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MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
A Constituent Institution of Manipal University

VI SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
END SEMESTER EXAMINATIONS, APRIL - MAY 2017

SUBJECT: CONTROL SYSTEM DESIGN [ELE4013]
REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 29, April 2017** **Max. Marks: 50**

Instructions to Candidates:

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

1A. Design a Lead compensator using root locus method for the unity feedback system with $G(s) = \dfrac{K}{s(s+5)(s+11)}$ to satisfy the following specifications. The system operates with a damping ratio of ζ=0.5 , reduce the peak time and percentage overshoot by a factor of 2. Verify performance of the compensated system. Clearly write the design procedure and relevant design values.

Obtain passive circuit realization for the above designed controller. ***(06)***

1B. Design a lag compensator using frequency domain methods for the unity feedback system with $G(s) = \dfrac{K}{s(s+1)(0.5s+1)}$ to satisfy the following specifications. Staic velocity error constant to be 5 sec^{-1}, phase margin 40^{o} , gain margin to be 10dB or more. Verify the performance. ***(04)***

2A. For the spring –mass-damper system shown in Fig 2A, compare the performance of P/PI/PID controller for obtaining overshoot below 10% and settling time less than 1 sec.

M=1 kg; B=10N sec / m; k=20N/m; Unit step force applied to the system. Give the results in the form of transfer function of each controller and step response of uncompensated and compensated systems. Also compare steady state error of compensated system in each case. ***(05)***

2B. Explain Kalman filter with relevant equations, block diagram and with a suitable example. ***(03)***

2C. Derive the optimal state feedback controller using reduced matrix Riccati equations. ***(02)***

3A. Design a linear state feedback controller to yield peak overshoot of about 10% and a settling time of less than 0.5sec for the system represented by the state space model

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -3 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \quad and \quad y = \begin{bmatrix} 1 & 0 \end{bmatrix} x$$

Evaluate the steady state error for step input ii) design an observer which is 5 times faster than the control loop, plot the estimated states for zero initial values iii) design an integrator and state feedback controller combination and compare the performance.

Draw the state model of the system with integrator and state feedback controller. ***(07)***

3B. Explain Model reference adaptive control scheme with relevant equations, block diagram and with a suitable example **(03)**

4A. Assess the stability of equilibrium state of a nonlinear system represented by the state equations given below. Use Lyapunov stability criterion.

$$\dot{x}_1 = -x_1 + x_1^2 x_2 \;;\;\; \dot{x}_2 = -x_2$$

Draw the region of stability and un stability. **(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 system, using Lyapunov stability criterion and also derive the corresponding Lyapunov function. **(04)**

4C. Describe the condition of boundedness and asymptotically with respect to non- linear stability analysis using Lyapunov method. **(02)**

5A. Using the describing function analysis, find the range of k for which a limit cycle is predicted for the system shown in Fig 5A.

The describing function for the non-linear element is

$$G_N = \frac{4N}{\pi M}\cos\beta + \frac{k}{\pi}[\pi - 2\beta - \sin 2\beta] \;\; for\; M \geq 1,\; N = 1, \text{ with input } \; m(t) = M \sin \omega t$$

Draw $n(t)$. Also determine the amplitude and frequency of the limit cycle. **(06)**

5B. Derive the describing function for cubic non- linearity. **(02)**

5C. Describe subharmonic oscillation and jump resonance property of non-linear systems. **(02)**

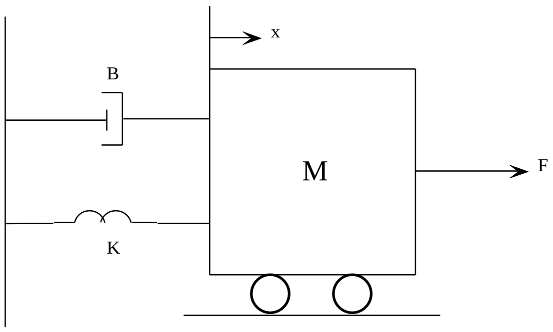

Fig.2A

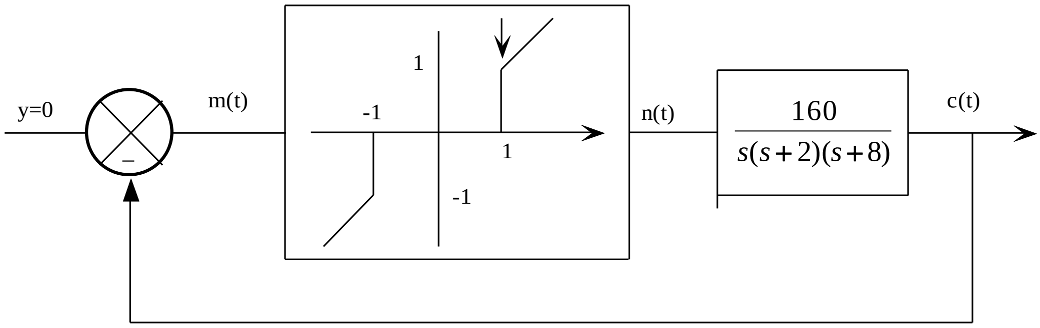

Fig 5A