

CS/B.Tech-(ICE-NEW)/SEM-6/IC-602/2013 2013 ADVANCED CONTROL SYSTEM

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.

GROUP – A (Multiple Choice Type Questions)

- 1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$
 - i) A matrix is said to be positive semidefinite for all *X*, if

a) $X \stackrel{T}{=} Q \stackrel{X}{=} > 0$ b) $X \stackrel{T}{=} Q \stackrel{X}{=} \ge 0$ c) $X \stackrel{T}{=} Q \stackrel{X}{=} 2$ d) $X \stackrel{Q}{=} Q \stackrel{X}{=} 2$.

ii) The sufficient conditions for a relative minimum of a twice differentiable function f(x) at an interior point x^* is

a)
$$\frac{\partial f}{\partial x}\Big|_{X^*} > 0$$

b) $\frac{\partial f}{\partial x}\Big|_{X^*} = 0$
c) $\frac{\partial^2 f}{\partial x^2}\Big|_{X^*} \le 0$
d) $\frac{\partial^2 f}{\partial x^2}\Big|_{X^*} > 0.$

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then the target set is a

iii)

- In the minimum time problem, if the final state is fired, e aria
- straight line ellipse a) b)
- hyperbola. c) parabola d)
- The variation, δv of the given functional iv)

$$v = \int_{0}^{1} (2x^{2} + x) dt \text{ is}$$

a)
$$\int_{0}^{1} (4x + 1) \delta x dt$$

b)
$$\int_{0}^{1} 2(x + 1) \delta x dt$$

c)
$$\int_{0}^{1} 4x \delta x dt$$

- d) zero.
- If x^* is a constrained extremum for a Lagrangian v) λ ($\textbf{\textit{x}}^{\,*},\,\lambda^{\,*}$), then the condition for optimality is

a)
$$\frac{\partial L}{\partial x}\Big|_{X^*, \lambda^*} = 0$$
 b) $\frac{\partial L}{\partial \lambda}\Big|_{X^*, \lambda^*} = 0$
c) both (a) and (b) d) $\frac{\partial^2 L}{\partial x^2}\Big|_{X^*, \lambda^*} = 0$

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a)
$$PI = \int_{t_0}^{t_f} \sum_{i=1}^{m} |(u_i^2 t)|^2 dt$$

b) $PI = \int_{t_0}^{t_f} \sum_{i=1}^{m} u_i^2 t dt$
c) $PI = \int_{t_0}^{t_f} \sum_{i=1}^{m} u_i^2 dt$
d) $PI = \int_{t_0}^{t_f} \sum_{i=1}^{m} u_i t^2 dt.$

vii) Which of the following terms is for sensitivity derivative of the system in the MIT rule described as
$$\frac{d\theta}{dt} = -\gamma e \frac{\delta e}{\delta \theta}$$
?

a)
$$\gamma$$
 b) e
c) $\frac{\delta e}{\delta \theta}$ d) $\frac{d\theta}{dt}$

- viii) The basic objective of the adaptive control system is monitoring of the of the control system for parametres.
 - a) performance index, unknown and varying
 - b) controlled variable, unknown and varying
 - c) controlled variable, constant and known
 - d) performance index, constant and unknown.

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vi)

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- ix) In sliding phase, which type of stability is measure
 - a) Globally finite stability
 - b) Relative stability
 - c) Asymptotic stability
 - d) Conditional stability.

x) The minimisation of
$$PI = \int_{t_o}^{t_f} |u_t| dt$$
 for a control input

- *u*(*t*) represents
- a) minimum fuel problem
- b) minimum time problem
- c) minimum energy problem
- d) all of these.
- xi) In sliding mode control, if $\sigma(x) > 0$, for the function sign ($\sigma(x)$), then the control gain (ρ) would be
 - a) $\rho > 0$ b) $\rho < 0$
 - c) $\rho \ge 0$ d) $\rho \le 0$.
- xii) In input/output linearization technique, the number of internal dynamies is
 - a) n-r b) n+r
 - c) *n* d) *r*.

CS/B.Tech-(ICE-NEW)/SEM-6/IC602/2013 xiii) Minimum degree pole placement algorithm is applicable for

- a) Gain scheduling b) Self tuning regulator
- c) Dual control d) none of these.

GROUP – B (Short Answer Type Questions) Answer any *three* of the following. $3 \times 5 = 15$

- 2. If a scalar valued function, $f(x) = f(x_1, x_2, \dots, x_n)$ is continuous for all $x \in \mathbb{R}^n$, find out the condition for minimization of the function f(x) applying Taylor series expansion method.
- 3. Find the equation of the curve that is an extremal for the functional $J = \int_{0}^{t_{f}} \left(\frac{1}{2} \dot{x}^{2} t\dot{x} + 2x^{2}\right) dt$

subject to the boundary conditions x(0) = 1, $t_f = 2$, and x(2) = 10.

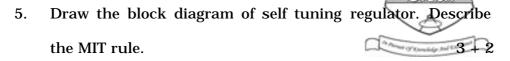
4. Let a function $f(x) = -x_1 x_2$ and $g(x) = x_1^2 + x_2^2 - 1$.

Applying Lagrange multiplier method show that the points $\left(\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right)$ and $\left(-\frac{1}{\sqrt{2}}, -\frac{1}{\sqrt{2}}\right)$ provide the minima of f(x)

subject to the constraint given by g(x) = 0.

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6. What is internal dynamics in input/output linearization method ? Find out the internal dynamic equation for the given system

$$\begin{bmatrix} \dot{x}_{1} \\ \dot{x}_{2} \\ \dot{x}_{2} \end{bmatrix} \begin{bmatrix} x_{2}^{3} + u \\ u \end{bmatrix}; y = x_{1}$$

where variables x, u and y have their usual significances.

2 + 3

GROUP – **C**

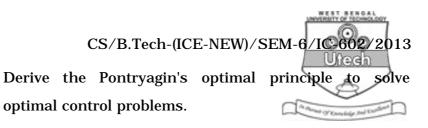
(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

- a) Describe the Euler-Lagrange equation for both end points fixed problems.
 - b) Optimize the following functional

$$L = \int_{0}^{3} \left(\dot{x^{2}}(t) + 2x(t) \dot{x}(t) + 2x^{2}(t) \right) dt$$

such that x(0) = 1 and x(3) is free. 7 + 8



b) The performance index of the system is given by

$$J = \int_{0}^{2} \left[x_{1}^{2}(t) + u^{2}(t) \right] dt.$$

The system is decribed by the equation, $\dot{x_1} = u - x_1$ with initial conditions $x_1 (0) = 1$ and $x_1 (2) = 0$. Find u (t) to minimize the system considering the above two-point boundary value problem applying Pontryagin's optimal principle. 5 + 10

9. a) Design the control law by input/output linearization method for the system

$$\dot{x}_{1} = \sin x_{2} + (x_{2} + 1) x_{3}$$
$$\dot{x}_{2} = x_{1}^{5} + x_{3}$$
$$\dot{x}_{3} = x_{1}^{2} + u$$
$$y = x_{1}.$$

b) What is reaching phase in sliding mode control ? Find the general value of reaching time from a Lyapunov function V(x) and the switching variable σ(x).

$$9 + (2 + 4)$$

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8.

a)

- 10. a) Why feedback linearization is important over Jacobian linearization ?
 - b) Consider an non-linear system with state equations

 $\vec{x}_1 = x_2$ $\vec{x}_2 = C_1 (1 - x_1^2) x_2 - C_2 x_1 + u$

and the output equation is $y = x_1$, where $C_1 = 0.5$ and $C_2 = 1$ are constants.

- Represent this non-linear system into "affine form".
- ii) Obtain a state feedback control law employing feedback linearization method. 1 + (2 + 12)
- 11. Write short notes on any *three* of the following : 3×5
 - a) Lagrange, Mayer and Bolza problems
 - b) State regulator (LQR) problem
 - c) Principle of optimality
 - d) Gain scheduling
 - e) Switching surface.