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

I SEMESTER M.TECH (ENERGY SYSTEMS & MANAGEMENT / POWER ELECTRONICS & DRIVES)
END SEMESTER EXAMINATIONS, NOVEMBER 2019
DESIGN OF CONTROL SYSTEMS [ELE 5152]
REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 21,November 2019** **Max. Marks: 50**

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

1. A dc motor develops 50N-m of torque at a speed of 500rad/sec when 10 volts applied. It stalls out at this voltage with 100 N-m of torque. If the inertia and damping of the armature are 5kg-m^2 and 1 N-m/rad respectively.

i. Find the transfer function $G(s) = \dfrac{\theta_L(s)}{E_a(s)}$ of this motor, if it drives an inertia load of 100 kg-m^2 through a gear train as shown in Fig 1.

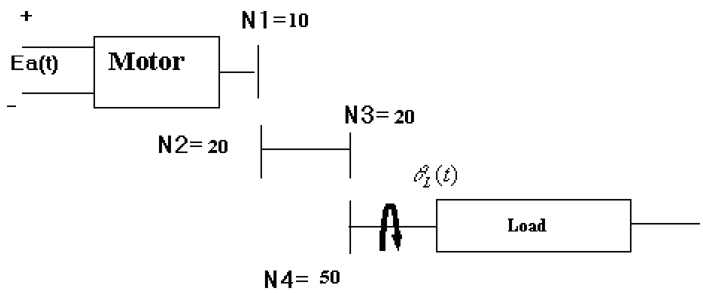

Fig 1.

ii. Evaluate the system time domain specifications and steady state error

iii. Design a suitable cascade controller using root locus method or Zeigler Nichols tuning method to reduce the percentage overshoot to one third and steady state error to zero.

iv. Obtain the controller circuit realization (only circuit)

v. How do you verify the second order approximation of compensated system? **(10)**

2A. Explain the design procedure of lag compensator using frequency domain methods. **(04)**

2B. Design an adaptive model reference control for DC motor speed control. **(06)**

3. For the system transfer function $\frac{y(s)}{u(s)} = \frac{1}{s(s+1)(s+2)}$, when the system state model is in controllable canonical form:

i. design a state feedback controller with desired closed loop poles $s = -2 \pm j2\sqrt{3}$, s=-10.

ii. Design an observer which is 10 times faster than the control loop.

iii. Obtain the step response of the system with controller, comment on the performance.

iv. Design an integrator with state feedback controller, comment on the performance.

v. Draw the block diagram of the system with both controllers and observer, derive from fundamentals the equations used for the design.

vi. Comment on uncompensated system controllability and observability. **(10)**

4A. Explian the state regulator using Lyapunov method. **(02)**

4B. For the system represented by the state model, $\dot{x} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$;

$y = [2 \quad 0]x$, $x(0) = [1 \quad -1]^T$,

i) design an optimal feedback control law that minimizes the performance measure $J = \frac{1}{2}\int_0^\infty (Y^T Y + U^T U)\, dt$, using matrix Riccati equation.

ii) find the minimum value of J.

iii) analyse the stability of the system with and without controller. **(05)**

4C. State and explain Lyapunov stability theorems. **(03)**

5A. From fundamentals, identify a suitable model of a boost converter (with varying PWM) through Least square data fit technique. **(04)**

5B. i) With a suitable example, state the involved equation and explain the Kalman filter algorithm.

ii) For the system given in Q.4B., design an appropriate linear quadratic Gaussian controller. **(04)**

5C. With respect to a relay system explain the sliding mode control scheme. **(02)**