Minor-II question paper on Control Theory and Applications

This paper has two parts, Part-I and Part-II. Answer them in two different answer-books.

Full Marks: 40 (Part-I: 20 and Part-II: 20), Time: 1 hour.

Problem-1

The hardware of an armature controlled DC motor is shown below to control the angular position of a load. The intended angular position θ_i and the actual angular position θ_L of the load are converted into voltages by using two similar rotary potentiometers of gain K_P each and these two voltages are compared for the error and amplified by an amplifier of gain K_A. The amplified voltage is given to the armature circuit of the DC motor which has a torque constant K_T and back e.m.f. constant K_b. A reduction gear train of train value 1/n, (where n>1) is used to couple the motor shaft and the load shaft, the equivalent polar mass moment of inertia and viscous damping constant of which are J_{eq}, B_{eq} respectively as perceived at the motor end.

(a) Draw the block diagram to represent the system dynamics. Use the symbols given (4)

(b) What is the order of the system? (1)

(c) Which physical variables as shown by the block diagram will you select as states to represent the system dynamics in state space? (1)

(d) Write down the state and the output equations. Note that all the states are needed as the outputs. (6)

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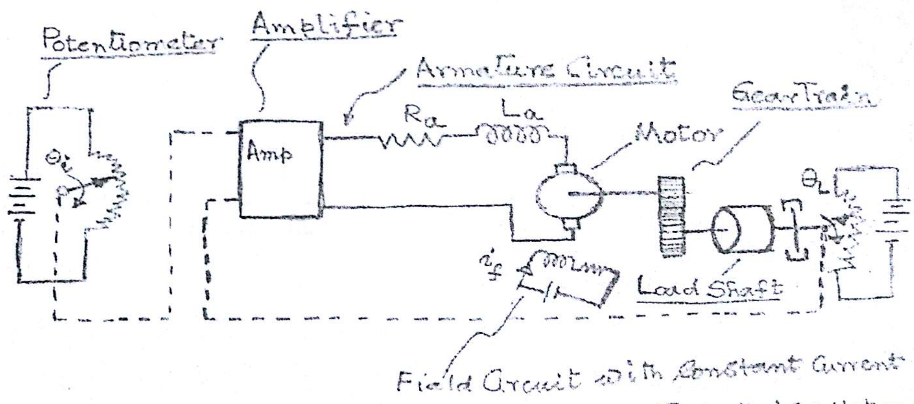


Schematic diagram of an Armature Controlled DC Motor

$\dot{X} = AX + BU$

$Y = CX + DU$

Problem-2

(a) The transfer function of a SISO system is given as $\frac{Y(s)}{U(s)} = \frac{2s+3}{12s^2+23s+10}$. Express the system dynamics in the state space using the Controllable canonical form. (4)

8

(b) Use the state and the output matrices to prove that you get back the same transfer function. (4)

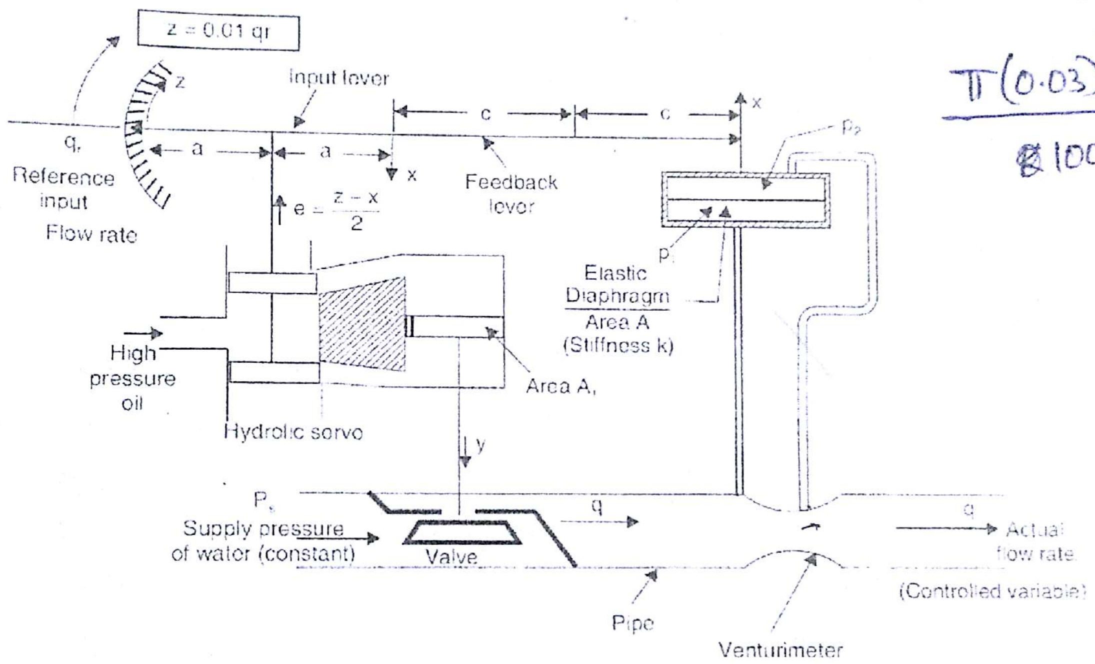
$$(I - HO)G = O \qquad O(1+HG) = IG \qquad \frac{O}{I} = \frac{G}{1+HG}$$

PART II

Q1 . Figure below shows a flow control system, with controlled variable as 'q', the volume flow rate of water (m^3/sec). The desired or reference flow rate is 'qr' (m^3/sec). The actual flow rate is sensed as shown using a venturimeter. The sensor equation is: $q = 10^{-4}(p1 - p2)$, with pressures p1 and p2 being in N/m^2. Diaphragm stiffness ~~'k' is 1000 N/m and its~~ diameter is 0.06 metres. The port constant of the hydraulic servo is 0.05 m^2/sec and Area A_1 of the power piston is 0.01 m^2. Further, the flow rate is related to the motion y by the equation : Q = 300 y, where y is in meters. Other relations are as shown in the figure. Draw the block diagram of the system and find the transfer function relating q and q_r. (10)

10

$$\frac{\pi(0.03)^2}{1000}$$



Q2 What are the advantages of pneumatic controllers over hydraulic electronic controllers. What are its limitations? Make the block diagram signal flow graph and derive the transfer function P_c/e of the given pneumatic circuit shown below. Prove that this acts like a PID controller. (10)