Master of Mech. Engg. 1st Sem. Examination, 2017

Subject: Electro Hydraulic Systems and Control

Time : Three hours **Full Marks: 100**

*Answer any **FIVE** QUESTIONS.*
All symbols have the usual meaning.

1.(a) Explain the working of a *pressure compensated* swash plate type axial piston pump with a sketch?
(b) With a neat sketch – explain the working of a basic hydraulic circuit with a symmetric linear actuator. [10+10]

2.(a) Explain with a schematic what is meant by *cushioning* in hydraulic actuators.
(b)For the electromechanical servo model shown in Fig. P2 below, Find the limits of K for the stability of the closed loop system. [8+12]

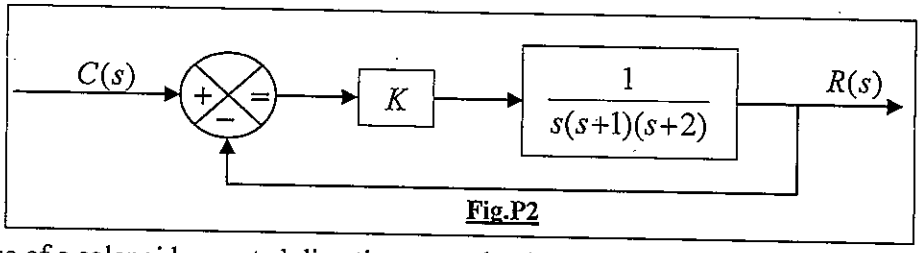

Fig.P2

3. (a) Consider the case of a solenoid operated direction control valve driving a symmetric linear actuator. The DCV has a solenoid, driving a 3 landed critically-lapped spool valve with negligible spool-bush radial leakage. The spool valve metered ports with the land diameter d_s and total port wrap angle θ_p, are rectangular, the discharge coefficient of the ports C_d, the fluid density ρ and the supply and return pressures P_P and P_T respectively. The actuator piston has a mass m and it is connected to a spring of stiffness k_a and a dashpot of damping coefficient C_a. The solenoid coil resitance is R, inductance L, back emf coefficient k_b, motor constant k_m, magnetic stiffness k_{mag} and spool valve spring stiffness k_s. Obtain the corresponding transfer function model of the system relating the actuator displacement $y(t)$ and solenoid voltage $e(t)$. Assume any symbols required for the problem.
(b) Define the terms characteristic equation, poles and zeroes. [12+6]

4. (a) For a system with transfer function $G(s)=\dfrac{C(s)}{R(s)}=\dfrac{3(s+2)}{s^2+4s+3}$, where $c(t)$ and $r(t)$ are the output and input of the system, indicate poles and zeroes in the Argand Diagram, comment on the stability and obtain system response to a unit step input of $r(t)$.
(b) Explain the meaning of open-centre and closed centre direction control valves with sketch. [12+8]

5. (a) Describe four main characteristics of non-linear behaviour encountered in nonlinear dynamic systems.
(b) For an underdamped second order system, write the phase-plane and isocline equations. Draw a phase-plane diagram of the system showing atleast 4 isoclines. Indicate the focus in the diagram. [10+10]

6. (a) Comment on the nature of the forced response of a plant with transfer function $G(s)$ for a sinusoidal input. What is the meaning of the term *frequency response function*?
(b) What are essential elements of a closed loop system? What are the advantages of a closed loop system over open loop systems?
(c) Draw the polar plot of the loop gain function $1/(s+1)$. [6+7+7]

7. Construct an approximate BODE Plot of the following loop transfer function: $G_L(s)=\dfrac{K}{s(s+1)(0.5s+1)}$ for K=0.325 and K=0.45. Draw the corner plots, indentify the corner frequencies, gain and phase crossover frequencies, gain and phase margins. Comment on the plant stability. Which of the two cases has higher stability margin? [20]

8. Write short notes on any **TWO** of the following: [20]
(a) *Ziegler* and *Nichols* methods of tuning gains of PID controllers;
(b) Configuration and working of a Linear Force Motor used for driving a spool valve;
(c) Implementation of a Proportional Controller using a lever and float mechanism for a hydraulic (tank-filling) system.