Ref. No.: **Ex/ET/T/324/2019**

B.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING THIRD YEAR SECOND SEMESTER - 2019

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

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

1. (a) State and prove Nyquist sampling theorem. 9

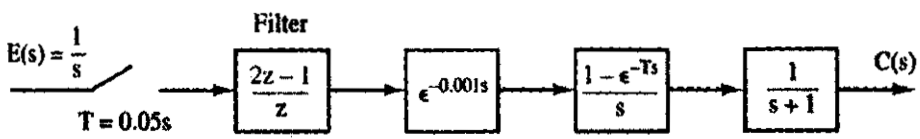
(b) Define starred transform. 3

(c) What is a fractional order hold circuit? How it overcomes the limitation of a first order hold? 8

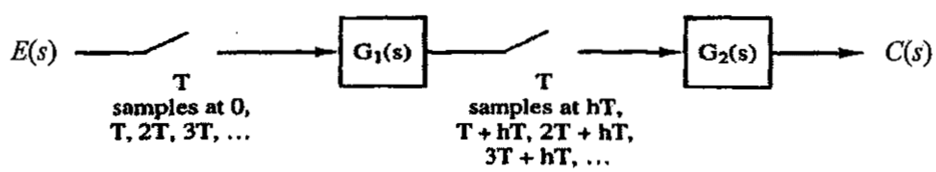
Answer Question 2 OR Question 3

2. Determine $C(z)$ of the following systems.

(a) 5



(b) 15



3. (a) Derive the transfer function of a polygonal hold circuit. 8

(b) Explain how a fast sampler with sampling period T/N can be realized by a slow sampler of sampling period T. 5

(c) Determine the output response of a fast-slow sampling system using the model of the fast sampler derived in part (b). 7

Answer Question 4 OR Question 5

4. (a) Evaluate the closed loop transfer function of the following antenna control system with $D(z) = 1$, $T = 0.05$ s, $K = 20$. 15

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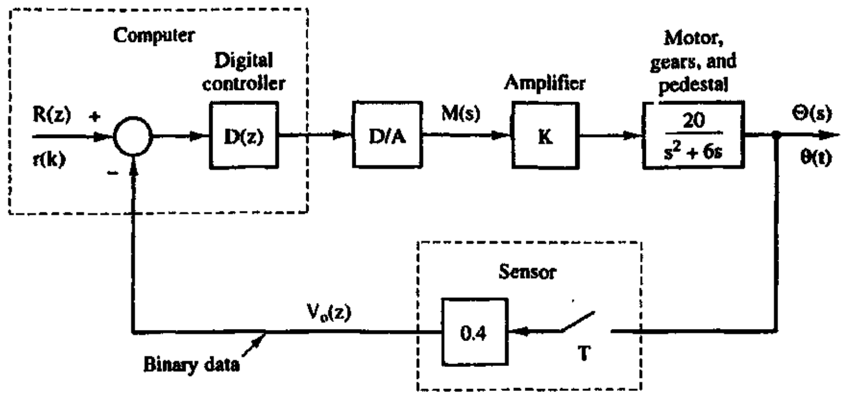
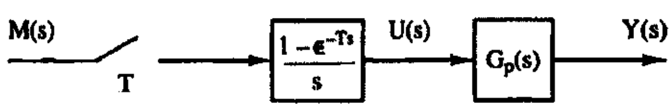


(b) Draw the Direct Form-II realization of a *PID* controller using trapezoidal rule for numerical integration. 5

5. (a) Show that for the similarity transformation 5

$$\mathbf{C}\left[z\mathbf{I}-\mathbf{A}\right]^{-1}\mathbf{B}+\mathbf{D}=\mathbf{C}_{\mathbf{W}}\left[z\mathbf{I}-\mathbf{A}_{\mathbf{W}}\right]^{-1}\mathbf{B}_{\mathbf{W}}+\mathbf{D}_{\mathbf{W}}.$$

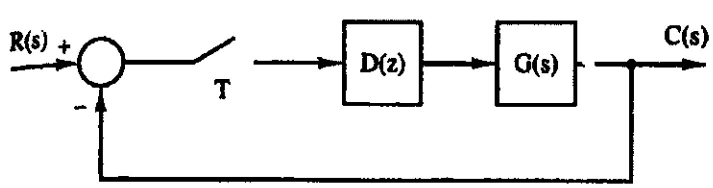
(b) Derive the expressions of the system matrix **A** and input matrix **B** of the following open loop digital control system in terms of the system and input matrices of the continuous plant $G_p(s)$. 9



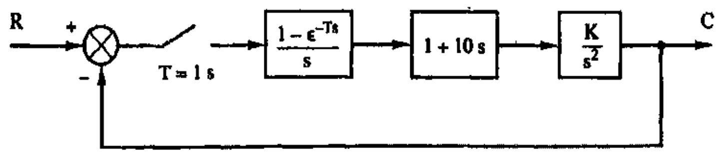
(c) Hence determine **A** and **B** for $G_p(s)=\dfrac{10}{s(s+1)}$. 6

Answer Question 6 OR Question 7

6. (a) Design a digital controller $D(z)$ 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. 8



(b) Find the range of K for stability of the system from its root locus. Also determine the 12 oscillating frequency for the marginal stability.



7. (a) State and prove Nyquist stability criterion for digital control system. 12

(b) Explain the effect of addition of open loop poles to the system stability with the help of root locus technique. 8

Answer Question 8 OR Question 9

8. (a) Explain the significance of a state observer in the context of state feedback. 5

(b) Deduce the state dynamics and the transfer function of a reduced order state observer. 10

(b) Derive the condition of observability. 5

9. (a) Prove that $\mathbf{A}^T\mathbf{P}\mathbf{A} - \mathbf{P} = -\mathbf{Q}$ where the symbols carry their usual meaning. 5

(b) Define optimal control. 3

(c) State principle of optimality. 2

(d) Given a first order plant described by $x(k+1) = 0.9x(k) + 0.1u(k)$ with the cost function 10

$$J_3 = \sum_{k=0}^{3} \left(x^2(k) + 5u^2(k)\right)$$

calculate the feedback gains required to minimize the cost function.