

M.E. Mechanical Engineering - First Year - First Semester, 2025
ELECTROHYDRAULIC CONTROL SYSTEM

Time : Three hours

Full Marks: 100

Answer Question (1) and any **FOUR** from the rest.

All symbols have the usual meaning.

- 1.(a) Classify the different types of actuators used in hydraulic systems.
(b) What is a *check valve*? Where is it used in a hydraulic circuit? What is its symbol?
(c) Explain what are *overlapped*, *underlapped* and *critically lapped* spool valves? Show the flow characteristic for each.
(d) What is meant by transfer function of an LTI system? What is the condition of stability for such a system?

[6+5+5+4=20]

[2] (a) Draw a schematic of a swash plate type axial piston pump and explain its operation. How can the delivery of such a pump be altered using a pressure compensation? [20]

[3] (a) Draw the schematic of a simple pressure relief valve. Explain what is meant by pressure override.

(b) Explain a method for tuning the gains of a PID controller.

(c) Give a classification of pumps and state which type is used in electrohydraulic actuation systems. [8+6+6=20]

[4] Consider a symmetric linear actuator, connected to a spring of stiffness k_s , which is controlled by a critically lapped spool valve, connected to a pump at pressure p_p and tank at pressure p_r . The moving mass is m . Assume the fluid to be *compressible* with bulk modulus β . The spool is moved by an electromagnetic motor where the voltage across the coils is $v(t)$, the displacement of the spool is $x(t)$, and the displacement of the actuator is $y(t)$.

(a) Obtain a linear mathematical model for the system stating any assumptions necessary. Assume any symbols required for the problem.

(c) Draw the block diagram the system.

(d) Obtain the system transfer function relating $V(s)$ and $Y(s)$. What is the order of the system? [8+6+6=20]

[5] (a) Use the *Routh-Hurwitz* stability criteria to determine the stability of the system with the following characteristic equation: $s^4 + 2s^3 + 6s^2 + 2s + 24 = 0$.

(b) Construct *Bode Plot* (approximate plot) for the loop transfer function $\frac{5K(s+1)}{s(2.5s+1)(s+2)}$ for $K=100$. Sketch

approximately the true profile of the plots on the corner plots. Identify gain crossover frequency, phase crossover frequency, gain margin and phase margin. Comment on the stability of the plant. State how the stability margins change by changing the value of K to 10. [8+12=20]

[6] Draw the schematic of a two stage electrohydraulic servo valve and explain its operation. Why is it called a two stage valve? What are its advantages and disadvantages over a proportional valve? [20]

[7] Write short notes on any **FOUR** of the following:

- (i) Advantages of hydraulic systems in power transmission;
- (ii) Components of Electrohydraulic Control System;
- (iii) Difference between a direction control valve and a proportional valve;
- (iv) Valve flow gain and pressure coefficient of a spool valve;
- (v) Open loop and closed loop systems;
- (vi) The *Routh-Hurwitz* stability criterion.

[4×5=20]