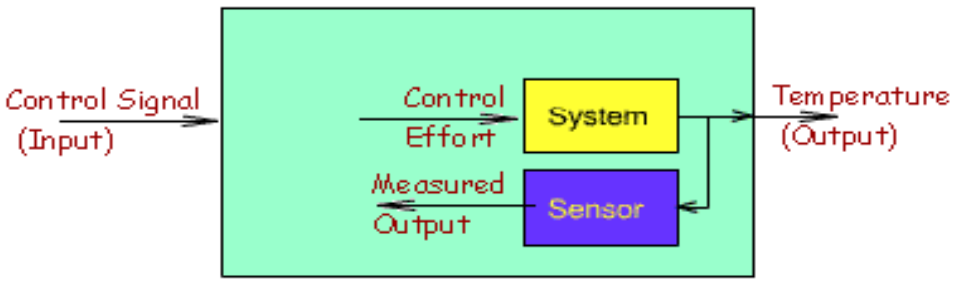
Introduction to control system

What Is A Control System?

In most systems there will be an input and an output. This block diagram represents that. (Control system designers and engineers use block diagrams to represent systems. Get used to them.) 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.

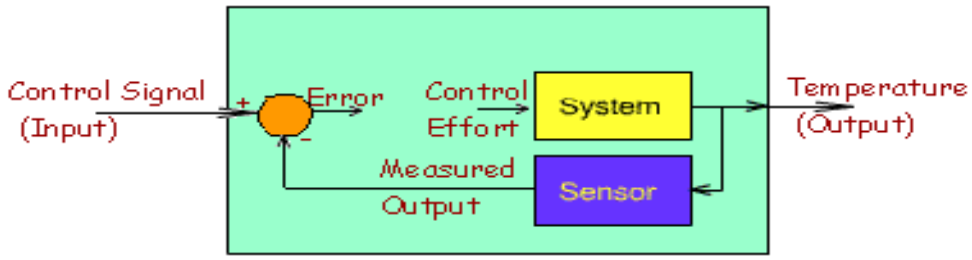


If we want to control the output, we first need to measure the output. Within the whole system is the system we want to control - the plant - along with a **sensor** that measures what the output actually is.

- 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.

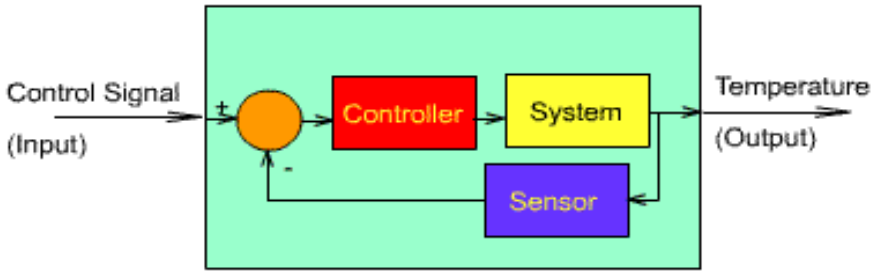
We need the sensor in the system to measure what the system is doing.
To control the system we need to use the information provided by the sensor.

- 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.



Basic definitions:

Controlled Variable: The controlled variable is the quantity or condition that is measured and controlled. Normally, the controlled variable is the output of the system.

Manipulated Variable: The manipulated variable is the quantity or condition that is varied by the controller so as to affect the value of the controlled variable.

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

In studying control engineering, we need to define additional terms that are necessary to describe control systems.

Plants: a plant may be a piece of equipment, perhaps just a set of machine parts functioning together, the purpose of which is to perform a particular operation. In this lecture, we shall call any physical object to be controlled (such as a mechanical device, a heating furnace, a chemical reactor, or a spacecraft) a plant.

Process: a process to be a natural, progressively continuing operation or development marked by a series of gradual changes that succeed one another in a relatively fixed way and lead toward a particular result or end; or an artificial or voluntary, progressively continuing operation that consists of a series of controlled actions or movements systematically directed toward a particular result or end. In this lecture we shall call any operation to be controlled a process. Examples are chemical, economic, and biological processes.
Systems: a system is a combination of components that act together and perform a

certain objective. A system is not limited to physical ones. The concept of the system can be applied to abstract, dynamic phenomena such as those encountered in economics.
The word system should, therefore, be interpreted to imply physical, biological, economic, and the like, systems.

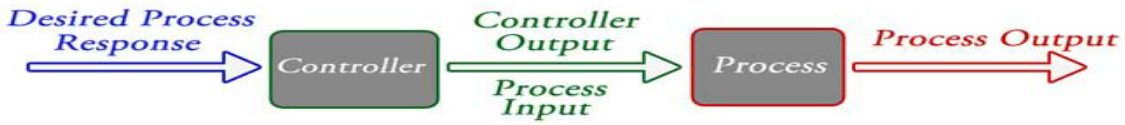
Disturbances: a disturbance is a signal that tends to adversely affect the value of the output of a system. If a disturbance is generated within the system, it is called internal, while an external disturbance is generated outside the system and is an input.

Types of Control Systems

There are various **types of control system** but all of them are created to control outputs. The system used for controlling the position, velocity, acceleration, temperature, pressure, voltage and current etc. are examples of control systems. there are two main types of control system. They are as follow
Open loop control system Closed loop control system

Open Loop Control System

A control system in which the control action is totally independent of output of the system then it is called **open loop control system**. Manual control system is also an open loop control system. Fig - 1 shows the block diagram of open loop control system in which process output is totally independent of controller action.



Practical Examples of Open Loop Control System

1. **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.
2. **Automatic Washing Machine** – This machine runs according to the pre-set time irrespective of washing is completed or not.
3. **Bread Toaster** - This machine runs as per adjusted time irrespective of toasting is completed or not.
4. **Automatic Tea/Coffee Maker** – These machines also function for pre adjusted time only.
5. **Timer Based Clothes Drier** – This machine dries wet clothes for pre – adjusted time, it does not matter how much the clothes are dried.

Advantages of Open Loop Control System

1. Simple in construction and design.
2. Economical.

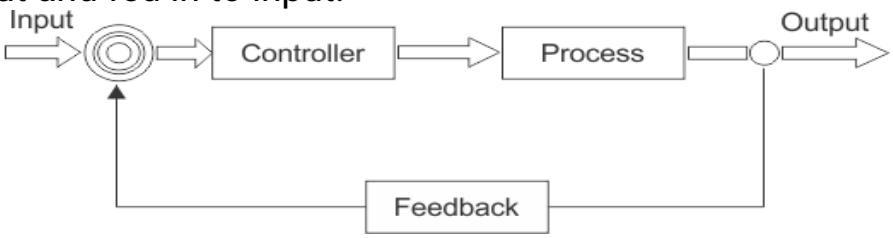
3. Easy to maintain.
4. Generally stable.
5. Convenient to use as output is difficult to measure.

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 System

Control system in which the output has an effect on the input quantity in such a manner that the input quantity will adjust itself based on the output generated is called **closed loop control system**. Open loop control system can be converted in to closed loop control system by providing a feedback. This feedback automatically makes the suitable changes in the output due to external disturbance. In this way closed loop control system is called automatic control system. Figure below shows the block diagram of closed loop control system in which feedback is taken from output and fed in to input.



Practical Examples of Closed Loop Control System

1. **Automatic Electric Iron** – Heating elements are controlled by output temperature of the iron.
2. **Water Level Controller**– Input water is controlled by water level of the reservoir.
3. **Missile Launched & Auto Tracked by Radar** – The direction of missile is controlled by comparing the target and position of the missile.
4. **An Air Conditioner** – An air conditioner functions depending upon the temperature of the room.
5. **Cooling System in Car** – It operates depending upon the temperature which it controls.

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

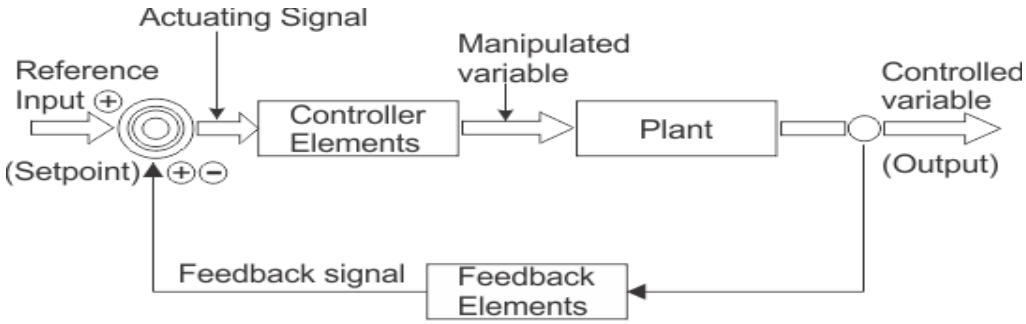
1. They are costlier.
2. They are complicated to design.
3. Required more maintenance.
4. Feedback leads to oscillatory response.
5. Overall gain is reduced due to presence of feedback.
6. Stability is the major problem and more care is needed to design a stable closed loop system.

Comparison of Closed Loop And Open Loop Control System

Sr. 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 Loop of Control System

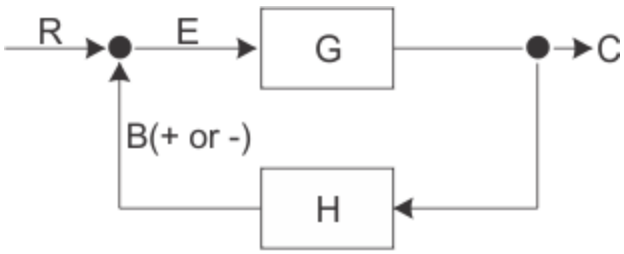
In any control system, output is affected due to change in environmental condition or any kind of disturbance. So one signal is taken from output and is fed back to the input. This signal is compared with reference input and then error signal is generated. This error signal is applied to controller and output is corrected. Such a system is called feedback system. Figure below shows the block diagram of feedback system.



When feedback signal is positive then system called positive feedback system. For positive feedback system, the error signal is the addition of reference input signal and feedback signal. When feedback signal is negative then system is called negative feedback system. For negative feedback system, the error signal is given by difference of reference input signal and feedback signal.

Effect of Feedback

Refer figure beside, which represents feedback system where
R = Input signal E = Error signal G = forward path gain
H = Feedback 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.