Experiment 12

Star Delta Motor Starter by PLC

Theory

Most three phase (3-ph) induction motors are started directly on line, but when large motors (>5 HP) are started that way, they cause a disturbance of voltage on the supply lines due to large starting current surges. To limit the starting current surge, large induction motors are started at reduced voltage and then have full supply voltage reconnected when they run up to near rotated speed. The high starting current will produce severe a voltage drop and will affect the operation of other equipment. It is not desirable to start large motors direct on line (giving full voltage to the stator). For reduction in the starting current, a lower voltage is applied to the stator, especially for the squirrel cage induction motors. Full voltage is only applied when the motor picks up speed.

Supply reliability and reserve power generation dictates the use of reduced voltage or not to reduce the starting current of an induction motor, the voltage across the motor need to be reduced. This can be done by: i) Auto transformer starter, ii) Star-delta starter or iii) Resistor starter. For this experiment we are concerned just about Star/Delta starter for 3-ph induction motors.

Simple motor starter needs to be reviewed before getting into the process of Star/Delta starter.

Simple motor starter

Motor starters are of many types however the scope of this experiment is confined to simple motor starter.

It should have the following provisions.

- Push button to start the motor: The motor should continue to rotate even when the push button is released.
- Stop Push button to halt the motor after it started.
- Over current protection: In case of over load, the motor should stop automatically by the signal coming from contactors of overload relay.
- Limit switch: It should prevent the motor from starting and can also stop the running motor.
- The motor starter should also have indicator (Lights) to show ON or OFF status of motor.

Figure 1 shows the physical layout of motor starter however this would be designed through ladder logic in this experiment. The figure does not show limit switch because it depends on external interlock like say level switch, flow switch, pressure switch…etc depending on application. Figure 2 shows the ladder diagram for motor starter.

- I1 normally open contact (Make contact) is used because the motor should only start when the button is pressed.

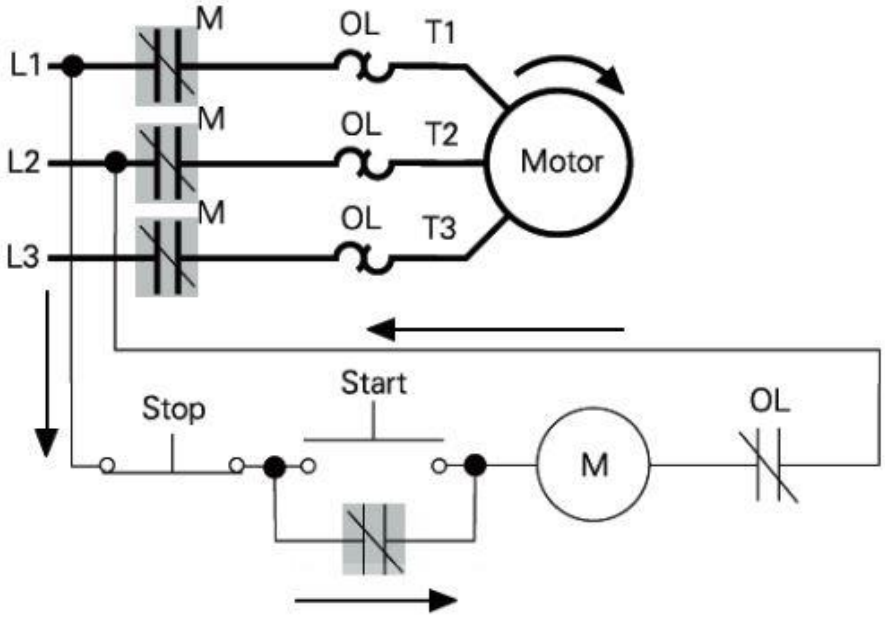

Fig. 1 Motor Starter

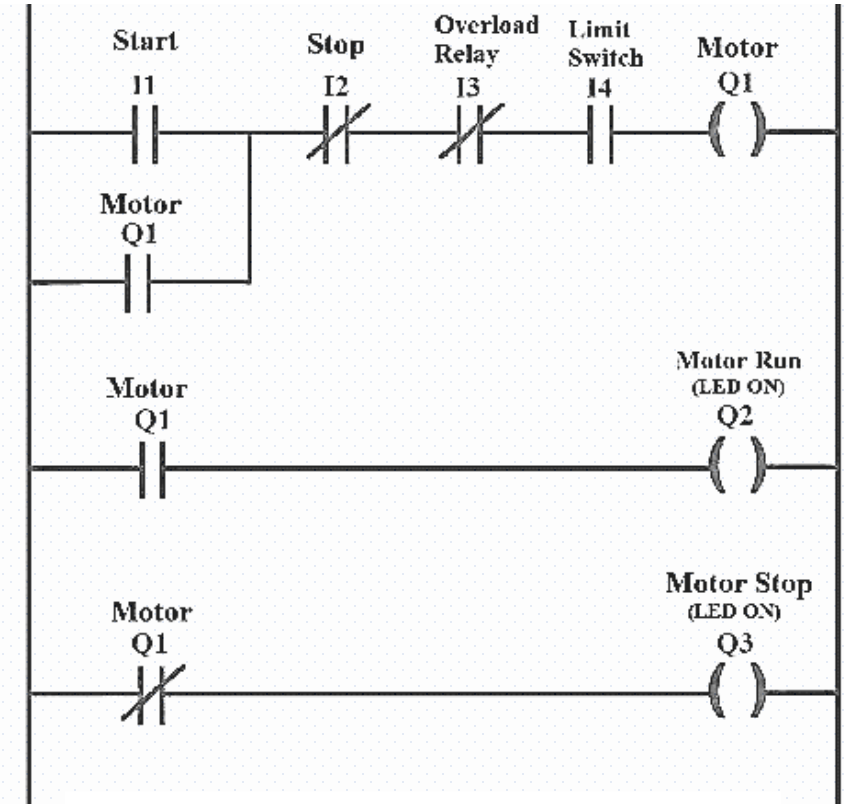

Fig.2 Ladder diagram for Motor starter

- I2 normally close (break contact) contact is used because the button should normally be closed or high so that the motor keeps on running. It should open when the button is pressed. It is opposite to start push button.

- I3 in normal condition, this relay should allow the motor to rotate so normally close contact is selected for it. In case of overload it will stop the motor by opening its contact.

- I4 the motor should only rotate when the limit switch is closed therefore normally open contact is used.

- Relay coil Q1, Q2 and Q3 represent motor output, motor indication ON and OFF respectively. ON indicator gets input from normally open input which depends upon output Q1. OFF indicator is fed by normally close input which depends upon output Q2.

Since it is required that once push button is pressed, motor should run continuously even if the push button is released. To achieve this part, an input Q1 (normally open) is used and connected in parallel with I1. This input depends upon output Q1. When output is high, input Q1 is also high. Since input Q1 provides parallel path with I1, so if any of them is to be high, motor will run (if other conditions are also satisfied). Start button (Normally open), stop button (Normally close), overload relay (Normally close) and limit switch (Normally open) are connected in series. So, the motor will run if start button is pushed, stop button is not pressed, overload relay is not picked, and limit switch is closed.

Star/Delta starters

Star/Delta starters are probably the most common reduced voltage starters. They are used to reduce the start current applied to the motor during start as a means of reducing the disturbances and interference on the electrical supply. Figure 3 shows the winding connections in star and delta configuration one by one.

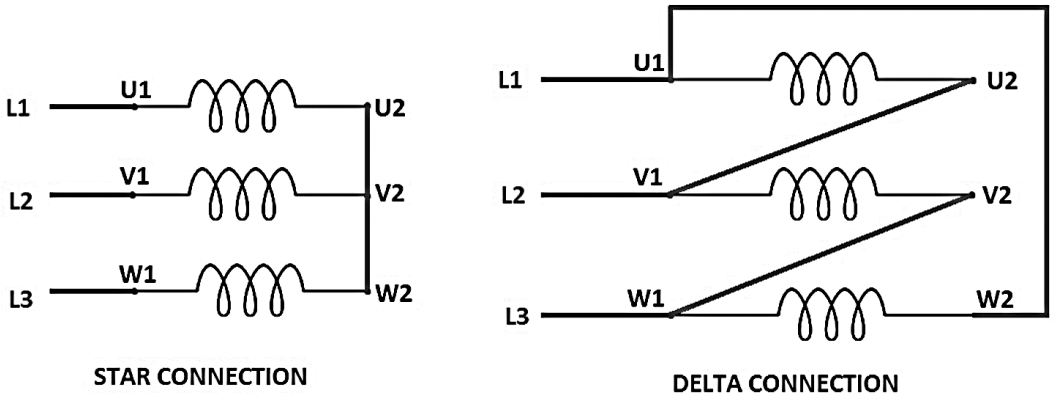

Fig.3 Star and Delta Configuration

It can be seen that 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 in figure 4.

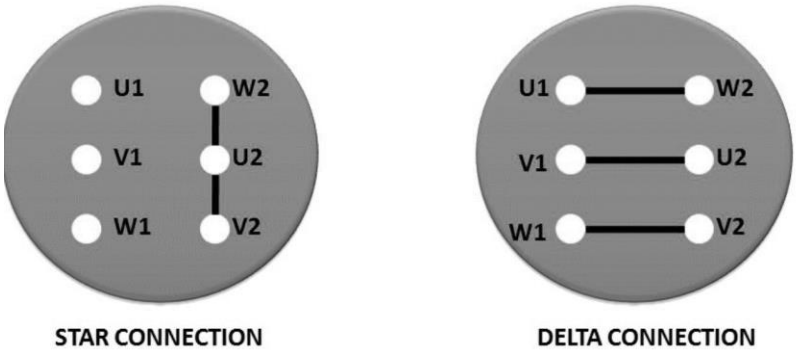

Fig.4 Motor Terminals Connections in Star and Delta Configuration

Figure 5 shows the diagram of Star/Delta starter using contactors. Main contractor is used to supply power to the windings. It must be turned on all the time. Initially the star contactor is closed while delta contactor is open It makes the motor windings in star configuration. When the motor gains speed, the star contactor is opened while delta contactor is closed turning the motor windings into delta configuration.

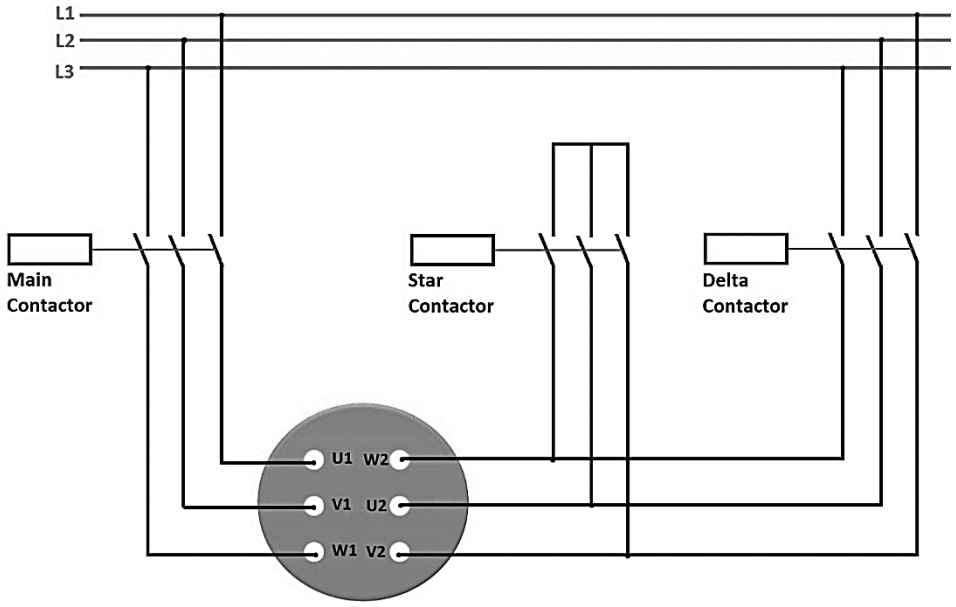

Fig.5 Star/Delta starter by Contactors

When the motor gains speed, the star contactor is opened while delta contactor is closed turning the motor windings into delta configuration. The contactors are controlled by using PLC as shown in figure 6.

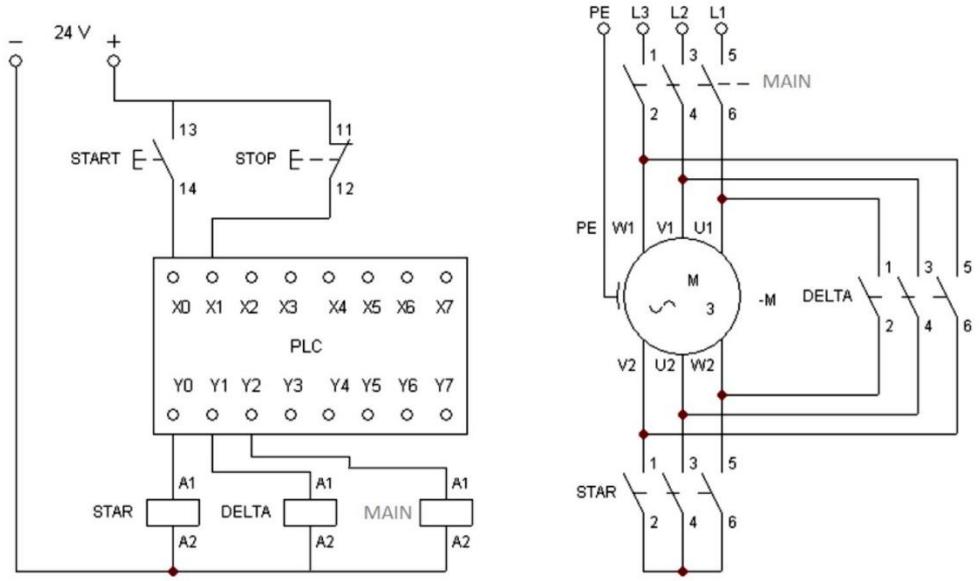

Fig.6 PLC Controlling the Contactors

Ladder Program

After wiring the PLC we need to program it by the suitable ladder logic as shown in figure 7.

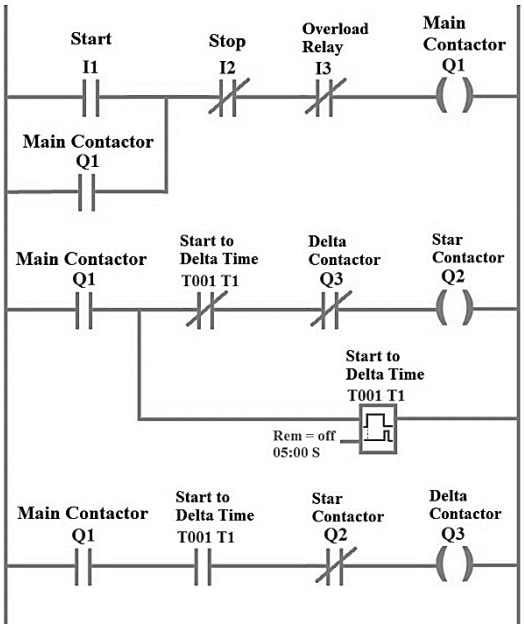

Fig.6 Ladder diagram for star/delta starter

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

Procedure

1) Connect the circuit in figure 1 and wire the plc.
2) Write the ladder for step 1, which is shown in figure 2 and upload it to the plc.
3) Run the system and observe the operation.
4) Repeat step 1, 2, 3 & 4 for the circuit in figure 6 & 7.