Ref. No.: EX/PG/ETCE/T/111C/16/2017

M. ETCE 1ST SEMESTER EXAMINATION-2017

Subject: DIGITAL CONTROL SYSTEM Time: 3 Hours Full Marks: 100

Answer ANY FOUR.

All parts of the same question must be answered at one place only.

1. (a) What is similarity transformation?
   (b) Show that the stability of a system remains unchanged after similarity transformation.
   (c) Consider a system with state equation given by

$$\overrightarrow{x}(k+1)=\begin{bmatrix}0 & 1\\ 0 & .3\end{bmatrix}\overrightarrow{x}(k)+\begin{bmatrix}1\\ 1\end{bmatrix}u(k)$$

$$\overrightarrow{y}(k)=\begin{bmatrix}-2 & 1\end{bmatrix}\overrightarrow{x}(k)$$

   (i) Draw the block diagram of the system.
   (ii) Obtain the transfer function of the system
   (d) A similarity transformation of the system described above yields

$$\overrightarrow{w}(k+1)=\begin{bmatrix}d_1 & 0\\ 0 & d_2\end{bmatrix}\overrightarrow{w}(k)+\mathbf{B_w}u(k)$$

$$\overrightarrow{y}(k)=\mathbf{C_w}\overrightarrow{w}(k)$$

   (i) Determine d_1 and d_2.
   (ii) Find a similarity transformation that results in $\mathbf{A_w}=\begin{bmatrix}d_1 & 0\\ 0 & d_2\end{bmatrix}$.
   (iii) Find $\mathbf{B_w}$ and $\mathbf{C_w}$.

2+3+3+3+3+6+5=25

2. (a) Derive the transfer function of a polygonal hold circuit.
   (b) Find $C(z)$ of the system given in Fig. 1.

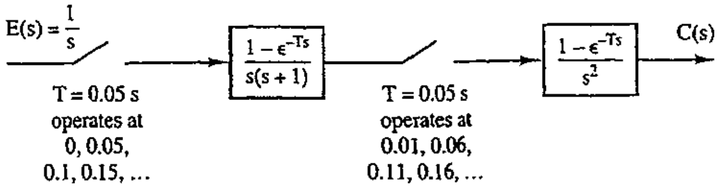

Fig. 1

   (c) Derive the state space representation of the open loop discrete-time system in Fig. 2.

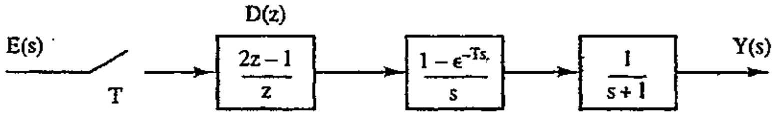

Fig. 2

7+10+8=25

3. (a) Derive the state equation of the close loop discrete-time system given in Fig. 3.

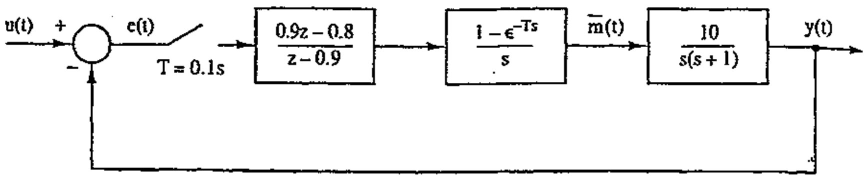

Fig. 3

   (b) Draw the signal flow diagram of the system given in Fig. 4. Hence obtain $C(z)$.

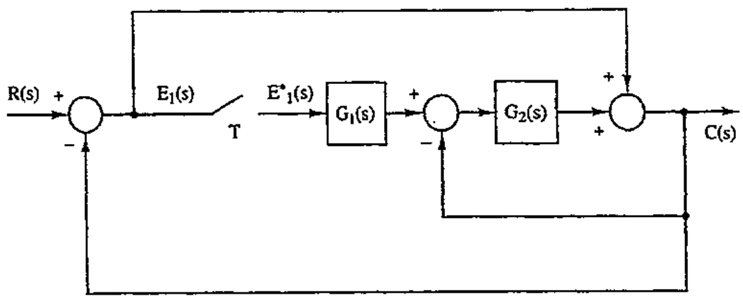

Fig. 4

16+9=25

4. (a) Comment on the stability of the system given in Fig. 5 for T=1 sec and T=0.1 sec based on the respective time constants.

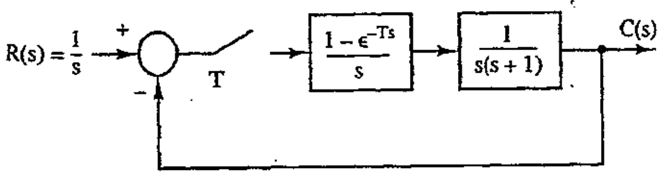

Fig. 5

(b) Find out the characteristic equation of the system given in Fig. 6.

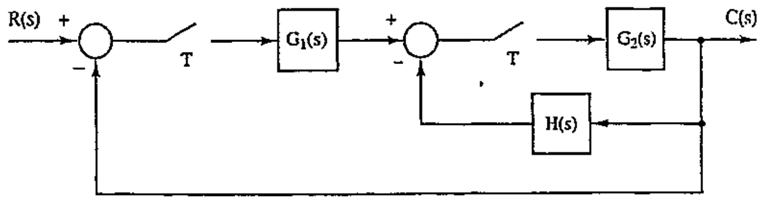

Fig. 6

(c) Explain bilinear transformation.

14+7+4=25

5. (a) Design a digital controller $D(z)$ as given in Fig. 7 to attain a steady state error less than 0.01 for unit ramp input and to ensure stability of the entire system with $G(s)=\dfrac{1-\exp(-Ts)}{s(s+1)}$ and T=0.1 sec.

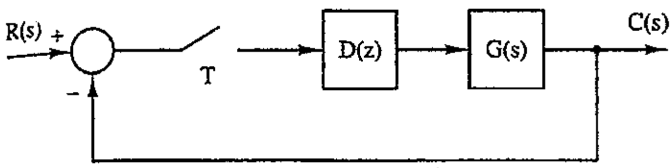

Fig. 7

(b) Find the range of K for stability of the system in Fig. 8 from its root locus.

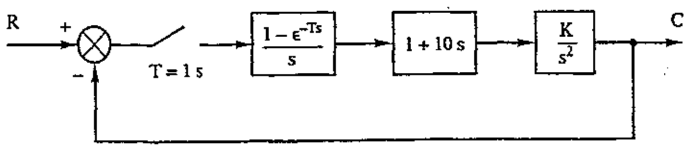

Fig. 8

(c) Find out the oscillating frequency for the marginal stability of a unity feedback discrete-time control system with

$$G(z)=\frac{0.368z+0.264}{z^2-1.368z+0.368}K\ .$$

(d) Comment on the controllability and observability of a system with

$$\vec{x}(k+1)=\begin{bmatrix}-0.2 & 0\\ -1 & 0.8\end{bmatrix}\vec{x}(k)+\begin{bmatrix}1\\ 1\end{bmatrix}u(k)$$

$$\vec{y}(k)=\begin{bmatrix}-1 & 1\end{bmatrix}\vec{x}(k)+u(k)$$

6+9+5+5=25

6. (a) Design a full state feedback of the system given in Fig. 9 to achieve a time constant of 1 sec.

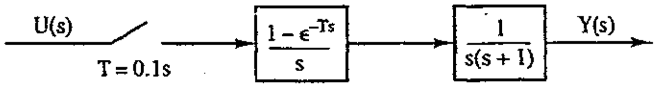

Fig. 9

(b) Prove that the state equation of a full order state observer is given by

$$\vec{q}(k+1)=[\mathbf{A}-\mathbf{GC}]\vec{q}(k)+\mathbf{G}\vec{y}(k)+\mathbf{B}\vec{u}(k)$$

where the symbols carry their usual meaning.

(c) Derive the transfer function of a reduced order observer with full state feedback.

(d) What is current observer?

10+7+7+1=25