Programmable Logic Controller (PLC)

Third Year-Mechatronics Eng.

Lecturer
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1- Introduction to PLC:

Definitions and characteristic functions of a PLC

2- Description of PLC Software:

Processor software, user software, Language

3- PLC Architecture:

Central processing unit (CPU), power supply, Input/output system, Input/output modules

4- Description of Basic PLC Functions & Examples

5- PLC Programming Devices:

Man Machine Interface, PLC Communications

6- Reliability:

Noise immunity, Availability

References:

1. L.A. Bryan and E.A. Bryan, "Programmable Controllers: Theory and Implementation", Second Edition, 1997 by Industrial Text Company.
2. S. Brian Morriss, "Programmable Logic Controllers", 2000 by Prentice-Hall, Inc.
3. John R. Hackworth and Frederick D. Hackworth, Jr., "Programmable Logic Controllers: Programming Methods and Applications".
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Introduction to PLC

Before the advent of solid-state logic circuits, logical control systems were designed and built exclusively around electromechanical relays. A relay control panel is comprised of a single to thousands of relays. Relays are far from obsolete in modern design, but have been replaced in many of their former roles as logic-level control devices, relegated most often to those applications demanding high current and/or high voltage switching.

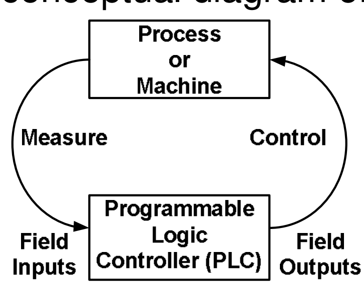
Systems and processes requiring " on/off " control abound in modern commerce and industry, but such control systems are rarely built from either electromechanical relays or discrete logic gates. Instead, digital computers fill the need, which may be programmed to do a variety of logical functions.

1-1. The Role of the Programmable Logic Controllers (PLC)

Programmable logic controllers, also called *programmable controllers* or *PLCs*, are **solid-state** members of the computer family, using integrated circuits instead of electromechanical devices to implement control functions. They are capable of storing instructions, such as sequencing, timing, counting, arithmetic, data manipulation, and communication, to control industrial machines and processes.

In an automated system, the PLC is commonly regarded as the heart of the control system. With a control application program (stored within the PLC memory) in execution, the PLC constantly monitors the state of the system through the field input devices' feedback signal. It will then depend on the program logic to determine the course of action to be carried out at the field output devices.

Figure 1-1 illustrates a conceptual diagram of a PLC application.



(Figure 1-1) PLC conceptual application diagram

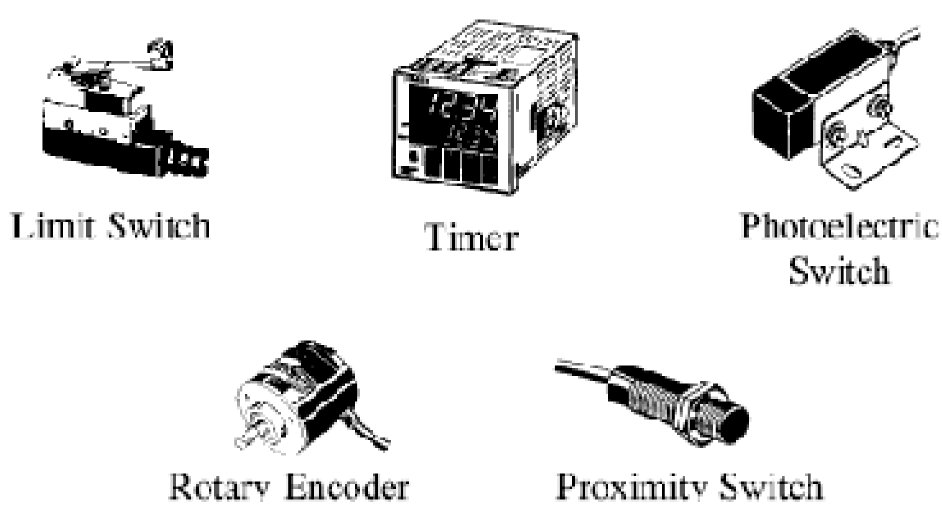
The PLC may be used to control a simple and repetitive task, or a few of them may be interconnected together with other host controllers or host computers through a sort of communication network, in order to integrate the control of a complex process.

Programmable controllers have many definitions. However, PLCs can be thought of in simple terms as industrial computers with specially designed architecture in both their central units (the PLC itself) and their interfacing circuitry to field devices (input/output connections to the real world).

a) **<u>Input Devices</u>**

Intelligence of an automated system is greatly depending on the ability of a PLC to read in the signal from various types of automatic sensing and manual input field devices.

Push-buttons, keypad and toggle switches, which form the basic man-machine interface, are types of manual input device. On the other hand, for detection of work-piece, monitoring of moving mechanism, checking on pressure and or liquid level and many others, the PLC will have to tap the signal from the specific automatic sensing devices like proximity switch, limit switch, photoelectric sensor, level sensor and so on. Types of input signal to the PLC would be of ON/OFF logic or analogue. These input signals are interfaced to PLC through various types of PLC input module.

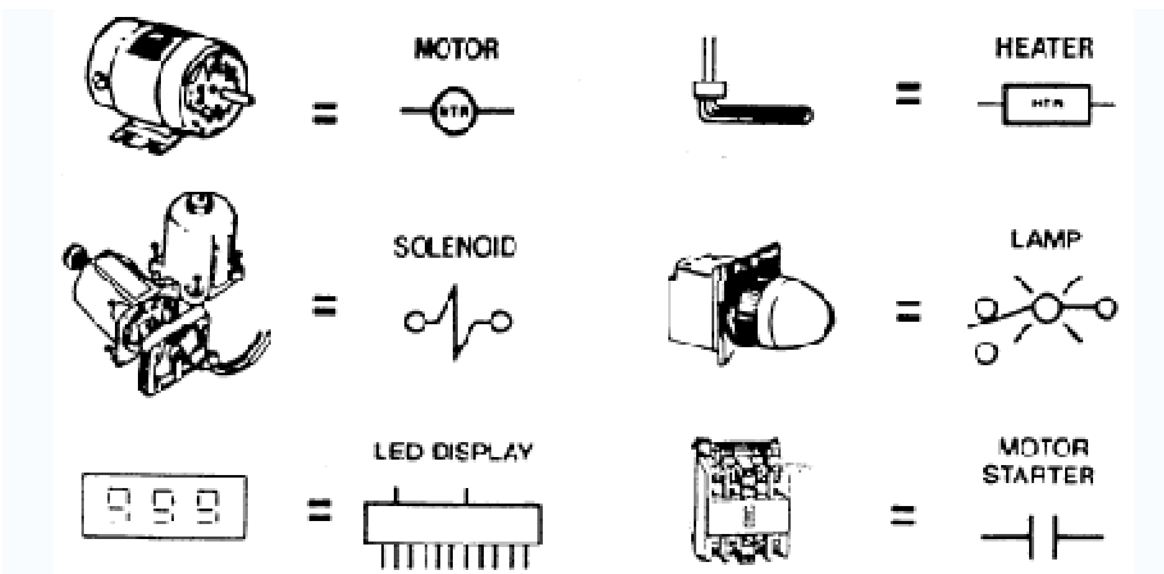


(Figure 1-2) Input devices

b) **Output Devices**

An automatic system is incomplete and the PLC system is virtually paralyzed without means of interface to the field output devices. Some of the most commonly controlled devices are motors, solenoids, relays indicators, buzzers and etc. Through activation of motors and solenoids the PLC can control from a simple pick and place system to a much complex servo positioning system. These type of output devices are the mechanism of an automated system and so its direct effect on the system performance.

However, other output devices such as the pilot lamp, buzzers and alarms are merely meant for notifying purpose. Like input signal interfacing, signal from output devices are interfaced to the PLC through the wide range of PLC output module.



(Figure 1-3) Output Devices

1-2. **Characteristic Functions of a PLC**

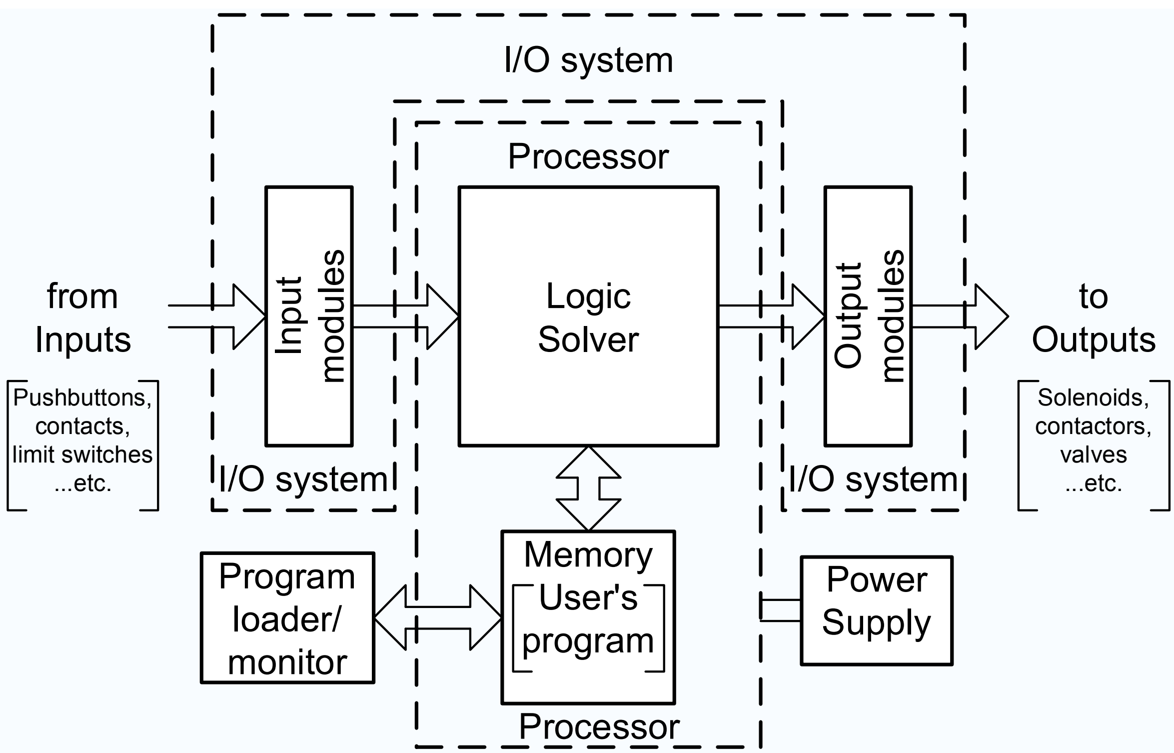
A programmable controller is currently defined by the National Electrical Manufacturers Association (NEMA) as a digital electronic device that uses a programmable memory to store instructions and to implement specific functions such as logic, sequence, timing, counting, and arithmetic to control machines and processes. However, this definition is so broad as to encompass nearly every solid-state device used in manufacturing, from a simple timer to a mainframe computer. Instead of this definition it is more useful to examine **the most important and essential characteristics of a PLC that portray its unique aspects which are:**

1) **It is field programmable by the user**. This characteristic allows the user to write and change programs in the field without rewriting or sending the unit back to the manufacturer for this purpose.
2) **It contains programmed functions**. PLCs contain at least logic, timing, counting, and memory functions that the user can access through some type of control-oriented programming language.
3) **It scans memory and inputs and outputs (I/O) in a deterministic manner**. This critical feature allows the control engineer to determine precisely how the machine or process will respond to the program.
4) **It provides error checking and diagnostics**. A PLC will periodically run internal tests of its memory, processor, and I/O systems to ensure that what it is doing to the machine or process is what it was programmed to do.
5) **It can be monitored**. A PLC will provide some form of monitoring capability, either through indicating lights that show the status of inputs and outputs, or by external device that can display program execution status.
6) **It is packaged appropriately**. PLCs are designed to withstand the temperature, humidity, vibration, and noise found in most factory environments.
7) **It has general purpose suitability**. Generally a PLC is not designed for a specific application, but it can handle a wide variety of control tasks effectively.

1-3. **PLC Basics**

A PLC consists of a Central Processing Unit (CPU) containing processor, executive memory and application memory, Input and Output Interfacing modules, which are directly connected to the field I/O devices. The program controls the PLC so that when an input signal from an input device is turned on, the appropriate response is made. The response normally involves turning on or off an output signal to some sort of output devices.

A simplified model of a PLC is shown in Figure 1-4. The input modules convert the high-level signals that come from the field devices to logic-level signals that the PLC's processor can read directly. The logic solver reads these inputs and decides what the output states should be, based on the user's program logic. The output modules convert the logic-level output signals from the logic solver into the high-level signals that are needed by the various field devices. The program loader is used to enter the user's program into the memory or change it and to monitor the execution of the program.



(Figure 1-4) A PLC Block Diagram

The previous PLC Block Diagram, illustrating its basic functionality. The control engineer (user) enters the control program on the program loader. The program loader writes this program into the memory. The logic solver reads the states of the sensors through the input modules, then uses this information to solve the logic stored in the user memory (program) and also writes the resulting output states to the output devices through the output modules.

1-4. Construction of a PLC

Some PLCs are integrated into a single unit, whereas others are modular. **Integrated PLCs** are sometimes called **shoebox** or **brick PLCs** because of their small size. If an integrated PLC is available with the capabilities that a user needs, it is usually the most economical option. **Modular PLCs** consist of optional components required for a more complex control application, as selected and assembled by the user.

The **Modular PLCs** include the following components, as demonstrated in Figure 1-5:

1- The CPU module, containing the CPU and its memory.

2- Input and output modules (I/O modules), to allow the PLC to read sensors and control actuators.

3- A power supply module, to provide power to the CPU and often to provide power to drive sensors and low-power actuators connected to I/O modules.

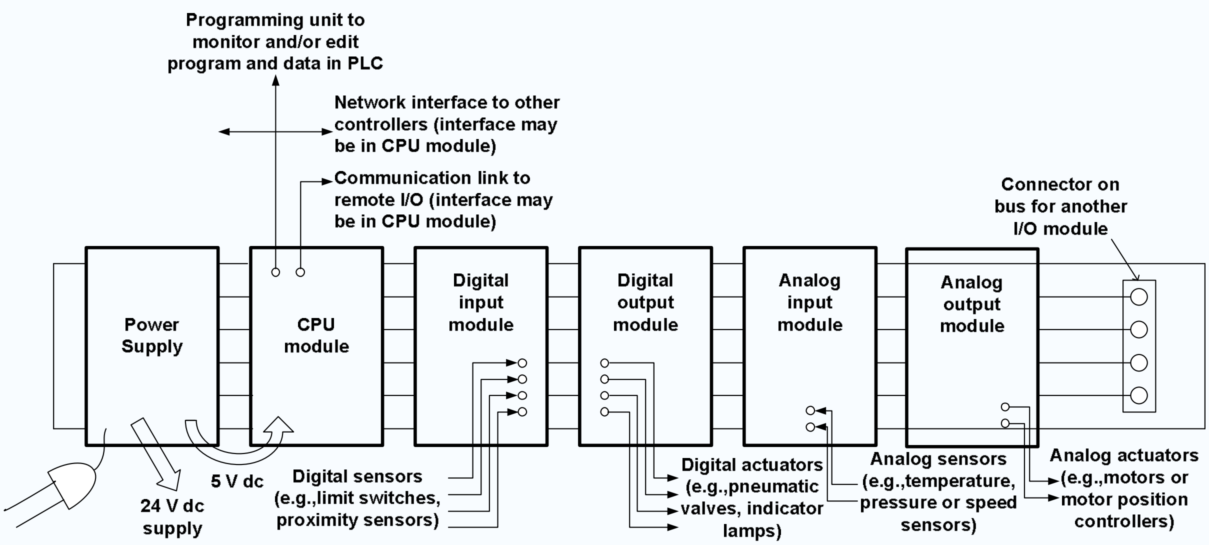
4- A rack or bus, so that the CPU module can exchange data with I/O modules. In some PLCs, this component isn't required because each module plugs directly into its neighboring module.

A PLC system with these components is all that is needed to control an automated system. Since a PLC must be programmed before it can be used, another component is required:

- A **programming unit** is necessary to create the user-program and send it to a PLC CPU module's memory.

Additional optional PLC components are often available, including:

- **Communications adapters for remote I/O**, so that a central controller can be connected to remote sensors and actuators.
- **Network interfaces** to allow interconnecting of PLCs and/or other controllers into distributed control systems.
- **Operator interface** devices to allow data entry and/or data monitoring by operators.



(Figure 1-5) Modular PLC in an automated system

Questions

1. What are the most important and essential characteristics of a PLC that portray its unique aspects?
2. Draw the PLC block diagram and explain the job of each component briefly.
3. Draw the Modular PLC and explain the job of each component briefly.

Description of the PLC Software

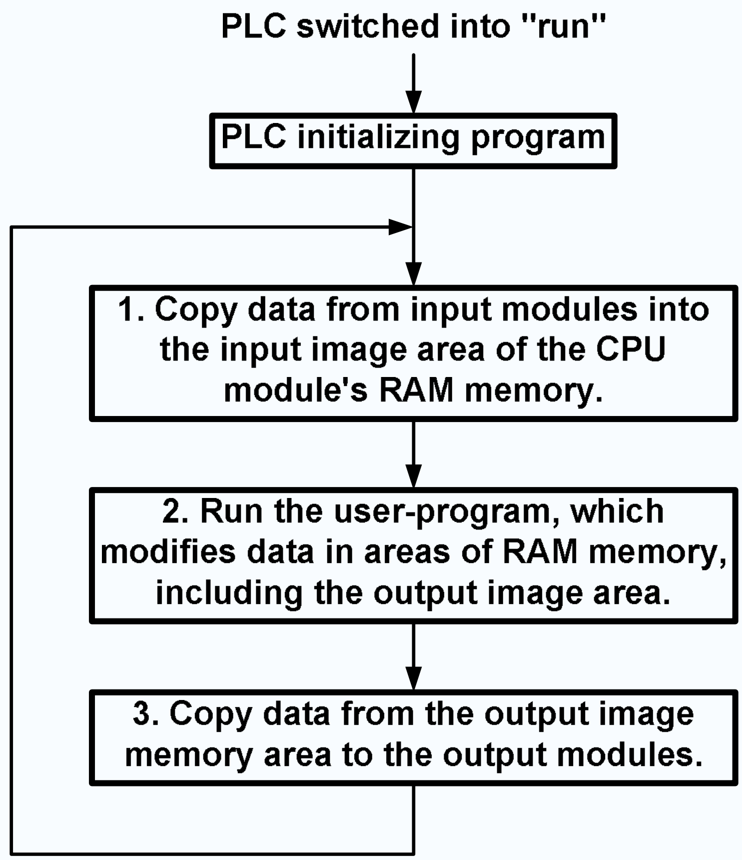
2-1. Operating System and Application Programs

The CPU module of a PLC comes with a very different operating system program than those used in most other computers, and comes complete with application programs programmed into the CPU's memory. **The operating system program causes the PLC to start when power is turned on, to run the user-program when the PLC is switched into run mode, and to respond to the user commands by running the appropriate application programs.** The application programs allow the user to enter programs and data into the PLC's memory. Some Parts of the user accessible memory are retained even when the PLC's power is disconnected.

A PLC retains its operating system, application programs, user programs, and some data in retentive memory (sometimes called nonvolatile memory) while the PLC is tuned off and even when disconnected from the power supply. A PLC can therefore resume running a user program as soon as power is restored, although PLCs are often programmed to require some operator action before restarting (for safety reasons).

The PLC operating system makes the PLC run user-programs very differently from the way other computers run user-programs. A PLC operating system executes an initialization step once each time it is put into run mode, and then repeatedly makes the PLC executes a scan cycle sequence as long as the PLC remains in run mode. This basic scan cycle inherent in all PLCs is shown in Figure 2-1.

Every time the PLC finishes one scan cycle and starts another, the operating system also restarts a **watchdog timer**. The watchdog timer runs while the scan cycle executes. If the watchdog timer reaches its pre-set value before being restarted (if a scan cycle takes unusually long to complete), the PLC will immediately fault, and stop running. After faulting, the PLC usually needs operator intervention before it can resume running.



(Figure 2-1) Standard PLC Scan Cycle

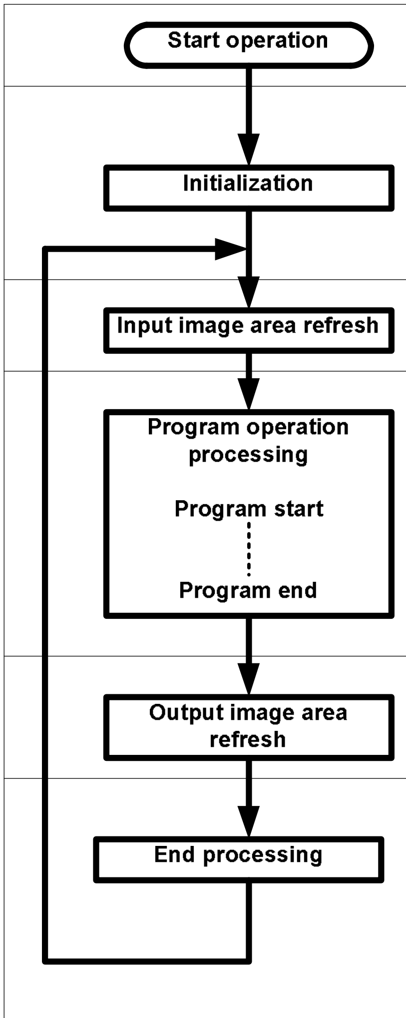
2-2. PLC User-Programs

User programs are not part of the preprogrammed set of programs purchased with the PLC. They must be entered into a PLC's RAM memory by a programmer using a programming unit, which can then be disconnected from the PLC. PLCs save user-programs in memory that is either unaffected by power loss or is maintained by a long-life battery. The user-program remains in the PLC's memory until a programming unit is used to change it.

2-3. **Processing Methods**

1) **Cyclic operation**

A PLC program is sequentially executed from the first step to the last step, which is called scan. This sequential processing is called cyclic operation. Cyclic operation of the PLC continues as long as conditions do not change for interrupt processing during program execution.



Stage for the start of a scan processing, it is executed only one time when the power is applied or reset is executed.
It executes the following processing:
1) I/O modules reset 2) Execution of self-diagnosis
3) Data Clear 4) I/O address allocation or type registration

Input module conditions are read and stored in the input image area before operation processing of a program.

Program is executed sequentially from the first step to the last step.

The contents, which stored in the output image area, output to output modules when operation processing of the program is finished.

Stage for return processing after the CPU module has finished one scan. The following processing are executed:
1) Self-diagnosis
2) Change of the present values of timers, counters...etc.
3) Processing data communications between computer link module and communications module.
4) Checking the switch for mode setting.

(Figure 2-2) Cyclic operation processing method

2) **Time driven interrupt operation method**

In time driven interrupt operation method, operations are processed not repeatedly but at every pre-set interval. This operation is used to process operation with a constant cycle.

3) **Event driven interrupt operation method**

If a situation occurs which is requested to be urgently processed during execution of a PLC program, this operation method processes immediately the operation which corresponds to interrupt program. The signal which informs the CPU module of those urgent conditions is called interrupt signal. Usually the CPU module has two kind of interrupt operation methods, which are internal and external interrupt signal methods.

2-4. **PLC Languages:**

The PLC language standardized by IEC consists of two illustrated languages, two character languages and SFC.

1. **Illustrated languages**

a) LD (Ladder Diagram):

It is a graphical language based on the relay ladder logic.

b) FBD (Function Block Diagram):

It is a graphical language for depicting signal and data flows through function blocks - re-usable software elements.

2. **Character language**

a) IL (Instruction List):

It is a low-level 'assembler like' language based on similar instruction list languages.

b) ST (Structured Text):

It is a high-level language of PASCAL type.

3. **SFC (Sequential Function Chart)**:

It is a graphical language for depicting sequential behavior of a control system. It is used for defining control sequences that are time and event-driven.

In this course, the ladder diagram programming language which is most popular language used in programming PLCs will be studied.

PLC Architecture

As mentioned previously, some PLCs are integrated into a single unit and some are modular. A modular PLC consists of several components that can be connected by being plugged into a common bus or rack. Every PLC needs:

- A CPU module
- A power supply module
- At least one I/O module

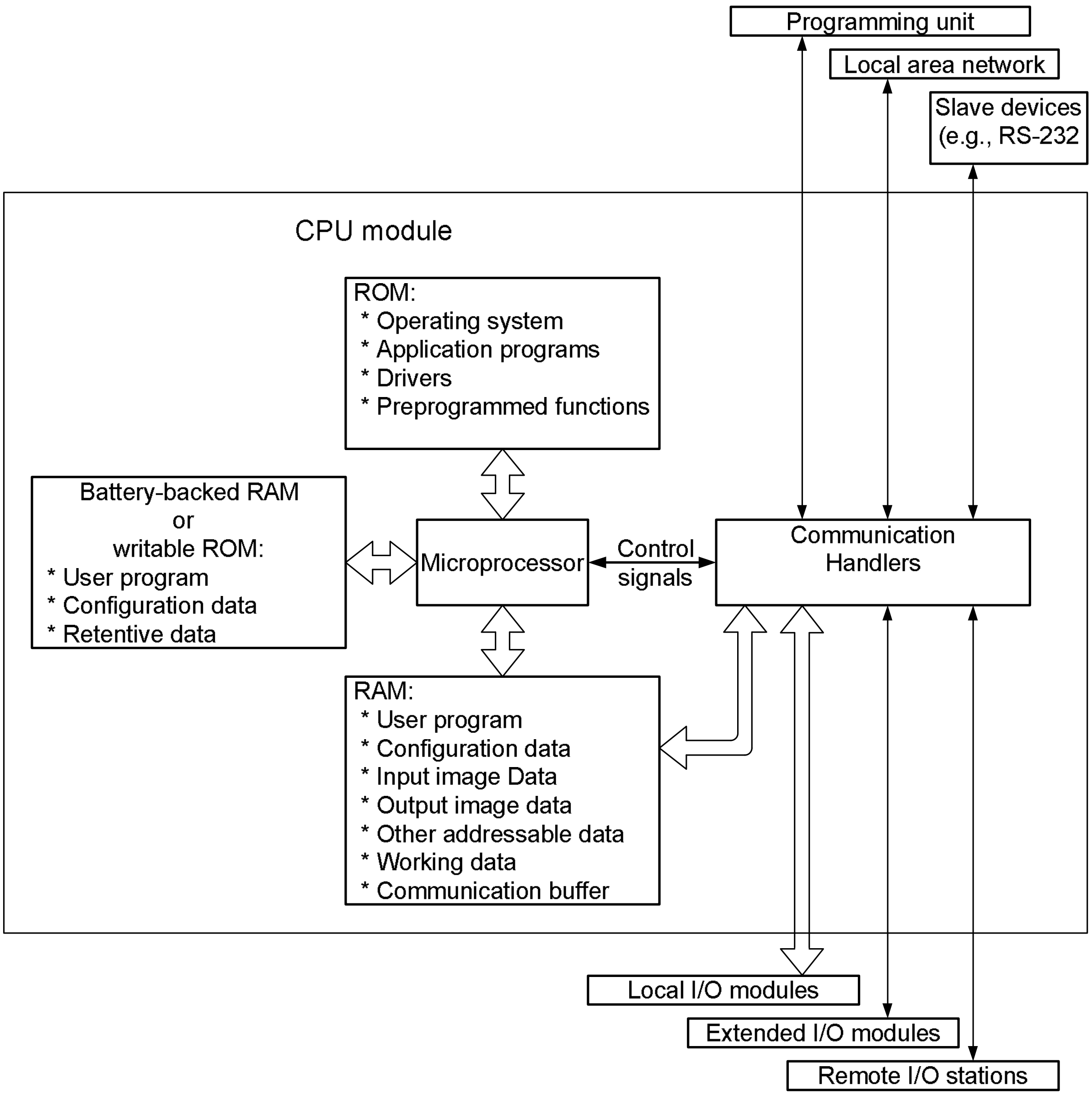
An Integrated PLC contains all of those components in a single case, so the I/O capabilities of an integrated PLC are decided by the manufacturer, not by the user. Some integrated PLCs can be expanded by having additional I/O modules plugged into expansion sockets, making them somewhat modular.

Modular PLCs must contain a CPU module, a power supply, and I/O modules in components purchased separately and plugging them into the same rack. Some manufacturers offer CPU modules with few built-in high speed I/O capabilities as CPUs for modular systems, making them somewhat integrated.

3-1. **The CPU Module**

As explained in Figure 3-1, the CPU module contains the central processing unit and its memory. The memory includes PROM (programmable read-only memory) containing the PLC's operating system, driver programs, and application programs, and RAM where the user-written programs and working data are stored. PLC manufacturers offer various types of retentive memory to save user-programs and data while power is removed, so that the PLC can resume execution of the user-written control program as soon as power is restored. If the PLC has one of the following retentive memory options, it doesn't have to be reprogrammed each time it is turned on, so a keyboard and monitor don't need to be included as a part of every PLC.

1. In most PLCs, at least part of the RAM memory's contents is protected by a long-life battery, for years of use. Other PLCs have only capacitor-based power backup, so RAM memory is saved only for short periods of power outages (measured in hours). A PLC with only capacitor RAM backup must also offer at least one of the options noted below.



(Figure 3-1) Memory and processors in the CPU module

2. Many PLCs also offer removable memory modules, which are plugged into the CPU module. The user can make a copy of the user-program and data on EEPROM (electrically erasable programmable read-only memory) chips in the removable memory modules. The user may have to purchase an optional EEPROM writer, but some PLCs contain the special circuitry needed to write data to the memory modules at higher voltage levels than the CPU module would normally use. PLCs can be configured to copy the contents of a memory module into RAM memory whenever power is switched on. An EEPROM module can be plugged into any PLC of the same make, so they are also useful in copying programs and data from one PLC to the next.
3. Recently, PLCs have started to include flash memory. Flash memory is like EEPROM memory except that it can be written to without needing special circuitry. Flash memory is used on some removable memory modules instead of using the older EEPROM memory chips, but flash memory is also sometimes built into the CPU module, where it automatically backs up parts of RAM memory even as the PLC runs. If power fails while a PLC with flash memory is running, the PLC will resume running without having lost any important working data after power is restored.

   Modem CPU modules often contain more than one microprocessor. The main microprocessor chip's job is to execute the scan cycle while slave microprocessors handle the communications functions required to exchange data with increasingly powerful I/O modules, remotely located sensors and actuators, and with other controllers via local area networks. The slave microprocessors work in response to commands from the main microprocessor or in response to messages from microprocessors connected to this CPU module via serial communications links. Slave microprocessors may have direct access to data memory that they share with the main microprocessor (in which case, memory contents can be changed outside the main processor's control) and/or may have their own memory, which the main microprocessor reads and writes as part of its scan cycle or in response to interrupt signals that the slave processor generates.

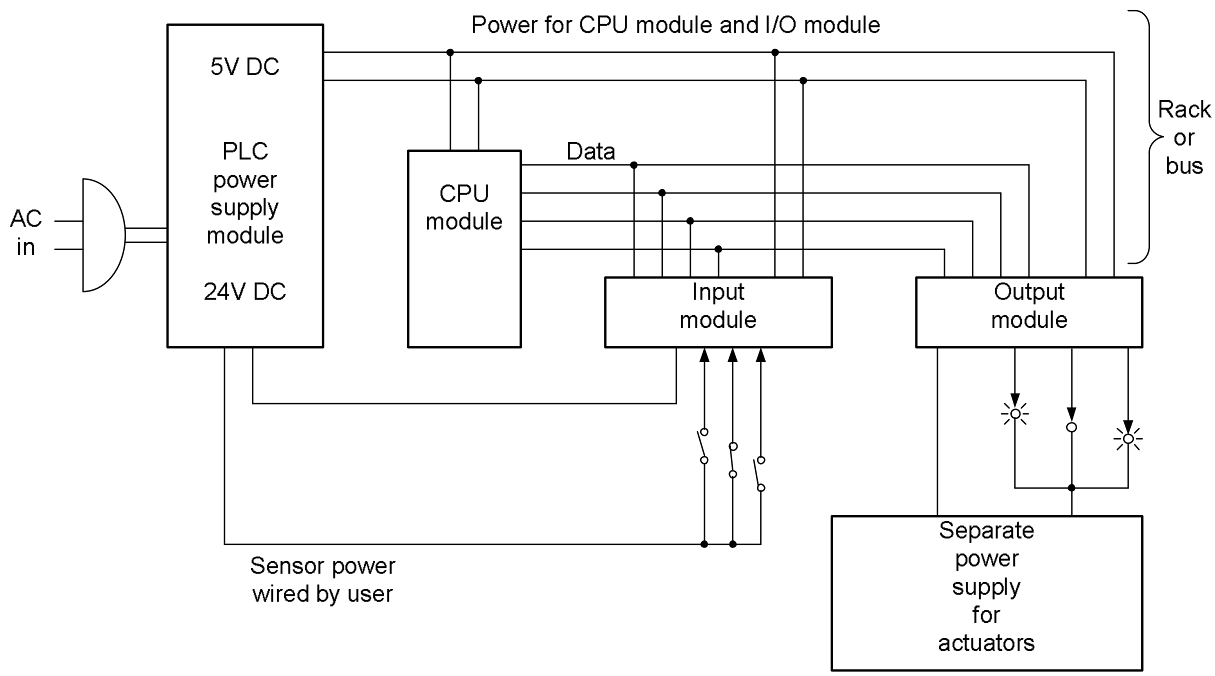
3-2. THE RACK OR BUS

During every scan cycle, a CPU module reads and writes I/O modules that are part of the modular PLC. The CPU module is connected to each of those I/O modules via a set of parallel conductors called a bus. In some modular systems, the bus is in a backplane circuit card in a rack, and all PLC modules are plugged into slots in the rack. In other modular systems, I/O modules are plugged into the side of the CPU module or into the side of an I/O module that is already plugged into the CPU, so bus conductors are connected through the I/O modules.

Bus conductors are used for data that the CPU can send to or receive from the I/O modules, several bits at a time. The CPU must specify which of the I/O modules the CPU wants to read from or write to. I/O module addresses are assigned automatically according to how far the module is located away from the CPU module along the bus. Some bus conductors are used for miscellaneous control signals passed between the CPU module and I/O modules and to provide power to run the circuitry inside I/O modules. The bus does not provide power to operate the sensors or actuators attached to I/O modules.

3-3. THE POWER SUPPLY

As shown in Figure 3-2, a power supply module converts available power to dc power at the level(s) required by the CPU and I/O module internal circuitry. Usually, the available power is typically 60 Hz/120 V ac or 50 Hz/220 V ac, although power supply modules are available for other input power characteristics. Output power must drive the computer circuitry at 5 V dc. Power supply modules may be connected to the bus or may have to be wired to the CPU module in modular PLC systems.



(Figure 3-2) Power Supplies in a PLC System

Some—but not all—power supplies include power conversion circuitry that outputs 24 V dc via screw terminals on the power supply module. These PLCs provide only enough power to drive a few of the sensors and actuators that are connected to I/O modules.

If the PLC-based control system requires significant power to drive sensors and actuators, or needs dc levels other than 5 or 24 V dc, or needs other electrical signal characteristics, the user must provide additional power supplies and (for the high-power applications typical of some actuators) may need to supply relays, optical isolators, or other circuit-isolation devices.

3-4. **I/O MODULES**

Input and output modules (I/O modules) allow the PLC to be connected to sensors and actuators. The I/O modules isolate the low-voltage, low-current signals that the PLC uses internally from the higher-power electrical circuits required by most sensors and actuators. The user purchases the types of I/O modules that are needed for the sensors and actuators that need to be used, and the user can connect several different types (or several of the same type) of I/O modules to a PLC's bus. I/O modules offered by PLC manufacturers are designed to work with that manufacturer's CPU module, so the user can be confident that compatibility won't be a problem.

Most manufacturers have a wide range of I/O modules that the user can select from, including:

1. **Digital I/O modules**, which are used to connect the PLC to sensors and actuators that can only be switch on and off. Modules are available for a variety of dc and ac voltages and currents. Each module typically can be connected to several digital sensors and/or to several digital actuators of similar electrical characteristics.
2. **Analog I/O modules**, which are used to connect the PLC to sensors that can provide electrical signals which are proportional to a measured value or to actuators that vary their output proportionally with the electrical signals they receive from an output analog module. A single analog I/O module can typically only be connected to a few sensors or actuators of similar electrical characteristics.
3. **Miscellaneous intelligent I/O modules**, each with its own built-in microprocessor and memory. Intelligent I/O modules are designed for special purposes such as counting high-frequency signals or providing servo control of motors.
4. **Communication interface modules**, which are intelligent I/O modules that handle the exchange of data via a communication link. The user-program in the CPU writes data to the communication interface module, and the module ensures that it is placed on the communication network. Similarly, the communication interface module can accept data from other computers via the communications network and hold it until the CPU reads it from the module. Modern CPU modules can be connected directly to communication networks, so communication interface modules are needed only if communications requirements exceed the CPU's built-in capabilities.

When most PLCs power up, they perform a self-check that includes searching the bus to determine how many modules are present, in order to optimize the data exchange that will be performed each scan cycle. The PLC often exchanges different amounts of information with different types of I/O modules, so optimization of communication also requires the PLC to know what type of module is in each slot of the rack. In a truly optimized data exchange, a PLC will not waste time reading from an output module and will not try to write data to an input module. (The CPU module's memory will still contain an input image and an output image data word for each slot, but the data won't reflect sensor or actuator states).

3-4-1. **<u>Digital I/O Modules</u>**

Digital input modules allow a CPU module to read input image data words from the module. Each individual bit of a data word reflects the open or closed state of a single switch or switched sensor.

Digital output modules accept output image data words from the CPU module. Each bit of the data word will turn a single actuator on or off.

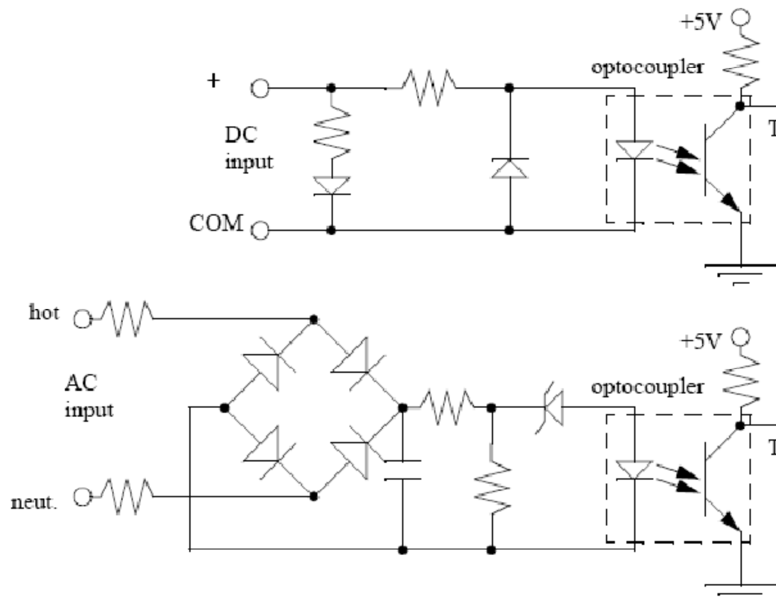
Digital I/O modules primarily provide electrical isolation between the low-power internal circuits of the PLC and the (typically) higher-power circuits containing sensors or actuators. A digital output module also provides a buffering feature so that after the CPU writes a data word to the output module, the module will retain that data word (holding some actuators on and others off) until the next scan cycle, when a new output image data word will be written to the output module.

a) **Digital Input Modules**

PLC inputs must convert a variety of logic levels to the 5VDC logic levels used on the data bus. This can be done with circuits similar to those shown Figure 3-3. Basically the circuits condition the input to drive an optocoupler. This electrically isolates the external electrical circuitry from the internal circuitry. Other circuit components are used to guard against excess or reversed voltage polarity.

In small PLCs the inputs are normally built in and are specified when purchasing the PLC. For large PLCs the inputs are purchased as modules, or cards, with 8 or 16 inputs of the same type on each card. The list below shows typical ranges of input voltages.

5 Vdc (TTL)	12-24 VDC	10-60 VDC	48 VDC
24 VAC	100-120 VAC	200-240 VAC	12-24 VAC/DC



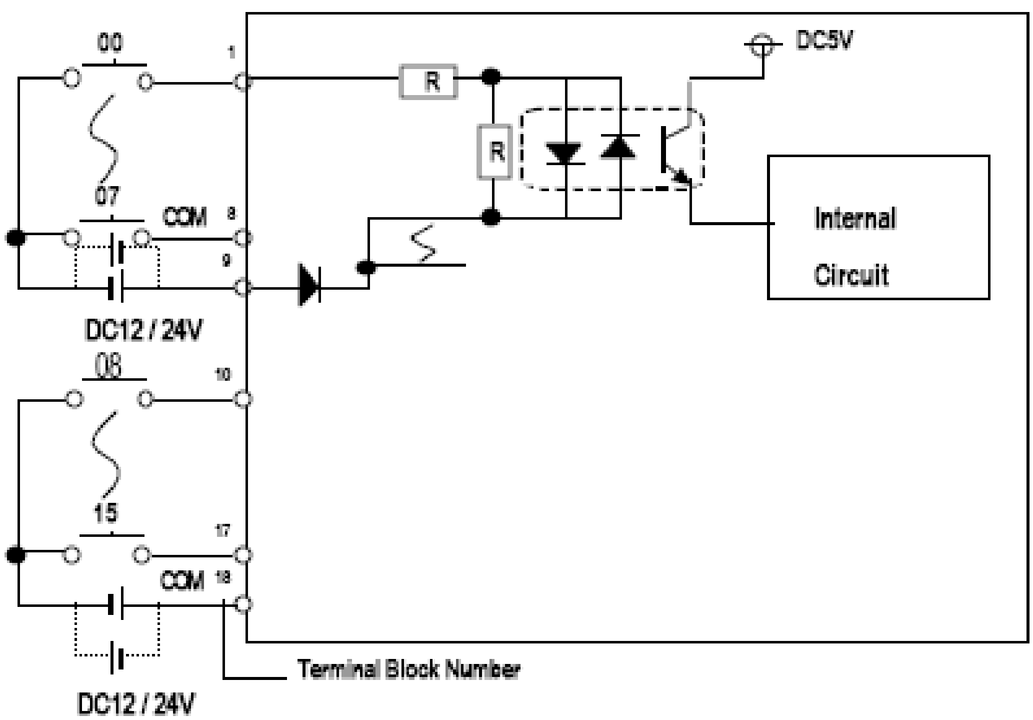
(Figure 3-3) PLC Input Circuits

As shown in the above figure, Input modules usually contain optoisolators in each sensor-controlled circuit. When current from an external power supply flows through the optoisolator input contacts because an external sensor switch is closed, a light-emitting diode in the optoisolator generates light. A light-sensitive diode in the optoisolator allows current to conduct in a lower-power PLC internal circuit when it receives light. The optoisolator allows an external circuit to control a PLC's internal circuit without any electrical connections between the two circuits.

Because light-emitting diodes are unidirectional devices, the external circuit with the sensor must be connected to the digital input module with the correct polarity, so digital input modules are also classified as either current sourcing or current sinking, depending on whether they require (conventional) current to conduct out of or into the individual sensor contacts. Although it is reasonable to assume that an input module would receive current from a sensor, most input modules are current sourcing and must be connected to sensors so that closing the sensor switch will allow current to be conducted from the input module, through the sensor, to a power supply's negative contact. Current-sourcing input modules are more common only because output modules used in the PLC system are often current sinking.

PLC input cards rarely supply power, this means that an external power supply is needed to supply power to the inputs and sensors. Note that inputs are normally high impedance. This means that they will use very little current.

Optoisolators with two light-emitting diodes, as shown in Figure 3-4, are dropping in price, so more input modules are being built like this. Whichever direction current flows, one LED generates light, so power supply polarity is no longer important (except within groups of contacts sharing a common contact), and ac power supplies are also allowable.



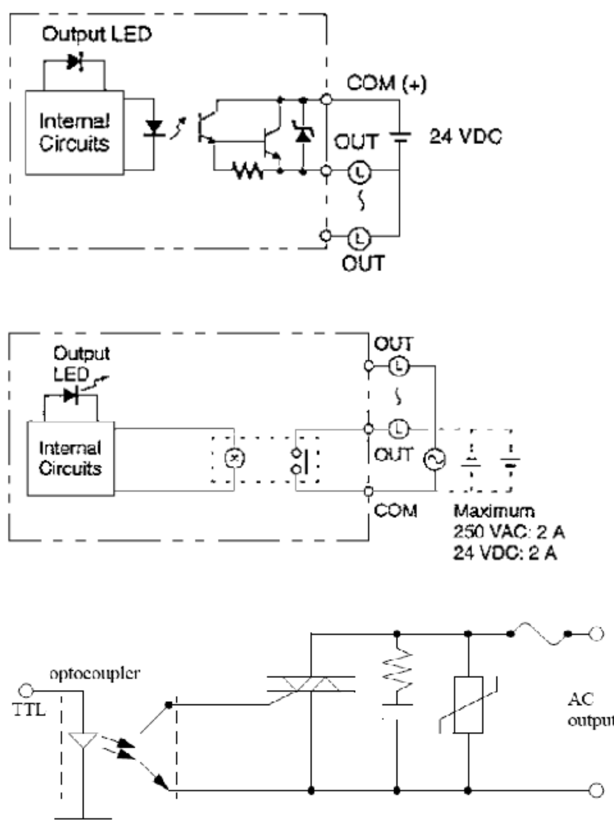
(Figure 3-4) Sinking or Sourcing Optoisolated Input Module

b) **Digital Output Modules**

Note that the PLC outputs must convert the 5VDC logic levels on the PLC data bus to external voltage levels. This can be done with circuits similar to those shown in Figure 3-5. Basically the circuits use an optocoupler to switch external circuitry. This electrically isolates the external electrical circuitry from the internal circuitry. Other circuit components are used to guard against excess or reversed voltage polarity.

The output modules rarely supply any power, but instead act as switches. External power supplies are connected to the output card and the card will switch the power on or off for each output. Typical output voltages are listed below, and roughly ordered by popularity.

12-48 V AC	5 V DC (TTL)
120 V AC	24 V DC
230 V AC	12-48 V DC



(Figure 3-5) PLC Output Circuits

These cards typically have 8 to 16 outputs of the same type and can be purchased with different current ratings. A common choice when purchasing output cards are relays, transistors or triacs. Relays are the most flexible output devices. They are capable of switching both AC and DC outputs. But, they are slower (about 10ms switching is typical), they are bulkier, they cost more, and they will wear out after millions of cycles. Relay outputs are often called dry contacts. Transistors are limited to DC outputs, and Triacs are limited to AC outputs. Transistor and Triac outputs are called switched outputs.

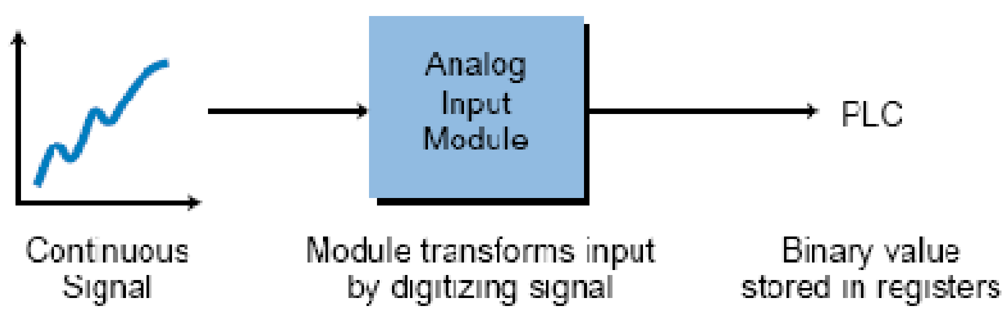
3-4-2. **Analog I/O Modules**

Sometimes, the control system requires the PLC to either monitor an analog voltage or produce an analog voltage. Because analog I/O modules can interpret continuous signals, analog I/O interfaces are used in applications, such as batching and temperature control, where the simple two-state capabilities of discrete I/O systems are insufficient.

a) **Analog Input Modules**

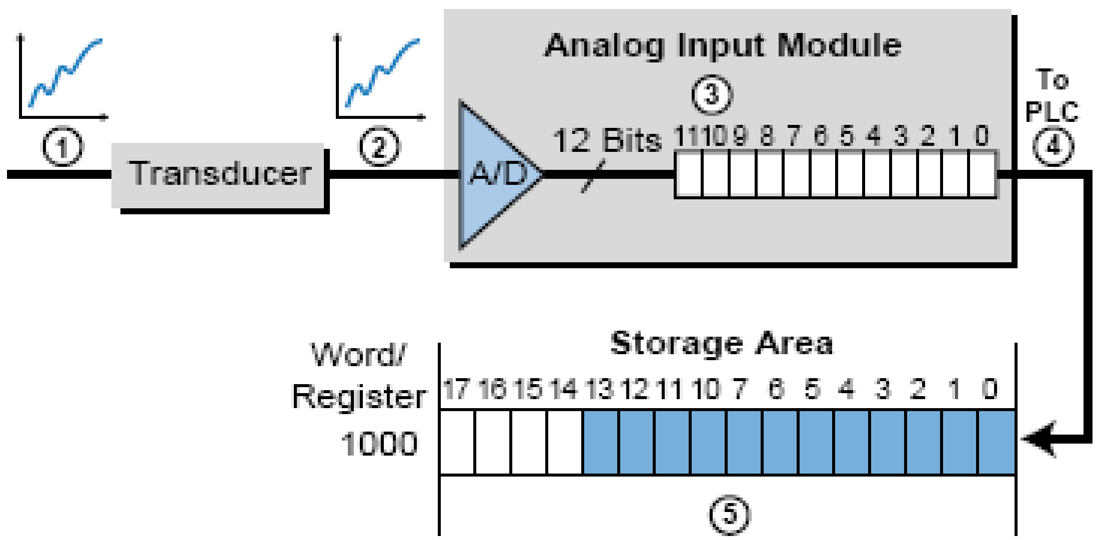
Control systems sometimes receive analog signals from analog transducers like flow transducers, humidity transducers, load cell transducers, potentiometers, pressure transducers, vibration transducers, temperature transducers …etc.

Analog input modules digitize analog input signals, thereby bringing analog information into the PLC (see Figure 3-6). The modules store this multi-bit information in register locations inside the PLC.



(Figure 3-6)Digitization of Analog Signal

(Figure 3-7) illustrates the sequence of events that occurs while reading an analog input signal. The module transforms the analog signal, through an analog-to-digital converter (A/D), into 12 bits of digital information that will be stored in register 1000 after the instruction is executed. After the PLC reads this information, the control program can reference the register address for comparisons, arithmetic calculations, etc. The analog value stored in the register will be in either BCD or binary format.



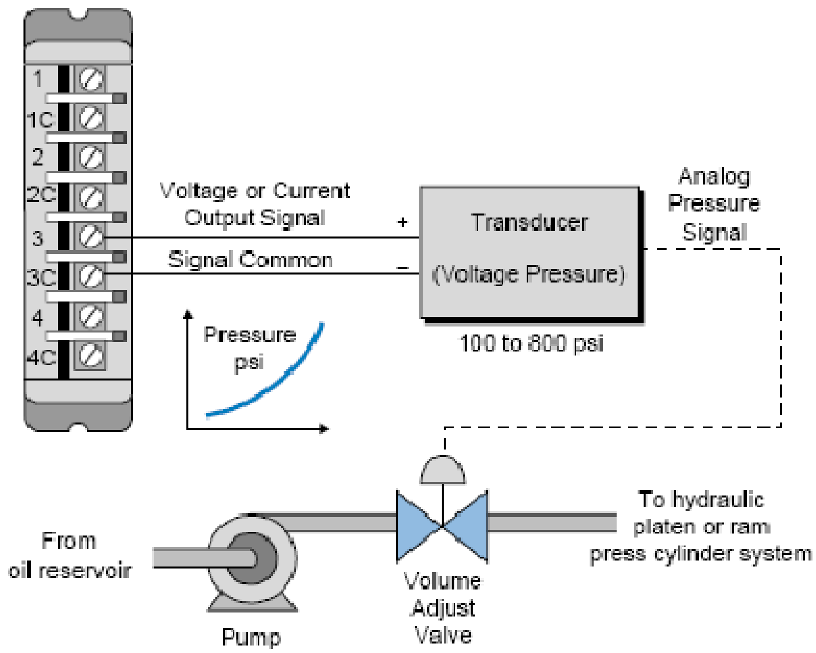
(Figure 3-7) Conversion of an Analog Signal into Binary Format

The steps of converting an analog signal into binary format are:

1. The transducer detects the process signal (e.g., temperature).
2. The transducer transforms the process signal into an electrical signal that the analog input can recognize.
3. The analog input transforms the signal into a 12-bit value proportional to the electrical input to the module.
4. A block transfer instruction, or another analog input instruction, transfers the 12-bit value to the PLC.
5. The PLC stores the 12-bit digital value in a memory location for future use.

b) **Analog Output Modules**

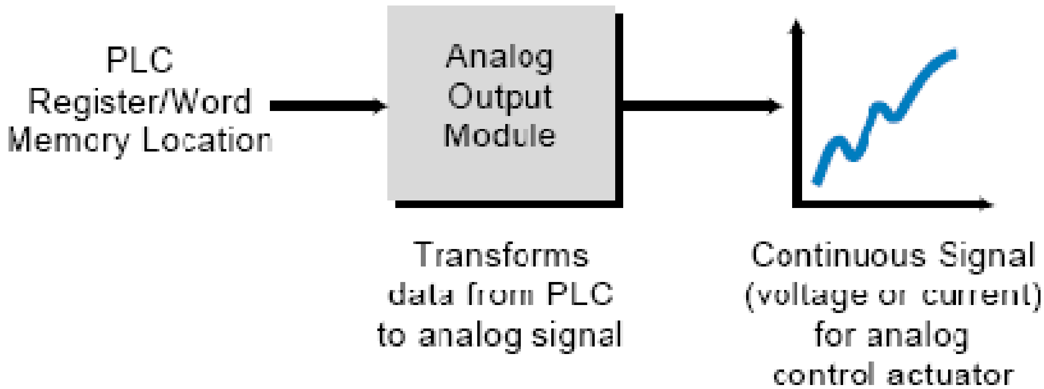
Analog output interfaces are used in applications requiring the control of field devices that respond to continuous voltage or current levels like analog valves, actuators, meters, electric motor drives…etc. An example of this type of field device is a volume adjust valve (see Figure 3-8). This type of valve, which is used in hydraulic-based punch presses, requires a 0–10 VDC signal to vary the volume of oil being pumped to the press cylinders, thereby changing the speed of the ram or platen.



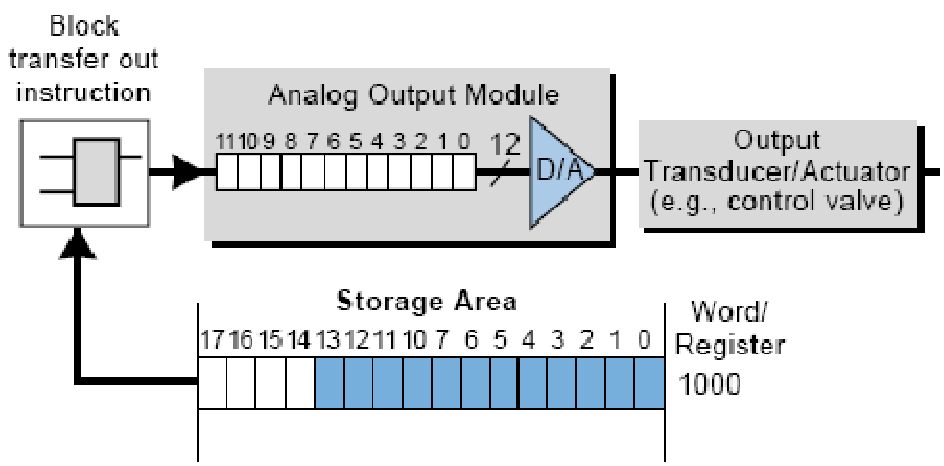
(Figure 3-8) Representation of a volume adjust valve

The PLC transfers the contents of a register, generally specified by 12 bits, to the output module upon the execution of the instruction (see Figure 3-9).

The module then transforms this value, whether BCD or binary, from digital to analog and passes it to the field control device. Figure 3-10 illustrates a multi-bit instruction transferring 12 bits of data from register 1000 to an analog output module that is connected to a control valve. These 12 bits of information, which are transferred to the field device for control, may be the result of other computations in the PLC program.



(Figure 3-9) Conversion of Register Data into an Analog Signal



(Figure 3-10) Conversion a Binary Value into an Analog Signal

Questions

1. Compare between the brick and modular PLCs.
2. Explain the CPU structure and operation with drawing.
3. Explain the I/O types briefly.
4. Explain the PLC electronic output circuits that used to interface the PLC with the AC digital actuators.
5. Explain the PLC electronic output circuit that used to interface the PLC with DC digital actuator.
6. Explain the electronic input circuit that used to interface the PLC with AC digital input.