ME(Power Engg.) 2nd Semester Examination 2023-2024
Power Plant Instrumentation and Control

Full Marks 100 **Answer all Questions** **Time: 3 hrs**

1. Enumerate the desirable characteristics of a Controller.
   Show that if $G(jw)H(jw)$ has a low-pass characteristics then all controller design criteria can be met for most practical systems CO(1) 4+16

   Or

   Define sensitivity and Complementary sensitivity .
   Formulate the controller design problem for a plant $G(jw)$ controlled by a controller $H(jw)$ as a mathematical problem which satisfies a set of constraints.
   Enumerate the considerations regarding reference input change, measurement noise and output disturbance for your problem. CO(1) 4+10+6

2. What is meant by (i) Asymptotic and (ii) Exponential Stability.
   Derive stability in terms of Lyapunov Stability for an autonomous system $\dot{\boldsymbol{X}}(t) = \boldsymbol{AX}(t)$.
   Derive the condition for stability if an autonomous system $\dot{\boldsymbol{X}}(t) = \boldsymbol{AX}(t)$ in terms of the Eigen values of the matrix $\boldsymbol{A}$ CO(2) 6+8+6

   Or

   Prove that if an autonomous system defined by $\dot{\boldsymbol{X}}(t) = \boldsymbol{AX}(t), \boldsymbol{Y}(t) = \boldsymbol{CX}(t)$ is stable with an Output Feedback Controller, it will be stable with a Full State Feedback Controller and not vice-versa.
   Consider a linear SISO system defined as $\frac{y(s)}{u(s)} = \frac{5}{s(s+1)(s+2)}$. Examine the (i)Controllability and (ii)Observability of the system CO(2) 10+5+5

3. Consider a linear system defined as $\frac{y(s)}{u(s)} = \frac{5e^{-0.5s}}{(2s+1)}$.
   What kind of controller(P/PI/PID) will you recommend for this to obtain a satisfactory close loop response? Design the Controller parameters using a suitable Z-N tuning method.
   Write the MATLAB command for defining the system in transfer function form. CO(3) 16+4

Consider a second order system defined by $\frac{y(s)}{u(s)} = \frac{4}{s^2+2.4s+4}$.

Design a PID controller for this plant to achieve a closed loop damping $\xi_{cl} = 0.8$ and closed loop frequency $\omega_{cl} = 2.0$. Design a suitable placement for the real-pole of the closed-loop plant and also a suitable coefficient for the filter associated with the derivative term in your controller.

What is derivative-kick? CO(3) 14+6

4. Enumerate the different interacting control loops in a typical thermal power plant and represent their interactions with schematic diagrams.

   Establish the requirement of a frequency correction for power control in a thermal power plant.

   Represent a co-ordinated digital control scheme for a modern thermal power plant. CO(4)8+6+6

Or

Analyse the operation of a cross-linked combustion control in an oil-fired boiler under an increasing load scenario. CO(4) 20

5. With reference to the swell and shrinkage phenomena, derive from first principles, the 3 element drum level controller for a thermal power plant. CO(4)20

Or

Represent the combustion control loop of a coal-fired thermal power plant. Design the mill load-line for an air-fuel ratio 1:K.

Design a scheme for control of two PA fans with consideration of reliability and operational constraints in view, using set-point tracking. CO(4)20