PLC & MICROCONTROLLER.

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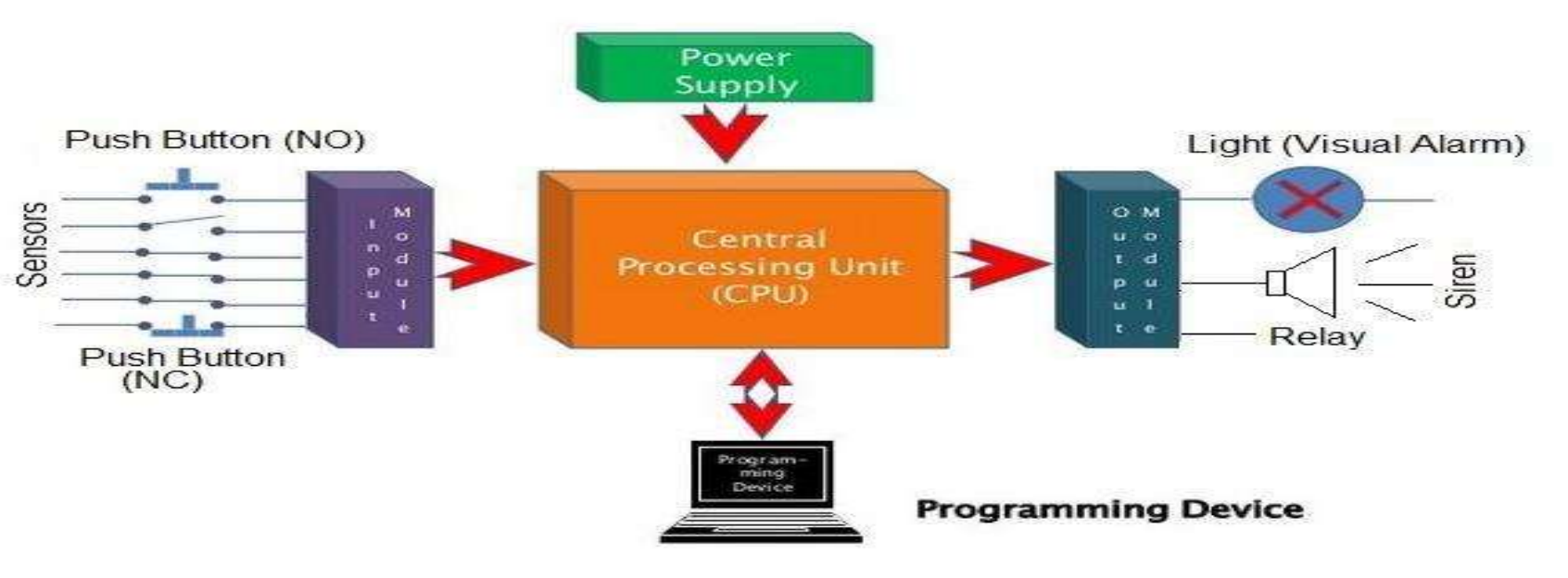
- What is meant by a PLC?
- PLC stands for **Programmable Logic Controller.** They are industrial computers used to control different electro-mechanical processes for use in manufacturing, plants, or other automation environments. PLCs vary in size and form factors



ADVANTAGES OF PLC

- Flexibility: One single Programmable Logic Controller can easily run many machines.
- Correcting Errors: In old days, with wired relay-type panels, any program alterations required time for rewiring of panels and devices. With PLC control any change in circuit design or sequence is as simple as retyping the logic. Correcting errors in PLC is extremely short and cost effective.
- Space Efficient: Today's Programmable Logic Control memory is getting bigger and bigger this means that we can generate more and more contacts, coils, timers, sequencers, counters and so on. We can have thousands of contact timers and counters in a single PLC. Imagine what it would be like to have so many things in one panel.

ADVANTAGES OF PLC

- Low Cost: Prices of Programmable Logic Controllers vary from few hundreds to few thousands. This is nothing compared to the prices of the contact and coils and timers that you would pay to match the same things. Add to that the installation cost, the shipping cost and so on.
- Testing: A Programmable Logic Control program can be tested and evaluated in a lab. The program can be tested, validated and corrected saving very valuable time.
- Visual observation: When running a PLC program a visual operation can be seen on the screen. Hence troubleshooting a circuit is really quick, easy and simple

APPLICATION OF PLC

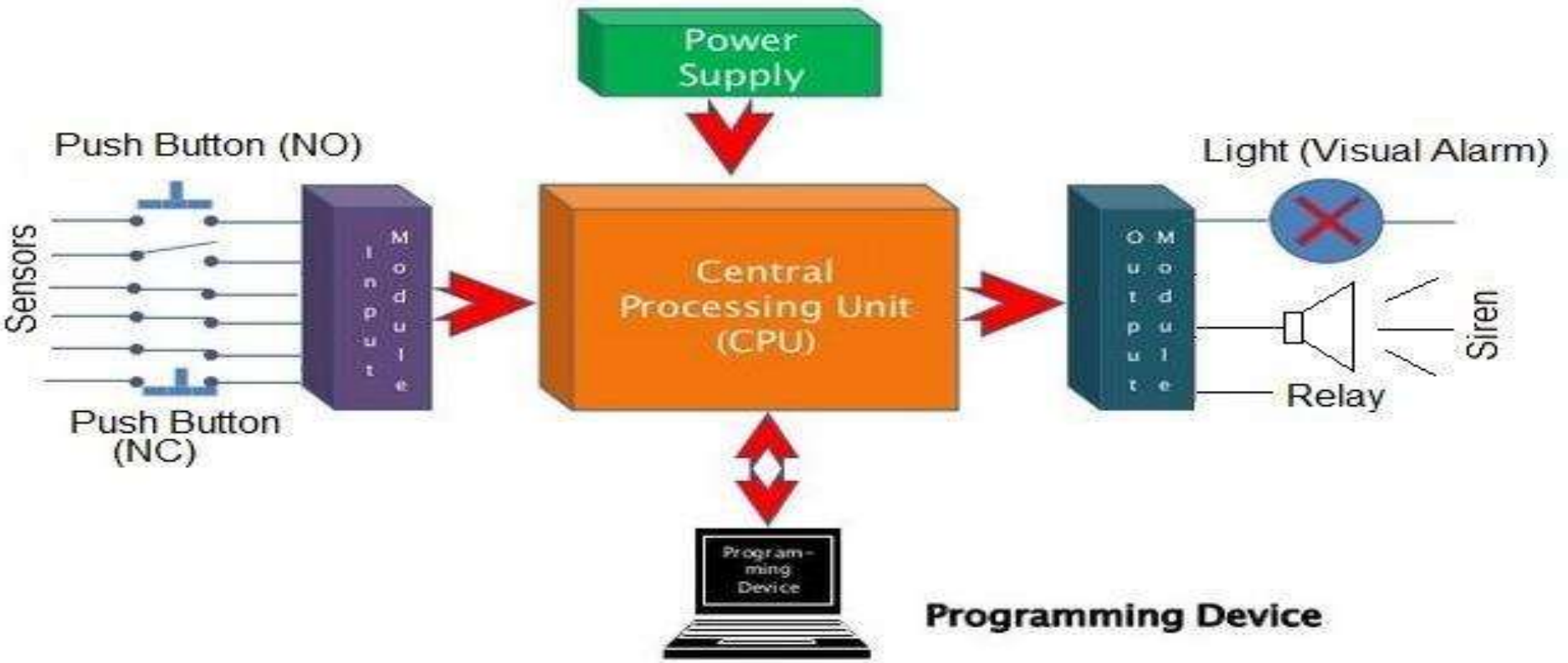
- 1. Application of PLC in Glass Industry From the year 1980 the Programmable-logic controllers are in use in the glass industry, and they are assembled bit by bit. PLCs are used mainly in every procedure and workshop for controlling the material ratio, processing of flat glasses, etc.
- Applications of PLC in Cement Industry Along with the best-quality raw materials, the accurate data regarding process variables, especially during mixing processes within the kiln, ensures that the output provided should be of the best possible quality.

APPLICATION OF PLC

- Production machine Controls and monitor automatic production machines like – packaging machines at high efficiency rates.
- Conveyor System Control all sequential operations, alarms and safety logics
- IC Engine Monitoring Acquires and analysis the data recorded from the sensor located at the internet combustion engine.
- Paint Spraying Control the printing sequence in auto manufacturing.
- Power plant system Monitor and control burning rates, temperature generated sequencing of valves and analog controller jet valves.

BASIC OPERATION OF PLC

- PLC is a centralized digital computer used for automation of electromechanical process.



BASIC PARTS OF PLC

The basic parts of PLC architecture are:

- Input module
- Output scan
- CPU (Central Processing Unit)
- Memory
- Power supply
- Monitoring
- Display
- Racks or chases

- Input Module: Input devices, such as switches, can be manipulated to give the open and closed contact conditions and the corresponding LED on the input module observed. It should be illuminated when the input is closed and not illuminated when it is open. Failure of an LED to illuminate could be because the input device is not correctly operating, there are incorrect wiring connections to the input module, the input device is not correctly powered, or the LED or input module is defective. For output devices that can be safely started, push buttons might have been installed so that each output could be tested.
- Output Module: Output modules convert control signals from the CPU into digital or analog values that can be used to control various output devices. The programming device is used to enter or change the PLCs program or to monitor or change stored values.
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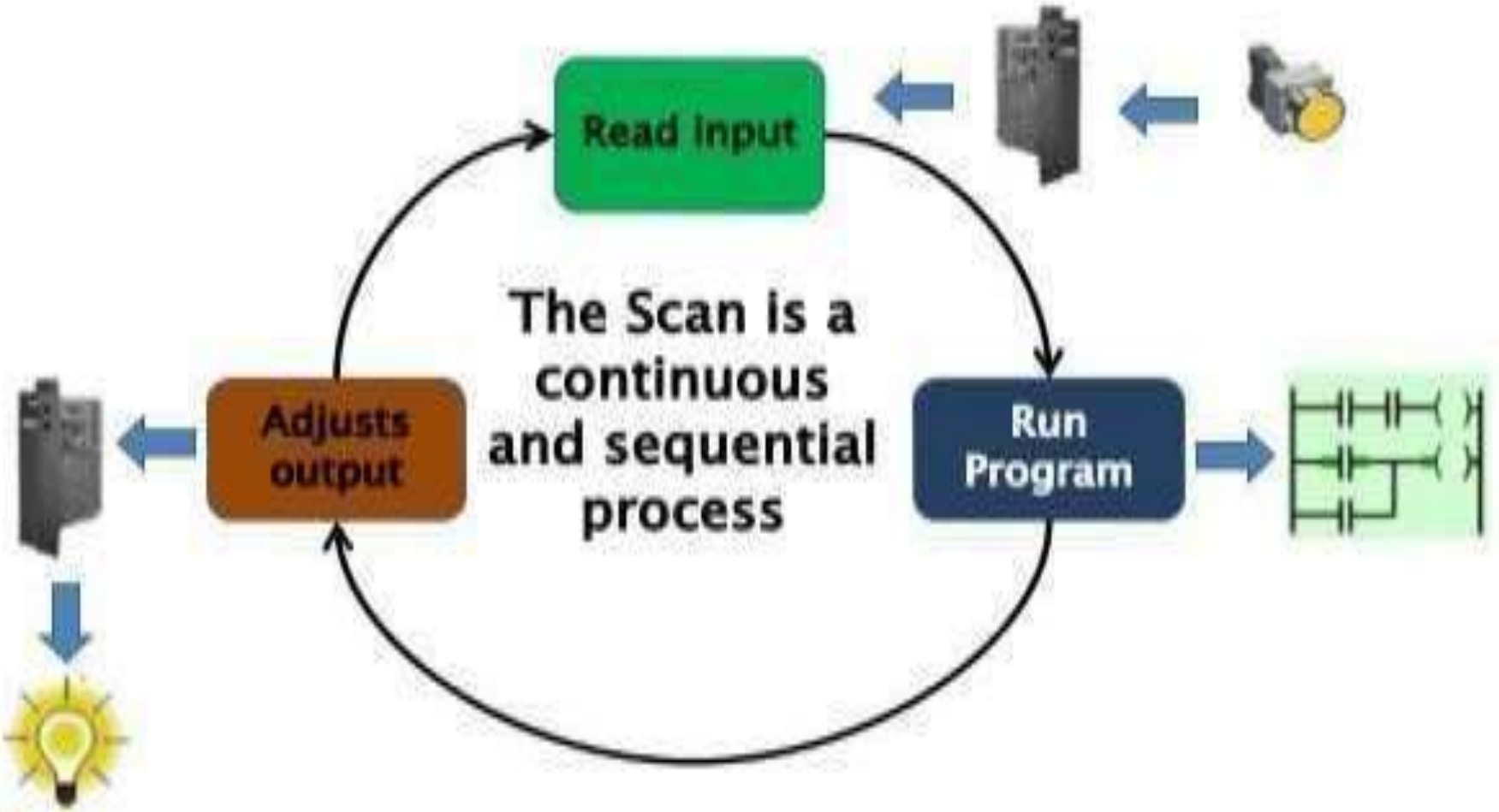
- CPU: The processor unit or central processing unit (CPU) is the unit containing the microprocessor. This unit interprets the input signals and carries out the control actions according to the program stored in its memory, communicating the decisions as action signals to the outputs.
- Power supply: The power supply unit is needed to convert the mains AC voltage to the low DC voltage (5 V) necessary for the processor and the circuits in the input and output interface modules

- Memory: The memory unit is where the program containing the control actions to be exercised by the microprocessor is stored and where the data is stored from the input for processing and for the output. Two types of memory
  1. Program memory (user memory)
  2. Storage memory (data memory

PLC OPERATION:

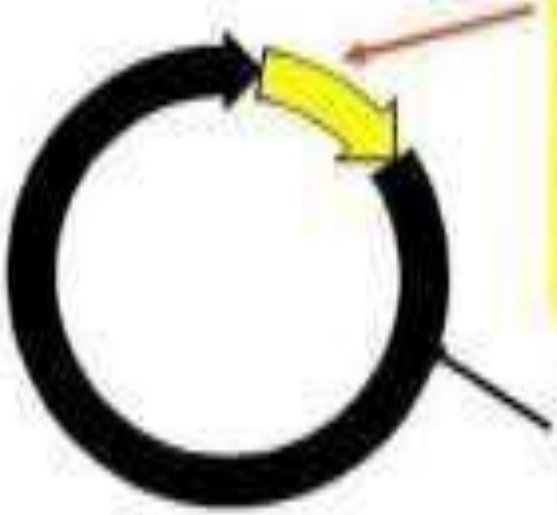
- When the PLC id power On , the processor checks for memory , input output device before the actual start of execution of user program .
- During PLC operation CPU read the input status, execute the user ladder program stored in system memory and output the data to output device and repeat the same program again and again. This processing technique is called PLC scanning.
- PLC scanning operation is divided into three parts : A) Input scan B) Output scan c) Program scan

Scan Cycle of PLC



Program Scan

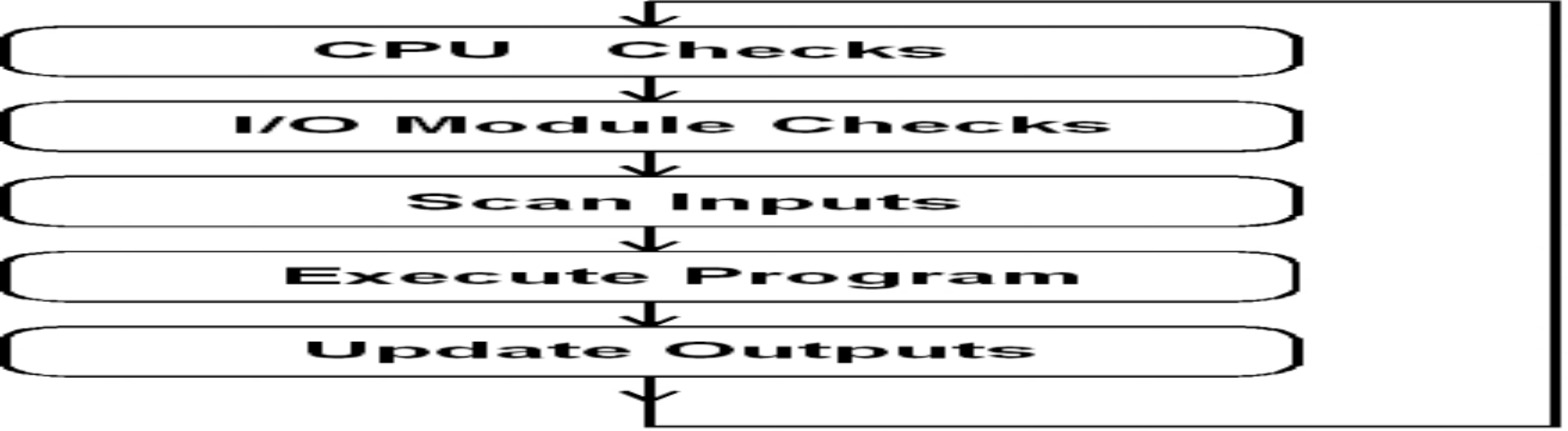
During each operating cycle, the processor reads all inputs, takes these values, and energizes or de-energizes the outputs according to the user program. This process is known as a *scan*.



I/O scan – records status data of input devices. Energizes output devices that have their associated status bits set to ON (1)

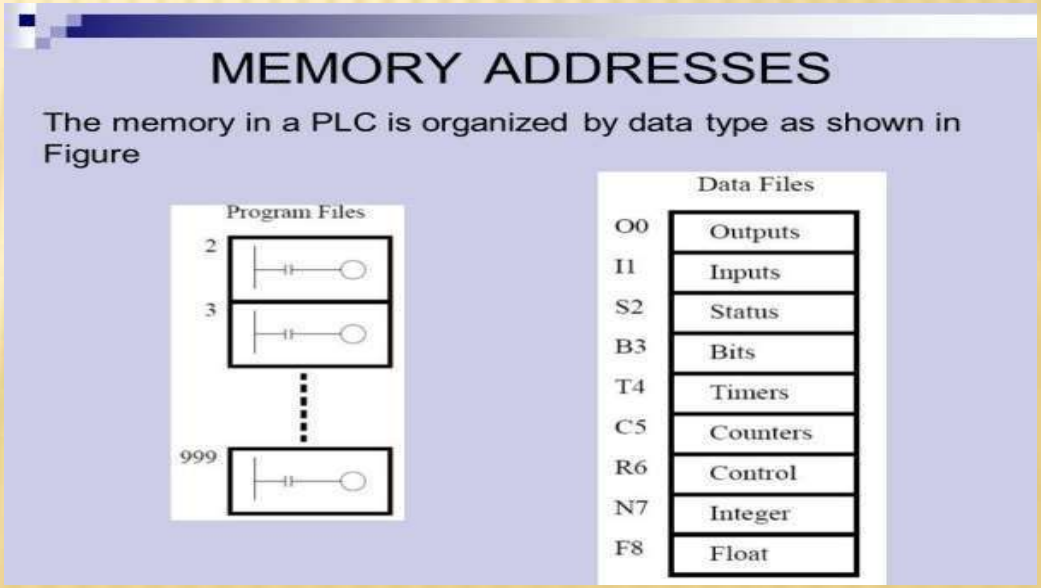
Program scan – instructions are executed sequentially

Because the inputs can change at any time, the PLC must carry on this process continuously.



- **Data File memory**

Output image status bit: This file store the status of discrete output terminals .during program scan, this data is updated and at the end of program scan, It is transferred to real world outputs.



Input Image status file: This file store the status of input terminal of the controller.

Status file: This file is store controller operation status**, error** codes, arithmetic status bits etc. this file is useful for troubleshooting controller and program operation.

Bit file: This file is used for internal relay logic storage.

Timer File: This file stores the timer status bits, present value and accumulated value of each timer .Each timer uses three word memory.

Counter file: This file is stores the counter status bit, preset value and accumulated value of each counter. Each counter uses three word memory.

Control file: This file stores the length, pointer, position and status bits for instruction such as shift register and sequencer.

Integer data file: This file stores numeric value or bit information.

Floating point file : Some PLC can also uses floating point values .This file is used to solve numeric values in floating point notation.

User defined file: This memory area can be used by a user for any of the above types of file. Some PLC can work with string data values which are also defined in this area.

- **Input/output Modules :**

The input output modules works as an interface between the processor and the real world devices like a switches, lamps, Contractor etc. attached to the PLC.

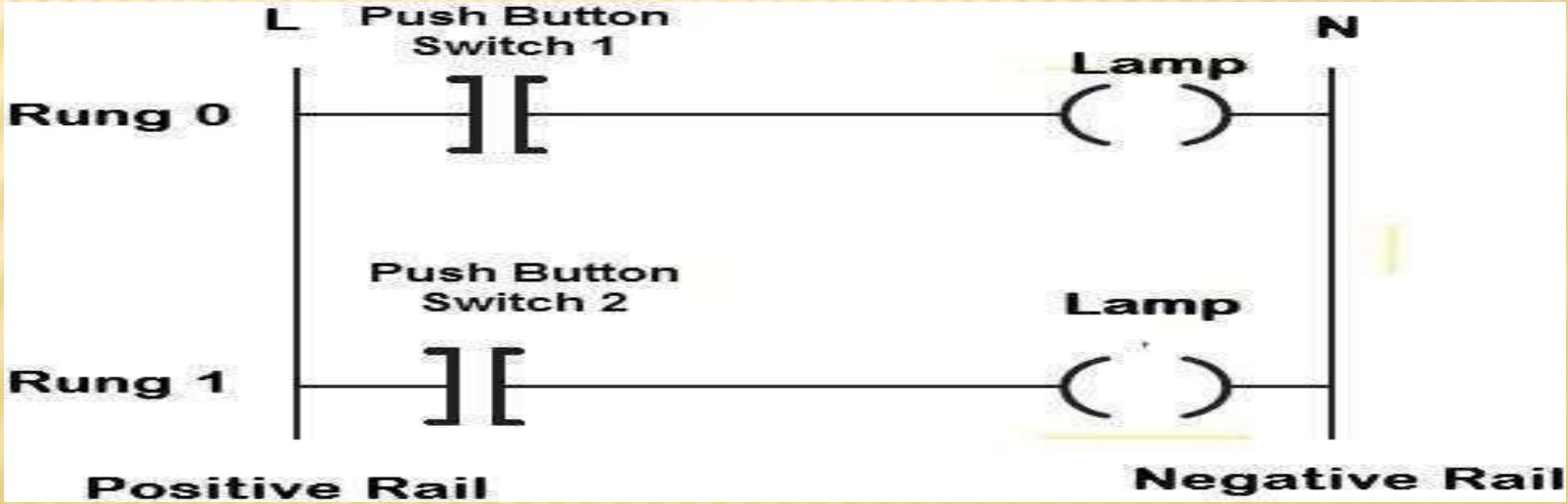
The input output, modules can be divided into three categories:

1. Discrete input /output modules
2. Analog input/output modules
3. Register modules

- **Sourcing and sinking input output**

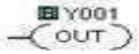
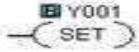
The terms sourcing and sinking are used to describe the way in which DC devices are connected to a PLC. With sourcing, using the conventional current flow direction as from positive to negative, an input device receives current from the input module, that is, the input module is the source of the current. With sinking, using the conventional current flow direction, an input device supplies current to the input module, that is, the input module is the sink for the current. If the current flows from the output module to an output load, the output module is referred to as sourcing .If the current flows to the output module from an output load, the output module is referred to as sinking.

- **Ladder diagram:** Ladder logic diagram are normally use in PLC to write program instruction ladder languages uses input and output symbols and is a graphic base language. The ladder diagram represents program steps using Input and Output symbols like in a electrical relay diagram.



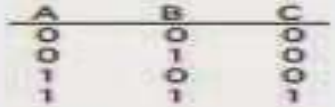
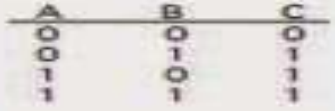
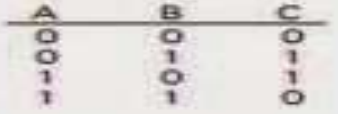
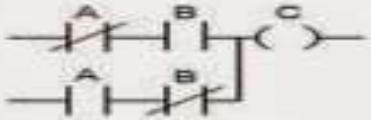
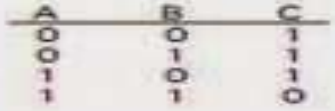
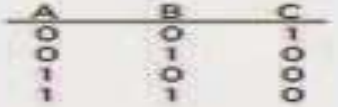
- **Bit instruction**

CLICK PLC Instruction Set

Ladder Symbol	Title	Type	Description
	Normally Open Contact	Bit Instruction	The Normally Open Contact mimics the behavior of a physical contact and changes in response to the status of a Bit Memory Address. The Normally Open Contact is ON when the related bit is ON.
	Normally Closed Contact	Bit Instruction	The Normally Closed Contact mimics the behavior of a physical contact and changes in response to the status of a Bit Memory Address. The Normally Closed Contact is ON when the related bit is OFF.
	Edge Contact	Bit Instruction	The Edge Contact turns ON when the related bit transitions from OFF to ON (Rising Edge) or ON to OFF (Falling Edge).
	Compare Contact	Word Instruction	The Compare instruction uses a Mathematical Operator as a basis for comparison of two data values. When the data values satisfy the selected mathematical relationship (>, <, =, etc.) the Compare Contact turns ON.
	Out Coil	Bit Instruction	An Out instruction turns ON its associated Bit Memory when the status of the rung is true. The Out instruction turns OFF its associated Bit Memory when the status of the rung is false.
	Set Coil	Bit Instruction	The Set instruction turns ON the associated Bit Memory when the status of the rung is true. The Bit Memory stays on after the rung becomes false.

- **Ladder diagram for Boolean Logic of input:** In process control application output condition may depend upon logic combination (AND, OR, XOR, NAND, NOR) of inputs these logic combination can be easily made in ladder diagram.

AND Combination: The ‘AND’ command is used to perform the logic and instruction on each bit of the value in source A with each bit of the value of source B, storing the output logic in the destination.

Logic Diagram	Truth Table	Ladder Diagram
 AND Gate		 AND Equivalent Circuit
 OR Gate		 OR Equivalent Circuit
 Exclusive-OR Gate		 Exclusive-OR Equivalent Circuit
 NAND Gate		 NAND Equivalent Circuit
 NOR Gate		 NOR Equivalent Circuit

OR Combination: For logical ‘OR’ combination of two or more inputs are put in parallel to each other. The rung condition will be TRUE if any one of the input is true if the inputs are false then only the rung condition will be false.

NOR Combination: For logical ‘NOR’ combination, normally closed contacts of inputs are put in series. The rung condition will be TRUE only if all the input is true are FALSE (0). If any of the inputs are TRUE, then only the rung condition will be FALSE.

Timer: PLC timers are instructions that provide the same functions as on- delay and off-delay mechanical and electronic timing relays. A PLC timer provides a preset delay to the control actions.

	D15	D14	D13	D7
Word 0	EN	TT	DN	INTERNAL USE
Word 1	PRESET VALUE (PRE)			
Word 2	ACCUMULATED VALUE			

Timer Address Format

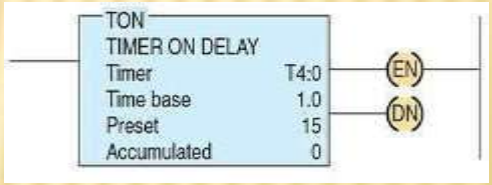
In general, there are three types of PLC timer delays, ON-delay timer, OFF-delay timer and retentive timer on.

The terms represented in the timer block in the PLC are a Preset value which means the delay period of the timer, an Accumulated value which is the current delay of the timer.

A timer begins the counting on time-based intervals and continues until the accumulated value equals the preset value. When the accumulated value equals the preset time the output will be energized. Then the timer sets the output.

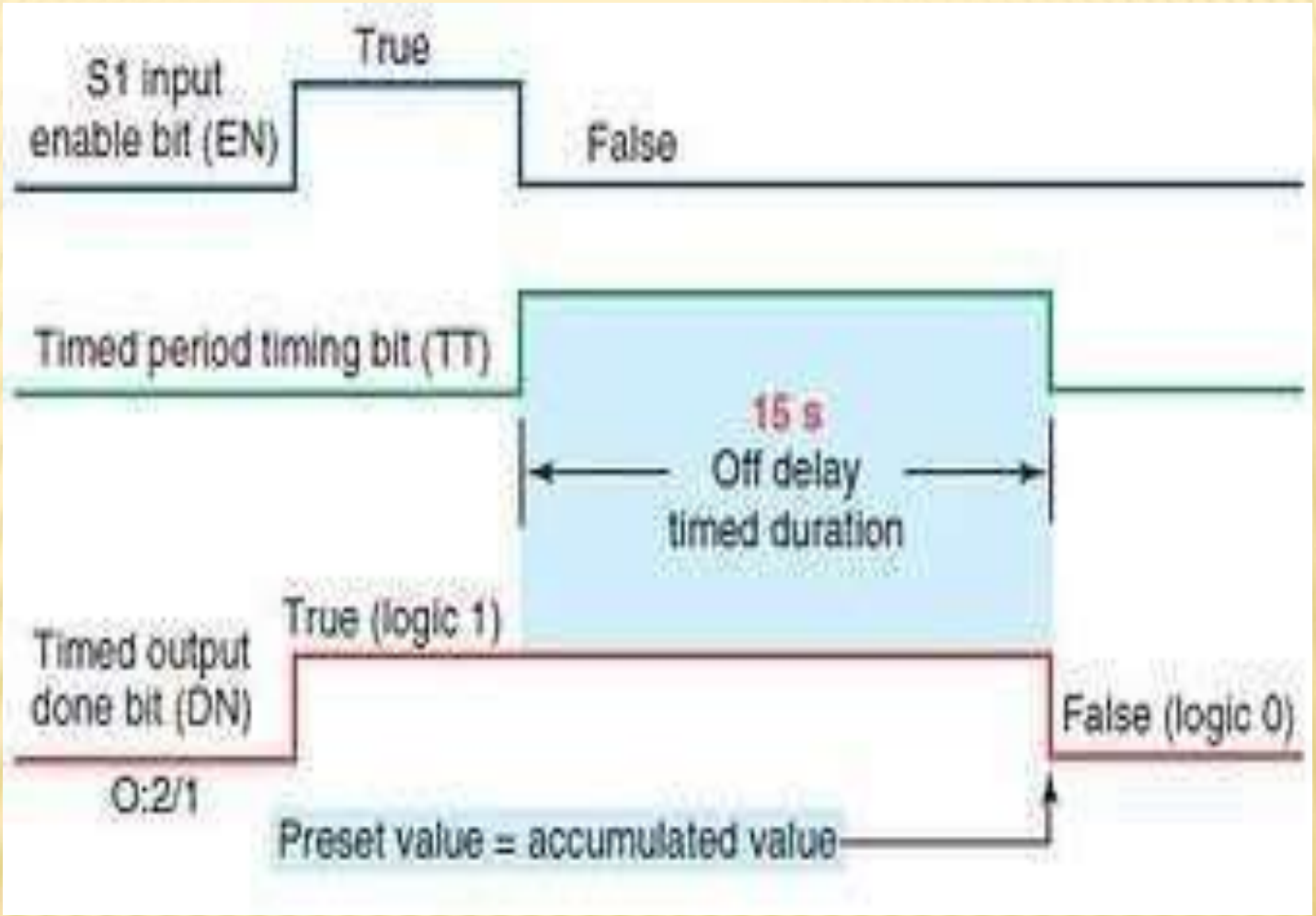
TON timer or ON delay timer

An ON delay timer is used where we need a time delay before the time delay before an instruction becomes true.



TON Instruction Symbol

The TOFF timer will have all the contents as in the TON timer, with the similar function.



OFF delay timer

When the rung timer is true, the output will be true without any delay. When the rung signal becomes false the timer starts operating.

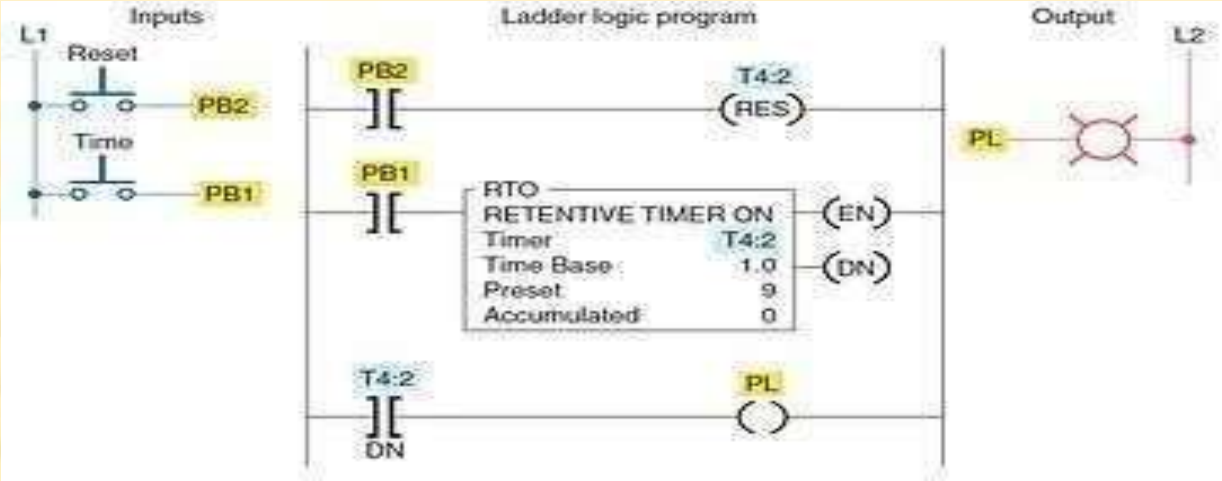
- The timer starts accumulating times when the rung condition becomes true, until the accumulated value becomes equal to the Preset value.
- The output turns off when the output will turn false when the accumulated value equals the preset value.

Retentive timer:

A retentive timer is used when you want to retain accumulated time value through the power loss or the change in the rung state.

A retentive timer accumulates time whenever the device receives power, and it maintains the current time should power be removed from the device

Loss of power to the timer after reaching its preset value does not affect the state of the contacts. The retentive timer must be intentionally reset with a separate signal for the accumulated time to be reset



Counter: Counters are PLC instruction that either increment or decrement or decrement the integer value when the input line make True from False. The counter which increment value is known as Up counters and Down counters decrement the integer values on a trigger. Both the Up and Down counter starts counting on one trigger.

The Up-Down counter has two input triggers one for Up counting and other for Down counting.

	D15	D14	D13	D12	D11	D7
Word 0	EN	TT	DN	OV	UN	INTERNAL USE
Word 1	PRESET VALUE (PRE)					
Word 2	ACCUMULATED VALUE					

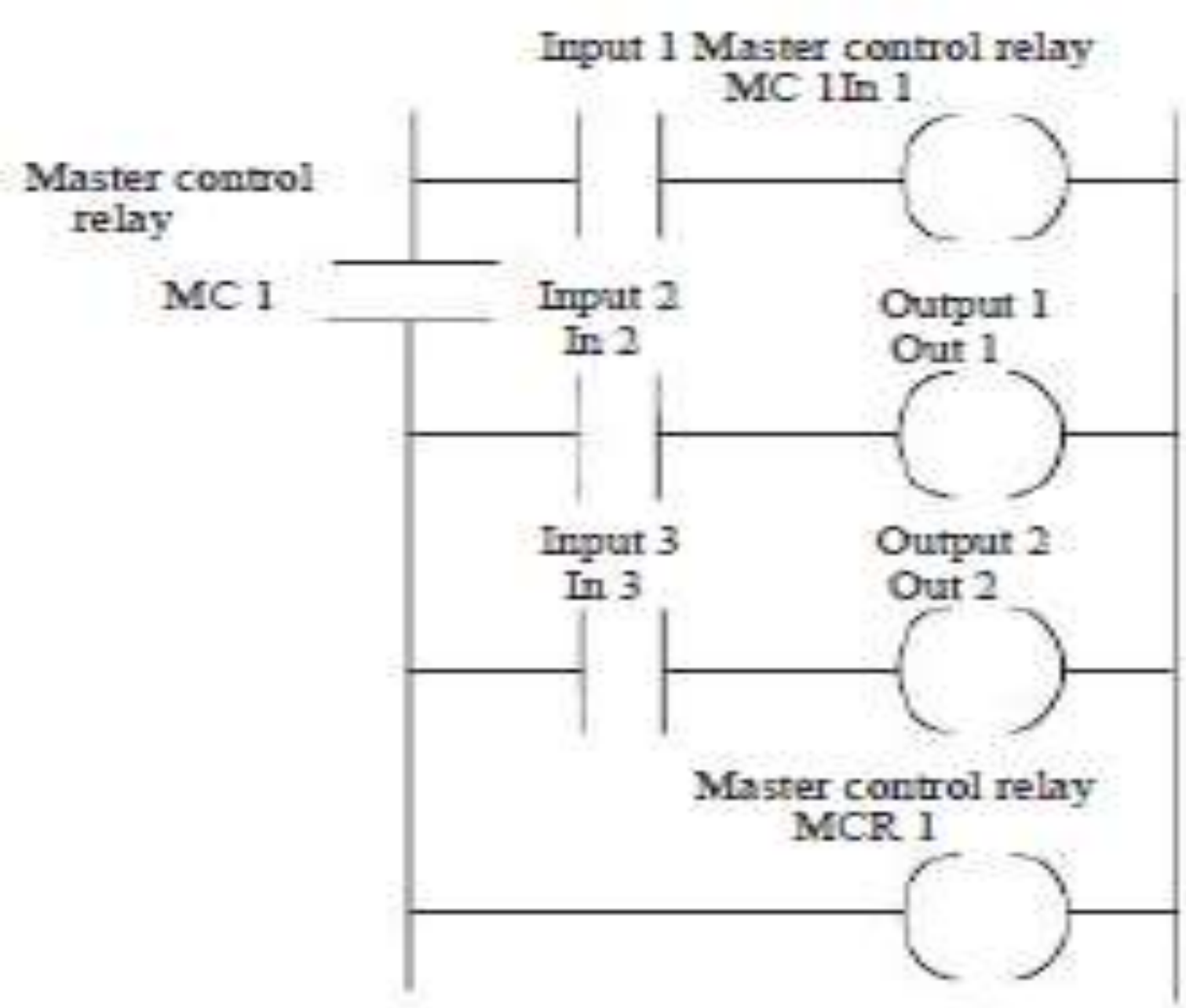
Counter Address Format

RTC (REAL TIME CLOCK)

- The click plc has a real-time clock that will allow us to control outputs based on a date or time of day. This real-time clock (RTC) can be set from the click programming software or through the program of the controller.

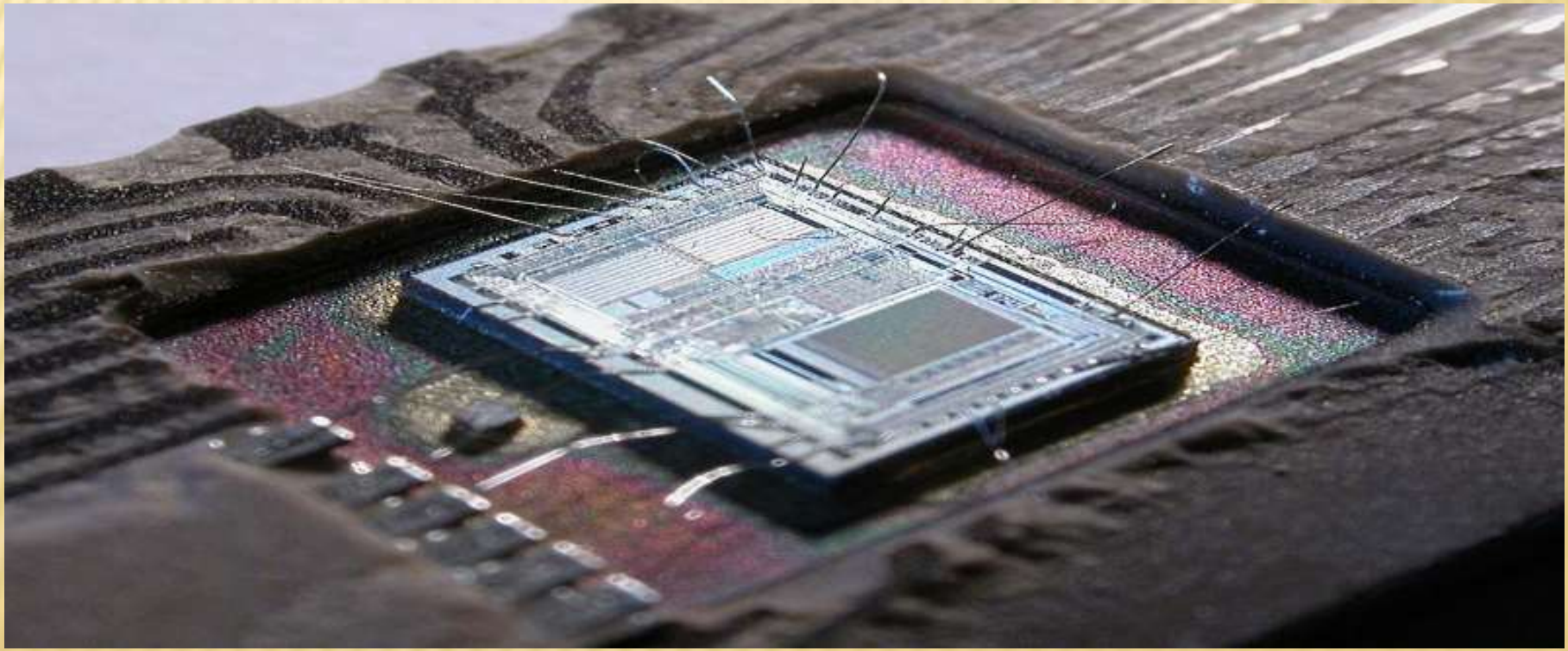
MASTER CONTROL RELAYS

- In an electrical circuit, Master control relays are used to shut down a section of an electrical system. In ladder logic, MCR is used to turn ON one section of a programming line. An MCR option should be opened and closed properly as shown in dia.



Principle of use of a master control relay.

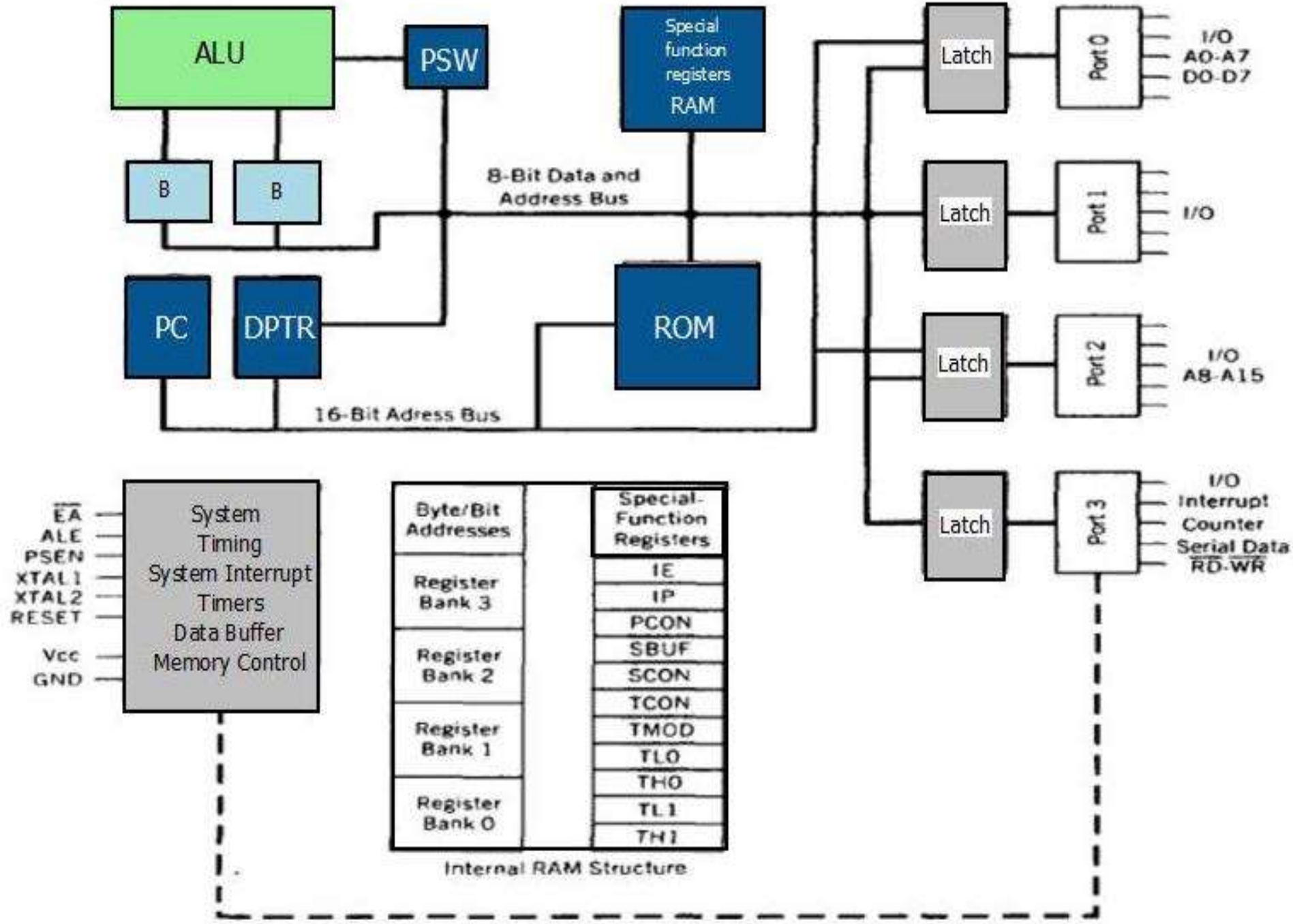
Microcontroller



- A microcontroller (MCU for *microcontroller unit*) is a small computer on a single VLSI integrated circuit (IC) chip. A microcontroller contains one or more CPUs (processor cores) along with memory and programmable input/output peripherals. Program memory in the form of ferroelectric RAM, NOR flash or OTP ROM is also often included on chip, as well as a small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications consisting of various discrete chips.
- In modern terminology, a microcontroller is similar to, but less sophisticated than, a system on a chip (SoC). An SoC may connect the external microcontroller chips as the motherboard components, but an SoC usually integrates the advanced peripherals like graphics processing unit (GPU) and Wi-Fi interface controller as its internal microcontroller unit circuits.
- Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. Mixed signal microcontrollers are common, integrating analog components needed to control non-digital electronic systems. In the context of the internet of things, microcontrollers are an economical and popular means of data collection, sensing and actuating the physical world as edge device

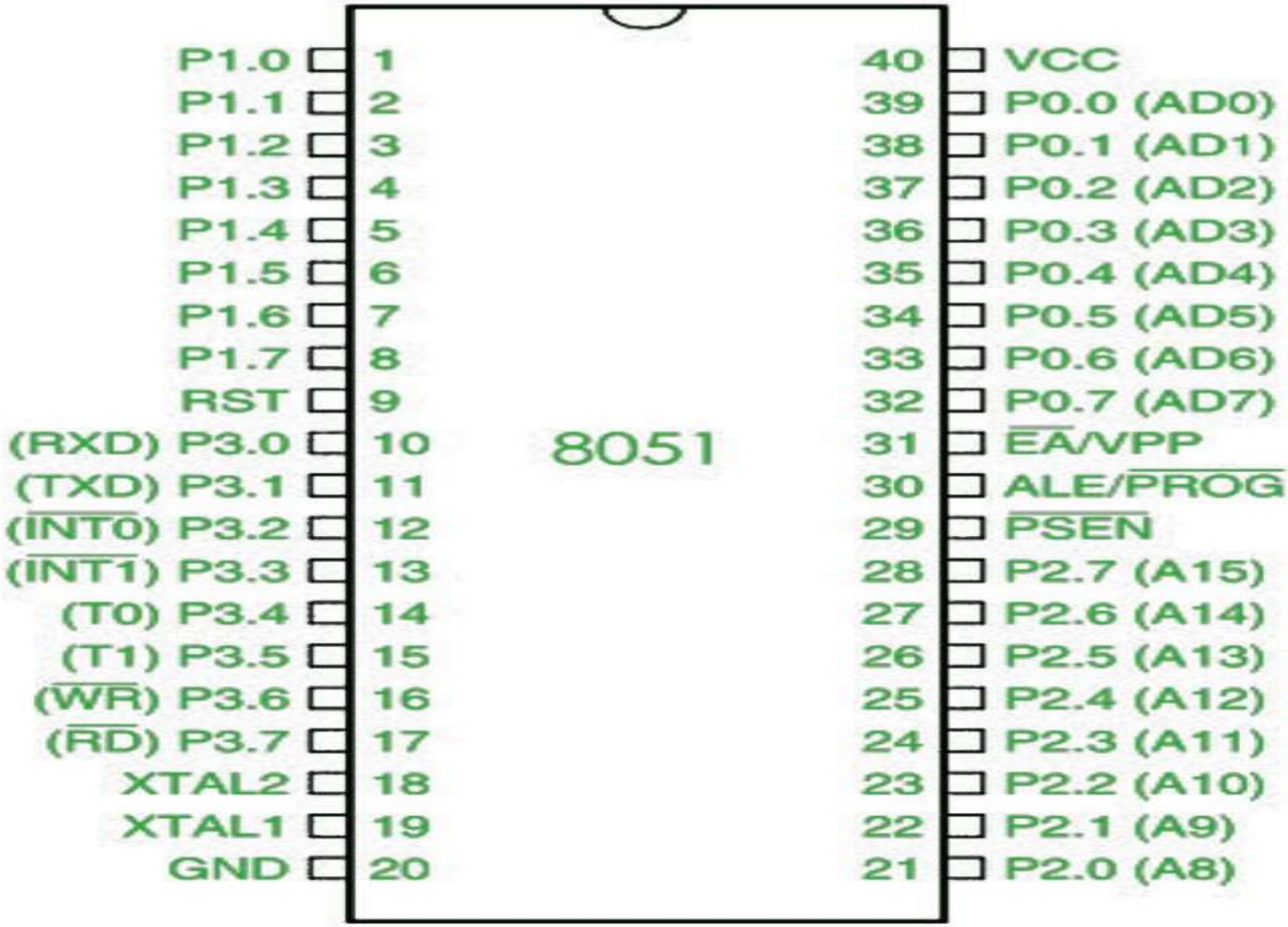
ARCHITECTURE OF 8051 MICROCONTROLLER

- 8051 microcontroller is designed by Intel in 1981. It is an 8-bit microcontroller. It is built with 40 pins DIP (dual inline package), 4kb of ROM storage and 128 bytes of RAM storage, 2 16-bit timers. It consists of are four parallel 8-bit ports, which are programmable as well as addressable as per the requirement. An on-chip crystal oscillator is integrated in the microcontroller having crystal frequency of 12 MHz.
- Let us now discuss the architecture of 8051 Microcontroller.
- In the following diagram, the system bus connects all the support devices to the CPU. The system bus consists of an 8-bit data bus, a 16-bit address bus and bus control signals. All other devices like program memory, ports, data memory, serial interface, interrupt control, timers, and the CPU are all interfaced together through the system bus.


ALU
PSW
Special function registers RAM
B
B
8-Bit Data and Address Bus
PC
DPTR
ROM
16-Bit Adress Bus
Latch
Latch
Latch
Latch
Port 0
Port 1
Port 2
Port 3
I/O A0-A7 D0-D7
I/O
I/O A8-A15
I/O Interrupt Counter Serial Data RD-WR
EA
ALE
PSEN
XTAL1
XTAL2
RESET
Vcc
GND
System Timing System Interrupt Timers Data Buffer Memory Control
Byte/Bit Addresses
Special-Function Registers
Register Bank 3
Register Bank 2
Register Bank 1
Register Bank 0
IE
IP
PCON
SBUF
SCON
TCON
TMOD
TL0
TH0
TL1
TH1
Internal RAM Structure

PIN DIAGRAM OF 8051 MICROCONTROLLER

- 8051 microcontroller is a 40 pin Dual Inline Package (DIP). These 40 pins serve different functions like read, write, I/O operations,
- interrupts etc. 8051 has four I/O ports wherein each port has 8 pins which can be configured as input or output depending upon the logic state of the pins.
- Therefore, 32 out of these 40 pins are dedicated to I/O ports. The rest of the pins are dedicated to VCC, GND, XTAL1, XTAL2, RST, ALE, EA' and PSEN'.


P1.0 1
P1.1 2
P1.2 3
P1.3 4
P1.4 5
P1.5 6
P1.6 7
P1.7 8
RST 9
(RXD) P3.0 10
(TXD) P3.1 11
(INT0) P3.2 12
(INT1) P3.3 13
(T0) P3.4 14
(T1) P3.5 15
(WR) P3.6 16
(RD) P3.7 17
XTAL2 18
XTAL1 19
GND 20
8051
40 VCC
39 P0.0 (AD0)
38 P0.1 (AD1)
37 P0.2 (AD2)
36 P0.3 (AD3)
35 P0.4 (AD4)
34 P0.5 (AD5)
33 P0.6 (AD6)
32 P0.7 (AD7)
31 EA/VPP
30 ALE/PROG
29 PSEN
28 P2.7 (A15)
27 P2.6 (A14)
26 P2.5 (A13)
25 P2.4 (A12)
24 P2.3 (A11)
23 P2.2 (A10)
22 P2.1 (A9)
21 P2.0 (A8)

40 - PIN DIP

- **Pin 1 to Pin 8 (Port 1) –**
  Pin 1 to Pin 8 are assigned to Port 1 for simple I/O operations. They can be configured as input or output pins depending on the logic control i.e. if logic zero (0) is applied to the I/O port it will act as an output pin and if logic one (1) is applied the pin will act as an input pin. These pins are also referred to as P1.0 to P1.7 (where P1 indicates that it is a pin in port 1 and the number after '.' tells the pin number i.e. 0 indicates first pin of the port. So, P1.0 means first pin of port 1, P1.1 means second pin of the port 1 and so on). These pins are bidirectional pins.
- **Pin 9 (RST) –**
  Reset pin. It is an active-high, input pin. Therefore if the RST pin is high for a minimum of 2 machine cycles, the microcontroller will reset i.e. it will close and terminate all activities. It is often referred as "power-on-reset" pin because it is used to reset the microcontroller to it's initial values when power is on (high).

- **Pin 10 to Pin 17 (Port 3) –**
  Pin 10 to pin 17 are port 3 pins which are also referred to as P3.0 to P3.7. These pins are similar to port 1 and can be used as universal input or output pins. These pins are bidirectional pins.These pins also have some additional functions which are as follows:
- **P3.0 (RXD) :**
  10th pin is RXD (serial data receive pin) which is for serial input. Through this input signal microcontroller receives data for serial communication.
- **P3.1 (TXD) :**
  11th pin is TXD (serial data transmit pin) which is serial output pin. Through this output signal microcontroller transmits data for serial communication.
- **P3.2 and P3.3 (INT0′, INT1′) :**
  12th and 13th pins are for External Hardware Interrupt 0 and Interrupt 1 respectively. When this interrupt is activated(i.e. when it is low), 8051 gets interrupted in whatever it is doing and jumps to the vector value of the interrupt (0003H for INT0 and 0013H for INT1) and starts performing Interrupt Service Routine (ISR) from that vector location.

- **P3.4 and P3.5 (T0 and T1) :**
  14th and 15th pin are for Timer 0 and Timer 1 external input. They can be connected with 16 bit timer/counter.
- **P3.6 (WR') :**
  16th pin is for external memory write i.e. writing data to the external memory.
- **P3.7 (RD') :**
  17th pin is for external memory read i.e. reading data from external memory.

- **Pin 18 and Pin 19 (XTAL2 And XTAL1) –**
  These pins are connected to an external oscillator which is generally a quartz crystal oscillator. They are used to provide an external clock frequency of 4MHz to 30MHz

- **Pin 20 (GND) –**
  This pin is connected to the ground. It has to be provided with 0V power supply. Hence it is connected to the negative terminal of the power supply.
- **Pin 21 to Pin 28 (Port 2) –**
  Pin 21 to pin 28 are port 2 pins also referred to as P2.0 to P2.7. When additional external memory is interfaced with the 8051 microcontroller, pins of port 2 act as higher-order address bytes. These pins are bidirectional.
- **Pin 29 (PSEN) –**
  PSEN stands for Program Store Enable. It is output, active-low pin. This is used to read external memory. In 8031 based system where external ROM holds the program code, this pin is connected to the OE pin of the ROM.
- **Pin 30 (ALE/ PROG) –**
  ALE stands for Address Latch Enable. It is input, active-high pin. This pin is used to distinguish between memory chips when multiple memory chips are used. It is also used to de-multiplex the multiplexed address and data signals available at port 0.During flash programming i.e. Programming of EPROM, this pin acts as program pulse input (PROG).

- **Pin 31 (EA/ VPP) –**
  EA stands for External Access input. It is used to enable/disable external memory interfacing. In 8051, EA is connected to Vcc as it comes with on-chip ROM to store programs. For other family members such as 8031 and 8032 in which there is no on-chip ROM, the EA pin is connected to the GND.
- **Pin 32 to Pin 39 (Port 0) –**
  Pin 32 to pin 39 are port 0 pins also referred to as P0.0 to P0.7. They are bidirectional input/output pins. They don't have any internal pull-ups. Hence, 10 K? pull-up registers are used as external pull-ups. Port 0 is also designated as AD0-AD7 because 8051 multiplexes address and data through port 0 to save pins.
- **Pin 40 (VCC) –**
  This pin provides power supply voltage i.e. +5 Volts to the circuit.

APPLICATIONS OF 8051 MICROCONTROLLER

- Even with the development of many advanced and superior Microcontrollers, 8051 Microcontroller is still being used in many embedded system and applications.
- Some of the applications of 8051 Microcontroller are mentioned below:
- Consumer Appliances (TV Tuners, Remote controls, Computers, Sewing Machines, etc.)
- Home Applications (TVs, VCR, Video Games, Camcorder, Music Instruments, Home Security Systems, Garage Door Openers, etc.)
- Communication Systems (Mobile Phones, Intercoms, Answering Machines, Paging Devices, etc.)
- Office (Fax Machines, Printers, Copiers, Laser Printers, etc.)
- Automobiles (Air Bags, ABS, Engine Control, Transmission Control, Temperature Control, Keyless Entry, etc)
- Aeronautical and Space
- Medical Equipment
- Defense Systems
- Robotics
- Industrial Process and Flow Control
- Radio and Networking Equipment
- Remote Sensing