Reg. No.

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

SIXTH SEMESTER B.TECH. (ELECTRONICS & INSTRUMENTATION ENGG.)
ONLINE GRADE IMPROVEMENT/MAKE-UP EXAMINATIONS, AUGUST - 2021

DIGITAL CONTROL SYSTEMS [ICE 4051] [P.E-II]

TIME: 2 HOURS 12-08-2021 **MAX.MARKS: 40**

Instructions to candidates: Answer any *FOUR FULL* questions.

Missing data may be suitably assumed.

Q1. A. Obtain the pulse transfer function C*(s)/R*(s) for the system shown in Figure.Q1.

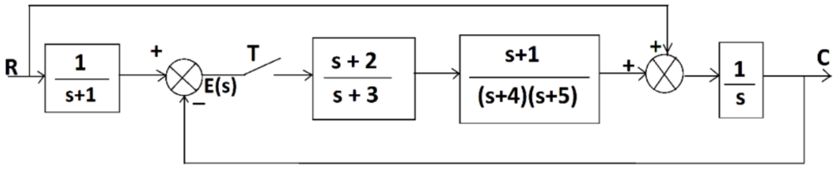

Figure. Q1

B. Obtain the unit-impulse and unit-step responses of a sampled data system, whose forward transfer function (in s-domain) is given as:

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

[5 + 5]

Q2. A. Given that the characteristic polynomial of a system, $f(z) = z^4 - 1.2z^3 + 0.07z^2 + 0.3z - 0.08$, check the stability of the system using Jury's Test. Also, verify the same using bilinear transformation method.

B. Investigate the stability of the system $GH(s) = \frac{K(1-e^{-s})}{s^2(s+2)}$ using root locus technique. Assume T = 400ms.

[5+ 5]

Q3. **A.** For the system shown in Figure.Q5, obtain the steady state error constants Kp, Kv and Ka, assuming T =1s and e(t) = 1 (t≥0).

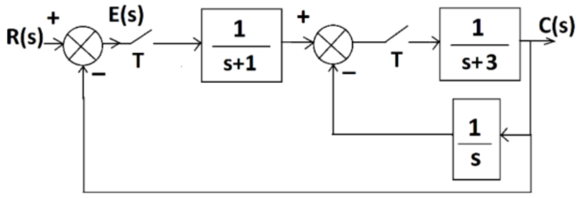

Figure.Q5

B. Express the following difference equation in its Jordan and Controllable Canonical forms:

$$y(k+3) + 7y(k+2) + 5y(k+1) - 4y(k) = u(k+1) + 3u(k)$$

[5 + 5]

Q4. **A.** Obtain the discrete-time model of the system whose continuous-time state-space model is given as follows:

$$A = \begin{bmatrix} -2 & 2 \\ 1 & -3 \end{bmatrix} \quad B = [-1 \quad 5]^T \quad C = [2 \quad -4] \quad D = [6]$$

Assume T = 20ms.

B. Compute the free-response x(k) at k = 3 using Caley-Hamilton theorem. Given:

$$x(k+1) = Fx(k), \qquad x(0) = [1 \quad -2 \quad 1]^T \quad and \quad F = \begin{bmatrix} 1 & 0 & 0 \\ -2 & 3 & 5 \\ 0 & 0 & 1 \end{bmatrix}$$

[6+ 4]

Q5. **A.** For the system given below, find the closed form response,

$$X(k+1) = \begin{bmatrix} 1.5 & -1 \\ 1 & -1 \end{bmatrix} X(k) + \begin{bmatrix} 3 \\ 2 \end{bmatrix} U(k)$$

$$Y(k) = \begin{bmatrix} -3 & 4 \\ -1 & 1 \end{bmatrix} X(k) + \begin{bmatrix} -2 \\ 0 \end{bmatrix} U(k)$$

when:

$$X(0) = \begin{bmatrix} -5 \\ 1 \end{bmatrix} \text{ and } U(k) = \left(\frac{1}{2}\right)^k$$

B. Diagonalize the following matrix:

$$A = \begin{bmatrix} -4 & 2 & -2 \\ 2 & -7 & 4 \\ -2 & 4 & -7 \end{bmatrix}$$

[5+ 5]

Q6. **A.** Given a system represented in state-space form as follows:

$$X_{k+1} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -5 & -6 & -1 \end{bmatrix} X_k + \begin{bmatrix} 1 \\ -2 \\ 1 \end{bmatrix} u(k)$$

$$y_k = [1 \quad 0 \quad 0]\, X_k$$

Then,

(i) Convert the system model to pulse transfer function [Assume all I/C =0]

(ii) State Transition matrix Ψ(k)

B. The block diagram of a speed control system with a dc motor is shown in Fig. Q 6B:

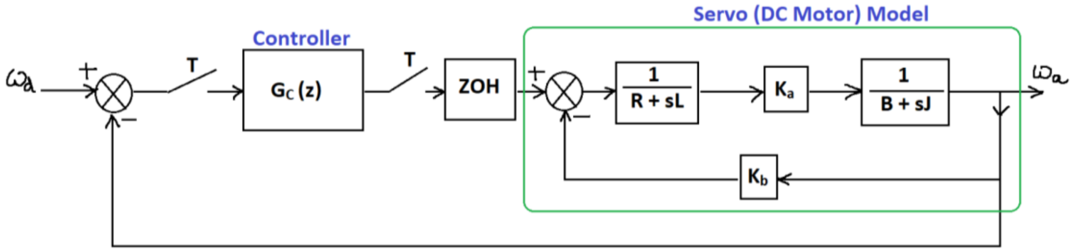

Fig. Q 6B

The system parameters are also given as follows:

Term	Definition	Value	Unit
K_a	Motor Torque Quotient	0.345	
K_b	Motor Back EMF constant	0.345	
R	Motor Armature resistance	1	Ohms
L	Motor Armature inductance	1	Milli-Henry
J	MoI of (Rotor + Load)	1.14	In 10 ^ (-3)
B	Viscous Friction (Rotor + Load)	0.25	
T	Sampling period	0.001	s

Also, the mathematical (discrete-time) model of the digital microcontroller in the system shown in Fig Q6B is approximated as follows:

$$G_c(z) = 1 + (147.638)\left(\frac{z+1}{z-1}\right) T$$

Using root-locus method, determine the stability of the forward open-loop system.

[4 + 6]

****