Journal Homepage: -www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI:10.21474/IJAR01/6965
DOI URL: http://dx.doi.org/10.21474/IJAR01/6965

RESEARCH ARTICLE

AUTOMATIC STAR DELTA STARTER.

Krunal Jayswal and Jay Modi.
Department of Electrical Engineering, Indus Institute of Technology and Engineering, Indus University.

Manuscript Info

Manuscript History

Received: 16 February 2018
Final Accepted: 18 March 2018
Published: April 2018

Abstract

This equipment/appliance reduces starting current and starting torque. Automatic Star Delta Starter design normally consists of three contactors, an overload relay or circuit breaker, and a timer for setting the time in the Star position (starting position). For the Star Delta Starter, a motor must be in delta connected position during a normal run and the main purpose is to be able to use the starter.
When the motor is at idle, it just is like the short-circuited transformer at secondary side because all the rotor bars are connected together to form a closed path. This will draw a large current flow through the rotor bars. So, when the motor is started, stator draws high current which is 8-10 times that of the rated current. Therefore, before starting the motor, it is necessary to reduce the voltage applied to the motor.
In Star connection current is in different phases but line voltage is root three times that of the phase voltage. So, the voltage is reduced which results in reduction of current if motor is started in star connection. In Delta connection the voltage is same as that of phase voltage so full voltage is applied if we run the motor in delta connection. The Star/Delta Starter is generally obtained from three contactors, pneumatic timer, and a thermal overload relay or circuit breaker, for 3 phase motor at 440 volt AC main supply 50 Hz.

Introduction:-

Function of Starters:-

The device which is used to limit the starting current and reduce the starting torque is called Starter. It reduces the starting current to a safe value.

Need of Starters:-

Rotor current at standstill, I = E/Z = E/$\sqrt{(r^2 + x^2)}$

The magnitude of E depends on the flux linking with the rotor conductors and its relative speed. The strength of the rotor flux depends upon the applied voltage. At the instant of applying rated voltage to the stator winding, rotor is stationary and as such the slip is unity. So, if full rated voltage is given to stator winding, then magnitude of the emf induced in rotor conductors will be high, because the relative speed between the rotor conductors and stator revolving flux is very high i.e. equal to the synchronous speed of the stator flux. Further the rotor conductors are short circuited and thus have low impedance.

Corresponding Author:- Krunal Jayswal, Jay Modi.
Address:- Department of Electrical Engineering, Indus Institute of Technology and Engineering Indus University.

Hence the current drawn by the stator winding or motor is very large, approximately 5 to 7 times the full load current.

The ill effects of high starting current are as follows:-
The copper losses occurring in the stator and rotor windings due high starting current are extremely large, which would produce a lot of heat inside the machine and may damage the insulation of the windings. Moreover, there will be a dip in supply voltage.

The starting current drawn by the motor can be reduced to a permissible value by:
1. Applying reduced voltage to the stator winding
2. Inserting resistance in the stator circuit
3. Inserting resistance in the rotor circuit

In case of slip ring induction motors, it is possible to add external resistance in rotor phases as wound rotor has 3 phase star connected winding to limit the starting high current. However, in case of squirrel cage induction motors it is not possible to add any kind external resistance as it consists of copper bars, which is short circuited by end rings on both sides. So, in case of squirrel cage induction motors, initial high current is controlled by applying reduced voltage to stator winding during starting period and the full normal voltage is applied when rotor has picked up speed to about 70 to 80% of its normal speed.

Different types of Starting methods:-
There mainly two types of starters available:-
DC Starters:-
1. Two-point Starter
2. Three-point Starter
3. Four-point Starter

AC Starters:-
1. D.O.L Starter (Direct Online)
2. Automatic/Manual Primary Resistance Starter
3. Automatic/Manual Autotransformer Starter
4. Automatic/Manual Star Delta Starter

Two Point Starter:-
As its name suggests this starter has two points for connections and is majorly used for DC Series motors to limit starting currents and torque. It works on principle of adding resistance between supply and armature due to which current is decreased for starting. As the resistance is decreased motor picks speed and runs a full supply voltage.

Three Point Starter:-
The working principle of this starter is similar to two-point starter unlike it has three points and is majorly used for DC Shunt Motors.

Four Point Starter:-
It has same working principles as that of two point and three points but here and extra resistance pair is added in field point connection which reduces current more efficiently for DC Compound Motors.

Direct Online Starter (D.O.L):-
It consists of contactors which a charged when supply is given to them and allows flowing same voltage to stator windings. This starter is very simple inexpensive and easy to install and maintain. Under faulty conditions overload relays are present which deenergize contactor and stops the flow of current. But in this starting the rate of temperature rise is very high and motor may get damaged if the starting period is large, which may be due to excessive voltage drop in supply lines. Thus, this type of starter is generally used for motor ratings up to 5KW.

Automatic/Manual Primary Resistance Starter:-

In this type of starting of 3 phase induction motor primary resistance are connected in all the three phases of the stator winding as a result of which the applied voltage across stator winding at the instant of starting is reduced to a fraction of rated voltage of motor. In manual starter resistance is increased or decreased manually while in automatic particular fixed value of resistance is there for fixed time with the help of pneumatic timer connected across contactors. This starting method heats up starting resistors and a large amount of power loss results. So, they are used for small motors or less rated value motors.

Automatic/Manual Autotransformer Starter:-
In this method 3 phase auto transformer with fixed tappings is used to obtain reduced voltage for starting of 3 phase induction motors. Normally 50 to 60% tappings can used to obtain a safe value of starting currents. Thuds 50 to 60% of the rated voltage is applied at starting and the autotransformer is cut out of the motor circuit, when motor has picked up the speed about 70 to 80% of the normal speed by changeover lever. Same thing is achieved in automatic starter by interlocking mechanism of contactor with pneumatic timer. This starter can be efficiently used instead or primary resistance starter where heating of resistors was a major problem. This starter provides same amount of voltage reduction and does not lead to heating effect.

Automatic/Manual Star Delta Starter:-
This is the most commonly used starter, compared to different types of starters. Star Delta starter works on the principle of voltage reduction during starting period. In star connection current is same as that of to line and phases but line voltage is times phase voltage which leads to reduction in voltages in starting period. When the motor has picked up speed we can say up to 70 to 80% of its rated speed the phases changeover to delta connection position. In delta connection voltage across lines is same as that of phase voltage. A star delta starter is cheaper compared to auto transformer starter. Thus, it is commonly used for both medium and small size motors. Since torque is proportional to square of applied voltage, star delta starting reduces starting torque to 1/3 of that obtained from Direct online. The automatic star to delta changeover is obtained by using interlocking connection in contactors with that of pneumatic timer which changes over to delta after a fixed period of time.

Star Delta Starter

This is a starting method that reduces the starting current and starting torque. Star delta starter design normally consists of three contactors, an overload relay or circuit breaker and a timer for setting the time in the star-position (starting position). For the star delta starter, a motor must be in delta connected during a normal run and the main purpose is to be able to use star delta starter.

In Star delta starter the received starting current is about 30 percent of the starting current during direct on line start and the starting torque is reduced to about 25 percent of the torque available at a D.O.L starter. Star delta starter only works when the application is light loaded during the start.

If the motor is too heavily loaded, there will not be enough torque to accelerate the motor up to speed before switching over to the delta position.

Figure 2.1 shows manual star delta starter where star to delta changeover of done by changeover switch mechanism. As the motor picks up speed and reaches up to desirable speed, switch is changeover of delta for running condition leading to full voltage supply.

Unlike manual star delta starter in automatic star delta starter as shown in figure 2.2 an external circuit namely control circuit is present which consists of timer contacts. With these timer contacts we can change star connection to delta connection automatically within time of 0-30 seconds as desired. This time duration can be varied as per starting and running characteristics as per our requirement. Contactors are used for changeover mechanism. These contactors are connected according to controlling circuit with timer box to work accordingly.

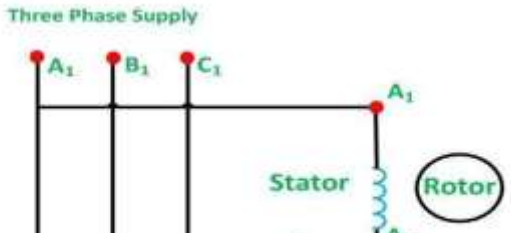

Figure 2.1:- Manual Star Delta Starter

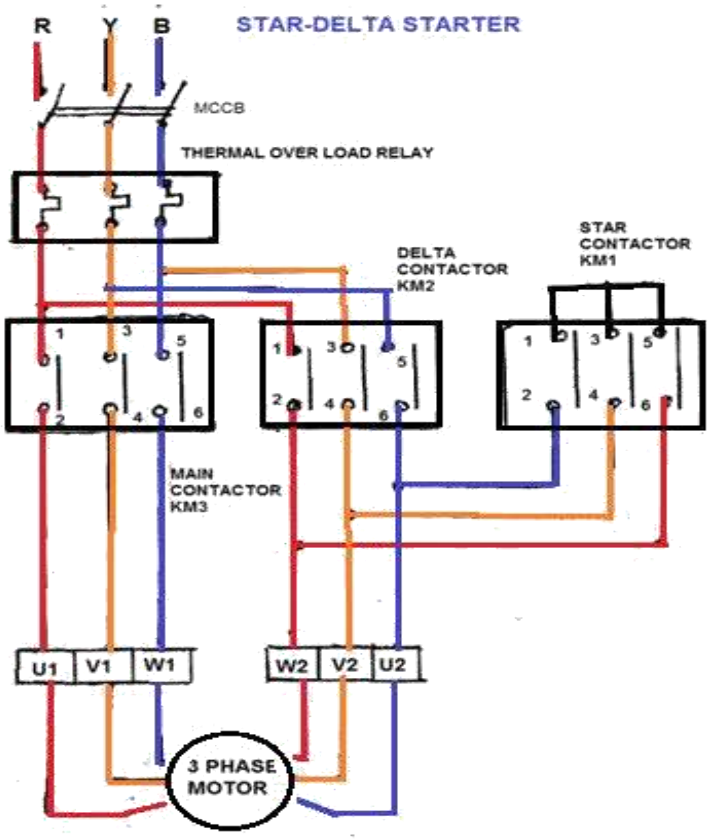

Figure 2.2:-Power Supply Diagram of Automatic Star Delta Starter

Working of Automatic Star Delta Starter

When the 'Start' push button PB1 is pressed the operating coil CM is energized. Hence, all the M contacts and auxiliary contact MA will be closed and therefore connects the supply lines to motor terminals U1, V1, W1. At the same time, the operating contacts CS for star contacts is also energized and closes its a contacts S and connects motor terminals U2, V2, W2, which forms star point causing the motor to start as star connected motor. Therefore, at starting the applied voltage to each phase of the winding will be 1/ of the rated voltage of the motor.

Now after a predetermined time, TR, operates which opens TO and closes TC, hence coil CD is energized and closes its contacts D and coil CS will be deenergized and hence opens the contacts S, causing the motor to run in delta at full supply voltage. The operating coil is energized by path 'L1-PB2-PB1-CM-OL-OL-OL-L2'. At the same time the operating coil CS get energized by path 'L1-PB2-PB1-TO-D-CS-OL-OL-OL-L2'. The operating coil CD is energized by path 'L1-PB2-MA-TC-OL-OL-OL-L2'. Pressing the OFF-push button, deenergizes all contactors and disconnects the motor from line.

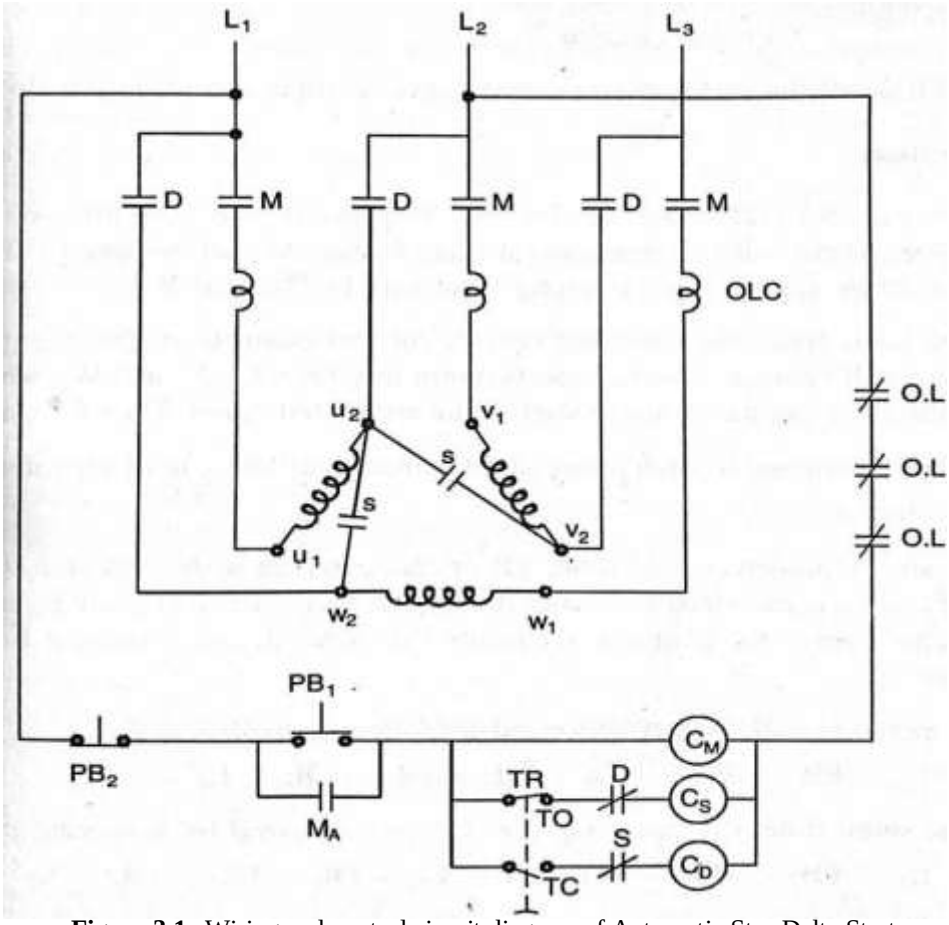

Figure 3.1:-Wiring and control circuit diagram of Automatic Star Delta Starter

L1, L2, L3 - Lines
S – Star Contacts
Cs – Operating coil for star contacts
D – Delta contacts
Cd – Operating coil for delta contacts
M – Line contacts
Cm – Operating coil for main contacts
TR – Pneumatic Timer
TO – Time Opening Contact
TC – Time Closing Contact

OLC – Overload relay coil
OL – Overload relay contact
PB1 – START push button
PB2 – OFF push button

Motor Starting Characteristics: The available starting current is 33% of full load current. The peak starting characteristics is about 1.3 to 2.6 full load current. Peak starting torque is about 33% of full load torque.

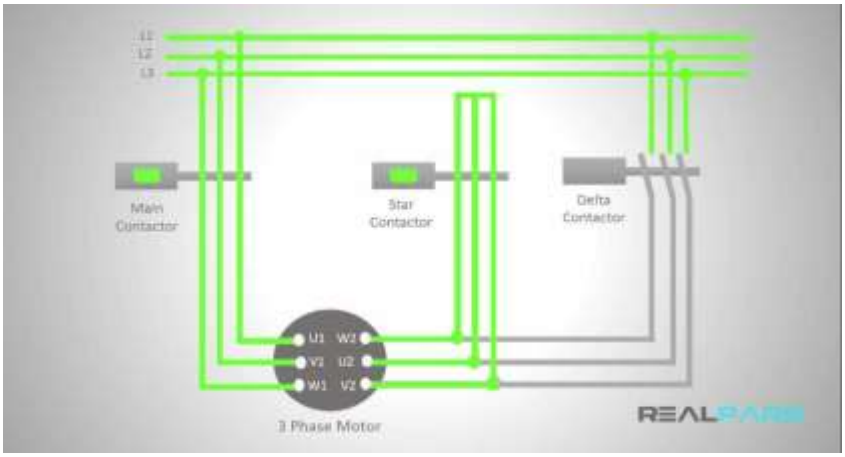

Figure 3.2:-Starting condition (star position)

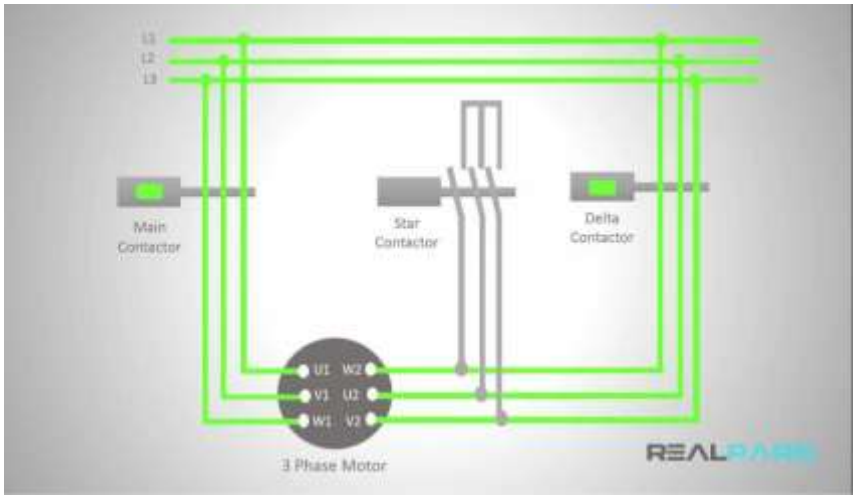

Figure 3.3:-Running condition (delta position).

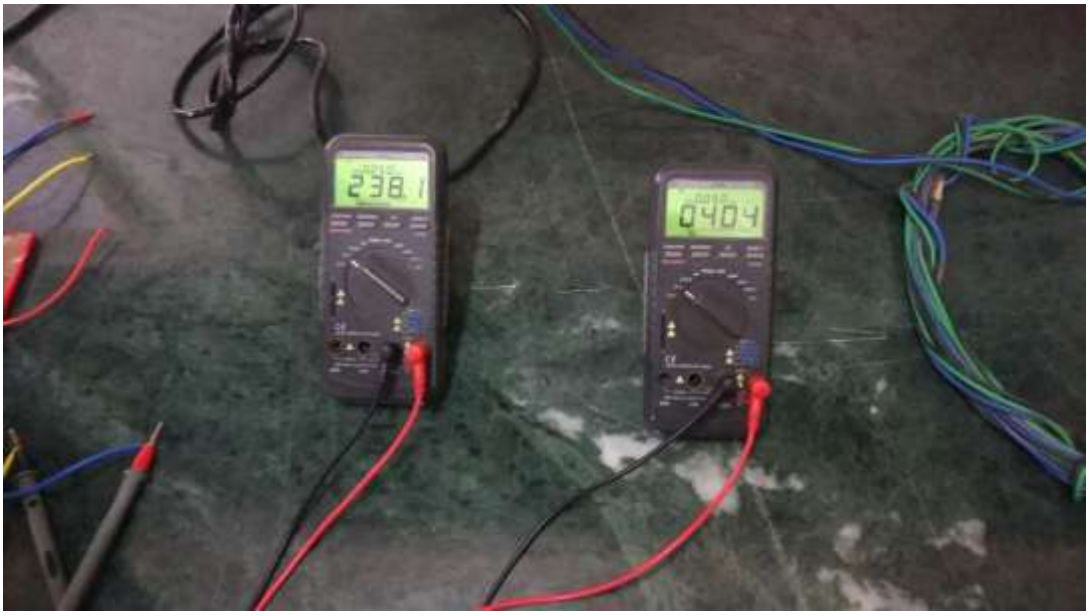

Figure 3.4:-Readings of line voltage and phase voltage for 3 phase star (starting condition)

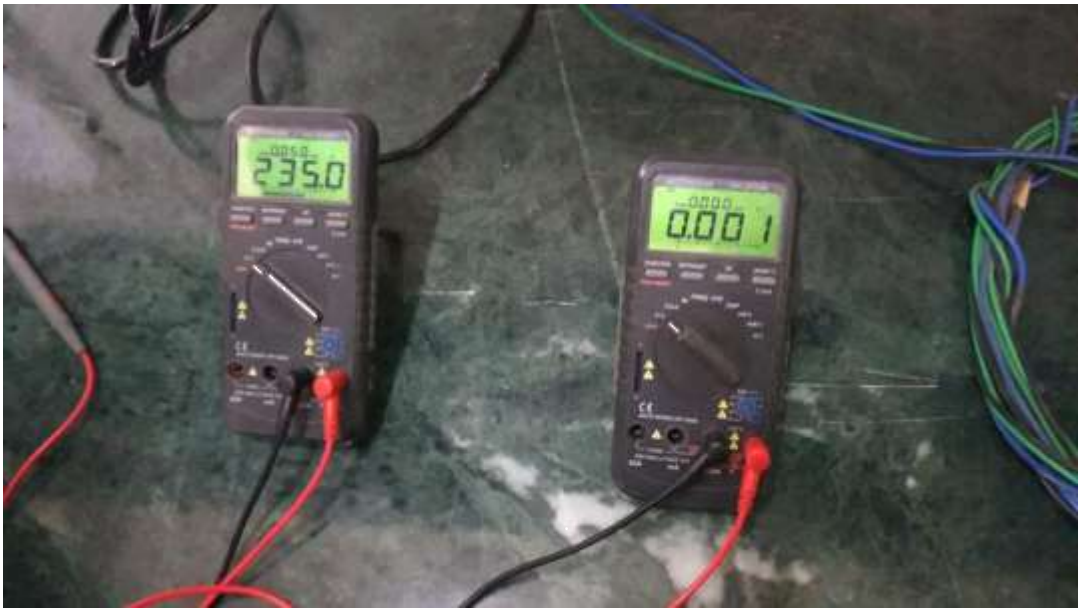

Figure 3.5:-Readings for line voltage and phase voltage for 3 phase Delta position (running condition)

Hardware Model

Our project consists of following hardware parts:

1. Contactors
2. Timer Box
3. Cable
4. START and STOP push button

Contactors:-

There are three assembled contactors used for star delta starter. The ratings of contactors are about 18A 230 VAC which can work for a motor of 3Hp which is approximately 2,237.1 watts. The star and delta contactors are interlocked with a particular fixed time after which star to delta changeover in connection occurs. Below is the figure of Contactor.

Figure 4.1:-Contactor: 18A 230 VAC ratings

Timer Box:-

The timer box is of ELLICO Company. Its rated current is 5A with 230V single phase AC supply 50Hz. The time within which star to delta changeover is done can be varied from 0 - 30 seconds. Below is the figure of Timer Box.

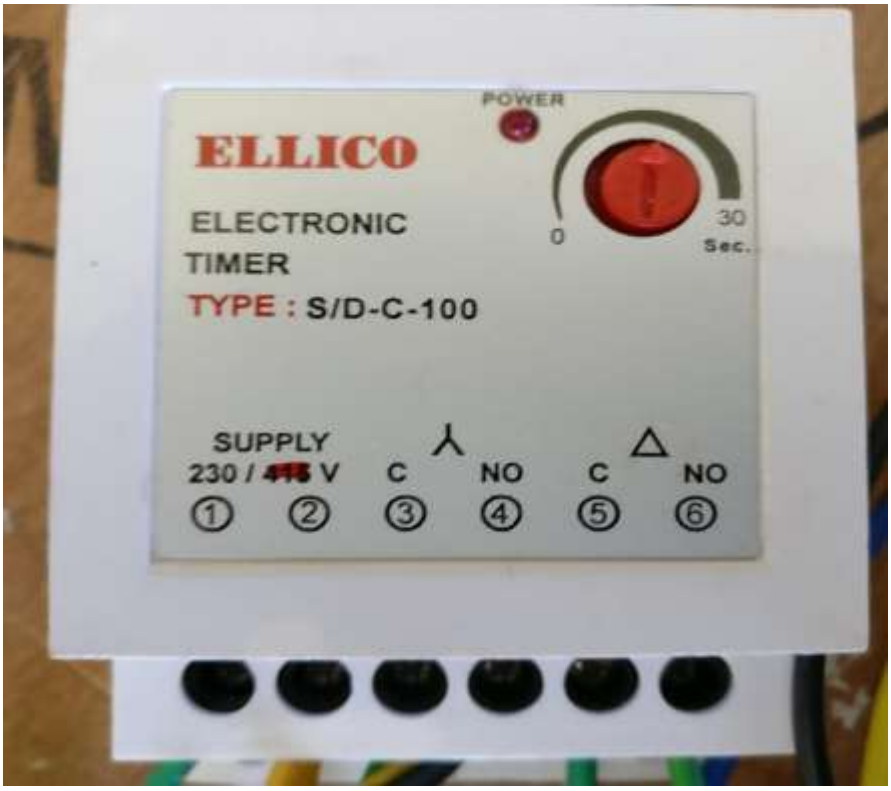

Figure 4.2 Timer Box 230V 5A

Cables:-

The cables used here are of 2.5*m*. They can allow passing up to 15-16A of current. The resistance of 2.5 *m* according to resistance table provided by standard units is 8.21Ω/Km, provided is the figure of cables used in the starter.

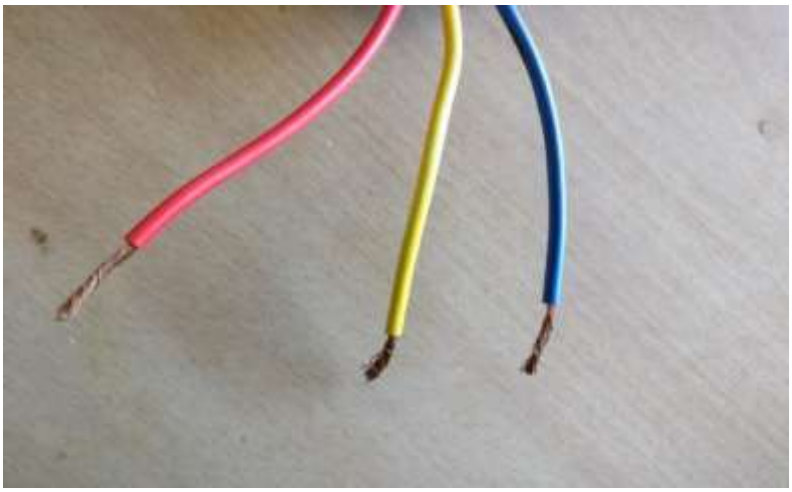

Figure 4.3:-Cables 2.5

START and STOP push buttons:-

These push buttons are based on the working principle of NO - normally open and NC - normally close type buttons. The START button here used is connected in NO type connection while for STOP button NC type connection is used. Below is the figure provided of START and STOP push buttons.

Figure 4.4:-STOP push buttons and START push buttons

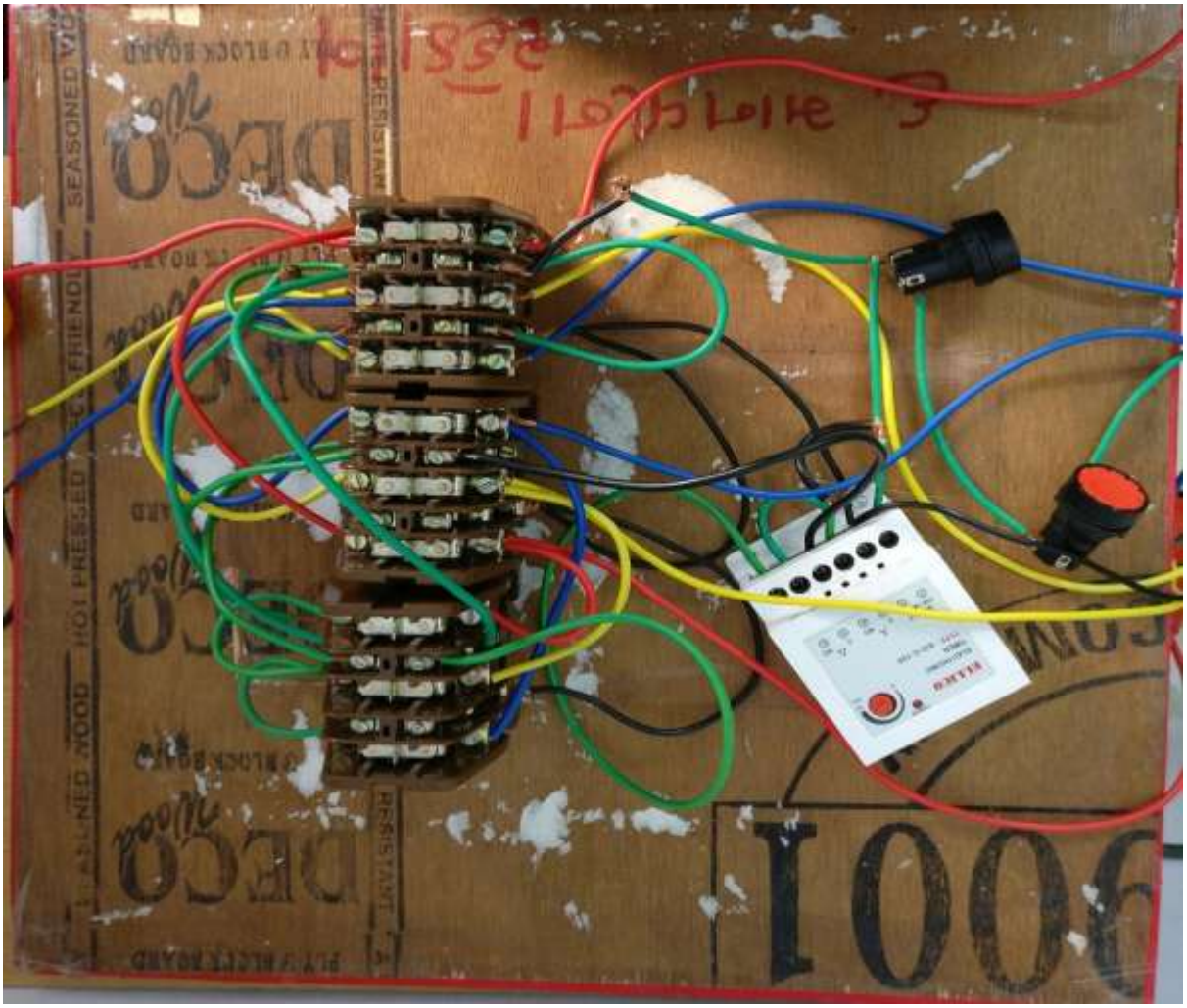

Figure 4.5:-Final Outcome After Assembling

Conclusion and Future Scope:-

This type of starting is used for low to medium voltage and light starting torque motors. It is the cheapest way to reduce the starting current and it is in the order of 3-4 times that in case of direct online starting of induction motor. It can be easily implemented by the relays and the timer circuit.

The way of connecting the relays also prevents the motor from the single phasing. The project is designed to provide low voltage start to induction motors. This is achieved by using star to delta conversion. Star/Delta starters are probably the most common reduced voltage starters in the 50Hz industrial motor world.

Star delta is used in an attempt to reduce the start current applied to the motor then after sometime full load current is applied to the motor. Since in star connection current is same in different phases while line voltage is the root three times the phase voltage. So, the voltage is reduced (results to reduce current) if motor is started as star.

The interlocking arrangement of all the contactor coils is traditionally wired in 440-volt AC. The project is designed to provide low voltage start to induction motors. The Star/Delta starter is generally manufactured from three contactors; and pneumatic timer for operating a 3-phase motor at 440 volts at ac mains supply 50 Hz.

Future Scope:-

Compared to the reduced voltage methods it is the simple and cheapest way of starting the motor. But it takes large in rush currents during switching operation. Further the project can be enhanced by using a thyristor in firing angle control principle for soft start of the induction motor that would overcome all the drawbacks of star delta starter.

References:-

1. Jamnani J.G, "Elements of Electrical Design", Mahajan Publications, 2015, chap-3, pp. 3.1-3.20.
2. Gupta J.B, Theory and performance of Electrical machines, Katson books publications, 15th edition: 2015 Section V, pp. - 5.1 – 5.30.
3. Jignesh Parmar, wordpress.com Star delta Starter, https://electricalnotes.wordpress.com/2012/03/16/star-delta-starter/
4. PLC training - Star Delta Starter, wiring animated video, Real Pars https://youtu.be./qA3Yg5CS-F8/
5. Star Delta 3-phase Motor automatic starter with timer, http://www.electricaltechnology.org/2012/02/star-delta-3-phase-motor-starting.html
6. Star delta starter motor control with circuit diagram – practical video, Motor circuits, https://www.youtube.com/watch?v=doBPliY-cik
7. Semi-automatic star delta starter, RJ electrical, https://www.youtube.com/watch?v=7pY7Koh-Gi8
8. 3 phase induction motor starting with industrial star delta starter, EL-PRO-CUS, https://www.elprocus.com/industrial-star-delta-starter-3-phase-induction-motor/
9. Circuit globe, Star delta starter, http://circuitglobe.com/star-delta-starter.html
10. Academia education, automatic star delta starter with adjustable timer, http://www.academia.edu/23086369/AUTOMATIC_STAR_DELTA_STARTER_USING_RELAYS_AND_ADJUSTABLE_ELECTRONIC_TIMER_FOR_INDU CTION_MOTOR_Project_Synopsis