

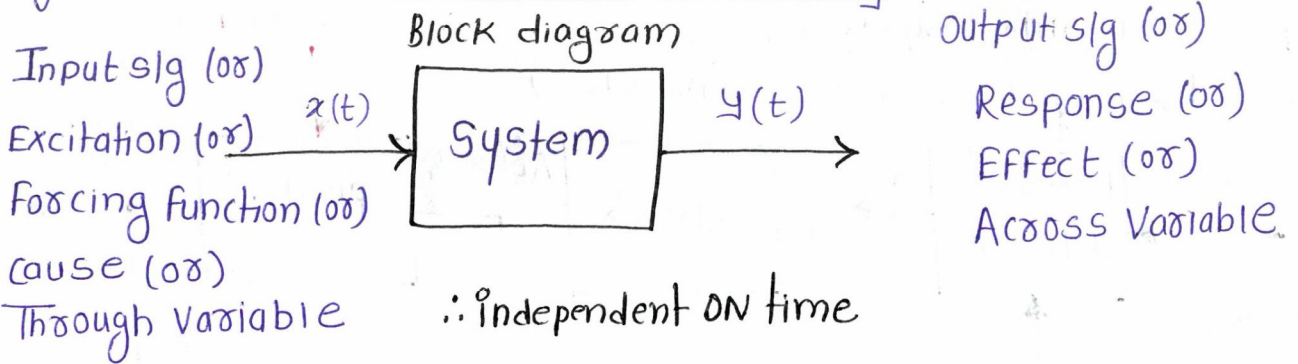
Date: 26-03-2026

Control System

J/K FF (system)
Master and slave (control system)

→ System means of transforming a signal

→ signal that contains information of an activity



→ Signal is a function of one or more no. of independent variable

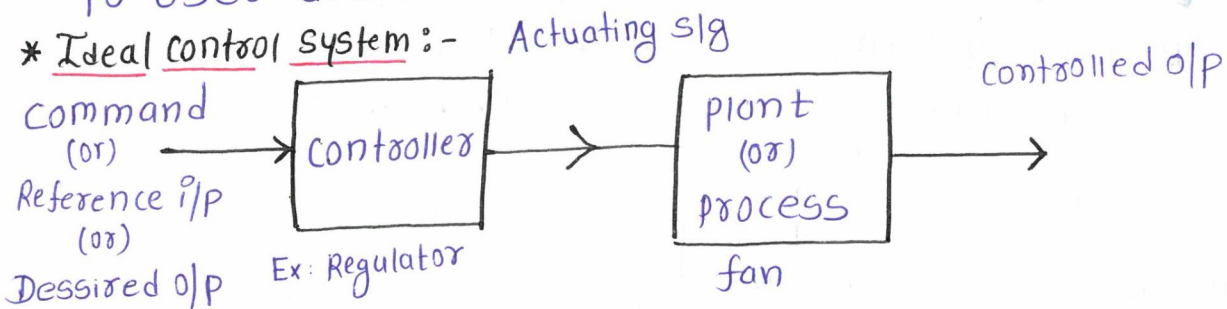
- Speech = $f(t)$
- Video = $f(l, b, t)$
- Image = $F(l, b)$
- Room Temp = $f(l, b, h, t)$

→ Mathematical representation $y(t) = F[x(t)]$ (Block diagram)

Control System :- (slave)

→ is that system whose o/p can be controlled according to user desires

* Ideal control system :-



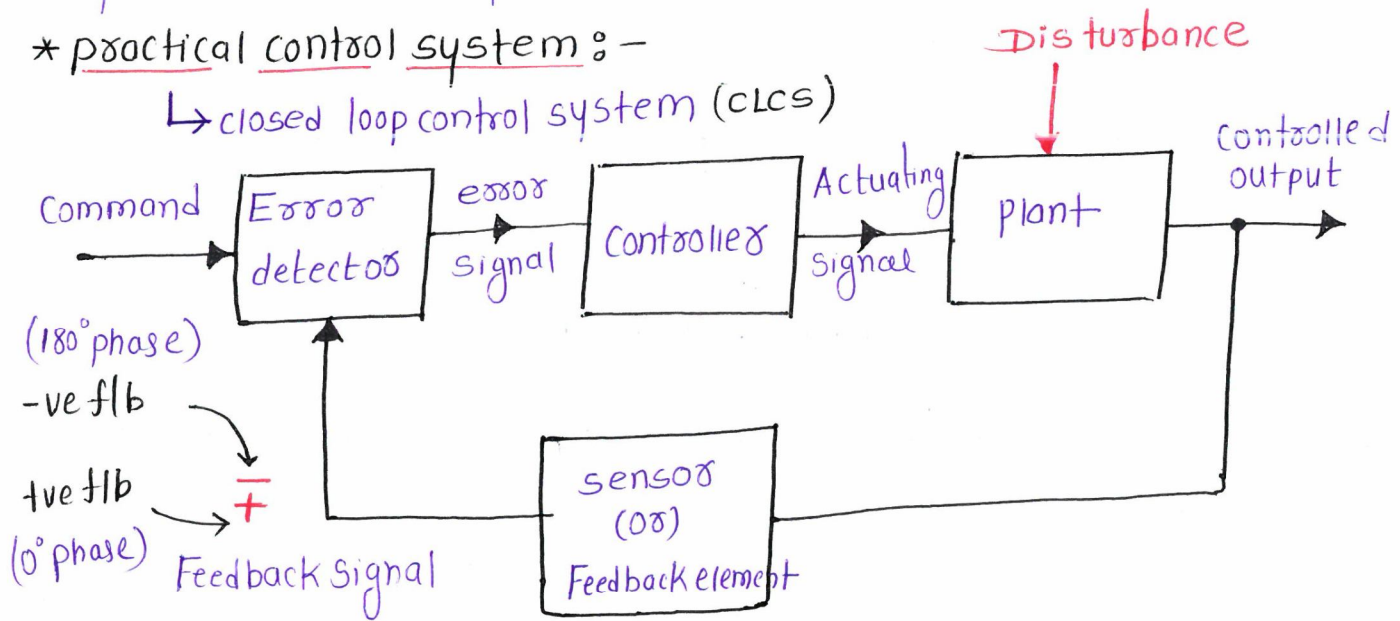
→ The purpose of any control system is to ensure that controlled o/p become same as desired o/p this state is called steady state or stable state

→ The state before steady state is known as transient state it is unwanted but unavoidable

→ Above diagram describe ideal condition in which NO disturbance is present but practically disturbance is always present and practical control system is as follows

* practical control system :-

→ closed loop control system (CLCS)

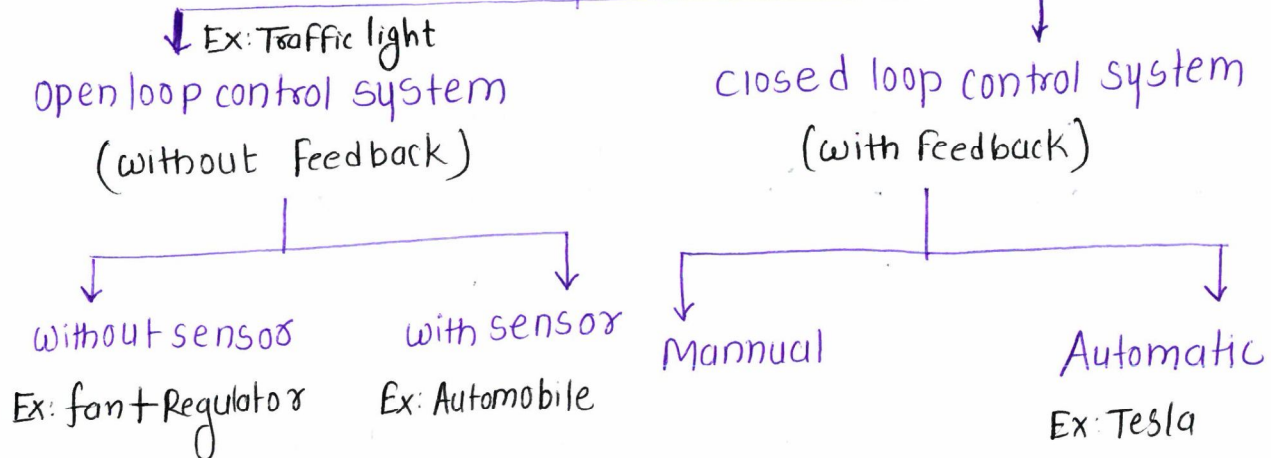


Disturbance → Distortion (Internal)

→ Noise (External)

$$\text{Error} = i/p - o/p$$

Practical control system



→ it is impossible to reach to steady state with 100% o/p within finite time

Defⁿ:-

→ in which either there is no sense or there is partial sense

→ In which there is complete sense

imp

OLCS

- ① Less accurate
- ② It is slow
(because of huge time constant)
- ③ More sensitive
(hence less stable)
- ④ Simple and economical
- ⑤ Generally stable but cannot be stabilized if become unstable

CLCS (better performance)

- ① More accurate
- ② It is Fast
(because of small time constant)
- ③ Less sensitive
(hence more stable)
- ④ Complex and expensive
- ⑤ Generally stable & can be stabilized if become unstable

imp

-ve Feedback CLCS

- | | |
|-----------------|---|
| ① Gain | ↓ |
| ② Band width | ↑ |
| ③ Time constant | ↓ |
| ④ speed | ↑ |
| ⑤ sensitivity | ↓ |
| ⑥ stability | ↑ |

+ve feedback CLCS

- | | |
|-----------------|---|
| ① Gain | ↑ |
| ② Band width | ↓ |
| ③ Time constant | ↑ |
| ④ speed | ↓ |
| ⑤ sensitivity | ↑ |
| ⑥ stability | ↓ |

Default:-

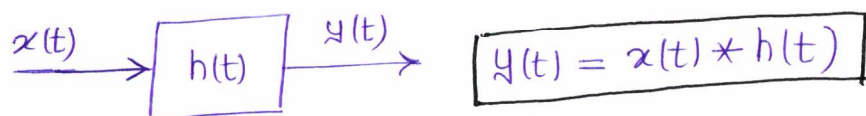
↳ -ve Feedback closed loop control system (it is better performance)

CH-01: Introduction and Mathematical Modeling of CS

* Transfer function :-

↳ It is the ratio of output to input then initial condition (or) state equal to zero

$$T.F = \frac{o/p}{i/p} \Big|_{\text{initial cond}^n \text{ (or) state} = 0}$$



↳ In control system used cont. time system in

↳ Time domain (L.T)

↳ Frequency domain (f.T)

↳ It is not use in Discrete time system in

↳ Time domain (Z-transform)

↳ Freqn domain (D.T.F.T)

Total Response = zero input response + zero state response
(ZIR) (ZSR)

[due to initial condition
(or) State] [Due to Input]

↳ Invertor → follows superposition theorem

Zero state response

Transient (or)
Dynamic (or)
Natural Response

Steady State (or)
Static (or)
Forced response

$$T.F = \frac{L[O/P]}{L[I/P]} = \frac{L[I/R]}{L[S(t)]} = \frac{L[S/R]}{L[u(t)]} = \frac{L[R/R]}{L[z(t)]} = \frac{L[P/R]}{L[P(t)]}$$

↳ Transfer function Model is unique representation of $t \cdot u(t)$

* Laplace transform :-

$$\begin{aligned} \textcircled{1} \quad s(t) &\longleftrightarrow 1 \\ \textcircled{2} \quad u(t) &\longleftrightarrow \frac{1}{s} \\ \textcircled{3} \quad t(t) &\longleftrightarrow \frac{1}{s^2} \\ \textcircled{4} \quad p(t) &\longleftrightarrow \frac{1}{s^3} \\ \textcircled{5} \quad e^{at} u(t) &\longleftrightarrow \frac{1}{s+a} \end{aligned}$$

$$\begin{aligned} \textcircled{6} \quad t^n e^{at} u(t) &\longleftrightarrow \frac{n!}{(s+a)^{n+1}} \\ \textcircled{7} \quad \sin \omega t u(t) &\longleftrightarrow \frac{\omega}{s^2 + \omega^2} \\ \textcircled{8} \quad \cos \omega t &\longleftrightarrow \frac{s}{s^2 + \omega^2} \\ \textcircled{9} \quad e^{at} \sin \omega t &\longleftrightarrow \frac{\omega}{(s+a)^2 + \omega^2} \\ \textcircled{10} \quad e^{at} \cos \omega t &\longleftrightarrow \frac{s+a}{(s+a)^2 + \omega^2} \end{aligned}$$

imp

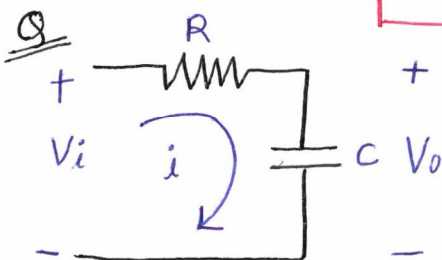
$$T.F = L[I.R] = sL[S.R] = s^2 L[R.R] = s^3 [P.R]$$

Block Diagram Representation

↳ It is graphical representation of mathematical relation b/w variable of the system describable in the form of set of Linear Algebraic equation in cause effect form.

↳ Block diagram is Valid form Linear system but Non-linear system is Valid form state diagram

$$\begin{array}{cc} \text{effect} & \text{cause} \\ y & = m x \end{array}$$

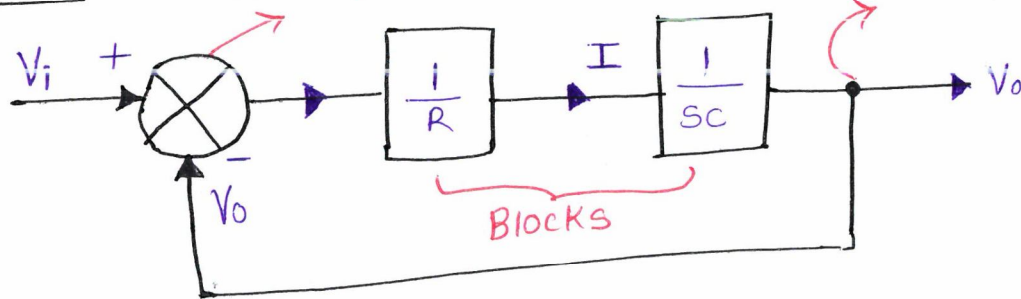


- ① Obtain BDR * Variable: V_i, i, V_o
- ② Obtain SFG * System components: (R, C)
- ③ Obtain TF

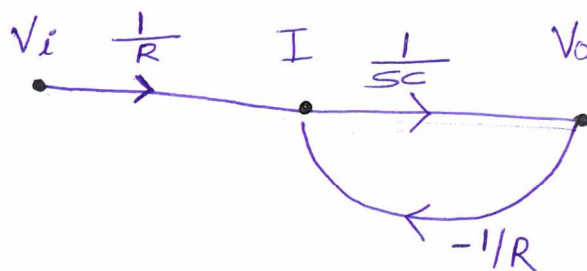
$$-V_i + R \cdot i + V_o = 0 \rightarrow i = \frac{V_i - V_o}{R} \quad \begin{matrix} \text{effect} \\ \text{causes} \end{matrix}$$

$$V_o = \frac{1}{C} \int i dt \rightarrow V_o = \frac{1}{Cs} \cdot I \quad \begin{matrix} \text{effect} \\ \text{causes} \end{matrix}$$

BDR



SFG



Transfer Function:-

$$T.F = \frac{V_o}{V_i} \text{ (or) } \frac{I}{V_i}$$

$$-V_i + R(sC V_o) + V_o = 0$$

$$-V_i + V_o [1 + RSC] = 0$$

$$\boxed{\frac{V_o}{V_i} = \frac{1}{1 + RCS}}$$

$$-V_i + R \cdot i + V_o = 0$$

$$-V_i + R i + \left(\frac{1}{Cs}\right) i = 0$$

$$-V_i + i \left(R + \frac{1}{Cs}\right) = 0$$

$$\boxed{\frac{I}{V_i} = \frac{Cs}{1 + RCS}}$$

* BDR:-

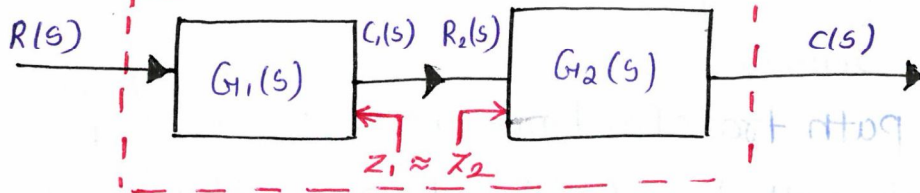
* Standard Topologies:-

① series/cascade

② parallel / feed forwards

③ closed loop / feedback / canonical

① series/cascade :- AND Gate



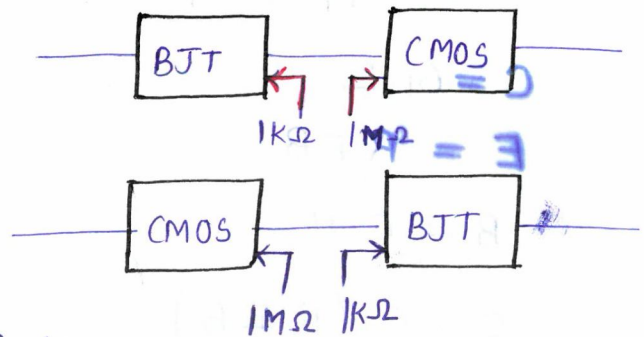
✓ (i) $R_2(s) = C_1(s)$; Non-Interactive cascading (No loading effect)

✗ (ii) $R_2(s) \neq C_1(s)$; Interactive cascading (Loading effect)
 ↳ NO T.F possible for Block diagram

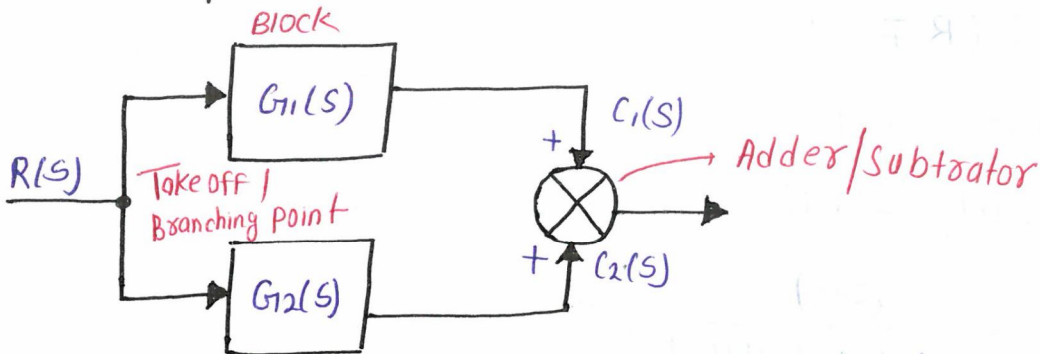
$$C = G_2 R_2 ; C_1 = R G_1$$

$$C = G_2 \cdot R G_1$$

$$\boxed{\frac{C}{R} = G_1 \cdot G_2}$$



② parallel / Feed forwards: OR Gate



$$C_1 = R \cdot G_1$$

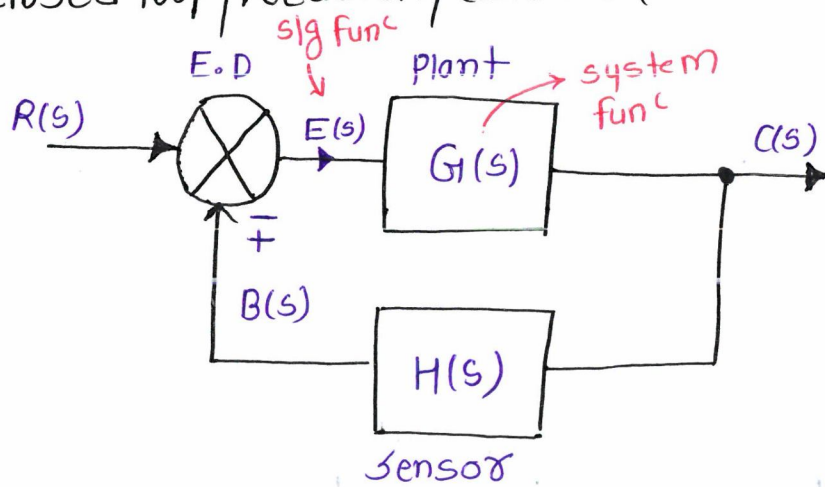
$$C_2 = R \cdot G_2$$

$$C = C_1 + C_2$$

$$= R G_1 + R G_2$$

$$\boxed{\frac{C}{R} = G_1 + G_2}$$

③ closed loop / Feedback / Canonical :-

 $G(s) \rightarrow$ Dependent $E(s) \rightarrow$ Independent

$\rightarrow G(s) = \text{Forward path transfer function} = \frac{C(s)}{E(s)}$ } Individual Element T.F
 $\rightarrow H(s) = \text{Feedback path transfer function} = \frac{B(s)}{C(s)}$ }

$$\frac{B(s)}{R(s)} = \frac{B(s)}{E(s)} = \frac{C(s)}{E(s)} \times \frac{B(s)}{C(s)} = G(s) \cdot H(s)$$

$\rightarrow$ open loop transfer function (or) Loop T.F

$$C = G \cdot E$$

$$E = R - B$$

$$B = C \cdot H$$

$$C = G(R - B)$$

$$C = G(R - CH)$$

$$C \pm GCH = GR$$

$$C(1 \pm GH) = GR$$

$$\boxed{\frac{C}{R} = \frac{G(s)}{1 \pm G(s)H(s)}}$$

$\rightarrow$ closed loop T.F (or) T.F

