Open/Closed Loop Systems

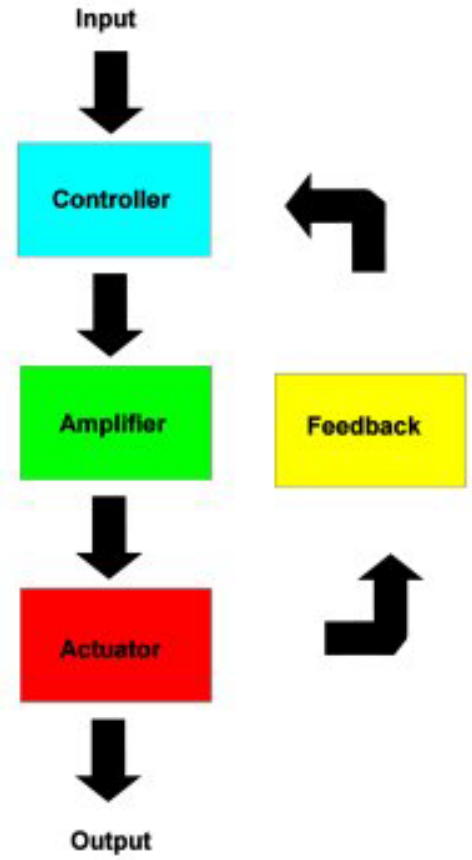
What is a control system?

- A **control system** is a system that manages, directs, or regulates the behaviour of other systems to achieve a desired output.

- A control system will communicate with sensors and actuators to fulfil a desired function

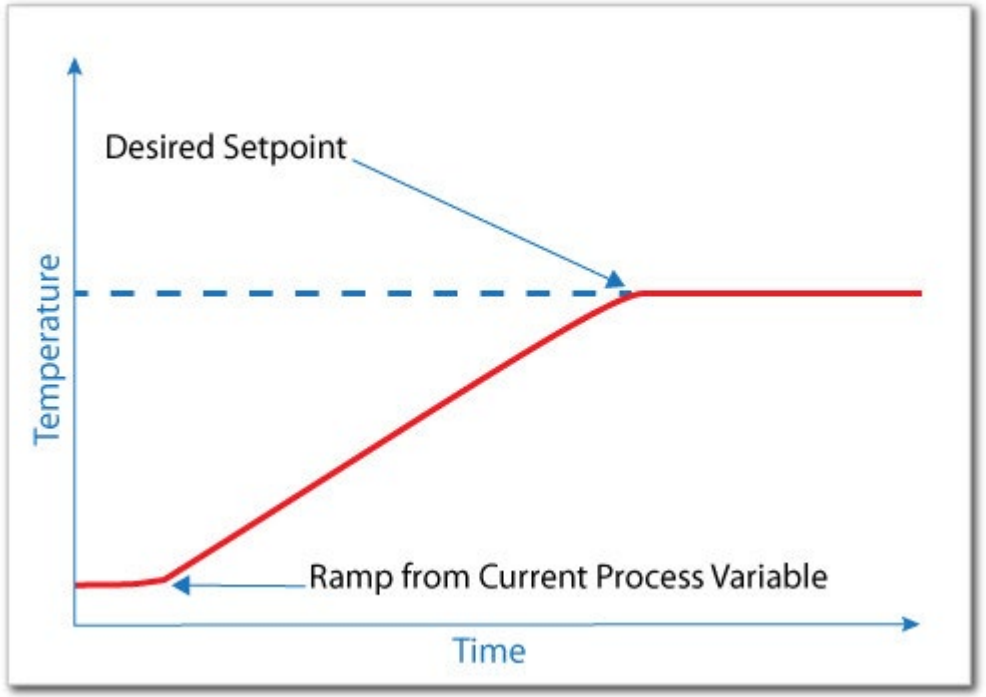
Parts of a control system

- Input (reference signal)
- Controller
- Process/System
- Actuator
- Output
- Feedback (Only in Closed-Loop Systems)
- Disturbance



Input (reference signal)

- The input, also called the reference signal or setpoint, is the value that the system is trying to achieve or maintain.
- It represents the user's or system's intended target — what you want the output to be.
- The controller compares this input against the actual output (in closed-loop systems) to determine what actions are required.
- Example: Setting the temperature on an air conditioner.

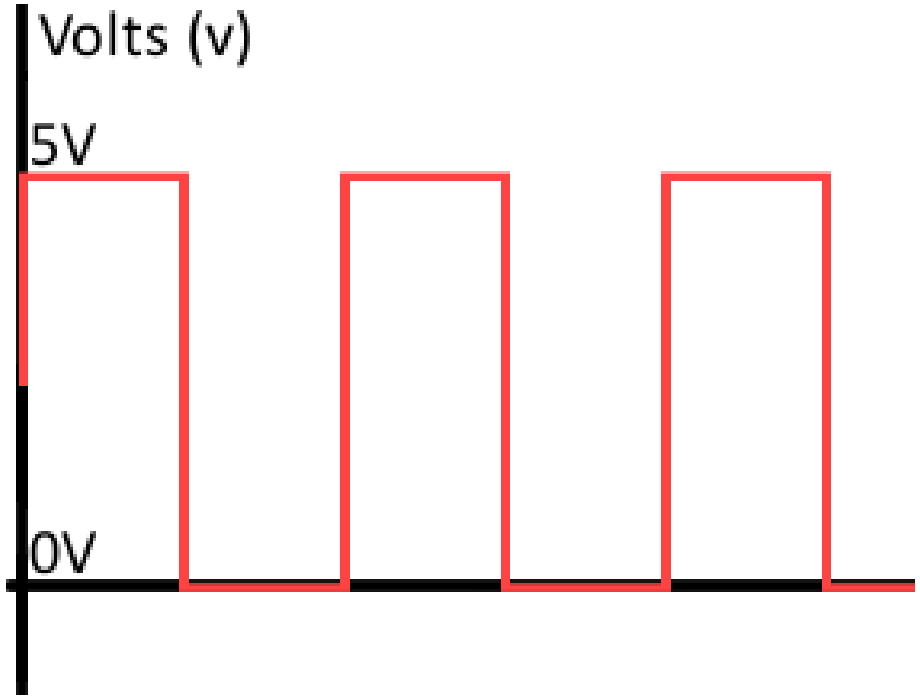


Controller

- The decision-making unit that processes the input and determines how to control the system.
- Example: A thermostat in a heating system.
- In our PLC systems this is the PLC

Process/System

- The process (or system) is the part of the control loop where the actual operation takes place.
- It is the physical or logical system being controlled, and it determines how the actuator's action affects the real-world output.
- In simple terms: The process is what the controller is trying to influence or regulate.
- Example: A movement signal sent to a motor or an analogue signal sent to a heater



Actuator

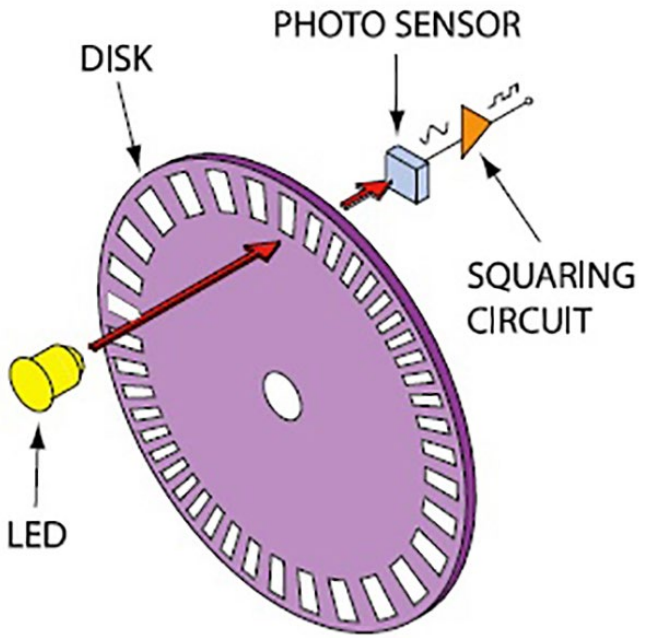
- An actuator converts the controller's electrical signal into a physical action.
- It's the component that moves, opens, closes, pushes, or adjusts something in the real world.
- The controller decides what should happen, but the actuator is the device that makes it happen.
- Example: A motor in a robotic system or a valve in a hydraulic system.

Output

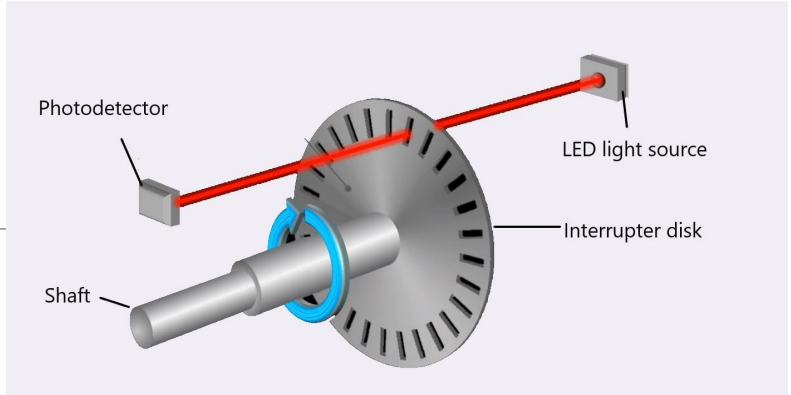
- The output is the actual behaviour or measurable result produced by the system after the controller and actuator have done their job.
- It represents what the system achieved, not what it was told to do.
- Example:
  - The adjusted room temperature in an HVAC system.
  - The speed of a conveyor after the motor command is applied

Feedback (Only in Closed-Loop Systems)

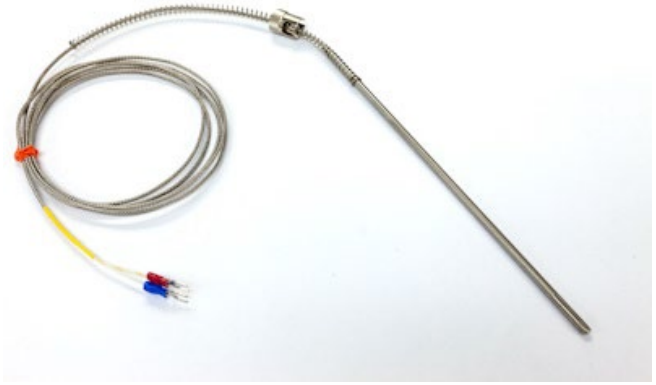
- A sensor or measuring device that continuously monitors the output and sends data back to the controller.
- This ensures the process has reached the correct value
- Example: A temperature sensor in an air conditioner or an encoder measuring a motor turning



Feedback Device Types

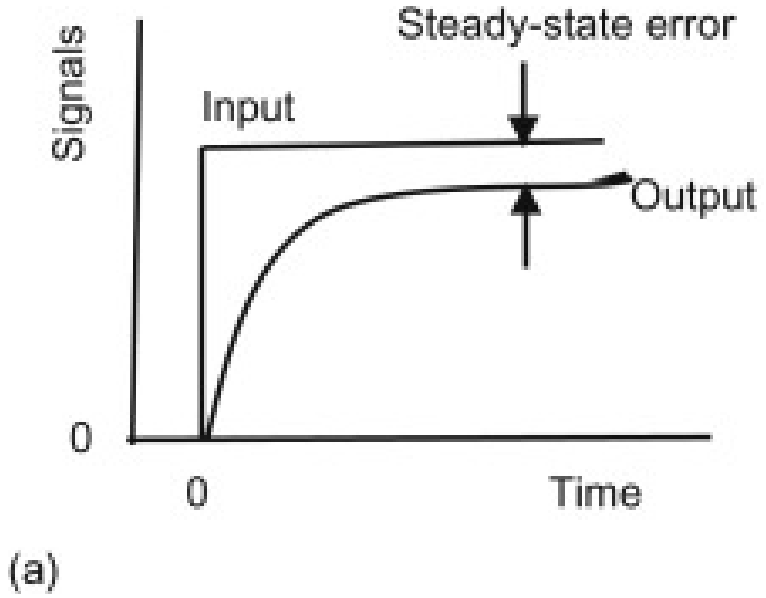


- Position → Encoders, potentiometers
- Speed → Tachogenerators
- Temperature → Thermocouples, RTDs
- Pressure → Bourdon transducers
- Flow → Flow meters



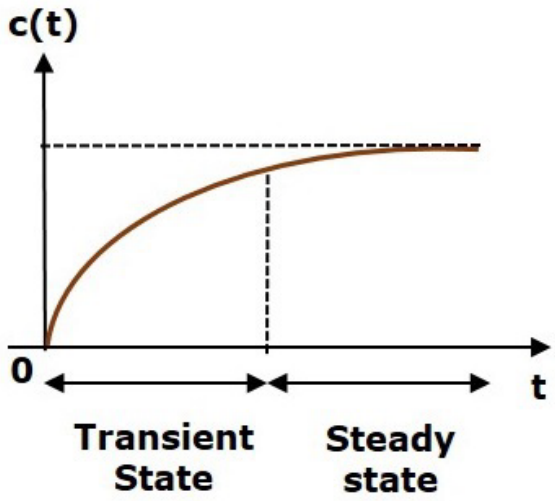
Error

- Error is the difference between the setpoint (desired value) and the process variable (measured output).
- Error = Setpoint − Actual Value
- Closed-loop systems use feedback to detect and correct error.
- Lower error → higher accuracy, stability, and efficiency.



Types of Error

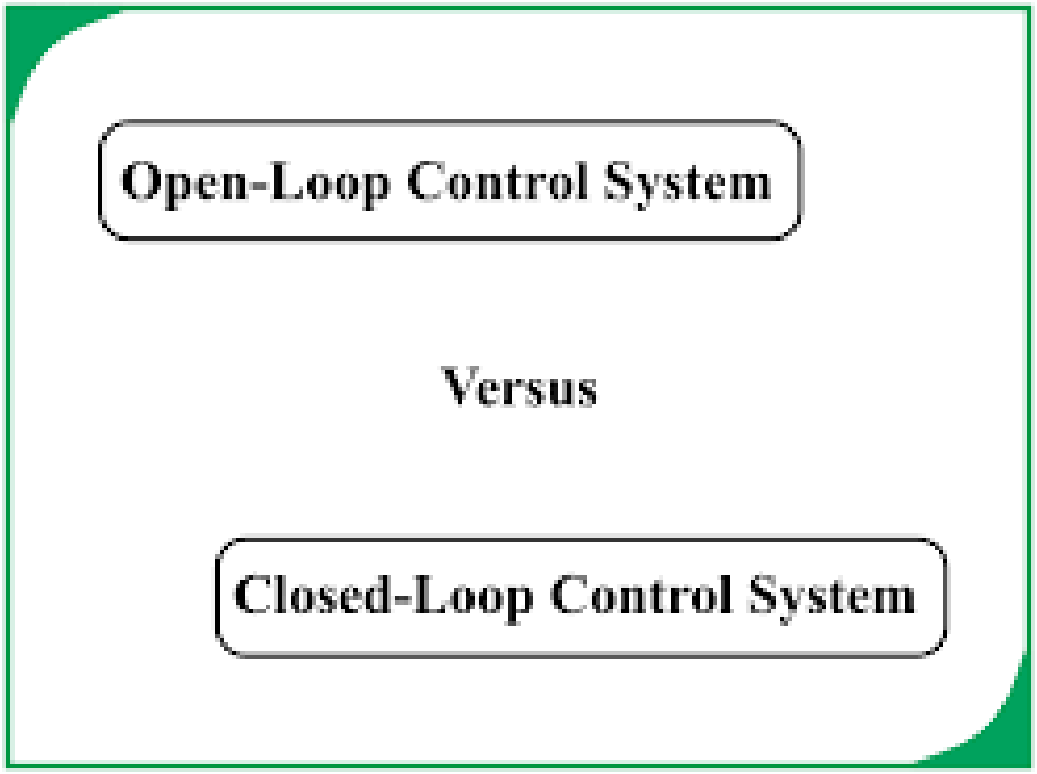
- **Steady-State Error**
  - The system settles, but not exactly at the setpoint.
  - Examples: Motor holds 2950 rpm instead of 3000 rpm.
- **Transient Error**
  - Short-term deviation while the system is reacting to a change.
  - Examples: Temperature overshoot when a heater first starts.



- **Drift Error**
  - Output slowly moves away from the setpoint over time due to wear, heat, or component changes.
- **Disturbance Error**
  - External influences push the output away from the setpoint.
  - Examples: Load changes on a motor, wind on a drone.

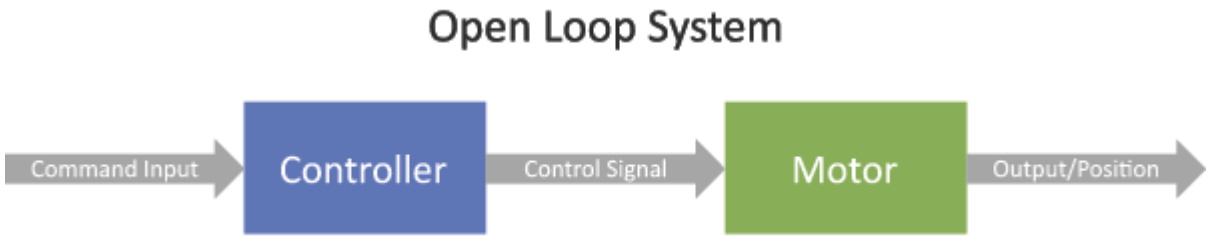
Types of Control Systems

- There are two ways control systems are set up:
  - Open Loop Systems
  - Closed Loop Systems



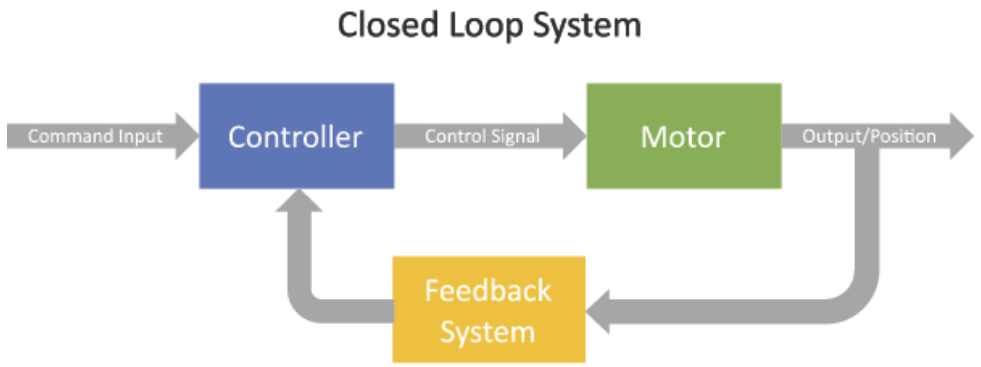
Open Loop Systems

- Works without feedback.
- Example: Microwave oven (fixed heating time, no temperature adjustment).
- Advantages: Simple, cost-effective, easy to design.
- Disadvantages: No error correction, less accuracy.

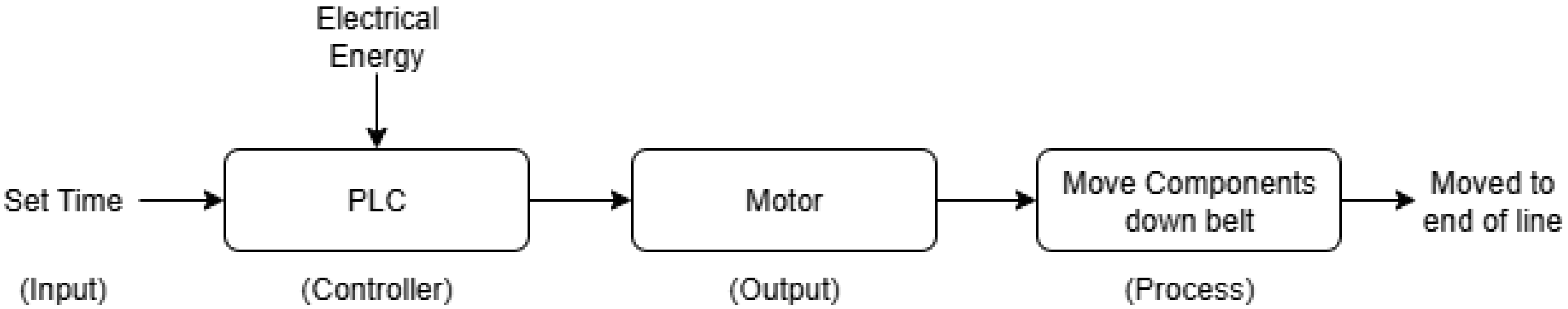


Closed Loop Systems

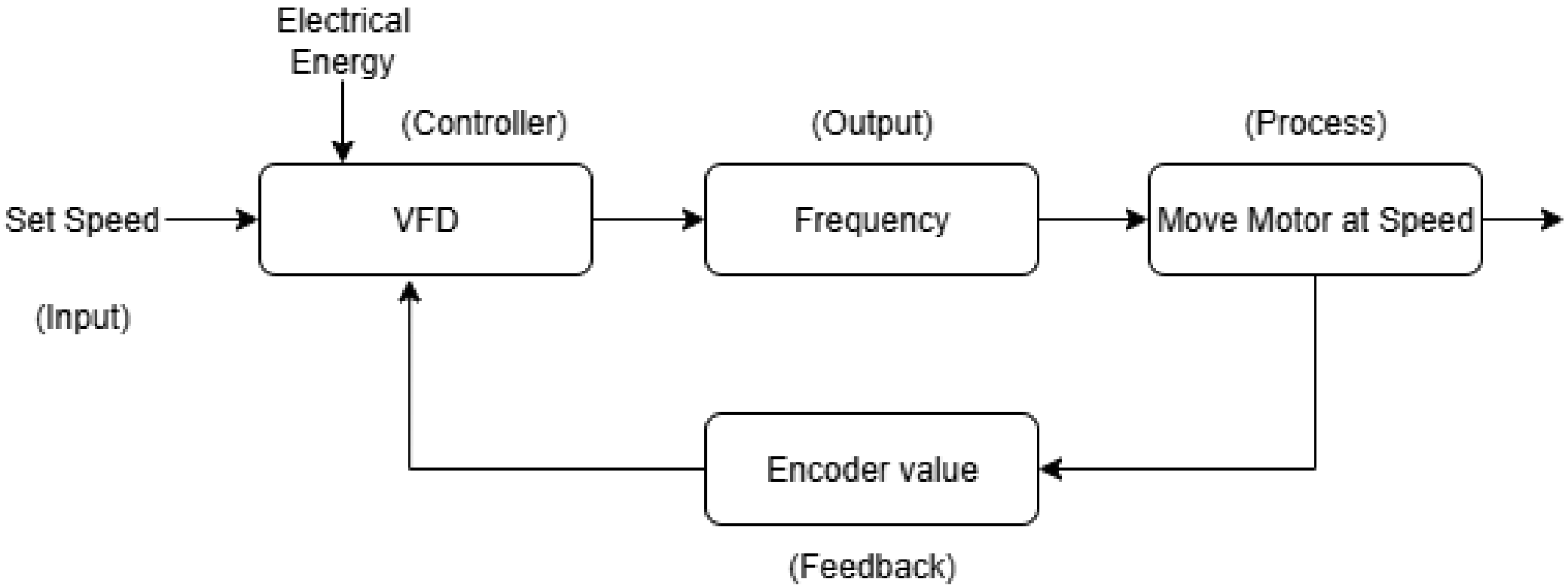
- Uses feedback to adjust operation.
- Example: Air conditioner (adjusts temperature based on sensor feedback).
- Advantages: More accurate, self-correcting, efficient.
- Disadvantages: More complex, higher cost.



Example open loop system

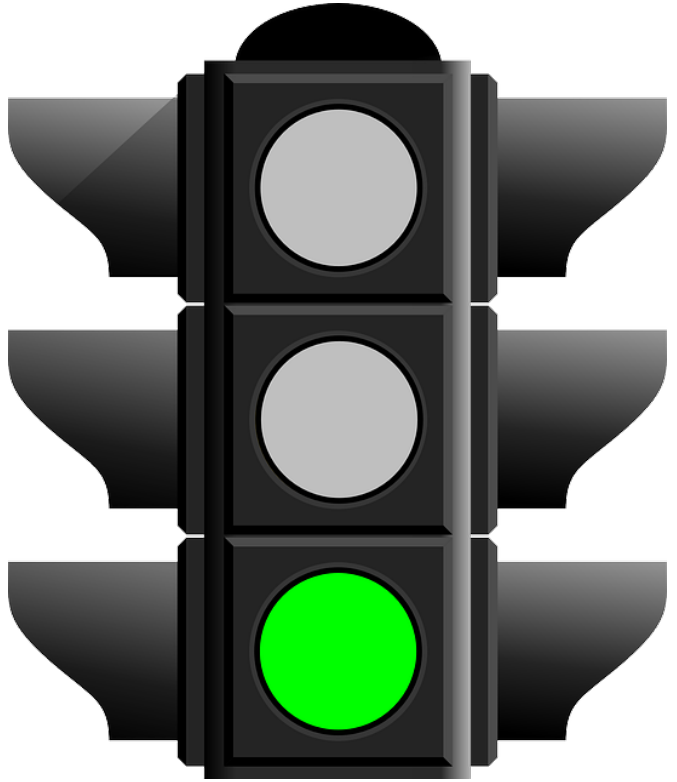


Example closed loop system



Design Task 1:

- Determine the different parts of this control system (input, controller, process ect.) and whether it is open or closed loop:
- **Simple traffic light timer**
- Draw a diagram of the control system



Design Task 2:

- Determine the different parts of this control system (input, controller, process ect.) and whether it is open or closed loop:
- **Cruise control in vehicles**
- Draw a diagram of the control system

Pairs Design Task:

- Come to the front in pairs and get a design task from me
- You must determine the different parts of this control system (input, controller, process ect.) and whether it is open or closed loop
- You must then draw a diagram of the control system
- This must be all put onto a presentation and presented in class