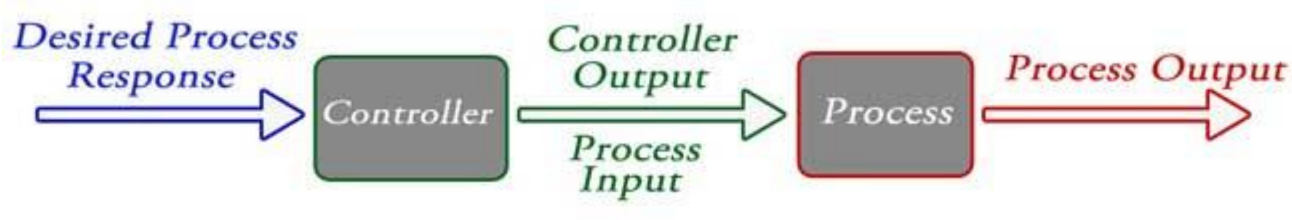
Open Loop & Close loop Control System

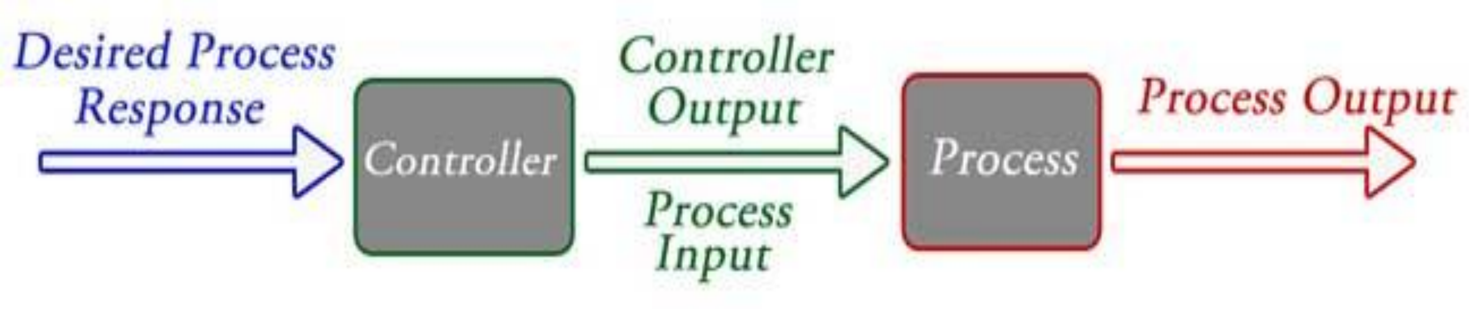
Positive & Negative Feedback

Open-loop control system:

- It is a control system where its control action only depends on input signal and does not depend on its output response.



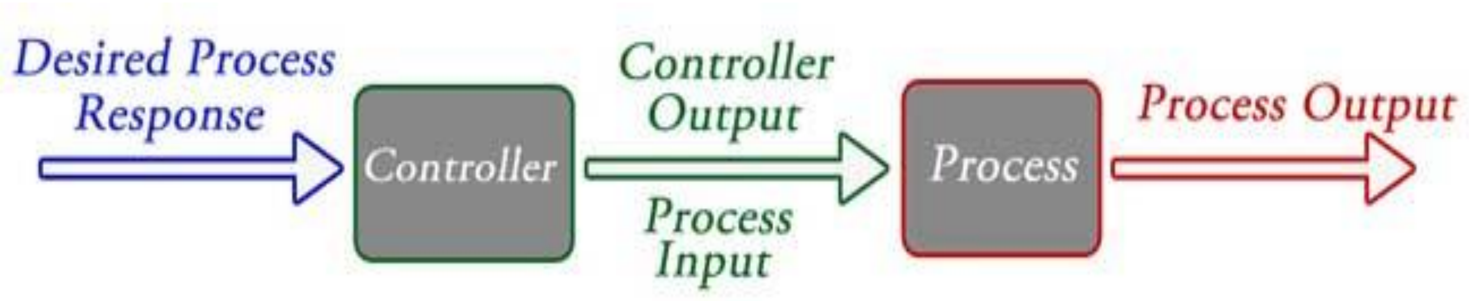
- In an open loop control system the output has no effect on the control action.
- In an open-loop control system the output is neither measured nor fed back for comparison with the input.
- The elements of an open-loop control system can usually be divided into two parts - the controller and the controlled process, as shown in fig.



An input signal or command r is applied to the controller, whose output acts as the actuating signal u.

The actuating signal then controls the controlled process so that controlled variable y will perform according to prescribed standards.

In simple cases, the controller can be an **amplifier, mechanical linkage, filter or other control element**, depending on the nature of the system. The controller can be a **computer such as a microprocessor** in more sophisticated cases.



Practical Examples of Open Loop Control System

- **Electric Hand Drier** – Hot air (output) comes out as long as you keep your hand under the machine, irrespective of how much your hand is dried.
- **Automatic Washing Machine** – This machine runs according to the pre-set time irrespective of washing is completed or not.
- **Bread Toaster** – This machine runs as per adjusted time irrespective of toasting is completed or not.

- **Automatic Tea/Coffee Maker** – These machines also function for pre adjusted time only.
- **Timer Based Clothes Drier** – This machine dries wet clothes for pre-adjusted time, it does not matter how much the clothes are dried.
- **Light Switch** – Lamps glow whenever light switch is on irrespective of light is required or not.
- **Volume on Stereo System** – Volume is adjusted manually irrespective of output volume level.

Advantages:

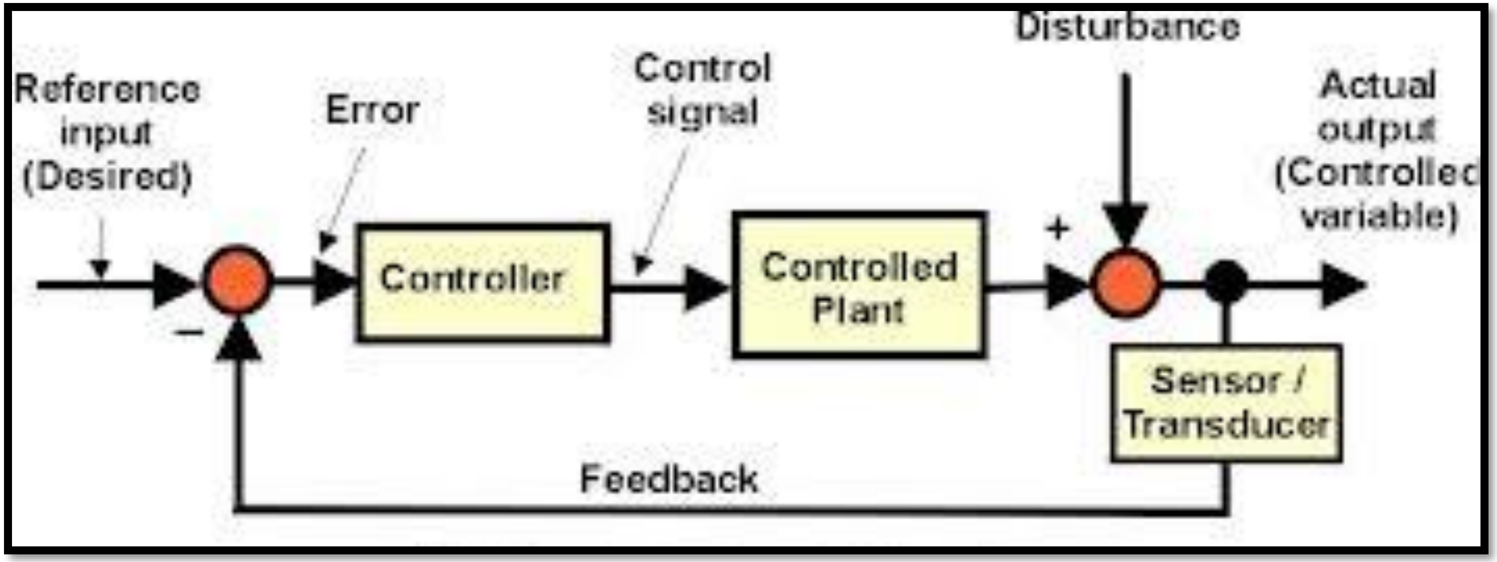
- Simple design and easy to construct.
- Economical.
- Easy for maintenance.
- Highly stable operation.

Dis-advantages:

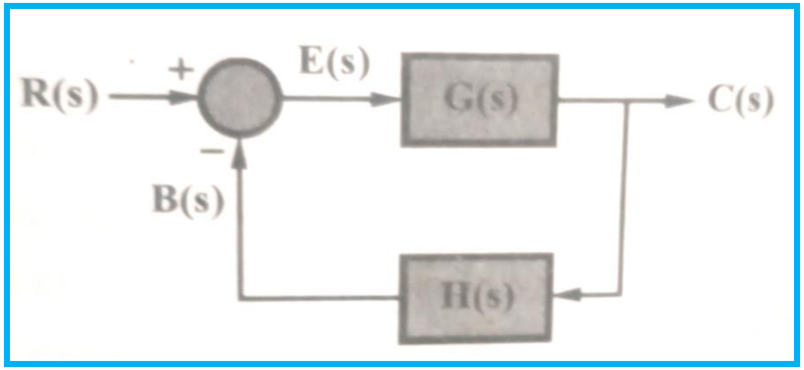
- Not accurate and reliable when input or system parameters are variable in nature.
- Recalibration of the parameters are required time to time.

Closed-loop control system:

It is a control system where its control action depends on both of its input signal and output response.

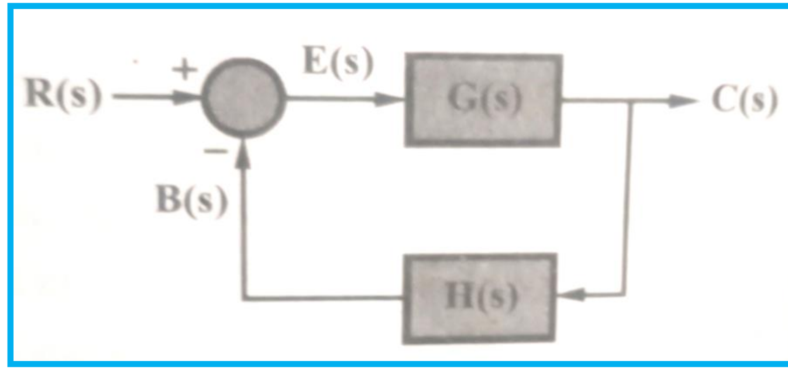


- A closed-loop control system uses a measurement of the output and feedback of this signal to compare it with the desired input.



- A simple closed-loop control system is shown in fig. A feedback control system often uses a function of a prescribed relationship between the output and the reference input to control the process.

- Often the difference between the output of the process under control and the reference input is amplified and used to control the process, so that the difference is continually reduced.



An example of a closed-loop control system is a person steering an automobile by looking at the auto's location on the road and making the appropriate adjustments.

Practical Examples of Closed Loop Control System

- **Automatic Electric Iron** – Heating elements are controlled by output temperature of the iron.
- **Servo Voltage Stabilizer** – Voltage controller operates depending upon output voltage of the system.
- **Water Level Controller** – Input water is controlled by water level of the reservoir.

Missile Launched and Auto Tracked by Radar – The direction of missile is controlled by comparing the target and position of the missile.

An Air Conditioner – An air conditioner functions depending upon the temperature of the room.

Cooling System in Car – It operates depending upon the temperature which it controls.

Advantages:

- More accurate operation than that of open-loop control system.
- Can operate efficiently when input or system parameters are variable in nature.
- Less nonlinearity effect of these systems on output response.
- High bandwidth of operation
- There is facility of automation
- Time to time recalibration of the parameters are not required

Dis-advantages:

- Complex design and difficult to construct.

- Expensive than that of open-loop control system.

- Complicate for maintenance

- Less stable operation than that of open-loop control system

Comparison between Open-loop and Closed-loop control systems:

Sl. No.	Open-loop control systems	Closed-loop control systems
1	No feedback is given to the control system	A feedback is given to the control system
2	Cannot be intelligent	Intelligent controlling action
3	There is no possibility of undesirable system oscillation(hunting)	Closed loop control introduces the possibility of undesirable system oscillation(hunting)
4	The output will not very for a constant input, provided the system parameters remain unaltered	In the system the output may vary for a constant input, depending upon the feedback
5	System output variation due to variation in parameters of the system is greater and the output very in an uncontrolled way	System output variation due to variation in parameters of the system is less.
6	Error detection is not present	Error detection is present
7	Small bandwidth	Large bandwidth
8	More stable	Less stable or prone to instability
9	Affected by non-linearities	Not affected by non-linearities
10	Very sensitive in nature	Less sensitive to disturbances
11	Simple design	Complex design
12	Cheap	Costly

Basic block diagram of a closed-loop negative feedback control system

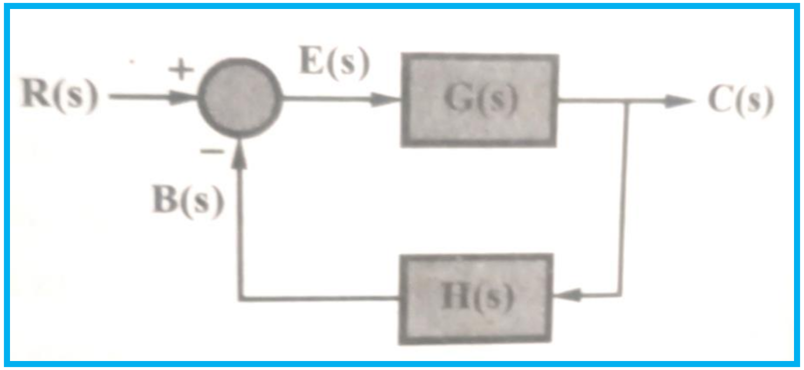
Let R(s) = Reference Input

B(s)= Feedback Signal

E(S) = Manipulated Signal

G(S) = Forward path transfer function

H(S) = Feedback path transfer function



As $$E(S) = R(s) - B(s) \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

and $$B(s) = C(s).H(S) \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

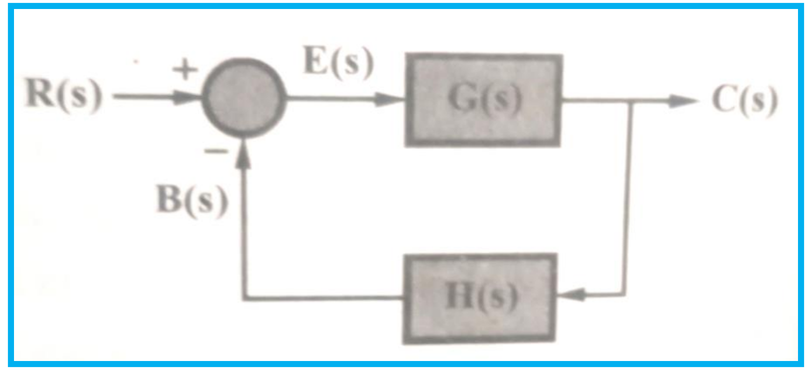
Substituting the value of B(s) from eq. (2) in equation (1) from (in), we have

$$E(S) = R(S) - C(s).H(S) \quad \ldots\ldots\ldots\ldots\ldots(3)$$

It is also seen that

$C(S) = E(s).G(s)$

Or $E(s) = \frac{C(s)}{G(s)}$ ....(4)



Put the value of E(s) from Eq. 4 in Eq.3

$$\frac{C(s)}{G(s)} = R(S) - C(s).H(s)$$

$C(s) = G(s).\ R(S) - G(s).\ C(s).H(s)$

$C(s) + G(s).\ C(s).H(s) = G(s).R(S)$

$C(s)\ [1+G(s).H(s)] = G(s).\ R(S)$

$C(s) = \frac{G(s).R(S)}{[1+G(s).H(s)]}$

$$\frac{C(s)}{R(S)} = \frac{G(s)}{[1+G(s).H(s)]}$$