IQRA National University
Peshawar
Department of Electrical Engineering

Industrial Automation

Programmable Logic Controller PLC

Industrial Electronics

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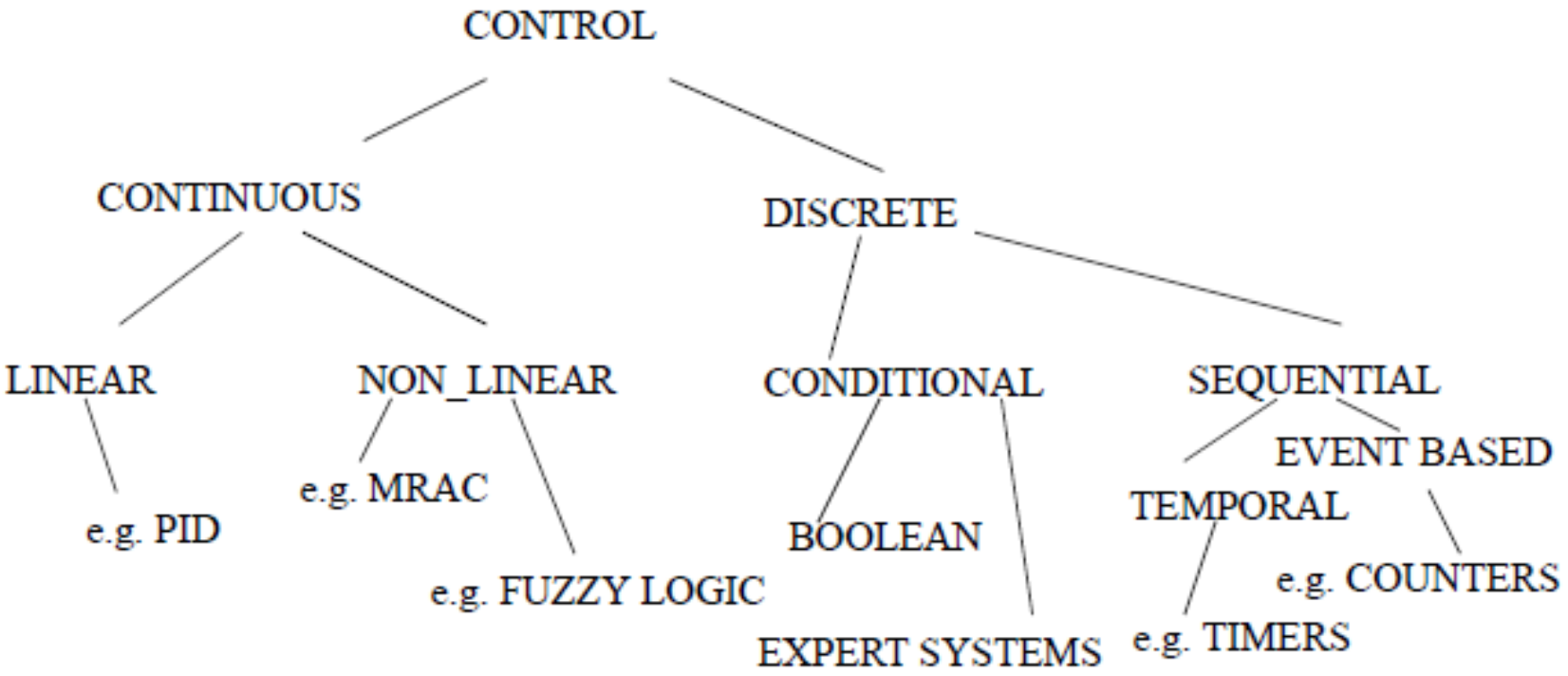
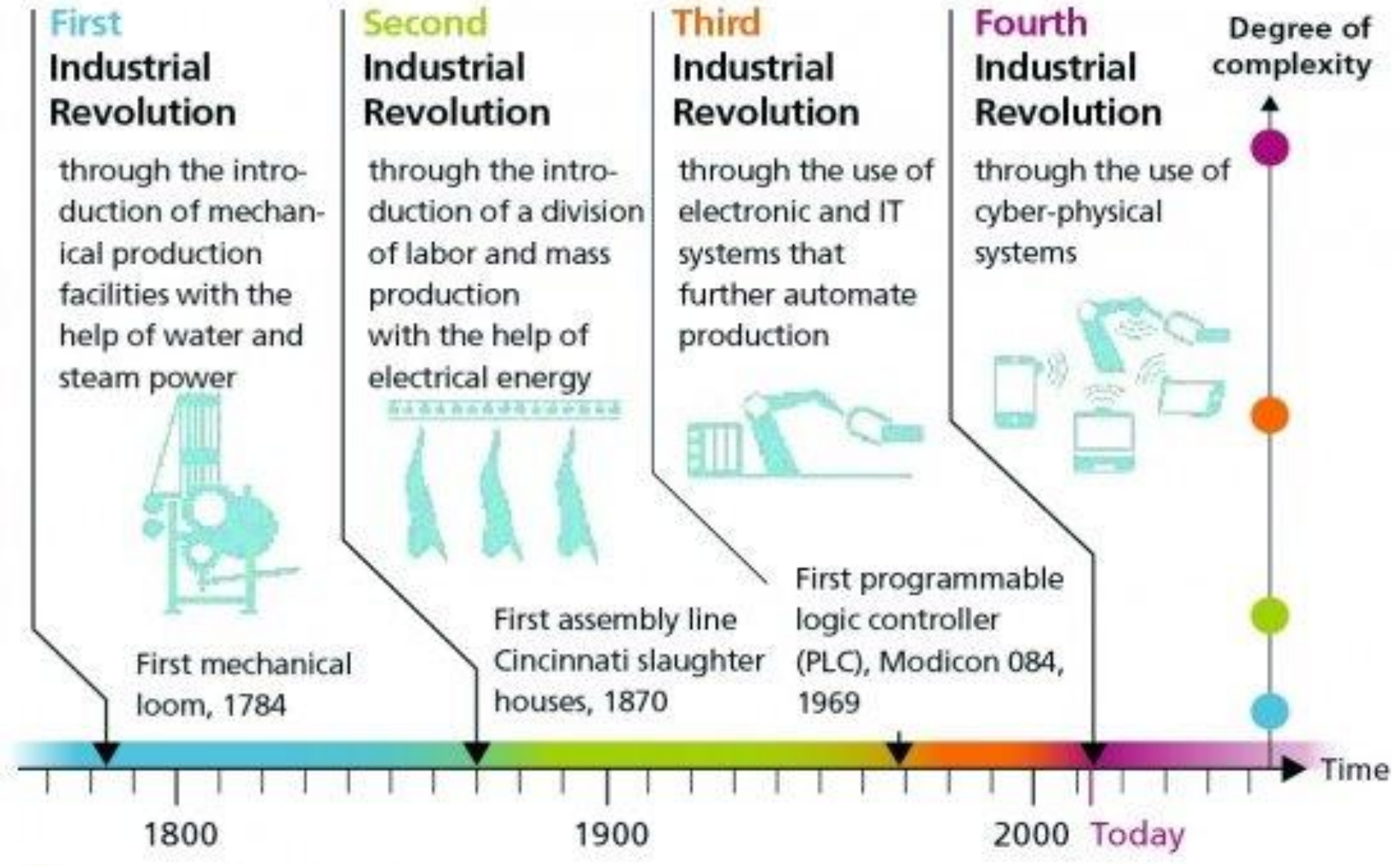
- Now a days every system involves some type of control system. etc room heating system , Air conditioning etc.
- In any sector of industry you will find control system e.g Automatic assembly lines, Machines control etc.
- There are application where we required to control Temp, Pressure, liquid etc (know as Process control).
- In 2nd world war automatic pilot control system based on servomechanism which is slave to command from system and this mechanism is called servomechanism.

Control Dichotomy

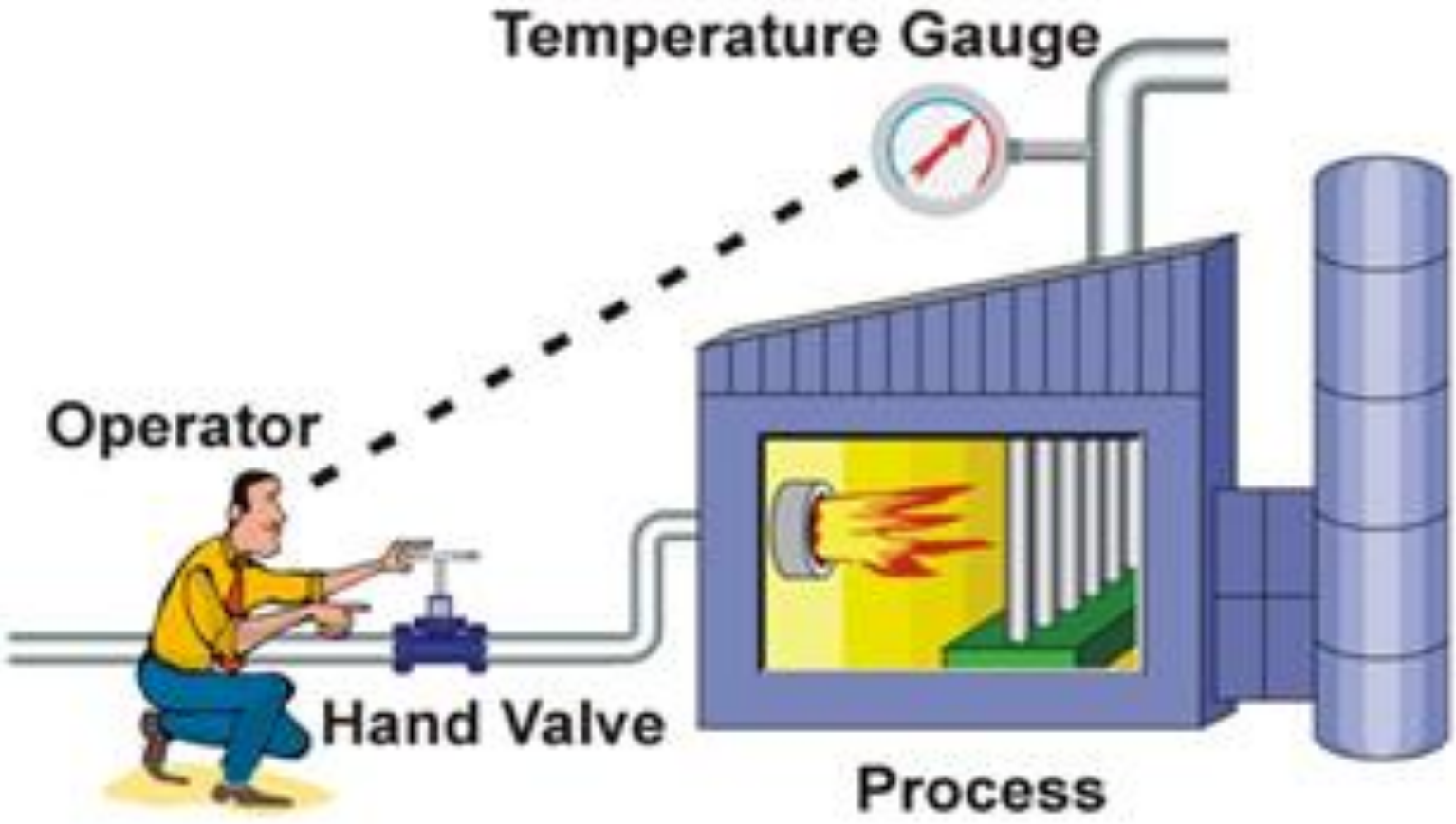


- Continuous - The values to be controlled change smoothly. e.g. the speed of a car.
- Logical - The value to be controlled are easily described as on-off. e.g. the car motor is on-off.
- Linear - This is the preferred starting point for simplicity, and a common approximation for real world problems.
- Non-Linear -This is how the world works and the mathematics become much more complex.
- Sequential - A logical controller that will keep track of time and previous events.

Industrial Revolutions

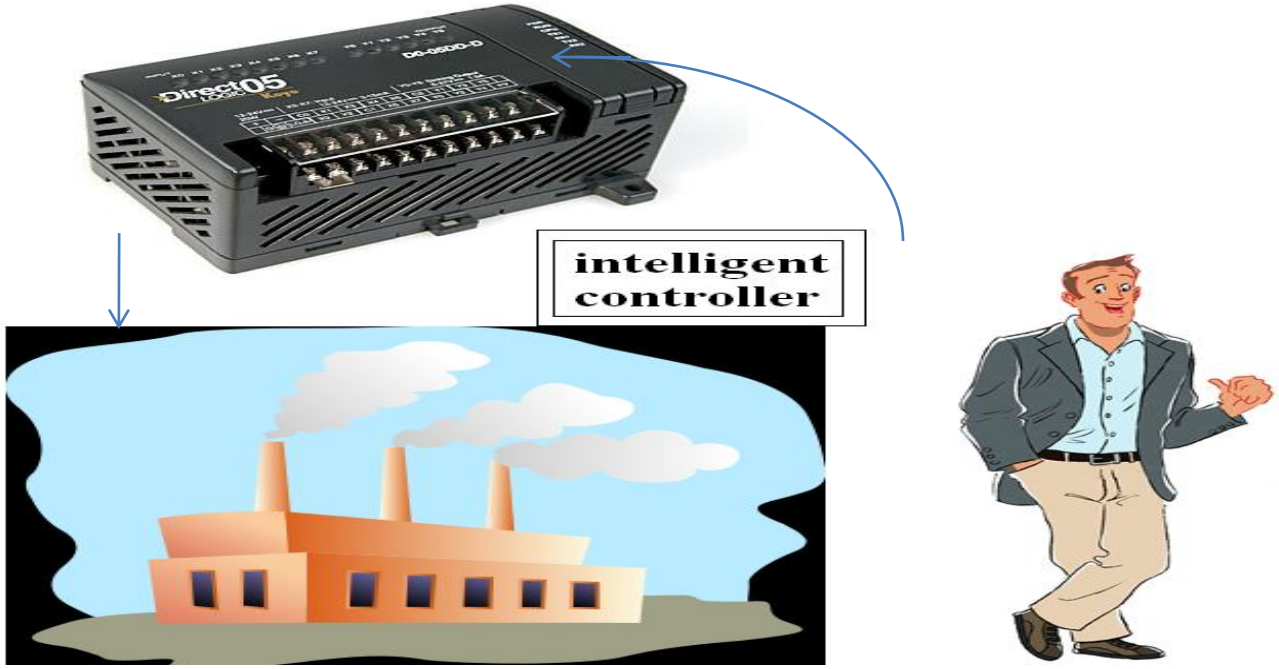


Manual Control



Industrial Automation

Automation is basically the allocation of human control function to technical equipment to automate the systems that produce their goods or services in the most efficient manner possible.



INFORMATION

COMMANDS

CONTROL SYSTEM

SENSORS

ACTUATORS

PLANT

Benefits of Industrial Automation

- Increasing Productivity
  - Increased productivity = more units/day = more money
- Products produced more consistently
  - increased consistency = higher quality = increased consumer satisfaction
  - Example - A bottled soft drink such as a Coke or a Pepsi always tastes the same no matter where or when you purchase it. Consumers count on this.
- Products produced more reliably
  - robots can run 24 hours/day without getting tired or bored
- Decreased labor expenses
  - Automated systems reduce the amount of people needed to produce the goods
- Increasing Safety in working conditions

TYPES OF AUTOMATION

Building automation

Example: lifts, smoke detectors

Office automation

Example: printers, cctv cameras

Scientific automation

Example: rocket launching

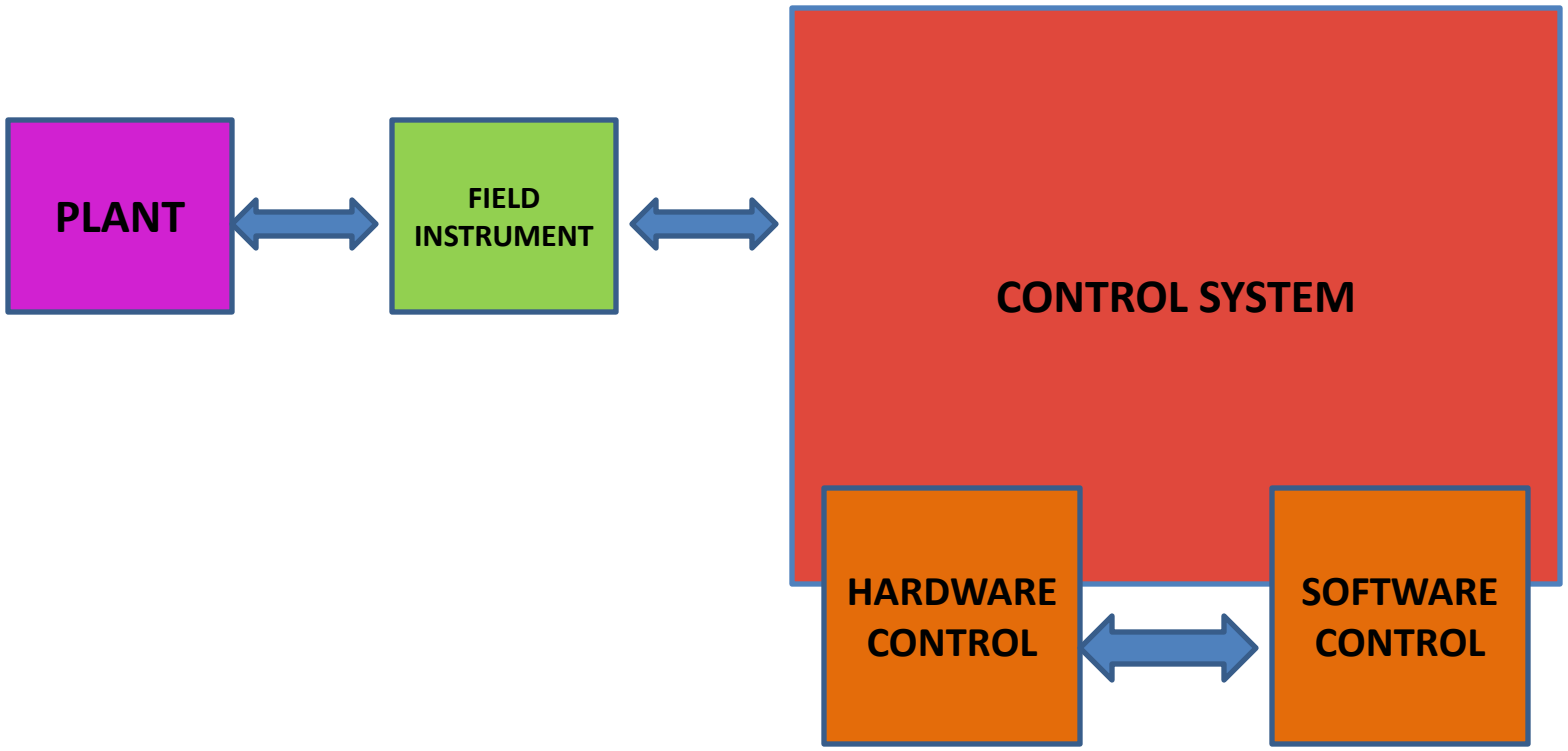
Light automation

Example: street solar lightening

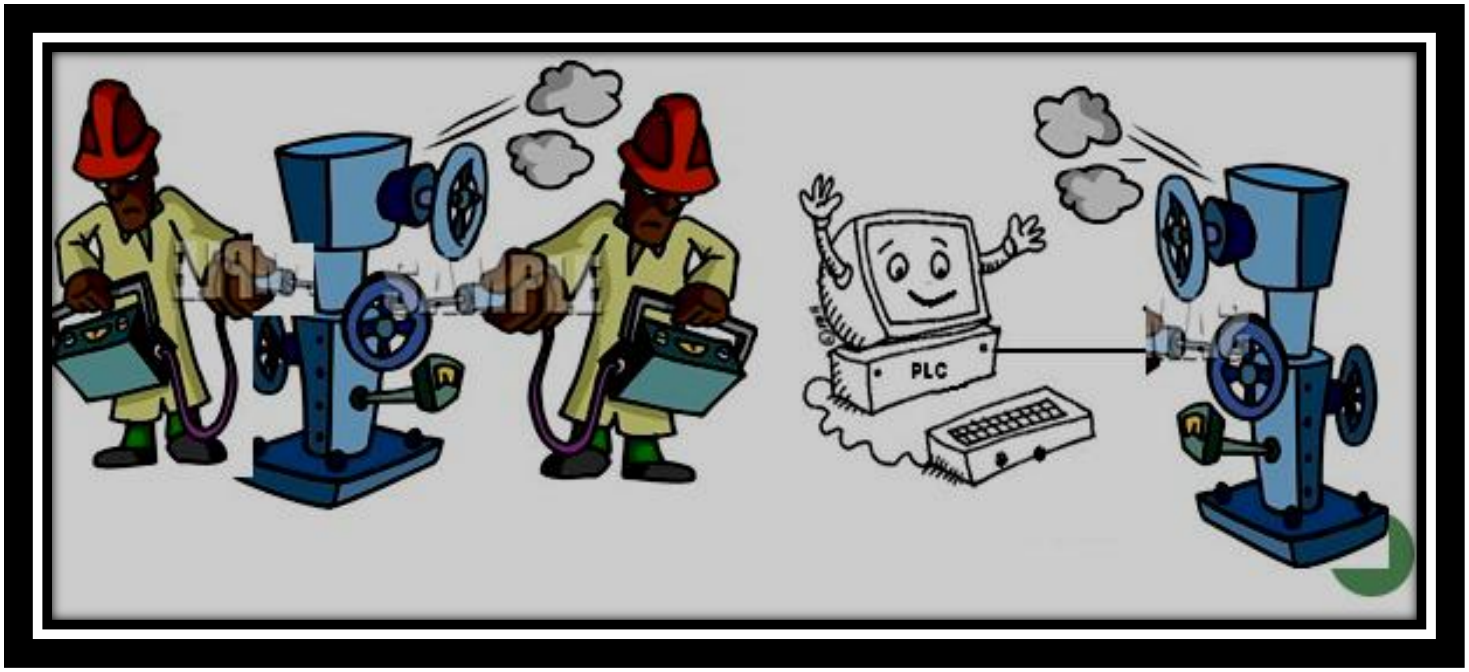
Industrial automation

Example: automated bottle filling stations , steel factories etc

INDUSTRIAL AUTOMATION



Machine can be controlled by Computers without human efforts

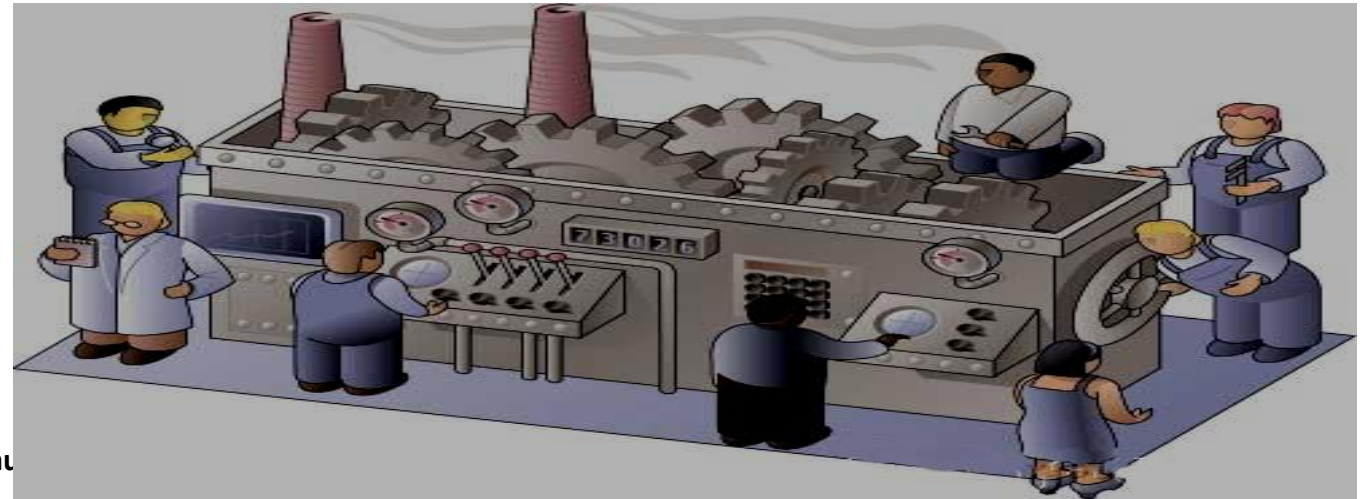


Industrial Computer
OR
Programmable Logic Controller (PLC)

- ***Programmable Logic Controller (PLC)*** is an industrial computer that *monitors inputs*, *makes decisions* based on its program and *controls outputs* to automate a process or machine.
- The automation of many different processes, such as controlling machines or factory assembly lines, is done through the use of small computers called PLC.

Why PLC

- To reduce human efforts .
- To get maximum efficiency from machine and control them with human logic .
- To reduce complex circuitry of entire system
- To eliminate the high costs associated with inflexible, relay-controlled systems.



History of PLC

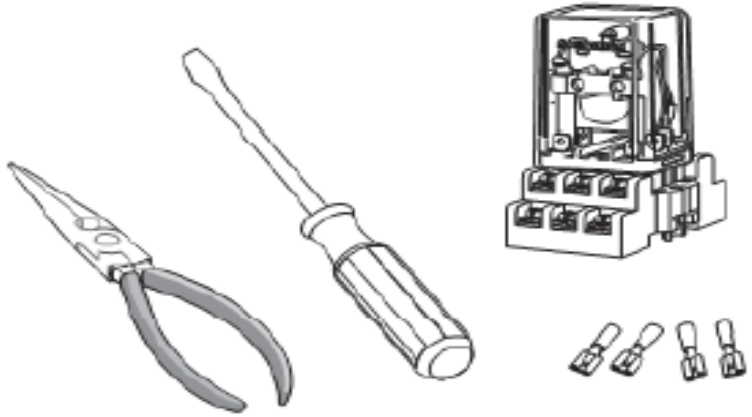
- PLC was introduced in late 1960's
- First commercial & successful Programmable Logic Controllers was designed and developed by **Modicon** as a relay replacer for General Motors.
- Earlier, it was a machine with thousands of electronic parts.
- Later ,in late 1970's,the microprocessor became reality & greatly enhanced the role of PLC permitting it to evolve form simply relay to the sophisticated system as it is today.

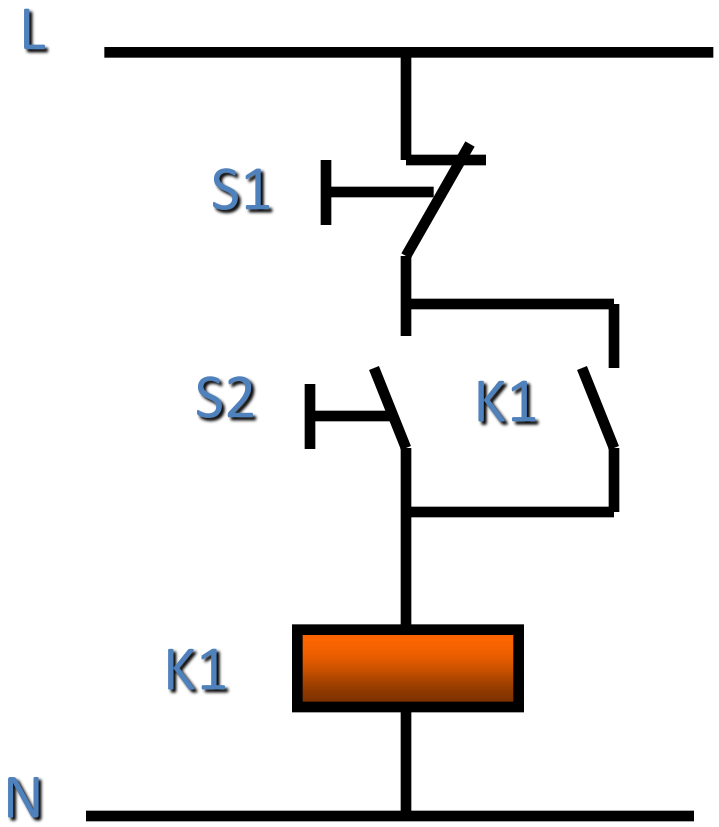
Replacing Relays

PLCs were invented to Replace Relays and hard Wiring.

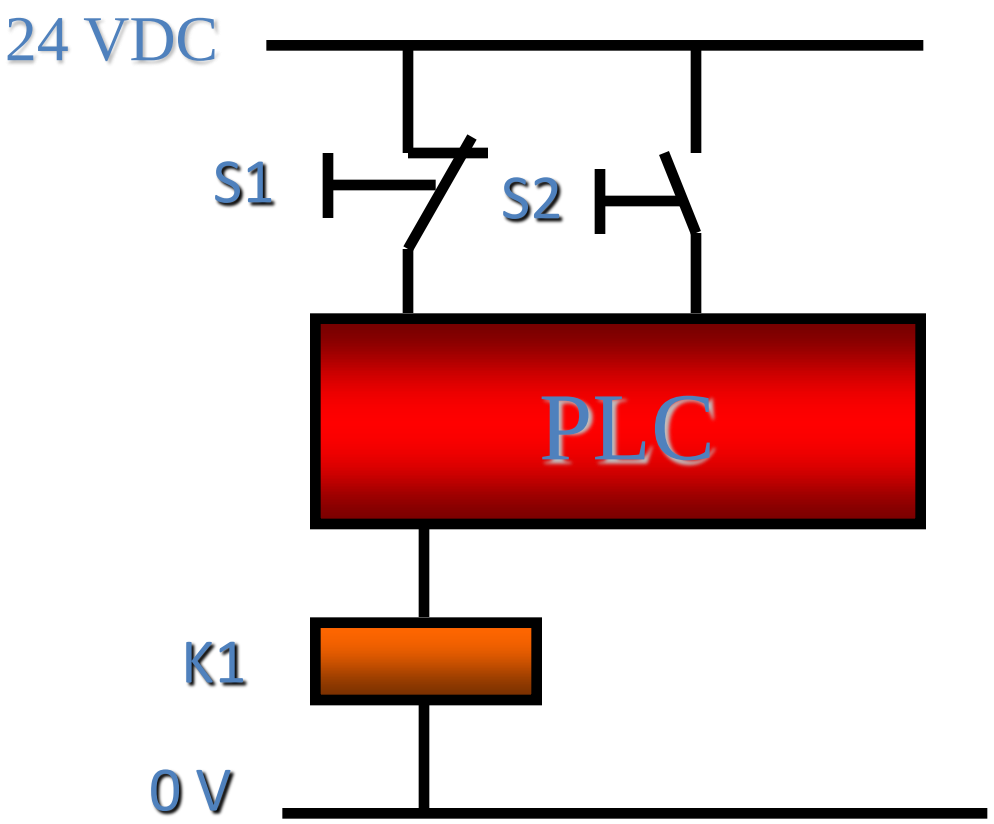
Introducing solid state switching devices.

Prior to PLCs, many of these control tasks were solved with contactor or relay controls.





Hardwire



PLC

Comparison

Hardwired control systems	PLC Systems
• The functions are determined by the physical wiring.	• The functions are determined by a program stored in the memory.
• Changing the function means changing the wiring.	• The control functions can be changed simply by changing the program.
• Can be contact-making type (relays, contactors) or electronic type (logic circuits)	• Consist of a control device, to which all the sensors and actuators are connected.

PLC functions:

CONTROL TYPE:	FUNCTIONS
Sequence Control	i. Conventional Relay Control Logic replacer ii. Timers/ Counter iii. PCB Card controller replacer iv. Auto/Semi-auto/Manual control of machine and process.
Advanced/ Sophisticated Control	i. Arithmetic operation (+, -, × , ÷) ii. Information Handling iii. Analog Control (Temperature, Pressure) iv. P.I.D (Proportional Integral Derivation) v. Servo Motor Control vi. Stepper Motor control

PLC functions:

CONTROL TYPE:	FUNCTIONS
Supervisory Control	i. Process monitoring and alarm. ii. Fault Diagnostic and monitoring iii. Interfacing with Computer (RS-232C/RS 422) iv. Factory Automation Networking v. Local Area Network (LAN) vi. Wide Area Network (WAN) vii. Factory Automation .

PLC Types:

- **Small : Compact PLC**

  - it covers units with up to 128 I/O's and memories up to 2 Kbytes.
  - Capable of providing simple to advance levels or machine controls.

- **Medium : Modular PLC**

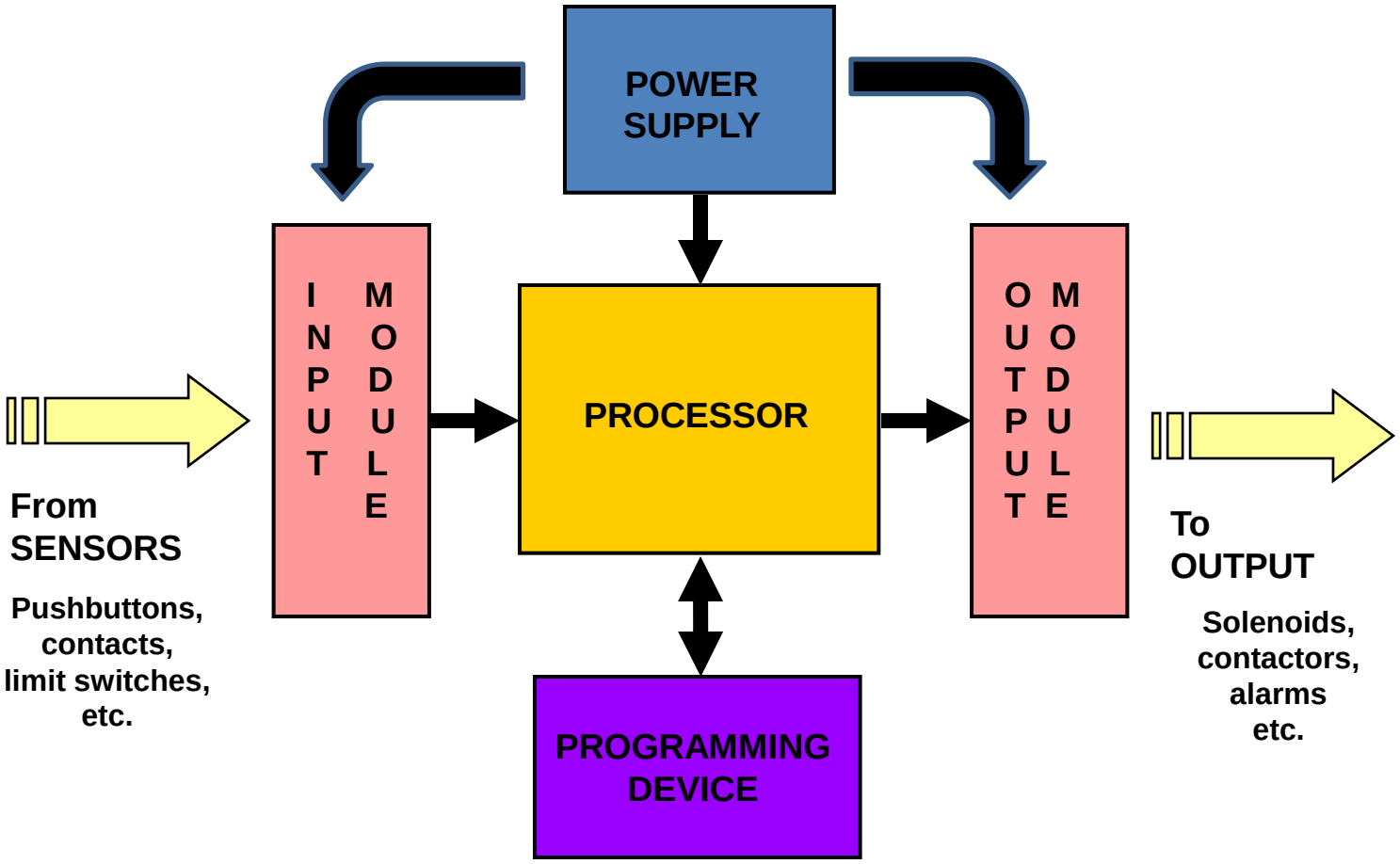
  - Have up to 2048 I/O's and memories up to 32 Kbytes.

- **Large :**
  - The most sophisticated units of the PLC family. They have up to 8192 I/O and memories up to 750 Kbytes.
  - Can control individual production processes or entire plant.

Small

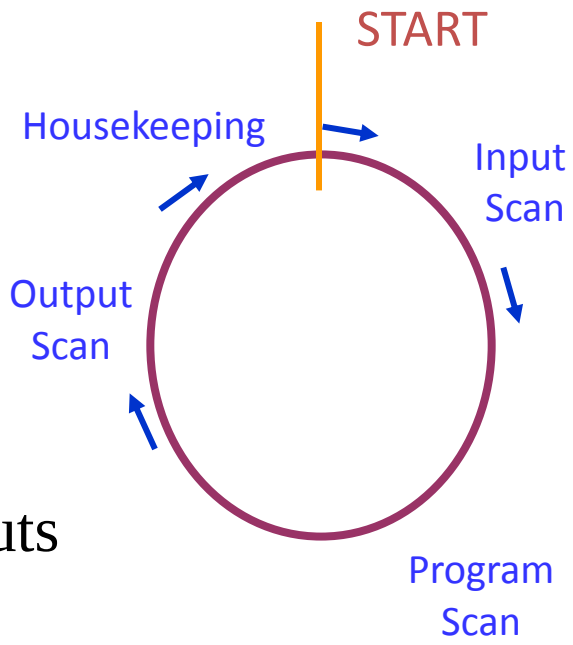
Modular

Architecture



PLC Operating Cycle

- Four Steps in the PLC Operations
  - Input Scan
    - Scan the state of the Inputs
  - Program Scan
    - Processes the program logic
  - Output Scan
    - Energize/de-energize the outputs
  - Housekeeping
    - This step includes communications, Internal Diagnostics, etc.
- The steps are continually repeated - processed in a loop.



FUNCTION OF EACH BLOCK:

Input/ Output (*I/O)* Unit

- **Input Unit:**

  Function as a medium that connects the external input devices

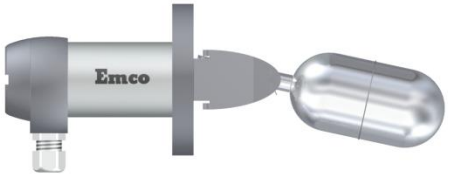
  (Switch, sensor & timer)

- **Output Unit:**

  Function as a medium that connects the external output devices to the CPU within PLC.

  (Lamp, motor & solenoid)

INPUT DEVICES:

Push Button	 JXB2-BC42
Limit Switch	
Thumbwheel SW	
Level SW	
Flow SW	

Output Deceives:

Motor	
Solenoid	
LED Display	
Heater Coil	
Lamp	

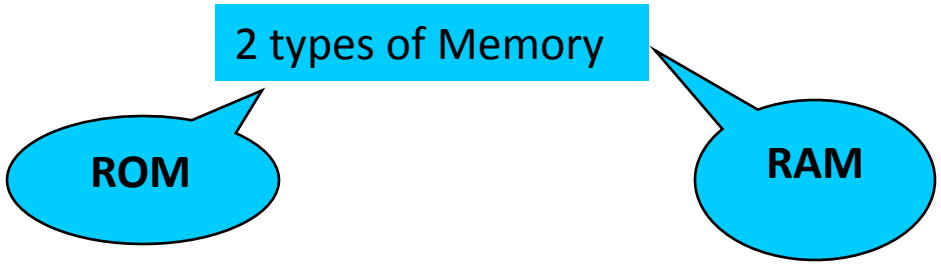
FUNCTION OF EACH BLOCK:

A .Central Processing Unit (CPU)

- The CPU controls, monitors and supervises all operations within PLC.
- It is also caries out programmed instructions stored in the memory.
- An internal communications highway also known as a bus system, carries information to and from the CPU, memory and I/O units under the control of the CPU.

B. Memory Unit

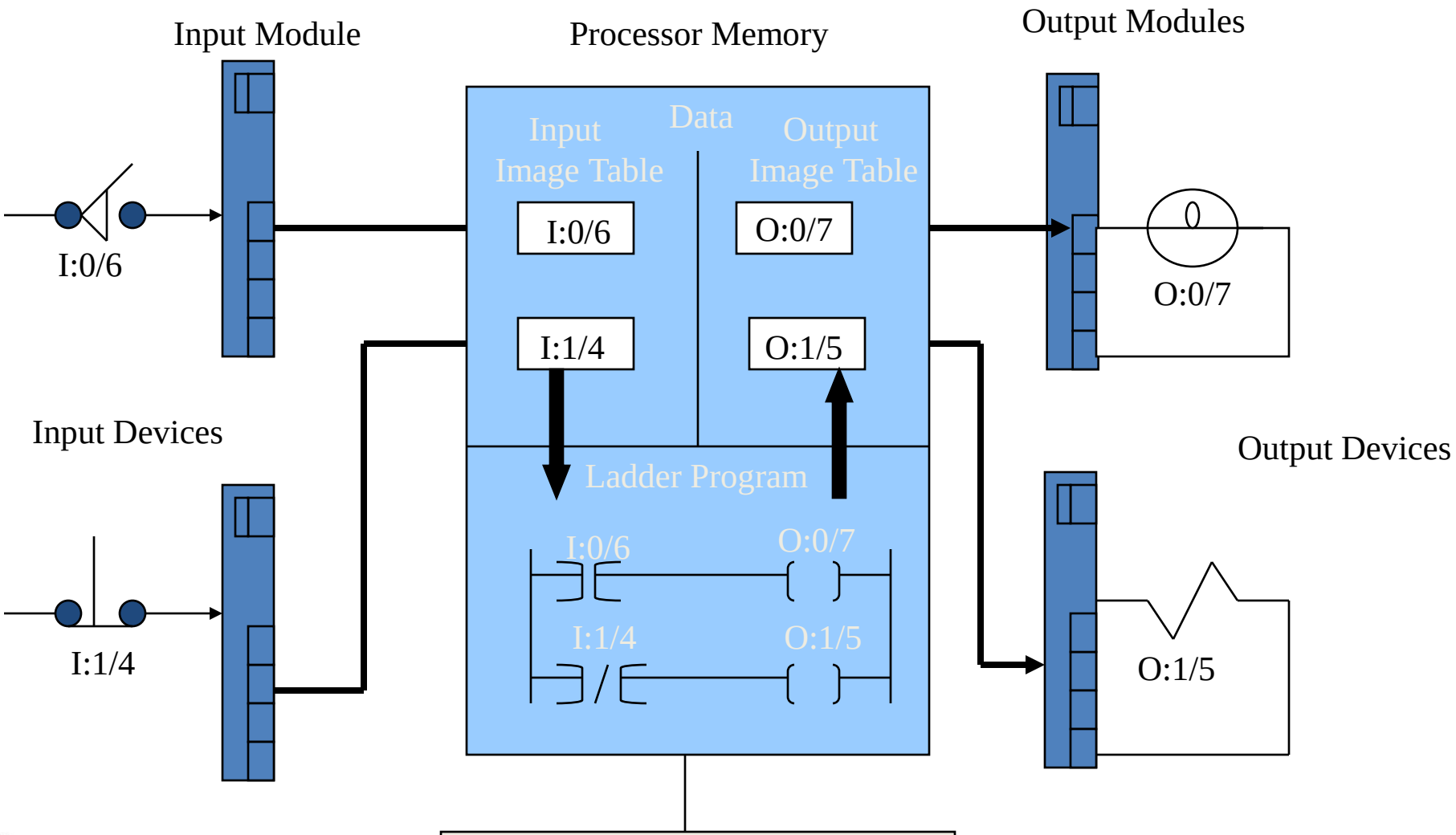
- For storage of programs.
- The user's ladder logic program, the state of I/O in the memory of PLC.
- The organization of the data and information in the memory is called memory map.



TYPES OF MEMORY:

RAM **Random Access Memory**	**ROM** **Read Only Memory (read)**
This memory can be read from and written to.	This memory can be read only
Storing all user's programs	Storing all system's program
Entire contents will be lost if power is switched off.	Memory content remain when the power is switched off.

PLC Signal Flow



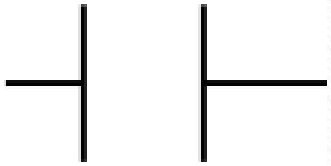
PLC PROGRAMMING

- Ladder logic (ladder diagram) is symbolic (graphical) programming language used in PLC for industrial control applications.

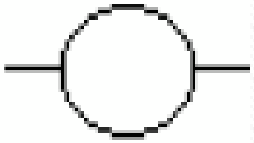
- In Ladder diagrams vertical line represent the power lines (rails) while horizontal steps are called rungs.

- It is well suited to express Combinational logic.

First step- We have to translate all of the items we're using into symbols the plc understands



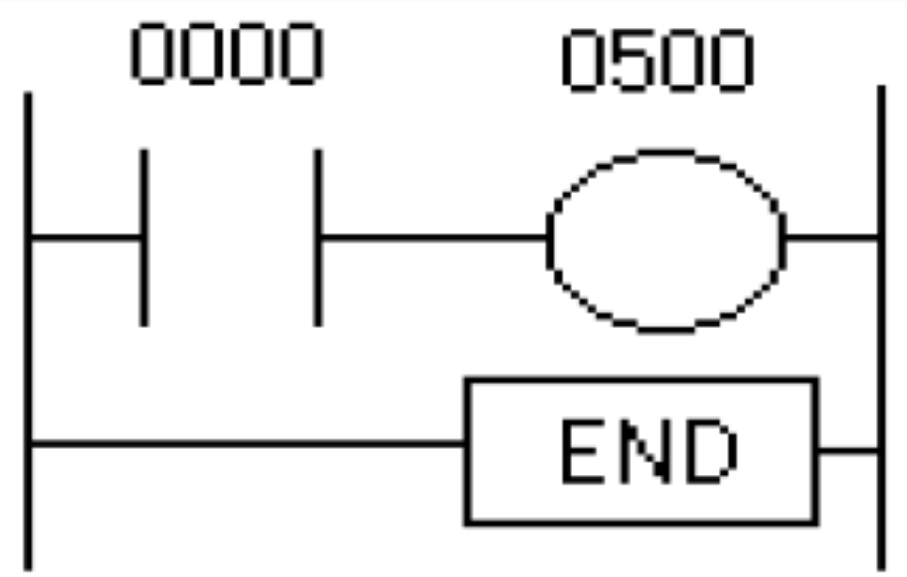
A contact symbol

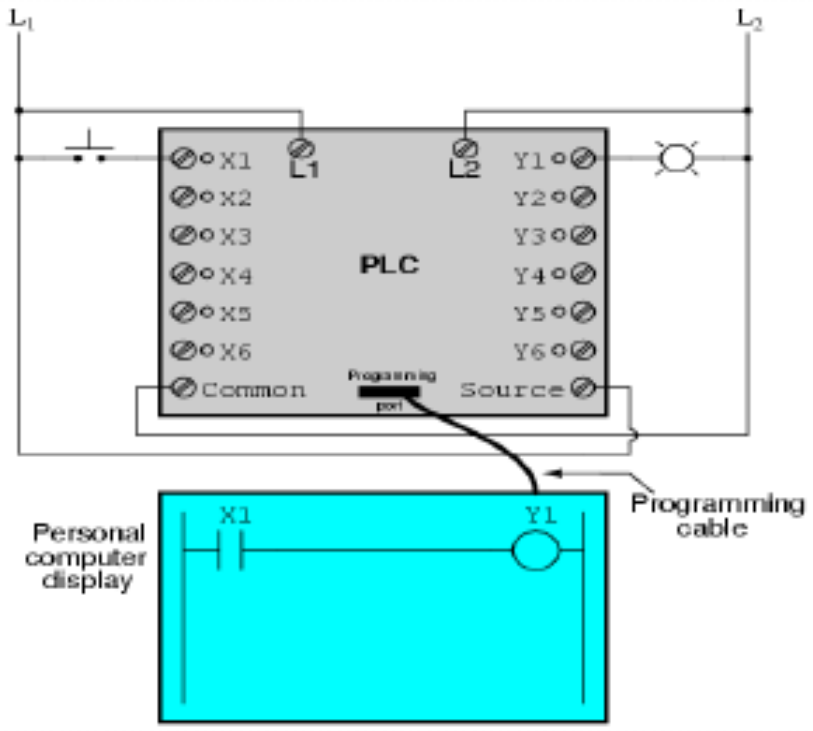


A coil symbol

Second step- We must tell the plc where everything is located. In other words we have to give all the devices an address.

Final step- We have to convert the schematic into a logical sequence of events.

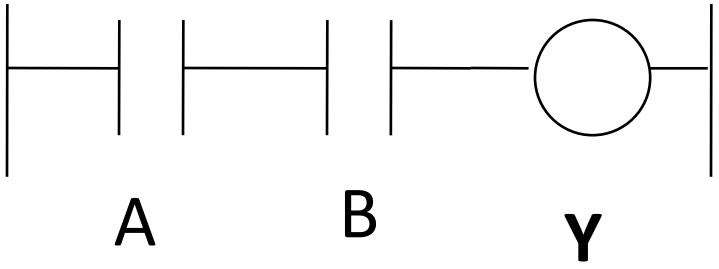




Ladder Logic For Basic gates

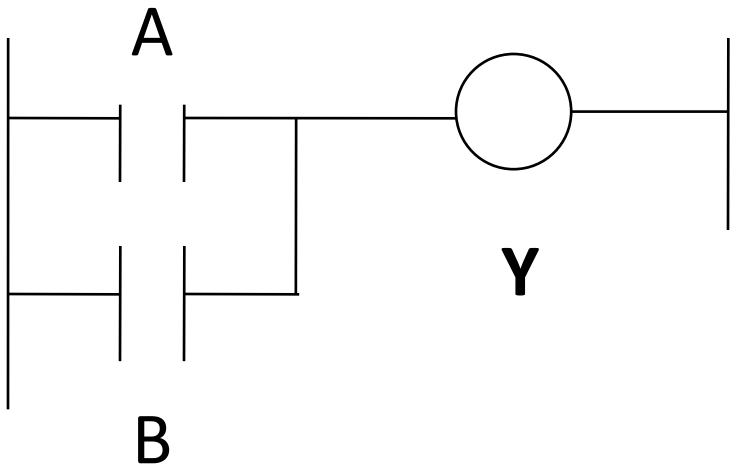
AND Gate

A	B	Logic(Y)
OFF	OFF	OFF
OFF	ON	OFF
ON	OFF	OFF
ON	ON	ON



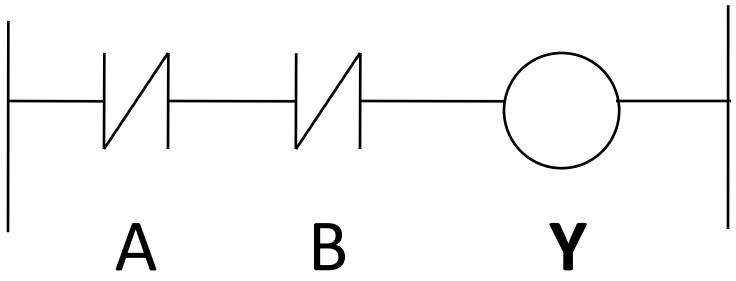
OR Gate

A	B	Logic(Y)
OFF	OFF	OFF
OFF	ON	ON
ON	OFF	ON
ON	ON	ON



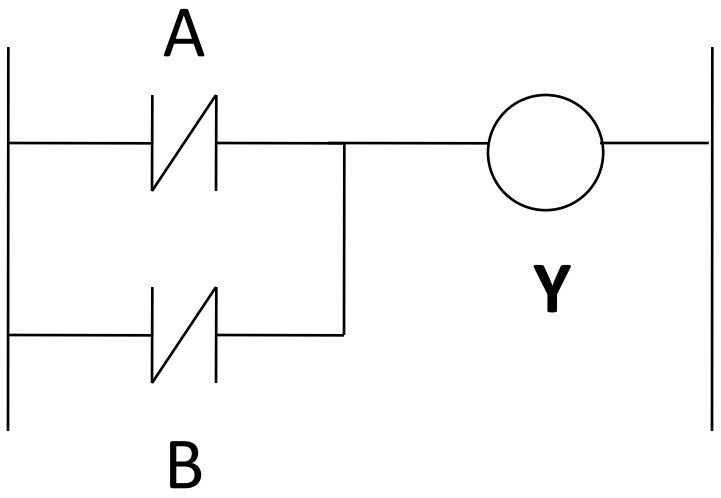
NOR Gate

A	B	Logic(Y)
OFF	OFF	ON
OFF	ON	OFF
ON	OFF	OFF
ON	ON	OFF

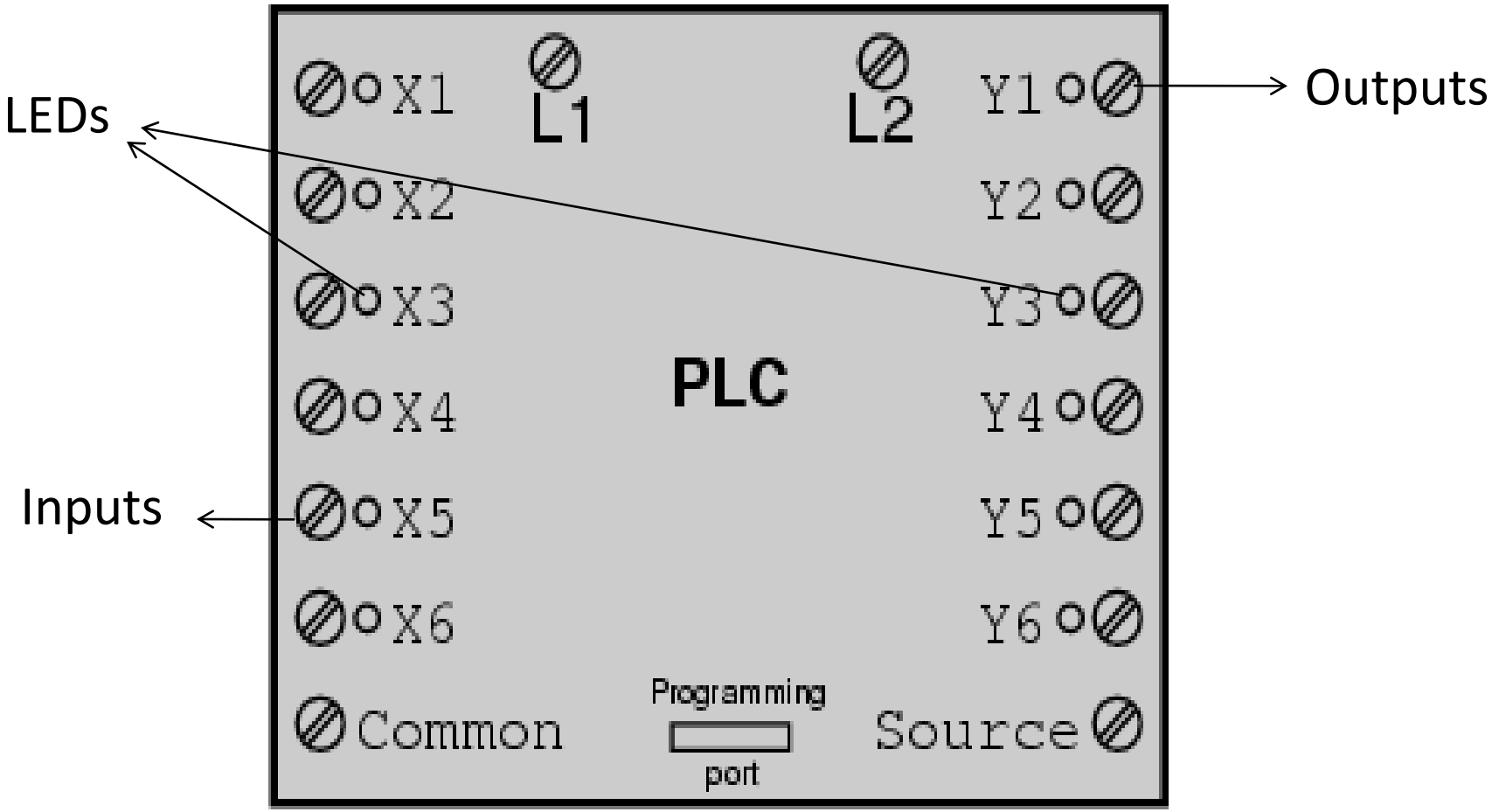


NAND Gate

A	B	Logic(Y)
OFF	OFF	ON
OFF	ON	ON
ON	OFF	ON
ON	ON	OFF

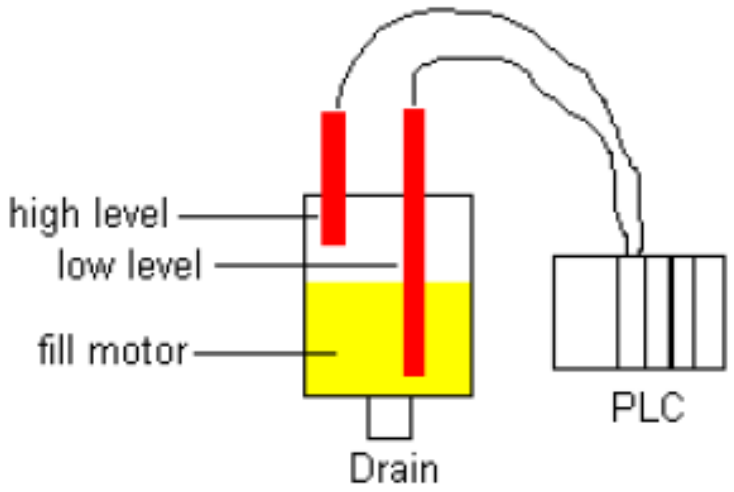


Block diagram of a PLC



•We are controlling lubricating oil being dispensed from a tank. This is possible by using two sensors. We put one near the bottom and one near the top, as shown in the picture below

•Here, we want the fill motor to pump lubricating oil into the tank until the high level sensor turns on. At that point we want to turn off the motor until the level falls below the low level sensor. Then we should turn on the fill motor and repeat the process.



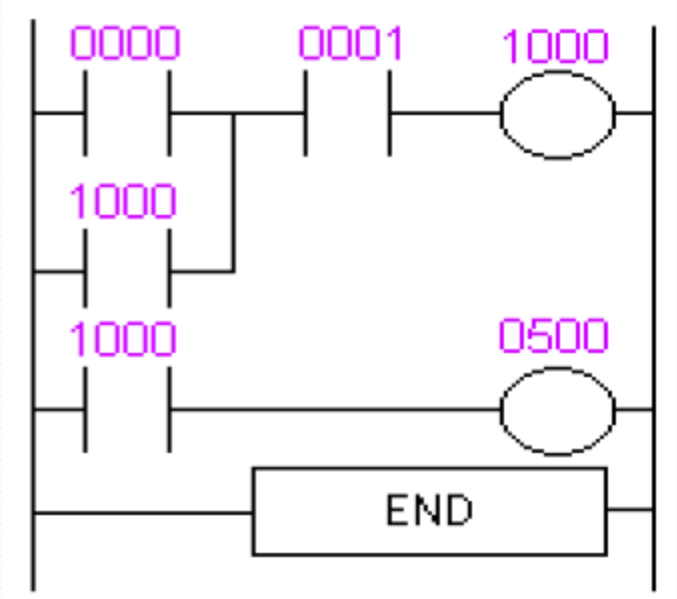
Dispensing oil from a tank

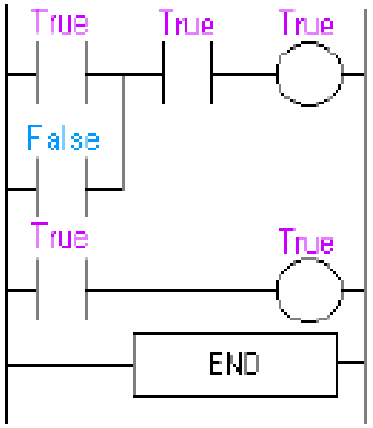
Inputs	Address
Low level sensor	0000
High level Sensor	0001

Output	Address
Motor	0500

Internal Utility Relay
1000

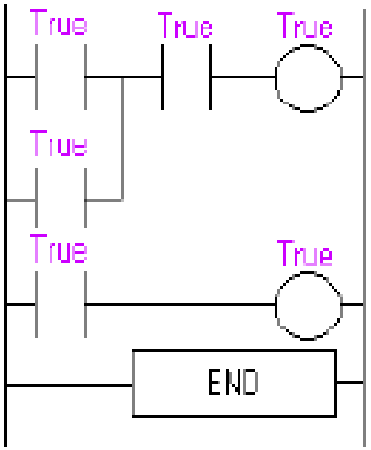
The Ladder Diagram





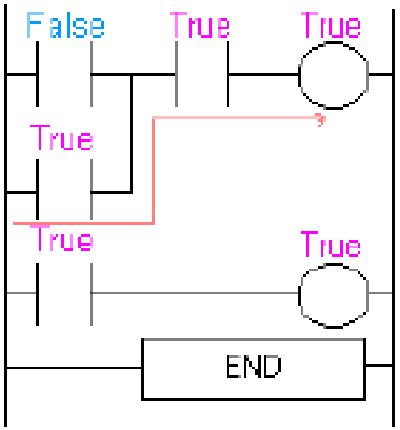
Scan 1

Initially the tank is empty. Therefore, input 0000 is TRUE and input 0001 is also TRUE



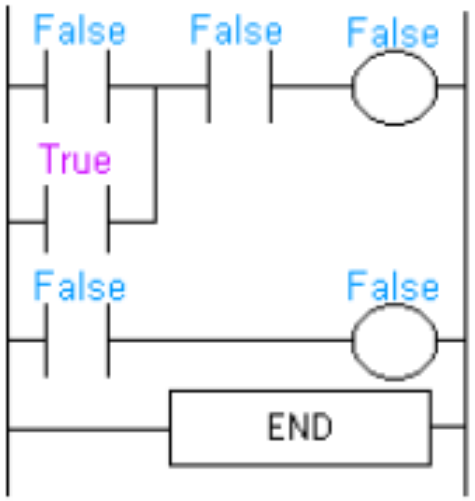
Scan 2

The internal relay is turned on as the water level rises.



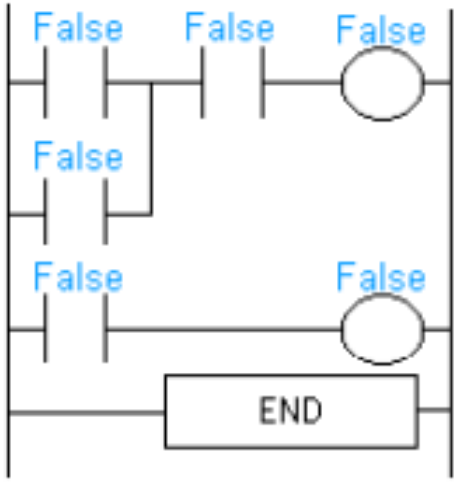
Scan 3

After scan 2 the oil level rises above the low level sensor and it becomes open. (i.e. FALSE)



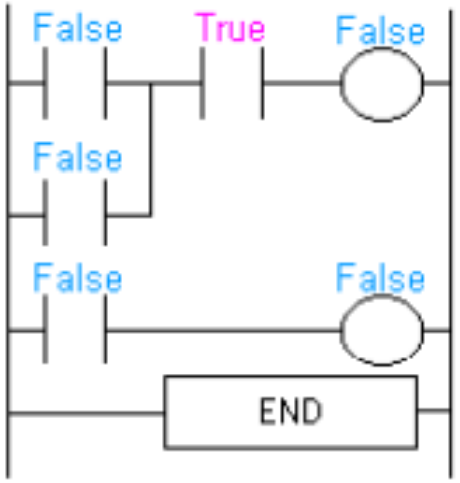
Scan 4

After scan 4 the oil level rises above the high level sensor at it also becomes open (i.e. false)



Scan 5

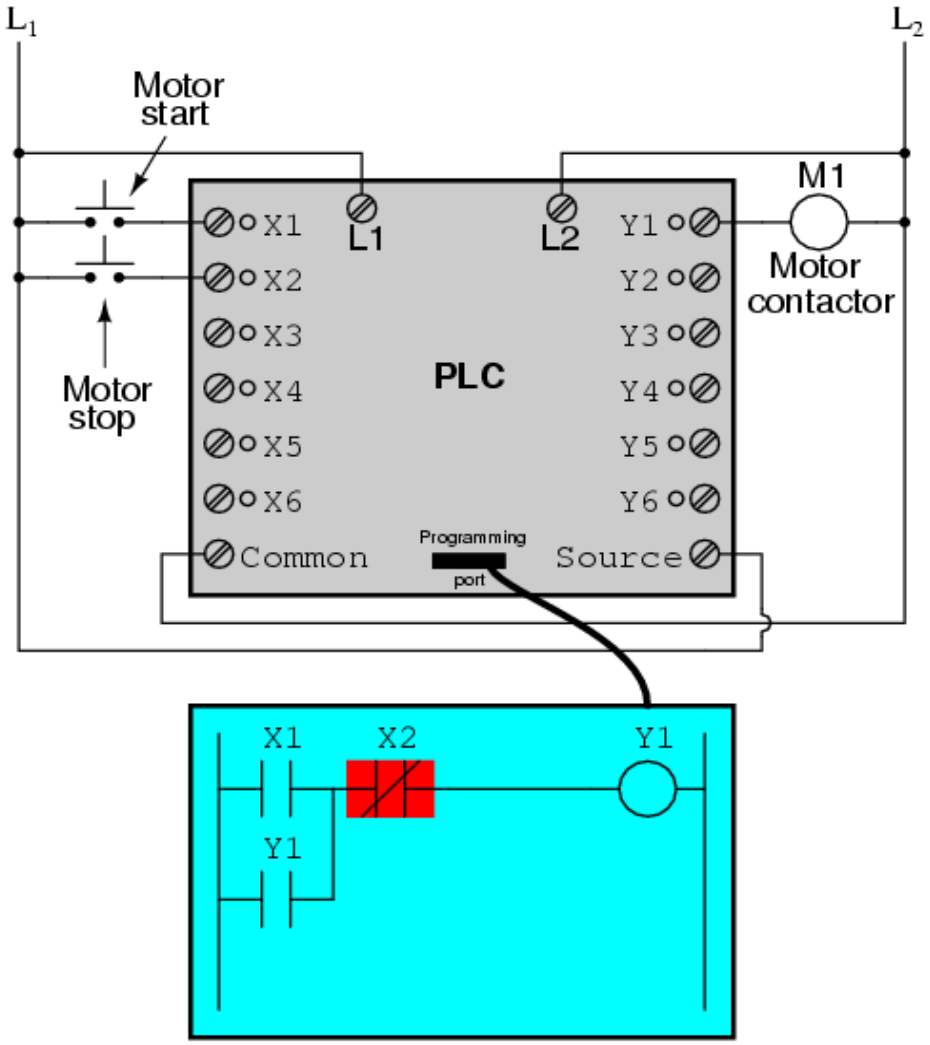
Since there is no more true logic path, output 500 is no longer energized (true) and therefore the motor turns off.



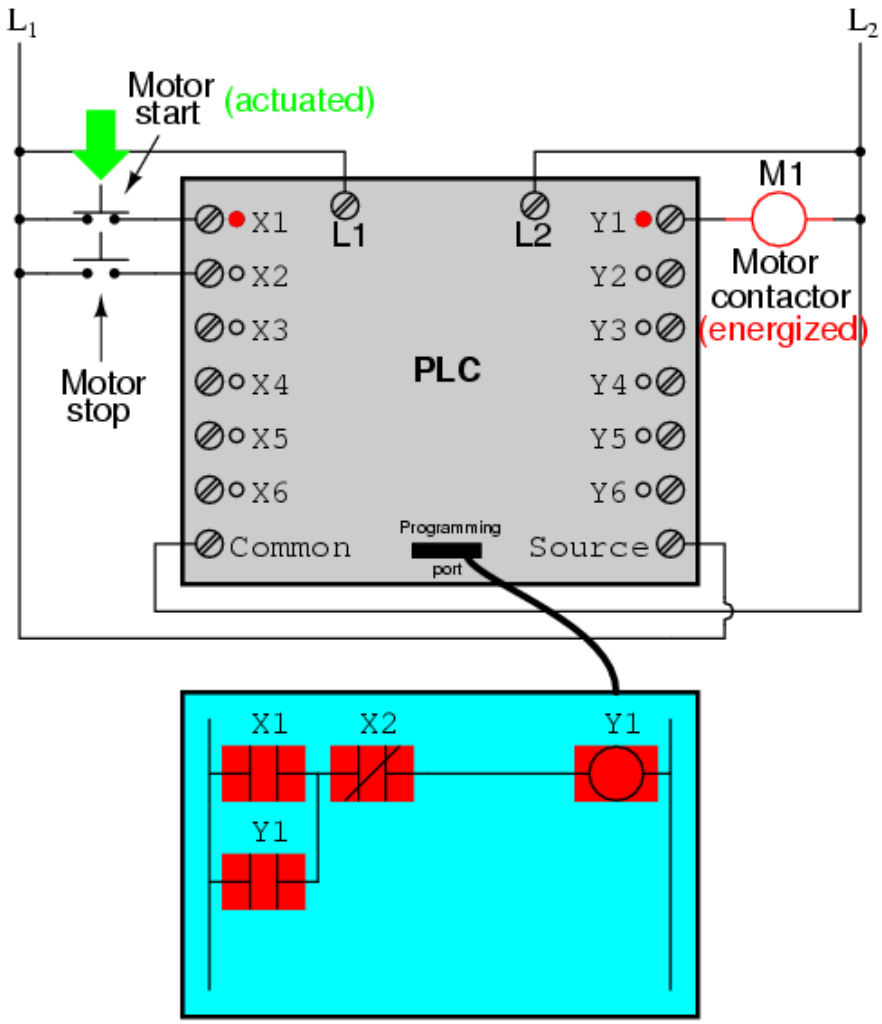
Scan 6

After scan 6 the oil level falls below the high level sensor and it will become true again.

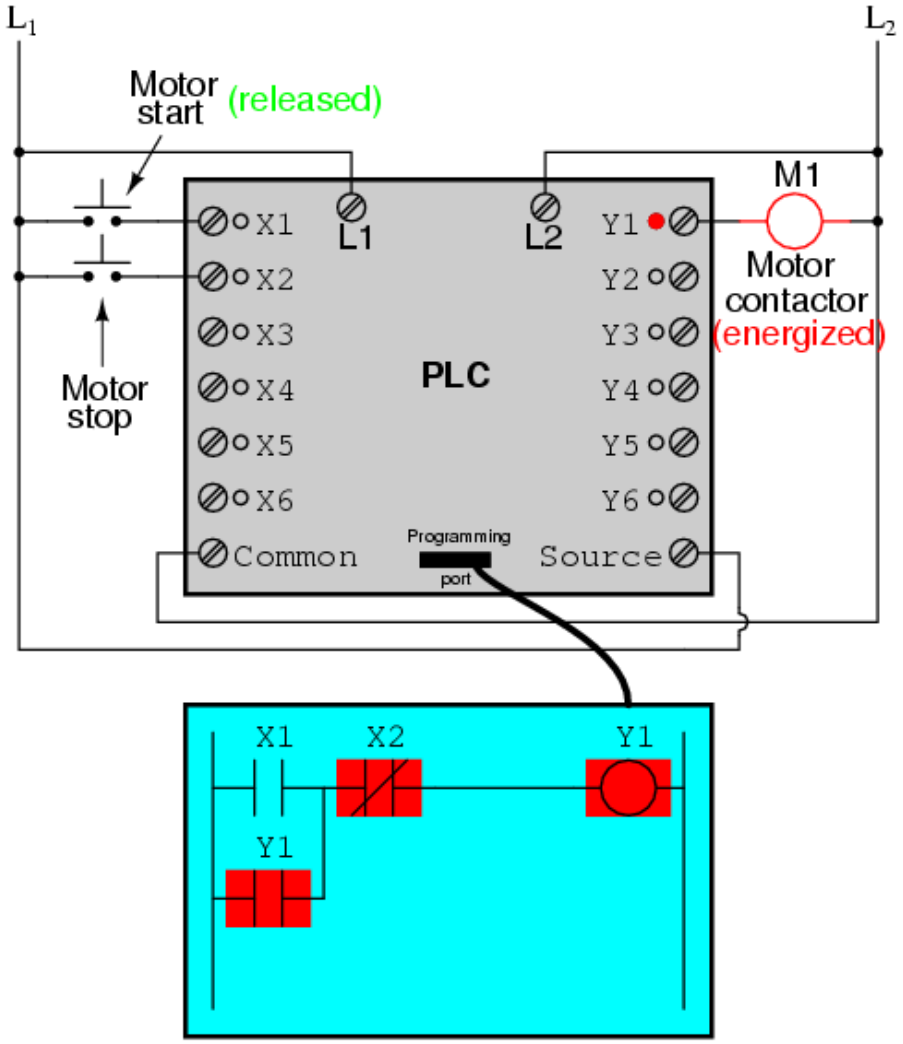
Programming PLC:



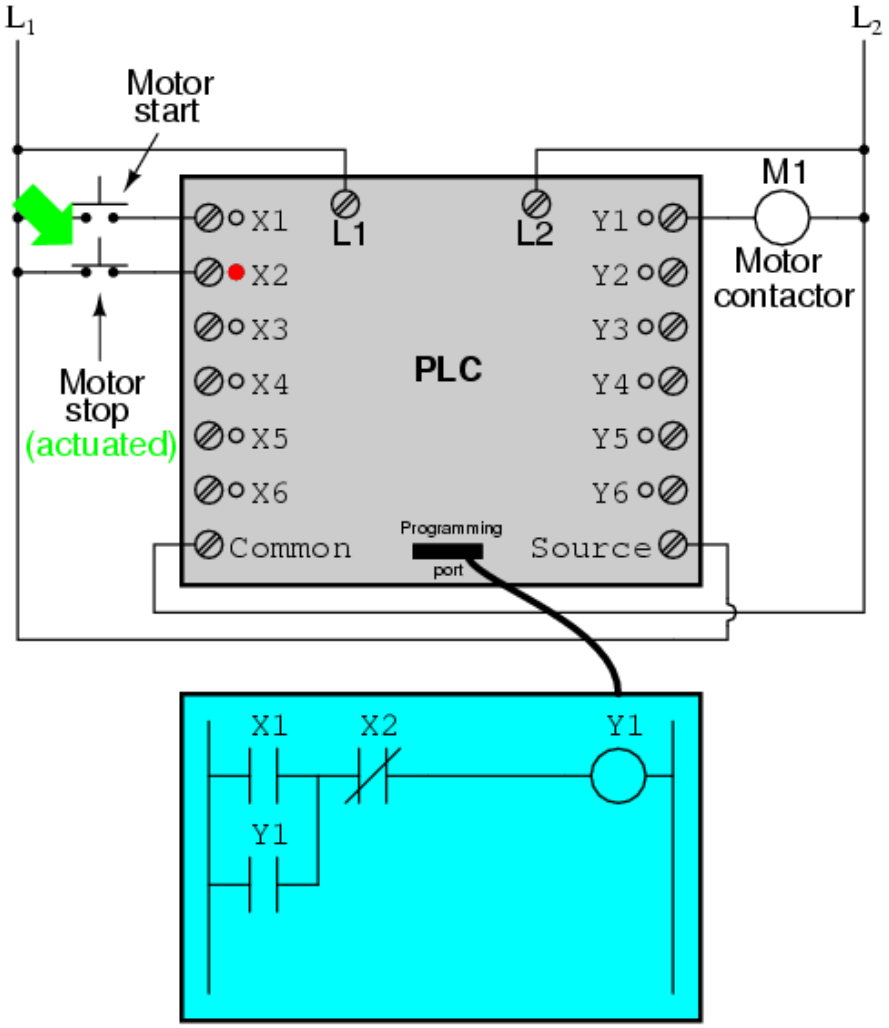
Starting of Motor:



Continuous Running (latching) of motor when Start Button is released:



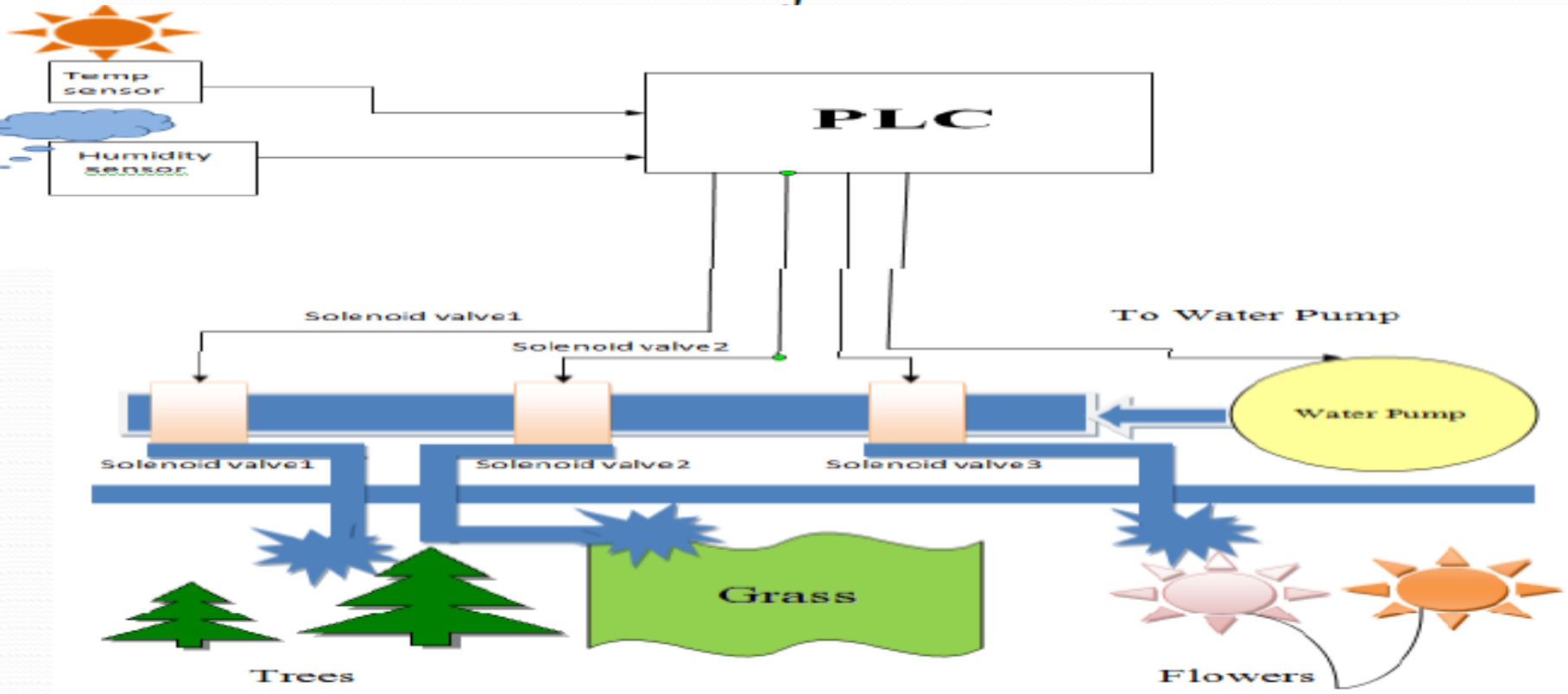
To Stop the Motor :



Example

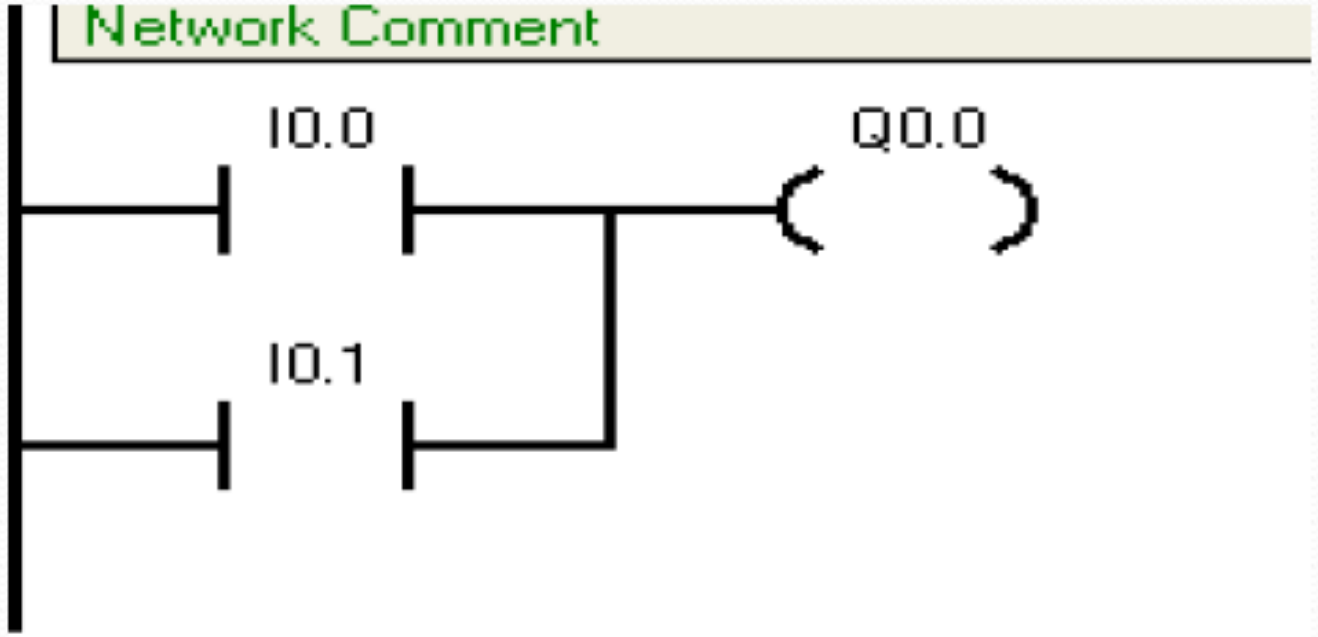
Automatic water sprinkler system of a garden

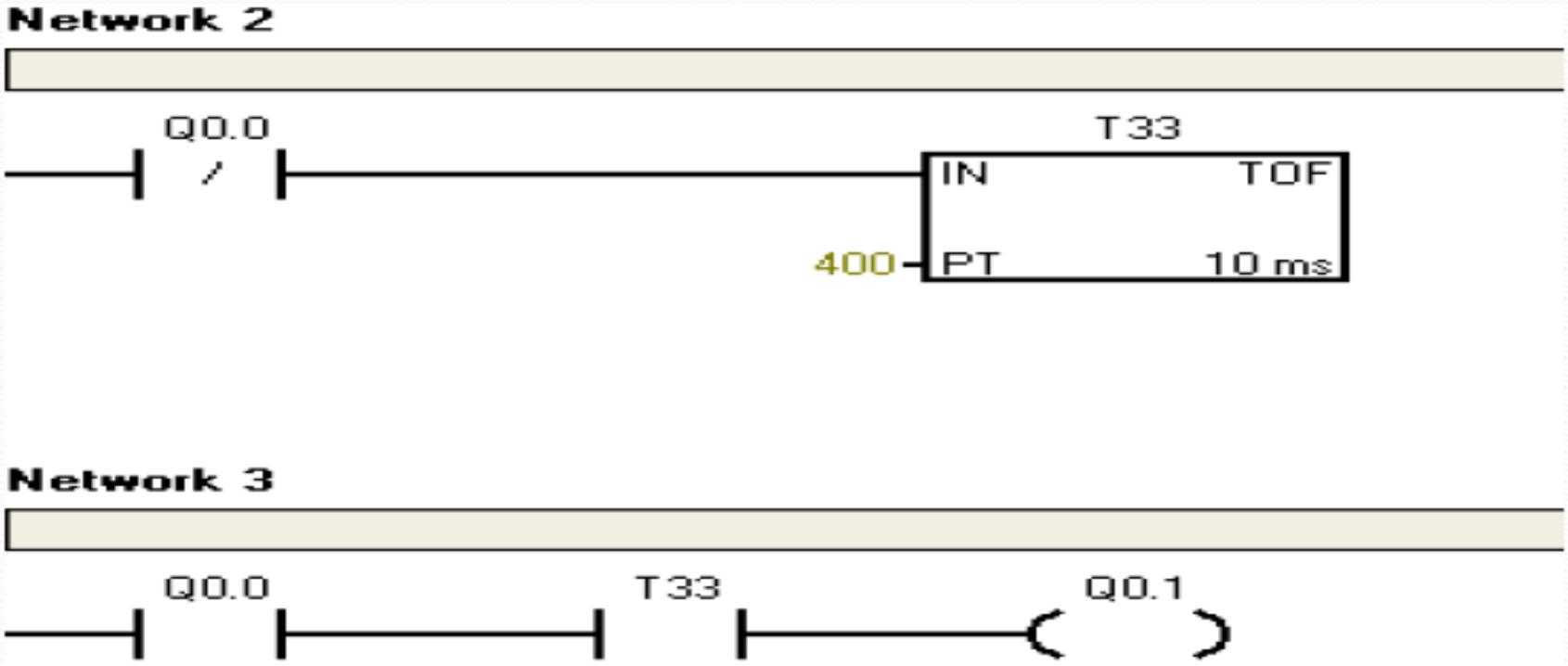
This example is based on Automatic water sprinkler system of a garden. It delivers water to grass, flowers and trees. Watering of whole garden depends upon humidity and temperature conditions which are adjustable.



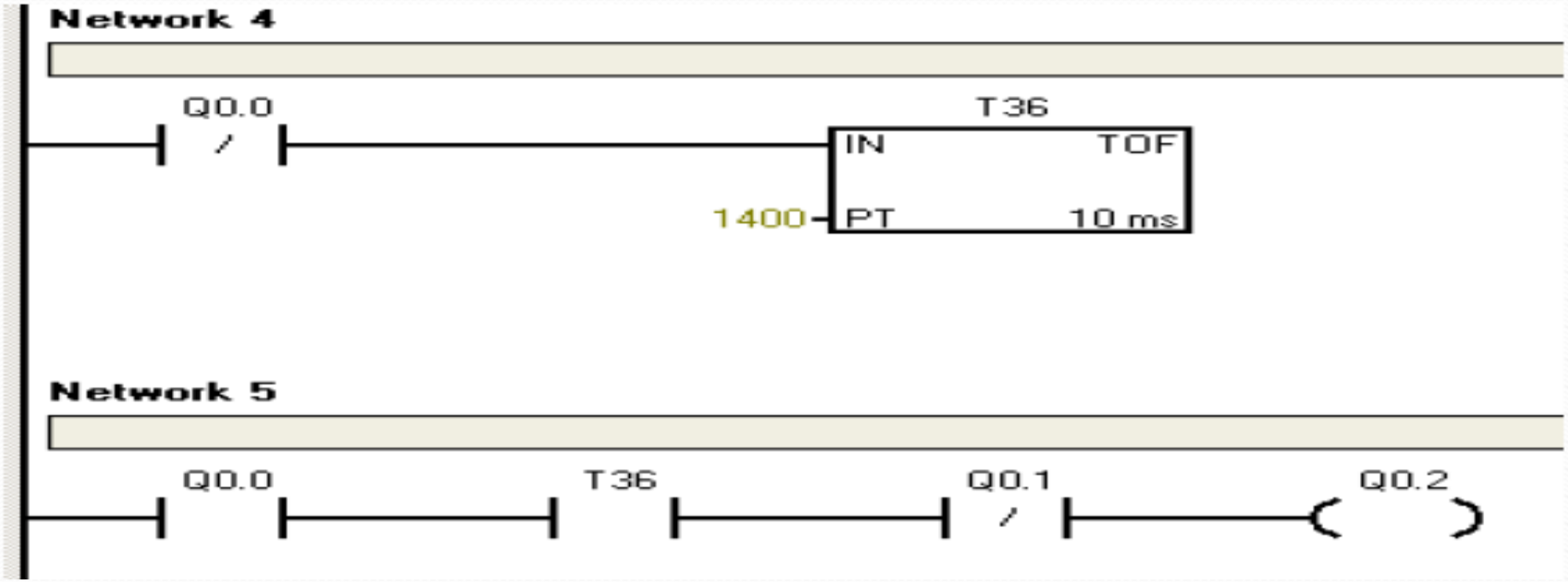
Here the water sprinkler system (Q0.0) starts to work when either temperature sensor(I0.0) or humidity sensor (I0.1) send a signal to it. In this scenario grass will be water first (water the grass Q0.1) fro 4 second (it is assumed very small for simplicity) and then flowers will be water (water the flowers Q0.2) for 10 second and at last trees will be watered (water the trees Q0.3) for 18 seconds. Since it is required to avoid pressure drop in the water line ,each section is separated and here the order to water this garden is given: First grass, second flowers and third trees.

Here you can see that either temperature sensor I0.0 or humidity sensor I0.1 can turn on the sprinkler system (Q0.0). If the humidity or temperature falls below a specific point the system will start working.

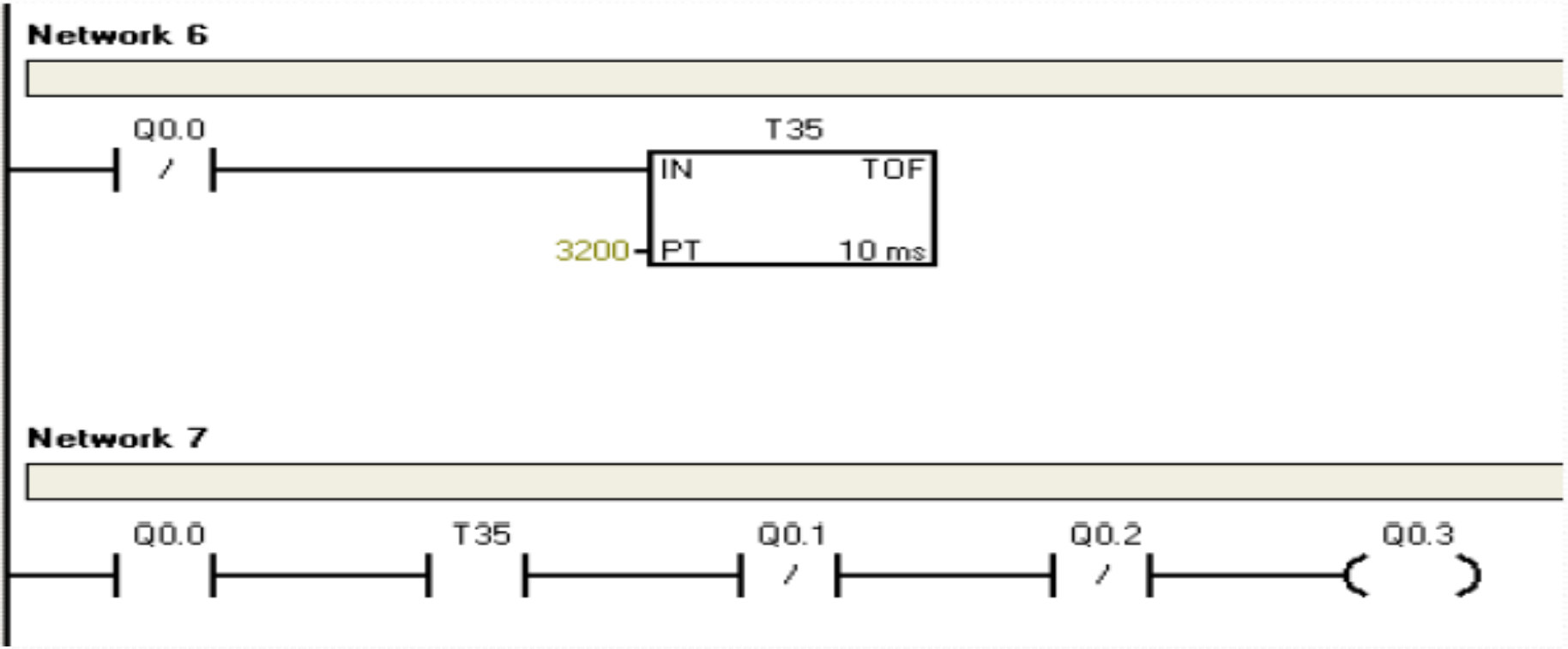




In this Example it is needed to water the grass for 4 seconds. Since the increment is 10 ms, it is written 400ms in the timer. The input is assume to be the Q0.0 which was the switch for sprinkler system. Here it is assumed that if the sprinkler is on, the output Q0.1 will also become on and it will remain on for 4 seconds. If you take a look at the ladder diagram you will see that the input Q0.0 turn the timer on and it will count 4 seconds until it breaks the second line.



Since the input switch Q0.0 turn on all the timers in this ladder diagram at the same time it is required to add the time for watering of each section with the time elapsed in the previous sequence. For example although it is required to water the flowers for only 10 second but in the timer it is written 1400ms with the increment 10 ms which will eventually be equal to 14 second. Now if you subtract 14 seconds from 4 second (the time required for the first section) you will get the required time which is 10 seconds. There is one more important parameter here. In the ladder diagram it is written if the first section is done start the second section. You can see this in the second line of the ladder diagram. The output here is Q0.2 which is assumed for watering flowers.



This part is like the second part. Watering the trees is started when previous section are finished. The time for this section is 18 second which is added to 14 seconds counted before and now it is written as 3200 ms with 10ms increment. You can see when both Q0.1 and Q0.2 are off the third part (Q0.3) is started.

PLC Advantages

- Handles much more complicated systems.
- Less and simple wiring.
- Increased Reliability.
- More Flexibility.
- Lower Cost .
- Faster Response.
- Easier to troubleshoot.
- Remote control capability.
- Communication Capability.

Disadvantages of PLCs

- PLC devices are proprietary it means that part or software of one manufacturer can't be used in combination with parts of another manufacturer.
- Limited design and cost option
- Fixed Circuit Operations.
- PLCs manufacturers offer only closed architectures.
- Unemployment.

Applications:

- Wherever automation is desired the PLCs are best suited to meet the task.

- Few examples of industries where PLCs are used :
  1) Robots manufacturing and control
  2) Car park control
  3) Train control station system
  4) Food processing
  5) Materials handling
  6)Machine tools
  7)Conveyer system etc.

Current Situation

Automation is a high growth sector globally hence it is essential to all professionals and students to have practical knowledge about the hardware and software used in Industrial Automation.

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COMPANY

End of Lecture.