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

FIRST SEMESTER M.TECH. (POWER ELECTRONICS & DRIVES / ELECTRIC VEHICLE TECHNOLOGY) END SEMESTER EXAMINATIONS, JANUARY 2023

DESIGN OF CONTROL SYSTEMS [ELE 5152]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 03 January 2023** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. Derive the transfer function $G(s) = \frac{\theta_L(s)}{E_a(s)}$ of this motor, if it drives an inertia load of 100 kg-m^2 through a gear train as shown in Fig 1. If the inertia and damping of the armature are 5kg-m^2 and 1 N-m/rad respectively. The torque – speed relation is given by $T_m = -0.1w_m + 100$

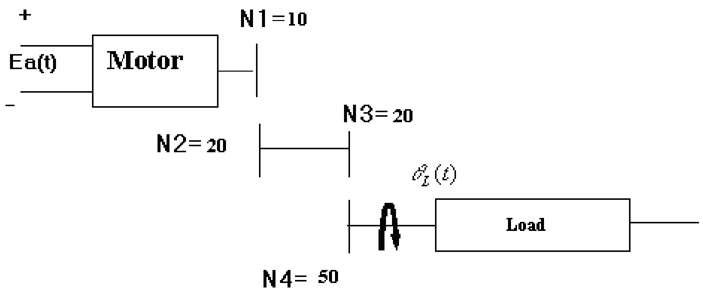

Fig 1A. **(04)**

1B. An industrial Robot system with controller is represented by the closed loop transfer function

$$G(s) = \frac{K}{(s+10)(s^2+4s+10)}$$

i) Check for second order approximation

ii) Obtain the time domain specifications percentage overshoot, settling time and peak time of the step response. **(04)**

1C. Realize the PI controller using an operational amplifier circuit. **(02)**

2A. For the transfer function $\frac{Y(s)}{R(s)} = \frac{(s+4)}{(s+1)(s+2)(s+5)}$, derive the state model in i) controllable canonical form ii) parallel form. Using parallel form analyze the controllability and observability of the system. **(04)**

2B. The state space model of DC -DC Converter is given as $\begin{bmatrix} \dot{i_L} \\ \dot{v_C} \end{bmatrix} = \begin{bmatrix} -3 & 1 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} i_L \\ v_C \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u; y = \begin{bmatrix} 2 & 1 \end{bmatrix} \begin{bmatrix} i_L \\ v_C \end{bmatrix}$, i) design a state feedback controller that places the closed loop poles at $-3 \pm j4$. Use coefficient matching method. ***(03)***

2C. The state space model of DC -DC Converter is given as $\begin{bmatrix} \dot{i_L} \\ \dot{v_C} \end{bmatrix} = \begin{bmatrix} -3 & 1 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} i_L \\ v_C \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u; y = \begin{bmatrix} 2 & 1 \end{bmatrix} \begin{bmatrix} i_L \\ v_C \end{bmatrix}$, i) design an observer 5 times faster than the controller loop poles at $-3 \pm j4$. Use coefficient matching method. ***(03)***

3A. A Linear Time Invariant system is represented by the state equation $\dot{x} = \begin{bmatrix} -2 & 1 \\ 0 & -2 \end{bmatrix} x$, Using Lyapunov stability criterion, assess the stability of the system, and also find the corresponding Lyapunov function. ***(04)***

3B. Derive state regulator using Lyapunov Method and optimal control theory. ***(03)***

3C. Discuss the significance of controllability and observability in controller design? ***(03)***

4A. For a system represented by a state model $\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$, $x(0) = \begin{bmatrix} 1 & -1 \end{bmatrix}^T$, design using reduced matrix Riccati equation, an optimal control law that minimizes the performance index $J = \int_0^\infty (4x_1^2 + u^2)\, dt$. Comment on stability of the compensated system. ***(04)***

4B. Discuss the procedure for designing a stable PID controller using Zeigler Nichols tuning method. ***(03)***

4C. Discuss the Procedure for LAG compensator design using frequency domain methods ***(03)***

5A. Explain System identification with an example. ***(02)***

5B. Derive Model reference control with suitable example ***(03)***

5C. Design a sliding mode control scheme for a single mass motion control. Show how can we extend this for a Buck converter application. ***(05)***