CIGRÉ Generic Steam Turbine Model for Combined Cycle Power Plants

This model is located at system bus #_____IBUS
Machine #_____I
This model uses CONs starting with #_____J
and STATEs starting with #_____K
and VARs starting with #_____L
and ICONs starting with #_____M

ICON	#	Value	DESCRIPTION
M			bus number for gas turbine #1
M+1			machine ID for gas turbine #1
M+2			bus number for gas turbine #2
M+3			machine ID for gas turbine #2
M+4			bus number for gas turbine #3
M+5			machine ID for gas turbine #3
M+6			bus number for gas turbine #4
M+7			machine ID for gas turbine #4
M+8			bus number for gas turbine #5
M+9			machine ID for gas turbine #5
M+10			bus number for gas turbine #6
M+11			machine ID for gas turbine #6

VARs	#	Description
L		Steam flow through bypass valve (q_b)
L+1		Steam mass flow (q_t)
L+2		Turbine inlet pressure (P_t)
L+3		$Q_{imbalance}$
L+4		Power output from GT (P_{gt})
L+5		Heat from GT exhaust (Q_g)
L+6		Calculated Bv

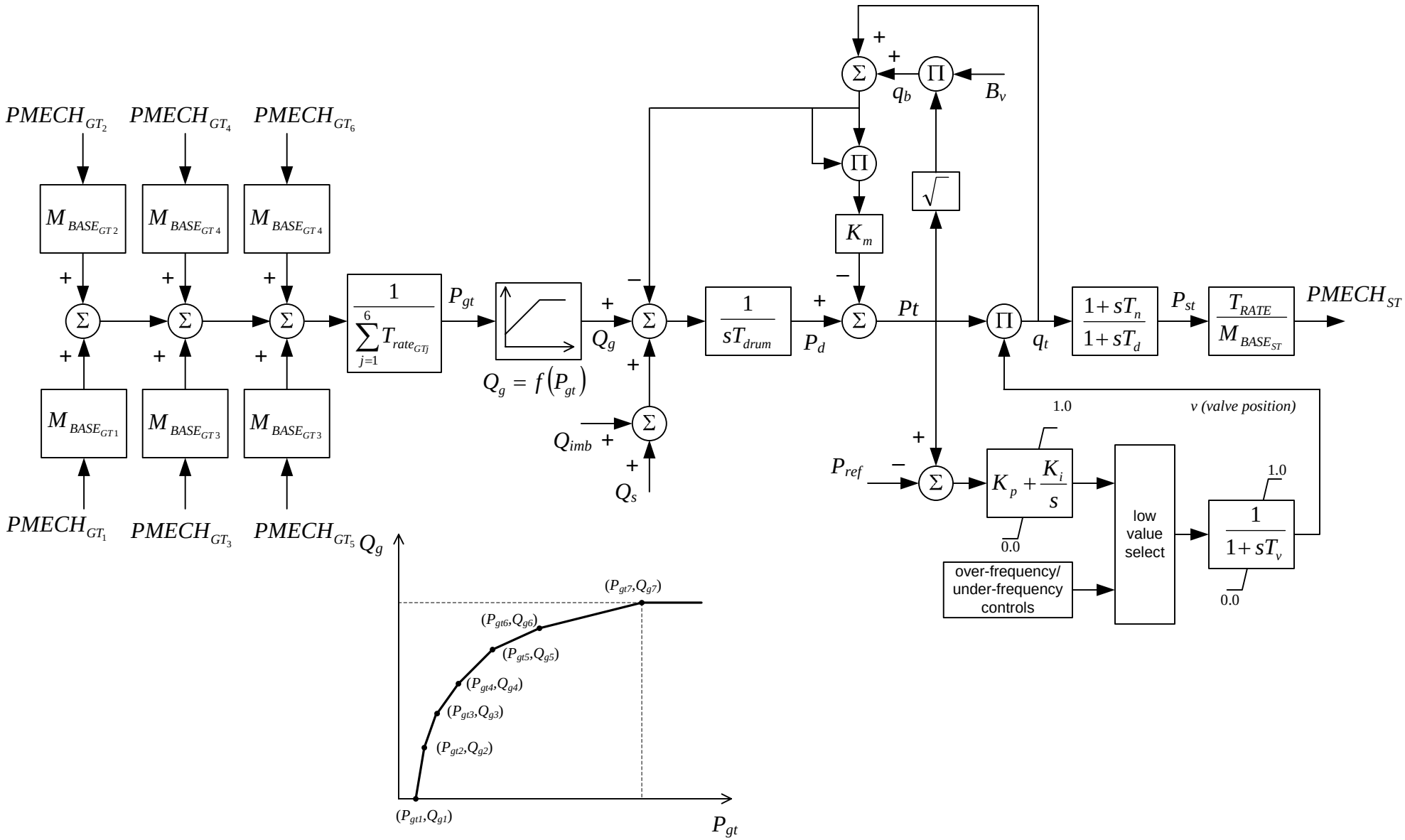
STATEs	#	Description
K		Drum pressure (P_d)
K+1		Turbine lead-lag block
K+2		Pressure control
K+3		Valve position (v)

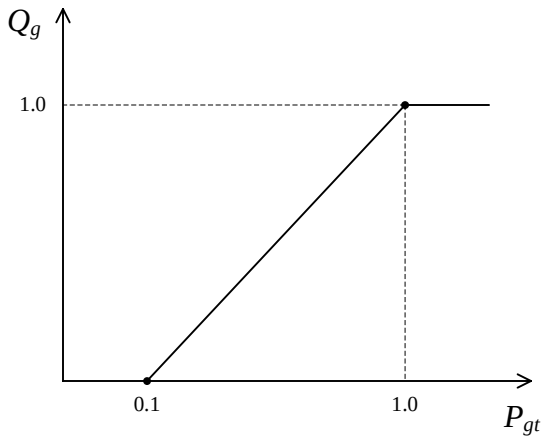
CON	#	value	DESCRIPTION
J			P_{gt1} (p.u.) – point 1
J+1			Q_{g1} (p.u.)
J+2			P_{gt2} (p.u.) – point 2
J+3			Q_{g2} (p.u.)
J+4			P_{gt3} (p.u.) – point 3
J+5			Q_{g3} (p.u.)
J+6			P_{gt4} (p.u.) –point 4
J+7			Q_{g4} (p.u.)
J+8			P_{gt5} (p.u.) – point 5
J+9			Q_{g5} (p.u.)
J+10			P_{gt6} (p.u.) – point 6
J+11			Q_{g6} (p.u.)
J+12			P_{gt7} (p.u.) – point 7
J+13			Q_{g7} (p.u.)
J+14			T_{drum} (>0) – Drum time constant (s)
J+15			K_m – Pressure loss due to flow friction in the boiler tubes (p.u.)
J+16			T_v (>0) – Actuator time constant for main steam (p.u.)
J+17			K_p – Pressure controller proportional gain (p.u.)
J+18			K_i – Pressure controller integral gain (p.u./s)
J+19			T_n –Turbine lead time constant (s)
J+20			T_d –Turbine lag time constant (s)
J+21			Q_s – heat from sSupplemental firing (p.u.)
J+22			B_v –Bypass valve opening (p.u.)
J+23			P_{ref} – Minimum steam pressure reference (p.u.)
J+24			Trate – Turbine rating (MW)

IBUS 'USRMDL' ID 'UHRSG' 5 0 12 25 4 7 ICONs from (M) to (M+11)
CONs from (J) to (J+24) /

Notes:

1) If less than six gas turbines are connected to this HRSG, bus number should be set to 0 and ID should be set to ‘ ‘ (2 spaces between quotes). Machine ID should always be entered within quotes (2 characters ID).
2) Any PSS™E turbine/speed governor model can be used in the gas turbines coupled to this model. The UHRSG model will retrieve gas turbine rating from the following PSS™E models: GAST2A, GASTWD, GGOV1, URGS3T, WSHYGP, WSHYDD and UCBGT. All other PSS™E models will have gas turbine rating set to generator MVA base.
3) Points in the look-up table should have Q_g greater or equal to zero and should monotonically increase. Once a decrease is detected, no more points are considered in the look-up table. Thus, the user can enter [0.0, 0.0] for those points not needed.
4) If less than 7 points are required in the look-up table, the remainder data points should be set to [0.0, 0.0]. The heat Q_g is considered constant and equal to the last value Q_{gi} when P_{gt} is greater than P_{gti}. **Heat is not extrapolated beyond the last point in the look-up table.**
5) The bypass valve opening B_v should be a number between 0 and 1. If a negative value is entered, the model will calculate the bypass valve opening to minimize any imbalances in heat
6) Setting B_v to 0.0 corresponds to no steam bypass and all available steam is used for electric power production
7) This model does not provide speed governor action (primary frequency control) in a stand-alone mode, i.e., the speed governor control of the combined cycle power plant is done via the gas turbines, with the steam turbine responding to the changes in power output of the gas turbines. Therefore, this model cannot be used in the speed governor test activities GSTR/GRUN, where each generator is considered in isolated operation. The model will maintain constant mechanical power output if GSTR/GRUN is applied and thus frequency (speed) will ramp down at a constant rate. These results should be simply discarded.
8) This model was proposed in CIGRÉ Technical Brochure on Modeling of Gas Turbines and Steam Turbines in Combined-Cycle Power Plants, Task Force 25 of Advisory Group 02 of Study Committee 38, April 2003.


PMECH_GT2
PMECH_GT4
PMECH_GT6
M_BASE_GT2
M_BASE_GT4
M_BASE_GT4
M_BASE_GT1
M_BASE_GT3
M_BASE_GT3
PMECH_GT1
PMECH_GT3
PMECH_GT5
1 / Σ_{j=1}^{6} T_rate_GTj
P_gt
Q_g = f(P_gt)
Q_g
Q_imb
Q_s
1 / sT_drum
P_d
Pt
q_b
B_v
K_m
q_t
(1+sT_n)/(1+sT_d)
P_st
T_RATE / M_BASE_ST
PMECH_ST
P_ref
K_p + K_i/s
1.0
0.0
v (valve position)
over-frequency/ under-frequency controls
low value select
1/(1+sT_v)
(P_gt1,Q_g1)
(P_gt2,Q_g2)
(P_gt3,Q_g3)
(P_gt4,Q_g4)
(P_gt5,Q_g5)
(P_gt6,Q_g6)
(P_gt7,Q_g7)
P_gt


Q_g
1.0
0.1
1.0
P_{gt}