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Unit V

Programmable Logic Controller (PLC) Functions, applications, advantages and disadvantages of PLC over conventional relay controllers, comparison of PLC with process control computer system, factors to be considered in selecting PLC, functional block diagram of PLC, microprocessor in PLC, memory, input and output modules (interface cards), sequence of operations in a PLC, status of PLC, event driven device, ladder logic language, simple process control applications of PLC, Programming examples.

Introduction

PLC is a computer designed for use in machines. It is designed to operate in the industrial environment and is equipped with special Input, Output and a controlled programming language. PLC is event driven device used for turning on & off devices used in industry.

Programmable Logic Controller (PLC) Functions

1. To monitor process parameters and adjust process operations.
2. Process parameters and process operation can be programmed and controlled.
3. Operates any system which has output that turn ON & OFF.

Applications

1. Used in machines tool industry where CNC (computer numerical control) is used
2. Filling and capping of bottles
3. Printing of news papers
4. Assembly of automobiles
5. Petroleum refinery
6. Monitor pressure, Temperature, motor speed and valve status.
7. Sequential control of pressure, temperature and level.

Advantages and disadvantages of PLC over conventional relay controllers

Advantages

1. Flexibility: A PLC can easily run in different electronically controlled production machines.
2. Implementing changes and correcting errors: Alternation of PLC program can be changes without rewiring the system.
3. Large number of contacts: Large number of contacts for each coil is available in its programming.
4. Lower Cost: PLC contain relays, timers, counters and sequencers for controlling the devices.
5. Pilot running: Program can be tested, observed and modified in the laboratory.
6. Visual Observation: Operation and disoperation can be directly visualized on CRT screen by using logic path which light up on as they are energized.
7. Speed of operation: In PLC the operation for controlling the parameters is very fast.
8. Reliability and maintainability: Solid state components with high reliability are used so maintenance cost is low.
9. Security: PLC program cannot be altered unless PLC is properly unlocked.
10. Ease of changes in programming: Program of the PLC can be easily reprogrammed.

Disadvantages

Plc cannot be used in the environment where high heat, electromagnetic interference with electronics devices and vibrations occurs.

Comparison of PLC with process control computer system

The PLC differs from process control computer system on the basic of various parameters which are listed in tabular column in Table I

Table I Comparison of PLC with Data processing computer system

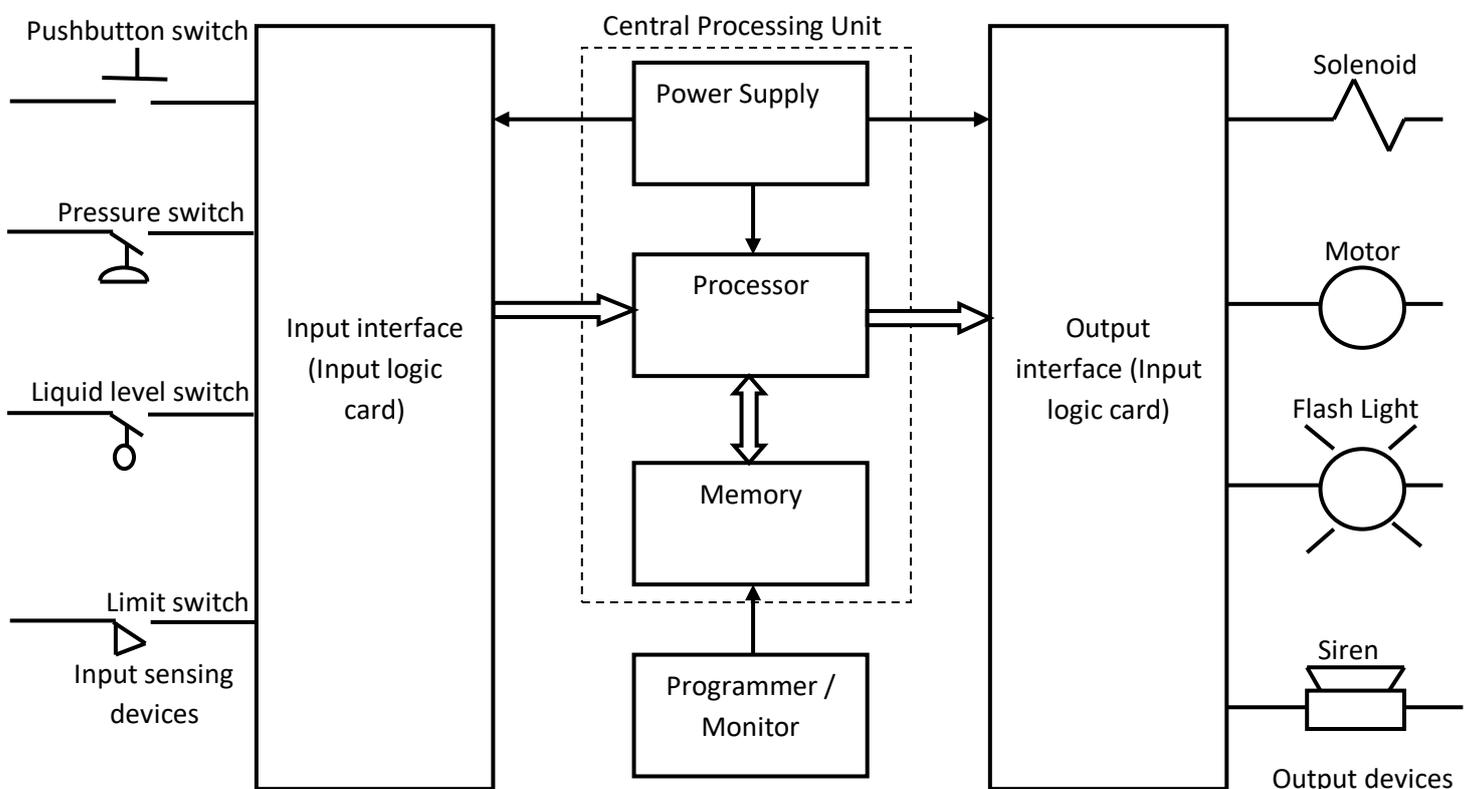
Parameters	Comparison of PLC with process control computer system	PLC
Uses	General propose	Specific purpose to handle industrial process
System driven mechanism	Non event	Event
Input peripherals used	Keyboard, Light pen and mouse	Sensors like light, temperature, motion
Output peripherals used	Video display, Printers and Plotters	Video display, Printer ,Plotters, motors solenoids and heater
Software of PC designed	Different purposes	Particular purposes
Diagnose and trouble shoot	Difficult	Easy
Used for	Batch processing	Real time control systems
Cost	Less	More

Factors to be considered in selecting PLC

1. Flexibility and Expandability: According to the needs of industry PLC input and output increases so the PLC must be used. So while selecting PLC following consideration must be taken into account like memory, input, output and system expansion.
2. Cost: cost is the important factor while selecting the PLC for industry. With Initial cost, installation and maintenance cost is also important.
3. Serviceability and supportability: PLC is equipped with self diagnosis. If any problem occurs during the operation of PLC it can be corrected with minimal effort and time

Functional block diagram of PLC

Figure 1 shows the functional block diagram of PLC system.

**Figure 1 Functional block diagram of PLC system**

Microprocessor in PLC

Microprocessor is a device which is designed to carry out arithmetic and logic operations. The processor or CPU is known as microprocessor because the complex circuitry necessary to do arithmetic and logic operations is fabricated on to a single chip. The microprocessor in PLC receives, analyzes, processes and send data to the output through the output module. The two factors- bit size and clock speed –determines the power of microprocessor. The larger bit size, more powerful the computer. Clock speed determines how quickly a microprocessor can execute instructions. Table II shows the bit size and clock speed of different types of microprocessors.

Microprocessor	Bit Size(bits)	Clock speed(MHz)
8085	8	1
8086	16	4.77
80186	16	8
80286	16	12.5
80386	32	33
80486	32	50
Pentium	32/64	1.2 GHz
Pentium 4	32/64	2.3 GHz

Memory

Computer memory is the space where data to be processed and instructions required for processing are stored. The memory is divided into large number of small parts called cells. Each location or cell has a unique address, which varies from zero to memory size minus one.

RAM (Random Access Memory) is the internal memory of the CPU which is used for storing data, program, and program result. It is a read or writes type of memory which can read data from the memory as well can write the data into the memory. Access time in RAM is independent of the address of memory location. Data can be accessed randomly but it is very expensive. RAM is volatile type of memory which stores data till the power is ON and lost as soon as power is switched off.

ROM stands for Read Only Memory which is non-volatile type of memory. The information is permanently stored in such memory. A ROM stores instructions that are required to start a computer. There are various types of ROMs which are classified as:

1. MROM (Masked ROM)

Masked ROM was hard-wired devices that contained a pre-programmed set of instructions and which are inexpensive.

2. PROM (Programmable Read Only Memory)

PROM is read-only memory that contains small fuses which are burnt open during programming. It can be programmed once and is not erasable.

3. EPROM (Erasable and Programmable Read Only Memory)

EPROM can be erased by exposing it to ultra-violet light. Usually, an EPROM eraser achieves this function, during programming; an electrical charge is trapped in an insulated gate region. For erasing this charge, ultra-violet light is passed through a quartz crystal window (lid). This exposure to ultra-violet light dissipates the charge.

4. EEPROM (Electrically Erasable and Programmable Read Only Memory)

EEPROM is programmed and erased electrically. It can be erased and reprogrammed about ten thousand times. In EEPROM, any location can be selectively erased and programmed. EEPROMs can be erased one byte at a time, rather than erasing the entire chip. Hence, the process of reprogramming is flexible but slow.

Advantages of ROM

The advantages of ROM are as follows –

- Non-volatile memory
- Cheaper than RAM
- Easy to test

- More reliable than RAM
- Static and do not require refreshing

Input and output modules

Input modules

The addressing format of an input module in figure 2:

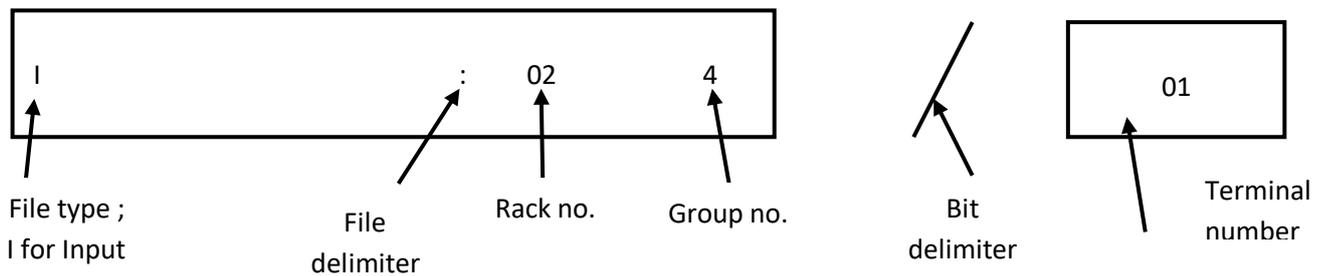


Figure 2 Addressing format of an input module

File type: Specify the input/output module I for input and O for output.

Rack number: This determines the particular rack in which the module sits in.

Group number: It is a set of terminals within a rack. There are 8 groups in a rack.

Terminal number: This is a bit address for a particular terminal.

Functions of I/P module:

1. Senses the input signal from sensors.
2. Convert AC input to its DC equivalent level.
3. Opto isolator is used to transfer DC signal.
4. Input module produces an output voltage by output logic.

Output modules

The addressing format of an output module in figure 3:

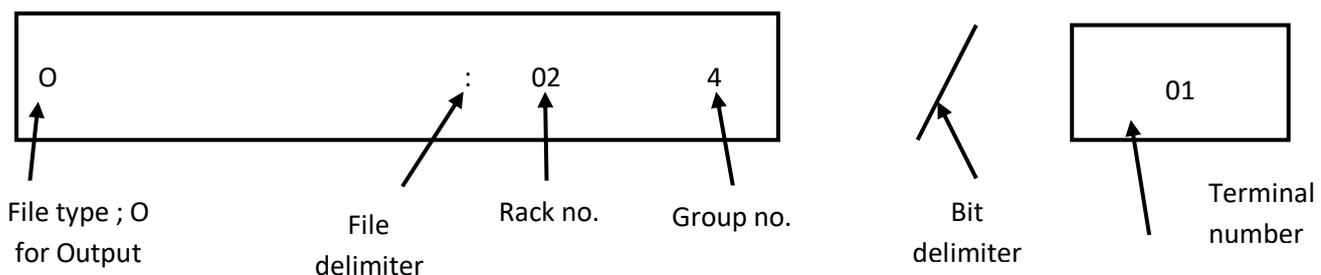


Figure 3 Addressing format of an output module

Functions of O/P module:

1. Receive digital signal from Processor
2. Isolate CPU signal by isolator
3. Converts the output signal into Dc or AC which is desirable for output devices.
4. Output module drives the load.

Both input and output can be categories into two basic types:

1. Logical Light bulb can be used to turn On-Off and it is logical control.
2. Continuous: Light can be dimmed to different levels.

Power supply

Covers the AC supply into various DC voltages

Necessity of Using Opto isolator: The figure 4 shows the circuit diagram of Opto isolator.

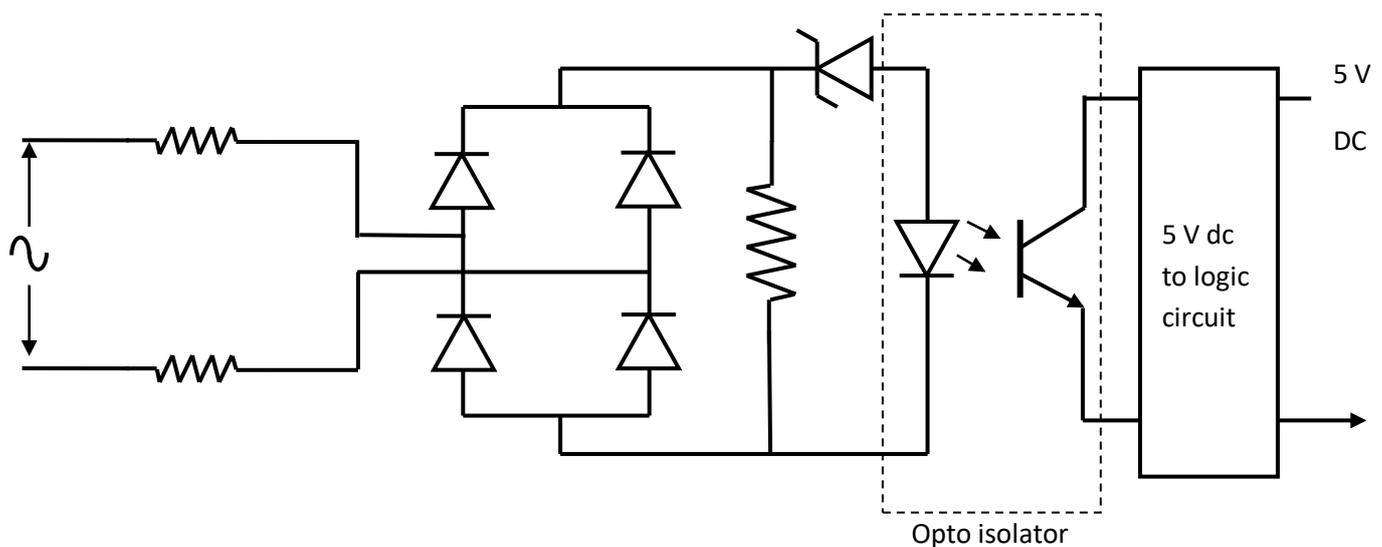


Figure 4 shows the circuit diagram of Opto isolator

If rectifier gets short circuited the 230 v AC supply voltage could be fed to the CPU resulting in CPU damage but Opto isolator protects the CPU from such type of damage.

Programming Device:

It provides the primary means for user to communicate with the circuit of the PLC. Allow user to enter, edit and monitor programs by connecting the processor unit and allow access to the user memory. Programming unit communicates with the processor via a serial or parallel data communication link.

Sequence of operations in a PLC

When a process is controlled by a PLC, it uses inputs from sensors to make decisions and update outputs to drive actuators as shown in figure 5.

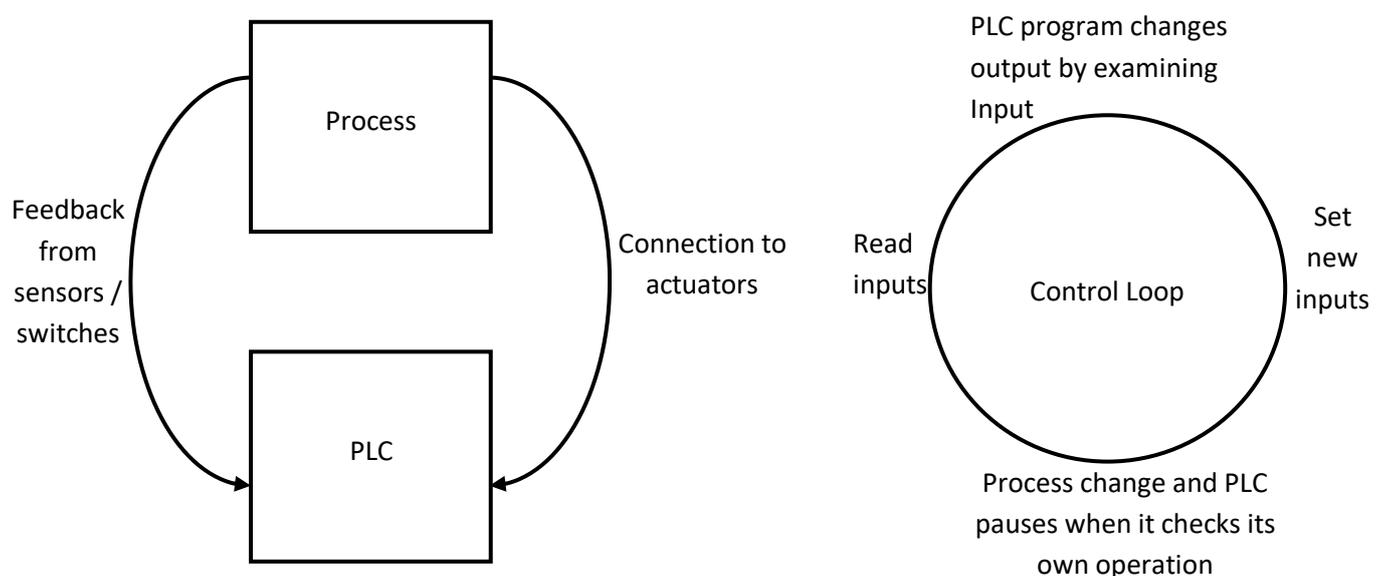


Figure 5 Basic operation of a PLC

Status of PLC

On the front panel of the PLC there are normally limited status lights. Common lights indicate the following:

Power ON: It is ON when the PLC is powered

Program running: when the program is running it indicates light.

Fault: This will indicate when the PLC has experienced a major hardware or software.

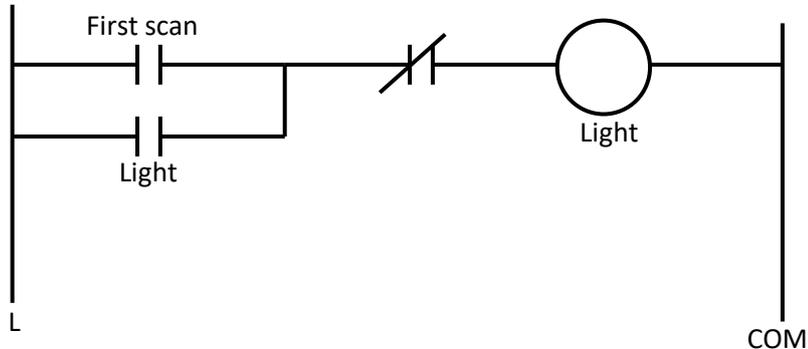


Figure 6 Program that checks for the first scan of the PLC

The status of the PLC can be detected by ladder logic also. It is common for programs to check to see if they are being executed for the first time as shown in figure 6. The first scan input will be true when the first ladder is scan. So light will be turned on when the PLC is turned on.

Event driven device

Highly complex system cannot be controlled with combinational logic. The main reason for this is that it is not possible to add sensors to detect all conditions. In these cases event can be estimated the condition of the system. The figure 7 shows an event based device of the PLC. Events used by the PLC include the following:

First scan of the PLC: this indicates that the PLC has just been turned ON.

Time since on input turned ON/Off: A delay

Count of event: To wait until a set number of events have occurred

Latch ON or unlatch: To lock something On or Off

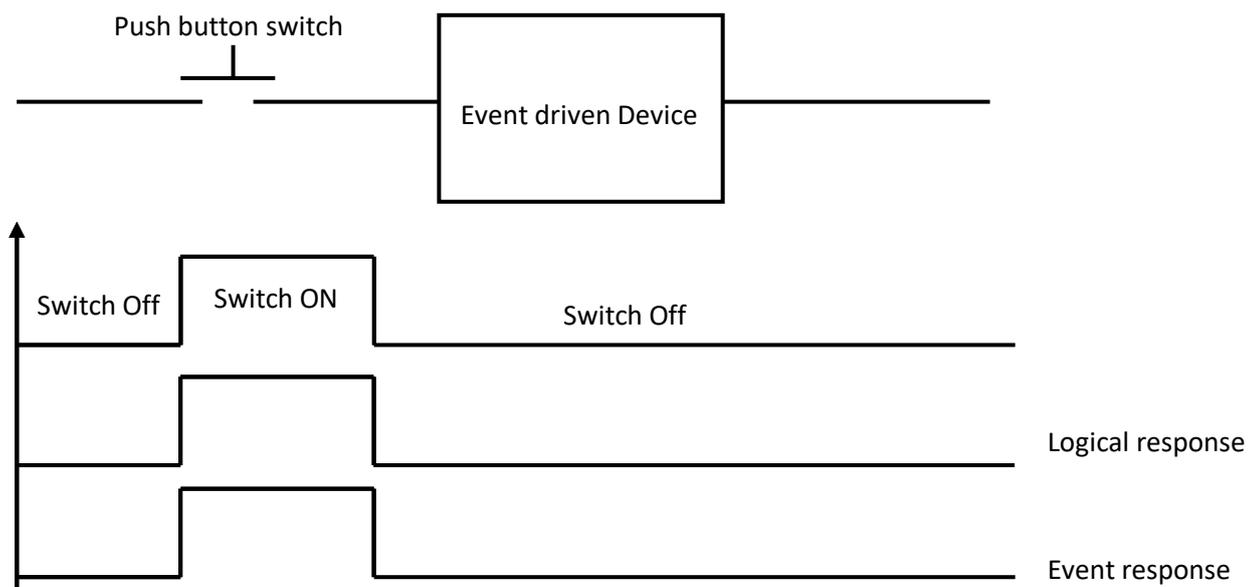


Figure 7 an event based device of the PLC

Ladder logic language

PLC programs are typically written on a personal computer, and then downloaded to the PLC. The program is stored in non-volatile flash memory. Often, a single PLC can be programmed to replace thousands of relays. A graphical programming notation called Sequential Function Charts is available on certain programmable controllers. Initially most PLCs utilized Ladder Logic Diagram Programming, a model which excites electromechanical control panel devices such as coils of relays which PLCs replaced. This technique emphasizes logical organization of operations. While the fundamental concepts of PLC programming are common to all manufacturers, differences in I/O addressing, memory organization and instruction sets mean that PLC programs are never perfectly interchangeable.

Simple process control applications of PLC

Example 1: figure 8 shows an example where a mixer motor is used to automatically stir the liquid in a vat when the pressure and temperature reaches a preset value. Direct manual operation is provided by means of pushbutton switch. The process is monitored with temperature and pressure sensors that close their respective contacts when a condition reaches their preset values. In the relay method of motor control the starter coil M of the motor is energized when both the pressure and temperature switches are closed when the push button is closed.

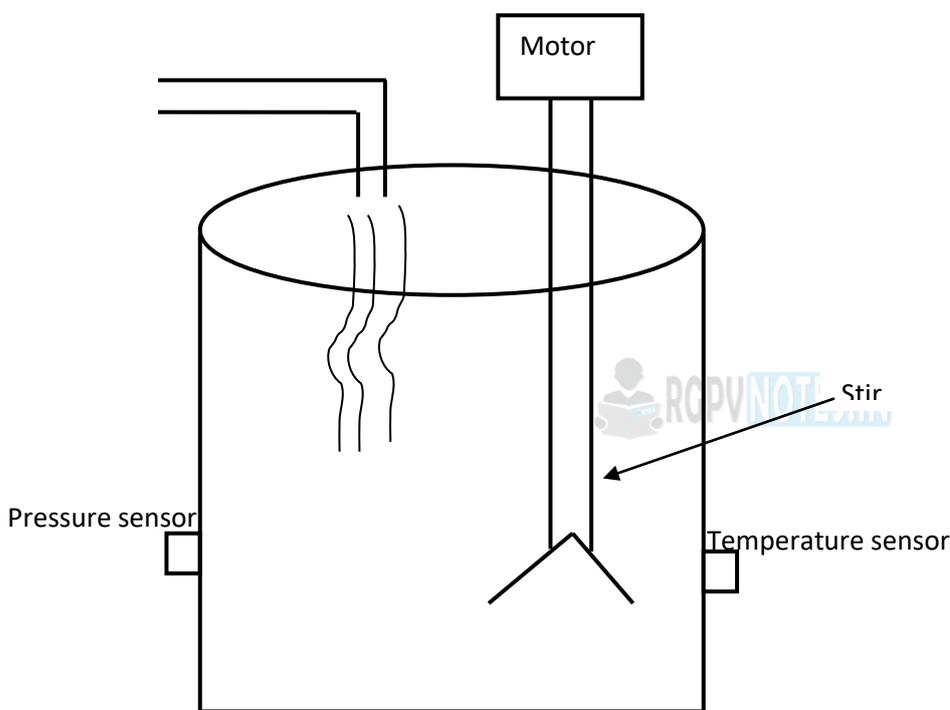


Figure 8 Container with stir and motor

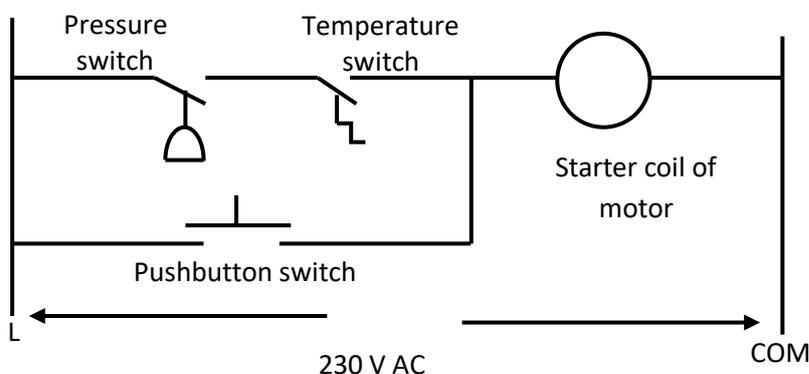


Figure 9 Relay logic diagram for Automatic control of stir motor

Figure 9 shows the relay logic diagram for automatic control of stir motor when both the switches are closed. For such type of relay logic diagram two sensor switches are connected in series with starter coil of motor when it is to be control in automatic mode. The same process can be controlled in manual manner

with the help of pushbutton, which is connected in parallel with both the switches. The whole system is operated with the help of AC power supply. Figure 10 shows the PLC ladder diagram for above given problem.

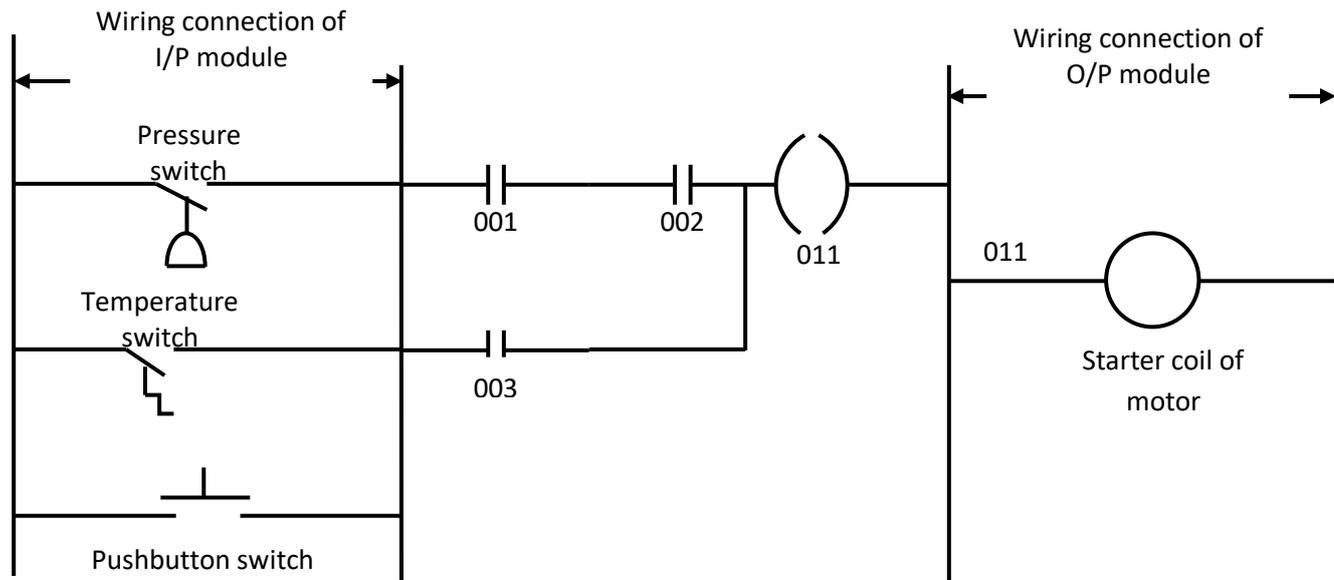


Figure 10 PLC ladder diagram

To operate the program, the controller is placed in the run mode, during each operating cycle; the controller examines the status of the input devices, executes the program and changes the output accordingly. When 001,002 or 003 are closed, the coil 011 is energized. Either of these conditions provides a continuous path from left to right across the rung that includes the coil shown in figure 10.

Programming examples

Implementation of various Logic Gates AND & OR in PLC using Ladder Diagram programming language.

AND Gate

AND gate has two inputs which are connected in series and one output which is connected in series with both the inputs, both inputs acts as open switch. When both the inputs are high the A and B contacts are acts as a closed switch results high output. The implementation of AND gate using Ladder program is shown in figure 11.

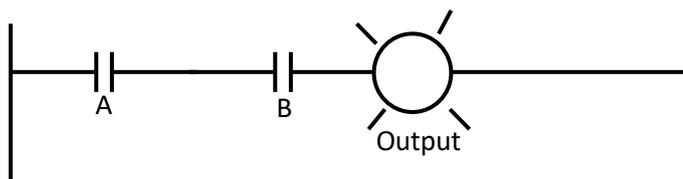


Figure 11 AND gate implementation using ladder program

OR Gate

OR gate has two inputs which are connected in parallel and one output which is connected in series with both parallel inputs, both inputs acts as open switch. When both or one of the input is high then the A or B or both contacts acts as a closed switch results high output. The implementation of OR gate using Ladder program is shown in figure 12.

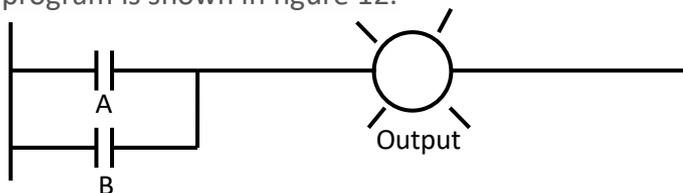
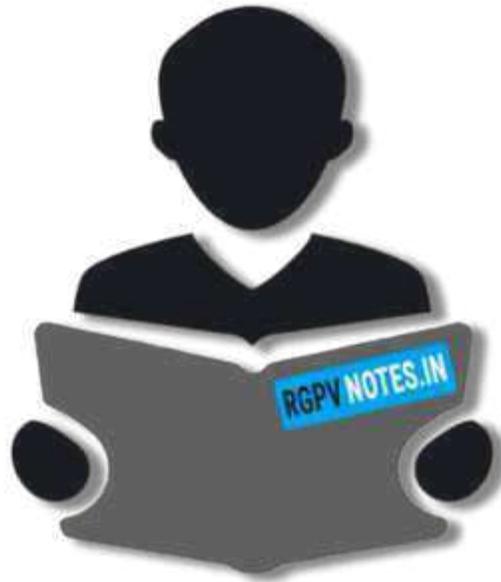


Figure 12 OR gate implementation using ladder program



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