SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

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DEPARTMENT OF ELECTRONICS & INSTRUMENTATION ENGINEERING

LAB MANUAL

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1907709 - INDUSTRIAL AUTOMATION LAB

LIST OF EXPERIMENTS

1. Study of PLC field device interface modules (AI,AO,DI,DO modules)
2. Programming Logic Gates Function in PLC
3. Implementing Mathematical Operations in PLC
4. Programming Jump-to-subroutine & return operations in PLC
5. PLC Exercises:- 1. Traffic Light Control and Filling/Draining Control Operation
6. PLC Exercise: 1. Reversal of DC Motor Direction 2. ON/OFF Controller for Thermal Process
7. PC based control of Level Process
8. On-line Monitoring and Control of a Pilot plant using DCS
9. PLC based Control of Flow Process
10. Study of Foundation Field bus /IOT/Wireless HART Enabled Transmitter

BEYOND THE SYLLABUS

11. Speed control of AC servo motor using PLC

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1. Study of PLC field device interface modules

Aim:

To study about the programmable logic controller (PLC) field interface module and hardware working and application.

Theory:

Initially industries used relays to control the manufacturing processes. The relay control panels had to be regularly replaced, consumed lot of power and it was difficult to figure out the problems associated with it. To sort these issues, Programmable logic controller (PLC) was introduced.

Fig. 1: Graphical Representation Of PLC

What is PLC?

Programmable Logic Controller (**PLC**) is a digital computer used for the automation of various electro-mechanical processes in industries. These controllers are specially designed to survive in harsh situations and shielded from heat, cold, dust, and moisture etc. **PLC** consists of a microprocessor which is programmed using the computer language.

The program is written on a computer and is downloaded to the PLC via cable. These loaded programs are stored in non – volatile memory of the PLC. During the transition of relay control panels to PLC, the hard wired relay logic was exchanged for the program fed by the user. A visual programming language known as the Ladder Logic was created to program the PLC.

PLC Hardware

The hardware components of a PLC system are CPU, Memory, Input/Output, Power supply unit, and programming device. Below is a diagram of the system overview of PLC.

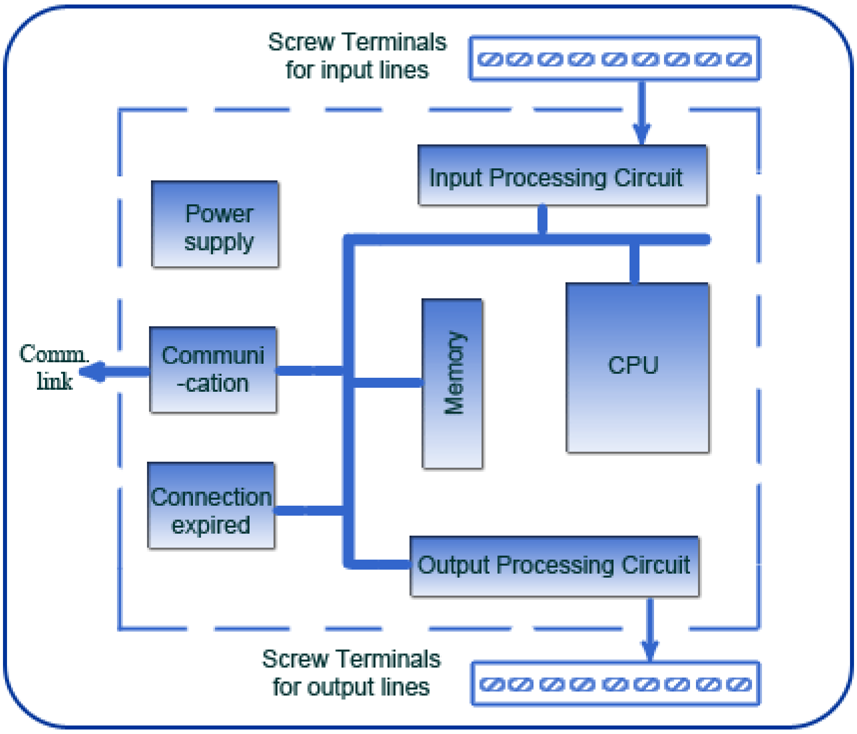


Fig. 2: An Overview Of Hardware Components Of A PLC System

- **CPU** – Keeps checking the PLC controller to avoid errors. They perform functions including logic operations, arithmetic operations, computer interface and many more.

- **Memory** – Fixed data is used by the CPU. System (ROM) stores the data permanently for the operating system. RAM stores the information of the status of input and output devices, and the values of timers, counters and other internal devices.

- **I/O section** – Input keeps a track on field devices which includes sensors, switches.

- **O/P Section –** Output has a control over the other devices which includes motors, pumps, lights and solenoids. The I/O ports are based on Reduced Instruction Set Computer (RISC).

- **Power supply** – Certain PLCs have an isolated power supply. But, most of the PLCs work at 220VAC or 24VDC.
- **Programming device** – This device is used to feed the program into the memory of the processor. The program is first fed to the programming device and later it is transmitted to the PLC's memory.

System Buses – Buses are the paths through which the digital signal flows internally of the PLC. The four system buses are:

- Data bus is used by the CPU to transfer data among different elements.
- Control bus transfers signals related to the action that are controlled internally.
- Address bus sends the location's addresses to access the data.
- System bus helps the I/O port and I/O unit to communicate with each other.

Working & Application

Working of PLC (Programmable Logic Controller)

The Programmable logic controller functions in four steps.

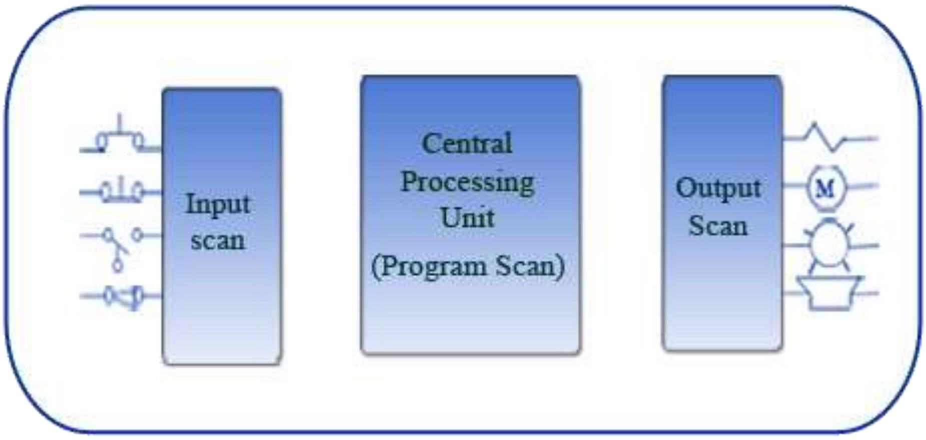


Fig. 3: Typical Block Diagram Of Programmable Logic Controller Functions

- **Input scan**: The state of the input is scanned which is connected externally. The inputs include switches, pushbuttons, and proximity sensors, limit switches, pressure switches. Ideally, they are transformers and not relays.

- **Program scan**: The loaded program is executed to carry out the function appropriately.

- **Output scan**: The input sources have a control over the output ports to energize or de-energize them. The outputs include solenoids, valves, motors, actuator, and pumps. Depending on the model of PLC, these relays can be transistors, triacs or relays.

- **Housekeeping**

PLC Applications

The simple suitable application is a conveyor system. The requirements of the conveyor systems are as follows:

- A programmable logic controller is used to start and stop the motors of the conveyor belt.
- The conveyor system has three segmented conveyor belts. Each segment is run by a motor.
- To detect the position of a plate, a proximity switch is positioned at the segment’s end.
- The first conveyor segment is turned ON always.
- The proximity switch in the first segment detects the plate to turn ON the second conveyor segment.
- The third conveyor segment is turned ON when the proximity switch detects the plate at the second conveyor.

- As the plate comes out of the detection range, the second conveyor is stopped after 20 secs.
- When the proximity switch fails to detect the plate, the third conveyor is stopped after 20 secs.

History

Programmable Logic Controllers were discovered by the automotive industry to substitute the re-wiring of the machine's control panel.Prior to the invention of PLC, automobiles were manufactured using plenty of relays, cam timers, and closed loop controllers. The electricians had to re-wire every part of the machine daily which was time consuming and highly expensive on the financial front.

Later in the year 1968, a request for an electronic device for the hard-wired relay systems was made by GM hydramatic. Bedford Associates won the proposal and started a new company to develop, fabricate, sell, and service this new launched product. The first PLC launched was designated 084 as it was the eighty fourth projects of Bedford Associates. Dick Morley worked on this project and is being considered as the Father of PLC. In the year 1977, the brand invented by Modicon was sold to Gould Electronics. The Gould Electronics later sold it to German Company AEG which was later taken over by French Schneider Electric.

The first 084 model of PLC was revealed in North Andover, Massachusetts at the Modicon headquarters. The automotive industry is one of the largest users of PLC.

Advantages

- PLCs can be programmed easily which can be understood clearly well.
- They are fabricated to survive vibrations, noise, humidity, and temperature.
- The controller has the input and output for interfacing.

Disadvantages

- It is a tedious job when replacing or bringing any changes to it.

- Skilful work force is required to find its errors.
- Lot of effort is put to connect the wires.
- The hold up time is usually indefinite when any problem arises.

Result:

Thus the study about the programmable logic controller (PLC) field interface module and hardware working and application were done.

VIVA QUESTIONS

i. What is PLC?
ii. Role of PLC in Automation ?

iii. Difference Between Fixed and Modular PLCs ?
iv. What is meaning of scan time in PLC?
v. What is redundancy ?
vi. What are components of redundant PLC system ?
vii. What is ladder diagram ?
viii. Difference between PLC & Relay ?

2.Programming logic gates function in PLC

Aim:

To program various logic function like ANR,OR, NOT,NAND ,NOR and XOR in Programmable logic controller(PLC) and to verify the result

Apparatus Required:

(i) Programmable logic controller

(ii) Programmable logic controller software

(iii) Personal Computer

Theory:

Apparatus Required:

(iv) Programmable logic controller

(v) Programmable logic controller software

(vi) Personal Computer

Theory:

There are many control situations requiring actions to be initiated when a certain combination of **logic functions** conditions is realized in a **PLC**.

PLC Logic Functions :

For an automatic drilling machine, there might be the condition that the drill motor is to be activated when the limit switches are activated that indicate the presence of the workpiece and the drill position as being at the surface of the workpiece.

Such a situation involves the AND logic function, condition A **AND** condition B having both to be realized for an output to occur. This section is a consideration of such logic functions.

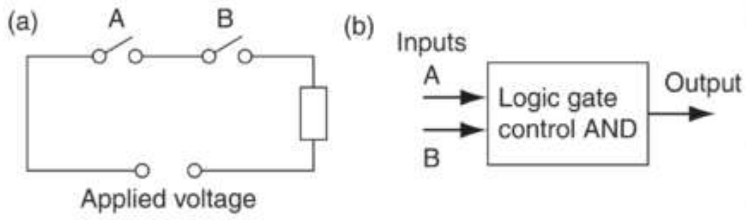
PLC AND LOGIC

In a PLC AND logic output is not energized unless two, normally open, switches are both closed. Switch A and switch B have both to be closed, which thus gives an AND logic situation.

.Only when A and B are both on then is there an output. Thus if we use 1 to indicate an on signal and 0 to represent an off signal, then for there to be a 1 output we must have A and B both 1.

Such an operation is said to be controlled by a logic gate and the relationship between the inputs to a logic gate and the outputs is tabulated in a form known as a truth table. Thus for the AND gate we have:

Figure: (a) AND circuit (b) AND logic gate



Inputs		Output
A	B	
0	0	0
0	1	0
1	0	0
1	1	1

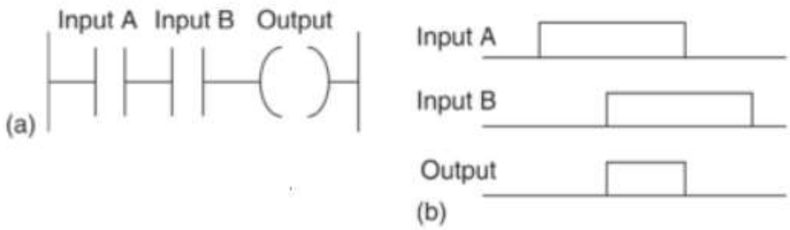
An example of an AND gate is an interlock control system for a machine tool so that it can only be operated when the safety guard is in position and the power switched on.

The ladder diagram starts with j j, a normally open set of contacts labeled input A, to represent switch A and in series with it j j, another normally open set of contacts labeled input B, to represent switch B.

The line then terminates with O to represent the output. For there to be an output, both input A and input B have to occur, i.e., input A and input B contacts have to be closed (Figure 1.8b). In general:

On a ladder diagram contacts in a horizontal rung, i.e., contacts in series, represent the logical AND operations.

Figure: AND gate with a ladder diagram rung



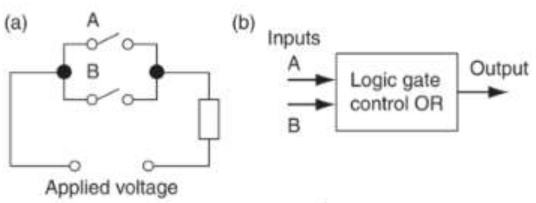
PLC OR LOGIC

In a OR logic electrical circuit where an output is energized when switch A or B, both normally open, are closed.

This describes an OR logic gate in that input A or input B must be on for there to be an output.

The truth table is:

Figure: (a) OR electrical circuit (b) OR logic gate



Inputs		Output
A	B	
0	0	0
0	1	1
1	0	1
1	1	1

The ladder diagram starts with j j, normally open contacts labeled input A, to represent switch A and in parallel with it j j, normally open contacts labeled input B, to represent switch B.

Either input A or input B have to be closed for the output to be energized.The line then terminates with O to represent the output. In general:

Alternative paths provided by vertical paths from the main rung of a ladder diagram, i.e., paths in parallel represent logical OR operations.

An example of an OR gate control system is a conveyor belt transporting bottled products to packaging where a deflector plate is activated to deflect bottles into a reject bin if either the weight is not within certain tolerances or there is no cap on the bottle.

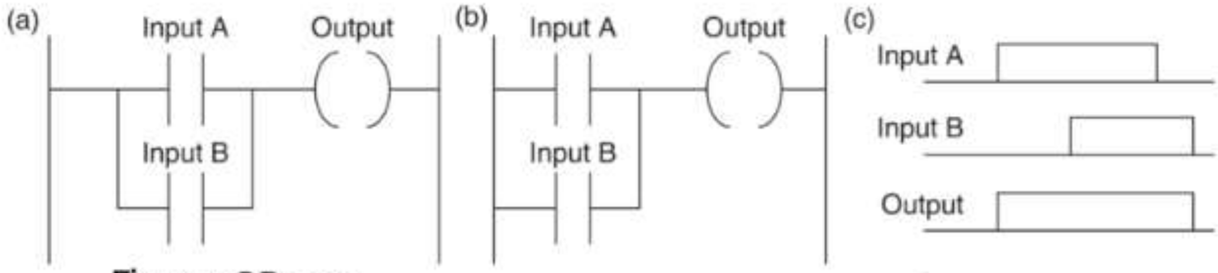


Figure: OR gate

PLC NOT LOGIC

In a NOT gate in that there is an output when there is no input and no output when there is an input . The gate is sometimes referred to as an inverter.

The truth table is:

Input A	Output
0	1
1	0

The input A contacts are shown as being normally closed.This is in series with the output ( ). With no input to input A, the contacts are closed and so there is an output. When there is an input to input A, it opens and there is then no output.

An example of a NOT gate control system is a light that comes on when it becomes dark, i.e., when there is no light input to the light sensor there is an output.

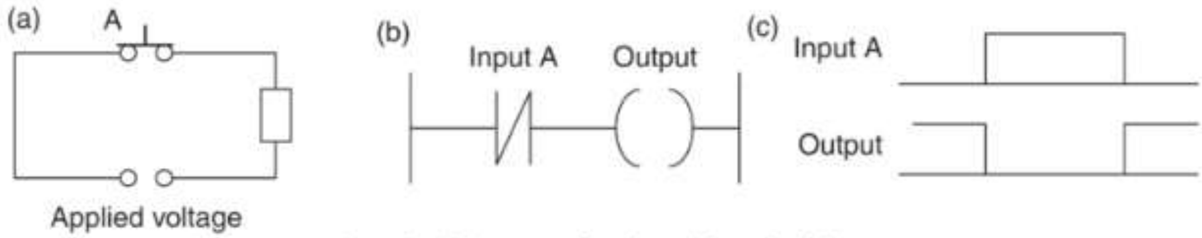


Figure: (a) NOT circuit (b) NOT logic with a ladder rung (c) high output when no input to A

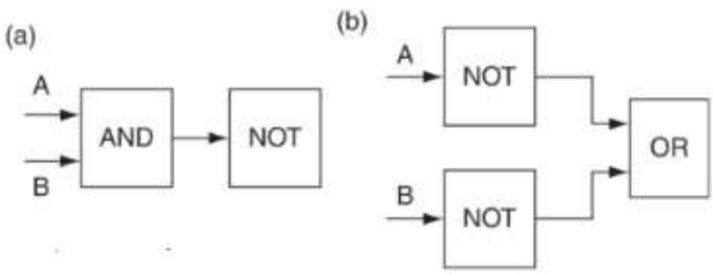
PLC NAND LOGIC

Suppose we follow an AND gate with a NOT gate . The consequence of having the NOT gate is to invert all the outputs from the AND gate.

An alternative, which gives exactly the same results, is to put a NOT gate on each input and then follow that with OR .

The same truth table occurs, namely:

Figure : NAND gate



Inputs		Output
A	B	
0	0	1
0	1	1
1	0	1
1	1	0

Both the inputs A and B have to be 0 for there to be a 1 output.

There is an output when input A and input B are not 1.

The combination of these gates is termed a NAND gate .

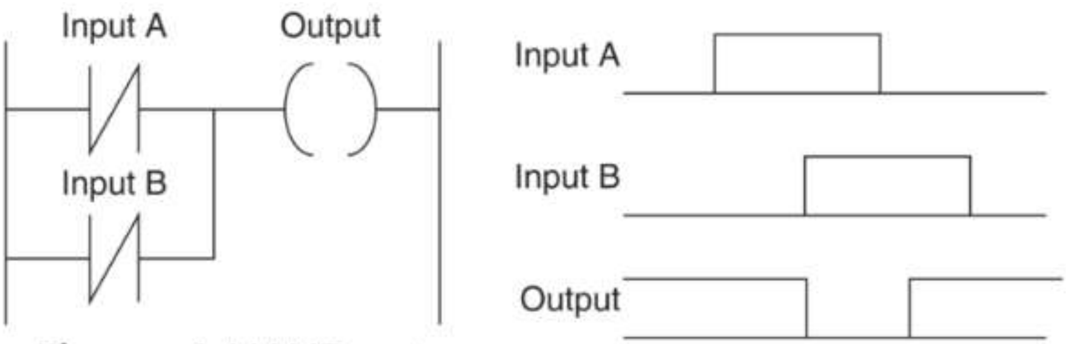


Figure: A NAND gate

An example of a NAND gate control system is a warning light that comes on if, with a machine tool, the safety guard switch has not been activated and the limit switch signalling the presence of the workpiece has not been activated.

PLC NOR LOGIC

Suppose we follow an OR gate by a NOT gate .

The consequence of having the NOT gate is to invert the outputs of the OR gate.

An alternative, which gives exactly the same results, is to put a NOT gate on each input and then an AND gate for the resulting inverted inputs .

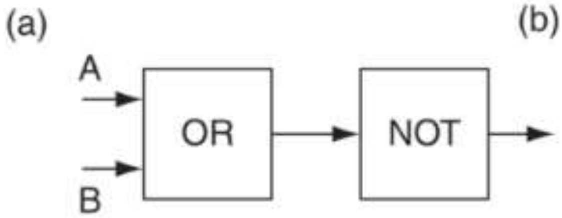
The following is the resulting truth table:

Inputs		Output
A	B	
0	0	1
0	1	0
1	0	0
1	1	0

The combination of OR and NOT gates is termed a NOR gate. There is an output when neither input A or input B is 1.

Figure 1.15 shows a ladder diagram of a NOR system.

When input A and input B are both not activated, there is a 1 output.



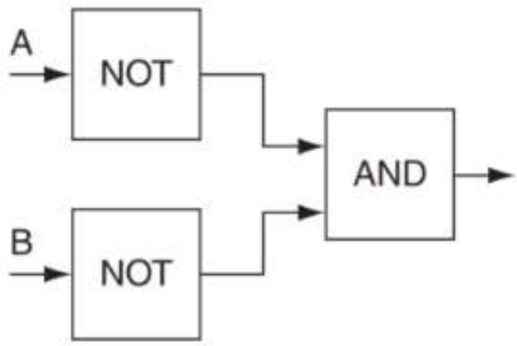


Figure: NOR gate

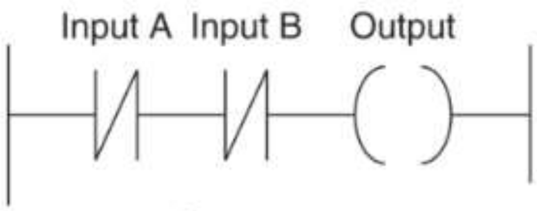
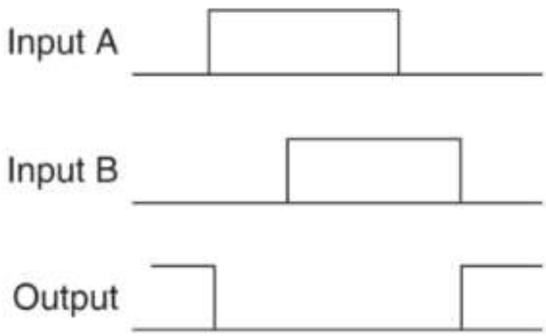


Figure : NOR gate



PLC Exclusive OR (XOR) LOGIC

The OR gate gives an output when either or both of the inputs are 1.

Sometimes there is, however, a need for a gate that gives an output when either of the inputs is 1 but not when both are 1, i.e., has the truth table:

Inputs		Output
A	B	
0	0	0
0	1	1
1	0	1
1	1	0

Such a gate is called an Exclusive OR or XOR gate.

One way of obtaining such a gate is by using NOT, AND and OR gates as shown in Figure .

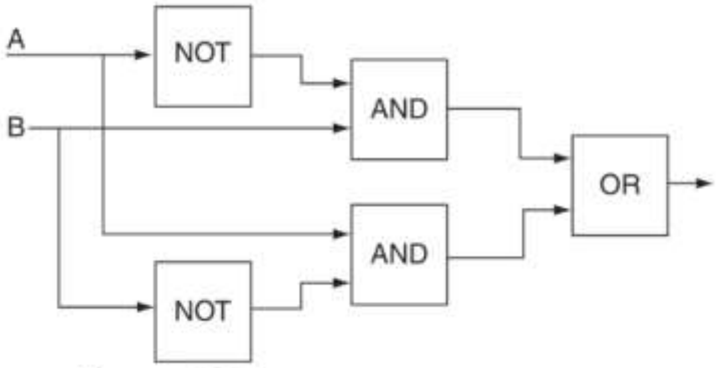


Figure : XOR gate

When input A and input B are not activated then there is 0 output.When just input A is activated, then the upper branch results in the output being 1. When just input B is activated, then the lower branch results in the output being 1.

When both input A and input B are activated, there is no output.

In this example of a logic gate, input A and input B have two sets of contacts in the circuits, one set being normally open and the other normally closed.

With PLC programming, each input may have as many sets of contacts as necessary.

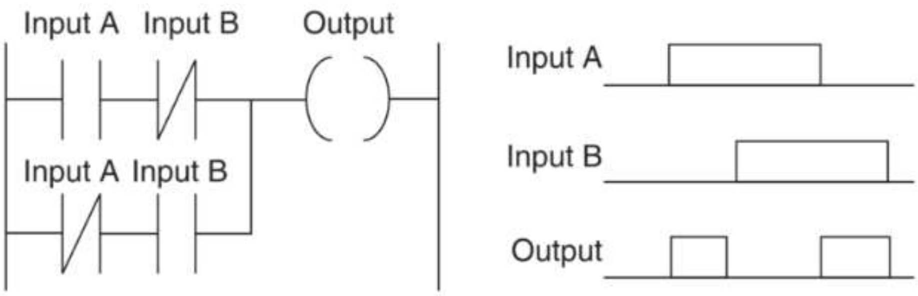


Figure : XOR gate

Result:

Thus the various logic function like ANR, OR, NOT,NAND ,NOR and XOR in Programmable logic controller(PLC) are programmed and verified the result

VIVA QUESTIONS

1. In a PLC “I” is used for output and “Q” is used for input
    a. True
    b. False
    c. None of the above
2. To increase the number of inputs and outputs of the PLC, one can use expansion modules.
    a. True
    b. False
    c. None of the above
3. Solenoids, lamps, motors are connected to:
    a. Analog output
    b. Digital output
    c. Analog input
    d. Digital input
4. What is the programmable language used in PLC?
5. What does Central Processing Unit (CPU) of PLC consists?
6. What is SCAN in PLC ?
7. Difference between PLCs and Computers
8. PLCs Advantages or Benefits
9. What is Programmable Logic Controllers (PLCs)

3. Implementing Mathematical operation on PLC

Aim:

To program various mathematical like Addition, subtraction ,multiplication ,division negation and modulus operation in Programmable logic controller(PLC) and to verify the result

Apparatus Required:

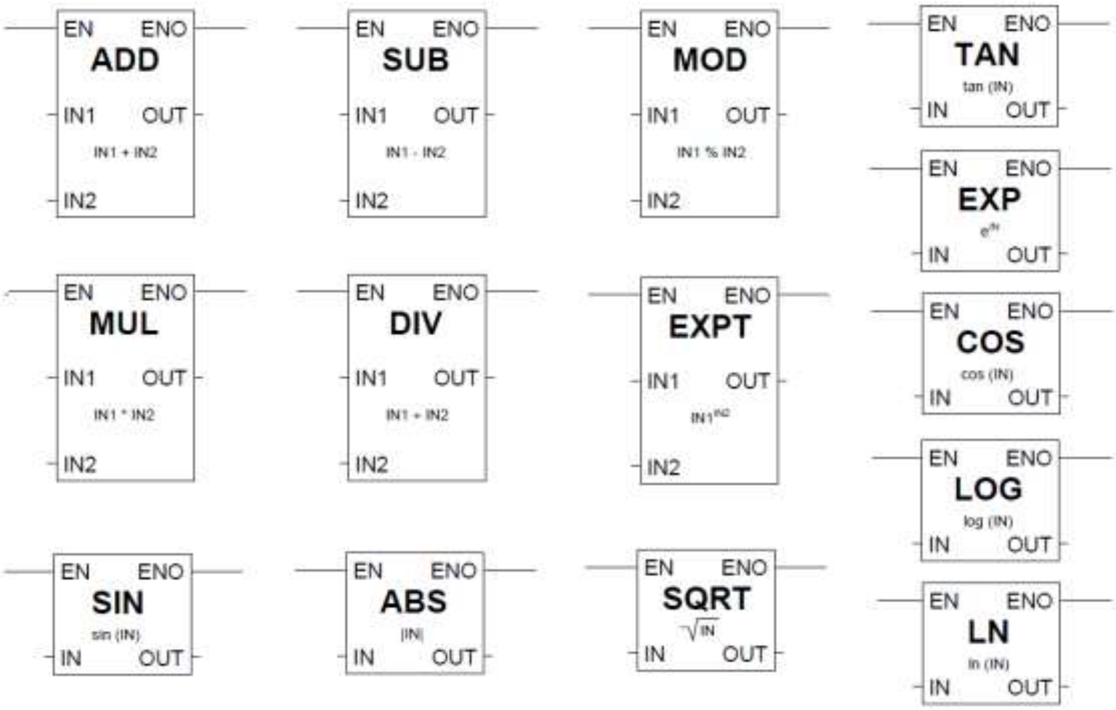
(vii) Programmable logic controller

(viii) Programmable logic controller software

(ix) Personal Computer

Theory:

The IEC 61131-3 standard specifies several dedicated ladder instructions for performing arithmetic calculations. Some of them are shown here:



As with the data comparison instructions, each of these math instructions must be enabled by an “energized” signal to the enable (EN) input. Input and output values are linked to each math instruction by tag name.

An example showing the use of such instructions is shown here, converting a temperature measurement in units of degrees Fahrenheit to units of degrees Celsius.

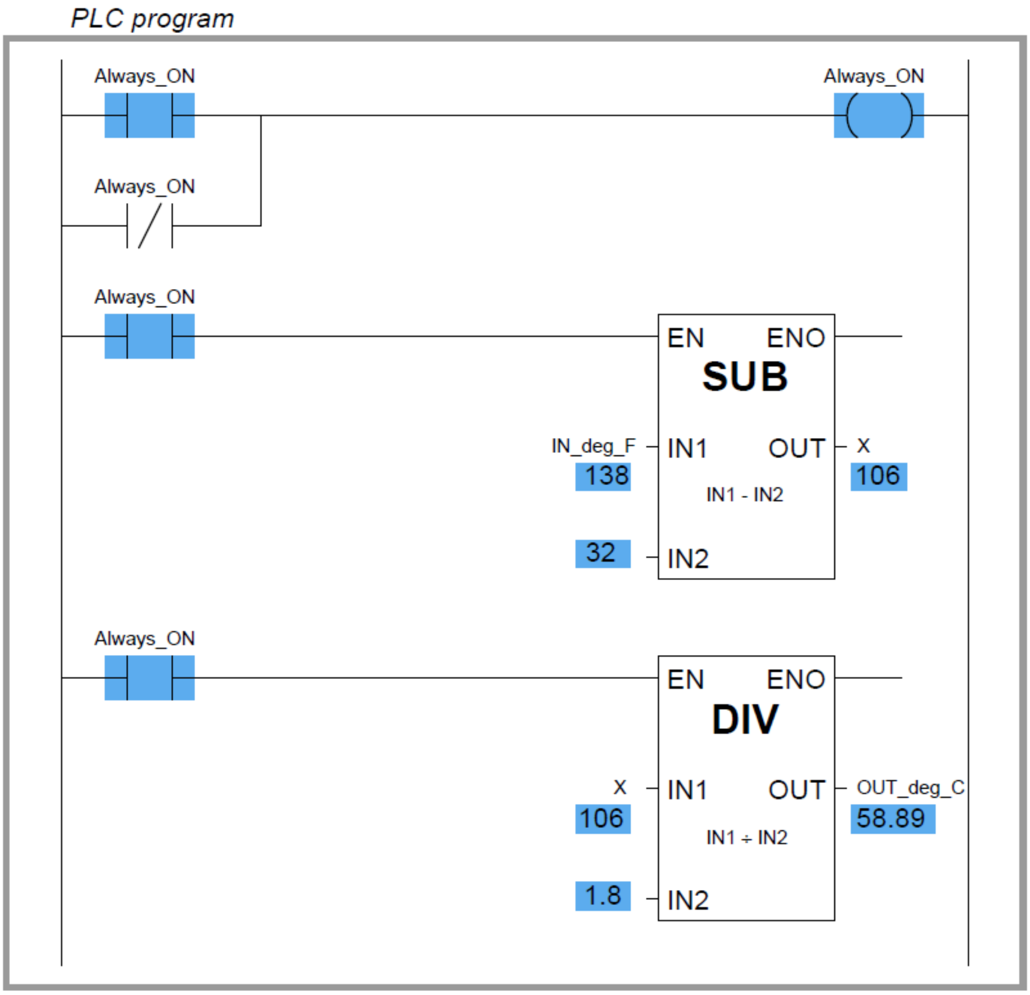
In this particular case, the program inputs a temperature measurement of 138 deg F and calculates the equivalent temperature of 58.89 deg C:

well as a dedicated variable (X) used to store the intermediate calculation between the subtraction and the division “boxes.”

Although not specified in the IEC 61131-3 standard, many programmable logic controllers support Ladder Diagram math instructions allowing the direct entry of arbitrary equations.
Rockwell (Allen-Bradley) Logix5000 programming, for example, has the “Compute” (CPT) function, which allows any typed expression to be computed in a single instruction as opposed to using several dedicated math instructions such as “Add,” “Subtract,” etc.

General-purpose math instructions dramatically shorten the length of a ladder program compared to the use of dedicated math instructions for any applications requiring non-trivial calculations.

For example, the same Fahrenheit-to-Celsius temperature conversion program implemented in Logix5000 programming only requires a single math instruction and no declarations of intermediate variables:



Implement ADD, SUB, MUL, DIV, MOD and NEG instructions in S7-1200 PLC using ladder diagram language.

One can use the Add instruction to add the value at input IN1 and the value at input IN2 and query the sum at output OUT (OUT := IN1+IN2).

Subtract instruction is used to subtract the value at input IN2 from the value at input IN1 and query the difference at output OUT (OUT := IN1-IN2).

Multiply instruction is used to multiply the value at input IN1 with the value at input IN2 and query the product at output OUT (OUT := IN1*IN2).

Divide instruction is used to divide the value at input IN1 by the value at input IN2 and query the quotient at output OUT (OUT := IN1/IN2).

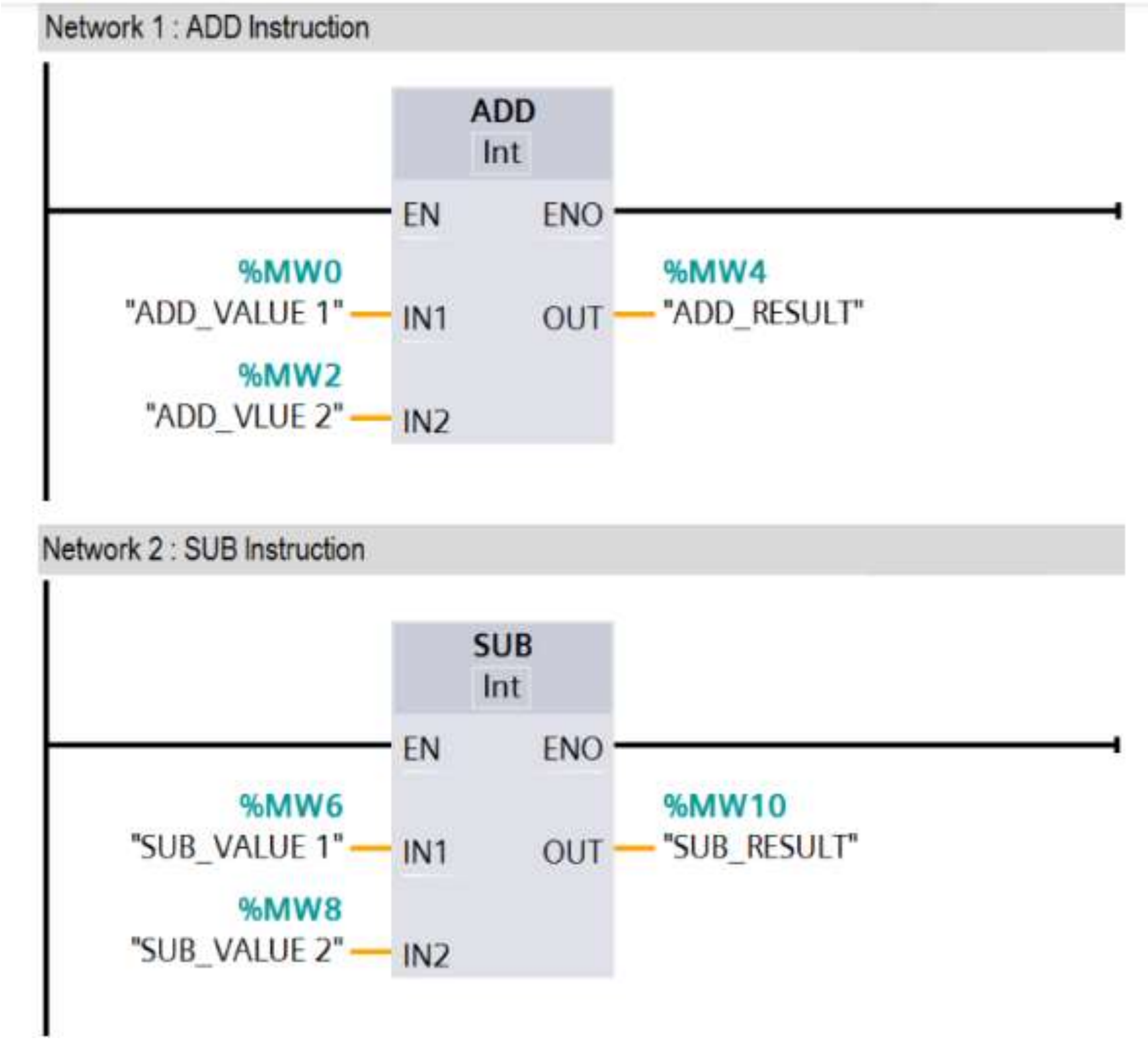
We can use the Return remainder of division instruction to divide the value at input IN1 by the value at input IN2 and query the remainder of division at output OUT.

We can use the "Create twos complement" instruction to change the sign of the value at the IN input and query the result at the OUT output. If there is a positive value at input IN, for example, the negative equivalent of this value is sent to output OUT.

List of Inputs/Outputs

M memory

- MW0 :- "ADD_VALUE 1"
- MW2 :- "ADD_VALUE 2"
- MW4 :- "ADD_RESULT"
- MW6 :- "SUB_VALUE 1"
- MW8 :- "SUB_VALUE 2"
- MW10 :- "SUB_RESULT"
- MW12 :- "MUL_VALUE 1"
- MW14 :- "MUL_VALUE 2"
- MW16 :- "MUL_RESULT"
- MW18 :- "DIV_VALUE 1"
- MW20 :- "DIV_VALUE 2"
- MW22 :- "DIV_RESULT"
- MW24 :- "NEG_VALUE"
- MW226 :- "NEG_RESULT"
- MD100 :- "MOD_VALUE 1"
- MD104 :- "MOD_VALUE 2"
- MD108 :- "MOD_RESULT"



Program Description

In this program we have used Siemens S7-1200 PLC and TIA Portal Software for programming.

Network 1 :-

The value of MW0 is added to the value of MW2.The result of the addition is stored in the MW4.

Network2 :-

The value of MW6 is subtracted from the value of MW8.The result of the subtraction is stored in MW10.

Network 3 :-

The value of operand MW12 is multiplied by the value of MW14. The result of the multiplication is stored in MW16.

Network 4 :-

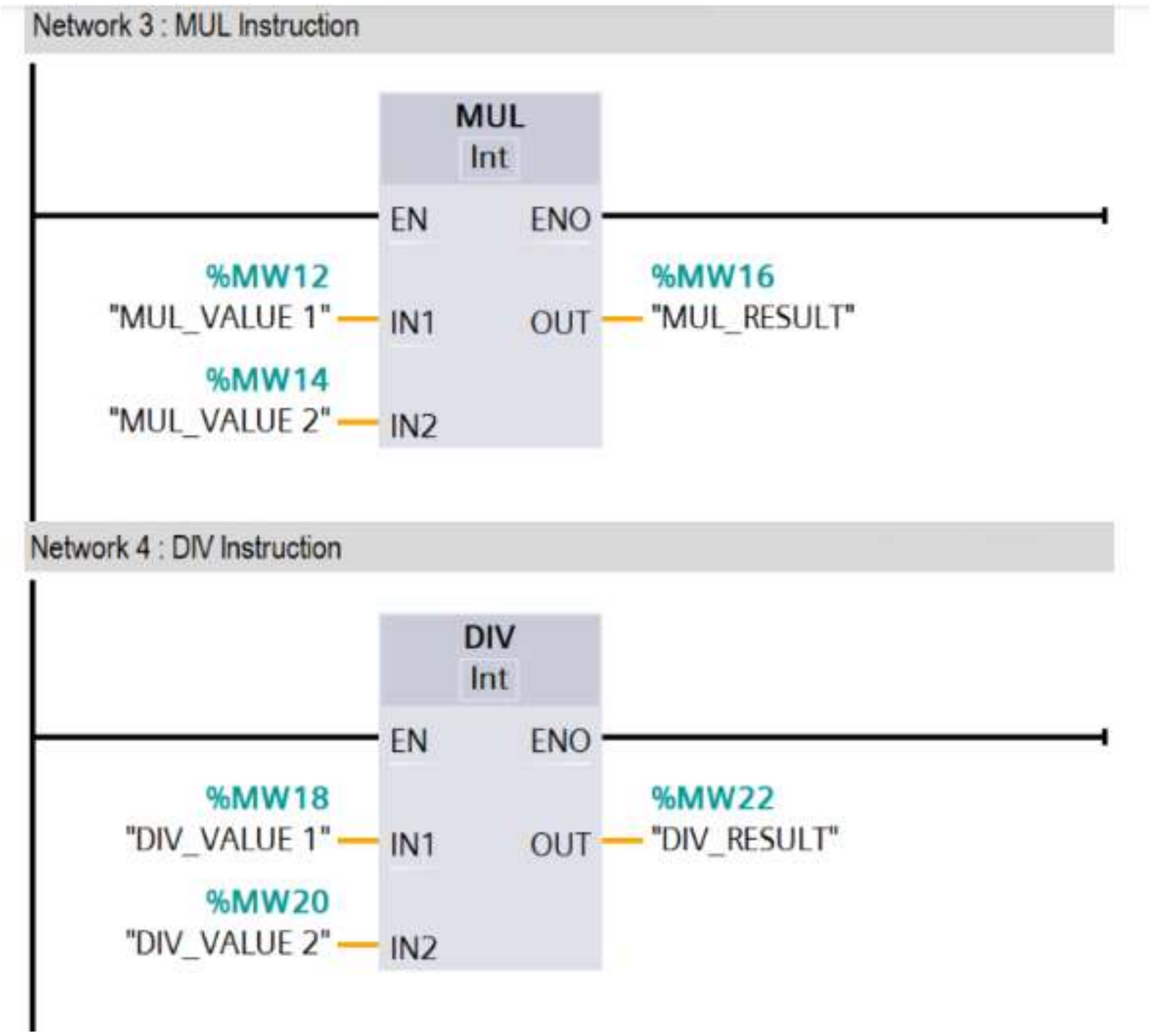
The value of operand MW18 is divided by the value of MW20. The division result is stored in MW22.

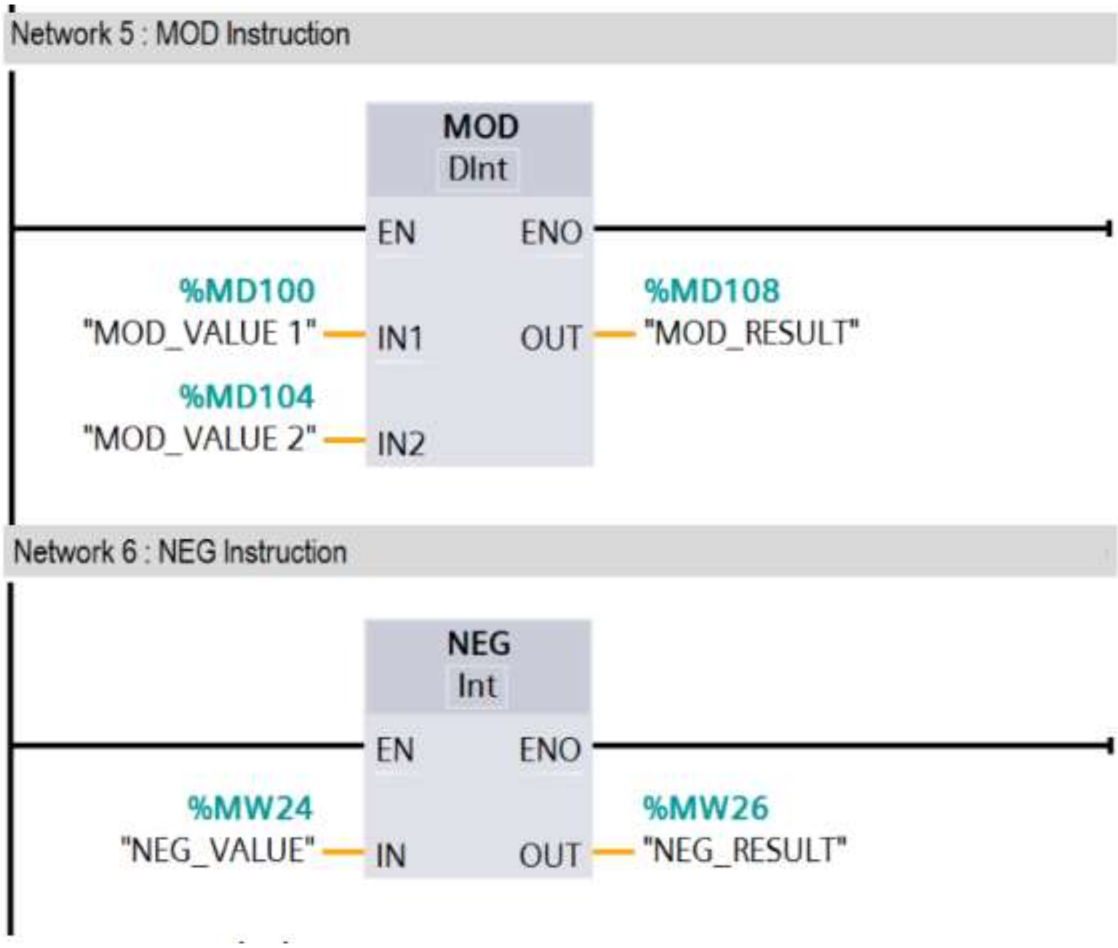
Network 5 :-

The value of MD100 is divided by the value of MD104. The remainder of division is stored in operand MD108.

Network 6 :-

The sign of the value at input MW24 is changed and the result is provided at output MW26.





Result:

Thus the various mathematical like Addition, subtraction, multiplication, division negation and modulus operation in Programmable logic controller(PLC) were programmed and verified the result.

VIVA QUESTIONS

1) What is redundancy in PLC?
2) What is an HMI in PLC?
3) What is SCAN in PLC?
4) List the advantages of PLC over Relays?
5) Explain scan cycle of PLC?
6) What is role of I/O modules in PLC?
7) What is LD in PLC?

4. Programming jump to –subroutine &return operations in PLC

Aim :

To do Programming jump to –subroutine & return operations in PLC and to verify the result

Apparatus Required:

(x) Programmable logic controller

(xi) Programmable logic controller software

(xii) Personal Computer

Theory:

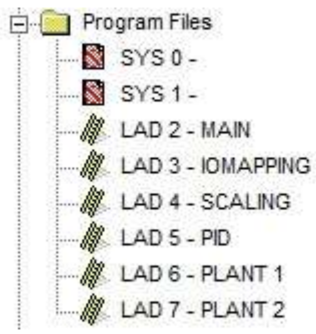
The SBR instruction must be the first instruction on the first rung in the program file that contains the subroutine.

- Use a subroutine to store recurring sections of program logic that must be executed from several points within your application program
- A subroutine saves memory because you program it only once.
- Update critical I/O within subroutines using immediate input and/or output instructions (IIM, IOM), especially if your application calls for nested or relatively long subroutines
- Otherwise, the controller does not update I/O until it reaches the end of the main program (after executing all subroutines)
- Outputs controlled within a subroutine remain in their last state until the subroutine is executed again.

When the JSR instruction is executed, the controller jumps to the subroutine instruction (SBR) at the beginning of the target subroutine file and resumes execution at that point. You cannot jump into any part of a subroutine except the first instruction in that file.

The target subroutine is identified by the file number that you entered in the JSR instruction. The SBR instruction serves as a label or identifier for a program file as a regular subroutine file. The instruction must be programmed as the first instruction of the first rung of a subroutine.

The RET instruction marks the end of subroutine execution or the end of the subroutine file. The rung containing the RET instruction may be conditional if this rung precedes the end of the subroutine.

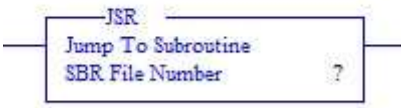


In the above picture, there are totally 8 files listed. In that SYS 0 and SYS 1 are default files.

- LAD 2-Main is the main page of the program, that means PLC starts executing IO's from this page only.
- LAD-3-IO MAPPING, LAD 4-SCALING, LAD 5-PID, LAD 6-PLANT 1 and LAD 7 PLANT 2 are sub programs categorized by project function and sequence.

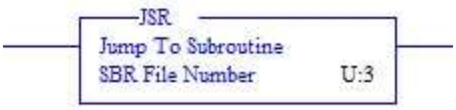
PLC Instruction Description

1.JSR-Jump to Sub routine

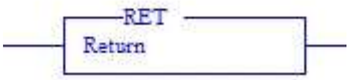


We can use this instruction using condition by adding some input before the instruction like,

In the SBR File number, we should give the ladder number i.e. which sub routine we should call at this place as shown in below figure.



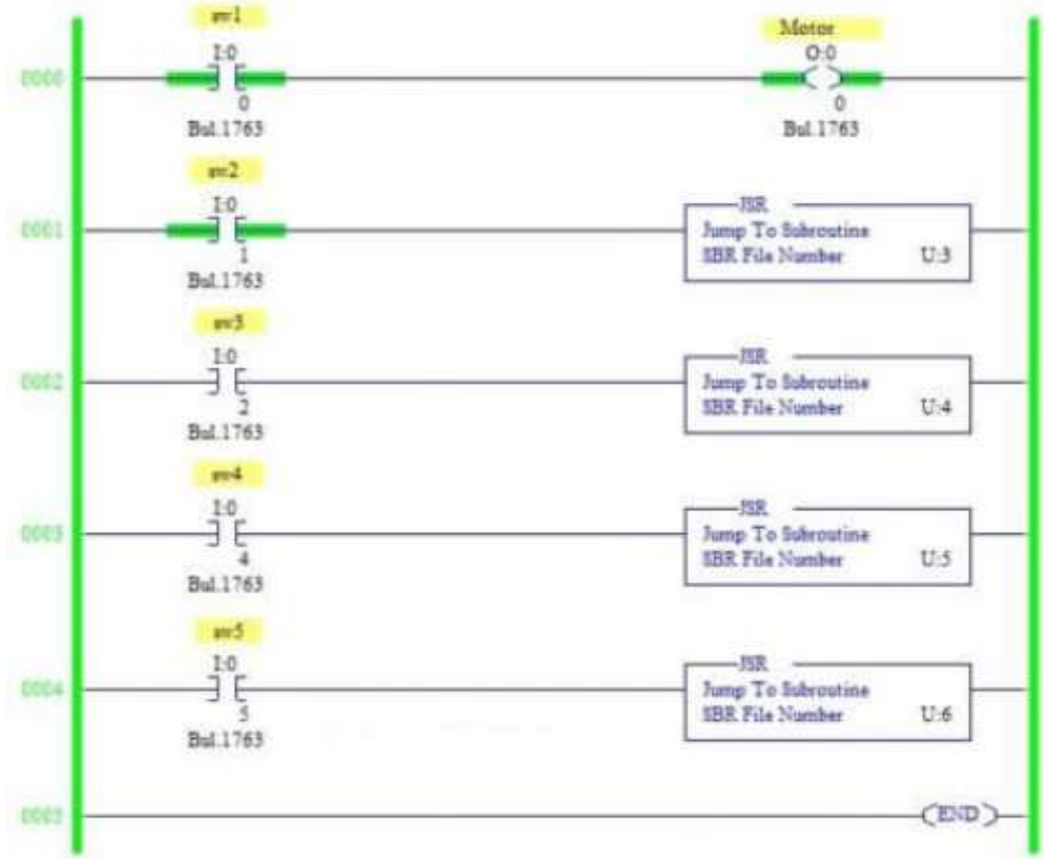
2. RET: Return to Main Page



Return instruction should add at the end of the sub routine program.

PLC Program

LAD 2-MAIN PAGE:



LAD 3–IO MAPPING:

Note: Since its for example, LAD 4, LAD 5,LAD 6,LAD 7 pages are not included in this program

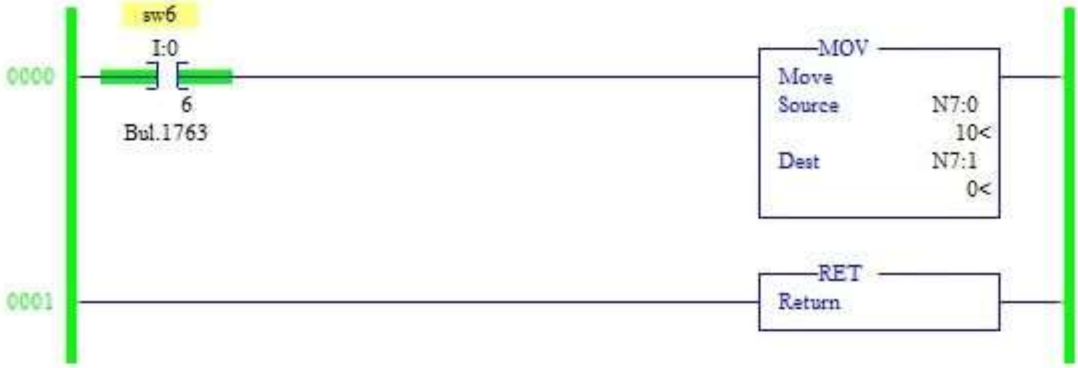
Program Description:

Case 1 :
If Sw2 is not turned on, In LAD 3-IO Mapping, no operations will be happen.

LAD 2-MAIN PAGE:

LAD 3–IO MAPPING:

Even though, sw6 is turned ON, Move block is not doing any operation because in main page, JSR instruction is not activated



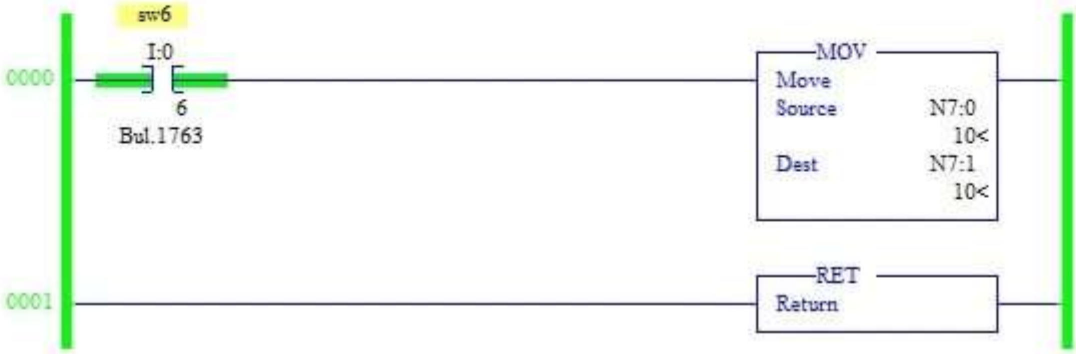
Case 2 :

If Sw2 is turned on, In LAD 3-IO Mapping, operations will be happen.

LAD 2-MAIN PAGE:

LAD 3–IO MAPPING:

sw6 is turned ON, Move block is doing it s operation because in main page, JSR instruction is activated



The above explained concept for subroutine is for example only. We can use this example program to understand the working of JSR and RET function in AB PLC ladder logic programming.

Result:

Thus the Programming jump to –subroutine & return operations in PLC were done and the result is verified.

VIVA QUESTIONS

1) What is MCR in PLC?
2) How Do Fixed PLCs differ from modular PLCs?
3) Which programmable languages are used in PLCs?
4) Differentiate between PLCs and DCS.
5) Differentiate between PLCs are Relays
6) Which PLC ranges are available in Rockwell?
7) What is the RS LINX software used for?
8) How are PLCs more advantageous than hard-wired Relay?

5(i) PLC based 4 Way Traffic Light Control System

Aim:

To program PLC based 4 Way Traffic Light Control System and to verify the result

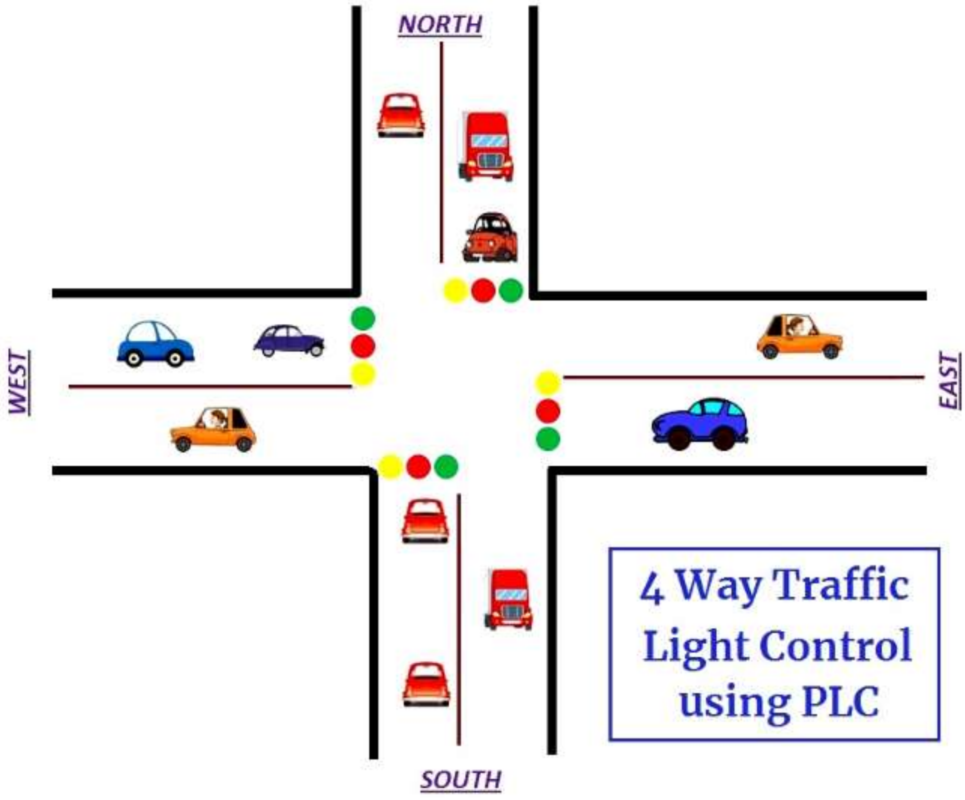
Apparatus Required:

(xiii) Programmable logic controller

(xiv) Programmable logic controller software

(xv) Personal Computer

We most often come across four way traffic jam in our city. This PLC ladder logic gives the solution to control city traffic using programmable logic control.



Problem Solution

1. They are so many ways to write a program for traffic light control ex: sequencer output method but in this normal input, outputs and timers are used.
2. Timers are used to give time delay for output to turn on and off.
3. Reset using timer done bit at the end to run the program continuously.
4. Program done in AB RSLogix 500 Software.
5.

List of Inputs and Outputs

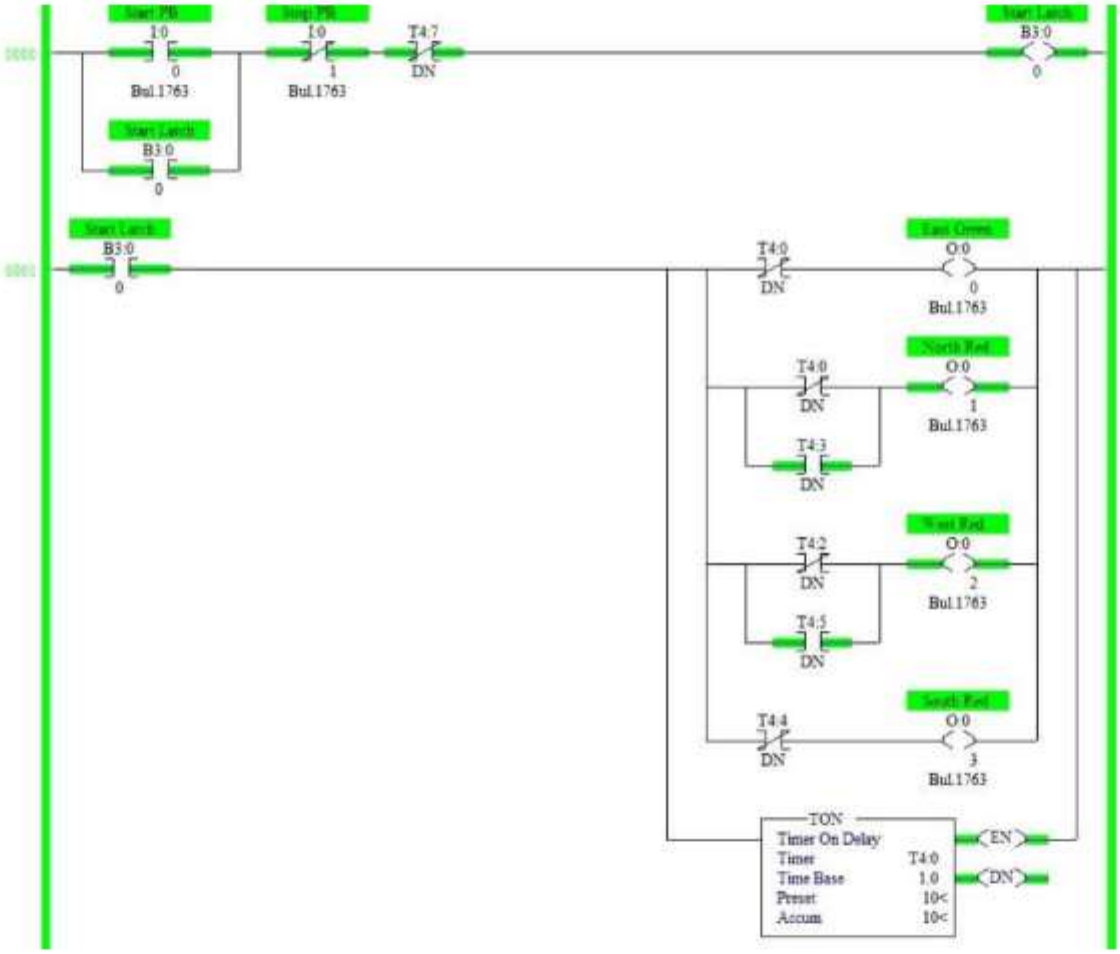
S.no	Address	Name	Input/ Output
1	I:0/0	Start	Input
2	I:0/1	Stop	Input
3	B3.0	Memory	Memory
4	O:0/0	East Green	Output
5	O:0/1	North Red	Output
6	O:0/2	West Red	Output
7	O:0/3	South Yellow	Output
8	O:0/4	East Yellow	Output
9	O:0/5	North Yellow	Output
10	O:0/6	North Green	Output
11	O:0/7	East Red	Output
12	O:0/8	West Yellow	Output
13	O:0/9	West Green	Output
14	O:0/10	South Yellow	Output
15	O:0/11	South Green	Output

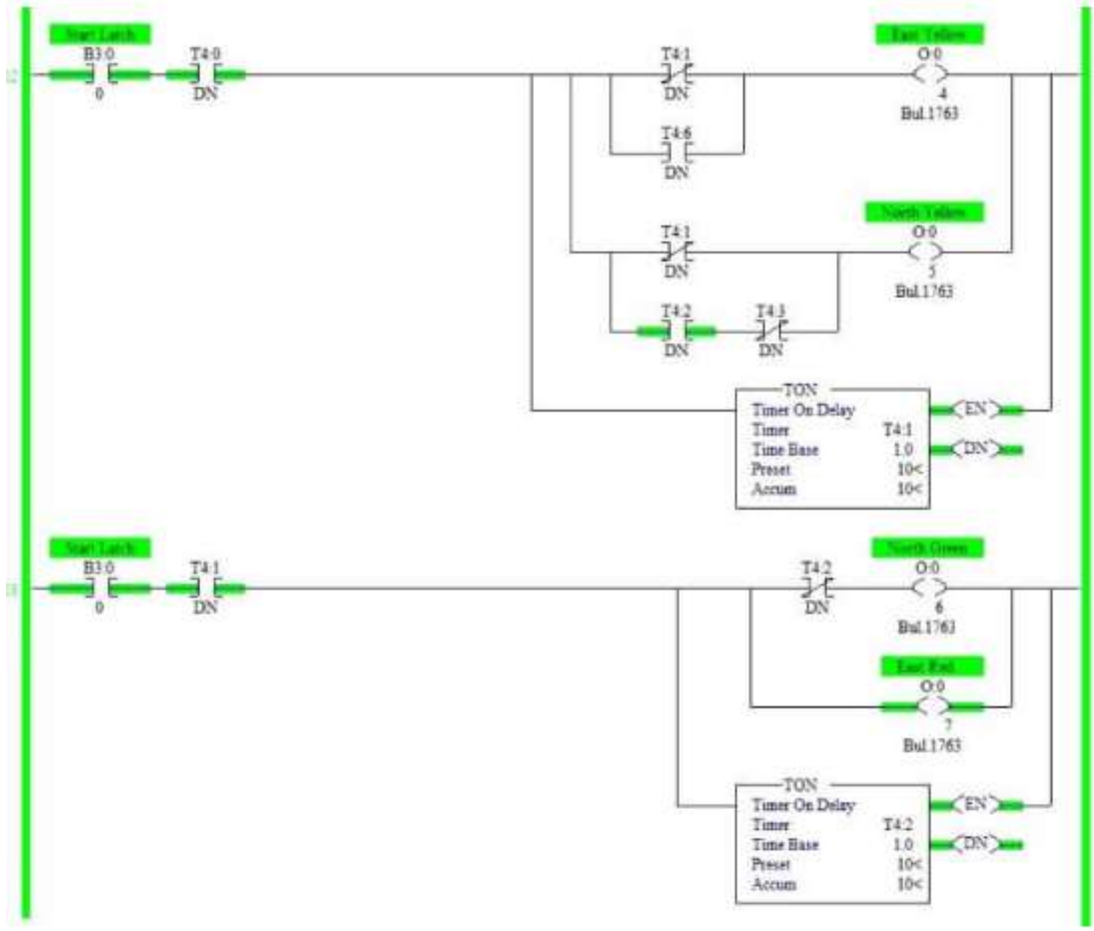
Sequence of Operation

Below tabular column gives the Steps or sequence of outputs to turn ON the traffic system lamps (RED, GREEN, YELLOW)

S.NO	EAST	WEST	NORTH	SOUTH
1	G	R	R	R
2	Y	R	Y	R
3	R	R	G	R
4	R	Y	Y	R
5	R	G	R	R
6	R	Y	R	Y
7	R	R	R	G
8	Y	R	R	Y

PLC Ladder Logic





Logic Description

RUNG000

Latching rung to operate the system through Master Start and Stop PB.
RUNG001

Starting the timer to turn on output East Green ,North-South-West are in red. Parallel circuits are added to turn ON/OFF the output in up next sequence.
RUNG 0002

Turning on North Yellow and East Yellow. Parallel circuits are added to turn ON/OFF the output in up next sequence.

Rung 0003

Turn on East Red and North Green.

Rung 0004-0005-0006-0007

Same procedures followed to turn on further outputs.(Refer Above Tabular column for sequence of operation)

RUNG 0008

Timer (T4:7) done bit is used to restart the cycle from beginning
Program runs continuously until STOP PB is pressed

Time delay of 10s has given using timers.
Note: We can reduce the number of timers using comparator block
Conclusion:

The above explained 4 ways traffic light control using PLC is for example only. It may vary from real time. We can use this example program to understand the working of timers and Interlocking function in AB PLC.

Result:

Thus the program PLC based 4 Way Traffic Light Control System is done and verified the result

5.(ii)PLC Program for Water filling and Discharging Process

Aim:

To program for Water filling and Discharging Process in Programmable logic controller(PLC) and to verify the result

Apparatus Required:

(xvi) Programmable logic controller

(xvii) Programmable logic controller software

(xviii) Personal Computer

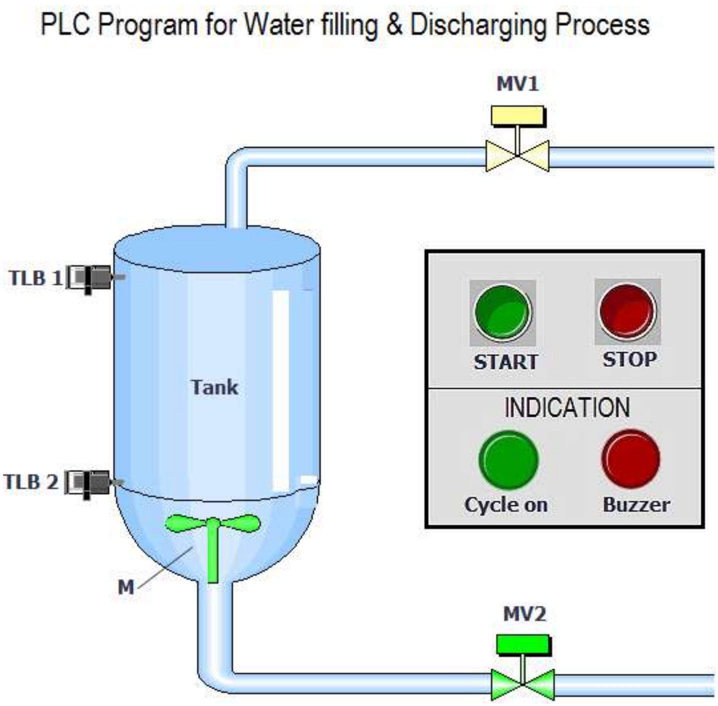
Water filling and Discharging Process

This is PLC Program for Water filling and discharging process using S7-1200 PLC.

Problem Description

- Many industries or plant, there are lots of manual water filling system are used for water storage.
- In manual system, there are so many disadvantages such as Accuracy, time delay problem, loss of liquids, Time consuming.
- And due to manual system we have to arrange an operator for machine operation. Water wastage occurs due to manual system
- Here we are discussing a semi-automatic system.

Problem Diagram



Problem Solution

- To solve this problem, we will use S7-1200 PLC for programming.
- Here we use two sensors for level measurement, one is for High level and second is for low level.
- We use feeding valve (MV1) for filling Cycle of the tank and discharge valve (MV2) for discharging cycle of the tank. Both will be controlled according to sensor logic. So when the water level goes below low level then feeding valve will turned ON automatically and when water level reaches high and the it senses by high level sensor, then discharging process will be turned ON automatically.
- When high level is detected then buzzer will turn ON for alarm purpose. Cycle will stop if user will press stop button from the control panel.

List of inputs/outputs

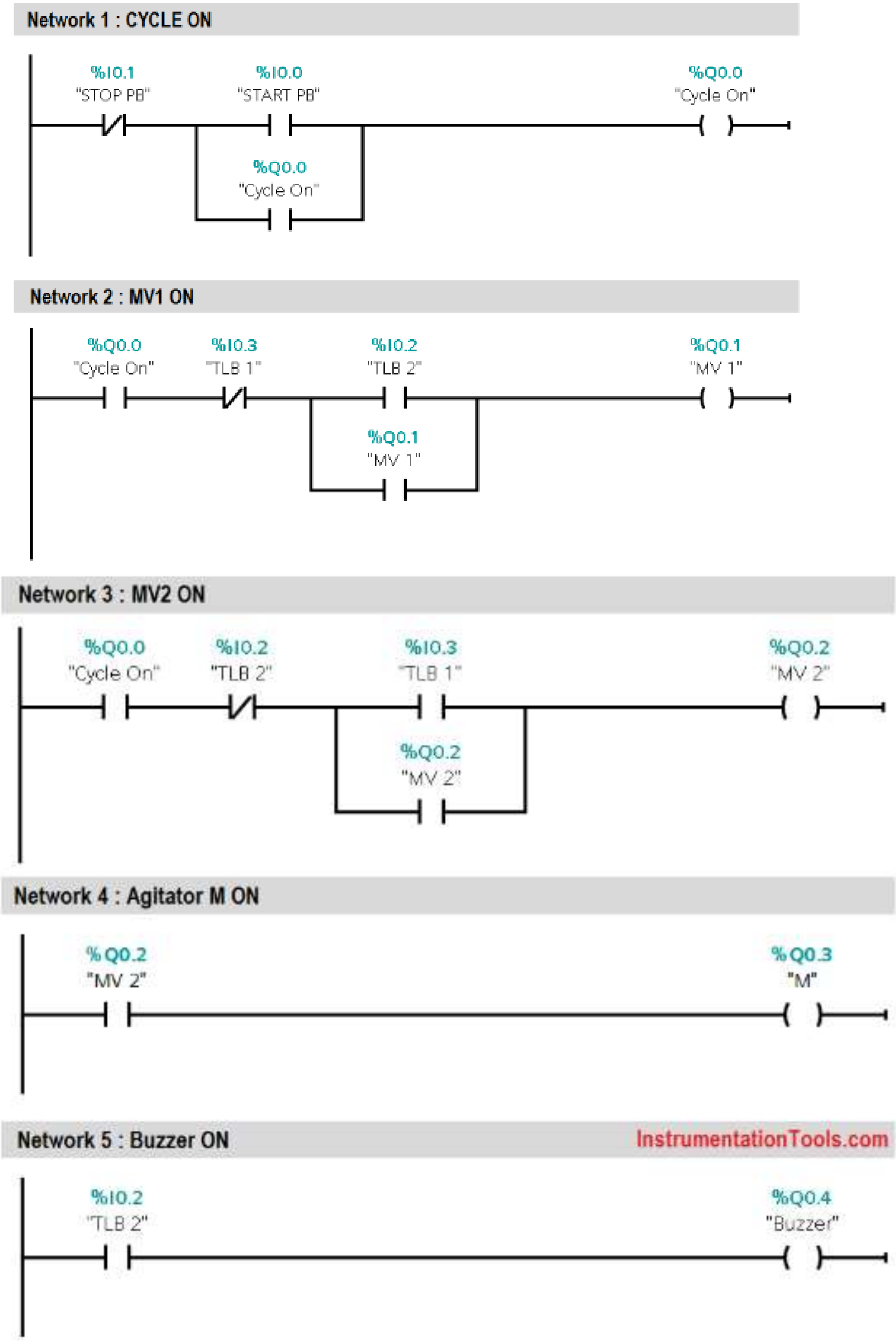
Digital Inputs

- Start PB : I0.0
- Stop PB : I0.1
- TLB 1 : I0.3
- TLB 2 : I0.2

Digital Outputs

- Cycle ON : Q0.0
- Valve MV1 (Feed) : Q0.1
- Valve MV2 (Discharge) : Q0.2
- Agitator/Mixer M : Q0.3
- Buzzer : Q0.4

PLC Water Filling and Discharging Process



Program Description

- For this application, we used S7-1200 PLC and TIA portal software for programming.

- In Network 1 we used latching circuit for cycle ON (Q0.0) output. It can be started by pressing START PB (I0.0) and stop by pressing STOP PB (I0.1).
- When cycle will be started then system will check level of the tank. If tank level is low then then feeding process will start and tank level is high then Discharge cycle will start.
- Here we have taken NO contact for both sensors in the program for simplicity. It can be done by relay logic in field or you can use such type of sensors.
- When tank will detect low level then TLB 2 (I0.2) will be activated and then feeding cycle will be ON. Here we have taken NC contact of TLB1 (I0.3) so when PLC will detect high level then it will stop Feeding cycle.
- When tank will detect high level then TLB 1 (I0.3) will be activated and discharging cycle will be ON. Here we have taken NC contact of TLB2 (I0.2) so when PLC will detect low level then it will stop discharge cycle cycle.
- Mixer M (Q0.3) should be ON during discharging cycle for mixing purpose.
- Here we also considered an alarm for high level to inform operator. When TLB 1(I0.3) will be detected then buzzer (Q0.4) will be activated.
- During all function, cycle should be ON.
- Runtime Test Cases

PLC Program for Water filling and Discharging Process

Inputs	Outputs	Physical Elements
I0.0=1	Q0.0=1	Cycle ON
I0.2=1	Q0.1=1	Feeding Cycle ON
I0.3=1	Q0.2=1, Q0.3 & Q0.4	Discharge Cycle ON, M & Buzzer ON
I0.1=1	Q0.0,Q0.1,Q0.2,Q0.3&Q0.4=0	Cycle stop

Result:

Thus the program for Water filling and Discharging Process in Programmable logic controller (PLC) were done and verified the result.

VIVA QUESTIONS

1.How do you program a traffic light on a PLC?

2.How are traffic lights controlled?

3.What are the applications of PLC?

4.What is a PLC Programmer?

5.How are traffic lights controlled?

6.What is PLC scan time?

6.(i)ON OFF CONTROL FOR THERMAL PROCESS

Aim:

To obtain the ON OFF Control for thermal process by PLC programming

Apparatus required:

S. No.	Components / Equipments	Specification	Quantity
1.	Power Supply		1
2.	PLC		1
3.	Potentiometer		1
4.	Connecting Wires		Few
5.	Relay		3
6.	Heaters		3
7.	Temperature process		1

THEORY

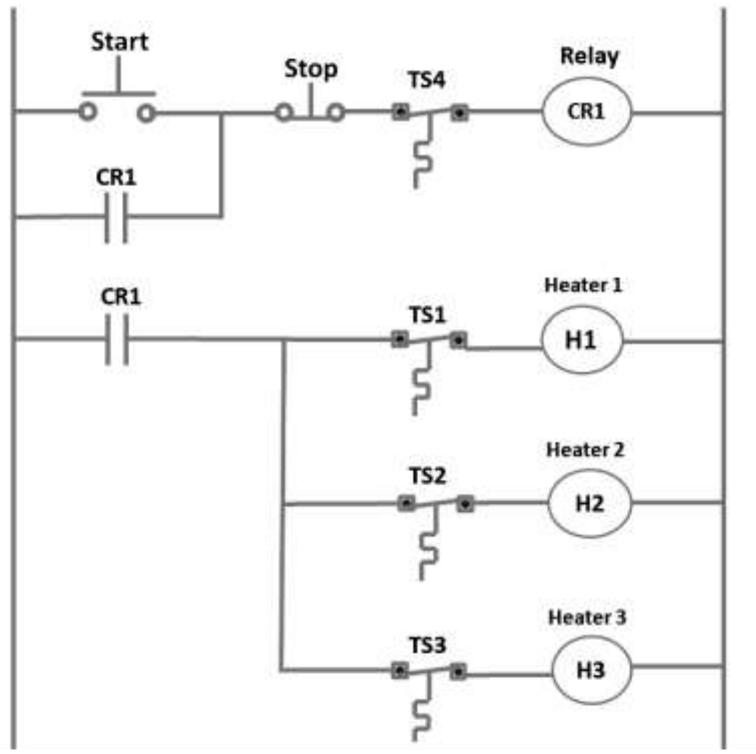
We are using Three Thermostats to measure the temperature at each heater. also another thermostat for safety shutoff in case of malfunction or emergency or to avoid over temperatures.
All these heaters have different setpoints or different temperature ranges where heaters can be turned ON accordingly (below table shows the temperature ranges).

1. A temperature control system consists of four thermostats. The system operates three heating units. The thermostats (TS1/TS2/TS3/TS4 are set at 55°C, 60°C, 65°C and 70°C.
2. Below 55°C temperature, three heaters (H1,H2,H3) are to be in ON state
3. Between 55°C – 60°C two heaters (H2,H3) are to be in ON state.
4. Between 60°C – 65°C one heater (H3) is to be in ON state.
5. Above 70°C all heaters are to be in OFF state, there is a safety shutoff (Relay CR1) in case any heater is operating by mistake.
6. A master switch turns the system ON and OFF.

There are four thermostats; assume them be in NC state when the set point is not reached.
Let there be a control relay (CR1) to work as a safety shutoff.
Master Switch: The Start switch is NO and Stop switch NC type.
The below table shows the temperature ranges where Thermostats (TS1, TS2, TS3, TS4) status will be indicated as per the temperature value.
Also the Heaters (H1, H2,H3) status in which either those Heaters will be ON or OFF as per the temperature value.

Temperature	Thermostats	Heater 1	Heater 2	Heater3
Below 55°C	TS1 Closed TS2 Closed TS3 Closed TS4 Closed	ON	ON	ON
55°C-60°C	TS1 Open TS2 Closed TS3 Closed TS4 Closed	OFF	ON	ON
60°C-65°C	TS1 Open TS2 Open TS3 Closed TS4 Closed	OFF	OFF	ON
65°C-70°C	TS1 Open TS2 Open TS3 Open TS4 Closed	OFF	OFF	OFF
Above 70°C	TS1 Open TS2 Open TS3 Open TS4 Open	OFF	OFF	OFF

PLC Ladder Logic



Ladder Logic Operation :

First Rung :

It has START button (default NO contact) and STOP button (default NC contact). A Relay CR1 is used to control the heaters depending on the thermostats status.
A Thermostat TS4 is connected in between STOP & Relay, if TS4 activated (means TS4 contact changes from NC to NO) then all heaters will be OFF.
An NO contact of Relay CR1 is used across the START button in order to latch or hold the START command.

Second Rung :

An NO contact of Relay CR1 is used to control the Heaters (H1,H2,H3) with the thermostats (TS1,TS2,TS3) status.

After giving START command, This NO contact becomes NC contact. if temperature below 55 Deg C, TS1, TS2 & TS3 will be in Close Status so all heaters will be ON, if Temperature is in between 55 to 60 Deg C, Then TS1 will be Open, so Heater H1 will be OFF.

Then, if temperature in between 60 to 65 Deg C then TS2 also be Open, so Heater H2 will be OFF if temperature in between 65 to 70 Deg C then TS3 also be Open, so Heater H3 will be OFF

There is a safety Shutoff which is used to avoid any malfunctions of Thermostats or to avoid over temperatures. if temperature reaches above 70 Deg C then TS4 will activates and de-energizes the Relay, thus all Heaters will be turned OFF.

Note: Here Heaters H1, H2, H3 are either Relays or Contactors we energizing. so an NO contact of these relays are connected to Electrical Heater feeder circuits (MCC).These Electrical Feeder circuits will be controlled as per these signals and accordingly the heaters will be either ON or OFF.

RESULT:

Thus the ON OFF control of Thermal process by PLC programming is performed.

6.(ii) Reversal of DC Motor Direction

Aim:

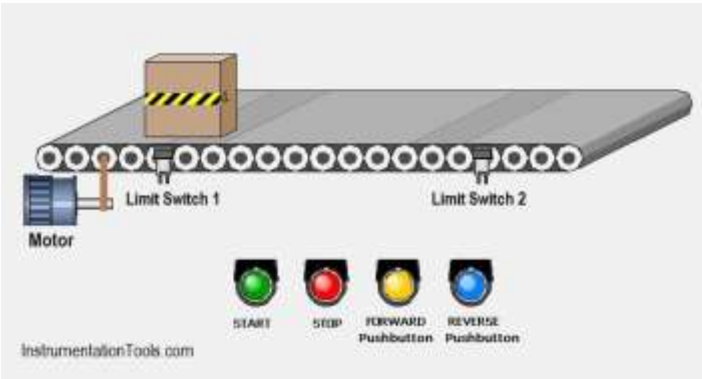
To obtain the Control of DC motor by PLC programming and to verify the result.

Apparatus required:

S. No.	Components / Equipments	Specification	Quantity
1.	Power Supply		1
2.	PLC		1
3.	Potentiometer		1
4.	Connecting Wires		Few

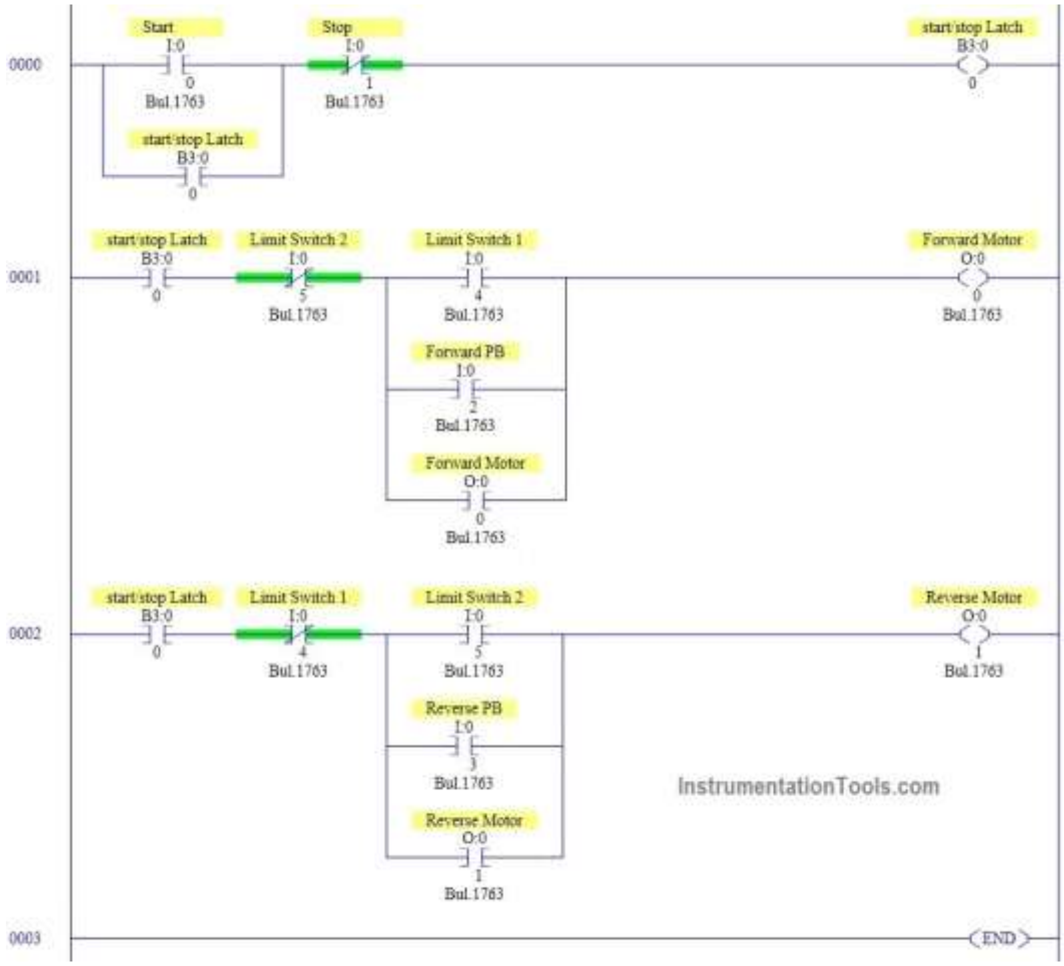
THEORY

The Workpiece starts moving on the left side and moves to the right when the start button is pressed. When it reaches the rightmost limit, the drive **motor reverses** and brings the workpiece back to the leftmost position again and the process repeats. The forward and reverse pushbuttons provides a means of starting the motor in either forward or reverse so that the limit switches can take over automatic control.

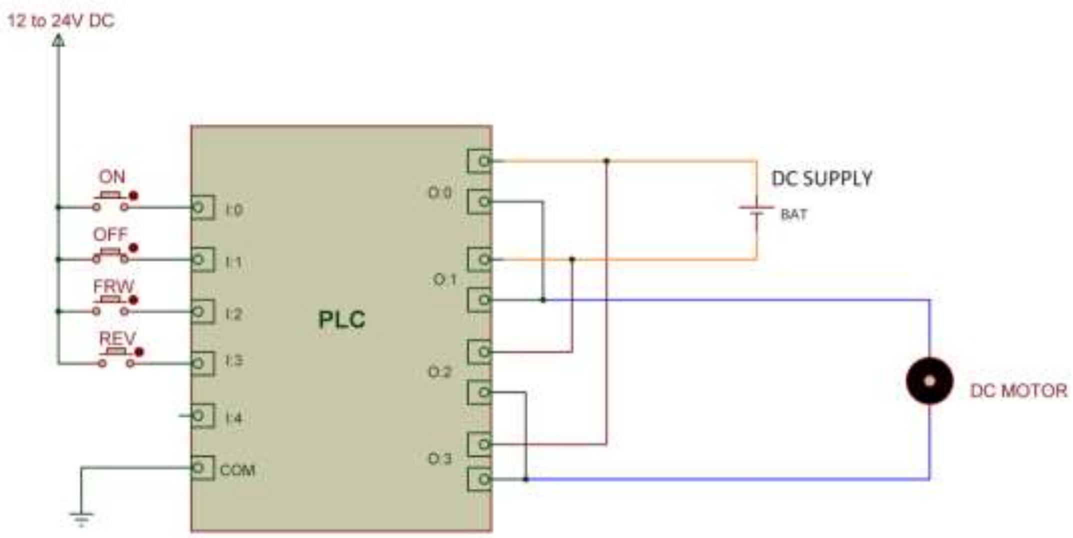


List of Inputs and Outputs

S.no	Address	Name	Input/output
1	I:0/0	Start	Input
2	I:0/1	Stop	Input
3	B3:0	Start Latch	Binary
4	I:0/2	Forward switch	Input
5	I:0/3	Reverse Switch	Input
6	I:0/4	Limit Switch 1	Input
7	I:0/5	Limit Switch 2	Input
7	O:0/0	Forward Motor	Output
8	O:0/1	Reverse Motor	Output



CONNECTION DIAGRAM:



Ladder Logic Operation :

RUNG 0000

Latching rung to operate the system through Master Start and Stop PB.

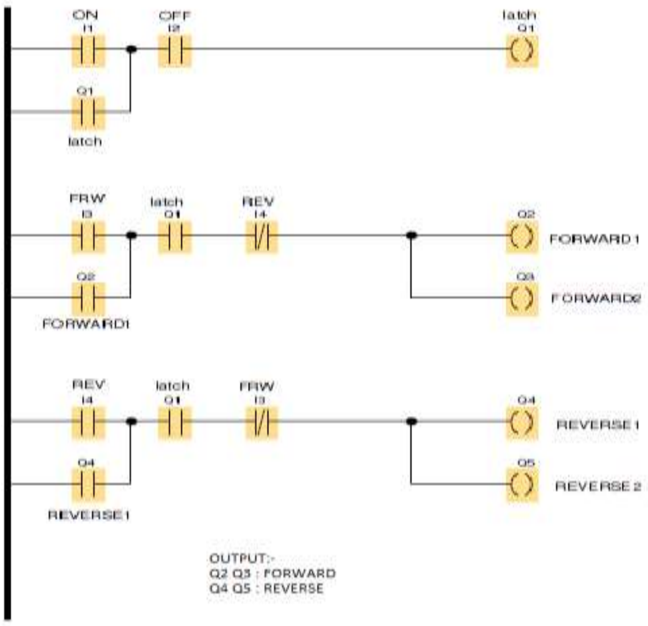
RUNG 0001

When the workpiece is near Limit switch1, It will enable forward motor, for latching forward Motor is connected in parallel with limit switch 1. Forward Pushbutton (PB) is also connected in parallel to manually operate forward motor.

RUNG 0002

When the workpiece is near Limit switch2, It will enable reverse motor, for latching reverse Motor is connected in parallel with limit switch 2.Reverse Pushbutton (PB) is also connected in parallel to manually operate Reverse motor.

LADDER LOGIC DIAGRAM



PROCEDURE

At starting, after pressing the START/ON button, you must press the FRW or REV button to run/rotate the motor. After under the running condition also can control direction.

In above ladder diagram, when START =1 and STOP also 1 (because STOP button is physically NC-normally close), OUT relay is energized. And it remains in ON condition because OUT relay contact is used as auxiliary contact in parallel with START contact. It requires STOP=0 to turn off the OUT.

In second rung, to turn on FORWARD1 and FORWARD2, OUT relay must be 1. When physically FRW button is pressed here both FORWARD relay gets energized and it remains ON until STOP or REV gets input.

In third rung, to turn on REVERSE1 and REVERSE2, OUT relay must be 1. When physically REV Button is pressed here both FORWARD relay gets energized and it remains ON until STOP or FRW gets input.

Before connecting Motor:

1) Check the Rating of PLC output Relay voltage, current etc
2) If output Relay rating is less than motor Voltage Rating then you have to use External Relay, it should be Actuated by DC supply

3) Check the input Rating of Relay, connection of input requires mentioned voltage as per the
PLC manual

Above precaution should be taken before making the connections, otherwise wrong rating or connection may cause permanent damage to the PLC.

RESULT:

Thus the control of of DC motor by PLC programming is performed.

VIVA QUESTIONS

1.What is meant by ON-Off controller ?

2.What are the merits of ON-OFF controller?

3. What are the disadvantages of ON-OFF controller?

4.What are the types of DC motor?

5.What are the limitations of DC motor?

6.Briefly summarize about working of DC motor.

7. PC BASED CONTROL OF LEVEL PROCESS

Aim:

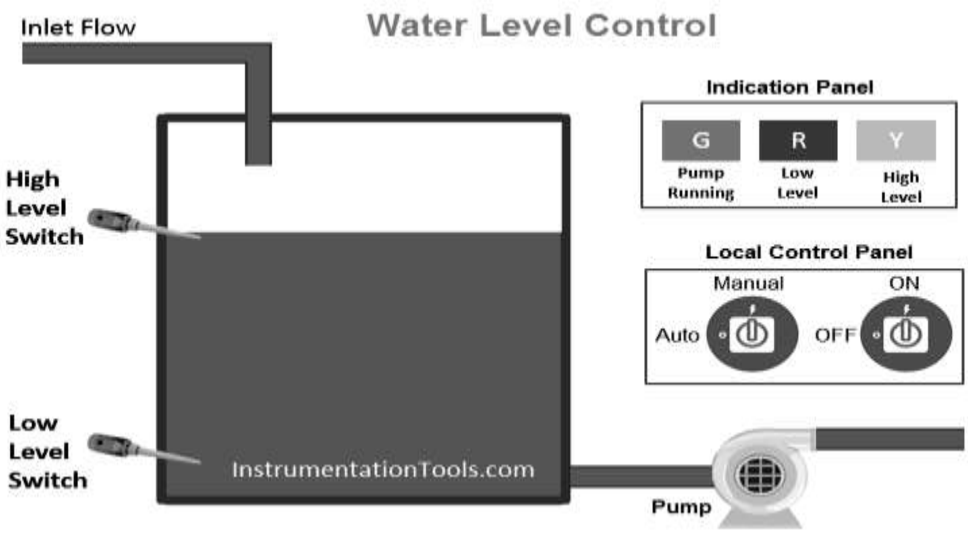
To obtain the control of level process by plc programming

Apparatus required:

S. No.	Components / Equipments	Specification	Quantity
1.	Power Supply		1
2.	PLC		1
3.	Connecting Wires		Few
4.	Pump		1
5.	Level process		1

THEORY

Liquid level control is a basic and necessary process for all the process industry. Here the level of liquid is to be maintained inside the tank to a specific height. Here there is a water reservoir from which the water needs to be pumped out to the process tank. In the process tank there are two sensors connected around the edges of the tank according to the required heights i.e., one sensor is connected at the near bottom end of the tank called as lower level sensor and another one on the near top edge of the tank called as higher level tank. To let the water out of the tank there is a pipe connected at the bottom of the tank with a valve. This valve is to be used by user for the process application The level sensor is a magnetic sensor and when the liquid level is above the high level sensor a HL (high level) signal is send to the PLC. When the liquid level goes down the low level sensor LL (low level) signal is send to the PLC.

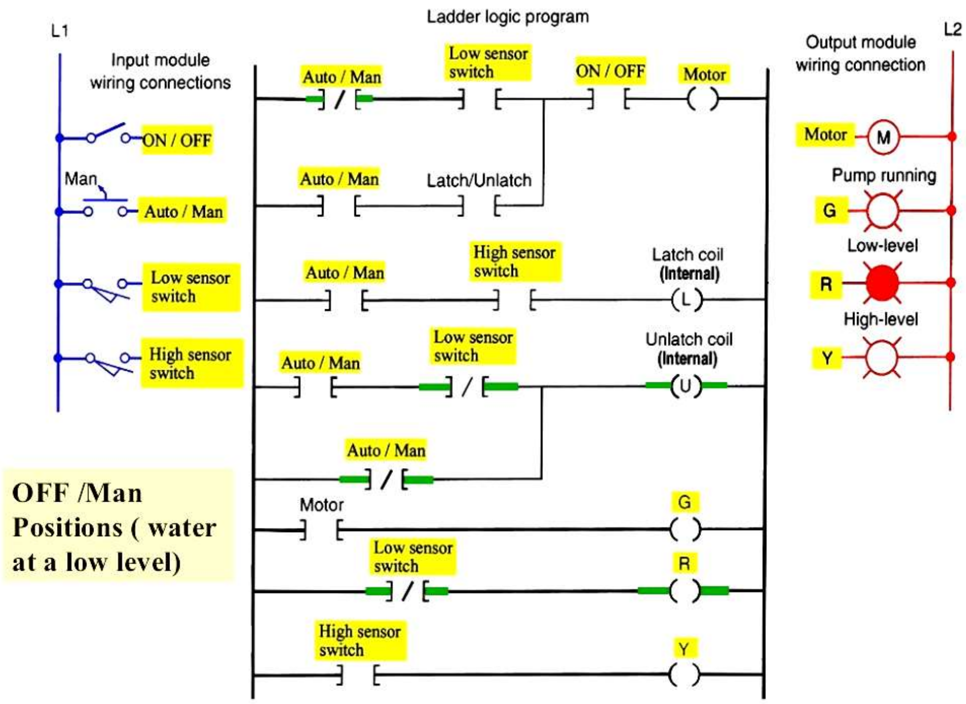


The PLC checks the signals send by these sensors through its input port and give the proper signals through its output port as per the ladder logic program. Sequence of process control actions done by the PLC:

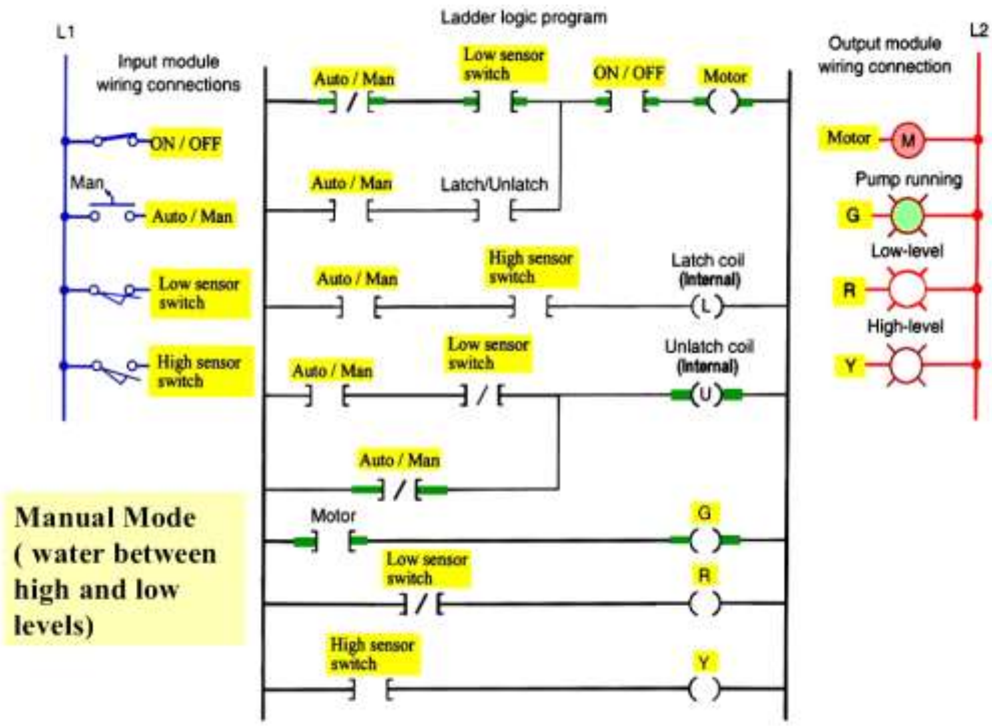
1. When the water level in the tank is less than the lower level then the lower level 15 sensor senses and turns the motor on to fill the tank.
2. Then the tank is filled up until it reaches the higher level where the higher level sensor senses and makes the motor off and filling of water stops.

PLC Ladder Logic :

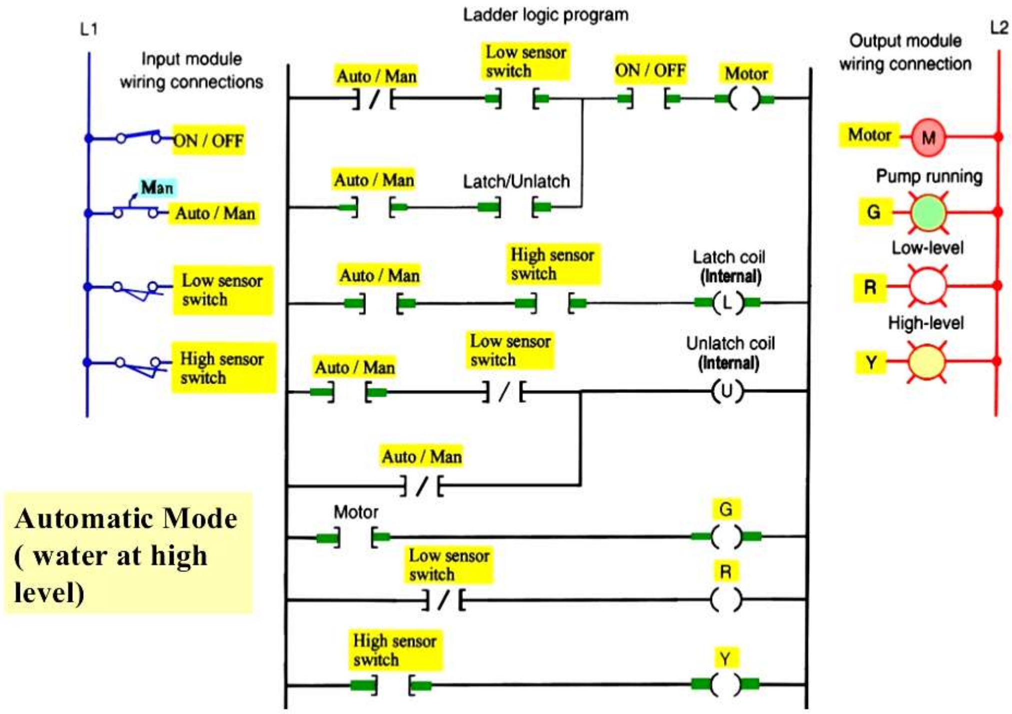
Manual Mode Selected, OFF Position and Water at Low Level



Manual Mode Selected & Water between Low & High Levels



Auto Mode Selected & High Level Switch Activated



LADDER LOGIC OPERATION:

- **Auto:** if Auto Mode selected in Local Control Panel, then pump will be logically controlled based on Low Level Switch and High Level Switch
- **Manual:** if Manual Mode Selected in Local Control Panel, then irrespective of Low Level Switch & High Level Switch Status, Pump will be controlled manually using ON/OFF button in Local Control Panel.
- When the water level reaches low level then pump will be stopped.
- If the level of the water reaches high point, the pump will started so that the water can be drained and thus lowering the level.
- Indication Panel: This panel contains LED's to show the status of the water level control. It has Pump Running, Low Level & High Level Signals
- If pump is running then the Pump Running status lamp will be ON.
- Then, if Low Level Switch activated then Low Level Status lamp will be ON.
- If High Level Switch activated then High Level Status lamp will be ON.

RESULT:

Thus the control of Level process by PLC programming is performed and the result is verified.

VIVA QUESTIONS

1.What is meant by level process?

2.Where mostly level process control is used in industry?

3.What are the importance of level process control in industry?

4.Summarize the working of level process control

5.How PLC is working for level control process in industry**?**

8. PILOT PLANT CONTROL USING PLC – BATCH PROCESS REACTOR

Aim:

To obtain the control of Pilot Plant – Batch Process Reactor by plc programming and to verify the result

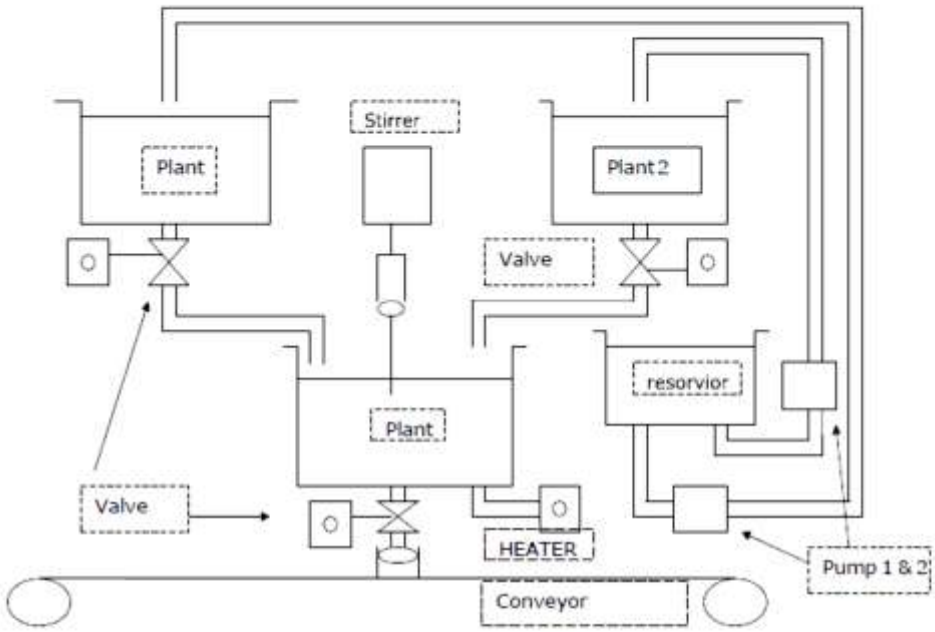
Apparatus required:

S. No.	Components / Equipments	Specification	Quantity
1.	Power Supply		1
2.	PLC		1
3.	Connecting Wires		Few
4.	Pump		1
5.	Batch Process Reactor		1

THEORY

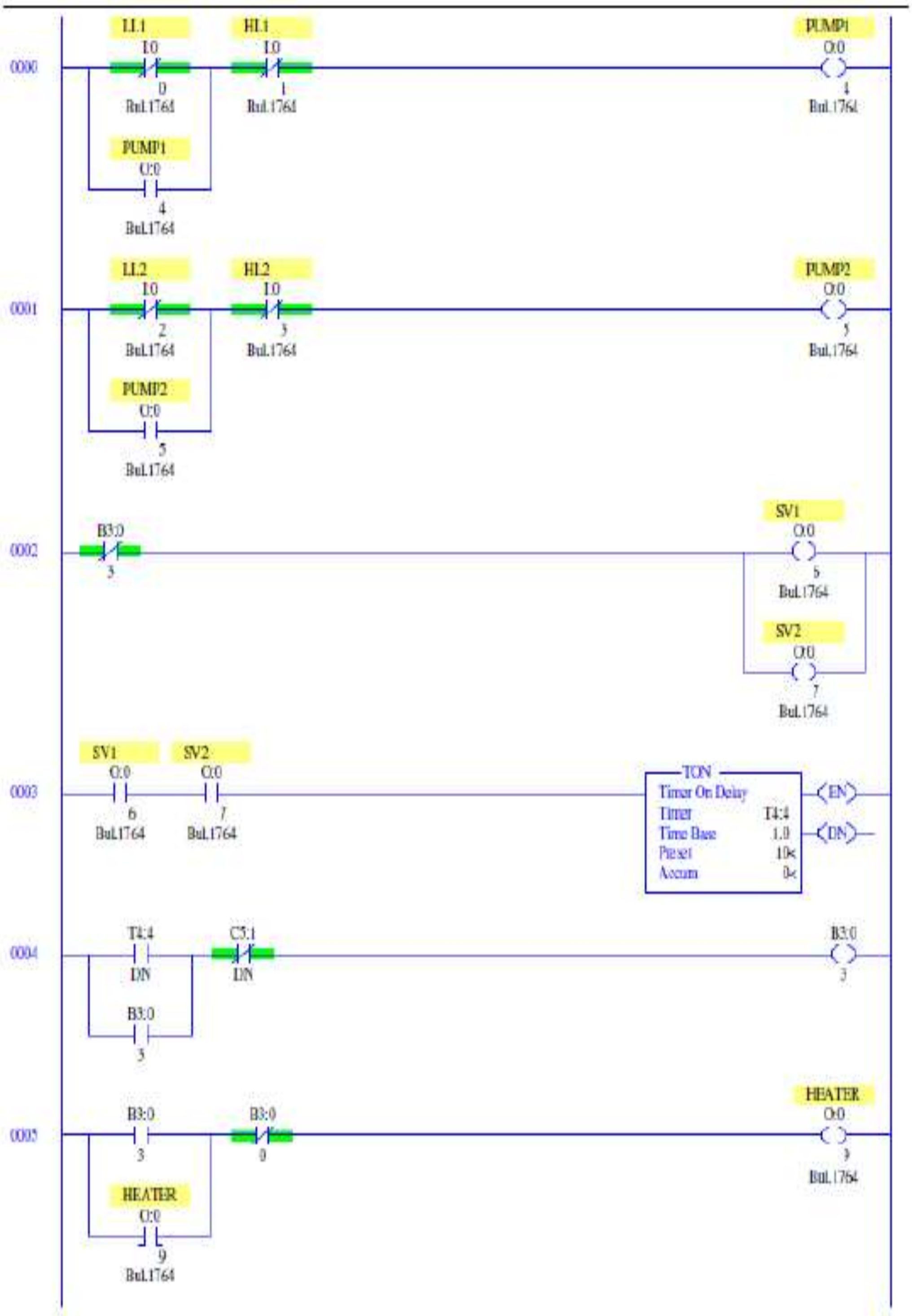
Batch process reactor is a blending process, where two liquids are mixed together to get the output mixture. The programmable logic controller is used to control the whole process. The process tanks 1 & 2 consist of two liquids, which are blended in process tank 3. The process tank 1 & 2 consists of a low liquid level sensor and a high liquid level sensor. The liquids are pumped to the process tanks using respective pumps.

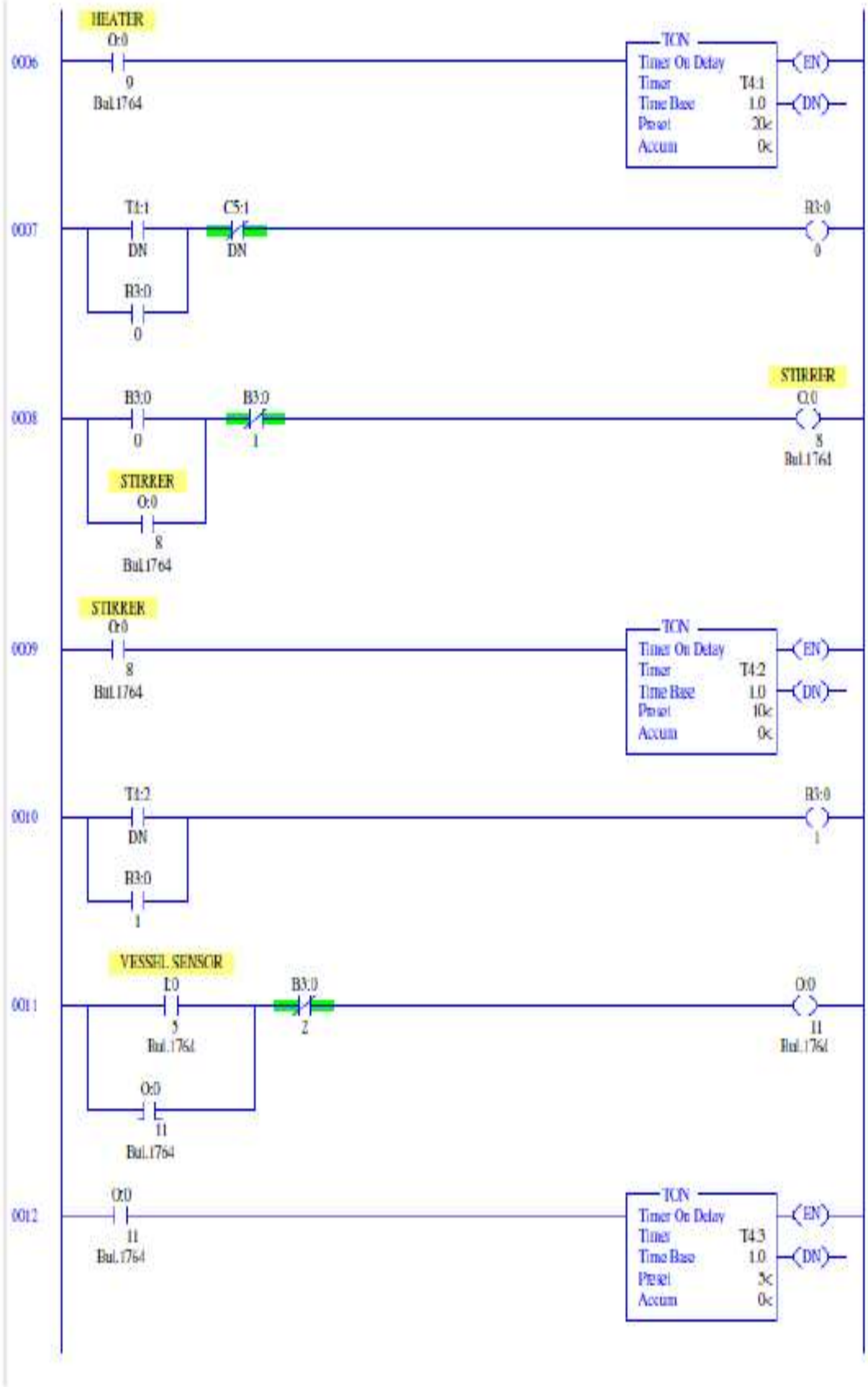
The two liquids are mixed in the process tank 3 using a stirrer. Heater is used to heat the mixture. The solenoid valves provide the liquids to the process tank 3 when the mixture level is low. Solenoid valve 3 is connected to the output of the process tank 3, which feeds mixed liquid to a vessel when it is sensed by the vessel proximity sensor. The container is fed through a conveyor belt run by stepper motor.



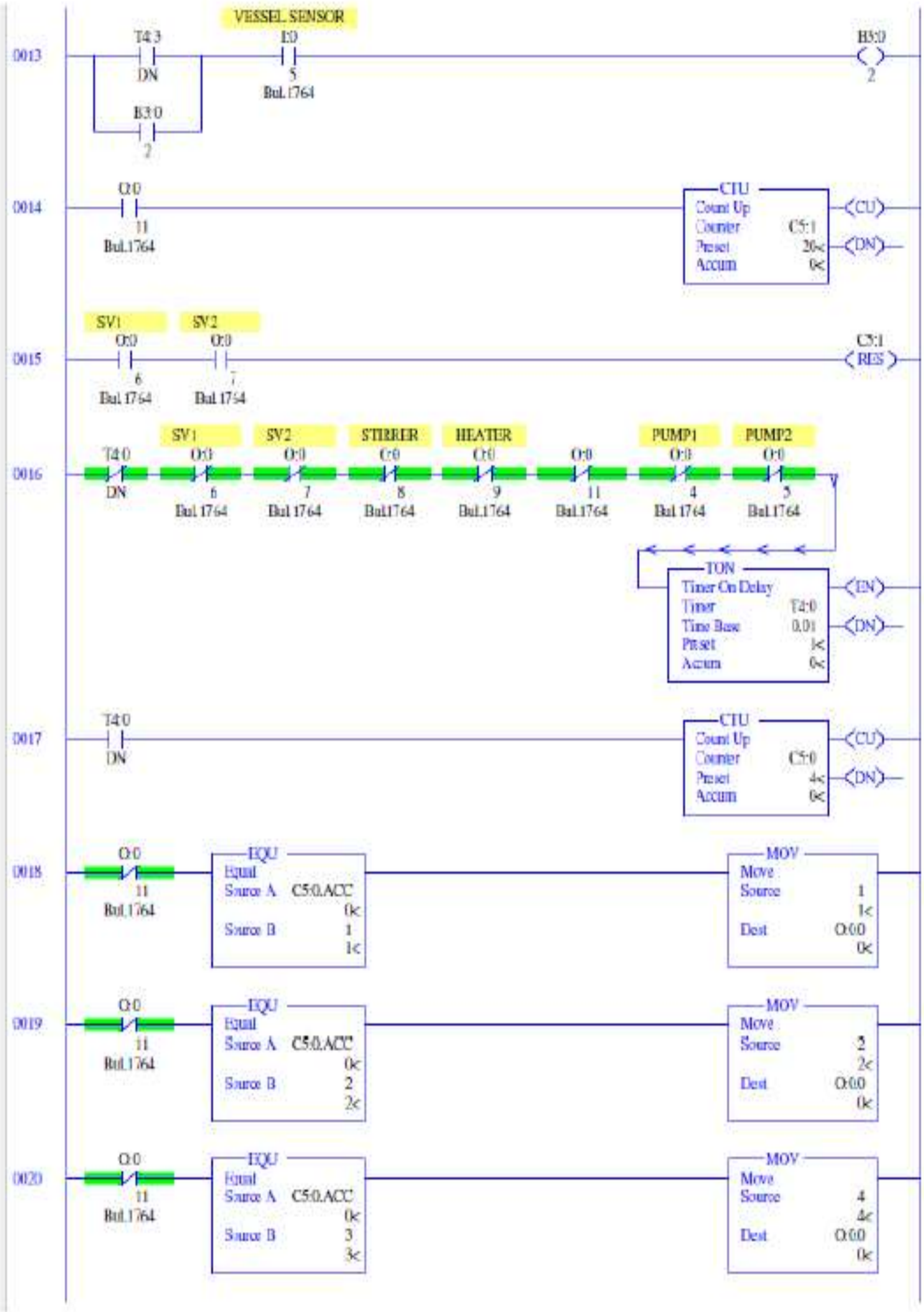
Two solenoid valves 1 & 2 control the flow of two liquids to the tank 4. The level sensors sense the level in the process tanks 1 and 2. The level sensor is a magnetic sensor and when the liquid level is above the high level sensor a HL (high level) signal is send to the PLC. When the liquid level goes down the low level sensor LL (low level) signal is send to the PLC. The PLC checks the signals send by these sensors through its input port and give the proper signals through its output port as per the ladder logic program.

PLC Ladder Logic :

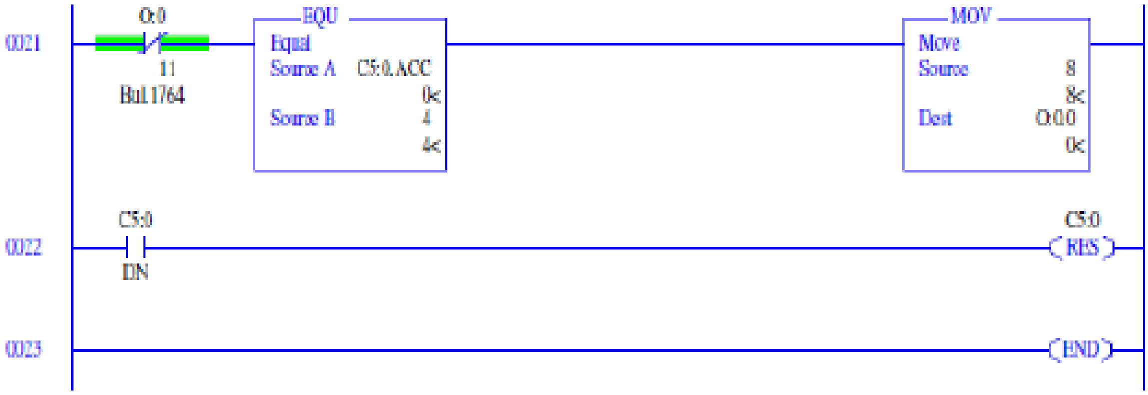




HEATER
O:0
0006
9
Bul.1764
TON
Timer On Delay
Timer T4:1
Time Base 1.0
Preset 20<
Accum 0<
EN
DN
T4:1
C5:1
B3:0
0007
DN
DN
0
B3:0
0
STIRRER
B3:0
B3:0
O:0
0008
0
1
8
Bul.1764
STIRRER
O:0
8
Bul.1764
STIRRER
O:0
0009
8
Bul.1764
TON
Timer On Delay
Timer T4:2
Time Base 1.0
Preset 10<
Accum 0<
EN
DN
T4:2
B3:0
0010
DN
1
B3:0
1
VESSEL SENSOR
I:0
B3:0
O:0
0011
5
Bul.1764
2
11
Bul.1764
O:0
11
Bul.1764
O:0
0012
11
Bul.1764
TON
Timer On Delay
Timer T4:3
Time Base 1.0
Preset 5<
Accum 0<
EN
DN



0013
T4:3
DN
B3:0
2
VESSEL SENSOR
I:0
5
Bul.1764
B3:0
2
0014
O:0
11
Bul.1764
CTU
Count Up
Counter C5:1
Preset 20<
Accum 0<
(CU)
(DN)
0015
SV1
O:0
6
Bul.1764
SV2
O:0
7
Bul.1764
C5:1
RES
0016
T4:0
DN
SV1
O:0
6
Bul.1764
SV2
O:0
7
Bul.1764
STIRRER
O:0
8
Bul.1764
HEATER
O:0
9
Bul.1764
O:0
11
Bul.1764
PUMP1
O:0
4
Bul.1764
PUMP2
O:0
5
Bul.1764
TON
Timer On Delay
Timer T4:0
Time Base 0.01
Preset 1<
Accum 0<
(EN)
(DN)
0017
T4:0
DN
CTU
Count Up
Counter C5:0
Preset 4<
Accum 0<
(CU)
(DN)
0018
O:0
11
Bul.1764
EQU
Equal
Source A C5:0.ACC
0<
Source B 1
1<
MOV
Move
Source 1
1<
Dest O:0.0
0<
0019
O:0
11
Bul.1764
EQU
Equal
Source A C5:0.ACC
0<
Source B 2
2<
MOV
Move
Source 2
2<
Dest O:0.0
0<
0020
O:0
11
Bul.1764
EQU
Equal
Source A C5:0.ACC
0<
Source B 3
3<
MOV
Move
Source 4
4<
Dest O:0.0
0<



LADDER LOGIC OPERATION:

1. When the low level sensor is sensed respective pump is on.
2. When the high level sensor is sensed respective pump is off
3. When both the tanks reached two higher level then the respective solenoids open and allows
   two liquids two mix in the 3rd one for 10 seconds.
4. Then the heater gets energized and heats the mixture for 10 seconds.
5. Then the stirrer gets on and stirring process continues for next 10 seconds.
6. A stepper motor is made ON to run the conveyor belt
7. When the proximity sensor senses a container, solenoid valve 3 is made on for a particular time as set in the program.
8. This process goes on for filling up of 20 bottles and then the total process starts from the beginning by filling up the two overhead tanks.

RESULT:

Thus the Batch process reactor was set up and controlled by using PLC ladder logic program and the result is verified.

VIVA QUESTIONS

1.What is meant by PILOT plant process?

2.Where mostly level PILOT plant process is used in industry?

3.What are the importance of PILOT plant process control in industry?

4.Summarize the working of level process control

5.What is meant by DCS?

9. PC BASED CONTROL OF FLOW PROCESS

Aim:

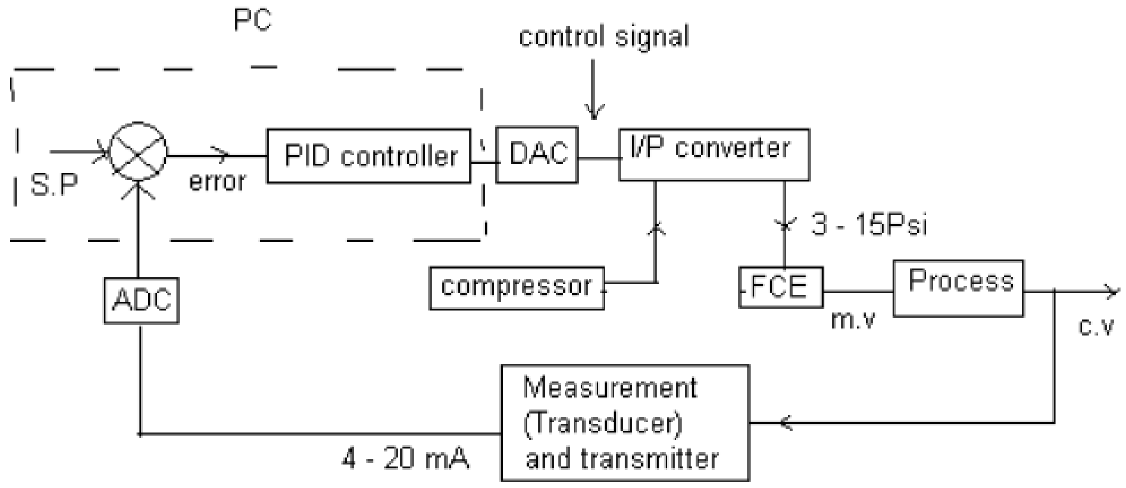
To obtain the control of Flow process using Programmable logic controller and to verify the result.

Apparatus required:

S. No.	Components / Equipments	Specification	Quantity
1.	Power Supply		1
2.	PLC		1
3.	Connecting Wires		Few
4.	Pump		1
5.	Flow process		1

THEORY

The flow transmitter used here is DPT. It comes under Head type flow meter, where an Orifice is placed in the pipe line. Change in Flow causes change in differential pressure across orifice, which is picked up and converted into electric signal (current) and standardized to 4- 20mA.



On-Off control:

ON-Off control also referred as „Two-position‟ control and „Open and close‟ control in which the manipulated variable is quickly changed to either maximum or minimum value depending upon whether the controlled variable is greater than or less than set-point. If the controlled variable is below set-point the controller output is 100% and if the controlled variable is more than set-point the controller output is 0% considering „0‟ differential gap. If differential gap is introduced, then the controller output is generated only when the controlled variable crosses above or below differential gap. Differential gap is defined as „A small range of values through which the controlied variable must pass in order to move the FCE to both its extreme positions‟. Here in this experiment „the number of LPH change necessary to go from On to OFF

or vice-versa of FCE‟
This type of control applied to a process results in continuous oscillation of controlled variable and it never reaches steady value.

Proportional control:
To overcome the above problem Proportional control is used which is also called Throttling or Gradual or Modulating control action. This is defined as controlled action in which there is a continuous linear relation between value of controlled variable and position of
the final control element with in proportional band.

Tuning parameters are;
1. Proportional Band
2. Proportional Gain
3. Time delay

Proportional Band: The percentage deviation in measured variable corresponding to 100% deviation in FCE.

The disadvantage of this mode is sustained deviation from set-point which is called OFFSET.

Proportional Integral control:
Integral control or reset control combined with proportional control gives a controller action which always acts to maintain the controlled variable at set-point. The proportional control mode provides stabilizing influence while integral mode will help to overcome Offset. Integral controller provides corrective action as long as there is deviation in controlled variable form set-point. Integral control has a phase lag of 90º over proportional control and this lagging feature will result in slow response. The combination is most popular on applications of flow and pressure controls.
Proportional Derivative control:
Derivative control or Rate control combined with Proportional control provides a good control on processes having lags, since lags are compensated by anticipatory nature of derivative control or it provides the necessary boostto counter act the time delay associated. This is due to the fact that derivative control leads the proportional control by 90º. Hence this control is used on most multicapacity process applications.

Where the process lag is short, this combination could not be used. This controller combination does not eliminate Offset after sustained load disturbance because of narrow proportional band. This control properly tuned can act to prevent controlled variable from deviating excessively and reduces the time required to stabilize.

Proportional Integral Derivative control:
When all the three control effects are combined together, we obtain the benefits of each control action and moreover the effect duplicates the action of a good human operator. Three mode controller contains stability of proportional control and ability to eliminate Offset, because of reset control and ability to provide an „immediate correction‟ (anticipatory control) for a disturbance because of rate control.

Procedure:
1. Make the connections as per circuit diagram.

2. Make the pneumatic connections.
3. Ensure that the PCS cable is connected between PC and Analyser.
4. See that HV1 & HV3 are fully opened, HV4 & HV5 are fully closed and HV2 is partially opened.
5. Adjust the air supply output of Pressure regulator to 20PSI which acts as input to I/P converter.
6. Switch ON the mains supply of the process.
7. Invoke process control software on the PC and press any of the control action by using "Control" menu.
8. Place the control mode in „On-Off" mode.
9. In settings / parameters" menu set set-point & Differential gap. Observe the response.
10. View the response by changing set-point and differential gap.
16. Change the control mode to „Proportional" and observe the response.
17. Also change control modes to PI, PD and PID observe the responses. Also observe responses by change of settings.

Tabulate the values of Process Variable (Controlled variable) for specific periods of time

RESULT:

Thus the control of Flow process by Programmable logic controller is performed and the result is verified.

VIVA QUESTIONS

1.What is meant by Flow process?

2.Where mostly flow process control is used in industry?

3.What are the importance of flow process control in industry?

4.Summarize the working of flow process control

5.How PLC is working for flow control process in industry**?**

10. STUDY OF FOUNDATION FIELD BUS / IOT /WIRELESS HART ENABLED TRANSMITTER

Aim :

To study about the foundation of Field bus /IOT /Wireless Hart Enabled Transmitter

FOUNDATION FIELD BUS

In analog controls systems, instruments produce a 4-20mA output signal that travels all the way from the remote field areas to the control room through marshalling rack, remote I/O cards or RTU over twisted pair cables.

Similarly, 4-20mA control signals travel from the control system to valve actuators, pumps and other control devices. Hundreds, sometimes thousands, of cables layed through cable trays, termination racks, cabinets, enclosures and conduit (Figure 1).

Figure 1. Traditional 4-20mA field wiring often results in a rat's nest of wires, cables and terminations.

Figure 2. A fieldbus installation substantially simplifies wiring.

The availability of low cost, powerful processors suitable for field instrumentation now opens the way to remove the bulk of these cables and, at the same time, enhance data available from the plant. Instead of running individual cables, fieldbus allows multiple instruments to use a single cable, called a "trunk" or a "segment," (Figure 2); each instrument connects to the cable as a "drop." Instruments, of course, must have a fieldbus interface to connect to the segment, and some sort of software running to provide the fieldbus communications.

A fieldbus trunk or segment—either FOUNDATION fieldbus H1 or PROFIBUS PA—is a single twisted pair wire carrying both a digital signal and DC power that connects up to 32 fieldbus devices (temperature, flow, level and pressure transmitters, smart valves, actuators, etc.) to a DCS or similar control system. Most devices are two-wire bus-powered units requiring 10 to 20mA, but it is also possible to have 4-wire fieldbus devices, typically where a device has a particularly high current draw.

The fieldbus segment begins at an interface device at the control system. On a FOUNDATION fieldbus H1 (FF) system, the interface is called an H1 card; on a PROFIBUS PA system (PA), it is a PROFIBUS DP/PA segment coupler. In terms of signal wiring and power requirements for the segment, FF and PA are identical:

Minimum device operating voltage of 9V

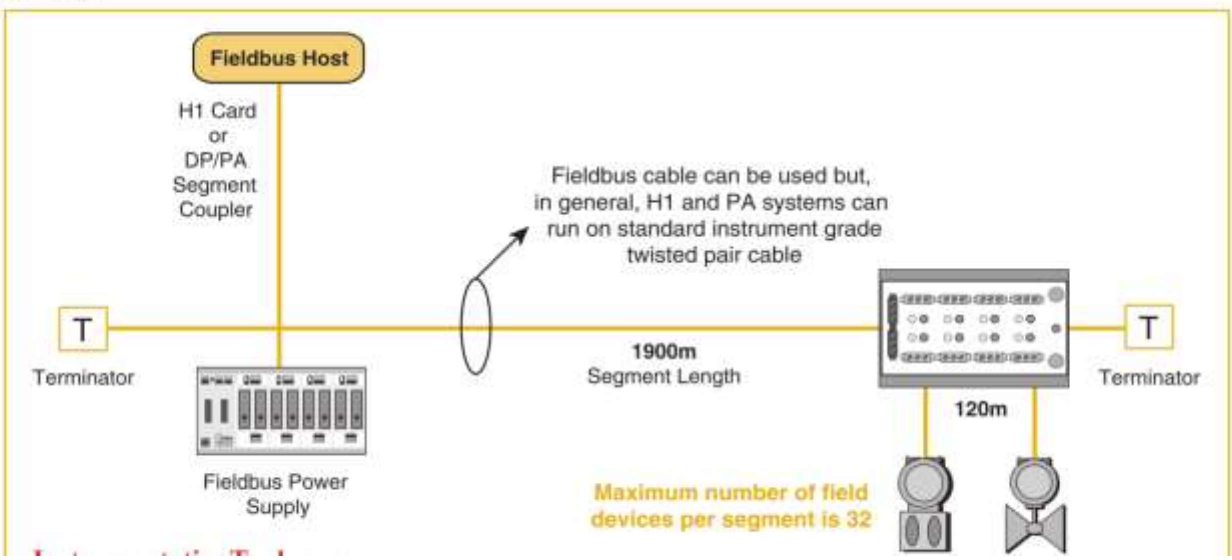
Maximum bus voltage of 32V

Maximum cable length of 1900m (shielded twisted pair)

The DC power required by the bus is normally sourced through a fieldbus power supply or "power conditioner" which prevents the high frequency communications signal from being shorted out by the DC voltage regulators.

Typical power conditioners make 350 to 500mA available on the bus and usually incorporate isolation to prevent segment-to-segment cross talk. For PA, the "segment coupler" usually incorporates the power conditioning component.
In FF segments, the power conditioners are separate from the H1 interface card and are often installed in redundant pairs to improve the overall reliability. Figure 3 shows a typical fieldbus segment.
When calculating how many devices can fit on a fieldbus segment, a user must take into account the maximum current requirement of each device, the length of the segment (because of voltage drops along the cable), and other factors.
The calculation is a simple Ohm's law problem, with the aim of showing that at least 9V can be delivered at the farthest end of the segment, after taking into account all the voltage drops from the total segment current.
For example, driving 16 devices at 20mA each requires 320mA, so if the segment is based on 18AWG cable (50 Ohms/km/loop) with a 25V power conditioner, the maximum cable length is 1000m to guarantee 9V at the end.
Note that many users also specify a safety margin on top of the 9V minimum operating voltage, to allow for unexpected current loads and adding additional devices in the future.

Figure 3. A fieldbus segment starts with an H1 interface card and a power supply for FOUNDATION fieldbus or a segment coupler for PROFIBUS. Up to 32 devices can be supported on a single segment. The boxes with a "T" in them indicate the location of the segment terminators.



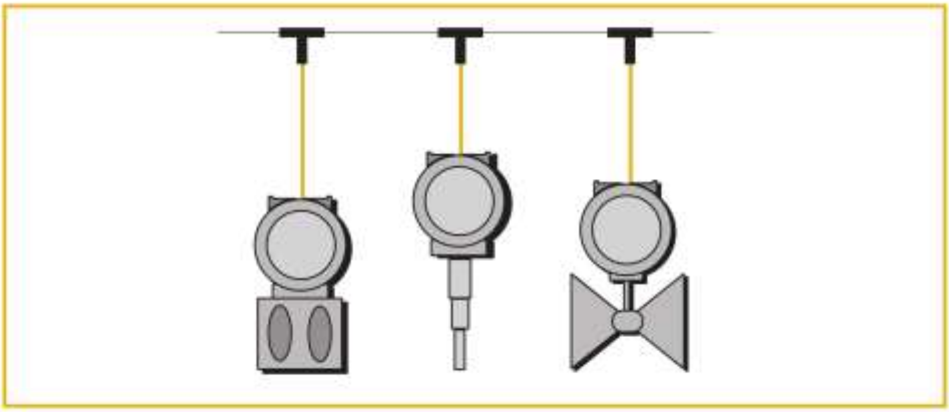
Connecting Instruments

As noted, each fieldbus device connects to the segment in parallel, via a "drop" on the fieldbus segment called a spur. The simplest spur connection is a "T." The problem with simple "T" connections (Figure 4), is that if any one of the devices or cables short out, it takes down the entire segment.

A short can occur during field maintenance of an instrument, from an accident in the field, corrosion causing electrical problems, or a host of other possibilities. Short-circuit protection is therefore a requirement for proper fieldbus implementation.

Another way to connect fieldbus devices is via junction boxes specifically designed for fieldbus, often referred to as "device couplers".

Figure 4. *"T" configurations are the simplest fieldbus connection. However, if one device fails or short-circuits, it "takes down" the entire segment.*



When a short circuit deprives other instruments of power, some may "drop off" the segment because they do not have enough power to operate properly.

Consequently, when current limiting protection is used in a device coupler, many end users allow a safety margin. That is, they do not install as many instruments as the segment can theoretically power; instead, they leave a certain number of spurs empty.

For example, if a user wants the segment to be able to keep working with two failures—which can draw up to 120mA of current—the segment calculations must assume a maximum current availability of 350mA minus 120mA for the faults, or 230mA.

Instead of theoretically being able to power 32 devices that draw 10mA each, the segment is now only able to support 23 such devices. In practice, some users are wary of relying on current limiting couplers, and most limit each segment to only 16 devices to prevent large-scale segment failures.

Advantages of Fieldbus Communication

Fieldbus was initially justified by the considerable cost savings that resulted from using less wiring. Instead of running hundreds or thousands of wires, fieldbus often required only a few dozen segments or trunks.

In recent years, the savings from running cables has been offset by the high cost of fieldbus components, and the reluctance of many users to install all the instruments possible on a segment. Being forced to provide for short circuits, for example, limits the number of instruments

that can be put on a segment. In many cases, it's a toss- up, from a hardware cost and labor perspective. In other cases, when the full capability of a segment can be used, hardware cost savings become more realistic.

The true advantage of fieldbus is its ability to diagnose equipment problems, cut maintenance costs, provide information for asset management, allow control at the device level, and allow the use of smart devices. One oil company in Alaska did a study of savings it found by using a FOUNDATION fieldbus system. The savings included:

Wiring — They achieved a 98% reduction in home- run wiring because with fieldbus they could eliminate the costly maze of wiring between each remote field instrument and the control room. Terminations were also reduced by 84%.

Control room — Fewer terminations also freed up two-thirds of the cabinet space that would be required with traditional technology.

Commissioning — Field check-out and QA/AC time was reduced by 83%. Installation of each transmitter took only 20 minutes rather than the two hours needed with non-fieldbus technology.

Engineering drawings — Reduced the effort required for new drawings when adding oil wells by 92% because of FOUNDATION fieldbus and the host system's configuration tools and object- oriented capabilities.

The oil and gas industry was the first to fully embrace fieldbus, and now installs it at many new refineries, offshore platforms and other facilities.

IOT

IoT (Internet of Things) is an advanced automation and analytics system which exploits networking, sensing, big data, and artificial intelligence technology to deliver complete systems for a product or service. These systems allow greater transparency, control, and performance when applied to any industry or system.

IoT systems have applications across industries through their unique flexibility and ability to be suitable in any environment. They enhance data collection, automation, operations, and much more through smart devices and powerful enabling technology.

This tutorial aims to provide you with a thorough introduction to IoT. It introduces the key concepts of IoT, necessary in using and deploying IoT systems.

IoT systems allow users to achieve deeper automation, analysis, and integration within a system. They improve the reach of these areas and their accuracy. IoT utilizes existing and emerging technology for sensing, networking, and robotics.

IoT exploits recent advances in software, falling hardware prices, and modern attitudes towards technology. Its new and advanced elements bring major changes in the delivery of products, goods, and services; and the social, economic, and political impact of those changes.

IoT − Key Features

The most important features of IoT include artificial intelligence, connectivity, sensors, active engagement, and small device use. A brief review of these features is given below −

AI − IoT essentially makes virtually anything "smart", meaning it enhances every aspect of life with the power of data collection, artificial intelligence algorithms, and networks. This can mean something as simple as enhancing your refrigerator and cabinets to detect when milk and your favorite cereal run low, and to then place an order with your preferred grocer.

Connectivity − New enabling technologies for networking, and specifically IoT networking, mean networks are no longer exclusively tied to major providers. Networks can exist on a much smaller and cheaper scale while still being practical. IoT creates these small networks between its system devices.

Sensors − IoT loses its distinction without sensors. They act as defining instruments which transform IoT from a standard passive network of devices into an active system capable of real-world integration.

Active Engagement − Much of today's interaction with connected technology happens through passive engagement. IoT introduces a new paradigm for active content, product, or service engagement.

Small Devices − Devices, as predicted, have become smaller, cheaper, and more powerful over time. IoT exploits purpose-built small devices to deliver its precision, scalability, and versatility.

IoT − Advantages

The advantages of IoT span across every area of lifestyle and business. Here is a list of some of the advantages that IoT has to offer −

Improved Customer Engagement − Current analytics suffer from blind-spots and significant flaws in accuracy; and as noted, engagement remains passive. IoT completely transforms this to achieve richer and more effective engagement with audiences.

Technology Optimization − The same technologies and data which improve the customer experience also improve device use, and aid in more potent improvements to technology. IoT unlocks a world of critical functional and field data.

Reduced Waste − IoT makes areas of improvement clear. Current analytics give us superficial insight, but IoT provides real-world information leading to more effective management of resources.

Enhanced Data Collection − Modern data collection suffers from its limitations and its design for passive use. IoT breaks it out of those spaces, and places it exactly where humans really want to go to analyze our world. It allows an accurate picture of everything.

IoT − Disadvantages

Though IoT delivers an impressive set of benefits, it also presents a significant set of challenges. Here is a list of some its major issues −

Security − IoT creates an ecosystem of constantly connected devices communicating over networks. The system offers little control despite any security measures. This leaves users exposed to various kinds of attackers.

Privacy − The sophistication of IoT provides substantial personal data in extreme detail without the user's active participation.

Complexity − Some find IoT systems complicated in terms of design, deployment, and maintenance given their use of multiple technologies and a large set of new enabling technologies.

Flexibility − Many are concerned about the flexibility of an IoT system to integrate easily with another. They worry about finding themselves with several conflicting or locked systems.

Compliance − IoT, like any other technology in the realm of business, must comply with regulations. Its complexity makes the issue of compliance seem incredibly challenging when many consider standard software compliance a battle.

Internet of Things - Hardware

The hardware utilized in IoT systems includes devices for a remote dashboard, devices for control, servers, a routing or bridge device, and sensors. These devices manage key tasks and functions such as system activation, action specifications, security, communication, and detection to support-specific goals and actions.

IoT − Sensors

The most important hardware in IoT might be its sensors. These devices consist of energy modules, power management modules, RF modules, and sensing modules. RF modules manage communications through their signal processing, WiFi, ZigBee, Bluetooth, radio transceiver, duplexer, and BAW.

The sensing module manages sensing through assorted active and passive measurement devices.

Standard Devices

The desktop, tablet, and cellphone remain integral parts of IoT as the command center and remotes.

The desktop provides the user with the highest level of control over the system and its settings.

The tablet provides access to the key features of the system in a way resembling the desktop, and also acts as a remote.

The cellphone allows some essential settings modification and also provides remote functionality.

Other key connected devices include standard network devices like routers and switches.

Internet of Things - Software

IoT software addresses its key areas of networking and action through platforms, embedded systems, partner systems, and middleware. These individual and master applications are responsible for data collection, device integration, real-time analytics, and application and process extension within the IoT network. They exploit integration with critical business systems (e.g., ordering systems, robotics, scheduling, and more) in the execution of related tasks.

Data Collection

This software manages sensing, measurements, light data filtering, light data security, and aggregation of data. It uses certain protocols to aid sensors in connecting with real-time, machine-to-machine networks. Then it collects data from multiple devices and distributes it in accordance with settings. It also works in reverse by distributing data over devices. The system eventually transmits all collected data to a central server.

Device Integration

Software supporting integration binds (dependent relationships) all system devices to create the body of the IoT system. It ensures the necessary cooperation and stable networking between devices. These applications are the defining software technology of the IoT network because without them, it is not an IoT system. They manage the various applications, protocols, and limitations of each device to allow communication.

Real-Time Analytics

These applications take data or input from various devices and convert it into viable actions or clear patterns for human analysis. They analyze information based on various settings and designs in order to perform automation-related tasks or provide the data required by industry.

Application and Process Extension

These applications extend the reach of existing systems and software to allow a wider, more effective system. They integrate predefined devices for specific purposes such as allowing certain mobile devices or engineering instruments access. It supports improved productivity and more accurate data collection.

Internet of Things - Technology and Protocols

IoT primarily exploits standard protocols and networking technologies. However, the major enabling technologies and protocols of IoT are RFID, NFC, low-energy Bluetooth, low-energy wireless, low-energy radio protocols, LTE-A, and WiFi-Direct. These technologies support the specific networking functionality needed in an IoT system in contrast to a standard uniform network of common systems.

NFC and RFID

RFID (radio-frequency identification) and NFC (near-field communication) provide simple, lowenergy, and versatile options for identity and access tokens, connection bootstrapping, and payments.

RFID technology employs 2-way radio transmitter-receivers to identify and track tags associated with objects.

NFC consists of communication protocols for electronic devices, typically a mobile device and a standard device.

Low-Energy Bluetooth

This technology supports the low-power, long-use need of IoT function while exploiting a standard technology with native support across systems.

Low-Energy Wireless

This technology replaces the most power hungry aspect of an IoT system. Though sensors and other elements can power down over long periods, communication links (i.e., wireless) must remain in listening mode. Low-energy wireless not only reduces consumption, but also extends the life of the device through less use.

Radio Protocols

ZigBee, Z-Wave, and Thread are radio protocols for creating low-rate private area networks. These technologies are low-power, but offer high throughput unlike many similar options. This increases the power of small local device networks without the typical costs.

LTE-A

LTE-A, or LTE Advanced, delivers an important upgrade to LTE technology by increasing not only its coverage, but also reducing its latency and raising its throughput. It gives IoT a tremendous power through expanding its range, with its most significant applications being vehicle, UAV, and similar communication.

WiFi-Direct

WiFi-Direct eliminates the need for an access point. It allows P2P (peer-to-peer) connections with the speed of WiFi, but with lower latency. WiFi-Direct eliminates an element of a network that often bogs it down, and it does not compromise on speed or throughput.

Internet of Things - Common Uses

Engineering, Industry, and Infrastructure

Applications of IoT in these areas include improving production, marketing, service delivery, and safety. IoT provides a strong means of monitoring various processes; and real transparency creates greater visibility for improvement opportunities.

The deep level of control afforded by IoT allows rapid and more action on those opportunities, which include events like obvious customer needs, nonconforming product, malfunctions in equipment, problems in the distribution network, and more.

Government and Safety

IoT applied to government and safety allows improved law enforcement, defense, city planning, and economic management. The technology fills in the current gaps, corrects many current flaws, and expands the reach of these efforts. For example, IoT can help city planners have a clearer view of the impact of their design, and governments have a better idea of the local economy.

Home and Office

In our daily lives, IoT provides a personalized experience from the home to the office to the organizations we frequently do business with. This improves our overall satisfaction, enhances productivity, and improves our health and safety. For example, IoT can help us customize our office space to optimize our work.

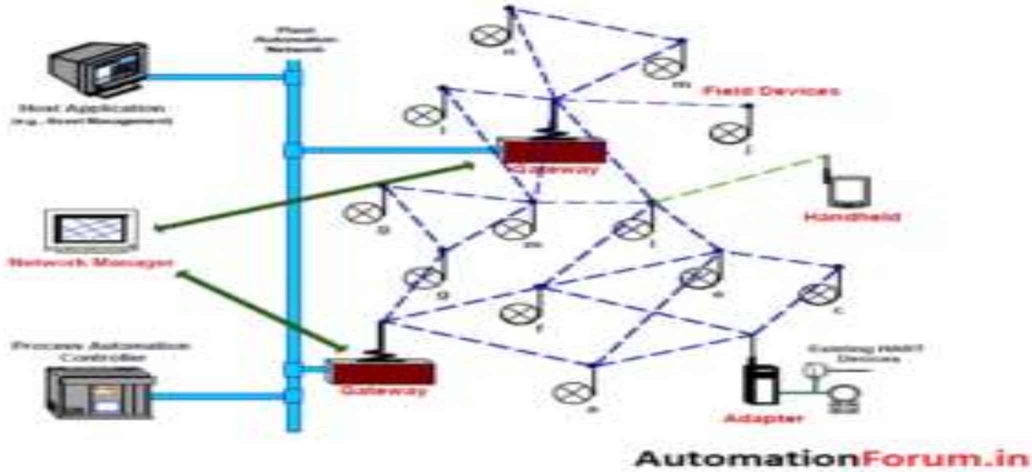
Health and Medicine

IoT pushes us towards our imagined future of medicine which exploits a highly integrated network of sophisticated medical devices. Today, IoT can dramatically enhance medical research, devices, care, and emergency care. The integration of all elements provides more accuracy, more attention to detail, faster reactions to events, and constant improvement while reducing the typical overhead of medical research and organizations.

Wireless HART™

The WirelessHART™ standard provides a robust wireless protocol for the full range of process measurement, control, and asset management applications. It adds wireless capabilities to the HART Protocol while maintaining compatibility with existing HART devices, commands, and tools.

WirelessHART is a subset of the HART industrial instrument communication standard as of version 7, communicating process data over 2.4 GHz radio waves. WirelessHART is a wireless mesh network communications protocol for process automation applications.



Each individual instrument in the HART wireless connection is connected through a mesh network. Each individual instrument is connected to a common input and adjustment instruments. If an instrument is far from the gateway or the route is blocked, it can not connect to the gateway. Although you can communicate with the gateway through other instruments. Therefore, each device in the mesh network can serve as a router for messages from other devices.

The purpose of a mesh network is to provide redundant data pathways in case of device failure or changes in the environment interrupting radio communication between devices.

A network administrator responsible for configuring the network, scheduling communications between devices, managing message routes, and monitoring the state of the network. Network Manager can be integrated into the gateway, the host application or the process automation controller.

This extends the reach of the network and provides redundant communication paths to increase reliability. Network Manager determines redundant routes based on latency, efficiency and reliability. To ensure that redundant routes remain open and unobstructed.

WirelessHART protocol:

Physical Layer:

2.4 GHz to 2.5 GHz (“ISM” – Industrial, Scientific, Medical) signal band

O-QPSK modulation (offset quadrature phase-shift keying)

250 kbps data rate

Direct-sequence spread-spectrum (DSSS) with frequency-hopping between 15 channels within that band for security and interference reduction

TDMA (Time-Division Multiple Access) bus arbitration, with 10-millisecond timeslots allocated for device transmission

Variable transmit power, with 10 dBm (10 milliwatts) being default

Data Link Layer:

Network ID number uniquely identifies each WirelessHART network, allowing multiple networks to overlap the same physical area
Channel “blacklisting” – automatically avoids hopping to noisy channels
Network Layer:
“Mesh” networking
Signal repeating – devices may act as “repeaters” for other devices too far away from the master unit
A Network Manager device determines communication routes between field devices, as well as timing schedules
Four levels of data message priority (listed from highest to lowest): Command, Process data, Normal (all messages other than command), Alarm.
Application layer:
128-bit encryption of data
Backward-compatibility with a wired-HART command structure and DDL (Device Description Language)

Result:
Thus study about the foundation of Field bus /IOT /Wireless Hart Enabled Transmitter was done.

VIVA QUESTIONS

1.What is meant by Field bus

2.Expand IOT and give its advantages.

3.Summarize the working of HART enabled transmitter.

4.What are the advantages of wireless HART transmitter.

5.What is the range of current in a field bus ?

ADDITIONAL EXPERIMENT

Speed control of AC servo motor using PLC

Aim:

To control the speed of an AC servomotor by implementing pi controller using PLC ladder
logic program.

Apparatus required:

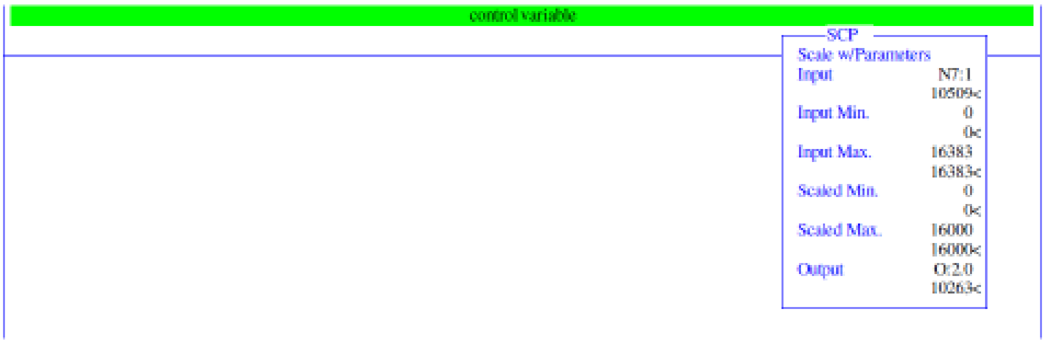
1. AC servomotor kit
2. PLC (Allen Bradley Micrologix 1500 LRP series C)
3. PC with RXlogix Software
4. RS232 cable
5. Patch chords

Procedure:

1. Load the RXlogix software to the PC
2. Open the RXlogix software
3. Switch on the PLC trainer and lift controls system
4. Connect PLC with AC servomotor kit.
5. Open the New folder and draw the ladder logic program
6. Select the correct hardware configuration.
7. Store the Program to PLC
8. Run the program
9. Verify the performance to the control AC servomotor.

Description:

Applying different voltages can control speed of the AC servomotor. For this purpose AC voltage controller has been used. Accordingly triggering angle control for this circuit has accomplished by plc ladder logic program. For measurement of speed an optocoupler is used in conjunction with a square geared wheel connected to the shaft of the motor. The optocoupler measures speed of motor by noting the number of tooth that it encountered in a fixed time. The optocoupler output is given to the analog input port of plc kit. Then control algorithm will compare this value with the default set point value, which give an error signal. This error signal is used in manipulating the firing angle of thyristor circuit to control applied voltage to the servomotor. Ladder logic program also facilitates the user to tune the controller parameters to change the performance of the controller and to set the desired speed value.



Result:

Thus the control the speed of an AC servomotor by implementing pi controller using PLC ladder logic programis done and the result is verified.