MULTIMODE STARTERS FOR THREE PHASE INDUCTION MOTOR USING MICROCONTROLLER

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Abstract - In this Paper microcontroller based multi mode starter is very interesting one. In this Paper consists of three types of starters. To reduce the starting current we need different types of starters for start the induction Motor. The type of the starter is varied with respect to motor ratings and type of supply voltages. DOL, semi automatic Star-Delta and automatic Star-Delta starters are used for start the three phase induction motors. But these motors are needed separate hard wired control circuits and enclosures. The objective of this Paper is to design a simple, easy to install, microcontroller-based circuit to control the contactors through relays. The control circuit for various types of the starters is programmed in a single microcontroller IC. Relay switches are provide to select the mode of the starter like DOL, semi automatic Star-Delta and automatic Star-Delta starters of the motor. Hardware part contains contactors/relays. These relays are control by microcontroller for different contactor programming of starters. The controller used is a low power, cost efficient chip manufactured by 16F877 having 8K bytes of on-chip flash memory. This Paper provides one electronic circuit for various starters, hence reduce the cost of starter and one starter can operate different starter mode.

1. INTRODUCTION

An induction motor is a sort of asynchronous AC motor where power is made available to a turning device by induced electromagnetic fields. A wrapped rotor induction motor was invented in 1882 by Nikola Tesla while he was in France, and then in the year 1888, a patent was issued to him when he had already relocated to the US. In cause of Tesla's work, he showed the basics for comprehending the operation of electric motors. (Lemme, 2005) After some years in Europe, the caged rotor induction motor was invented by Mikhail Dolivo – Dobrovolsky. Sizing was greatly enhanced by technological improvement where a 100hp (74.6kW) motor of 1976 takes about the same volume as a 7.5hp (5.5kW) motor of 1897 (Arnold & Alger, 2017). Induction motors are currently the most popular alternative for industrial motors thanks to their robust construction, absence of brushes which are present in most DC motors and the ability to control the speed of the motor. Over the years, researchers have designed and proposed means of starting up three phase induction motor. In industries where variation of loads is present, having a compact portable module which combines several starting methods would be very necessary. This would provide an easy for the operator to be able to select the desired starting method which is required. In this paper, a compact portable module which houses three different start up methods which includes; Direct – on – line (DOL), Start – Delta (S – D) and Variable Frequency Drives (VFD) methods is to be designed and constructed. The construction would be a compact portable multi – mode three phase motor starter which will be able to start the three-phase motor using the three modes which are Direct on Line, Star – Delta and Variable Frequency Drive. Each of the three-phase induction motor starter methods should be able to start the induction motor independently. The portable multi – mode induction motor starter should provide protection for the induction motor to be started and the operator should be able to view the starting and running current of the induction motor through an ammeter.

2. PROBLEM STATEMENT

For DOL starter, STAR- DELTA starter having the timing problem for overload and star to delta conversion. Due to this lot of electrical accident happens in the motor, like hunting, overloading and unbalanced circuits.

3. PROPOSED METHODOLOGY

To avoid this problem here we proposed the new methodology to control and start the motor by various methods as DOL mode, Automatic and semi automatic star delta starter with proper time delay for star to delta conversion.

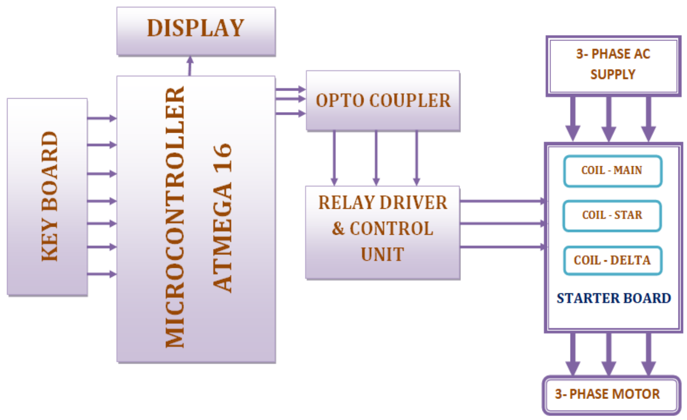

Fig 3.1 Block Diagram of Microcontroller Based Multimode Starter

4. STARTERS

Different starting methods are employed for starting induction motors because Induction Motor draws more starting current during starting. To prevent damage to the windings due to the high starting current flow, we employ different types of starters. The simplest form of motor starter for the induction motor is the Direct On Line starter. The DOL starter consist a MCCB or Circuit Breaker, Contactor and an overload relay for protection. Typically, the contactor will be controlled by separate start and stop buttons, and an auxiliary contact on the contactor is used, across the start button, as a hold in contact. I.e. the contactor is electrically latched closed while the motor is operating.

4.1 Principle of DOL Starter

To start, the contactor is closed, applying full line voltage to the motor windings. The motor will draw a very high inrush current for a very short time, the magnetic field in the iron, and then the current will be limited to the Locked Rotor Current of the motor. The motor will develop Locked Rotor Torque and begin to accelerate towards full speed. As the motor accelerates, the current will begin to drop, but will not drop significantly until the motor is at a high speed, typically about 85% of synchronous speed. The actual starting current curve is a function of the motor design, and the terminal voltage, and is totally independent of the motor load. The motor load will affect the time taken for the motor to accelerate to full speed and therefore the duration of the high starting current, but not the magnitude of the starting current. Provided the torque developed by the motor exceeds the load torque at all speeds during the start cycle, the motor will reach full speed. If the torque delivered by the motor is less than the torque of the load at any speed during the start cycle, the motor will stops accelerating. If the starting torque with a DOL starter is insufficient for the load, the motor must be replaced with a motor which can develop a higher starting torque. The acceleration torque is the torque developed by the motor minus the load torque, and will change as the motor accelerates due to the motor speed torque curve and the load speed torque curve. The start time is dependent on the acceleration torque and the load inertia. DOL starting have a maximum start current and maximum start torque. This may cause an electrical problem with the supply, or it may cause a mechanical problem with the driven load. So this will be inconvenient for the users of the supply line, always experience a voltage drop when starting a motor. But if this motor is not a high power one it does not affect much.

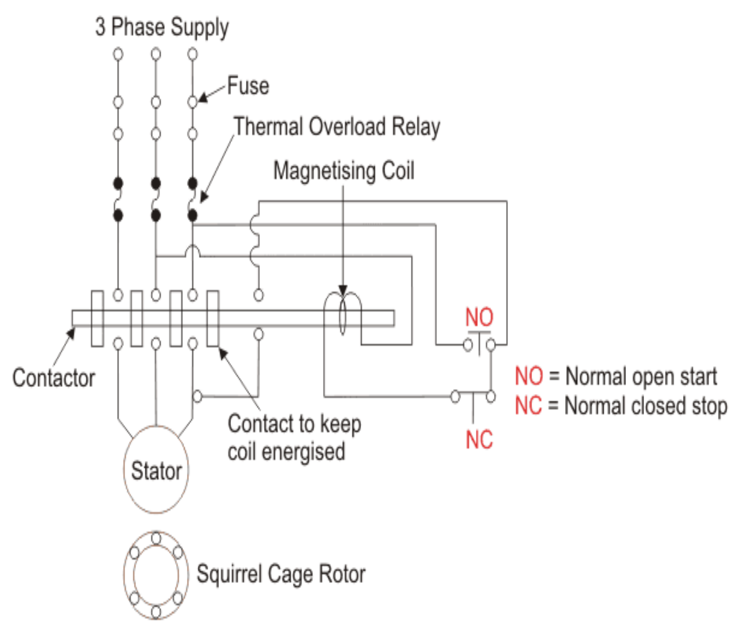

Fig 4.1 Connection Diagram of DOL Starter

4.2 START DELTA STARTER

Electrical motors have been used in industries for quite a long period of time to convert electrical energy into mechanical energy. Three phase induction motors, also called asynchronous motors, are most extensively used motors in industries because of certain advantages like self starting, robust design, simple construction, less maintenance, efficient and comparatively low cost, though there is a problem of peak starting current associated with these motors.

Peak starting current can be up to 5 to 7 times of full load current (FLC) and sometimes it may become as high as 10 times of FLC. However, the problem of peak starting current remains only for few seconds till the motor attains its speed, this problem may become severe especially with the motors above 10 HP. To deal with the problem of peak starting current or inrush current associated with three phase induction motors, many different starters having different mechanism and principle of operation are used.

Star-delta starters are used for motors ranges from 5 hp or 3.5 kW. Star delta starters first configure windings of 3 phase motors in star thereby reduce voltage across each winding and then after few seconds these starters configure windings in delta and motors start run at full load voltage without any difficulty.

Items required to making STAR DELTA Starter

1. Three Contactors (One Main Contactor, One Star Contactor and One Delta Contactor)
2. Over Load Relay (or OLR)
3. Timer
4. Fuse Switch Unit (or FSU)
5. 2 Pole MCB
6. Fuse
7. Start Push Button (NO)
8. Stop Push Button (NC)

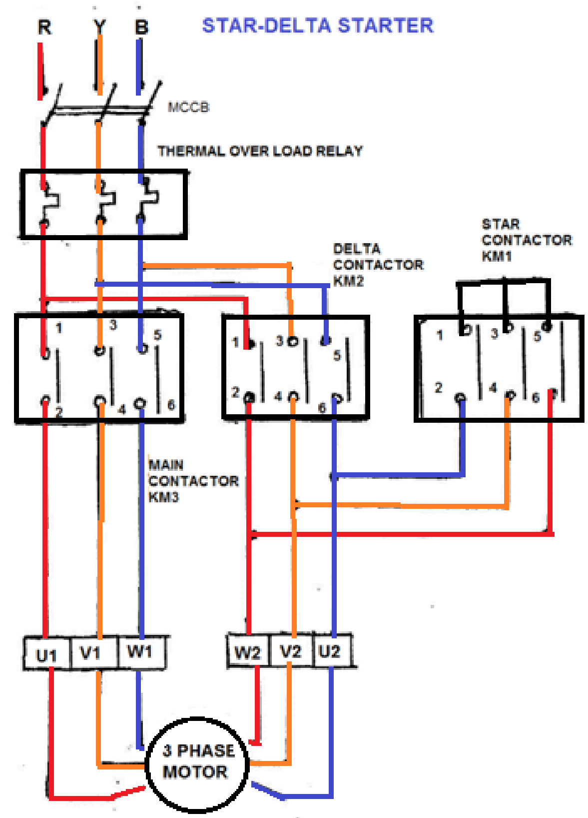

Fig 4.2 Connection Diagram of STAR - DELTA Starter

5. SOLID STATE RELAY

While the **Electromechanical Relay** (EMR) are inexpensive, easy to use and allow the switching of a load circuit controlled by a low power, electrically isolated input signal, one of the main disadvantages of an electromechanical relay is that it is a “mechanical device”, that is it has moving parts so their switching speed (response time) due to physically movement of the metal contacts using a magnetic field is slow. Over a period of time these moving parts will wear out and fail, or that the contact resistance through the constant arcing and erosion may make the relay unusable and shortens its life. Also, they are electrically noisy with the contacts suffering from contact bounce which may affect any electronic circuits to which they are connected.

To overcome these disadvantages of the electrical relay, another type of relay called a **Solid State Relay** or (**SSR**) for short was developed which is a solid state contactless, pure electronic relay. The solid state relay being a purely electronic device has no moving parts within its design as the mechanical contacts have been

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replaced by power transistors, thyristors or TRIAC'S. The electrical separation between the input control signal and the output load voltage is accomplished with the aid of an opto-coupler type Light Sensor. The **Solid State Relay** provides a high degree of reliability, long life and reduced electromagnetic interference (EMI), (no arcing contacts or magnetic fields), together with a much faster almost instant response time, as compared to the conventional electromechanical relay.

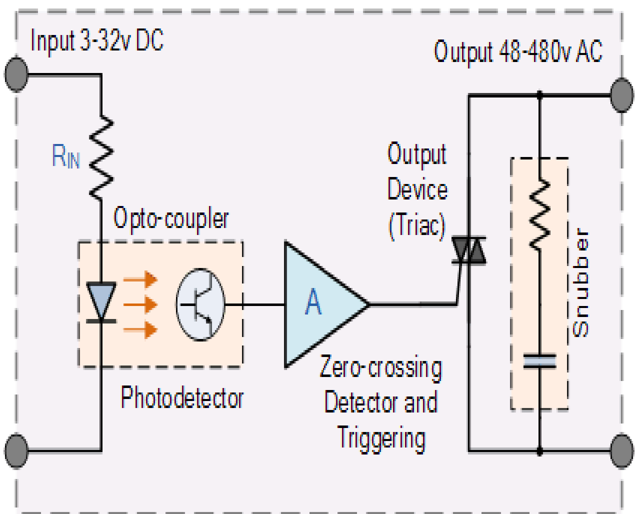

Fig 5.1 Connection Diagram Solid State Relay

6. ALGORITHM AND HARDWARE MODULE

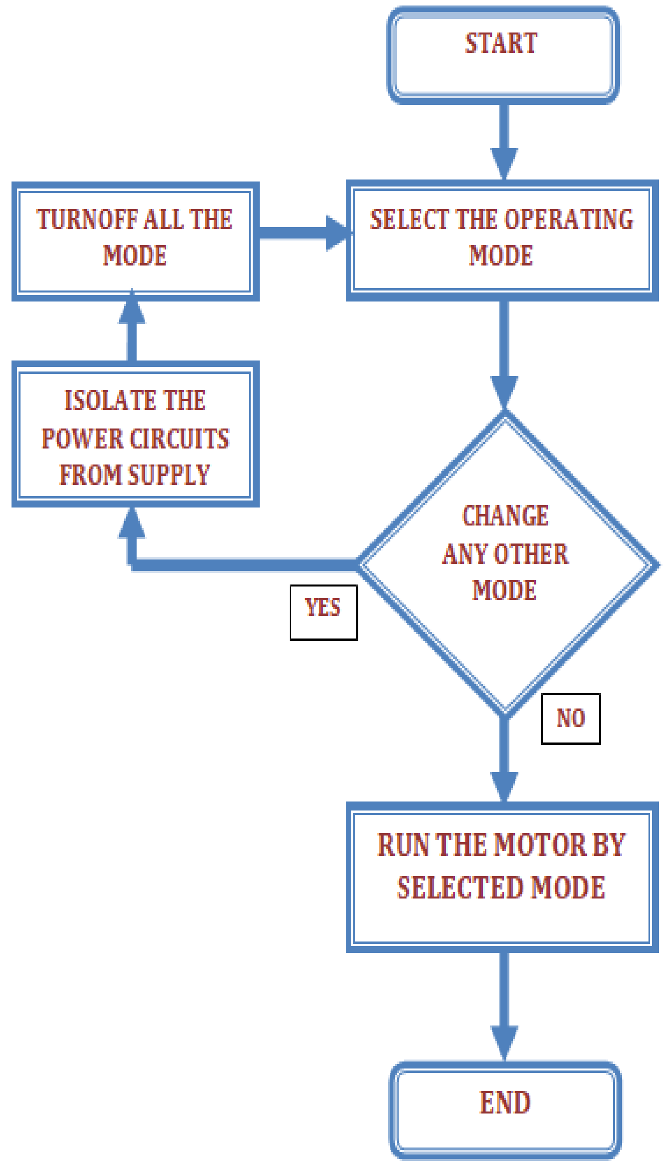

Fig 6.1 Algorithm for Multimode Starter for 3 Phase Induction Motor

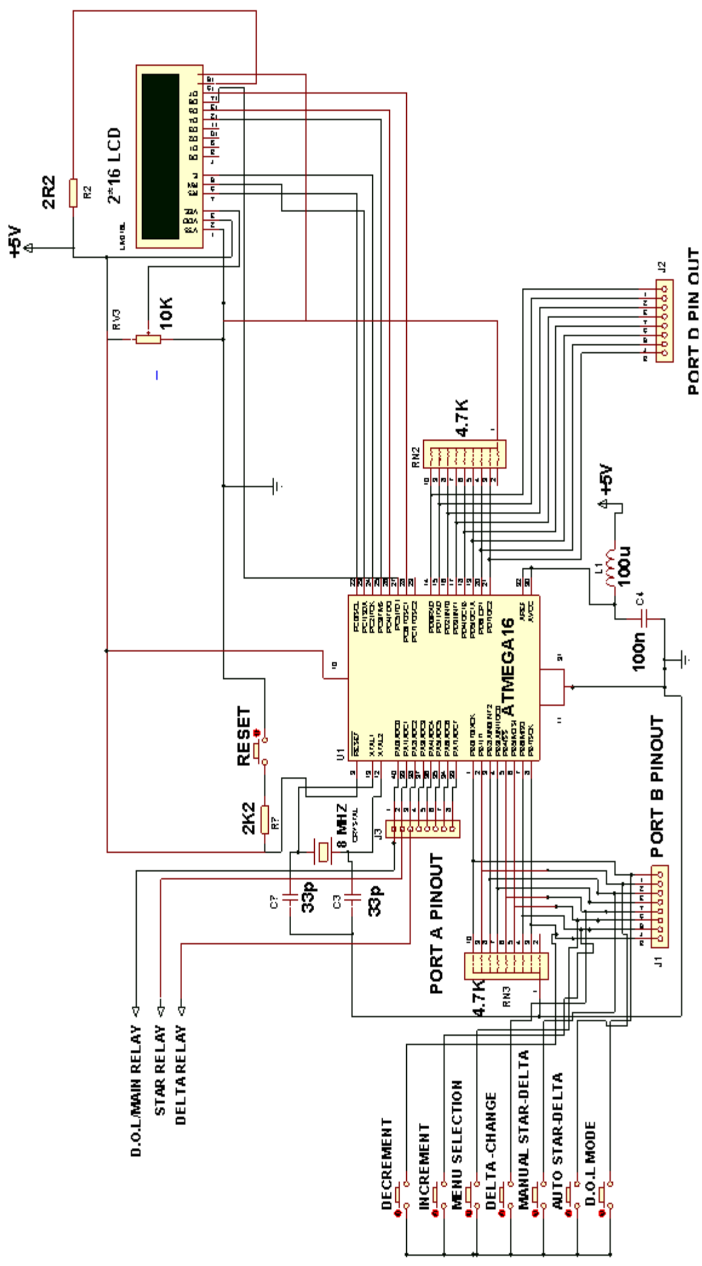

Fig 6.2 Multimode Starter for 3 Phase Induction Motor

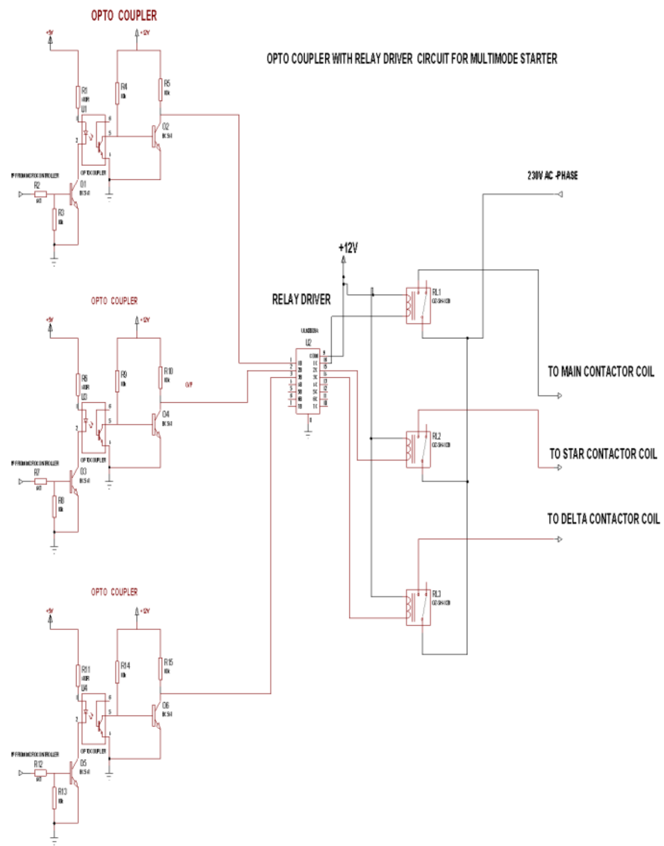

Fig 6.3 Opto Coupler & Relay Driver

Mathematical Analysis of How Components Were Selected for DOL and Star – Delta

$$N = \frac{120\,f}{p} \quad (1)$$

Where;

N = speed of motor

f = Power supply frequency in Hz,

p = Number of poles in the stator of the motor.

A. Fuses Calculations

Time delay fuses maximum size

= 300% x full load line current (2)

Full load current for 1Hp motor

$$\text{Motor line Full load current} = \frac{KW\ X\ Motor\ Rating}{\sqrt{3}\ X\ 415} \quad (3)$$

$$\text{Motor line Full load current} = \frac{KW\ X\ 1000}{\sqrt{3}\ X\ 415} = 1.04A$$

$$\text{Motor phase full load current} = \frac{LFLC}{\sqrt{3}} \quad (4)$$

$$\text{Motor phase full load current} = \frac{1.04}{\sqrt{3}} = 0.6A$$

Starting current of motor = 6 to 7 times full load current (5)

Starting current of Motor = 7 x 1.04 = 7.28A
Maximum size of time delay fuses = 300% x 1.04
= 3.12A
Maximum size of time delay fuses = 175% x full load line current (6)
Maximum size of time delay fuses = 1.75 x 1.04 =1.82A

Types of motor	Time delay Fuse	Non – time Delay fuse
Single phase	300%	175%
3 phase	300%	175%
Synchronous	300%	175%
Wound rotor	150%	150%

B. Size of Circuit Breaker

Maximum size of instantaneous trip circuit breaker
= 800% x full load current (7)
Maximum size of instantaneous trip circuit breaker
= 800% x 1.04 = 8.32A
Maximum size of inverse trip circuit breaker
= 250% x full load current (8)
Maximum size of inverse trip circuit breaker
= 250% x 1.04 = 2.6A

Types of Motors	Instantaneous Trip	Inverse Time
Single phase	800%	250%
3 phase	800%	250%
Synchronous	800%	250%
Wound Rotor	800%	150%
Direct Current	200%	150%

C. Thermal Overload Relay

Minimum thermal overload relay setting
= 70% x full load current (phase) (9)

Minimum thermal overload relay setting

= 70% xfull load current (phase)

= 0.7 x 0.6 = 0.42A

Maximum thermal overload relay setting

= 120% xfull load current (phase) (10)

Maximum thermal overload relay setting= 120% xfull load current (phase)
= 1.2 x 0.6 = 0.72A

D. Main Contactor

Size of main contactor = 100% x full load current(line) (11)

Size of main contactor = 100% x full load current(line)
= 100% x 1.04 = 1.04A

Multimode Starter Features:

- Multiple starter loads in single unit.
- Automatic star-delta changeover and automatic star delta starter.
- Programmable star-delta changes over with adjustable time delay.
- Manual star-delta with separate change over switch.

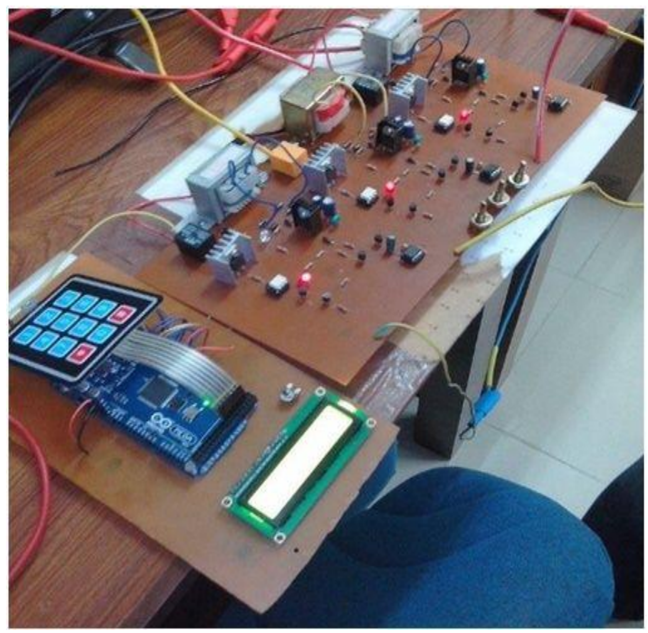

Fig 6.3 Hardware Module

- Delay time storage with EEPROM memory.
- Real time system update with 2*16 LCD display.
- Inherent protection due to usage of opto-coupler and relay.

Advantages:

- We can use the different type of starter by simple
- Micro switch type key board method.

- There is no chance to error operation because of
- Formatted data system using MC.
- Any modification is very simple
- More reliability
- Change over time is easy to modify
- Starter selection and status is displayed.

Applications:

This kit can be implemented in areas where various HP motor drives are used for different load constrains. The rolling and the spinning mills is the best place for the use of logic where variable HP motors are operated for various bundle sizes.

7. CONCLUSION

This starting method is used for medium voltage and light starting torque motors. This is one of the best ways to reduce the high starting current. If the large induction motor starts in direct online method, the motor can draw 5-6 times of rated current. The large amount of current can be easily reduced by the magnetic contactor, relays and the timer circuit. The starter is designed to provide low voltage start to motors. This is achieved by using star to delta conversion. Different types of starters are available. Star/Delta starters are most common and best way to reduced voltage in the 50Hz industrial motor world. The practical module for star delta starter designed and constructed is characterize by good finishing, optimal cost, use of contactors for the continuous operation of the motor, decent arrangement of internal cabling, use of good quality conductors, standard electrical codes and the need for structural safety has been observed in the paper. Compared to the reduced voltage methods it is the simple and cheapest way of starting the motor.

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