INTRODUCTION

PLC is a specialized digital computer used for automation of electromechanical processes. In this chapter, we will discuss in detail about the architecture of the PLC and the basic principle of its operation.

2.1 PLC ARCHITECTURE

A PLC is a specialized computer and has all the basic parts of a computer central processing unit, memory, input/output interfacing. Figure 2.1 shows the block diagram of a PLC which has following blocks :

1. Central Processing Unit (CPU)
2. Memory
3. Input Module
4. Output Module
5. Programmer/Monitor
6. Racks and Chassis

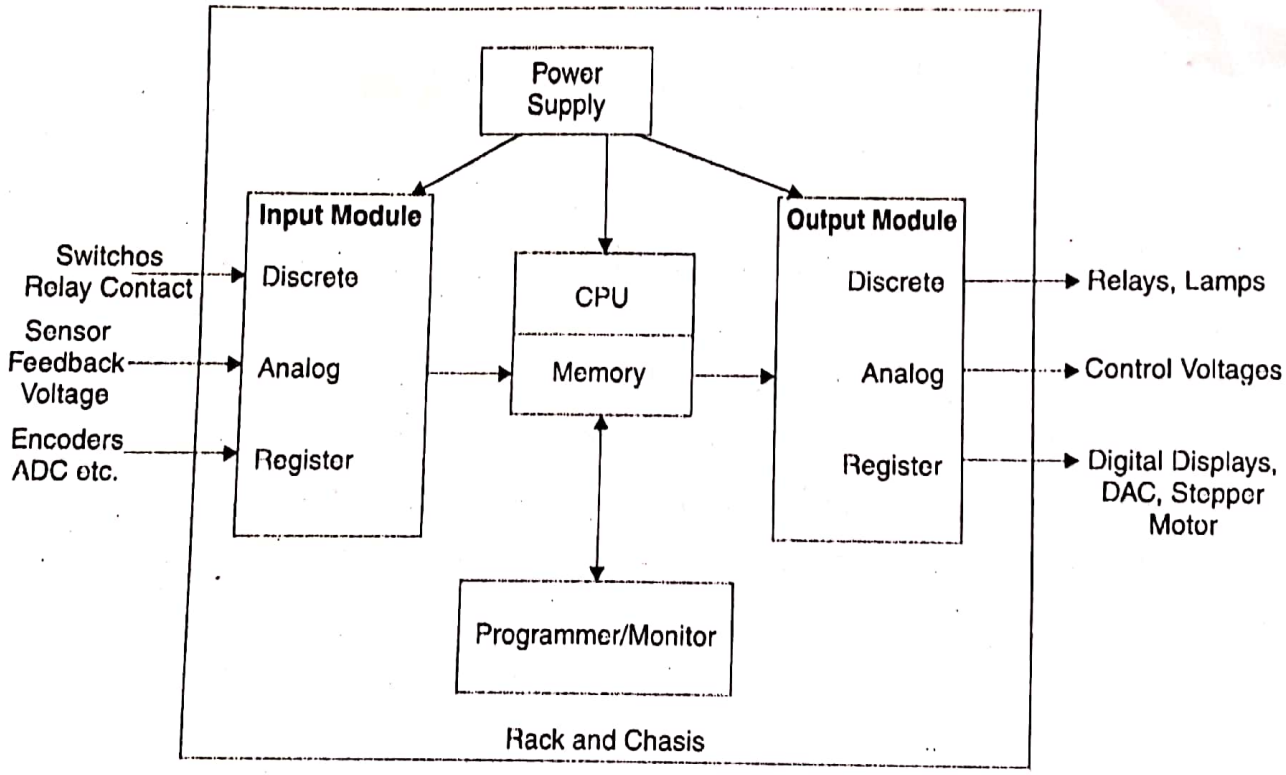

Fig. 2.1 : PLC Block Diagram

2.1.1 Central Processing Unit (CPU)

The CPU also called processor module is the brain of PLC. It controls the functions and sequences of operation of all the blocks of PLC. It is responsible for all the arithmetic and logical operations of data as per ladder program instructions. A PLC CPU may have less powerfull 8 bit/16 bit microprocessor like 8085, 8086, Z80 or may have high speed 64 bit pentium. Many small PLCs have a microcontroller instead of a microprocessor which have microprocessor, I/O interface, RAM and ROM all in one chip. Program scan time depends upon CPU speed.

2.1.2 PLC Memory

PLC memory is used to store monitor program (operating system), user ladder program, status of I/O devices, pre-assigned values for timers/counters etc. in binary (1s and 0s) form. The types of solid state memory chips used in PLCs are RAM, ROM, PROM, EPROM, EEPROM and NOVRAM. Electrically Eraseable Programmble Read-Only Memory (EEPROM) has advantage over EPROM is ease and speed with which it can be erased and reprogrammed. Non-volatile RAM (NOVRAM) is a combination chip. It is a combination of an EEPROM and a RAM and is widely used in PLCs. When the power is about to go off, the contents of RAM memory are quickly stored in the EEPROM. The stored data can then be read into the RAM when the power is again restored. Normally a PLC has solid state memory from 1 to 256 KB, most of which is RAM.

PLC Memory Organisation : The solid state memory within PLC can be divided into two broad categories :

- User Memory (or Program File Memory)
- Storage Memory (or Data File Memory)

Program File Memory : Program file memory contains System Program File, Main Laddar Program, interrupt subroutines and subroutine programs files. System program file contains various system related information and user- program information such as processor type, input/output configuration, processor file-name and password. Main ladder program file contains user-programmed instructions defining how the controller is to operate. There can be user created subroutine Ladder Program files which are accessed according to subroutine instructions present in the main ladder program file.

A large portion of the total memory (75% or more) is occupied by program file memory. While downloading from the programming device, program files are copied into RAM with a copy in EEPROM.

Data File Memory (or Storage Memory) This memory area is normally organised as 16-bit word registers. It stores information needed to carryout the user program like the states of discrete input and output devices, the present and accumulated values of counters and timers, numerical values, shift register and sequencer files, internal input/output relay equivalents etc.

Figure 2.2 shows Data File memory map of a typical PLC. This Data File Memory (or storage memory) stores following types of data files :

- **Output Image Status File :** This file stores 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 stores the status of the input terminals for the controller.
- **Status File :** This file stores controller operation status, error codes, arithmetic status bits, etc. This file is usefull 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 stores the counter status bits, present 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 instructions such as shift registers and sequencers.
- **Integer Data File :** This file stores numeric constants/value or bit information.
- **Floating Point File :** Some PLCs can also use floating point values. This file is used to store numeric values in floating point notation.
- **User Defined File :** This memory area can be used by the user for any of the above type of files. Some PLCs can work with string and ASCII data values which are also defined in this area.

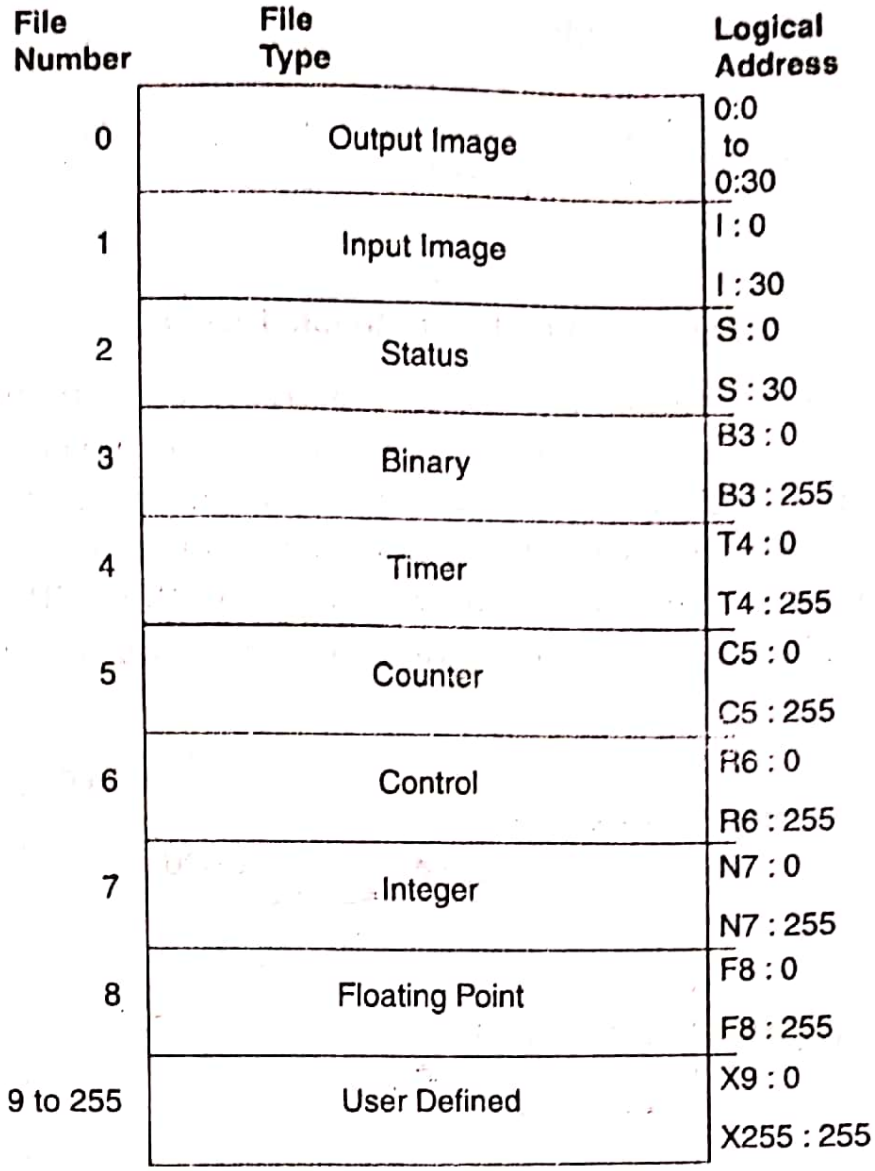

Fig. 2.2 : Data File Memory Map

2.1.3 Input/Output Modules

The I/O modules work as an interface between the processor (CPU) and the real world devices like switches, lamps, contactors, etc. attached to the PLC. These I/O modules can be divided into three categories :

- **Discrete I/O Modules**
- **Analog I/O Modules**
- **Register I/O Modules**

Discrete I/O Modules are generally capable of handling 4, 8 or 16 ON-OFF type inputs or outputs per modules. The inputs and outputs of the module can be specified as AC only, DC only, or AC/DC type alongwith the voltage values for which it is designed.

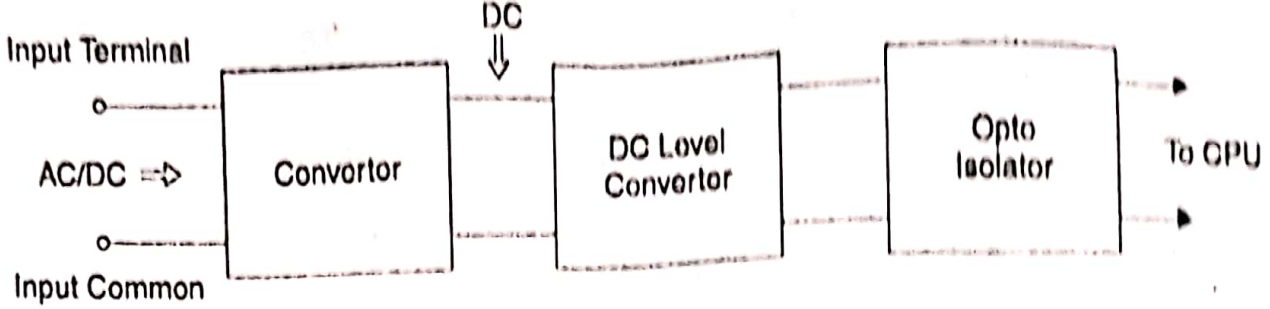

Fig. 2.3 : PLC Input Module Layout

Each discrete input terminal is associated with one bit of Input Image file. The input module senses the input signals at each of its input terminals and converts this signal to DC level suitable for next section. Then input module carries out isolation of inputs from CPU with the help of opto isolators to protect the CPU. Figure 2.4 shows Input Modules with 4 discrete inputs to PLC. CPU scans all inputs during input scan and stores the result in Input Image Status Word assigned to this input module.

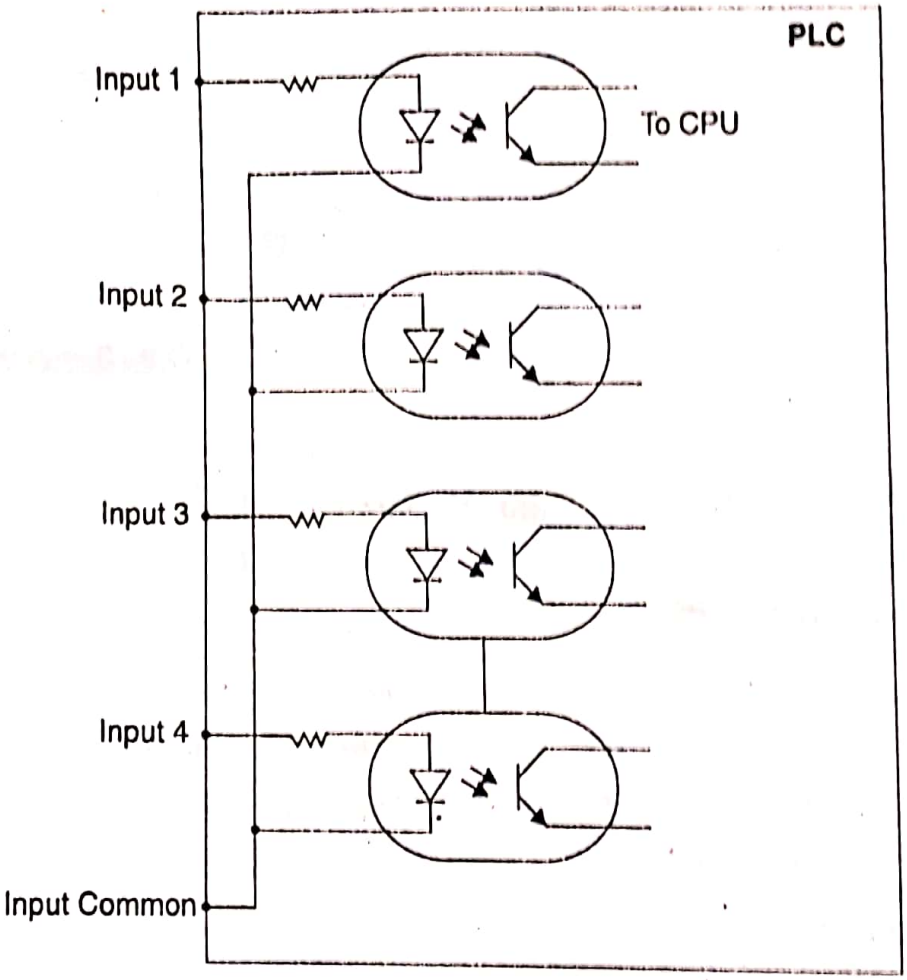

Fig. 2.4 : PLC Input Module

The output module operates in opposite manner from the input module. Like input module, an output module may have 4, 8, or 16 output terminals for discrete outputs. A signal from CPU is received by the output module logic during output scan. This signal then goes through an isolation stage to protect the CPU from any

voltage surge from the output device back into PLC. The isolator output is then fed to switching circuitry or an output relay.

AC switching is usually done by turing on a triac. The output of module may be through a relay, or a DC or a AC output. Each discrete output terminal is associated with one bit of output status register.

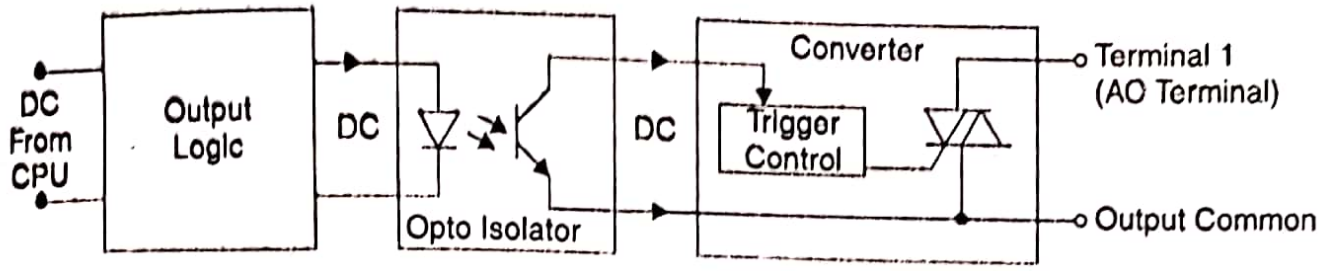

Fig. 2.5 : PLC Output Module Layout

Analog input and output modules can receive and provide analog signals directly and are specified according to the desired resolution and voltage/current range. Analog modules (TC) that can directly accept thermocouple inputs for temperature measurement/monitoring are also available. Input modules converts analog input into digital with the help of ADC converters and CPU stores digital data into storage memory. Similarly, the analog output module receives digital data (multibits per terminal of output module) from CPU and converts it into analog signal with the help of DAC converter.

Register input and output modules transfer 8 or 16 bits of information to and from the PLC. The input/output information is generally in the form of BCD numbers. Other types of modules may also be available depending upon the manufacturer of the PLC and its capabilities. These include specialized communication modules to allow transfer of information from one controller to another.

2.1.4 Programmer/Monitor

The programmer/monitor unit allows the engineer/technician to enter, edit and check the ladder program to be executed. The programming units are of three types :

- **Hand Held Units**
- **Full-size Programmer/Monitor**
- **Personal Computer (PC)**

Hand held PLC programmes are palm-size units with dual function keypads (like in calculators) and liquid crystal display (LCD). Due to compact and lightweight, these are easy to carry and are usefull for modification/monitoring of

PLC ladder programs at work place. Due to small size, these have limited display and editing facilities.

Full size Programmer/Monitor has a complete keyboard and a large monitor which may be Liquid Crystal Display or Cathod-Ray Tube (CRT) Screen. Because of its large size display, it can show considerable amount of display at a time, and are more user friendly. Both Hand Held and Full size Programmer/Monitor are dedicated device for programming PLC. These device communicate with the PLC through a cable connected to a special programming port on the PLC.

Personal Computers are also used for programming PLC using specialised PLC programming softwares. Normally a PC communicates with PLC through a serial port. Programming through PC provides more facilities and memory to store large numbers of ladder programs. PLC simulators are also available for PC for testing of programes.

2.1.5 Power Supply

The PLC has two section of power supplies : Internal Power Supply and External Power Supply. Internal power supply provides supply to CPU module. This section normally requires a +5V and –5V DC supply and should be highly regulated. External power supply section feeds supply to I/O modules were power supply requirement depends upon types of interface provided by the PLC. This section may require +5V, +24V, +120V DC supply as well as AC supply. Figure 2.6 shows block diagram of PLC Power Supply. Rectifier block converts AC supply into pulsating DC. Next Filter block converts this pulsating DC into pure DC. Regulator section regulates the DC supply so that its output voltage is not affected by input voltage and load variations.

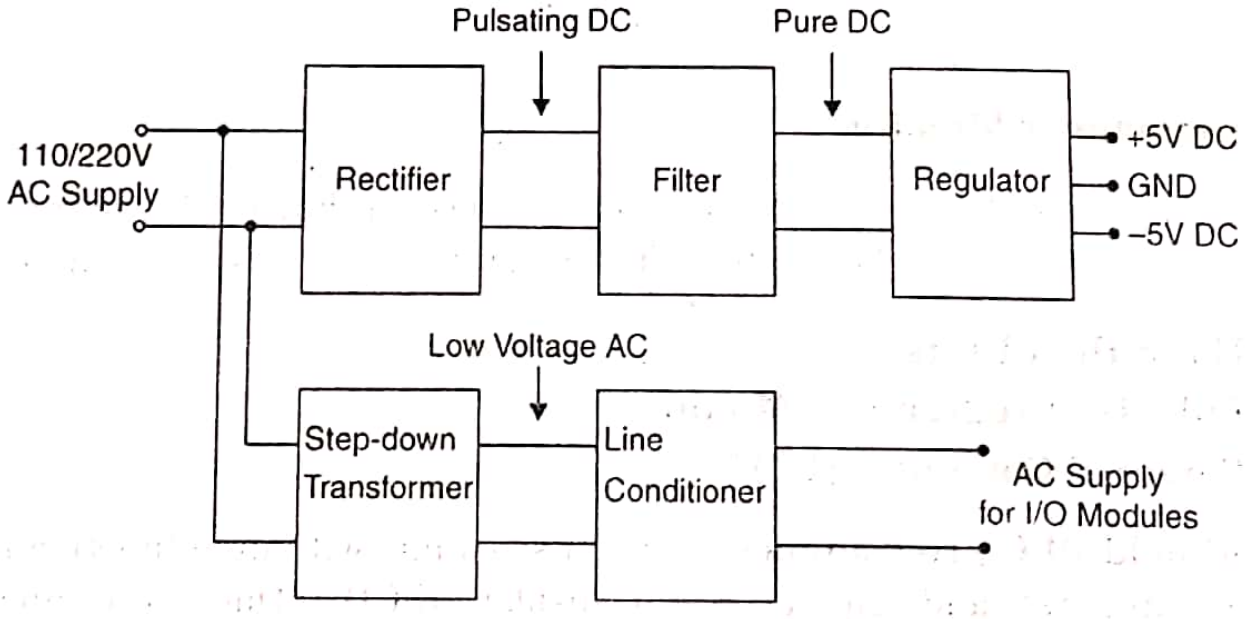

Fig. 2.6 : PLC Power Supply

2.1.6 Racks and Chassis

In smaller PLCs, the input and output terminals may be included on the same frame of the CPU. In larger PLC systems, the input and output modules are separate units. These I/O modules are placed in groups on racks and rack are connected to CPU via appropriate connectors.

Rack is usually a metal framework with a printed circuit board backplane on which PLC I/O modules and processor module are mounted. The mounting rack provides data path and power connections to the processor and I/O modules through the backplane PCB. These racks can be interconnected to accommodate a large number of I/O modules. The racks are then installed in a chassis.