Jawahar Education Societys Annasaheb Chudaman Patil College of Engineering, Kharghar, Navi Mumbai

EXPERMINT: 07

● **Title**: Programmable Logical Controller application of IIoT.

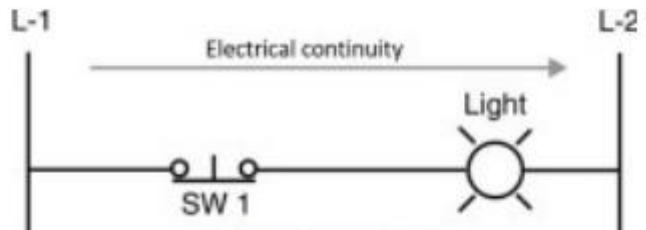
● **Aim:** To study PLC basics, programming elements and their operation for Ladder Diagram in IIoT.

●**Theory:**

1) Introduction to Logic: A hardwired control circuit can be represented by conventional hardwired relay ladder diagram. In any hardwired circuit, there should be electrical continuity in order for the load to energize.

1.1) Basics about conventional ladder and PLC ladder logic:

Electrical sequence of operation in hardwired relay circuits can be represented by electrical ladder diagram. Ladder diagram shows the interconnection of field devices. In the ladder diagram, each rung shows how a field device is turned on and also shows how it interacts with next field devices. The difference between a PLC ladder program and relay ladder rungs is the continuity. In an electrical rung diagram, there is an electrical continuity only when the current flows from left power rail to right power rail.

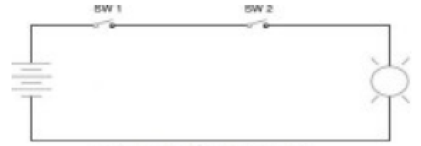


Hardwired relay circuit
Fig(a)

Fig (a), shows electrical continuity when SW 1 is closed, as the current flows from L-1 to L-2 energizing the load. Even though PLC ladder logic was modelled after the conventional relay ladder, there is no electrical continuity in PLC ladder logic. PLC ladder rungs should have logical continuity in order for the output to energize. PLC ladder program uses familiar terms like "rungs" and "normally open" and "normally closed" contacts, but the relay ladder logic has no electrical continuity between an input and the controlled output. Each rung in a ladder diagram is a program statement. This program statement consists of a condition or sometimes conditions, along with some type of action. Inputs are the conditions, and the action, or output, is the result of the conditions.

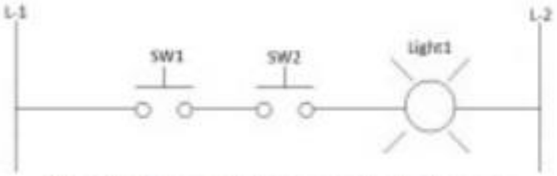
As in case of physical wiring hardware devices connected in series or parallel, PLC also combines ladder program instructions in series or parallel. However, rather than working in series or parallel, the PLC combines instructions logically using logic operators. Logical operations performed by PLC are nothing but fundamental logic operation, using fundamental logic operators like: AND, OR, and NOT. These operators are used to combine the instructions on a PLC rung so as to make the outcome of each rung either true or false.

a) The AND-logic function:



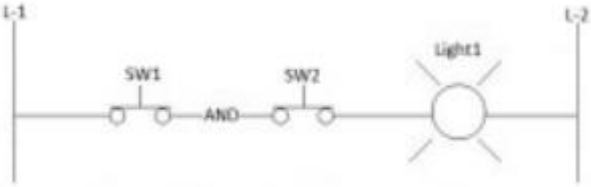
Conventional Series Circuit
Fig(b)

The series circuit of 2 switches can be looked as an AND logic function. In fig (b) and fig (c), both switch1 and switch2, must be closed to have electrical continuity. When there is electrical continuity, output (light1) will energize. Hence the keyword here is AND



Series circuit represented as a conventional ladder rung
Fig(c)

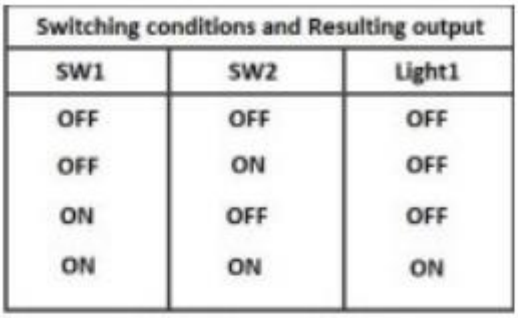
The circuit in fig (b) is represented as a schematic diagram ladder rung in fig (c). When the switch1 and switch2 is closed, electrical continuity is established to L-2. This is shown in fig (d).



Switch1 AND Switch2 need to be closed to energize Light-1
Fig(d)

The various possible switch combinations are shown in the truth table below.

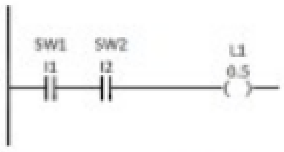
Table 1: Truth table for AND logic



Switching conditions and Resulting output		
SW1	SW2	Light1
OFF	OFF	OFF
OFF	ON	OFF
ON	OFF	OFF
ON	ON	ON

Truth table for AND logic
Fig(e)

Fig (d) can be written in PLC ladder format as shown in the figure below

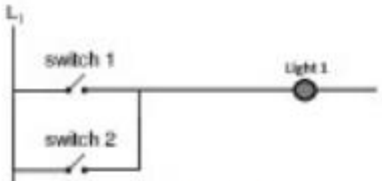


PLC representation of the rung
Fig(f)

Here is the program listing for a typical PLC, if you are entering the program with a handheld programmer. LOAD I1 AND I2 OUT O5 The above instruction tell the processor to load input 1 (I1) into memory, AND it with input 2 (I2) and then output the result to output 5 (O5). The resulting output will be based on the truth table fig (e).

b) The OR-logic function:

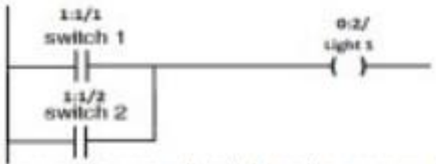
In an OR - LOGIC function, the output is true if any input is true. The OR logic also states that if all inputs are true, the output will be true.



Conventional parallel circuit where switch1 or switch2 can energize the load,light1
Fig(g)

In the above figure, if switch1 OR switch2 is energized then light1 will energize. Also, if both SW 1 and SW2 are true, the output will also be true.

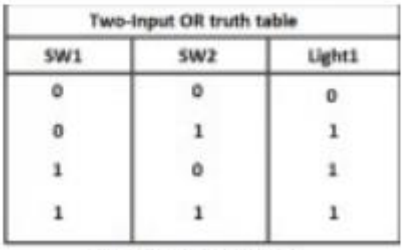
Fig (g) is converted to PLC ladder rung and it looks like fig (h)



Programmable controller ladder diagram symbology
Fig(h)

A PLC rung of logic will have normally open or normally closed contacts instead of normally open or normally closed switch symbols. Addresses and instructions are included. Here, in additions to each contact and its address, text information such as SW1, SW2 and L-1 is used and they are referred to as instruction comments. These instruction comments can be added from programming software.

Table 2: Truth table representing two-input OR function



Two-Input OR truth table

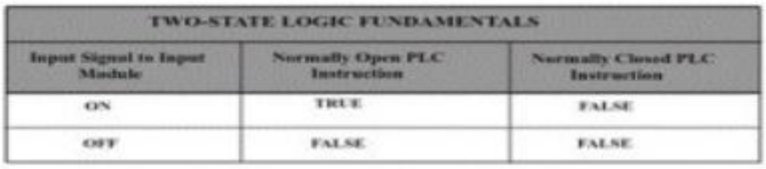
SW1	SW2	Light1
0	0	0
0	1	1
1	0	1
1	1	1

Two-Input OR truth table
Fig(e)

c) The NOT-logic function:

A normally closed relay contact passes power any time when the relay coil is not energized. In the same manner, the normally closed PLC ladder logic instruction will pass power any time when the input status file bit associated is not a 1. In this condition, the physical hardware input is not sending an input signal into the PLC's input module. The opposite of normally open PLC instruction or contact is the NOT logic. NOT logic can be used in conjunction with AND or OR logic, when a logical 0 in the status file is expected to activate some output device. In other words, NOT logic is used when an input is not energized i.e., 0 in the associated status bit, the output should be energized. Also, when the input is energized i.e., 1 in the associated status bit, the output should not be energized.

Table 3: Truth table for NOT function



TWO-STATE LOGIC FUNDAMENTALS		
Input Signal to Input Module	Normally Open PLC Instruction	Normally Closed PLC Instruction
ON	TRUE	FALSE
OFF	FALSE	FALSE

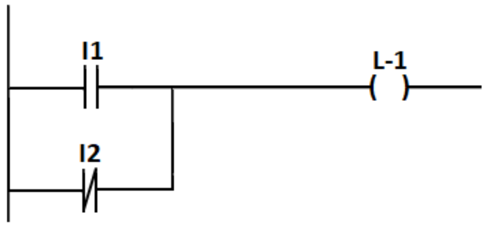
Truth table for NOT Logic
Fig (j)

2 Analysis:

2.1) Analysis of rung 1: When I1 is true i.e. the input status file bit regarding I1 is true (1), the instruction I1 will energize the output. The instruction I1 is considered true when it passes logical continuity. If there is no valid input signal from the field input devices attached to I1's screw terminal on the input module, a logical 0 will be placed in the associated input status file bit. A logical 0 in the input status file will make the normally open input instruction to become false .When normally open instruction is false, it will not pass logical continuity.

2.2) Analysis of rung 2: The normally closed instruction works much like normally closed contacts on a hardware relay. In the fig (k), when the normally closed instruction I2 is true, i.e. the associated status file bit has a valid zero (0), logical continuity is established to energize the output. When the associated status file bit has valid 1, the NC instruction goes false and there is no logical continuity and the output is not energized.

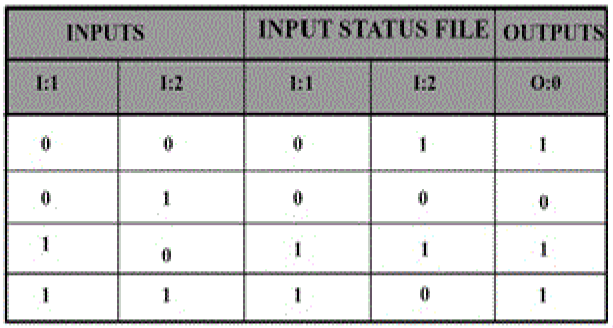
a) The PARALLEL NOT- logic function:



Parallel NOT logic
Fig(l)

PLC ladder rung has 2 input instructions, one normally open and the other one is normally closed. This circuit contains parallel NOT logic. This schematic rung will be true under the conditions shown in the truth table below.

Table 4: Input and output relation of a parallel NOT function. Output L-1 will be energized only when input1 must be true OR input2 must not be true

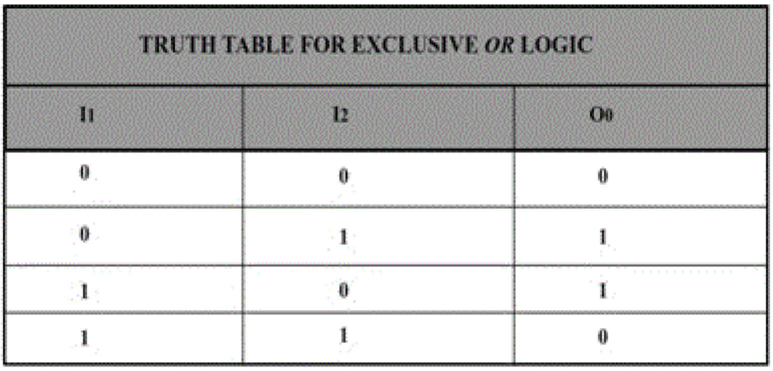


INPUTS		INPUT STATUS FILE		OUTPUTS
I:1	I:2	I:1	I:2	O:0
0	0	0	1	1
0	1	0	0	0
1	0	1	1	1
1	1	1	0	1

Parallel NOT logic truth table.
Fig(m)

b) The EXCLUSIVE OR-logic function:

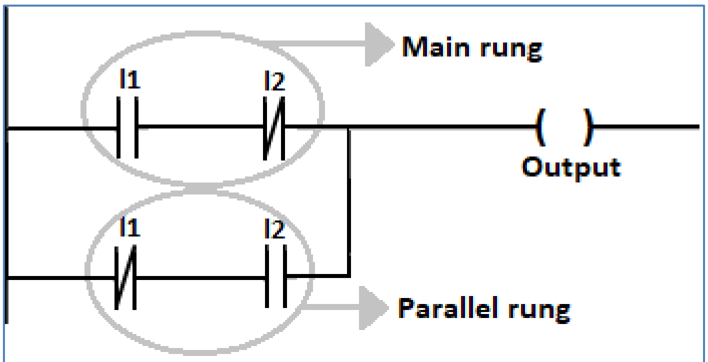
Table 5: Input and output relation of an exclusive OR function.



TRUTH TABLE FOR EXCLUSIVE *OR* LOGIC		
I1	I2	O0
0	0	0
0	1	1
1	0	1
1	1	0

Exclusive OR logic truth table.
Fig (o)

Ladder rung of EXOR GATE would look like this



Exclusive OR logic
Fig(p)

Case 1

When I1 = 0 and I2 = 0 : Let us analyze main rung. When I1 = 0, the normally open instruction is false and, normally closed instruction is true, but since normally open instruction is false, there is no logical continuity and output cannot be energized. Similar analysis can be done in parallel rung, normally closed instruction will be true and normally open instruction will be false and output is not energized.

Case 2

When I1= 0 and I2 = 1: In main rung, normally open instruction will be false and, normally closed instruction will be true, but since there is no logical continuity this rung logic cannot energize the output. But, in parallel rung, normally closed instruction will be true, as well as normally open instruction will also be true, hence there is logical continuity, and output is energized.

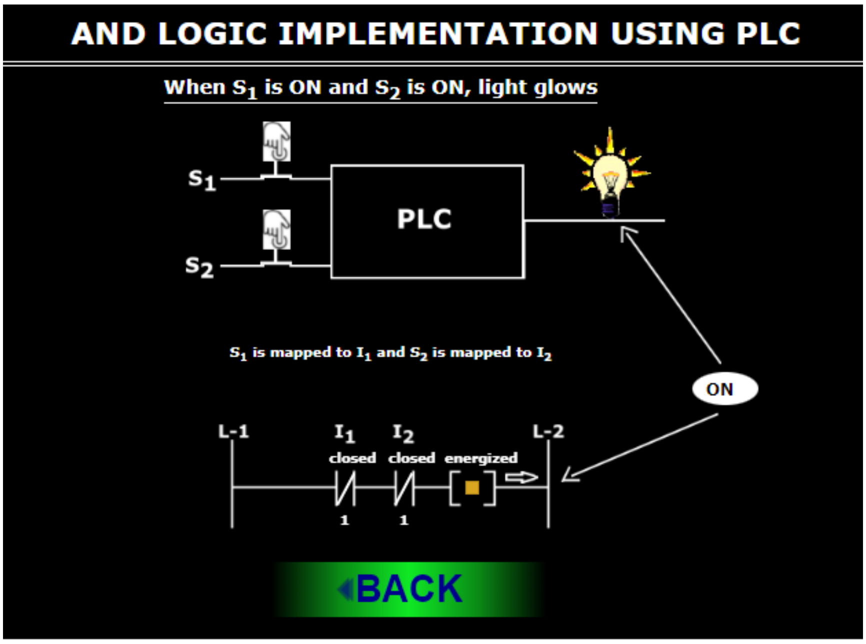
Case 3 When I1 = 1 and I2 = 0: This case is similar to case 2, only the role of inputs are interchanged i.e. here main rung is true and energizes the output and parallel rung is false**.**

Case 4 When both inputs are true, the main ladder rung as well as the parallel ladder rung goes false. In main rung, normally open instruction is true but normally closed instruction is false. Hence, there is no logical continuity. In parallel ladder rung, normally closed instruction is false and normally open instruction is true, and here also there is no logical continuity. Hence, the output is not energized.

Procedure: Apparatus required: Power supplies (for PLC, light/load), two switches, PLC, programmer (programming device). Steps to be followed:

- Step 1: To connect the switches to the corresponding input screw terminal and light to the corresponding output screw terminal.
- Step 2: To develop ladder logic that implements the required logic function.
- Step 3: To download the logic into the PLC memory.
- Step 4: Verify its truthfulness, by changing the switch conditions and observe the behaviour of the output.

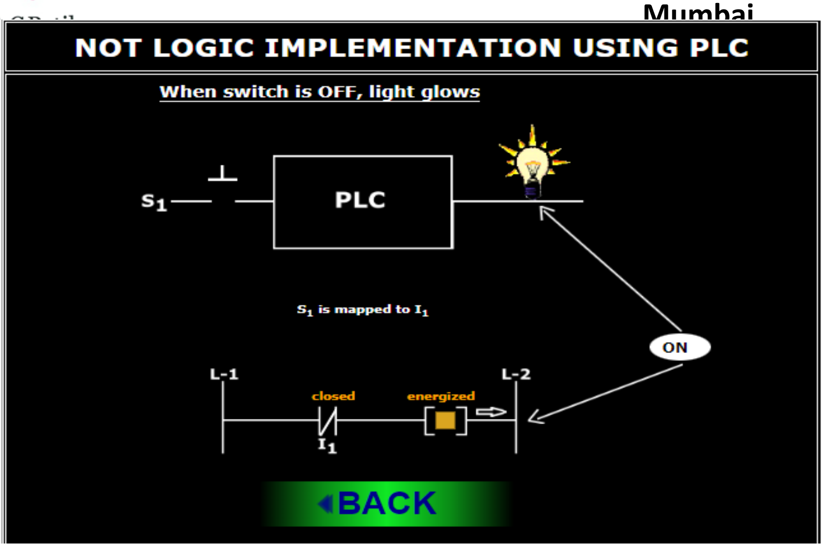
<u>Result:</u>



AND LOGIC IMPLEMENTATION USING PLC

When S_1 is ON and S_2 is ON, light glows

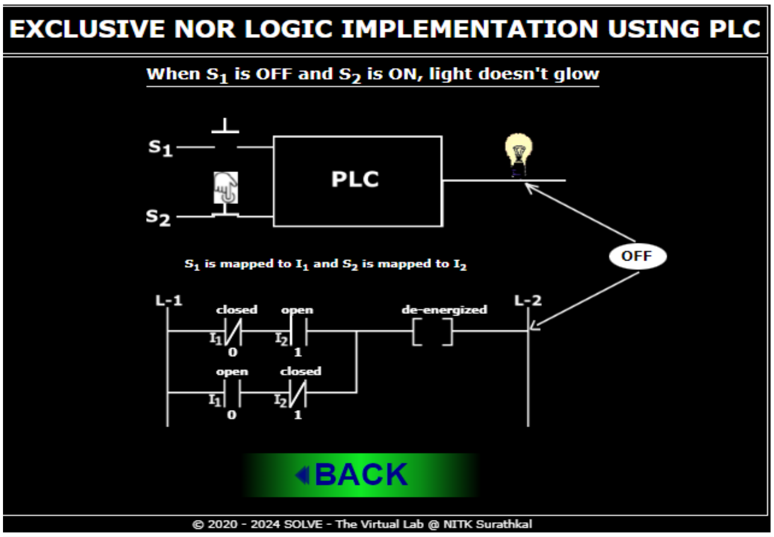
S_1 is mapped to I_1 and S_2 is mapped to I_2



NOT LOGIC IMPLEMENTATION USING PLC

When switch is OFF, light glows

S_1 is mapped to I_1



EXCLUSIVE NOR LOGIC IMPLEMENTATION USING PLC

When S_1 is OFF and S_2 is ON, light doesn't glow

S_1 is mapped to I_1 and S_2 is mapped to I_2

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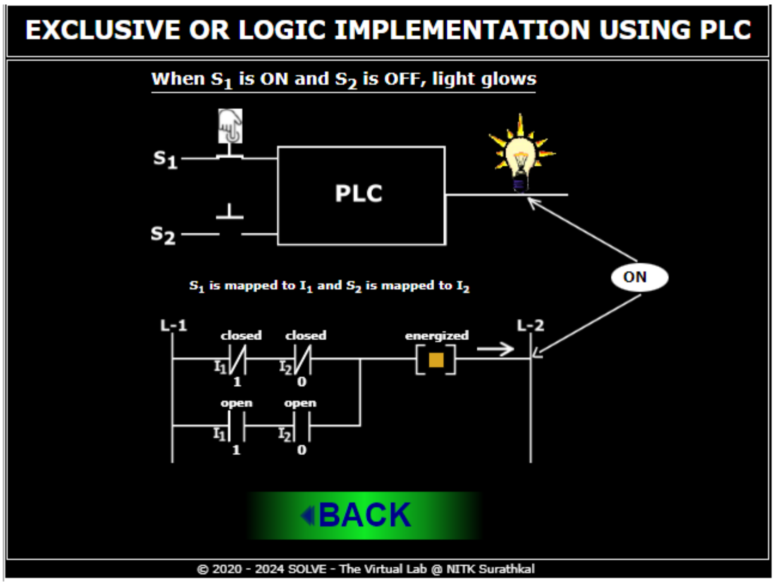

EXCLUSIVE OR LOGIC IMPLEMENTATION USING PLC

When S_1 is ON and S_2 is OFF, light glows

S_1 is mapped to I_1 and S_2 is mapped to I_2

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Conclusion:

The study of Programmable Logic Controller (PLC) basics, programming elements, and their operation for Ladder Diagrams in the Industrial Internet of Things (IIoT) offers invaluable insights into the heart of modern industrial automation.