Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY
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A Constituent Institution of Manipal University

I SEMESTER M.TECH (POWER ELECTRONICS & DRIVES / ENERGY SYSTEMS & MANAGEMENT)

END SEMESTER EXAMINATIONS, NOV/DEC 2016

SUBJECT: CONTROL SYSTEM DESIGN [ELE 5101]

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.
- Use of **MATLAB/Simulink** is permitted

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 =0.5 and a settling time of 2 seconds 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 iv) obtain the finite steady state error of the compensated system and un compensated system . Sampling time T=0.2sec. ***(08)***

1B. Derive and explain the mapping of constant setting time Ts line from s plane to z plane. ***(02)***

2. For the negative unity feedback system with feed forward transfer function $G(s) = \frac{4K}{s(s+0.5)}$, design a lag-lead compensator using root locus method to obtain damping ratio 0.5, undamped natural frequency 5rad/sec and static velocity error constant 80sec^{-1}. Compare the step response and ramp response of un compensated and compensated system. Draw the circuit schematic of the compensator. ***(10)***

3A. For the negative unity feedback system with feed forward transfer function $G(s) = \frac{K}{s(s^2+s+4)}$, determine the value of gain K such that the phase margin is 50^{o}. What is the gain margin with this gain K. ***(05)***

3B. For the negative unity feedback system with plant transfer function $G(s) = \frac{4}{s^3+6s^2+8s+4}$, design a PID Controller and obtain the range of controller parameters such that the closed loop system have overshoot between 15% and 10% and the resulting settling time will be less than 3 sec. ***(05)***

4A. Determine the equilibrium points and investigate the stability of the following system using Liapunov stability analysis.

$$\dot{x}_1 = -x_1^3 + x_2$$
$$\dot{x}_2 = -ax_1 - bx_2; \;\; a > 0, b > 0$$

(03)

4B. A boost converter is represented by the following state model $\begin{bmatrix} \dot{i}_L \\ \dot{v}_C \end{bmatrix} = \begin{bmatrix} 0 & -83.33 \\ 500 & -10 \end{bmatrix} x + \begin{bmatrix} 166.67 \\ 0 \end{bmatrix} E_s \;\; y = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} i_L \\ v_C \end{bmatrix}$ i_L be the current through the inductor, E_S be the dc input voltage and u_c the capacitor voltage which is the converter output. i) design a state feedback controller to obtain 20% overshoot and a settling time of 0.5second iii) 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. A continuous time system described by $\dot{x} = Ax + Bu$, where $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix}$ & $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$, performance index $J = \int_0^{\infty} (x^T Q x + u^T R u) dt$, $R = 0.01$, $Q = \begin{bmatrix} 100 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$, solve for i) the positive definite solution matrix 'P' of the Riccati equation ii) the optimal feedback gain matrix 'K' and iii) the eign values of A-BK

(05)

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

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -1 & 1 \\ 2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

(05)