Ref. No. : Ex/IEE/PC/H/T/321/2023

B.E. Instrumentation & Electronics Engg. 3rd Year, 2nd Semester Examination 2023

SUBJECT : Advanced Process Control (Hons.)

Time : *03 hours* Full Marks : *100*

[CO1] :

1. Mention some of the merits of sampled data control systems. Why zero-order holds (ZOH) are usually used in digital control systems? Find the transfer function of the ZOH and its frequency response. **2+2+6**

2. What is meant by an ideal or impulse sampler? Prove that a practical sampler is equivalent to an ideal sampler followed by an attenuator. A Zero-order Hold (ZOH) introduces an additional dead-time of $0.5T$ (T is the sampling period) in discrete time control systems – *Justify* **2 +5+3**

OR

A system is described by the following difference equation:

$$x(k+2) - 1.5x(k+1) + 0.5x(k) = u(k),$$

where $x(0) = 1$ and $x(1) = \frac{5}{2}$. Find its response $x(k)$ for a unit-step input $u(k)$ applied at $t = 0$. **10**

[CO2] : Answer *any* **Four** questions (from 3 to 7):

3. Why Routh-Hurwitz stability criterion cannot be directly applied for sampled data control systems? For the characteristic equation, $F(z) = z^4 - 2z^3 + 1.5z^2 - 0.1z - 0.02 = 0$, determine the stability of the system using Jury's test. **2+10**

4. For the characteristic equation, $F(z) = z^3 + (0.084K - 1.5)z^2 + (0.17K + 0.533)z + (0.019K - 0.05) = 0$, using the bilinear transformation, $r = \dfrac{z+1}{z-1}$ and Routh-Hurwitz criterion, find out the range of K for which the system is stable, where K is a real constant. **12**

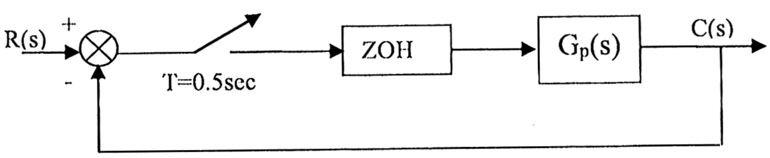
5. *a*) Find the pulse transfer function of the digital PID controller considering 'backward difference' and 'trapezoidal integration' rules, and draw the parallel realization diagram of its digital program implementation. **7**

   b) Consider the digital controller defined by

$$D(z) = \frac{M(z)}{E(z)} = \frac{5(0.25z^{-1} + 1)}{(1 - 0.5z^{-1})(1 - 0.1z^{-1})}.$$

Draw the parallel realization diagram of its digital program implementation. **5**

6. For the close-loop system shown below:

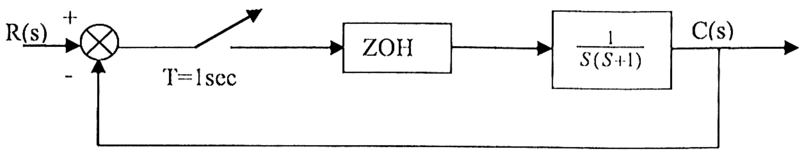


Find the unit step response of the system, when $G_p(s) = \frac{1}{(S+1)}$. **12**

[Turn over

OR

For the close-loop system shown below :



Find the final value of $C(kT)$, when $R(s)=\frac{1}{s}$ and k is the sampling instant. **12**

7. Discuss about the steady state error analysis of discrete time control systems. **12**

[CO3]:

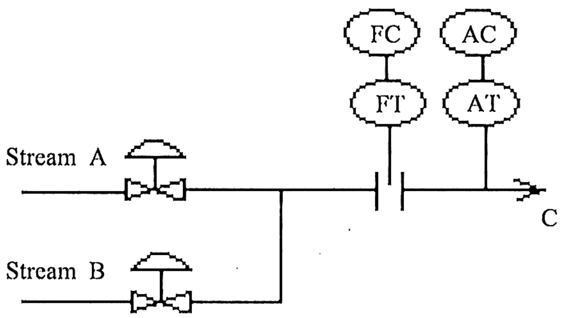
8. What is meant by loop interaction in a multivariable control system ? Derive the relative gain array (RGA) for a 2×2 (TITO) multivariable control system. **2+6**

9. Calculate the relative gain array (RGA) for the 3×3 multivariable control system having the following open loop gain matrix K : **8**

$$K=\begin{bmatrix} 0.10 & 0.79 & 0 \\ 14 & -4.1 & -0.8 \\ 0.0031 & 0.054 & -0.015 \end{bmatrix}$$

OR

For the below multivariable control system, what will be the control policy for regulating the total flow of C and the desired composition (0.3 mass fraction of A) of C, that will minimize the loop-interaction : **8**



[CO4]:

10. Providing the block diagram of a simple fuzzy logic controller (FLC), explain the role of its various computational blocks. **8**

OR

Mention the flexibilities and limitations of fuzzy logic controller design. Briefly discuss about the tuning of FLC parameters. **4+4**

11. What are meant by Self-tuning and Self-organizing FLCs? Illustrate a self-tuning PI-type FLC with an online output scaling factor modifying scheme using fuzzy rules defined on *error* and *change of error* of the controlled variable. **8**