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21.12.2015 VSSUT (Set-Q₁)

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

(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)

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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

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

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

$$y = x_2 + d_0$$

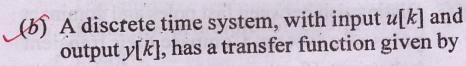
Comment on the stability of the zero dynamics.

(e) Find the stability of the non-linear system $\dot{x}_1 = 10x_1 - 10x_2$ $\dot{x}_2 = 16 \cdot 925x_1 - 16x_2 + 0.1 \tan^{-1}(x_2) - 0.1u$ $y = x_2$



- (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. Midsem Q
- (j) The step response of a system (initially at rest) is measured to be $y(t) = 1 0.5 e^{-2t}$. 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

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



$$G_q(z) = \frac{z - 0.8}{z^2 - 1.3z + 0.42}$$

Develop a state-space model.

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.

(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 -0.5 and -1.

4. Assume that the response of a discrete time system to a Kronecker delta (with zero initial conditions) is given by $h[k] = 2(0.5)^k - 2(0.2)^k$

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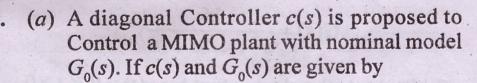
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- (i) Find the system transfer function.
- (ii) Find the system recursive equation in shift operator form.
- 5. Consider a continuous-time system having a sampled transfer function given by

$$G_{oq}(z) = \frac{0 \cdot 1(z + 0 \cdot 8)}{(z - 1 \cdot 5)(z - 0 \cdot 6)}$$

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



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

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

Determine whether the closed loop is stable.



(b) Consider the matrix transfer function

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

Check whether there is a zero at s = -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 $u(t) = 0 \forall t \ge 0$, $y(0) \pm 1$ and $\dot{y}(t) = 0$.

(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.

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 $s^2 + 4s + 9$.

(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.