B.E. MECHANICAL ENGINEERING THIRD YEAR SECOND SEMESTER - 2022

ELECTROHYDRAULIC CONTROL SYSTEMS

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

Instructions:

***Question 1** is compulsory. Answer any **four** from the rest.*

All the parts of a question must be answered together.

1. **[4x5=20]**

i) State the relative merits and demerits of an electrohydraulic system with respect to electrical system and electro-mechanical type system with gear transmission.

ii) With the help of a simple sketch briefly describe the working of a solenoid-operated 3/3 on-off DCV. Give one example of the application of such type of valve.

iii) How the nonlinear characteristics of friction on the piston in a hydraulic cylinder can be modelled? What is its approximate linear form?

iv) A closed-loop system provides performance enhancement through accurate feedback of the output measurement, nullifying uncertainties of the system modelling to a great extent – justify the statement from the perspective of Transfer Function.

Answer any **four**

2. i) With the help of a neat circuit diagram, identifying each components, describe the working of a pneumatic bi-directional motion control system.

ii) What is the role of an intensifier in hydraulic system? Explain its application through a circuit diagram.

[10+10=20]

3. What is the origin of steady-state flow force in a spool valve? Obtain expressions for flow forces on a four-land spool valve. How is zero flow force damping ensured on such valve?

[20]

4. i) 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.

ii) 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. Consider an electrohydraulic circuit with a fixed displacement pump, relief valve, critically lapped servovalve and a single-rod double-acting cylinder driving a constant external load. For a feedforward-PID controller, obtain an estimate of the feedforward voltage (consider L-R circuit) input to the solenoid for the extension stroke of the piston and the equation for the error dynamics for the system. Discuss the roles of the feedback gains in the control.

[20]

6. (i) 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.

ii) Using Routh-Hurwitz criterion, comment on the stability of a system represented by the characteristic equation, $s^4 + 2s^3 + 3s^2 + 4s + 5 = 0$. How many roots are having positive real parts?

[12+8=20]

7. (i) What is meant by frequency domain analysis? Starting from a general transfer function, obtain the Bode plot for a typical 1st order system.

(ii) Define gain margin and phase margin.

[15+5=20]