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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2015

ELECTRICAL & ELECTRONICS ENGINEERING

Stream: CONTROL SYSTEMS, GUIDANCE AND NAVIGATIONAL CONTROL

01EE6103: DIGITAL CONTROL SYSTEMS

Time: 3 hours Max marks: 60

Answer any two full questions from each part.

PART–A (Module I and II)

1 a. Analyse the sampling process in frequency domain (3)

b. Obtain the frequency response characteristics of a First-Order Hold (3)

c. Find the inverse z transform of $\frac{z^{-2}}{(1-z^{-1})^3}$. (3)

2 a. Obtain the pulse transfer function of a digital PID controller (6)

b. For the following analog controller, find the transfer function of the corresponding digital controller using pole-zero matching method. (3)

$$G(s) = \frac{s+1}{s^2+5s+6}, T = 0.01$$

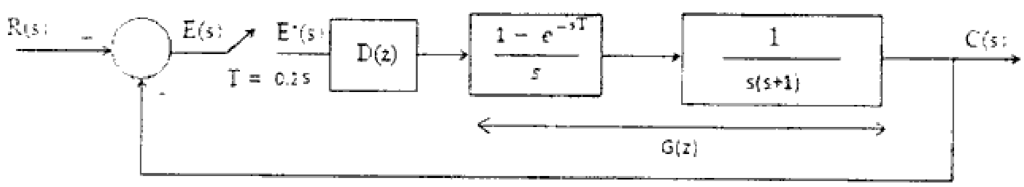
3 a. For a unity feedback system, with sampling time T=1sec, open loop pulse transfer function is $G(z) = \frac{K(0.3679z+0.2542)}{(z-0.3679)(z-1)}$. Determine the value of K for stability by use of Jury's stability test. Also determine the frequency of oscillations at the output (4)

b. Explain Folding and Aliasing (2)

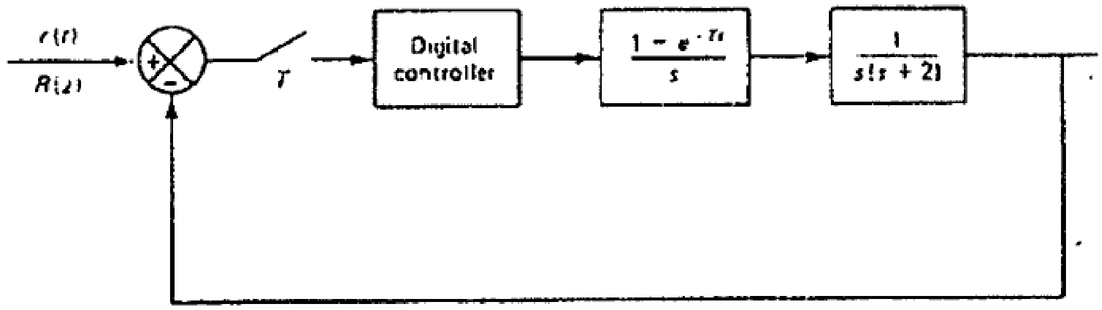
c. Explain the effects of sampling period on transient response characteristics (3)

PART–B (Module III and IV)

4 Consider the digital control system shown in figure. Design a digital controller D(z) such that the closed loop system has a damping ratio 0.5 and the number of samples per cycle of damped sinusoidal oscillation to be 8. (9)



5 Design a digital controller for the system shown in figure using Bode diagram in w plane so that the phase margin is 55° and gain margin be at least 10dB. The static velocity error consatnt be 5 sec $^{-1}$. The sampling period is 0.1 sec. (9)



6 a. Obtain the discrete time equivalent of the system (5)

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} -2 & 2 \\ 1 & -3 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} -1 \\ 5 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} 2 & -4 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + 6u(t)$$

with a sampling interval T=0.2s

b. Design a controller to place the poles at $-0.5 \pm j0.5, 0$ for the system (4)

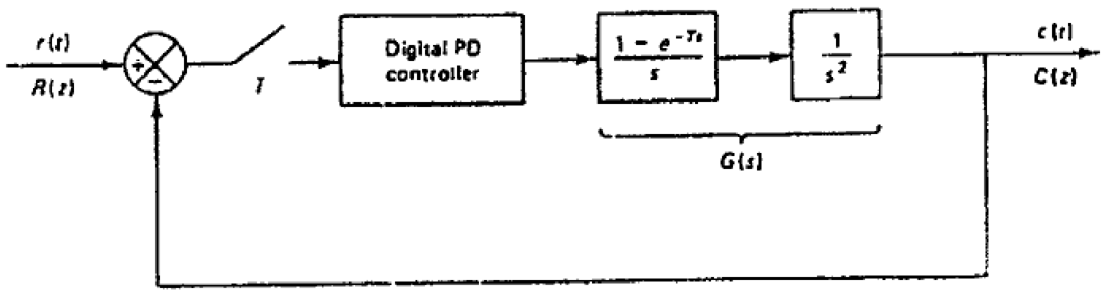
$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \\ x_3(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -4 & -2 & -1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(k)$$

$$y(k) = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix}$$

Assume any additional data if required.

PART–C (Module V and VI)

7 Design a digital propotional plus derivative controller for the system shown in figure so that the damping ratio of the closed loop poles be 0.5 and the undamped natural frequency be 4rad/sec. The sampling period is 0.1 sec. (12)



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8 a. Consider the discrete time system defined by the equation (6)

$$x(k+1) = Gx(k) + Hu(k)$$
$$y(k) = Cx(k)$$

where $G = \begin{bmatrix} 0 & 0 & -0.25 \\ 1 & 0 & 0 \\ 0 & 1 & 0.5 \end{bmatrix}, H = \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$..

Assuming that the output y(k) is measurable, design a minimum order observer, such that the error will exhibit deadbeat response.

b. Prove that if a discrete system is completely state controllable and observable, then there is no pole zero cancellation in the pulse transfer function. (6 marks) (6)

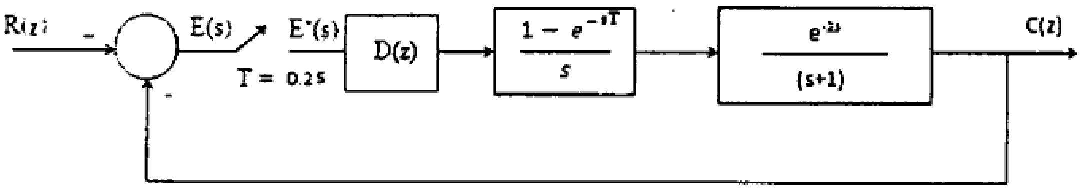
9 a. Consider a multi output linear system described by the state model (4)

$$x(k+1) = Fx(k) + Gu(k)$$
$$y(k) = Cx(k) - Du(k)$$

$$where, F = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & 1 & -1 \end{bmatrix}, G = \begin{bmatrix} 0 & 1 \\ 1 & 0 \\ 1 & 1 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}, D = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Check whether the system is observable.

b. Consider the digital control system shown in figure where the plant is of first order and has a dead time of 2sec. The sampling period is assumed to be 1 sec or T=1. Design a digital PI controller such that the dominant closed loop poles have a damping ratio of 0.5 and the no. of samples per cycle of damped sinusoidal oscillation is 10. Obtain the response of the system to a unit step input. Also obtain the static velocity error constant K_v and find the steady state error in the response to a unit ramp input. (8)



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