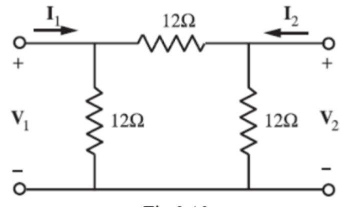
1. Determine the h parameters of the circuit shown in fig 1.



Performing Δ to Y transformation, the network shown in Fig.8.13 takes the form as shown in Fig.8.14

Since all the resistors are of same value $R_Y = \frac{1}{3} R_\Delta$

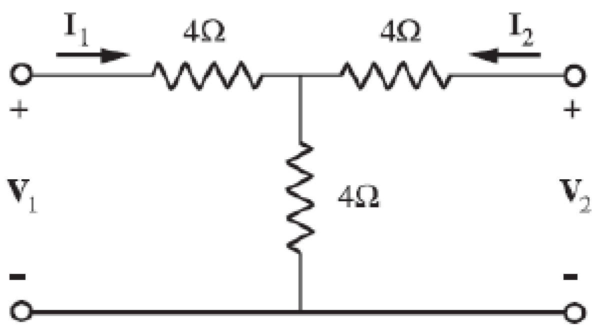


Fig.8.14

To find h_{11} and h_{21}, short-circuit the output port and connect a current source I_1 to the input port as in Fig. 8.15

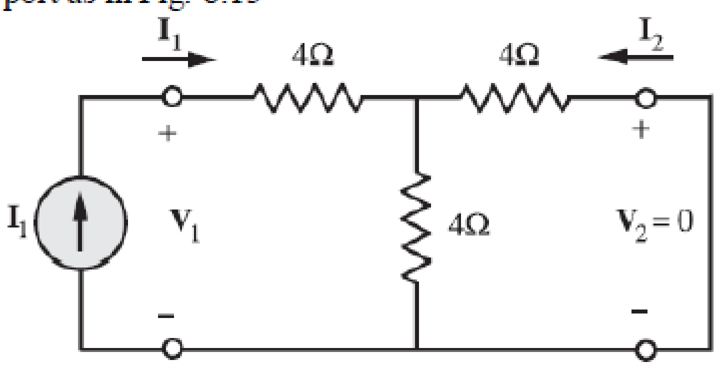


Fig.8.15

$$V_1 = I_1[4 + (4||4)]$$
$$V_1 = 6I_1$$

Hence $h_{11} = \left.\frac{V_1}{I_1}\right|_{V_2=0} = 6\Omega$

Using the principle of current division

$$-I_2 = \frac{I_1}{4+4} \times 4$$
$$\Rightarrow \quad -I_2 = \frac{I_1}{2}$$
$$\Rightarrow \quad h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0} = -\frac{1}{2}$$

To find h_{12} and h_{22}, open-circuit the input port and connect a voltage source V_2 to the output port as shown in Fig. 8.16

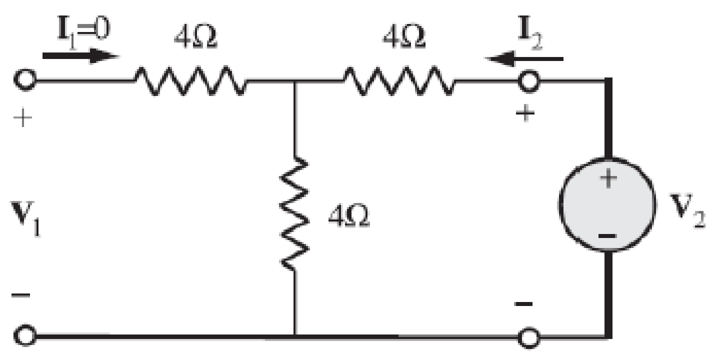
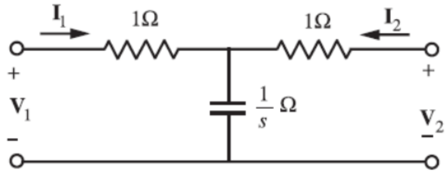


Fig.8.16

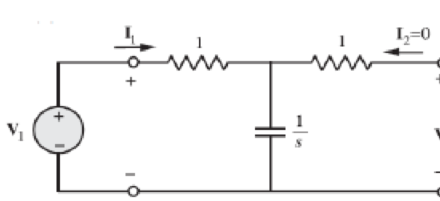
Using the principle of voltage division, we get

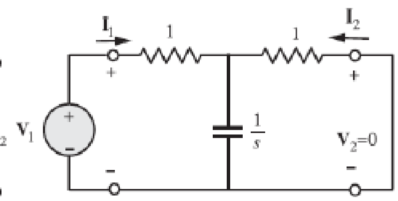
$$V_1 = \frac{V_2}{4+4} \times 4$$
$$\Rightarrow \quad h_{12} = \left.\frac{V_1}{V_2}\right|_{I_1=0} = \frac{1}{2}$$
$$V_2 = (4+4)I_2 = 8I_2$$

2. Refer the circuit shown in Fig. 2. Find the transmission parameters.



To find the parameters **A** and **C**, open-circuit the output port and connect a voltage source V_1 at the input port as shown in Fig. below (Left side)





$$I_1 = \frac{V_1}{1+\frac{1}{s}} = \frac{sV_1}{s+1}$$

$$V_2 = \frac{1}{s}I_1 = \frac{V_1}{s+1}$$

Therefore $A = \left.\frac{V_1}{V_2}\right|_{I_2=0} = s+1$

And $C = \left.\frac{I_1}{V_2}\right|_{I_2=0} = s$

To find the parameters B and D, short-circuit the output port and connect a voltage source V_1 to the input port as shown in Fig. above (Right)

Applying the current division formula

$$I_2 = -I_1\left(\frac{1}{s+1}\right)$$

Hence $D = \left.\frac{I_1}{-I_2}\right|_{V_2=0} = (s+1)$

The total impedance as seen by the source V_1 is

$$Z = 1 + \frac{1\times\frac{1}{s}}{1+\frac{1}{s}} = \frac{s+2}{s+1} = \frac{V_1}{I_1}$$

$$I_1 = -I_2(s+1) = \frac{V_1(s+1)}{(s+2)}$$

Hence $B = \left.\frac{V_1}{-I_2}\right|_{V_2=0} = (s+2)$

3. Find initial value of $f(t)$ if $F(s)$ is the Laplace transform of $f(t)$.

$$F(s) = \frac{0.9(s+1)}{2.1s^2+5s+16}$$

Sol:

$$F(s) = \frac{0.9(s+1)}{2.1s^2+5s+16}$$

By initial value theorem

$$Since,\ \lim_{t \to 0^+} f(t) = \lim_{s \to \infty} sF(s) = f(0^+),\ and\ here\ sF(s) = \frac{0.9s^2+0.9s}{2.1s^2+5s+16}$$

$$Hence,\ \lim_{s \to \infty} sF(s) = \lim_{s \to \infty} \frac{0.9s^2+0.9s}{2.1s^2+5s+16} = \frac{0.9}{2.1}$$

Find final value of the $f(t)$ if $F(s)$ is the Laplace transform of $f(t)$.

$$F(s) = \frac{2s+51}{47s^2+67s}$$

$$f(\infty) = \lim_{s \to 0} sF(s) = \lim_{s \to 0} \frac{2s+51}{47s+67} = \frac{51}{67}$$

4. Define control system and differentiate between open loop and closed loop control system with examples.

A **control system** is defined as the mechanism or a system that provides the desired response or output by controlling the input and processing system.

Depending on the feedback path present in the system, the control systems can be classified into following two types, viz –

- Open Loop Control System
- Closed Loop Control System

- An **open loop control system** is the one in which the output signal is not fed back to the input of the system. Therefore, an open loop control system is also referred to as a non-feedback control system.

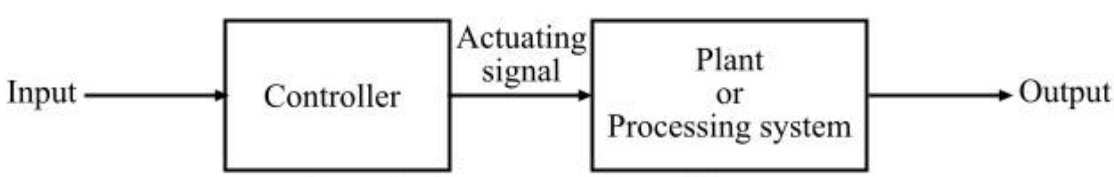


Figure 1 - Open Loop Control System

- In case of open loop control system, the output has no control on the control action of the system. Thus, the open loop control system follows its input signals regardless of the final results.
- The major disadvantage of an open loop control system is that it is poorly equipped to handle the disturbances which may reduce its ability to complete the desired task. Some common examples of open loop control system are: traffic light system, field controlled DC motor, automatic washing machine, immersion rod, etc.

A **closed loop control system** is the one in which the output signal is fed-back to the input of the system. Therefore, in a closed loop control system, the control action is a function of desired output signal.

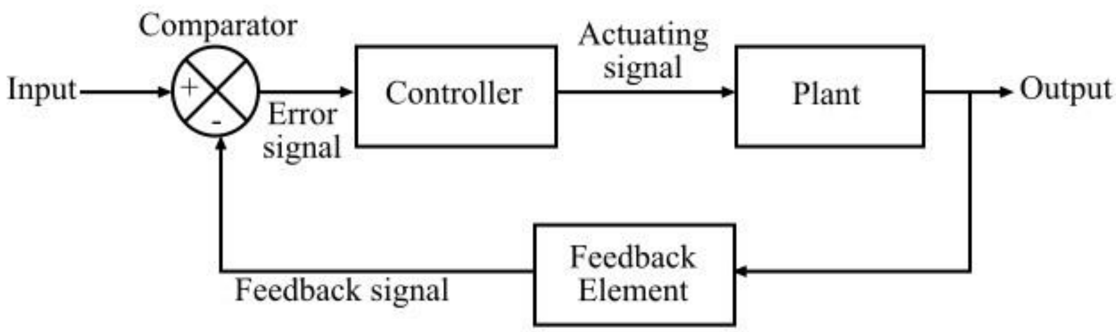


Figure 2 - Closed Loop Control System

Difference between open loop and closed loop control system

Open Loop Control System	Closed Loop Control System
A control system in which there is no feedback path is provided is called an *open loop control system*.	The control system in which there is a feedback path present is called a *closed loop control system*.
In open loop control system, the control action is independent of the output of the overall system.	In closed loop control system, the control action is dependent on the output of the system.
The design and construction of an open loop control system is quite simple.	Closed loop control system has comparatively complex design and construction.
The major components of an open loop control system are – controller and plant.	The main components of a closed loop control system are – Controller, plant or process,

	feedback element and error detector (comparator).
The stability of open loop control system is more, i.e., the output of the open loop system remains constant.	Closed loop control system is comparatively less stable.
Open loop control system requires less maintenance.	Comparatively more maintenance is needed in closed loop control system.
Common practical examples of open loop control systems are – automatic traffic light system, automatic washing machine, immersion heater, etc.	Examples of closed loop control systems include: ACs, fridge, toaster, rocket launching system, radar tracking system, etc.

5. Define transfer function and find the transfer function of the series RLC circuit shown in Fig.3. Considering the voltage across capacitor as output.

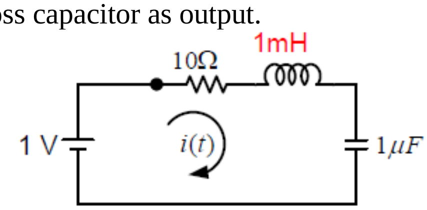


Fig.3

Solution:

$$i(0^-) = i(0^+) = 0$$

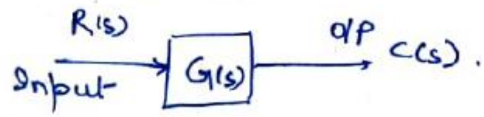
$$V = 10i + L\frac{di}{dt} + \frac{1}{C}\int idt$$

Taking the Laplace transform on both sides

$$\begin{aligned}
\frac{1}{s} &= 10I(s) + L[sI(s) - i(0^+)] \\
&\quad + \frac{1}{C}\left[\frac{I(s)}{s} + \frac{q(0^-)}{s}\right] \\
\frac{1}{s} &= 10I(s) + LsI(s) + \frac{1}{C}\frac{1}{s} \\
&= I(s)[10 + 10^{-3}s + \frac{10^6}{s}] \\
11 &= I(s)[10s + 10^{-3}s^2 + 10^6] \\
1 &= I(s)[10^{-3}s^2 + 10s + +10^6] \\
I(s) &= \frac{1}{10^{-3}s^2 + 10s + +10^6}
\end{aligned}$$

6. Illustrate how to perform the following, in connection with block diagram reduction rules:
   (i) Shifting a take-off point after a summing point.
   (ii) Shifting a take-off point before a summing point.
   (iii) Reducing a simple feedback loop

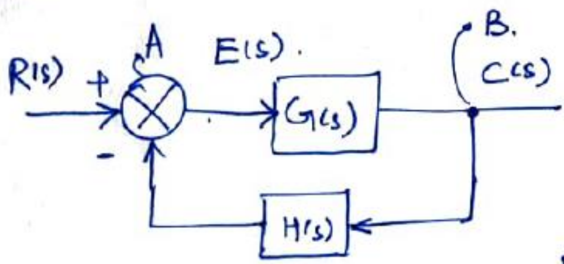
Block diagram Algebra



$$\frac{C(s)}{R(s)} = G(s)$$

$$C(s) = G(s)\,R(s).$$

Block diagram of a closed-loop system



A – summing point

B – Take off point

$$E(s) = R(s) - C(s)H(s).$$

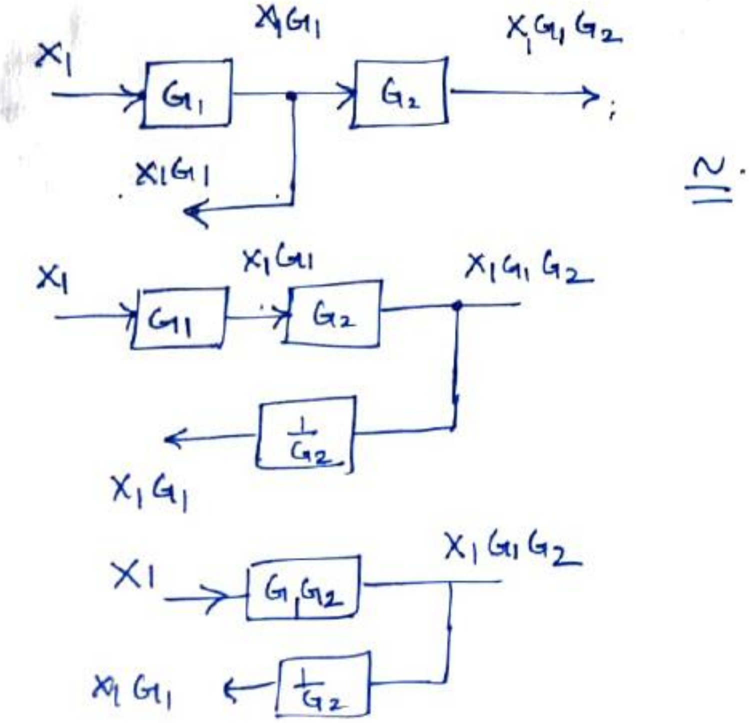
$$C(s) = E(s)\,G(s)$$

$$C(s) = \left[R(s) - C(s)H(s)\right]G(s).$$

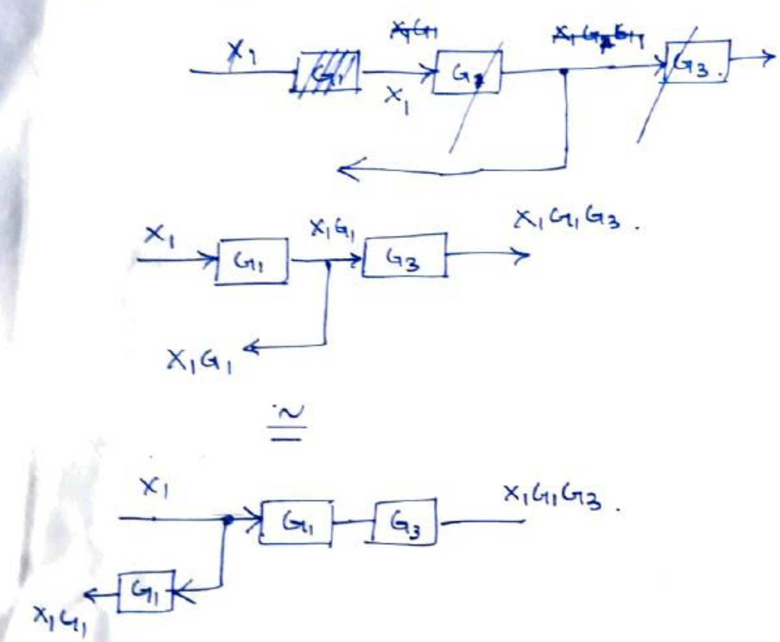
$$C(s) = R(s)G(s) - C(s)H(s)G(s)$$

$$C(s)\left[1 + H(s)G(s)\right] = R(s)\,G(s)$$

(3) Moving a take off point after a block.



(4) Moving a take off point ahead of a block.

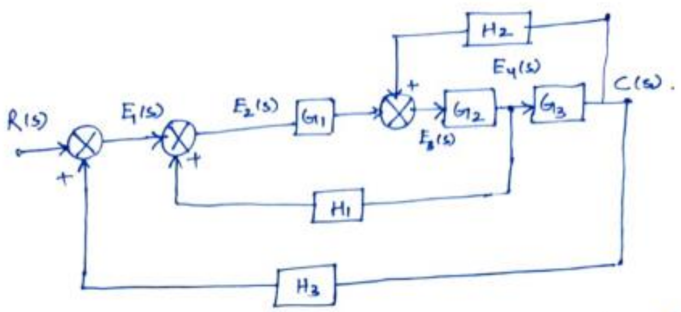


7. The performance equations of a controlled system are given by the following set of linear algebraic equations:

$$E_1(s) = R(s) + H_3(s)C(s)$$
$$E_2(s) = E_1(s) + H_1(s)E_4(s)$$
$$E_3(s) = G_1(s)E_2(s) + H_2(s)C(s)$$
$$E_4(s) = G_2(s)E_3(s)$$
$$C(s) = G_3(s)E_4(s)$$

(i) Draw the block diagram.

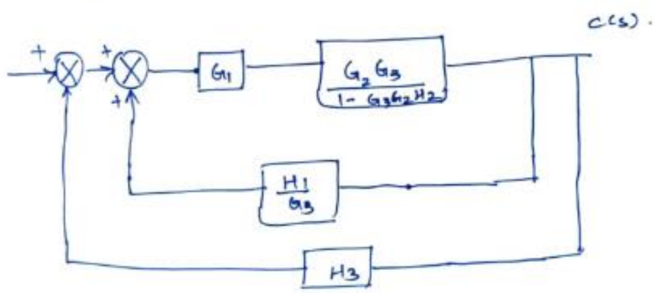
(ii) Find the overall transfer function $\frac{C(s)}{R(s)}$ using block diagram reduction technique.



(i) Shifting Take off point from b/w G_2 and G_3 to beyond G_3.

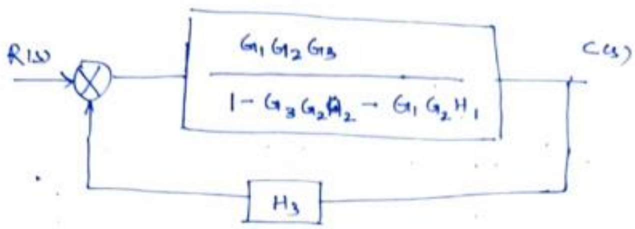
(ii) Combining $G_2 G_3$ in cascade

(iii) Reducing feed back loop $G_2 G_3$ and H_2



(iv) Reducing inner feedback loop.

$$\frac{\dfrac{G_1 G_2 G_3}{1 - G_2 G_3 H_2}}{1 - \dfrac{G_1 G_2 G_3 H_1}{G_3 (1 - G_3 G_2 H_2)}}$$



(v) Reducing final feedback loop.

$$\frac{C(s)}{R(s)} = \frac{\dfrac{G_1G_2G_3}{1-G_2G_3H_2-G_1G_2H_1}}{1-\dfrac{G_1G_2G_3H_3}{1-G_2G_3H_2-G_1G_2H_1}}$$

$$\frac{C(s)}{R(s)} = \frac{G_1G_2G_3}{1-G_2G_3H_2-G_1G_2H_1-G_1G_2G_3H_3}$$