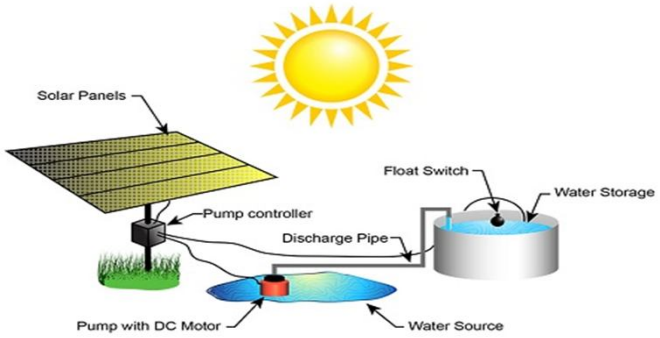


Control System

Control System and its Classification

Content

- Control System.
- Classification of Control System.
- Open Loop and Closed Loop Control System.
- Linear and Non-Linear System.

Learning Objective

- Able to classify the type of system.
- Understand the mechanism of open loop and closed loop system.
- Differentiate Linear and Non-Linear System.

Control System

- **Control**

- A means of limiting or regulating something.

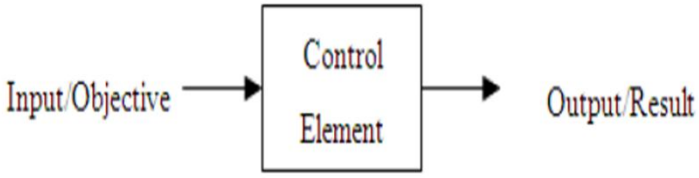
- **System**

- A set of connected things or devices that operate together.

Control System

- **Control System**

-Control system is a **system** of devices or set of devices, that manages, commands, directs or regulates the behavior of other device(s) or **system**(s) to achieve desire results.



Basic components of a control system.

Requirement of Good Control System

- **Accuracy** - Measurement tolerance of instrument.
- **Sensitivity** - Sensitive to input signals only.
- **Noise** - Reduce noise effect for better performance.
- **Stability** - For bounded input signal, output must be bounded.
- **Bandwidth** - Should be large for better response.
- **Speed** - Should possesses high speed.
- **Oscillation** - Should have small numbers of oscillation or constant oscillation.

Classification of Control System

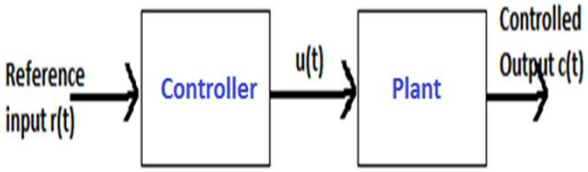
- **Open Loop & Closed Loop Control System.**
- **Linear & Non-linear Control System**
- **Time Varying and Time-invarying Control System**

Open Loop Control System

- " Control action is totally independent of output of the system. "

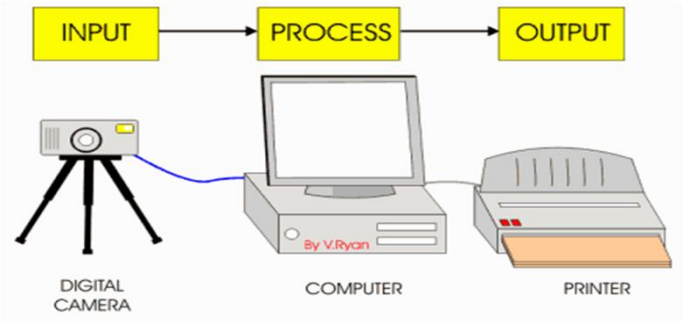
- Non-feedback system.
- Normally works once and then stops.
- Non-automatic.

Open Loop Control System



- r(t) – reference input
- u(t) – actuating signal
- c(t) – controlled output

Practical : Open Loop CS



- When we click for photo from camera.
- Computer process the input received from camera.
- Final result is printed photograph from printer.

Examples of Open Loop CS

- **Electric Hand Drier**

Aim	To dry wet hands
Input	Wet hands
Output	Dry hands
Mechanism	Hot air is passed on wet hands
Open or Closed Loop	Open Loop

Examples of Open Loop CS

- **Washing Machine**

Aim	To clean cloths
Input	Dirty cloths
Output	Clean cloths
Mechanism	Washes cloth with detergent for fixed time
Open or Closed Loop	Open Loop: System does not see degree of clenliness.

Examples of Open Loop CS

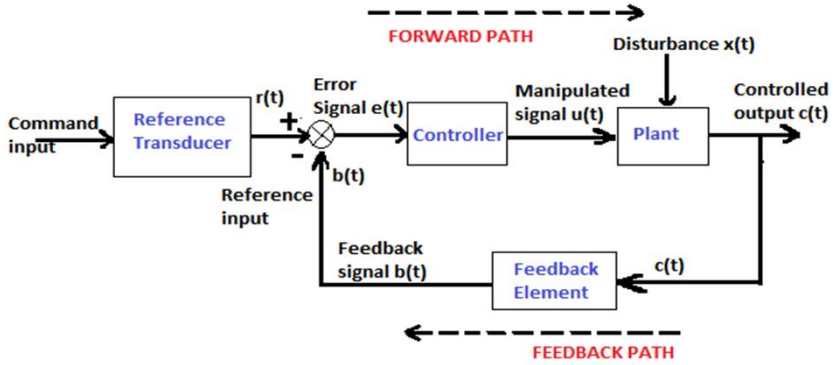
- Bread Toaster
- Automatic Coffee/Milk Server
- Electric lift
- Light Switch
- Volume on Stereo System

Closed Loop Control System

- "System in which the output has an effect on input quantity in such a way that input quantity will adjust itself based on the output generated"

- Feedback system.
- Normally works in loop.

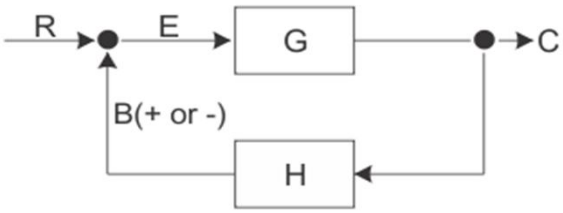
Closed Loop Control System



- **r(t) – reference input**
- **u(t) – actuating / manipulated signal**
- **e(t) –error signal**
- **c(t) – controlled output**
- **b(t) – feedback signal**

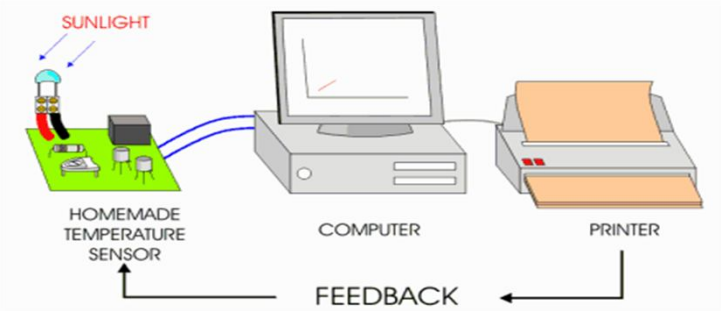
Closed Loop Control System

Effect of Feedback:-



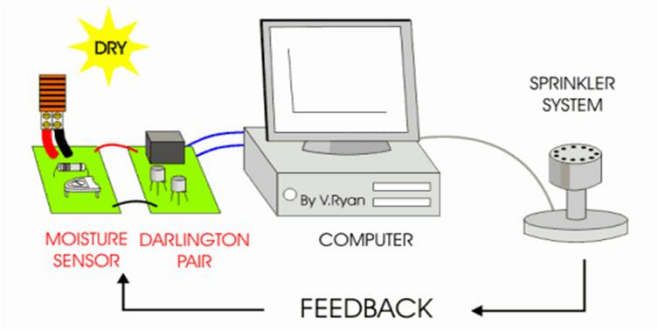
- Error between system input and system output is reduced.
- System gain is reduced by a factor $1/(1\pm GH)$.
- Improvement in sensitivity.
- Stability may be affected.
- Improve the speed of response

Practical : Closed Loop CS



- Heat from the sun causes the temperature sensor to produce data.
- Received data is processed by computer as graph.
- Temperature levels are printed from printer

Practical : Closed Loop CS



- Moisture sensor detects when the soil is dry.
- Received data is processed by computer and switches sprinkler.
- Sprinkler device which is turned on when the computer detects the need for water.

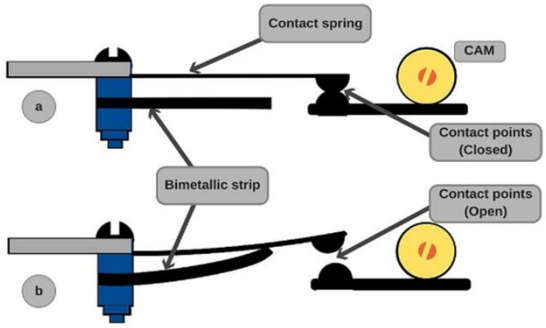
Examples of Closed Loop CS

- **Electric Iron**

Aim	To press creased cloths
Input	Creased cloths
Output	Ironed cloths
Mechanism	Thermostat and Bimetallic strip operation
Open or Closed Loop	Closed Loop

Examples of Closed Loop CS

- **Electric Iron operation**



(a) Under normal temperature, (b) When the iron becomes too hot

Examples of Closed Loop CS

- Servo Voltage Stabilizer
- Water Level Controller
- An Air Conditioner
- Perspiration
- Walking on road
- Missile Launched and Auto Tracked by Radar

Comparison of Open & Closed Loop CS

Open Loop	Closed Loop
The feedback element is absent.	The feedback element is always present.
An error detector is not present.	An error detector is always present.
It is stable one.	It may become unstable.
Easy to construct	Complicated construction.
It is an economical	It is costly
Having small bandwidth	Having large bandwidth
Inaccurate	Accurate
Less maintenance	More maintenance.
Unreliable	Reliable

Linear System

- Control systems which follow the principle of homogeneity and additivity.

- **Homogeneity:-**

  If we multiply input with some constant A then output will also be multiplied by the same value of constant (i.e. A).

- **Additivity:-**

  Suppose we have a system S and we are giving the input to this system as a1 for the first time and we are getting output as b1 corresponding to input a1. On second time we are giving input a2 and correspond to this we are getting output as b2.

Non-linear System

- Nonlinear does not obey the law of superposition.
- In practical, all systems contain non-linear characteristics.
- Non-linear system exhibit self sustained oscillations of fixed frequency.
- Non - linearities commonly present are saturation, friction, relay etc.

Comparison of Linear & Non-linear CS

Linear	Non-linear
Obey superposition.	Does not obey superposition.
Can be analyzed by standard test signals.	Cannot be analyzed by standard test signals.
Stability depends only on root location.	Stability depends only on root location, initial condition & type of input.
Do not exhibit limit cycles.	Exhibit limit cycles.
Can be analyzed by Laplace transform, Z transform	Cannot be analyzed by Laplace transform, Z transform
Eg:-Purely resistive n/w with constant DC	Eg:-Magnetization curve or no load curve of a DC machine.

Summary

- Types of control system.
- Importance of feedback.
- Practical example of each type of system.
- Comparison between the systems.