

SAARC Training Workshop 'Power System Studies for Synchronization of Multiple Systems'

Speed Governors Modeling in PSS/E

Day-3-D

Kabul, Afghanistan

20-22 October 2014



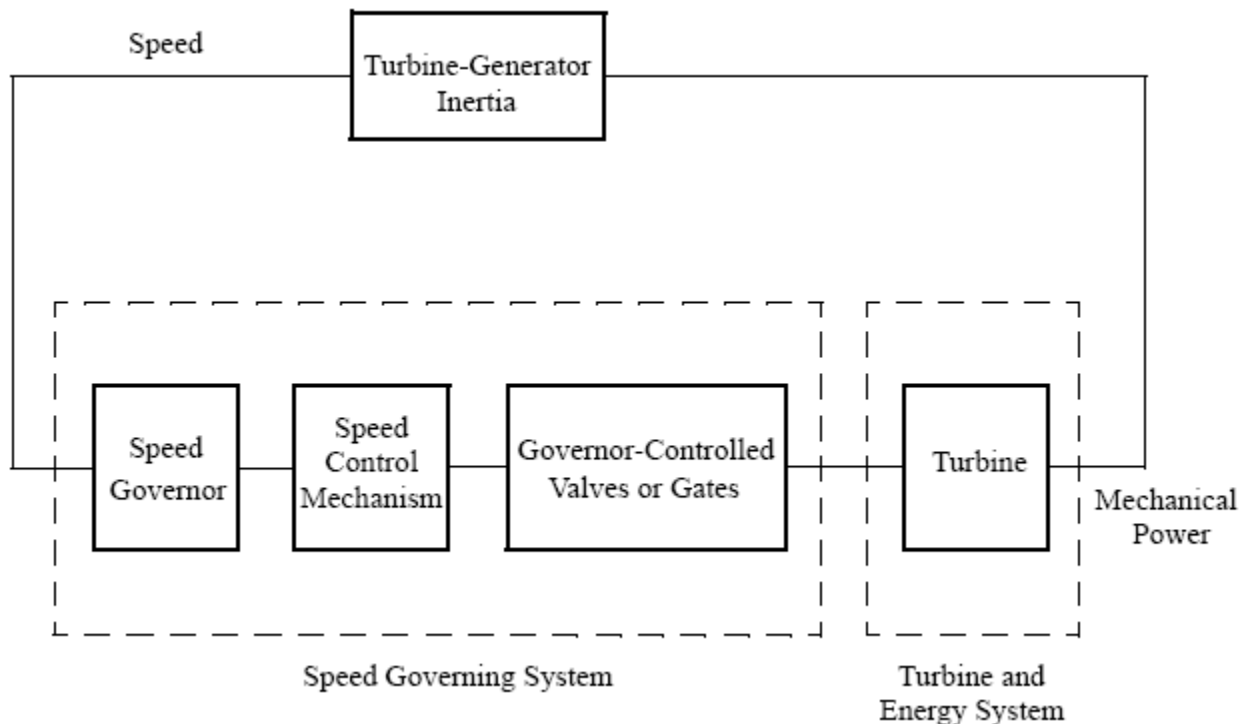
SAARC Energy Centre, Islamabad
www.saarcenergy.org



hassan@powerplannersint.com
www.powerplannersint.com

Speed Governors

- The speed governing systems provide a means of controlling power and frequency, a function commonly referred to as load-frequency control or automatic generation control (AGC)



Droop

The definition of droop is the amount of speed (or frequency) change that is necessary to cause the main prime mover control mechanism to move from fully closed to fully open. In general, the percent movement of the main prime mover control mechanism can be calculated as the speed change (in percent) divided by the per unit droop.

Droop speed control is the primary instantaneous system using net frequency deviations to distribute with stability load changes over generating plants .

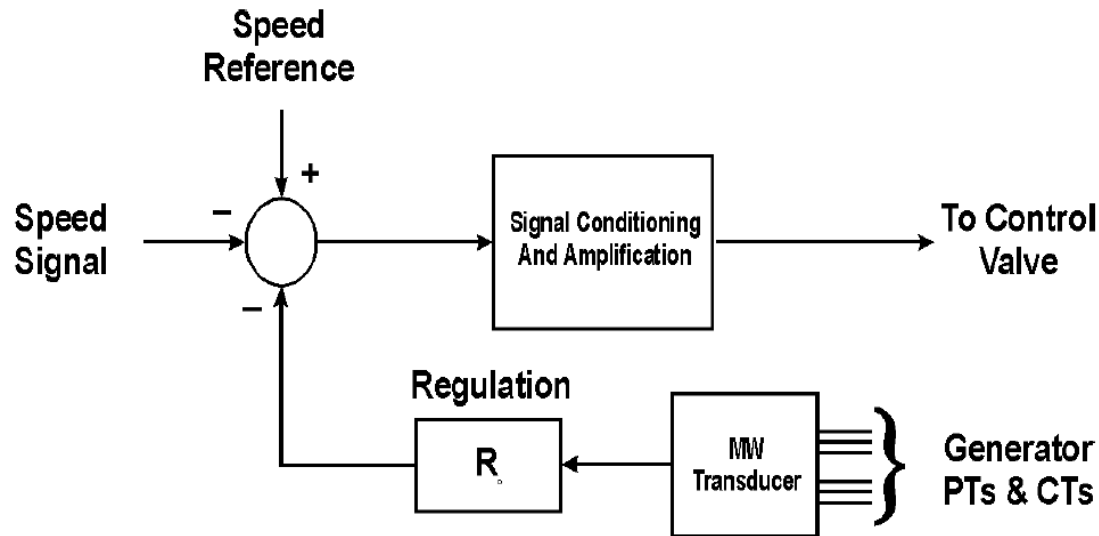
For stable operation of the Grid, power plants operate with a five percent speed droop. ¹ This means the full-load speed is 100% and the no-load speed is 105% if the droop is 5 %.

$$\text{Droop, } R = \frac{\Delta f_n}{f_n}$$

R is the ratio of frequency deviation when comparing the load versus the nominal frequency.

Droop Mode: It is the mode of operation in which the machine will react to the load variation by changing its speed. It is utilized when multiple machine run in parallel so that load is shared between the machines. For this sharing to be equal the machine need to have same droop characteristics. Typically if a machine has droop of 4% it means for a change of 1% in rated speed the machine takes 25% of its rated load. This is also referred to as load control mode of operation.

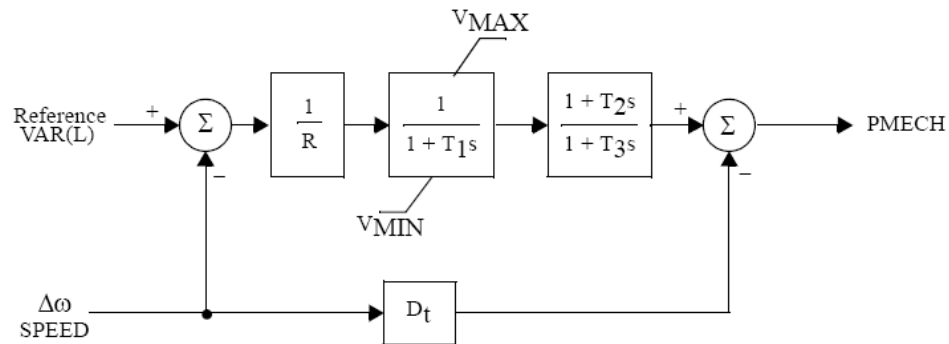
Types of Governor Systems in Generating Units



$$\text{Droop, } R = \frac{\text{System Droop}}{\frac{P_{\max}}{\text{Rated MVA}}}$$

All turbine-governor data should be specified on the same base used for the generator. Hence, if all machine data is entered on each machine's individual base, the governor permanent droop, R , of all units should be set equal to ensure equal load sharing on all units.

Governor Model TGOV1



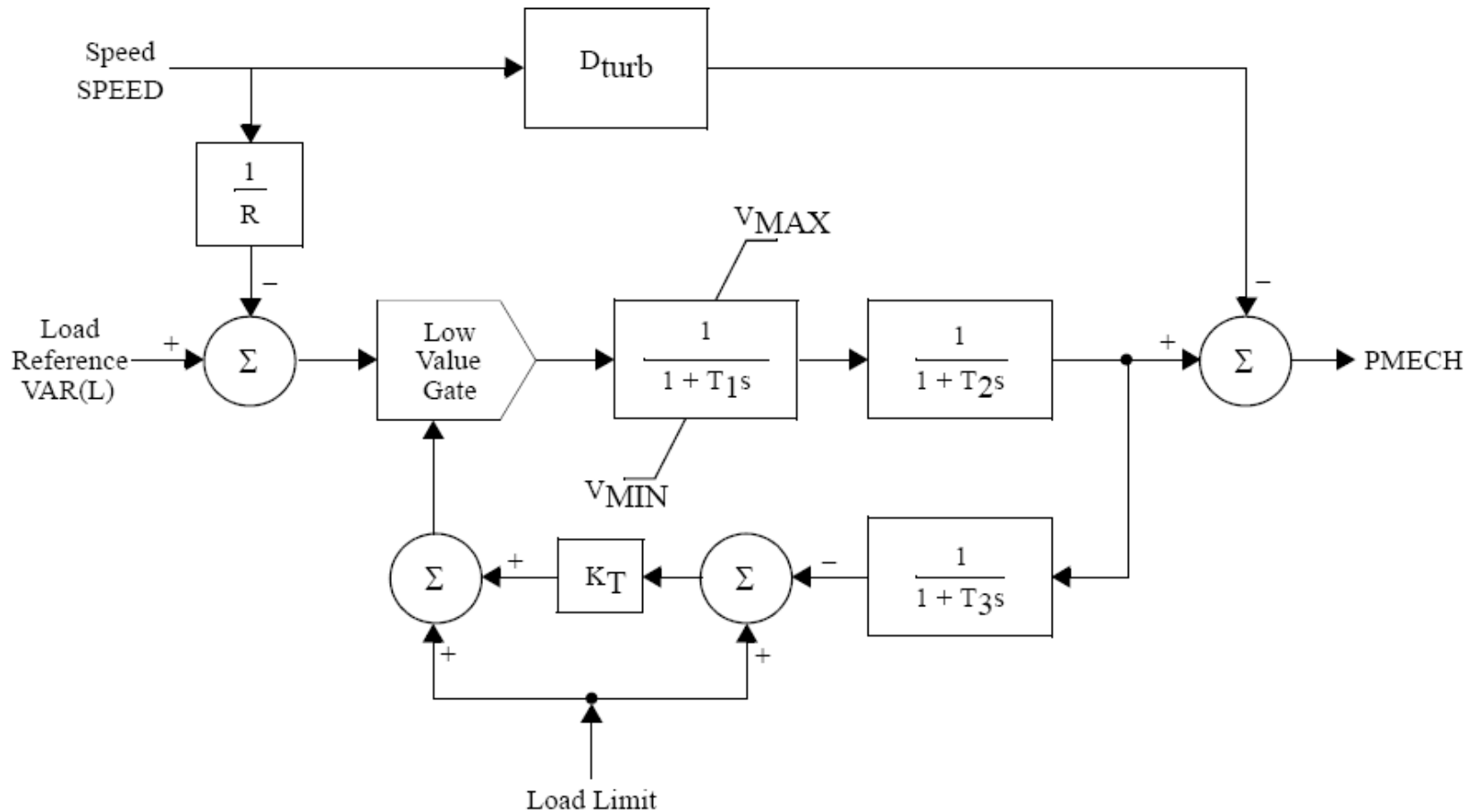
CONs	#	Value	Description
J			R
J+1			$T_1 (>0)$ (sec)
J+2			V_{MAX}^1
J+3			V_{MIN}^1
J+4			T_2 (sec) ²
J+5			$T_3 (>0)$ (sec) ³
J+6			D_t^1

¹ V_{MAX} , V_{MIN} , D_t are in per unit on generator base.

² T_2/T_3 = high-pressure fraction.

³ T_3 = reheater time constant.

Governor Model GAST

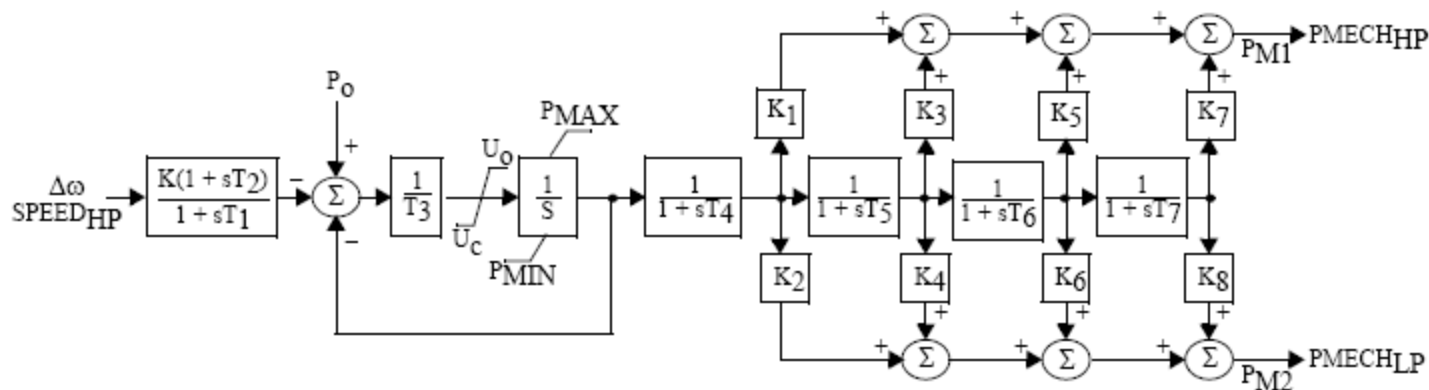


Governor Model GAST, Contd.

CONs	#	Value	Description
J			R (speed droop)
J+1			T_1 (>0) (sec)
J+2			T_2 (>0) (sec)
J+3			T_3 (>0) (sec)
J+4			Ambient temperature load limit, AT
J+5			K_T
J+6			V_{MAX}
J+7			V_{MIN}
J+8			D_{turb}

Governor Model IEEE G1

- Most commonly used for steam turbines



Governor Model IEEEG1

- Data sheet of IEEEG1

CONs	#	Value	Description
J			K
J+1			T_1 (sec)
J+2			T_2 (sec)
J+3			T_3 (> 0) (sec)
J+4			U_0 (pu/sec)
J+5			U_c (< 0) (pu/sec)
J+6			P_{MAX} (pu on machine MVA rating)
J+7			P_{MIN} (pu on machine MVA rating)
J+8			T_4 (sec)
J+9			K_1
J+10			K_2
J+11			T_5 (sec)
J+12			K_3
J+13			K_4
J+14			T_6 (sec)
J+15			K_5
J+16			K_6
J+17			T_7 (sec)
J+18			K_7
J+19			K_8

Governor Model IEEEG1

- States

STATes	#	Description
K		First governor integrator
K+1		Governor output
K+2		First turbine integrator
K+3		Second turbine integrator
K+4		Third turbine integrator
K+5		Fourth turbine integrator

- VARs

VARs	#	Description
L		Reference, P_0
L+1		Internal memory

- Syntax: `IBUS, 'IEEEG1', ID, JBUS, M, CON(J) to CON(J+19) /`