INDUSTRIAL AUTOMATION

DIPLOMA WALLAH

UNIT 2: PROCESS CONTROL SYSTEMS AND PLC APPLICATIONS

---

1. Open Loop and Closed Loop Systems

Definition and Concept

Open Loop System

An **open loop system** is a type of control system where the output is **not fed back** to the input for correction. It performs its operation based on a fixed set of instructions or input signals. There is **no automatic adjustment** for changes or disturbances in the process.

In other words, once started, the system works independently of the actual result.

Electrical Example:

- An **electric toaster** is an open-loop system — it heats for a fixed time whether the bread is toasted or not.
- **Washing machine timer**, **street light timer**, and **manual fan regulator** are also examples.

Closed Loop System

A **closed loop system** (feedback control system) continuously measures the output and feeds it back to the controller. The controller compares the actual output with the desired value (setpoint) and automatically adjusts inputs to minimize error.

This system improves **accuracy, stability, and performance** because it reacts to changes in conditions or disturbances.

Electrical Example:

- **Automatic Voltage Regulator (AVR)**: maintains generator voltage constant by adjusting field current automatically.
- **Temperature-controlled heater** or **speed control of DC motor** using feedback sensor.

Diagram

Open Loop:

[Input] → [Controller] → [Actuator/Process] → [Output]

(No feedback)

Closed Loop:

[Input/Setpoint] → [Controller] → [Actuator] → [Process] → [Sensor] → [Feedback to Controller]

Key Differences Table

Feature	Open Loop	Closed Loop
Feedback	Not used	Used
Accuracy	Low	High
Complexity	Simple	Complex
Example	Timer-based street light	Automatic street light with LDR sensor
Response to disturbances	No correction	Auto correction through feedback

---

Hinglish Summary (3 lines)

Open loop system bina feedback ke kaam karta hai, jaise timer-based fan.
Closed loop system feedback lekar apna output automatically control karta hai, jaise voltage regulator.
Closed loop zyada accurate aur efficient hota hai.

- **2. Demonstrate a Closed-Loop Feedback System (with Applications)**

Concept:
A **closed-loop feedback system** continuously measures the output and automatically adjusts the input to maintain desired performance. Feedback ensures **stability**, **accuracy**, and **self-correction**.

Main Components:

1. **Setpoint (Reference Input):** Desired value (e.g., motor speed = 1500 RPM).
2. **Sensor / Transducer:** Measures actual output.

3. **Controller:** Compares setpoint and feedback, calculates error.
4. **Actuator:** Makes necessary adjustment (e.g., changes voltage/speed).
5. **Process / Plant:** The system being controlled.

Example 1: Speed Control of DC Motor

Working Process:

1. Speed sensor (tachometer) measures actual RPM.
2. Controller compares it with setpoint.
3. If speed < setpoint → increases voltage.
4. If speed > setpoint → decreases voltage.
5. Motor speed remains constant under varying loads.

Block Diagram:

[Set Speed] → [Controller (PID/PLC)] → [Motor Driver] → [Motor] → [Speed Sensor] → [Feedback]

Application Areas:

- Conveyor belt speed control
- Pump flow regulation
- Elevator and escalator speed control
- Automatic voltage regulation in power systems

Example 2: Temperature Control System

- Uses a temperature sensor (RTD/Thermocouple).
- Controller compares measured temperature with setpoint.
- Heater ON/OFF or power is adjusted to maintain desired temperature.
  Used in: ovens, chemical reactors, and transformers' oil cooling systems.

---

3. Components Used in Process Control

Component	Function	Electrical Example
Sensor / Transducer	Measures process variable (temperature, pressure, current, etc.)	RTD, thermocouple, current transformer
Transmitter	Converts sensor signal into standard output (e.g., 4–20 mA)	Temperature transmitter
Controller	Computes error and generates control signal	PLC, DCS, PID Controller
Actuator / Final Control Element	Executes control action	Motor, valve, solenoid, relay
HMI / SCADA	Interface for monitoring and control	Industrial operator display
Power Supply & Communication	Provide power and data exchange	Fieldbus, Modbus, Ethernet

---

Working Example: Pressure Control in Boiler

1. Pressure sensor measures steam pressure.
2. Signal sent to PLC.
3. PLC compares it to setpoint.
4. If pressure exceeds limit → output relay turns off fuel valve.
5. Process stabilizes automatically.

---

4. Working of Process Control System (Step-by-Step)

1. **Measurement:**
   Sensors collect data about the process (e.g., voltage, flow, temperature).
2. **Signal Transmission:**
   Transmitters convert sensor signals into standardized signals (4–20 mA or 0–10 V).
3. **Control Decision:**
   The controller (PLC/DCS) compares actual values with desired values and calculates error.

4. **Control Action:**
   Controller generates output signals to actuators to correct the process (e.g., open valve, change motor speed).
5. **Feedback:**
   The system continuously monitors results, forming a closed-loop control.
6. **Monitoring and Display:**
   SCADA or HMI shows process data, alarms, and historical trends for the operator.

Diagram (Text Version):

Sensor → Transmitter → Controller → Actuator → Process → Feedback → Controller

Real Example:
In a **transformer oil cooling system**, a temperature sensor detects oil heat. PLC turns ON fans/pumps automatically to maintain proper temperature.

🔹 5. Industrial Automation Demonstrations (Video Concepts)

(a) Automation of Beverage Industry

- PLC controls filling, capping, and labeling of bottles.
- Sensors detect bottle presence, actuators start filling.
- Level sensors ensure exact volume.
- Reduces wastage and human error.

(b) Automation of Motor Stator Production

- Robotic arms perform coil winding and slot insertion.
- PLC synchronizes all machines.
- Ensures uniform tension, accurate turns, and improved quality.

(c) Automation of Transformer Core

- Automated lamination stacking, cutting, and joining.
- Uses servo motors for precision cutting.
- Reduces manual error and enhances efficiency.

(d) Role of PLCs in Manufacturing

- PLC acts as the brain of the process.

- Controls sequence of operations, handles safety interlocks, and monitors all I/O devices.
- Examples: conveyor control, mixing process, automatic packaging.

(e) PLC Application Stories

- **Automated Power Plant:** PLC handles start/stop of pumps, fans, and conveyors.
- **Material Handling System:** Sensors and motors controlled by ladder logic.
- **Smart Grids:** PLC + SCADA used for substation automation.

---

6. Bit Logic Instructions in PLC

Bit logic instructions are **basic logic operations** used in ladder logic programming.

Instruction	Symbol / Meaning	Function / Example
Standard Contact	`–	
Normally Closed (NOT)	`–	/
Immediate Contact	Fast response contact used for high-speed inputs	
Positive Transition (↑)	Detects rising edge of signal (OFF → ON)	
Negative Transition (↓)	Detects falling edge of signal (ON → OFF)	
Output Coil	( )	Turns ON an output device (motor, lamp)
Set (Latch)	(S)	Keeps output ON even after input OFF
Reset (Unlatch)	(R)	Turns OFF latched output
Output Immediate	Forces output without waiting for scan completion	

Example:
When Start switch is pressed, motor runs (SET).
When Stop switch is pressed, motor stops (RESET).

---

7. Ladder Diagram (LAD) for Automatic Stamp System

System Description:

An **automatic stamp system** works as follows:

- When **Start switch** is pressed, the system becomes ready.
- When the operator places a **box** on **Limit Switch LS1**, the **motor** starts moving the conveyor.
- When the box reaches **Limit Switch LS2**, the **stamper** activates.
- After stamping, the **motor stops** until the next box arrives.

Components Required:

Component	Type	Function
Start Switch	Push Button	System ON
Stop Switch	Push Button	System OFF
LS1	Limit Switch	Detects box at conveyor start
LS2	Limit Switch	Detects box at stamping position
Motor	Actuator	Drives conveyor
Solenoid / Cylinder	Actuator	Performs stamping
PLC	Controller	Controls logic
Power Supply	Electrical	Powers system

Ladder Logic Design (Text Version)

Inputs:

- I0.0 = Start Switch
- I0.1 = Stop Switch
- I0.2 = LS1
- I0.3 = LS2

Outputs:

- Q0.0 = Motor
- Q0.1 = Stamp Solenoid

Logic:

Rung 1: Start Switch (I0.0) —| |— Stop Switch (I0.1 NC) —(Set Ready Bit)

Rung 2: Ready Bit —| |— LS1 —| |— (Q0.0 Motor ON)

Rung 3: LS2 —| |— (Q0.1 Stamp Solenoid ON)

LS2 —|/|— (Q0.0 Motor OFF)

Working:

1. System starts when "Start" is pressed.
2. When a box is detected by LS1, conveyor motor starts.
3. When box reaches LS2, motor stops, stamp activates.
4. After stamping, system resets for next box.

Hinglish Summary

PLC ladder logic system automatic stamping process ko control karta hai.
Sensors aur limit switches se signal milta hai, jisse motor aur stamper control hota hai.
Is process se manual kaam kam hota hai aur accuracy badhti hai.

- **8. Applications of PLC in Industry (Electrical Focus)**

1. **Substation Automation** – switching, fault detection, load control.
2. **Motor Speed Control** – VFD integration for conveyors or pumps.
3. **Power Factor Correction Systems** – automatic capacitor switching.
4. **Manufacturing Lines** – sequencing, interlocking, and safety.
5. **Building Management Systems** – controlling lighting and HVAC.

- **9. Advantages and Disadvantages**

Advantages:

1. Fast and reliable operation.
2. Easy to reprogram and modify logic.

3. Compact and rugged design.
4. Real-time monitoring and diagnostics.
5. Reduces manual labor and increases safety.

Disadvantages:

1. High initial cost of PLC and sensors.
2. Requires skilled personnel for programming.
3. Sensitive to electrical noise or voltage fluctuation.
4. System failure may stop whole process.
5. Regular maintenance required.

🔹 10. Final Summary

Industrial process control system feedback ke basis par automatic operation karta hai.
PLC iska brain hota hai jo sensors ke input par motor aur actuators ko control karta hai.
Open loop simple hota hai jabki closed loop feedback system zyada accurate hota hai.
PLC automation se industries mein speed, safety, aur productivity sab badh jati hai.

Diploma Wallah

Made with 💗 by Sagar Sangam