Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY
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I SEMESTER M.TECH (ESM / PED)
MAKEUP EXAMINATIONS, DECEMBER 2017
SUBJECT: CONTROL SYSTEM DESIGN [ELE 5101]
REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 20 December 2017** **MAX. MARKS: 50**

Instructions to Candidates:
- Answer **ALL** the questions.
- Missing data may be suitable assumed.
- Permitted to use **MATLAB.**

1A. For the digital control system with $G(s) = \frac{K}{s(s+2}$, design a digital lead compensator $G_C(z)$ so that the system will operate with ζ =0.479 and $\omega_d = 3.66 rad/\sec$ i) obtain the open loop pulse transfer function of uncompensated system with ZOH ii) obtain the response of compensated system for verifying the design specifications iii) obtain the finite steady state error of the compensated system and un compensated system. Sampling time T=0.2sec. ***(08)***

1B. Derive the mapping of constant ‘ settling time ‘ from s plane to z plane ***(02)***

2A. Determine the increase in gain and phase lag network compensation required to stabilize a unity feedback system with feed forward transfer function $G(s) = \frac{K}{s(s+1)(0.5s+1)}$, The requirement for the system phase margin is 40° and the velocity constant 5sec^{-1}. Compare the ramp response of un compensated and compensated system. ***(05)***

2B. Using the describing function analysis, predict the existence of the limit cycle for the system with saturation non-linearity and linear plant with transfer function $G(s) = \frac{16}{s(s+2)^2}$.

The describing function for the non-linear element is $G_N = \frac{k}{\pi}[2\beta + \sin 2\beta]\ for\ M \geq 2$, $G_N = k\ for M < 2$, with input $m(t) = M \sin \omega t$, k =5 is the slope. Draw the input- output waveform.

Also determine the amplitude and frequency of the limit cycle. Assess the stability of the limit cycle. ***(05)***

3A. For the transfer function $G(s) = \frac{s^2 + 3s + 2}{s^4 + 14s^3 + 65s^2 + 100s}$, i) obtain the state model in observable canonical form ii) draw the state diagram ii) find the controllability and observability of the system. ***(04)***

3B. For the negative unity feedback system with plant transfer function $G(s) = \dfrac{K}{(s+1)(s+2)(s+10)}$, is operating with a damping ratio of 0.2, Design a PI controller and analyze its performance. ***(03)***

3C. Explain Kalman filter with relevant equations, block diagram. ***(03)***

4A. What is meant by stability in the sense of Lyapunov ***(03)***

4B. For the system represented by the following state model

$$\dot{x} = \begin{bmatrix} -5 & 1 & 0 \\ 0 & -2 & 1 \\ 0 & 0 & -1 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u,\ y = \begin{bmatrix} -5 & 5 & 0 \end{bmatrix} x$$

i) design a state feedback controller to obtain 20% overshoot and a settling time of 4 second, the third pole at s=-6. ii) design an observer that should have time constant 10 times smaller than the system with controller. iii) draw the state diagram of the system with controller and observer . ***(07)***

5A. 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 $A = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}$ & $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, $R = [1]$, $Q = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$. ***(03)***

5B. Find a Liapunov function for the given linear time invariant system and hence find the stability of the equilibrium point.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

(04)

5C. Explain model reference adaptive control scheme with relevant equations and block diagram. ***(03)***