BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

2nd Semester, 2022-2023

Control Systems (ECE/EEE/INSTR F242)

Mid-Semester Test (Open Book)

Max Time- 1.5 Hr | Max Marks - 60 | Date: 14.03.2023

Q.1 For the closed loop system whose schematic diagram is shown in Fig. 1(a), write all the related governing equations, draw the block diagram and find the transfer function $\frac{\Delta q_2(s)}{e_r(s)}$. Assume the following parameters for the various components:

i) actuator dynamics: $e_a = \frac{d\theta_R}{dt} + 2\theta_R$

ii) valve gain =2 $\frac{m^3}{s.\ rad}$

iii) flow-rate sensor gain $= 0.5\ \frac{V}{m^3/s}$

iv) gears ratios: $\frac{\theta_M}{\theta_L} = 10$ and $\frac{\theta_M}{\theta_S} = 1$

v) synchro pair sensitivity $= 5\ \frac{V}{rad}$

vi) amplifier gains: $K_A = 4\ \frac{V}{V}$, $K = 5\ \frac{V}{V}$

vii) load: $J_L = 1\ k_g\,.m^2$ and $B_L = 2\ \frac{N.m}{rad\,.s}$

viii) tanks: capacitance $C = 10\ m^2$ and resistance $R = 0.1\ \frac{s}{m^2}$ (for both the tanks)

ix) PD controller: $K_p = 4;\ K_d = 2$

The torque-speed characteristics of the AC Motor with 110 V, 50 Hz supplied to the control winding is given in Fig. 1(b). Assume motor-losses and its inertia and friction to be negligible. [17]

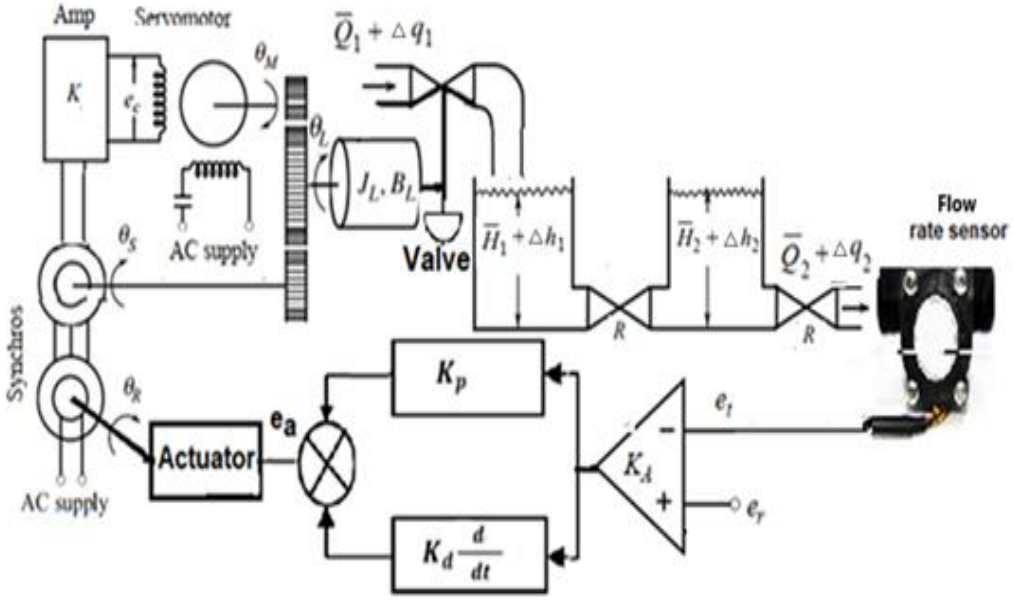

Fig. 1 (a)

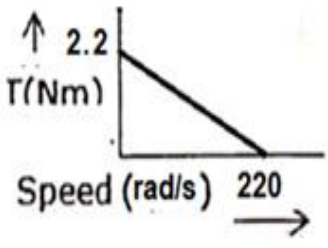

Fig. 1 (b)

PTO

Q2. Determine the overall gain (C/R) of the signal flow graph as shown in Fig.2. Leave the final answer in the form of $\Sigma(P_i\Delta_i/\Delta)$ without simplifying. [16]

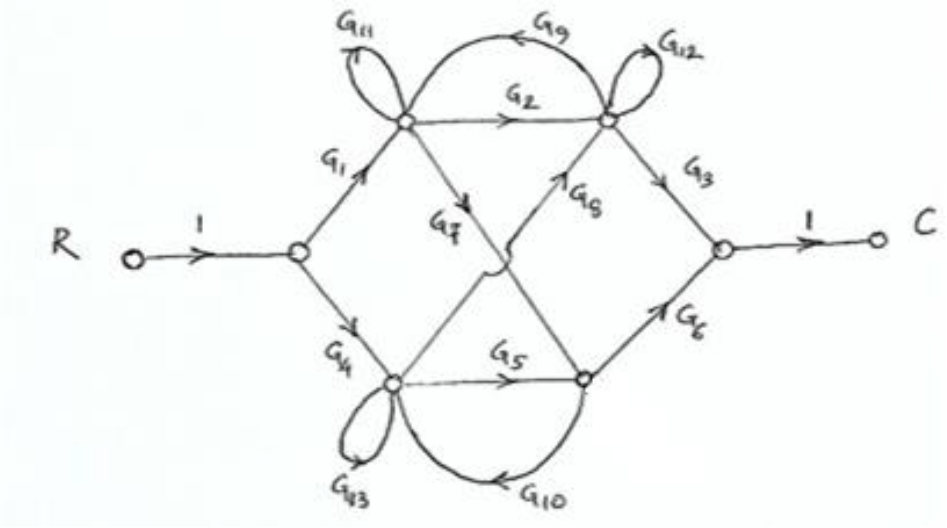

Fig. 2

Q3. The forward path transfer function of a negative unity feedback system is given by $\frac{10}{(s+a)(s^2+2s+2)}$. Determine the conditions on the parameter 'a' (where $-\infty < a < \infty$) for the closed loop system to have [15]

i) no right half plane pole

ii) one right half plane pole

iii) two right half plane poles

iv) three right half plane poles

Also determine 'a' for the closed loop system to have a steady state error of 0.01 (or 1%) to a unit step input.

Q4. The unit step response for a second order plant (without any zero) is shown in Fig 4(a). The response settles in 8 s (2% tolerance band) . Determine the transfer function of the plant.

Now this plant is connected with a controller & feedback mechanism as shown in Fig 4 (b) and the pole-zero map of this closed loop system is shown in Fig 4(c). This closed loop system has zero steady state error to a unit step input. Determine the transfer function of the controller. [12]

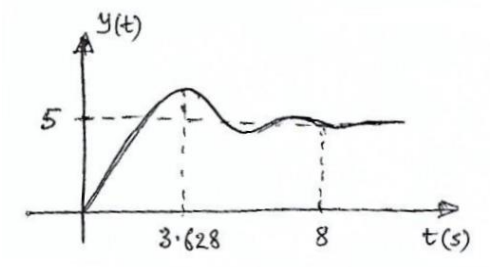

Fig. 4(a)

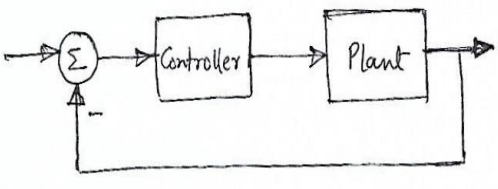

Fig. 4(b)

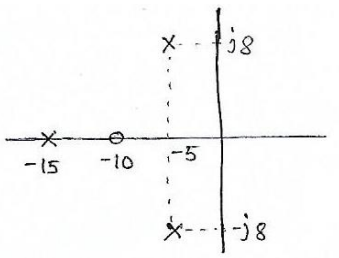

Fig. (4c)

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