Total Pages—7

21·12·2015
VSSUT

(Set-Q_1)

M.Tech.-1st (PECD/C & I)

Advanced Control Systems

Full Marks : 70

Time : 3 hours

Answer **Q. No. 1** which is compulsory and any **five** from the rest

The figures in the right-hand margin indicate marks

1. Answer the following questions : 2×10

(*a*) A non-linear system has an input-output model given by

$$\frac{dy(t)}{dt} + (1 + 0\cdot 2y(t))y(t) = u(t) + 0\cdot 2u(t)^3$$

Compute the operating point(s) for $u_Q = 2$. Assuming it is an equilibrium point.

(*b*) Determine the transfer function of a linear time invariant system given the following information :
The system has relative degree 3.
It has 3 poles of which 2 are at –2 and –4.

(Turn Over)

The impulse response resembles a step response for a stable linear system with a steady state value of 0·25.

(*c*) Show that the Nyquist Plot of

$$G(s) = \frac{1}{s+a}$$

is a semicircle of radius $\frac{1}{2a}$ and centre at $\left(\frac{1}{2a}, 0\right)$.

(*d*) Find the zero dynamics of a non-linear system given by

$$\dot{x}_1 = 10x_1 - 10x_2$$

$$\dot{x}_2 = 16 \cdot 925x_1 - 16x_2 - 0 \cdot 1(u - \tan^{-1} x_2)$$

$$y = x_2 + d_0$$

Comment on the stability of the zero dynamics.

(*e*) Find the stability of the non-linear system

$$\dot{x}_1 = 10x_1 - 10x_2$$

$$\dot{x}_2 = 16 \cdot 925x_1 - 16x_2 + 0 \cdot 1\tan^{-1}(x_2) - 0 \cdot 1u$$

$$y = x_2$$

(*f*) Distinguish between fast poles and dominant poles of a system. Compare their transient behavior. If the system poles are at (-1; $-2 \pm j6$; -4; $-5 \pm j3$) identify fast and dominant poles.

(*g*) One of the possible solutions to a control problem is via inversion. What is the control law in such a case ?

(*h*) Using Nyquist plot how the relative stability specifications can be determined.

(*i*) Draw the structure of Smith predictor for compensating dead time. Mid Sem Q

(*j*) The step response of a system (initially at rest) is measured to be $y(t) = 1 - 0{\cdot}5\, e^{-2t}$. Find the transfer function of the system.

2. (*a*) Find suitable values for the PID parameters using the Z-N tuning strategy for the nominal plant

$$G_0(s) = \frac{e^{-s}}{s+1}$$ 5

(*b*) A discrete time system, with input $u[k]$ and output $y[k]$, has a transfer function given by

$$G_q(z) = \frac{z - 0\cdot 8}{z^2 - 1\cdot 3z + 0\cdot 42}$$

Develop a state-space model. 5

3. (*a*) Consider a plant having a nominal model given by

$$G_0(s) = \frac{e^{-2s}}{s+1} = e^{-2s}\overline{G}_0(s)$$

Develop a Smith Predictor so that the settling time for a step reference is no more than 3 sec. Assume that the reference and disturbances are step like signals. 6

(*b*) The nominal model of an unstable system is given by

$$G_0(s) = \frac{1}{s-1}$$

Synthesize a PI controller such as the closed loop poles are located at $-0\cdot 5$ and -1. 4

4. Assume that the response of a discrete time system to a Kronecker delta (with zero initial conditions) is given by 10

$$h[k] = 2(0\cdot 5)^k - 2(0\cdot 2)^k$$

(*i*) Find the system transfer function.

(*ii*) Find the system recursive equation in shift operator form.

5. Consider a continuous-time system having a sampled transfer function given by

$$G_{oq}(z) = \frac{0\cdot1(z+0\cdot8)}{(z-1\cdot5)(z-0\cdot6)}$$

Design a minimum time dead-beat controller for step references. 10

6. (*a*) A diagonal Controller $c(s)$ is proposed to Control a MIMO plant with nominal model $G_0(s)$. If $c(s)$ and $G_0(s)$ are given by

$$G_0(s) = \begin{bmatrix} \dfrac{2}{s+1} & \dfrac{1}{(s+1)(s+2)} \\ \dfrac{1}{(s+1)(s+2)} & \dfrac{2}{s+2} \end{bmatrix}$$

$$C(s) = \begin{bmatrix} \dfrac{2}{s} & 0 \\ 0 & \dfrac{1}{s} \end{bmatrix}$$

Determine whether the closed loop is stable. 7

(*b*) Consider the matrix transfer function

$$G(s) = \begin{bmatrix} \dfrac{4}{(s+1)(s+2)} & \dfrac{-1}{(s+1)} \\ \dfrac{2}{s+1} & \dfrac{-1}{2(s+1)(s+2)} \end{bmatrix},$$

Check whether there is a zero at $s = -3$. 3

7. (*a*) Consider a plant with input $u(t)$, output $y(t)$ and transfer function

$$G(s) = \frac{16}{s^2 + 4 \cdot 8s + 16}$$

Compute the plant output for $u(t) = 0 \; \forall \; t \geq 0$, $y(0) \pm 1$ and $\dot{y}(t) = 0$. 5

(*b*) Consider a system given by its open loop transfer function

$$G(s) = \frac{(s+2)}{s(s+1)}.$$

Draw its Nyquist plot and determine stability of the associated closed loop system by applying Nyquist Stability Theorem. 5

8. (*a*) A plant has a nominal model given by

$$G_0(s) = \frac{2}{(s+1)(s+2)}$$

Synthesize a PID Controller that yields a closed-loop with dynamics dominated by the factor $s^2 + 4s + 9$. 5

(*b*) Consider a plant having a nominal model $G_0(s)$. Assume a one degree of freedom control loop with Controller $c(s)$, where

$$G_0(s) = \frac{1}{(s+1)(s+2)}, \quad c(s) = \frac{as+b}{s}$$

Find the conditions for a and b for which the nominal feedback loop is stable. 5
