Basic PLC

Basic PLC

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Objectives

At the end of the training the participants should be able to:

- Describe the major components of a common PLC.
- Interpret PLC specifications.
- Apply troubleshooting techniques.
- Convert conventional relay logic to a PLC language.
- Operate and program a PLC for a given application.

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INTRODUCTION TO PLCS

Advantages of PLCs

• Less wiring.
• Wiring between devices and relay contacts are done in the PLC program.
• Easier and faster to make changes.
• Trouble shooting aids make programming easier and reduce downtime.
• Reliable components make these likely to operate for years before failure.

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PLC Origin

•- Developed to replace relays in the late 1960s

•- Costs dropped and became popular by 1980s

•- Now used in many industrial designs

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Historical Background

The **Hydramatic Division** of the **General Motors Corporation** specified the design criteria for the first programmable controller in **1968**

Their primary goal

To eliminate the high costs associated with inflexible, relay-controlled systems.

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Historical Background

• The controller had to be designed in modular form, so that sub-assemblies could be removed easily for replacement or repair.

• The control system needed the capability to pass data collection to a central system.

• The system had to be reusable.

• The method used to program the controller had to be simple, so that it could be easily understood by plant personnel.

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Programmable Controller Development

- 1968 – Programmable concept developed
- 1969 – Hardware CPU controller, with logic instructions, 1 K of memory and 128 I/O points
- 1974 – Use of several (multi) processors within a PLC - timers and counters; arithmetic operations; 12 K of memory and 1024 I/O points
- 1976 – Remote input/output systems introduced
- 1977 – Microprocessors - based PLC introduced

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Programmable Controller Development

- 1980 – Intelligent I/O modules developed
  Enhanced communications facilities
  Enhanced software features (e.g. documentation)
  Use of personal microcomputers as programming aids
- 1983 – Low - cost small PLC's introduced
- 1985 on – Networking of all levels of PLC, computer and machine using SCADA software.

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Programmable Logic Controllers

(Definition according to NEMA standard ICS3-1978)

A digitally operating electronic apparatus which uses a programming memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic to control through digital or analog modules, various types of machines or process.

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Leading Brands Of PLC

AMERICAN
1. Allen Bradley
2. Modicon (Schneider)
3. Texas Instruments
4. General Electric
5. Cutler Hammer

EUROPEAN
1. Siemens
2. Klockner & Moller
3. Festo
4. Modicon (Schneider)

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Leading Brands Of PLC

JAPANESE
1. Toshiba
2. Omron
3. Fanuc
4. Mitsubishi

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Areas of Application

- Manufacturing / Machining
- Food / Beverage
- Metals
- Power
- Mining
- Petrochemical / Chemical

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PLC Size

1. SMALL - it covers units with up to 128 I/O's and memories up to 2 Kbytes.
   - these PLC's are capable of providing simple to advance levels or machine controls.
2. MEDIUM - have up to 2048 I/O's and memories up to 32 Kbytes.
3. LARGE - the most sophisticated units of the PLC family. They have up to 8192 I/O's and memories up to 750 Kbytes.
   - can control individual production processes or entire plant.

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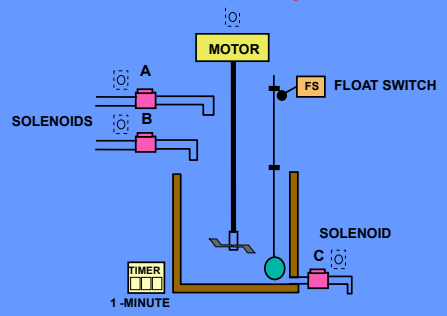
Tank Used to Mix Two Liquids



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Tank Used to Mix Two Liquids

A tank is used to mix two liquids. The control circuit operates as follows:

1. When the start button is pressed, solenoids A and B energize. This permits the two liquids to begin filling the tank.

2. When the tank is filled, the float switch trips. This de-energizes solenoids A and B and starts the motor used to mix the liquids together.

3. The motor is permitted to run for one minute. After one minute has elapsed, the motor turns off and solenoid C energizes to drain the tank.

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Tank Used to Mix Two Liquids

4. When the tank is empty, the float switch de-energizes solenoid C.

5. A stop button can be used to stop the process at any point.

6. If the motor becomes overloaded, the action of the entire circuit will stop.

7. Once the circuit has been energized it will continue to operate until it is manually stopped.

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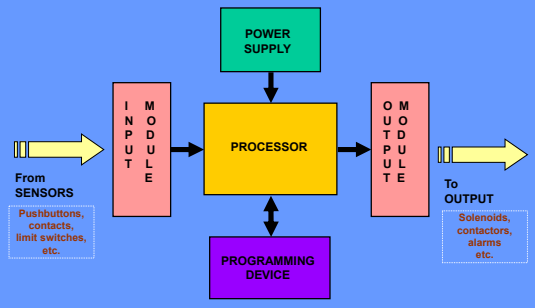
Major Components of a Common PLC



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Major Components of a Common PLC

POWER SUPPLY

Provides the voltage needed to run the primary PLC components

I/O MODULES

Provides signal conversion and isolation between the internal logic- level signals inside the PLC and the field's high level signal.

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Major Components of a Common PLC

PROCESSOR

Provides intelligence to command and govern the activities of the entire PLC systems.

PROGRAMMING DEVICE

used to enter the desired program that will determine the sequence of operation and control of process equipment or driven machine.

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Programming Device

Also known as:

- Industrial Terminal (Allen Bradley)
- Program Development Terminal (General Electric)
- Programming Panel (Gould Modicon)
- Programmer (Square D)
- Program Loader (Idec-Izumi)
- Programming Console (Keyence / Omron)

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Programming Device

Types:

- Hand held unit with LED / LCD display
- Desktop type with a CRT display
- Compatible computer terminal

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I/O Module

• The I/O interface section of a PLC connects it to external field devices.

• The main purpose of the I/O interface is to condition the various signals received from or sent to the external input and output devices.

• Input modules converts signals from discrete or analog input devices to logic levels acceptable to PLC's processor.

• Output modules converts signal from the processor to levels capable of driving the connected discrete or analog output devices.

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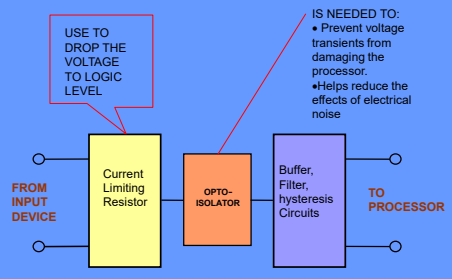
I/O Module

DC INPUT MODULE



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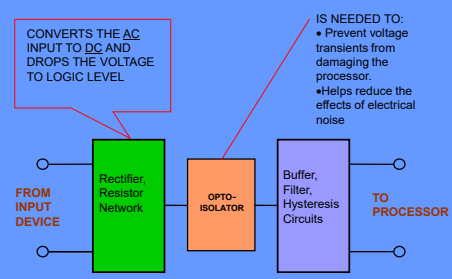
I/O Module

AC INPUT MODULE



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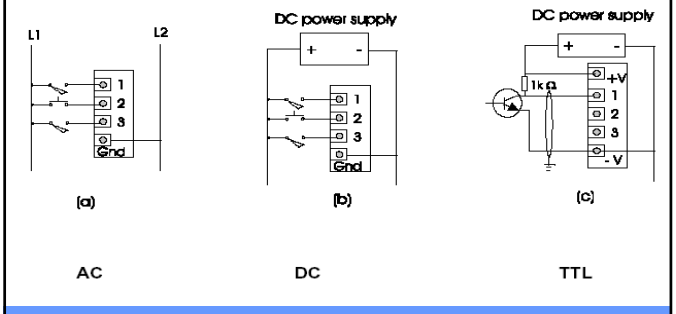
Input Connections



AC DC TTL

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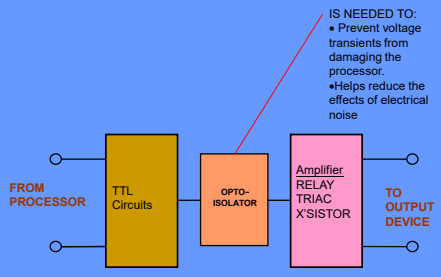
I/O Module

DC / AC OUTPUT MODULE



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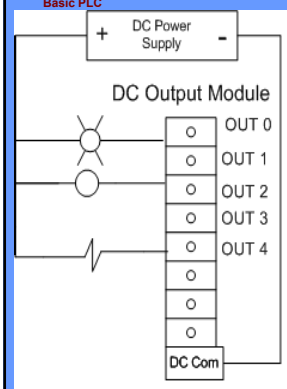

Figure 3.8 DC OUTPUT WIRING CONNECTIONS

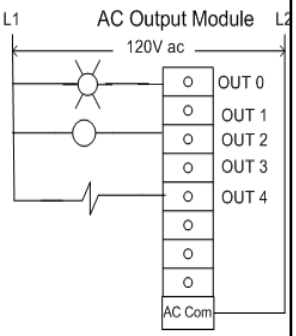

Figure 3.9 AC OUTPUT WIRING CONNECTIONS

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I/O Circuits

DIFFERENT TYPES OF I/O CIRCUITS

1. Pilot Duty Outputs

Outputs of this type typically are used to drive high-current electromagnetic loads such as solenoids, relays, valves, and motor starters.

These loads are highly inductive and exhibit a large inrush current.

Pilot duty outputs should be capable of withstanding an inrush current of 10 times the rated load for a short period of time without failure.

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I/O Circuits

2. General - Purpose Outputs

These are usually low- voltage and low-current and are used to drive indicating lights and other non-inductive loads. Noise suppression may or may not be included on this types of modules.

3. Discrete Inputs

Circuits of this type are used to sense the status of limit switches, push buttons, and other discrete sensors. Noise suppression is of great importance in preventing false indication of inputs turning on or off because of noise.

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I/O Circuits

4. Analog I/O

Circuits of this type sense or drive analog signals.

Analog inputs come from devices, such as thermocouples, strain gages, or pressure sensors, that provide a signal voltage or current that is derived from the process variable.
Standard Analog Input signals: 4-20mA; 0-10V

Analog outputs can be used to drive devices such as voltmeters, X-Y recorders, servomotor drives, and valves through the use of transducers.
Standard Analog Output signals: 4-20mA; 0-5V; 0-10V

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I/O Circuits

5. Special - Purpose I/O

Circuits of this type are used to interface PLCs to very specific types of circuits such as servomotors, stepping motors PID (proportional plus integral plus derivative) loops, high-speed pulse counting, resolver and decoder inputs, multiplexed displays, and keyboards.

This module allows for limited access to timer and counter presets and other PLC variables without requiring a program loader.

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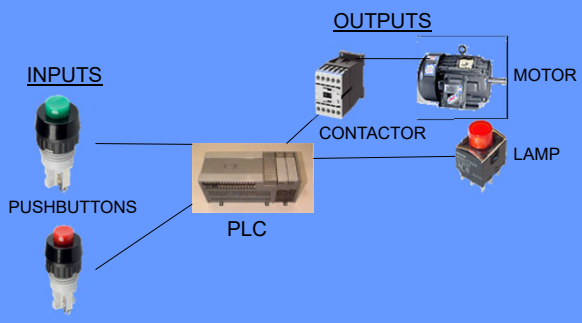

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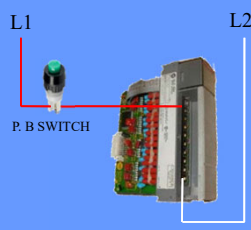
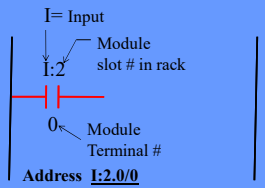
Allen-Bradley 1746-1A16



INPUT MODULE WIRING DIAGRAM



LADDER PROGRAM

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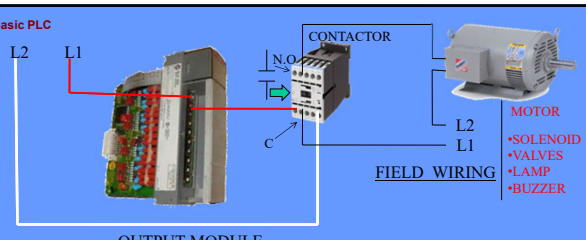
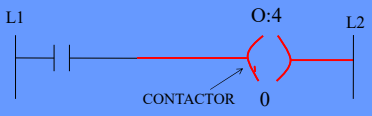


OUTPUT MODULE WIRING



LADDER PROGRAM

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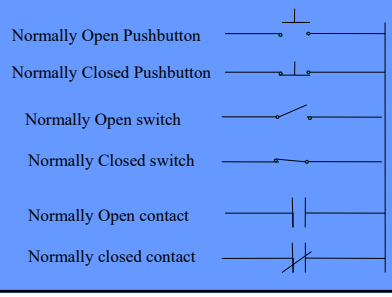
Discrete Input

A discrete input also referred as digital input is an input that is either ON or OFF are connected to the PLC digital input. In the ON condition it is referred to as logic 1 or a logic high and in the OFF condition maybe referred to as logic o or logic low.



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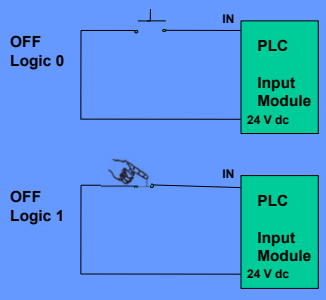

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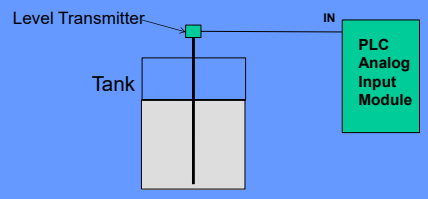
Analog Input

An analog input is an input signal that has a continuous signal. Typical inputs may vary from 0 to 20mA, 4 to 20mA or 0 to10V. Below, a level transmitter monitors the level of liquid in the tank. Depending on the level Tx, the signal to the PLC can either increase or decrease as the level increases or decreases.



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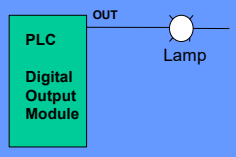
Digital Output

A discrete output is either in an ON or OFF condition. Solenoids, contactors coils, lamps are example of devices connected to the Discrete or digital outputs. Below, the lamp can be turned ON or OFF by the PLC output it is connected to.



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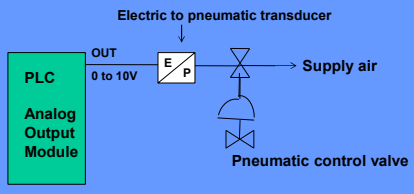
Analog Output

An analog output is an output signal that has a continuous signal. Typical outputs may vary from 0 to 20mA, 4 to 20mA or 0 to10V.



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Processor

The processor module contains the PLC's microprocessor, its supporting circuitry, and its memory system.

The main function of the microprocessor is to analyze data coming from field sensors through input modules, make decisions based on the user's defined control program and return signal back through output modules to the field devices. Field sensors: switches, flow, level, pressure, temp. transmitters, etc. Field output devices: motors, valves, solenoids, lamps, or audible devices.

The memory system in the processor module has two parts: a *system memory* and an *application memory*.

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Memory Map Organization

SYSTEM

- System memory includes an area called the EXECUTIVE, composed of permanently-stored programs that direct all system activities, such as execution of the users control program, communication with peripheral devices, and other system activities.
- The system memory also contains the routines that implement the PLC's instruction set, which is composed of specific control functions such as logic, sequencing, timing, counting, and arithmetic.
- System memory is generally built from read-only memory devices.

APPLICATION

- Data Table
- User Program

- The application memory is divided into the data table area and user program area.
- The data table stores any data associated with the user's control program, such as system input and output status data, and any stored constants, variables, or preset values. The data table is where data is monitored, manipulated, and changed for control purposes.
- The user program area is where the programmed instructions entered by the user are stored as an application control program.

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Memory Designs

VOLATILE.
A volatile memory is one that loses its stored information when power is removed.

Even momentary losses of power will erase any information stored or programmed on a volatile memory chip.

Common Type of Volatile Memory

RAM. Random **A**ccess **M**emory(Read/Write)
Read/write indicates that the information stored in the memory can be retrieved or read, while write indicates that the user can program or write information into the memory.

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Memory Designs

The words **random access** refer to the ability of any location (address) in the memory to be accessed or used. Ram memory is used for both the user memory (ladder diagrams) and storage memory in many PLC's.

RAM memory must have battery backup to retain or protect the stored program.

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Memory Designs

NON-VOLATILE
Has the ability to retain stored information when power is removed, accidentally or intentionally. These memories do not require battery back-up.

Common Type of Non-Volatile Memory

ROM, Read **O**nly **M**emory
Read only indicates that the information stored in memory can be read only and cannot be changed. Information in ROM is placed there by the manufacturer for the internal use and operation of the PLC.

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Memory Designs

Other Types of Non-Volatile Memory

PROM, Programmable **R**ead **O**nly **M**emory
Allows initial and/or additional information to be written into the chip.

PROM may be written into only once after being received from the PLC manufacturer; programming is accomplish by pulses of current.

The current melts the fusible links in the device, preventing it from being reprogrammed. This type of memory is used to prevent unauthorized program changes.

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Memory Designs

EPROM, Erasable **P**rogrammable **R**ead **O**nly **M**emory

Ideally suited when program storage is to be semi-permanent or additional security is needed to prevent unauthorized program changes.

The EPROM chip has a quartz window over a silicon material that contains the electronic integrated circuits. This window normally is covered by an opaque material, but when the opaque material is removed and the circuitry exposed to ultra violet light, the memory content can be erased.

The EPROM chip is also referred to as **UVPROM.**

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Memory Designs

EEPROM, **E**lectrically **E**rasable **P**rogrammable **R**ead **O**nly **M**emory

Also referred to as E^2PROM, is a chip that can be programmed using a standard programming device and can be erased by the proper signal being applied to the erase pin.

EEPROM is used primarily as a non-volatile backup for the normal RAM memory. If the program in RAM is lost or erased, a copy of the program stored on an EEPROM chip can be down loaded into the RAM.

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PLC Operation

Basic Function of a Typical PLC

Read all field input devices via the input interfaces, execute the user program stored in application memory, then, based on whatever control scheme has been programmed by the user, turn the field output devices on or off, or perform whatever control is necessary for the process application.

This process of sequentially reading the inputs, executing the program in memory, and updating the outputs is known as scanning.

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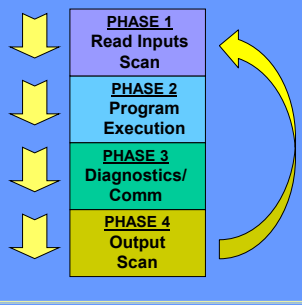
While the PLC is running, the scanning process includes the following four phases, which are repeated continuously as individual cycles of operation:



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PHASE 1 – Input Status scan

- A PLC scan cycle begins with the CPU reading the status of its inputs.

PHASE 2– Logic Solve/Program Execution

- The application program is executed using the status of the inputs

PHASE 3– Logic Solve/Program Execution

- Once the program is executed, the CPU performs diagnostics and communication tasks

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PHASE 4 - Output Status Scan

•An output status scan is then performed, whereby the stored output values are sent to actuators and other field output devices. The cycle ends by updating the outputs.

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As soon as Phase 4 are completed, the entire cycle begins again with Phase 1 input scan.

The time it takes to implement a scan cycle is called SCAN TIME. The scan time composed of the program scan time, which is the time required for solving the control program, and the I/O update time, or time required to read inputs and update outputs. The program scan time generally depends on the amount of memory taken by the control program and type of instructions used in the program. The time to make a single scan can vary from 1 ms to 100 ms.

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PLC Communications

Common Uses of PLC Communications Ports

- Changing resident PLC programs - uploading/downloading from a supervisory controller (Laptop or desktop computer).
- Forcing I/O points and memory elements from a remote terminal.
- Linking a PLC into a control hierarchy containing several sizes of PLC and computer.
- Monitoring data and alarms, etc. via printers or Operator Interface Units (OIUs).

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PLC Communications

Serial Communications

PLC communications facilities normally provides serial transmission of information.

Common Standards

RS 232

- Used in short-distance computer communications, with the majority of computer hardware and peripherals.
- Has a maximum effective distance of approx. 30 m at 9600 baud.

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PLC Communications

Local Area Network (LAN)

Local Area Network provides a physical link between all devices plus providing overall data exchange management or protocol, ensuring that each device can “talk” to other machines and understand data received from them.

LANs provide the common, high-speed data communications bus which interconnects any or all devices within the local area.

LANs are commonly used in business applications to allow several users to share costly software packages and peripheral equipment such as printers and hard disk storage.

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PLC Communications

RS 422 / RS 485

- Used for longer-distance links, often between several PCs in a distributed system. RS 485 can have a maximum distance of about 10,000 feet.

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PLC Communications

Programmable Controllers and Networks

Dedicated Network System of Different Manufacturers

Manufacturer	Network
Allen-Bradley	Data Highway
Gould Modicon	Modbus
General Electric	GE Net Factory LAN
Mitsubishi	Melsec-NET
Square D	SY/NET
Texas Instruments	TIWAY

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Specifications

Several factors are used for evaluating the quality and performance of programmable controllers when selecting a unit for a particular application. These are listed below.

NUMBER OF I /O PORTS

This specifies the number of I/O devices that can be connected to the controller. There should be sufficient I/O ports to meet present requirements with enough spares to provide for moderate future expansion.

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Selecting a PLC

Criteria

- Number of logical inputs and outputs.
- Memory
- Number of special I/O modules
- Scan Time
- Communications
- Software

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A Detailed Design Process

1. Understand the process
2. Hardware/software selection
3. Develop ladder logic
4. Determine scan times and memory requirements

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Specifications

OUTPUT-PORT POWER RATINGS

Each output port should be capable of supplying sufficient voltage and current to drive the output peripheral connected to it.

SCAN TIME

This is the speed at which the controller executes the relay-ladder logic program. This variable is usually specified as the scan time per 1000 logic nodes and typically ranges from 1 to 200 milliseconds.

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Specifications

MEMORY CAPACITY

The amount of memory required for a particular application is related to the length of the program and the complexity of the control system. Simple applications having just a few relays do not require significant amount of memory. Program length tend to expand after the system have been used for a while. It is advantageous to a acquire a controller that has more memory than is presently needed.

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PLC Status Indicators

- Power On
- Run Mode
- Programming Mode
- Fault

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Troubleshooting

1. Look at the process
2. PLC status lights
   HALT - something has stopped the CPU
   RUN - the PLC thinks it is OK (and probably is)
   ERROR - a physical problem has occurred with the PLC
3. Indicator lights on I/O cards and sensors
4. Consult the manuals, or use software if available.
5. Use programming terminal / laptop.

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List of items required when working with PLCs:

1. Programming Terminal - laptop or desktop PC.
2. PLC Software. PLC manufacturers have their own specific software and license key.
3. Communication cable for connection from Laptop to PLC.
4. Backup copy of the ladder program (on diskette, CDROM, hard disk, flash memory). If none, upload it from the PLC.
5. Documentation- (PLC manual, Software manual, drawings, ladder program printout, and Seq. of Operations manual.)

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Examples of PLC Programming Software:

1. Allen-Bradley – Rockwell Software RSLogix500
2. Modicon - Unity Pro
3. Omron - Syswin
4. GE-Fanuc Series 6 – LogicMaster6
5. Texas Instruments – Simatic
6. Telemecanique – Modicon TSX Micro

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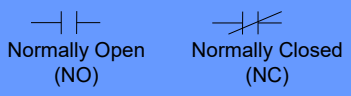
PROGRAMMING



Power flows through these contacts when they are closed. The normally open (NO) is true when the input or output status bit controlling the contact is 1. The normally closed (NC) is true when the input or output status bit controlling the contact is 0.

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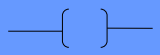
Coils



Coils represent relays that are energized when power flows to them. When a coil is energized it causes a corresponding output to turn on by changing the state of the status bit controlling the output to 1. That same output status bit maybe used to control normally open or normally closed contact anywhere in the program.

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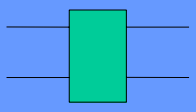
Basic PLC

Boxes



Boxes represent various instructions or functions that are Executed when power flows to the box. Some of these Functions are timers, counters and math operations.

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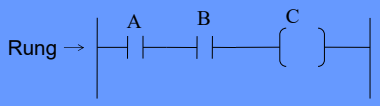
Basic PLC

AND OPERATION



Each rung or network on a ladder program represents a logic operation. In the rung above, both inputs A and B must be true (1) in order for the output C to be true (1).

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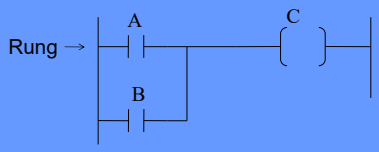
Basic PLC

OR OPERATION



In the rung above, it can be seen that either input A or B is be true (1), or both are true, then the output C is true (1).

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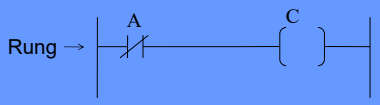
Basic PLC

NOT OPERATION



In the rung above, it can be seen that if input A is be true (1), then the output C is true (0) or when A is (0), output C is 1.

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