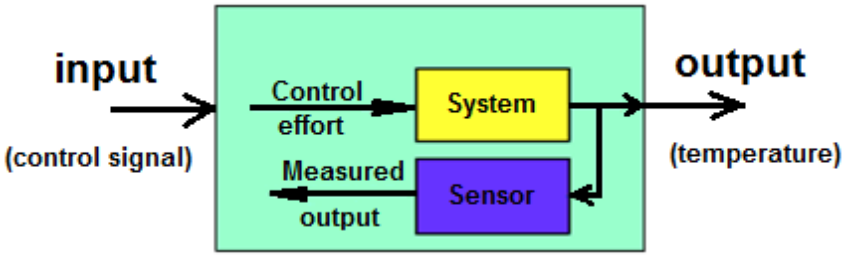
Introduction to control system:

What is Control System?

In most systems there will be an input and an output as shown in the following block diagram. (Control system designers and engineers use block diagrams to represent systems). Signals flow from the input, through the system and produce an output.

- The input will usually be an ideal form of the output. In other words the input is really what we want the output to be. It's the desired output.
- The output of the system has to be measured. In the figure below, we show the **system we are trying to control -the "plant"**- and a **sensor** that measures what the controlled system is doing.
- The input to the plant is usually called the **control effort**, and the output of the sensor is usually called the **measured output**, as shown below in the figure.

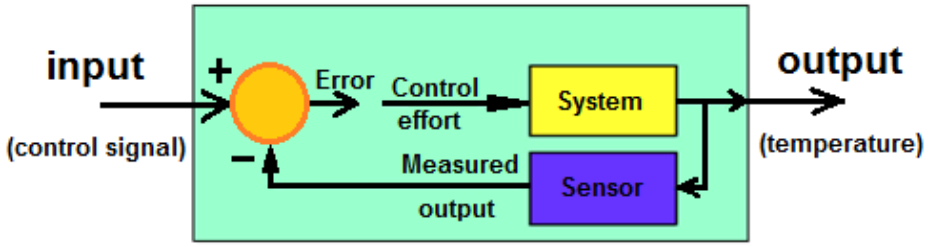


If we want to control the output, we first need to measure the output. Within the whole system is the system we want to control - the plant - along with a **sensor** that measures what the output actually is.

- In our block diagram representation, we show the output signal being fed to the sensor which produces another signal that is dependent upon the output.
- A sensor, which produces a voltage proportional to temperature - if the output signal is a temperature.

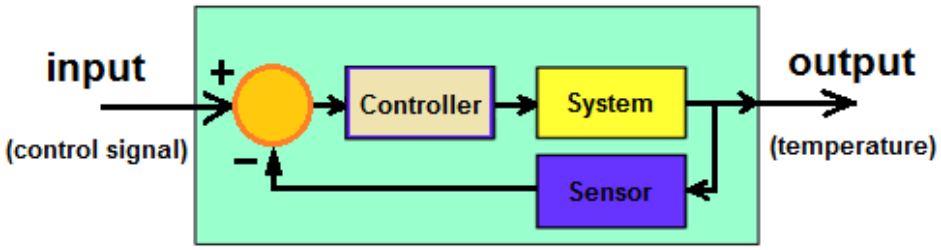
We need the sensor in the system to measure what the system is doing.
To control the system we need to use the information provided by the sensor.

- Usually, the output, as measured by the sensor is subtracted from the input (which is the desired output) as shown below. That forms an error signal that the controller can use to control the plant.



- The device which performs the subtraction to compute the error, E, is a **comparator.**

Finally, the last part of this system is the controller.



Definitions

System – An interconnection of elements and devices for a desired purpose.

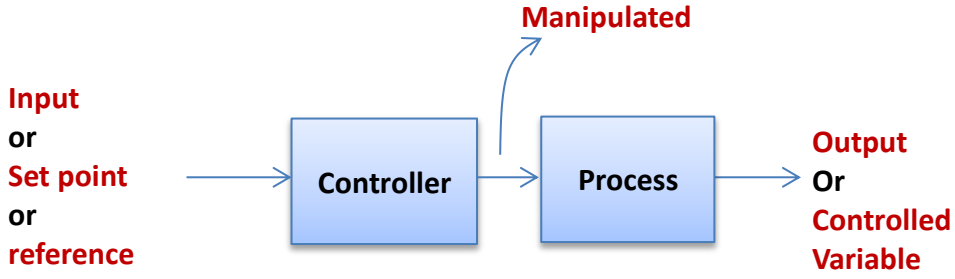
Control System – An interconnection of components forming a system configuration that will provide a desired response.

Process – The device, plant, or system under control. The input and output relationship represents the cause-and-effect relationship of the process.

Controlled Variable– It is the quantity or condition that is measured and Controlled. Normally *controlled variable* is the output of the control system.

Manipulated Variable– It is the quantity of the condition that is varied by the controller so as to affect the value of *controlled variable*.

Control – Control means measuring the value of *controlled variable* of the system and applying the *manipulated variable* to the system to correct or limit the deviation of the measured value from a desired value.



Disturbances– A disturbance is a signal that tends to adversely affect the value of the system. It is an unwanted input of the system.

- If a disturbance is generated within the system, it is called ***internal disturbance*.** While an ***external disturbance*** is generated outside the system.

Types of Control System

- Manual Control Systems
  - Room Temperature regulation Via Electric Fan
  - Water Level Control
- Automatic Control System
  - Room Temperature regulation Via A.C
  - Human Body Temperature Control

Types of Control System

Open-Loop Control Systems utilize a controller or control actuator to obtain the desired response.

- Output has no effect on the control action.
- In other words output is neither measured nor fed back.

Open-Loop Control Systems

Practical Examples of Open Loop Control System:

1.Automatic Washing Machine – This machine runs according to the pre-set time irrespective of washing is completed or not.
2. Bread Toaster - This machine runs as per adjusted time irrespective of toasting is completed or not.
3. Automatic Tea/Coffee Maker – These machines also function for pre adjusted time only.

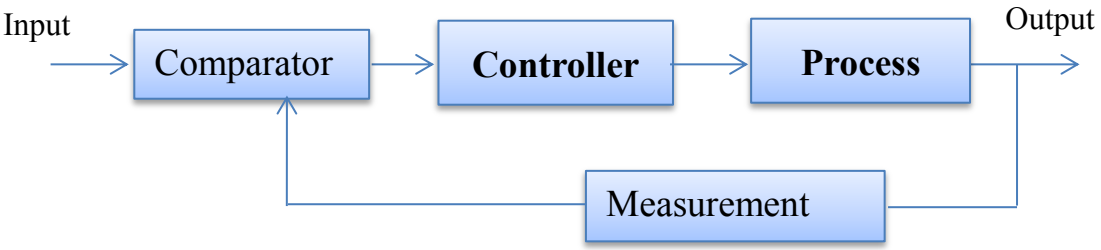
Advantages of Open Loop Control System:

1. Simple in construction and design.
2. Economical.
3. Easy to maintain.
4. Generally stable.
5. Convenient to use when output is difficult to measure.

Disadvantages of Open Loop Control System:

1. They are inaccurate.
2. They are unreliable.
3. Any change in output cannot be corrected automatically.

Closed-Loop Control Systems utilizes feedback to compare the actual output to the desired output response.



Closed-Loop Control Systems

Practical Examples of Closed Loop Control System:

1. Automatic Electric Iron – Heating elements are controlled by output temperature of the iron.
2. Servo Voltage Stabilizer – Voltage controller operates depending upon output voltage of the system.
3. Water Level Controller– Input water is controlled by water level of the reservoir.
4. Missile Launched & Auto Tracked by Radar – The direction of missile is controlled by comparing the target and position of the missile.

Advantages of Closed Loop Control System:

1. Closed loop control systems are more accurate even in the presence of non-linearity.
2. Highly accurate as any error arising is corrected due to presence of feedback signal.
3. Bandwidth range is large.
4. Facilitates automation.
5. The sensitivity of system may be made small to make system more stable.
6. This system is less affected by noise.

Disadvantages of Closed Loop Control System:

1. They are costlier.
2. They are complicated to design.
3. Required more maintenance.
4. Feedback leads to oscillatory response.
5. Overall gain is reduced due to presence of feedback.
6. Stability is the major problem and more care is needed to design a stable closed loop system.

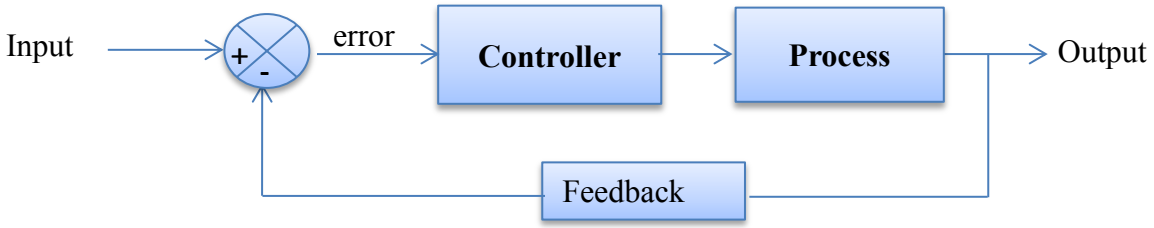
Comparison of Closed Loop and Open Loop Control System:

No.	Open loop control system	Closed loop control system
1	The feedback element is absent.	The feedback element is always present.
2	An error detector is not present.	An error detector is always present.
3	It is stable one.	It may become unstable.
4	Easy to construct.	Complicated construction.
5	It is an economical.	It is costly.

6	Having small bandwidth.	Having large bandwidth.
7	It is inaccurate.	It is accurate.
8	Less maintenance.	More maintenance.
9	It is unreliable.	It is reliable.
10	Examples: Hand drier, tea maker	Examples: Servo voltage stabilizer, perspiration

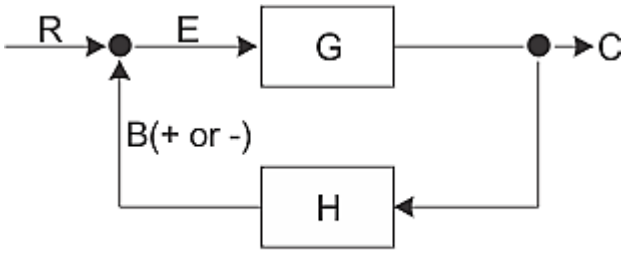
Feedback Control System:

- A system that maintains a prescribed relationship between the output and some reference input by comparing them and using the difference (i.e. error) as a means of control is called a feedback control system.
- Feedback can be positive or negative.



Effect of Feedback:

As can be seen in figure below, which represents feedback system where:
R = Input signal, E = Error signal, G = forward path gain
H = Feedback gain, C = Output signal, B = Feedback signal



Block Diagram

1. Error between system input and system output is reduced.
2. System gain is reduced by a factor 1/(1 ± GH).
3. Improvement in sensitivity.
4. Stability may be affected.
5. Improve the speed of response.