Code No: RR322204 **RR** **Set No. 2**

III B.Tech II Semester Examinations,December 2010
DIGITAL AND OPTIMAL CONTROL SYSTEMS
Instrumentation And Control Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. Consider the system defined by
$$X(k+1) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -0.5 & -0.2 & 1.1 \end{bmatrix} X(k) + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(k)$$
Determine the state feedback gain matrix K such that when the control signal is given by u(k) = -KX(k), the closed loop system will exhibit the dead beat response to any initial state x(0). Give the state variable model of the closed loop system. [16]

2. Obtain the closed loop pulse transfer function of the following system configuration shown below Figure 5 [16]

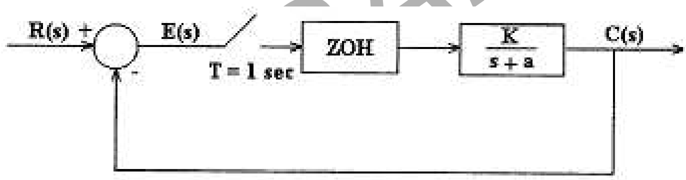

Figure 5

3. Show that the transfer function U(s) / E(s) of the PID controller shown below(figure 2).
$$\frac{U(s)}{E(s)} = K_o \frac{T_1 + T_2}{T_1} \left[1 + \frac{1}{(T_1 + T_2)} + \left(\frac{T_1 T_2 \cdot s}{T_1 + T_2} \right) \right]$$
Assume the gain **k** is very large compared with unity, or **k** >>**1.** [16]

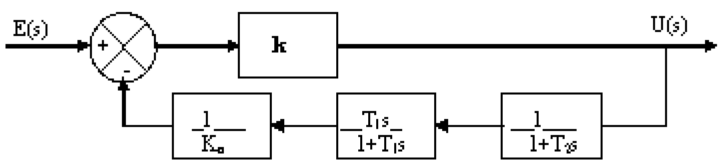

Figure 2

4. Define controllability and observability of discrete time systems. For the following system,
$$\frac{Y(z)}{U(z)} = \frac{z^{-1}\,(1 + 0.8z^{-1})}{1 + 1.3z^{-1} + 0.4z^{-2}}$$
Determine whether the system is observable and controllable. [16]

5. (a) Explain the input decoupling zeros and output decoupling zeros. [6]

   (b) Obtain minimal differential operator realization of T(s) given below. Further, convert the D.O. form to the state space form.

$$T(s) = \begin{bmatrix} \frac{s+1}{s^2} & \frac{s+2}{s^2+1} \\ \\ \frac{2}{s} & \frac{2s+3}{s^2+1} \end{bmatrix}$$

[10]

6. (a) With suitable diagrams illustrate the one point is fixed end, terminal time t_1 free and x(t_1) is specified problem and derive the necessary conditions of variational calculus.

   (b) For the system
   $\frac{d^2y}{dt^2} = u$
   with $|u| \leq 1$, find the control which drives the system from an arbitrary initial state to the origin in a condition satisfying $|y| \leq 0.5$ in the minimum time. [8+8]

7. A discrete time system has state and output equations given by

$$x_1\left(k+1\right) = \tfrac{1}{4}x_1\left(k\right) + u\left(k\right)$$
$$x_2\left(k+2\right) = \tfrac{1}{8}x_1\left(k\right) + \tfrac{1}{8}x_2\left(k\right) + u(k)$$
$$y(k) = \begin{bmatrix} 1/2 & 0 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

Find the output y(k) when u(k)=unit impulse and X(0)=0. [16]

8. (a) State and explain the minimum-energy problems. Describe its performance index.

   (b) Show that the extremal for the functional
   $J(\mathrm{x}) = \int_0^{\pi/2} (\dot{x}^2 - x^2)dt$
   which satisfies the boundary conditions x(0) =0; x(π/2)=1 , is x*(t) =sin t. [8+8]

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Code No: RR322204 **RR** **Set No. 4**

III B.Tech II Semester Examinations,December 2010
DIGITAL AND OPTIMAL CONTROL SYSTEMS
Instrumentation And Control Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. Define controllability and observability of discrete time systems. For the following system,

$$\frac{Y(z)}{U(z)} = \frac{z^{-1}\left(1 + 0.8z^{-1}\right)}{1 + 1.3z^{-1} + 0.4z^{-2}}$$

Determine whether the system is observable and controllable. [16]

2. (a) With suitable diagrams illustrate the one point is fixed end, terminal time t_1 free and x(t_1) is specified problem and derive the necessary conditions of variational calculus.

   (b) For the system
   $\frac{d^2y}{dt^2} = u$
   with $|u| \leq 1$, find the control which drives the system from an arbitrary initial state to the origin in a condition satisfying $|y| \leq 0.5$ in the minimum time. [8+8]

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   (b) Obtain minimal differential operator realization of T(s) given below. Further, convert the D.O. form to the state space form.

$$T(s) = \begin{bmatrix} \frac{s+1}{s^2} & \frac{s+2}{s^2+1} \\ \\ \frac{2}{s} & \frac{2s+3}{s^2+1} \end{bmatrix}$$

[10]

4. Show that the transfer function U(s) / E(s) of the PID controller shown below.

$$\frac{U(s)}{E(s)} = K_o \frac{T_1 + T_2}{T_1}\left[1 + \frac{1}{(T_1 + T_2)} + \left(\frac{T_1T_2 \cdot s}{T_1 + T_2}\right)\right]$$

Assume the gain **k** is very large compared with unity, or **k** >>**1**as shown in the figure 2 [16]

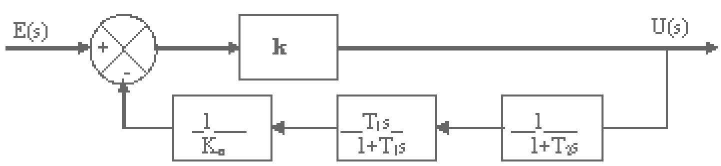

Figure 2

5. Consider the system defined by
$$X(k+1) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -0.5 & -0.2 & 1.1 \end{bmatrix} X(k) + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(k)$$
Determine the state feedback gain matrix K such that when the control signal is given by u(k) = -KX(k), the closed loop system will exhibit the dead beat response to any initial state x(0). Give the state variable model of the closed loop system. [16]

6. A discrete time system has state and output equations given by
$$x_1(k+1) = \tfrac{1}{4}x_1(k) + u(k)$$
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$$y(k) = \begin{bmatrix} 1/2 & 0 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$
Find the output y(k) when u(k)=unit impulse and X(0)=0. [16]

7. (a) State and explain the minimum-energy problems. Describe its performance index.
   (b) Show that the extremal for the functional
   $$J(\mathrm{x}) = \int_0^{\pi/2} (\dot{x}^2 - x^2)dt$$
   which satisfies the boundary conditions x(0) =0; x(π/2)=1 , is x*(t) =sin t. [8+8]

8. Obtain the closed loop pulse transfer function of the following system configuration shown below Figure 5 [16]

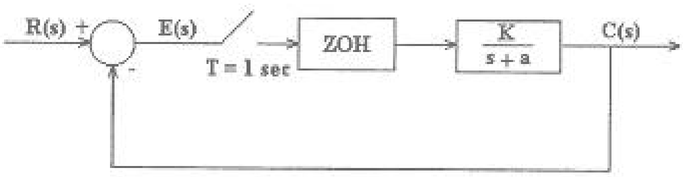

Figure 5

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Code No: RR322204 **RR** **Set No. 1**

III B.Tech II Semester Examinations,December 2010
DIGITAL AND OPTIMAL CONTROL SYSTEMS
Instrumentation And Control Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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⋆ ⋆ ⋆ ⋆ ⋆

1. Show that the transfer function U(s) / E(s) of the PID controller shown below.
$$\frac{U(s)}{E(s)} = K_o \frac{T_1 + T_2}{T_1}\left[1 + \frac{1}{(T_1 + T_2)} + \left(\frac{T_1 T_2 \cdot s}{T_1 + T_2}\right)\right]$$
Assume the gain **k** is very large compared with unity, or **k** >>**1**as shown in the figure 2 [16]

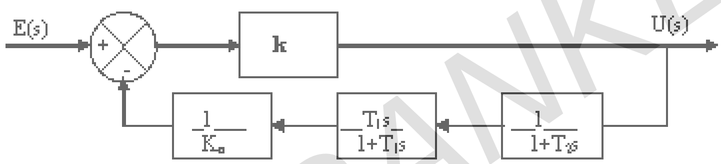

Figure 2

2. Consider the system defined by
$$X(k+1) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -0.5 & -0.2 & 1.1 \end{bmatrix} X(k) + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(k)$$
Determine the state feedback gain matrix K such that when the control signal is given by u(k) = -KX(k), the closed loop system will exhibit the dead beat response to any initial state x(0). Give the state variable model of the closed loop system. [16]

3. (a) With suitable diagrams illustrate the one point is fixed end, terminal time t_1 free and x(t_1) is specified problem and derive the necessary conditions of variational calculus.
   (b) For the system
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   with $|u| \le 1$, find the control which drives the system from an arbitrary initial state to the origin in a condition satisfying $|y| \le 0.5$ in the minimum time. [8+8]

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$$T(s) = \begin{bmatrix} \frac{s+1}{s^2} & \frac{s+2}{s^2+1} \\ \frac{2}{s} & \frac{2s+3}{s^2+1} \end{bmatrix}$$
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$$y(k) = \begin{bmatrix} 1/2 & 0 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

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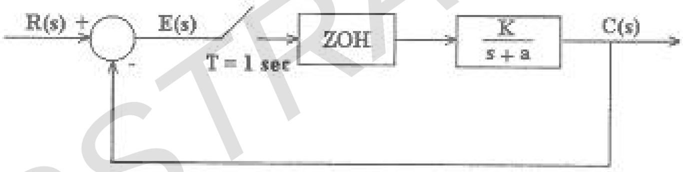

Figure 5

8. Define controllability and observability of discrete time systems. For the following system,

$$\frac{Y(z)}{U(z)} = \frac{z^{-1}(1 + 0.8z^{-1})}{1 + 1.3z^{-1} + 0.4z^{-2}}$$

Determine whether the system is observable and controllable.

[16]

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Code No: RR322204 **RR** **Set No. 3**

III B.Tech II Semester Examinations,December 2010
DIGITAL AND OPTIMAL CONTROL SYSTEMS
Instrumentation And Control Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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$$y(k) = \begin{bmatrix} 1/2 & 0 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

Find the output y(k) when u(k)=unit impulse and X(0)=0. [16]

2. Show that the transfer function U(s) / E(s) of the PID controller shown below.

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Assume the gain **k** is very large compared with unity, or **k** >>**1**as shown in the figure 2 [16]

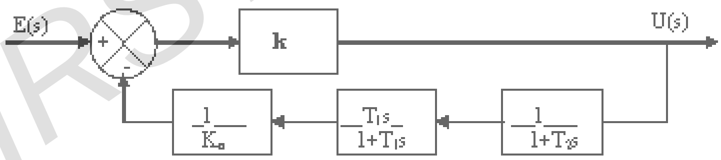

Figure 2

3. (a) With suitable diagrams illustrate the one point is fixed end, terminal time t_1 free and x(t_1) is specified problem and derive the necessary conditions of variational calculus.

(b) For the system
$\frac{d^2y}{dt^2} = u$
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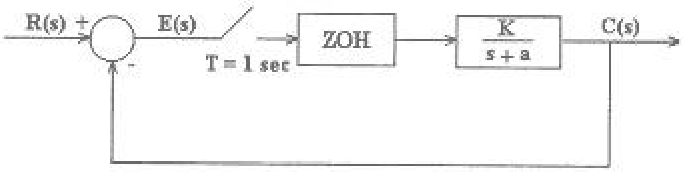

Figure 5

6. (a) State and explain the minimum-energy problems. Describe its performance index.
   (b) Show that the extremal for the functional
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