B.E. MECHANICAL ENGINEERING
THIRD YEAR SECOND SEMESTER EXAMINATION 2023
ELECTROHYDRAULIC CONTROL SYSTEMS

Time: Three Hours **Full Marks: 100**

***Question 1** is compulsory. Answer any **four** from the rest.*
All the parts of a question must be answered together.

Question 1 is compulsory

1. (i) Classify the different types of actuators used in fluid power applications.

   (ii) What is the difference between a 3-position direction control valve and a proportional valve? What are their symbols?

   (iii) Sketch the flow variation with spool displacement of overlapped, critically lapped and underlapped proportional valves?

   (iv) What is the steady state forced response of a linear system to a sinusoidal input $A\sin(\omega t)$? Explain all the terms in the expression of the response. **[4x5=20]**

Answer any four from the rest

2. (i) With the help of a schematic diagram, identify each component and explain the working of a permanent-magnet linear motor (PMLM).

   ii) What is the role of an accumulator in a hydraulic system? Explain its application through a circuit diagram for a bi-directional motion control hydraulic system with a double-acting double rod cylinder, a solenoid operated 4/3 DCV, an accumulator with a counterbalance valve and a fixed displacement pump with a PRV. **[10+10=20]**

3. What is the advantage of using a variable displacement pump over a fixed displacement pump? With the help of a schematic describe the working of the pressure compensation arrangement in a variable displacement swash plate type axial piston pump. **[5+15=20]**

4. A force motor consists of a cylindrical armature with a coil winding over it. The armature is supported by two mechanical springs – lying on either side of the armature. Each spring is supported by the armature on one side and a permanent magnet on the other. The two identical poles of the permanent magnets face each other. Obtain the expressions for force constant and magnetic elastance. **[20]**

5. Consider an electrohydraulic circuit with a fixed displacement pump, relief valve, critically lapped proportional valve and a single-rod double-acting cylinder driving a spring load. Obtain an expression for the feedforward excitation signal to the valve solenoid for the extension stroke (positive cylinder piston velocity) of the piston by assuming oil as incompressible. **[20]**

6. (i) A dynamic system is represented by $\ddot{c} + 5\dot{c} + 4c = \dot{r} + 2r$ having an input $r(t)$ and output $c(t)$. Obtain the system transfer function and locate the poles and zeroes in the Argand diagram. Obtain response $c(t)$ for a unit step input of $r(t)$.

   (ii) If a system has an open loop transfer function $G(s) = s/(s^2+3)$, and is to be controlled by a simple proportional (P) controller of gain $K_P = 4$, determine the closed-loop pole positions for unity feedback. Comment on the stability of the plant. **[10+10=20]**

7. Find the steady state error for a plant with transfer function as $1/(s^2+7s+25)$, operating in a closed loop under unit step demand and unity feedback, where the controller ahead of the plant in the forward path is (a) proportional type with $K_P = 1.5$, (b) integral type with $K_I = 0.5$. **[20]**

8. (a) Consider a close-loop system where the transfer functions in forward-path and feedback-path are G and H respectively. Find the condition for which the system becomes virtually insensitive to parameter variation in G.

   (b) Using *Routh's Criteria,* comment on stability of the system with characteristic equation:

   $$s^4 + s^3 + 3s^2 + 2s + 5 = 0.$$ **[8+12=20]**

9. For a system with transfer function $\frac{100}{(s+1)(0.04s^2+0.28s+1)}$, identify the corner frequencies and draw the BODE plots. Also, identify Gain Cross-over Frequency, Phase Cross-over Frequency, Gain Margin, Phase Margin and comment on the stability of the plant. **[20]**