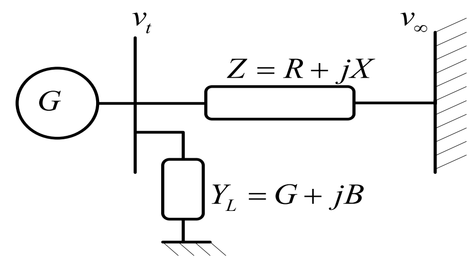
Consider the single-machine infinite bus power system shown with the following data: -



P = 1.0 pu; Q = 0.21 pu; v_t = 1.0 pu; Z_{line} = 0+j0.4 pu;

Y_{load} = 0; x_d = 1.6 pu; x_q = 1.55 pu; x_d' = 0.32 pu;

M = 10 s; K_A = 200; T_A = 0.05 s; T_{do}' = 6.0; D = 0

Write computer programs to carry out the following cases.

CASE 1 (No Control) (10 Points)

Step 1: Find the initial steady state current and voltage in d-q components and the torque angle.

Step 2: Derive the linearization constants K_1- K_6.

Step 3: Form the linearized model and state equations $\dot{X} = AX + BU$ and $Y = CX$ considering the speed as your output.

Step 4: Carry out the eigenvalue analysis.

Step 5: Carry out the time-domain simulations with a 10% pulse input of mechanical torque from 1.0s to 1.1s.

CASE 2 (Conventional Control) (40 Points)

Step 1: Using the frequency domain, design a lead-lag PSS with the following structure.

$$u_{PSS} = K \frac{sT_w}{1+sT_w} \cdot \left(\frac{1+sT_1}{1+sT_2} \right) \Delta\omega \qquad (1)$$

Assume T_w = 5 s and T_2 = 0.1 s. Consider a damping coefficient of ζ_n = 0.5 pu and use ω_n for the design.

Step 2: Form the linearized model and state equation. Carry out the eigenvalue analysis.

Step 3: Carry out the time-domain simulations with a 10% pulse input of mechanical torque from 1.0s to 1.1s.

Step 4: If a PI controller with the following structure of

$$u_{PSS} = \frac{sT_w}{1+sT_w} \cdot \left(\frac{K_I + sK_P}{s} \right) \Delta\omega \qquad (2)$$

is going to be designed using pole placement approach where K_P and K_I can be obtained by solving the following equation

$$\frac{\lambda T_w}{1+\lambda T_w}\left(K_P+\frac{K_I}{\lambda}\right)=\frac{1}{C(\lambda I-A)^{-1}B} \tag{3}$$

Substituting by a pair of prespecified eigenvalues $\lambda = \lambda_1$ and $\lambda = \lambda_2$ for the mechanical mode K_P and K_I can be obtained. I is the identity matrix. It is required to place the electromechanical mode eigenvalues at $-3\pm j7$ while keeping the others at their places. Calculate K_P and K_I that can achieve this target.

Step 5: Form the closed loop matrix A_C including the PI controller. Find the closed loop eigenvalues.

Step 6: Carry out the time-domain simulations with a 10% pulse input of mechanical torque from 1.0s to 1.1s.

CASE 3 (Global-Local-Based Control) (50 Points)

Step 1: Design a hybrid intelligent power system stabilizer (HIPSS) using $\Delta\omega$ as the control input. In HIPSS, optimize locally each solution in the population of genetic algorithm using tabu search and replace the individual by its locally optimized version. This process should be repeated in all GA generations. The structure of HIPSS is as that given in (1). Carry out the design using the following eigenvalue-based objective function.

$$J = \sum(\sigma-\sigma_0)^2 + 10\sum(\zeta-\zeta_0)^2$$

where σ is the real part of the eigenvalue and ζ is the damping coefficient. Set $\sigma_0 = -3$ and $\zeta_0 = 0.5$. Carry out 200 GA generations with 30 iterations of tabu search. Set the population size to 30 solutions. Stop your search if the value of the objective function reaches zero or the best solution does not change for 30 iterations.

a. List the optimal settings of HIPSS.

b. Draw the convergence of the objective function versus iterations.

Step 2: Carry out the eigenvalue analysis of the system with HIPSS.

Step 3: Carry out the time-domain simulations for 5 seconds with a 10% pulse input of mechanical torque from 1.0s to 1.1s.

Step 4: Compare among the three designed controllers.

<u>GENERAL INSTRUCTIONS: -</u>

1. All time-domain simulations should be for 5 seconds.
2. The nonlinear model should be used in all time-domain simulations.
3. All time-domain simulations should include the torque angle, speed, and terminal voltage responses.
4. All time-domain simulations should consider the following nonlinearities: -
   a. $|E_{fd}| \le 7.3$ pu
   b. $|U_{PSS}| \le 0.2$ pu
5. All results should be thoroughly discussed.
6. Settings of the intelligent techniques should be optimized by trial and error, e.g. the settings of GA and TS.

<u>SUBMISSION:</u>

Write a formal report that includes detailed analysis, simulation results, and discussions. A hardcopy of the program developed must be attached. A CD contains softcopy of all materials (**final exam report and programs and all your computer projects**) must be submitted. All materials are due on January 12, 2008 from 5:15 - 6:15 PM. If you face any ambiguity, please send me an e-mail or call me on 0508757838.