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Ref. No.: EX/EE/5/T/512A/2019

BACHELOR OF ENGINEERING (ELECTRICAL ENGINEERING)

5TH YEAR 1ST SEMESTER EXAMINATION- 2019

Subject: DIGITAL CONTROL TECHNIQUES

Time: Three Hours | **Full Marks: 100**

Answer ***Any Five*** questions (5×20)

Question No.			Marks
Q1	(a)	What is an Impulse Sampler? Show how it can also be referred to as an **Impulse Modulator.**	2+4
	(b)	Given $e(k)=1$ for all k, find $E(z)$. Justify the result by using Initial Value Theorem and Final Value Theorem.	2+4
	(c)	Obtain the transfer function $C(z)/R(z)$ for the closed loop configuration shown in Figure Q1(c).	8

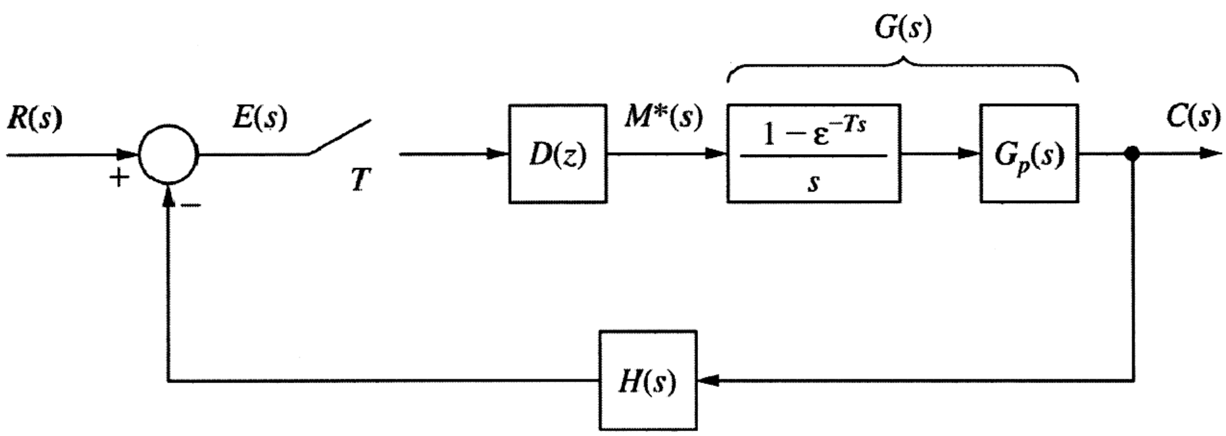

Figure Q1(c)

Q2	(a)	Show that for a Type-0 continuous-time system the sample and hold operation does not affect the static error constants.	10
	(b)	Find the expression for $e(k)$ for $$E(z) = \frac{z}{(z-1)(z-2)}$$	4
	(c)	Given the system shown in Figure Q2(c), with input $e(t)$ being a unit step function, determine the output function $C(z)$.	6

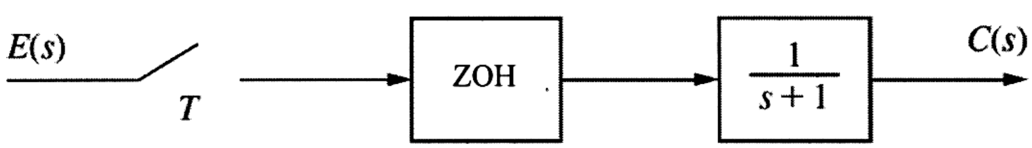

Figure Q2(c)

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Q3 (a) State and explain Jury's Stability Test for a closed-loop discrete-time system. 10

(b) The closed loop characteristic equation of a discrete-time system is given as

$$Q(z) = z^3 - 1.8z^2 + 1.05z + 0.2 = 0$$ 10

Determine whether the system is stable or not.

Q4 (a) Show how the left half of the s-plane will be mapped into the z-plane. 6

(b) Consider the system shown in Figure Q4(b). Draw the root locus and determine the range of K for which the system remains stable. 14

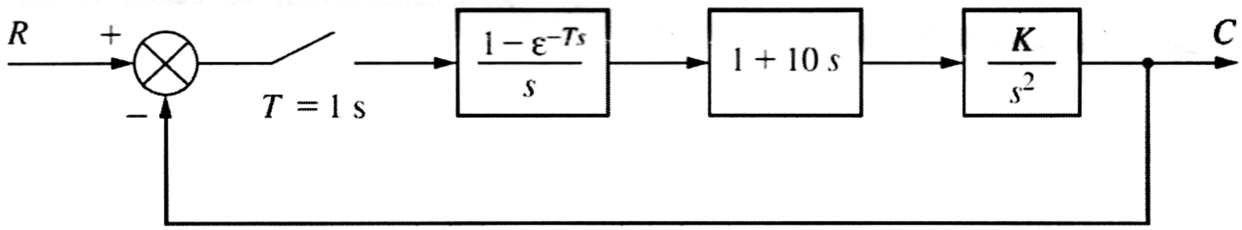

Figure Q4(b)

Q5 (a) Consider the discrete-time system defined by

$$\frac{Y(z)}{U(z)} = \frac{b_0 z^n + b_1 z^{n-1} + \cdots + b_n}{z^n + a_1 z^{n-1} + \cdots + a_n}$$

Show that a state-space representation of this system may be given by

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \\ \vdots \\ x_{n-1}(k+1) \\ x_n(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & \cdots & 0 & 0 \\ 0 & 0 & 1 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & 0 & 1 \\ -a_n & -a_{n-1} & -a_{n-2} & \cdots & -a_2 & -a_1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ \vdots \\ x_{n-1}(k) \\ x_n(k) \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \vdots \\ 0 \\ 1 \end{bmatrix} u(k)$$ 14

$$y(k) = [(b_n - a_n b_0) \quad (b_{n-1} - a_{n-1} b_0) \quad \cdots \quad (b_1 - a_1 b_0)] \begin{bmatrix} x_1(k) \\ x_2(k) \\ \vdots \\ x_{n-1}(k) \\ x_n(k) \end{bmatrix} + b_0 u(k)$$

(b) Obtain the state-variable model of the system described by the difference equation

$$y(k+2) = u(k) + 1.7y(k+1) - 0.72y(k)$$ 6

where, $u(k)$ is the input and $y(k)$ is the output of the system.

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Q6 (a) The state-space representation of an *n*-th order linear time-invariant discrete-time system is given as

$$\boldsymbol{x}(k+1) = \boldsymbol{G}\boldsymbol{x}(k) + \boldsymbol{H}u(k),$$
$$y = \boldsymbol{C}\boldsymbol{x}(k) + \boldsymbol{D}u(k)$$

Obtain the *Pulse Transfer Function* of the system. State the necessary assumptions. 4

(b) Show that the Pulse Transfer Function is invariant under the similarity transformation $\boldsymbol{x}(k) = \boldsymbol{P}\hat{\boldsymbol{x}}(k)$. 6

(c) Obtain the transfer function for the system described by the state equations 10

$$\boldsymbol{x}(k+1) = \begin{bmatrix} 1.35 & 0.55 \\ -0.45 & 0.35 \end{bmatrix} \boldsymbol{x}(k) + \begin{bmatrix} 0.5 \\ 0.5 \end{bmatrix} u(k)$$
$$\mathrm{y(k)} = [1 \quad -1]\boldsymbol{x}(k)$$

Q7 (a) Define, with the help of a block diagram, the State and Output equations in respect of a liner discrete-time invariant system. 6

(b) Consider the continuous-time system given by

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

(i) Obtain the continuous-time state space representation of the system.

(ii) Discretize the state and output equations to obtain the discrete-time state space representation of the system. 2+4+8

(iii) Determine the pulse transfer function of the system and show that it is identical to the transfer function of the system obtained by taking *z*-transform of *G*(*s*) preceded by a sampler and a ZOH.

Q8 Write short notes on ***any two*** from the following:

(a) Zero Order Hold circuit as a Data Hold Circuit. 10

(b) Significance of Bilinear Transformation in respect of discrete-time systems. 10

(c) Various types of analog and digital signals associated with a discrete-time control system. 10

(d) Non-uniqueness of discrete-time state-space representation. 10