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MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent Institution of MAHE, Manipal)

VI SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
END SEMESTER EXAMINATIONS, APRIL 2018

SUBJECT: CONTROL SYSTEM DESIGN [ELE 4013]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 26 April 2018** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Use of MATLAB is permitted.

1A. Given the uncompensated unity feedback system with $G(s) = \frac{K}{s(s+1)(s+3)}$, design a suitable compensator / controller to yield the following specifications. Settling time 2.86sec, percentage overshoot 4.32, steady state error to be improved by a factor of 2.

Tabulate the gain, transient and steady state error of compensated and un compensated systems.

Discuss the validity of second order approximations. ***(05)***

1B. Consider the unity feedback system with $(s) = \frac{K}{s(s+36)(s+100)}$, use frequency domain methods to design a lead compensator to yield K_V=40 with phase margin of 48°.

Realize the lead compensator using passive circuit. ***(05)***

2A. A system is described by the transfer function $G(s) = \dfrac{s^2+4s+4}{s^3+5s^2+4s}$, develop a state model in i) controllable canonical form ii) diagonal or Jordan form iii) Draw the state diagram for both the cases. Comment on controllability and observability of the system. ***(06)***

2B. Explain Kalman filter with relevant equations, block diagram and with a suitable example. ***(04)***

3A. Design a linear state feedback controller that places the system poles at $s = -1 \pm j2\ and\ s = -5$

$$\dot{x} = \begin{bmatrix} -3 & 0 & 1 \\ 1 & -2 & 0 \\ 0 & 0 & -1 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} u \quad y = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix} x$$

Also design an observer which is 10 times faster than the control loop.

Evaluate the steady state error for step input.

Draw the state diagram of the system with controller and observer. ***(06)***

3B. Explain robust H-infinity control scheme. ***(02)***

3C. State and explain any two characteristics of non-linear systems. ***(02)***

4A. Determine the stability of the origin of the following system using Lyapunov stability theorem.

$$\dot{x}_1 = -x_1 + x_2 + x_1(x_1^2 + x_2^2)$$

$$\dot{x}_2 = -x_1 - x_2 + x_2(x_1^2 + x_2^2)$$

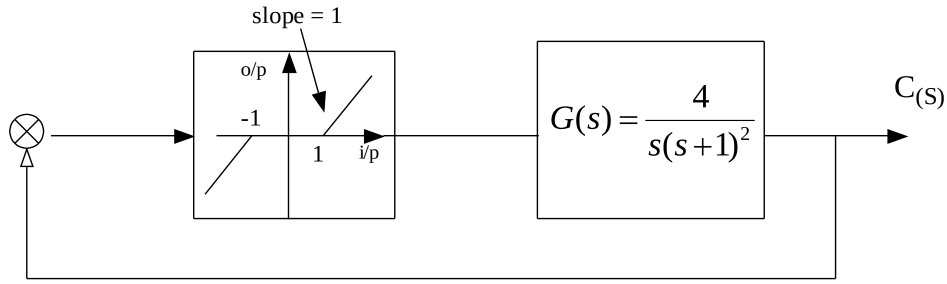
Draw the region of stability and un stability. ***(04)***

4B. For the linear time invariant system represented by the state equation $\dot{x} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} x$, assess the stability of the system using Lyapunov stability criterion and also derive the corresponding Lyapunov function. ***(04)***

4C. State and explain Zeigler Nichols tuning method. ***(02)***

5A. For the system given in Figure, predict the possibility of a limit cycle. If it exists determine the amplitude and frequency. Also investigate the stability of the limit cycle.

The describing function for the non-linear element is $G_{N=}\frac{K[\pi-2\beta-sin2\beta]}{\pi}$ for M ≥ 1, with input $m(t) = M \sin \omega t$.



(04)

5B. Explain the concept of Model reference control with a neat block diagram ***(03)***

5C. Obtain the control law that minimizes the performance index $J = \int_0^\infty (x_1^2 + u^2)dt$, for the system described by $\dot{x} = Ax + Bu$, where $A = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}$ & $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, $R = [2]$, $Q = \begin{bmatrix} 2 & 0 \\ 0 & 0 \end{bmatrix}$. ***(03)***