Programmable Logic Controllers

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Target Audience

This course is for Engineers/PLC users involved in developing or sustaining automation systems and their application programs.

Instructor Profile

An Electronic Engineer with around 12 years experience in the design, construction, operation and maintenance of Process Automation and Telecommunication Systems. Work included planning and implementation of autonomous SCADA Systems and Power Spectrum for energy management using SIMATIC WinCC (Siemens Software). Expertise includes management of Remote Terminal Units (RTUs) and WinCC options for plant intelligence and SCADA expansion. Conversion of Control Diagrams into Ladder Logic using Programmable Logic Controllers of various manufacturers for implementation of Programmable Automation. Expert in programming for Power Factor Correction related automatic control systems. Router configuration for Voice over Internet Protocol (VOIP) and database management of call records.

Programmable Logic Controller (PLC)

Programmable Logic Controllers (PLCs), also referred to as programmable controllers, are in the computer family. They are used in commercial and industrial applications.

A PLC monitors inputs, makes decisions based on its program, and controls outputs to automate a process or machine.

Programmable Logic Controller (PLC)
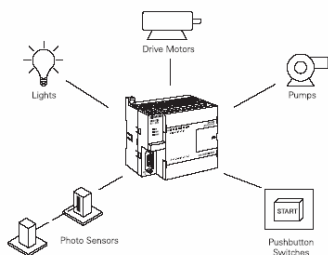
Solutions Communities [1]

Solutions Communities are:

Automotive
Cement
Chemical
Food & Beverage
Glass
Machine Tools
Marine
MES

Metals
Mining
Oil & Gas
Pharmaceutical
Production
Machines
Pulp & Paper
Semiconductor

Solutions Communities [2]

Transport facilities
- Conveyor systems
- Hoisting platforms
- Elevators
- Silo works
- Automatic dry feeders

Special solutions
- Solar-electric systems
- Use on ships
- Use under extreme environmental conditions
- Display panels and traffic control signs

House and building services management
- Lighting control (outside and inside lighting)
- Door/gate control
- Shutter, sun blind and awning control
- Watering and sprinkler system control

Solutions Communities [3]

Machine controls
- Motor, pump and valve controls
- Air compressors
- Exhaust and filtering systems
- Water-treatment plants
- Sawing machines and planing machines
- Etching and purification plants

Operational monitoring systems
- Access control
- Vehicle control monitoring
- Alarm systems
- Limit-value monitoring
- Traffic light control systems
- Baggage control

Heating/ventilation/air conditioning
- Energy management
- Heating
- Cooling systems
- Ventilation systems
- Air conditioning systems

Ten Fundamental Questions [1]

1. What is a programmable controller?
A programmable controller is a microprocessor-based industrial controller, the functions of which are determined by a stored program.

2. What is a program?
A program is a set of instructions 'telling' the controller how to behave. It is stored in the controller's memory.

Ten Fundamental Questions [2]

3. How does a programmable controller differ from a computer?
A computer is optimized for calculation and display tasks and is programmed by specialists. A programmable controller is optimized for control and regulation tasks and can be programmed by non-specialists. It is also well adapted to the industrial environment.

A Common Example of Regulation Task is Traffic Signals.

Ten Fundamental Questions [3]

4. Why are programmable controllers so common?
Because they are cost-effective and have significant advantages over traditional control systems based on relays or pneumatics.
5. Where are they used?
In virtually every industry where automation is involved, from individual machines to whole processes, in commercial, institutional and industrial premises.

Ten Fundamental Questions [4]

6. What are the main advantages?
A control system based on a programmable controller is flexible, reliable and compact and can be assembled at a relatively low cost.
7. Are all programmable controllers the same?
They are broadly similar in a functional sense, but they differ in size, programming detail and mechanical design. Most manufacturers offer several models with different levels of performance.

Ten Fundamental Questions [5]

8. What tasks does a programmable controller perform?
The control tasks previously undertaken with electrical and/or pneumatic controls, e.g. interlocking, sequencing, timing and counting. It can, in addition, perform a variety of calculation, communication and monitoring tasks.

9. Does a programmable controller eliminate contactors and valves?
No, but these items are brought under the programmable controller's influence in modern control systems.

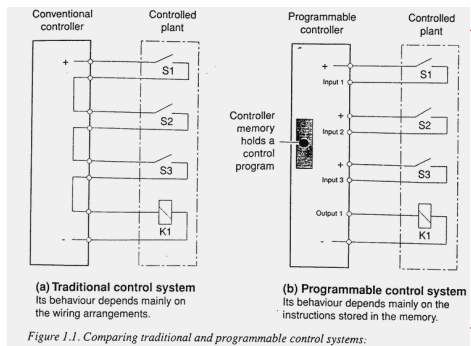## Ten Fundamental Questions [6]

10. Are there drawbacks?
Yes. Programmable controllers still do not enjoy the same trust or acceptance as traditional control techniques, even though the technology is nearly 35 years old. The natural resistance to accept the 'new' technology is understandable; most of our current industrial staff were educated and trained before this technology became common. Some technical adaptations have to be made in implementing programmed control.

Control System Overview [1]

There are three characteristic features of a control system, whether it is programmable or not:
1.There are certain actions to be taken (such as turning a valve ON or OFF or regulating its position).
2.There are certain rules governing those actions.
3.The rules take account of certain relevant conditions in the plant (such as manual switches, sensors for level, pressure, temperature, position).

Control System Overview [2]

(a) Traditional control system
Its behaviour depends mainly on the wiring arrangements.

(b) Programmable control system
Its behaviour depends mainly on the instructions stored in the memory.

Figure 1.1. Comparing traditional and programmable control systems:

Basic PLC Operation [1]

•PLCs consist of input modules or points, a Central Processing Unit (CPU), and output modules or points. (Refer to Figure)
•An input accepts a variety of digital or analog signals from various field devices (sensors) and converts them into a logic signal that can be used by the CPU.
•The CPU makes decisions and executes control instructions based on program instructions in memory.

Basic PLC Operation [2]
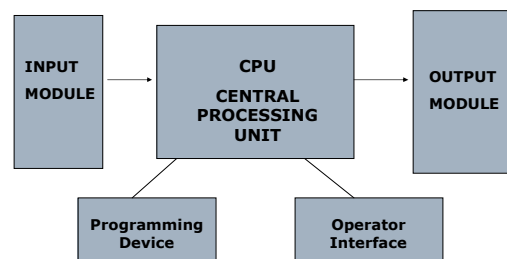
Basic PLC Operation [3]

- Output modules convert control instructions from the CPU into a digital or analog signal that can be used to control various field devices (actuators).
- A programming device is used to input the desired instructions.
- These instructions determine what the PLC will do for a specific input.
- An operator interface device allows process information to be displayed and new control parameters to be entered.

PLC Operation Example
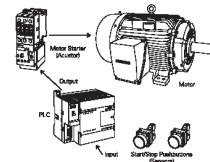
Pushbuttons (sensors), in this simple example, connected to PLC inputs, can be used to start and stop a motor connected to a PLC through a motor starter (actuator).
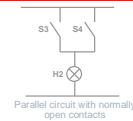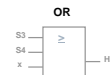
Hard Wired Control or WLC

- Prior to PLCs, many of these control tasks were solved with contactor or relay controls. This is often referred to as hardwired control.
- Circuit diagrams had to be designed, electrical components specified and installed, and wiring lists created.
- Also Referred to as Wired Logic Control (WLC)

WLC Example

For lamp H2 to illuminate, switch S3 or S4 must be closed. This dependency of the output state on the input states is referred to as an OR logic operation.

This means that at least one of the two switches--S3 or S4-- must be closed in order for lamp H2 to illuminate.

The symbol for this operation is ≥1

Parallel circuit with normally open contacts

OR

The state of the OR output =1 if the state of at least one input = 1. An unconnected input pin in this block is automatically assigned state = 0.

Logic Table for OR Block:

Input 1	Input 2	Input 3	Output
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

Hard Wired Control or WLC

- If an error was made the wires had to be reconnected correctly.

- A change in function or system expansion required extensive component changes and rewiring.

- A programmable controller can be *reprogrammed* to accommodate a change of rules—no rewiring is needed

Advantages of PLCs [1]

- The same (WLC), as well as more complex tasks, can be done with a PLC.
- Wiring between devices and relay contacts is done in the PLC program.
- Hard-wiring, though still required to connect field devices, is less intensive.
- Modifying the application and correcting errors are easier to handle.
- It is easier to create and change a program in a PLC than it is to wire and rewire a circuit.

Advantages of PLCs [2]

• Smaller physical size than hard-wire solutions.
● Easier and faster to make changes.
● PLCs have integrated diagnostics and override functions.
● Diagnostics are centrally available.
● Applications can be immediately documented.
● Applications can be duplicated faster and less expensively.

Applications [1]

1. Automobile Industries
Automatic drilling/assembly and test equipment, painting facilities, shock absorber test benches.
2. Plastic Industries
Blow, injection and thermal molding machines, synthetic production systems, temperature & pressure control.
3. Heavy Industries
Molding equipment, industrial furnaces, rolling mills, temperature control systems.
4. Chemical Industries
Proportioning & mixing systems, temperature & pressure control, boiler & chiller control.
5. Food & Beverages Industries
Centrifuging, batch processing, temperature & pressure control, boiler & chiller control.

Applications [2]

6. Machinery's
Packing, wood-working, machine control, machine tools, drilling mills, fault alarm centers, welding technology.
7. Building Services
Elevators, climate control, ventilation, lighting, alarm & security systems.
8. Transport Systems
Transport and sorting equipment, ware-houses, conveyor and crane systems, traffic signals.
9. Energy, Gas, Water & Air
Pressure booster stations, standby power supplies, pump control, water & air treatment, filtering and gas recovery systems, emergency systems.
10. Textile Industries
AC/DC drive control, temperature control, heating/drying control, spinning, dying and color mixing.

History of PLCs

•The first PLC systems evolved from conventional computers in the late 1960s and early 1970s.
•These first PLCs were mostly installed in automotive plants. Tradi-tionally, the auto plants had to be shut down for up to a month at model change-over time.
•The early PLCs were used along with other new automation techniques to shorten the changeover time. One of the major time-consuming changeover procedures had been the wiring of new or revised relay and control panels.
•The PLC keyboard reprogramming procedure replaced the rewiring of a panel full of wires, relays, timers, and other components.
•The new PLCs helped reduce repro-gramming time to a matter of a few days.

Knowledge Level For PLC Programming

• A person knowledgeable in relay logic systems can master the major PLC function in a few hours.
• These functions might include coils, contacts, timers, and counters.
• The same is true for a person with Knowledge of digital principles, however, the learning process takes more time.
Remember: A relay is digital in nature because it is basically an on/off, two-state device.

Terminology

❑ The language of PLCs consists of a commonly used set of terms; many of which are unique to PLCs.
❑ In order to understand the ideas and concepts of PLCs, an understanding of these terms is necessary.

PLC Related Terms [1]

Sensor: A sensor is a device that converts a physical condition into an electrical signal for use by the PLC. Sensors are connected to the input of a PLC.
❑ **A pushbutton is one example of a sensor that is connected to the PLC input.**
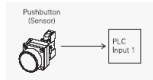
PLC Related Terms [2]

Actuator: Actuators convert an electrical signal from the PLC into a physical condition. Actuators are connected to the PLC output.
A motor starter is one example of an actuator that is connected to the PLC output. Depending on the output PLC signal, the motor starter will either start or stop the motor.
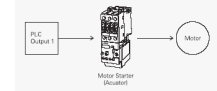
PLC Related Terms [3]

Discrete Input: A discrete input, also referred to as a digital input, is an input that is either in an ON or OFF condition.

❑ **In the ON condition a discrete input may be referred to as a logic 1 or a logic high. In the OFF condition a discrete input may be referred to as a logic 0 or a logic low.**
❑ **Examples are: Pushbuttons, Limit Switches, Proximity Switches.**

PLC Related Terms [4]

Discrete Output: A discrete output is an output that is either in an ON or OFF condition. Discrete outputs may also be referred to as digital outputs.

❑ **Examples are: Solenoids, contactor coils, and lamps**

PLC Related Terms [5]

Analog Input: An analog input is an input signal that has a continuous signal. Examples are: Temperature Sensor, Level Sensor

Analog Output: An analog output is an output signal that has a continuous signal. Examples are: Analog Meters to display speed, weight etc.
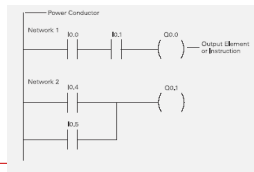
PLC Related Terms [6]

CPU: The central processor unit (CPU) is a microprocessor based system that contains the system memory and it is the PLC decision making unit. The CPU monitors the inputs and makes decisions based on instructions held in the program memory.

Programming: A program consists of one or more instructions that accomplish a task. Programming a PLC is simply constructing a set of instructions. There are several ways to look at a program such as ladder logic, statement lists, or function block diagrams.

PLC Related Terms [7]

Ladder Logic: Ladder logic (LAD) is one programming language used with PLCs. Ladder logic uses components that resemble elements used in a line diagram format to describe Wired Logic Control.

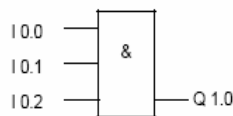## PLC Related Terms [8]

Statement List (STL): STL represents the program as a sequence of operation mnemonics. A statement has the following format:

```
NETWORK 1
          LD        I0.0
          A         I0.1
          =         Q0.0
NETWORK 2
          LD        I0.4
          O         I0.5
          =         Q0.1
```

PLC Related Terms [9]

Function Block Diagram (FBD): FBD represents logic operations with graphics symbols.

More Terms

1. Software (e.g. STEP-7 by Siemens)
2. Hardware (Actual PLC)
3. Programming Device
4. Connector Cable

General Instruction Set

1. Boolean Logic Operation (AND, OR, AND before OR, OR before AND)
2. Flip Flop Operations (RS and SR)
3. Timer Operations (Five Types)
4. Counter Operations (UP and DOWN)
5. Comparison Operation (Six Types)
6. Jump Operations (To Jump between Blocks)
7. Analog Value Processing
8. Troubleshoot common software/hardware errors

PLC Manufacturers

- ❑ Around 100 various manufacturers all over the world
- ❑ Leading Manufacturers are:

1. SIEMENS
2. ALLEN BRADLEY
3. OMRON
4. MITSUBISHI
5. GE FANUC

Link for Complete List:
http://www.plcs.net/chapters/links.htm

Recommended Links

www.sea.siemens.com

www.plcs.net

www.mhj-software.com/de/

www.gefanuc.com/en/

www.siemens.com/logo

www.automation.siemens.com/s7-200/index_76.htm

www.automation.siemens.com/s7-200/html_76/primer.htm

Recommended Books

Programmable Controllers by Dennis Collins & Eamon Lane

A Guide To Understanding PLCs by Phil Melore –
The PLC Tutor

Programmable Logic Controllers
by Max Rabiee - Goodheart-Wilcox

Programmable Logic Controllers by Frank D. Petruzella

**Fundamentals of Programmable Logic Controllers,
Sensors, and Communications** by Jon Stenerson

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