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MANIPAL INSTITUTE OF TECHNOLOGY
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I SEMESTER M.TECH (ENERGY SYSTEMS AND MANAGEMENT / POWER ELECTRONICS AND DRIVES) END SEMESTER EXAMINATIONS, NOV 2017

SUBJECT: CONTROL SYSTEM DESIGN [ELE 5101]

REVISED CREDIT SYSTEM

Time: 3 Hours | **Date: 16 November 2017** | **MAX. MARKS: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.
- Permitted to use **MATLAB.**

1A. For the digital control system with $G(s)=\frac{K}{s(s+1)}$, design a digital lead compensator $G_C(z)$ so that the system will operate with ζ =0.5 and $\omega_d = 3.92\, rad/\sec$ obtain i) the open loop pulse transfer function of uncompensated system with ZOH ii) the response of compensated system for verifying the design specifications iv) the finite steady state error of the compensated system and un compensated system. Sampling time T=0.2sec. ***(08)***

1B. Derive the mapping of constant ‘ damping ratio loci ‘ from s plane to z plane ***(02)***

2A. Determine the increase in gain and phase lag network compensation required to stabilize a unity feedback system with feed forward transfer function $G(s)=\frac{K}{s(s+3)(s+4)}$, The requirement for the system damping ratio is 0.707 and the velocity constant is $100 sec^{-1}$. Compare the step response and ramp response of the un compensated and compensated system. ***(05)***

2B. Using the describing function analysis, find the range of k for which a limit cycle is predicted for the system with saturation non-linearity and linear plant with transfer function $G(s)=\frac{160}{(s+2)(s+4)(s+6)}$.

The describing function for the non-linear element is

$$G_N = \frac{k}{\pi}[2\beta + \sin 2\beta] \; for\; M \ge a \;,\; G_N = k \; for M < a$$, with

input $m(t) = M \sin \omega t$, k is the slope. Draw the input- output waveform.

Also determine the amplitude and frequency of the limit cycle. ***(05)***

3A. For the transfer function $G(s)=\frac{s+6}{s^3+5s^2+7s+3}$, i) obtain the state model in Jordan canonical form ii) draw the state diagram ii) find the controllability and observability of the system. ***(04)***

3B. For the negative unity feedback system with plant transfer function $G(s)=\dfrac{4}{s^3+6s^2+8s+4}$, obtain an initial stabilizing PID controller using Zeigler Nichols method and analyze its performance. ***(03)***

3C. Explain Kalman filter with relevant equations and block diagram. ***(03)***

4A. Describe the condition of boundedness and asymptotically with respect to non- linear stability analysis using Lyapunov method. ***(03)***

4B. For the system represented by the following state model

$$\dot{x}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -8 & -14 & -7\end{bmatrix}x+\begin{bmatrix}0\\0\\1\end{bmatrix}u,\ y=\begin{bmatrix}3 & 1 & 0\end{bmatrix}x$$

i) design a state feedback controller to obtain 4.33% overshoot and a settling time of 6sec, the third pole at s=-3.

ii) design an observer that should have time constant 10 times smaller than the system with controller.

iii) draw the state diagram of the system with controller and observer . ***(07)***

5A. Obtain the control law that minimizes the performance index $J=\int_0^{\infty}(x_1^{\ 2}+u^2)dt$, for the system described by $\dot{x}=Ax+Bu$, where $A=\begin{bmatrix}0 & 1\\ 0 & 0\end{bmatrix}$ & $B=\begin{bmatrix}0\\1\end{bmatrix}$, $R=[2]$, $Q=\begin{bmatrix}2 & 0\\ 0 & 0\end{bmatrix}$. ***(03)***

5B. Find a Liapunov function for the given linear time invariant system and hence find the stability of the equilibrium point.

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}-1 & 1\\ -1 & -1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

(04)

5C. Explain adaptive control scheme with relevant equations and block diagram. ***(03)***