B.E. MECHANICAL ENGINEERING
THIRD YEAR SECOND SEMESTER EXAMINATION 2024

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. (a) With the help of a symbolic diagram briefly describe the working of a solenoid-operated 4/3 on-off DCV.
   (b) What are the different types of pumps used in an electrohydraulic systems?
   (c) What are the role of individual controllers in a combined feedforward-feedback controller?
   (d) How does a high gain in the forward path help in a closed-loop control? **[4x5=20]**

Answer any four from the rest

[2] (a) With the help of a symbolic diagram, explain the working of a hydraulic circuit with meter-in for both extension and retraction of a double-acting cylinder.
(b) Briefly describe the operation of a regenerative circuit with the help of a neat sketch. **[10+10=20]**

[3] (a) What is the role of an intensifier in hydraulic system? Explain the application of a single-acting intensifier for piercing operation carried out on a flat plate through a circuit diagram of a bi-directional motion control hydraulic system with a double-acting single rod cylinder, a manually operated 4/3 DCV, an intensifier with a counterbalance valve, a remote pilot operated check valve and a fixed displacement pump with a PRV and CV.
(b) Give a suitable friction model and draw the typical friction characteristics for a hydraulic cylinder with proper nomenclature. **[10+10=20]**

[4] (a) The cylindrical core of an armature is supported by two mechanical springs, each placed on a flat end of the core on one side and a solenoid core on the other side. Obtain the expressions for force constant and magnetic elastance for concurrent bi-solenoid excitation of an armature undergoing linear displacement. Comment on the role of the mechanical springs in stabilizing the system.
(b) Why is only one solenoid excited at a time, despite having two solenoids in a proportional valve with three-land spool? **[15+5=20]**

[5] A spool valve has two lands for metering the pump and tank ports and an in-between unmetered cylinder port for communicating with a single-acting cylinder. Obtain the expressions for the transient flow forces during extension and retraction of the piston. Comment on the effect of this transient force on the stability on spool displacement. **[15+5=20]**

[6] Using usual notations, obtain the expressions of steady error of a 1st order system with unity feedback and step demand under proportional controller in one case and integral controller in another case. **[20]**

[7] Using Routh's Criterion, indicate the stability of the following characteristic equation:

$$s^5 + 2s^4 + 3s^3 + 6s^2 + 2s + 1 = 0$$ **[20]**

[8] (a) What is meant by frequency domain analysis? Starting from a general transfer function, obtain the Bode plot for a typical 1st order system.
(b) Define gain margin and phase margin. **[15+5=20]**

[9] (a) The displacement x of a mass m driven by a bi-solenoid motor is controlled by a PID controller through a power amplifier of fixed gain K_a. Represent the transfer functions of the individual components through a block diagram. Obtain the overall close-loop transfer function of the system.

(b) A dynamic system is represented by $\dddot{r} + 2\ddot{r} + 2\dot{r} + r = d(t)$ having an input $d(t)$ and output $r(t)$. Obtain the system transfer function and find the poles of the transfer function. Obtain response $r(t)$ for a unit step input of $d(t)$. **[12+8=20]**