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MANIPAL INSTITUTE OF TECHNOLOGY
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A Constituent Institution of Manipal University

V SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, NOV/DEC 2016

SUBJECT: LINEAR CONTROL THEROY [ELE 3101]

REVISED CREDIT SYSTEM

Time: 3 Hours | **Date: 24 November 2016** | **MAX. MARKS: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.
- Semi-log graph sheets shall be supplied.

1A. For the translation mechanical system shown in Figure Fig. Q1A.

(i) Draw mechanical network. (ii) Write down the dynamic equations that describe the system (iii) Draw a block diagram representation, representing each element by a block. ***(03)***

1B. Using block reduction technique reduce the given block diagram shown in Fig Q1B in its simple form and obtain the equivalent transfer function $\frac{C(s)}{R(s)}$ ***(03)***

1C. Obtain the overall transfer function of a closed loop system represented by the signal flow graph shown in Fig. Q1C using mason's gain formula. ***(04)***

2A. A unity feedback control system (with positive feedback) is shown in Fig Q2A. Using Routh-Hurwitz criterion determine how many poles of closed loop system that lie (i) in RH plane (ii) in LH plane (iii) on $j\omega$ axis. Also comment on stability of system. ***(04)***

2B. For a unit step input closed loop control system shown in Fig Q2B, find the values of K_1 and K_2 so that the peak overshoot is 25 % and peak time of 4 sec. ***(03)***

2C. For a unity feedback system with open loop transfer function, $G(s) = \frac{K}{s^n(s+\beta)}$, find the values of $"n"$, K and β in order to meet the specifications of 10% overshoot and the velocity error constant $K_V = 100$ ***(03)***

3A. Select the Nyquist contour and obtain the Nyquist diagram by mapping each section of contour to a $G(s)H(s)$ plane showing step by step procedure for a negative feedback system with open loop transfer function, $G(s)H(s) = \frac{k}{s(s^2+4s+10)}$.

Find the value of K for which (i) system is stable (ii) system is marginally stable (iii) the phase margin is 45°. ***(05)***

3B. The open loop transfer function of a negative feedback system is, $G(s)H(s) = \dfrac{k}{s(s+1)(s^2+2s++5)}$. By step by step procedure draw the root locus plot for k > 0. Also determine the range of K for which (i) system is sable (ii) system is critically damped. ***(05)***

4A. The open loop transfer function of a negative feedback system is given by

$G(s)H(s) = \dfrac{2000}{s(s+10)(s+20)}$. Using Bode plot obtain (i) Gain margin and Phase margin (ii) the stability of the system (iii) steady state error (iv) the open loop gain for a G. M. of 24 dB. ***(05)***

4B. The state model of an armature controlled D.C motor is given by

$$\dot{x}\,(\text{t})=\begin{bmatrix}0 & 1\\ -8 & -6\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\end{bmatrix}+\begin{bmatrix}0\\ 1\end{bmatrix}u(t);\;\; y(t)=[1\;\;0];\;\; x(0)=\begin{bmatrix}1\\ 0\end{bmatrix}$$

Where the state variables chosen are : $x_1(t) = \omega(t)$, the angular velocity of the motor shaft, and $x_2(t) = i_a(t)$, the armature current. Find (i) state transition matrix using Cayley-Hamilton Technique (ii) Find the unit step response y(t) of the system ***(05)***

5A. An LTI single input single output system is described by the transfer function

$\dfrac{Y(s)}{R(s)} = \dfrac{s^2+6s+5}{s^3+5s^2+7s+3}$, develop a state model in controllable canonical form. ***(03)***

5B. Design a suitable controller to reduce the steady state error to zero for a unity feedback system with forward path transfer function $G(s)=\dfrac{K}{s(s+8)}$. The system is operating with an overshoot of 16%. ***(04)***

5C. A linear system is described by following state equation

$$\dot{x}\,\textbf{(t)}=\begin{bmatrix}0 & 1\\ 0 & 0\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\end{bmatrix}+\begin{bmatrix}0\\ 1\end{bmatrix}u(t);$$

Find the state feedback gain matrix by Ackermann's formula for the system poles to be placed with a damping ratio of 0.707 and setting time of 1 sec. ***(03)***

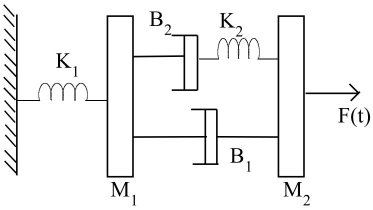

Fig.Q1A

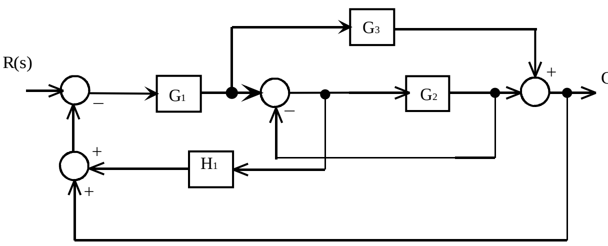

Fig.Q1B

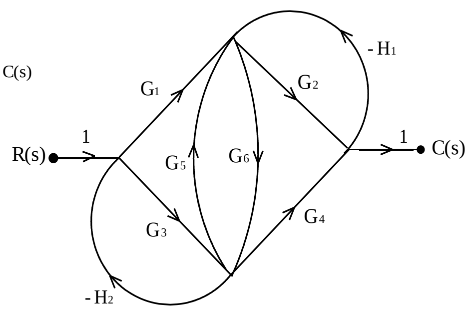

Fig.Q1C

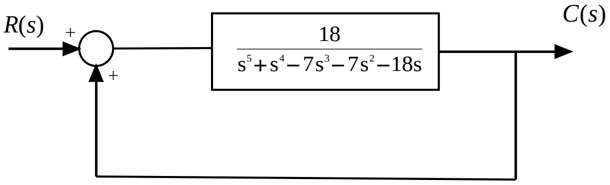

Fig.Q2A

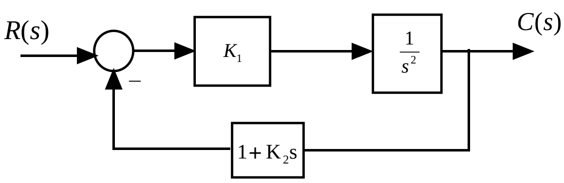

Fig.Q2B