Reg. No.									

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

VI SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, APRIL / MAY 2019

SUBJECT: CONTROL SYSTEMS DESIGN [ELE 4013]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 30, April 2019** **Max. Marks: 50**

Instructions to Candidates:

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

1. For the unity feedback system with $G(s) = \frac{6}{(s+2)(s+1)(s+3)}$, design an initial stable P, PI, PD and PID controllers using Zeigler Nichols tuning method and tabulate transfer function of controllers, their gain, transient and steady state error of compensated and un compensated systems.

Draw the responses in one graph, including uncompensated system.

Obtain the active circuit for realizing the PI controller. **(10)**

2A. Given a unity feedback system with $G(s) = \frac{100}{s(s+1)(0.1s+1)}$, design a lag compensator using frequency domain methods to so that the phase margin of the compensated system is 45°. **(05)**

2B. For the system $\dot{x} = \begin{bmatrix} 0 & 1 \\ -1 & a \end{bmatrix} x + \begin{bmatrix} 1 \\ b \end{bmatrix} u$, draw the region in the a-b plane such that the system is completely state controllable.

Explain the significance of state controllability and state observability in design. **(05)**

3. Design a linear state feedback controller that places the system poles at $s = -2 \pm j4 \; and \; s = -10$

$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -5 & -6 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u \quad y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} x$$

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 system with controller and observer.

Design a state feedback controller and integrator, plot step response of system with state feedback controller alone and the controller with integrator.

Clearly derive the state equations to be used for obtaining the plot, using a neat block diagram. ***(10)***

4A. Explain Kalman filter with relevant mathematical equations and block diagram. ***(02)***

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 equilibrium point using Lyapunov stability criterion and also derive the corresponding Lyapunov function. State Lyapunov stability theorem for asymptotic stability ***(04)***

4C. Explain with a neat block diagram and relevant equations i) model reference control system ii) adaptive control scheme using MIT rule and Lyapunov rule. ***(04)***

5A. For the system given in Fig.Q5A, predict the possibility of a limit cycle. If it exists determine the amplitude and frequency. Also investigate the stability of the limit cycle. Verify the answer using MATLAB.

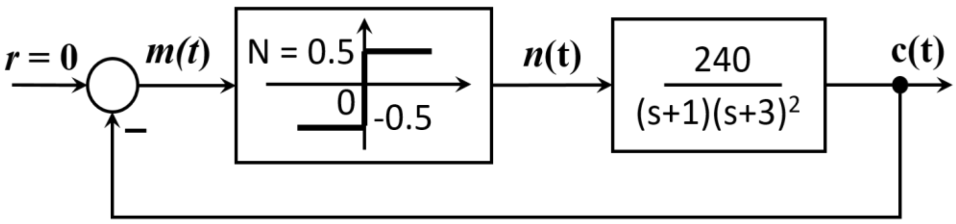

Fig.Q5A ***(04)***

5B. Derive an optimal feedback control law that minimizes the performance measure using reduced matrix Riccati equation

$J = \frac{1}{2}\int_0^{\infty}(Y^TY + U^TU)dt$, for the system described by

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u;\ \ y = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} x;\ \ x(0) = [1 \quad -1]^T x$$

Verify the answers using MATLAB, plot the system response with controller. ***(06)***