18ECO134T - Industrial Automation

UNIT - 1

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

Contents

Session	Topic	Reference
1	PLC vs Computer	Frank D. Petruzella, Programmable Logic Controller
2	Parts of a PLC	
3	Architecture, PLC size and Application.	
4	Fixed and Modular I/O	
5	Discrete Input Modules, Discrete Output Modules	
6	Analog Input Modules, Analog Output Modules	
7	Special I/O Modules, High Speed Counter Module	
8	Power Supplies, isolators, sensors	
9	Input/output Devices: Switches, Relays, Solenoid valve	

Introduction

Automation is a set of technologies that results in operation of machines and systems without significant human intervention and achieves performance superior to manual operation.

‘Automation’ is derived from Greek words

Auto - self

Matos - moving.

Automation therefore is the mechanism for systems that “move by itself”

Effects of automation

- Increased productivity - Production can run round the clock, except for a few maintenance interval periods
- Improved quality
- Reduced operation time and work handling time
- Reduced direct human labor costs and expenses
- Reduced processing time - larger quantities can be shipped faster
- Automation relieves people of boring, physically heavy or hazardous work

Programmable Logic Controller (PLC)

PLC is an assembly of solid state digital logic elements designed to make logical decisions and provide outputs to control the process.

History of PLC's

- First PLC was introduced in the late 1960s.
- The automobile sector was the first industry to deploy PLCs into its operations.
- Father of the PLC -Dick Morley
- The first company to build PLC – Modicon

The Need for PLC's

Relay based control panel.

PLC-based control panel

- Relays have to be hardwired to perform a specific function.
- The PLC has eliminated much of the hardwiring associated with conventional relay control circuits.

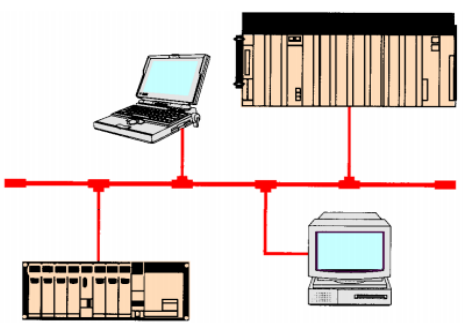
What is a PLC ?

- The PLC is an industrial computer used to control machines and process.
- It is capable of storing instructions to implement control functions such as sequencing, timing, counting, arithmetic, data manipulation and communication.
- The I/O interfaces provide the connection between the PLC and the inputs like pushbuttons, sensors,…and the outputs like valves, relays, lamps,….
- In different areas of the industry PLC are being applied.

  e.g.: materials handling, filling, packaging,..etc.

Advantages

- Increased Reliability
- More Flexibility.
- Lower Cost.
- Communications Capability
- Faster Response Time.
- Easier to Troubleshoot.



PLCs versus Computers

- The PLC is designed to operate in the industrial environment with wide ranges of ambient temperature and humidity.

- PLC is programmed in ladder logic or other easily learned languages.

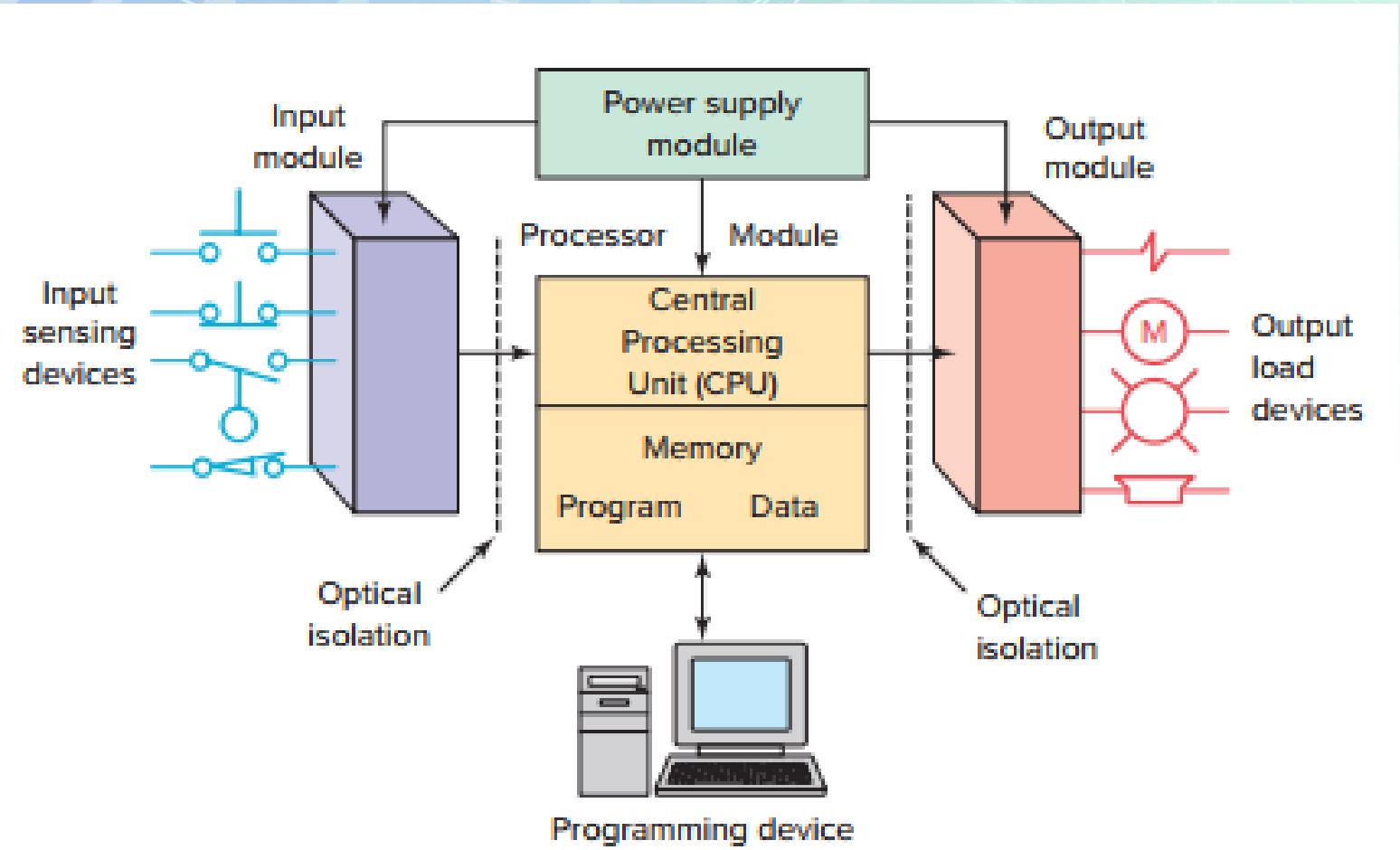
- Computers are complex computing machines capable
of executing several programs or tasks simultaneously
- PLC control systems have been designed to be easily installed and maintained.

PLC	PC
Industrial environment	Office / Home environment
Wide ranges ambient temperature	Controlled low temperatures
Varied humidity	Controlled humidity
Varied dust/dirt	Controlled dust / dirt

A PLC module

PLC installed in an industrial environment

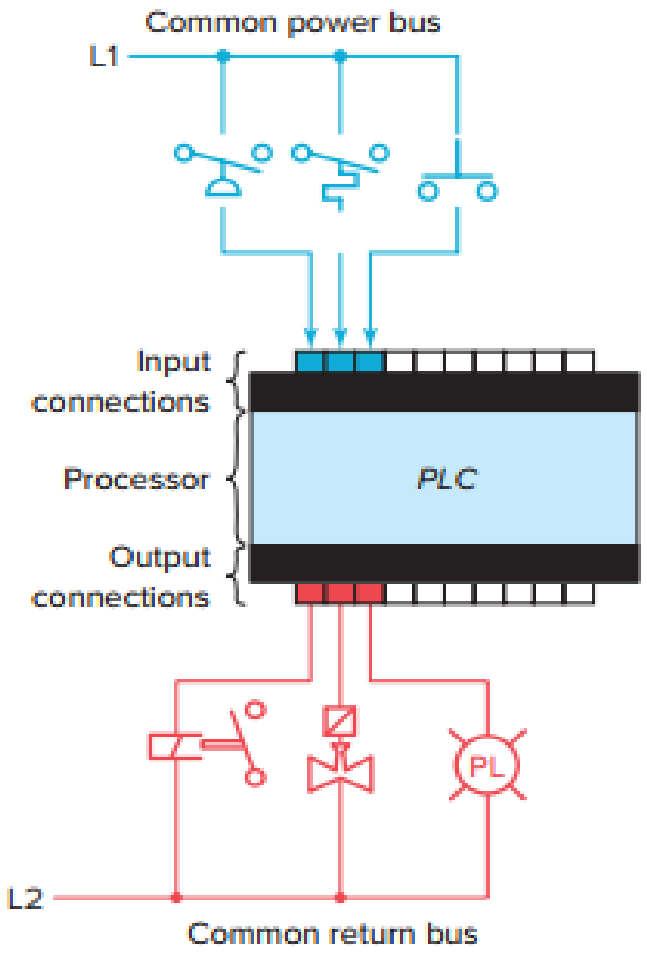
Parts of a PLC



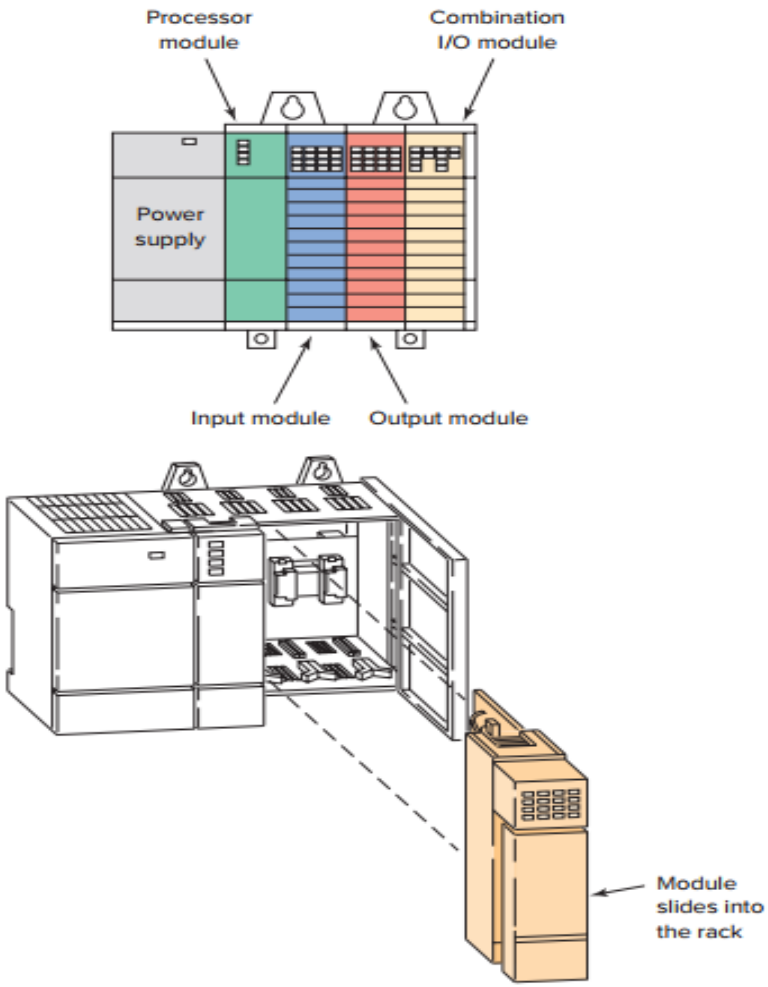
Input / Output Module

- ***Fixed I/O-*** typical of small PLCs that come in one package with no separate, removable units. The main advantage of this type of packaging is lower cost. One disadvantage of fixed I/O is its lack of flexibility.

- ***Modular I/O -*** divided by compartments into which separate modules can be plugged. The main advantage of this type of packaging is flexibility.



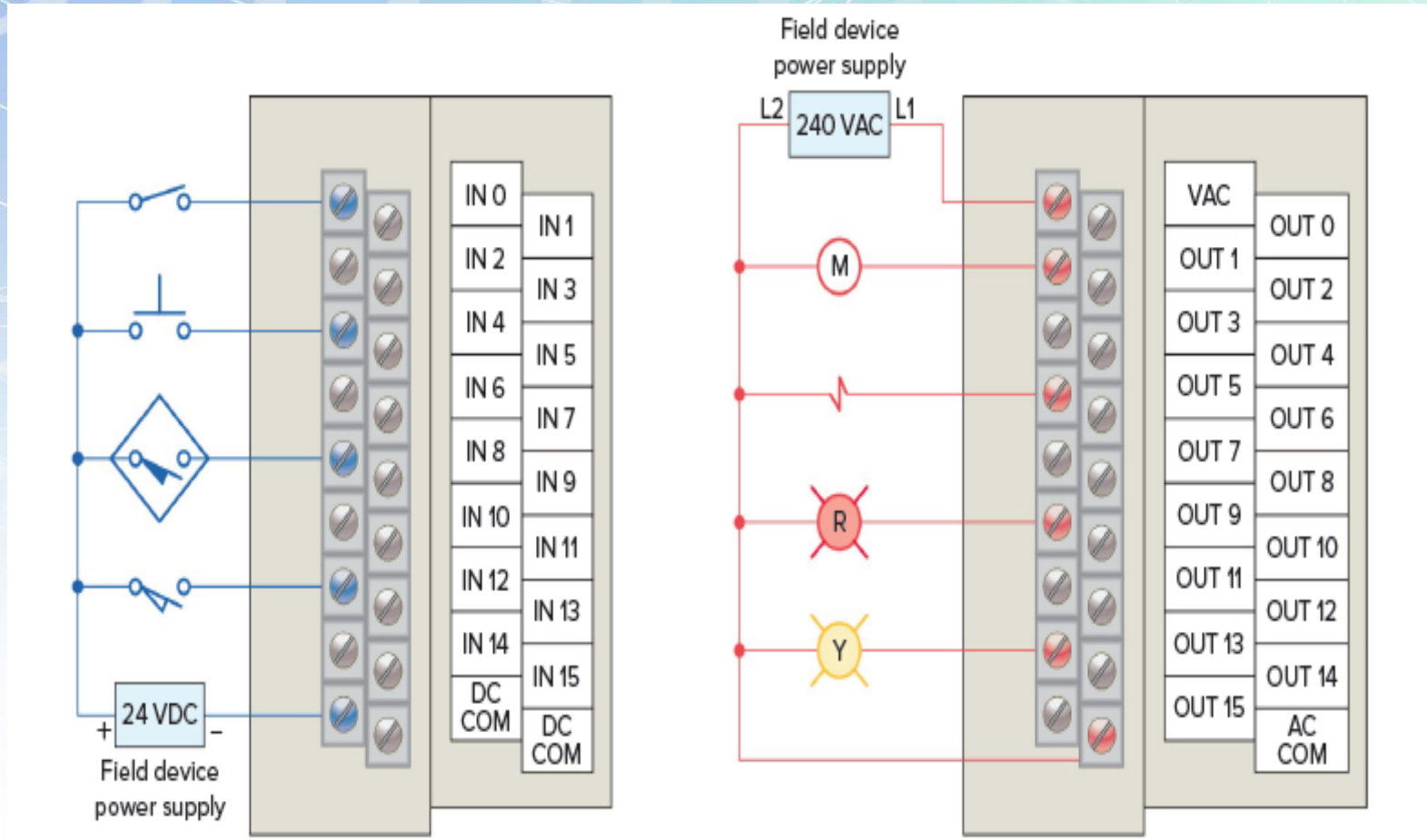
Fixed I/O configuration.



Modular I/O configuration.

- The ***I/O system*** forms the interface by which field devices are connected to the controller.
- **Input devices** such as pushbuttons, limit switches, and sensors are hardwired to the input terminals.
- **Output devices** such as small motors, motor starters, solenoid valves, and indicator lights are hardwired to the output terminals.
- To electrically **isolate the internal components** from the input and output terminals, PLCs commonly employ an **optical isolator**, which uses light to couple the circuits together.

Typical PLC input/output



- The **power supply unit** supplies DC power to other modules that plug into the rack.
- The ***processor (CPU)*** is the “brain” of the PLC.
- A typical processor usually consists of a **microprocessor** for implementing the logic and controlling the communications among the modules. The processor requires memory for storing user program instructions, numerical values, and I/O devices status.
- A ***programming device*** is used to enter the desired program into the memory of the processor. The program can be entered using relay ladder logic, which is one of the most popular programming languages.

PLC Size

- The criteria used in categorizing PLCs include functionality, number of inputs and outputs, cost, and physical size.
- The ***I/O count*** is the most important factor.

✔ Nano PLC - less than 15 I/O points.

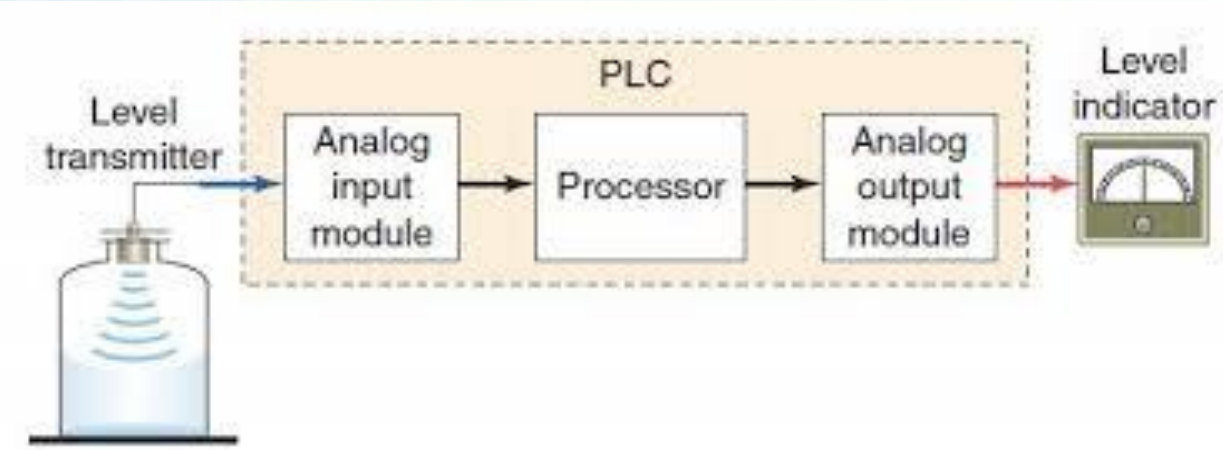
✔ Micro PLC - 15 to 128 I/O points

✔ Medium type -128 to 512 I/O points

✔ Large type - over 512 I/O points.

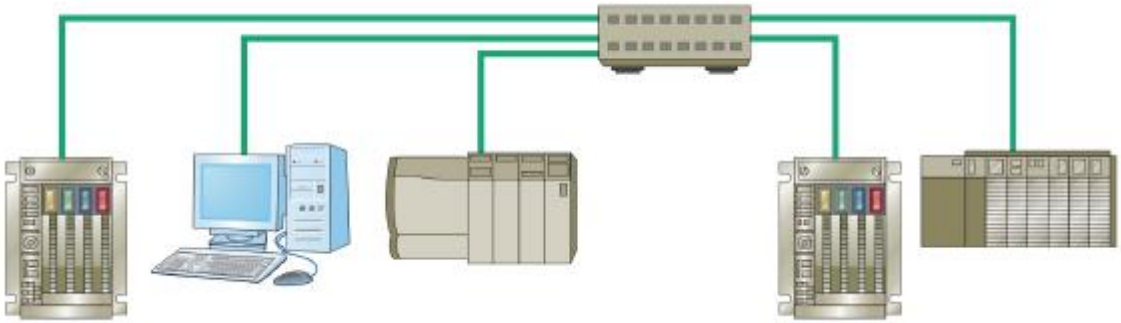
PLC Application

- **Types** – Single ended, multitask, and control management
- A ***single-ended*** or stand-alone PLC application involves one PLC controlling one process.



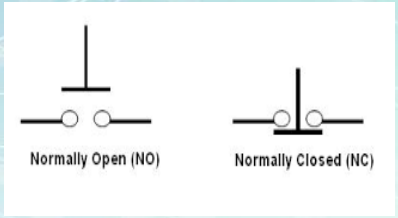
- A **multitask PLC** application involves one PLC controlling several processes(Ex. Level, Flow etc.)

- A ***control management PLC*** application involves one PLC controlling several other PLC’s
- Requires large PLC processor
- Control management PLC supervises several PLCs
- Downloads programs to other PLCs
- Specifies what operation needs done

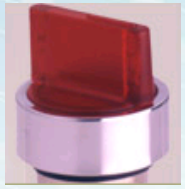


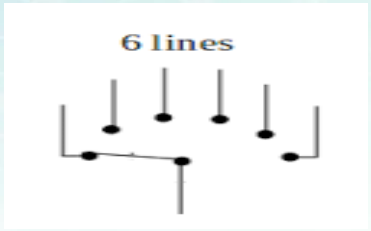
Inputs – Sample Pictures

Push Button

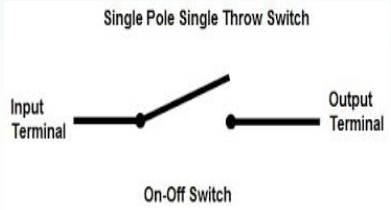


Selector Switch





Toggle Switch



Outputs – Sample Pictures

Indicators

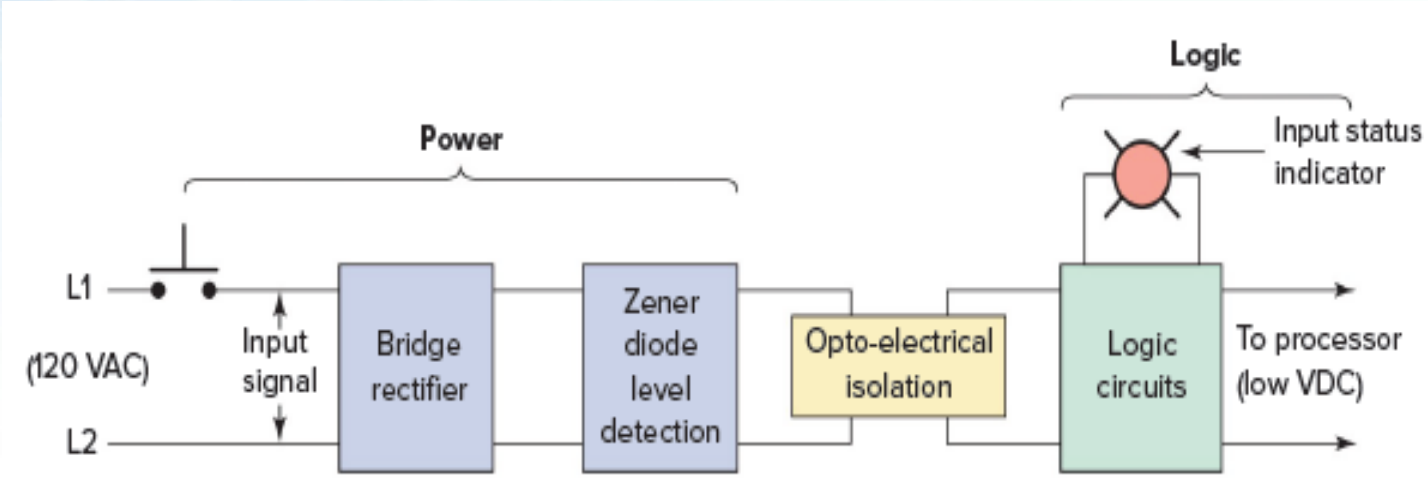
Relay

Motor

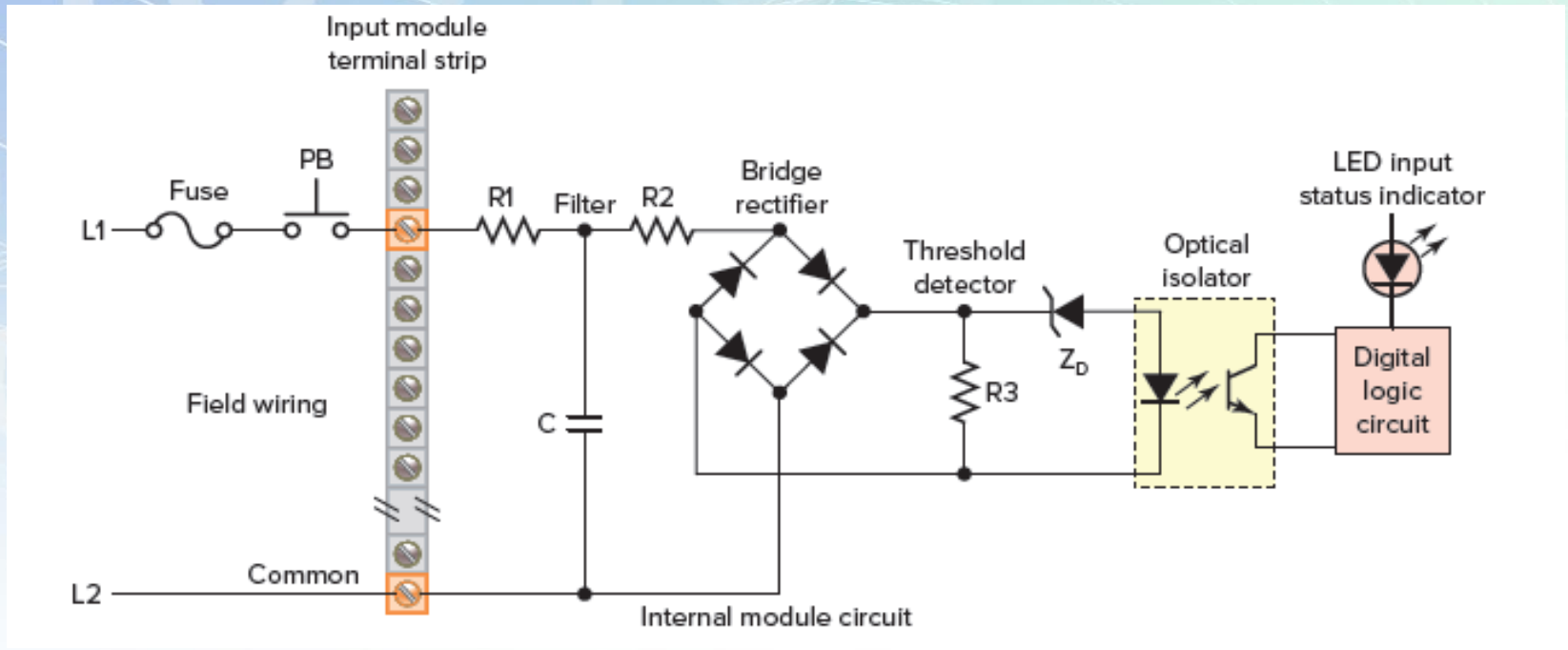
Solenoid valve

Discrete Input Module

- This type of interface connects field input devices of the ON/OFF nature such as selector switches, pushbuttons, and limit switches.



Discrete Input Module



Electrical optical isolator:

A device that couples input to output using a semiconductor light source and detector in the same package

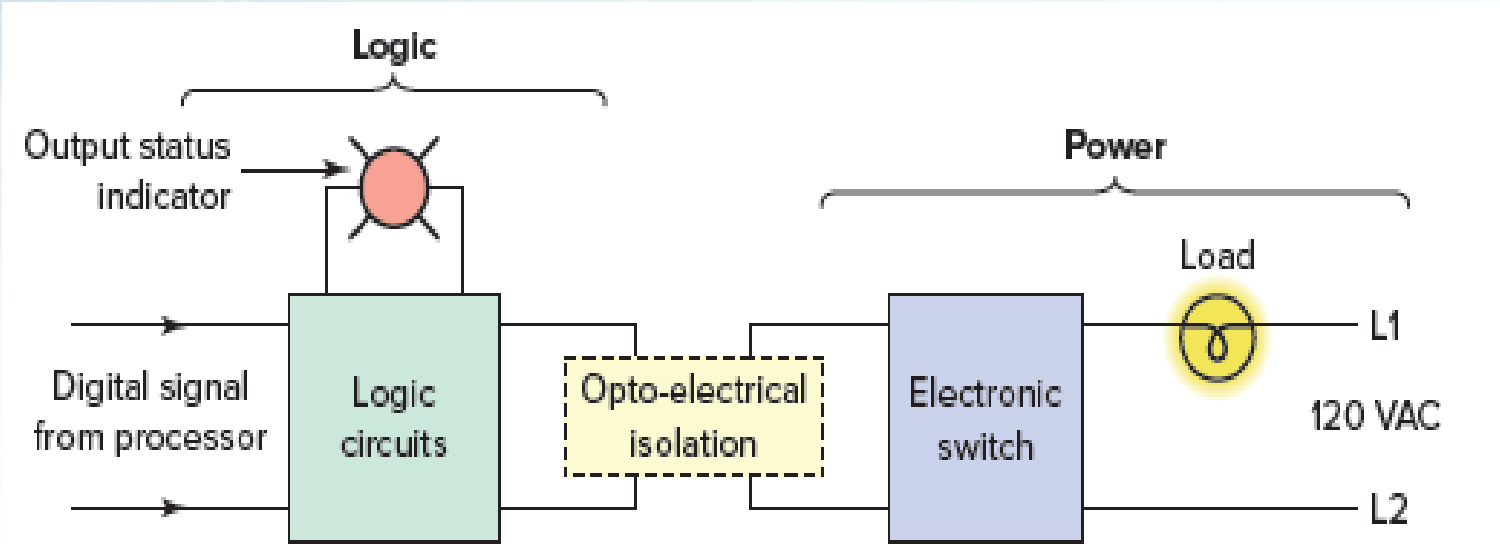
- When the pushbutton is closed, 120 VAC is applied to the bridge rectifier input.
- This results in a low-level DC output voltage that is applied across the LED of the optical isolator.
- The zener diode (ZD) voltage rating sets the minimum threshold level of voltage that can be detected.
- When light from the LED strikes the phototransistor, it switches into conduction and the status of the pushbutton is communicated in logic to the processor.

Discrete input modules perform four tasks in the PLC control system.

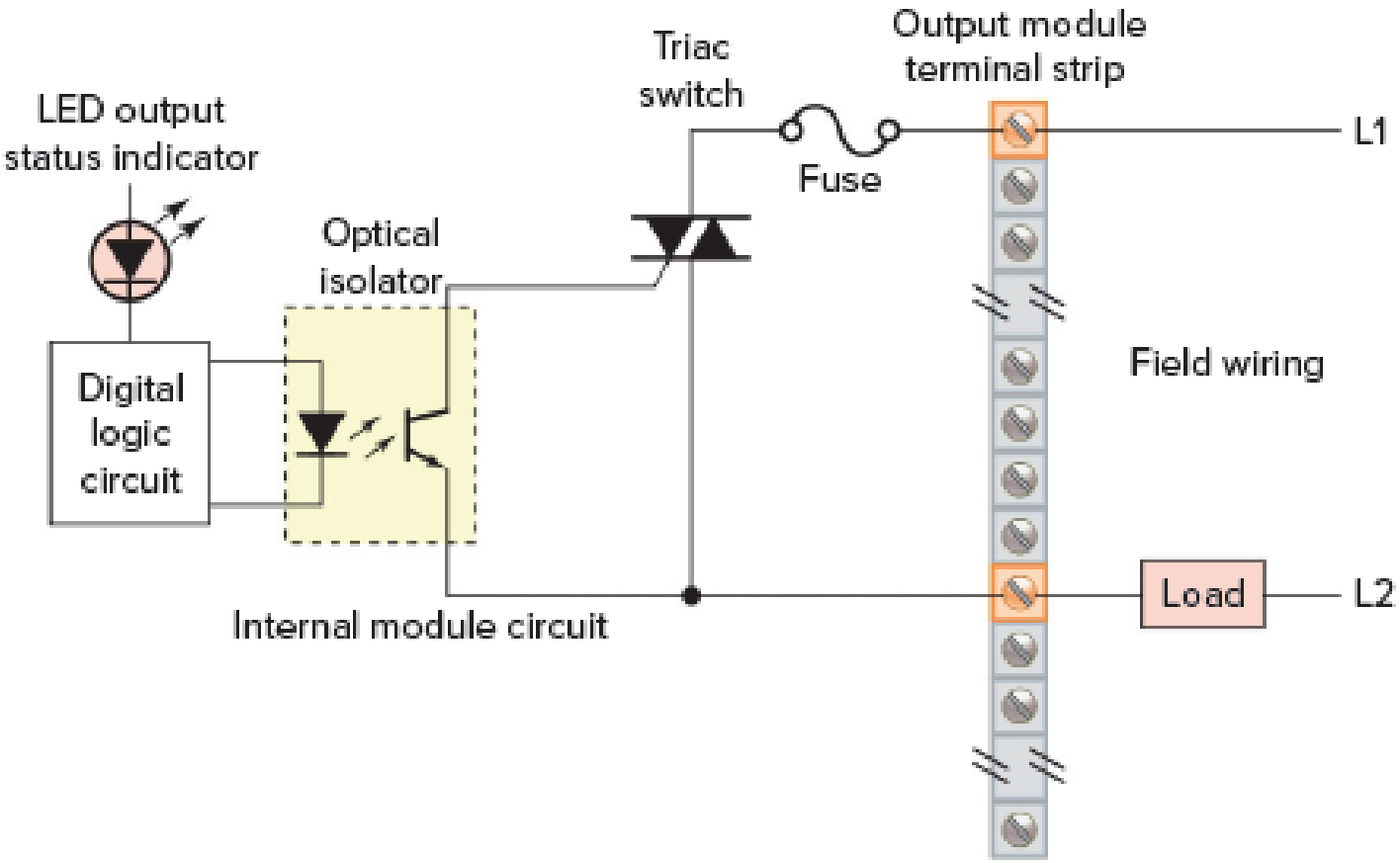
- Sense when a signal is received from a field device.
- Convert the input signal to the correct voltage level for the particular PLC.
- Isolate the PLC from fluctuations in the input signal's voltage or current.
- Send a signal to the processor indicating which sensor originated the signal.

Discrete Output Module

This type of interface connects field output devices and turns the output load device on and off.



Discrete Output Module



- When the processor calls for an output load to be energized, a voltage is applied across the LED of the opto-isolator.
- The LED then emits light, which switches the phototransistor into conduction.
- This in turn triggers the triac AC semiconductor switch into conduction, allowing current to flow to the output load.
- Since the triac conducts in either direction, the output to the load is alternating current.

- As with input circuits, the output interface is usually provided with LEDs that indicate the status of each output.

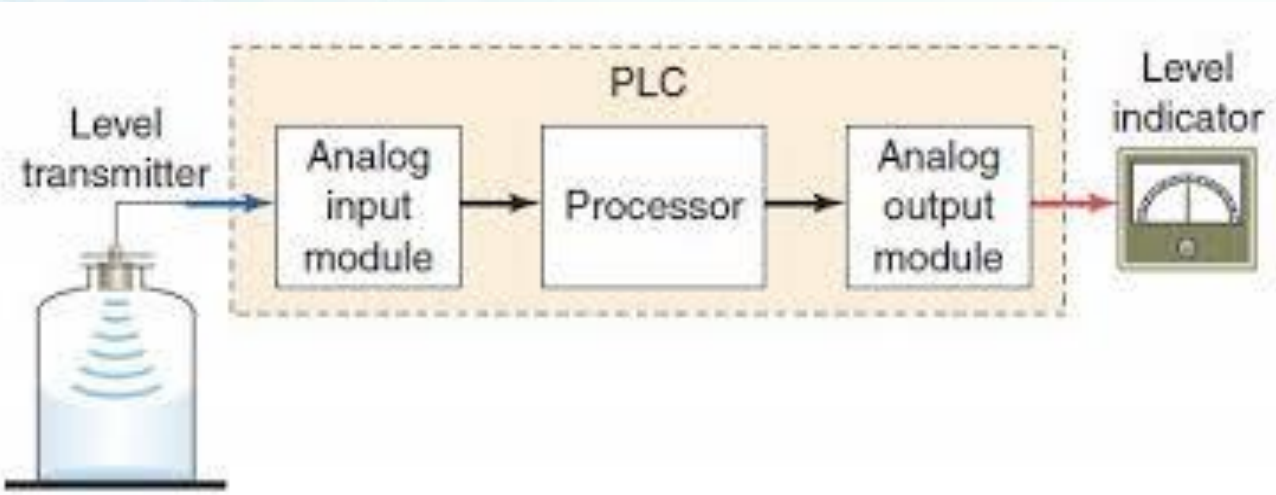
- The triac cannot be used to switch a DC load.

Analog I/O Modules

- **Analog devices** represent physical quantities that can have an infinite number of values. Typical analog inputs and outputs vary from 0 to 20 mA, 4 to 20 mA, or 0 to 10V.
- Analog sensors measure a varying physical quantity over a specific range and generate a corresponding voltage or current signal.
- Common physical quantities measured by a PLC analog module include temperature, speed, level, flow, weight, pressure, and position.

Example

- PLC analog input and output modules are used in measuring and displaying the level of fluid in a tank.

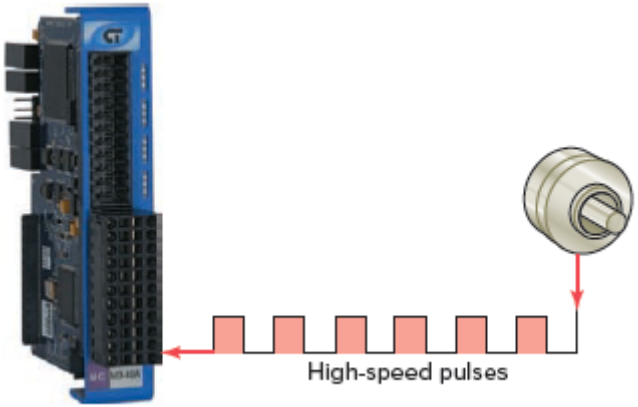


- The analog input interface module contains the circuitry necessary to accept an analog voltage or current signal from the level transmitter field device.
- This input is converted from an analog to a digital value for use by the processor.
- The circuitry of the analog output module accepts the digital value from the processor and converts it back to an analog signal that drives the field tank level meter.

Special I/O Modules

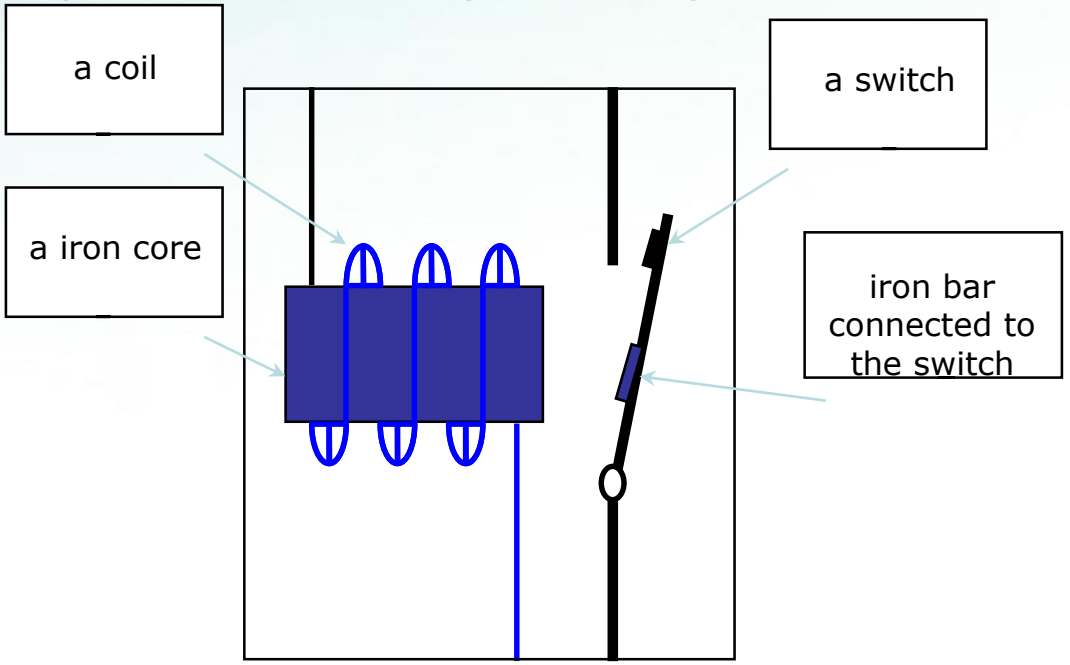
- **HIGH-SPEED COUNTER MODULE**

  It is used to count pulses from sensors, encoders, and switches that operate at very high speeds.
- A typical count rate available is 0 to 100 kHz, which means the module would be able to count 100,000 pulses per second.

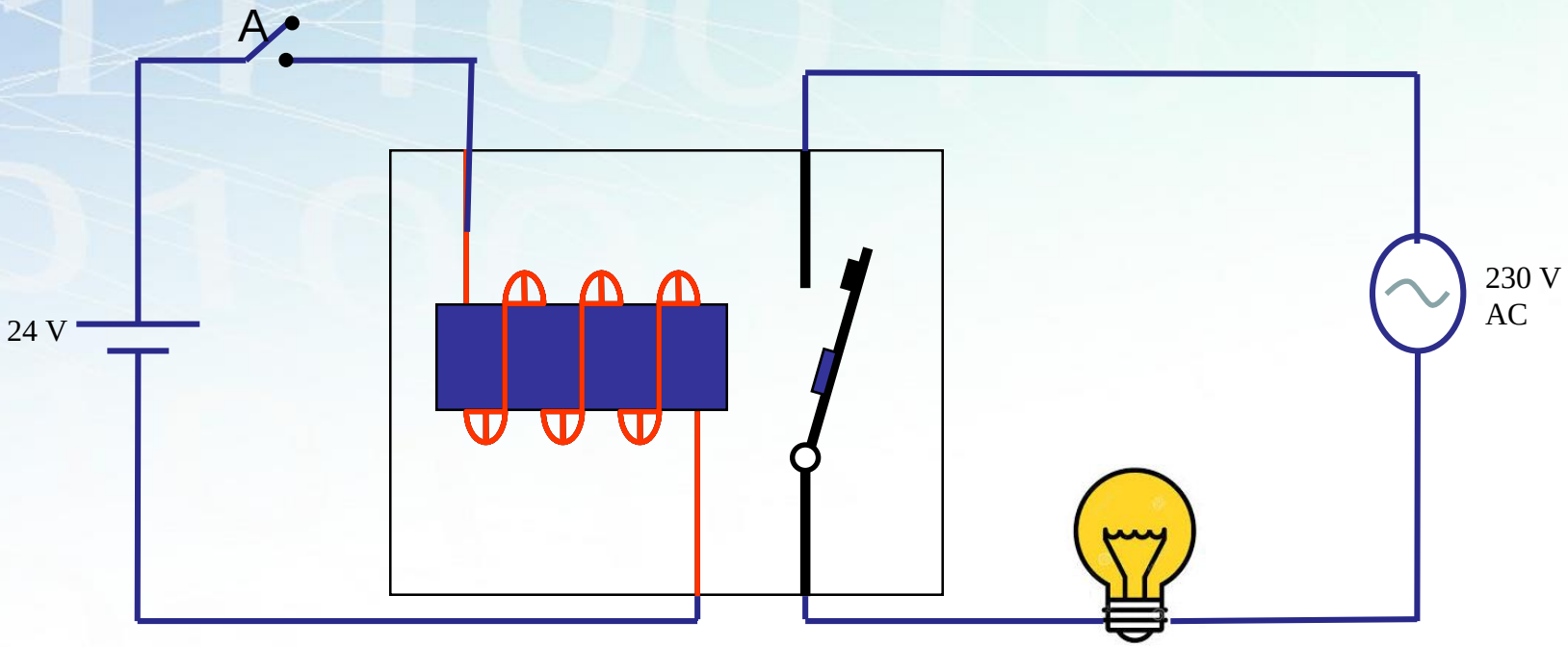


Electromagnetic Control Relays

- An electrical relay is a magnetic switch. It uses electromagnetism to switch contacts.
- A relay will usually have only one coil but may have any number of different contacts.
- Used to handle heavy current or high voltage

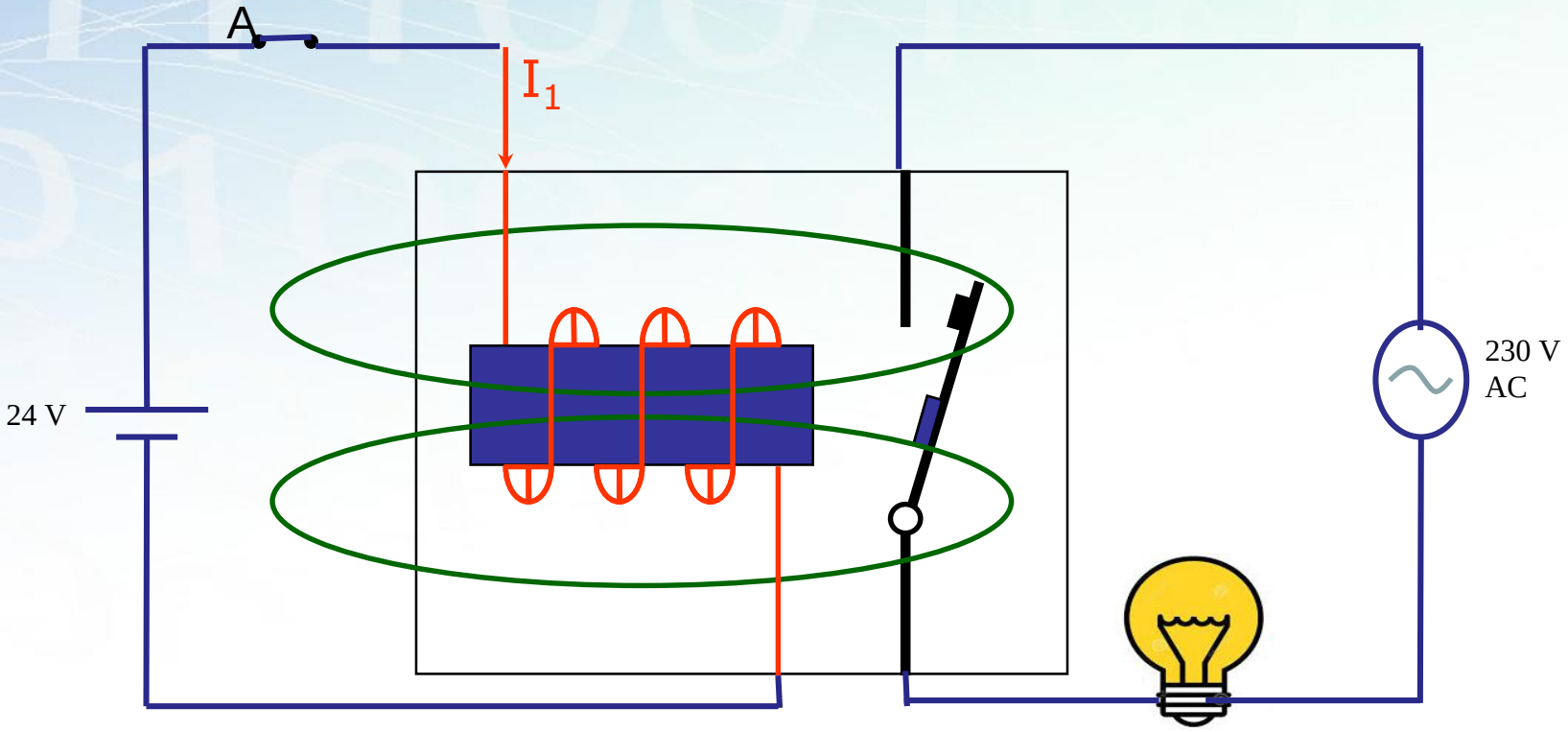


How does a Relay work ?



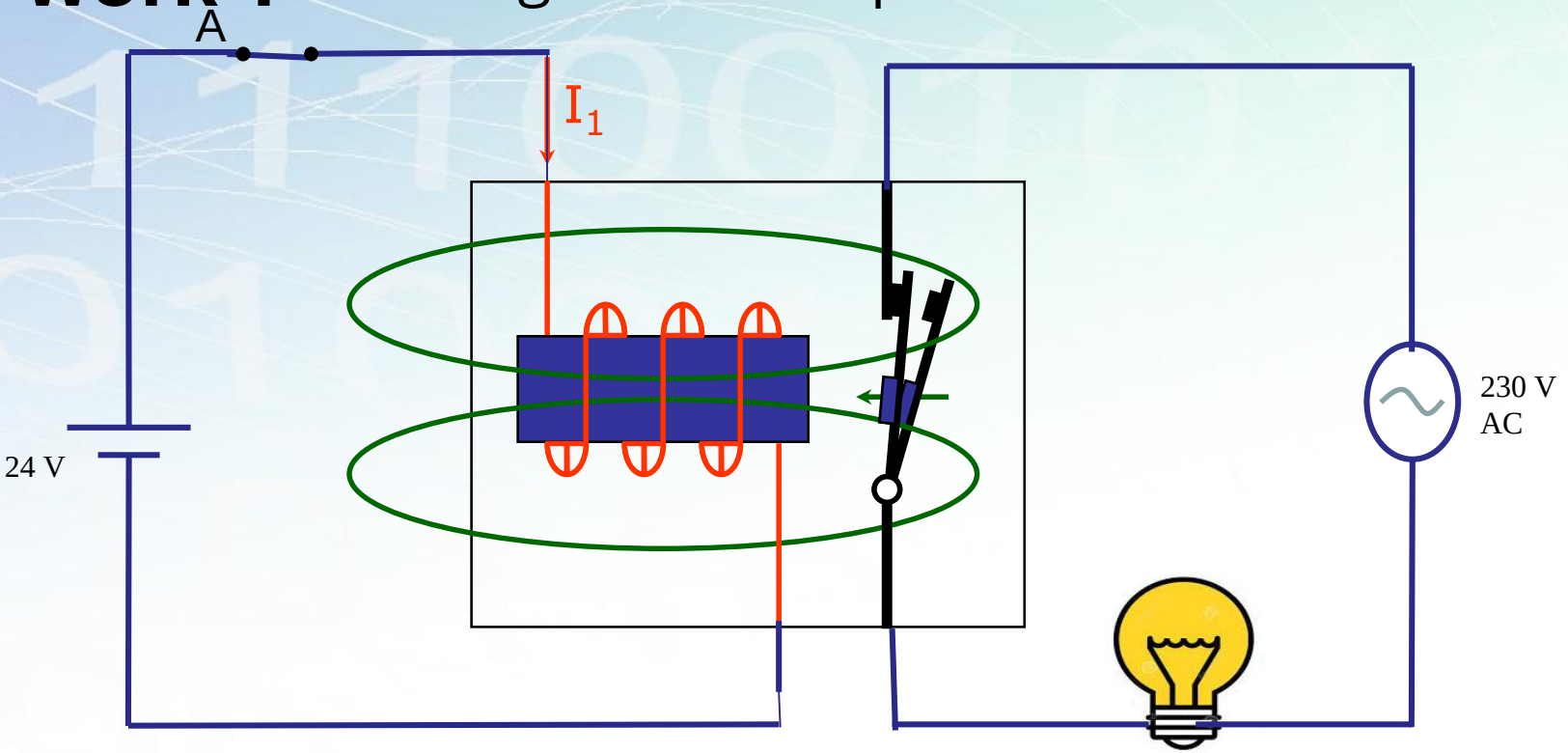
How does a Relay work ?

When a current goes through the coil a magnetic field is produced in the coil and the iron core in the coil becomes magnetic.



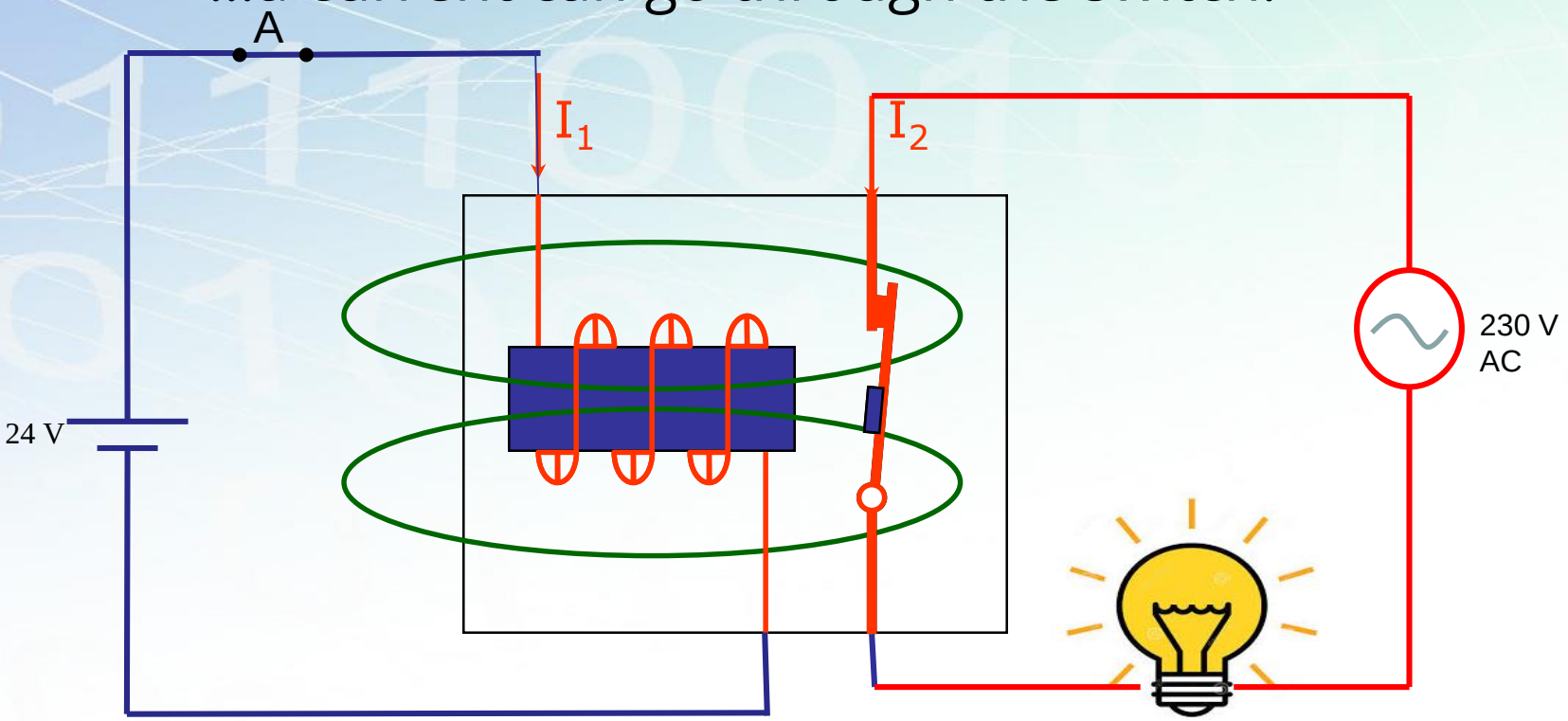
How does a Relay work ?

Thk electromagnetic force pulls in the switch and...

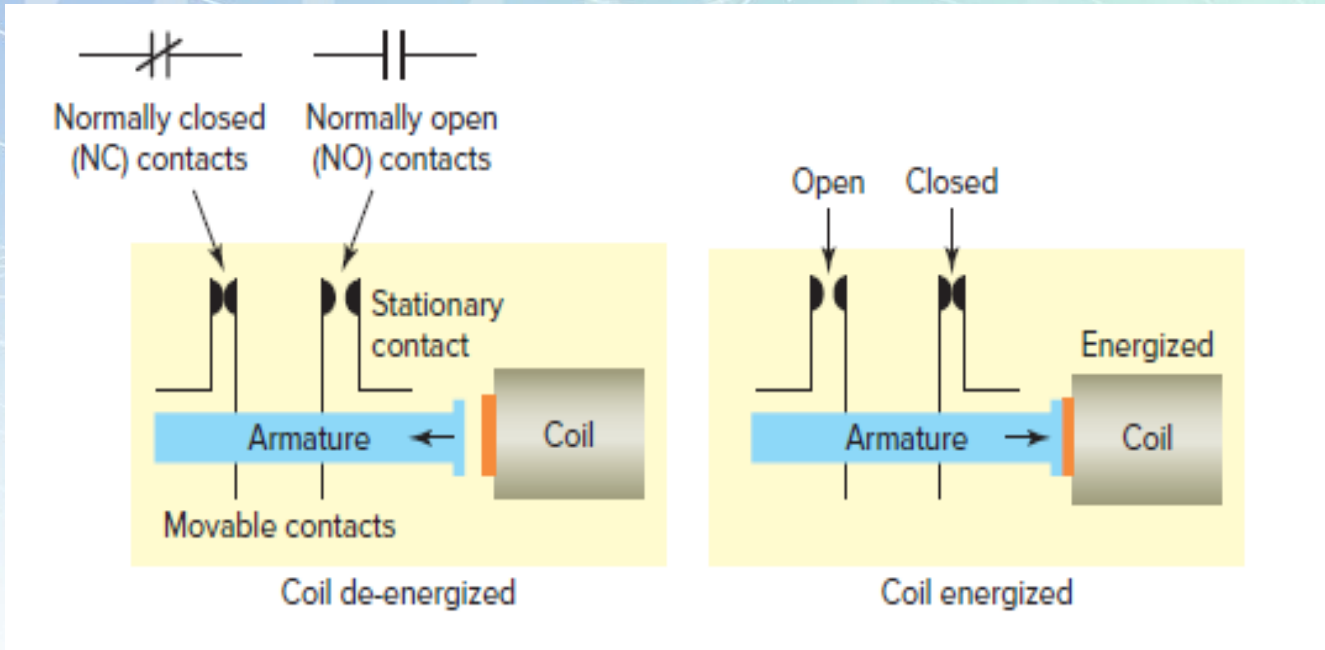


How does a Relay work ?

...a current can go through the switch.



Relay normally open and normally closed contacts.



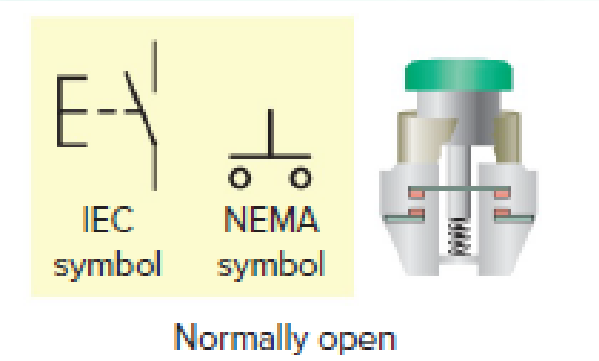
Switches

- ***Manually operated switches -***are controlled by hand. These include toggle switches, pushbutton switches, knife switches, and selector switches.
- ***Mechanically operated switches -*** are controlled automatically by factors such as pressure, position, or temperature.

Manually operated switches

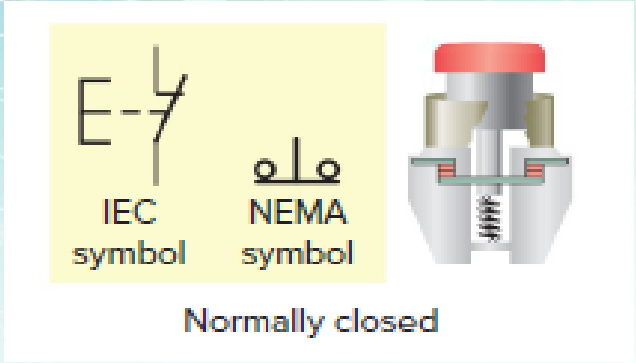
- ***Pushbutton switches*** - It operates by opening or closing contacts when pressed.

- ***Normally open (NO)*** *pushbutton, which makes a* circuit when it is pressed and returns to its open position when the button is released.

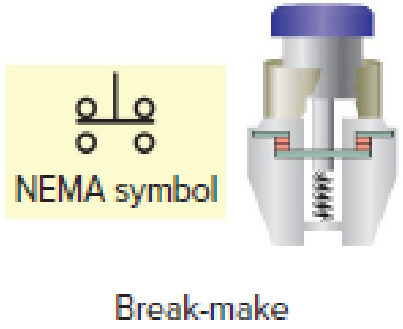


Normally open

Normally closed (NC) *pushbutton, which opens the* circuit when it is pressed and returns to the closed position when the button is released.

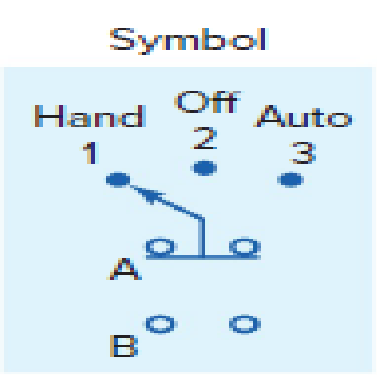


Break-before-make *pushbutton in which the top* section contacts are NC and the bottom section contacts are NO. When the button is pressed, the top contacts open before the bottom contacts are closed.



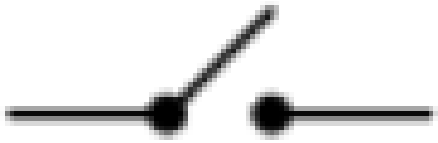
- ***Selector switch***

  Switch positions are established by turning the operator knob right or left. Selector switches may have two or more selector positions



Toggle Switch

- **Toggle switches** are actuated by a lever angled in one of two or more positions. The common light switch used in household wiring is an example of a toggle switch.



Mechanically Operated Switches

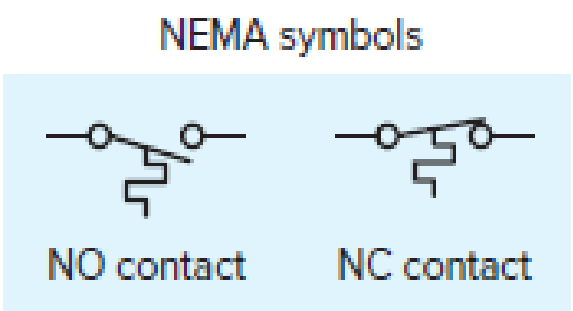
- **Limit switch**

  Limit switches are designed to operate only when a predetermined limit is reached, and they are usually actuated by contact with an object such as a cam.
- They are often used in the control circuits of machine processes to govern the starting, stopping, or reversal of motors.

- ***Temperature switch, or thermostat***

✓ These switches open or close when a designated temperature is reached.

✓ Industrial applications for these devices include maintaining the desired temperature range of air, gases, liquids, or solids.



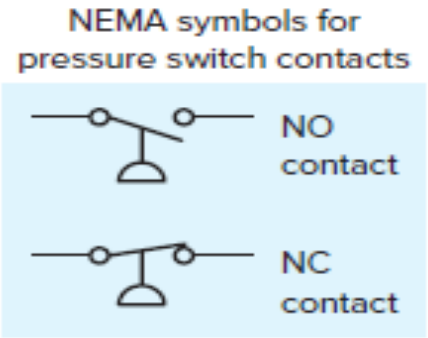
- **Pressure switches**

✔ used to control the pressure of liquids and gases.

✔ They are all basically designed to actuate (open or close) their contacts when a specified pressure is reached.

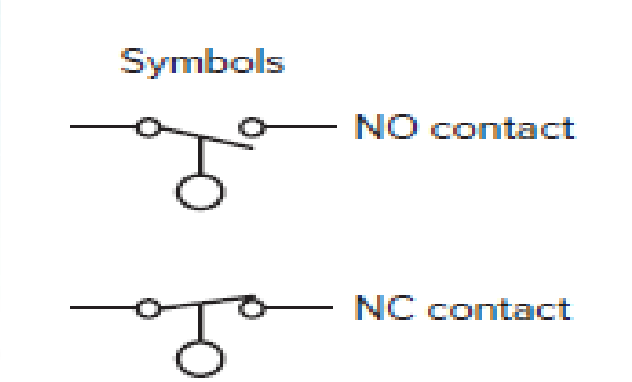
✔ Pressure switches can be pneumatically (air) or hydraulically (liquid) operated switches.

✔ Generally, bellows or a diaphragm presses up against a small microswitch and causes it to open or close.

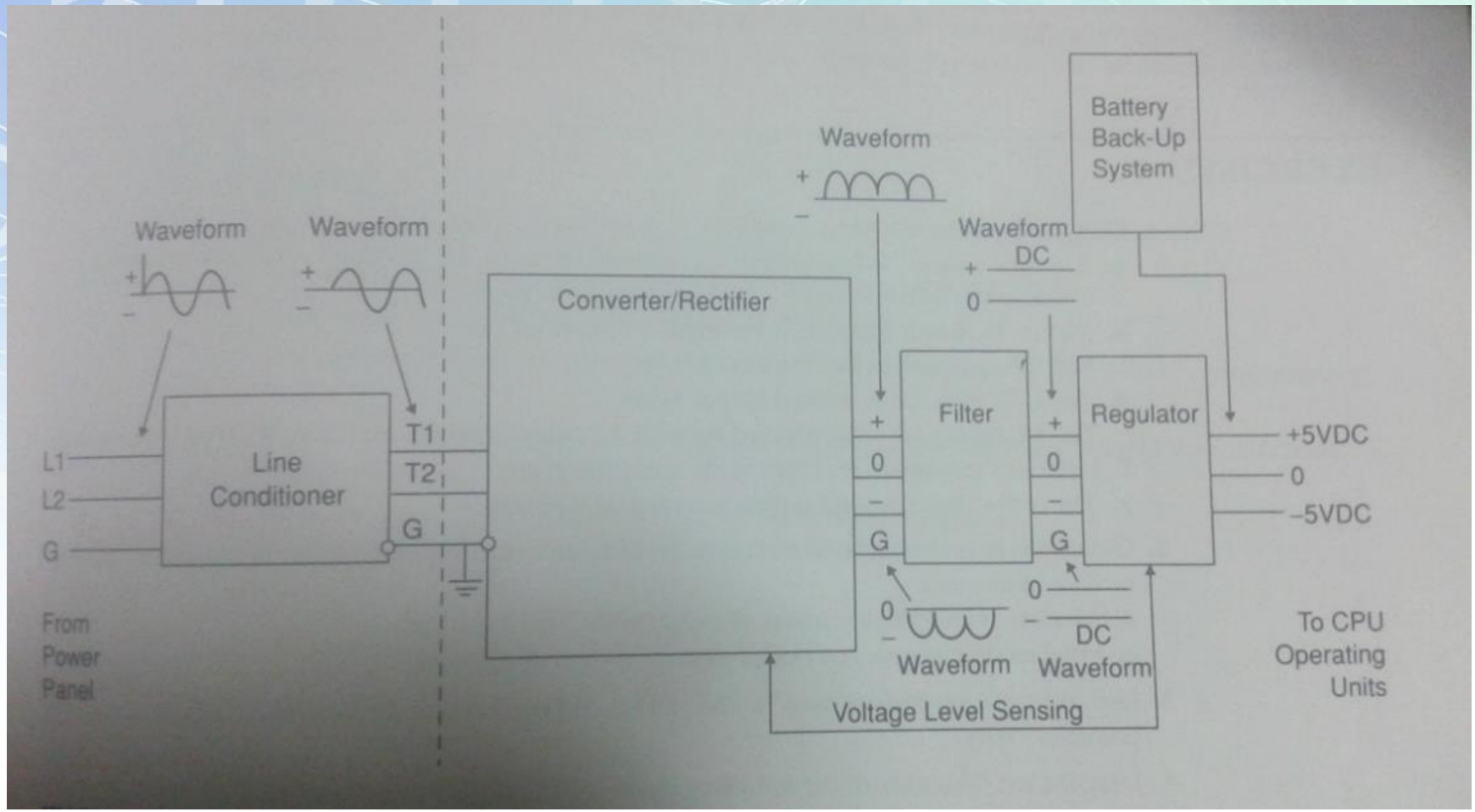


- ***Level switches***

✓ ***used to sense liquid levels in vessels*** and provide automatic control for motors that transfer liquids from sumps or into tanks.



Power Supply



Sensors

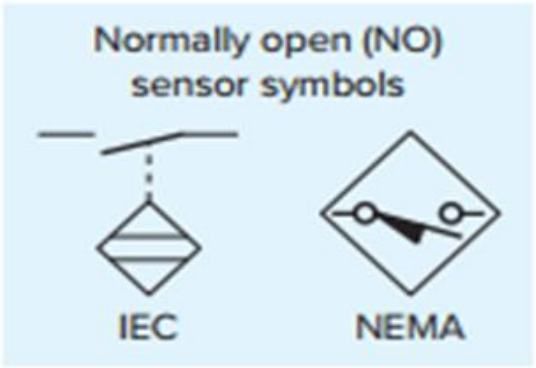
- Sensors are used for detecting, and often measuring, the magnitude of something.
- They convert mechanical, magnetic, thermal, optical, and chemical variations into electric voltages and currents.

Types

- ✔ Proximity Sensor
- ✔ Magnetic Reed Switch
- ✔ Light Sensors
- ✔ Ultrasonic Sensors
- ✔ Strain/Weight Sensors
- ✔ Temperature Sensors
- ✔ Flow Measurement
- ✔ Velocity and Position Sensors

Proximity Sensor

- **Proximity sensors or switches,** are pilot devices that detect the presence of an object (usually called the target) *without physical contact.*

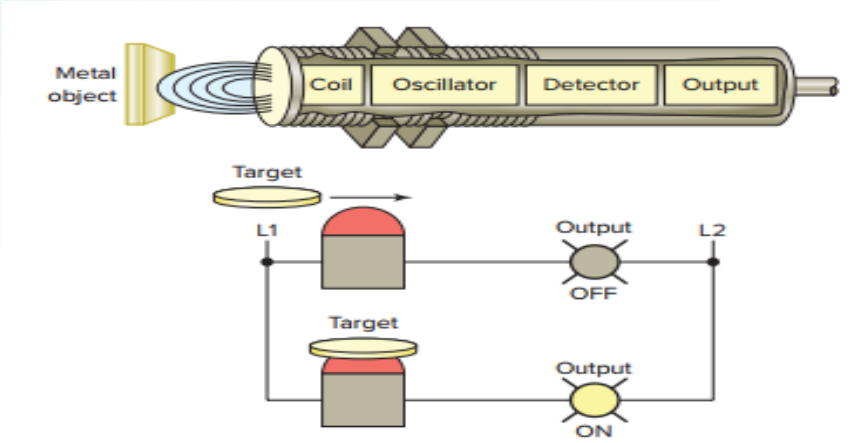


Proximity sensor.

Inductive-type *proximity sensor*

- Used to detect both ferrous metals (containing iron) and nonferrous metals (such as copper, aluminum, and brass).
- Inductive proximity sensors operate under the electrical principle of inductance, where a fluctuating current induces an electromotive force (emf) in a target object.

- The oscillator circuit generates a high-frequency electromagnetic field that radiates from the end of the sensor.
- When a metal object enters the field, eddy currents are induced in the surface of the object.
- The eddy currents on the object absorb some of the radiated energy from the sensor, resulting in a loss of energy and change of strength of the oscillator.

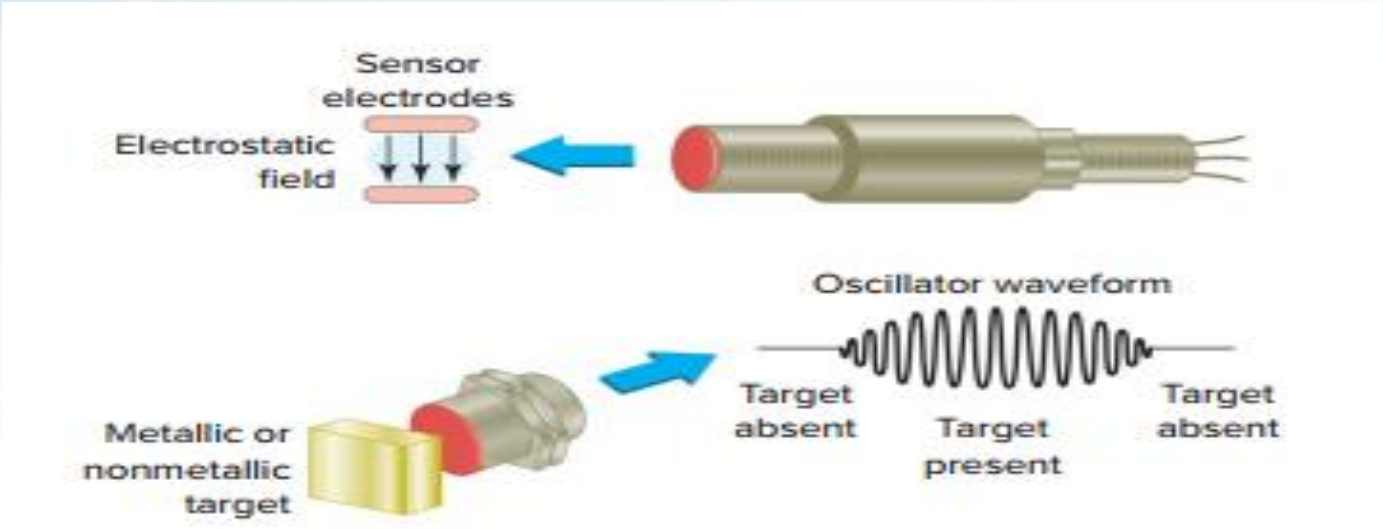


Inductive proximity sensor.

- The sensor’s detection circuit monitors the oscillator’s strength and triggers a solid-state output at a specific level.
- Once the metal object leaves the sensing area, the oscillator returns to its initial value.

Capacitive proximity sensors

- Senses both conductive and nonconductive materials such as paper, glass, liquids, and cloth.



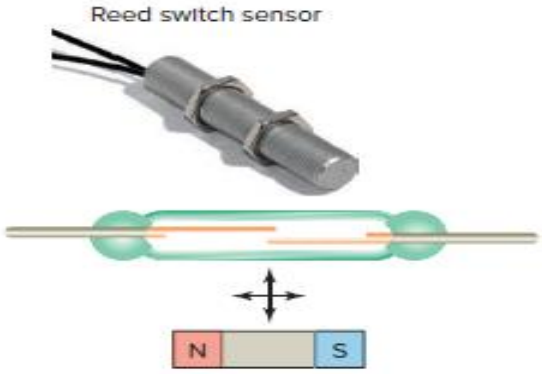
Capacitive proximity sensor.

Operation

- A capacitive sensor contains a high-frequency oscillator along with a sensing surface formed by two metal electrodes.
- When the target nears the sensing surface, it enters the electrostatic field of the electrodes and changes the capacitance of the oscillator.
- As a result, the oscillator circuit begins oscillating and changes the output state of the sensor when it reaches a certain amplitude.
- As the target moves away from the sensor, the oscillator's amplitude decreases, switching the sensor back to its original state.

Magnetic Reed Switch

- A magnetic reed switch is composed of two flat contact tabs that are hermetically sealed (airtight) in a glass tube filled with protective gas.

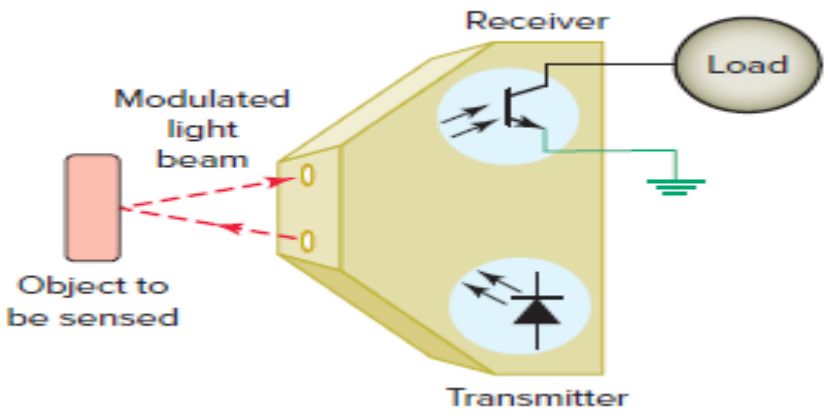


Magnetic reed switch.
Source: Courtesy of Reed Switch Developments Corp., used with permission.

Light Sensors

- A ***photoelectric sensor –*** It is an optical control device that operates by detecting a visible or invisible beam of light and responding to a change in the received light intensity.

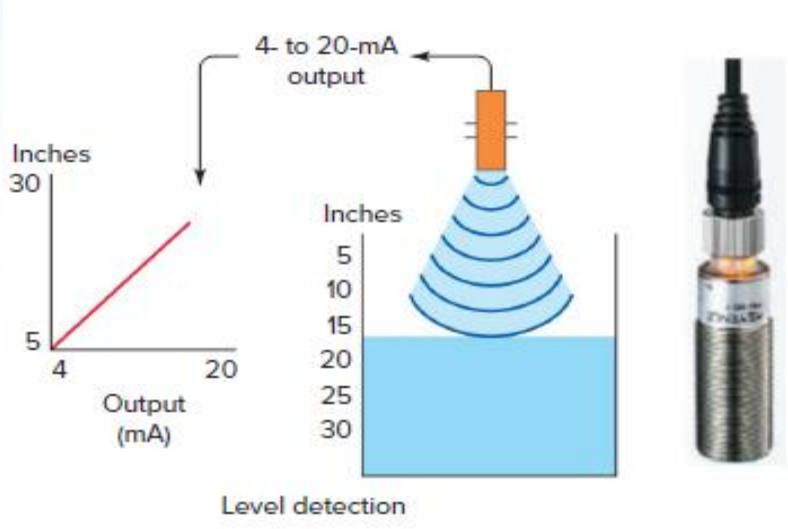
- The transmitter contains a light source, usually an LED along with an oscillator.
- The oscillator modulates or turns the LED on and off at a high rate of speed.
- The transmitter sends this modulated light beam to the receiver.
- The receiver decodes the light beam and switches
- the output device, which interfaces with the load.



Ultrasonic Sensors

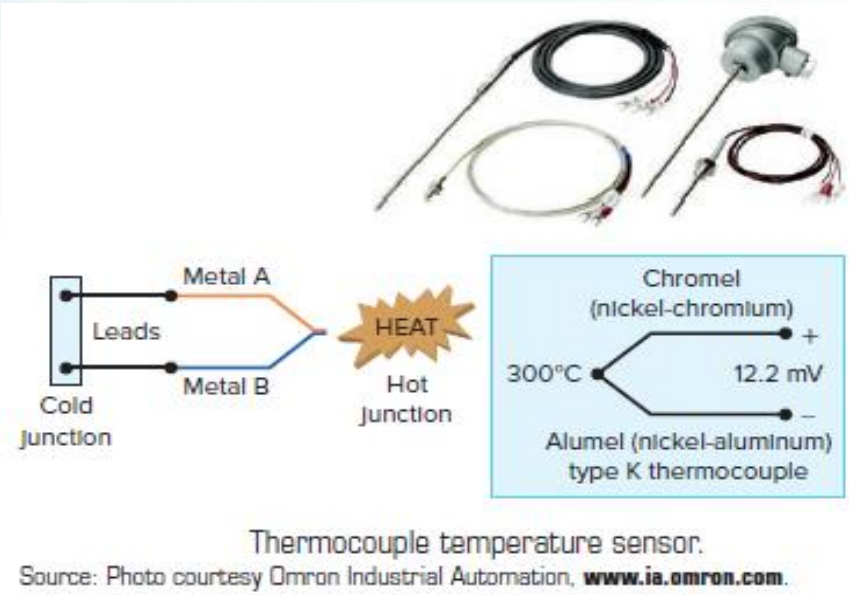
- An ***ultrasonic sensor operates by sending high-frequency*** sound waves toward the target and measuring the time it takes for the pulses to bounce back.
- The time taken for this echo to return to the sensor is directly proportional to the distance or height of the object because sound has a constant velocity.

- A practical application in which the returning echo signal is electronically converted to a 4 to 20 mA output.
- The 4- to 20-mA mA represents the sensor's measurement span.
- The sensor will proportionately generate a 4-mA signal when the tank is empty and a 20-mA signal when the tank is full.



Temperature Sensors

- The **thermocouple** is the most widely used temperature sensor.
- Thermocouples operate on the principle that when two dissimilar metals are joined, a predictable DC voltage will be generated that relates to the difference in temperature between the hot junction and the cold junction



Thermocouple temperature sensor.
Source: Photo courtesy Omron Industrial Automation, **www.ia.omron.com**.

- **Resistance temperature detectors (RTDs)** are wire wound temperature-sensing devices that operate on the principle of the positive temperature coefficient (PTC) of metals.
- That means the electrical resistance of metals is directly proportional to temperature.
- Platinum is the material most often used in RTDs because of its superiority regarding temperature limit, linearity, and stability.