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**Subject: Instrumentation and control**

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**Topic: Control system**



**A control system** is a system of devices or set of devices, that manages commands, directs or regulates the behavior of other devices or systems to achieve desired results. In other words, the definition of a control system can be simplified as a system, which controls other systems.

**Or**

A control system is a system, which provides the desired response by controlling the output.

Control system engineering is the branch of engineering which deals with the principles of control theory, to design a system which gives yields the desired behavior in a controlled manner.

Examples: Automatic Washing Machine, Electric Hand Drier etc.

### **Silent Features of a Control System:**

The feature of a control system is that there should be a clear mathematical relationship between input and output of the system. When the relation between input and output of the system can be represented by a linear proportionality, the system is called a linear control system. When the relationship between input and output cannot be represented by single linear proportionality, the system is referred to as a non-linear control system.

### **Good Control System:**

Control system have some requirements which is needed for proper output, input behavior which make control system good or bad as per the use. Following are the essential requirements for good control system.

- 1) **Accuracy:** Accuracy is the measurement of the closeness to true value or tolerance of the instrument and defines the limits of the errors made when the instrument is used in normal operating conditions. Accuracy can be improved by using feedback elements. To increase accuracy of any control system error detector should be present in it.
- 2) **Stability:** It is an important characteristic of control system. For the bounded input signal, the output must be bounded and if input is zero then output must be zero then such a control system is said to be stable system.
- 3) **Sensitivity:** The parameters of control system are always changing with change in surrounding conditions, internal disturbance or any other parameters. This change can be

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expressed in terms of sensitivity. Any system should be insensitive to such parameters but sensitive to input signals only.

- 4) **Speed:** It is the time taken by it to achieve its stable output. A good control system possesses high speed. The transient period for such system is very small.
- 5) **Oscillation:** A small numbers of oscillation or constant oscillation of output tend to system to be stable.
- 6) **Bandwidth:** An operating frequency range decides the bandwidth of control system. Bandwidth should be large as possible for frequency response of good control system.

### Systems can be different types:

- ✓ Mechanical system
- ✓ Electronic system
- ✓ Computer control system
- ✓ Pneumatic system
- ✓ Sub-systems
- ✓ Control systems

**Mechanical system:** A mechanical system is a device made up of various mechanical parts. Its input is provided by an effort. Once the effort and is applied, it can set off a motion to move a load. The force applied to the load is the output of the mechanical system. Examples of mechanical systems include levers, gears and shafts.



Gears

**Electronic system:** An electronic system is a system that employs electronic signals to control devices, such as radios, calculators, video game machines, mobile phones, portable computers etc. The input of an electronic system is provided by electronic signals. After they are processed, they can generate output signals, which control the operation of various devices, such as amplifiers and LCD. Electronic systems can carry out many different tasks, such as generating sound, transmitting information, displaying video, measuring, memorizing, calculating, etc.

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Common examples of electronic devices include semi-conducting diode, transistors, and capacitors that they are usually welded onto electronic circuit boards.



Computer and chip set

**Computer control system:** A computer control system uses a computer to control its output devices according to different input signals. Its function is similar to that of an electronic system. Examples of computer control systems include computer numerical control press brakes, computer controlled home appliances, computer controlled underground railway systems, etc.



Cnc machine

**Pneumatic system:** A pneumatic system is a system that uses compressed air to transport and control energy. The use of pneumatic systems is very extensive, for example, in controlling the movement of train doors, the operation of automatic production lines and mechanical clamps, etc.

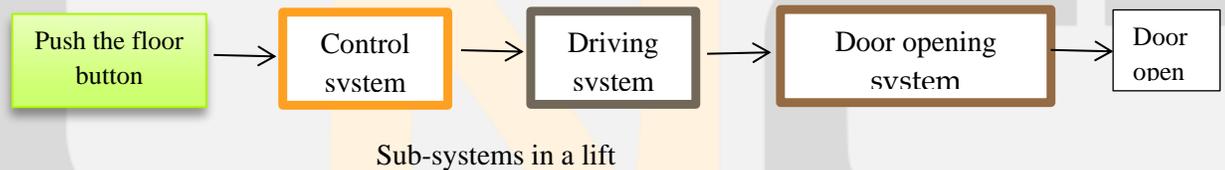


Pneumatic press

**Sub-systems:** A system may comprise some relatively small parts. They are known as sub-systems. For instance, a lift system includes driving system, door opening system, control system, safety system, lighting system, ventilation system and security system



Lift



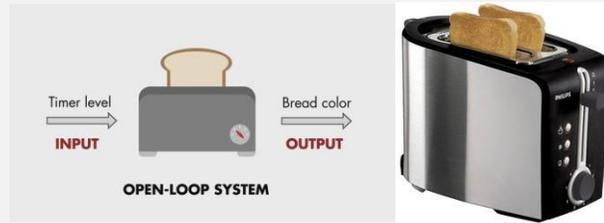
### DIFFERENT TYPES OF CONTROL SYSTEMS:

Open loop and closed loop control systems there are basically two types of control system: the open loop system and the closed loop system. They can both be represented by block diagrams. A block diagram uses blocks to represent processes, while arrows are used to connect different input, process and output parts.

- a) **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.



Block diagram of an open loop control system



### 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.
6. Light Switch – Lamps glow whenever light switch is on irrespective of light is required or not.
7. Volume on Stereo System – Volume is adjusted manually irrespective of output volume level.

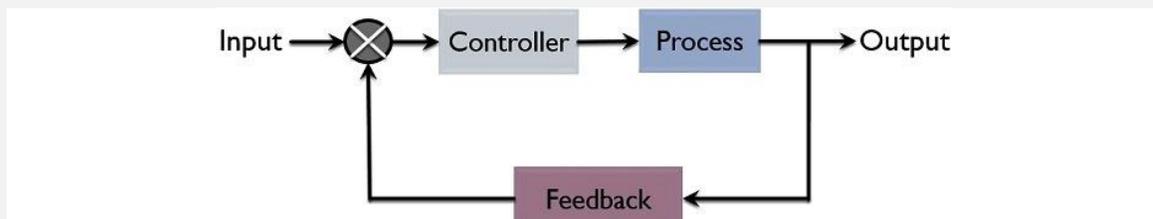
### Advantages of Open Loop Control System:

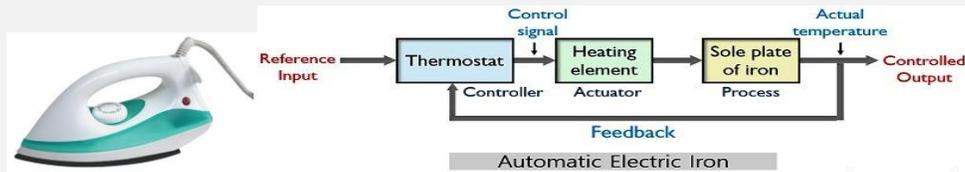
1. Simple in construction and design.
2. Economical.
3. Easy to maintain.
4. Generally stable.
5. Convenient to use as output is difficult to measure.

### Disadvantages of Open Loop Control System:

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

- b) **Closed Loop Control System:** A 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.





### 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 and Auto Tracked by Radar – The direction of missile is controlled by comparing the target and position of the missile.
5. An Air Conditioner – An air conditioner functions depending upon the temperature of the room.
6. 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

**Describe the types of control system on the basis of driving medium, with advantages and disadvantages?**

**On the basis of driving medium there are three types of it:**

- 1) Electrical
- 2) Pneumatic
- 3) Hydraulic

#### **Advantages of Electrical Control System**

- 1) No air compressor and associated machinery required.
- 2) High efficiency since there is no leakages.
- 3) Very little affected by normal temperature variations.
- 4) Very accurate and quick response.
- 5) Electric cables are cheap and easy to lay.
- 6) No time lag or transmission delay.
- 7) No contamination in control medium

#### **Disadvantages of Electrical Control System**

- 1) The system requires uninterrupted power supply with no voltage fluctuations.
- 2) Complex networks
- 3) Standby batteries required in case of power failure.
- 4) There is risk of fire due to overheating. Expensive intrinsically safe / explosion proof equipment may be required.
- 5) Difficult maintenance and test kit requirements
- 6) Moisture may cause damage to the system.
- 7) Damage readily occurs in the event of a fire.

#### **Advantages of Pneumatic Control System**

- 1) Not affected by ship's power supply variations for short term.
- 2) Low cost of installation
- 3) No heat generated and hence no risk of fire.
- 4) Simplicity of the components and no complex structure
- 5) Actuators are cheaper and accurate than electric systems.
- 6) Simple control air piping system.

### **Disadvantages of Pneumatic Control System**

- 1) Require air compressor and associated systems.
- 2) Copper piping is vulnerable to damage
- 3) A clean, dry and oil free supply of good quality air is essential for satisfactory operation of the system.
- 4) Good quality air require driers, filters with drains, etc. which increases maintenance.
- 5) May have transmission lags in large systems.
- 6) Pipe-couplings can give rise to leaks in certain ambient conditions
- 7) Potential noise

### **Advantages of Hydraulic Control System**

- 1) High horsepower-to-weight ratio
- 2) Its reliable to operate
- 3) Leaks easier to find
- 4) Maintains constant torque and force
- 5) Hydraulic power can be transmitted in long distances
- 6) Motion reversal is fast
- 7) Handles strong, heavy loads, shock forces
- 8) Costs less energy to operate
- 9) Lesser overall wear because of oil lubrication
- 10) Does not generate sparks
- 11) Smooth operation for lifting and movement of loads
- 12) Costs less energy to operate
- 13) Operates in hot environments

### **Disadvantages of Hydraulic Control System**

- 1) More expensive initial installation than pneumatic system
- 2) Slower motion than pneumatic.
- 3) Noisy
- 4) Risk of contamination
- 5) Leakage of oil problem
- 6) Requires more energy to operate
- 7) Requires more maintenance
- 8) Heavier components, parts
- 9) Hydraulic fluid dangerous to humans
- 10) Hydraulic fluid not environment friendly

RGPV Previous questions.

Q.1 Define control system and its types?

Q.2 Explain open loop and closed loop control system with examples?

Q.3 Write down the difference between open loop and closed loop system?