Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.TECH(EE)/SEM-2/CAM-201/2012

2012

CONTROL SYSTEMS – II

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer any *five* questions. 5 × 14 = 70

1. a) Explain what you mean by describing function.

   b) Obtain the describing function of 'dead-zone with saturation' nonlinearity. Use standard notation. 3 + 11

2. a) Describe Krasovaskii's method for determination of stability of nonlinear systems.

   b) Determine stability of the origin of the following system by Lyapunov's method :

$$\dot{x}_1 = -x_1 + x_2 + x_1 (x_1^2 + x_2^2)$$

$$\dot{x}_2 = -x_1 - x_2 + x_2 (x_1^2 + x_2^2)$$ 5 + 9

3. a) Find the extremal for the functional,

$$J (\underline{x}) = \int_0^{\pi} [\dot{x}_1^2 (t) + \dot{x}_2^2 (t) + 2 x_1 (t) x_2 (t)] \, dt$$

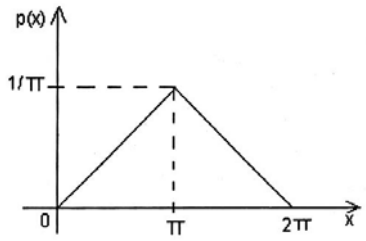
b) Find the curve x^* that passes through $x(0) = 1$ and $x(1) = 4$ and minimizes the functional,

$$J(x) = \int_0^1 [0 \cdot 5\dot{x}^2(t) + 2x^2(t) + 3x(t)\dot{x}(t) + 4x(t)]\,dt$$

7 + 7

4. a) Distinguish between a random variable and a random process.

A random variable has the probability density function as shown below. Obtain its mean, variance and standard deviation.



b) What do you mean by a First Order Markov process ?

Obtain the transfer function of the shaping filter that will convert a unity white noise signal into a noise signal having a spectral density function,

$$S(\omega) = \frac{(\omega^2 + 1)}{(\omega^4 + 8\omega^2 + 16)}$$

7 + 7

5. a) Using standard notations and mentioning the assumptions made, derive the standard Kalman filter algorithm. The following formulae may be used :

$$\frac{\partial}{\partial x} tr\,[AXB\,] = A^T B^T,\ \frac{\partial}{\partial x} tr\,[AX^T\,] = A \text{ and}$$

$$\frac{\partial}{\partial x} tr\,[XBX^T\,] = XB^T + XB$$

b) What do you mean by 'bad-data problem' in Kalman filter implementation ? How can it be overcome ? 11 + 3

6. a) Define sensitivity function. What do you mean by 'structured and unstructured uncertainty' and 'additive and multiplicative uncertainty' ?

b) Show that for a SISO system to have robust stability under multiplicative uncertainty the following condition is to be satisfied :

$\| W_2 T \|_\infty < 1$, where W_2 and T have their usual meanings.

c) An uncertain LTI system has the following characteristic equation :

$p(s) = s^3 + p_2 s^2 + p_1 s + p_0$ where $p_2 \in [7, 25]$,
$p_1 \in [12, 100]$, $p_0 \in [8, 60]$

Determine whether the system is stable. 5 + 4 + 5

7. Write short notes on any *two* of the following : 7 + 7

a) Jump resonance and sub-harmonic oscillations

b) Various optimal control problems

c) Linearized Kalman Filter

d) LQG control.

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