16-9-2020 Sebin Wilson E

Roll No. 26

EXPERIMENT No:6

AUTOMATIC GENERATION CONTROL – SINGLE AREA SYSTEM

Aim

To determine the change in speed, frequency and steady state error corresponding to a load disturbance in a single area power system, with and without supplementary control using any software.

Software Platform

MATLAB/Simulink

Theory

Active power control is one of the important control actions to be performed during normal operation of the system to match the system generation with the continuously changing system load in order to maintain the constancy of system frequency to a fine tolerance level. This is one of the foremost requirements in providing quality power supply. A change in system load causes a change in the speed of all rotating masses (Turbine – generator rotor systems) of the system leading to change in system frequency. The speed change from synchronous speed initiates the governor control (Primary control) action resulting in all the participating generator – turbine units taking up the change in load, stabilizing the system frequency. Restoration of frequency to nominal value requires secondary control action which adjusts the load-reference set points of selected (regulating) generator – turbine units. The primary objectives of automatic generation control (AGC) are to regulate system frequency to the set nominal value and also to regulate the net interchange of each area to the scheduled value by adjusting the outputs of the regulating units. This function is referred to as load – frequency control (LFC).

A large power system can be divided into a number of sub-areas in which all the generators are tightly coupled such that they swing in unison with change in load or due to a speed –changer setting. Such an area, where all the generators are running coherently is termed as a control area. In this area, frequency may be same in steady state and dynamic conditions. For developing a suitable control strategy, a control area can be reduced to a single generator, speed governor and load system.

Generator Model

The swing equation with small deviation

$$\frac{2H}{\omega_s}\frac{d^2\Delta\delta}{dt^2} = \Delta P_m - \Delta P$$

In terms of small deviation in speed

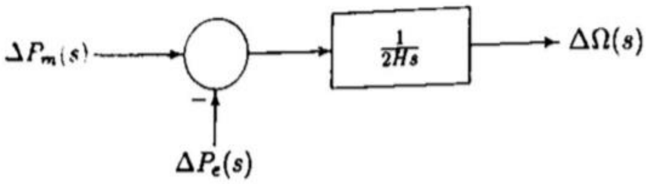
$$\frac{d\Delta\dfrac{\omega}{\omega_s}}{dt} = \frac{1}{2H}\left(\Delta P_m - \Delta P_e\right)$$

With speed expressed in pu

$$\frac{d\Delta\omega}{dt} = \frac{1}{2H}\left(\Delta P_m - \Delta P_e\right)$$

Taking Laplace transforms

$$\Delta\Omega(s) = \frac{1}{2Hs}\left(\Delta P_m(s) - \Delta P_e(s)\right)$$

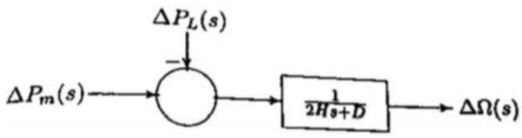


Load Model

The speed-load characteristics of a composite load is approximated as

$$\Delta P_e = \Delta P_L + \Delta\omega D$$

where, ΔP_L is the non-frequency sensitive load change and $\Delta\omega D$ is the frequency sensitive load change. D is expressed as percent change in load divided by percent change in frequency.



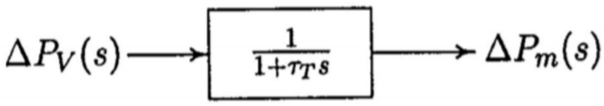
(Generator-load block diagram)

Prime mover Model

The simplest prime mover model for a non-reheat steam turbine can be approximated with a single time constant τ_T

$$G_T(s) = \frac{\Delta P_m(s)}{\Delta P_V(s)} = \frac{1}{1+\tau_T(s)}$$

where, ΔP_m is the change in mechanical power output and ΔP_V is the change in steam valve position



(Steam Turbine model)

Governor Model

The speed governor mechanism act as a comparator whose output ΔP_g is the difference between the reference set power ΔP_{ref} and the power $\frac{1}{R}\Delta\omega$

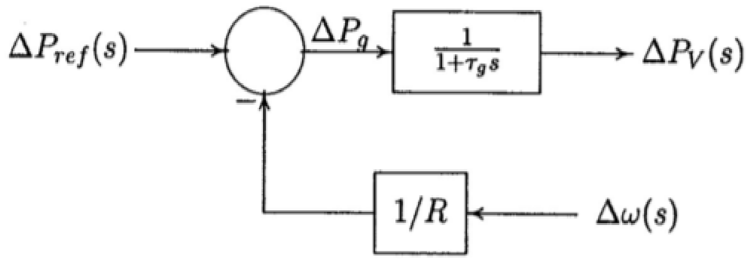
$$\Delta P_g = \Delta P_{ref} - \frac{1}{R}\Delta\omega$$

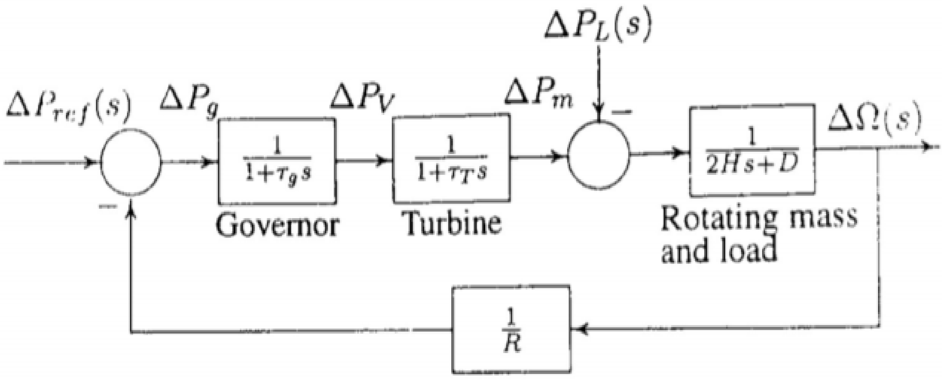
In s domain

$$\Delta P_g(s) = \Delta P_{ref}(s) - \frac{1}{R}\Delta\Omega(s)$$

The command ΔP_g is transferred through the hydraulic amplifier to the steam valve position command ΔP_V. Considering a simple time constant τ_g we have,

$$\Delta P_V(s) = \frac{1}{1+\tau_g}\Delta P_g(s)$$





AGC for an isolated power system without supplementary control

Exercise1: An isolated power system with following parameters

Governor time constant = 0.2 sec

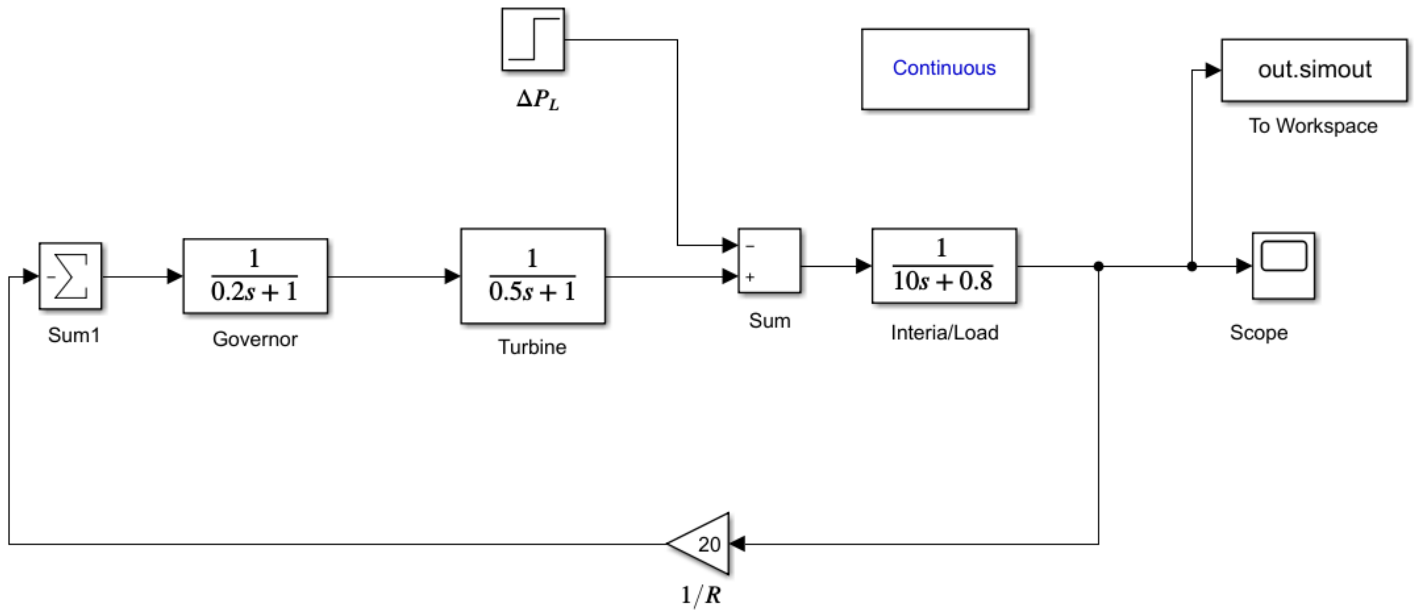
Turbine time constant = 0.5 sec

Generator inertia constant, H=5 sec

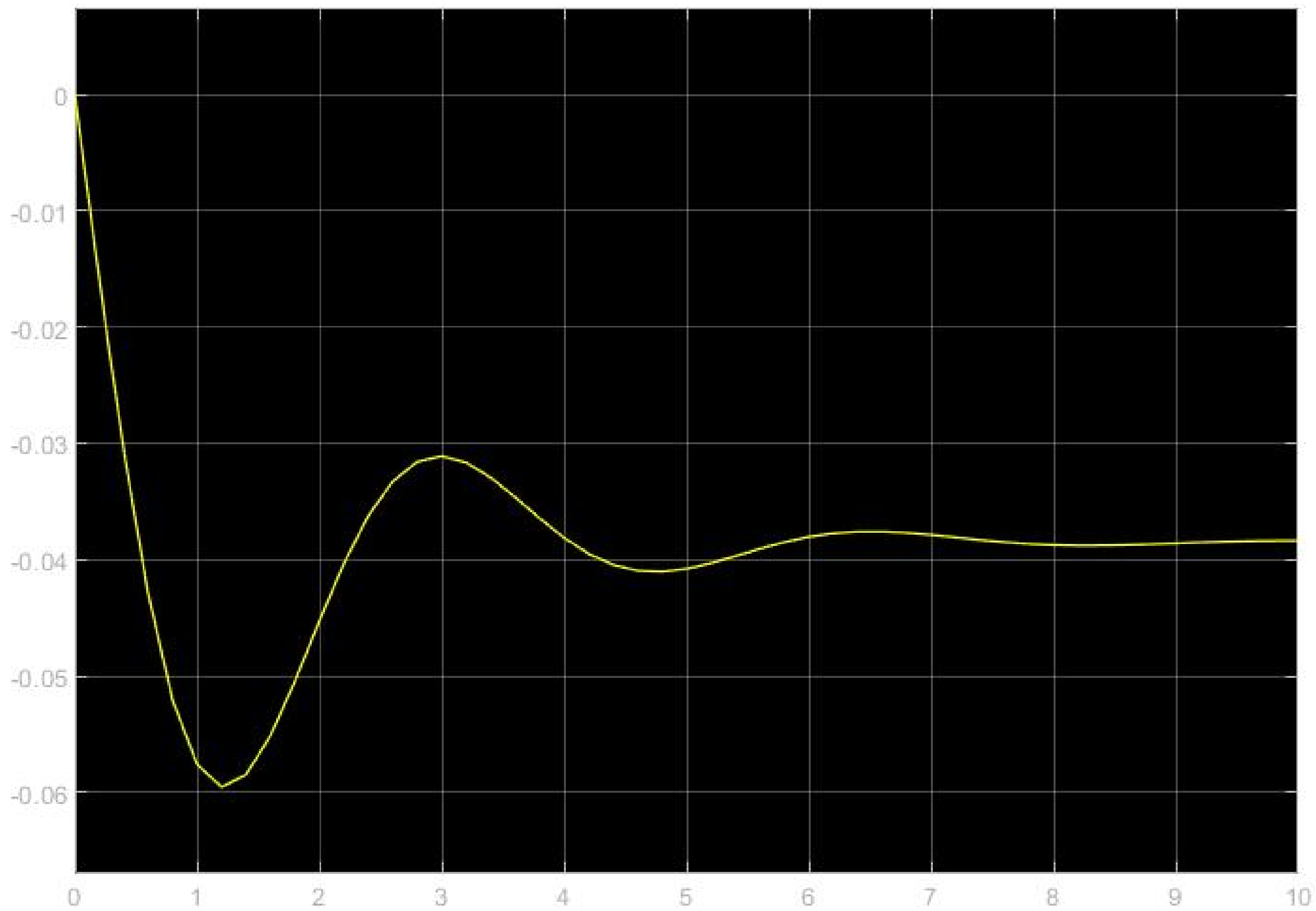
Governor speed regulation, R = 0.05 pu

The load varies by 0.8 percent for 1 percent change in frequency (ie, load damping constant, D=0.8. The turbine rated output is 250 MW at nominal frequency of 60 Hz. A sudden load change of 50 MW occurs (ie, ΔP_L=50/250=0.2 pu)

Simulation Diagram

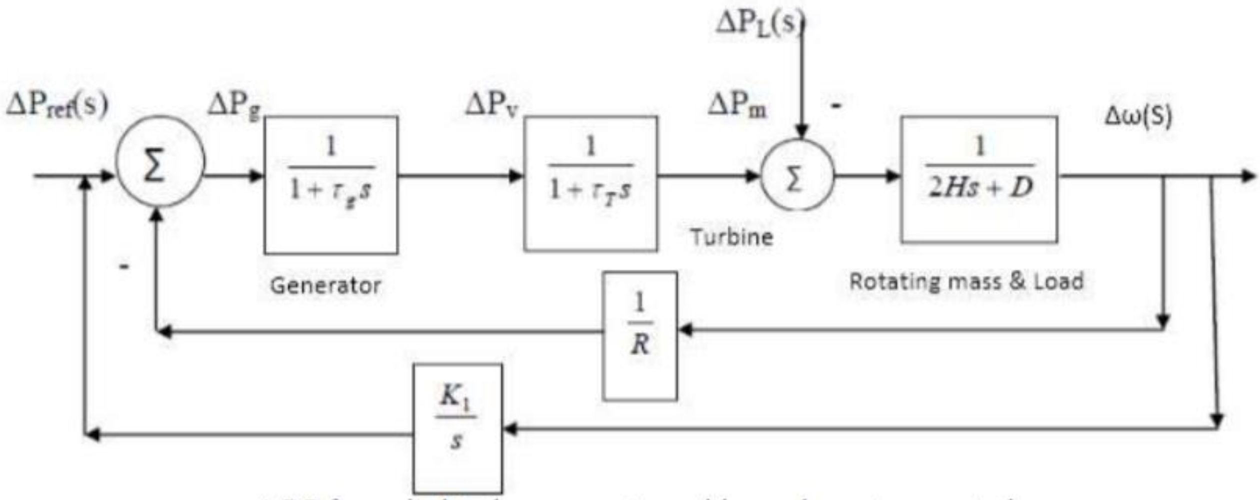


Output



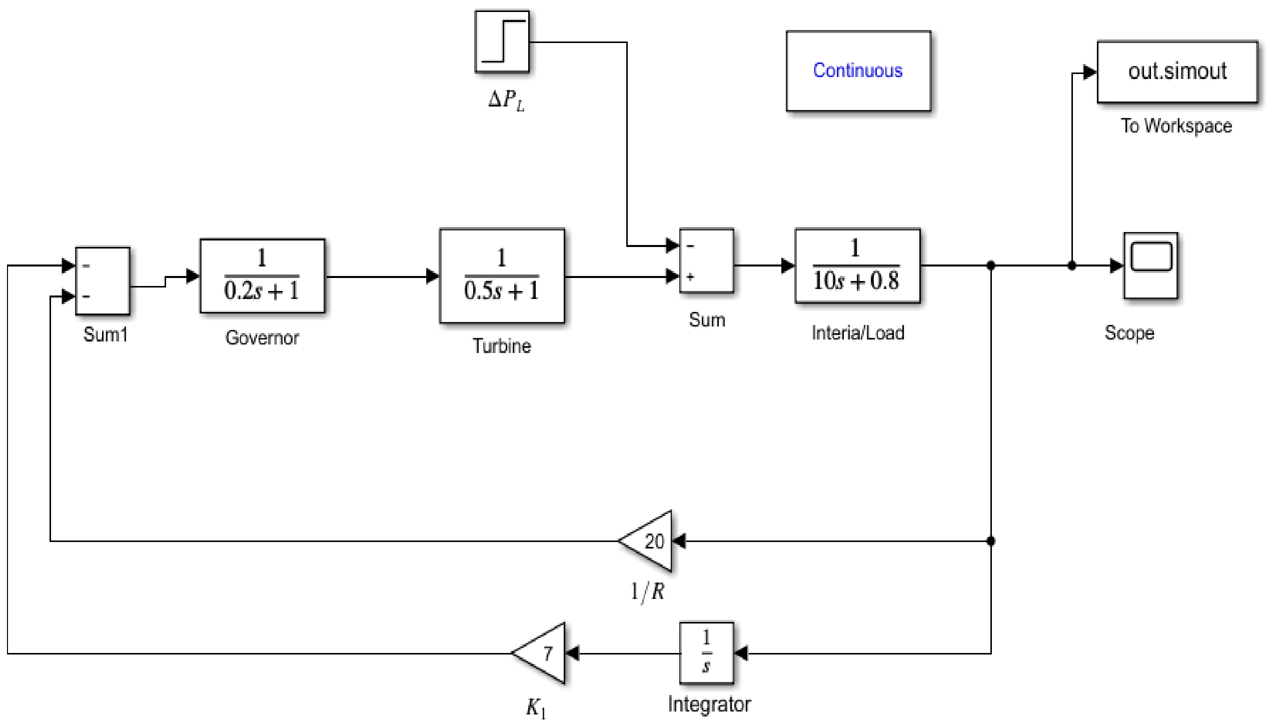
AGC in single area system

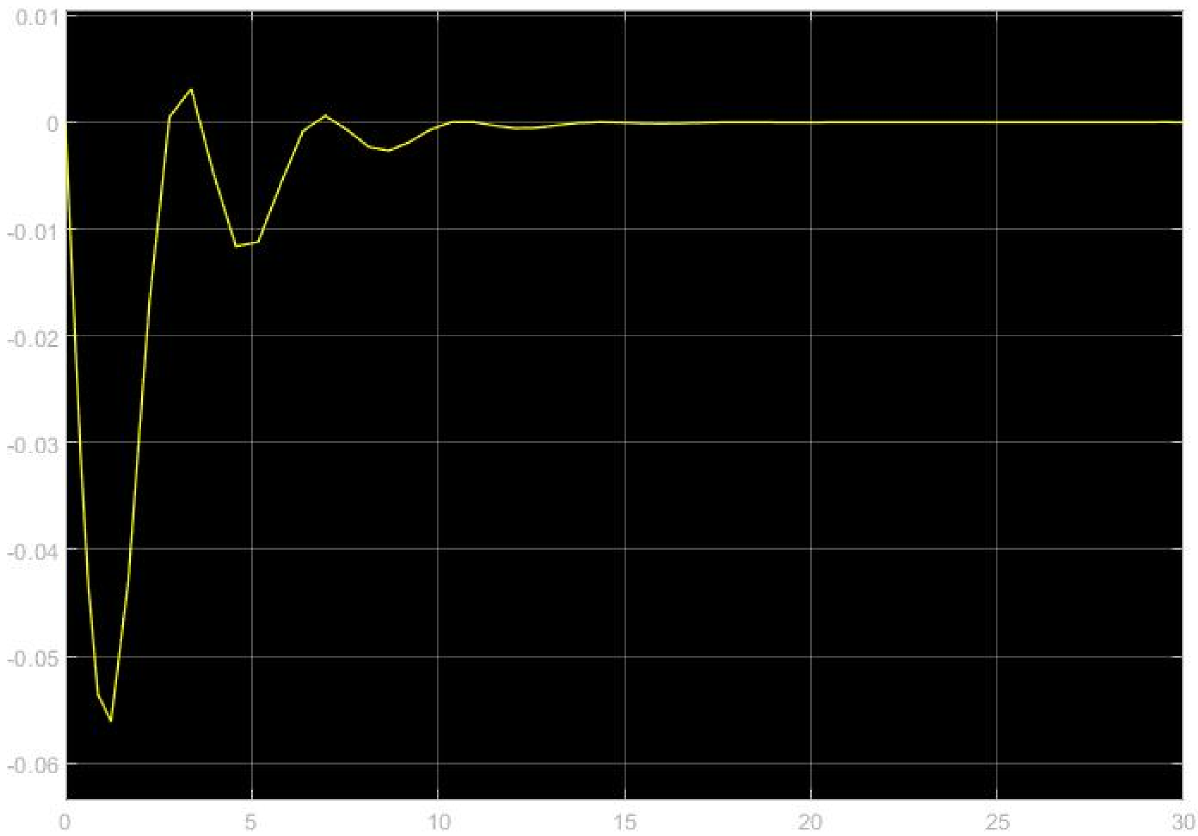
Depending on the governor speed regulation, a change in the system load will results in a steady state frequency deviation. To reduce the frequency deviation, an integral controller is provided, which act on the load reference setting to change the speed set point. The integral controller gain K_I must be adjusted for a satisfactory transient response.



AGC for an isolated power system with supplementary control

Exercise: An isolated power system with integral control





Result

Single area power system is simulated using MATLAB and the waveforms are plotted.