Ref: PG/PE/T/129D/2019

Jadavpur University
ME(.Power Engg.)2nd Semester 2019
Power Plant Control & Instrumentation

Answer Any Five **Time:3hours**
Full Marks 100

1. For a system $G(s)$ controlled by a controller $H(s)$ write expressions for sensitivity and complementary sensitivity. With suitable assumptions regarding the spectra of input disturbance and measurement noise, deduce how $H(s)$ should be chosen for a given $G(s)$ for a satisfactory tracking and noise rejection. 4+6

   For the MIMO System shown in Fig. 1 deduce the transfer function matrix from first principles

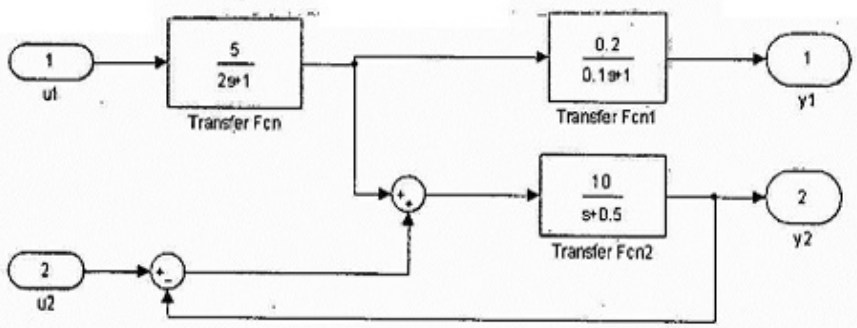

Fig.1

and hence deduce the order of the system. 10

2. For the system defined by:
   $A = \begin{matrix} 1 & -2 \\ 0 & -5 \end{matrix}$; $B = \begin{matrix} 0 \\ 1 \end{matrix}$; $C = 0$ 1 and $D = 0$ deduce the controllability and observability. 10

   Deduce a suitable sampling interval for this system and hence discretize the system using ZOH approximation. 10

3. Write the expression for the controller output $u(t)$ from a discrete PID controller in terms of the error $e(t)$, the controller gains K_p, K_i, K_d and the sampling time T_s.Hence deduce an expression for the controller transfer function $\frac{u(z)}{e(z)}$. 10

   Using the expression deduced above derive an expression for the controller gains K_p, K_i, K_d for a system defined by $(0.5z^{-2} + 2z^{-1} + 1)y(z) = 5z^{-1}u(z)$to place the closed loop poles at $z_1, z_2 = 0.8 \pm j0.2$ and $\alpha = 0.6$ for a sampling time of 100msec. Is the sampling rate adequate? 8+2

4. With suitable state augmentation design an optimal PI controller for the system $G(s) = \frac{K}{(Ts+1)}$ using LQR approach with suitable assumptions and an ARE. Show that if a controller exists, then the resultant closed-loop system is Lyapunov stable. 10

   Deduce an expression for Lypaunov stability of a discrete system $x(k+1) = \phi x(k)$ in parametric form. 10

5. Represent Co-ordinated control of a thermal power plant with a suitable schematic. 6
   Using the schematics of interaction between the modulating control loops illustrate the sequence of interactions for (i) frequency error correction at constant load and (ii) demand power set-point raise at constant frequency. 4+4
   What is sliding mode of operation of a boiler and what is its advantage? 6

6. Explain the functioning of cross-linked combustion control in an oil-fired boiler for **increasing** load. 20

7. Two PA fans are controlled by (i) single controller and (ii) separate controllers. Represent the schemes and analyze the scenario where one of the PA fans has failed and the other is being brought online in each case. How does set-point tracking help in this case? 7+7+6

8. Explain the swell and shrinkage phenomenon in a drum boiler. Can a single element controller with a delayed response to change in the drum level signal help in this case? 6+4

   Deduce the schematic of a 3 element drum level controller with appropriate justifications. 10