Ref. No.: **Ex/ET/PC/B/T/323/2022**

B.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING THIRD YEAR SECOND SEMESTER - 2022

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

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

PART-A: Answer any ONE

1. State and prove Nyquist sampling theorem. 10

2. For an open loop digital control system, derive the expression of the spectra of the flat-top sampled error signal. 10

PART-B: Answer any TWO

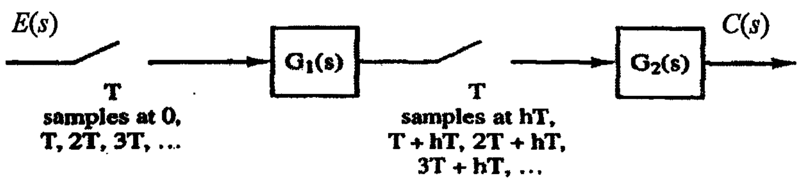
3. What is a fractional order hold circuit? How it overcomes the limitation of a first order hold? 10

4. (a) A sampler cannot be represented by transfer function. Justify. 3
   (b) Derive the transfer function of a polygonal hold circuit. 7

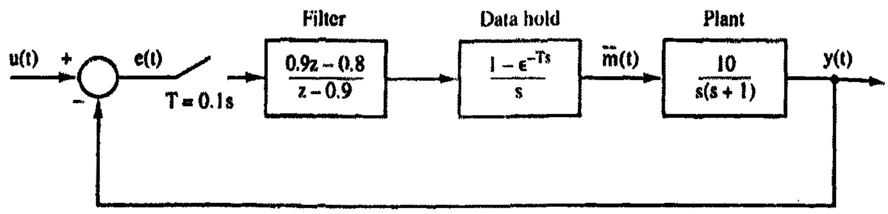
5. (a) Explain how a fast sampler with sampling period *T/N* can be realized by a slow sampler of sampling period *T*. 3
   (b) Determine the output response of a fast-slow sampling system using the model of the fast sampler derived in part (b). 7

PART-C: Answer any TWO

6. Determine *C*(*z*) of the following system. 15



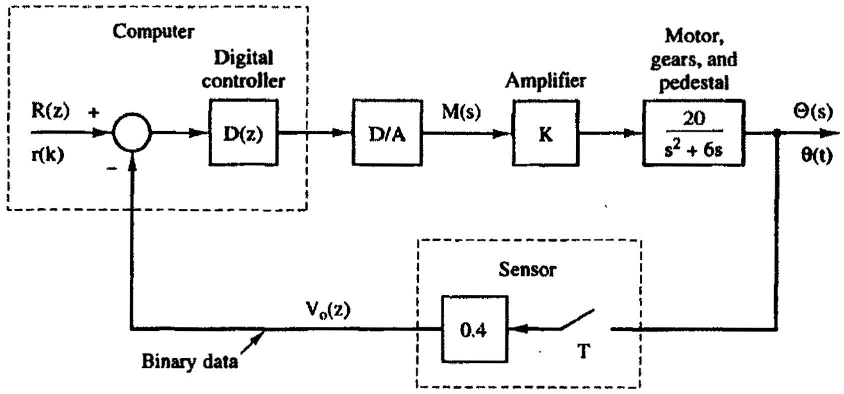
7. Derive the state-space representation of the following closed loop digital control system. 15



8. Derive the expression of maximum overshoot of a second-order closed loop digital control system. 15

[Turn over

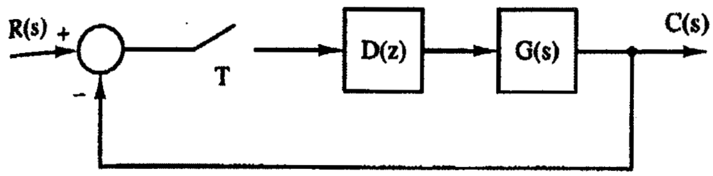
9. Evaluate the closed loop transfer function of the following antenna control system with $D(z) = 1$, $T = 0.05$ s, $K = 20$. 15



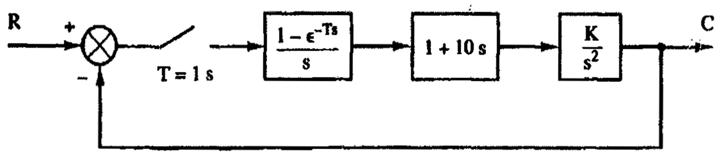
PART-D: Answer any TWO

10. (a) What is bilinear transform? 4

(b) Design a digital controller $D(z)$ for the following system 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. 6



11. Find the range of K for stability of the system from its root locus. Also determine the oscillating frequency for the marginal stability. 10



12. State and prove Nyquist stability criterion for digital control system. 10

13. (a) Discuss how the stability of a closed loop digital control system is influenced by the addition of poles to an open loop transfer function using root locus. 5

(b) Using Nyquist stability criteria, comment on stability of a closed loop system with open loop transfer function $\overline{GH}(z) = \dfrac{0.632Kz}{(z-1)(z-0.368)}$. 5

PART-E: Answer any TWO

14. For a plant described by 10

$$\vec{x}(k+1)=\begin{bmatrix}1 & 0.0952\\ 0 & 0.905\end{bmatrix}\vec{x}(k)+\begin{bmatrix}0.00484\\ 0.0952\end{bmatrix}u(k)$$

find the gain matrix K required to realize the closed loop characteristic equation with zeros providing a damping ratio of 0.46 and a time constant of 0.5 s.

15. Derive the state dynamics and hence the transfer function of a state observer. 10

16. Determine the control law $u(k)$ that minimizes 10

$$J_2=\sum_{k=0}^{2}\left(x^2(k)+u^2(k)\right)$$

for the plant given by $x(k+1) = 2x(k) + u(k)$.

17. Consider a linear digital control system described by 10

$$\vec{x}(k+1)=\begin{bmatrix}0.5 & 0\\ 0 & 0.2\end{bmatrix}\vec{x}(k)+\begin{bmatrix}1\\ 1\end{bmatrix}u(k).$$

Find the optimal control $u^o(k)$ so that the Lyapunov function $V(\vec{x})=\vec{x}^T(k)\mathbf{P}\vec{x}(k)$ is minimized where $\mathbf{P}$ is a positive definite solution of $\mathbf{A}^T\mathbf{P}\mathbf{A}-\mathbf{P}=-\mathbf{I}$.