Computer Aided Manufacturing

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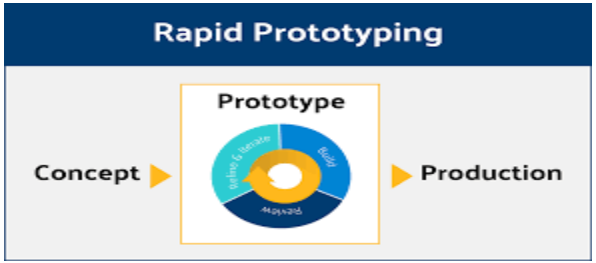


Unit II

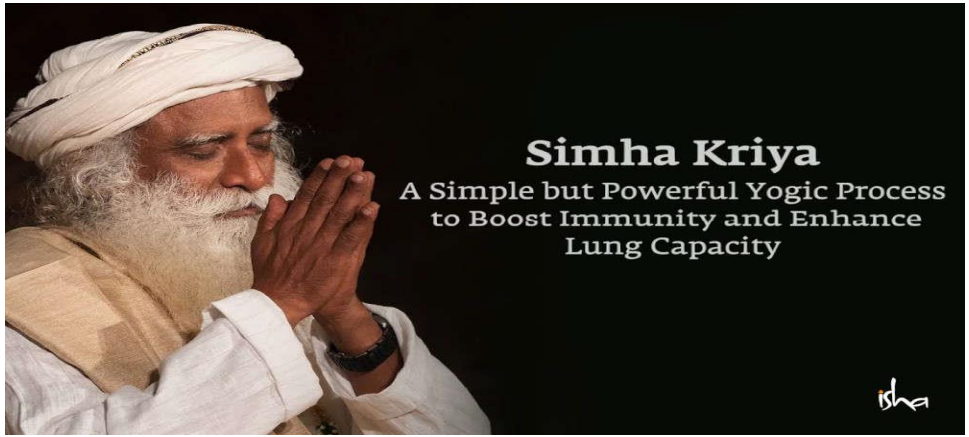
DRIVES AND CONTROL

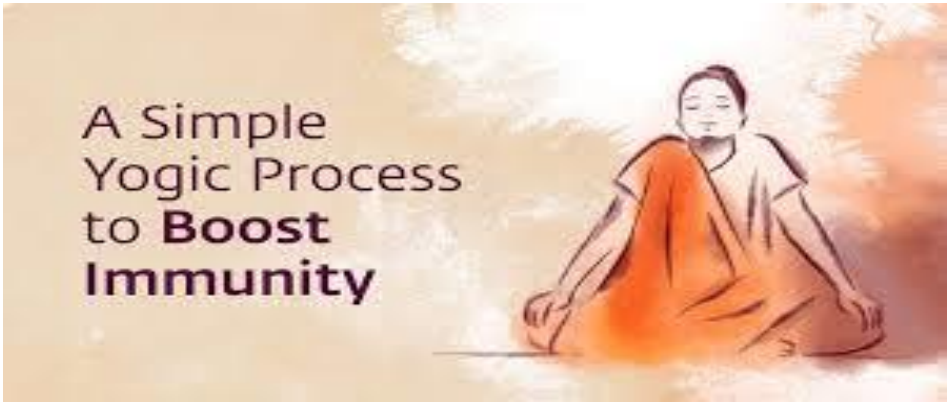
Spindle and feed drives - Sensors - Position, Encoders, Proximity, Limit switch -**Interfacing system -Microcontroller and PLC based** -Introduction to Graphical User interface - Communication protocol -RS232, RS 485, USB, Ethernet -PLC -Ladder diagram -Peripherals -Timer, Counter, Encoder interface, Human Machine Interface

Prerequisites Knowledge

- Working principles of Electronics
- Basics of Communication

Immunity Boosting Breathing

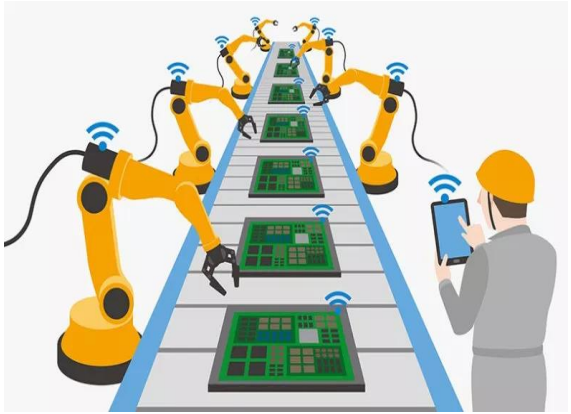


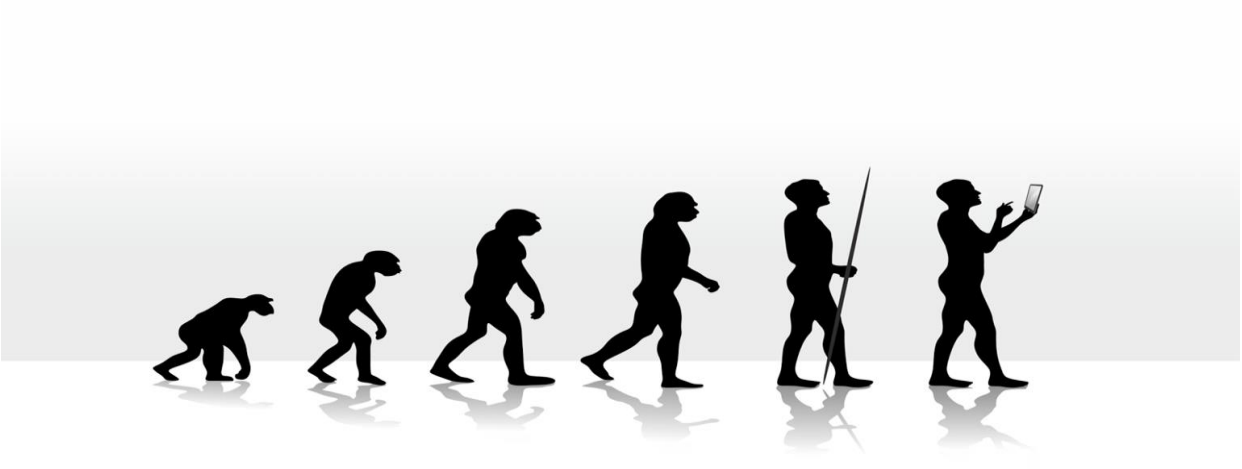


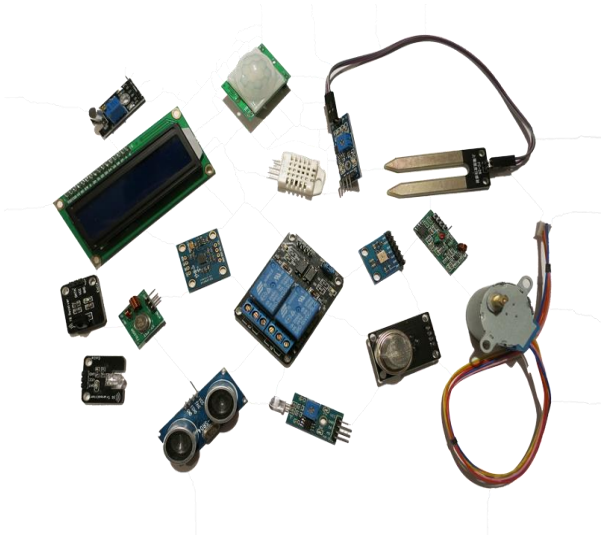
1 min

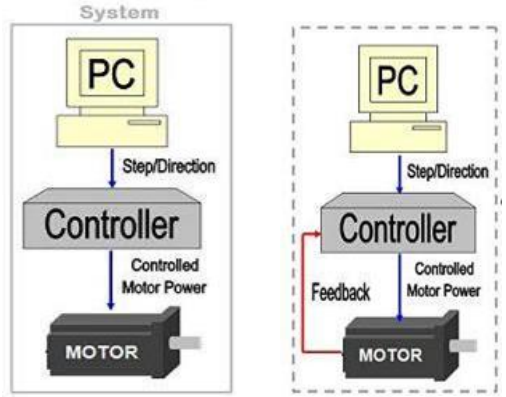
Recap and review of previous class

5 mins

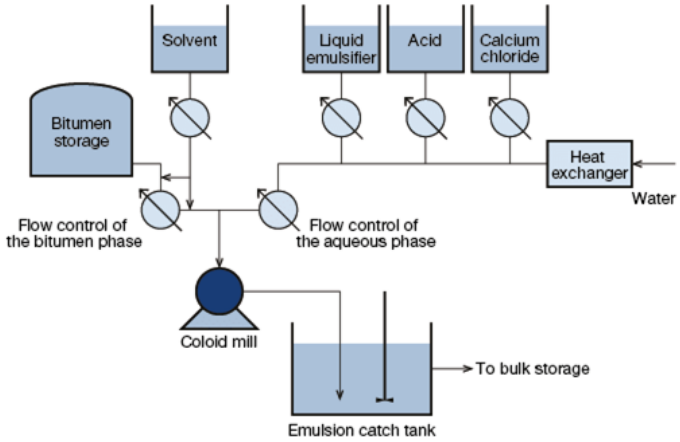







System
PC
Step/Direction
Controller
Controlled
Motor Power
MOTOR

PC
Step/Direction
Controller
Feedback
Controlled
Motor Power
MOTOR


Solvent
Liquid emulsifier
Acid
Calcium chloride
Bitumen storage
Heat exchanger
Water
Flow control of the bitumen phase
Flow control of the aqueous phase
Coloid mill
To bulk storage
Emulsion catch tank

General Objective (GO)

- Students will be able to understand the requirements of interfacing systems for CNC machines.

2 mins

Specific Objectives

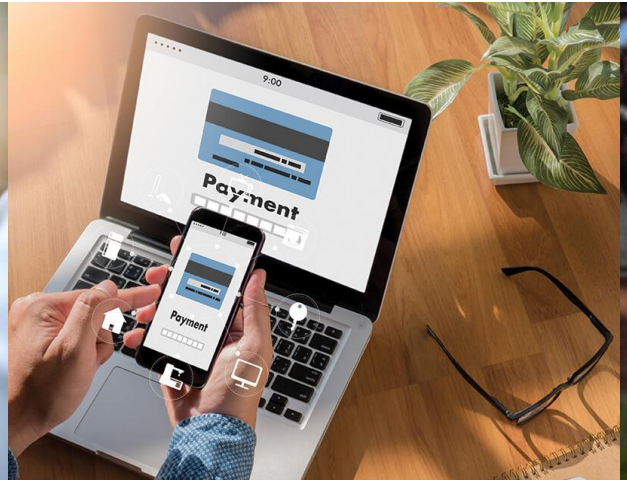
Students will be able to

- List the importance of interfacing systems. (R / F) (E&T)
- Explain the microcontroller based interfacing system. (U / C) (E&T)
- Summarize the need of PLC based interfacing system in CNC machine. (U / C) (E&T)

35 mins

AUTOMATION

- **Automation**, the application of machines to tasks once performed by human beings.
- Automation covers applications ranging from a household thermostat controlling a boiler, to a large industrial control system with ten of thousands of input measurements and output control signals.
- In control complexity, it can range from simple on-off control to multi-variable high-level algorithms.



STONE AS TOOL

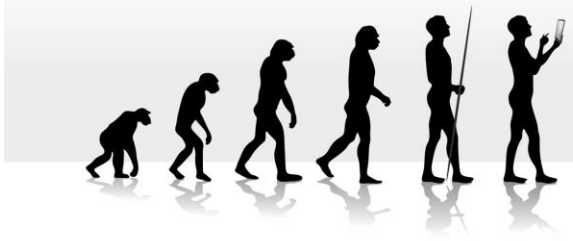
WHEEL

TURBINE (MANUAL VALVE CONTROL)

FLY BALL GOVERNOR (AUTOMATIC VALVE CONTROL)

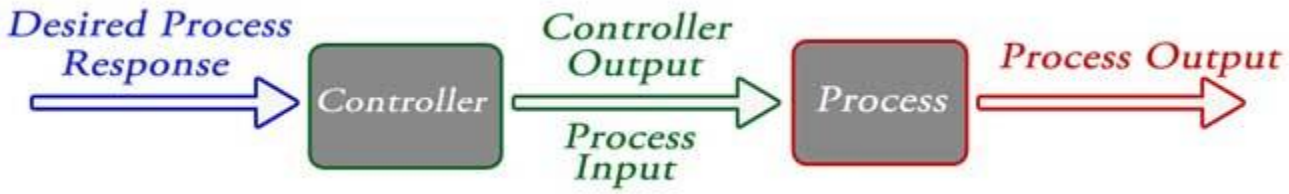
ELECTRONIC GOVERNOR

COMPUTER CONTROLLED



OPEN LOOP SYSTEM

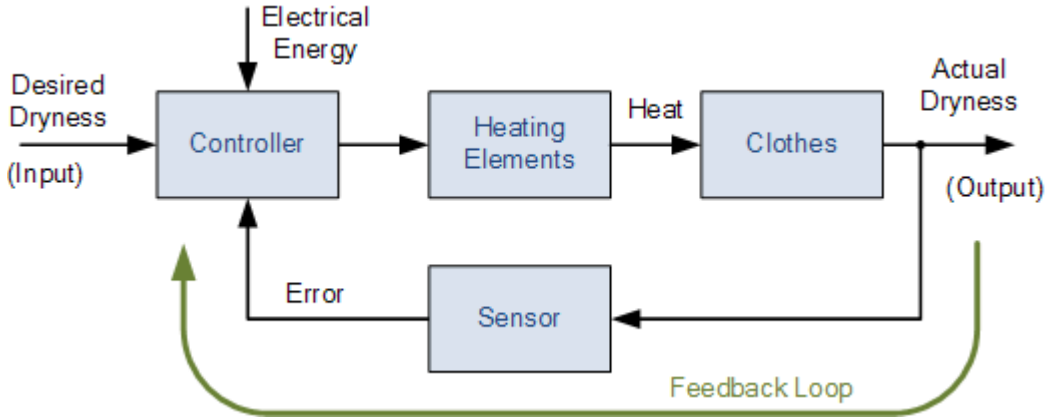
A control system in which the control action is totally independent of output of the system then it is called **open loop control system**.



- Automatic Washing Machine – This machine runs according to the pre-set time irrespective of washing is completed or not.
- Bread Toaster – This machine runs as per adjusted time irrespective of toasting is completed or not.

CLOSED LOOP SYSTEM

A control system which uses feedback signals to both control and adjust itself is called a **Closed-loop System**.



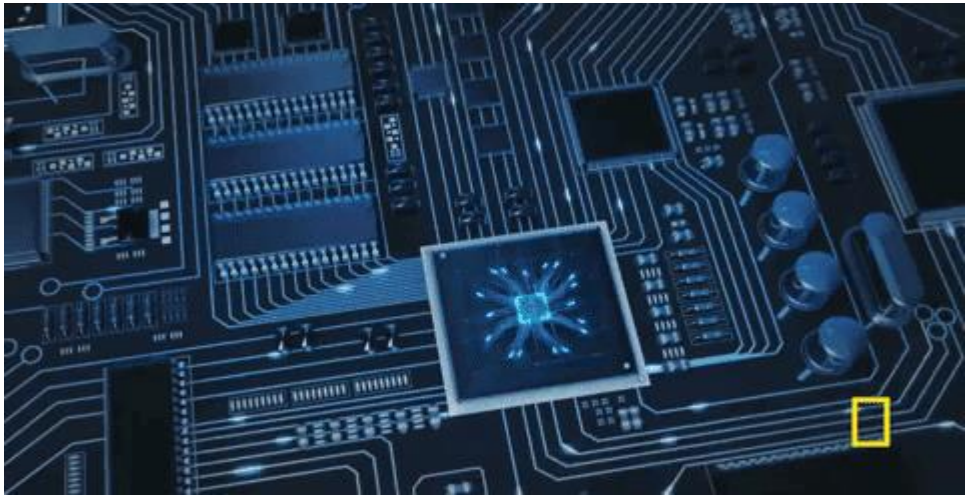
- Water Level Controller – Input water is controlled by water level of the reservoir.
- An Air Conditioner – An air conditioner functions depending upon the temperature of the room.

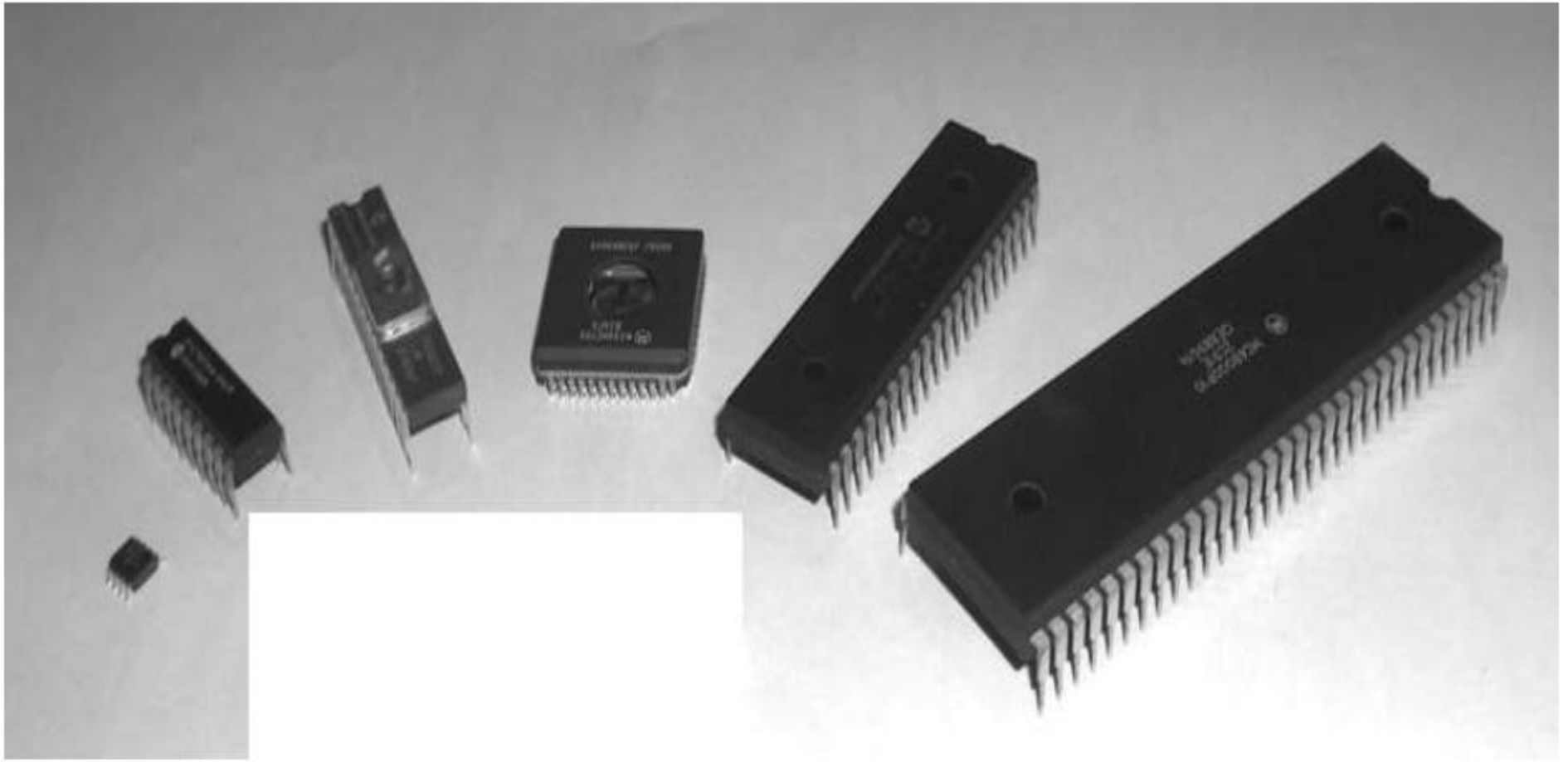
What is Microcontroller?

- In simple term – Microcontroller is a small computer that is capable of performing specific task(s)
  - e.g car alarm, washing machine, handphone, PDA…
- There are many similar names
  - Microprocessor-based system, controller, MCU, MPU, CPU…
- They can be grouped into two classification
  - → MCU - Micro Controller Unit
  - → MPU - Micro Processor Unit
- In general, these microcontroller are the brain of the embedded system

WHAT IS A MICROCONTROLLER?

- A microcontroller is an integrated circuit (IC) that can be programmed to perform a set of functions to control a collection of electronic devices.
- A self-contained system in which a processor, support, memory, and input/output (I/O) are all contained in a single package.
- Being programmable is what makes the microcontroller unique.



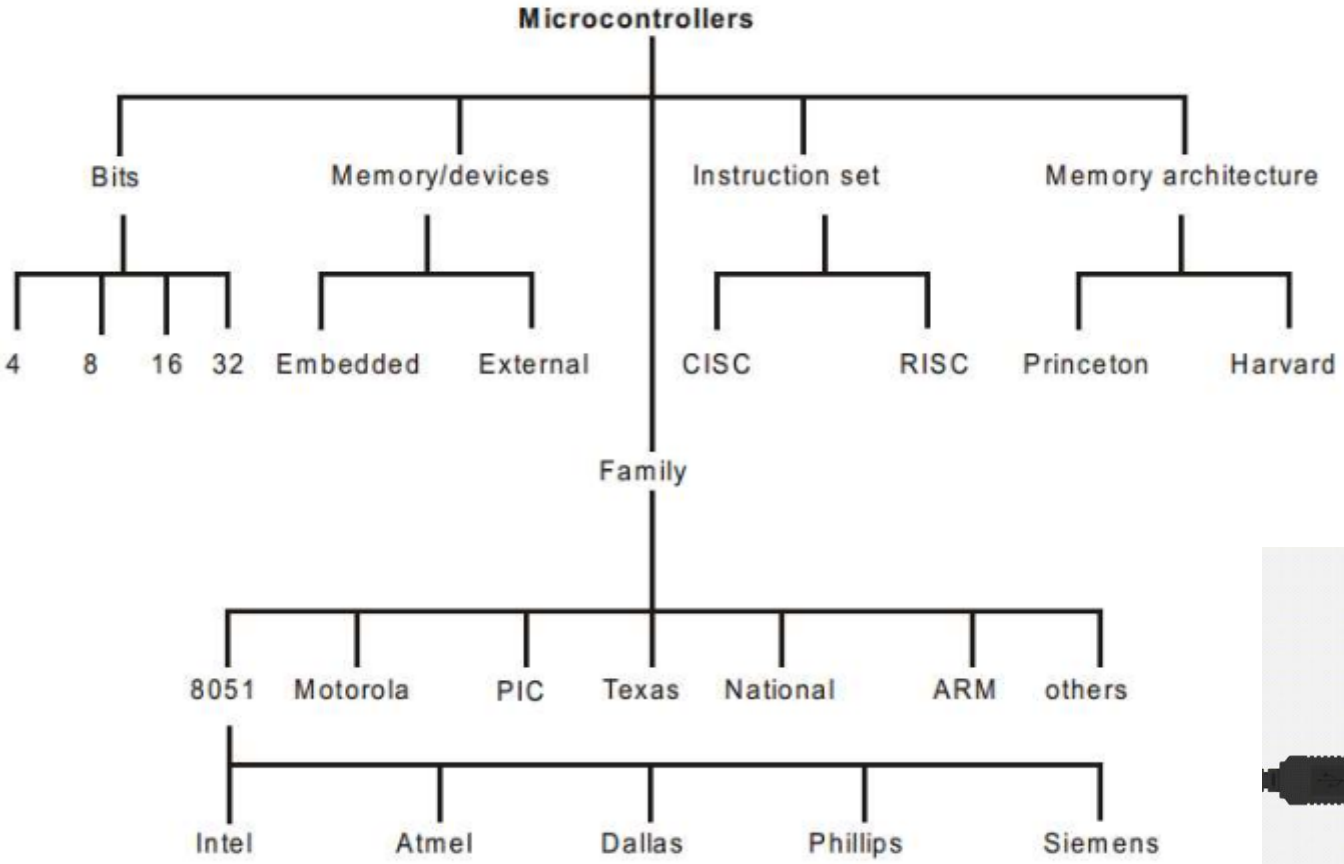


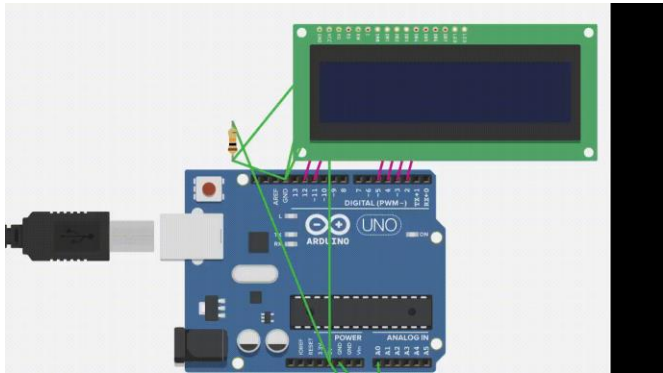
- From left to right: PIC 12F508, PIC 16F84A, PIC 16C72, Motorola 68HC05B16, PIC 16F877, Motorola 68000

Difference between Microprocessor and Microcontroller

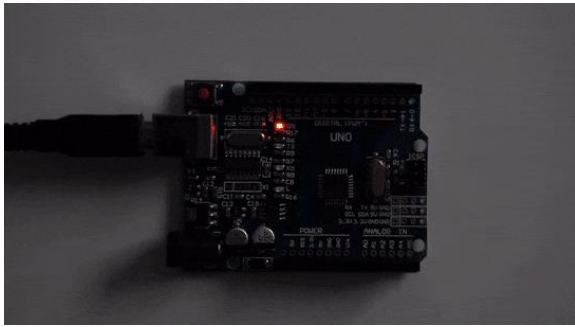
Microcontroller	Microprocessor
Microcontrollers are used to execute a single task within an application.	Microprocessors are used for big applications.
Its designing and hardware cost is low.	Its designing and hardware cost is high.
Easy to replace.	Not so easy to replace.
It is built with CMOS technology, which requires less power to operate.	Its power consumption is high because it has to control the entire system.
It consists of CPU, RAM, ROM, I/O ports.	It doesn't consist of RAM, ROM, I/O ports. It uses its pins to interface to peripheral devices.

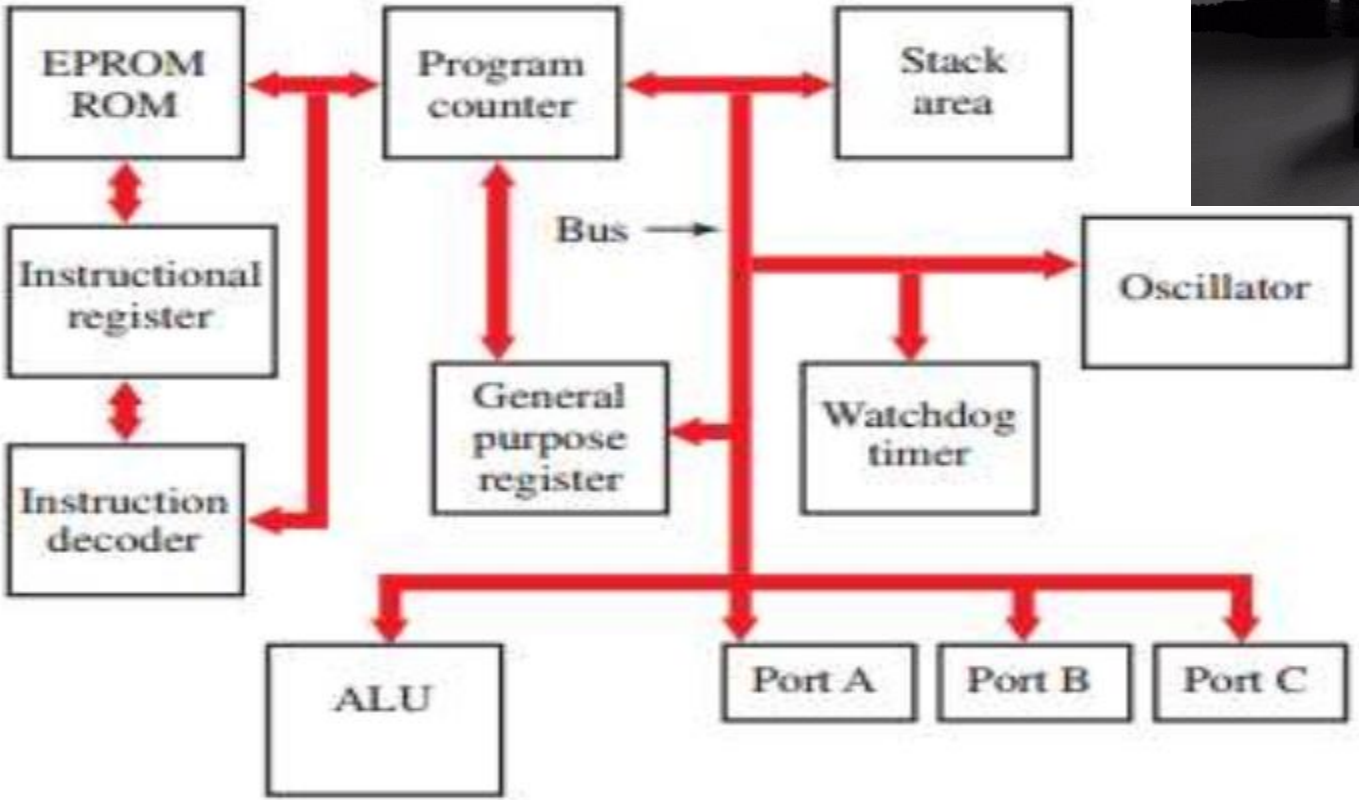
Types of Microcontrollers

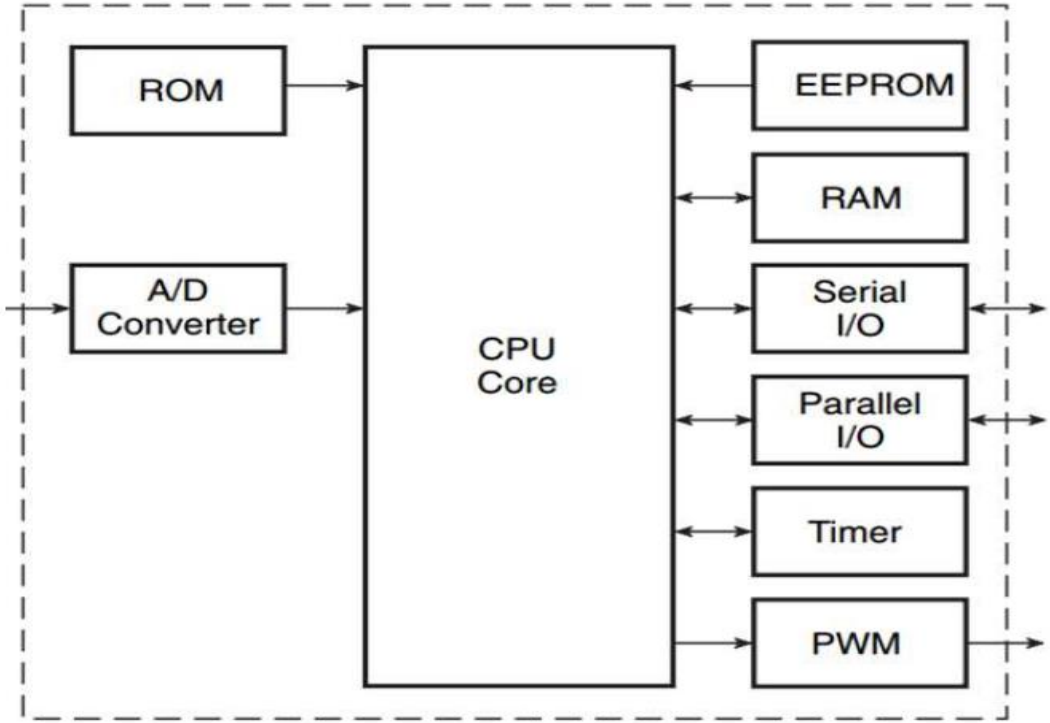




GENERAL MICROCONTROLLER ARCHITECTURE






ROM
A/D Converter
CPU Core
EEPROM
RAM
Serial I/O
Parallel I/O
Timer
PWM

Central Processing Unit (CPU)

The central processing unit processes the program. It executes the instructions stored in the program memory pointed to by the program counter in synchronization with the clock signal.

ALU

The arithmetic/logic unit (ALU) performs mathematical and logical operations on data.

Oscillator

A complex digital device that generates steady pulse rate required for timing. All of the separate functions are controlled by one central timing system. The timing pulse provides the basis for proper sequence of all the separate sections of the microcontroller chip.

Read Only Memory (ROM)

ROM holds the program instructions and the constant data.
Microcontrollers use one or more of the following memory types for this purpose:
ROM (mask-programmed ROM),
PROM (one-time programmable ROM, which is not field programmable),
EPROM (field programmable and usually UV erasable),
EEPROM (field programmable, electrically erasable, byte erasable) and flash (similar to EEPROM technology).Microcontrollers can have 4K, 8K and 16K, etc. of ROM

Random Access Memory (RAM)

is used to hold intermediate results and other temporary data during the execution of the program. Typically, microcontrollers have a few hundreds of bytes of RAM.

Special-Function Registers

control various functions of a microcontroller. These are divided into two groups:

Registers wired into the CPU

- Do not necessarily form part of addressable memory.
- Used to control program flow and arithmetic functions.
- Examples, status register, program counter, stack pointer, etc.

Registers

 Register is used to hold the contents of data being manipulated.

Registers required by peripheral components

- The contents of these registers include set a timer or enable serial communication.

- Examples, a program counter, stack pointer, RAM address register, program address register and PC incrementer.

Peripheral Components

The analogue-to-digital converter - provides an interface

between the microcontroller and the sensors that produce analogue electrical equivalents of the actual physical parameters to be controlled.

The digital-to-analogue converter - provides an interface

between the microcontroller and the actuators that provide the control function.

I/O ports - provide an interface between the microcontroller and

the peripheral I/O devices such as the keyboard, display, etc.

Counters/timers - are used to keep time and/or measure the time

interval between events, count the number of events and generate baud rates for the serial ports.

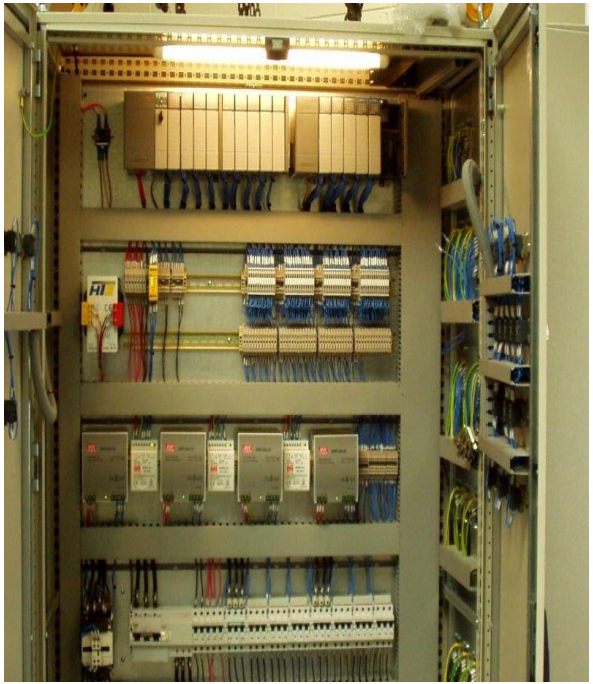
ADVANTAGEOUS FEATURES-Microcontrollers

- Easy to use and Programmable.
- Reusable - Ability to reprogram using Flash, EEPROM or EPROM.
- Flexibility and dependable.
- Design and Simulation.
- Energy efficient, small and cost effective.
- Ports multifunctionality.
- High Integration and can fit inside other devices.
- Easy upgrade.

INTRODUCTION TO PLC

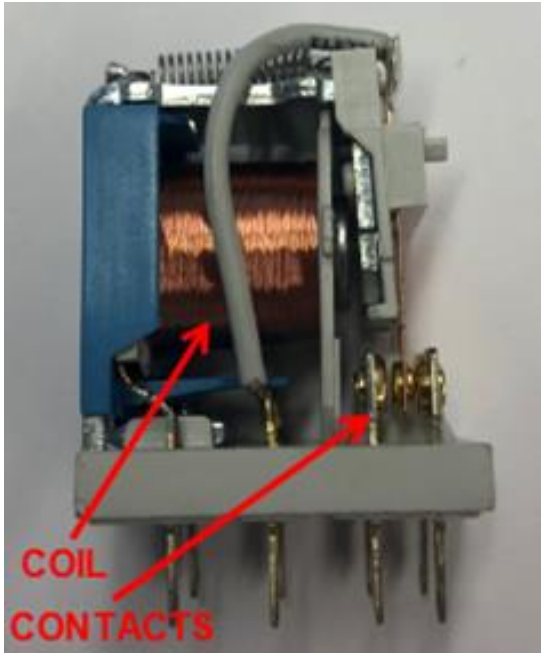
- A programmable logic controller (PLC) is an industrial grade computer that is capable of being programmed to perform control functions.

- PLC started out as a replacement for hardwired relay control systems.
- Gradually, various math and logic manipulation functions were added.
- The programmable controller has eliminated much of the hardwiring associated with conventional relay control circuits.



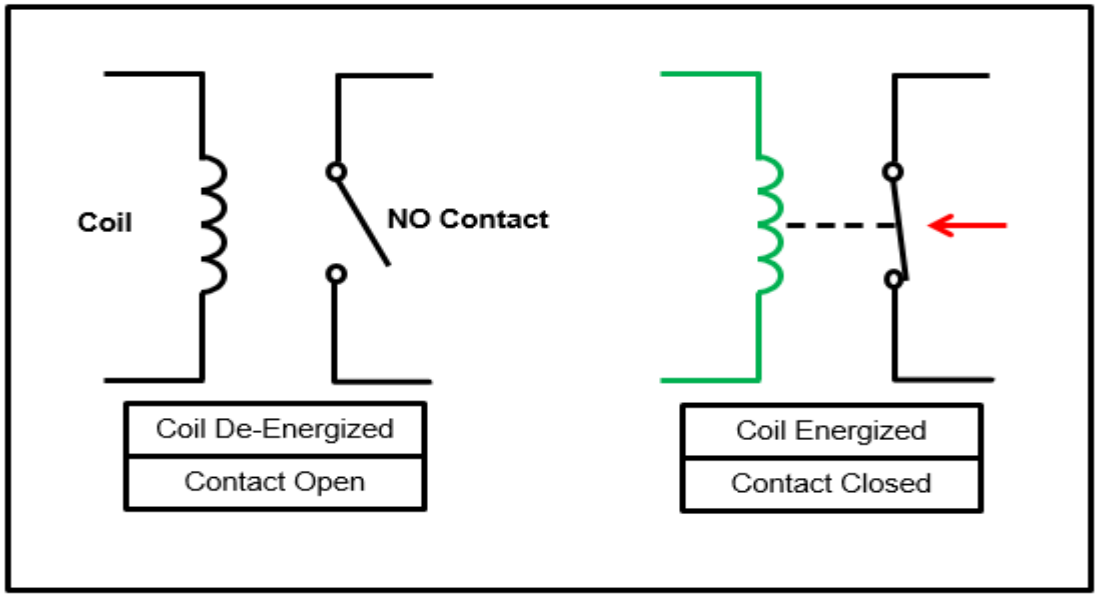
RELAY LOGIC

- Relay logic controlled systems are hard wired.
- The fundamental component of these systems is a relay.
- A relay is used to switch electric circuits on and off.
- To energize the coil we need to connect it to a voltage source, which is sometimes called a relay input.
- Some common DC voltage relays are 5V relay, 12V relay and 24V relay. Another common relay is a 120VAC relay.

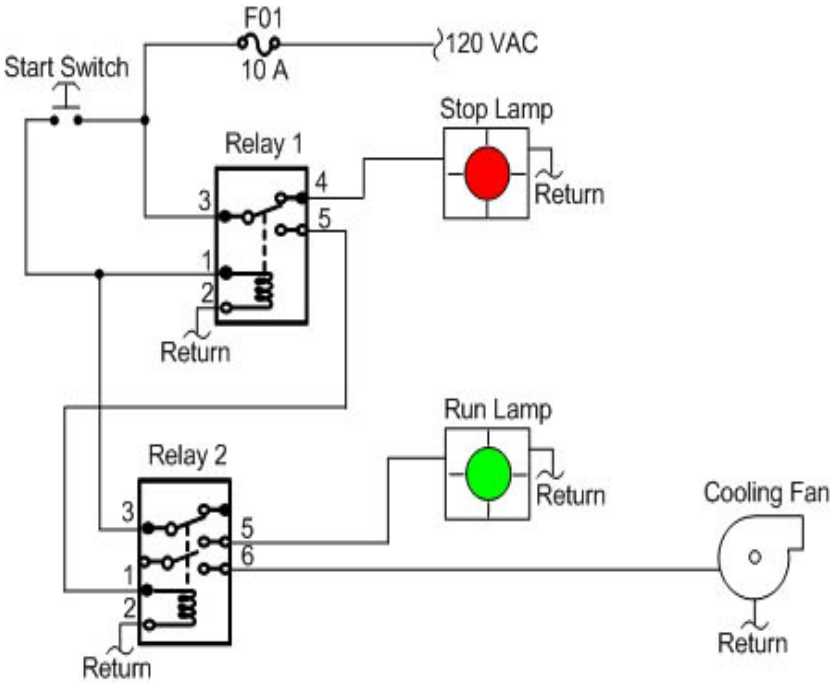


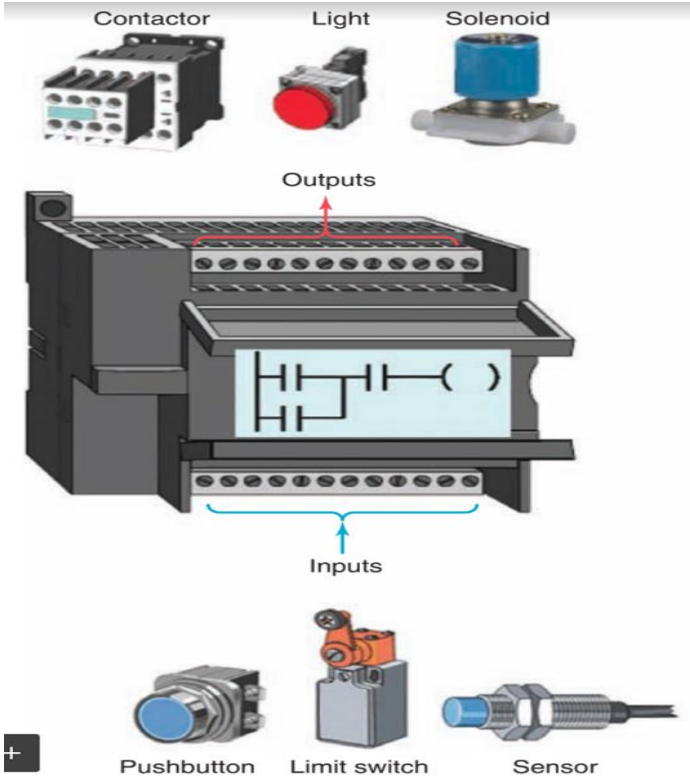
RELAY OPERATION

- If a relay is wired to a normally open (NO) contact and the relay is energized then the contact will change state from OPEN to CLOSED.

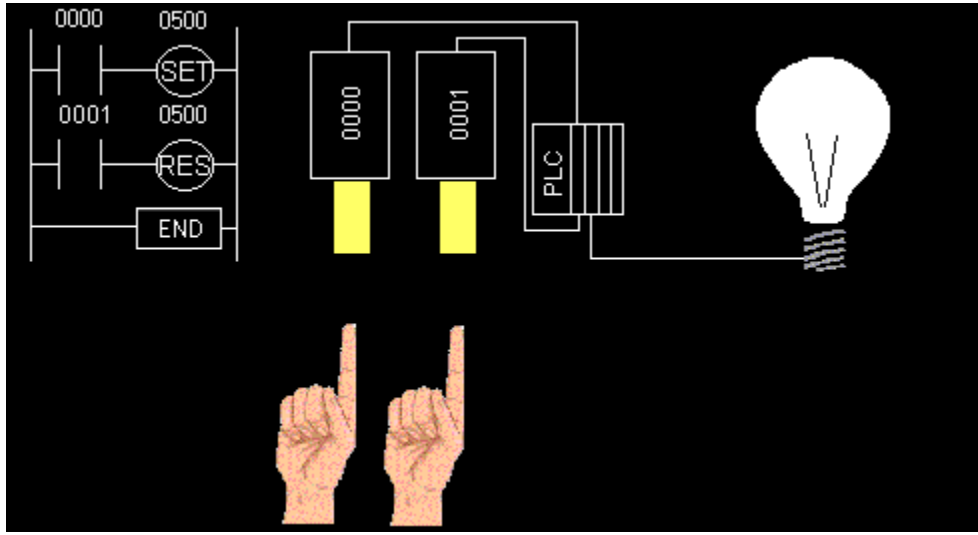


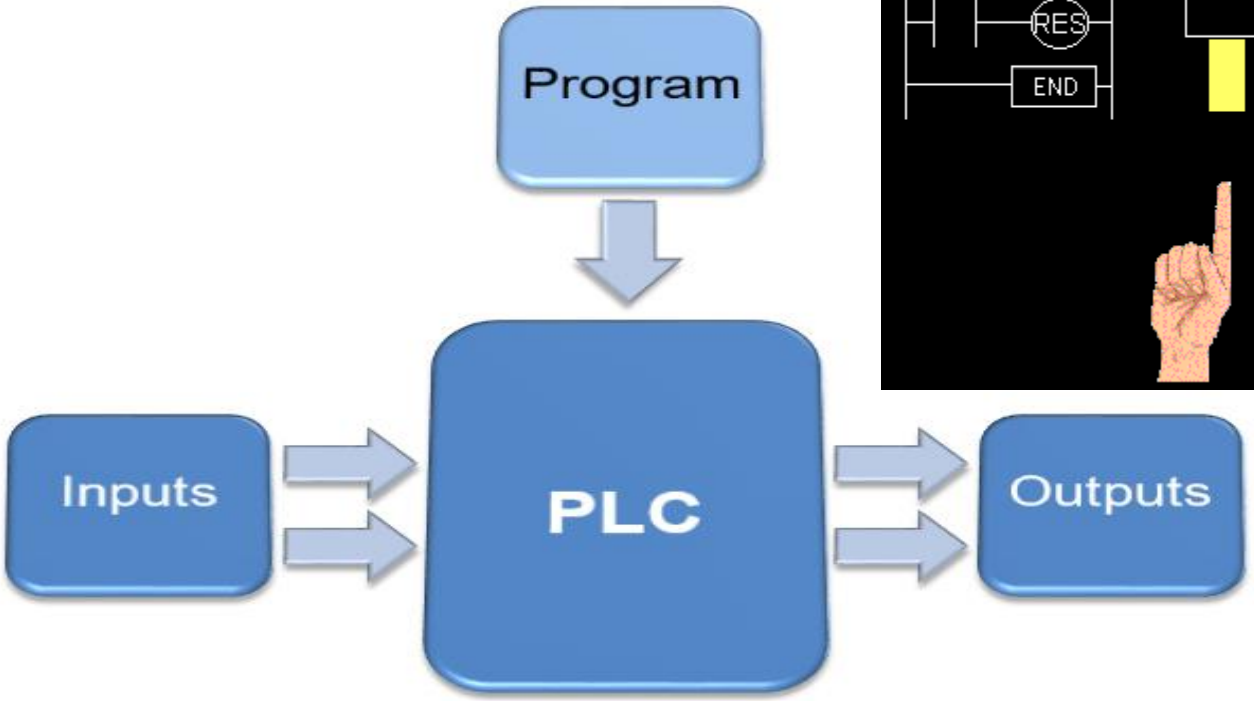
EXAMPLE OF RELAY LOGIC



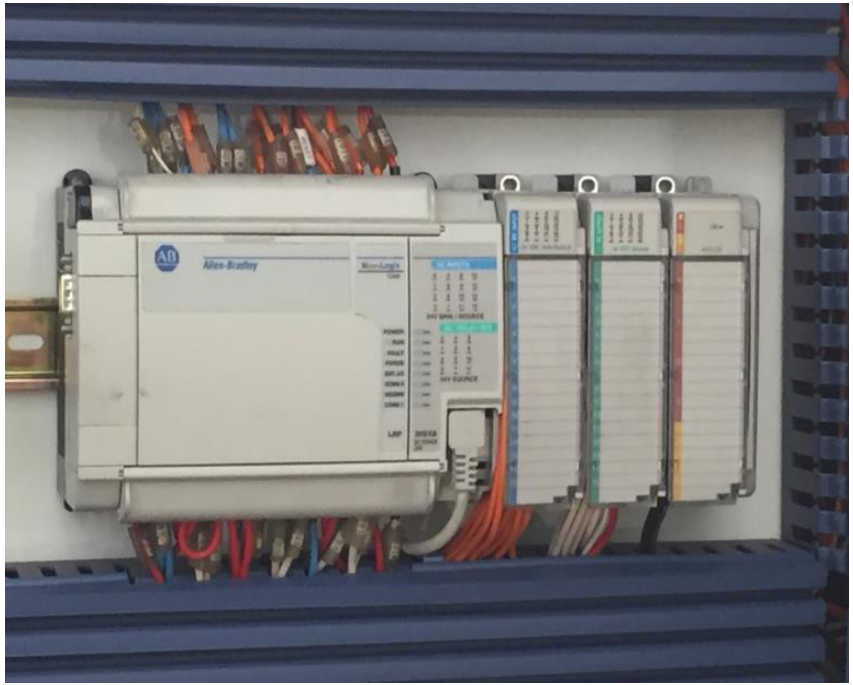


PLC LOGIC


0000
0500
SET
0001
0500
RES
END
0000
0001
PLC


Program
Inputs
PLC
Outputs

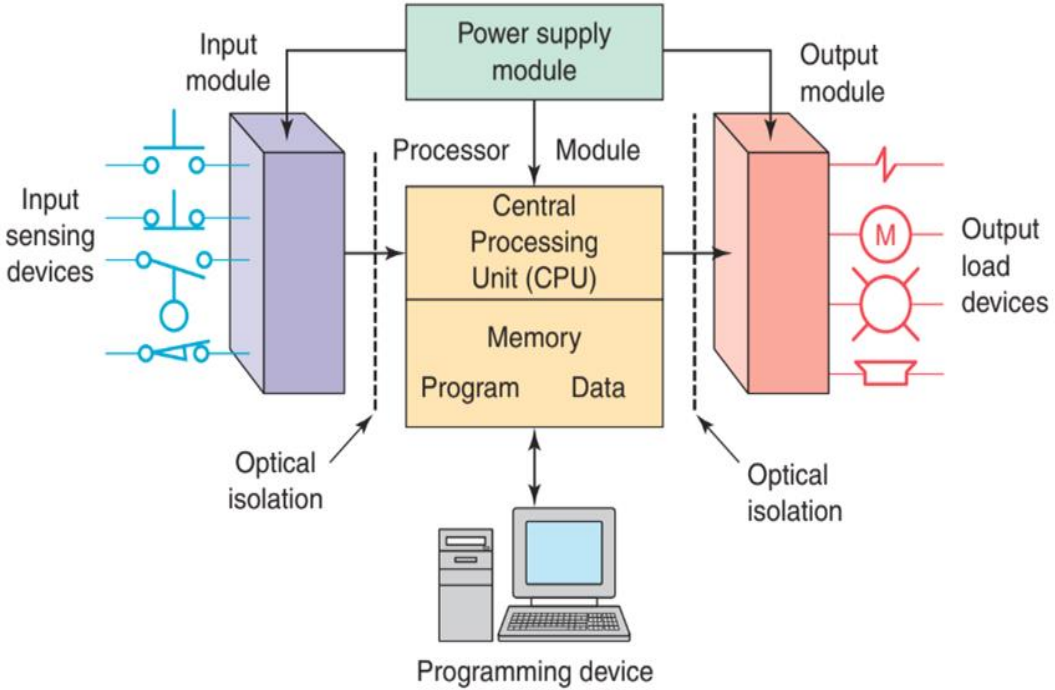
RELAY LOGIC VS PLC



ADVANTAGES OF PLC OVER RELAY LOGIC

- The internal relay systems of a PLC are solid state. This means that the relay function is not mechanical like conventional relay systems and components.
- In a PLC system, a good technician can read through the programming and usually figure out what is and isn't working.In a relay system, there will be several more wires plus the relays and possibly other components that aren't needed in a PLC.
- One of the best features that a PLC system has over a traditional relay system is versatility with the programming and easy expandability.
- The physical size requirements of a PLC system are far smaller than a cabinet needed for relay logic circuitry.

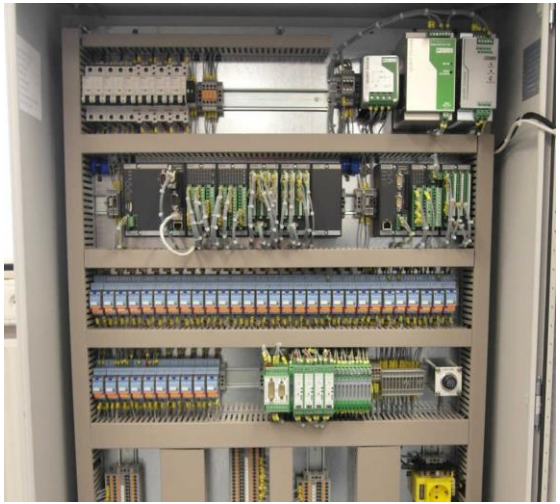
COMPONENTS OF PLC



COMPONENTS OF PLC

A typical PLC can be divided into the following parts:-

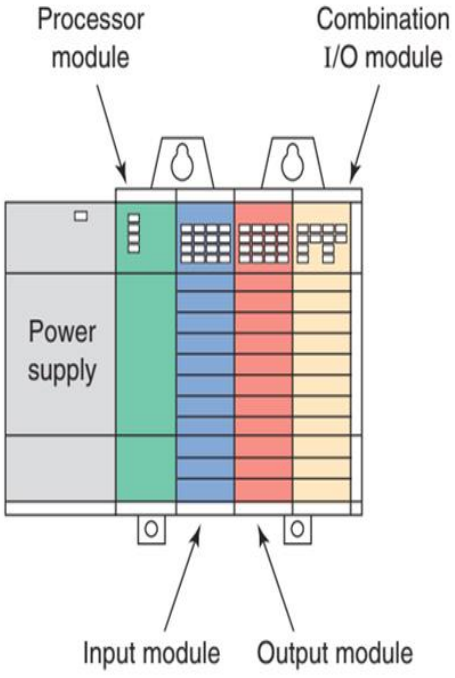
- Central processing unit (CPU)
- Input/Output (I/O) section
- Power supply
- and
- Programming device.



ARCHITECTURE

- **Open Architecture** - allows the system to be connected easily to devices and programs made by other manufacturers. (e.g Using Microsoft make keyboard for Lenovo laptop) (i.e. In PLC using Siemens make PLC Input module with Yokogawa make Transmitter as input)
- **Closed Architecture** - design is proprietary, making it more difficult to connect to other systems.

PROCESSOR MODULE

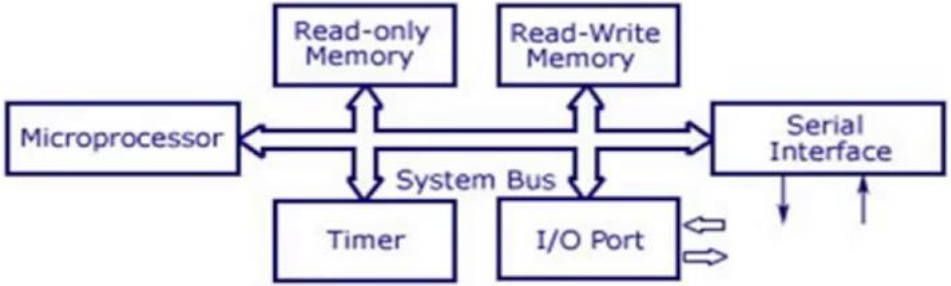


PROCESSOR

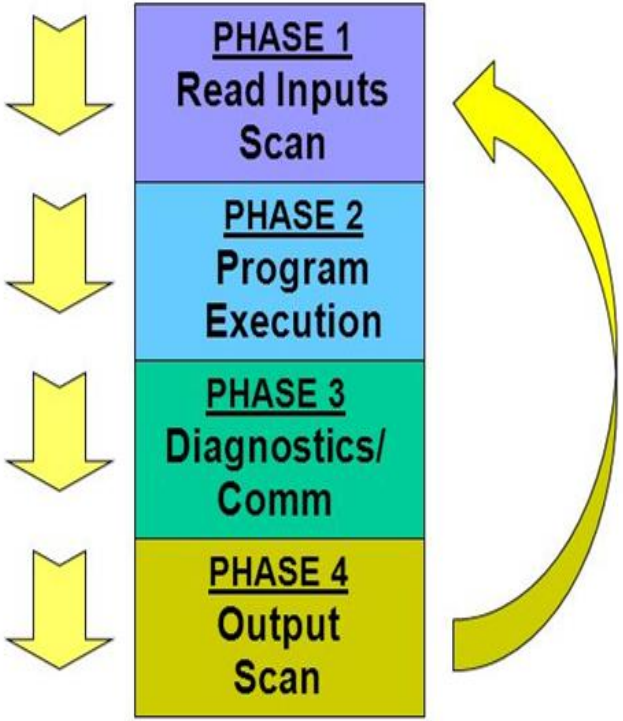
- The processor (CPU) is the “brain” of the PLC.
- A typical processor usually consists of a micro-processor for implementing the logic and controlling the communications among the modules.
- The processor requires memory for storing the results of the logical operations performed by the microprocessor.

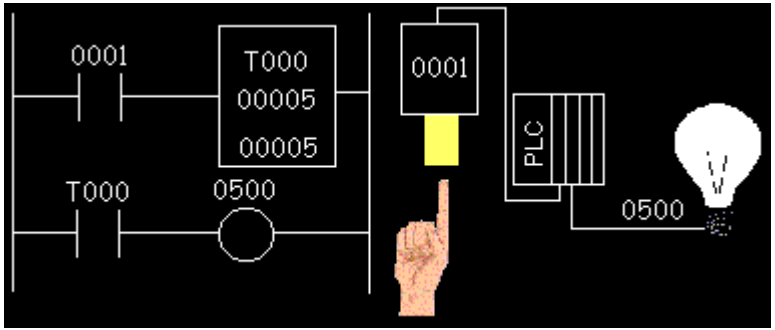
CPU Module


CPU
PWR
BATT
RUN
CPU
DL240
CPU
RUN
TERM
CH1
CH2
CH3
CH4
PORT1
PORT2
D2-240 CPU


Read-only Memory
Read-Write Memory
Microprocessor
Serial Interface
System Bus
Timer
I/O Port

CPU OPERATION



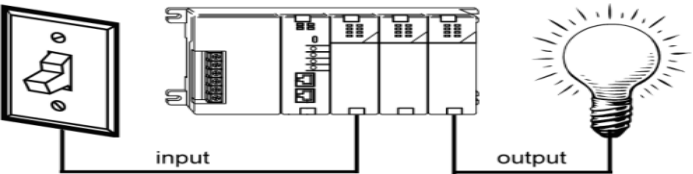


Scans if input switch is pressed (high)

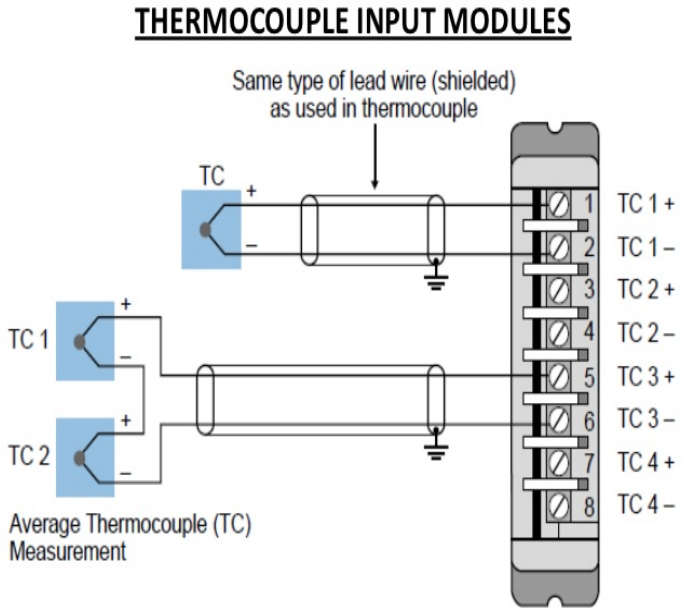
Executes Program - If input is high the output is high

Performs Internal Diagnostics and Communication to HMI

Output of Bulb is turned to high



INPUT / OUTPUT MODULE

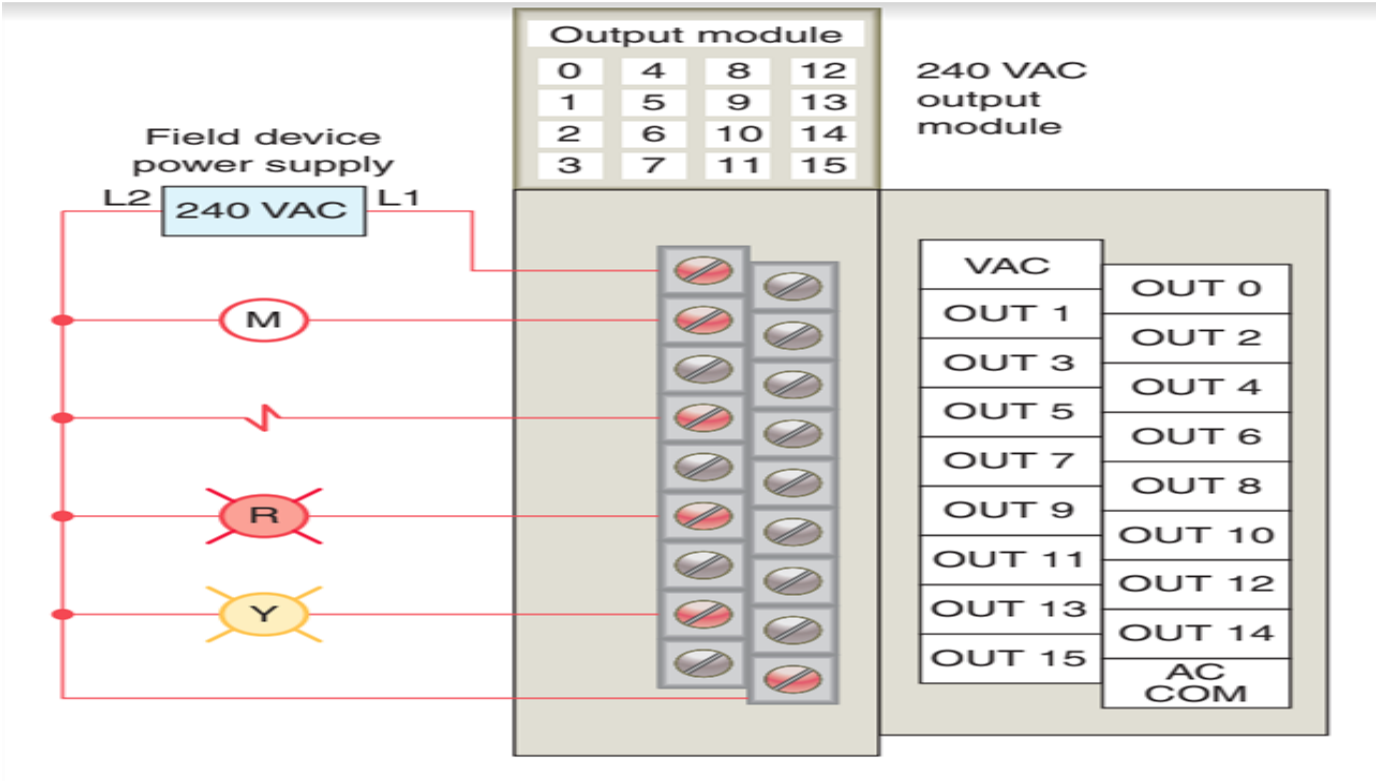


- The I/O system forms the interface by which field devices are connected to the controller.
- The purpose of this interface is to condition the various signals received from or sent to external field devices. Input devices such as pushbuttons, limit switches, and sensors are hardwired to the input terminals.
- 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.

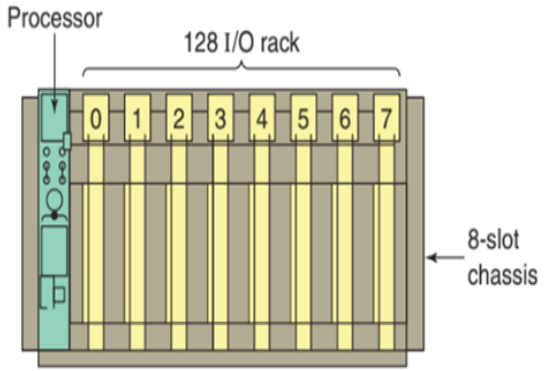
I/O MODULE CONFIGURATION

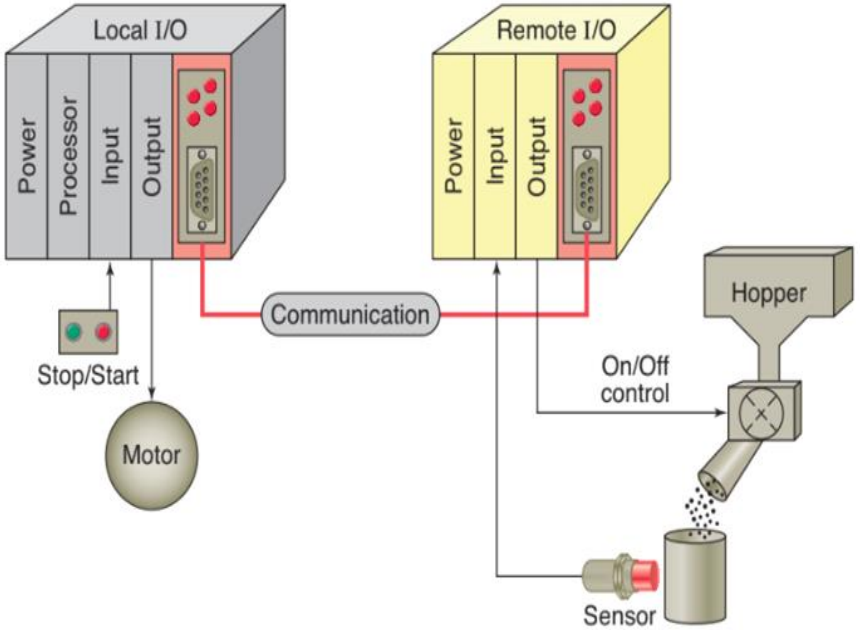
- **Fixed I/O** - comes in single package with no separate, removable units.
- The processor and I/O are packaged together, and the I/O terminals will have a fixed number of connections built in for inputs and outputs.
- **Modular I/O** - divided by compartments into which separate modules can be plugged.
- This feature greatly increases your options and the unit’s flexibility.
- When a module is slid into the rack, it makes an electrical connection with a series of contacts called the backplane, located at the rear of the rack.
- The PLC processor is also connected to the backplane and can communicate with all the modules in the rack.

OUTPUT MODULE



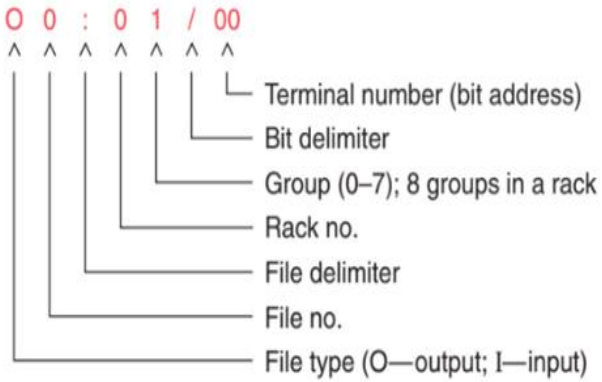
- The input interface allows status information regarding processes to be communicated to the CPU.





ADDRESSING

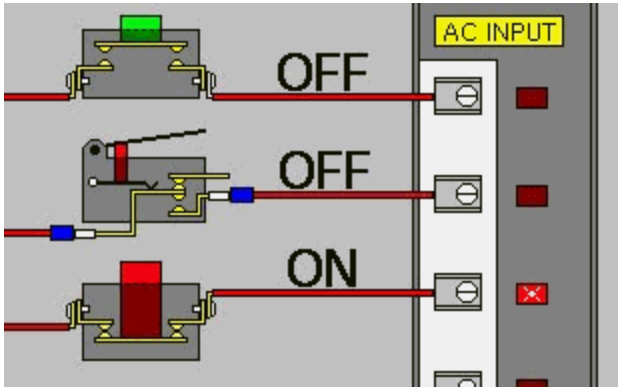
- To keep track of the status of input and outputs the PLC uses a system called addressing. An address is a label or number that indicates where a certain piece of information is located in a PLC’s memory.



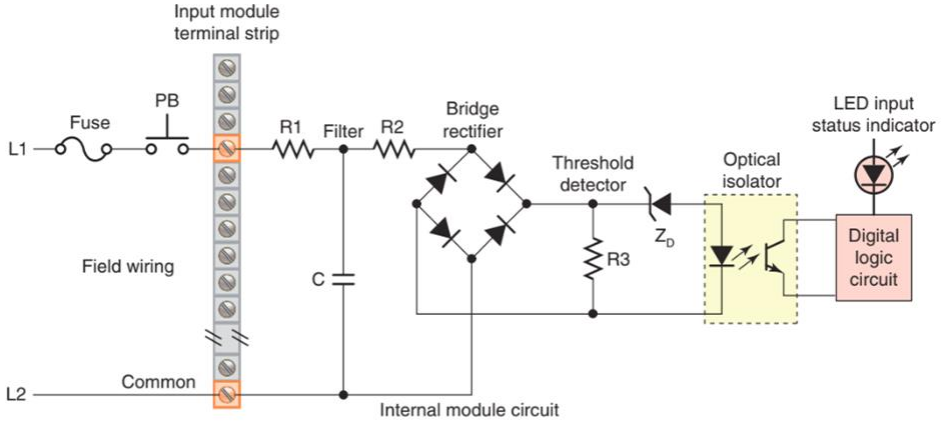
- The terminal assembly, which is attached to the front edge of the printed circuit board, is used for making field-wiring connections.
- Modules contain terminals for each input and output connection, status lights for each of the inputs and outputs, and connections to the power supply used to power the inputs and outputs.
- I/O modules can be 8, 16, 32, or 64 point cards.
- Backplane power is provided by the PLC module power supply and is used to power the electronics that reside on the I/O module circuit board.

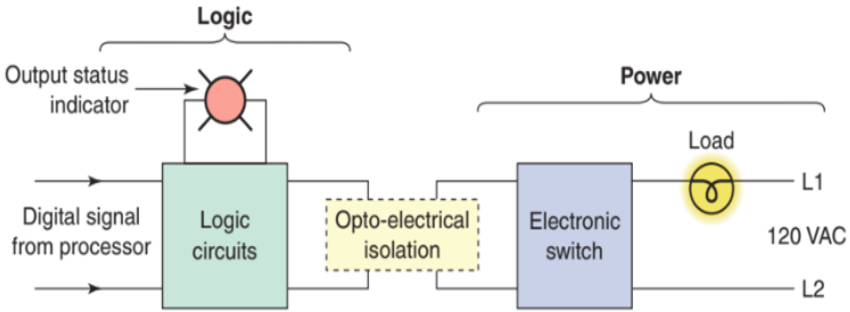
DISCRETE I/O MODULES

- Discrete Input - selector switches, pushbuttons, and limit switches.
- Discrete Output - lights, relays, solenoids and motor starters.
- Each discrete I/O module is powered by some field supplied voltage source.
- The modules themselves receive their voltage and current for proper operation from the backplane of the rack.

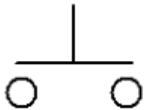



Indicator lights
Signaling column
Relays
Motor starter
Discrete outputs
Discrete inputs
Pushbuttons
Selector switch
Limit switch
Proximity switches



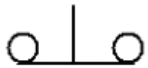


Input



Normally Open

NO

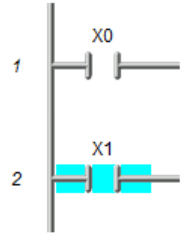


Normally Closed

NC

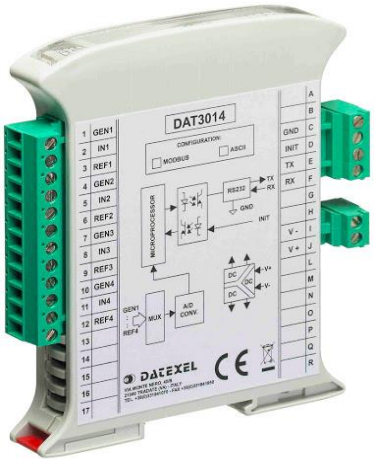
Scan

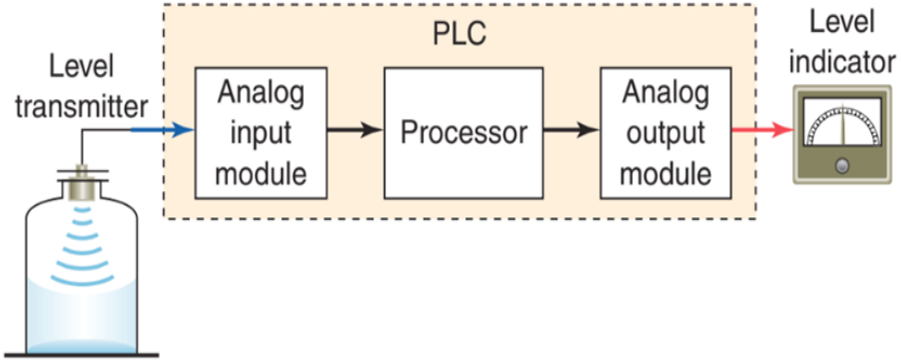
Ladder

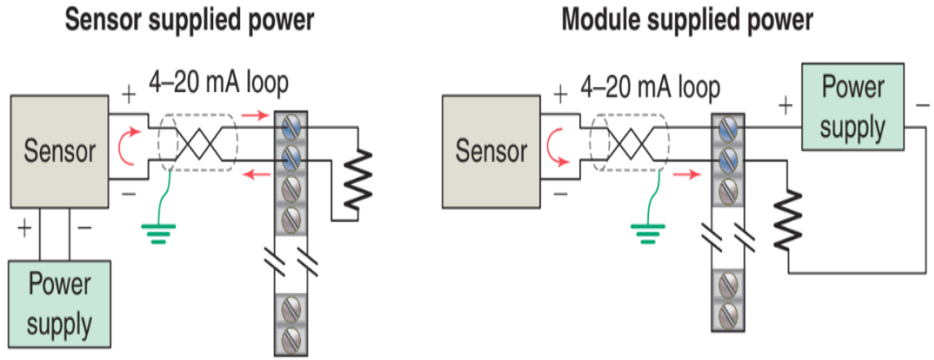


ANALOG I/O MODULES

- Analog devices represent physical quantities that can have an infinite number of values.
- Typical analog inputs and outputs vary from 0 to 20 milliamps, 4 to 20 milliamps, or 0 to 10 volts.
- The circuitry of the analog output module accepts the digital value from the processor and converts it back to an analog signal.
- The transition of an analog signal to digital values is accomplished by an analog-to-digital (A/D) converter, the main element of the analog input module.

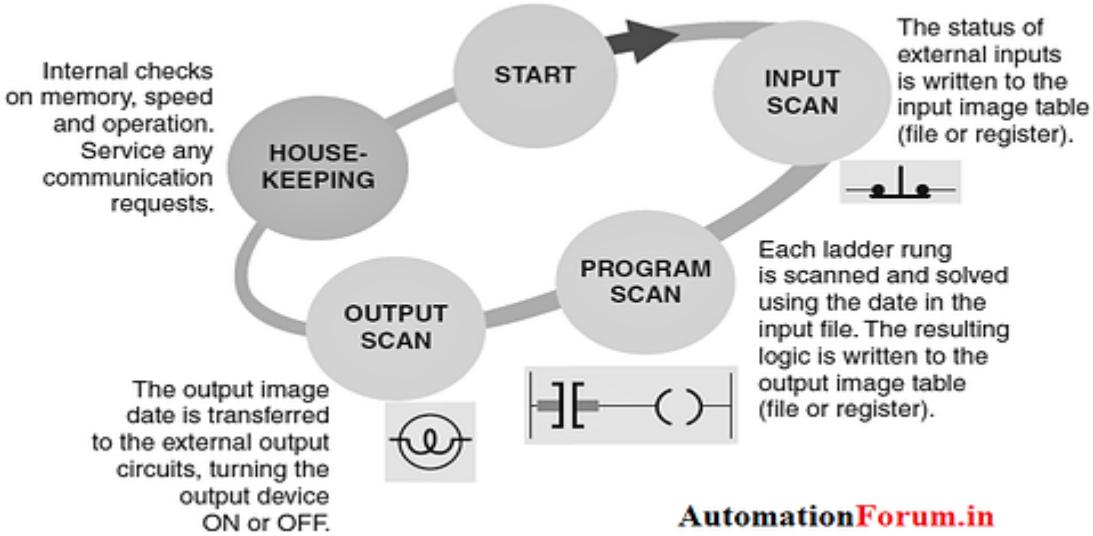



PLC
Level transmitter
Analog input module
Processor
Analog output module
Level indicator


Sensor supplied power
4–20 mA loop
Sensor
Power supply
Module supplied power
4–20 mA loop
Sensor
Power supply

SCAN TIME

The scan cycle is the cycle of which the PLC gathers the inputs, runs your PLC program and then updates the outputs. This will take some amount of time often measured in milliseconds or ms. The amount of time it takes for the PLC to make one scan cycle is called the scan time of the PLC.

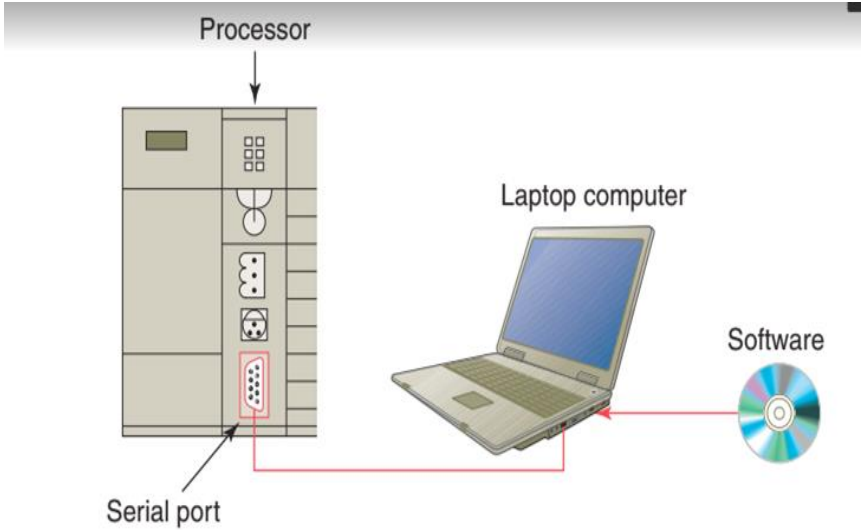


The scan time is a function of the following:

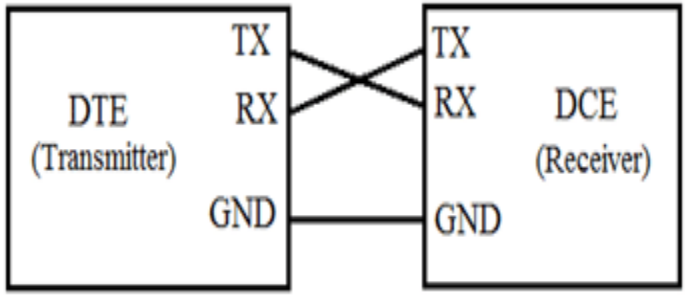
- The speed of the processor module
- The length of the ladder program
- The type of instructions executed
- The actual ladder true/false conditions

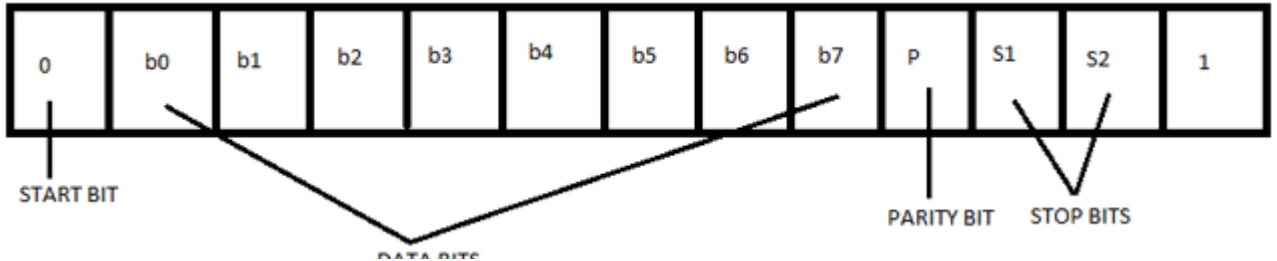
INTERFACING COMPUTER AND PLC

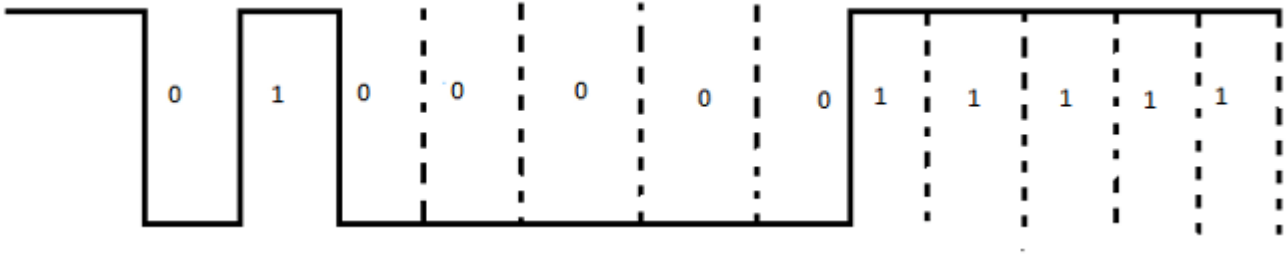
The most popular method of PLC programming is to use a personal computer (PC) in conjunction with the manufacturer's programming software.



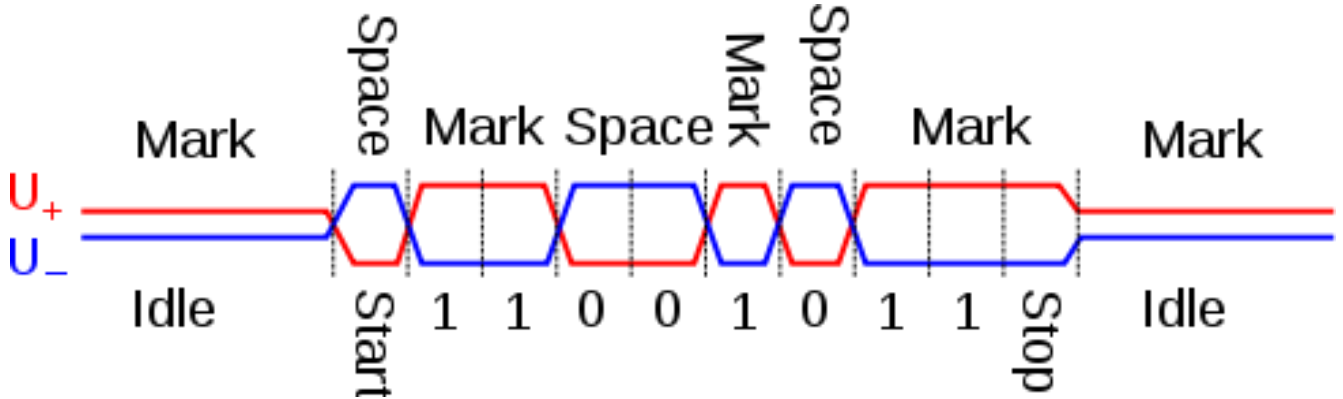
- Serial communication is when data is transmitted one bit at a time.
- Serial communication is used for transmitting data over long distances. Might be used for the connection between a computer and a PLC.
- RS-232 is an asynchronous communications method.
- PLCs serial port is used for transmission/reception of the data, it works by sending/receiving a voltage, With RS232, normally, a 1 bit is represented by a voltage -12 V, and a 0 by a voltage +12 V.
- There are 2 types of RS-232 devices:
- **DTE** – Data Terminal Equipment and a common example is a computer.
- **DCE** – Data Communications Equipment and a common example is a modem.
- PLC may be either a DTE or DCE device.


TX
RX
GND
DTE
(Transmitter)
TX
RX
GND
DCE
(Receiver)

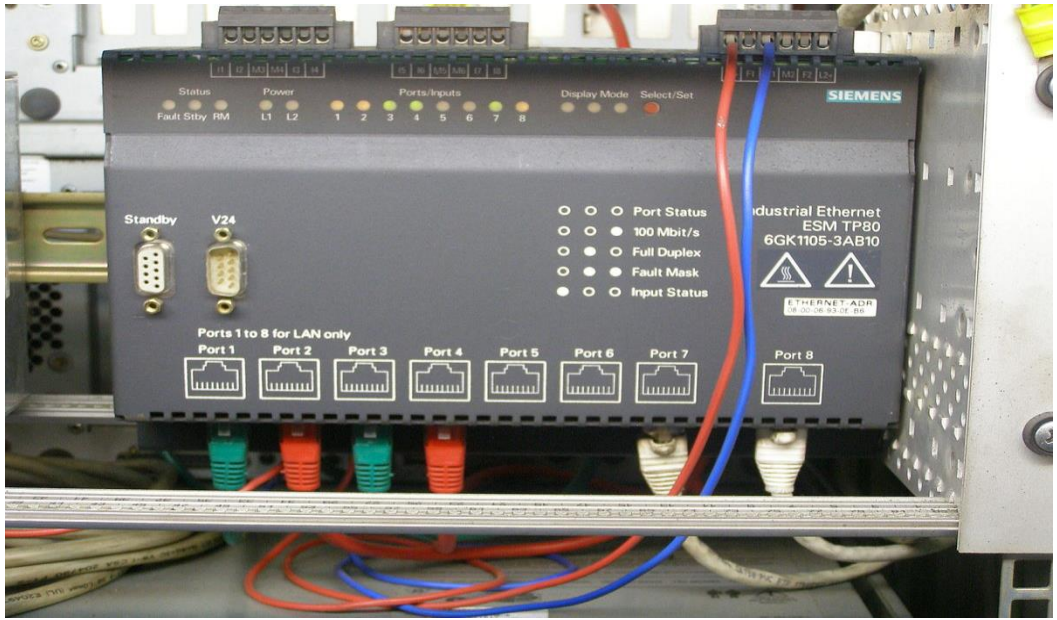

0
b0
b1
b2
b3
b4
b5
b6
b7
P
S1
S2
1
START BIT
PARITY BIT
STOP BITS


0
1
0
0
0
0
0
1
1
1
1
1

- RS-485 is one of multi-drop communication that allows us to ‘talk’ to multiple devices at the same time.
- Uses differential signaling over twisted pair



- **Industrial Ethernet** (**IE**) is the use of Ethernet in an industrial environment with protocols that provide determinism and real-time control.
- Industrial Ethernet can also refer to the use of standard Ethernet protocols with rugged connectors and extended temperature switches in an industrial environment, for automation or process control.
- The use of fiber-optic Ethernet variants reduces the problems of electrical noise and provides electrical isolation.



Discussion

10 mins