- Answer all the following questions.
- Illustrate your answers with sketches if necessary.
- Number of questions: 4
- The exam consists of two pages.

Q.1 Write true or false with correcting the wrong statement ***(10 marks)***

1- When normally open type contacts are actuated, they disrupt the power supply through them. (F) closed

2- RAM, the type of memory which is fast and temporarily stores the data which are immediately required for use. (T)

3- Base 10 refers to binary coded decimal number system. (F) Decimal

4- In a PLC, the scan time refers to the amount of time in which the entire program takes to execute. (T)

5- Hardware test stand used to execute the I/Os of hardware devices in the field. (F) simulate

6- In PLC programming, a retentive function is one that is not reset after a power cycle. (T)

7- A HMI based simulator can be automate response for the command of a PLC program. (F) not automated

8- An OR function implemented in ladder logic uses Normally-open contacts in parallel. (T)

9- The latch circuit it maintain that state until another input is received. (T)

10- A switch or a pushbutton is a discrete input. (T)

11- The basic logic gate whose output is the complement of the input is the OR gate. (F) NOT

12- Cumulative addition of four bits (1 + 1 + 1 + 1) gives 1111. (F) 111

13- During programming the PLC should be in the Terminal mode. (T)

14- Term that refers to infinite no of values in range is Digital signal. (F) analog

15- Binary values are represented by values or ranges of values of physical quantities. (T)

16- Positive integer means encoding data into bits. (F) Data representation

17- Binary to Hex Conversion, four binary digits can be converted to three hexadecimal digit. (F) one

18- The I/O module units form the interface between the micro-electronics of the programmable controller and the real world outside. (T)

19- The power supply of the PLC executes the user-program over and over again when it is in the RUN mode. (F) CPU

20- One of the advantages of PLC is that it can be programmed by non-specialists. (T)

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Q.*2** ***(10 marks)

a) Explain briefly the main components of industrial control system.

1. Sensors and actuators:
   - allow interaction with the physical world (pressure sensor, valves, motors, …).
2. Local HMI:
   - Human-Machine Interface permits the supervision and control of a sub process.
3. PLC:
   - Programmable Logic Controller: manages the sensors and actuators
4. Supervision screen:
   - remote supervision of the industrial process.
5. Data historian:
   - Records all the data from the production and Scada networks and allows exporting to the corporate IS

b) Construct the power, control and ladder circuit diagrams for starting a 3-phase electric motor. Use light indicators to indicate the status of the motor.

- **PLC for motor starter It should have the following provisions:**

1. Push button: to start the motor, the motor should continue to rotate even when the push button is released.
2. Stop Push button: to halt the motor after it started.
3. Over current protection: In case of over load, the motor should stop automatically by the signal coming from contactors of overload relay.
4. Limit switch: It should prevent the motor from starting and can also stop the running motor.

5. The motor starter should also have indicator (Lights) to show ON or OFF status of motor.

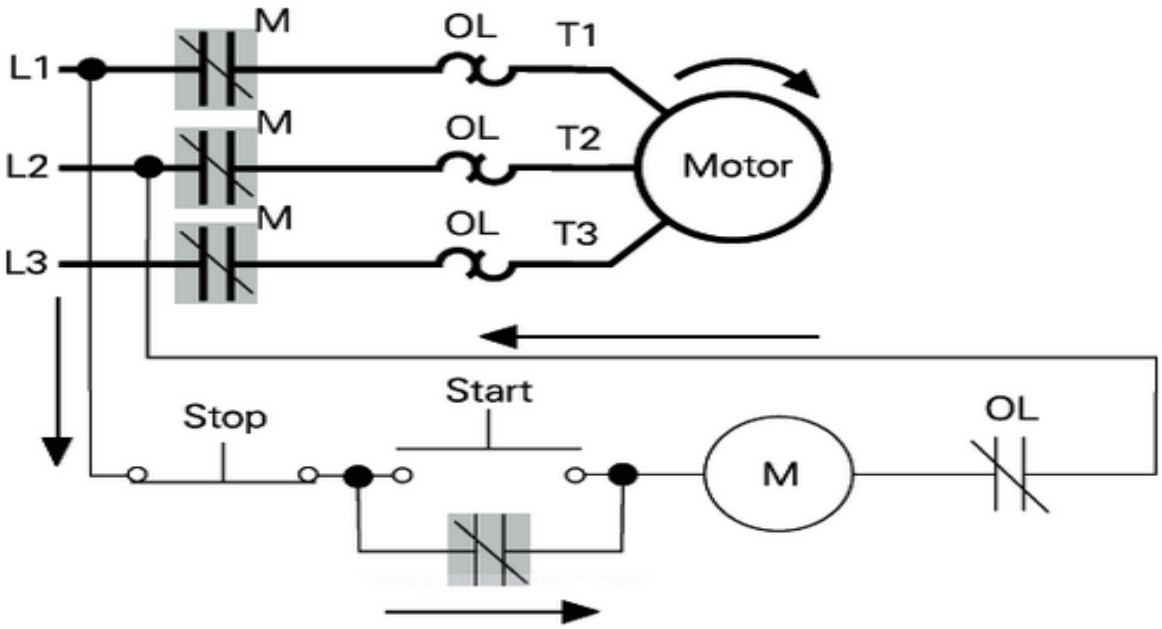
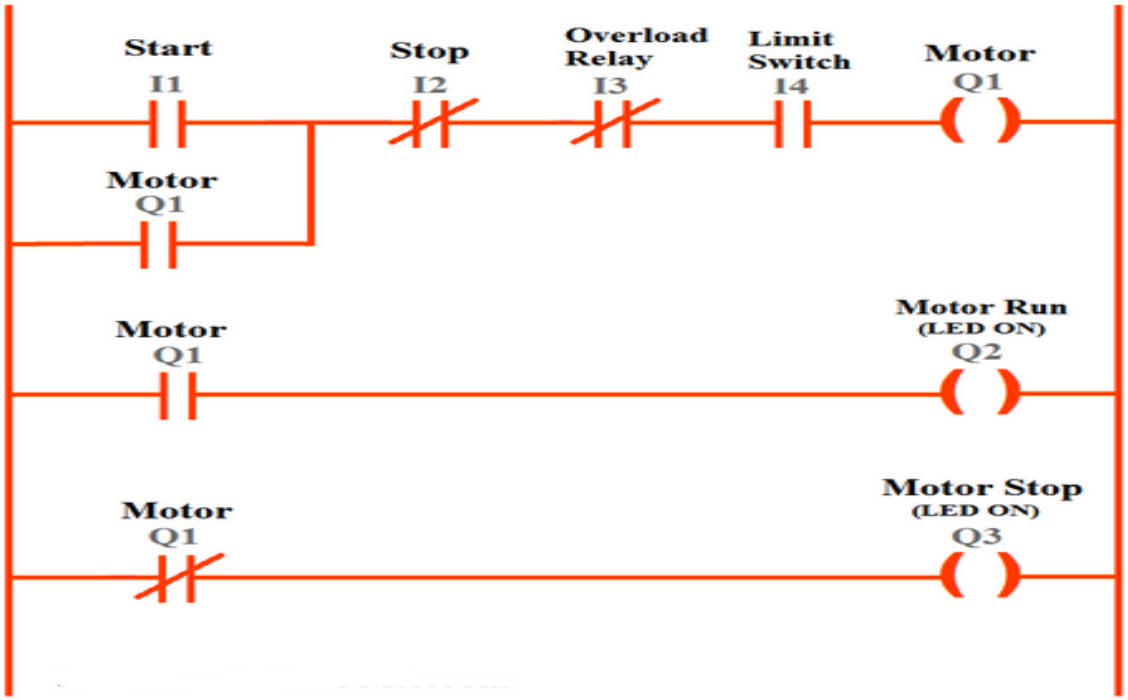


Figure (1): Motor Electrical Schematic



Ladder (1): Ladder diagram for Motor starter

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Q.*3** ***(10 marks)

a) Classify the sensors according to the type of energy they detect. Mention the factors which affect the selection of a suitable sensor to measure the desired physical parameter.

Types of sensors which are classified by the type of energy they detect

A. Thermal Sensors.
B. Mechanical Sensors.
C. Electrical Sensors.
D. Chemical Sensors.
E. Other sensors.

Selecting Criteria for Sensors

- A number of static and dynamic factors must be considered in selecting a suitable sensor to measure the desired physical parameter.
- **Following is a list of typical factors:**

a) Range: Difference between the maximum and minimum value of the sensed parameter.
b) Resolution: The smallest change the sensor can differentiate.
c) Accuracy: Difference between the measured value and the true value.
d) Precision: Ability to reproduce repeatedly with a given accuracy.
e) Sensitivity: Ratio of change in output to a unit change of the input.
f) Zero offset: A nonzero value output for no input.
g) Linearity: Percentage of deviation from the best-fit linear calibration curve.
h) Zero Drift: The departure of output from zero value over a period of time for no input.
i) Response time: The time lag between the input and output.

j) Bandwidth: Frequency at which the output magnitude drops by 3 dB.

k) Resonance: The frequency at which the output magnitude peak occurs.

l) Operating temperature: The range in which the sensor performs as specified.

m) Dead band: The range of input for which there is no output.

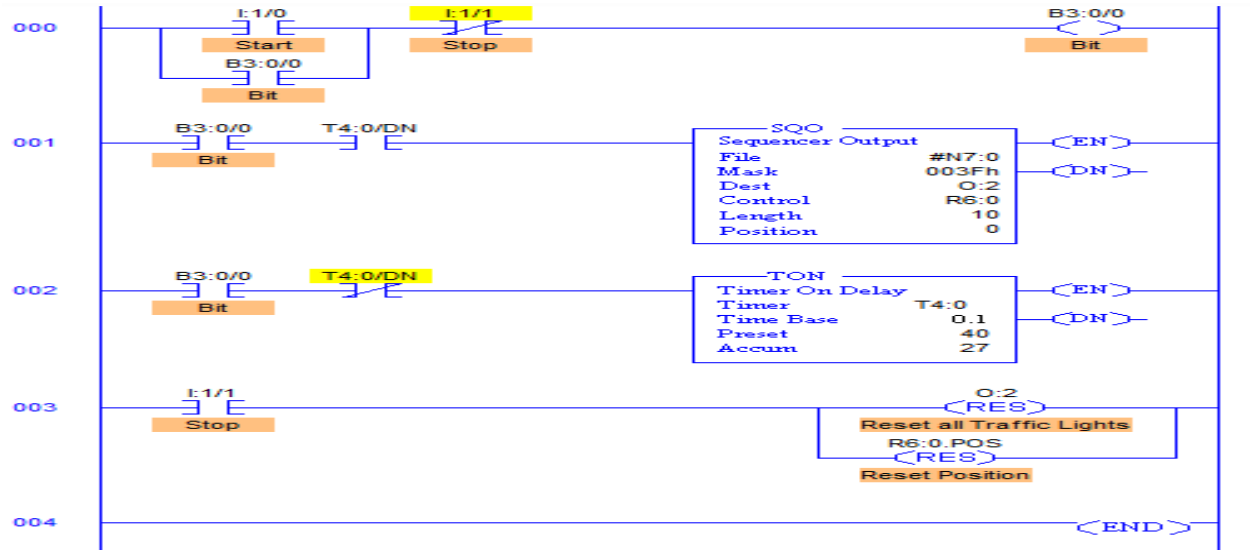
n) Signal-to-noise ratio: Ratio between the magnitudes of the signal and the noise at the output

b) Construct the ladder diagrams for the following control processes:

1- Traffic light as follows: 60 Sec. green, 5 Sec. yellow and 60 Sec. red.

- **List of I/P and O/P:**

```
List of Inputs and Outputs
 I:1/0   = Start                                    (Input)
 I:1/1   = Stop                                     (Input)
 B3:0/0  = Latched Coil Bit                         (Bit)
 T4:0    = Timer to update output sequence          (Timer)
 SQO     = Sequencer output                         (Sequencer)
 O:2/0   = North-South Green Light                  (Output)
 O:2/1   = North-South Yellow Light                 (Output)
 O:2/2   = North-South Red Light                    (Output)
 O:2/3   = East-West Green Light                    (Output)
 O:2/4   = East-West Yellow Light                   (Output)
 O:2/5   = East-West Red Light                      (Output)
```

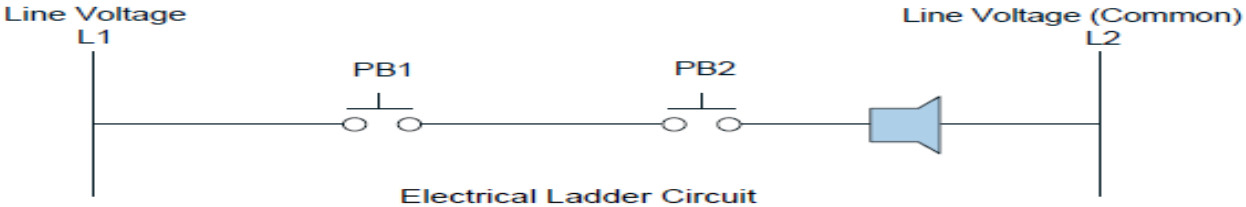


Ladder Diagram to control Traffic Light

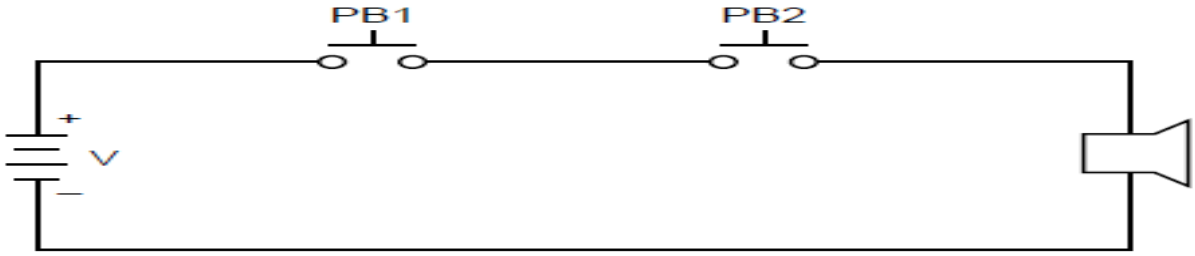
2- Cutting machine using two switches in series.

Logic Representation

PB1	PB2	Alarm Horn
Not pushed (0)	Not pushed (0)	Silent (0)
Not pushed (0)	Pushed (1)	Silent (0)
Pushed (1)	Not pushed (0)	Silent (0)
Pushed (1)	Pushed (1)	Sounding (1)

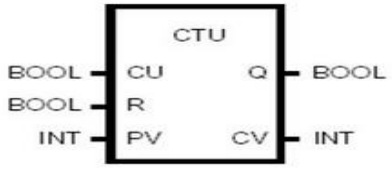


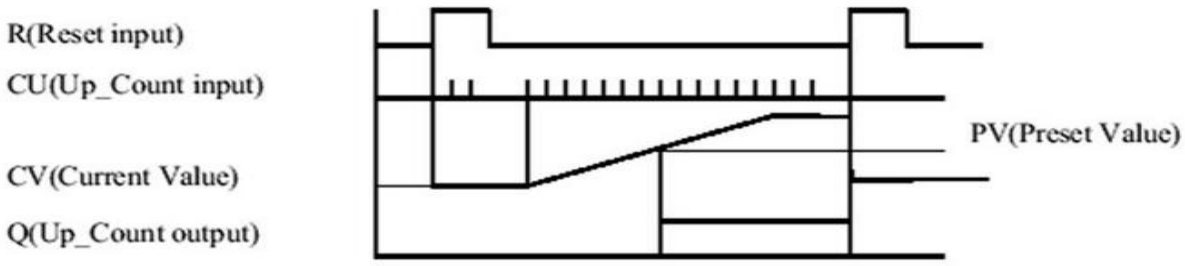
Electrical Ladder Circuit



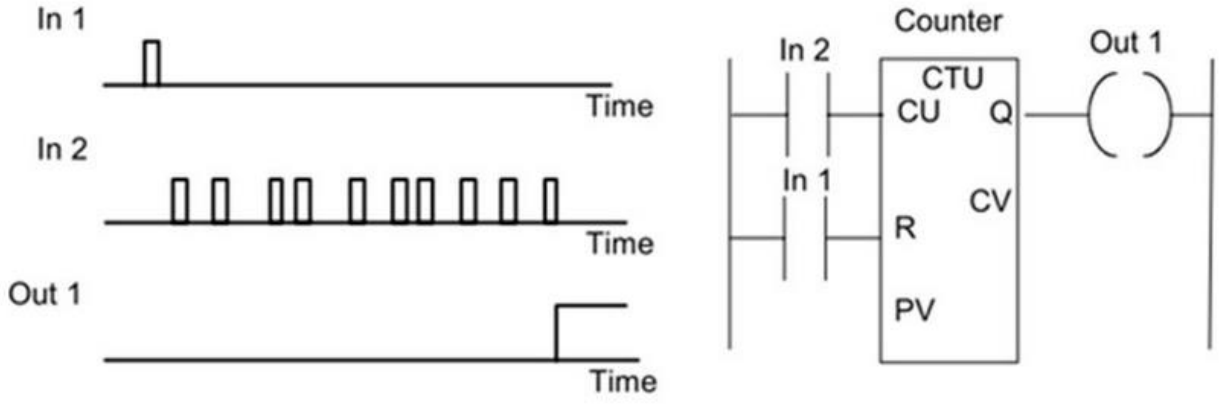
Electrical Circuit

3- Count-up process where output will turn on after the input switch has been closed 15 times. Use push button to reset the counter.

Function	Description
	**Input** CU : Up_Count pulse input R : Reset input PV : Preset Value **Output** Q : Up_Count output CV : Current Value



- **PV** (preset value) is the count value to be stored in the counter.
- Up counter CTU increases **CV** (current value) by 1 when input **CU** changes from 0 to 1 (i.e. positive edge).
- Output **Q** is 1 when **CV** ≥ **PV**.
- When reset input **R** is 1, **CV** is cleared (becomes 0).



Basic counter program

In this example, **Out1** will turn on after switch **In2** has been closed 10 times. Push button **In1** will reset the counters.

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Q.*4** ***(10 marks)

a) Explain briefly the various PLC testing methods.

1. **Hardware test stand**

Hardware test stand used to simulate the I/Os of hardware devices in the field.

Typical hardware Test Stand.

2. **Human Machine Interface (HMI) Based Simulator**

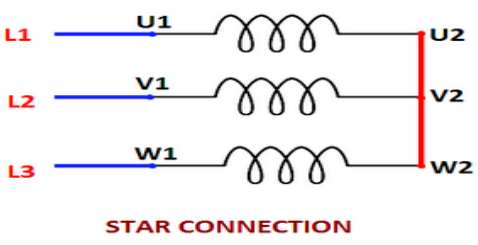
- ☐ Another approach that is often used for simulating the PLC I/Os is a HMI based software simulation.
- ☐ In this approach, a HMI control screen is developed and used for the PLC I/O simulation. The HMI control screen can be made as a SCADA system screen or a standalone Operator Terminal screen.
- ☐ it is still a manual simulation and it's time-consuming to make the I/O simulation screens themselves.
- ☐ A HMI based simulator can be used to test all functions of a PLC program. But the timing between a command and the response for the command is not automated.

3. **New approach "virtual" simulator**

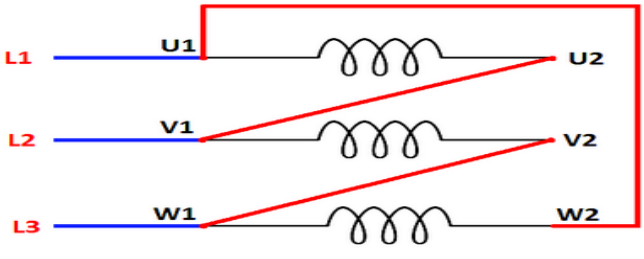
This research proposes an automated testing tool that can simulate the PLC I/O signals via "virtual" wires and automate the test execution. There are no physical hard wires connected between LogixPlcTester and the PLC being tested. This tool helps PLC software developers and testers test PLC programs during the entire software development stage and the testing stage. It can be used for both unit testing and system testing. The goal of this tool is to assure quality of PLC programs and to deliver reliable PLC programs for industrial control systems.

b) Construct the power, control and ladder circuit diagrams for starting a 3-phase electric motor using Star/Delta method.

- **Objective:**
- In DC motors there is no back emf at starting therefore initial current is very high as compared to the normal current.
- To protect the motor from these high starting currents we use a star and delta starter.
- Simply in Star connection, supply voltage to motor will be less. so, we use star connection during starting of the motor, after motor running we will change the connection form star to delta to gain full speed of the motor.
- in the tank are sensed by the level sensor switches.
- The following figure shows the winding connections in star and delta configuration one by one.

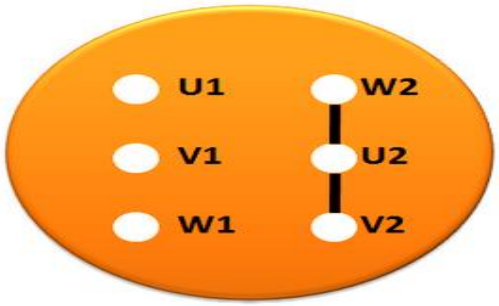


STAR CONNECTION

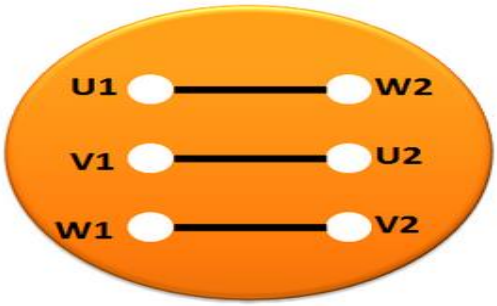


DELTA CONNECTION

- In star connection, one end of all three windings are shorted to make star point while other end of each winding is connected to power supply.
- In delta configuration, the windings are connected such that to make a close loop.
- The connection of each winding is shown in above figure. In actual motor the three phase connections are provided in the following order as shown

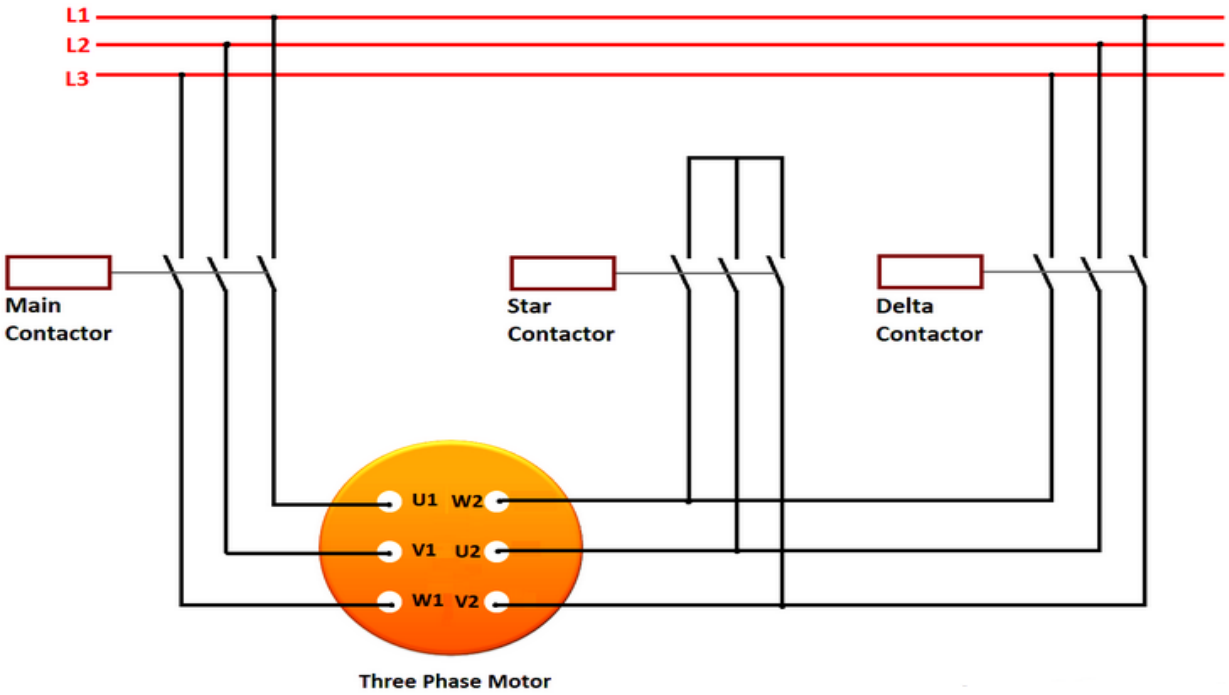


STAR CONNECTION

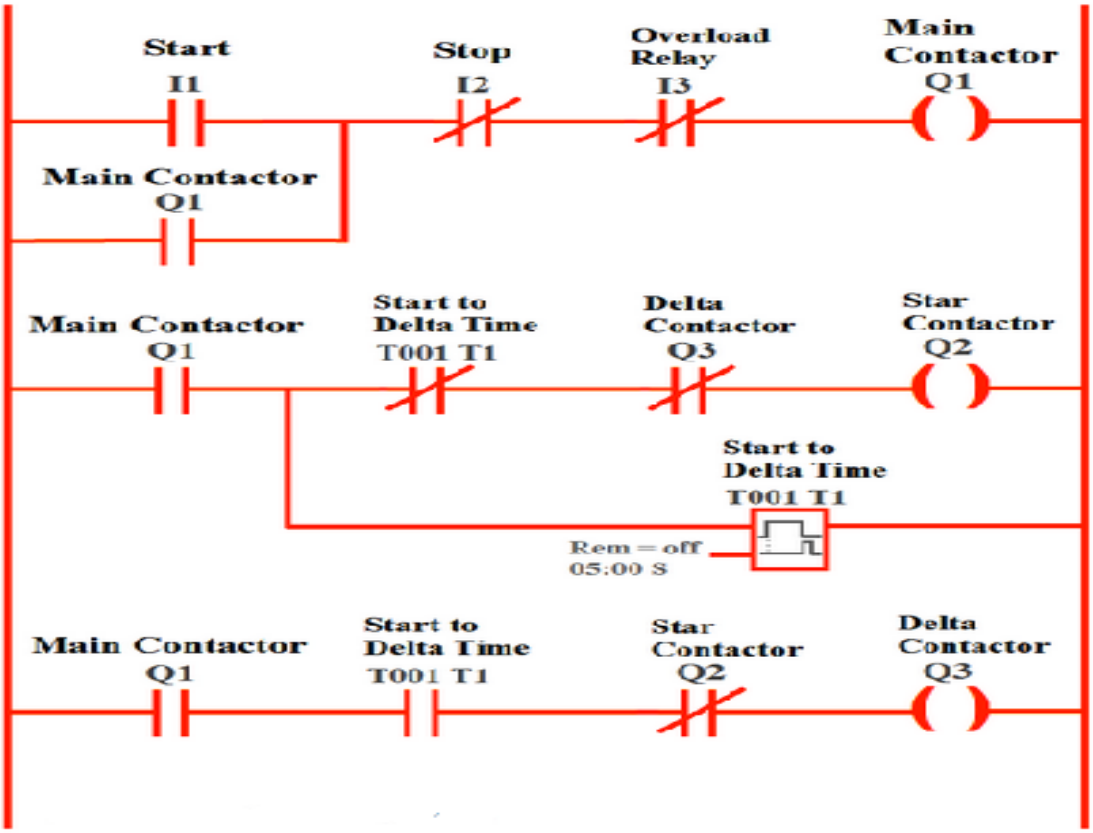


DELTA CONNECTION

- winding connection in star and delta style in practical motor



- PLC program for star delta motor starter:



- **Observation: -**

1. **Rung 1 Main contactor:**

- The main contactor depends upon the normally open input start push button (I1), normally closed stop button (I2) and normally closed overload relay.
- It means that Main contactor will only be energized if start button is pressed, while stop is not pressed and overload relay is not activated.
- A normally open input named (Q1) is added in parallel to the start button I1.
- By doing so, a push button is created which means that once motor is started, it will be kept started even if start button is released

2. **Rung 2 Star contactor:**

- Star contactor depends upon main contactor, normally close contacts of timer (T1), and normally close contacts of output delta contactor (Q3).
- So, star contactor will only be energized if main contactor is ON, time output is not activated and delta contactor is not energized.
- **Timer T1:**

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- Timer T1 measures the time after which the winding connection of star delta starter is to be changed. It will start counting time after main contactor is energized.

3. **Rung 3 Delta contactor:**

- Delta contactor will be energized when main contactor (Q1) is energized, timer T1 is activated and star contactor (Q3) is de-energized.