Ref. No. : Ex/IEE/PC/H/T/321/2024

B.E. Instrumentation & Electronics Engg. 3rd Year, 2nd Semester Examination 2024
SUBJECT : Advanced Process Control (Hons)

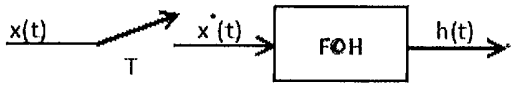
Time : *03 hours* Full Marks : *100*

[CO1] :

1. *a*) Prove that a practical sampler is equivalent to an ideal sampler followed by an attenuator. **5**

   b) Why Zero-order Holds (ZOH) are generally used in sampled data control systems? A ZOH introduces an additional dead-time of $0.5T$ (T is the sampling period) in discrete time control systems – *Justify* **2+3**

2. An *impulse sampler* is followed by a *first-order hold* (FOH) as shown below. Draw the output of FOH, $h(t)$ for the pulse input, $x(t) = [1(t) - 1(t-T)]$ and hence derive the transfer function of the FOH (T is the sampling period).



3+7

OR

For the discrete time system described by the difference equation,

$$x(k+2) - 3x(k+1) + 2x(k) = u(k).$$

Find its response $x(k)$ for the unit-impulse input $u(k)$ at $k = 0$, when $x(k) = 0$ for $k \le 0$. **10**

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

3. Consider the system described by

$$y(k) - 0.6y(k-1) - 0.81y(k-2) + 0.67y(k-3) - 0.12y(k-4) = x(k)$$

where $x(k)$ and $y(k)$ are the input and output of the system, respectively. Determine stability of the system using *Jury's test.* **12**

4. Using the bilinear transformation $r = \dfrac{z-1}{z+1}$ and Routh-Hurwitz criterion test the stability of the discrete time control system with characteristics equation: $F(z) = z^4 - 1.2z^3 + 0.07z^2 + 0.3z - 0.08 = 0$. **12**

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

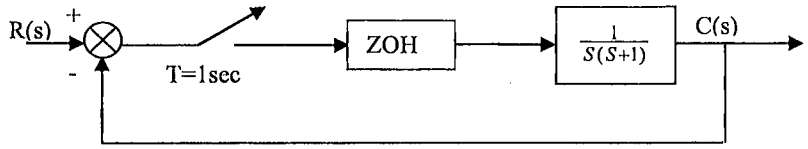
   b) Consider the digital controller defined by

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

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

[Turn over

6. For the close-loop system shown below :



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

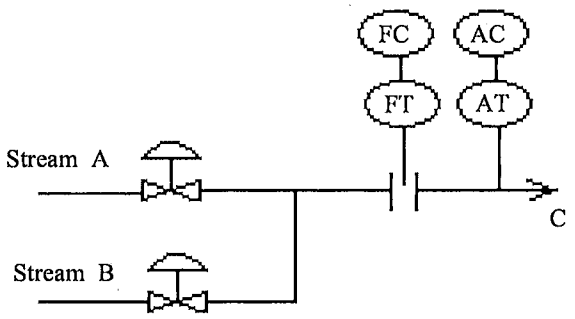
7. Discuss about the steady state error analysis of discrete data control systems. **12**

[CO3]:

8. Why dead-time compensation is important for those processes with high ratio of dead-time to time constant? Explain the Smith's predictor algorithm for first-order dead-time processes. **1+4**

9. *a*) Derive the relative gain array (RGA) for a 2×2 (TITO) multivariable control system. **5**

   b) For the TITO multivariable system shown below, find the suitable pairing of controlled and manipulated variables to minimize the loop-interaction for regulating the total flow of C and the desired composition (0.25 mass fraction of A) of C: **6**



[CO4]:

10. *a*) What are the advantages of fuzzy logic controllers (FLCs) over traditional model based controllers. **2**

    b) Providing the block diagram of a simple FLC, describe the role of its various computational blocks. **8**

    c) Discuss about the tuning of various FLC parameters. **4**

    d) Why PID-type FLCs are rarely designed in its direct form? What are the usual techniques for realizing such types of FLCs? **1+1**