# Concept of Feedback and Closed Loop System

Submitted to
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# Contents

# 1. What is a Control System?

A **Control system** consist of subsystems and processes assembled for the purpose of controlling the output of the processes. We can say that the control system will take the input, process it in a predefined manner to get the desired results.

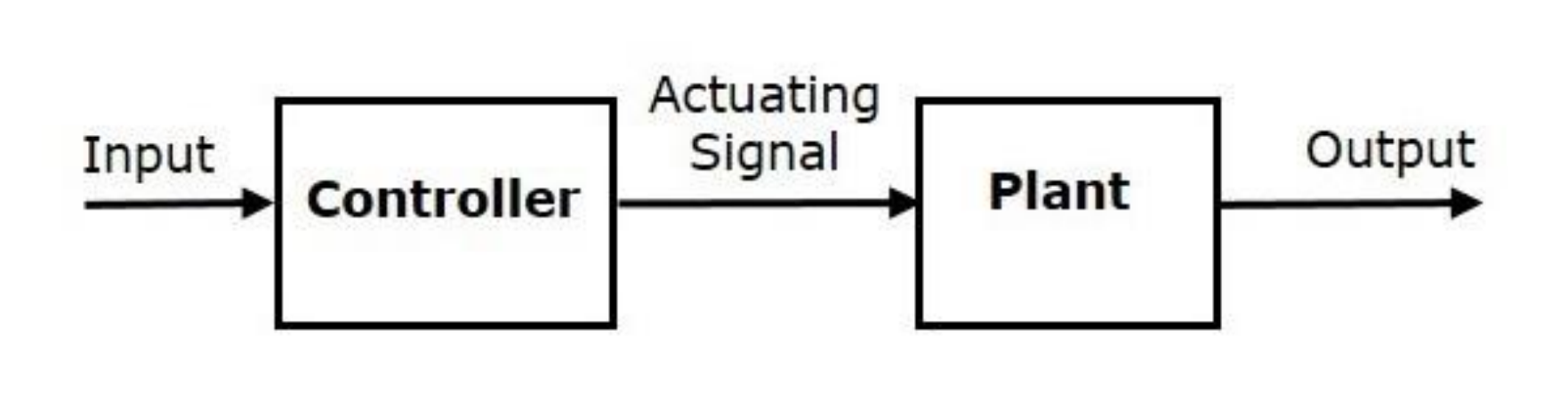
**Examples: Washing machine, Voltage Stabilizer**

There are basically two types of control systems:

- **Open-loop control system**
- **Closed-loop control system**

# 2. What is an Open Loop System?

Open loop systems operate without feedback, relying on predefined control actions i.e. the output has no control on the control action of the system. Thus, the open loop control system follows its input signals regardless of the final results.



# Some Examples of Open Loop Control Systems

### Traffic lights

These operate based on a timer and do not consider the actual traffic conditions.

### Electric room lights

Turning on an electric room light sends a control signal, but does not sense if the light is actually on.

### Washing machines

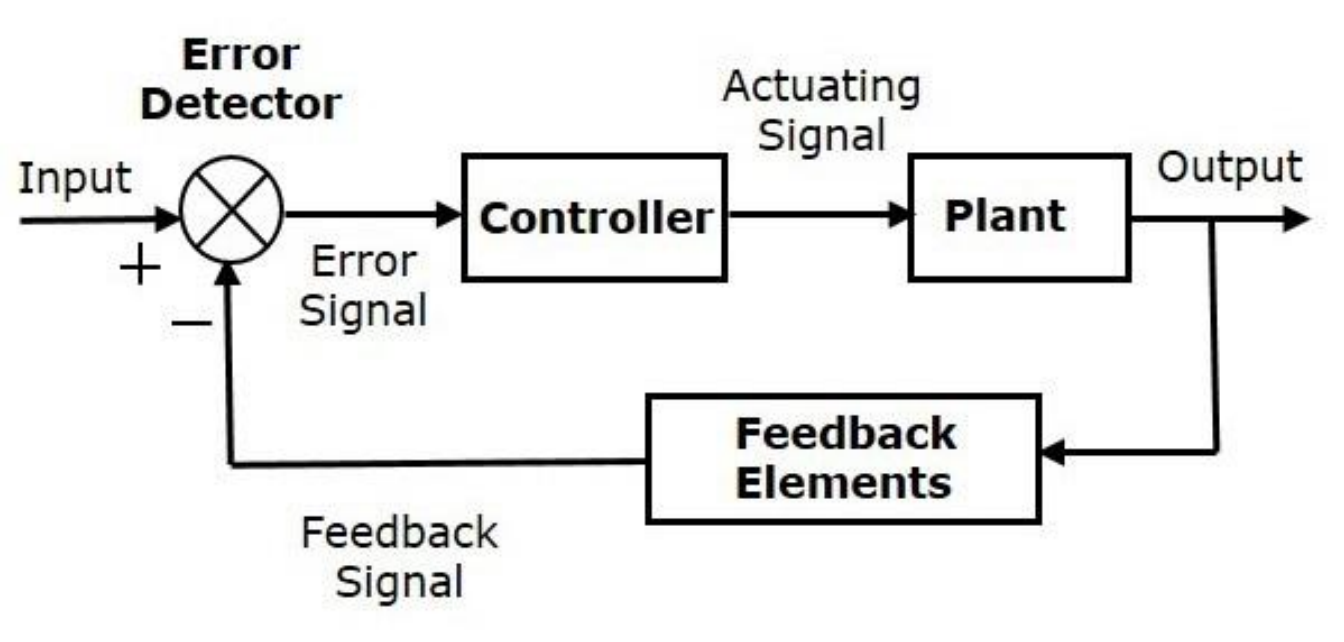
Selecting a cycle on a washing machine is an open-loop process that does not check the water level or the state of the clothes.

### Ovens

Setting a temperature on an oven does not provide feedback to adjust the heating dynamically.

# 3. What is a Closed Loop System?

A **closed loop control system** is the one in which the output signal is fed-back to the input of the system. Therefore, in a closed loop control system, the control action is a function of desired output signal.



# 4. Concept Of Feedback

**Feedback** is the signal that is sent after monitoring the output which fed to the error detector for comparison with reference input. This information is then compared to the reference input to determine the error, which is the difference between the desired and actual outputs.

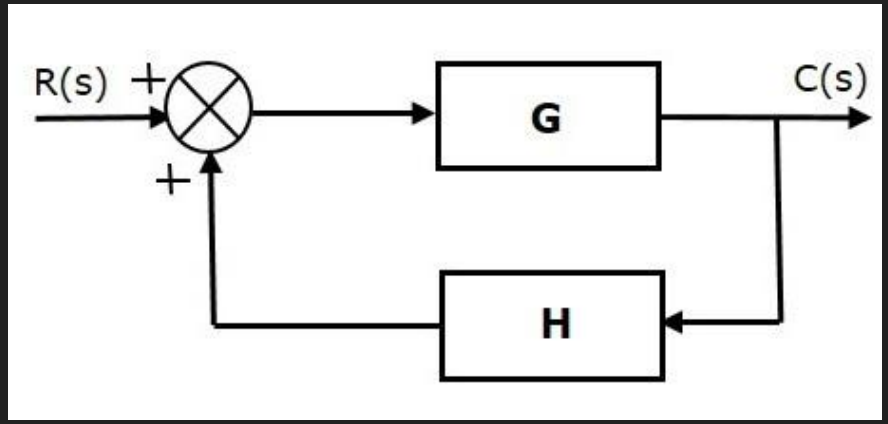
There are two types of feedback −

- Positive feedback
- Negative feedback

# 1. Positive Feedback

The positive feedback adds the reference input, R(s)and feedback output. The following figure shows the block diagram of **positive feedback control**

$$T = \frac{G}{1-GH}$$

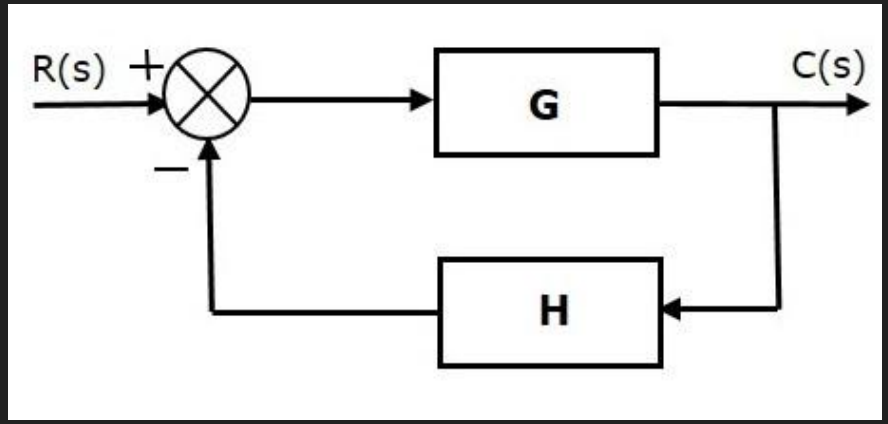



Where,

**T** is the transfer function or overall gain of positive feedback control system.
**G** is the open loop gain, which is function of frequency.
**H** is the gain of feedback path, which is function of frequency.

# 2. Negative Feedback

Negative feedback reduces the error between the reference input, R(s) and system output. The following figure shows the block diagram of the **negative feedback control system**.




$$T = \frac{G}{1+GH}$$

Where,

**T** is the transfer function or overall gain of negative feedback control system.
**G** is the open loop gain, which is function of frequency.
**H** is the gain of feedback path, which is function of frequency.

## 5. Difference Between Open Loop Control System & Closed Loop Control System

| Open Loop Control System | Closed Loop Control System |
| --- | --- |
| A control system in which there is no feedback path is provided is called an open loop control system. | The control system in which there is a feedback path present is called a closed loop control system. |
| In open loop control system, the control action is independent of the output of the overall system. | In closed loop control system, the control action is dependent on the output of the system. |
| The design and construction of an open loop control system is quite simple. | Closed loop control system has comparatively complex design and construction. |
| The major components of an open loop control system are – controller and plant. | The main components of a closed loop control system are – Controller, plant or process, feedback element and error detector (comparator). |
| Open loop control system has fast response because there is no measurement and feedback of output. | The response of the closed loop control system is slow due to presence of feedback. |
| The reliability of open loop control system is less. | The closed loop control system is more reliable. |
| The accuracy of open loop control system depends upon the system calibration and therefore, may be less. | Closed loop control system is comparatively accurate because the feedback maintains its accuracy. |

| Open Loop Control System | Closed Loop Control System |
| --- | --- |
| The stability of open loop control system is more, i.e., the output of the open loop system remains constant. | Closed loop control system is comparatively less stable. |
| The open loop control system is not optimized. | Closed loop control system is optimized to produce the desired output. |
| Open loop control system requires less maintenance. | Comparatively more maintenance is needed in closed loop control system. |
| Open loop control system is easy to implement. | The implementation of a closed loop control system is relatively difficult. |
| Open loop control system is less expensive. | The cost of the closed loop control system is relatively high. |
| Open loop control system has more internal noise. | In closed loop system, the internal noise in the system is less. |
| Common practical examples of open loop control systems are – automatic traffic light system, automatic washing machine, immersion heater, etc. | Examples of closed loop control systems include: ACs, fridge, toaster, rocket launching system, radar tracking system, etc. |

# 6. Real-World Examples

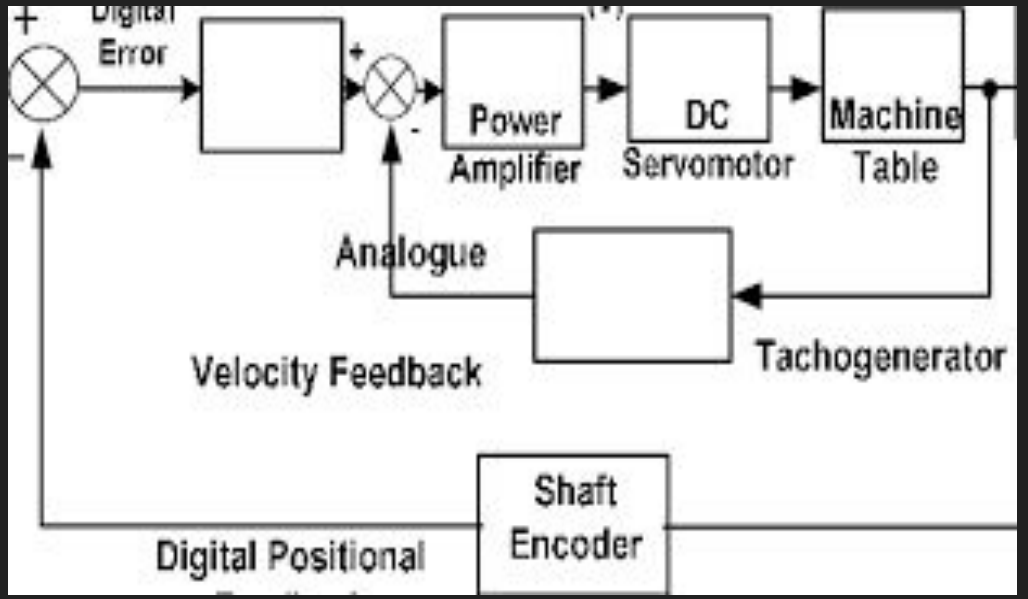
1. CNC Machines
2. ADAS
3. Smart Thermostat
4. Industrial Robots.

…etc

# 1. CNC Machines

A CNC (Computer Numerical Control) machine is a highly automated machine tool that uses computer programming to control its movements and operations. These machines are widely used in manufacturing for tasks such as cutting, milling, drilling, and turning.

In a CNC machine, a closed-loop system plays a crucial role by continuously monitoring the machine's operations and making real-time adjustments to ensure high precision and accuracy. It uses feedback from sensors to compare the actual performance with the desired outcome and corrects any deviations immediately. This helps maintain consistent quality and reduces errors in the machining process.




# CNC Machining

# 2. ADAS

Advanced Driver Assistance Systems (ADAS) are designed to enhance vehicle safety and driving comfort by automating and improving various driving tasks. A closed-loop system in ADAS uses feedback to continuously monitor and adjust the system's performance in real-time.

### How It Works

1. **Detection**: Sensors detect obstacles, lane markings, and other vehicles.
2. **Processing**: The controller analyzes the sensor data and determines the necessary actions.
3. **Action**: Actuators carry out the required adjustments, such as braking to avoid a collision.
4. **Feedback**: Sensor data is continuously fed back to the controller to refine and improve the system's responses.

**Example: Adaptive Cruise Control (ACC)**

In Adaptive Cruise Control, the closed-loop system maintains a set speed and distance from the vehicle ahead.

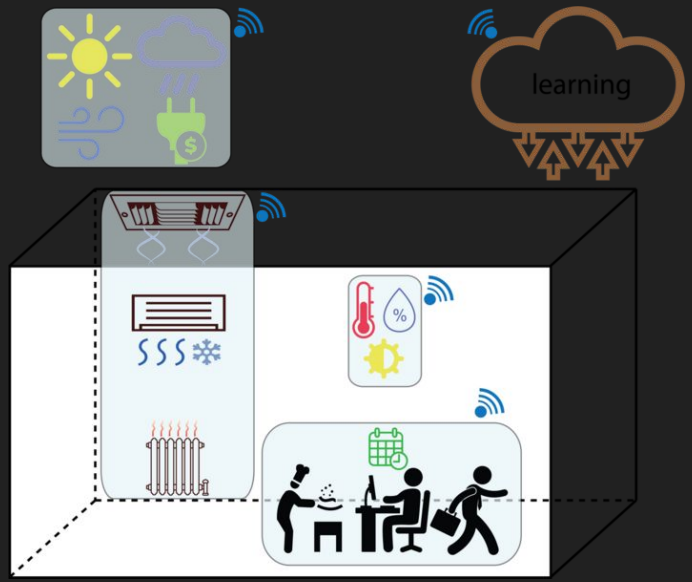
### Benefits

- **Safety**: Enhances vehicle safety by providing real-time adjustments.
- **Precision**: Ensures accurate and timely responses to changing driving conditions.
- **Automation**: Reduces driver workload and improves driving comfort.

ADAS (Advanced Driver Assistance Systems)

## 3. Smart Thermostat

A smart thermostat is an advanced device that controls your home’s heating and cooling systems more efficiently by learning your preferences and adjusting settings automatically.



## 4. Industrial Robots

Industrial robots are automated machines used in manufacturing to perform tasks such as welding, painting, assembly, and material handling with high precision and speed.

# 7. Advantages/Disadvantages of Closed Loop system

## Advantages

1. **Accurate Process Control**: These systems maintain the desired output by precisely adjusting process variables, ensuring consistent and reliable performance .
2. **Reduced Sensitivity to External Disturbances**: They are designed to minimize the impact of external changes, such as temperature or load variations, keeping the process steady and predictable .
3. **Automatic Error Correction**: Closed-loop systems can detect and correct errors automatically, reducing the need for human intervention.
4. **Stable System Operation**: They help avoid significant fluctuations in performance, making them dependable for long-term use.
5. **High Efficiency**: In applications like water systems, closed-loop designs prevent water loss due to evaporation, increasing efficiency .
6. **Support for Automation**: These systems can operate autonomously, making them suitable for automated processes .

## Disadvantages

1. **Complex Design**: These systems are often intricate and require detailed planning and engineering, making them more challenging to develop compared to simpler systems.
2. **Higher Cost**: Due to the need for additional components like sensors and feedback mechanisms, closed-loop systems tend to be more expensive.
3. **Maintenance Requirements**: They require regular maintenance to ensure all components, especially the feedback mechanisms, are functioning correctly.
4. **Potential Instability**: Feedback loops can sometimes cause the system to oscillate or become unstable if not properly designed .
5. **Sensitivity to External Disturbances**: Despite their design to minimize external impacts, they can still be sensitive to environmental changes such as temperature fluctuations or electrical noise.
6. **Time-Consuming Development**: Designing a stable and efficient closed-loop system can be time-consuming and require significant effort.

# 8. Conclusion

Closed-loop systems have many advantages over open-loop systems. The type of control system which uses feedback signals to both control and adjust itself is called a Closed-loop System. Closed-Loop Control System are considered as fully automatic control system because it is designed in a way that the achieved output is automatically compared with the reference input to have the required output. Closed-loop systems are designed to automatically achieve and maintain the desired output condition by comparing it with the actual condition.


Thank You