Programmable Logic Controller(PLC)

A Programmable Logic Controller, PLC is a digital computer used for automation.

A PLC is an example of a real time application and therefore used to control various devices.

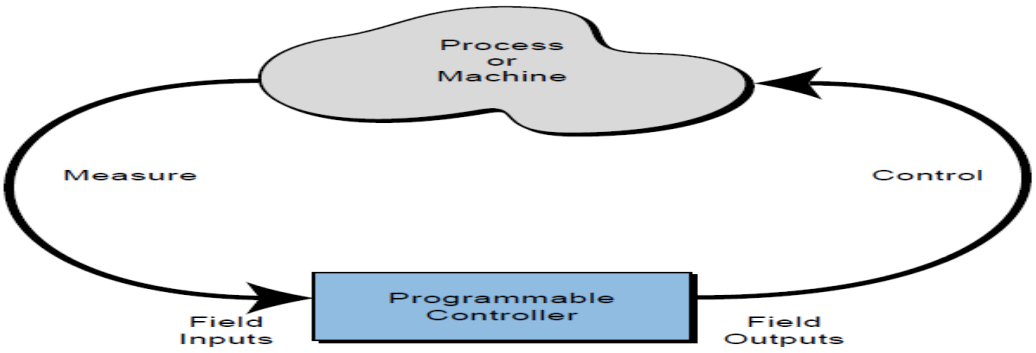


Figure 1-1. PLC conceptual application diagram.

A programmable controller, as illustrated in Figure below, consists of two basic sections:

- the central processing unit
- the input/output interface system

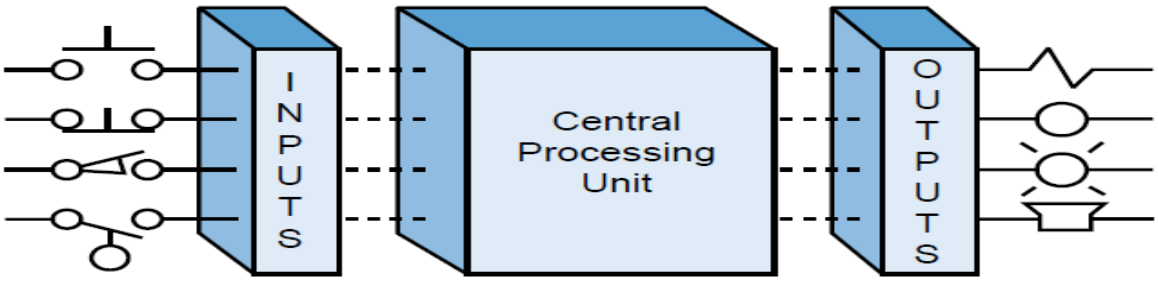


Figure 1-5. Programmable controller block diagram.

All types of PLC are consisting of a power supply, central processing unit (CPU), memory, input/output(I/O) modules and programming device, as shown in Fig. (1).

The central processing unit (CPU) governs all PLC activities. The following three components, shown in Figure 1-6, form the CPU:

1) processor 2) memory system 3) system power supply

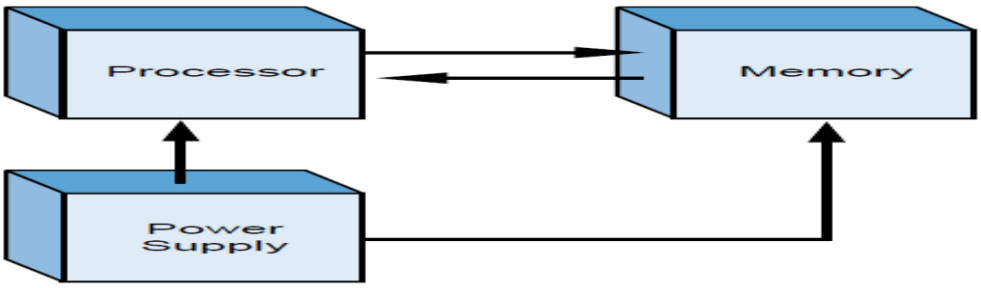


Figure 1-6. Block diagram of major CPU components.

PLC has many programming languages but the most famous and important language is Ladder diagram language which are used to programming the PLC in this paper. The PLC used in this lectures is Zelio of the relay type.

During its operation, the CPU completes three processes: (1) it reads, or accepts, the input data from the field devices via the input interfaces, (2) it executes, or performs, the control program stored in the memory system, and (3) it writes, or updates, the output devices via the output interfaces.

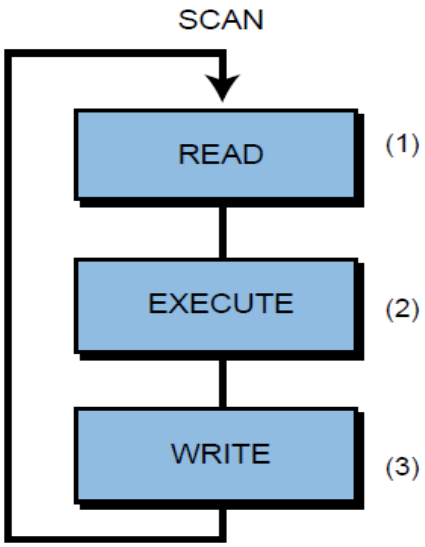


Figure 1-7. Illustration of a scan.

This process of sequentially reading the inputs, executing the program in memory, and updating the outputs is known as scanning. Figure 1-7 illustrates a graphic representation of a scan.

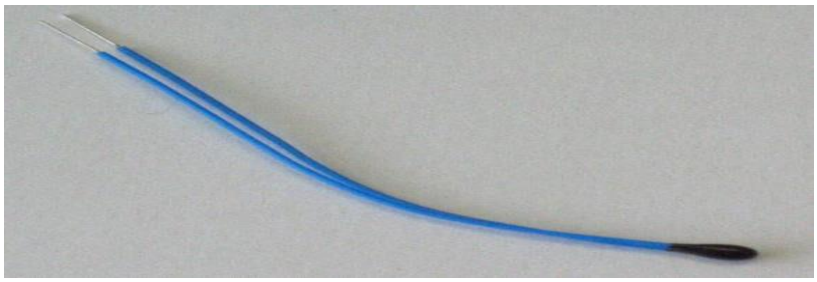
Electrical temperature sensors

1- Thermistor

A thermistor is a type of resistor whose resistance is dependent on temperature, more so than in standard resistors.

With NTC thermistors, resistance decreases as temperature rises. An NTC is commonly used as a temperature sensor, or in series with a circuit as an inrush current limiter.

With PTC thermistors, resistance increases as temperature rises. PTC thermistors are commonly installed in series with a circuit, and used to protect against overcurrent conditions, as resettable fuses.

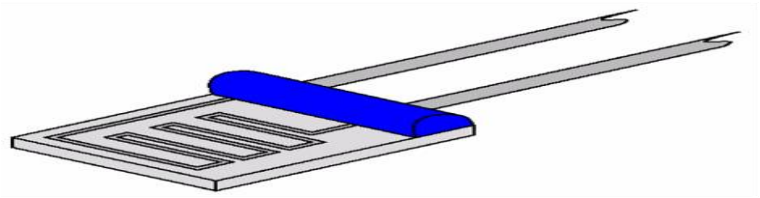


2- Thermocouple

A thermocouple is an electrical device consisting of two dissimilar electrical conductors forming electrical junctions at differing temperatures

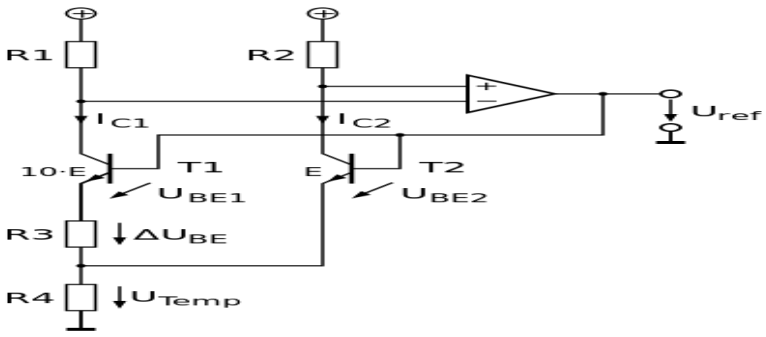
3- Resistance thermometers

Resistance thermometers, also called resistance temperature detectors (RTDs), are sensors used to measure temperature



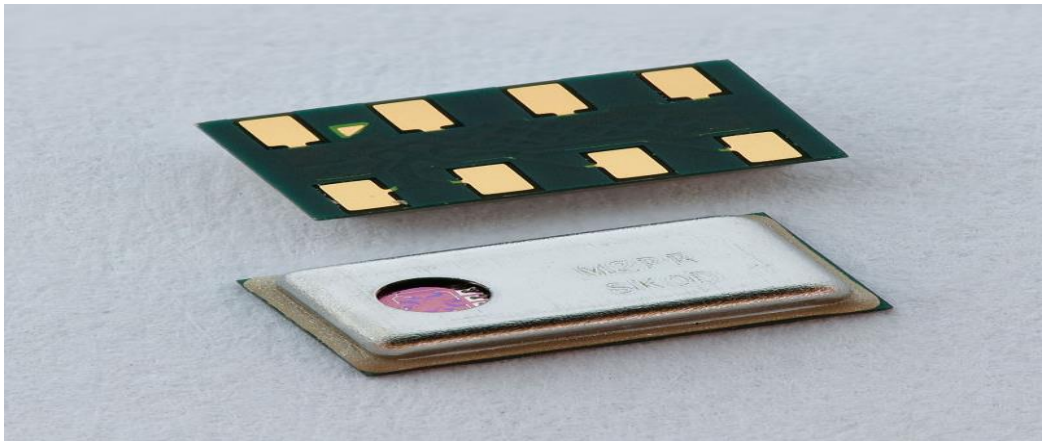
4- The silicon bandgap temperature sensor

The silicon bandgap temperature sensor is an extremely common form of temperature sensor (thermometer) used in electronic equipment.



Electrical Pressure sensors

A pressure sensor is a device for pressure measurement of gases or liquids.



Types of pressure measurements

Pressure sensors can be classified in terms of pressure ranges they measure, temperature ranges of operation, and most importantly the type of pressure they measure.

1) **Absolute pressure sensor**

This sensor measures the pressure relative to perfect vacuum.

2) **Gauge pressure sensor**

This sensor measures the pressure relative to atmospheric pressure.

3) **Vacuum pressure sensor**

It may be used to describe a sensor that measures pressures below atmospheric pressure, showing the difference between that low pressure and atmospheric pressure

4) **Differential pressure sensor**

This sensor measures the difference between two pressures, one connected to each side of the sensor.

5) **Sealed pressure sensor**

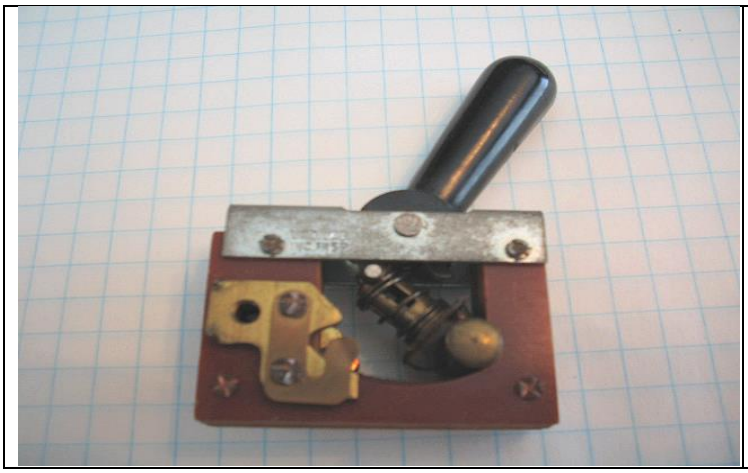
This sensor is similar to a gauge pressure sensor except that it measures pressure relative to some fixed pressure rather than the ambient atmospheric pressure.

Electrical Switches

In electrical engineering, a switch is an electrical component that can "Execute" or "break" an electrical circuit, interrupting the current or diverting it from one conductor to another.

1- Toggle switches

A toggle switch is a class of electrical switches that are manually actuated by a mechanical lever, handle, or rocking mechanism.



2- Push button switch

A push-button (also spelled pushbutton) or simply button is a simple switch mechanism for controlling some aspect of a machine or a process.

PROGRAMMING LANGUAGES

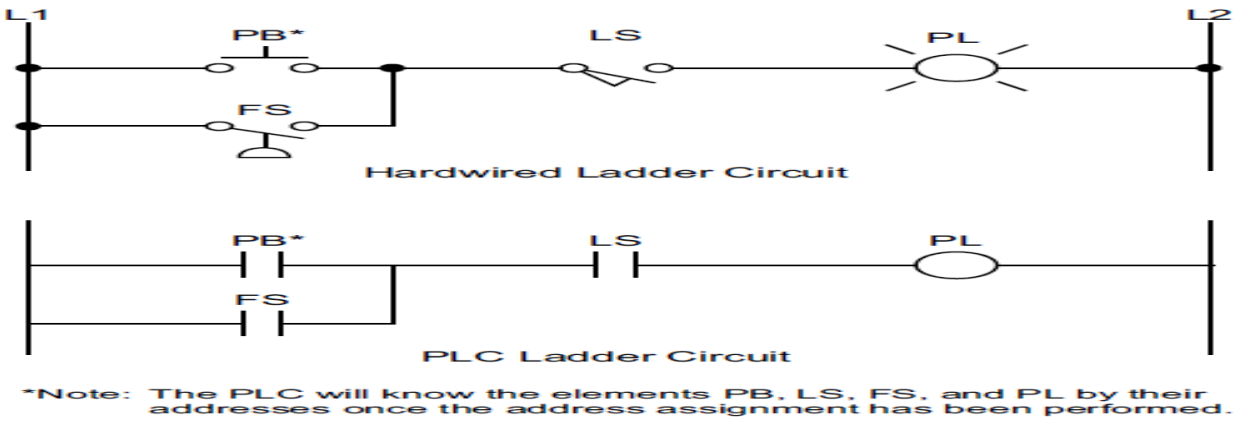
As PLCs have developed and expanded, programming languages have developed with them. Programming languages allow the user to enter a control program into a PLC using an established syntax.

The three types of programming languages used in PLCs are:

- Ladder Diagram
- Function Block
- Statement List (STL)

Ladder Diagram Language

The programmable controller was developed for ease of programming using existing relay ladder symbols and expressions to represent the program logic needed to control the machine or process.



LADDER DIAGRAM FORMAT

The ladder diagram language is a symbolic instruction set that is used to create PLC programs. The ladder instruction symbols can be formatted to obtain the desired control logic, which is then entered into memory.

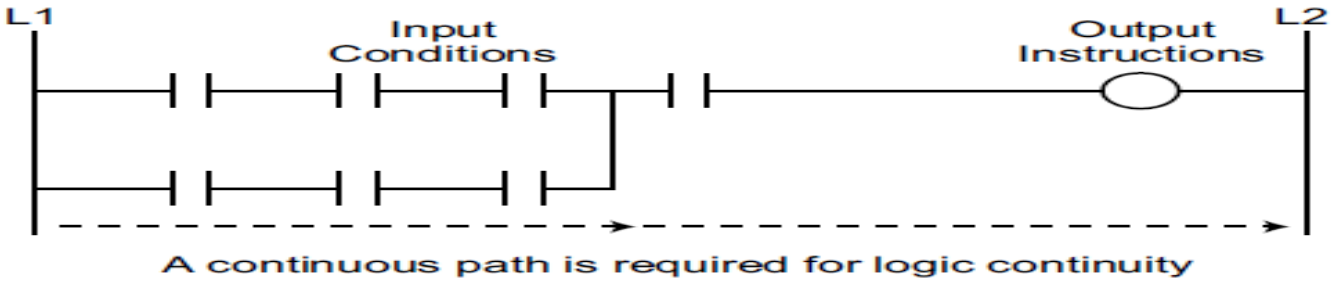


Figure 9-6. Ladder rung structure.

Figure 9-7 illustrates several continuous paths that provide continuity and energize the output of the rung. Power continuity is normally represented on a PLC's monitoring device

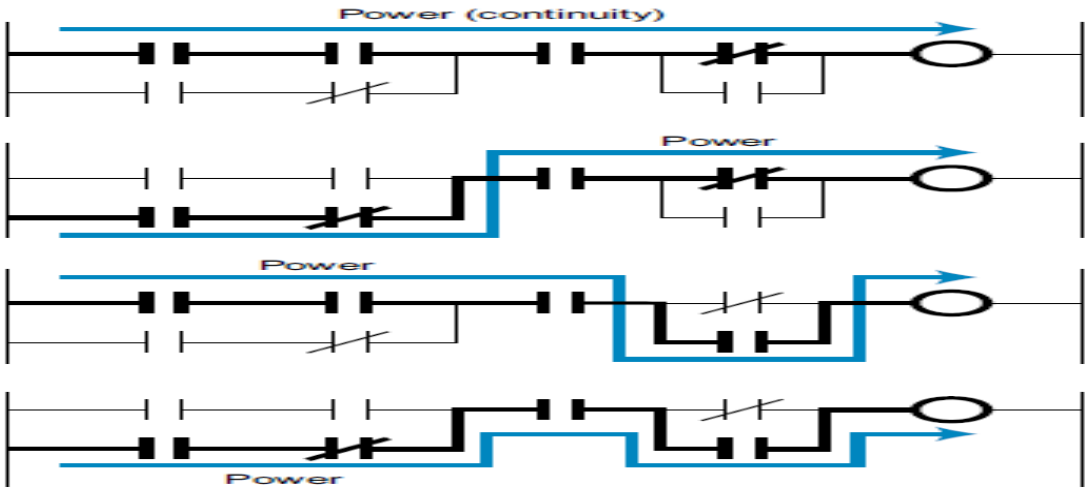
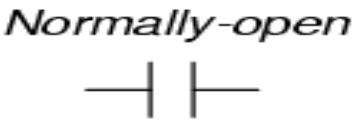


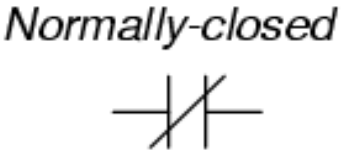
Figure 9-7. Illustration of several different continuity paths in a ladder rung.

Important samples that used in Ladder Diagram

1- Normally Open contact



2- Normally Closed contact



3- Coil contact

H.W

1) List types of temperature Sensors and explain one only
2) List types of pressure sensors and explain one only
3) Give the difference between NTC and PTC
4) List PLC parts
5) List CPU parts and Sketch its block diagram
6) List any programmable controller parts and Sketch its block diagram
7) List types of programming languages used in PLCs
8) List PLC processes and Sketch their block diagram
9) Define scanning and Sketch its block diagram

LOGIC FUNCTIONS

1- AND gate

Figure 3-1 shows a symbol called an AND gate, which is used to graphically represent the AND function.

AND Truth Table		
Inputs		Output
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

Figure 3-2. Two-input AND gate and its truth table.

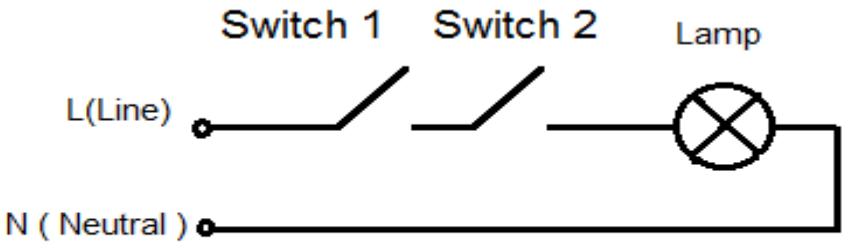
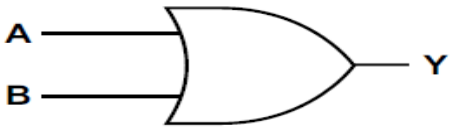


Figure [2]

Fig. [5] LD language

2- OR gate

Figure 3-3 shows the OR gate symbol used to graphically represent the OR function.



OR Truth Table		
Inputs		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

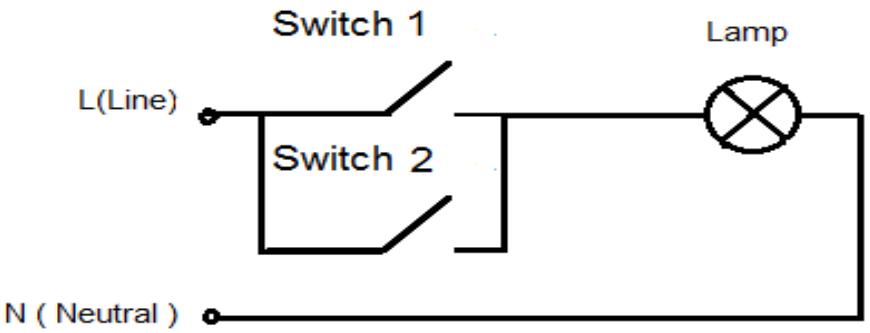


Figure [3]

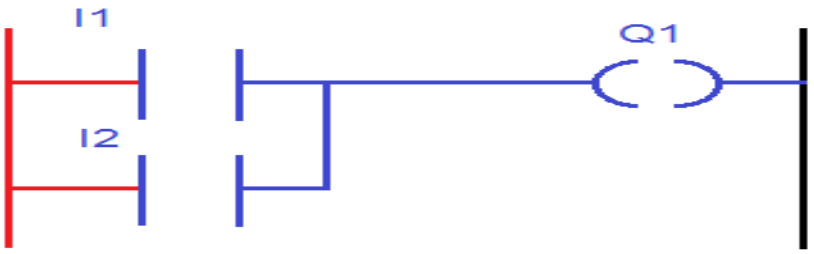


Fig. [6] LD language

3- NOT gate

A	B
0	1
1	0

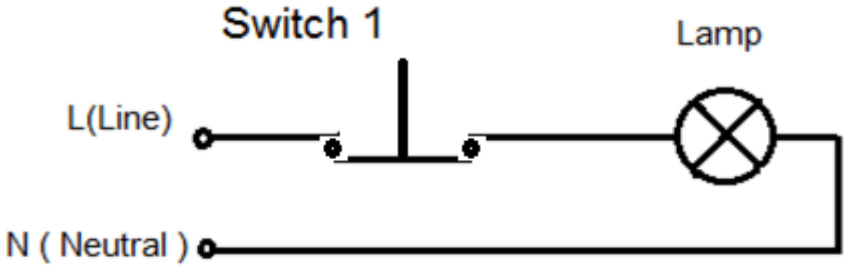


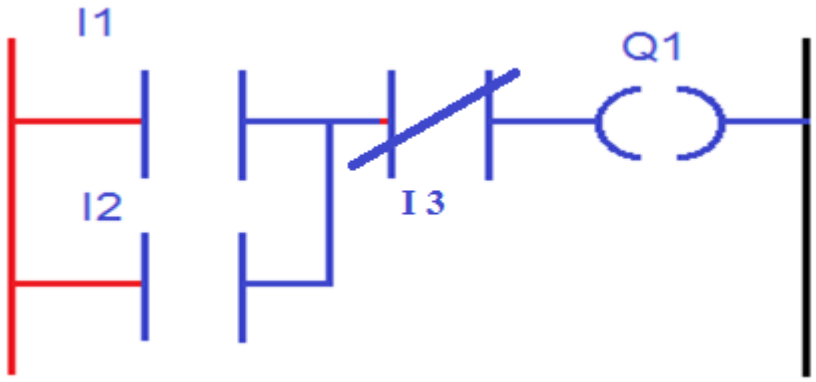
Fig. [6] LD language

H. W.

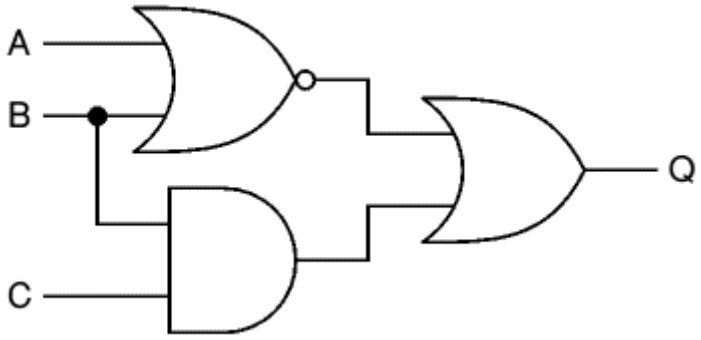
1- Write truth table and a program in Ladder diagram for XOR gate

2- Write truth table and a program in Ladder diagram for XNOR gate

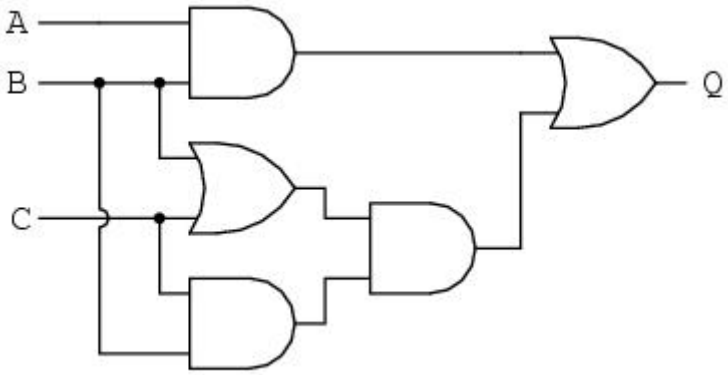
3- Write truth table for a program in Ladder diagram shown in figure below



4- Write program in ladder diagram for logic circuit shown in figure below



5- Write program in ladder diagram for logic circuit shown in figure below



APPLICATION PART

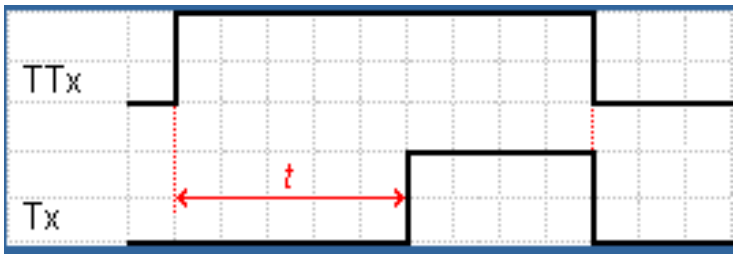
In this section we take some experiments and sketch the control circuit in ladder diagram

1- Operation several types of Timers using Ladder diagram

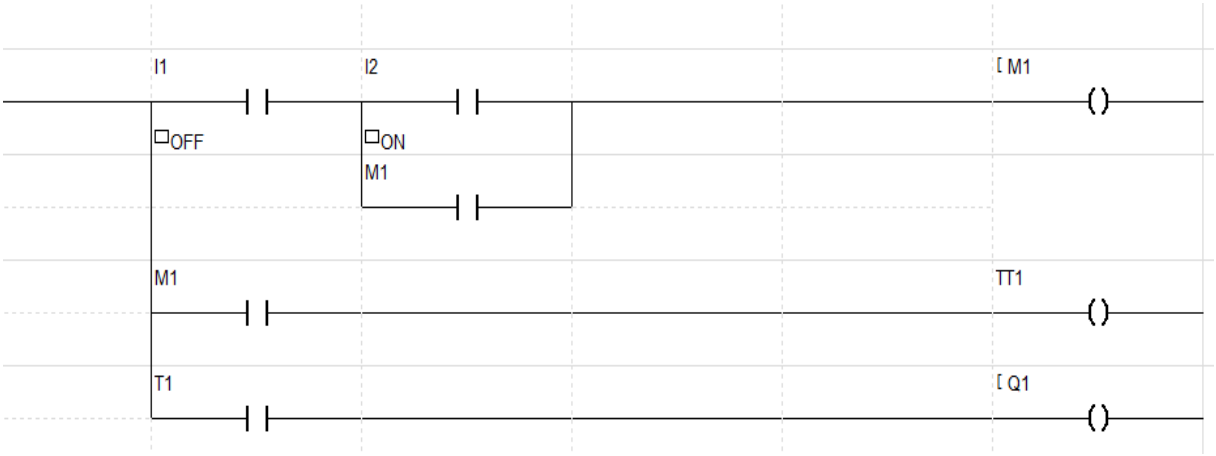
a) On delay Timer

The load is delayed by time (preset value (t))

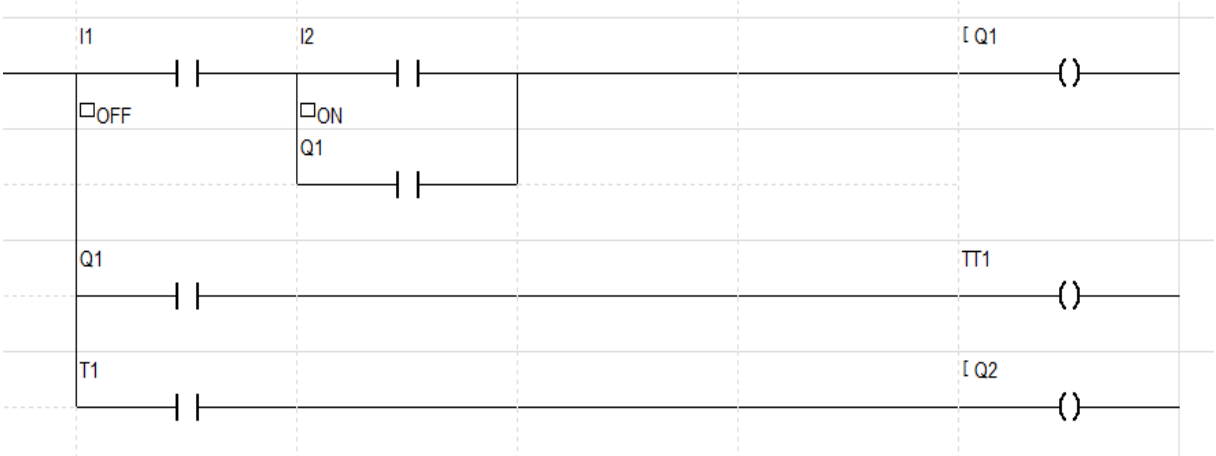
The operation time between {Push ON energized + preset value and Push OFF energized}



1) And the simulation circuit that operation delaying one load by preset time = 5.00 sec is shown in figure below.



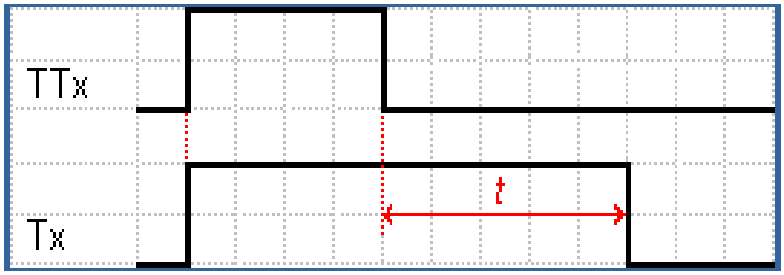
2) And the simulation circuit that operation delaying one load is executing at pressing on the Push ON and the second load delayed by preset time = 10sec



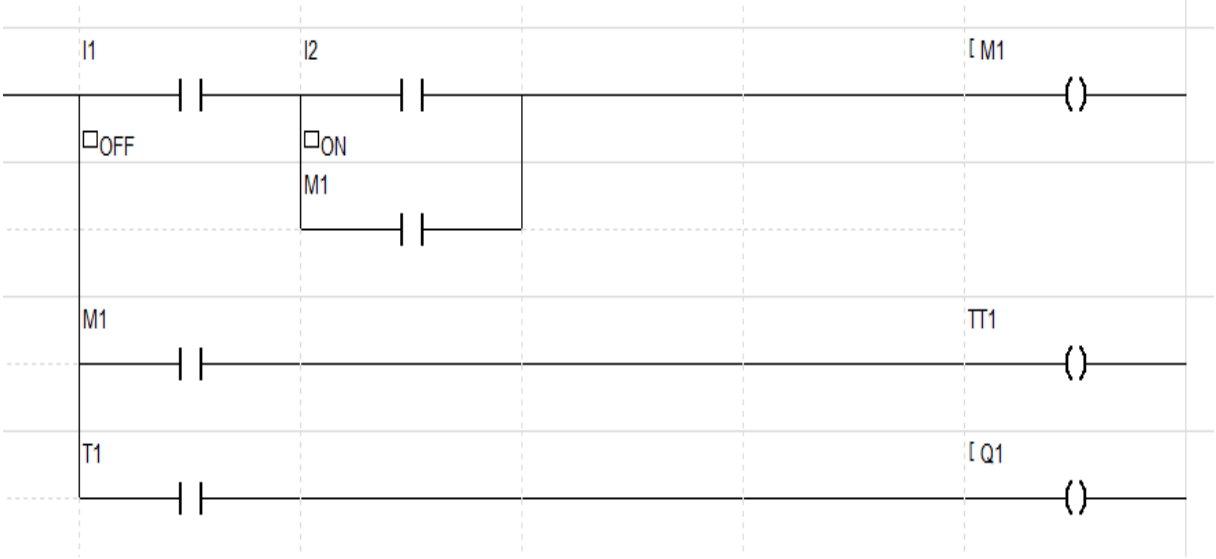
b) OFF delay Timer

The off time of load is delayed by time (preset value (t))

The operation time is between Push ON energized and Push OFF energized + preset time (t)

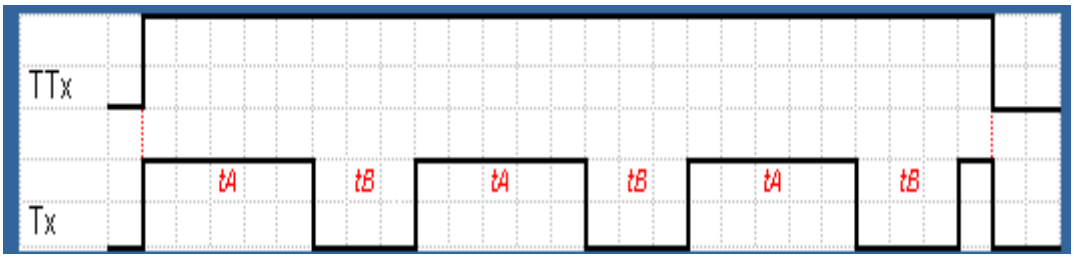


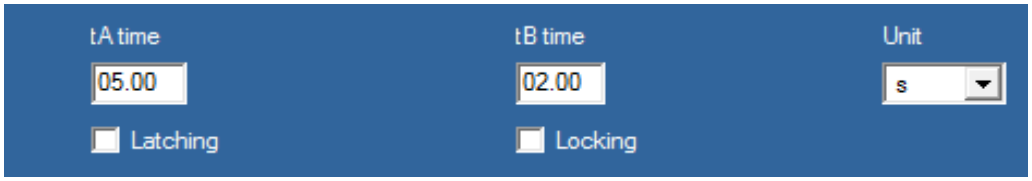
And the simulation circuit that switch off of the one load is delayed by preset time = 5.00 sec is shown in figure below.



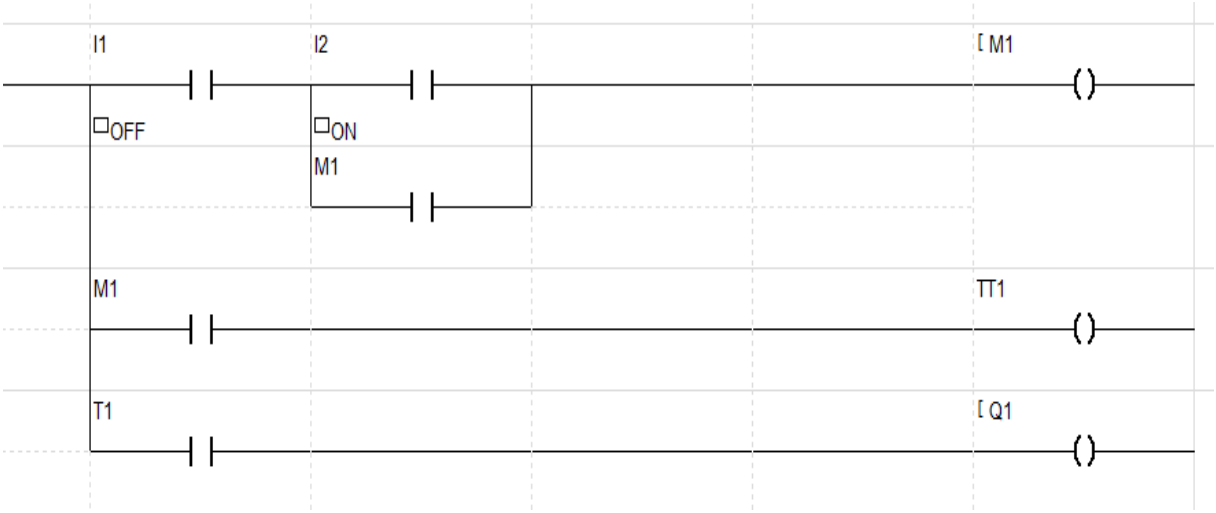
c) Pulsing Delay Timer

In this case the load is operate at tA and stop at tB



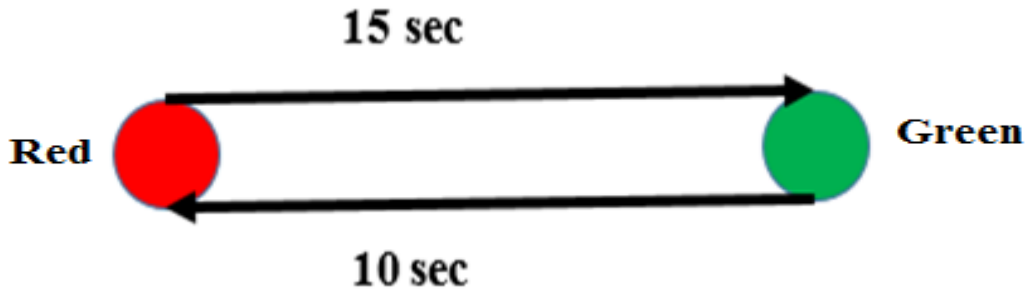


And the simulation circuit that operation of one load by preset time tA = 5.00 sec is and stop preset time tB =2.00 sec shown in figure below.

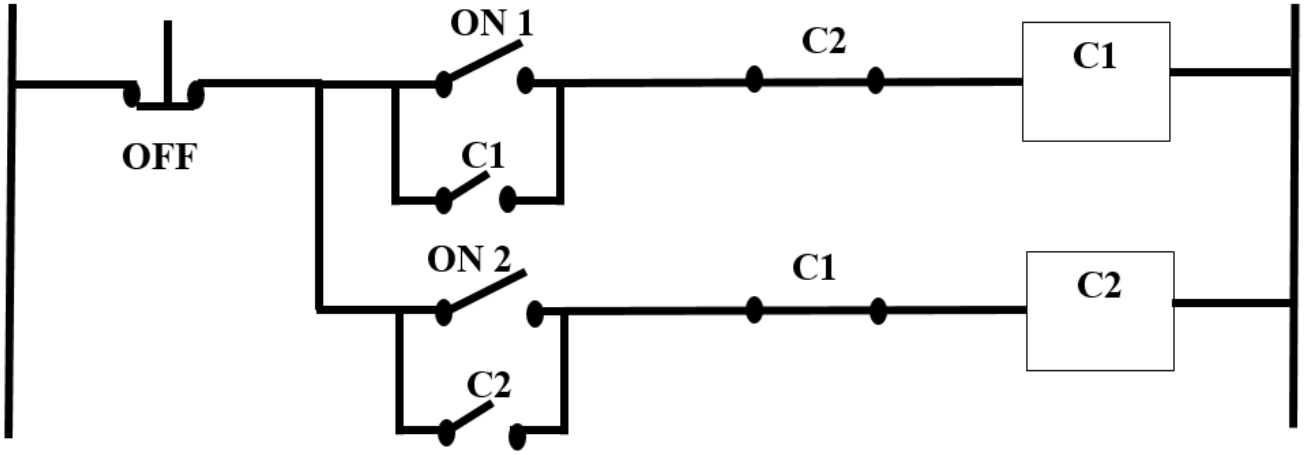


H.W

1) Write a program in ladder diagram to operate two light red and green as figure below red to green 15 secs and green to red 10 sec one by one



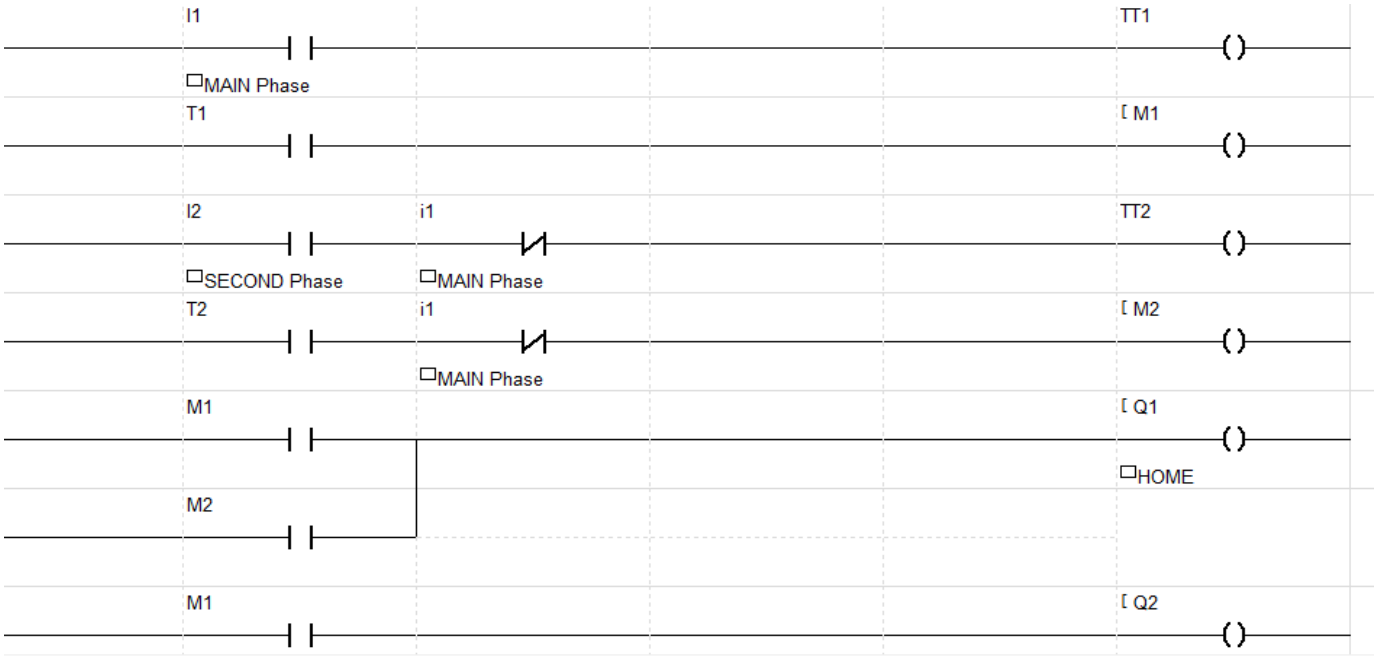
2) Convert the electrical circuit to LD diagram and then Sketch the Logic circuit



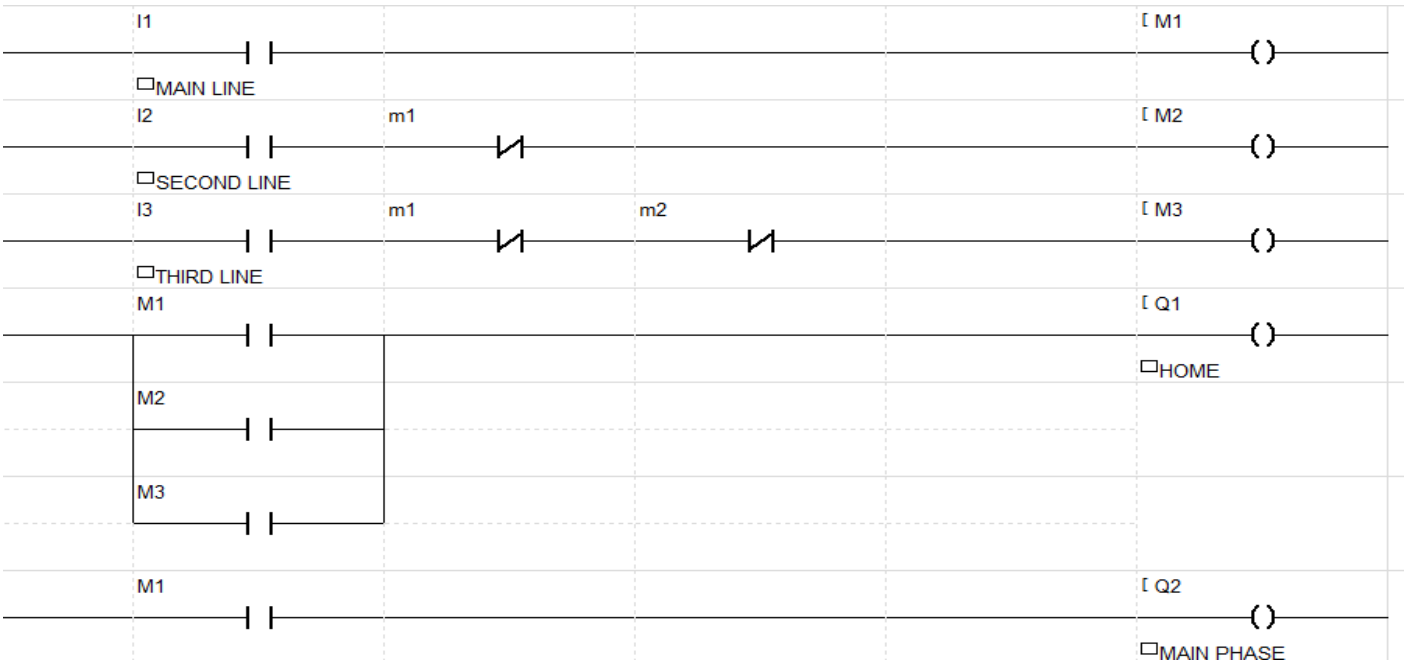
2- Automatic Change Over circuit using ladder diagram

If the sources change, there is a process called synchronization to connect two exporters together without interruption, even for a short period, by changing one of the sources to make it close to the source of the other source and then at a certain point called the point of extinguishing the exporters can be combined together

1) The circuit in figure below shows the changeover about two lines, one of them is main phase and the second line using timer of each line.



2) The circuit in figure below shows changeover that has three lines without using any timer



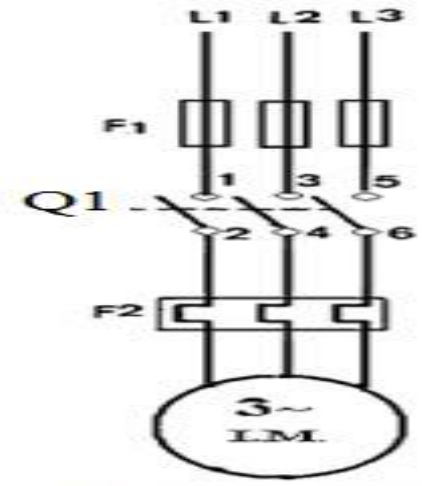
H.W

1) Write a program in the ladder language (LD) for two supplying lines without using timer
2) Write a program in the ladder language (LD) for three supplying lines with using timers
3) Write a program in the ladder language (LD) for four supplying lines without using timer
4) Write a program in the ladder language (LD) for four supplying lines with using timers
5) Draw the logic circuit for program in LD for three supplying lines without using timer

3- Operating Three-Phase motor using ladder diagram

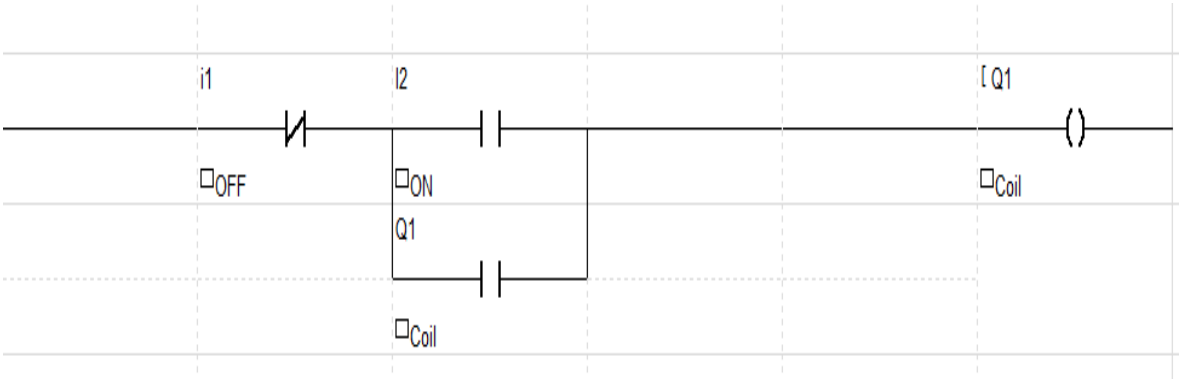
In the experiment we control the ON and OFF the three phase motor.

The switch ON to energized the 3-phase motor and the switch OFF to De energized the motor the power circuit is shown in figure below,



Power Circuit

The control circuit is shown in figure below

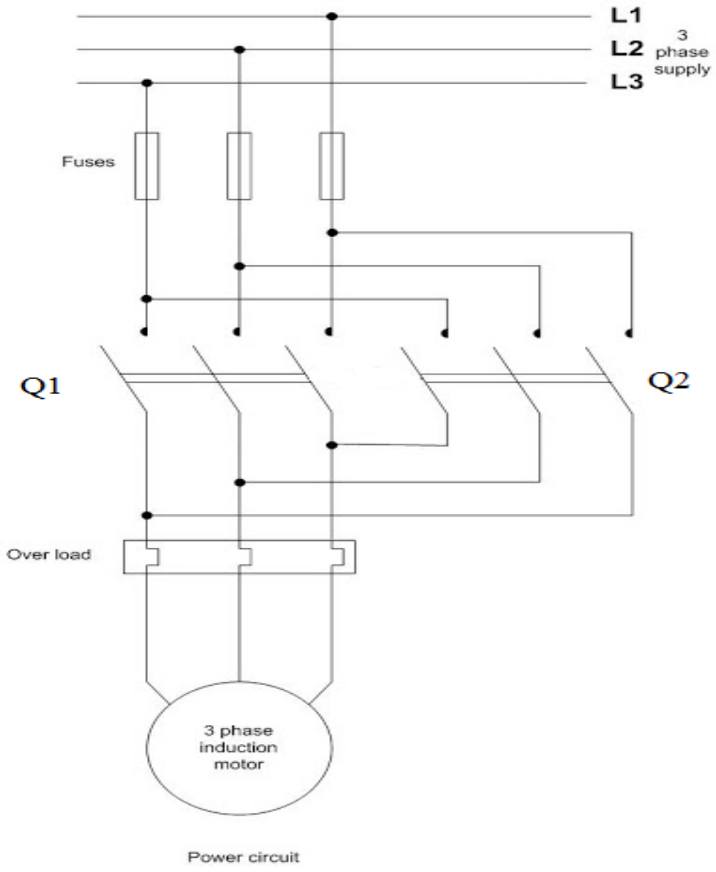


4- changing direction of three phase motor

in the experiment we control the direction of three phase motor, in single-phase motors, the rotation of the motor can only be reversed by changing the direction of the current passing through the start winding.

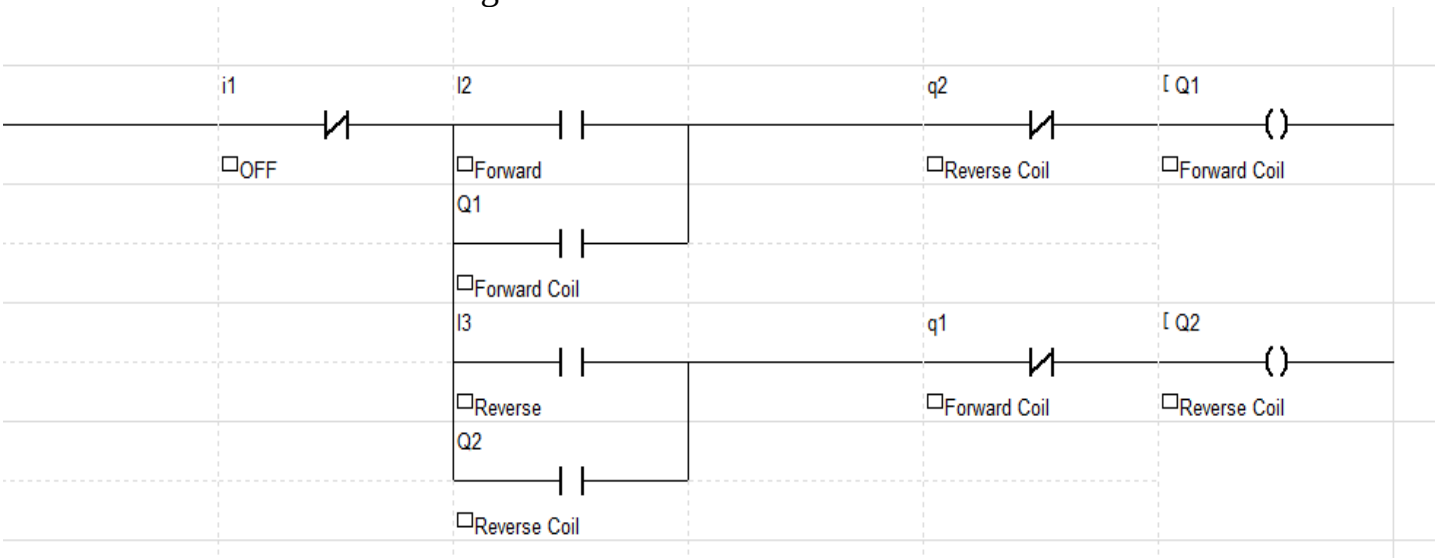
In the case of a three-phase motor, change the direction of motor is being by changing two phases and respect the third phase in the same position.

The control circuit to reverse the rotation of the single phase and three phase motors is the same in both engines. the power circuit is shown in figure below



Power circuit

the control circuit is shown in figure below

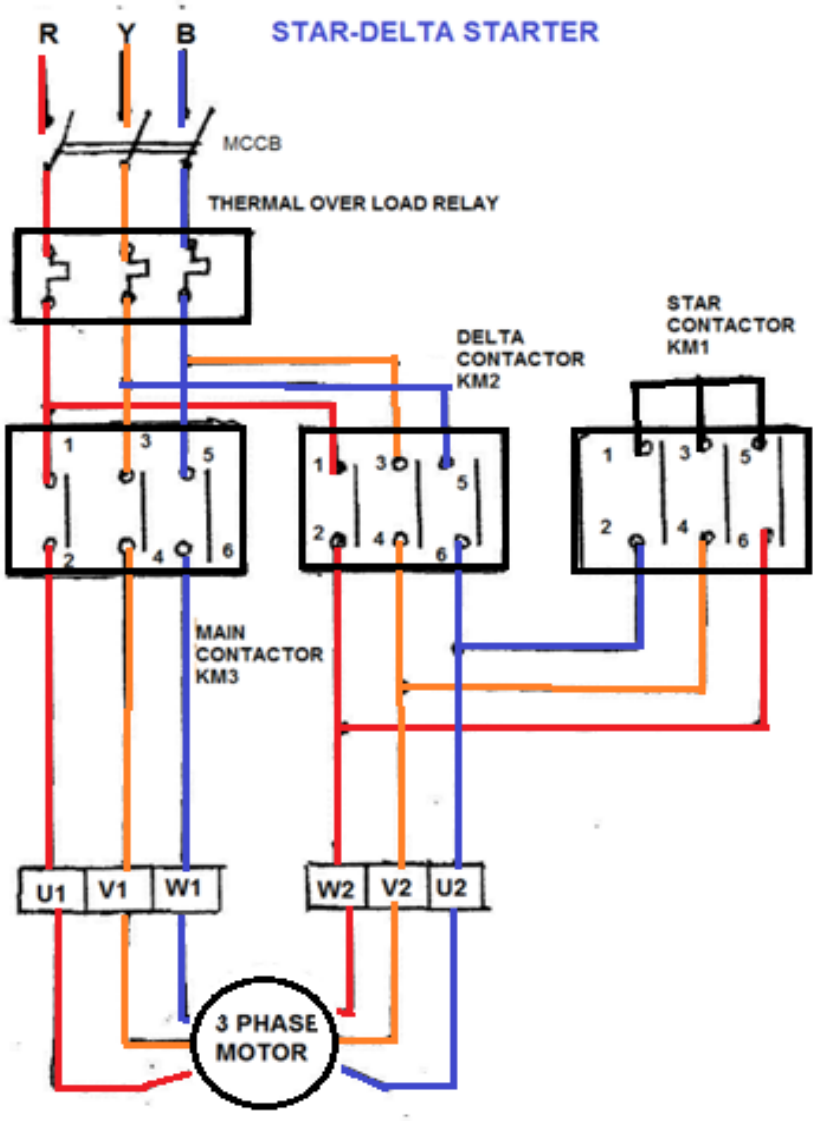


5- Operating Three phase motor as star-delta

In large motors with a capacity greater than 3kw, the starting current is large and thus affects the grid when it draws a high current. Using the conversion from Y to Δ the current decrease by one third as in the following equation.

$$I_Y = \frac{I_\Delta}{3}$$

the power circuit is shown in figure below



the control circuit is shown in figure below