Introduction to Basic Programmable Logic Controller

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1. PLC Introduction

- What does PLC stand for?

  PLC – Programmable Logic Controller

  PLC implements Logic Control Functions by means of a program
1. PLC Introduction

A collection of electronic devices & equipments

To assure:
1. Stability
2. Accuracy
3. Smooth transition
1. PLC Introduction

- Feature

- Completely come with power supply and basic Input/Output modules.
1. PLC Introduction

- An application examples 1: Gate Control

- PLC can sense a vehicles at the entrance or exit, and open and close the gate automatically.

- The current vehicles count is easily determined by programming a simple counter.
1. PLC Introduction

- An application examples 2: Conveyor system

- PLC can be used to Start/Stop latching logic for motor control.

- Counters can be used for monitoring product amount.
1. PLC introduction

Comparing traditional and programmable control system

- Traditional control system: the behavior depends mainly on the wiring arrangement.
- Programmable control system: the behavior depends mainly on the instruction stored in the memory.

It is much simpler to change programs than wiring.
1. Introduction

- How does PLC differ from a computer?
  - A computer optimized for calculation and display tasks
  - A computer is programmed by a specialist
  - A PLC is designed for (logic) control and regulation tasks
  - A PLC is programmed by a non-specialist
  - A PLC is well adapted to industrial environment
What is a Programmable Controller

- In an automated system, the PLC is commonly regarded as the heart of the control system.
- The PLC may be used to control a simple and repetitive task.
- Or a few of them may be interconnected together with other controller or host computer through a sort of communication network, in order to integrate the control in a complex process.
What is a Programmable Controller cont...

- A PLC consists of a Central Processing Unit (CPU) containing an application program and an input and output interface module, which is directly connected to I/O devices.

- The program controls a PLC so that when an input signal from an input device turns ON, the appropriate response is made.

- The response normally involves turning ON an output signal to some sort of output device.
What is a Programmable Controller cont...
What is a Programmable Controller cont...

- **Central Processing Unit (CPU)**
  The CPU is a microprocessor that co-ordinates the activities of the PLC system. It executes the program, process I/O signals and communicates with external devices.

- **Memory**
  There are various types of memory units. It is the area that holds the operating system and user memory. The operating system is actually software that co-ordinates the PLC.
What is a Programmable Controller cont...

Ladder program, Timer and Counter Values are stored in the user memory.

Various type of memory:

1. Read Only Memory (ROM)

ROM is a non-volatile memory that can be programmed only once. It is therefore unsuitable. It is least popular as compared with others memory type.
2. Random Access Memory (RAM)

RAM is commonly used memory type for storing the user program and data. The data in the volatile RAM would be lost if the power source is removed. However, backing up the RAM with battery solves the problem.
3. Erasable Programmable Read Only Memory (EPROM)

EPROM hold data permanently just like ROM. It does not require battery back up. However, exposing it to ultraviolet light can erase its content. A PROM writer is required to reprogram the memory.
What is a Programmable Controller cont...

4. Electrically Erasable Programming Read Only Memory (EEPROM)

EEPROM combines the access flexibility of RAM and the non-volatility of ROM in one. Its contents can be erased and reprogrammed electrically, however, to a limit number of times.
What is a Programmable Controller cont...

- Input devices
  Intelligence of an automated system is greatly depending on the ability of a PLC to read in the signal from various of types of automatic sensing and manual input field devices.
- Manual input
  Basic man-machine interface are Push button, keypad, barcode reader, toggle switch.
What is a Programmable Controller cont...

- Automatic sensing devices
  
  Detection of work piece, monitoring of moving mechanism, checking on the pressure, and detect liquid level PLC need to tap signal from devices like proximity switch, limit switch, photo electric sensor, level sensor or etc.
What is a Programmable Controller cont...
What is a Programmable Controller cont...

• Output devices

Some of commonly controlled devices are motors, solenoids, relays indicators, buzzers, pilot lamp, alarms and etc.

Through activation of motor and solenoids the PLC can control from a simple pick and place system to much complex servo positioning system.

However, devices like pilot run, buzzers and alarms are for notifying purpose.
What is a Programmable Controller cont...
PLC Operation (Scan time)

- The process of reading the inputs, executing the program and updating the outputs is known as scan.
- The scan time is normally a continuous and sequentially process of reading the status of inputs, evaluating the control logic and updating outputs.
- Scan time specification indicates how fast the controller can react to the field inputs and correctly solve the control logic.
PLC Operation (Scan time) cont...
PLC Operation (Scan time) cont...

1. CHECK INPUT STATUS
   - First the PLC takes a look at each input to determine if it is on or off. In other words, is the sensor connected to the first input on? How about the second input? How about the third... It records this data into its memory to be used.

2. EXECUTE PROGRAM
   - Next the PLC executes your program one instruction at a time. Maybe your program said that if the first input was on then it should turn on the first output. Since it already knows which inputs are on/off from the previous step it will be able to decide whether the first output should be turned on based on the state of the first input. It will store the execution results for use later during the next step.
3. UPDATE OUTPUT STATUS

- Finally the PLC updates the status of the outputs. It updates the outputs based on which inputs were on during the first step and the results of executing your program during the second step. Based on the example in step 2 it would now turn on the first output because the first input was on and your program said to turn on the first output when this condition is true.
Factors influencing Scan Time

- The time required to make a single scan varies from 0.1 ms up to 10 ms depending on its CPU processing speed and the length of the user program.
- The user of remote I/O subsystem increase the scan time as a result of having to transmit the I/O update to the remote subsystem.
- Monitoring of the control program also adds overhead time to the scan, as the controller’s CPU has to send the status of coils and contact to the CRT or other monitoring devices.
Conventional Control Panel and its difficulties

- Beginning of industrial revolution, in 1960 & 1970 automated machines were controlled by electromechanical relays.
- Relays were all hardwired together inside control panel.
- Conventional relay control panel is very inflexible.
Conventional Control Panel and its difficulties cont..
Disadvantage of Conventional Control Panel

- There is too much wiring work in the panel.
- Modification can be quite difficult.
- Troubleshooting can be quite troublesome as you may require a skillful person.
- Power consumption can be quite high as the coil consumer power.
- Machine downtime is usually long when problem occur, as it take long time to trouble shooting.
- Difficult to do modification and maintenance.
PLC Control Panel and Advantages
The wiring of the system usually reduces by 80%.

Power consumption greatly reduced as PLC consume much less power.

The PLC self-diagnostic function enable easy and fast troubleshooting of the system.

Modification of the control sequence or application can easily be done by programming through the console or computer software without changing of I/O wiring.
PLC Control Panel and Advantages cont..

- In PLC system, spare parts for relays and hardware timers are greatly reduced as compared to conventional control panel.
- The machine cycle time is improve due to the speed of PLC operation is in millisecond.
- It cost much less compared to conventional system in situation when the number of I/Os is very large and control function are complex.
- The reliability is high an easily maintenance.
<table>
<thead>
<tr>
<th>ITEM</th>
<th>WIRED LOGIC</th>
<th>PLC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controlled Device (Hardware)</td>
<td>Specific Purpose</td>
<td>General Purpose</td>
</tr>
<tr>
<td>Control Scale</td>
<td>Small and Medium</td>
<td>Medium and large</td>
</tr>
<tr>
<td>Change or addition to specification</td>
<td>Difficult</td>
<td>Easy</td>
</tr>
<tr>
<td>Delivery period</td>
<td>Several Days</td>
<td>Almost immediate</td>
</tr>
<tr>
<td>Maintenance (by makers and users)</td>
<td>Difficult</td>
<td>Easy</td>
</tr>
<tr>
<td>Reliability</td>
<td>Depends on design and manufacture</td>
<td>Very High</td>
</tr>
<tr>
<td>Economic Efficiency</td>
<td>Advantage on small scale operation</td>
<td>Advantage on small medium and large scale operation</td>
</tr>
<tr>
<td><strong>CONTROL TYPE</strong></td>
<td><strong>FUNCTIONS</strong></td>
<td></td>
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<tr>
<td>--------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
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<tr>
<td>Sequences Control</td>
<td>• Conventional Relay Control Logic Replacer / P.C.B Card Controller Replacer</td>
<td></td>
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<tr>
<td></td>
<td>• Timers/Counters</td>
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<tr>
<td></td>
<td>• Auto/Semi-auto/Manual Control of machine and Processes</td>
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<tr>
<td>Sophisticated Control / Regulatory Control</td>
<td>• Arithmetic Operation</td>
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<tr>
<td></td>
<td>• Information handling</td>
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<tr>
<td></td>
<td>• Analog Control (Temperature, Pressure)</td>
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<tr>
<td></td>
<td>• P.I.D (Proportional-Integral-Derivation)</td>
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<tr>
<td></td>
<td>• Servo Motor and Stepper Motor</td>
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<tr>
<td>Supervisory Control</td>
<td>• Process Monitoring and Alarm</td>
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<td></td>
<td>• Fault Diagnostic and Monitoring</td>
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<tr>
<td></td>
<td>• Interfacing with Computer - Printer/ASCII</td>
<td></td>
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<td></td>
<td>• Factory Automation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Local Area Network / Wide Area Network</td>
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</tbody>
</table>
PLCs’ manufacturer

- OMRON
- Allen Bradley
- Schneider (Modicon, Telemechanique, Square D)
- GE Fanuc
- Siemens
- Automation Direct (Koyo)
- Toshiba
- Mitsubishi
- Hitachi
- Keyence
- Festo
- Eberle
- Texas Instruments

- Honeywell
- Yokogawa
- Emerson

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PLC Application

- There are many applications:
  1. Material Handling
  2. Conveyor system
  3. Packaging Machine
  4. Pump Control
  5. Water Treatment
  6. Chemical Processing Plant
  7. Printing Industries
  8. Traffic Light system
  9. Etc...
A relay

- An electrical operated switch.
- Many relays use electromagnet to operate a switching mechanism.
A relay cont...

Basic design and operation

A simple electromagnetic relay, such as the one taken from a car in the first picture, is an adaptation of an electromagnet. It consists of a coil of wire surrounding a soft iron core, an iron yoke, which provides a low reluctance path for magnetic flux, a movable iron armature, and a set, or sets, of contacts; two in the relay pictured. The armature is hinged to the yoke and mechanically linked to a moving contact or contacts. It is held in place by a spring so that when the relay is de-energised there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their function. The relay in the picture also has a wire connecting the armature to the yoke. This ensures continuity of the circuit between the moving contacts on the armature, and the circuit track on the printed circuit board (PCB) via the yoke, which is soldered to the PCB.

When an electric current is passed through the coil, the resulting magnetic field attracts the armature, and the consequent movement of the movable contact or contacts either makes or breaks a connection with a fixed contact. If the set of contacts was closed when the relay was de-energised, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low voltage application, this is to reduce noise. In a high voltage or high current application, this is to reduce arcing.

If the coil is energized with DC, a diode is frequently installed across the coil, to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a voltage spike dangerous to circuit components. Some automotive relays already include that diode inside the relay case. Alternatively a contact protection network, consisting of a capacitor and resistor in series, may absorb the surge. If the coil is designed to be energized with AC, a small copper ring can be crimped to the end of the solenoid. This “shading ring” creates a small out-of-phase current, which increases the minimum pull on the armature during the AC cycle.¹

By analogy with the functions of the original electromagnetic device, a solid-state relay is made with a thyristor or other solid-state switching device. To achieve electrical isolation an optocoupler can be used which is a light-emitting diode (LED) coupled with a photo transistor.