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NEPLAN V555

TURBINE-GOVERNOR MODELS

Standard Dynamic Turbine-Governor Systems in NEPLAN Power System Analysis Tool

NEPLAN
Smarter Tools

Contents

General

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

In old Simpow turbine models, the turbine are composed of two models

- One Governor (Input = Speed, output = Gate)
- One Turbine (Input = Gate, Output = TM)

In new dynamic simulator the turbine models include the governor part.

One Turbine (Input Speed, Output = TM)

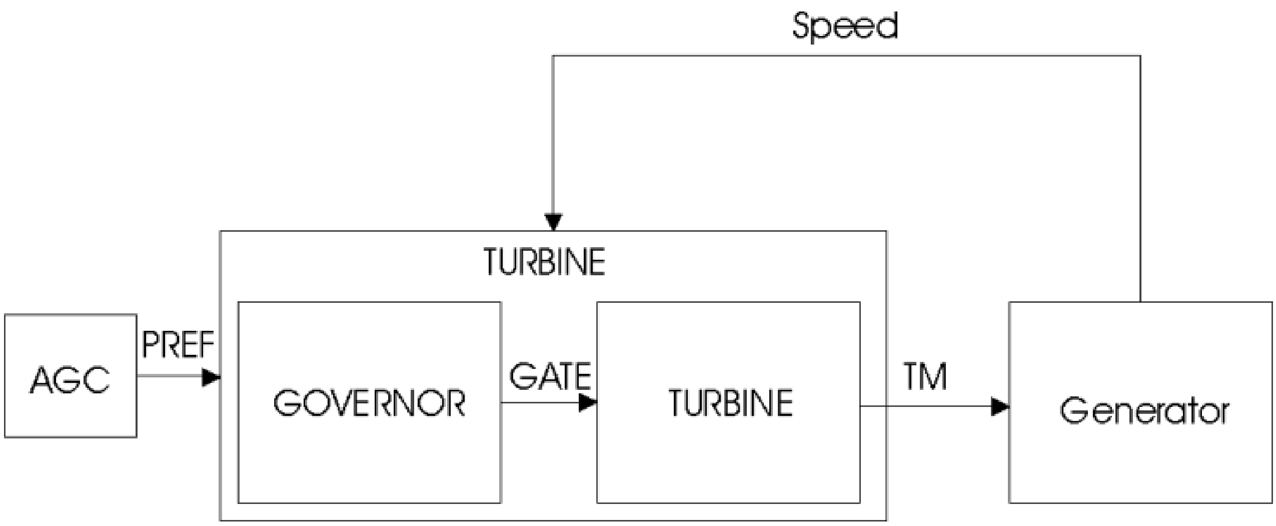
Note: The old Simpow models are also supported in new Dynamic simulator.

ENTSO-E, an association of the European electricity transmission system operators, selected the Common Information Model (CIM) standards of the International Electrotechnical Commission (IEC) as a basis for its own CIM standards. These standards aim at ensuring the reliability of grid models and market information exchanges.
In 2013, ENTSO-E adopted a new standard for grid models exchange called the Common Grid Model Exchange Standard (CGMES). The CGMES is a superset of the IEC CIM standards (belonging to IEC CIM16). It was developed to meet necessary requirements for the transmission system operators, which exchange data in the areas of system operations, network planning and integrated electricity markets.

All the CIM/CGMES regulators models are included in NEPLAN Power System Analysis Tools.

Per Unit (p.u.) System:
All p.u. values are based on the machine ratings.

Turbine-Governor Diagram



Input Signals to the Turbine System:

GATE	Gate opening p.u. (only if govenor and turbine are in different regulator model)
P	Active electrical power of generator in p.u.
W	Rotor Speed of the machine in p.u.

Input Signals to the Governor System:

P	Active electrical power of generator
F	Frequency on the bus in p.u.
W	Speed of the machine in p.u..

Output Signals to the Turbine System:

TM	Mechanical torque in pu

Output Signals to the Governor System:

GATE	Gate opening p.u.

Inputs <<enumeration>> of TURBINES, STEREOTYPE <<enum>> Governor droop signal feedback source

<<enumeration>> Droop SignalFeedbackKind

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

Governor control flag for Francis hydro model<<enumeration>>

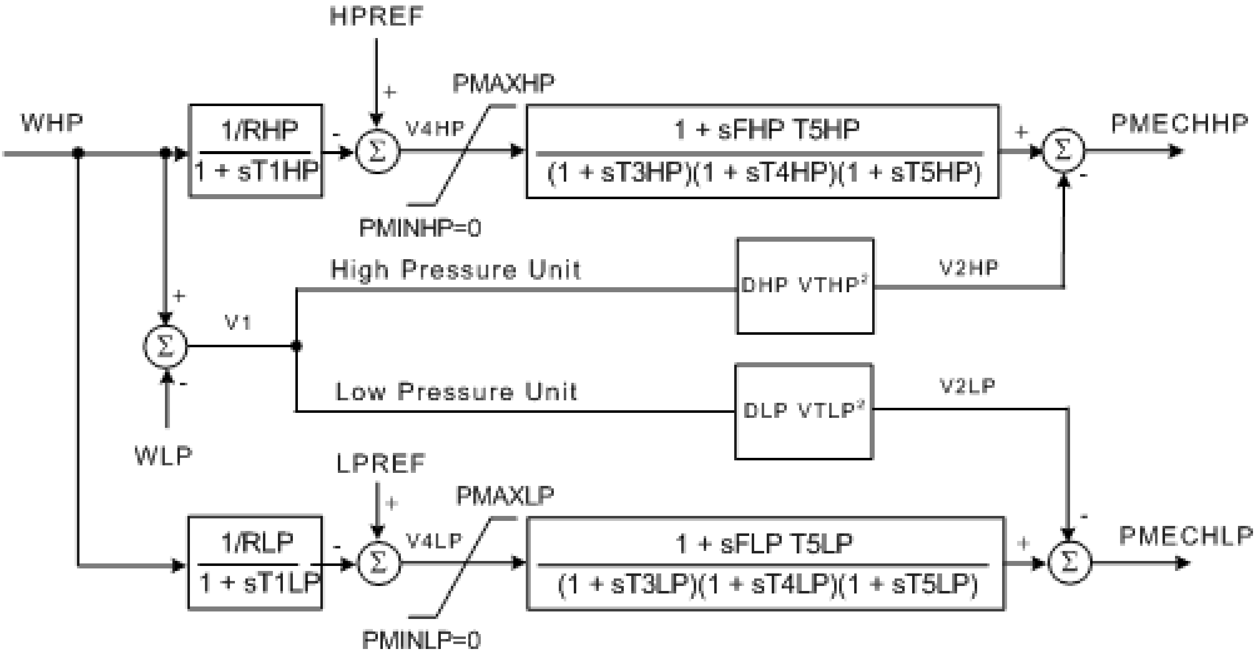
FrancisGovernorControlKind

0	Mechanic-hydraulic regulator with tacho-accelerometer (Cflag = 1)	<<enum>> mechanicHydrolicTachoAccelerator
1	Mechanic-hydraulic regulator with transient feedback (Cflag=2)	<<enum>> mechanicHydraulicTransientFeedback
2	Electromechanical and electrohydraulic regulator (Cflag=3)	<<enum>> electromechanicalElectrohydraulic

Turbine Models

TURBINE – CRCMGV

Cross compound turbine governor model.



Parameters

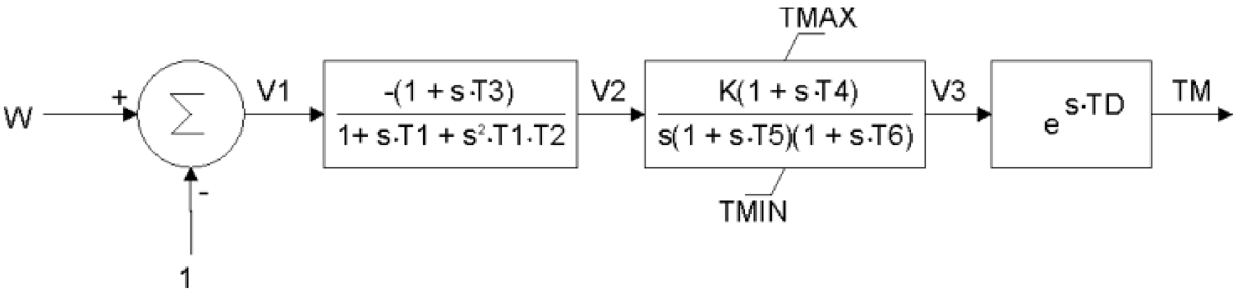
NAME	Type	Description
RHP	PU	HP governor droop
RLP	PU	LP governor droop
PMAXHP	PU	maximum HP value position (on generator base)
PMAXLP	PU	maximum LP value position (on generator base)
DHHP	PU	HP damping factor (on generator base)
DHLP	PU	LP damping factor (on generator base)
FHP	PU	fraction of HP power ahead of reheater
FLP	PU	fraction of LP power ahead of reheater
T1HP	Seconds	HP governor time constant
T1LP	Seconds	LP governor time constant
T3HP	Seconds	HP turbine time constant
T3LP	Seconds	LP turbine time constant
T4HP	Seconds	HP turbine time constant
T4LP	Seconds	LP turbine time constant
T5HP	Seconds	HP reheater time constant
T5LP	Seconds	LP reheater time constant

Notes

Equivalent model in CIM/CGMES:
- GovSteamCC

TURBINE - DEGOV

Woodward Diesel Governor



Parameters

NAME	Type	Description
T1	Seconds	Time constant
T2	Seconds	Time constant
T3	Seconds	Time constant
K10	PU	Turbine Gain
T4	Seconds	Time constant
T5	Seconds	Time constant
T6	Seconds	Time constant
TMAX	PU	Maximum limit
TMIN	PU	Minimum limit
TD	Seconds	time delay

Parameters Range:

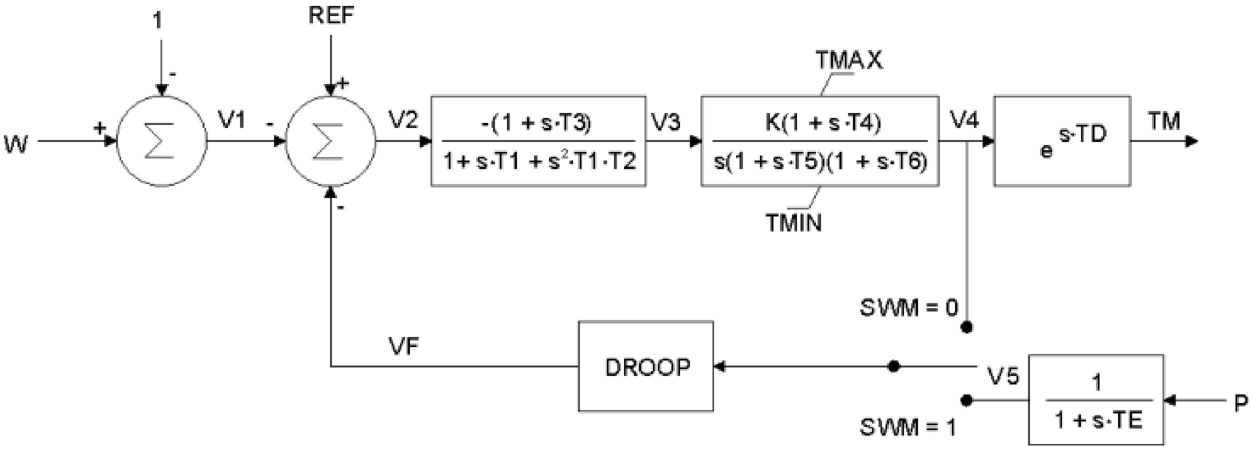
$0 < T1 < 25.0$
$0 < T2 < 0.5$
$0 < T3 < 10$
$15 \le K < 25.0$
$0 < T4 < 25.0$
$0 < T5 < 10$
$0 < T6 < 0.5$
$0 < TD < 0.125$
$0 \le TMAX < 1.5$
$-0.05 \le TMIN < 0.5$
If $T1 = 0$, then $T3 = 0$

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - DEGOV1

Woodward Diesel Governor



Parameters

NAME	Type	Description
SWM	Booleanr	Feedback switch control 0 = Feedback signal is take from siganl V4 1 = Feedback signal is take from siganl V5
T1	Seconds	Time constant
T2	Seconds	Time constant
T3	Seconds	Time constant
K10	PU	Turbine Gain
T4	Seconds	Time constant
T5	Seconds	Time constant
T6	Seconds	Time constant
TMAX	PU	Maximum limit
TMIN	PU	Minimum limit
TD	Seconds	time delay
DROOP	PU	Feedback gain
TE	Seconds	Power time constant

Parameters Range:

0 < T1 < 25.0
0 < T2 < 0.5
0 < T3 < 10
15 ≤ K < 25.0
0 < T4 < 25.0
0 < T5 < 10
0 < T6 < 0.5

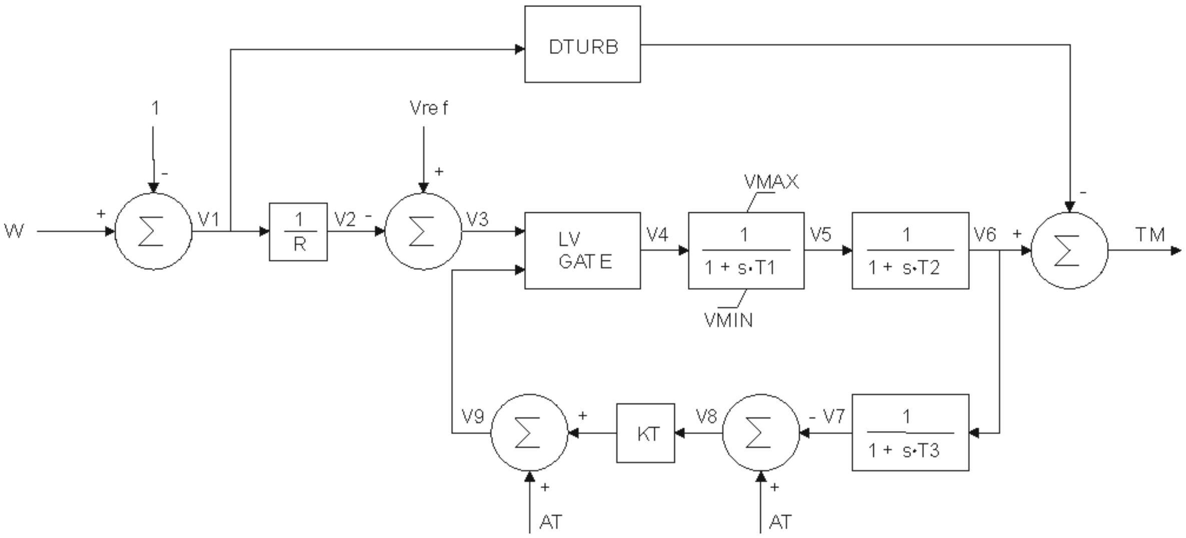
0 < TD < 0.125
0 ≤ TMAX < 1.5
-0.05 ≤ TMIN < 0.5
0 ≤ DROOP < 0.1
0 < TE < 1.0
If T1 = 0, then T3 = 0

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - GAST

Gas turbine model with governor.



Parameters

NAME	Type	Description
R	PU	Permanent droop
T1	Seconds	Governor mechanism time constant
T2	Seconds	Turbine power time constant
T3	Seconds	Turbine exhaust temperature time constant
AT	PU	Ambient temperature load limit
KT	PU	Temperature limiter gain
VMAX	PU	Maximum turbine power
VMIN	PU	Minimum turbine power
DTRUB	PU	Turbine damping factor

Parameters Range:

$0 < R < 0.1$
$0.04 < T1 < 0.5$
$0.04 < T2 < 0.5$
$0.04 < T3 < 5.0$
$0 < AT \leq 1.0$

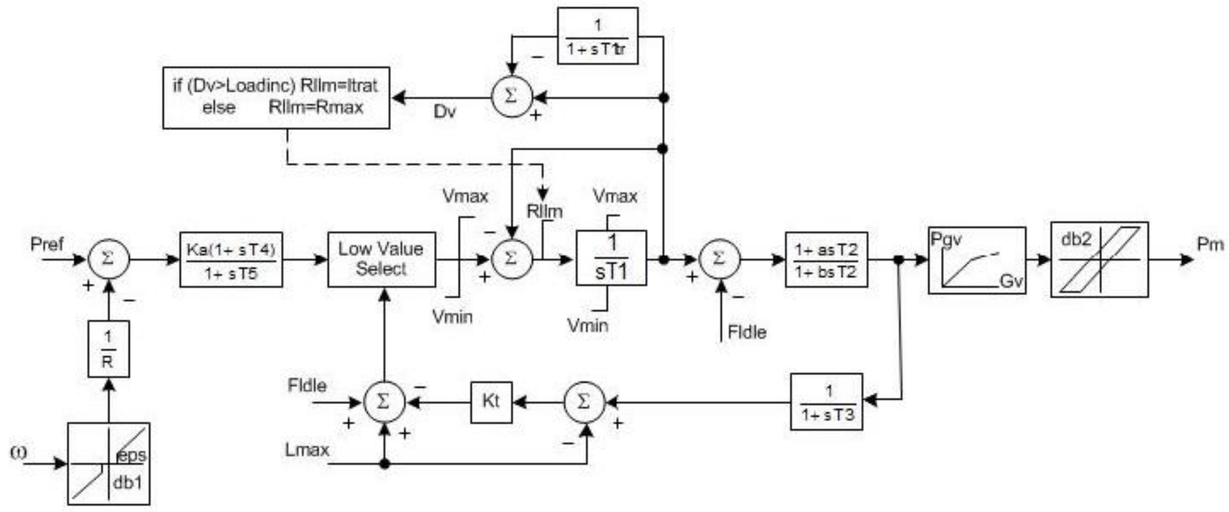
$0 < KT < 5.0$
$0.5 < VMAX < 1.2$
$0 \leq VMIN < 1.0$
$VMIN < VMAX$
$0 \leq DTURB < 0.5$

Notes

Equivalent model in CIM/CGMES:
- GovGAST

TURBINE – GAST1

Gas turbine model with governor.



Parameters

NAME	Type	Description
A	Float	Turbine power time constant numerator scale factor
B	Float	Turbine power time constant denominator scale factor
DB1	PU	Intentional dead-band width
DB2	PU	Unintentional dead-band
EPS	PU	Intentional db hysteresis
FIDLE	PU	Fuel flow at zero power output
GV1	PU	Nonlinear gain point 1, PU gv
GV2	PU	Nonlinear gain point 2, PU gv
GV3	PU	Nonlinear gain point 3, PU gv
GV4	PU	Nonlinear gain point 4, PU gv
GV5	PU	Nonlinear gain point 5, PU gv
GV6	PU	Nonlinear gain point 6, PU gv
KA	PU	Governor gain
KT	PU	Temperature limiter gain
LMAX	PU	Ambient temperature load limit. It is the turbine power output corresponding to the limiting exhaust gas
LOADINC	PU	Valve position change allowed at fast rate
LTRATE	PU	Maximum long term fuel valve opening rate
PGV1	PU	Nonlinear gain point 1, PU power
PGV2	PU	Nonlinear gain point 2, PU power
PGV3	PU	Nonlinear gain point 3, PU power
PGV4	PU	Nonlinear gain point 4, PU power
PGV5	PU	Nonlinear gain point 5, PU power
PGV6	PU	Nonlinear gain point 6, PU power

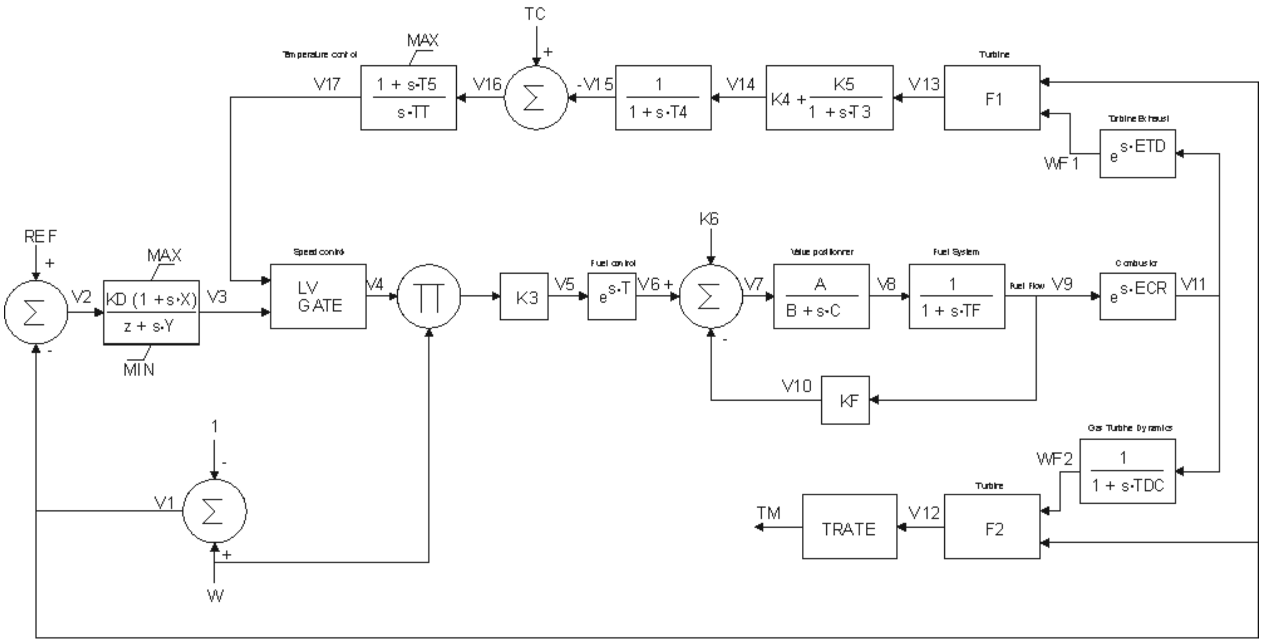
R	PU	Permanent droop
RMAX	PU	Maximum fuel valve opening rate
T1	Seconds	Governor mechanism time constant. It represents the natural valve positioning time constant of the governor for small disturbances, as seen when rate limiting is not in effect..
T2	Seconds	Turbine power time constant . It represents delay due to internal energy storage of the gas turbine engine. T2 can be used to give a rough approximation to the delay associated with acceleration of the compressor spool of a multi-shaft engine, or with the compressibility of gas in the plenum of the free power turbine of an aero-derivative unit, for example.
T3	Seconds	Turbine exhaust temperature time constant. It represents delay in the exhaust temperature and load limiting system.
T4	Seconds	Governor lead time constant
T5	Seconds	Governor lag time constant
TLTR	Seconds	Valve position averaging time constant
VMAX	PU	Maximum turbine power
VMIN	PU	Minimum turbine power
MWBASE	MW	Base for power values

Notes

Equivalent model in CIM/CGMES:
- GovGAST1

TURBINE - GAST2A

Gas turbine model with governor.



F1 = TR – AF1 (1-WF1) – BF1 (W–1)
F2 = AF2 + BF2 (WF2) – CF2 (W–1)

Parameters

NAME	Type	Description
KD	PU	Governor gain (1/DROOP) on turbine rating
X	Seconds	Governor lead time constant
Y	Seconds	Governor lag time constant
Z	Boolean	Governor mode (Z). 1 = Droop 0 = ISO.
ETD	Seconds	Turbine exhausts time constant
TCD	Seconds	Gas turbine dynamic time constant
TRATE	ActivePower	Turbine rating
T	Seconds	Fuel control time constant
MAX	PU	Maximum limit on turbie rating
MIN	PU	Minimum limit on turbie rating
ECR	Seconds	Combustor time constant
K3	PU	Fuel control gain
AA	Float	Valve positioner
BB	Float	Valve positioner
CC	Float	Valve positioner
TF	Seconds	Fuel system time constant
KF	PU	feedback gain
K5	PU	Radiation shield

K4	PU	Radiation shield
T3	Seconds	Radiation shield time constant
T4	Seconds	Thermocouple time constant, seconds
TT	Seconds	Temperature control time constant
T5	Seconds	Temperature control time constant
AF1	PU	describes the turbine characteristic
BF1	PU	describes the turbine characteristic
AF2	PU	describes the turbine characteristic
BF2	PU	describes the turbine characteristic
CF2	PU	describes the turbine characteristic
TR	Seconds	Rated temperature. Unit = °F or °C depending on parameters AF1 and BF1
K6	PU	Minimum fuel flow
TC	Seconds	Temperature control. Units = °F or °C depending on constants AF1 and BF1

Parameters Range:

0 ≤ X
0.04 < Y < 0.5
Z ≠ 1
0.5 < Max < 1.8
-0.2 < Min < 0.1
0.5 < K3 < 1
0.5 < A < 50
0.04 < B < 2
0 ≤ c ≤ 1.01
0.05 < TF < 0.8
0 ≤ KF ≤ 1.0
0.05 < K5 < 0.5
0.8 x MBASE ≤ TRATE ≤ 1.05 x MBASE
0 < T ≤ 0.05

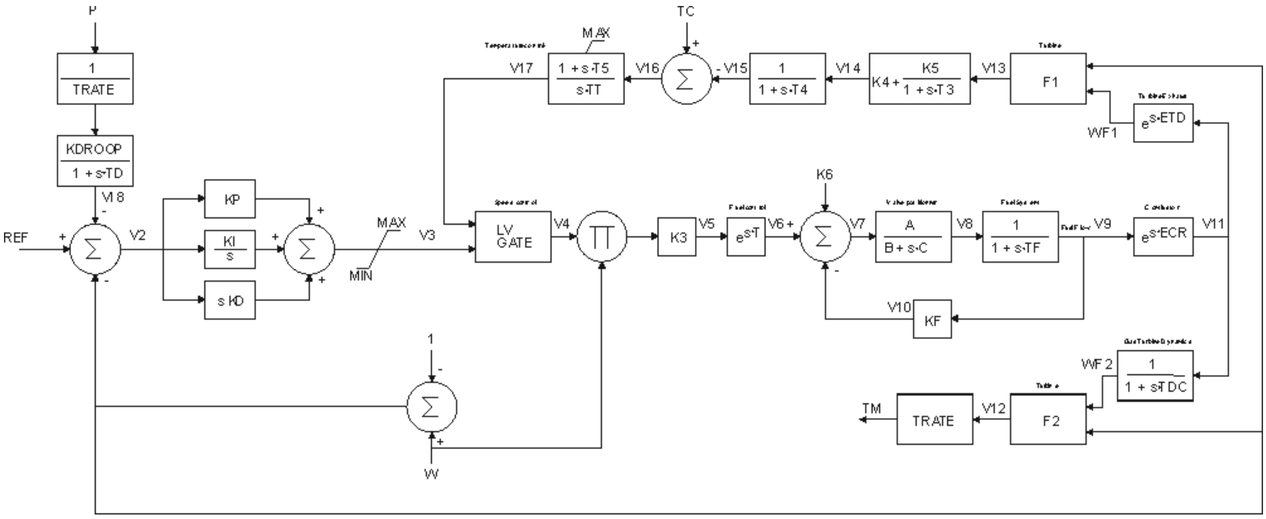
10 < T3 < 25
0 ≤ CF2 ≤ 1
1 < T4 < 5
100 < TT < 600
1 < T5 < 5
500 < AF1 < 1000
300 < BF1 < 700
-1 < AF2 < 1
0.9 < BF2 < 1.5
700 < TR < 1050
0.1 < K6 < 0.5
0 < ETD < 0.5
0 < ECR < 0.5
0 < TDC < 0.5

Notes

Equivalent model in CIM/CGMES:
- GovGAST2

TURBINE - GASTWD

Gas turbine model with governor.



F1 = TR – AF1 (1-WF1) – BF1 (W–1)
F2 = AF2 + BF2 (WF2) – CF2 (W–1)

Parameters

NAME	Type	Description
KDDROOP	PU	Power droop
TD	Seconds	Power time constant
KP	PU	Proportional gain
KI	PU	Integral gain
KD	PU	Derivative gain
ETD	Seconds	Turbine exhaust time constant
TCD	Seconds	Gas turbine dynamic time constant
TRATE	ActivePower	Turbine rating
T	Seconds	Fuel control time constant
MAX	PU	Maximum limit on turbie rating
MIN	PU	Minimum limit on turbie rating
ECR	Seconds	Combustor time constant
K3	PU	Fuel control gain
AA	Float	Valve positioner
BB	Float	Valve positioner
CC	Float	Valve positioner
TF	Seconds	Fuel system time constant
KF	PU	feedback gain
K5	PU	Radiation shield
K4	PU	Radiation shield
T3	Seconds	Radiation shield time constant
T4	Seconds	Thermocouple time constant, seconds
TT	Seconds	Temperature control time constant

T5	Seconds	Temperature control time constant
AF1	PU	describes the turbine characteristic
BF1	PU	describes the turbine characteristic
AF2	PU	describes the turbine characteristic
BF2	PU	describes the turbine characteristic
CF2	PU	describes the turbine characteristic
TR	Seconds	Rated temperature. Unit = °F or °C depending on parameters AF1 and BF1
K6	PU	Minimum fuel flow
TC	Seconds	Temperature control. Units = °F or °C depending on constants AF1 and BF1

Parameters Range:
0 ≤ KDROOP ≤ 0.1
0 ≤ KP ≤ 20
0 ≤ KI ≤ 10
0 ≤ KD ≤ 20
0.5 < Max < 1.8
-0.2 < Min < 0.1
0.5 < K3 < 1
0.5 < A < 50
0.04 < B < 2
0 ≤ c ≤ 1.01
0.05 < TF < 0.8
0 ≤ KF ≤ 1.0
0.05 < K5 < 0.5
0 < T ≤ 0.05
0.8 x MBASE ≤ TRATE ≤ 1.05 x MBASE
10 < T3 < 25
0 ≤ CF2 ≤ 1
1 < T4 < 5
100 < TT < 600
1 < T5 < 5
500 < AF1 < 1000
300 < BF1 < 700
-1 < AF2 < 1
0.9 < BF2 < 1.5
700 < TR < 1050
0.1 < K6 < 0.5
0 < ETD < 0.5
0 < ECR < 0.5
0 < TDC < 0.5

Notes

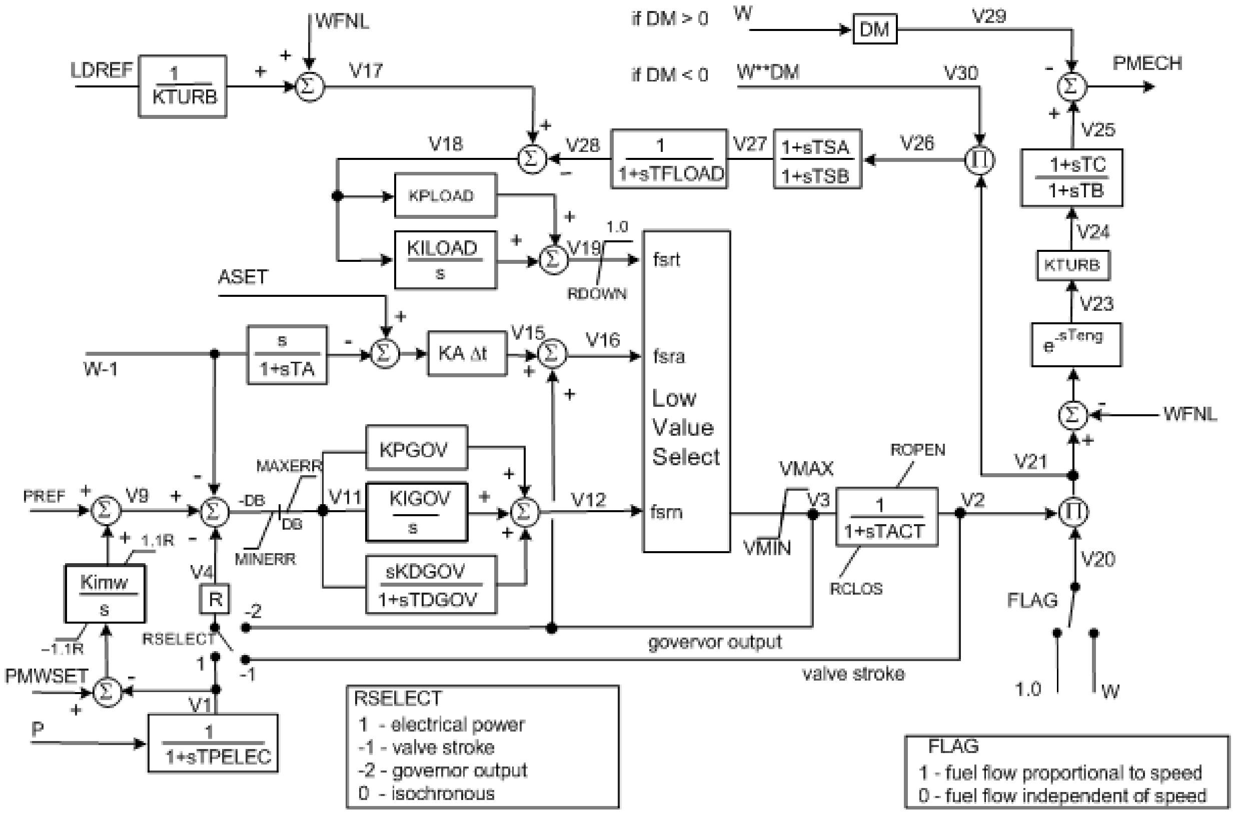
Equivalent model in CIM/CGMES:
- GovGASTWD

TURBINE - GGOV1

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

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

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



Parameters

NAME	Type	Description
R	PU	Permanent droop
TPELEC	Seconds	Electrical power transducer time constan
MAXERR	PU	Maximum value for speed error signal
MINERR	PU	Minimum value for speed error signal
KPGOV	PU	Governor proportional gain
KIGOV	PU	Governor integral gain
KDGOV	PU	Governor derivative gain

TDGOG	Seconds	Governor derivative controller time constant
VMAX	PU	Maximum valve position limit
VMIN	PU	Minimum valve position limit
TACT	Seconds	Actuator time constant
KTURB	PU	Turbine gain
WFNL	PU	No load fuel flow
TB	Seconds	Turbine lag time constant
TC	Seconds	Turbine lead time constant
TENG	Seconds	Transport time delay for diesel engine
TFLOAD	Seconds	Load Limiter time constant
KPLOAD	PU	Load limiter proportional gain for PI controller
KILOAD	PU	Load limiter integral gain for PI controller
LDREF	PU	Load limiter reference value
DM	PU	Speed sensitivity coefficient
ROPEN	PU	Maximum valve opening rate
RCLOSE	PU	Minimum valve opening rate
KIMW	PU	Power controller (reset) gain
PMWSET	ActivePower	Power controller setpoint
ASET	PU	Acceleration limiter setpoint
KA	PU	Acceleration limiter gain
TA	Seconds	Acceleration limiter time constant
TRATE	ActivePower	Base for power values
DB	PU	Speed governor dead band
TSA	Seconds	Temperature detection lead time constant
TSB	Seconds	Temperature detection lag time constant
RUP	PU	Maximum rate of load limit increase (Not used in NEPLAN)
RDOWN	PU	Maximum rate of load limit decrease (Not used in NEPLAN)
RSELECT	enum	Feedback signal for droop (Rselect). Typical Value = electricalPower
FLAG	Boolean	Switch for fuel source characteristic. 0 = fuel flow independent of speed 1 = fuel flow proportional to speed.

Notes

1. Per unit parameters are on base of TRATE, which is normally the MW capability of the turbine.

2. The range of fuel valve travel and of fuel flow is unity. Thus the largest possible value of VMAX is 1.0 and the smallest possible value of VMIN is zero. VMAX may, however, be reduced below unity to represent a loading limit that may be imposed by the operator or a supervisory control system. For gas turbines VMIN should normally be greater than zero and less than WFNL to represent a minimum firing limit. The value of the fuel flow at maximum output must be less than, or equal to unity, depending on the value of KTURB.

3. The parameter TENG is provided for use in representing diesel engines where there is a small but measurable transport delay between a change in fuel flow setting and the development of torque. Teng should be zero in all but special cases where this transport delay is of particular concern.

4. The parameter FLAG is provided to recognize that fuel flow, for a given fuel valve stroke, can be proportional to engine speed. This is the case for GE gas turbines and for diesel engines with positive displacement fuel injectors. Wfspd should be set to unity for all GE gas turbines and most diesel engines. FLAG should be set to zero where it is known that the fuel control system keeps fuel flow independent of the engine speed.

5. The load limiter module may be used to impose a maximum output limit such as an exhaust temperature limit. To do this the time constant TFLOAD should be set to represent the time constant in the measurement of temperature (or other signal), and the gains of the limiter, KPLOAD, KILOAD, should be set to give prompt stable control when on limit. The load limit can be deactivated by setting the parameter LDREF to a high value.

6. The parameter DM can represent either the variation of the engine power with the shaft speed or the variation of maximum power capability with shaft speed. If DM is positive it describes the falling slope of the engine speed verses power characteristic as speed increases. A slightly falling characteristic is typical for reciprocating engines and some aero-derivative turbines. If DM is negative the engine power is assumed to be unaffected by the shaft speed, but the maximum permissible fuel flow is taken to fall with falling shaft speed. This is characteristic of single-shaft industrial turbines due to exhaust temperature limits.

7. This model includes a simple representation of a supervisory load controller. This controller is active if the parameter KIMW is non-zero. The load controller is a slow acting reset loop that adjusts the speed/load reference of the turbine governor to hold the electrical power output of the unit at its initial condition value. This value is stored in the parameter PMWSET when the model is initialized, and can be changed thereafter. The load controller must be adjusted to respond gently relative to the speed governor. A typical value for KIMW is 0.01, corresponding to a reset time of 100 seconds.

8. The parameters ASET, KA, and TA describe an acceleration limiter. TA must be non-zero, but the acceleration limiter can be disabled by setting ASET to a large value, such as 1.

9. The parameter, DB, is the speed governor dead band. This parameter is stated in terms of per unit speed. In the majority of applications, it is recommended that this value be set to zero.

10. The parameters TSA and TSB, are provided to augment the exhaust gas temperature measurement subsystem in gas turbines. For example, they may be set to values such as 4., 5., to represent the ‘radiation shield’ element of large gas turbines. If both parameters are omitted, they default to 1.0.

11. The parameters RUP and RDOWN specify the maximum rate of increase and decrease of the output of the load limit controller (KPLOAD/KILOAD). These parameters should normally be set, or defaulted to 99/-99, but may be given particular values to represent the temperature limit controls of some GE heavy-duty engine controls. If both parameters are omitted, they default to 99 and –99. (In NEPLAN the parameters RUP and RDOWN are not used)

12. The fuel flow command fsr is determined by whichever is lowest of fsrt, fsra, and fsrn. Although not explicitly shown in the GGOV1 diagram, the signals that are not in

control track fsr so that they do not “windup” beyond that value. This represents GE gas turbine control practice but may not be true for other controller designs.

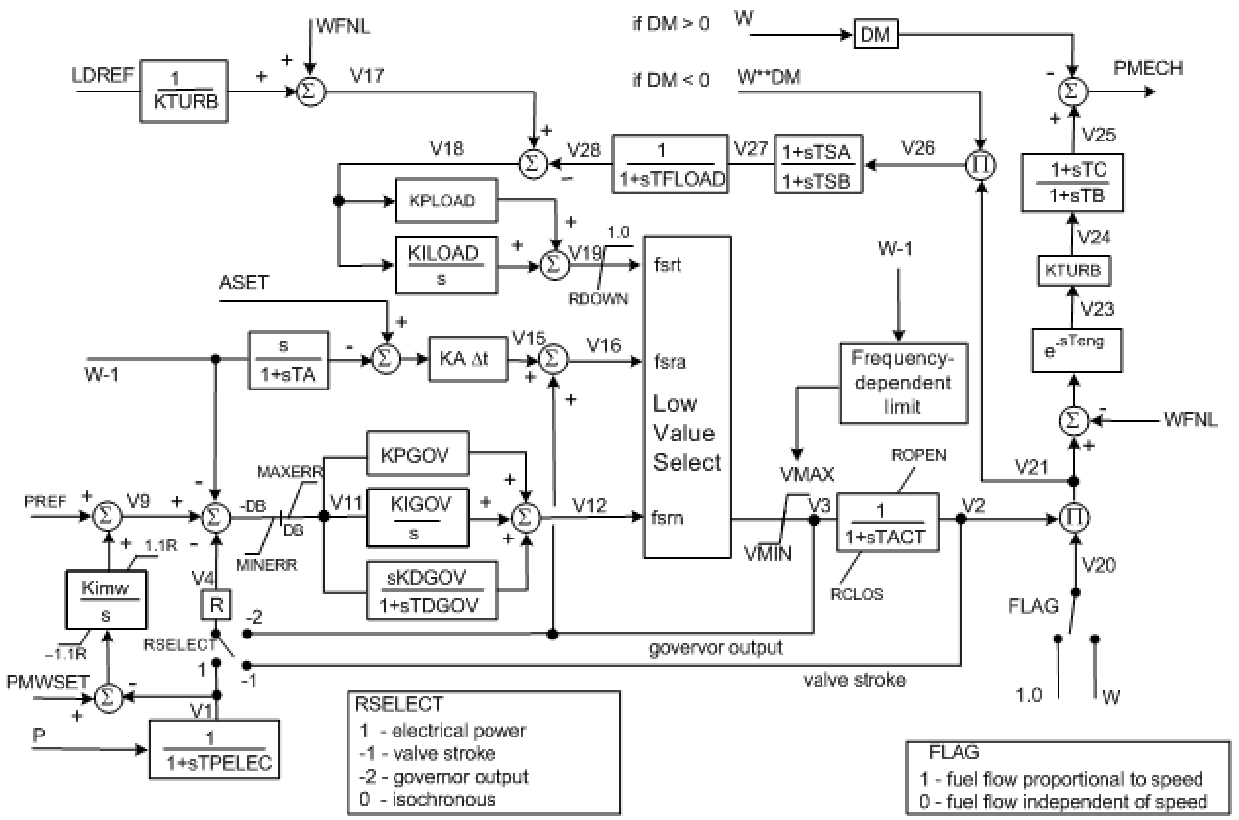
13. As shown in the GGOV1 diagram, when KPGOV is non-zero, the governor PI control is implemented to “track” fsr to prevent windup when fsr is limited by another signal (fsrt, fsra) or VMAX/VMIN. If KPGOV is zero, the integral path is implemented directly. The same applies to the load limiter PI control with regard to KPLOAD.

14. PREF has units of p.u. speed.

Equivalent model in CIM/CGMES:
- GovCT1

TURBINE - GGOV2

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



Parameters

NAME	Type	Description
R	PU	Permanent droop
TPELEC	Seconds	Electrical power transducer time constan
MAXERR	PU	Maximum value for speed error signal
MINERR	PU	Minimum value for speed error signal
KPGOV	PU	Governor proportional gain
KIGOV	PU	Governor integral gain
KDGOV	PU	Governor derivative gain
TDGOG	Seconds	Governor derivative controller time constant
VMAX	PU	Maximum valve position limit
VMIN	PU	Minimum valve position limit
TACT	Seconds	Actuator time constant
KTURB	PU	Turbine gain
WFNL	PU	No load fuel flow

TB	Seconds	Turbine lag time constant
TC	Seconds	Turbine lead time constant
TENG	Seconds	Transport time delay for diesel engine
TFLOAD	Seconds	Load Limiter time constant
KPLOAD	PU	Load limiter proportional gain for PI controller
KILOAD	PU	Load limiter integral gain for PI controller
LDREF	PU	Load limiter reference value
DM	PU	Speed sensitivity coefficient
ROPEN	PU	Maximum valve opening rate
RCLOSE	PU	Minimum valve opening rate
KIMW	PU	Power controller (reset) gain
PMWSET	ActivePower	Power controller setpoint
ASET	PU	Acceleration limiter setpoint
KA	PU	Acceleration limiter gain
TA	Seconds	Acceleration limiter time constant
TRATE	ActivePower	Base for power values
DB	PU	Speed governor dead band
TSA	Seconds	Temperature detection lead time constant
TSB	Seconds	Temperature detection lag time constant
RUP	PU	Maximum rate of load limit increase (Not used in NEPLAN)
RDOWN	PU	Maximum rate of load limit decrease (Not used in NEPLAN)
PRATE	PU	Ramp rate for frequency-dependent power limit
FLIM1	Frequency	Frequency threshold 1
PLIM1	PU	Power limit 1
FLIM2	Frequency	Frequency threshold 2
PLIM2	PU	Power limit 2
FLIM3	Frequency	Frequency threshold 3
PLIM3	PU	Power limit 3
FLIM4	Frequency	Frequency threshold 4
PLIM4	PU	Power limit 4
FLIM5	Frequency	Frequency threshold 5
PLIM5	PU	Power limit 5
FLIM6	Frequency	Frequency threshold 6
PLIM6	PU	Power limit 6
FLIM7	Frequency	Frequency threshold 7
PLIM7	PU	Power limit 7
FLIM8	Frequency	Frequency threshold 8
PLIM8	PU	Power limit 8
FLIM9	Frequency	Frequency threshold 9
PLIM9	PU	Power limit 9
FLIM10	Frequency	Frequency threshold 10
PLIM10	PU	Power limit 10
RSELECT	enum	Feedback signal for droop (Rselect). Typical Value = electricalPower
FLAG	boolean	Switch for fuel source characteristic. 0 = fuel flow independent of speed 1 = fuel flow proportional to speed.

Notes

1. The frequency-dependent limit reduces the VMAX limit on fuel flow signal (fsr). For normal operation, the limiter performs no action. When frequency (generator speed) drops below FLIM1, the highest frequency data point, the desired value for the power limit (PLIM) is determined by linear interpolation between associated data pairs. The maximum value of the limiter (VMAX) will ramp to the fsr value corresponding to PLIM (PLIM / KTURB + WFNL) at the PRATE ramp rate. PLIM will be updated as frequency changes. If frequency subsequently rises back above FLIM1, the value of the limit will ramp up at the rate PRATE back to the normal value of VMAX.

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

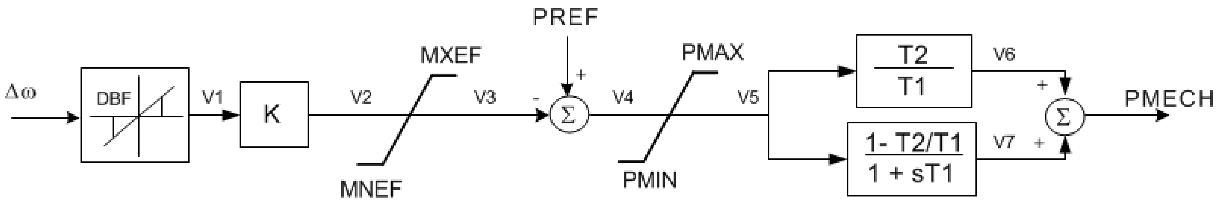
3. Refer to GGOV1 model for other notes. Aside from the frequency-dependent limt, GGOV2 is identical to GGOV1, except that the temperature fuel command fsrt does not track fsr when it is not in control. Instead, it stays at its upper limit (1.).

4. The KPGOV/KIGOV and KPLOAD/KILOAD controllers include tracking logic to ensure smooth transfer between active controllers. This logic is not shown on the GGOV2 diagram.

Equivalent model in CIM/CGMES:
- GovCT2

TURBINE – GOV21GEQ

Simplified governor model



Parameters

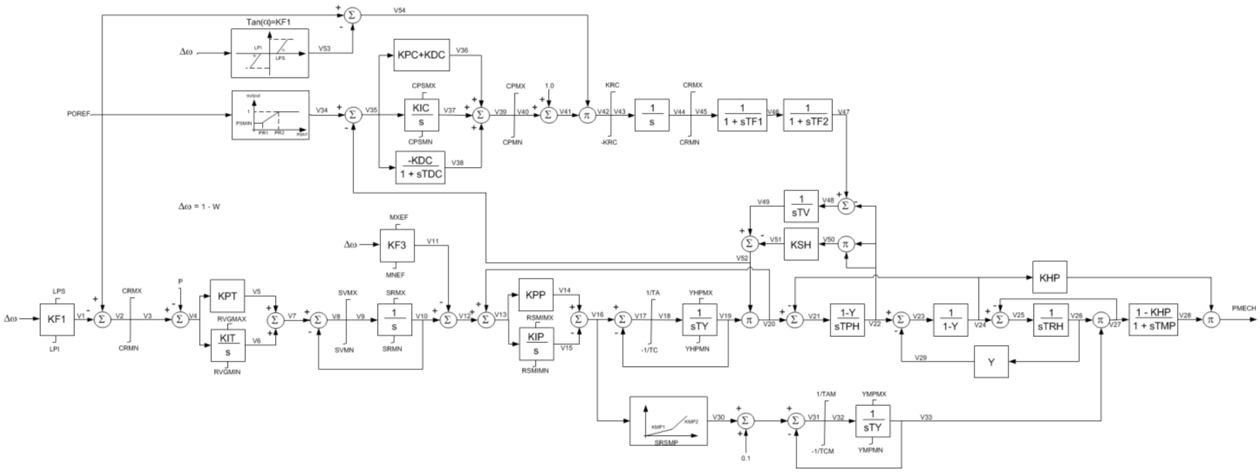
NAME	Type	Description
K	Simple Float	Governor gain (reciprocal of droop)
DBF	pu	Frequency dead band
PMAX	pu	Maximum fuel flow
PMIN	pu	Minimum fuel flow
T1	Seconds	Governor lag time constant
T2	Seconds	Governor lead time constant
MNEF	pu	Fuel flow maximum negative error value
MXEF	pu	Fuel flow maximum positive error value

Notes

Equivalent model in CIM/CGMES:
- GovSteam2

TURBINE – GOV22TER

Detailed electro-hydraulic governor for steam unit



Parameters

NAME	Type	Description
KF1	pu	Frequency bias (reciprocal of droop)
KF3	pu	Frequency control (reciprocal of droop)
LPS	pu	Maximum positive power error
LPI	pu	Maximum negative power error
CRMX	pu	Maximum value of regulator set-point
CRMN	pu	Minimum value of regulator set-point
KPT	pu	Proportional gain of electro-hydraulic regulator
KIT	pu	Integral gain of electro-hydraulic regulator
RVGMX	pu	Maximum value of integral regulator
RVGMN	pu	Minimum value of integral regulator
SVMX	pu	Maximum regulator gate opening velocity
SVMN	pu	Maximum regulator gate closing velocity
SRMX	pu	Maximum valve opening
SRMN	pu	Minimum valve opening
KPP	pu	Proportional gain of pressure feedback regulator
KIP	pu	Integral gain of pressure feedback regulator
RSMIMX	pu	Maximum value of integral regulator
RSMIMN	pu	Minimum value of integral regulator
KMP1	pu	First gain coefficient of intercept valves characteristic
KMP2	pu	Second gain coefficient of intercept valves characteristic
SRSMP	pu	Intercept valves characteristic discontinuity point
YHPMX	pu	Maximum control valve position
YHPMN	pu	Minimum control valve position
TAM	Seconds	Intercept valves rate opening time
Y	pu	Coefficient of linearized equations of turbine (Stodola formulation)
YMPMX	pu	Maximum intercept valve position

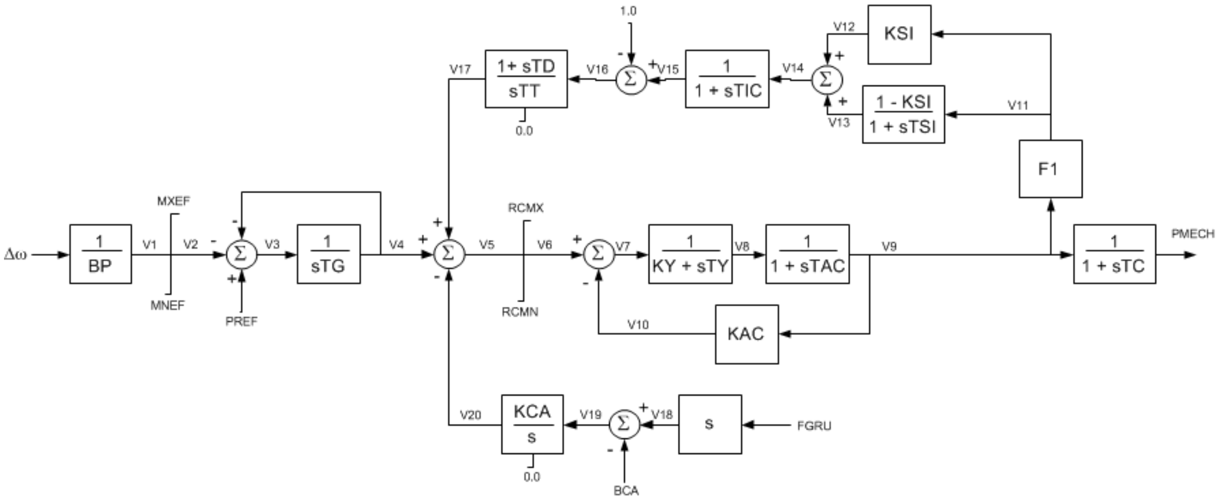
YMPMN	pu	Minimum intercept valve position
TPH	Seconds	High pressure (HP) time constant of the turbine
TRH	Seconds	Reheater time constant of the turbine
TMP	Seconds	Low pressure (LP) time constant of the turbine
KHP	pu	Fraction of total turbine output generated by HP part
PR1	pu	First value of pressure set point static characteristic
PR2	pu	Second value of pressure set point static characteristic, corresponding to Ps0 = 1.0 PU
PSMN	pu	Minimum value of pressure set point static characteristic
KPC	pu	Proportional gain of pressure regulator
KIC	pu	Integral gain of pressure regulator
KDC	pu	Derivative gain of pressure regulator
TDC	Seconds	Derivative time constant of pressure regulator
CPSMX	pu	Maximum value of pressure regulator output
CPSMN	pu	Minimum value of pressure regulator output
KRC	pu	Maximum variation of fuel flow
TF1	Seconds	Time constant of fuel regulation
TF2	Seconds	Time constant of steam chest
KSH	pu	Pressure loss due to flow friction in the boiler tubes
TY	Seconds	Control valves servo time constant
TV	Seconds	Boiler time constant
TA	Seconds	Control valves rate opening time
TC	Seconds	Control valves rate closing time
TCM	Seconds	Intercept valves rate closing time
MXEF	pu	Upper limit for frequency correction
MNEF	pu	Lower limit for frequency correction

Notes

Equivalent model in CIM/CGMES:
- GovSteamFV4

TURBINE – GOV33TGT

Generic turbogas with acceleration and temperature controller



Parameters

NAME	Type	Description
BP	pu	Droop
TG	Seconds	Time constant of speed governor
RCMX	pu	Maximum fuel flow
RCMN	pu	Minimum fuel flow
KY	pu	Coefficient of transfer function of fuel valve positioner
TY	Seconds	Time constant of fuel valve positioner
TAC	Seconds	Fuel control time constant
KAC	pu	Fuel system feedback
TC	Seconds	Compressor discharge volume time constant
BCA	pu	Acceleration limit set-point
KCA	pu	Acceleration control integral gain
DTC*	pu	Exhaust temperature variation due to fuel flow increasing from 0 to 1 PU
KA	pu	Minimum fuel flow
TSI	Seconds	Time constant of radiation shield
KSI	pu	Gain of radiation shield
TIC	Seconds	Time constant of thermocouple
TFEN	pu	Turbine rated exhaust temperature correspondent to Pm=1 pu
TD	Seconds	Temperature controller derivative gain
TT	Seconds	Temperature controller integration rate
MXEF	pu	Fuel flow maximum positive error value
MNEF	pu	Fuel flow maximum negative error value

Notes

Exhaust Temparature

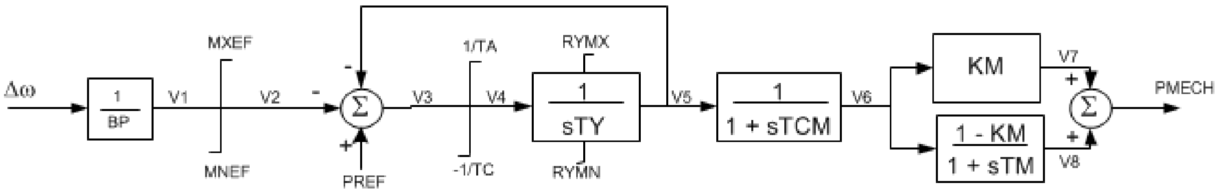
- Function for exhaust temperature calculation:

$$f_1 = (1 - K_t) \cdot K_t$$
$$where\ K_t = \frac{\Delta T_c (1 - K_a)}{T_{fen}}$$

Equivalent model in CIM/CGMES:
- GovGast3

TURBINE – GOV34TGF

Generic turbogas



Parameters

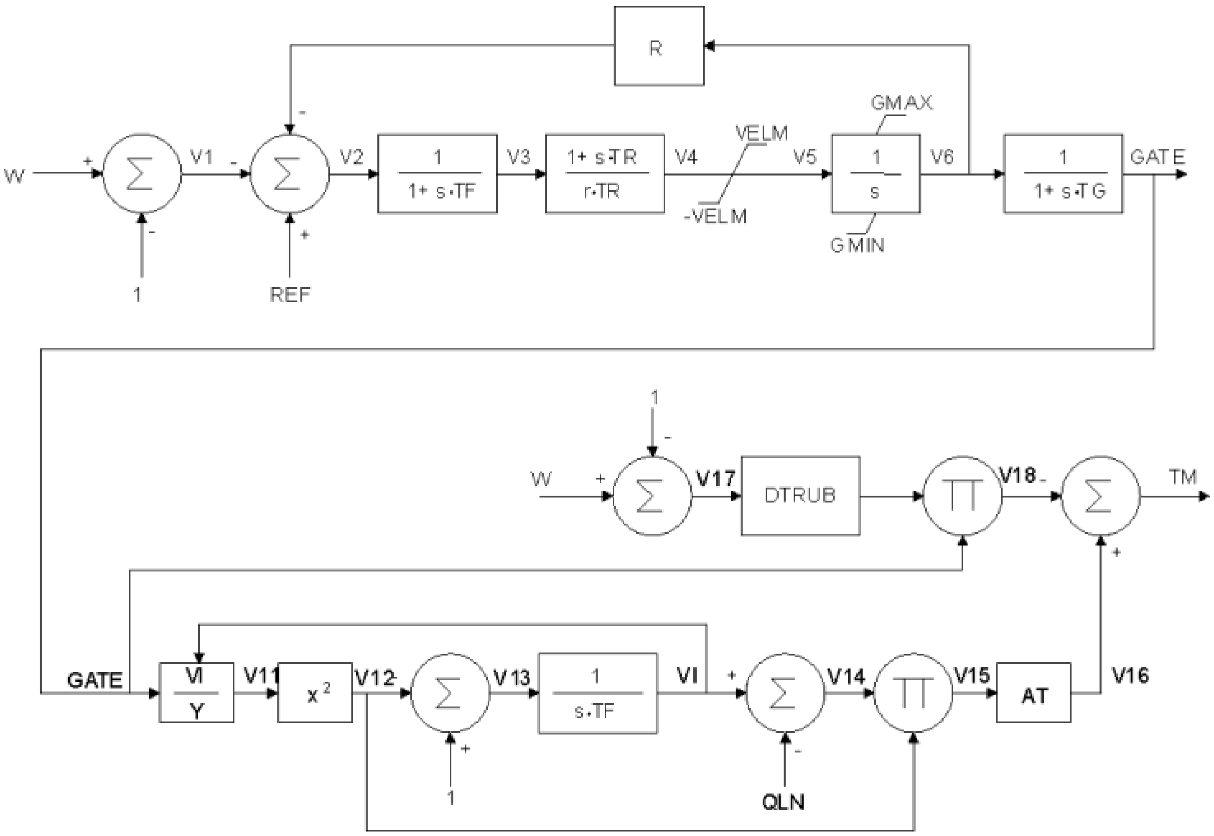
NAME	Type	Description
BP	pu	Droop
TY	Seconds	Time constant of fuel valve positioner
TA	Seconds	Maximum gate opening velocity
KM	pu	Compressor gain
TC	Seconds	Maximum gate closing velocity
TCM	Seconds	Fuel control time constant
TM	Seconds	Compressor discharge volume time constant
MXEF	pu	Fuel flow maximum positive error value
MNEF	pu	Fuel flow maximum negative error value
RYMX	pu	Maximum valve opening
RYMN	pu	Minimum valve opening

Notes

Equivalent model in CIM/CGMES:
- GovGast4

TURBINE – GOVHYDRO1

IEEE Simplified Hydro Governor-Turbine Model.



Parameters

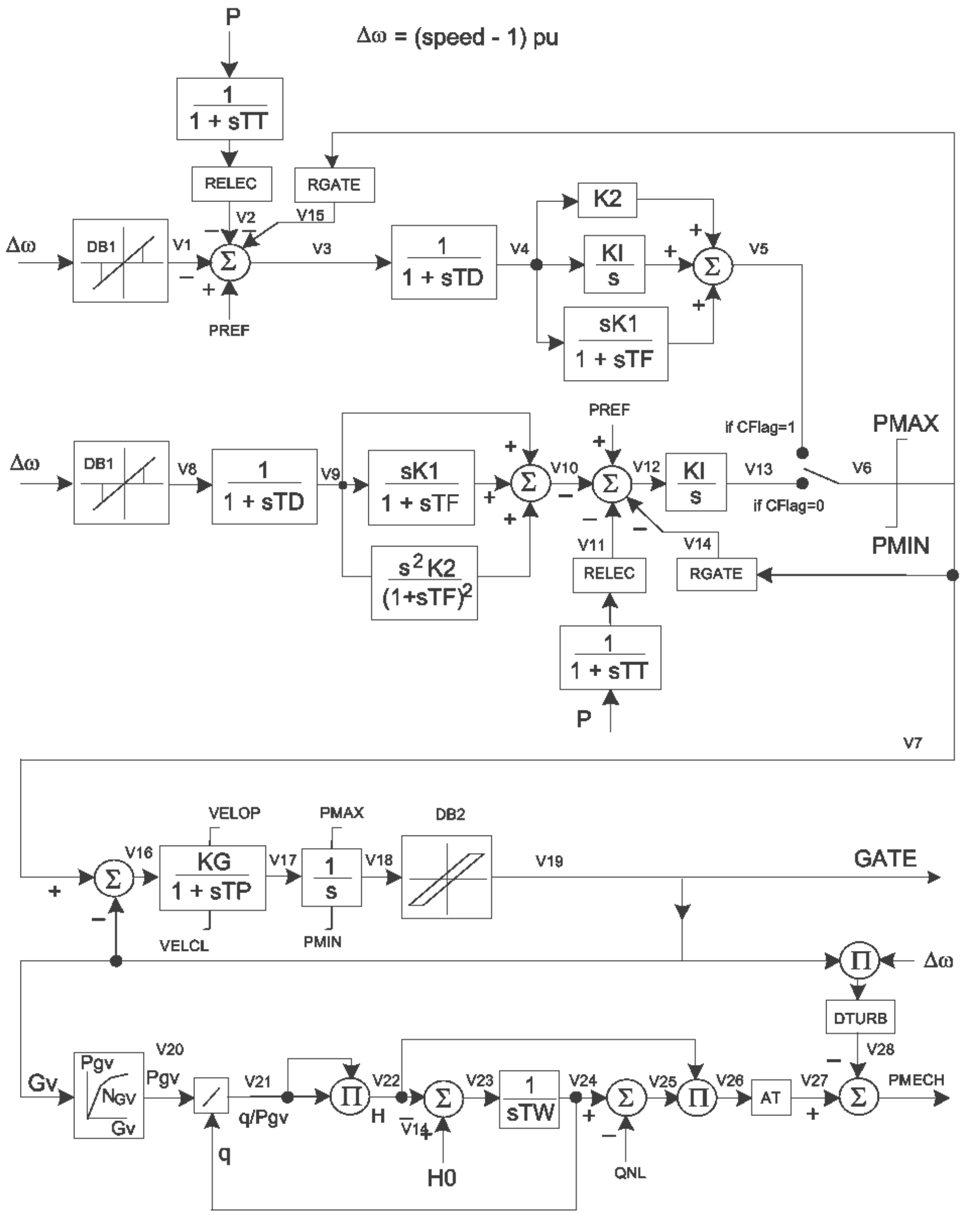
NAME	Type	Description
DTRUB	PU	Turbine damping factor
TW	Second	Water inertia time constant
AT	PU	Turbine gain
QNL	PU	No-load flow at nominal head
RBIG	PU	Permanent droop
RSMALL	PU	Temporary droop
TR	Second	Washout time constant
TF	Second	Filter time constant
TG	Second	Gate servo time constant
VELM	PU	Maximum gate velocity
GMAX	PU	Maximum gate opening
GMIN	PU	Minimum gate opening

Notes

Equivalent model in CIM/CGMES:
- GovHydro1

TURBINE – GOVHYDRO3

Modified IEEE Hydro Governor-Turbine Model. This model differs from that defined in the IEEE modeling guideline paper in that the limits on gate position and velocity do not permit "wind up" of the upstream signals



Parameters

NAME	Type	Description
AT	pu	Turbine gain
DB1	pu	Intentional dead-band width
DB2	pu	Unintentional dead-band
DTURB	pu	Turbine damping factor
EPS	Pu	Intentional db hysteresis

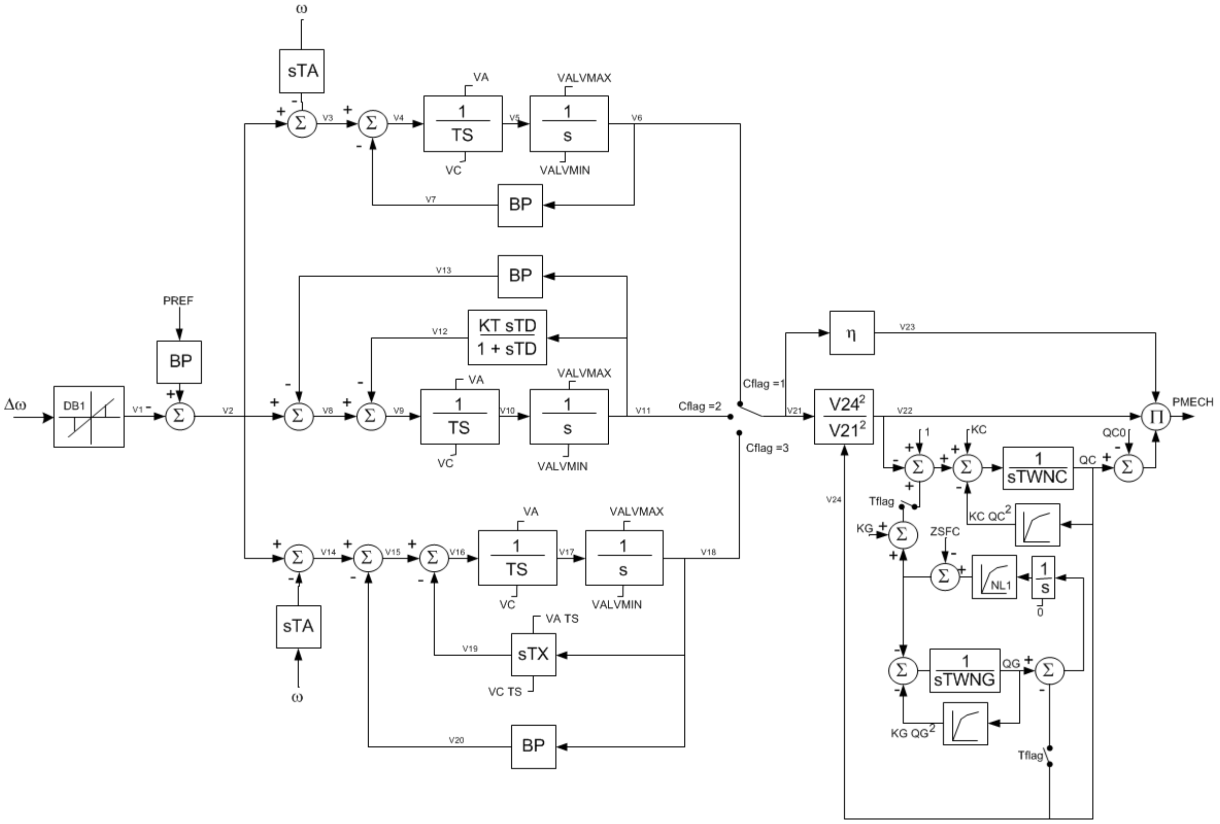
CFLAG	Boolean	Governor control flag, if CFLAG=1 PID control is active, else (CFLAG=0) double derivate control is active
GV1	pu	Nonlinear gain point 1
GV2	pu	Nonlinear gain point 2
GV3	pu	Nonlinear gain point 3
GV4	pu	Nonlinear gain point 4
GV5	pu	Nonlinear gain point 5
GV6	pu	Nonlinear gain point 6
HO	pu	Turbine nominal head
K1	pu	Derivative gain
K2	pu	Double derivative gain, if Cflag = -1
KG	pu	Gate servo gain
KI	pu	Integral gain
PVG1	pu	Nonlinear gain point 1
PVG2	pu	Nonlinear gain point 2
PVG3	pu	Nonlinear gain point 3
PVG4	pu	Nonlinear gain point 4
PVG5	pu	Nonlinear gain point 5
PVG6	pu	Nonlinear gain point 6
PMAX	pu	Maximum gate opening
PMIN	pu	Minimum gate opening
QNL	pu	No-load turbine flow at nominal head
RELEC	pu	Steady-state droop for electrical power feedback
RGATE	pu	Steady-state droop for governor output feedback
TD	Seconds	Input filter time constant
TF	Seconds	Washout time constant
TP	Seconds	Gate servo time constant
TT	Seconds	Power feedback time constant
TW	Seconds	Water inertia time constant
VELEC	Simple Float	Maximum gate closing velocity
VELOP	Simple Float	Maximum gate opening velocity

Notes

Equivalent model in CIM/CGMES:
- GovHydro3

TURBINE – GOVHYDROFRANCIS

Hydro unit, Francis model



Parameters

NAME	Type	Description
AM*	pu	Opening section s_{eff} at the maximum efficiency, used in (*)
BP	pu	Droop
DB1	pu	Intentional dead-band width
ETAMAX	pu	Maximum efficiency
CFLAG ***	enum	Governor control flag (Cflag). Typical Value = mechanicHydrolicTachoAccelerator
KC	pu	Penstock loss coefficient (due to friction)
KG	pu	Water tunnel and surge chamber loss coefficient (due to friction)
KT	pu	Washout gain
QC0	pu	No-load turbine flow at nominal head
TA	Seconds	Derivative gain
TD	Seconds	Washout time constant
TS	Seconds	Gate servo time constant
TWNC	Seconds	Water inertia time constant
TWNG	Seconds	Water tunnel and surge chamber inertia time constant
TX	Seconds	Derivative feedback gain
VA	Simple Float	Maximum gate opening velocity
VALVMAX	pu	Maximum gate opening

VALVMIN	pu	Minimum gate opening
VC	Simple Float	Maximum gate closing velocity
TFLAG	Boolean	Water tunnel and surge chamber simulation, if TFLAG=1 (switch ON) enable of water tunnel and surge chamber simulation, else (switch OFF) inhibit of water tunnel and surge chamber simulation
ZSFC	float	Head of upper water level respect to the level of penstock
QN	m^3/s	Rated flow
HN	m	Rated hydraulic head
AV1**	float	Area of the surge tank
AV2**	float	Area of the compensation tank
H1**	float	Head of compensation chamber water level with respect to the level of penstock
H2**	float	Head of surge tank water level with respect to the level of penstock
MWBASE	MW	Base for power values

Notes

1. This model can be used to represent three types of governors.
2. Governors per unit parameters are on base of MW capability of the turbine.
3. Rated hydraulic head Hn [m] an rated flow [m3/s] are the design parameters of the hydraulic system capability in CIM/CGMES manual, these not are indicated in NEPLAN manual.
4. Hydraulic system head attributes (Zsfc, H1, H2) are in meters but in the block diagram are in per unit on base of Hn.
5. Hydraulic area attributes (Av1, Av2) are in square meters but in the block diagram are in per unit on base of Qn/Hn [m2/s], in CIM/CGMES model the $A_{V0} = A_{V1}$, $A_{V1} = A_{V2}$.
6. omega has units of per unit speed.
7. Non-linear gain and efficiency equations shown below

Non Linear Gain and Efficiency

- **Non linear gain:

$$NL1\begin{cases} Z_p = \dfrac{W_p}{A_{V1}} & if \quad 0 \leq W_p \leq W_1 \\ Z_p = H_1 + \dfrac{W_p - W_1}{A_{V0}} & if \quad W_1 \leq W_p \leq W_2 \\ Z_p = H_2 & if \quad W_p \geq W_2 \end{cases}$$

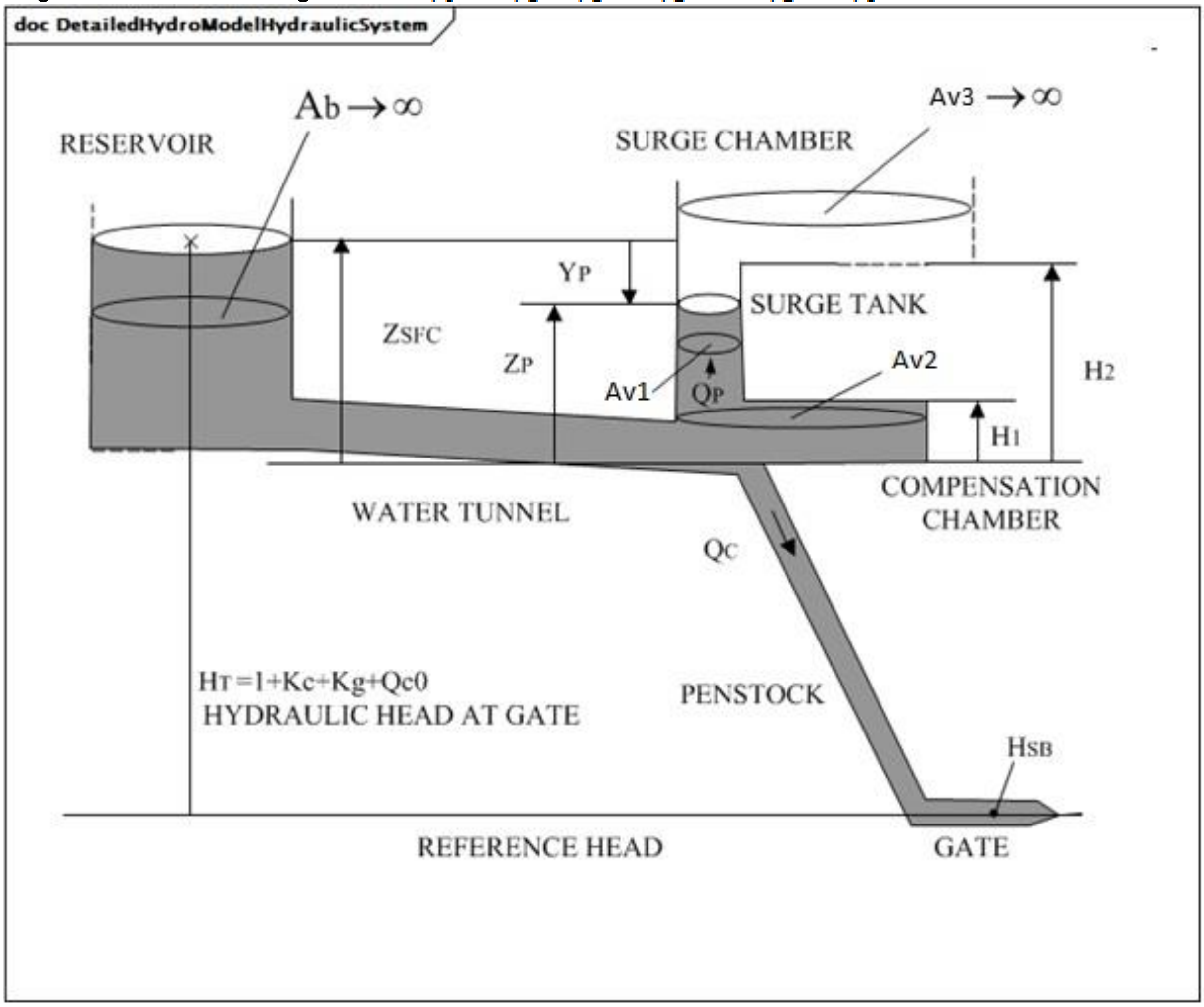
$$W_1 = H_1 \cdot A_{V1} = Compensation\ chamber\ volume$$

$$W_2 = W_1 + (H_2 - H_1) = Compensation\ chamber\ volume + tank\ volume$$

- *Efficiency:

$$\eta = \eta_{max}\left(\sqrt{4 - \left(\frac{S_{eff}}{AM} - 1\right)^2} - 1\right)$$

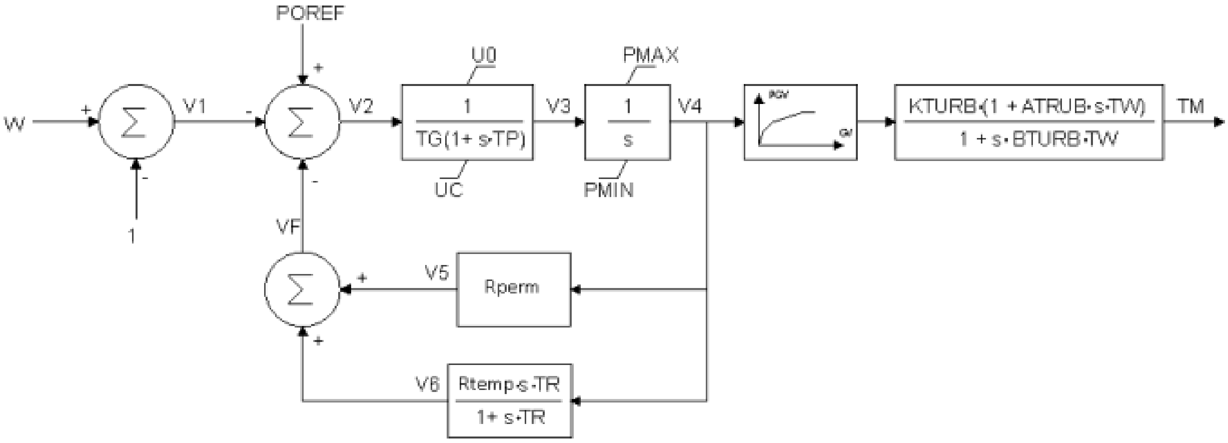
The following figure shows the deteiled hydro model for the hydraulic system, note that in the original CIM/CGMES figure the $A_{V0} = A_{V1}$, $A_{V1} = A_{V2}$ and $A_{V2} = A_{V3}$



Equivalent model in CIM/CGMES:
- GovHydroFrancis

TURBINE – GOVHYDROIEEE2

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



Parameters

NAME	Type	Description
UO	Float	Maximum gate opening velocity
UC	Float	Maximum gate closing velocity
TG	Seconds	Gate servo time constant
TP	Seconds	Pilot servo valve time constant
UO	PU	Maximum gate opening velocity
UC	PU	Minimum gate opening velocity
PMAX	PU	Maximum gate opening
PMIN	PU	Minimum gate opening
RPERM	PU	Permanent droop
RTEMP	PU	Temporary droop
TR	Seconds	Dashpot time constant
TW	Seconds	Water inertia time constant
BTURB	PU	Turbine denominator multiplier
ATURB	PU	Turbine numerator multiplier
KTURB	PU	Turbine gain
GV1	PU	Nonlinear gain point 1, PU gv
GV2	PU	Nonlinear gain point 2, PU gv
GV3	PU	Nonlinear gain point 3, PU gv
GV4	PU	Nonlinear gain point 4, PU gv
GV5	PU	Nonlinear gain point 5, PU gv
GV6	PU	Nonlinear gain point 6, PU gv
PGV1	PU	
PGV2	PU	
PGV3	PU	
PGV4	PU	
PGV5	PU	
PGV6	PU	
MWBASE	MW	

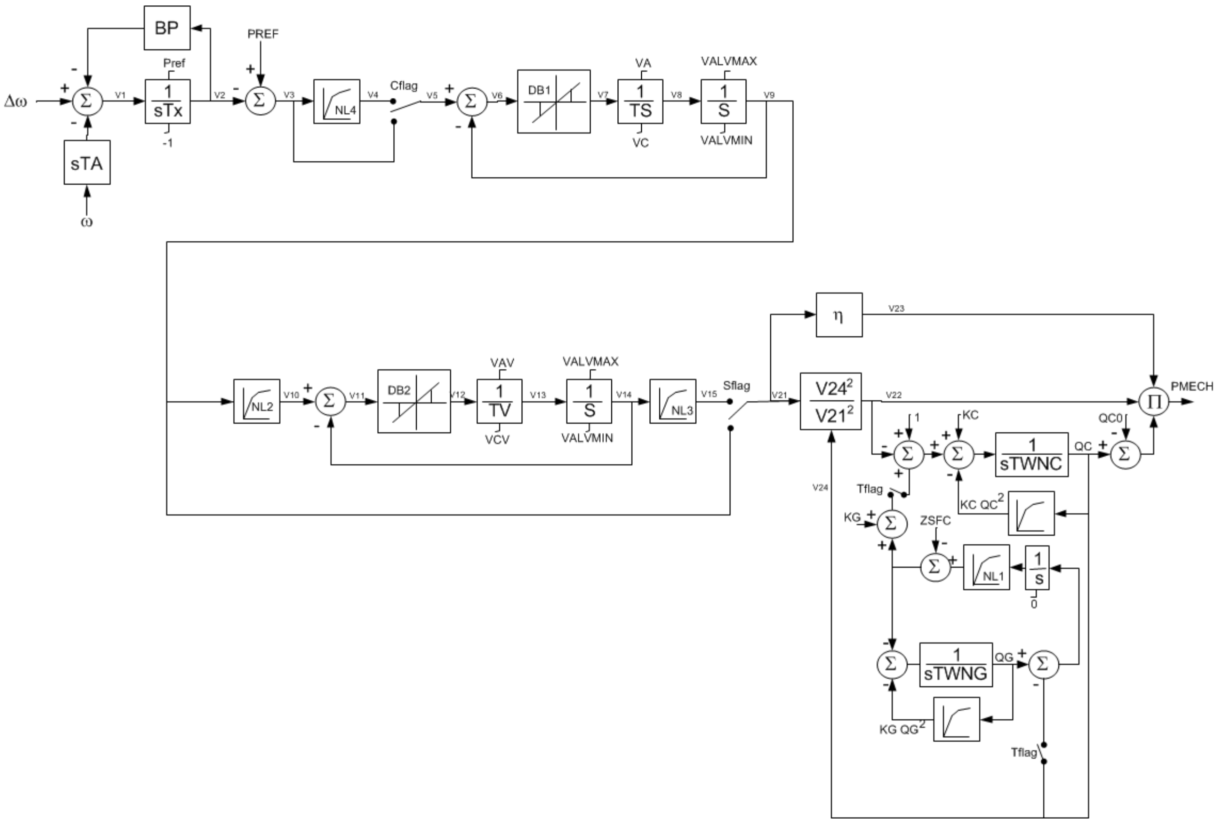
Notes

Equivalent model in CIM/CGMES:
- GovHydroIEEE2

TURBINE – GOVHYDROPELTON

Detailed hydro unit, Pelton model

A schematic of the hydraulic system of detailed hydro unit models, such as Francis and Pelton, is located under the Turbine – GOVHYDROFRANCIS class



Parameters

NAME	Type	Description
BP	pu	Droop
DB1	pu	Intentional dead-band width
DB2	pu	Intentional dead-band width of valve opening error
CFLAG	Boolean	Static compensating characteristic, if CFLAG=1 enable of static compensating characteristic, else inhibit of static compensating characteristic
KC	pu	Penstock loss coefficient (due to friction)
KG	pu	Water tunnel and surge chamber loss coefficient (due to friction)
QC0	pu	No-load turbine flow at nominal head
TA	Seconds	Derivative gain (accelerometer time constant)
TV	Seconds	Servomotor integrator time constant
TS	Seconds	Gate servo time constant
TWNC	Seconds	Water inertia time constant
TWNG	Seconds	Water tunnel and surge chamber inertia time constan
TX	Seconds	Electronic integrator time constant
VA	pu	Maximum gate opening velocity

VALVMAX	pu	Maximum gate opening
VALVMIN	pu	Minimum gate opening
TFLAG	Boolean	Water tunnel and surge chamber simulation, if TFLAG=1 enable of water tunnel and surge chamber simulation, else inhibit of water tunnel and surge chamber simulation
ZSFC	pu	Head of upper water level respect to the level of penstock
VAV	pu	Maximum servomotor valve opening velocity
VC	pu	Maximum gate closing velocity
VCV	pu	Maximum servomotor valve closing velocity
SFLAG	Boolean	Simplified Pelton model simulation, if SFLAG=1 enable of static compensating characteristic, else inhibit of static compensating characteristic
QN	m^3/s	Rated flow
HN	m	Rated hydraulic head
AV1*	float	Area of the surge tank
AV2*	float	Area of the compensation tank
H1*	float	Head of compensation chamber water level with respect to the level of penstock
H2*	float	Head of surge tank water level with respect to the level of penstock
MWBASE	MW	Base for power values, ActivePower

Notes

1. This model can be used to represent the dynamic related to water tunnel and surge chamber.
2. Governors per unit parameters are on base of MW capability of the turbine.
3. Rated hydraulic head Hn [m] an rated flow [m3/s] are the design parameters of the hydraulic system capability in CIM/CGMES manual, these not are indicated in NEPLAN manual.
4. Hydraulic system head attributes (Zsfc, H1, H2) are in meters but in the block diagram are in per unit on base of Hn.
5. Hydraulic area attributes (Av1, Av2) are in square meters but in the block diagram are in per unit on base of Qn/Hn [m2/s], in CIM/CGMES model the $A_{V0} = A_{V1}$, $A_{V1} = A_{V2}$.
6. omega has units of per unit speed.
7. Non-linear gain and efficiency equations shown below

- *Non linear gains:

$$NL1: \begin{cases} Z_p = \dfrac{W_p}{A_{V1}} & if \quad 0 \leq W_p \leq W_1 \\ Z_p = H_1 + \dfrac{W_p - W_1}{A_{V0}} & if \quad W_1 \leq W_p \leq W_2 \\ Z_p = H_2 & if \quad W_p \geq W_2 \end{cases}$$

$$NL2: Y_{V0} = (TetaR)^3$$

$$NL3: S_{eff} = -1.1 + \sqrt{1.21 + Y_V \cdot (4.2 - Y_V)}$$

$$NL4:\ TetaR0 = \left(2.1 - \sqrt{5.62 - (U_0 + 1.1)^2}\right)^{1/3}$$

$$W_1 = H_1 \cdot A_{V1} = Compensation\ chamber\ volume$$

$$W_2 = W_1 + (H_2 - H_1) = Compensation\ chamber\ volume + tank\ volume$$

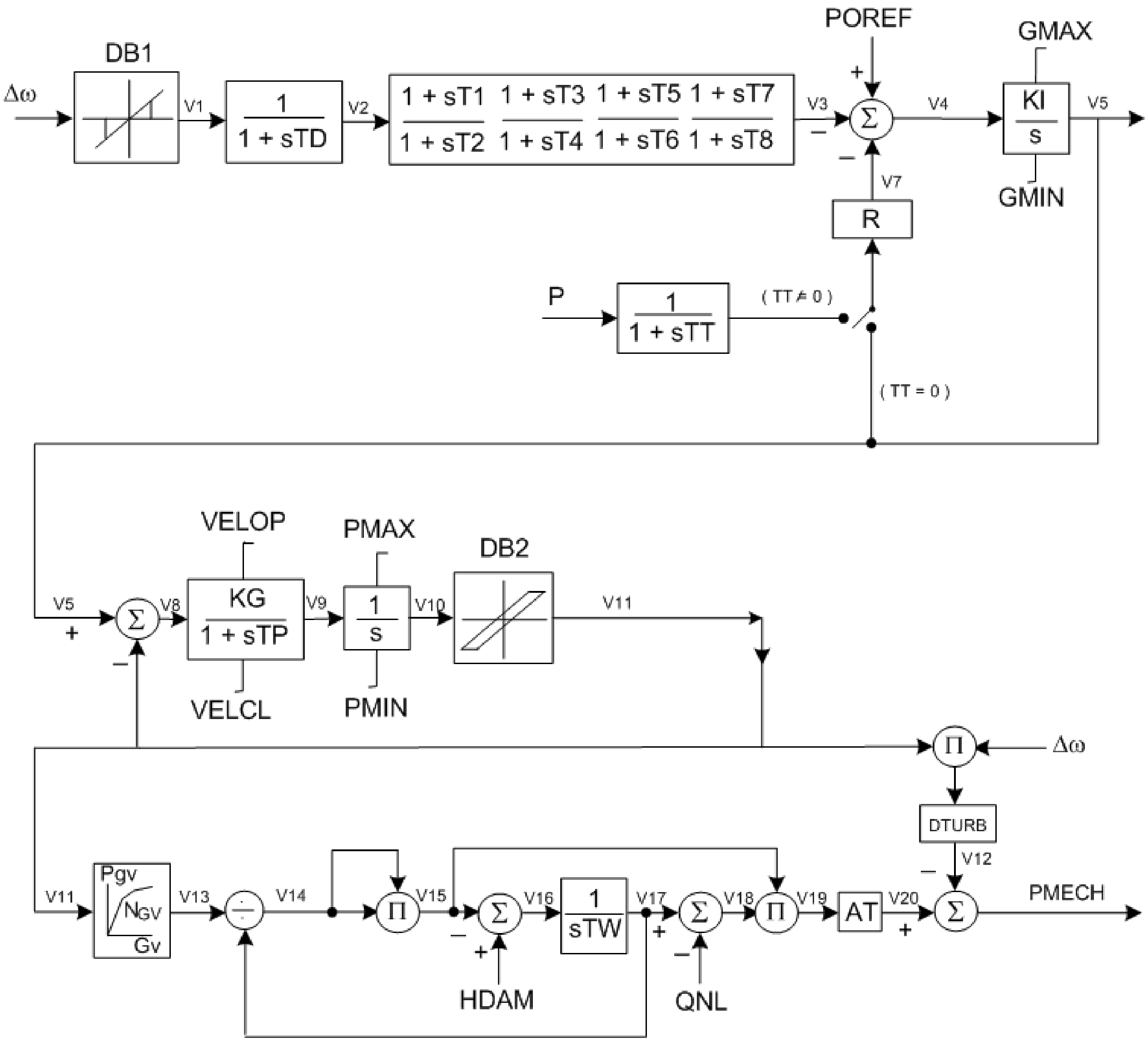
- *Efficiency:

$$\eta = \begin{cases} 1 & if\quad S_{eff} \geq 0.3 \\ 0.7 + S_{eff} & if\quad 0.13 \leq S_{eff} < 0.3 \\ 13.83 \cdot (S_{eff} - 0.07) & if\quad 0.07 \leq S_{eff} < 0.13 \\ 0 & if\quad S_{eff} < 0.07 \end{cases}$$

Equivalent model in CIM/CGMES:
- GovHydroPelton

TURBINE –HYDROGOVR

Fourth order lead-lag governor and hydro turbine.



Parameters

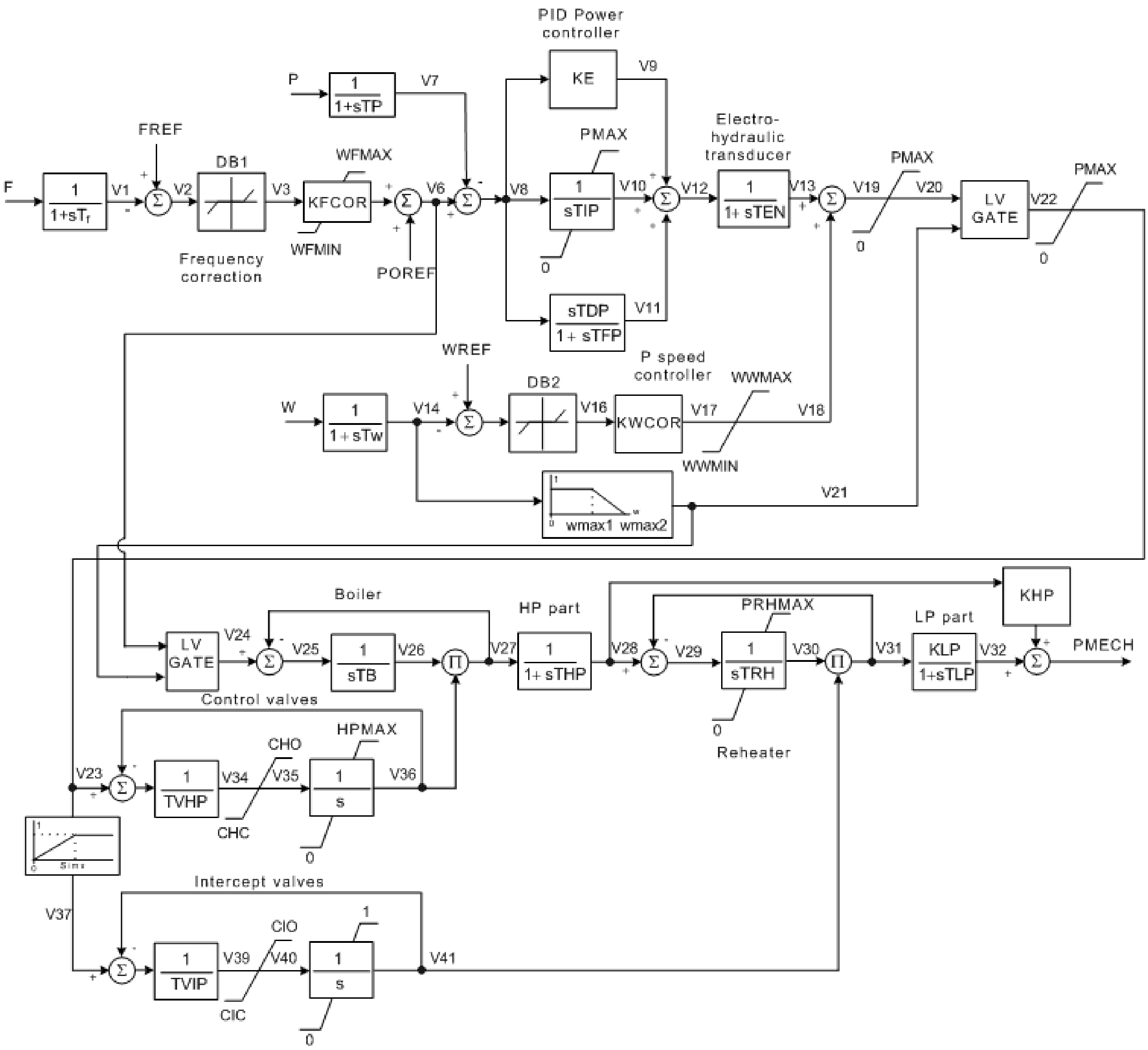
NAME	Type	Description
DB1	PU	Intentional dead-band width
EPZ	PU	Intentional db hysteresis
TD	Seconds	Input filter time constant
T1	Seconds	Time constant
T2	Seconds	Time constant
T3	Seconds	Time constant
T4	Seconds	Time constant

T5	Seconds	Time constant
T6	Seconds	Time constant
T7	Seconds	Time constant
T8	Seconds	Time constant
KI	PU	Integral gain
GMIN	PU	Minimum governor output
GMAX	PU	Maximum governor output
TT	Seconds	Power feedback time constant
RR	PU	Steady-state droop
KG	PU	Gate servo gain
TP	Seconds	Gate servo time constant
VELCL	PU	Maximum gate closing velocity
VELOP	PU	Maximum gate opening velocity
PMIN	PU	Minimum gate opening
PMAX	PU	Maximum gate opening
DB2	PU	Unintentional dead-band
DTURB	PU	Turbine damping factor
HDAM	PU	Turbine nominal head1
TW	Seconds	Water inertia time const
QNL	PU	No-load turbine flow at nominal head
AT	PU	Turbine gain
GV0	PU	Nonlinear gain point 0
PGV0	PU	Nonlinear gain point 0
GV1	PU	Nonlinear gain point 1
PGV1	PU	Nonlinear gain point 1
GV2	PU	Nonlinear gain point 2
PGV2	PU	Nonlinear gain point 2
GV3	PU	Nonlinear gain point 3
PGV3	PU	Nonlinear gain point 3
GV4	PU	Nonlinear gain point 4
PGV4	PU	Nonlinear gain point 4
GV5	PU	Nonlinear gain point 5
PGV5	PU	Nonlinear gain point 5

Notes

Equivalent model in CIM/CGMES:
- GovHydror

TURBINE – GOVSTEAMEU



Parameters

NAME	Type	Description
TP	Seconds	Power transducer time constant
KE	PU	Gain of the power controller
TIP	Seconds	Integral time constant of the power controller
TDP	Seconds	Derivative time constant of the power controller
TFP	Seconds	Time constant of the power controller
TF	Seconds	Frequency transducer time constant

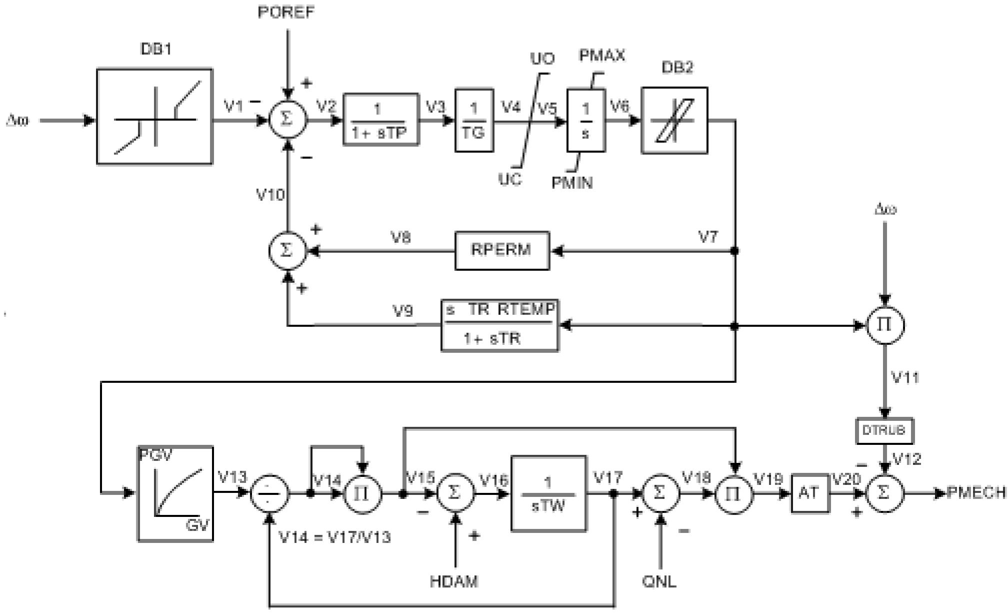
KFCOR	PU	Gain of the frequency corrector
DB1	PU	Dead band of the frequency corrector
WFMAX	PU	Upper limit for frequency correction
WFMIN	PU	Lower limit for frequency correction
PMAX	PU	Maximal active power of the turbine
TEN	Seconds	Electro hydraulic transducer
TW	Seconds	Speed transducer time constant
KWCOR	PU	Gain of the speed governor
DB2	PU	Dead band of the speed governor
WWMAX	PU	Upper limit for the speed governor
WWMIN	PU	Lower limit for the speed governor
WMAX1	PU	Emergency speed control lower limit
WMAX2	PU	Emergency speed control upper limit
TVHP	Seconds	Control valves servo time constant
CHO	PU	Control valves rate opening limit
CHC	PU	Control valves rate closing limit
HHPMAXv	PU	Maximum control valve position
TVIP	Seconds	Intercept valves servo time constant
CIO	PU	Intercept valves rate opening limit
CIC	PU	Intercept valves rate closing limit
SIMX	PU	Intercept valves transfer limit
THP	Seconds	High pressure (HP) time constant of the turbine
TRH	Seconds	Reheater time constant of the turbine
TLP	Seconds	Low pressure(LP) time constant of the turbine
PRHMAX	PU	Maximum low pressure limit
KHP	PU	Fraction of total turbine output generated by HP part
KLP	PU	Fraction of total turbine output generated by LP part
TB	Seconds	Boiler time constant

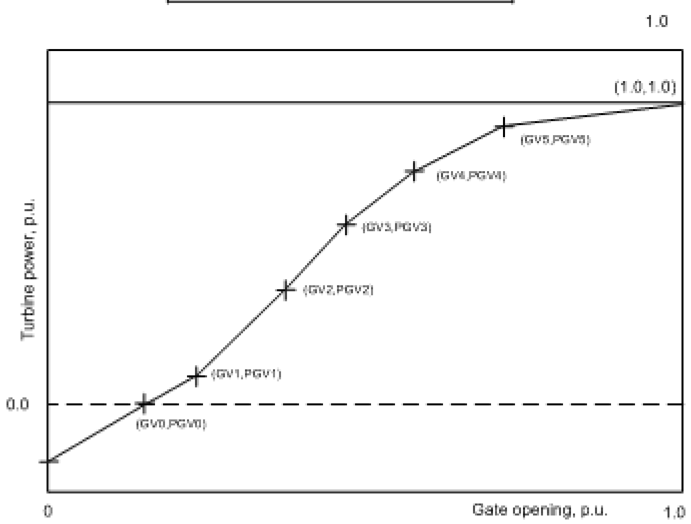
Notes

Equivalent model in CIM/CGMES:
- GovSteamEU

TURBINE - HYGOV4

Hydro turbine and governor. Represents plants with straight-forward penstock configurations and hydraulic governors of traditional 'dashpot' type.





Parameters

NAME	Type	Description
DB1	PU	Intentional deadband width
TP	Seconds	Pilot servo time constant
TG	Seconds	Gate servo time constant
UO	PU	Max gate opening velocity
UC	PU	Max gate closing velocity
PMAX	PU	Maximum gate opening
PMIN	PU	Minimum gate opening

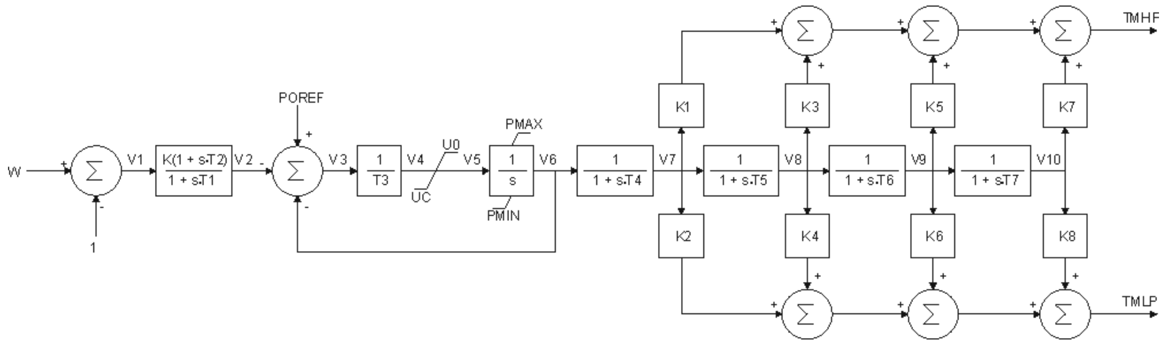
DB2	PU	Unintentional dead-band
EPS	PU	Intentional db hysteresis
RPERM	PU	Permanent droop
RTEMP	PU	Temporary droop
TR	Seconds	Dashpot time constant
DTURB	PU	Turbine damping factor
HDAM	PU	Head available at dam
TW	Seconds	Water inertia time constant
QNL	PU	No-load flow at nominal head
AT	PU	Turbine gain
GV0	PU	Nonlinear gain point 0
PGV0	PU	Nonlinear gain point 0
GV1	PU	Nonlinear gain point 1
PGV1	PU	Nonlinear gain point 1
GV2	PU	Nonlinear gain point 2
PGV2	PU	Nonlinear gain point 2
GV3	PU	Nonlinear gain point 3
PGV3	PU	Nonlinear gain point 3
GV4	PU	Nonlinear gain point 4
PGV4	PU	Nonlinear gain point 4
GV5	PU	Nonlinear gain point 5
PGV5	PU	Nonlinear gain point 5

Notes

Equivalent model in CIM/CGMES:
- GovHydro4

TURBINE - IEEEG1

IEEE Type 1 Speed-Governing Model



Parameters

NAME	Type	Description
K	PU	Governor gain
T1	Seconds	Governor lag time constant
T2	Seconds	Governor lead time constant
T3	Seconds	Valve positioner time constant
U0	PU	Maximum valve opening velocity
UC	PU	Maximum valve closing velocity
PMAX	PU	Maximum valve opening
PMIN	PU	Minimum valve opening
T4	Seconds	Inlet piping/steam bowl time constant
T5	Seconds	Time constant of second boiler pass
T6	Seconds	Time constant of third boiler pass
T7	Seconds	Time constant of fourth boiler pass
K1	PU	Fraction of HP shaft power after first boiler pass
K2	PU	Fraction of LP shaft power after first boiler pass
K3	PU	Fraction of HP shaft power after second boiler pass
K4	PU	Fraction of LP shaft power after second boiler pass
K5	PU	Fraction of HP shaft power after third boiler pass
K6	PU	Fraction of LP shaft power after third boiler pass
K7	PU	Fraction of HP shaft power after fourth boiler pass
K8	PU	Fraction of LP shaft power after fourth boiler pass

Parameters Range:

$5.0 \le K \le 30$
$0 < T1 < 5.0$
$0 < T2 < 10.0$
$0.04 < T3 \le 1.0$
$0.01 \le Uo \le 0.3$
$-0.3 \le Uc < 0$
$-2.0 \le K1 \le 1$
$K2 = 0$
$0 < T4 \le 1.0$
$0 < T5 < 10.0$
$0 \le K3 < 0.5$
$0 \le K4 < 0.5$
$0 < T6 < 10.0$
$0 \le K5 < 0.35$
$0 \le K6 < 0.55$
$0 < T7 < 10.0$
$0 \le K7 < 0.3$
$0 \le K8 < 0.3$
$0.5 \le PMAX \le 2.0$
$0 \le PMIN < 0.5$

Notes

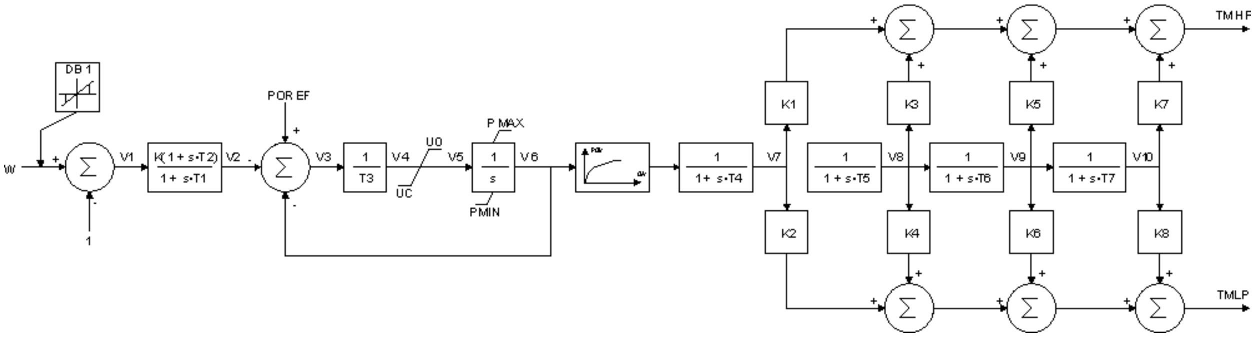
For a tandem-compound turbine the parameters K2, K4, K6, and K8 are ignored. For a cross-compound turbine, two generators are connected to this turbine-governor model.

Each generator must be represented in the load flow by data on its own MVA base. The values of K1, K3, K5, K7 must be specified to describe the proportionate development of power on the first turbine shaft. K2, K4, K6, K8 must describe the second turbine shaft. Normally K1 + K3 + K5 + K7 = 1.0 and K2 + K4 + K6 + K8 = 1.0 (if second generator is present).

Equivalent model in CIM/CGMES:
- GovHydroIEEE1

TURBINE - IEEEG1 2005

IEEE Type 1 Speed-Governing Model, version 2005



Parameters

NAME	Type	Description
K	PU	Governor gain
T1	Seconds	Governor lag time constant
T2	Seconds	Governor lead time constant
T3	Seconds	Valve positioner time constant
U0	PU	Maximum valve opening velocity
UC	PU	Maximum valve closing velocity
PMAX	PU	Maximum valve opening
PMIN	PU	Minimum valve opening
T4	Seconds	Inlet piping/steam bowl time constant
T5	Seconds	Time constant of second boiler pass
T6	Seconds	Time constant of third boiler pass
T7	Seconds	Time constant of fourth boiler pass
K1	PU	Fraction of HP shaft power after first boiler pass
K2	PU	Fraction of LP shaft power after first boiler pass
K3	PU	Fraction of HP shaft power after second boiler pass
K4	PU	Fraction of LP shaft power after second boiler pass
K5	PU	Fraction of HP shaft power after third boiler pass
K6	PU	Fraction of LP shaft power after third boiler pass
K7	PU	Fraction of HP shaft power after fourth boiler pass
K8	PU	Fraction of LP shaft power after fourth boiler pass
DB1	PU	Intentional deadband width
EPS	PU	Intentional db hysteresis
DB2	PU	Unintentional deadband
GV1	PU	Nonlinear gain valve position point 1
PGV1	PU	Nonlinear gain power value point 1
GV2	PU	Nonlinear gain valve position point 2
PGV2	PU	Nonlinear gain power value point 2
GV3	PU	Nonlinear gain valve position point 3
PGV3	PU	Nonlinear gain power value point 3
GV4	PU	Nonlinear gain valve position point 4

PGV4	PU	Nonlinear gain power value point 4
GV5	PU	Nonlinear gain valve position point 5
PGV5	PU	Nonlinear gain power value point 5
GV6	PU	Nonlinear gain valve position point 6
PGV6	PU	Nonlinear gain power value point 6

Notes

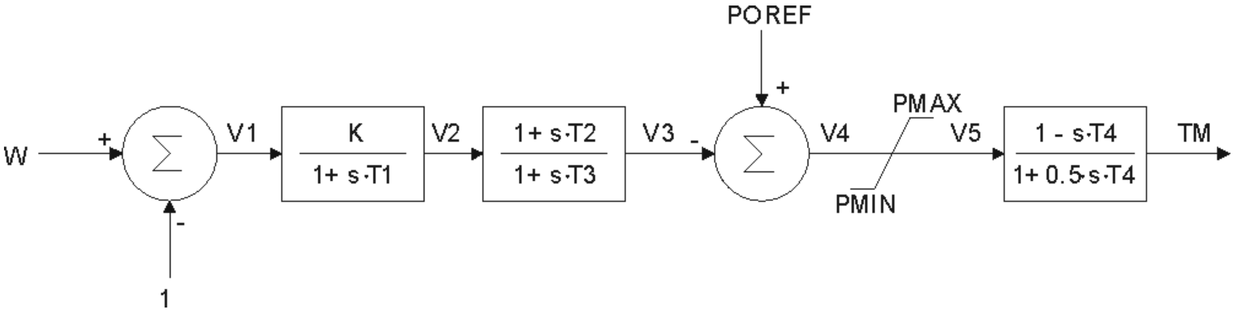
For a tandem-compound turbine the parameters K2, K4, K6, and K8 are ignored. For a cross-compound turbine, two generators are connected to this turbine-governor model.

Each generator must be represented in the load flow by data on its own MVA base. The values of K1, K3, K5, K7 must be specified to describe the proportionate development of power on the first turbine shaft. K2, K4, K6, K8 must describe the second turbine shaft. Normally K1 + K3 + K5 + K7 = 1.0 and K2 + K4 + K6 + K8 = 1.0 (if second generator is present).

Equivalent model in CIM/CGMES:
- GovSteam1

TURBINE - IEEEG2

IEEE Type 2 Speed-Governing Model



Parameters

NAME	Type	Description
K	PU	Governor gain
T1	Seconds	Governor lag time constant
T2	Seconds	Governor lead time constant
T3	Seconds	Gate actuator time constant
T4	Seconds	Water starting time
PMAX	PU	Gate maximum
PMIN	PU	Gate minimum

Parameters Range:

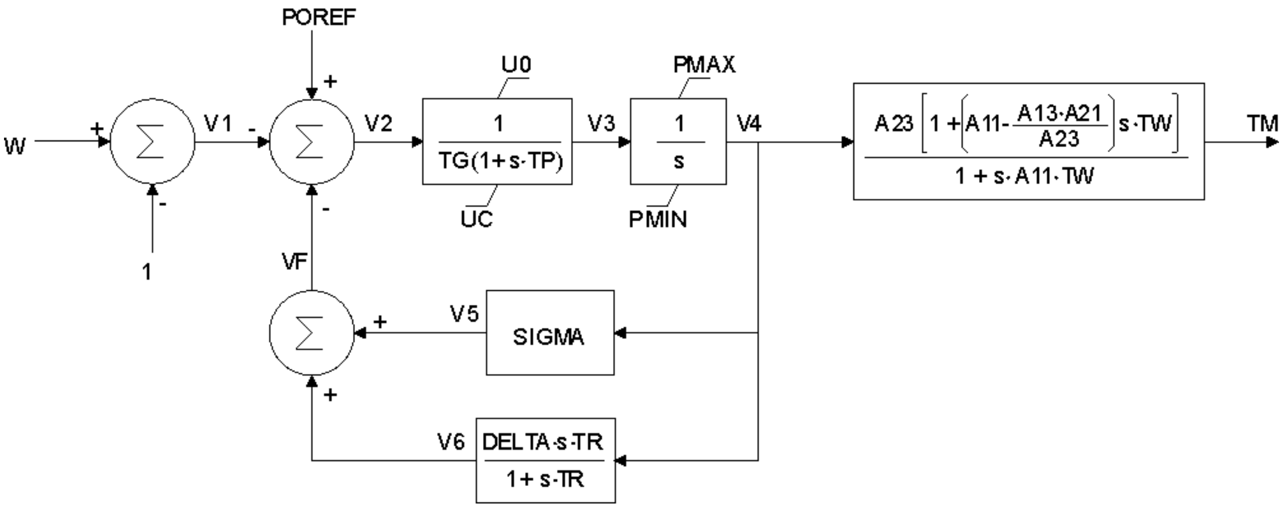
$5.0 \leq K \leq 30$
$0 < T1 < 100$
$0 \leq T2 < 10$
$0.04 < T3 \leq 1$
$0.5 \leq PMAX \leq 1.5$
$0 \leq PMIN < 0.5$
$PMIN < PMAX$
$0.04 \leq T4 \leq 5.0$

Notes

Equivalent model in CIM/CGMES:
- GovHydroIEEE0

TURBINE - IEEEG3

IEEE Type 3 Speed-Governing Model



Parameters

NAME	Type	Description
TG	Seconds	Gate servo time constant
TP	Seconds	Pilot servo valve time constant
UO	PU	Maximum gate opening velocity
UC	PU	Minimum gate opening velocity
PMAX	PU	Maximum gate opening
PMIN	PU	Minimum gate opening
SIGMA	PU	Permanent droop
DELTA	PU	Temporary droop
TR	Seconds	Dashpot time constant
TW	Seconds	Water inertia time constant
A11	PU	Turbine coefficient
A13	PU	Turbine coefficient
A21	PU	Turbine coefficient
A23	PU	Turbine coefficient

Parameters Range:

$0.04 \le TG \le 1.0$
$0.04 \le Tp < 0.1$
$0 \le Uo < 0.3$
$-0.3 < Uc \le 0$
$0.5 \le PMAX \le 1.0$
$0 \le PMIN < 0.5$
$0 < SIGMA \le 0.1$

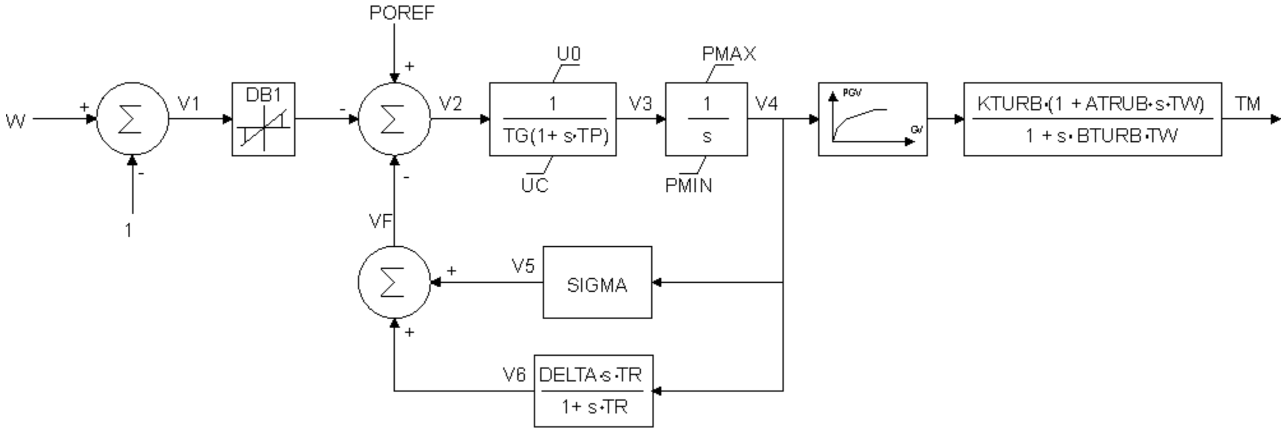
$0 < DELTA \le 1.2$
$1.0 \le TR < 50$
$0.04 < Tw < 10$
$0 < A11 < 1.5$
$0 < A13 < 1.5$
0 < A21 ! 1.5
$0 < A23 < 1.5$

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - IEEEG3 2005

IEEE Type 3 Speed-Governing Model, version 2005



Parameters

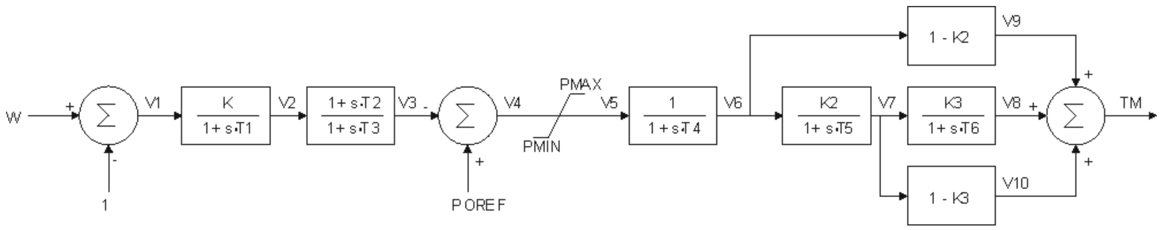
NAME	Type	Description
TG	Seconds	Gate servo time constant
TP	Seconds	Pilot servo valve time constant
UO	PU	Maximum gate opening velocity
UC	PU	Minimum gate opening velocity
PMAX	PU	Maximum gate opening
PMIN	PU	Minimum gate opening
SIGMA	PU	Permanent droop
DELTA	PU	Temporary droop
TR	Seconds	Dashpot time constant
TW	Seconds	Water inertia time constant
KTURB	PU	Turbine gain
BTURB	PU	Turbine numerator multiplier
ATURB	PU	Turbine denominator multiplier
DB1	PU	Intentional deadband width
EPS	PU	Intentional db hysteresis
DB2	PU	Unintentional deadband
GV1	PU	Nonlinear gain point 1
PV1	PU	Nonlinear gain point 1
GV2	PU	Nonlinear gain point 2
PV2	PU	Nonlinear gain point 2
GV3	PU	Nonlinear gain point 3
PV3	PU	Nonlinear gain point 3
GV4	PU	Nonlinear gain point 4
PV4	PU	Nonlinear gain point 4
GV5	PU	Nonlinear gain point 5
PV5	PU	Nonlinear gain point 5
GV6	PU	Nonlinear gain point 6
PV6	PU	Nonlinear gain point 6

Notes

Equivalent model in CIM/CGMES:
- GovHydro2

TURBINE - IEESGO

IEEE standard Governor



Parameters

NAME	Type	Description
K	PU	One/per unit regulation
T1	Seconds	Controller lag
T2	Seconds	Controller lead compensation
T3	Seconds	Governor lag
PMIN	PU	Upper power limit
PMAX	PU	Lower power limit
T4	Seconds	Delay due to steam inlet volumes associated with steam chest and inlet piping
K2	PU	Fraction
T5	Seconds	Reheater delay including hot and cold leads
K3	PU	Fraction
T6	Seconds	Delay due to IP-LP turbine, crossover pipes and LP end hoods

Parameters Range:

0 < T1 < 100
0 < T2 < 10
0.04 < T3 ≤ 1.0
0 < T4 ≤ 1.0
0 < T5 ≤ 50
0 < T6 ≤ 1.0

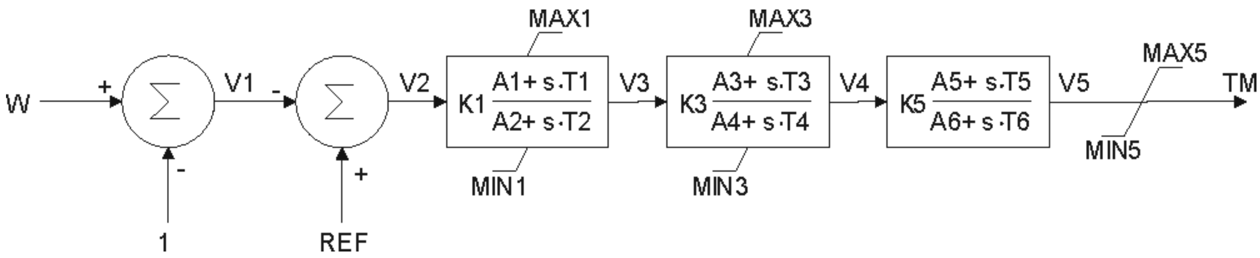
5 ≤ K1 ≤ 30
0 ≤ K2 ≤ 3.0
-1.0 ≤ K3 ≤ 1.0
0.5 ≤ PMAX ≤ 1.5
0 ≤ PMIN ≤ 0.5
PMIN < PMAX

Notes

Equivalent model in CIM/CGMES:
- GovSteamSGO

TURBINE - IVOGO

IVO Governor Model.
A governor is included in the model and therefore no other governor can be associated with the turbine model.



Parameters

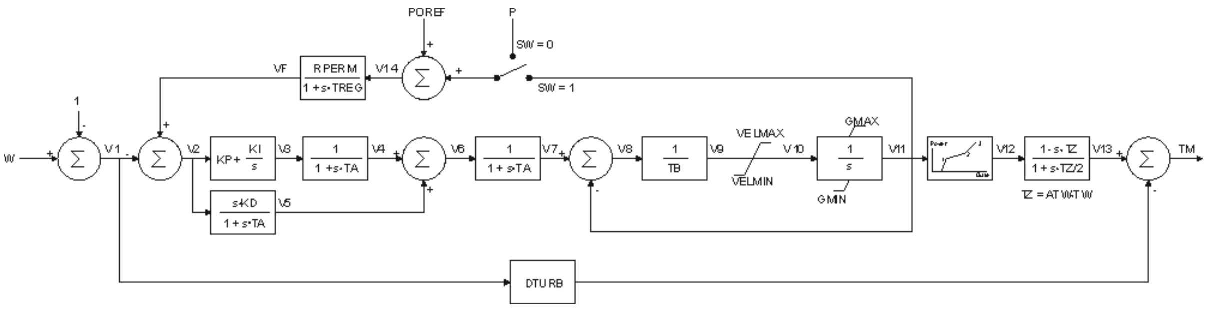
NAME	Type	Description
K1	PU	Gain first stage
A1	PU	Lead lag coefficient first stage
A2	PU	Lead lag coefficient first stage
T1	Seconds	Time constant first stage
T2	Seconds	Time constant first stage
MAX1	PU	Maximum limit first stage
MIN1	PU	Minimum limit first stage
K3	PU	Gain second stage
A3	PU	Lead lag coefficient second stage
A4	PU	Lead lag coefficient second stage
T3	Seconds	Time constant second stage
T4	Seconds	Time constant second stage
MAX3	PU	Maximum limit second stage
MIN3	PU	Minimum limit second stage
K5	PU	Gain third stage
A5	PU	Lead lag coefficient third stage
A6	PU	Lead lag coefficient third stage
T5	Seconds	Time constant third stage
T6	Seconds	Time constant third stage
MAX5	PU	Maximum limit
MIN5	PU	Minimum limit

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - PIDGOV

Hydro Turbine and Governor



Parameters

NAME	Type	Description
SW	Boolean	Feedback switch control 0 = P is used 1 = Feedback signal is used
RPERM	PU	Permanent drop
TREG	Seconds	Speed detector time constant
KD	PU	Derivative gain
TA	Seconds	Controller time constant
KP	PU	Proportional gain
KI	PU	Reset gain
TB	Seconds	Gate servo time constant
VELMIN	PU	Maximum gate closing velocity
VELMAX	PU	Maximum gate opening velocity
GMIN	PU	Minimum gate opening
GMAX	PU	Maximum gate opening
P1	PU	Power at gate opening G1
P2	PU	Power at gate opening G2
P3	PU	Power at full opened gate
G0	PU	Gate opening at speed no load
G1	PU	Intermediate gate opening
G2	PU	Intermediate gate opening
ATW	PU	Factor multiplying Tw
TW	Seconds	Water inertia time constant
DTURB	PU	Turbine damping factor

Parameters Range:

0.02 < Ta < 1

0.02 < Tb < 1

0.02 < TW < 1

P1 –> P3 ascending value order

0.01 ≤ Velmax ≤ 0.3

-0.3 ≤ Velmin < 0

G0 -> G2 ascending value order

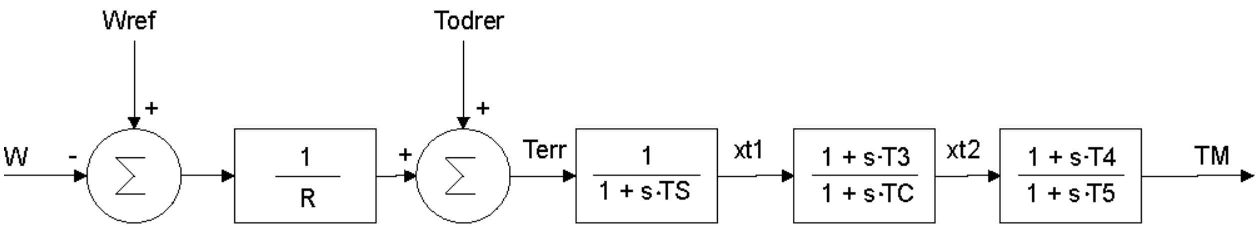
Notes

Equivalent model in CIM/CGMES:

- GovHydroPID2

TURBINE - TG_P

Turbine-Governor TYPE 1



Parameters

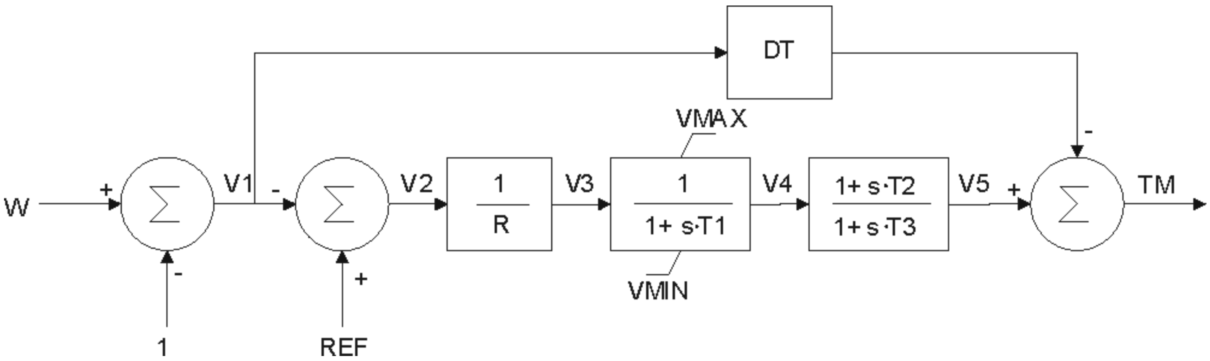
NAME	Type	Description
R	PU	Permanent Droop
TS	Seconds	Time constant
T3	Seconds	Time constant
TC	Seconds	Time constant
T4	Seconds	Time constant
T5	Seconds	Time constant

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - TGOV1

Steam turbine governor.



Parameters

NAME	Type	Description
R	PU	Permanent droop
T1	Seconds	Steam bowl time constant
VMAX	PU	Maximum valve position
VMIN	PU	Minimum valve position
T2	Seconds	Time constant
T3	Seconds	Time constant
DT	PU	Turbine damping coefficient
MWBASE	ActivePower	Base for power values

Parameters Range:

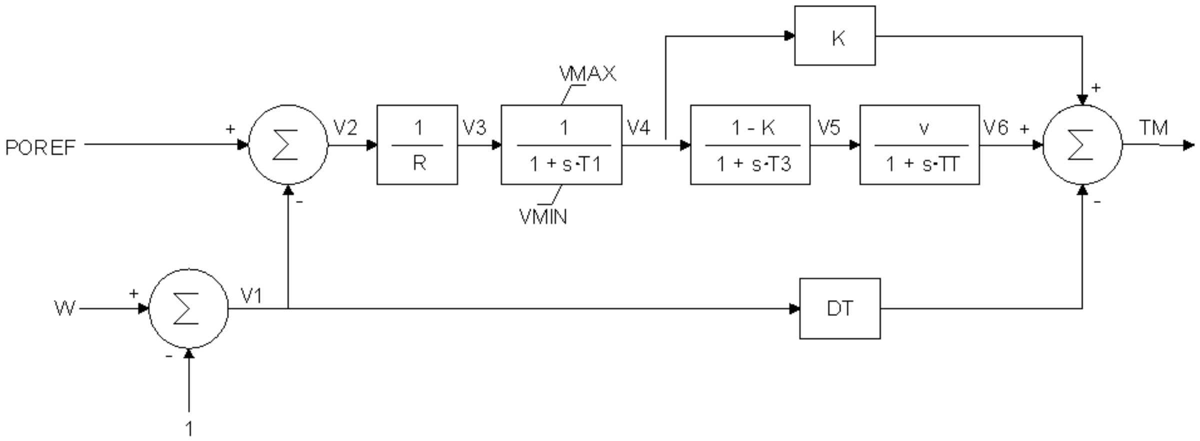
$0 < R < 0.1$
$0.04 < T1 < 0.5$
$0.5 \leq VMAX \leq 1.2$
$VMIN < VMAX$
$0 \leq VMIN < 1.0$
$0 < T2$
$0.04 < T3 < 10.0$
$T2 < T3/2.0$
$0 \leq DT < 0.5$

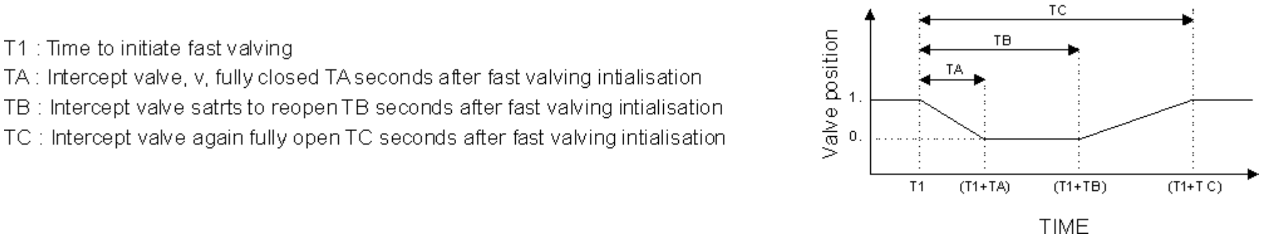
Notes

Equivalent model in CIM/CGMES:
- GovSteam0

TURBINE - TGOV2

Steam Turbine-Governor With Fast Valving





Parameters

NAME	Type	Description
R	PU	Permanent droop
T1	Seconds	Steam bowl time constant
VMAX	PU	Maximum valve position
VMIN	PU	Minimum valve position
K	PU	Governor gain
T3	Seconds	Time constant
TT	Seconds	Valve time constant
DT	PU	Turbine damping coefficient
TI	Seconds	Valve position at time 1 (initial fast valving)
TA	Seconds	Valve position at time 2 (fully closed after fast valving initialisation)
TB	Seconds	Valve position at time 3 (start to reopen after fast valving initialisation)
TC	Seconds	Valve position at time 4 (again fully open after fast valving initialisation)

Parameters Range:

$0 < R < 0.1$
$0.04 < T1 < 0.5$
$0.5 < VMAX < 1.2$
$VMIN < VMAX$
$1.0 < T3 < 10.0$
$0 \leq DT < 0.5$
$0.04 < TT < 0.5$
$0.04 < TA < 0.25$

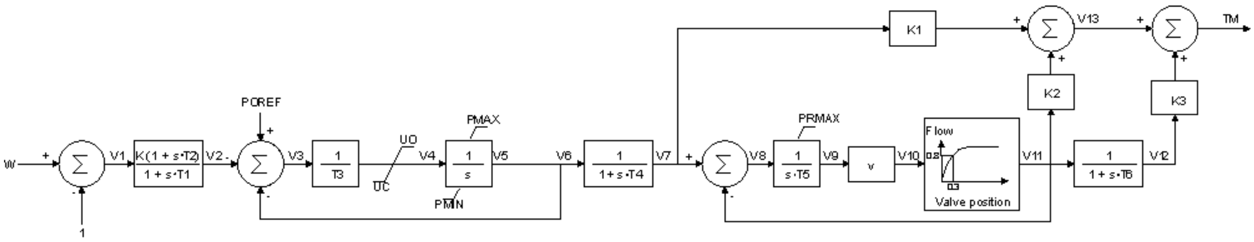
$0 \leq VMIN < 1.0$	$TA+0.1 < TB < 50.0$
$0.1 < K < 0.5$	$TB+1.0 < TC < 50.0$

Notes

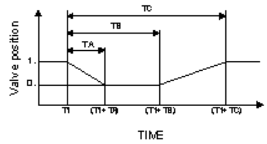
Equivalent model in CIM/CGMES:
- GovSteamFV2

TURBINE - TGOV3

Modified IEEE Type 1 Speed-Governing Model With Fast Valving



T1 : Time to initiate fast valving
TA : Intercept valve, v, fully closed TA seconds afterfast valving intialisation
TB : Intercept valve satrts to reopen TB seconds after fast valving intialisation
TC : Intercept valve again fully open TC seconds after fast valving intialisation



Parameters

NAME	Type	Description
K	PU	Governor gain
T1	Seconds	Governor lead time constant
T2	Seconds	Governor lag time constant
T3	Seconds	Valve positioner time constant
UO	PU	Maximum valve opening velocity
UC	PU	Maximum valve closing velocity
PMAX	PU	Maximum valve opening
PMIN	PU	Minimum valve opening
T4	Seconds	Inlet piping/steam bowl time constant
T5	Seconds	Time constant of second boiler pass
PRMAX	PU	Max. pressure in reheater
T6	Seconds	Time constant of crossover or third boiler pass
K1	PU	Fraction of turbine power developed after first boiler pass
K2	PU	Fraction of turbine power developed after second boiler pass
K3	PU	Fraction of hp turbine power developed after crossover or third boiler pass
TI	Seconds	Valve position at time 1 (initial fast valving)
TA	Seconds	Valve position at time 2 (fully closed after fast valving initialisation)
TB	Seconds	Valve position at time 3 (start to reopen after fast valving initialisation)
TC	Seconds	Valve position at time 4 (again fully open after fast valving initialisation)
P0	PU	Nonlinear gain point 1 (valve position)
P1	PU	Nonlinear gain point 2 (valve position)
P2	PU	Nonlinear gain point 3 (valve position)
P3	PU	Nonlinear gain point 4 (valve position)
P4	PU	Nonlinear gain point 5 (valve position)
F0	PU	Nonlinear gain point 1 (flow)

F1	PU	Nonlinear gain point 2 (flow)
F2	PU	Nonlinear gain point 3 (flow)
F3	PU	Nonlinear gain point 4 (flow)
F4	PU	Nonlinear gain point 5 (flow)

Parameters Range:

$5.0 \le K \le 30$
$0 < T1 < 5$
$0 < T2 < 10$
$0.04 < T3 \le 1.0$
$0.01 \le Uo \le 0.3$
$-0.3 \le Uc < 0$
$0.5 \le PMAX \le 1.0$
$0 \le PMIN < 0.5$
$PMIN < PMAX$

$0 < T4 \le 1$
$-2.0 \le K1 \le 1$
$0.04 < T5 < 10$
$0 \le K2 < 0.5$
$0 < T6 < 10$
$0 \le K3 < 0.35$
$0.04 < TA < 0.25$
$TA+0.1 < TB < 50.0$
$TB+1.0 < TC < 50.0$

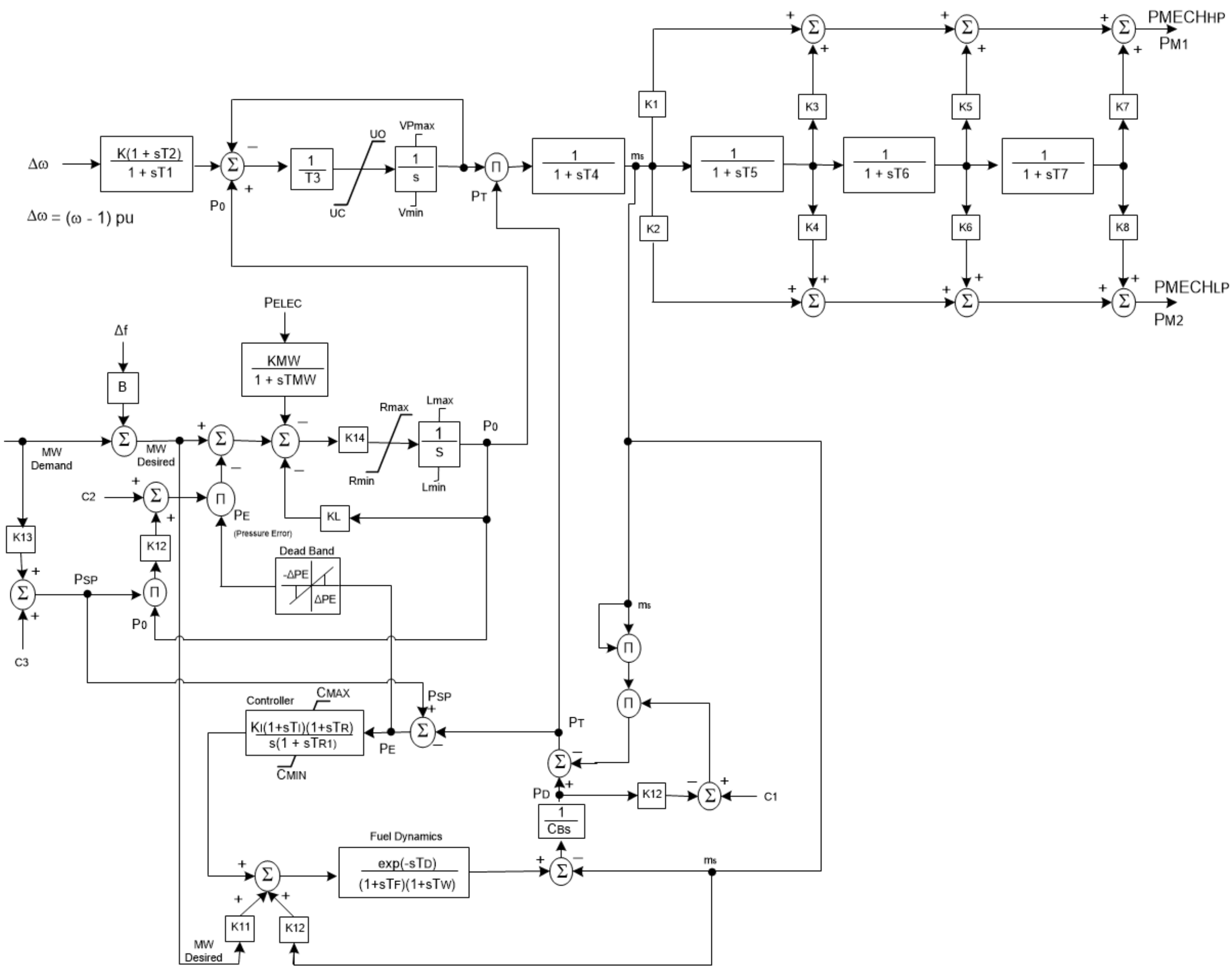
Notes

The gains K1-K3 and describe the division of power output among turbine stages. Normally, K1+ K2 + K3 = 1.0.

Equivalent model in CIM/CGMES:
- GovSteamFV3

TURBINE – TGOV5

TGOV5 is a model of a steam turbine and boiler that represents governor action, main, reheat and low-pressure effects, including boiler effects. The boiler controls will handle practically any mode of control including coordinated, base, variable pressure, and conventional. The control mode is selected by the proper choice of constants.



Parameters

NAME	Type	Description
K	PU	The inverse of the governor speed droop.
T1	Seconds	The governor controller lag time costant
T2	Seconds	The governor controller lead time costant
T3	Seconds	The valve servomotor time constant for the control valves
UO	PU/Seconds	The control valve open rate limit
UC	PU/Seconds	The control valve close rate limit
VMAX	PU	The maximum valve area
VMIN	PU	The minimum valve area
T4	Seconds	The steam flow time constan

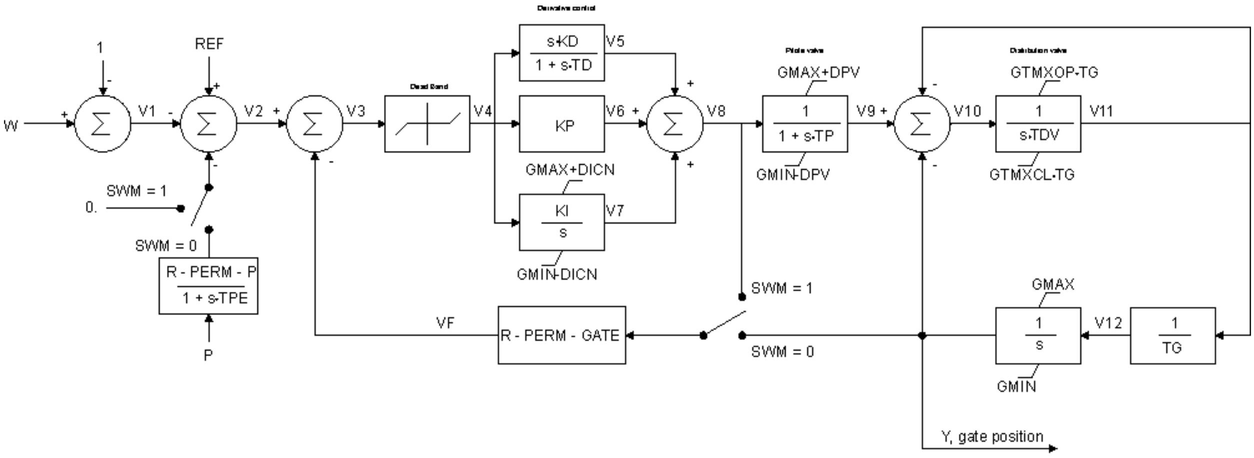
K1, K3, K5 and K7	PU	The fractions of the HP unit's mechanical power developed by the various turbine stages. The sum of these constants should be one for a non cross-compound unit.
K2, K4, K6 and K8	PU	Similar fractions of the LP unit's mechanical power. These fractions should be zero for a noncross-compound unit. For a cross-compound unit, the sum of K1 through K8 should equal one
T5,T6 and T7	Seconds	The first and second reheater time constants and the crossover time constant. They may be set to zero if all steps are not necessary: i.e., no second reheat stage.
K9	PU	The adjustment to the pressure drop coefficient as a function of drum pressure
K10	PU	The gain of anticipation signal from main stream flow
K11	PU	The gain of anticipation signal from load demand.
K12	PU	The gain for pressure error bias
K13	PU	The gain between MW demand and pressure set point
K14	PU	Inverse of load reference servomotor time constant (= 0.0 if load reference does not change).
RMAX	PU/Seconds	The load reference positive rate of change limit
RMIN	PU/Seconds	The load reference negative rate of change limit
LMAX	PU	The maximum load reference.
LMIN	PU	The minimum load reference.
C1	PU	The pressure drop coefficient.
C2	PU	The gain for the pressure error bias.
C3	PU	The adjustment to the pressure set point
B	PU	The frequency bias for load reference control.
CB	Seconds	The boiler storage time constant
KI	PU	The controller integral gain.
TI	Seconds	The controller proportional lead time constant
TR	Seconds	The controller rate lead time constant
TR1	Seconds	The inherent lag associated with lead TR (usually about TR/10)
CMAX	PU	The maximum controller output.
CMIN	PU	The minimum controller output.
TD	Seconds	The time delay in the fuel supply system
TF	Seconds	The fuel and air system time constant
TW	Seconds	The water wall time constant
Psp_ini	PU	The initial throttle pressure set point
TMW	Seconds	The MW transducer time constant
KL	PU	The feedback gain from the load reference
KMW	PU	The gain of the MW transducer
deltaPE	PU	The deadband in the pressure error signal for load reference control

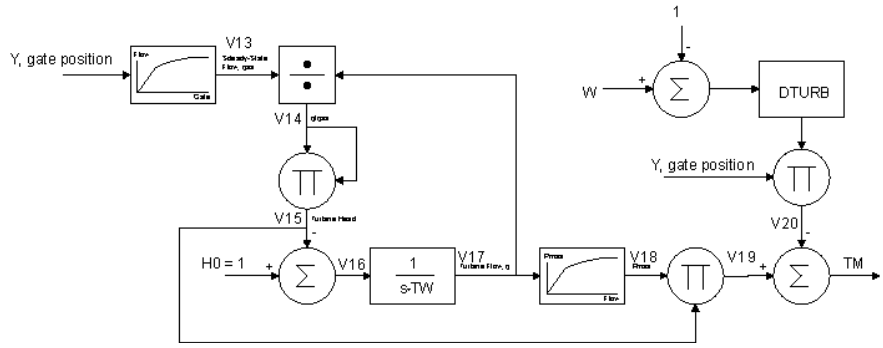
Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - WEHGOV1

Woodward Electric Hydro Governor Model





Parameters

NAME	Type	Description
SWM	Boolean	Feedback signal selection (Sw). 0 = Feedback siganl come from gate position 1 = Feedback siganl come from signal V8
RPP	PU	R-Perm-Pe
TPE	Seconds	Power time constant
DBAND	PU	Intentional dead-band width
KD	PU	Derivative gain
TD	Seconds	Derivative time constant
KP	PU	Proportional gain
RPG	PU	R-Perm-Gate
KI	PU	Integral gain
GMIN	PU	Minimum governor output
GMAX	PU	Maximum governor output
DICN	PU	Gate limiter modifier
DPV	PU	Governor limit factor
TP	Seconds	Gate servo time constant
TDV	Seconds	Time constant

GTMXCL	PU	Max gate closing velocity
GTMXOP	PU	Max gate opening velocity
TG	Seconds	Gate servo time constant
TW	Seconds	Water inertia time constant
DTURB	PU	Turbine damping factor
G1	PU	Gate 1
G2	PU	Gate 2
G3	PU	Gate 3
G4	PU	Gate 4
G5	PU	Gate 5
FG1	PU	Flow Gate 1
FG2	PU	Flow Gate 2
FG3	PU	Flow Gate 3
FG4	PU	Flow Gate 4
FG5	PU	Flow Gate 5
FP1	PU	Flow P1
FP2	PU	Flow P2
FP3	PU	Flow P3
FP4	PU	Flow P4
FP5	PU	Flow P5
FP6	PU	Flow P6
FP7	PU	Flow P7
FP8	PU	Flow P8
FP9	PU	Flow P9
FP10	PU	Flow P10
PM1	PU	Pmss Flow P1
PM2	PU	Pmss Flow P2
PM3	PU	Pmss Flow P3
PM4	PU	Pmss Flow P4
PM5	PU	Pmss Flow P5
PM6	PU	Pmss Flow P6
PM7	PU	Pmss Flow P7
PM8	PU	Pmss Flow P8
PM9	PU	Pmss Flow P9
PM10	PU	Pmss Flow P10

Parameters Range:

0 < RPG < 0
0 < RPP < 0.1
0.04 < TPE < 0.5
1 < KP < 10
1 < KI < 20
0 < KD < 20
0.04 < TD < 0.1
0.04 < TP < 0.2
0.04 < TDV < 0.2
0.04 < TG <1
0 < GTMXOP < 0.3
-0.3 < GTMXCL < 0

0 ≤ DTURB < 0.5
0.5 < TW < 3
0 < DBAND < 0.005
0 ≤ DPV < 0.1
0 ≤ DICN < 0.1
GATE1 -> GATE5 ascending value order
0.8 < GATE5 < 1.3
FLOWG1 -> FLOWG5 ascending value order
0.8 < FLOWG5 < 1.3
FLOWP1 -> FLOWP10 ascending value order
0.8 < FLOWP10 < 1.3
PMECH1 -> PMECH10 ascending value order

0 ≤ GMAX < 1
-0.1 < GMIN < 0.3

0.8 < PMECH10 < 1.3

Notes

Switch:
See Block diagram

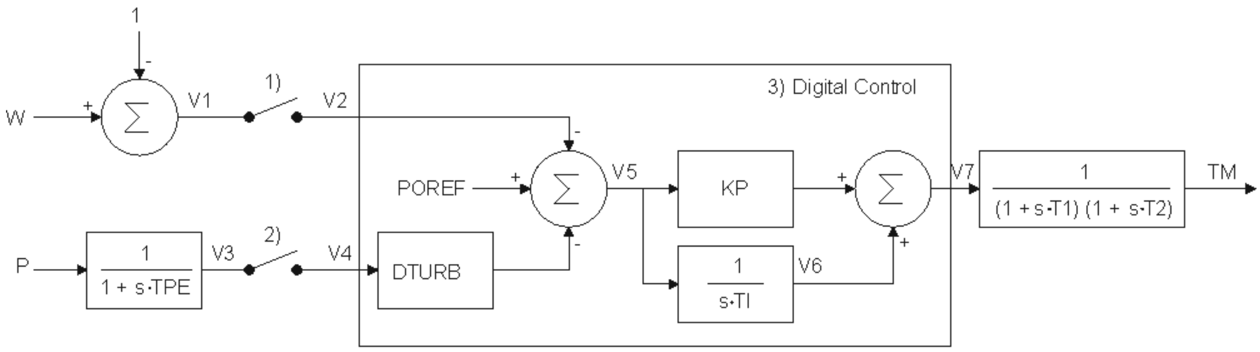
The Steady-State Flow is calculated using 10 parameters, 5 Gate points (G1… G5) and 5 Flow points (FG1… FG5)

The Pmss value is calculed using 20 parameters, 10 Turbine Flow points (FP1…FP10) and 10 Pmss points.

Equivalent model in CIM/CGMES:
- GovHydroWEH

TURBINE - WESGOV

Westinghouse Digital Governor for Gas Turbine



1) Sample hold with sample period define by deta TC
2) Sample hold with sample period define by deta TP
3) Maximum change is limited to ALIM between sampling times

Parameters

NAME	Type	Description
TPE	Seconds	Power time constant
DELTA_TP	Seconds	Sample hold, see note 1) in block diagram
DELTA_TC	Seconds	Sample hold, see note 2) in block diagram
DROOP	PU	Power droop
KP	PU	Trubine proportional gain
TI	Seconds	Integral time constant
T1	Seconds	Constant time
T2	Seconds	Constant time
ALIM	PU	(not used in NEPLAN)

Parameters Range:

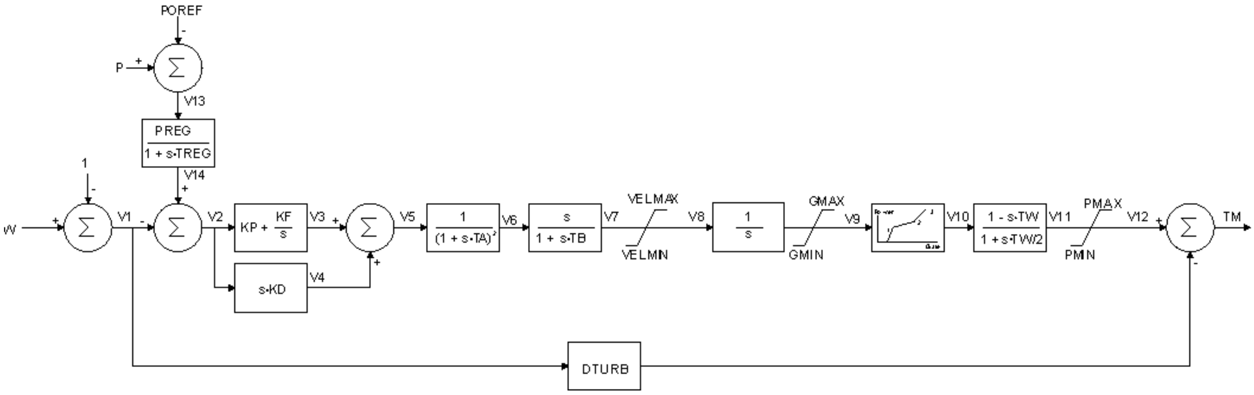
$0 < DELTA\_TP \le 0.25$
$0 < DELTA\_TC \le 0.25$
$0 < DROOP < 0.10$
$10 \le KP < 25$
$1.0 \le TI < 10$
$0 \le T1 < 0.2$
$0.2 \le T2 \le 0.6$
$0.15 \le ALIM < 0.4$
$0 < TPE < 0.2$

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - WPIDHY

Woodward PID Hydro Governor



Parameters

NAME	Type	Description
REG	PU	Speed detector gain
TREG	Seconds	Speed detector time constant
KF	PU	Integral gain
KD	PU	Derivative gain
KP	PU	Proportional gain
TA	Seconds	Time constant
TB	Seconds	Time constant
VELMIN	PU	Maximum gate closing velocity
VELMAX	PU	Maximum gate opening velocity
GATMIN	PU	Minimum gate opening
GATMAX	PU	Maximum gate opening
G0	PU	Nonlinear gain point 1
G1	PU	Nonlinear gain point 2
G2	PU	Nonlinear gain point 3
P1	PU	Nonlinear gain point 1
P2	PU	Nonlinear gain point 2
P3	PU	Nonlinear gain point 3
TW	Seconds	Water inertia time constant
PMIN	PU	Minimum limit
PMAX	PU	Maximum limit
DTURB	PU	Turbine damping factor
MWBASE	MW	Base for power values, Active Power

Parameters Range:

$0.05 \le TREG < 5.0$
$0 < REG < 0.1$
$0 \le KP < 10$
$0 \le KI \le 5$
$0 \le KD \le 5$
$0.04 < TA \le 2$
$0.3 \le GATMX \le 1$
$0 \le GATMN \le 0.5$
$0.5 \le TW \le 3.0$
$0.5 \le PMAX \le 1.1$
$0 \le PMIN \le 0.5$
$0 < D < 0.5$

0.04 < TB ≤ 2
0 ≤ VELMX ≤ 1
-1 ≤ VELMN ≤ 0

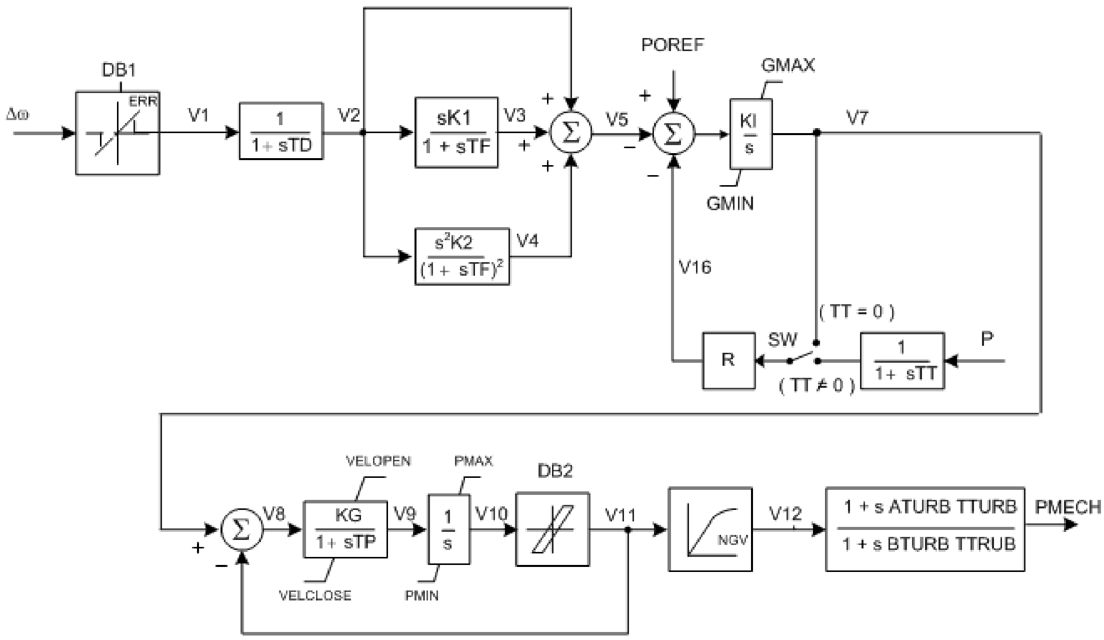
G0 ≤ G1 ≤ G2
P1 ≤ P2 ≤ P3

Notes

Equivalent model in CIM/CGMES:
- GovHydroWPID

TURBINE – WSHYDD

Double derivative hydro governor and turbine.



Parameters

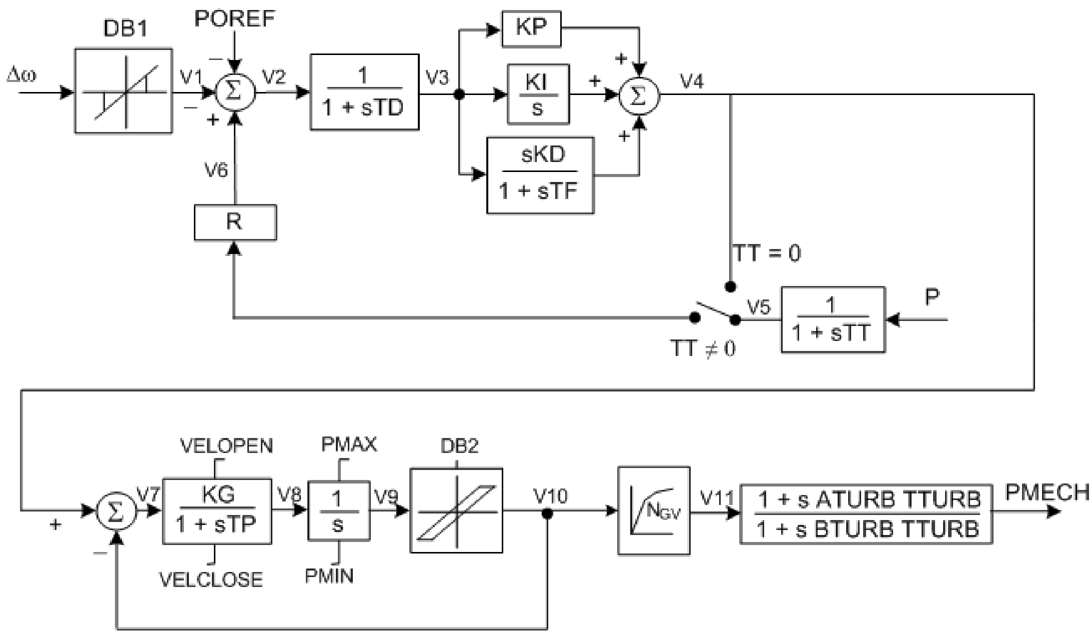
NAME	Type	Description
DB1	PU	Intentional dead-band width
DB2	PU	Unintentional dead-band
ERR	PU	Intentional db hysteresis
TD	Seconds	Input filter time constant
K1	PU	Single derivative gain
K2	PU	Double derivative gain
TF	Seconds	Washout time constant
KI	PU	Integral gain
R	PU	Steady state droop
TT	Seconds	Power feedback time constant
KG	PU	Gate servo gain
TP	Seconds	Gate servo time constant
VELOPEN	PU	Max gate opening velocity
VELCLOS	PU	Max gate closing velocity
PMAX	PU	Maximum gate opening
PMIN	PU	Minimum gate opening
GV1	PU	Nonlinear gain point 1
PGV1	PU	Nonlinear gain point 1
GV2	PU	Nonlinear gain point 2
PGV2	PU	Nonlinear gain point 2
GV3	PU	Nonlinear gain point 3
PGV3	PU	Nonlinear gain point 3
GV4	PU	Nonlinear gain point 4

PGV4	PU	Nonlinear gain point 4
GV5	PU	Nonlinear gain point 5
PGV5	PU	Nonlinear gain point 5
GV6	PU	Nonlinear gain point 6
PGV6	PU	Nonlinear gain point 6
ATURB	PU	Turbine numerator multiplier
BTURB	PU	Turbine denominator multiplier
TTURB	Second	Turbine time constant
FLAG	Boolean	Input signal switch
MWBASE	MW	Base for power values, Active Power

Notes

Equivalent model in CIM/CGMES:
- GovHydroDD

TURBINE – WSHYGP



Parameters

NAME	Type	Description
DB1	PU	intentional dead band width
DB2	PU	unintentional dead band
ERR	PU	intentional dead band hysteresis
TD	Seconds	input filter time constant
TF	Seconds	washout time constant
KP	PU	proportional gain
KI	PU	integral gain
KD	PU	derivative gain
R	PU	staedy state droop
TT	Seconds	power feedback time constant
KG	PU	gate servo gain
TP	Seconds	gate servo time constant
VELOPEN	PU	maximum gate opening velocity
VELCLOS	PU	minimum gate opening velocity
PMAX	PU	maximum gate opening
PMIN	PU	minimum gate opening
GV1	PU	non linear gain point 1
PGV1	PU	non linear gain point 1
GV2	PU	non linear gain point 2
PGV2	PU	non linear gain point 2
GV3	PU	non linear gain point 3
PGV3	PU	non linear gain point 3
GV4	PU	non linear gain point 4
PGV4	PU	non linear gain point 4

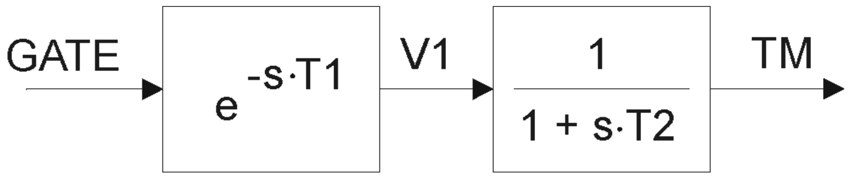
GV5	PU	non linear gain point 5
PGV5	PU	non linear gain point 5
GV6	PU	non linear gain point 6
PGV6	PU	non linear gain point 6
FLAG	Boolean	Input signal switch
ATURB	PU	turbine numerator multiplier
BTURB	PU	turbine denominator multiplier
TTURB	Seconds	turbine time constant
MWBASE	MW	Base for power values, Active Power

Notes

Equivalent model in CIM/CGMES:
- GovHydroPID

TURBINE - DE1

Diesel engine or aero-driven gas turbine model



Parameters

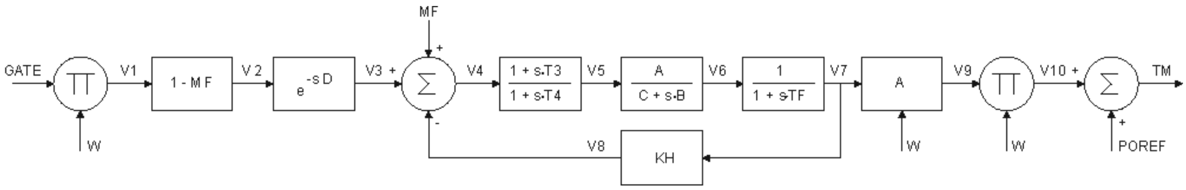
NAME	Type	Description
T1	Seconds	Time delay
T2	Seconds	Time constant

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - GT1

Gas turbine model. Droop and isochronous modes.



Parameters

NAME	Type	Description
MF	PU	Minimum fuel flow
T3	Seconds	Lead lag time constant
T4	Seconds	Lead lag time constant
AA	PU	Valve positioner coefficient
BB	PU	Valve positioner coefficient
CC	PU	Valve positioner coefficient
TF	Seconds	Valve positioner time constant
KF	PU	Feedback Gain
DD	PU	Time delay

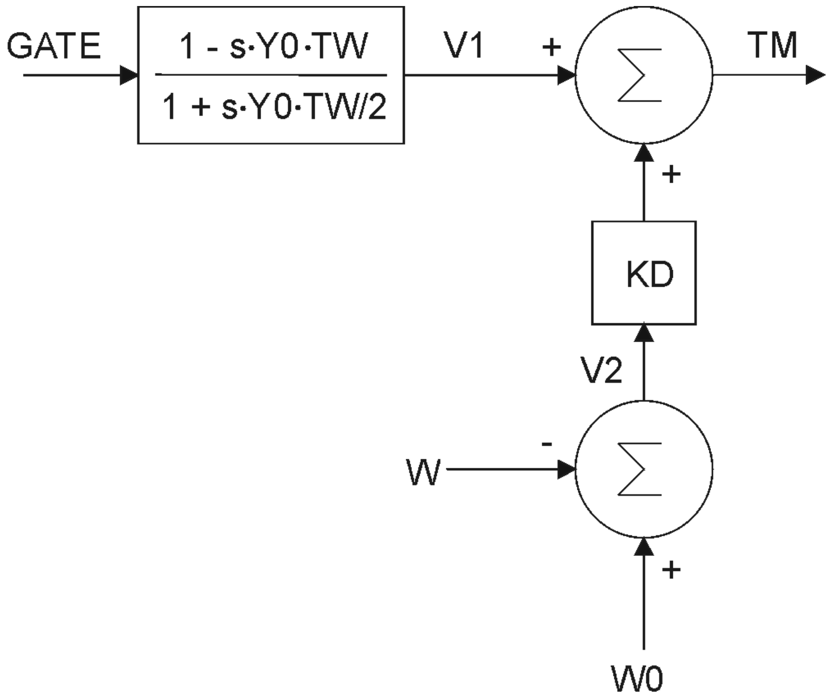
Notes

A: $$T = \frac{WF - MF}{1 - MF} + \frac{1 - W}{2}$$

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - HT1

Classical penstock turbine model.



Parameters

NAME	Type	Description
TW	Seconds	Turbine time constant
KD	PU	Turbine Gain

Notes

Y0	Initial gate opening
W0	Nominal speed in p.u.

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - HT2

General hydro turbine model.

$$\text{GATE} \longrightarrow \boxed{\frac{A23\left[1+\left(A11-\dfrac{A13\cdot A21}{A23}\right)s\cdot TW\right]}{1+A11\cdot s\cdot TW}} \longrightarrow \text{TM}$$

Parameters

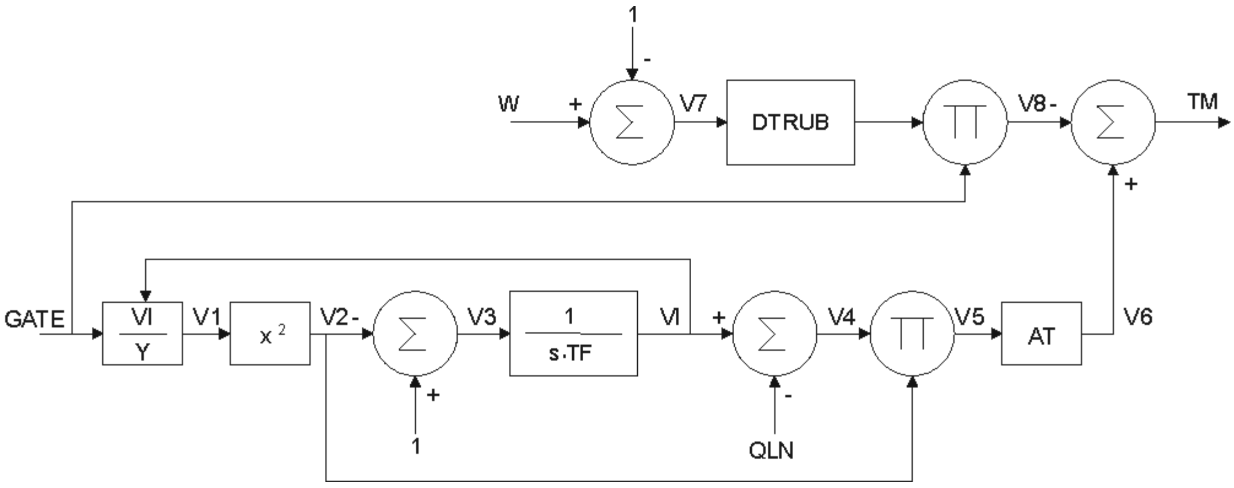
NAME	Type	Description
A11	PU	Turbine coefficient
A13	PU	Turbine coefficient
A21	PU	Turbine coefficient
A23	PU	Turbine coefficient
TW	Seconds	Turine time constant

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE – HYTUR

Hydro turbine.



Parameters

NAME	Type	Description
DTRUB	PU	Turbine damping factor
TW	Second	Water inertia time constant
AT	PU	Turbine gain
QNL	PU	No-load flow at nominal head

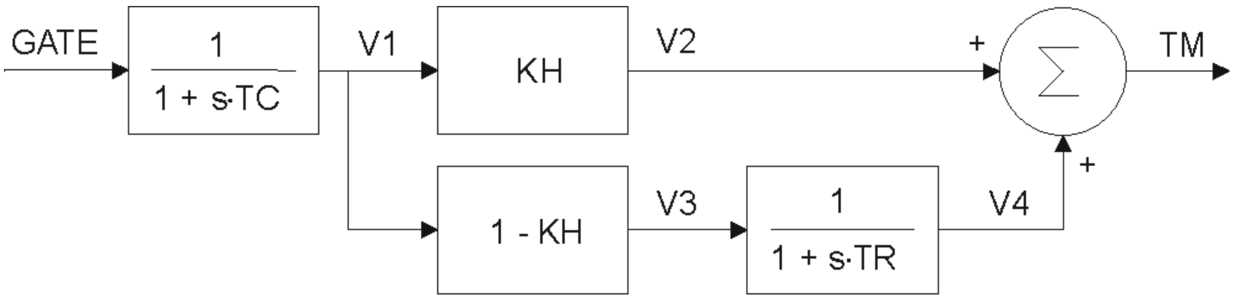
Parameters Range:
0.5 < TF < 3.0
0.8 < AT < 1.5
0 ≤ DTRUB < 0.5
0 < QLN < 0.15

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE – Type ST1

Approximate model of steam turbine with single reheat.



Parameters

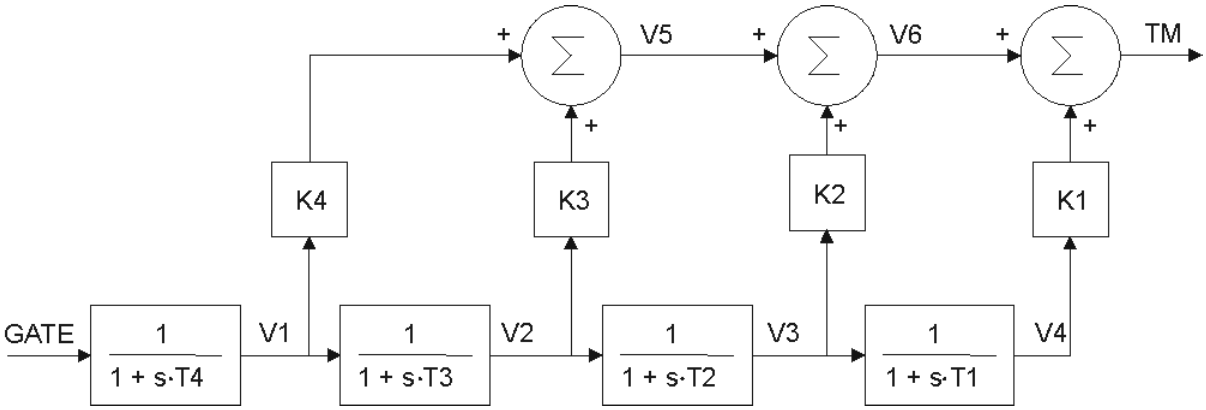
NAME	Type	Description
TC	Seconds	Turbine time constant
KH	PU	Turbine coefficient
TR	Seconds	Reheat time constant

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - ST2

General steam turbine model.



Parameters

NAME	Type	Description
T4	Seconds	Time constant first stage
K4	PU	Gain fist stage
T3	Seconds	Time constant second stage
K3	PU	Gain second stage
T2	Seconds	Time constant third stage
K2	PU	Gain third stage
T1	Seconds	Time constant fourth stage
K1	PU	Gain fourth stage

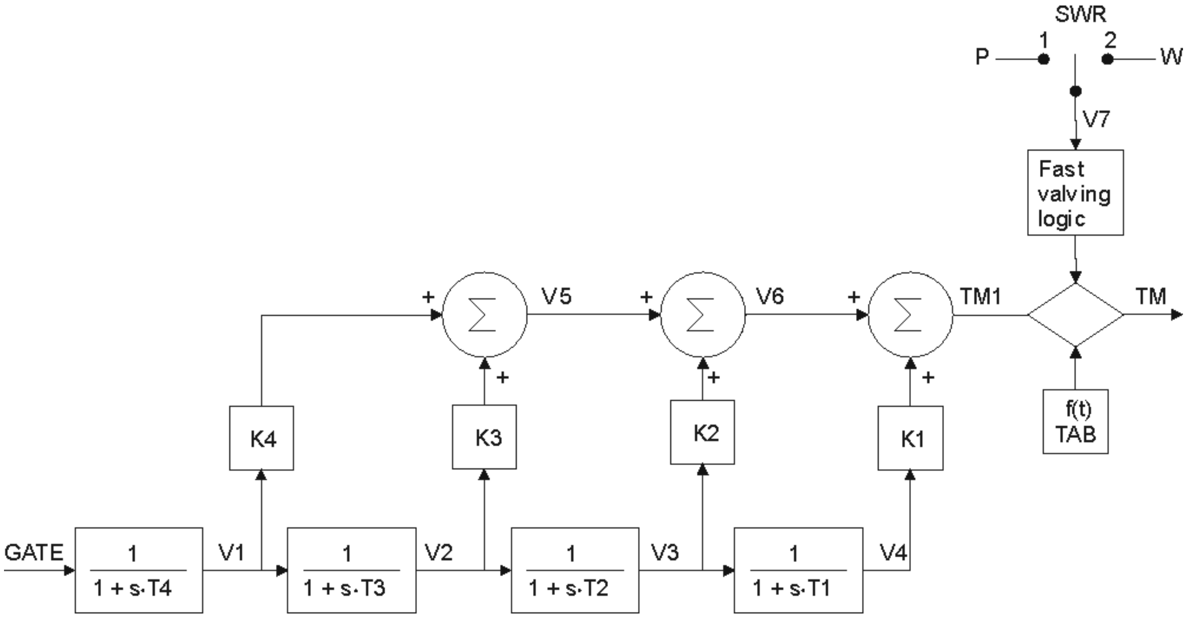
Notes

The sum of K1+K2+K3+K4 must be equal to 1.

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - ST3

Non reheat or tandem compound reheat turbine model including fast-valving (turbine power decay curve)



Parameters

NAME	Type	Description
T4	Seconds	Time constant first stage
K4	PU	Gain fist stage
T3	Seconds	Time constant second stage
K3	PU	Gain second stage
T2	Seconds	Time constant third stage
K2	PU	Gain third stage
T1	Seconds	Time constant fourth stage
K1	PU	Gain fourth stage
SWR	Integer	Switch control (Only used with SIMPOW) 1 = The active electrical power P will be used 2 = The rotor speed W will be used.
PFV	PU	(Only used with SIMPOW)

Notes

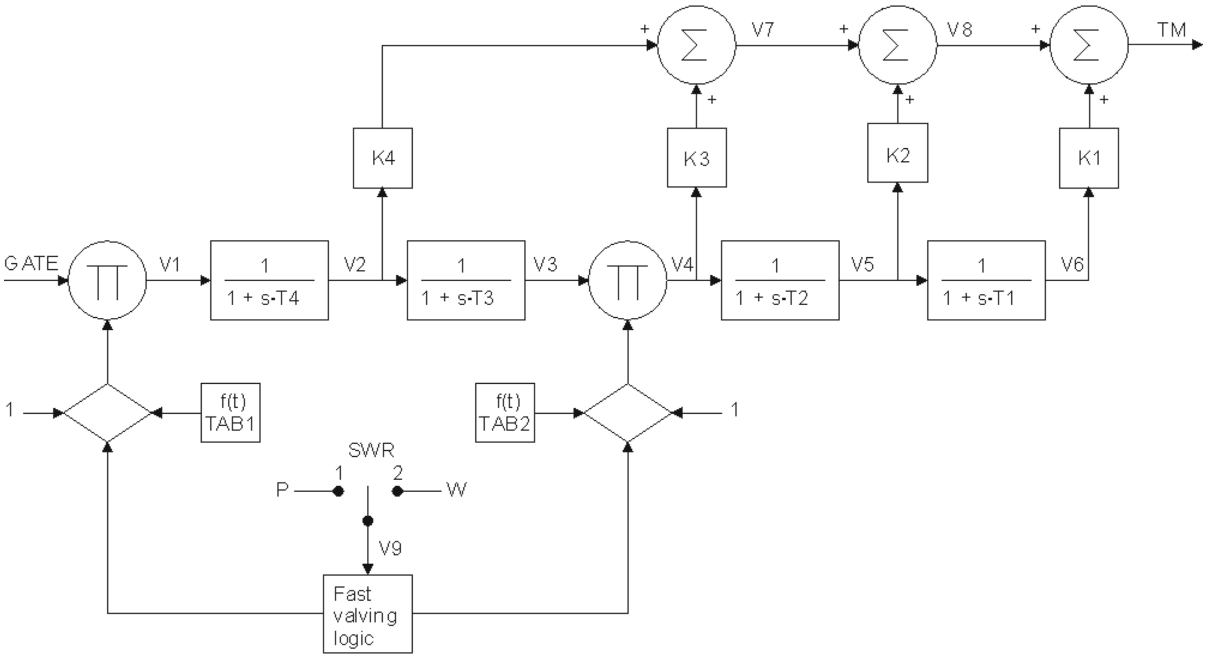
The sum of K1+K2+K3+K4 must be equal to 1.

The fast valving logic is not implemented for moment in Dynamic Simualtor.

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - ST4

Non reheat or tandem compound reheat turbine model including fast-valving (emergency closing of governor and intercept valves).



Parameters

NAME	Type	Description
T4	Seconds	Time constant first stage
K4	PU	Gain fist stage
T3	Seconds	Time constant second stage
K3	PU	Gain second stage
T2	Seconds	Time constant third stage
K2	PU	Gain third stage
T1	Seconds	Time constant fourth stage
K1	PU	Gain fourth stage
SWR	Integer	Switch control (Only used with SIMPOW) 1 = The active electrical power P will be used 2 = The rotor speed W will be used.
PFV	PU	(Only used with SIMPOW)

Notes

The sum of K1+K2+K3+K4 must be equal to 1.

The fast valving logic is not implemented for moment in Dynamic Simualtor.

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - TYPE 21

A sinusoidal variation as a function of time with arbitrary amplitude and frequency is superimposed on the initial mechanical torque Tm_0.

$$Tm = Tm_0 + \sum_{i=1}^{i=N}(A_i \times \sin(2\pi \times F_i \times t + FI_i))$$

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - TYPE 22

An arbitrary time function f(t) is multiplied with the initial value of the mechanical torque Tm_0.

$$Tm = Tm_0 \times f(t)$$

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE - TYPE 3

A part of the mechanical torque varies with the speed and is superimposed on the initial mechanical torque Tm_0.

$$TM = TM0 + KD \cdot (W0 - W)$$

With:

W	Speed in p.u.
W0	Nominal speed in p.u.

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE – Type 23

An arbitrary time function f(t) is superimposed on the initial mechanical torque Tm_0.

$$Tm = Tm_0 + f(t)$$

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE – Type 24

An arbitrary cyclic time funtion f(t) is multiplied with the initial value of the mechanical torque Tm_0.

$$Tm = Tm_0 \cdot f(t)$$

If in a particular situation (e.g. additional turbine or at idling) Tm_0 has the value zero, the following relation will be used:

$$Tm = f(t)$$

Parameters

TAB : The table of the time function $f(t)$. Corresponding values of time and function values should be given

NC : The power pattern specified in the table is repeated after NC second.

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE – Type 25

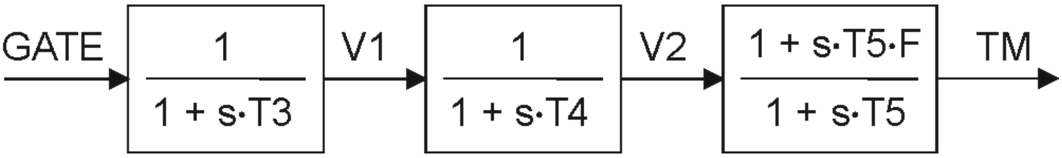
An arbitrary cyclic time funtion f(t) is superimposed on the initial mechanical torque TM0.
TM = TM0 + f(t)

Parameters

NC : The power pattern specified in the table is repeated after NC second.

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

TURBINE – WC



Parameters

NAME	Type	Description
T3	Seconds	Time constant
T4	Seconds	Time constant
T5	Seconds	Time constant
F	PU	Coefficient

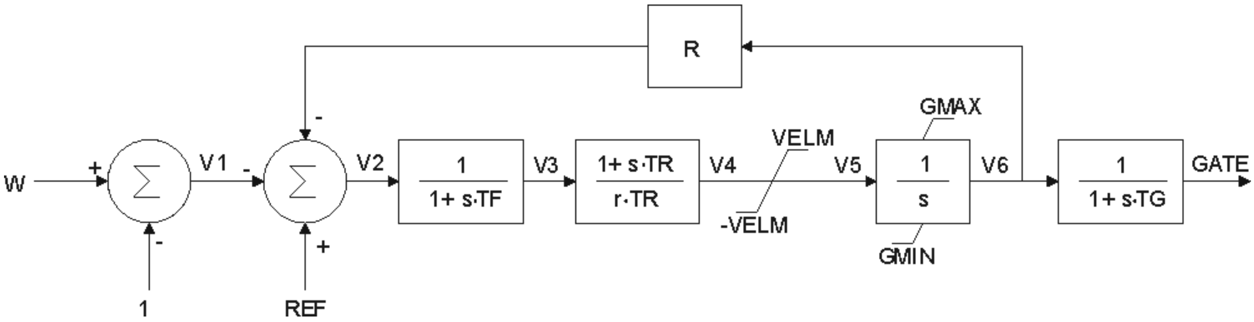
Notes

Equivalent model in CIM/CGMES:
No CIM/CGMES model

Governor Models

GOVERNOR – HYGOV

Hydro governor.
This is the first part of the PSS/E-model HYGOV and it contains the governor part.



Parameters

NAME	Type	Description
RBIG	PU	Permanent droop
RSMALL	PU	Temporary droop
TR	Seconds	Governor time constant
TF	Seconds	Filter time constant, seconds
TG	Seconds	Servo time constant
VELM	PU	Gate velocity limit
GMAX	PU	Maximum gate limit
GMIN	PU	Minimum gate limit

Parameters Range:

$0 < R < 0.1$
$0 < r < 2.0$
$R < r$
$0.04 < TR < 30$
$0.04 < TF < 0.1$

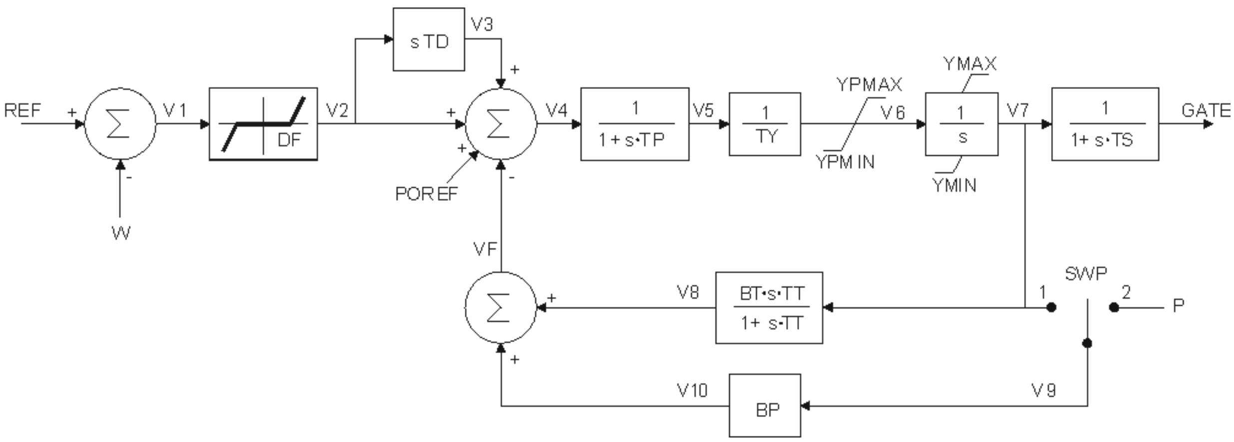
$0 < GMAX \leq 1.0$
$0 \leq GMIN < 1.0$
$GMIN < GMAX$
$0.04 < TG < 1.0$
$0 < VELM < 0.3$

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

GOVERNOR - SG1

General speed-governing model.



Parameters

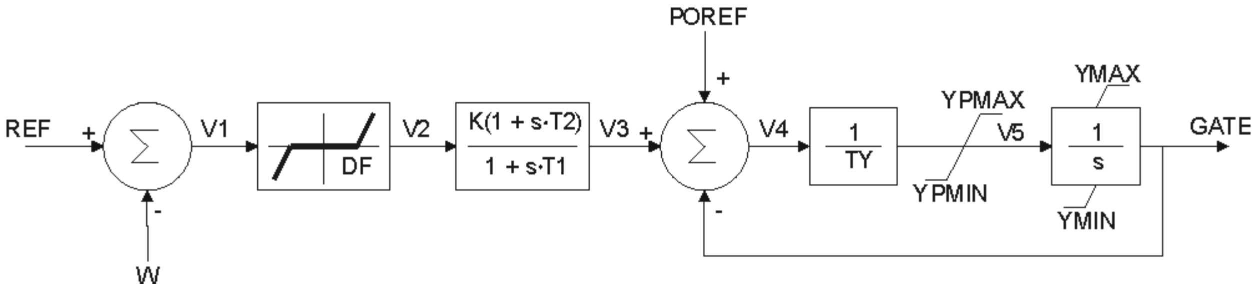
NAME	Type	Description
SWS	Interger	Switch for choosing input speed signal (only used in SIMPOW) = 1 The rotor speed Wr will be used. = 2 The terminal voltage frequency f will be used.
SWP	Interger	Switch for choosing input signal for the permanent droop compensation = 1 The pilot or main servo-motor position will be used. = 2 The active electrical power will be used.
SW	Boolean	= 0 The internal variable is limited by a non-windup limiter to YMAX (or YMIN). = 1 The internal variable is limited by a windup limiter to YMAX (or YMIN).
DF	PU	Frequency dead band
TD	Seconds	Derivate circuit time constant
TP	Seconds	Pilot valve time constant
TY	Seconds	Response time; pilot or main servomotor
TS	Seconds	Main servo-motor time constant
TT	Seconds	Transient droop time constant
BT	PU	Transient droop constant
BP	PU	Permanent droop constant
YPMAX	PU	Servo rate limit
YPMIN	PU	Servo rate limit
YMAX	PU	Servo position limit
YMIN	PU	Servo position limit

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

GOVERNOR - SG2

Approximate speed-governing model (steam turbines).



Parameters

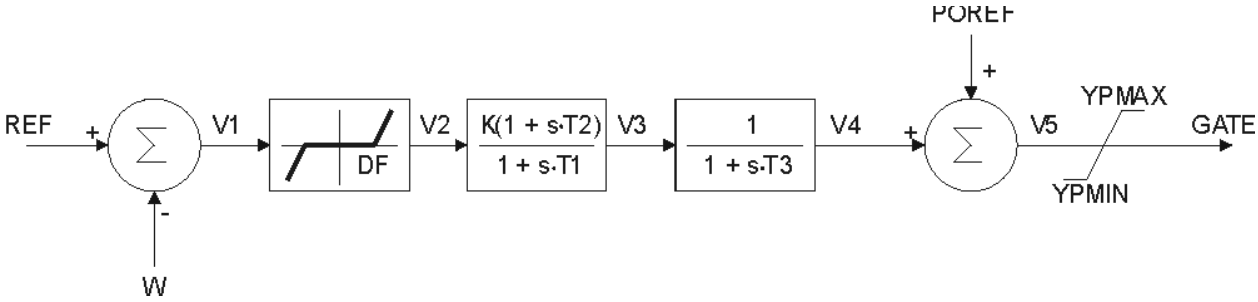
NAME	Type	Description
SW	Boolean	Switch control 0 = The internal variable is limited by a non-windup limiter to YMAX (or YMIN). 1 = The internal variable is limited by a windup limiter to YMAX (or YMIN).
DF	PU	Frequency dead band
YMAX	PU	Valve position limit
YMIN	PU	Valve position limit
YPMAX	PU	Valve servo rate limit
YPMIN	PU	Valve servo rate limit
K	PU	Effective speed-governing system gain
T1	Seconds	Equivalent time constant
T2	Seconds	Equivalent time constant
TY	Seconds	Valve servo motor time constant

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

GOVERNOR - SG3

Approximate speed-governing model (hydro turbines).



Parameters

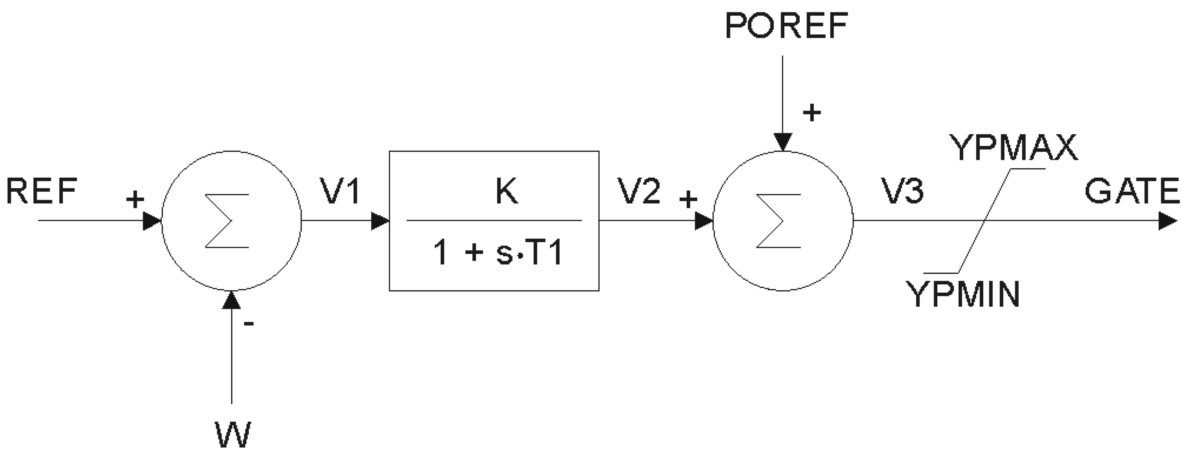
NAME	Type	Description
DF	PU	Frequency dead band
YMAX	PU	Valve position limit
YMIN	PU	Valve position limit
K	PU	Effective speed-governing system gain
T1	Seconds	Equivalent time constant
T2	Seconds	Equivalent time constant
T3	Seconds	Valve servo motor time constant

Notes

POREF	Initial value calculated in preprocessor

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

GOVERNOR – SGC



Parameters

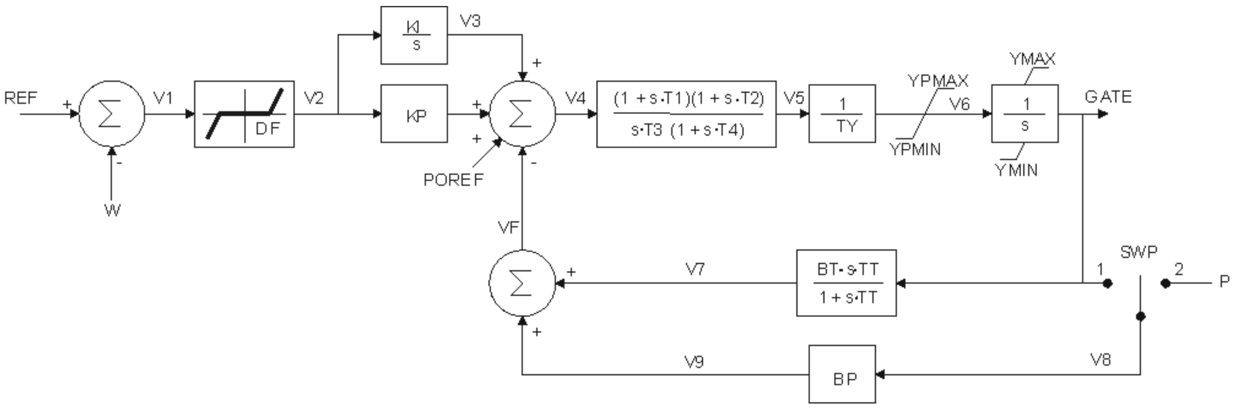
NAME	Type	Description
K	PU	Gain
T1	Seconds	Time constant
YPMAX	PU	Maximum gate limit
YPMIN	PU	Minimum gate limit

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

GOVERNOR - SG4

Hydro turbine speed-governing model.



Parameters

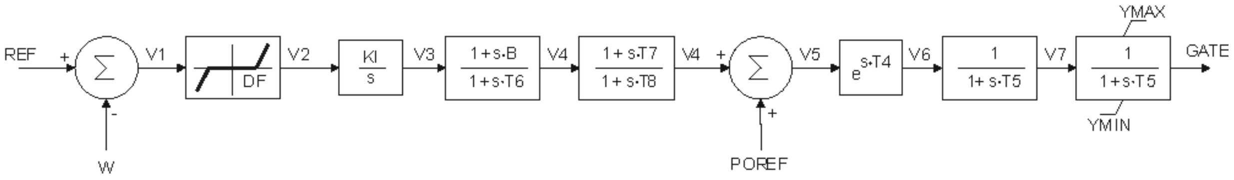
NAME	Type	Description
SWP	Interger	Switch for choosing input signal for the permanent droop compensation = 1 The pilot or main servo-motor position will be used. = 2 The active electrical power will be used.
SW	Interger	= 0 The internal variable is limited by a non-windup limiter to YMAX (or YMIN). = 1 The internal variable is limited by a windup limiter to YMAX (or YMIN).
DF	PU	Frequency dead band
KP	PU	Joint load control constant (proportional).
KI	PU	Joint load control constant (integral).
T1	Seconds	Controller time constants
T2	Seconds	Controller time constants
T3	Seconds	Controller time constants
T4	Seconds	Controller time constants
TY	Seconds	Response time; pilot or main servomotor
TT	Seconds	Transient droop time constant
BT	PU	Transient droop constant
BP	PU	Permanent droop constant
YPMAX	PU	Servo rate limit
YPMIN	PU	Servo rate limit
YMAX	PU	Servo position limit
YMIN	PU	Servo position limit

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

GOVERNOR - SG5

Diesel engine or aero-driven gas turbine speed-governing model.



Parameters

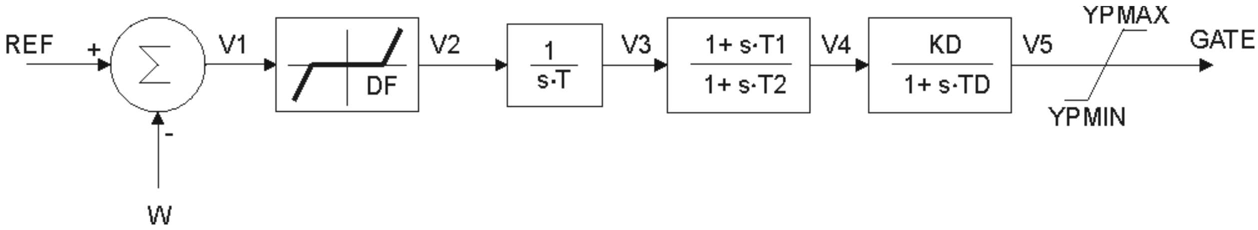
NAME	Type	Description
DF	PU	Frequency dead band
YMAX	PU	Servo position limit
YMIN	PU	Servo position limit
BB	PU	Amplifier lead time constant
T3	Seconds	Actuator time delay
T4	Seconds	Current driver dead time
T5	Seconds	Current driver time delay
T6	Seconds	Amplifier time delay
T7	Seconds	Lead compensation
T8	Seconds	Lag compensation

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model

GOVERNOR - SG6

Gas turbine speed-governing model. Droop and isochronous modes.



Parameters

NAME	Type	Description
DF	PU	Frequency dead band
KD	PU	Governor gain.
YPMAX	PU	Upper incremental power limit
YPMIN	PU	Lower incremental power limit
T	Seconds	Time constant for isochronous operation
TD	Seconds	Speed governor time constant
T1	Seconds	Governor lead term
T2	Seconds	Governor lag term

Notes

Equivalent model in CIM/CGMES:
- No CIM/CGMES model