Manufacturing Laboratory (21-410)

Advanced Manufacturing Laboratory
Department of Industrial Engineering
Sharif University of Technology

Session # 1

PLC

Description

- This training introduces the basic hardware and software components of a Programmable Controller (PLC). It details the architecture and basic instruction set common to all PLC's. Basic programming techniques and logic designs are covered. This training describes the operating features of the PLC, the advantages of the PLC over hard-wired control systems, practical applications, troubleshooting and maintenance of PLC's.

Session contents

- History of Programmable Controllers
- Relay Ladder Logic
- Central Processing Unit
- Input/Output System
- Programming and Peripheral Devices
- Programming Concepts
- Applications

PLC Origin

- Developed to replace relays in the late 1960s
- Costs dropped and became popular by 1980s
- Now used in many industrial designs

Historical Background

- *The Hydramatic Division of the General Motors Corporation specified the design criteria for the first programmable controller in 1968*
- *Their primary goal was to eliminate the high costs associated with inflexible, relay-controlled systems.*

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*

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.*

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.*

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.

Leading Brands Of PLC

- *AMERICAN*
  1. *Allen Bradley*
  2. *Gould Modicon*
  3. *Texas Instruments*
  4. *General Electric*
  5. *Westinghouse*
  6. *Cutter Hammer*
  7. *Square D*

- *EUROPEAN*
  1. *Siemens*
  2. *Klockner & Mouller*
  3. *Festo*
  4. *Telemechanique*

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

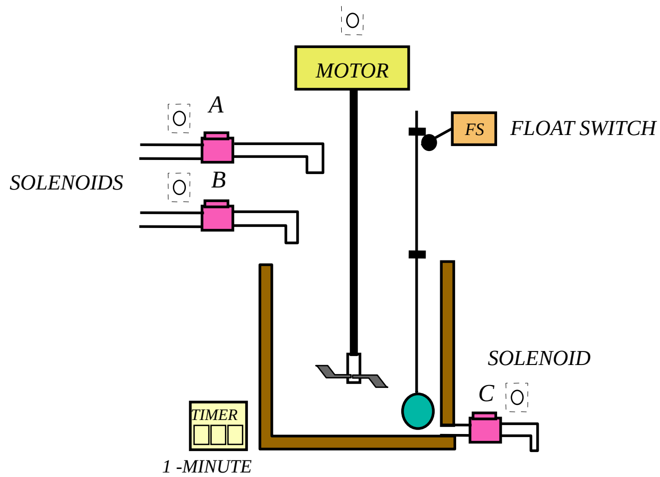
Areas of Application

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

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.*

Example: Tank Used to Mix Two Liquids



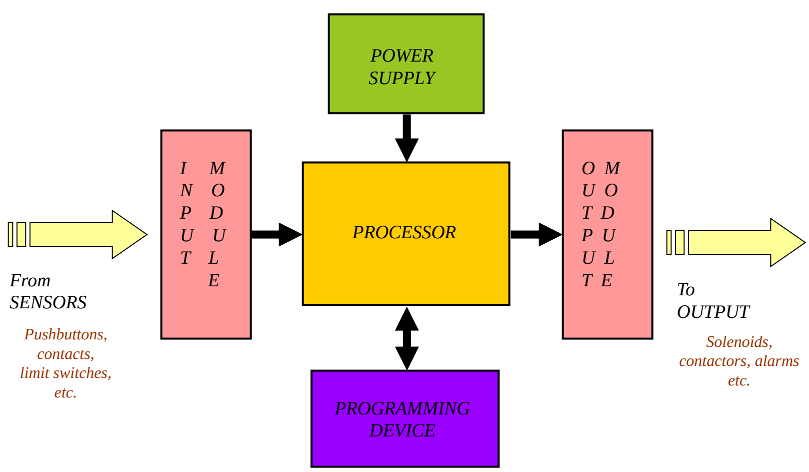
Example: Tank Used to Mix Two Liquids

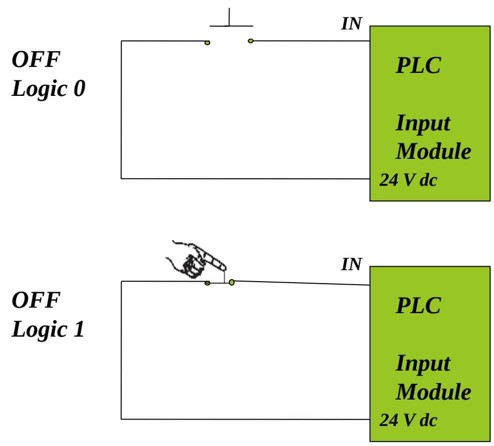
- *A tank is used to mix two liquids. The control circuit operates as follows:*
- *1. When the start button is pressed, solenoids A and B energize. This permits the two liquids to begin filling the tank.*
- *2. When the tank is filled, the float switch trips. This de-energizes solenoids A and B and starts 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.*

Example: 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.

Major Components of a Common PLC



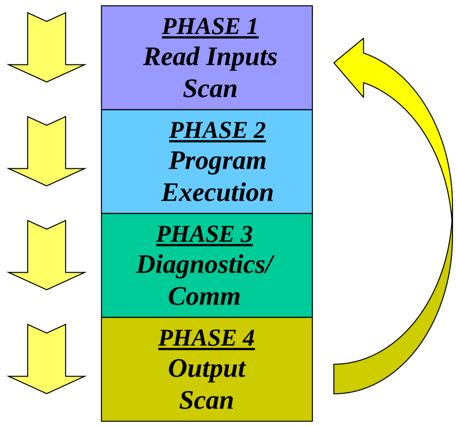


PLC Operation

- 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.

PLC Operation

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



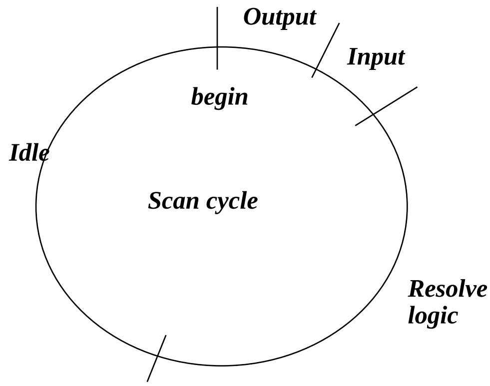
PLC Operation

- *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.*

SCAN

A PLC resolves the logic of a ladder diagram (program) rung by rung, from the top to the bottom. Usually, all the outputs are updated based on the status of the internal registers. Then the input states are checked and the corresponding input registers are updated. Only after the I/Os have been resolved, is the program then executed. This process is run in a endless cycle. The time it takes to finish one cycle is called the scan time.



Selecting a PLC

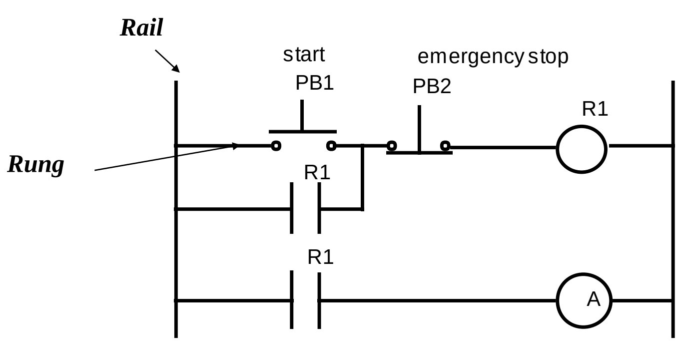
- *Criteria*
  - *Number of logical inputs and outputs.*
  - *Memory*
  - *Number of special I/O modules*
  - *Scan Time*
  - *Communications*
  - *Software*

A Detailed Design Process

- Understand the process
- Hardware/software selection
- Develop ladder logic
- Determine scan times and memory requirements

LADDER DIAGRAM

A ladder diagram (also called contact symbology) is a means of graphically representing the logic required in a relay logic system.



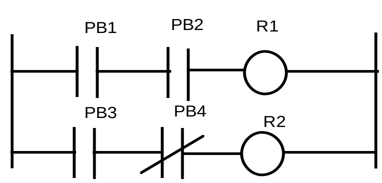
LOGIC STATES

ON : TRUE, contact closure, energize, etc.

OFF: FALSE, contact open , de-energize, etc.

AND and OR LOGIC

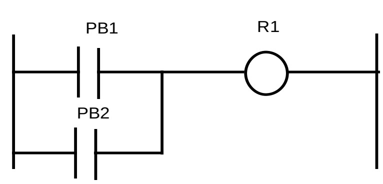
AND



R1 = PB1.AND.PB2

R2 = PB2.AND.~PB4

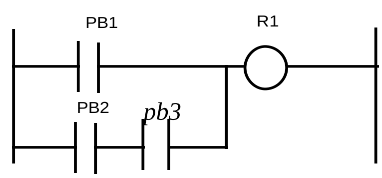
OR



R1 = PB1 .OR. PB2

COMBINED AND & OR

R1 = PB1 .OR. (PB2 .AND. PB3)

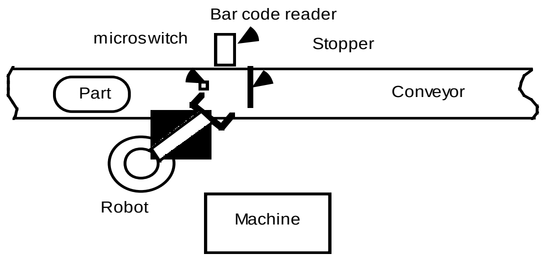


Other Languages

- ***Blocks*** *are built from small ladder logic subroutines and used through the code as user defined ladder logic instructions, the advantages of this approach is the reduction of repetitive ladder logic code.*
- ***Sequential Function Chart (SFC****) programming is similar to programming by computer flow chart. In SFC the program advances step by step through various blocks (where action happens such as a motor is started).*
- *Transition conditions determine when the program advances from one block to another.*
- *Both the action blocks and the transition conditions are created using ladder diagrams.*
- ***Structured text,*** *uses simple instructions common to medium level programming languages: If , While, Then etc.*

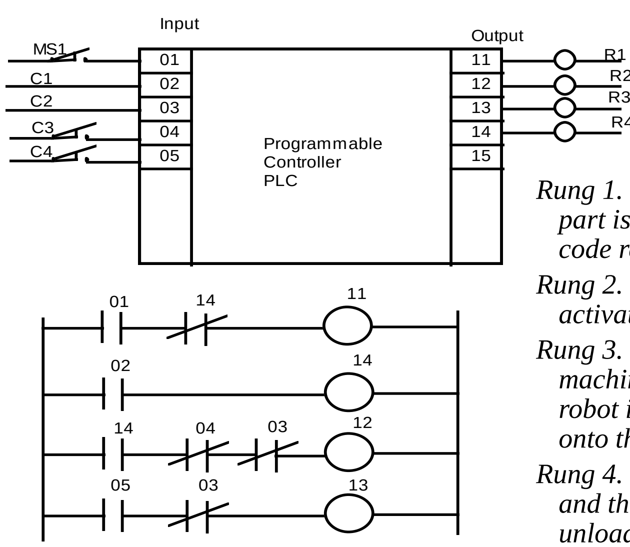
- *Note: Some programming packages allow the user to switch between Relay Ladder Logic and Structured text representations of the code.*

PROGRAMMING EXAMPLE 1



id	*description*	*state*	*explanation*
MSI	*microswitch*	*1*	*part arrive*
R1	*output to bar code reader*	*1*	*scan the part*
C1	*input from bar code reader*	*1*	*right part*
R2	*output robot*	*1*	*loading cycle*
R3	*output robot*	*1*	*unloading cycle*
C2	*input from robot*	*1*	*robot busy*
R4	*output to stopper*	*1*	*stopper up*
C3	*input from machine*	*1*	*machine busy*
C4	*input from machine*	*1*	*task complete*

SOLUTION



Rung 1. If part arrives and no part is stopped, trigger the bar code reader.

Rung 2. If it is a right part, activate the stopper.

Rung 3. If the stopper is up, the machine is not busy and the robot is not busy, load the part onto the machine.

Rung 4. If the task is completed and the robot is not busy, unload the machine.