Reg. No. :

Question Paper Code : 71688

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2015.

Seventh Semester

Instrumentation and Control Engineering

IC 2401/IC 71/10133 IC 701 — DIGITAL CONTROL SYSTEM

(Common to Eighth Semester Electronics and Instrumentation Engineering)

(Common to IC 71 Digital Control System for Electronics and Instrumentation Engineering)

(Regulation 2008/2010)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Mention the disadvantages of discrete control systems.

2. Give any four advantages of digital controllers over analog controllers.

3. What is quantization error?

4. Give the model of ADC.

5. Obtain the final value for the sequence whose z-transform is given by $X(z) = \dfrac{z^2(z-a)}{(z-1)(z-b)(z-c)}$.

6. Define static error constants.

7. Define state variables.

8. Give the formula to find the solution of non homogeneous state equation.

9. What is the function of a state observer?

10. Write the velocity form of PID controller.

PART B — (5 × 16 = 80 marks)

11. (a) Explain how a continuous time analog signal is converted to a digital signal with suitable explanation and graphs. (16)

Or

(b) (i) Explain the block diagram of a digital control scheme and explain about the components in it. (10)

(ii) Give an example for a discrete data system. (6)

12. (a) Consider a continuous-time signal $x(t)$ with frequency spectrum limited to between $-\omega_1$ and ω_1. That is $X(j\omega)=0$, for $\omega<-\omega_1$ and $\omega_1<\omega$. Prove that if this signal is sampled with frequency $\omega_S>2\omega_1$, then the Fourier transform of $x(t)$ is uniquely determined by $x(kT)$, $k=\ldots,-2,-1,0,1,2,\ldots$, and the original continuous-time signal $x(t)$ can be given by a sum of an infinite series of weighted sampled values $x(kT)$ as follows :

$$x(t)=\sum_{k=-\infty}^{\infty} x(kT)\frac{\sin[\omega_S(t-kT)/2]}{\omega_S(t-kT)/2}.$$

Or

(b) Solve the following difference equation :

$$x(k+2)-1.3x(k+1)+0.4x(k)=u(k)$$

where $x(0)=x(1)=0$ and $x(k)=0$ for $k<0$. For the input function $u(k)$, consider the following two cases :

$$u(k)=\begin{cases}1, & k=0,1,2,\ldots\\ 0, & k<0\end{cases} \text{ and } u(0)=1,\ u(k)=0,\ k\neq 0.$$

13. (a) (i) Obtain the z-transform of the system output for the block diagram shown in Fig. 1. (8)

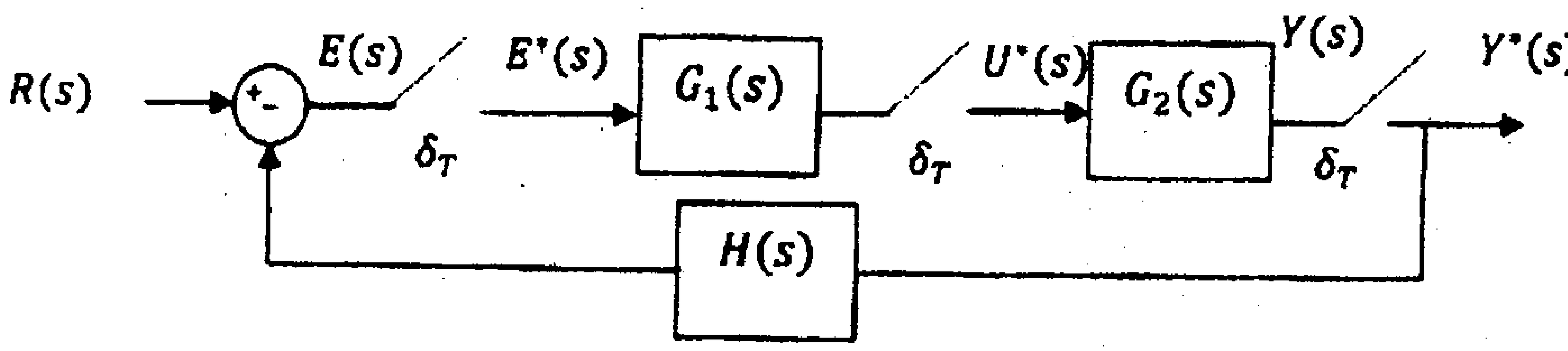

Fig. 1

(ii) Explain the mapping between s-plane and z-plane. (8)

Or

(b) (i) Find the equivalent sampled impulse response sequence and the equivalent z-transform for the cascade of the two analog systems with sampled input. (8)

$$H_1(s) = \frac{1}{s+2} \qquad H_2(s) = \frac{1}{s+4}$$

(1) If the systems are directly connected.

(2) If the systems are separated by a sampler.

(ii) Using Jury's stability test, check if all the roots of the following characteristic equation lie within the unit circle. (8)

$$z^3 + 2.1z^2 + 1.44z + 0.32 = 0.$$

14. (a) (i) Obtain the companion form realizations for the following transfer function $\frac{Y(z)}{U(z)} = \frac{-2z^3 + 2z^2 + 17z + 2}{z^3 + z^2 - z - 2}$. (8)

(ii) Consider the state variable model

$$x(k+1) = \begin{bmatrix} 0 & 1 \\ -1/8 & 3/4 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k);$$

$$y(k) = [-1/2 \quad 1] x(k).$$

(1) Find the transfer function $G(z) = Y(z)/R(z)$ and determine the poles of the transfer function.

(2) Comment on the controllability and observability properties of the given system without making any further calculations. (8)

Or

(b) (i) The linear continuous-time plant of a sampled-data system is described by the state equation $\dot{x}((k+1)T) = \begin{bmatrix} 0 & 1 \\ -4 & 0 \end{bmatrix} x(kT) + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u(kT)$. Determine the values of sampling period T which makes the system uncontrollable. (8)

(ii) Obtain the state transition matrix for the following discrete system

$$x(k+1) = \begin{bmatrix} 0 & 1 \\ -0.16 & -1 \end{bmatrix} x(k).$$ (8)

15. (a) Show that the digital PD controller acts as a phase lead compensator and digital PI controller acts as a phase lag compensator. (16)

Or

(b) Consider the double-integrator system

$$x((k+1)T) = \begin{bmatrix} 1 & T \\ 0 & 1 \end{bmatrix} x(kT) + \begin{bmatrix} T^2/2 \\ T \end{bmatrix} u(kT)$$

where T is the sampling period. Determine a state feedback gain matrix k such that the response to an arbitrary initial condition is deadbeat. (16)
