Signal Flow Graph and Block Diagram Questions

MCQ Question 1

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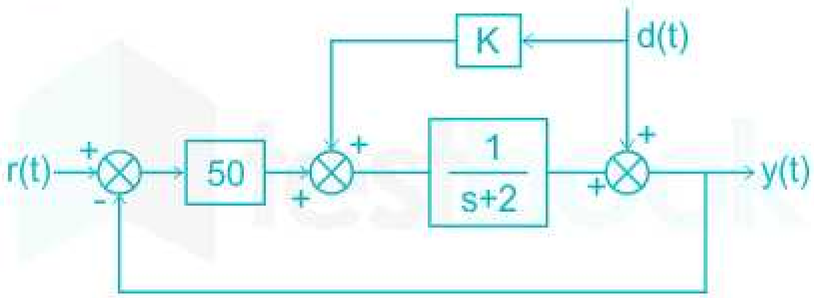
Consider the control system shown in figure with feed forward action for rejection of a measurable disturbance d(t). The value of k, for which the disturbance response at the output y(t) is zero mean, is



1. 1
2. -1
3. 2
4. -2

Answer (Detailed Solution Below)

Option 4 : -2

Signal Flow Graph and Block Diagram MCQ Question 1 Detailed Solution

$$Y(s) = [-50\,Y(s) + K\,D(s)]\,\frac{1}{s+2} + D(s)$$

$$Y(s)\left[1+\frac{50}{s+2}\right]=\left[\frac{K}{s+2}+1\right]D(s)$$

$$\Rightarrow Y(s)=\frac{K+s+2}{s+52}D(s)$$

$$\Rightarrow Y(j\omega)=\frac{K+2+j\omega}{52+j\omega}D(j\omega)$$

The disturbance response at the output y(t) is zero mean.

At ω = 0, Y(j0) = 0

$$\Rightarrow \frac{K+2+0}{52+0}=0$$

⇒ K = -2

MCQ Question 2

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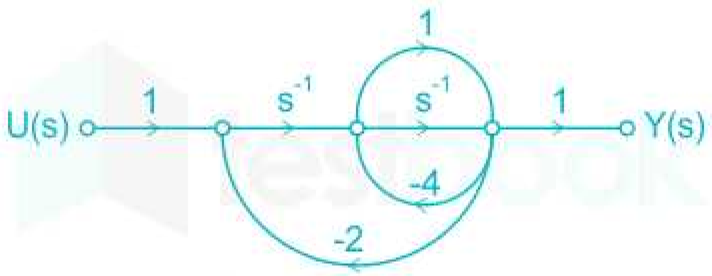
The signal flow graph for a system is given below.



The transfer function $\frac{Y(s)}{U(s)}$ for this system is

1. $\frac{s+1}{5s^2+6s+2}$

2. $\frac{s+1}{s^2+6s+2}$

3. $\frac{s+1}{s^2+4s+2}$

4. $\frac{1}{5s^2+6s+2}$

Answer (Detailed Solution Below)

Option 1 : $\frac{s+1}{5s^2+6s+2}$

Signal Flow Graph and Block Diagram MCQ Question 2 Detailed Solution

Concept:

Signal flow graph

- It is a graphical representation of a set of linear algebraic equations between input and output.
- The set of linear **algebraic** equations represents the **systems**.
- The signal flow graphs are developed to avoid mathematical calculation.

Maon gain formula is used to find the ratio of any two nodes or transfer function.

T F = $\sum_{k=1}^{i} \frac{P_k \Delta_k}{\Delta}$

Where P_k = k^{th} forward path gain

Δ = 1- ∑ individual loop gain + ∑ two non-touching loops gain - ∑ the gain product of three non-touching loops + ∑ gain of four non-touching loops

Shotcut: while writing Δ take the opposite sign for the odd number of non-touching loops snd the same sign for the even the number of non-touching loops.

Δ_K is obtained from Δ by removing the loops touching the K^{th} forward path.

Calculation:

For the given SFG two forward paths

$$P_{K1} = 1\left(s^{-1}\right)\left(s^{-1}\right)(1) = s^{-2}$$

$$P_{k2} = 1\left(s^{-1}\right)(1)(1) = s^{-1}$$

Since all loops are touching the paths P_{K1} and P_{K2} so $\Delta_{K1} = \Delta_{K2} = 1$

We have Δ = 1- ∑ individual loops + ∑ non-touching loops gain

Loops are

$$L_1 = (-4)(1) = -4$$

$$L_2 = (-4)\left(s^{-1}\right) = -4s^{-1}$$

$$L_3 = -2\left(s^{-1}\right)\left(s^{-1}\right) = -2s^{-2}$$

$$L_4 = -2\left(s^{-1}\right)(1) = -2s^{-1}$$

As all the loops are touching each other we have

Δ = 1 − (L1 + L2 + L3 + L4)

$\Delta = 1 - (- 4 - 4s^{-1} - 2s^{-2} - 2s^{-1})$

$\Delta = 5 + 6s^{-1} + 2s^{-2}$

$$T.F = \frac{s^{-2}+s^{-1}}{5+6s^{-1}+2s^{-2}}$$

$$= \frac{s+1}{5s^2+6s+2}$$

MCQ Question 3

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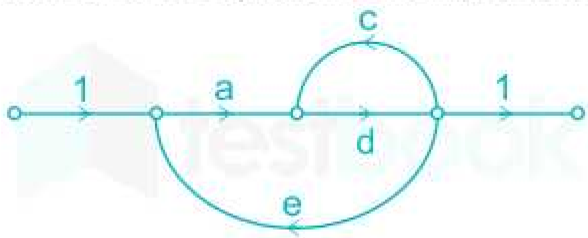
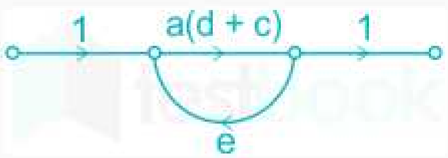
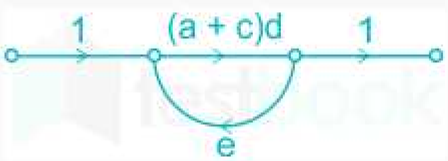
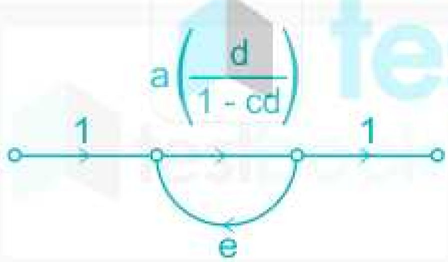
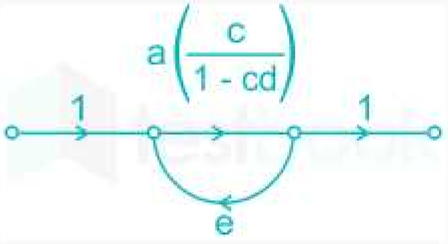
Which of the options is an equivalent representation of the signal flow graph shown here?



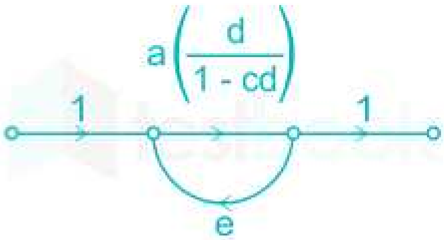
1. 

2. 

3. 

4. 

Answer (Detailed Solution Below)

Option 3 : 

Signal Flow Graph and Block Diagram MCQ Question 3 Detailed Solution

Concept:

According to **Mason's gain formula**, the transfer function is given by

$$TF = \frac{\sum_{k=1}^{n} M_k \Delta_k}{\Delta}$$

Where, n = no of forward paths

M_k = k^{th} forward path gain

Δ_k = the value of Δ which is not touching the k^{th} forward path

Δ = 1 − (sum of the loop gains) + (sum of the gain product of two non-touching loops) − (sum of the gain product of three non-touching loops)

Application:

In the given signal flow graph,

Forward paths: P_1 = ad

Loops: L_1 = cd, L_2 = ade

Δ = 1 − (cd + ade)

Δ_1 = 1

Transfer function $= \frac{ad}{1-(cd+ade)}$

Now, let us check the options.

Option 1:

Forward paths: P_1 = a(d + c)

Loops: L_1 = ae(d + c)

$\Delta = 1 - ae(d + c)$

$\Delta_1 = 1$

Transfer function $= \frac{a(d+c)}{1-ae(d+c)}$

Option 2:

Forward paths: $P_1 = d(a + c)$

Loops: $L_1 = de(a + c)$

$\Delta = 1 - de(a + c)$

$\Delta_1 = 1$

Transfer function $= \frac{d(a+c)}{1-de(a+c)}$

Option 3:

Forward paths: $P_1 = a\left(\frac{d}{1-cd}\right)$

Loops: $L_1 = ae\left(\frac{d}{1-cd}\right)$

$\Delta = 1 - ae\left(\frac{d}{1-cd}\right)$

$\Delta_1 = 1$

Transfer function $= \frac{a\left(\frac{d}{1-cd}\right)}{1-ae\left(\frac{d}{1-cd}\right)} = \frac{ad}{1-(cd+ade)}$

Option 4:

Forward paths: $P_1 = a\left(\frac{c}{1-cd}\right)$

Loops: $L_1 = ae\left(\frac{c}{1-cd}\right)$

$\Delta = 1 - ae\left(\frac{c}{1-cd}\right)$

$\Delta_1 = 1$

Transfer function $= \frac{a\left(\frac{c}{1-cd}\right)}{1-ae\left(\frac{c}{1-cd}\right)} = \frac{ad}{1-(cd+ace)}$

Hence the signal graph in option (3) is the equivalent representation of the signal flow graph given in the question.

MCQ Question 4

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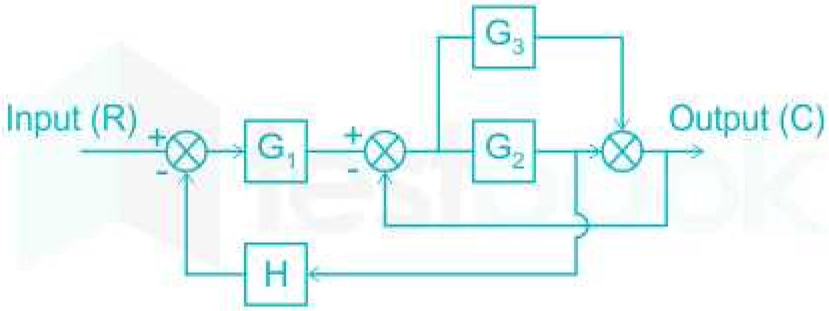
What will be the transfer function of the given block diagram?



1. $(G_1G_2 + G_1G_3) / (1 - G_1G_2H + G_2 + G_3)$

2. $(G_1 + G_3) / (1 + G_1G_2H + G_2 + G_3)$

3. $(G_1G_2 + G_1G_3) / (1 + G_1G_2H + G_2 + G_3)$

4. $(G_1G_2 - G_1G_3) / (1 - G_1G_2H - G_2 + G_3)$

Answer (Detailed Solution Below)

Option 3 : $(G_1G_2 + G_1G_3) / (1 + G_1G_2H + G_2 + G_3)$

Signal Flow Graph and Block Diagram MCQ Question 4 Detailed Solution

Concept:

Mason's Gain Formula is used to evaluate an overall transmittance (gain), which can be expressed as,

$$T = \frac{\sum P_k \Delta_k}{\Delta}$$

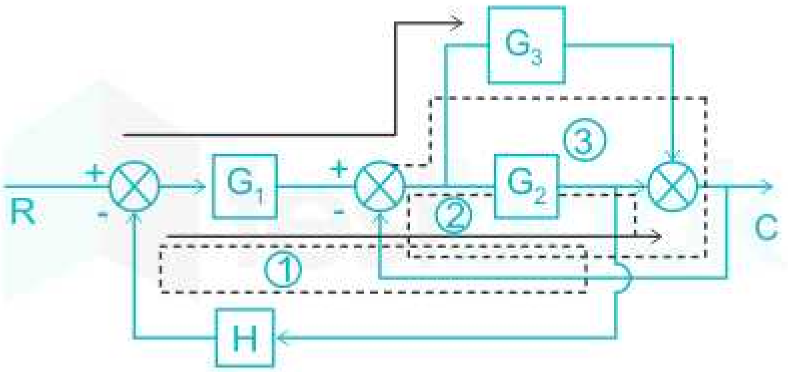
Where

P_k = forward path transmittance of k_{th} path

Δ = graph determinant comprising closed-loop transmittances & mutual interactions between non-touching loops.

Δ_K = path factor consisting of all isolated closed loops from the forward path in the graph.

Analysis:



Forward path: $G_1 G_2, G_1 G_3$

Loops: $-G_2, -G_1G_2H, -G_3$

Finding the transfer function using Mason's gain formula:

$$\frac{C}{R} = \frac{G_1G_2+G_1G_3}{1+G_2+G_3+G_1G_2H}$$

MCQ Question 5

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The point from which the signal is taken for the feedback purpose is called:

1. Summing point
2. Null point
3. Take-off point

4. Feedback point

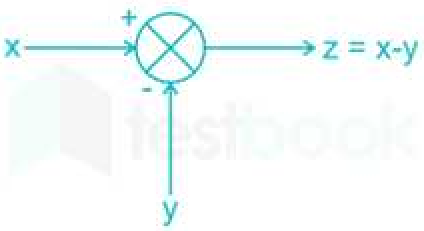
Answer (Detailed Solution Below)

Option 3 : Take-off point

Signal Flow Graph and Block Diagram MCQ Question 5 Detailed Solution

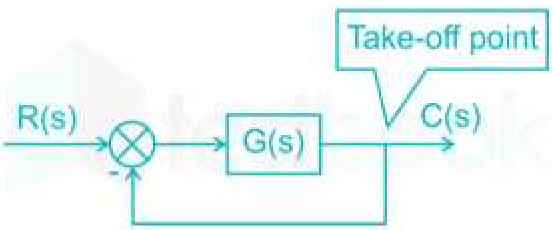
Summing point:

It is the point where two signals are added or subtracted.



Take-off point

Take off point is the point from where the signal is taken and feedback or forward to a summing point in the system.



MCQ Question 6

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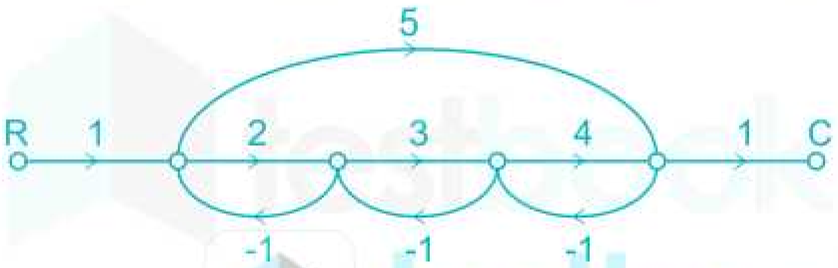
In the signal flow graph of figure given below, the gain C/R will be



1. 11/9
2. 22/15
3. 24/23
4. 44/23

Answer (Detailed Solution Below)

Option 4 : 44/23

Signal Flow Graph and Block Diagram MCQ Question 6 Detailed Solution

Concept:

Mason's Gain Formula

- It is a technique used for finding the transfer function of a control system. A formula that determines the transfer function of a linear system by making use of the signal flow graph is known as **Mason's Gain Formula**.
- It shows its significance in determining the relationship between input and output.

Suppose there are 'N' forward paths in a signal flow graph. The gain between the input and the output nodes of a signal flow graph is nothing but the **transfer function** of the system. It can be calculated by using Mason's gain formula.

Mason's gain formula is

$$T = \frac{C(s)}{R(s)} = \frac{\sum_{i=1}^{N} P_i \Delta_i}{\Delta}$$

Where,

C(s) is the output node

R(s) is the input node

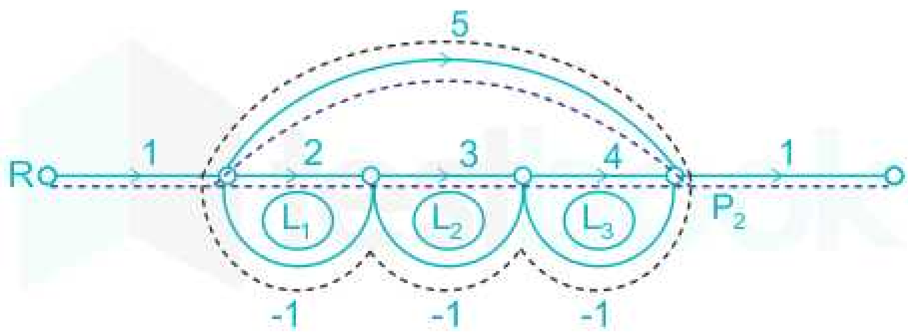
T is the transfer function or gain between $R(s)$ and $C(s)$

P_i is the i^{th} forward path gain

Δ = 1−(sum of all individual loop gains) + (sum of gain products of all possible two non-touching loops) − (sum of gain products of all possible three non-touching loops) + ...

Δ_i is obtained from Δ by removing the loops which are touching the i^{th} forward path.

Calculations:



The forward paths are as follows:

$P_1 = 5$

$P_2 = 2 \times 3 \times 4 = 24$

The loops are as follows:

$L_1 = -2$, $L_2 = -3$, $L_3 = -4$, $L_4 = -5$

The two non-touching loops are:

$L_1L_3 = 8$

There is no three non-touching loops

By Mason's gain formula:-

$$\frac{C}{R} = \frac{24 + 5(1+3)}{1+2+3+4+5+8}$$

$$= \frac{44}{23}$$

MCQ Question 7

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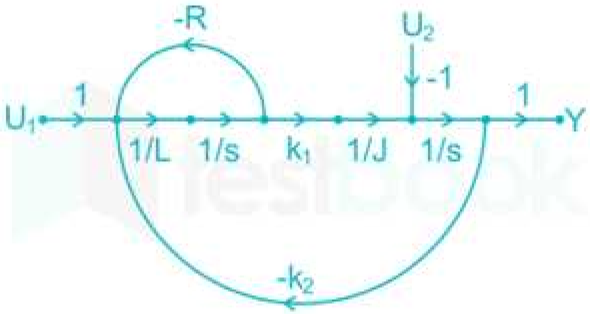
In the system whose signal flow graph is shown in the figure, $U_1(s)$ and $U_2(s)$ are inputs. The transfer function $\frac{Y(s)}{U_1(s)}$ is



1. $\frac{k_1}{JLs^2+JRs+k_1k_2}$

2. $\frac{k_1}{JLs^2-JRs-k_1k_2}$

3. $\frac{k_1-U_2(R+sL)}{JLs^2+(JR-U_2L)s+k_1k_2-U_2R}$

4. $\frac{k_1-U_2(sL-R)}{JLs^2-(JR+U_2L)s-k_1k_2+U_2R}$

Answer (Detailed Solution Below)

Option 1 : $\frac{k_1}{JLs^2+JRs+k_1k_2}$

Signal Flow Graph and Block Diagram MCQ Question 7 Detailed Solution

No. of forward paths from $u_1(s)$ to Y(s) are:

$$P_1 = (1)\left(\frac{1}{L}\right)\left(\frac{1}{S}\right)(K_1)\left(\frac{1}{J}\right)\left(\frac{1}{S}\right)(1) = \frac{K_1}{JLS^2}$$

No. of loops are:

$$L_1 = \left(\frac{1}{L}\right)\left(\frac{1}{S}\right)(-R) = \frac{-R}{SL}$$

$$L_2 = \left(\frac{1}{L}\right)\left(\frac{1}{s}\right)(K_1)\left(\frac{1}{J}\right)\left(\frac{1}{S}\right)(-K_2) = -\frac{K_1K_2}{JLS^2}$$

$$\Delta = 1-(L_1+L_2) = 1+\frac{R}{SL}+\frac{K_1K_2}{JLS^2}$$

From Mason's gain formula:

Transfer function $= \frac{\sum_{K=1}^{n} P_K \Delta_K}{\Delta}$

$= \frac{\frac{K_1}{JLS^2}(1)}{1+\frac{R}{SL}+\frac{K_1K_2}{JLS^2}}$

$\frac{Y(s)}{U_1(s)} = \frac{K_1}{JLS^2+JRS+K_1K_2}$

MCQ Question 8

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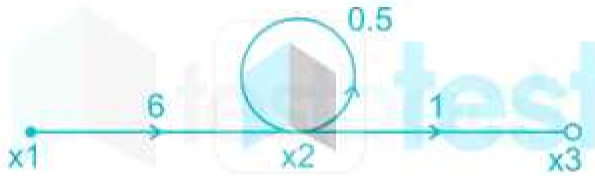
The value of x3/x1 in the below circuit is:



1. 2
2. 8
3. 12
4. 4

Answer (Detailed Solution Below)

Option 3 : 12

Signal Flow Graph and Block Diagram MCQ Question 8 Detailed Solution

Signal flow graph:

It is a graphical representation of a block diagram.

Formula:

Mason's gain formula is used to determine transfer function T(s) = C(s)/R(s).

Mason's gain formula is

$T(s) = \sum_k (P_k \Delta_k / \Delta)$

k = No. of forwarding paths

P_k = k_{th} forward path gain

Δ = 1 − (sum of all individual loop gains) + (sum of gain products of all possible two non-touching loops)

- (sum of gain products of all possible three non-touching loops) + ...

Δ_k is obtained from 'Δ' by removing the loops which are touching the k^{th} forward path.

Solution:

The ratio x_3/x_1 can be calculated using Mason Gain formula:

$$T.F. = \frac{\Sigma p_i \Delta_i}{\Delta}$$

$P_1 = 6$

$\Delta_1 = 1$

$\Delta = 1 - 0.5 = 0.5$

$$\frac{x_3}{x_1} = \frac{6}{0.5} = 12$$

MCQ Question 9

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The closed-loop transfer function $\frac{C(s)}{R(s)}$ of the system represented by the signal flow graph

as shown in figure is

1. $\frac{G_1G_2G_3G_4}{(1+G_1+G_2)}$

2. $\frac{G_1G_2G_3G_4}{(1+G_3+G_4)}$

3. $\frac{G_1G_2G_3G_4}{(1+G_1+G_2)(1+G_3+G_4)}$

4. $\frac{G_1G_2G_3G_4}{(1+G_1G_2)(1+G_3G_4)}$

Answer (Detailed Solution Below)

Option 3 : $\frac{G_1G_2G_3G_4}{(1+G_1+G_2)(1+G_3+G_4)}$

Signal Flow Graph and Block Diagram MCQ Question 9 Detailed Solution

Concept:

According to Mason's gain formula, the transfer function is given by

$$TF = \frac{\sum_{k-1}^{n} M_k\Delta_k}{\Delta}$$

Where

MCQ Question 10

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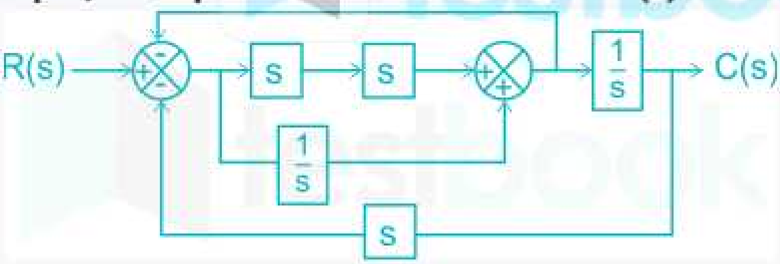
For following Fig. if C(s) is Laplace Transform of output and R(s) is Laplace transform of input, the equivalent transfer function T(s) will be



1. $T(s) = \frac{s^3+1}{2s^4+s^2+2s}$
2. $T(s) = \frac{s^3+1}{2s^4+s^2+1}$
3. $T(s) = \frac{s^3-1}{2s^4+s^2+2s}$
4. $T(s) = \frac{s^3+1}{2s^4+s^2-1}$

Answer (Detailed Solution Below)

Option 1 : $T(s) = \frac{s^3+1}{2s^4+s^2+2s}$