POSTAL Book Package 2021

Instrumentation Engineering

Objective Practice Sets

Control Systems & Process Control

Contents

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Publications

2 CHAPTER Block Diagram and Transfer Function

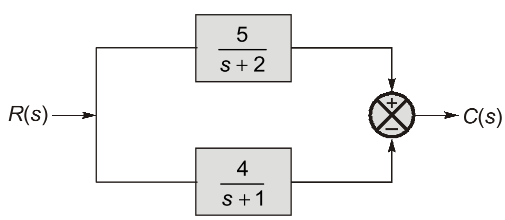
Q.1 Consider the following open-loop transfer function:

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

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

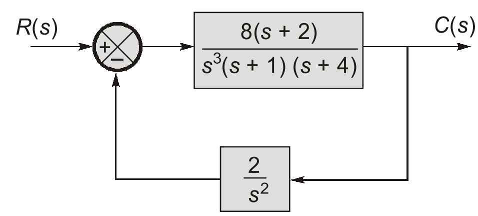
(c) $\frac{9s+13}{(s+2)(s+1)}$ (d) $\frac{1}{(s+2)(s+1)}$

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:

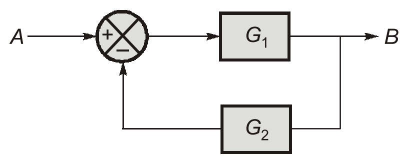
	A	B	C	D
(a)	2	1	4	3
(b)	4	3	2	1
(c)	2	3	4	1
(d)	4	1	2	3

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?

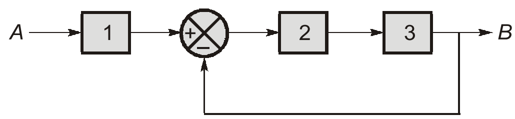
(a) $\frac{25}{s^2+10s}$ (b) $\frac{25}{s^2+25}$

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

Q.16 Original block diagram

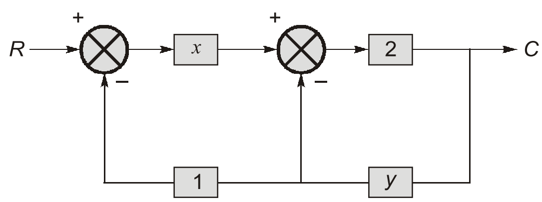


Equivalent block diagram blocks 1, 2, 3 are respectively.



(a) G_1, G_2, G_3 (b) $1/G_1$, $1/G_2$, $1/G_3$
(c) $1/G_1$, G_2, G_3 (d) $1/G_2$, G_1, G_2

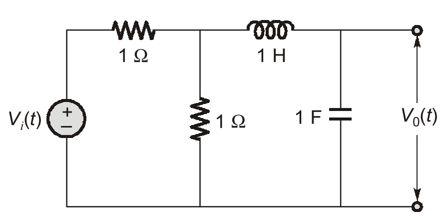
Q.17 Consider the diagram shown,



If $\frac{C}{R}$ = 1, then

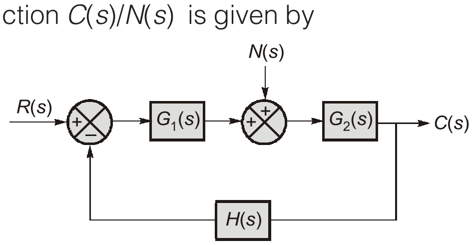
(a) $x - y - xy = 1$ (b) $x - y + xy = 1$
(c) $x - y - xy = \frac{1}{2}$ (d) $x - y + xy = \frac{1}{2}$

Q.18 Find the transfer function $\frac{V_0(s)}{V_i(s)}$ for the network shown in figure.



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

Q.19 The closed-loop system shown in the figure is subjected to a disturbance $N(s)$. The transfer function $C(s)/N(s)$ is given by



(a) $\frac{G_1(s)\, G_2(s)}{1 + G_1(s) G_2(s)\, H(s)}$ (b) $\frac{G_1(s)}{1 + G_1(s)\, H(s)}$
(c) $\frac{G_2(s)}{1 + G_2(s)\, H(s)}$ (d) $\frac{G_2(s)}{1 + G_1(s)\, G_2(s)\, H(s)}$

Q.20 Consider the following statements and choose the correct option:

Statement 1: Non minimum phase functions are the functions which have poles or zeros on the right hand side of s-plane.

Statement 2: Minimum phase systems are systems which have no poles or zeros with positive real parts.

Statement 3: A system having the transfer function as $F(s) = \frac{1 - sT}{1 + sT}$ represents an all pass system.

(a) Statements 1 and 2 are correct
(b) Statements 2 and 3 are correct
(c) Statements 1 and 3 are correct
(d) All the statements are correct

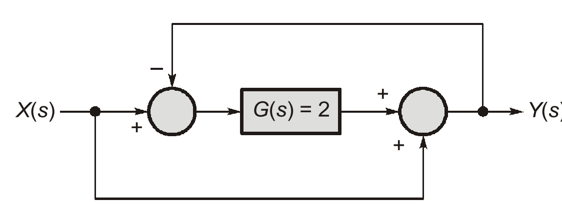
Q.21 **Statement (I):** The eigen values of the linear system explain about the stability of the system.

Statement (II): Eigen values of linear system give the location of zeros of closed loop transfer function.

Codes:

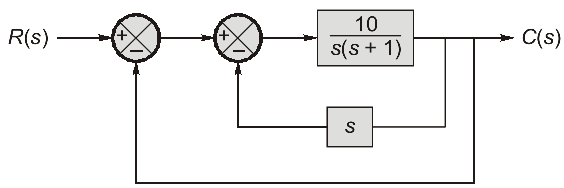
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

Q.22 For the system shown in the figure, $Y(s)/X(s)$ = _______.

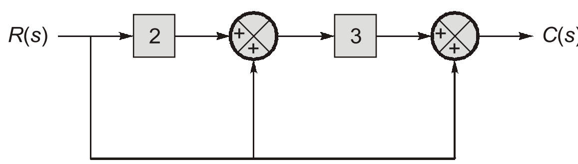


Q.23 For the system in figure the transfer function $\frac{C(s)}{R(s)}$ is given as $\frac{C(s)}{R(s)} = \frac{P}{s^2 + Rs + Q}$.

Then value of $P + R + Q$ wi will be ________.



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

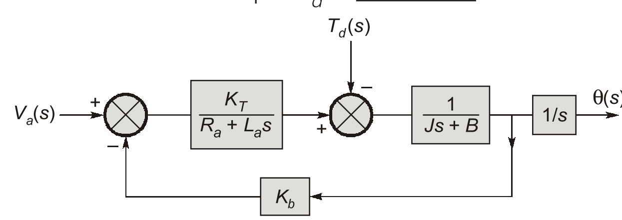


Q.25 The step response of a system is given by,

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

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 __________.



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)	

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.

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

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

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

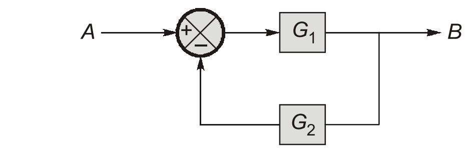
4. (d)

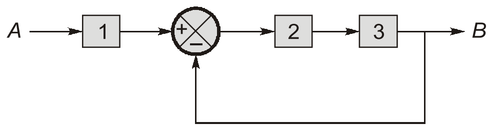
The type of the system = Number of open loop poles at origin

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

∴ Type-5.

16. (d)





We know, $\dfrac{B}{A} = \dfrac{G_1}{1+G_1G_2}$

$$\frac{B}{A} = \left[\frac{2.3}{1+2.3}\right]1$$

Now, option (a)

$$\text{TF} = \frac{G_1G_2G_3}{1+G_2G_3}$$

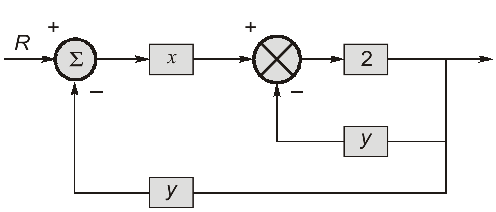
Option (b), $\text{TF} = \dfrac{\dfrac{1}{G_1}\cdot\dfrac{1}{G_2}\cdot\dfrac{1}{G_3}}{1+\dfrac{1}{G_2}\cdot\dfrac{1}{G_3}} = \dfrac{1}{G_1(1+G_2G_3)}$

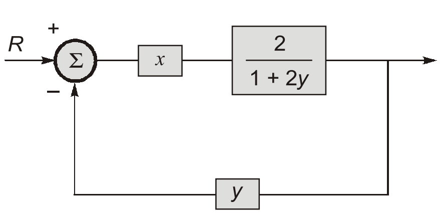
Option (c), $\text{TF} = \dfrac{\dfrac{1}{G_1}\cdot G_2\cdot G_3}{1+G_2G_3} = \dfrac{G_2G_3}{G_1(1+G_2G_3)}$

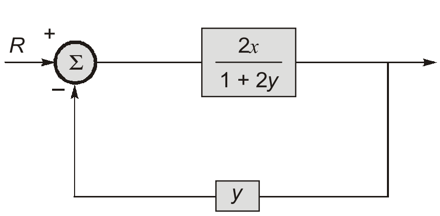
Option (d), $\text{TF} = \dfrac{\dfrac{1}{G_2}\cdot G_1G_2}{1+G_1G_2} = \dfrac{G_1}{1+G_1G_2}$

Hence option (d) is correct.

17. (c)







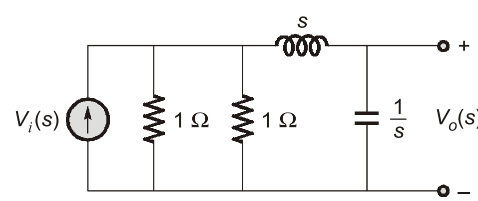
$$\frac{C}{R} = \frac{\dfrac{2x}{1+2y}}{1+\dfrac{2x.y}{1+2y}} = \frac{2x}{1+2y+2xy}$$

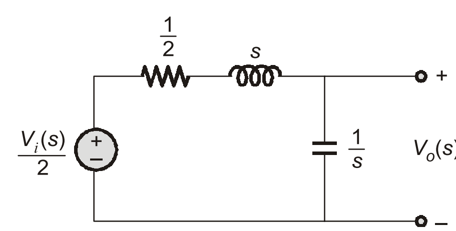
$$\frac{C}{R} = \frac{2x}{1+2y+2xy} = 1$$

$$2x = 1 + 2y + 2xy$$

$$\Rightarrow \quad x - y - xy = \frac{1}{2}$$

18. (b)





Applying voltage division

$$\frac{V_o(s)}{\dfrac{V_i(s)}{2}} = \frac{\dfrac{1}{s}}{\dfrac{1}{2}+s+\dfrac{1}{s}} = \frac{2}{2s^2+2+s}$$

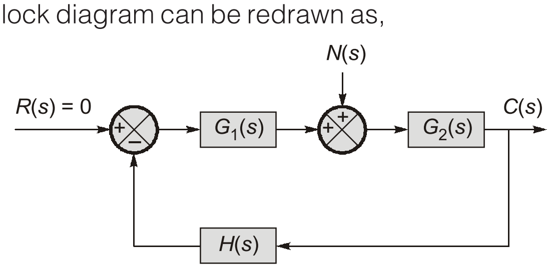
$$2\frac{V_o(s)}{V_i(s)} = \frac{2}{2s^2+s+2}$$

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

19. (d)

To calculate, $\dfrac{C(s)}{N(s)}$, input $R(s)$ is set to zero.

Block diagram can be redrawn as,



$$= \frac{15(s^2+8s+15) - s^2 - 5s + 105s^2 + 315s}{15s(s+3)(s+5)}$$

$$= \frac{119s^2 + 430s + 225}{15s(s+3)(s+5)}$$

∴ Transfer function,

$$T(s) = \frac{C(s)}{R(s)} = sC(s)$$

$$= \frac{119s^2 + 430s + 225}{15(s+3)(s+5)}$$

$$\text{DC gain} = \lim_{s \to 0} T(s) = \frac{225}{15 \times 3 \times 5} = 1$$

26. (–0.5)

The transfer function due to the disturbance torque $T_d(s)$ is

$$\frac{\theta(s)}{T_d(s)} = \frac{-\frac{1}{(Js+B)} \times \frac{1}{s}}{1 + \left(\frac{1}{Js+B}\right)\left(\frac{K_b K_T}{R_a + L_a s}\right)}$$

$$= \frac{-(R_a + L_a s) \cdot \frac{1}{s}}{(R_a + L_a s)(Js + B) + K_b K_T}$$

The steady value of response for unit impulse input

$$\theta(0) = \lim_{s \to 0} \frac{-s(R_a + L_a s) \cdot \frac{1}{s}}{(R_a + L_a s)(Js + B) + K_b K_T} \cdot T_d$$

$$= -\frac{R_a}{R_a B + K_b K_T} \cdot 1$$

Given:

K_T = 1 N-m/A R_a = 1 Ω,

B = 1 N-m/rad/sec

and K_b = 1 V/rad/sec

Substituting the given values into above equation, we get

$$\theta(0) = -\frac{1}{2} = -0.5 \text{ rad}$$

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