POSTAL Book Package 2023

GATE • ESE

Electronics Engineering

Objective Practice Sets

Control Systems

Contents

MADE EASY Publications

2 CHAPTER Block Diagram and Transfer Function

MCQ and NAT Questions

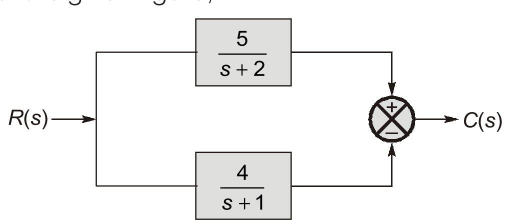
Q.1 Consider the following open-loop transfer function:

$$G = \frac{K(s+2)}{(s+1)(s+4)}$$

The characteristic equation of the unity negative feedback will be

(a) $(s + 1)(s + 4) + K(s + 2) = 0$
(b) $(s + 2)(s + 1) + K(s + 4) = 0$
(c) $(s + 1)(s - 2) + K(s + 4) = 0$
(d) $(s + 2)(s + 4) + K(s + 1) = 0$

Q.2 For the given figure,



(a) $\frac{4(s+2)}{(s+2)(s+1)}$ (b) $\frac{(s-3)}{(s+2)(s+1)}$

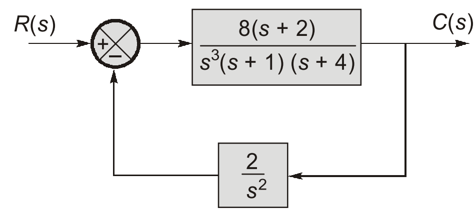
(c) $\frac{9s+13}{(s+2)(s+1)}$ (d) $\frac{1}{(s+2)(s+1)}$

Q.3 The transfer function of three blocks connected in cascade is given by $\frac{(s+1)}{s(s+2)(s+3)}$. If block 1 has transfer function of $\frac{1}{s(s+2)}$ and block 2 has transfer function of $\frac{(s+2)}{(s+3)}$ then the transfer function of the 3rd block is

(a) $(s + 1)(s + 2)$ (b) $\frac{(s+1)}{(s+2)}$

(c) $\frac{(s+1)}{s(s+3)}$ (d) $\frac{(s+1)^2}{(s+2)^2}$

Q.4 The type of the control system represented by the block diagram shown below is



(a) Type-2 (b) Type-3
(c) Type-4 (d) Type-5

Q.5 Match **List-I (Transfer Function of the System)** with **List-II (Type and Order of the System)** and select the correct answer using the codes given below the lists:

	List-I		List-II
A.	$\frac{2(s+2)}{s(s+5)}$	1.	Type 0, second order
B.	$\frac{(s+2)}{(s+3)(s+5)}$	2.	Type 1, second order
C.	$\frac{2(s+5)}{s^2(s+2)}$	3.	Type 0, third order
D.	$\frac{5(s+2)}{(s+1)(s+3)(s+5)}$	4.	Type 2, third order

Codes:

	A	B	C	D
(a)	2	1	4	3
(b)	4	3	2	1
(c)	2	3	4	1
(d)	4	1	2	3

Q.6 The closed-loop transfer function of a unity feedback control system is $\frac{25}{s^2+10s+25}$. What is the open loop transfer function of the system?

(a) $\frac{25}{s^2+10s}$ (b) $\frac{25}{s^2+25}$

(c) $\frac{25}{s+25}$ (d) $\frac{25}{s+10}$

Q.7 For a transfer function $H(s) = \dfrac{P(s)}{Q(s)}$, where $P(s)$ and $Q(s)$ are polynomials in s.

Then:

(a) the degree of $P(s)$ is always greater than the $Q(s)$.
(b) the degree of $P(s)$ and $Q(s)$ are same.
(c) degree of $P(s)$ is independent of degree of $Q(s)$.
(d) the maximum degree of $P(s)$ and $Q(s)$ differ at most by one.

Q.8 The transfer function is applicable to

(a) linear and time variant system
(b) non-linear and time variant system
(c) linear and time invariant system
(d) non-linear and time invariant system

Q.9 The transfer function, $G(s) = \dfrac{10(s-5)}{s(s+1)(s+2)}$ represents

(a) A non-minimum phase transfer function
(b) A minimum phase transfer function
(c) An all pass transfer function
(d) None of these

Q.10 Consider the following statement and choose the correct option:

Statement 1: The transfer function is said to be strictly proper if the order of the denominator polynomial is greater than that of numerator polynomial.

Statement 2: The transfer function is said to be proper if the order of the denominator polynomial is equal to than that numerator polynomial.

Statement 3: The function is called improper if the order of the denominator polynomial is greater than that of numerator polynomial.

(a) Statement 1 and 2 are correct
(b) Statement 2 and 3 are correct
(c) Only statement 1 is correct
(d) All the statements are correct

Q.11 The impulse response of an initially relaxed linear system is $e^{-2t}\,u(t)$. To produce a response of $te^{-2t}\,u(t)$, the input must be equal to

(a) $e^{-t}\,u(t)$ (b) $e^{-2t}\,u(t)$
(c) $2e^{-t}\,u(t)$ (d) $\dfrac{1}{2}e^{-2t}\,u(t)$

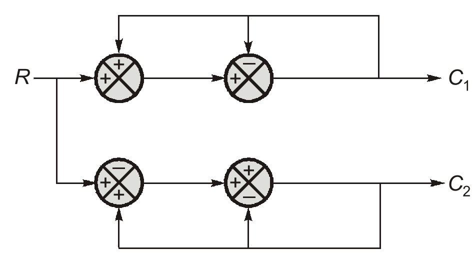
Q.12 The unit step response of a linear time invariant system is $y(t) = 5e^{-10t}\,u(t)$, where $u(t)$ is the unit step function. If the output of the system corresponding to an unit impulse input $\delta(t)$ is $h(t)$, then $h(t)$ is

(a) $-50\,e^{-10t}\,u(t)$ (b) $5\,u(t) - 50\,e^{-10t}\,\delta(t)$
(c) $5\,e^{-10t}\,\delta(t)$ (d) $5\,\delta(t) - 50\,e^{-10t}\,u(t)$

Q.13 A control system whose step response is $-0.5\,(1 + e^{-2t})$ is cascaded to another control block whose impulse response is e^{-t}. What is the transfer function of the cascaded combination?

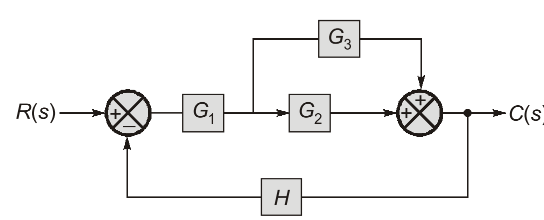
(a) $\dfrac{1}{(s+1)(s+2)}$ (b) $\dfrac{1}{s(s+1)}$
(c) $\dfrac{-1}{s+2}$ (d) $\dfrac{0.5}{(s+1)(s+2)}$

Q.14 Determine C_1/R and C_2/R for the block diagram.



(a) 0 and 1 (b) 1 and 1
(c) 0 and 0 (d) 1 and 0

Q.15 The transfer function of the block diagram of figure is



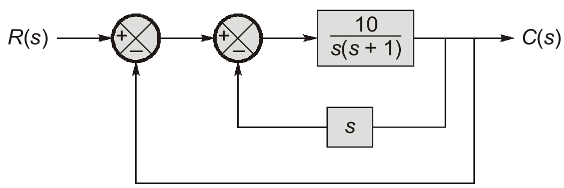
(a) $\dfrac{G_2(G_1+G_3)}{1+G_1G_2H+G_1G_3H}$

(b) $\dfrac{G_1(G_2+G_3)}{1+G_1G_2H+G_1G_3H}$

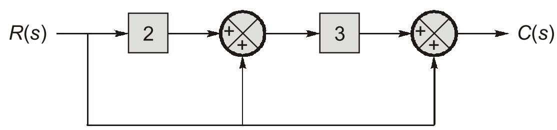
(c) $\dfrac{G_1(G_2-G_3)}{1+G_1H+G_2H}$

(d) $\dfrac{G_1(G_2+G_3)}{1+G_1H+G_3H}$

Q.23 For the system in figure the transfer function $\frac{C(s)}{R(s)}$ is given as $\frac{C(s)}{R(s)} = \frac{P}{s^2 + Rs + Q}$.
Then value of $P + R + Q$ will be _______.



Q.24 For the given block diagram, the value of $\frac{C(s)}{R(s)}$ will be ________.

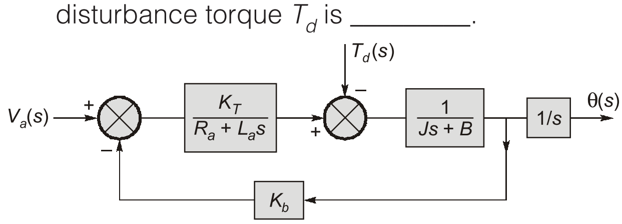


Q.25 The step response of a system is given by,

$$c(t) = \left[1 - \frac{1}{15}e^{-3t} + 7e^{-5t}\right]$$

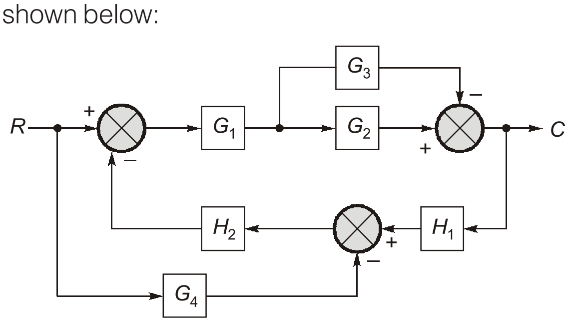
The DC gain of the system is __________.

Q.26 The position control of a DC servo-motor is given in the figure. The values of the parameters are K_T = 1 N-m A, R_a = 1 W, L_a = 0.1 H. J = 5 kg-m^2, B = 1 N-m (rad/sec) and K_b = 1 V/(rad/sec). The steady-state position response (in radians) due to unit impulse disturbance torque T_d is __________.



Multiple Select Questions (MSQs)

Q.27 Which of the following statement(s) is/are correct about the control system whose block diagram is shown below:



(a) For the above block diagram, the signal flow graph has four forward paths.

(b) For the above block diagram, the signal flow graph has two loops.

(c) Transfer function

$$\frac{C}{R} = \frac{G_1G_2 - G_1G_3 + G_1G_2G_4H_2 - G_1G_3G_4H_2}{1 + G_1G_2H_1H_2 - G_1G_3H_1H_2}$$

(d) Transfer function

$$\frac{C}{R} = \frac{G_1G_2 + G_1G_3 + G_1G_2G_4H_2 + G_1G_3G_4H_2}{1 + G_1G_2H_1H_2 + G_1G_3H_1H_2}$$

Q.28 Which of the following statements are correct regarding transfer function.

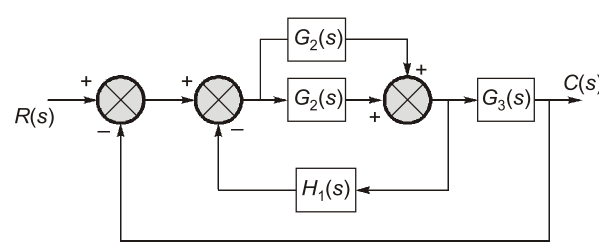
(a) The transfer function is defined only for a linear time-invariant system.

(b) The transfer function is defined for both linear and nonlinear systems.

(c) The transfer function is independent of the input of the system.

(d) The transfer function of a linear time-invariant system is Laplace transform of the impulse response with all the initial conditions set to zero.

Q.29 The overall closed loop transfer function $\frac{C(s)}{R(s)}$ represented in the figure will be



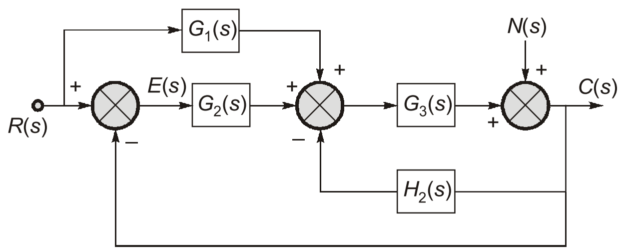
(a) $\frac{C(s)}{R(s)} = \frac{(G_1(s) + G_2(s))G_3(s)}{1 + (G_1(s) + G_2(s))(H_1(s) + G_3(s))}$

(b) $\frac{C(s)}{R(s)} = \frac{(G_1(s) + G_2(s))G_3(s)}{1 + G_1(s)H_1(s) + G_2(s)G_3(s)}$

(c) $\frac{C(s)}{R(s)} = \frac{G_1(s) + G_2(s)}{1 + G_1(s)H_1(s) + G_2(s)H_1(s)}$

(d) $\frac{C(s)}{R(s)} = \frac{G_1(s)G_3(s) + G_2(s)G_3(s)}{1 + G_1(s)H_1(s) + G_2(s)H_1(s) + G_1(s)G_3(s) + G_2(s)G_3(s)}$

Q.30 The block diagram of a control system is shown in figure.



Which of the following statements is/are true?

(a) $\left.\dfrac{C(s)}{R(s)}\right|_{N(s)=0} = \dfrac{G_1G_3 + G_2G_3}{1 + G_3H_1 + G_2G_3}$

(b) $\left.\dfrac{C(s)}{N(s)}\right|_{R(s)=0} = \dfrac{G_1G_3 + G_2G_3}{1 + G_3H_1 + G_2G_3}$

(c) $\left.\dfrac{C(s)}{N(s)}\right|_{R(s)=0} = \dfrac{1}{1 + G_3H_1 + G_2G_3}$

(d) $\left.\dfrac{C(s)}{R(s)}\right|_{N(s)=0} = \dfrac{1}{1 + G_3H_1 + G_2G_3}$

■■■■

Answers Block Diagram and Transfer Function

1.	(a)	2.	(b)	3.	(b)	4.	(d)	5.	(a)	6.	(a)	7.	(c)
8.	(c)	9.	(a)	10.	(a)	11.	(b)	12.	(d)	13.	(c)	14.	(b)
15.	(b)	16.	(d)	17.	(c)	18.	(b)	19.	(d)	20.	(d)	21.	(c)
22.	(1)	23.	(31)	24.	(10)	25.	(1)	26.	(–0.5)	27.	(a, b, c)	28.	(a, c, d)
29.	(a, d)	30.	(a, c)										

Explanations Block Diagram and Transfer Function

1. (a)

$$q(s) = 1 + G(s)H(s) = 0$$

$$q(s) = 1 + \frac{K(s+2)}{(s+1)(s+4)} = 0$$

$$q(s) = (s+1)(s+4) + K(s+2) = 0$$

2. (b)

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)H(s)} \quad \text{... For negative feedback}$$

$$\frac{C(s)}{R(s)} = G_1(s) + G_2(s) \quad \text{... For parallel feedback}$$

$$G_1(s) = \frac{5}{s+2}$$

$$G_2(s) = -\frac{4}{s+1}$$

$$\frac{C(s)}{R(s)} = \frac{5}{s+2} - \frac{4}{s+1} = \frac{s-3}{(s+1)(s+2)}$$

3. (b)

As the three blocks are connected in cascade the overall transfer function is given by the multiplication of individual blocks.

$$\therefore \quad x_1 \times x_2 \times x_3 = \frac{(s+1)}{s(s+2)(s+3)}$$

$$\frac{1}{s(s+2)} \times \frac{(s+2)}{(s+3)} \times x_3 = \frac{(s+1)}{s(s+2)(s+3)}$$

$$x_3 = \frac{(s+1)}{(s+2)}$$

4. (d)

The type of the system = Number of open loop poles at origin

$$\therefore \; G(s)H(s) = \frac{8(s+2)}{s^3(s+1)(s+4)} \times \frac{2}{s^2} = \frac{16(s+2)}{s^5(s+1)(s+4)}$$

∴ Type-5.

5. (a)

Type of system: Number of poles at origin

Order of system: Degree of denominator polynomial or number of total poles

A : Type-1, order 2

B : Type-0, order 2

C : Type-2, order 3

D : Type-0, order 3

6. (a)

Transfer function of unity feedback system with forward path,

$$G'(s) = \frac{G(s)}{1+G(s)}$$

$$\frac{G(s)}{1+G(s)} = \frac{25}{s^2+10s+25}$$

$$G(s)\,(s^2 + 10s + 25) = 25(1 + G(s))$$

$$G(s)\,(s^2 + 10s) = 25$$

$$\Rightarrow \quad G(s) = \frac{25}{s^2+10s}$$

7. (c)

$$\text{Transfer function} = H(s) = \frac{P(s)}{Q(s)}$$

For positive real function, the degree of $P(s)$ and $Q(s)$ must differ by one, but here nothing is mentioned, for transfer function to exist, only initial conditions must be made zero, degree of $P(s)$ and $Q(s)$ are not of importance.

8. (c)

Transfer function only applicable to LTI systems.

9. (a)

The given transfer function has one zero on RHS of s-plane. Hence it is a non-minimum phase transfer function.

10. (a)

Let, Order of denominator polynomial = n

Order of numerator polynomial = m

Transfer function is said to be

(i) Strictly proper if $m < n$

(ii) Proper if $m = n$

(iii) Improper if $m > n$

11. (b)

$$h(t) = e^{-2t}\,u(t)$$

$$y(t) = te^{-2t}\,u(t)$$

Taking Laplace transform:

$$H(s) = \frac{1}{s+2}$$

$$Y(s) = \frac{1}{(s+2)^2}$$

$$Y(s) = H(s)\cdot X(s)$$

$$\Rightarrow \quad \frac{Y(s)}{H(s)} = X(s)$$

$$X(s) = \frac{1}{s+2}$$

$$x(t) = e^{-2t}\,u(t)$$

12. (d)

$$h(t) = \frac{d}{dt}(s(t)) = \frac{d}{dt}(5e^{-10t}u(t))$$

$$h(t) = 5\left[e^{-10t}\delta(t) - 10e^{-10t}u(t)\right]$$

$$h(t) = 5e^{-0}\cdot\delta(t) - 50e^{-10t}\,u(t)$$

$$= 5\delta(t) - 50\,e^{-10t}\,u(t)$$

13. (c)

$$TF_1 = sL[sR]$$

$$= s\left[\frac{-0.5}{s} - \frac{0.5}{s+2}\right] = \frac{-(s+1)}{s+2}$$

$$TF_2 = L[IR] = \frac{1}{s+1}$$

$$\therefore \quad TF = TF_1 \times TF_2 = \frac{-1}{s+2}$$

14. (b)

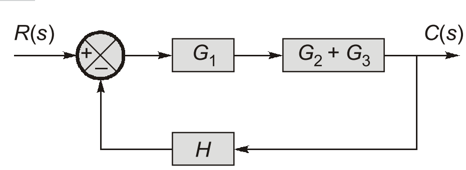
We have, $C_1 = R + C_1 - C_1 = R$

$$\Rightarrow \quad \frac{C_1}{R} = 1$$

Also, $C_2 = R + C_2 - C_2$

$$\Rightarrow \quad \frac{C_2}{R} = 1$$

15. (b)



$$\frac{C(s)}{R(s)} = \frac{G_1(G_2+G_3)}{1+G_1H(G_2+G_3)}$$