Jadavpur University
M.PowerEngg. 2nd Semester 2018
Advanced Power Plant Instrumentation and Control

Answer Any Five
Full Marks 100

Time:3hours

1. What are the desirable features of a controller? Why should a First Order system be controlled by a PI controller? Explain with the schematic of a control loop.
   Derive the controller gains of a PID controller for standard second order system $G(s)=\frac{w_n^2}{s^2+2\zeta w_n s+w_n^2}$ for a guaranteed gain margin Adb and phase margin ϕ_m degrees.
   4+6+10
2. What kind of controller (i.e. PI or PID of PD) would you recommend for the system $G(s)=\frac{5e^{-0.2s}}{(2s+1)(0.1s+1)}$? Draw the corresponding root-locus and justify your answer if the desired closed loop system is stable with dominant complex conjugate poles. Derive the controller gains using a suitable Z-N method. 5+15
3. Deduce the discrete state-space representation of a continuous time system represented by $\dot{\mathbf{x}}=\mathbf{Ax}+\mathbf{B}u, y=\mathbf{Cx}$ with ZOH approximation for a sample time of T_s.State the velocity algorithm representation of a discrete PID controller with gains k_p, k_i, k_d for a sampling time T_s. Hence deduce the transfer function $\frac{u(z)}{e(z)}$. 10+4+6
4. Define a controllable and a stabilizable system.
   For a system $\dot{\mathbf{x}}=\mathbf{Ax}+\mathbf{B}u, y=\mathbf{Cx}$ deduce the condition for output controllability.
   If a system is controllable with a Full State Feedback Controller (FSFC), is it controllable also with an Output Feedback Controller? Substantiate your answer mathematically. 5+10+5
5. For a system $\dot{\mathbf{x}}=\mathbf{Ax}+\mathbf{B}u, y=\mathbf{Cx}$ write the Algebraic Riccati Equation for an infinite time regulator and state the condition for existence of its unique solution. Derive the condition for Lyapunov stability for this system with a control law $u=-\mathbf{Kx}$ in parametric form.
   With suitable state augmentation design a PI controller for the system $G(s)=\frac{K}{(Ts+1)}$ using LQR approach. 10
6. For a system defined by the following equations
   $y_1=k_{11}u_1+k_{12}u_2$
   $y_2=k_{21}u_1+k_{22}u_2$
   calculate, from first principles, the elements of the Relative Gain Array(RGA). Hence deduce the relationship between RGA and the gain matrix. Is the variable matching achieved using this RGA valid during transient conditions also? 10+~~10~~ 8+2
7. Define Master Control Signal for a thermal power plant. With a neat schematic explain the co-ordinated control of a thermal power plant. What are the advantages of boiler following turbine mode of control of a thermal power plant? Why is it necessary to modify the demand power error signal with the frequency error for control of a thermal power plant?
   2+8+4+6

8. With a neat schematic represent the combustion control loop of a coal-fired thermal power plant. Deduce an expression for mill load line for your schematic. 20

9. Schematically represent the single element drum level controller. What are the problems associated with this? How is this problem addressed in 2-element drum level control? Why is the third element required- explain with a schematic. 4+4+6+6

10. Starting from first principles derive an expression for the transfer function $\frac{\Delta h_o(s)}{\Delta m_a(s)}$ for a superheater where h_0 represents the specific enthalpy of steam at the superheater output and m_a represents the atempertaor spray flow rate. Hence derive the thermal time constant and state which of the two superheaters has a higher time constant. With a neat schematic represent the steam temperature control mechanism in a thermal power plant. 10+5+5