Laboratory ”Modeling and Simulation of Dynamic Systems”
Institute of the Theory of Electrical Engineering, Measurement and Information Systems, WUT

Exercise No 5B
MACROMODEL OF THE POWER SYSTEM REGULATION OF FREQUENCY
Author: S. Osowski

1 The aim of experiments

The macromodel of the power system regulation of the frequency aims at learning the phenomena in the power system at the automatic, dynamic regulation of the temporary frequency in the single and two cooperating power systems.

2 The dynamic model of the system

2.1 Single power system

The model of the power system regulation of frequency is composed of the electrical generator, turbine, the hydraulic amplifier and the feedback sub-system. The linearized model of the single system is presented in Fig. 1. The parameters of the model correspond to the power station of 1000MW. The linearized models of the elements of the system are as follows:

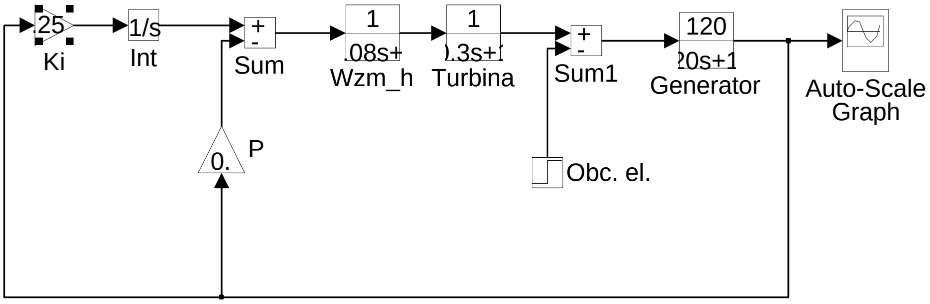

Figure 1: *Macromodel of the system containing single generator*

$$G_h(s) = \frac{K_h}{1+sT_h}, \;\; G_t(s) = \frac{K_t}{1+sT_t}, \;\; G_g(s) = \frac{K_g}{1+sT_g}, \;\; P = 1/R$$

at nominal values of parameters:

$$K_h = K_t = 1.0, \;\; K_g = 120, \;\; T_h = 80ms, \;\; T_t = 0.3s, \;\; T_g = 20s, \;\; R = 2.4$$

2.2 Cooperation of two power subsystems

At cooperation of two power subsystems we can observe the mutual flow of the power from one subsystem to the other (Δp_{12} or Δp_{21}), helping the other one to minimize the changes of frequency in transient state. Fig. 2 illustrates the Simulink model of two subsystems cooperating with each other. Th additional parameters B_1 i B_2 should be taken as $B_1 = B_2 = 0.425$. The parameter $G6$ in the feedback is equal $2\pi 0.0707$.

3 Program of the numerical experiments

Program of experiments includes both systems (the single one and cooperation of two subsystems). Their Simulink models are available in files **pow1.mdl** and **pow2.mdl**.

1. Using the model of the single system (file **pow1.mdl**) check the transient of local frequency at the change of load from 0 do 1.5 of the nominal value. In particular:

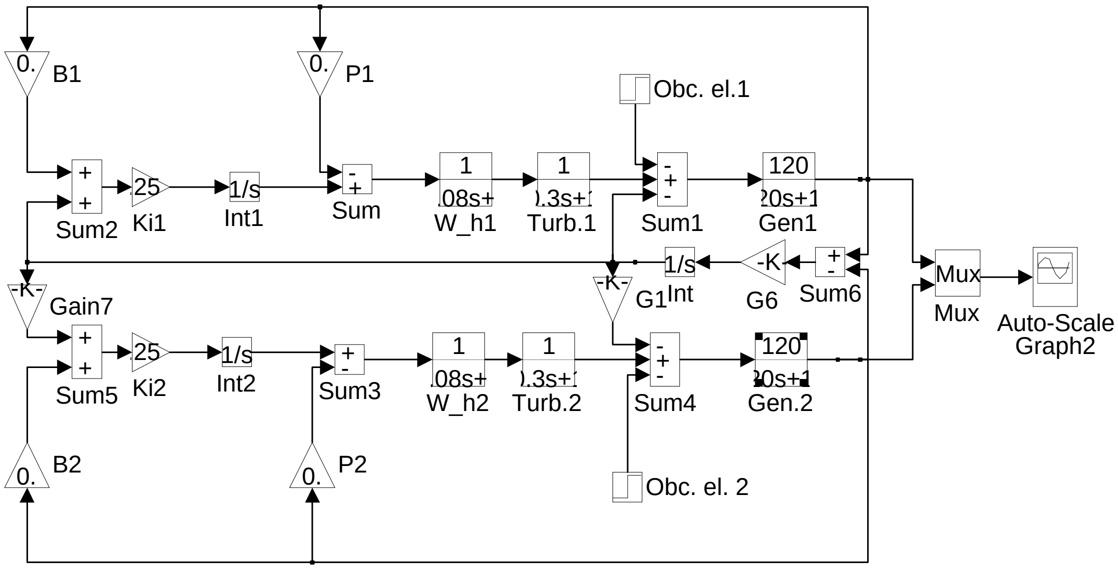

Figure 2: *Macromodel of the system containing two cooperating generators*

- At adjusted (constant) value od ΔP observe the transients of local frequency at different values of the K_i.
- Determine the optimal value of K_i providing the shortest time of transient
- At the optimal value of K_i simulate different cases of the changing load noting the maximum discrepancy of frequency with respect to the required value f=50Hz (the load of the system may be simulated using the block of *Band Limited White Noise*). Use the sample time of this block large enough to get the steady state of frequency.

2. Using the Simulink model of 2 cooperating subsystems (file **pow2.mdl**) observe the transient processes of both local frequencies and the flow of the compensating power from one subsystem to the other at different loads of both subsystems. The value of K_i should be set on the optimal level, adjusted in the first model. In particular:
   - Set $\Delta P_1 = 0$ and $\Delta P_2 = 0.5$ and observe the transients of both local frequencies and the flow of the compensating power. Repeat the same experiments for the reversed change and at different levels of changed load (for example 0.2, 0.7, 1.0 and 1.5)
   - Simulate the simultaneous changes of the loads of both subsystems at equal and not equal changes od load.
   - Observe the changes of the local frequencies and the flow of compensating power at the broken loop of the integral feedback ($K_i = 0$).
   - Simulate the random changes of the load of both subsystems (use the block of *Band Limited White Noise* of the sample time large enough to get the steady state of frequency) observing the actual loads, frequencies of both subsystems and the flow of compensating power ΔP_{12}.