WEEK-4 & SESSION-4

Familiarization of PLC Installation Practices, troubleshooting and programming

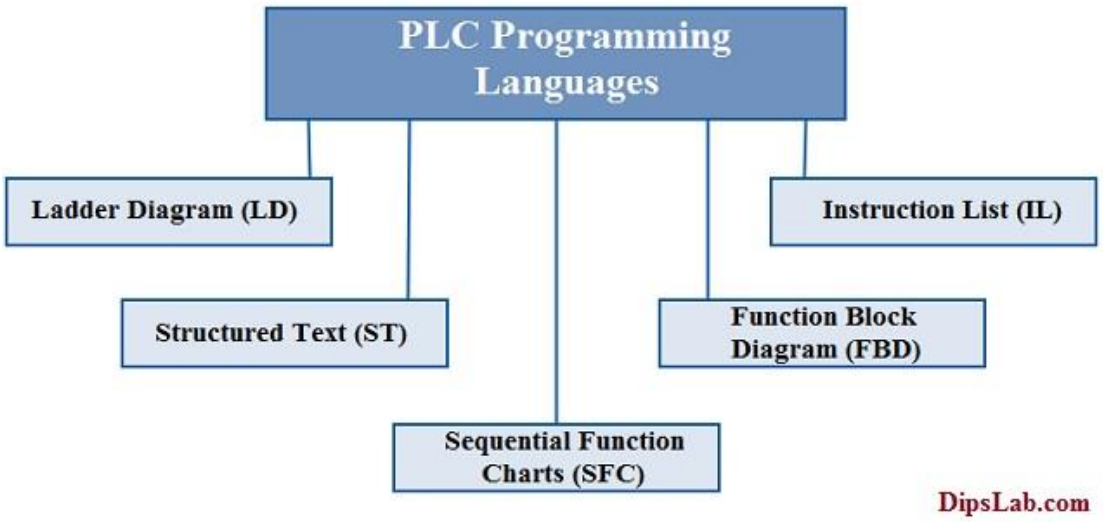
PLC Programming

1.1 Classification of PLC programming languages

The International Electro-technical Commission (IEC) 1131-3 standard on Programmable Controllers – Programming languages specifies the syntax and semantics of a unified suite of programming languages for PLCs. Some of the factors that vary between formats are nomenclature, numbering schemes, and screen appearance.

The 5 most popular types of PLC Programming Languages are:

1. Ladder Diagram (LD)
2. Sequential Function Charts (SFC)
3. Function Block Diagram (FBD)
4. Structured Text (ST)
5. Instruction List (IL)

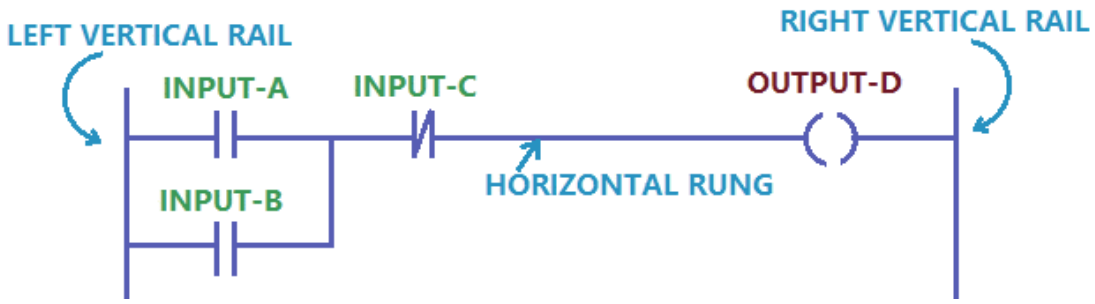


1.1.1 Ladder Diagram (LD)

Most Commonly used PLC programming method is Ladder Diagram.The initial paradigm for the Ladder diagram was derived from Relay Logic, which controlled operations using physical devices like switches and mechanical relays. Ladder diagrams internal logic replaces everything but physical devices, which require an electrical signal to be activated.

On Relay-logic schematic, the electrical connection is represented by two vertical rails. The Ladder diagram is constructed in the shape of horizontal rungs with vertical rails.

A ladder diagram identifies each of the elements in an electromechanical circuit and represents them graphically. This allows user to see how control circuit operates before actual physical operation the system starts.



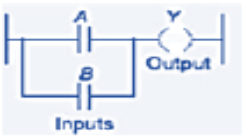
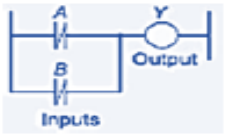
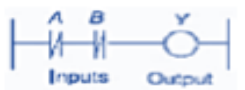
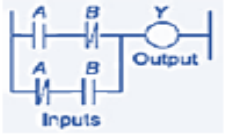
Ladder diagram

PLC programming based on the use of ladder diagrams involves writing a program in a similar manner to drawing a switching circuit. The ladder diagram consists of two vertical lines representing the power rails as shown in Fig. Circuits are connected as horizontal lines, i.e. the rungs of the ladder, between these two vertical lines.

The table shows input/output (I/O) symbols used in constructing the ladder diagram.

Element	Symbol Used	Description
Examine if ON		When the associated Input signal state is "1", the contact is "closed". if input signal state is "0" the contact is "open"
Examine if OFF		When the associated Input signal state is "0", the contact is "closed". if input signal state is "1" the contact is "open"
Output Coil		The signal state of this element is "1", if the associated input signal is "1", otherwise it is "0"
Negated Output		The signal state of this element is "0", if the associated input signal is "1" otherwise it is "0"
Latch Output Coil		To hold an input ON
Unlatch		To unlatch the Lathed output

Following Table shows the ladder diagrams for AND, OR, NOT, NAND, NOR and XOR logics.

Logic	Symbol	Truth Table	Ladder Diagram
AND			
OR			
NOT			
NAND			
NOR			
XOR			

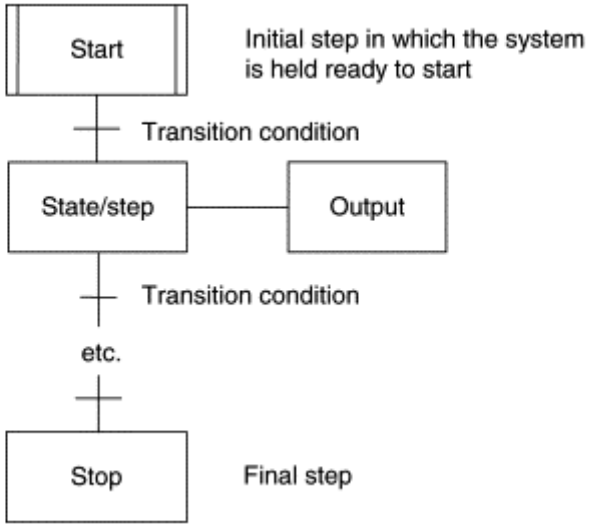
1.1.2 Sequential Function Charts (SFC)

Sequential Function Chart is a graphical programming language that is defined as Preparation of function charts for control systems.

This language is used when programming a process that can be split into several steps. There are 3 main components of an SFC:

- Steps with defined actions;
- Transitions with defined logic conditions;
- Links between steps and transitions.

The actions and the conditions can be described in any PLC programming language. The SFC is basically a chart that represents an overview of the project, aimed to ease the analysis of the process.

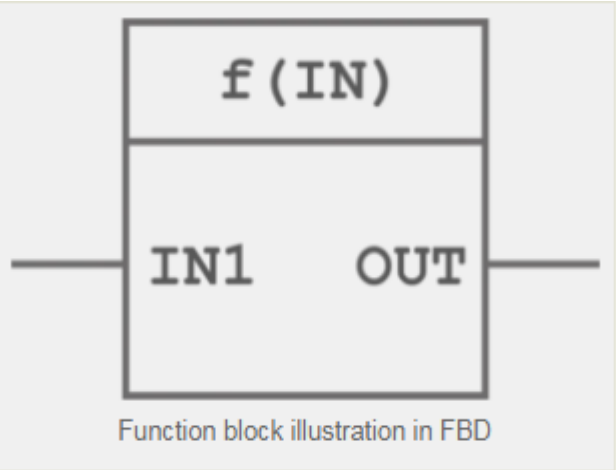


A condition is associated with every transition. If all the input steps of a transition are active, and the transition condition is satisfied then the transition is fired, which means deactivation of all its inputs steps and activation of all its output steps.

1.1.3 Function Block Diagram (FBD)

The Function Block Diagram is a form of graphical language in its own right. Fundamentally, a function is described using the Function Block Diagram, wherein inputs and outputs are represented as blocks linked to one another via connection lines. Function Blocks were designed and created to make it easier to configure various common functions, including timers, counters, and PID Loops.

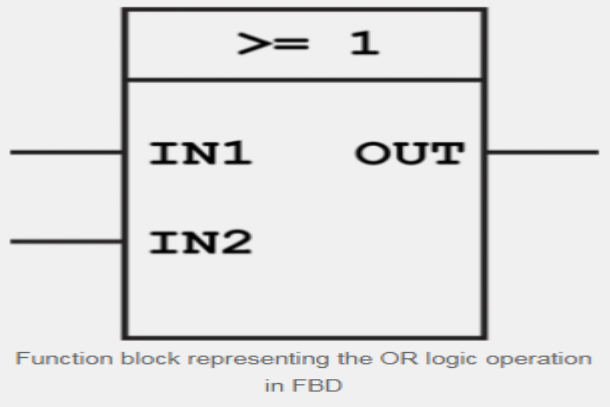
The function of the block is the relation between the state of its inputs and outputs. Here's how a simple function block could look like:



Function block illustration in FBD

In the middle of the box is often a symbol or a text. This symbol represents the actual functionality of the function block.

Consider OR function block. It takes 2 inputs and has 1 output, and works just like an OR gate. **If one of the inputs is true the output will also become true.** In FBD the block will typically look like this:



Function block representing the OR logic operation in FBD

1.1.4 Structured Text (ST)

Structured Text is the fourth PLC Programming Language that has been developed. This language relies heavily on written communication. Structured Text is a high level language, which represents a combination of three programming languages: Basic, Pascal and C. This language gives the possibility to operate with inputs and outputs, using different statements such as for, while, if and case.

It is easy to implement complex algorithms and work with mathematical functions. The following example shows the Structured Text format:

```
1  int a=5;
2  int b=7;
3  int c=0;
4  if (a>b){
5          c=a+b;
6  }
7  else{
8          c=a-b;
9  }
10 print(c);
```

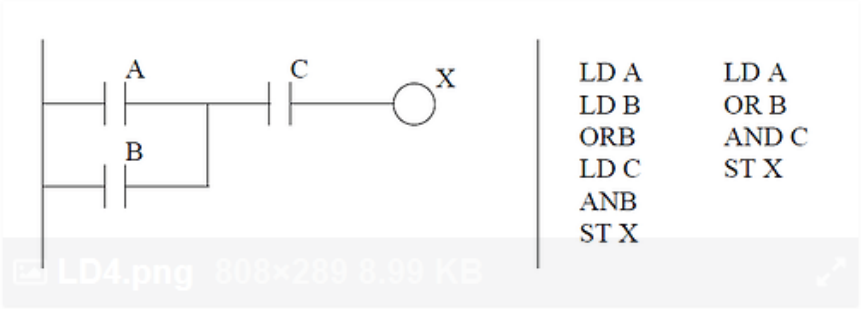
1.1.5 Instruction List (IL)

Instruction List is a low level language that resembles the assembly language OR Instruction List is a low level textual language used in PLC system, which has a structure similar to a simple machine assembler. This programming language consists of many lines of code, with a single instruction per line. It's read top to bottom and left to right.

Instruction List is very straight-forward to read because each line is executed sequentially. Some examples of these codes are LD (Load), AND, OR, etc. The Instruction List comprises instructions; each presented on a separate line and followed by a space at the end of the line for any comments.

Keywords			
TRUE	FALSE	LD	ST
AND	OR	XOR	ADD
SUB	MUL	DIV	LT
LE	EQ	NE	GE
GT	CAL	JMP	RET

The diagram shows how Instruction list will appear with reference to Ladder diagram.

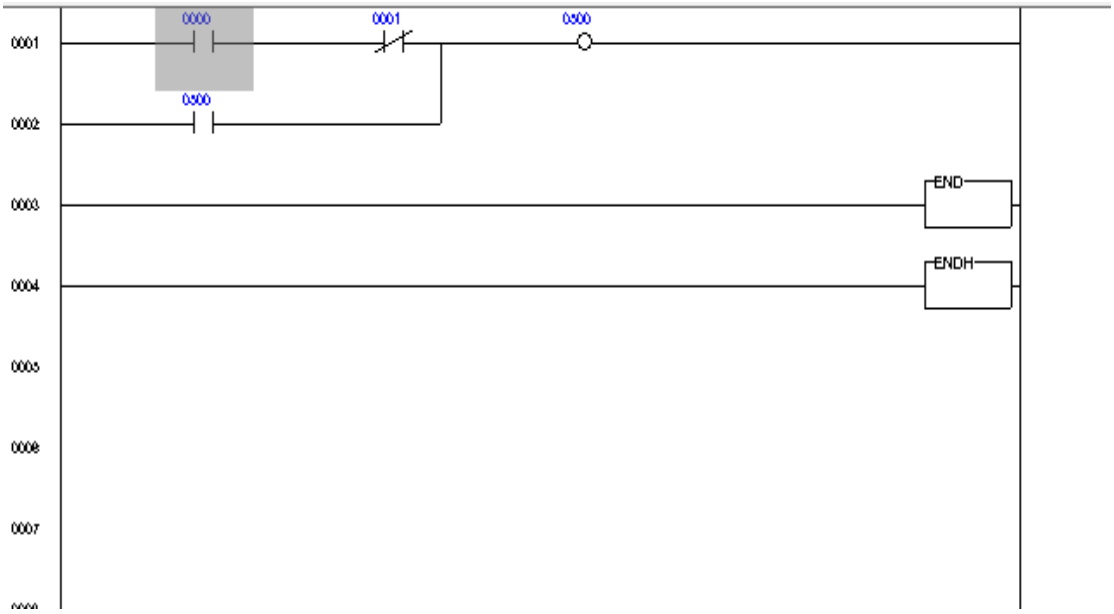


Practice: Conduct the following using any one of Textual language and Graphical form of PLC

1. DOL Starter

A DOL Starter also known as a Direct On Line Starter or Across the Line Starter is a method of starting a 3 phase Induction Motor. In a DOL Starter, an induction motor is connected directly across its 3-phase supply and the DOL starter applies the full line voltage to the motor terminals.

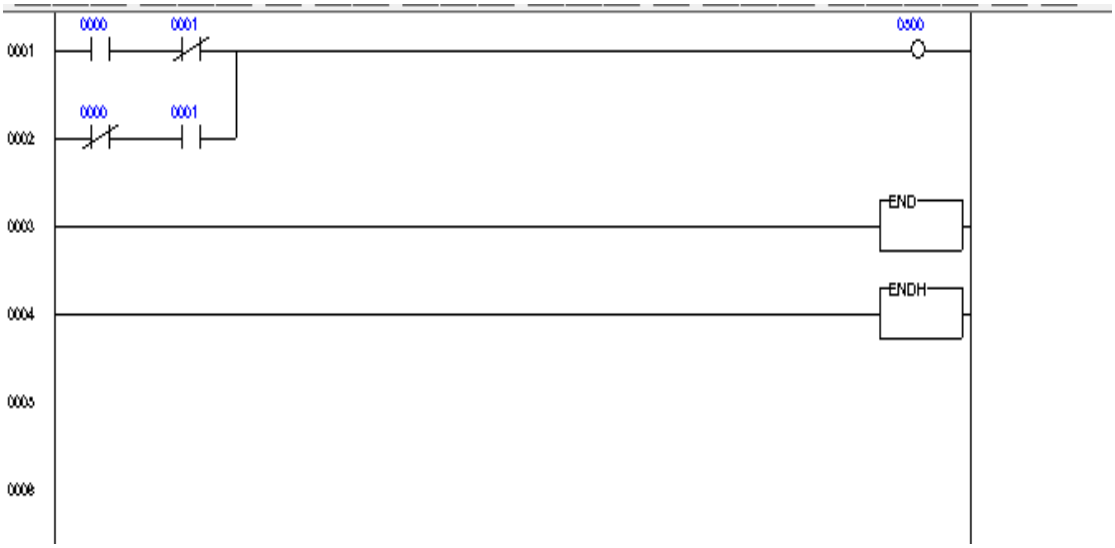
Ladder Diagram:



2. Staircase Light Application

This is one of the most frequently used projects in Building management systems. In this, one light is controlled using two switches. One switch is installed at the lower side of the Staircase while the other switch is installed at the upper side of the Staircase. With the help of this project, we can save electricity and reduce the electric bill.

Ladder Diagram:



3. Water Level Controller

The Water Level Controller system helps to prevent the overflowing of water from the tank and helps in maintaining the water level. Filling of tank is monitored by two sensors positioned to sense maximum and minimum water levels of tank. The water level is maintained by using two water level float sensors.

Ladder Diagram: