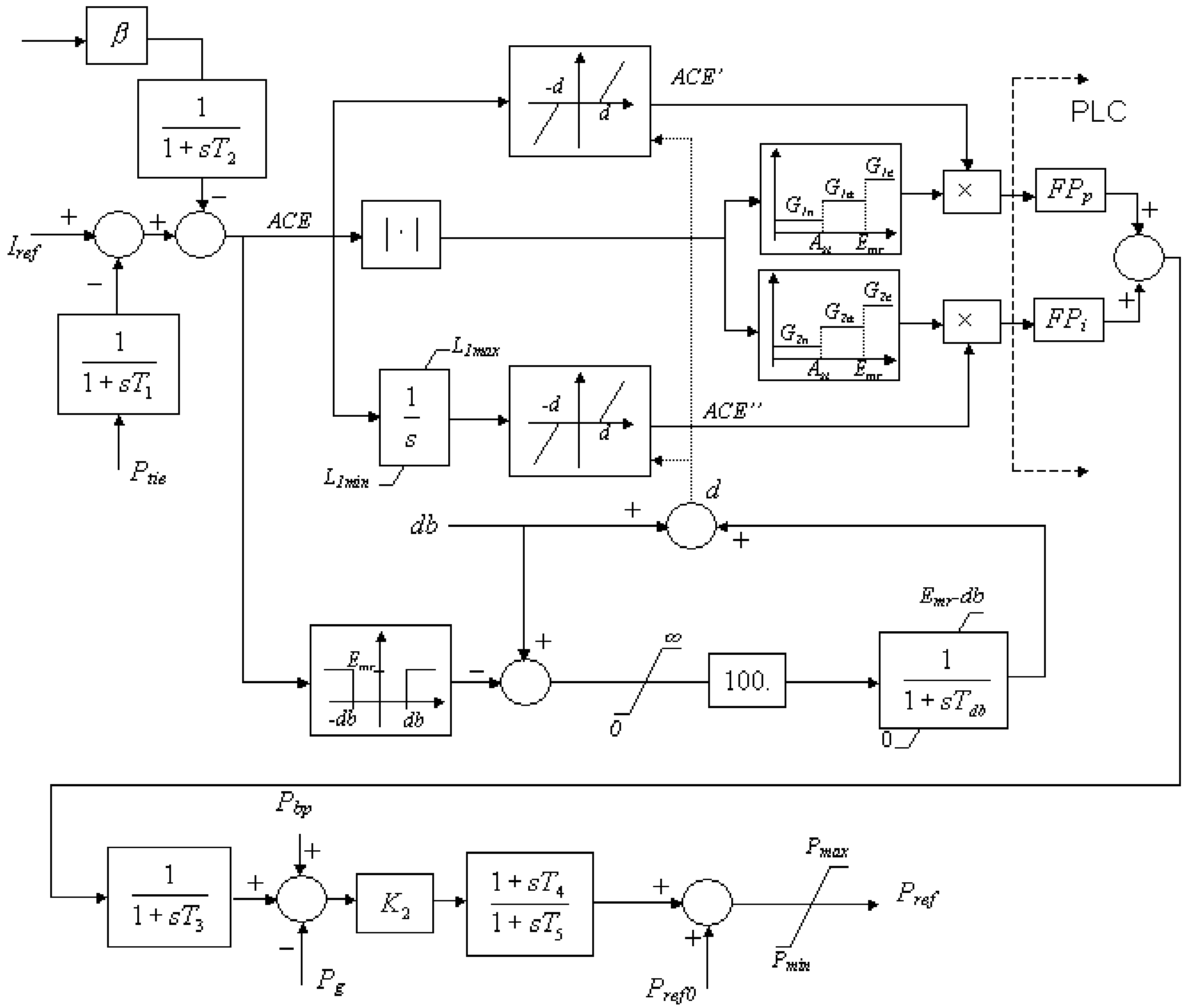
Var No.	Definition
1	*Freq* - Measured frequency
2	*Pintchg* – Measured power interchange (pu)
3	ACE – Area Control Error
4	ACE’
5	ACE’’

Example: (ACE of AGC for area 3)

Object Code	Var. No.	Area	Code No.
AGC	2	3	-

AGC03

Model number - 203



Data format:

The AGC data is entered in three groups. The first contains the AGC control parameters. The second group informs the tie lines. The third enter the control parameters for each power plant.

Header:

Type	Parameter
Integer	Model Number
Integer	Model Number

AGC control parameters:

Type	Parameter	Typical Value
Integer	Area Number	-
Integer	Number of Bus for Frequency Measurement	-
Real	Frequency Control Bias	
Real	db - static deadband	
Real	E_{mr} - Emergency level	
Real	A_{st} - Assistance level	
Real	T_{db} - Dynamic deadband time constant	
Real	T_1 (sec)	
Real	T_2 (sec)	
Real	L_{1min}	
Real	L_{1max}	
Real	G_{1n}	
Real	G_{1a}	
Real	G_{1e}	
Real	G_{2n}	
Real	G_{2a}	
Real	G_{2e}	
Char(12)	Name of Bus for Frequency Measurement (optional)	-

Tie line information (termination with –999 / code):

Type	Parameter	Typical Values
Integer	Measurement Bus of tie branch (positive or negative) §	-
Integer	Other bus of tie branch	-
Integer	Circuit ID of tie branch	

§ - If the number of measurement bus is positive the MW flow is considered as entering the branch. In other words, the flow is from measurement bus to the other branch bus. If it is negative, the flow is considered as leaving the branch, i.e., the negative of flow from measurement bus to the other branch bus. The branches interconnecting two areas are entered in the Tie Line information fields of both AGCs, but if in one of them the measurement bus is positive, in the other it must be negative, and vice-versa. By definition a positive flow is leaving the control area.

PLC information (one per generating unit under control):

Type	Parameter	Typical Values
Integer	Generator Bus Number	-
Integer	Generator Id	-
Real	P_{max} - Maximum power capability	
Real	P_{min} - Minimum power capability	
Real	PF_p - Proportional participation factor	
Real	Pf_i - Integral participation factor	
Real	T_3	
Real	T_4	
Real	T_5	
Real	K_2	
Char(12)	Name of Generator Bus (optional)	-

Plotting variables:

Var No.	Definition
1	*Freq* - Measured frequency
2	*Pintchg* - Measured power interchange (pu)
3	ACE - Area Control Error
4	ACE’
5	ACE’’

Example: (ACE of AGC for area 3)

Object Code	Var. No.	Area	Code No.
AGC	2	3	-

Protection System Models

Generic Models Available:

PROT01 – Distance Relay (21)

PROT02 – Distance Relay (21)

PROT03 – Breaking Resistor

PROT04 – Underfrequency Load Shedding (81)

PROT05 – Undervoltage Load Shedding (27)

PROT06 – Blinder Type Out of Step Relay Blocking and Tripping (68, 78)

PROT07 – Lens Type Out of Step Relay Blocking and Tripping (68, 78)

PROT08 - Overfrequency Generation Shedding

PROT09 - Distance Relay Based on Blinders and Directional Units (21)

PROT10 - Out-of-Step Blocking Relay (68, 78)

PROT11 - Lens Type Distance Relay (93)

PROT12 - Under/Overvoltage Relay (27, 59)

PROT13 - Overcurrent Relay - ANSI50 (50)

PROT14 - Under/Overfrequency Relay (81)

PROT15 - Distance Relay Based on Blinders (21)

Specific Models Available:

CEY21 - MHO Type Distance Relay

Table I - ANSI Functions.

Functions	Description
21 and 21N	Distance Protection
67 and 67N	Overcurrent directional protection
50, 50N, 51 and 51N	Instantaneous and temporized overcurrent protection
87 and 87N	Differential protection
62 BF	Breaker failure
27	Undervoltage protection
59	Overvoltage protection
68	Out-of-Step blocking relay
78	Phase angle measurement relay
81	Under/overfrequency relay
46	Umbalance phase current relay
47	Voltage phase sequency relay
24	Overexcitation V/Hz relay
32	Power directional relay
51V	Voltage constrained overcurrent relay
40	Loss of excitation relay

Table II - Relay applications

Equipment	Relays
Transmission Line	21, 21N, 67, 67N, 50, 50N, 51 e 51N
Transformer	87, 87N, 50/51 e 50/51N
Bus	87 e 50/62BF
Generator	21, 24, 27, 32, 40, 46, 47, 51V, 59, 67, 67N, 81 e 87

Table III - Relay model per vendor

Function	Technology	Model	Vendor
21	Electromechanical	CEY	GE
21	Digital	D60	GE
21	Digital	SEL311C	SEL
21	Digital	REL511	ABB
68, 78	Electromechanical	CEB	GE
68, 78	Digital	D60	GE
68, 78	Digital	SEL311C	SEL
68, 78	Digital	REL511	ABB
27, 59	Electromechanical	IAV	GE
27, 59	Digital	REL511	GE
27, 59	Digital	D60	ABB
50, 51	Electromechanical	IAC	GE
50, 51	Digital	SEL351A	SEL
24	Static	STV	GE
40	Electromechanical	CEH	GE
81	Digital	7SA6	Siemens

Note: - These ORGANON models are based on vendor's documentation. The implementation in ORGANON where done only by the ORGANON development team. Therefore, they are not officially validated by the respective vendors.

PROT01 Model- Distance Relay

Protection Function: 21

This distance relay model opens a branch whenever the system impedance, viewed from the reference bus, is within the protection zone of the relay. This protection zone is shown in Fig. 1. If the system impedance moves into the shadow circle (operation zone) the relay operates and sends a signal to open the branch breakers. After a specified delay time the breakers are effectively opened.

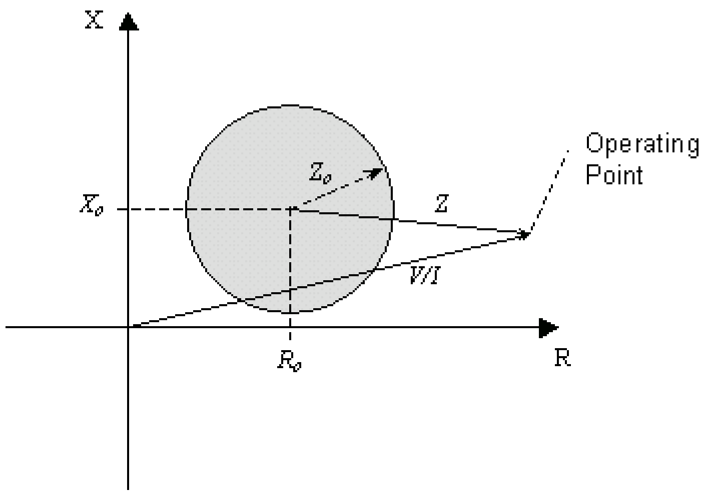


Figure 1. Distance Relay Zone

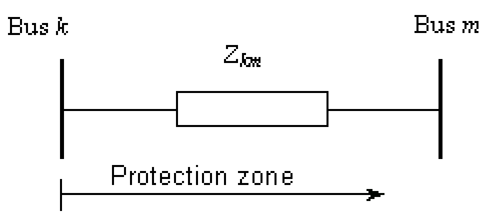


Figure 2. Distance relay protection zone

For a branch connecting buses *k* and *m* (Fig. 2), the relay sitting at bus *k* and looking in the direction of bus *m* is represented by the following equation

$$\overline{Z} = \frac{\overline{V}_k}{\overline{I}_{km}} - \left(R_o + jX_o\right)$$

If $\left|\overline{Z}\right| < Z_o$, then there is a violation and the relay operates. If the violation happen at instant T_o , the breakers will be opened at time T_o + T_{relay}. + $T_{breaker}$.

Data format:

Type	Parameter
Integer	Protection ID No.
Integer	Number of Bus From (reference)
Integer	Number of Bus To
Integer	Circuit Number
Real	R_o (pu)
Real	X_o (pu)
Real	Z_o (pu)
Real	*Trelay* (s)
Real	*Tbreaker*(s)

Plotting variables:

Var No.	Definition
1	|V/I| (pu)
2	Real part of (V/I) (pu)
3	Imaginary part of (V/I) (pu)
4	|Z| (pu)
5	Real part of (Z) (pu)
6	Imaginary part of Z (pu)

Example: (Impedance of protection #105)

Object Code	Var. No.	Protection ID	Code No.
PROT	4	105	-

PROT02 Model- Distance Relay

Protection Function: 21

This model has the following characteristics:

Mho, impedance, or reactance characteristic with up to three independent (separately specified diameter and centre offset) circles for mho or impedance units.

Trip of up to three remote lines (transfer trip) as well as monitored line (self trip).

Single attempt reclosure for self and transfer trip for zone 1 faults.

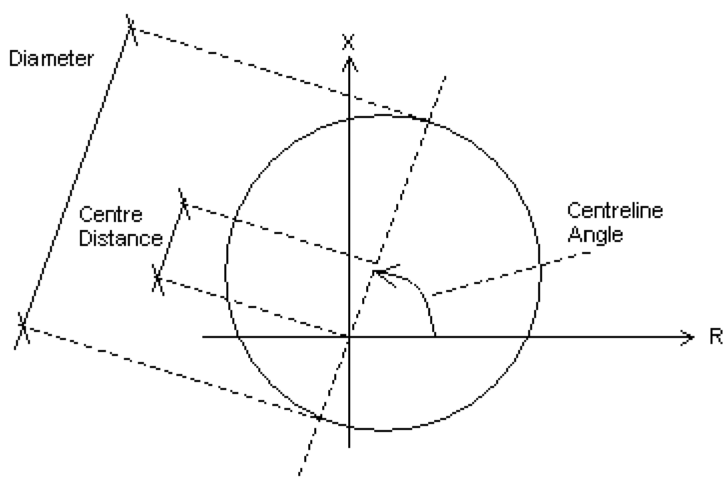
Supervisory signal input to prevent tripping or to force immediate tripping.

Up to two straight-line blinders.

Minimum pickup current logic.

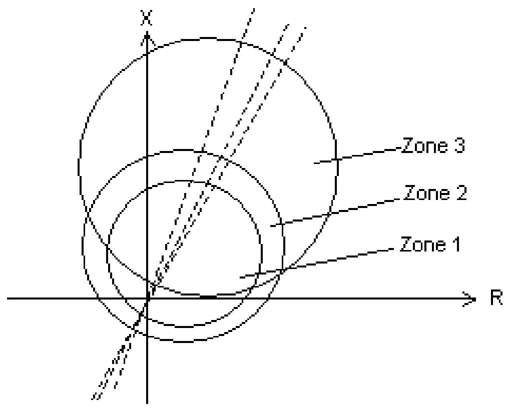
Model may be used in a monitoring only mode.

The timer for each zone detector starts whenever the line impedance lies inside its Effective-Tripping-Zone. The Effective-Tripping-Zone is defined as the intersection of the impedance, blinders and low-current relays. The timer for each zone is reset if the line impedance lies outside its Effective-Tripping-Zone. A trip signal is sent to the breakers (self-tripping and transfer trip) if the timer delay setting is reached for any of the zones. This trip signal is "anded" with the Self-Trip Permissive Flag.

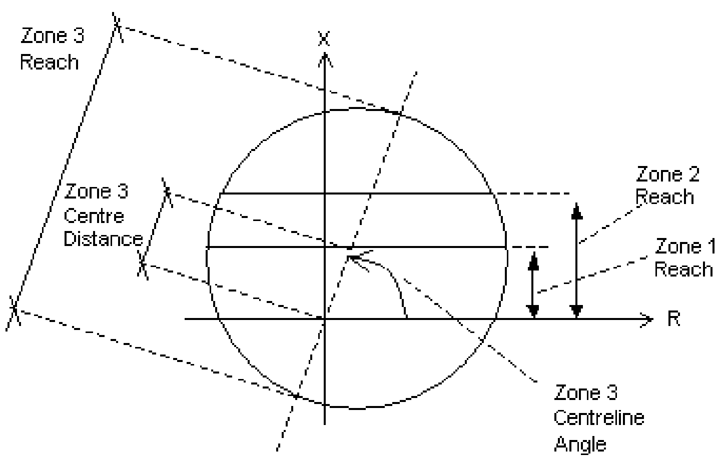


Zone Reach

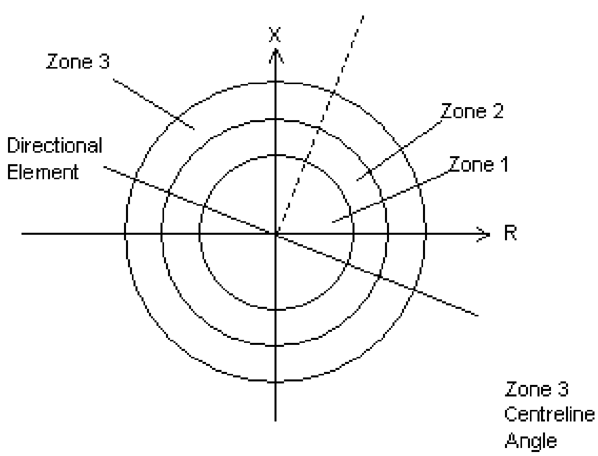
Types



mho

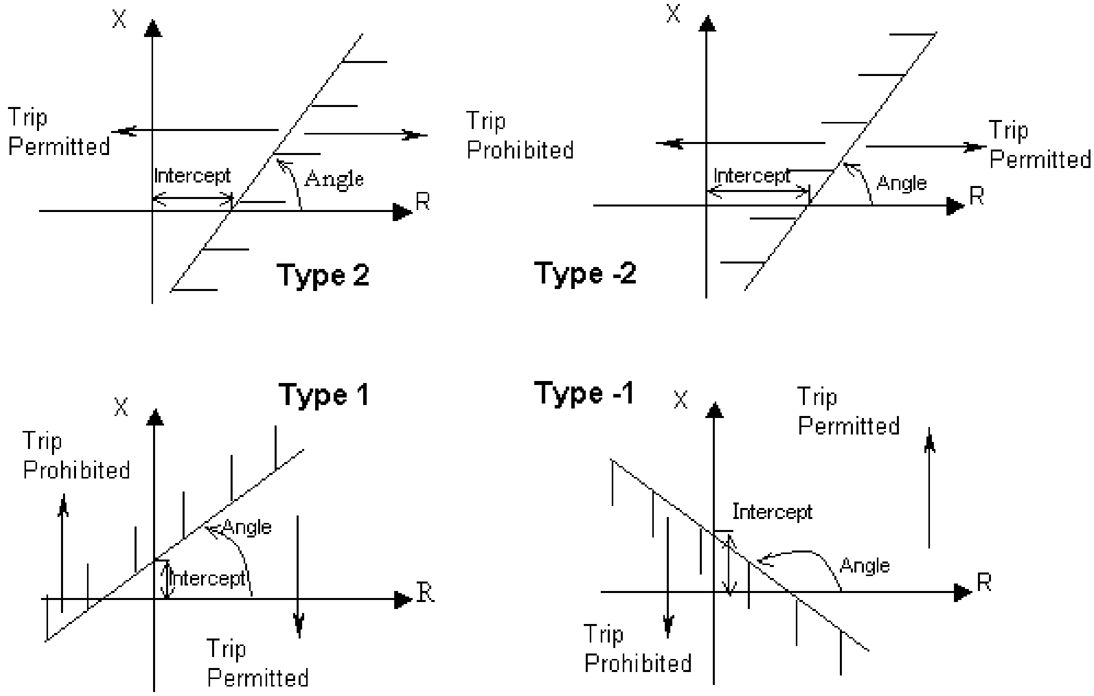


Reactance



Impedance

Blinder Types



Data format:

First Record

Type	Parameter
Integer	Protection ID No.
Char(6)	Protection ID Name
Integer	Type (1-mho, 2-impedance, 3-reactance)
Integer	‘From Bus’ number (Monitored line)
Integer	‘To Bus’ number (Monitored line)
Integer	Circuit Number (Monitored line)
Integer	‘From Bus’ number (First Transfer Trip)
Integer	‘To Bus’ number (First Transfer Trip)
Integer	Circuit Number (First Transfer Trip)
Integer	‘From Bus’ number (Second Transfer Trip)
Integer	‘To Bus’ number (Second Transfer Trip)
Integer	Circuit Number (Second Transfer Trip)
Integer	‘From Bus’ number (Third Transfer Trip)
Integer	‘To Bus’ number (Third Transfer Trip)
Integer	Circuit Number (Third Transfer Trip)
Integer	Permissive flag for self trip *
Integer	Permissive flag for transfer trip**
Real	Zone 1 pickup time (cycles)
Real	Zone 1 reach (diameter or reactance) (pu)
Real	Zone 1 centre angle (0 for reactance relay) (degrees)
Real	Zone 1 centre distance (0 for reactance relay) (pu)
Real	Zone 2 pickup time (cycles)
Real	Zone 2 reach (diameter or reactance) (pu)
Real	Zone 2 centre angle (0 for reactance relay) (degrees)
Real	Zone 2 centre distance (0 for reactance relay) (pu)

Real	Zone 3 pickup time (cycles)
Real	Zone 3 reach (diameter) (pu)
Real	Zone 3 centre angle (degrees)
Real	Zone 3 centre distance (pu)
Real	Directional angle(degrees)
Real	Threshold current (pu)
Real	Self trip breaker time (cycles)
Real	Self trip reclosure time (cycles)
Real	Transfer trip breaker time (cycles)
Real	Transfer trip reclosure time (cycles)
Real	1^{st} Blinder type (±1 or ±2)
Real	1^{st} Blinder intercept (pu)
Real	1^{st} Blinder rotation (degrees)
Real	2^{nd} Blinder type (±1 or ±2)
Real	2^{nd} Blinder intercept (pu)
Real	2^{nd} Blinder rotation (degrees)

Plotting variables:

Var No.	Definition
1	|V/I| (pu)
2	Real part of (V/I) (pu)
3	Imaginary part of (V/I) (pu)
4	|dZ1| (pu) - Distance to Zone 1 in pu
5	Real part of dZ1 (pu)
6	Imaginary part of dZ1 (pu)
7	|dZ2| (pu) - Distance to Zone 2 in pu
8	Real part of dZ2 (pu)
9	Imaginary part of dZ2 (pu)
10	|dZ3| (pu) - Distance to Zone 3 in pu
11	Real part of dZ3 (pu)
12	Imaginary part of dZ3 (pu)

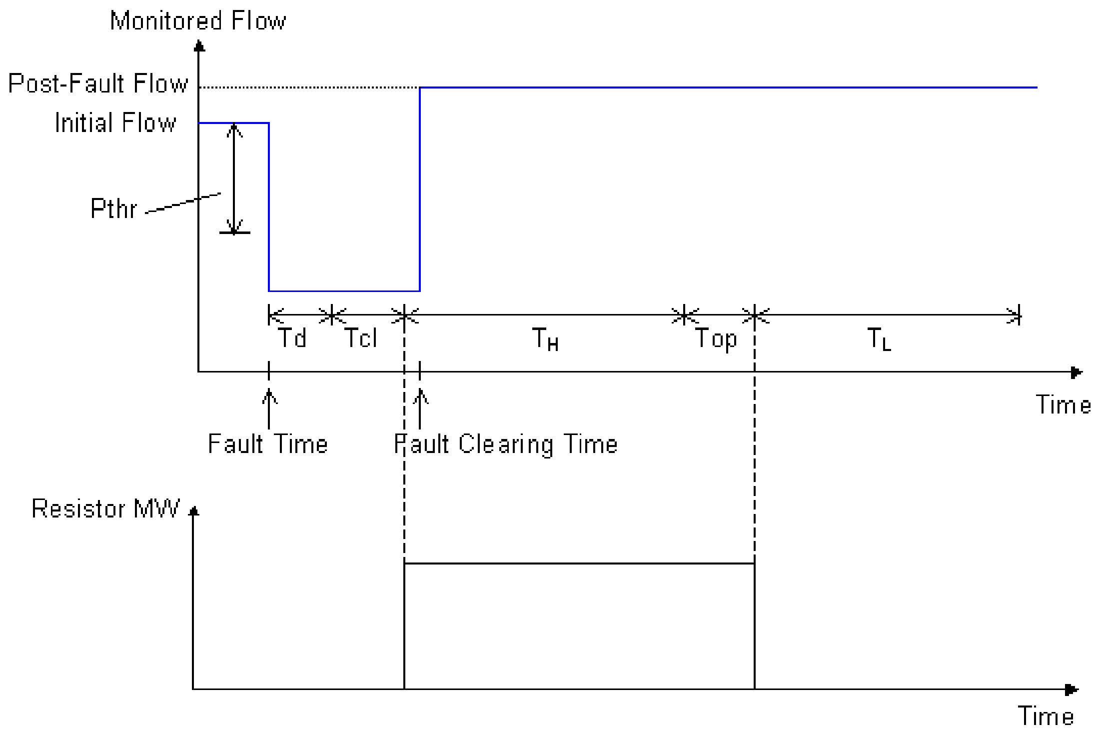
Example: (distance to zone 1 of protection #105)

Object Code	Var. No.	Protection ID	Code No.
PROT	4	105	-

PROT03 Model- Breaking Resistor

Protection Function:

The Breaking Resistor consists of three main components: Flow Measurement Unit, Accelerating Power Detector and Resistor Blocks. Its operation is described in the following Figure.



Data format:

First Record

Type	Parameter
Integer	Protection ID No.
Char(6)	Protection ID Name
Integer	NCir - Number of Circuits in the interface flow definition
Integer	NBrk - Number of Breaking Resistors
Real	Td - Delay Time

NCir Lines for Definition of the Interface Flow

Type	Parameter
Integer	Bus 'From' *
Integer	Bus 'To' *
Integer	Circuit ID

* - The direction of the flow is measured from bus 'From' to bus 'To'.

NBrk Lines for Breaking Resistor Data

Type	Parameter
Integer	Bus Number
Ineger	ID - Breaker ID
Real	*Pr* - Size for nominal voltage (MW)
Real	P_{thr} - Threshold accelerating power (MW)
Real	T_{cl} - Breaker Closing Time (s)
Real	T_{op} - Breaker Opening Time (s)
Real	T_H - Holding Time (s)
Real	T_L - Lockout Time (s)

Plotting variables:

Var No.	Definition
1	Accelerating Power (pu)
2	Total Resistor MW inserted

Example: (accelerating power of protection #105)

Object Code	Var. No.	Protection ID	Code No.
PROT	1	105	-

PROT04 Model- Underfrequency Load Shedding

Protection Function: 81

The underfrequency relay allows the implementation of up to four stages. Each stage can set its pickup characteristic (pickup threshold and time delay), ratio of frequency decay (*df/dt*), breaker time, resetting time and reset threshold. The pickup characteristic can be either a fixed time delay for a given threshold or an inverse time characteristic as shown in the Figure below. The load shedding for each stage can be specified for a bus, zone, area or the whole system.

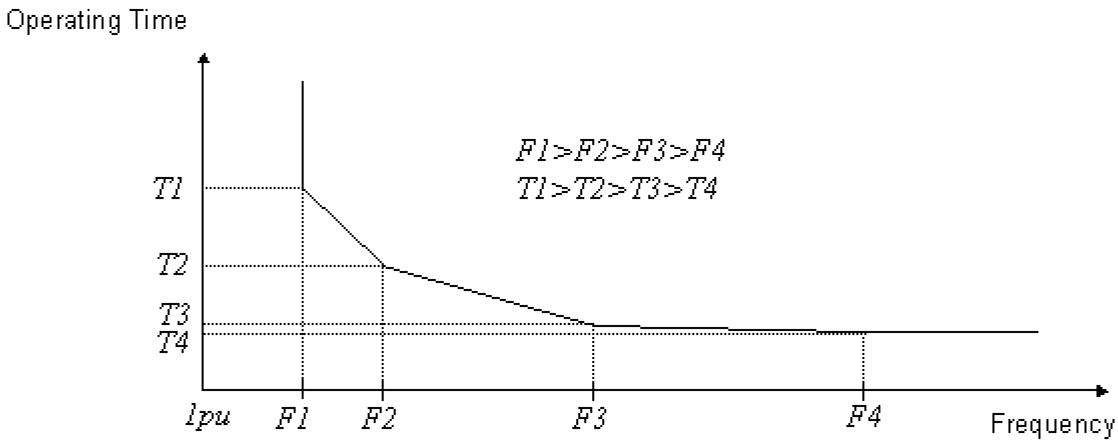


Figure - Inverse time characteristic.

Data format:

First Record

Type	Description
Integer	Number of Bus to measure frequency
Integer	Protection ID No
Integer	Protection ID Name
Integer	Number of stages
Integer	Type of shedding - bus(3), zone(2), area(1) or system(0)
Integer	Number of the bus, zone or area

One Record for Each Stage

Type	Parameter
Integer	Relay type - Fixed time trip (0) or Inverse time trip (1)
Real	Fraction of the load to be tripped by this stage (%)
Real	Frequency decay (*df/dt*) in (Hz/s) (<= 0)< /FONT>
Real	Reset frequency (Hz)
Real	Reset time (s) (>= 0)< /FONT>
Real	Breaker time (s) (>= 0)< /FONT>
Real	First point of the inverse time characteristic - F1 (Hz)[#]
Real	Time of the first point - T1 (s)[#] (>= 0)< /FONT>
Real	Second point of the inverse time characteristic - F2 (Hz)
Real	Time of the second point - T2 (s) (>= 0)< /FONT>
Real	Third point of the inverse time characteristic - F3 (Hz)
Real	Time of the third point - T3 (s) (>= 0)< /FONT>
Real	Fourth point of the inverse time characteristic - F4 (Hz)
Real	Time of the fourth point - T4 (s) (>= 0)< /FONT>

Note: # - F1 and T1 are the frequency threshold and time delay for the relays with fixed time trip (type 0).

Plotting variables:

Var No.	Definition
1	Percent of load armed for trip (%)
2	Percent of load tripped (%)
3	Frequency (pu)

Example: (accelerating power of protection #105)

Object Code	Var. No.	Protection ID	Code No.
PROT	1	99	-

PROT05 Model- Undervoltage Load Shedding

Protection Function: 27

The undervoltage relay allows the implementation of up to four stages. Each stage can set its pickup threshold, time delay, breaker time, resetting time and reset threshold. The load shedding for each stage can be specified for a bus, zone, area or the whole system.

Data format:

First Record

Type	Description
Integer	Number of Bus to measure voltage
Integer	Protection ID No
Integer	Protection ID Name
Integer	Number of stages
Integer	Type of shedding – bus(3), zone(2), area(1) or system(0)
Integer	Number of the bus, zone or area (where load can be shedded)

One Record for Each Stage

Type	Parameter
Real	Fraction of the load to be tripped by this stage (%)
Real	Threshold voltage (pu)
Real	Reset voltage (pu)
Real	Time delay (s) (>= 0)< /FONT>
Real	Reset time (s) (>= 0)< /FONT>
Real	Breaker time (s) (>= 0)< /FONT>

Plotting variables:

Var No.	Definition
1	Percent of load armed for trip (%)
2	Percent of load tripped (%)
3	Voltage (pu)

Example: (accelerating power of protection #105)

Object Code	Var. No.	Protection ID	Code No.
PROT	1	99	-

PROT06 Blinders Type Out of Step Relay Blocking and Tripping

Protection Function: 68 and 78

This model has the following characteristics:

Eight blinders defining two impedance regions for tripping or blocking. The first four blinders define the outer region whereas the last four define the inner region.

Trip of up to three remote lines (transfer trip) as well as monitored line (self trip).

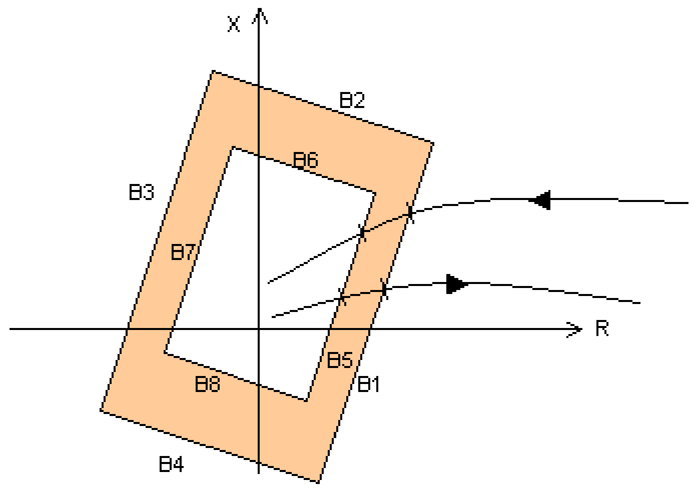
Supervisory signal input to prevent tripping or to force immediate tripping.

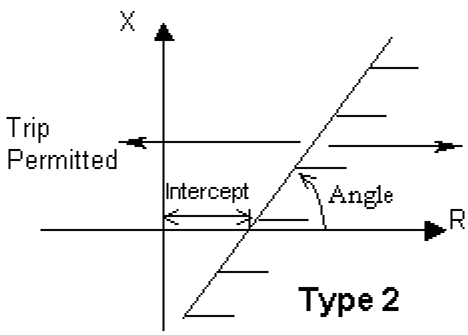
Minimum pickup current logic.

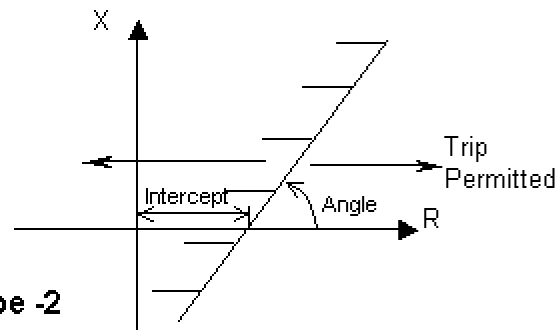
Model may be used in a monitoring only mode.

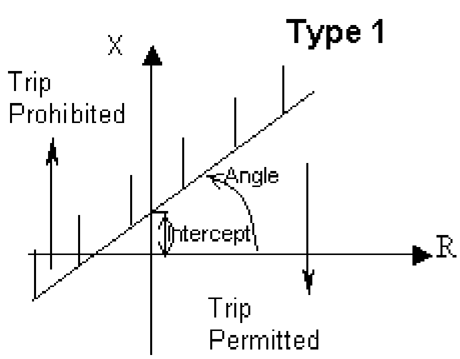
The relay timer T_r starts whenever the line impedance moves the outer region and reset if the impedance moves out this region. The relay sends a trip signal to breakers if the travel time between crossing of outer and inner regions, given by T_r, is greater than minimum pickup time - T_{min} and less than maximum pickup time T_{max}. Otherwise the relay is blocked.

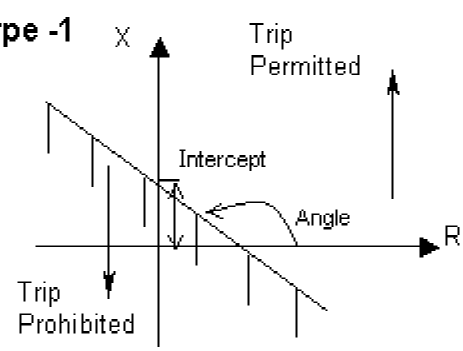
Typically, blinders B1 and B5 are type 2, blinders B3 and B7 are type -2, blinders B2 and B6 are type 1, and blinders B4 and B8 are type -1.


X
B2
B6
B3
B7
R
B5
B8
B1
B4


X
Trip
Permitted
Trip
Prohibited
Intercept
Angle
R
Type 2


X
Trip
Permitted
Intercept
Angle
R
Type -2


Type 1
X
Trip
Prohibited
Angle
Intercept
R
Trip
Permitted


Type -1
X
Trip
Permitted
Intercept
Angle
R
Trip
Prohibited

Data format:

First Record

Type	Parameter
Integer	Protection ID No.
Char(6)	Protection ID Name
Integer	‘From Bus’ number (Monitored line)
Integer	‘To Bus’ number (Monitored line)
Integer	Circuit Number (Monitored line)
Integer	‘From Bus’ number (First Transfer Trip)
Integer	‘To Bus’ number (First Transfer Trip)
Integer	Circuit Number (First Transfer Trip)
Integer	‘From Bus’ number (Second Transfer Trip)
Integer	‘To Bus’ number (Second Transfer Trip)
Integer	Circuit Number (Second Transfer Trip)
Integer	‘From Bus’ number (Third Transfer Trip)
Integer	‘To Bus’ number (Third Transfer Trip)
Integer	Circuit Number (Third Transfer Trip)
Integer	Permissive flag for self trip *
Integer	Permissive flag for transfer trip**
Real	Threshold current (pu)
Real	Minimum travel time - T_{min} (s)
Real	Maximum travel time - T_{max} (s)
Real	Self trip breaker time (s)
Real	Transfer trip breaker time (s)
Real	1st Blinder intercept (pu)
Real	1st Blinder rotation (degrees)
Real	2nd Blinder intercept (pu)
Real	2nd Blinder rotation (degrees)
Real	3rd Blinder intercept (pu)
Real	3rd Blinder rotation (degrees)

Real	4^{th} Blinder intercept (pu)
Real	4^{th} Blinder rotation (degrees)
Real	5^{th} Blinder intercept (pu)
Real	5^{th} Blinder rotation (degrees)
Real	6^{th} Blinder intercept (pu)
Real	6^{th} Blinder rotation (degrees)
Real	7^{th} Blinder intercept (pu)
Real	7^{th} Blinder rotation (degrees)
Real	8^{th} Blinder intercept (pu)
Real	8^{th} Blinder rotation (degrees)

Plotting variables:

Var No.	Definition
1	|V/I| (pu)
2	Real part of (V/I) (pu)
3	Imaginary part of (V/I) (pu)

Example: (distance to zone 1 of protection #105)

Object Code	Var. No.	Protection ID	Code No.
PROT	4	105	-

PROT07 Lens Type Out of Step Relay Blocking and Tripping

Protection Function: 68 and 78

This model has the following characteristics:

Two lens (four impedance circles) defining two impedance regions for tripping or blocking.

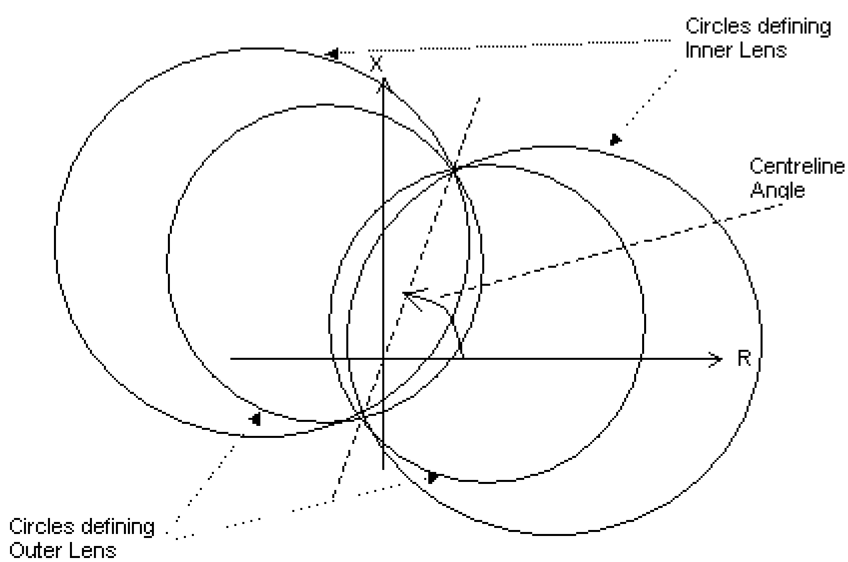
Trip of up to three remote lines (transfer trip) as well as monitored line (self trip).

Supervisory signal input to prevent tripping or to force immediate tripping.

Minimum pickup current logic.

Model may be used in a monitoring only mode.

The relay timer T_r starts whenever the line impedance moves in the outer lens region and resets if the impedance moves out this region. The relay sends a trip signal to breakers if the travel time between crossing of outer and inner lens regions, given by T_r, is greater than minimum pickup time – T_{min} and less than maximum pickup time T_{max}. Otherwise the relay is blocked. The data for the first two impedance circles are referred to the outer lens and the last two for the inner one.



Data format:

Type	Parameter
Integer	Protection ID No.
Char(6)	Protection ID Name
Integer	‘From Bus’ number (Monitored line)
Integer	‘To Bus’ number (Monitored line)
Integer	Circuit Number (Monitored line)
Integer	‘From Bus’ number (First Transfer Trip)
Integer	‘To Bus’ number (First Transfer Trip)
Integer	Circuit Number (First Transfer Trip)
Integer	‘From Bus’ number (Second Transfer Trip)
Integer	‘To Bus’ number (Second Transfer Trip)
Integer	Circuit Number (Second Transfer Trip)
Integer	‘From Bus’ number (Third Transfer Trip)
Integer	‘To Bus’ number (Third Transfer Trip)
Integer	Circuit Number (Third Transfer Trip)
Integer	Permissive flag for self trip *
Integer	Permissive flag for transfer trip**
Real	Outer Lens 1 reach (diameter) (pu)
Real	Outer Lens 1 centre angle (degrees)
Real	Outer Lens 1 centre distance (pu)
Real	Outer Lens 2 reach (diameter) (pu)
Real	Outer Lens 2 centre angle (degrees)
Real	Outer Lens 2 centre distance (pu)
Real	Inner Lens 1 reach (diameter) (pu)
Real	Inner Lens 1 centre angle (degrees)
Real	Inner Lens 1 centre distance (pu)
Real	Inner Lens 2 reach (diameter) (pu)
Real	Inner Lens 2 centre angle (degrees)
Real	Inner Lens 2 centre distance (pu)
Real	Threshold current (pu)
Real	Minimum travel time (s)
Real	Maximum travel time (s)

Real	Self trip breaker time (s)
Real	Transfer trip breaker time (s)

Plotting variables:

Var No.	Definition
1	|V/I| (pu)
2	Real part of (V/I) (pu)
3	Imaginary part of (V/I) (pu)

Example: (distance to zone 1 of protection #105)

Object Code	Var. No.	Protection ID	Code No.
PROT	4	105	-

PROT08 Overfrequency Generation Shedding

Protection Function:

The overfrequency relay allows the implementation of up to two stages. Each stage can set its pickup threshold and time delay.

The relay logic is such that:

- If the measured frequency remains below F1 threshold for more than T1 seconds, NU1 units are shed.

- If the measured frequency remains below F2 threshold for more than T2 seconds, NU2 units are shed.

The number of units in service must be greater than NU1 + NU2.

Data format:

Type	Description
Integer	Protection ID
Integer	Bus No for frequency measurment
Integer	Generator Bus Number
Integer	Generator Group Number
Real	F1 - Frequency threshold 1 (Hz) 60 < F1 < 66
Real	F2 - Frequency threshold 2 (Hz) 60 < F2 < 66
Real	T1 - Time delay 1 (s)
Real	T2 - Time delay 2 (s)
Real	Tbreaker - Breaker time (s)
Integer	NU1 - Number of units to shed at level 1
Integer	NU2 - Number of units fo shed at level 2

Plotting variables:

Var No.	Definition
1	Measured frequency (Hz)
2	Level 1 trip status (0 or 1)
3	Level 2 trip status (0 or 1)

Example: (measured frequency of protection #108)

Object Code	Var. No.	Protection ID	Code No.
PROT	1	99	-

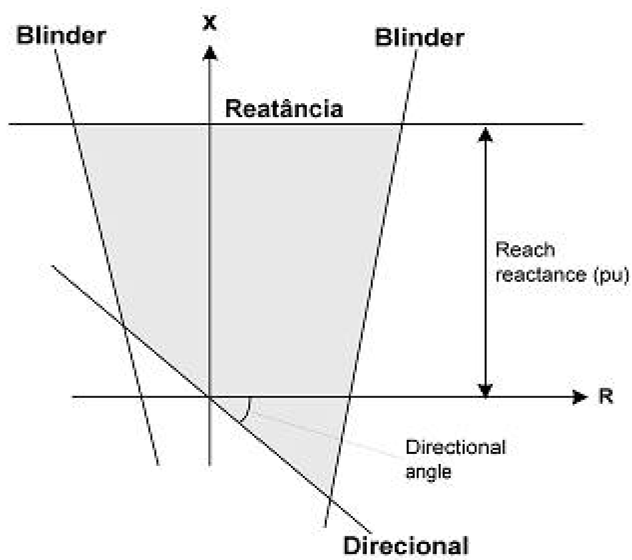
PROT09 Distance Relay Based on Blinders and Directional Units

Protection Function: 21

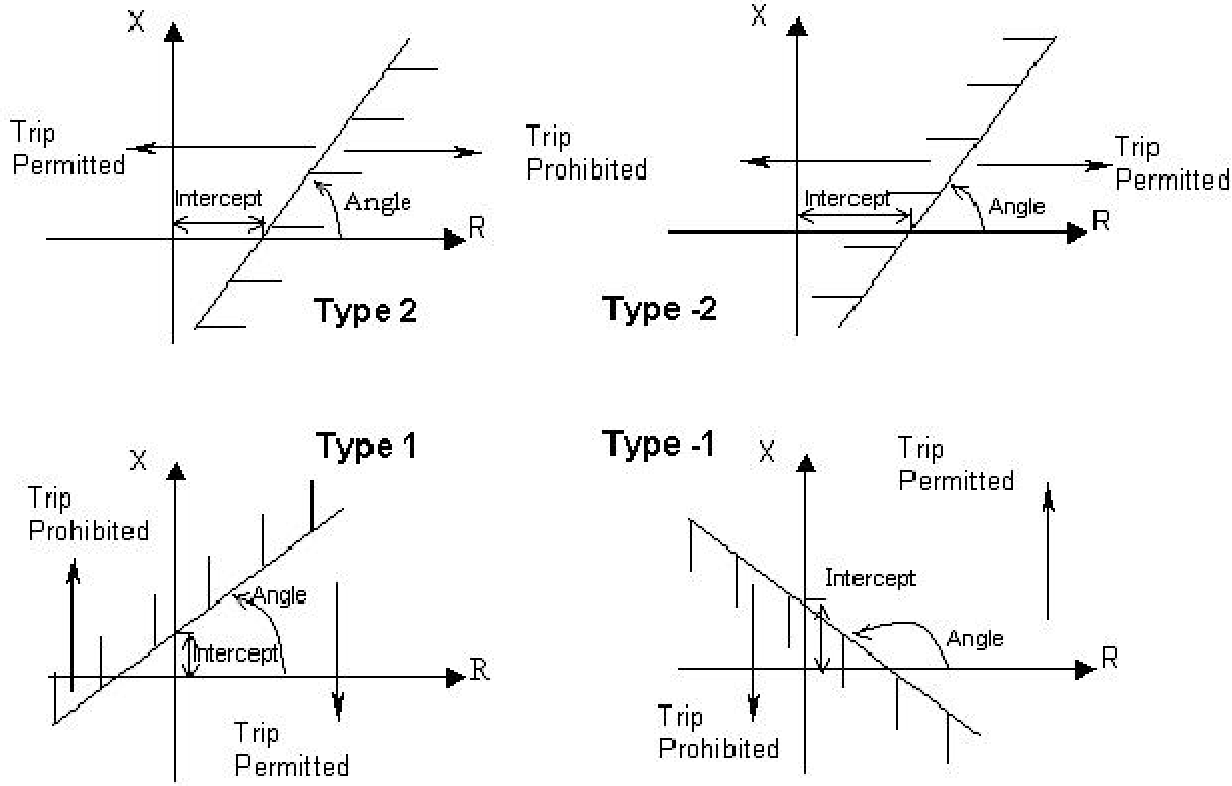
This model has the following components:

- Reactance unit.
- Two blinders.
- Minimum current threshold.
- Directional unit.

The effective operation zone is defined by the intersection of the relay characteristics.



The following convention is used to define the blinders.


X
R
Trip Permitted
Trip Prohibited
Intercept
Angle
Type 2
X
R
Trip Prohibited
Trip Permitted
Intercept
Angle
Type -2
Type 1
X
R
Trip Prohibited
Angle
Intercept
Trip Permitted
Type -1
X
R
Trip Permitted
Intercept
Angle
Trip Prohibited

Data format:

Type	Description
Integer	Protection ID
Integer	Bus From Number
Integer	Bus To Number
Integer	Circuit ID
Real	Reach (reactance) in pu
Real	Directional angle in degree
Real	Treshold current in pu
Real	1st Blinder Type (±1 or ±2)
Real	1st Blinder Intercept in pu
Real	1st Blinder Rotation in degree
Real	2st Blinder Type (±1 or ±2)
Real	2st Blinder Intercept in pu
Real	2st Blinder Rotation in degree
Real	Trelay (s)
Real	Tbreaker (s)

Plotting variables:

Var No.	Definition
1	|V/I| (pu)
2	Real part of (V/I) (pu)
3	Imaginary part of (V/I) (pu)

Example: (Real part of monitored impedance of protection #108)

Object Code	Var. No.	Protection ID	Code No.
PROT	2	99	-

PROT10 Out-of-Step Blocking Relay

Protection Function: 68 and 78

This model has the following characteristics:

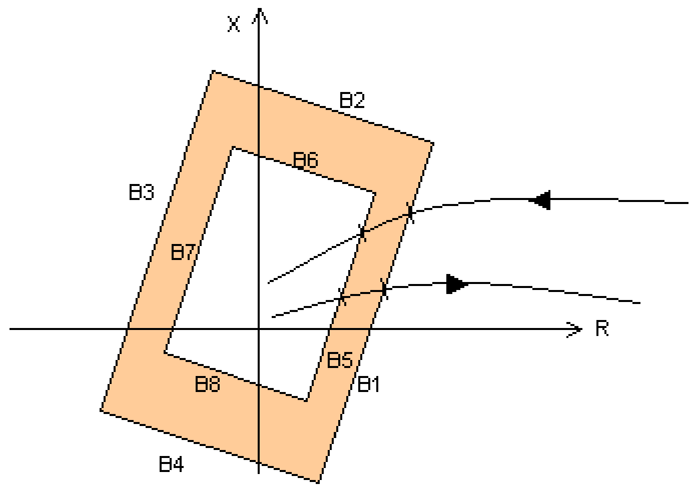
- Eight blinders defining two impedance regions for tripping or blocking.

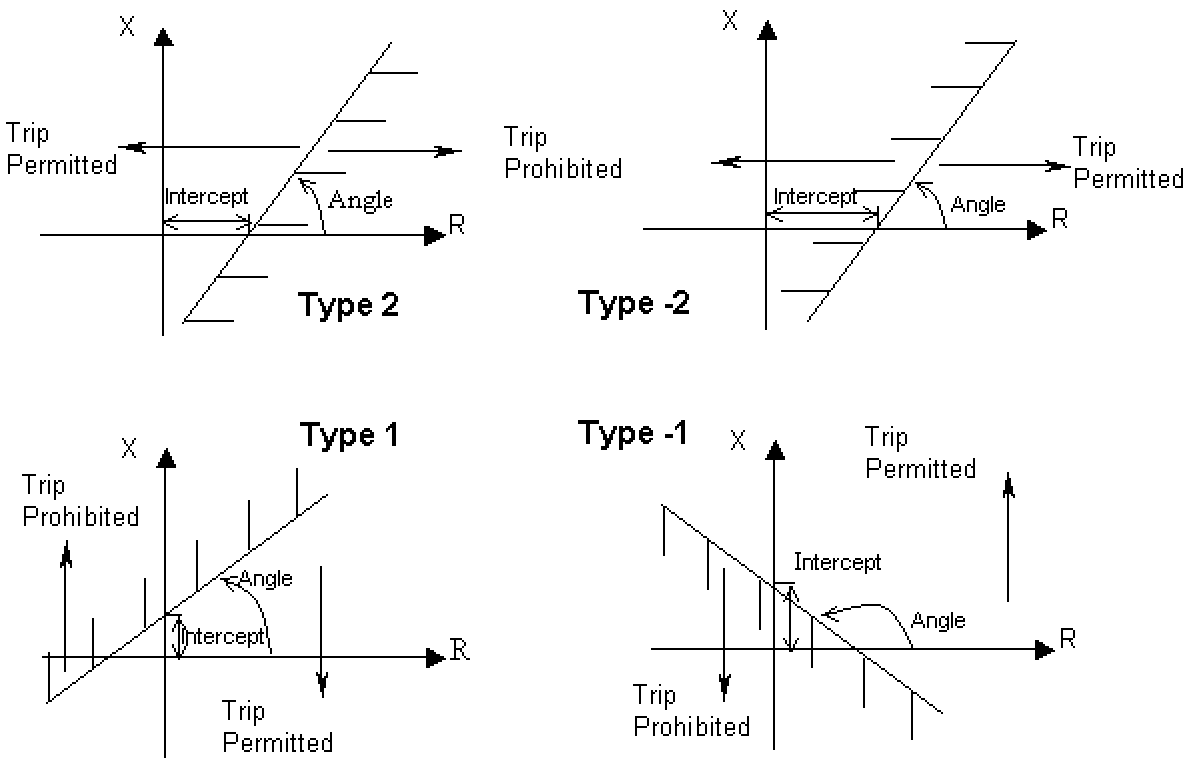
- The first four blinders define the outer region whereas the last four define the inner region.

- Minimum pickup current logic.

The relay timer T_r starts whenever the line impedance moves the outer region and reset if the impedance moves out this region. The relay sends a trip signal to breakers if the travel time between crossing of outer and inner regions, given by T_r, is greater than minimum pickup time - T_{min} and less than maximum pickup time T_{max}. Otherwise the relay is blocked.

Typically, blinders B1 and B5 are type 2, blinders B3 and B7 are type -2, blinders B2 and B6 are type 1, and blinders B4 and B8 are type -1.


X
R
B1
B2
B3
B4
B5
B6
B7
B8


X
R
Trip Permitted
Trip Prohibited
Intercept
Angle
Type 2
X
R
Trip Permitted
Intercept
Angle
Type -2
Type 1
X
R
Trip Prohibited
Angle
Intercept
Trip Permitted
Type -1
X
R
Trip Permitted
Intercept
Angle
Trip Prohibited

Data format:

Type	Parameter
Integer	Protection ID No.
Integer	‘From Bus’ number (Monitored line)
Integer	‘To Bus’ number (Monitored line)
Integer	Circuit Number (Monitored line)
Real	Threshold current (pu)
Real	Minimum travel time - T_{min} (s)
Real	Maximum travel time - T_{max} (s)
Real	Self trip breaker time (s)
Real	Transfer trip breaker time (s)
Real	1st Blinder intercept (pu)
Real	1st Blinder rotation (degrees)
Real	2nd Blinder intercept (pu)
Real	2nd Blinder rotation (degrees)
Real	3rd Blinder intercept (pu)
Real	3rd Blinder rotation (degrees)
Real	4th Blinder intercept (pu)
Real	4th Blinder rotation (degrees)
Real	5th Blinder intercept (pu)
Real	5th Blinder rotation (degrees)
Real	6th Blinder intercept (pu)
Real	6th Blinder rotation (degrees)
Real	7th Blinder intercept (pu)
Real	7th Blinder rotation (degrees)
Real	8th Blinder intercept (pu)
Real	8th Blinder rotation (degrees)
Real	Trelay (s)
Real	Tbreaker (s)

Plotting variables:

Var No.	Definition
1	|V/I| (pu)
2	Real part of (V/I) (pu)
3	Imaginary part of (V/I) (pu)

Example: (distance to zone 1 of protection #110)

Object Code	Var. No.	Protection ID	Code No.
PROT	1	456	-

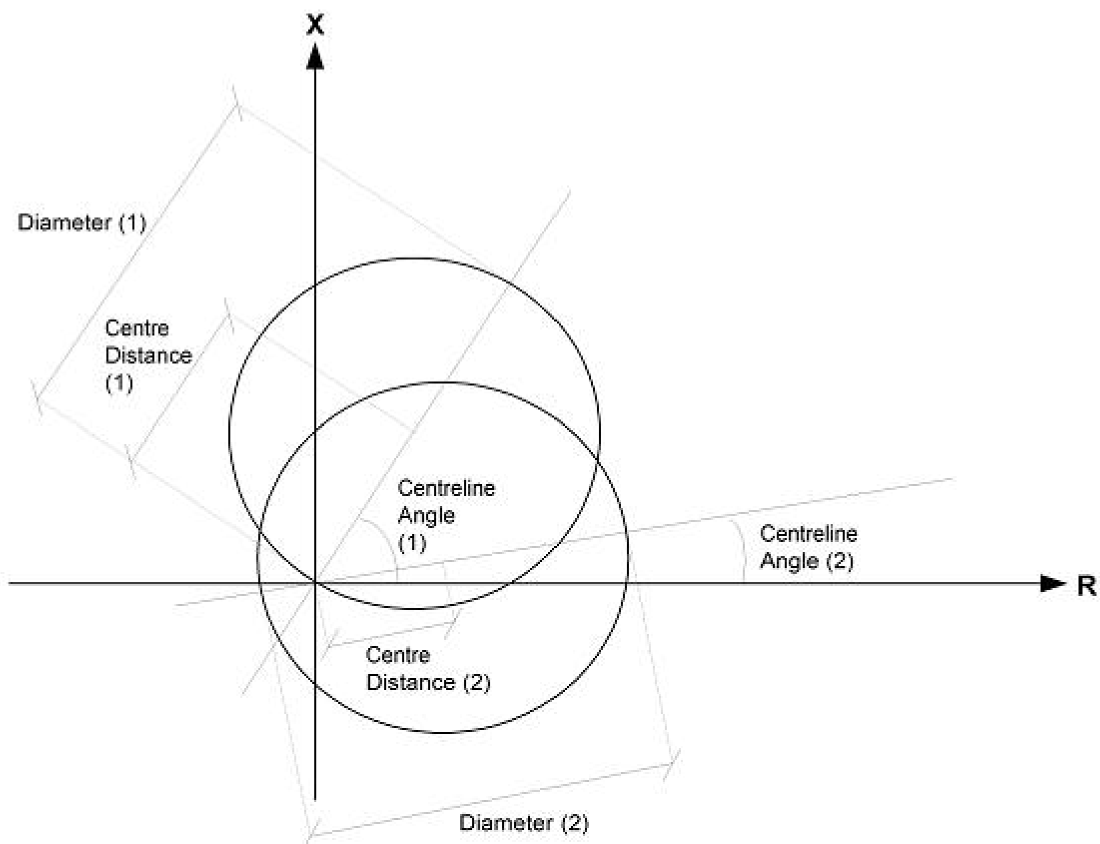
PROT11 Lens or Apple Types Distance Relay

Protection Function: 93

This model presents the following components.

- Lens characteristic.
- Minimum pickup current.

This relay operates whenever the monitored impedance follows within its protection zone. This zone, shown in the figure below, can be either the intersection (lens) or union (apple) of the two circular characteristics. The circuit trip occurs after the relay (Trelay) and breaker (Tbreaker) time delays.



Data format:

Type	Parameter
Integer	Protection ID No.
Integer	Type (0=lens; 1=apple)
Integer	'From Bus' number (Monitored line)
Integer	'To Bus' number (Monitored line)
Integer	Circuit Number (Monitored line)
Real	Lens 1 reach (diameter) (pu)
Real	Lens 1 centre angle (degrees)
Real	Lens 1 centre distance (pu)
Real	Lens 2 reach (diameter) (pu)
Real	Lens 2 centre angle (degrees)
Real	Lens 2 centre distance (pu)
Real	Threshold current (pu)
Real	T_{relay} (s)
Real	T_{breaker} (s)

Plotting variables:

Var No.	Definition
1	|V/I| (pu)
2	Real part of (V/I) (pu)
3	Imaginary part of (V/I) (pu)

Example: (distance to zone 1 of protection #111)

Object Code	Var. No.	Protection ID	Code No.
PROT	1	456	-

PROT12 Under/Overvoltage Relay

Protection Function: 27 and 59

This relay allows flagging both undervoltage and overvoltage. If the pickup voltage is greater than 1. pu, it will act as an overvoltage relay. Otherwise, it will act as an undervoltage relay. It will flag trip if the measured voltage remains above (below) pickup voltage for more than *Tdelay*. Reset will only occur if the voltage stays below (above) pickup voltage for more than *Treset.*

This relay does not acts directly on any physical device. Therefore, it can be used either for monitoring or as an input for a Special Protection Scheme.

Data Format:

Type	**Parameter**
Integer	Protection ID No.
Integer	Number of bus to measure voltage
Real	Pickup Voltage (pu)
Real	T_{delay} (s)
Real	T_{relay} (s)
Real	T_{reset} (s)
Real	$T_{breaker}$ (s)

Plotting Variables:

Var No.	**Definition**
1	|V| (pu)
2	Timer (Definit Time Characteristic) (sec)
3	Reset Timer (sec)

PROT13 Overcurrent Relay - ANSI50

Protection Function: 50

This relay operates whenever the monitored current remains above pickup value for more than T_{delay}.

If the monitored current falls below pickup value, the relay will be reset instantaneously.

Data Format:

Type	Parameter
Integer	Protection ID No.
Integer	'From Bus' number (Monitored line)
Integer	'To Bus' number (Monitored line)
Integer	Circuit Number (Monitored line)
Real	Primary Current Transformer
Real	Secondary Current Transformer
Real	Pickup Current (pu)
Real	T_{delay} (s)
Real	T_{relay} (s)
Real	$T_{breaker}$ (s)

Plotting Variables:

Var No.	Definition
1	|I| (pu)
2	Timer (Definit Time Characteristic) (s)

PROT14 Under/Overfrequency Relay

Protection Function: 81

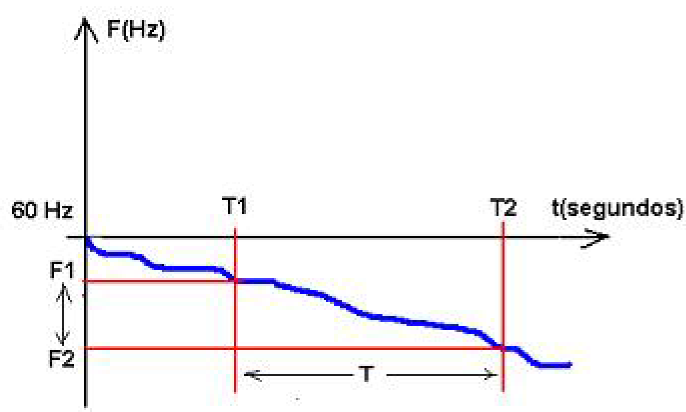
This relay supports both absolute frequency and rate of frequency change. If the frequency set is above 1 pu, the relay will function as an overfrequency realy, and as an underfrequency otherwise.

Absolutefrequency mode:

In this case the relayoperates if the measured frequency is above (below) thefrequency settingF1 fora period greater or equal to$T_{delay.}$Ifthemeasured frequency stays below (above) the frequency setting F1 for aperiod greater or equal to$T_{reset,}$the relay willreset.F2must be set to 0. in this operationmode.

Rate offrequency change mode:

In this case the relay operates if the elapsed time for measured frequency crossing F1 and F2 is less or equal T_{delay} and the undervoltage threshold has not been reached. Reset occurs if the relay does not operate within T_{delay} seconds or if the measured frequency stays below (above) ther frequency setting F1 for a period greater or equatl to T_{reset}.



Data format:

Type	Parameter
Integer	Protection ID No.
Integer	Number of bus to measure frequency
Real	F1 - 1st Frequency setting (Hz)
Real	F2 - 2nd Frequency setting (Hz)
Real	T_{delay} (s)
Real	Undervoltage unit (pu)
Real	T_{relay} (s)
Real	T_{reset} (s)
Real	$T_{breaker}$ (s)

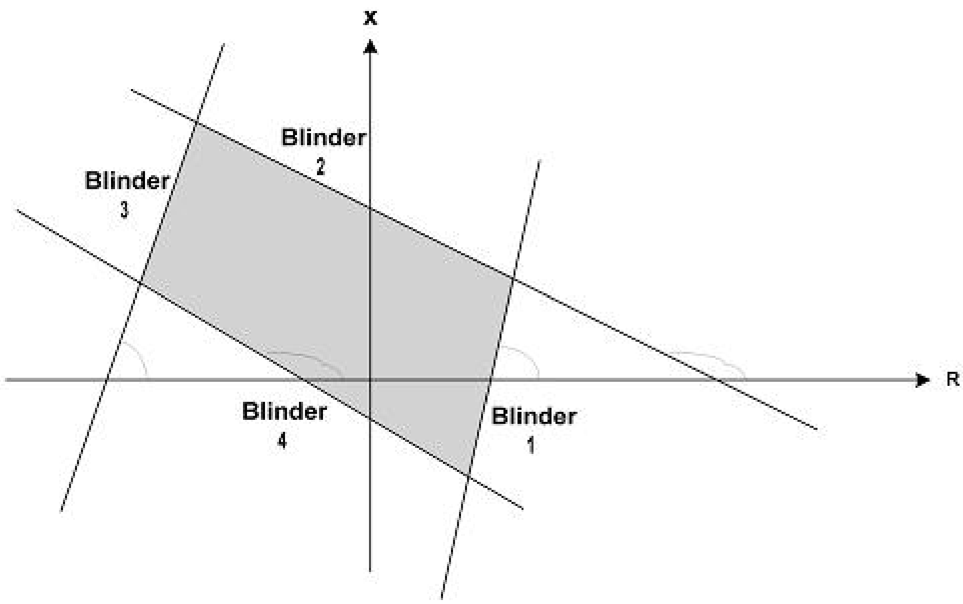
Plotting Variables:

Var No.	Definition
1	Frequency (Hz)
2	Timer (sec)
3	Reset Timer (sec)

PROT15 Distance Relay based on Blinders

Protection Function: 21

Thisdistance relay model isbased on the intersection region of fourblinders.



Data Format:

Type	Parameter
Integer	Protection ID No.
Integer	‘From Bus’ number (Monitored line)
Integer	‘To Bus’ number (Monitored line)
Integer	Circuit Number (Monitored line)
Real	1st Blinder intercept (pu)
Real	1st Blinder rotation (degrees)
Real	2nd Blinder intercept (pu)
Real	2nd Blinder rotation (degrees)
Real	3rd Blinder intercept (pu)
Real	3rd Blinder rotation (degrees)
Real	4th Blinder intercept (pu)
Real	4th Blinder rotation (degrees)
Real	T_{relay} (s)
Real	$T_{breaker}$ (s)

Plotting Variables:

Var No.	Definition
1	|V/I| (pu)
2	Real part of (V/I) (pu)
3	Imaginary part of (V/I) (pu)

CEY21 MHO Type Distance Relay

Protection Function: 21

The GE-CEY is an directional impedance electromechanical relay with MHO operating characteristic.

a) Adjustable Parameters

- "BMR" – Basic Minimum Reach (Alcance Mínimo Básico) (W);
- "TR" – Tap de Restrição (%);
- "PTS" – Percentual Tap Setting (Ajuste do Tap) (%);
- "AMT" – Ângulo Máximo de Torque (º).

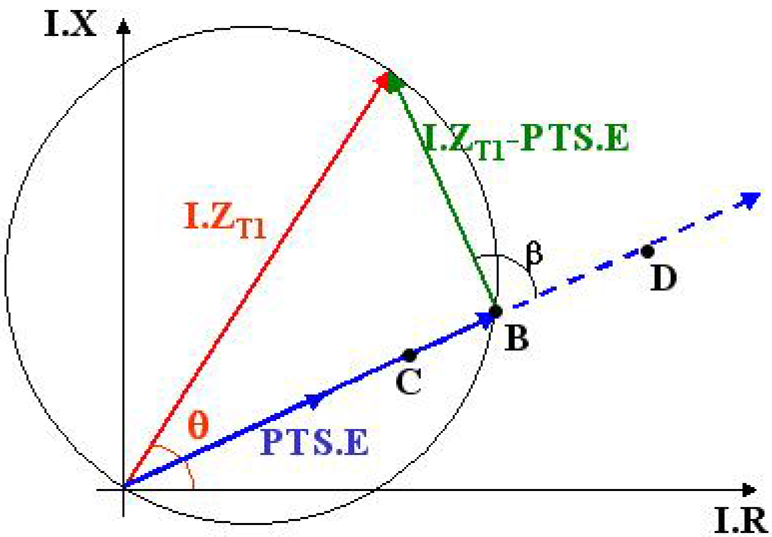
b) Relay Equation

Its torque equation is:

$$\text{Torque} = K \,.\, E \,.\, (I \,.\, Z_{T1} - PTS \,.\, E) \,.\, \cos \beta$$

Where
E : phase-phase voltage (E12);
I : delta current (I1 – I2);
Z_{T1} : adjust impedance (corresponds to the protection circle diameter given by parameters "BMR" – module and "AMT" – angle);
β : angle between (E) and ($I \,.\, Z_{T1} - PTS \,.\, E$);
K : spring constant;
PTS : transformer tap ("PTS").

The figure below presents the graphical representation of the MHO characteristic.



Where:

- I.Z_{T1} : vector with module = I.BMR and angle = "Maximum Angle Torque";
- PTS.E : vector with module = PTS.E and angle = LT impedance line (including fault impedance);
- β : angle between vectors (IZ_{T1} – PTS.E) and (PTS.E).

The relay operation occurs as follows, according to the "Torque Equation":
- Torque = 0 (relay non-operating limit) : occurs when cos β = 0, i.e., when $\beta = \pm 90^o$, a circle passing through the origin with diameter = IZ_{T1} . Example, point B in the figure;
- Torque < 0 (relay not operating) : occurs when cos β < 0, i.e., when $\beta < -90^o$ ou $\beta > +90^o$. Example, point D in the figure;
- Torque > 0 (relay operating) : occurs when cos β > 0, i.e., when $-90^o < \beta < 90^o$. Example, point C in the figure.

Data format:

Type	**Parameter**
Integer	Protection ID no.
Integer	'From Bus' number (monitored line)
Integer	'To Bus' number (monitored line)
Integer	Circuit number (monitored line)
Real	BMR – Basic Minimum Reach (ohms)
Real	MTA – Maximum Torque Angle
Real	PTS – Percentual Tap Setting (%)
Real	Primary current transformer (amperes)
Real	Secondary current transformer
Real	Primary potencial transformer (volts)
Real	Secondary pontecial transformer (volts)

Real	T_{relay} – Relay time (s)
Real	$T_{breaker}$ – Breaker time (s)

Plotting Variables:

Var No.	**Definition**
1	|V/I| (pu)
2	Real part of (V/I) (pu)
3	Imaginary part of (V/I) (pu)
4	b_{mho}– Angle of the comparator for mho characteristic (degrees)
5	Maximum torque (N.m)

Special Protection Schemes

Organon provides a facility for protection schemes modeling. A SPS is described by its name, command instructions and END instruction. There are commands to enter parameters, retrieve network simulation data, perform actions such as open a transmission line, logical functions etc. Comment records are those in which the first non-blank character is '!'. SPS models are edited in files of type *.SPS. Such files can only be loaded after loading a dynamic data file (*.dyn).

Example:

! Description of protection scheme 1

SPS <id1>

<command1>

<command2>

:

END

! Description of protection scheme 2

SPS <id1>

<command1>

<command2>

:

END

:

The syntax of a command is

<output name> = <function> ([arg_1,arg_2,...],[$param_1$,$param_2$,...])

where arg_n is an output name and $param_n$ is a numerical or character value.

The set of commands available is the following.

Title

Measurement Units

Parameter Input

Logical & Arithmetic Operations

Relays

Event Trigers

Miscellaneous

SPS Title

SPS <sps id>

Where the sps id can contain up to 8 characters

Measurement Units

<output name> = BUS(<bus id>,param)

where param must be one of the following:

FREQ - Bus frequency in Hz.

VOLT - Bus voltage in pu

PL - Bus MW load in pu

QL - Bus MVAR load in pu

Remark: The output of this block is real valued.

<output name> = GEN(<bus id>,group,param)

where param must be one of the following:

PG - Generator MW output in pu.

QG - Generator MVAR output in pu

I - Generator current output in pu

IFD - Generator field current in pu

EFD - Generator field voltage in pu

W - Generator rotor speed in pu

NG - number of generator units (for aggregated power plant model)

Remark: The type of output for this block depend on the param value, if NG the output is an integer, otherwise it is a real value.

<output name> = HVDC(<bus1 id>, <bus2 id>, <pole number>,param)

where param must be one of the following:

Pret - Rectifier MW output in pu.

Pinv - Inverter MW output in pu.

Qret - Rectifier MVAR output in pu.

Qinv - Inverter MVAR output in pu.

VDret - Rectifier DC voltage in pu

VDinv - Inverter DC voltage in pu

ID - DC current in pu

BLOCK - Pole status

Remark: The type of output for this block depend on the param value, if BLOCK the output is an logical, otherwise it is a real value.

<output name> = PROTEC(<protection id>,param)

where param must be:

STATUS - Logical condition of the protection device

Remark: The type of output for this block is logical.

<output name> = TLINE(<bus1 id>, <bus2 id>, <circuit id>,param)

where param must be one of the following

PFLOW - MW flow from bus1 to bus2 in pu

QFLOW - MVAR flow from bus1 to bus2 in pu

SFLOW - MVA flow from bus1 to bus2 in pu

IFLOW - Amper flow from bus1 to bus2 in pu

STATUS - Whether it is in service or not

Remark: The type of output for this block depend on the param value, if STATUS the output is a logical, otherwise it is a real value.

<output name> = TRAFO(<bus1 id>, <bus2 id>, <circuit id>,param)

where param must be one of the following

PFLOW - MW flow from bus1 to bus2 in pu

QFLOW - MVAR flow from bus1 to bus2 in pu

SFLOW - MVA flow from bus1 to bus2 in pu

IFLOW - Amper flow from bus1 to bus2 in pu

STATUS - Whether it is in service or not

Remark: The type of output for this block depend on the param value, if STATUS the output is a logical, otherwise it is a real value.

<output name> = SERCAP(<bus1 id>, <bus2 id>, <circuit id>,param)

where param must be one of the following

PFLOW - MW flow from bus1 to bus2 in pu

QFLOW - MVAR flow from bus1 to bus2 in pu

SFLOW - MVA flow from bus1 to bus2 in pu

IFLOW - Amper flow from bus1 to bus2 in pu

STATUS - Whether it is in service or not

Remark: The type of output for this block depend on the param value, if STATUS the output is a logical, otherwise it is a real value.

Parameter Input

<output name> = RPARAM(param)
where param must be a real number

< output name> = IPARAM(param)
where param must be an integer number

Operations

< output name> = AND(input1,input2,…)

where $input_n$ must be the output name of a logical command (e.g., relay output, Tline status, etc). Up to 20 inputs are allowed.

< output name> = OR(input1,input2,…)

where $input_n$ must be the output name of a logical command (e.g., relay output, Tline status, etc). Up to 20 inputs are allowed.

< output name> = NOT(input1)

where input must be the output name of a logical blocks.

< output name> = GT(input1,input2)

where input1 and input2 are the output names of two logical blocks.

< output name> = GE(input1,input2)

where input1 and input2 are the output names of two logical blocks.

< output name> = LT(input1,input2)

where input1 and input2 are the output names of two logical blocks.

< output name> = LE(input1,input2)

where input1 and input2 are the output names of two logical blocks.

< output name> = EQ(input1,input2)

where input1 and input2 are the output names of two logical blocks.

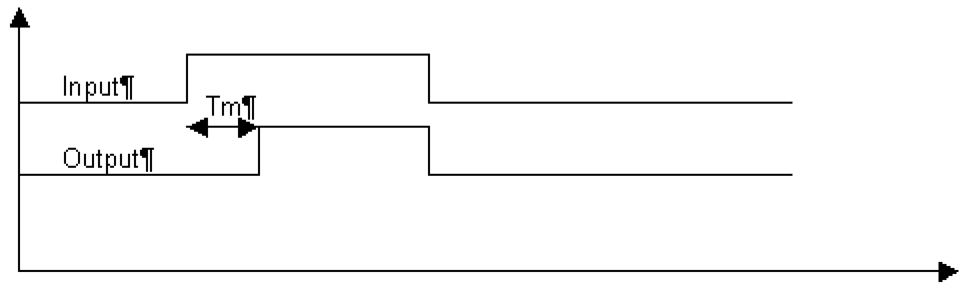
< output name> = NE(input1,input2)

where input1 and input2 are the output names of two logical blocks.

< output name> = TIMER(input,param)

where input is the output name of a logical blocks and param is the time delay.

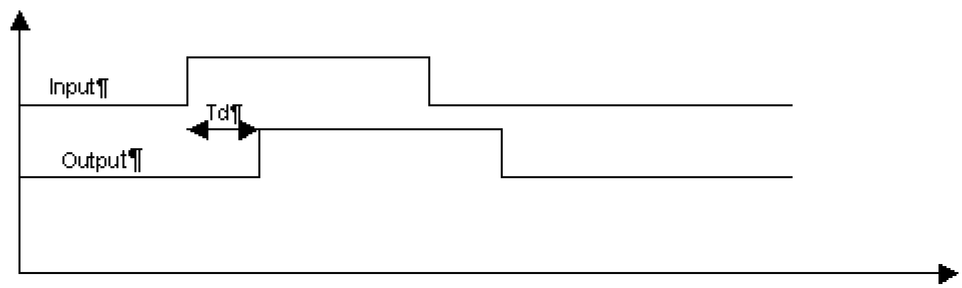
Remark: The output is true after a specified time constant (Tm), if the input remains true during this time. If the input resets before Tm the timer is also reset.



< output name> = DELAY(input,param)

where input is the output name of a logical blocks and param is the time delay (Td).

Remark: The logical output follows the input after the time delay.



< output name> = SAMPLE(input,param)

where input is the output name of a real valued blocks and *param* is the sample time (Ts).

Remark: The output is sampled from the input signal every Ts seconds and held during this time.

< output name> = LAST(input)

where input is the output name of a real valued.

Remark: The output is one step delayed the value of the input block.

< output name> = ADD(input1,input2,…)

where $input_n$ is the output name of a real valued. Up to 20 inputs can be used.

Remark: The result is input1 + input2 + …

< *output name*> = ADDP(param1,input1,param2,input2,...)

where $input_n$ is the output name of a real valued blocks and $param_n$ is a real parameter. Up to 20 inputs can be used.

Remark: The result is param1*input1 + param2*input2+...

< output name> = SUB(input1,input2)

where inputn is the output name of a real valued blocks.

Remark: The result is input1 - input2

< output name> = MULT(input1,input2)

where input$_n$ is the output name of a real valued block.

Remark: The result is input1*input2

< output name> = DIVIDE(input1,input2)

where input$_n$ is the output name of a real valued block.

Remark: The result is input1/input2

< output name> = GAIN(input,param)

where input is the output name of a real valued block and param is a real parameter.

Remark: The result is input*param

< output name> = SQRT(input)

where input is the output name of a real valued block.

< output name> = TRUNC(input)

where input is the output name of a real valued block.

Remark: The output is input value truncated.

< output name> = ROUND(input)

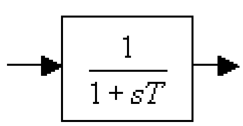
where input is the output name of a real valued block.

Remark: The output is input value rounded.

< output name> = LPASS1(input,param)

where input is the output name of a real valued block and param is a time constant in seconds.

Remark: The output is the low pass filter of the input.



Relays

In this context relays are just comparators.

< output name> = REL27(input,param)

where input is the output name of a real valued block and param is a real parameter.

Remark: Under voltage comparator. If input is lower than param, the output is true.

< output name> = REL37(input,param)

where input is the output name of a real valued block and param is a real parameter.

Remark: Minimum current comparator. If input is lower than param, the output is true.

< output name> = REL40(input,param)

where input is the output name of a real valued block and param is a real parameter.

Remark: Minimum field current comparator. If input is lower than param, the output is true.

< output name> = REL50(input,param)

where input is the output name of a real valued block and param is a real parameter.

Remark: Over current comparator. If input is greater than param, the output is true.

< output name> = REL59(input,param)

where input is the output name of a real valued block and param is a real parameter.

Remark: Overvoltage comparator. If input is greater than param, the output is true.

< output name> = REL81o(input,param)

where input is the output name of a real valued block and param is a real parameter.

Remark: Overfrequency comparator. If input is greater than param, the output is true.

< output name> = REL81u(input,param)

where input is the output name of a real valued block and param is a real parameter.

Remark: Underfrequency comparator. If input is less than param, the output is true.

< output name> = REL81x(input,param)

where input is the output name of a real valued block and param is a real parameter.

Remark: df/dt comparator. If the derivative of input is greater than param, the output is true.

Event Triggers

< output name> = OPEN(input,bus1,bus2,circuit,breaker time)

where input is the output name of a logical block.

Remark: Open branch breakers. If input is true, the branch identified by bus1, bus2 and circuit will be opened after breaker time seconds.

< output name> = OPENF(input,bus1,bus2,circuit,breaker time)

where input is the output name of a logical block.

Remark: Open branch breaker From. If input is true, the branch identified by bus1, bus2 and circuit will be opened after breaker time seconds.

< output name> = OPENT(input,bus1,bus2,circuit,breaker time)

where input is the output name of a logical block.

Remark: Open branch breaker To. If input is true, the branch identified by bus1, bus2 and circuit will be opened after breaker time seconds.

< output name> = LOADSHED(input,bus1,MW%,MVAR%,breaker time)

where input is the output name of a logical block.

Remark: Load shedding. If input is true, MW% and MVAR% will be shed at bus1 after breaker time seconds.

< output name> = GENSHED(input,bus1,groupN,nunits,breaker time)

where input is the output name of a logical block.

Remark: Generator shedding. If input is true, nunits will be shed from aggregated generator of groupN at bus1 after breaker time seconds.

< output name> = LOADRSTR(input,bus1,%MW,%MVAR,breaker time)

where input is the output name of a logical block. %MW and %MVAR correspond to the percentage of the original active and reactive bus load.

Remark: Load restoration. If input is true, the specified load percentage will be restored to the bus after breaker time seconds.

< output name> = SHUNT(input,bus1,MVAR,breaker time,action)

where input is the output name of a logical block. *MVAR* is the capacity of the shunt device for 1 pu terminal voltage. *Action* can be ADD or REMOVE.

Remark: Shunt device switching. If input is true, the specified *MVAR* amount will be added or removed from bus1 after *breaker time* seconds.

Miscellaneous

END

Termination of an SPS command list.

Example:

```
! roit scheme
SPS 1.12.34
E1=TLINE(539,542,1,status)
E2=TLINE(538,542,1,status)
E3=TLINE(673,541,1,status)
E4=TLINE(673,542,1,status)
E5=TLINE(673,543,1,status)
E6=TLINE(673,544,1,status)
!
F1=NOT(E1)
F2=NOT(E2)
F3=AND(F1,F2)
F4=AND(E3,E4,E5,E6)
F5=DELAY(F4,0.1)
F6=NOT(F5)
F7=AND(F3,F5)
F8=AND(F3,F6)
!
S1=GENSHED(F7,503,10,1,0.016)
S2=GENSHED(F8,503,10,2,0.016)
!
END
```

Security Criteria

Data for automatic diagnosis is entered after load modelling in the dynamic model data file (*.dyn). The following aspects can be verified.

Generators' stability margin. The margin is provided with respect to the generator's mechanical power and it is a rough estimation of the amount this power must be reschedule to stabilize (in case of negative margin) or instabilize (in case of positive margin) the case, considering fixed inertia. For a given simulation, only the generators with kinetic energy greater than or equal to 50% of the highest kinetic energy are considered in the diagnosis. This filtering is to avoid considering generators with low energy margin, but not impacted by the disturbance.

Generators' damping. Generators with low damping are selected for Prony analysis. The selection is based on the rate of decay of total energy of the machine. The one with lowest rate is selected as a reference. The units with rate up to 20 times the reference are also selected. The diagnosis provides frequency (Hz) and damping (s^{-1}) to the two main dominant modes.

Instantaneous voltage sag. If the transient volt (after fault clearing) reaches a specified undervoltage threshold, violation is flagged for the respective bus. It is possible to specify a voltage level above which this criterion is enabled (eg., 230 kV).

Instantaneous voltage swell. If the transient volt (after fault clearing) reaches a specified overvoltage threshold, violation is flagged for the respective bus. It is possible to specify a voltage level above which this criterion is enabled (eg., 230 kV).

Temporised voltage sag. If the transient volt (after fault clearing) stays under a specified undervoltage threshold for more than a specified duration, violation is flagged for the respective bus. It is possible to specify a voltage level above which this criterion is enabled (e.g., 230 kV).

Temporised voltage swel. If the transient volt (after fault clearing) stays under a specified overvoltage threshold for more than a specified duration, violation is flagged for the respective bus. It is possible to specify a voltage level above which this criterion is enabled (e.g., 230 kV).

Steady state voltage drop with respect to initial condition. If post contingency steady state is detected, the diagnosis routine can verify if the voltage drop for each bus is greater than a specified value. It is possible to specify a voltage level above which this criterion is enabled (e.g., 230 kV).

Steady state voltage limits with respect to bus specified values. If post contingency steady state is detected, the diagnosis routine can verify if the voltage for each bus remains within the power flow specified values.

Steady state thermal limits. If post contingency steady state is detected, the diagnosis routine can verify if the MVA for each branch remains within the power flow specified values.

Transient maximal angle. This criterion checks if during power swings rotor angle difference of three generators (two-by-two) violate specified threshold.

Steady-state maximal angle. This criterion checks if post-fault steady-state angles violate specified threshold.

Input Record

Type	Parameter	Default
Integer	Stu - Status of temporised sag check (0 or 1).	0
Real	Vtu - sag threshold (pu)	0.8 pu
Real	Ttu - sag duration (s)	0.08 s
Real	Ltu - Voltage level filter (kV)	13.8 kV
Integer	Sto - Status of temporised swell check (0 or 1).	0
Real	Vto - swell threshold (pu)	1.2 pu
Real	Tto - swell duration (s)	0.2 s
Real	Lto - Voltage level filter (kV)	138 kV
Integer	Siu - Status of instantaneous sag check (0 or 1).	0
Real	Viu - sag threshold (pu)	0.6 pu
Real	Liu - Voltage lever filter (kV)	13.8 kV
Integer	Sio - Status of instantaneous swell check (0 or 1).	0
Real	Vio - swell threshold (pu)	1.3 pu
Real	Lio - Voltage level filter (kV)	13.8 kV
Integer	Svd - Status of voltage drop check (0 or 1).	0
Real	Vvd - Voltage drop threshold (pu)	0.1 pu
Real	Lvd - Voltage level filter (kV)	13.8 kV
Integer	Svl - Status of voltage limits check (0 or 1).	0
Integer	Sth - Status of thermal limits check (0 or 1).	0
Real	Damp Threshold	0.15
Integer	Status of angle difference check (0 or 1)	-
Real	Transient angle threshold (degree)	-
Real	Steady-state angle threshold (degree)	-
Integer	Bus number of generator 1	-
Integer	Bus number of generator 2	-
Integer	Bus number of generator 3	-

Note: Status = 0 means disabled.

Programmed Events

The simulation ASCII file (*.plv) contains the total simulation time and a list of events. The first record in this file informs the simulation time. Each event added requires a record with the respective data.

Total simulation time

Event1

Event2

.

.

EventN

-999

ORGANON currently allows the following events to be programmed:

1 - Set branch longitudinal impedance

2 - Change branch longitudinal impedance

3 - Add an admittance to a bus

4 - Add an impedance to a bus

5 - Remove an admittance from a bus

6 - Remove and impedance from a bus

7 - Open a branch

8 - Close a branch

9 - Close breaker of bus From and open breaker of bus To

10 - Close breaker of bus To and open breaker of bus From

11 - Close gap of series capacitor

12 - Open gap of series capacitor

13 - Apply fault to the middle of a transmission line

14 - Remove fault from the middle of a transmission line

15 - Governor step function

16 - Voltage regulator step function

17 - Load shedding

18 - Gen shedding

19 - Load ramping

20 - DC link pole blocking

21 - DC link current order step change

22 - Disconnect a bus

Event data can be manually edit with the help of a word processor or through a specific dialog box in Organon GUI.

Event input data free format:

Type	Parameter
Integer	Event Number
Integer	Number of Bus 1
Integer	Number of Bus 2
Integer	Circuit Number
Real	Resistance or Conductance
Real	Reactance or Susceptance
Real	Event Time
Char(12)	Name of Bus 1
Char(12)	Name of Bus 2

Set Branch Longitudinal Impedance

This Event changes a transmission line or series capacitor longitudinal impedance to the specified (R + jX) new value.

Event 1 input data format:

Type	Parameter
Integer	1
Integer	Number of Bus 1
Integer	0
Integer	0
Real	Resistence (pu)
Real	Reactance (pu)
Real	Event Time (s)
Char(12)	Name of Bus 1
Char(12)	-

Note: the Name of Bus 1 is used if the bus number is zero.

Change Branch Longitudinal Impedance

This event adds incremental impedance (dR + jdX) to a transmission line or series capacitor longitudinal impedance.

Event 2 input data format:

Type	Parameter
Integer	2
Integer	Number of Bus 1
Integer	0
Integer	0
Real	Incremental Resistence (pu)
Real	Incremental Reactance (pu)
Real	Event Time (s)
Char(12)	Name of Bus 1
Char(12)	-

Note: the Name of Bus 1 is used if the bus number is zero.

Add/Remove Admittance to/from a Bus

Event 3/5 input data format:

Type	Parameter
Integer	3 (add) or 5 (remove)
Integer	Number of Bus 1
Integer	0
Integer	0
Real	Conductance(pu)
Real	Susceptance(pu)
Real	Event Time (s)
Char(12)	Name of Bus 1
Char(12)	-

Note: the Name of Bus 1 is used if the bus number is zero.

Add/Remove Impedance from/to a Bus

Event 4/6 input data format:

Type	Parameter
Integer	4 (add) or 6 (remove)
Integer	Number of Bus 1
Integer	0
Integer	0
Real	Resistance(pu)
Real	Inductance(pu)
Real	Event Time (s)
Char(12)	Name of Bus 1
Char(12)	-

Note: the Name of Bus 1 is used if the bus number is zero.

Open/Close Branch

Event 7/8 input data format:

Type	Parameter
Integer	7 (open) or 8 (close)
Integer	Number of Bus 1
Integer	Number of Bus 2
Integer	Circuit Number
Real	0.
Real	0.
Real	Event Time (s)
Char(12)	Name of Bus 1
Char(12)	Name of Bus 2

Note: the Name of Bus 1 and 2 are used if the respective bus numbers are zero.

Open/Close a Circuit Breaker

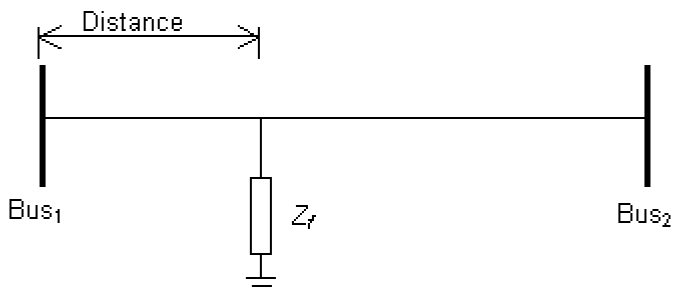
Event 9/10 input data format:

Type	Parameter
Integer	9 (Close From and Open To) or 10 (Close To and Open From)
Integer	Number of Bus From
Integer	Number of Bus To
Integer	Circuit Number
Real	0.
Real	0.
Real	Event Time (s)
Char(12)	Name of Bus From
Char(12)	Name of Bus To

Note: the Name of Bus 1 and 2 are used if the respective bus numbers are zero.

Apply/Remove Fault in a Transmission Line

This event allows applying a fault in a transmission line at some distance from one of the buses.



Remark: After applying a fault in a line, no other operation with the line can be done except for removing the fault. For example, after applying a faul in a transmission line, it can only be opened after removing the fault.

Event 13/14 input data format:

Type	Parameter
Integer	13 (apply) or 14 (remove)
Integer	Number of Bus 1
Integer	Number of Bus 2
Integer	Circuit Number
Real	Fault Resistance (pu)*
Real	Fault Reactance (pu)*
Real	Event Time (s)
Char(12)	Name of Bus 1@
Char(12)	Name of Bus 2@
Real	Distance from Bus 1 (0 – 100%)#

Notes:

@ - The Name of Bus 1 and 2 are used if the respective bus numbers are zero.

- 0% means the fault is at bus 1 whereas 100% means it is at bus 2.

* - Only necessary for applying the fault. When removing the fault, original branch parameters are recovered.

Open/Close Gap of Series Capacitor

Event 11/12 input data format:

Type	Parameter
Integer	11 (close) or 12 (open)
Integer	Number of Bus 1
Integer	Number of Bus 2
Integer	Circuit Number
Real	0.
Real	0.
Real	Event Time (s)
Char(12)	Name of Bus 1
Char(12)	Name of Bus 2

Note: the Name of Bus 1 and 2 are used if the respective bus numbers are zero.

Governor Step Function

Event 15 input data format:

Type	Parameter
Integer	15
Integer	Number of Bus 1
Integer	Synchronous Machine ID
Integer	Mode (1 for % or 0 for pu absolute value)
Real	Step Value (% or pu)
Real	0.
Real	Event Time (s)
Char(12)	Name of Bus 1
Char(12)	0

Note: the Name of Bus 1 is used if the respective bus number is zero.

Voltage Regulator Step Function

Event 16 input data format:

Type	Parameter
Integer	16
Integer	Number of Bus 1
Integer	Synchronous Machine ID
Integer	Mode (1 for % or 0 for pu absolute value)
Real	Step Value (% or pu)
Real	0.
Real	Event Time (s)
Char(12)	Name of Bus 1
Char(12)	0

Note: the Name of Bus 1 is used if the respective bus number is zero.

Load Shedding

Changes the load by subtracting the specified factors from the existing load

$Pc_{new} = Pc - (\text{MW factor}) \times Pc_{original} / 100$, $Pc_{new} \times Pc_{original} \geq 0$

$Qc_{new} = Qc - (\text{Mvar factor}) \times Qc_{original} / 100$, $Qc_{new} \times Qc_{original} \geq 0$

Event 17 input data format:

Type	Parameter
Integer	17
Integer	Type (Bus(3), Zone(2), Area(1), or System(0))
Integer	Number of Bus, Zone or Area
Integer	0
Real	MW factor (%) (>=0, <= 100.)< /FONT>
Real	Mvar factor (%) (>=0, <= 100.)< /FONT>
Real	Event Time (s)
Char(12)	-
Char(12)	-

Generation Shedding

There are two possibilities for shedding generators. One is to open the breakers of the step up transformer branch. In this case, all the units connected to this bus will be shed. Alternatively, event 18 can specify the amount of units to be shed in the generation bus.

Event 18 input data format:

Type	Parameter
Integer	18
Integer	Number of Bus
Integer	Synchronous generator group number
Integer	Number of units to shed
Real	0
Real	0
Real	Event Time (s)
Char(12)	-
Char(12)	-

Load Ramping

Event 19 input data format:

Type	Parameter
Integer	19
Integer	Type (Bus(3), Zone(2), Area(1), or System(0))
Integer	Number of Bus, Zone or Area
Integer	0 (for %/Min) or 1 (for MVA/Min)#
Real	Kp (%/Min or MW/Min)
Real	Kq (%/Min or MVAr/Min)
Real	Starting Event Time (s)
Char(12)	-
Char(12)	-
Real	Duration (s)$

- %/min is a loading ramping that is proportional to existing load *(load = $load_0$(1 +Kr*time)*

MVA/min is a loading ramping that is not dependent on the existing load *(load = $load_0$ + Kr*time)*

$ - Total load change will be (load = load(1 +Kr*duration) or (load = load + Kr*duration).

DC Link Pole Blocking

Event 20 input data format:

Type	Parameter
Integer	20
Integer	Rectifier Bus
Integer	Inverter Bus
Integer	Pole Number
Real	-
Real	-
Real	Event Time (s)
Char(12)	-
Char(12)	-
Real	-

DC Link Current Order Step Change

Event 21 input data format:

Type	Parameter
Integer	21
Integer	Rectifier Bus
Integer	Inverter Bus
Integer	Pole Number
Real	Current Step (%)
Real	-
Real	Event Time (s)
Char(12)	-
Char(12)	-
Real	-

Disconnect Bus

All branches connected to the specified bus are disconnected at Event Time.

Event 22 input data format:

Type	Parameter
Integer	22
Integer	Bus ID
Integer	0
Integer	0
Real	0
Real	0
Real	Event time (s)
Char(12)	-
Char(12)	-
Real	0

Infinite Bus Voltage Step Function

Event 23 input data format:

Type	Parameter
Integer	23
Integer	Number of Bus 1
Integer	0
Integer	Mode (1 for % or 0 for pu absolute value)
Real	Step Value (% or pu)
Real	0.
Real	Event Time (s)
Char(12)	Name of Bus 1
Char(12)	0

Note: the Name of Bus 1 is used if the respective bus number is zero.

Load Restoration

Changes the load by subtracting the specified factors from the existing load

Pc_{new} = Pc + (MW factor) x $Pc_{original}$ / 100, $|Pc_{new}| \leq |Pc_{original}|$

Qc_{new} = Qc + (MVAR factor) x $Qc_{original}$ / 100 $|Qc_{new}| \leq |Qc_{original}|$

Event 24 input data format:

Type	Parameter
Integer	24
Integer	Type (Bus(3), Zone(2), Area(1), or System(0))
Integer	Number of Bus, Zone or Area
Integer	0
Real	MW factor (%) (>=0, <= 100.)< /FONT>
Real	Mvar factor (%) (>=0, <= 100.)< /FONT>
Real	Event Time (s)
Char(12)	-
Char(12)	-

Load Step

Changes the load by subtracting the specified factors from the existing load

Pc_{new} = (100 + MW factor) x Pc / 100

Qc_{new} = (100 + MVAR factor) x Qc / 100

Event 25 input data format:

Type	Parameter
Integer	25
Integer	Type (Bus(3), Zone(2), Area(1), or System(0))
Integer	Number of Bus, Zone or Area
Integer	0
Real	MW factor (%)
Real	Mvar factor (%)
Real	Event Time (s)
Char(12)	-
Char(12)	-

Plotting

Output trajectory plotting needs specification of the required quantities to be stored during simulation and the plotting definition (scale, grid, etc). Users can only enter plotting data after a system dynamic model has been loaded.

The specified quantities can be those calculated during simulation (internal) or read from an External File.

The graph description includes the ID number of the quantity to be plotted, title, reference quantity (X-axis), scales, colours and grid options.

These data may be entered using the "Plottings" dialog box or in an ASCII data file (extension *.plv). The general format for this file is as follows:

1 SM 2 5022 10 0 0 100.0 /

2 SM 2 36 10 0 0 100.0 /

3 SM 2 250 10 0 0 100.0 /

4 BUS 1 191 10 /

5 BUS 1 1619 10 /

6 BUS 1 183 10 /

7 INT 1 /

-9 /

'c:\organon\ data\plot\previous.plt' /

'Graph 1 ' 0.00000000 0.00000000 00 00 0 /

1 /

2 /

3 /

-9 /

'Graph 2 ' 0.00000000 0.00000000 00 00 0 /

4 0 /

5 1 /

7 /

-9 /

'Graph 3 ' 0.00000000 0.00000000 00 00 0 /

7 /

-9 /

-99 /

This file can be edited using a text editor or generated by Plotting dialog box.

One plotting may have one or more quantities and one quantity may be added to one or more plotting. The same plotting may contain internal and external quantities.

Currently it is possible to store up to 1000 internal quantities for plotting and define up to 30 graphs. The code –9 indicates the end of internal variables list. This code is also used to indicate the end of the list of quantities per plotting. Each graph can plot up to 30 quantities at the same time. The code –99 is used to indicate the end of the list of graphs.

The grid pattern is:

Blank - both X and Y-axes grids are plotted;

X - only X-axis grid is plotted;

Y - only Y-axis grid is plotted;

N - no grid is plotted.

When both Ymin and Ymax are equal zero, the program sets these limits automatically.

Plotting Specification Data File

The program can plot quantities that are stored during simulation (internal variables) and variables retrieved from a file (external variables). The code –9 indicates the end of internal variables list. External quantities are useful for comparison purposes.

Internal Variables Specification

The specification of an internal quantities requires the following information:

Quantity Id	Quantity Identification Number
Object Code	Type of object whose quantity will be retrieved from (Bus, Branch, Load, Synchronous Machine, SVC, etc.) (see item 4.1.1.1)
Code	Specifies a quantity for the object (see item 4.1.1.1)
Bus 1	Bus where the object is connected or Bus From for branch type objects such as transformers, transmission lines, TCSC, DC Link, etc.
ID1	Object ID. In case there is more than one equipment of the same type at the bus
Bus2	Number of a Reference Bus (optional) or Bus To for branch type objects **(1)**
ID2	Object ID at bus 2.
Gain	Multiplication factor. Used for per unit conversion, for example (optional).
Name1	Name of Bus1. This is used if Bus1=0 (optional).
Name2	Name of Bus2. This is used only if Bus2=0 (optional).

Note: If the object is not of branch type, i.e., it is connected to only one bus, and the reference bus number is informed, the program takes the difference of the same quantity from the two different buses. Value = Value (Bus1) – Value (Bus 2). If a similar equipment is not found in Bus2, then Value = Value (Bus1).

Summary of Plotting Object and Variables Codes

Plotting Object		Quantity Code		Bus1	ID1	Bus2	ID2
Object	Code	Quantity	Code				
Bus	BUS	Voltage (pu)	1	Bus ID			
		Angle (deg)	2				
		Pload (pu)	3				
		QLoad (pu)	4				
Branch	BRA	Flow (MW)	1	Measuring Bus ID		Other Bus ID	Circuit Number
		Flow (Mvar)	2				
		Flow(MVA)	3				
		Current (A)	4				
Integration Method	INT	Time Step(s)	1				
		Integration Order	2				
		Iterations/Step	3				
		Convergence Rate/Stept	4				
Energy Function	EN	Potential Energy	1	Reference Bus ID in the Island **(1)**			
		Total Energy	2				
		Kinetic Energy	3				
		Dot Product	4				
		Angle OMIB	5	Bus ID **(2)**	Generation Group		
		Speed OMIB	6				
		Pe OMIB	7				
		Pm OMIB	8				
		Kin.En.OMIB	9				
		Pot.En. OMIB.	10				
		Total En. OMIB	11				
		Filt.Kin.En.OMIB	12				

		Angle	13	Cluster **(3)**			
		Speed	14				
		Pe	15				
		Pm	16				
		Kinetic Energy	17				
		Potential Energy	18				
		Total Energy	19				
Infinity Bus	INF	See Model		Bus ID			
Synchronous Machine and Controls	SM TD AVR PSS OEL UEL GOV	See Model		Bus ID	Generation Group		
Static Compensator	SVC	See Model		Bus ID	Unit ID		
Induction Motor	IM	See Model		Bus ID	Unit ID		
HVDC link	DC	See Model		Rectifier/ Inverter Bus ID	Bipole Number	Inverter /Rectifier Bus	
Rectifier	RECT	See Model		Rectifier Bus ID	Bipole Number	Inverter Bus ID	
Inverter	INV	See Model		Inverter Bus ID	Bipole Number	Rectifier Bus ID	
OLTC	OLTC	See Model		Measuring Bus ID	OLTC Number	Other Bus ID	
TCSC	TCSC	See Model		Measuring Bus ID	TCSC Number	Other Bus ID	
Angle Difference	AA	Rotor Angle	1	Bus ID	Generation Group	Bus ID	Generation Group
		Bus Voltage Angle	2		(4)		(4)

Notes:

(1) - Energy Function is computed per island in the system;

(2) - Energy Function refers to machine variables against the COI reference;

(3) - Energy Function refers to cluster of machines, which are defined by buses/areas/zone (see definition file *.def). Up to three clusters can be defined. Energy is computed for clusters [1, 2, 3, 4=(1+2), 5= (1+3) and 6= (2+3)];< /FONT>

(4) - For angle difference between bus voltage angles, these fields must be blank.

External Quantities

External quantities are read from a file, whose name is specified after the list of internal quantities and before the graph specification. This file contains columns with the time series of the listed variables.

The first record of data in this file contains the name of each quantity. The remaining records contain the numerical values of the respective quantities. Every record is terminated with a slash.

Plotting Specification

The plotting specification consists of a graph header and a list of quantity ID (internal and external) to be added to the plotting. The code –9 indicates the end of the list of quantity ID in the plotting. The code –99 indicates the end of the list of plottings.

The plotting header requires the following information:

Type	Parameter
Char(30)	Plotting Title
Real	Minimum Value on the Vertical Axis **(1)**
Real	Maximum Value on the Vertical Axis **(1)**
Integer	Internal Variable on the Horizontal Axis **(2)**
Integer	External Variable on the Horizontal Axis **(3)**
Char	Grid Pattern (blank/0, X, Y, N) **(4)**

Notes:

(1) – If = 0.0, the program sets these limits automatically (Default = 0.0); < /FONT >

(2) – If = 0, Time is used in the horizontal scale (Default = 0); < /FONT >

(3) – If = 0, the first column in the external file is used in the horizontal scale (Default = 0); < /FONT >

(4) – Blank or 0 means that both horizontal and vertical grids will be displayed. Other options are: X – grid only in the horizontal axis; Y – grid only in the vertical axis and N – no grid will be displayed.

Each quantity to be plotted must be in a different record. It is necessary to enter the quantity ID (see item 4.1.1) and its source (0 or blank for internal variables and 1 for external variables).

Plotting Specification Dialog Box

It is possible to enter and edit plotting specification data, using a dialog box, which is activated selecting: **Edit>>Dynamic Data>>Plottings**.

Reports

Time simulation diagnoses are listed in the Report Tables and can be saved in a report file.