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MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
A Constituent Institution of Manipal University

V SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, NOVEMBER 2017

SUBJECT: LINEAR CONTROL THEORY [ELE 3101]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 15th November 2017** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Semi-log graph sheet will be provided

1A. Derive the transfer function for a DC motor with load making suitable assumptions. Find the transfer function $\boldsymbol{G(s) = \theta_L(s)/E_a(s)}$, for the DC motor and load shown in **Fig. Q 1A**. The Torque-speed relation is given by $\boldsymbol{T_m = -8\omega_m + 200}$, when the input voltage (E_a) is 100 volts. The specifications given are:

$J_m = 1\ kgm^2,\ B_m = 5Nm - s/rad,\ J_L = 400\ kgm^2,\ B_L = 800Nm - s/rad$

$N_1 = 20,\ N_2 = 100,\ N_3 = 25,\ N_4 = 100.$ ***(04)***

1B. With detailed steps, determine the transfer function for the system representation shown in **Fig. Q 1B** using Mason Gain Formula. ***(03)***

1C. For the system shown in **Fig. Q 1C**, determine the value of **K** and **a**, so that the settling time is 0.8 seconds and damping factor is 0.707. ***(03)***

2A. Determine the capacitor voltage in the network shown in **Fig. Q 2A** if the switch closes at $t = 0\ s$. Assume zero initial conditions. Further, determine the time constant, rise time and settling time of the capacitor voltage ***(03)***

2B. The mathematical model of a system configured in unity feedback control loop is given as:

$$G(s) = \frac{K(s+4)}{s(s+1.2)(s+2)}$$

Determine:

a) The range of K that keeps the system stable.
b) The value of K that makes the system oscillate
c) The frequency of oscillation when K is set to that value which makes the system oscillate ***(03)***

2C. A unity feedback system has the open loop transfer function is given below:

$$G(s)H(s) = \frac{K(s+6)}{s(s+1)(s+4)}$$

Draw the Nyquist diagram and determine the range of ***'K' for*** which the system remains stable. ***(04)***

3A. Sketch the root locus for unity feedback system with open loop transfer function given and comment on the range of 'K' for system to be stable.

$$G(s) = \frac{K(s+1)}{s(s+4)+13}$$ ***(03)***

3B. For the asymptotic bode magnitude plot as shown in **Fig. Q 3B**,

a) Find the gain margin (dB) of the system
b) If a proportional controller having a gain of '2' is added to the system, find the gain margin in dB. ***(03)***

3C. A negative unity feedback system has plant transfer function given as:

$$G_p(s) = \frac{k(s+1)}{s^2(s+5)(s+20)}$$

Design and realize a suitable active lag compensator so as to achieve an acceleration error of $100s^{-2}$ while ensuring a phase margin of 25^0. ***(04)***

4A. Explain and realize a lead network using passive elements and also realize the same with an operational amplifier. Highlight the main difference between the two approaches. ***(03)***

4B. In a unity feedback control system, a PD controller is cascaded with the plant transfer function in the forward path. The transfer function of the plant is given as:

$$G_p(s) = \frac{100}{s(s+10)}$$

Determine the proportional and derivative gains of the controller for an overall velocity error constant $K_v = 1000$ and the damping ratio $\zeta = 0.5$. ***(03)***

4C. A unity feedback system has an open loop transfer function given by:

$$Gp(S) = \frac{k}{s(s+7)}$$

There exists a dominant pole damping ratio of 0.517. Design and realize a suitable controller so as to reduce the steady state error zero. ***(04)***

5A. Justify appropriately whether, the transfer function $G_c(s) = {(s+1)}/{(s+2)}$ can function as a lead compensator. Further, determine the frequency at which the phase of $G_c(s)$ is maximum. ***(03)***

5B. Represent the electrical network shown in **Fig. Q 5B**, in state space physical variable form if the output is current through the resistor. Convert the state space to represent the same electrical network in transfer function form. ***(03)***

5C. Design an observer for the plant represented in observer canonical form as:

$$G(s) = \frac{1}{(s+1)(s+2)(s+5)}$$

Assume the closed loop performance of the observer to be governed by the following characteristic polynomial:

$$\lambda^3 + 120\lambda^2 + 2500\lambda + 50000$$ ***(04)***

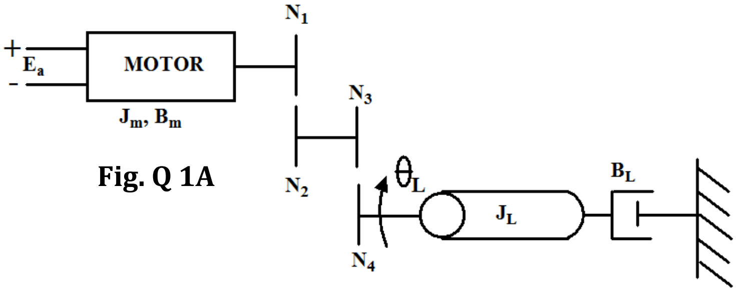

Fig. Q 1A

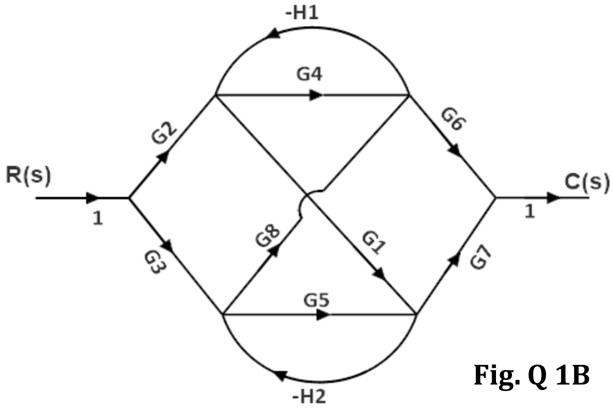

Fig. Q 1B

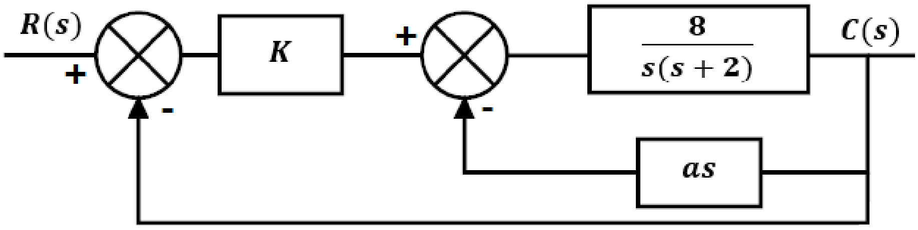

Fig. Q 1C

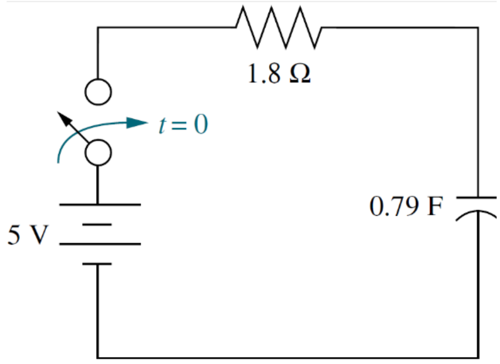

Fig. Q 2A

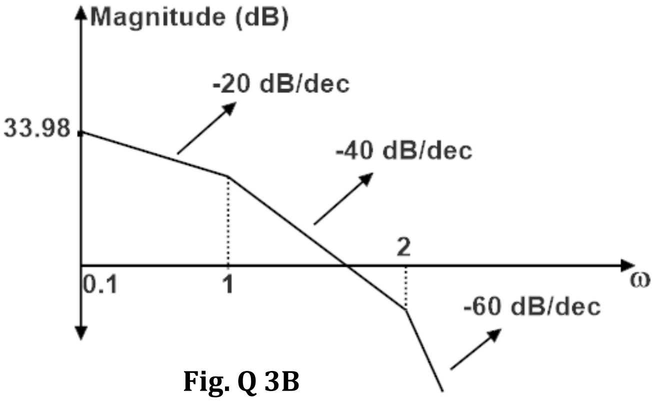

Fig. Q 3B

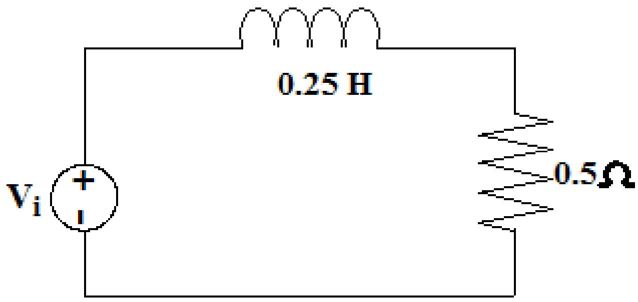

Fig. Q 5B