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PLC AUTOMATION OF STAR DELTA STARTER FOR USING INDUCTION MOTOR

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ABSTRACT: In this project the basic concepts of Programmable logic controller (PLC) and its applications are discussed. The hardware set up of 3 phase star delta starting of induction motor using PLC is implemented. Both the description of hardware and software is presented in this project. The flexibility and efficient controllability of plc helps in the growth of automation. Most induction motors are started directly on line, but when very large motors 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.

I. INTRODUCTION

Monitoring and inspection of several processes is becoming dominant part of the automation technique in any industry. So the automation is basically the delegation of human control function to technical equipments for increasing productivity and quality, reducing costs, increasing safety in working conditions. PLC forms one of the computerized machines and hence regarded as the heart of automated control system. The first PLC came into existence which was MODICON 084" and since the Dick Morley was one of the dedicated members working with the association so he is credited with the invention of PLC and known as "father of PLC". The product range now has been extended to 984 in its appearance. Earlier sequencers, cam timers, electromechanical relays were used for controlling and interlocking purposes. The control panel consists of thousands of wires which interconnects many relays to operate the various machines. So in case of error, machines have to be stopped and complete rewiring is required which is not only hectic job but also costs more. Also time was wasted in finding out errors and even distance control was not possible. Because of such problems the relays were replaced by PLCs. The control diagram for star delta starting of three phase induction motor for forward as well as reverse direction. The Star Delta starting method is a motor starting mechanism that minimizes the large amount of starting current that motors draw in. The Star Delta, as the name suggests basically involves feeding the motor with 1/√3 (58%) of the full load current until it attains speed then applying the full load current. It is required three contactors i.e., the Star Contactor (K3), the Delta Contactor (K4) and the Main Contactor (K1). However for the motor to be started in Star Delta, its internal connection at the terminal box has to be wired in Delta-giving it capability of receiving the full-load current at any instant. When the power is fed into the circuit, K1 allows current to flow to the motor. Current flows into the motor and out to the K3 which is the star-connected starter. After a specified period defined by the clock delay (usually 5 sec) the K4 (Delta) Closes and K3 opens to allow the motor to receive the full load current and run at delta. Traditionally, in many regions there was a requirement that all motor connections be fitted with a reduced voltage starter for motors greater than 4KW (5HP).This was to curb the high inrush of starting currents associated with starting induction motors. The star and delta contactors are mechanically interlocked i.e., if one of them is closed the other cannot close. This is done to avoid dead short circuit in case both the contactors closing simultaneously. Electrical interlocking has also been provided, by using contactors control contacts. An advantage of this method could be low or reduced cost as compared to other method

II. WORKING PRINCIPLE OF STAR DELTA STARTER

This is the reduced voltage starting method. Voltage reduction during star-delta starting is achieved by physically reconfiguring the motor windings as illustrated in the figure below. During starting the motor windings are connected in star configuration and this reduces the voltage across each winding 3. This also reduces the torque by a factor of three.

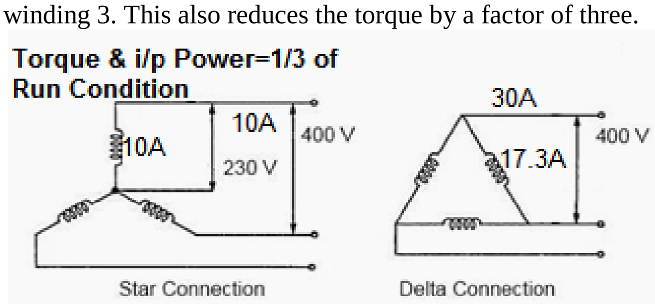


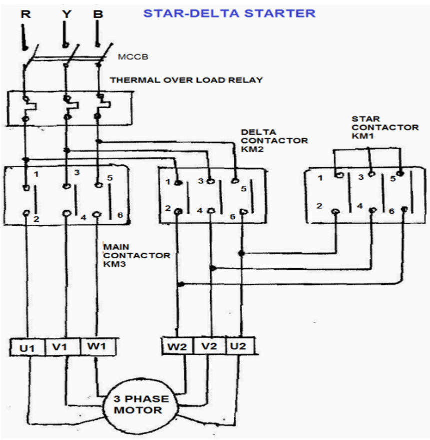
Fig 1. Working Principle of Star-Delta Starter

After a period of time the winding are reconfigured as delta and the run motor normally. Star/Delta starters are probably the most common reduced voltage starters. They are used in an attempt to reduce the start current applied to the motor during start as a means of reducing the disturbances and interference on the electrical supply. Traditionally in many supply regions, there has been a requirement to fit a reduced voltage starter on all motors greater than 5HP (4KW). The Star/Delta (or Wye/Delta) starter is one of the lowest cost electromechanical reduced voltage starters that can be applied. The Star/Delta starter is manufactured from three contactors, a timer and a thermal overload. The contactors are smaller than the single contactor used in a Direct on Line starter as they are controlling winding currents only. The currents through the winding are 1/root 3 (58%) of the current in the line. There are two contactors that are close during run, often referred to as the main contractor and the delta contactor. These are AC3 rated at 58% of the current rating of the motor. The third contactor is the star contactor and that only carries star current while the motor is connected in star. The current in star is one third of the current in delta, so this contactor can be AC3 rated at one third (33%) of the motor rating.

2.1 Star-delta Starter Consists following units

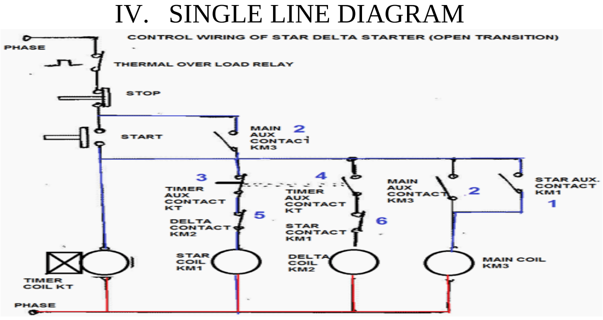
- Contactor (Main, star and delta contactors) 3 No's (For Open State Starter) or 4 No's (Close Transient Starter).
- Time relay (pull-in delayed).
- Three-pole thermal over current release.
- Fuse elements or automatic cut-outs for the main circuit.
- Fuse element or automatic cu t-out for the control circuit.

III. POWER CIRCUIT DIAGRAM



The main circuit breaker serves as the main power supply switch that supplies electricity to the power circuit. The main contactor connects the reference source voltage R, Y, B to the primary terminal of the motor U1, V1, and W1. In operation, the Main Contactor (KM3) and the Star Contactor (KM1) are closed initially, and then after a period of time, the star contactor is opened, and then the delta contactor (KM2) is closed. The control of the contactors is by the timer (K1T) built into the starter. The Star and Delta are electrically interlocked and preferably mechanically interlocked as well.

IV. SINGLE LINE DIAGRAM



Circuit of Star-Delta Starter (Open Transition)

The ON push button starts the circuit by initially energizing Star Contactor Coil (KM1) of star circuit and Timer Coil (KT) circuit. When Star Contactor Coil (KM1) energized, Star Main and Auxiliary contactor change its position from NO to NC. When Star Auxiliary Contactor (1) (which is placed on Main Contactor coil circuit) become NO to NC it's complete The Circuit of Main contactor Coil (KM3) so Main Contactor Coil energized and Main Contactor's Main and Auxiliary Contactor Change its Position from NO to NC. This sequence happens in a friction of time.After pushing the ON push button switch, the auxiliary contact of the main contactor coil which is connected in parallel across the ON push button will become NO to NC, thereby providing a latch to hold the main contactor coil activated which eventually maintains the control circuit active even after releasing the ON push button switch. When Star Main Contactor (KM1) close its connect Motor connects on STAR and it's connected in STAR until Time Delay Auxiliary contact KT (3) become NC to NO. Once the time delay is reached its specified Time, the timer's auxiliary contacts (KT)(3) in Star Coil circuit will change its position from NC to NO and at the Same Time Auxiliary contactor (KT) in Delta Coil Circuit(4) change its Position from NO To NC so Delta coil energized and Delta Main Contactor becomes NO To NC. Now Motor terminal connection change from star to delta connection. A normally close auxiliary contact from both star and delta contactors (5&6)are also placed opposite of both star and delta contactor coils, these interlock contacts serves as safety switches to prevent simultaneous activation of both star and delta contactor coils, so that one cannot be activated without the other deactivated first. Thus, the delta contactor coil cannot be active when the star contactor coil is active, and similarly, the star contactor coil cannot also be active while the delta contactor coil is active. The control circuit above also provides two interrupting contacts to shutdown the motor. The OFF push button switch break the control circuit and the motor when necessary. The thermal overload contact is a protective device which automatically opens the STOP Control circuit in case when motor overload current is detected by the thermal overload relay, this is to prevent burning of the motor in case of excessive load beyond the rated capacity of the motor is detected by the thermal overload relay. At some point during starting it is necessary to change from a star connected winding to a delta connected winding. Power and control circuits can be arranged to this in one of two ways – open transition or closed transition.

V. 3 PHASE SQUIRREL CAGE INDUCTION MOTAR OBJECTIVE

The aim of this chapter is to gather knowledge about the following topics of

Induction motors.

1. Construction, types and principle of operation of 3-phase induction motors.
2. Equivalent circuit of 3-phase induction motor.
3. The performance calculation by means of finding torque, slip and efficiency.
4. Different types of starters like auto-transformer starter, star-delta starter.

5. Various methods of speed control 3-phase induction motor.
6. Principle of operation of single phase induction motor

INTRODUCTION

An induction (IM) is a type of asynchronous AC motor where power is supplied to the rotating device by means of electromagnetic induction. The induction motor with a wrapped rotor was invented by Nikola Tesla Nikola Tesla in 1882 in France but the initial patent was issued in 1888 after Tesla had moved to the United States. In his scientific work, Tesla laid the foundations for understanding the way the motor operates. The induction motor with a cage was invented by Mikhail Dolivo-Dobrovolsky about a year later in Europe. Technological development in the field has improved to where a 100 hp (74.6 kW) motor from 1976 takes the same volume as a 7.5 hp (5.5 kW) motor did in 1897. Currently, the most common induction motor is the cage rotor motor. An electric motor converts electrical power to mechanical power in its rotor (rotating part). There are several ways to supply power to the rotor. In a DC motor this power is supplied to the armature directly from a DC source, while in an induction motor this power is induced in the rotating device. An induction motor is sometimes called a rotating transformer because the stator (stationary part) is essentially the primary side of the transformer and the rotor (rotating part) is the secondary side. Induction motors are widely used, especially polyphase induction motors, which are frequently used in industrial drives. Induction motors are now the preferred choice for industrial motors due to their rugged construction, absence of brushes (which are required in most DC motors) and the ability to control the speed of the motor.

CONSTRUCTION

A typical motor consists of two parts namely stator and rotor like other type of motors.
1. An outside stationary stator having coils supplied with AC current to produce a rotating magnetic field,
2. An inside rotor attached to the output shaft that is given a torque by the rotating
field.

Stator construction

The stator of an induction motor is laminated iron core with slots similar to a
Stator of a synchronous machine. Coils are placed in the slots to form a three or single
Phase winding.

Type of rotors

Rotor is of two different types.
1. Squirrel cage rotor
2. Wound rotor

Squirrel-Cage Rotor

In the squirrel cage rotor winding consists of single copper or aluminum bars placed in the slots and short-circuited by end-rings on both sides of the rotor. Most of single phase induction motors have Squirrel-Cage rotor. One or 2 fans are attached to the shaft in the sides of rotor to cool the circuit.

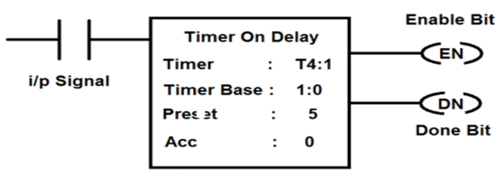
Wound Rotor

In the wound rotor, an insulated 3-phase winding similar to the stator winding wound for the same number of poles as stator is placed in the rotor slots. The ends of the star-connected rotor winding are brought to three slip rings on the shaft so that a connection can be made to it for starting or speed control. It is usually for large 3 phase induction motors.
Rotor has a winding the same as stator and the end of each phase is connected to a
slip ring. Compared to squirrel cage rotors, wound rotor motors are expensive and require
Maintenance of the slip rings and brushes, so it is not so common in industry applications.

PRINCIPLE OF OPERATION

An AC current is applied in the stator armature which generates a flux in the stator magnetic circuit. This flux induces an emf in the conducting bars of rotor as they are “cut” by the flux while the magnet is being moved (E = BVL (Faraday’s Law)) A current flows in the rotor circuit due to the induced emf, which in term produces a force, (F = BIL) can be changed to the torque as the output. In a 3-phase induction motor, the three-phase currents ia, ib and ic, each of equal magnitude, but differing in phase by 120°. Each phase current produces a magnetic flux and there is physical 120 °shift between each flux. The total flux in the machine is the sum of the three fluxes. The summation of the three ac fluxes results in a rotating flux, which turns with constant speed and has constant amplitude. Such a magnetic flux produced by balanced three phase currents flowing in three-phase windings is called a rotating magnetic flux or rotating magnetic field (RMF).RMF rotates with a constant speed (Synchronous Speed). Existence of a RFM is an essential condition for the Operation of an induction motor. If stator is energized by an ac current, RMF is generated due to the applied current to the stator winding. This flux produces magnetic field and the field revolves in the air gap between stator and rotor. So, the magnetic field induces a voltage in the short-circuited bars of the rotor. This voltage drives current through the bars. The interaction of the rotating flux and the rotor current generates a force that drives the motor and a torque is developed consequently. The torque is proportional with the flux density and the rotor bar current (F=BLI). The motor speed is less than the synchronous speed. The direction of the rotation of the rotor is the same as the direction of the rotation of the revolving magnetic field in the air gap. However, for these currents to be induced, the speed of the physical rotor and the speed of the rotating magnetic field in the stator must be different, or else the magnetic field will not be moving relative to the rotor conductors and no currents will be induced. If by some chance this happens, the rotor typically slows slightly until a current is reinduced and then the rotor continues as before. This difference between the speed of the rotor and speed of the rotating magnetic field in the stator is called slip. It is unitless and is the ratio between the relative speed of the magnetic field as seen by the rotor the speed of the rotating stator field. Due to this an induction motor is sometimes referred to as an asynchronous machine.

TIMER INTRODUCTION
There are four fundamental types of timers shown in Figure 101. An on-delay timer will wait for a set time after a line of ladder logic has been true before turning on, but it will turn off immediately. An off-delay timer will turn on immediately when a line of ladder logic is true, but it will delay before turning off. Consider the example of an old car. If you turn the key in the ignition and the car does not start immediately, that is an on-delay. If you turn the key to stop the engine but the engine doesn't stop for a few seconds, that is an off delay. An on-delay timer can be used to allow an oven to reach temperature before starting production. An off delay timer can keep cooling fans on for a set time after the oven has been turned off. The Four Basic Timer Types A retentive timer will sum all of the on or off time for a timer, even if the timer never finished. A non retentive timer will start timing the delay from zero each time. Typical applications for retentive timers include tracking the time before maintenance is needed. A non retentive timer can be used for a start button to give a short delay before a conveyor begins moving. An example of an Allen-Bradley TON timer is shown in Figure 102. The rung has a single input A and a function block for the TON. (Note: This timer block will look different for different PLCs, but it will contain the same information.) The information inside the timer block describes the timing parameters. The first item is the timer 'example'. This is a location in the PLC memory that will store the timer information. The preset is the millisecond delay for the timer, in this case it is 4s (4000ms). The accumulator value gives the current value of the timer as 0. While the timer is running the accumulated value will increase until it reaches the preset value. Whenever the input A is true the EN output will be true. The DN output will be false until the accumulator has reached the preset value. The EN and DN outputs cannot be changed when programming, but these are important when debugging a ladder logic program. The second line of ladder logic uses the timer DN output to control another output .
On Delay Timer



An Allen-Bradley TON Timer
The timing diagram in Figure 102 illustrates the operation of the TON timer with a 4 second on delay. A is the input to the timer, and whenever the timer input is true the EN enabled bit for the timer will also be true. If the accumulator value is equal to the preset value the DN bit will be set.
Note: For the older Allen-Bradley equipment the notations are similar, although the tag names are replaced with a more strict naming convention. The timers are kept in 'files' with names starting with 'T4:', followed by a timer number. The examples below show the older (PLC-5 and micrologix notations compared to the new RS-Logix (5000) notations. In the older PLCs the timer is given a unique number, in the RS Logix 5000 processors it is given a tag name (in this case 't') and type the TT bit will be set and the accumulator value will begin increasing. The first time A is true, it is only true for 3 seconds before turning off, after this the value resets to zero. (Note: in a retentive time the value would remain at 3 seconds.) The second time A is true, it is on more than 4 seconds. After 4 seconds the TT bit turns off, and the DN bit turns on. But, when A is released the accumulator resets to zero, and the DN bit is turned off. A value can be entered for the accumulator while programming. When the program is downloaded this value will be in the timer for the first scan. If the TON timer is not enabled the value will be set back to zero. Normally zero will be entered for the preset value. The timer in is identical to that in , except that it is retentive. The most significant difference is that when the input A is turned off the accumulator value does not reset to zero. As a result the timer turns on much sooner, and the timer does not turn off after it turns on. A reset instruction will be shown later that will allow the accumulator to be reset to zero. An Allen Bradley Retentive On-Delay Timer An off delay timer is shown in Figure 104. This timer has a time base of 0.01s, with a preset value of 3500, giving a total delay of 3.5s. As before the EN enable for the timer matches the input. When the input A is true the DN bit is on. Is is also on when the input A has turned off and the accumulator is counting. The DN bit only turns off when the input A has been off long enough so that the accumulator value reaches the preset. This type of timer is not retentive, so when the input A becomes true, the accumulator resets.

Programmable Logic Controller

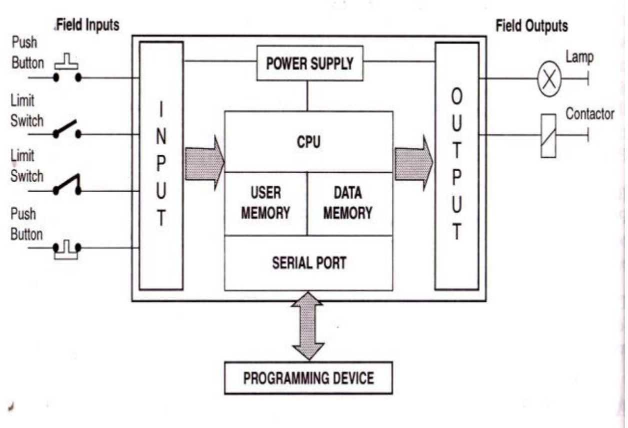


Fig.4 programmable logic controller

OBJECTIVES
After successfully completing this laboratory, you should be able to:
1. To convert a simple electrical ladder diagram to a PLC program.
2. Know the difference between physical components and program components.

3. Sketch the ladder programs using the tools available in WPLSoft.
4. Download the program to the PLC.
5. Operate the program, via placing the PLC in the RUN mode.

INTRODUCTION
PLCs are special computers designed to operate in the industrial environment with wide ranges of ambient temperature and humidity. They have a number of different programming languages which include Ladder logic, Mnemonic instructions, and Sequential Function Charts. Ladder logic is the main programming method used for PLCs. It is a graphical language which has been developed to mimic relay logic. The decision to use the relay logic diagrams was a strategic one. By selecting ladder logic as the main programming method, the amount of retraining needed for engineers and trade people was greatly reduced. a software tool called Wpl runs on a personal computer allows users to sketch the ladder diagram and then transfers its compiled code serially to the PLC. Such a software tool is more convenient and it supports mnemonic and SFC programming languages as well.

VI. ADVANTAGES

Flexibility
– In the past, each different electronically controlled production machine required its own controller; 15 machines might require 15 different controllers.
– Now it is possible to use just one model of a PLC to run any one of the 15 machines.
– Furthermore, you would probably need fewer than 15 controllers, because one PLC can easily run many machines.
– Each of the 15 machines under PLC control would have its own distinct program (or a portion of one running program).

Implementing Changes and Correcting Errors
– With a wired relay-type panel, any program alterations require time for rewiring of panels and devices.
– When a PLC program circuit or sequence design change is made, the PLC program can be changed from a keyboard sequence in a matter of minutes.
– No rewiring is required for a PLC-controlled system.
– Also, if a programming error has to be corrected in a PLC control ladder diagram, a change can be typed in quickly.

Pilot Running
– A PLC programmed circuit can be evaluated in the lab. The program can be typed in, tested, observed, and modified if needed, saving valuable
Factory time

Visual Observation
– A PLC circuit's operation can be seen during operation directly on a CRT screen.
– The operation or mis-operation of a circuit can be observed as it happens.
– Logic paths light up on the screen as they are energized.
– Troubleshooting can be done more quickly during visual observation.

Ladder or Boolean Programming Method
– The PLC programming can be accomplished in the ladder mode by an engineer, electrician or possibly a technician. Alternatively, a PLC programmer who works in digital or Boolean control systems can also easily perform PLC programming.

Reliability and Maintainability
– Solid-state devices are more reliable, in general, than mechanical systems or relays and timers. Consequently, the control system maintenance costs are low and downtime is minimal.

Documentation
– An immediate printout of the true PLC circuit is available in minutes, if required.
– There is no need to look for the blueprint of the circuit in remote files.
– The PLC prints out the actual circuit in operation at a given moment.
– Often, the file prints for relay panels are not properly kept up to date. A PLC printout is the circuit at the present time; no wire tracing is needed for verification

CHALLENGES

Fixed Program Applications
– Some applications are single-function applications. It does not pay to use a PLC that includes multiple programming capabilities if they are not needed.
– Their operational sequence is seldom or never changed, so the reprogramming available with the PLC would not be necessary.

Fail-Safe Operation
– In relay systems, the stop button electrically disconnects the circuit; if the power fails, the system stops.
– This, of course, can be programmed into the PLC; however, in some PLC programs, you may have to apply an input voltage to cause a device to stop. These systems may not be

Newer Technology
-Since it is new technology everybody well versed with the PLC environment

