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

VI SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING) MAKE-UP EXAMINATIONS, JUNE 2019

SUBJECT: CONTROL SYSTEMS DESIGN [ELE 4013]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 14 June 2019** **Max. Marks: 50**

Instructions to Candidates:

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

1A. For the unity feedback system with $G(s) = \frac{K}{s(s+5)(s+15)}$, is operating with 20% overshoot, design a PD controller to obtain 4 times reduction in settling time, using root locus method. **(06)**

1B. Explain Zeigler Nichols tuning method for the design of stable controllers. **(04)**

2A. For the unity feedback system with $G(s) = \frac{K}{s(s+1)(0.5s+1)}$, design a lag compensator to satisfy the following specifications. Static velocity error constant 5 sec^{-1}, phase margin 40^o **(05)**

2B. Explain state Controllability and state observability. Discuss Gilberts test and Kalman's test. **(05)**

3. Design a linear state feedback controller to yield a peak overshoot of 20% and settling time less than 4 sec for the given system state space model

$$\dot{x} = \begin{bmatrix} -5 & 1 & 0 \\ 0 & -2 & 1 \\ 0 & 0 & -1 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u \quad y = \begin{bmatrix} -5 & 5 & 0 \end{bmatrix} x;$$ consider the third pole at s=-6.

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 i)limit cycle ii) Jump phenomenon of nonlinear systems *(04)*

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

4C. Explain adaptive control scheme using MIT rule and Lyapunov rule. *(02)*

5A. For the system given in Fig.Q5A, predict the possibility of a limit cycle.

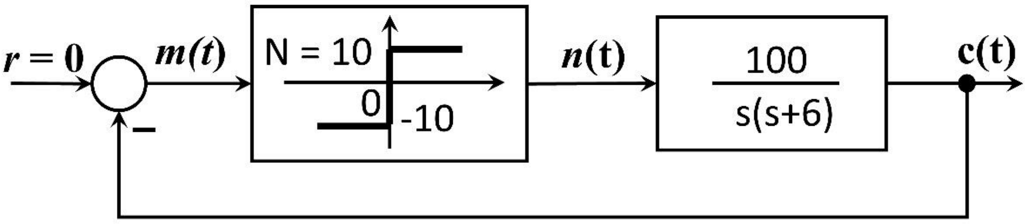

Fig.Q5A *(04)*

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

$J = \int_0^{\infty} (x_1^2 + x_2^2 + u^2) dt$, for the system described by

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

Verify using MATLAB, plot the system response with controller. Find J_{min}. *(06)*