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AUTOMATIC STAR-DELTA-STAR STARTER ENERGY SAVER

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Abstract: Power is the basic necessity for the economic development of the country. The power should be handled efficiently to meet the requirement. The proposed paper presents the effective usage of the Star- delta starter in power saving in the particular applications. The delta- star module is interfaced with the existing star-delta starter. When the load on the motor is less than 50% of the full load, it switches the motor to operate in the star mode to save the energy. When the load on the motor exceeds 50% of the full load, it switches the motor to operate in delta mode without disturbing the working of the motor. By implementing this reduction in power consumption can be achieved.

***Keywords*: Energy Saving, Star- delta starter, Timer.**

I. INTRODUCTION

In recent years, the power demand has increased drastically. But the expansion of the power generation and transmission has been limited due to limited resources and environmental restrictions. The increasing demand on power has led to considerable burning of fossil fuels which has an adverse effect on the environment. In this situation efficient managing of power is more important. It has been estimated that nearly 25,000 MW of energy can be saved by implementing end-use energy efficiency and demand side management resource throughout India. Efficient use of energy and its conservation assumes even greater importance in view of the fact that one unit of energy saved at the consumption level reduces the need for fresh capacity creation by 2 times to 2.5 times. Moreover, such saving is through proper usage of energy can be achieved by at less than 1/5th the cost of fresh energy. Therefore, conservation and proper management of energy is very important thing.

In industries 80% of motor used are AC induction motor. An AC induction motor can be single phase, poly phase, brushed or brushless. Since industries are consuming more power, we have to concentrate energy saving in this area. The proposed system saves energy by changing the stator windings connections either in star or delta fashion according to the load variation. When load on the motor reduces less than 50% of the full load; it switches the motor to operate in star connection to save energy. When the load increases beyond 50% of the full load, it switches the motor to operate in delta connection. Since the power consumption in delta is 3 times greater than star, this will lead to power saving.

II. CONVENTIONAL TYPE OF STAR-DELTA STARTER

The starter delta starter is a very common type of starter. Star delta starter is used more than any other type of starter. This method uses the concept of reduced supply voltage. This is first achieved by connecting the stator winding in star connection, after the motor attains the certain speed the

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contactor switches to the stator winding to delta connection. Since the motor is in star mode during starting the inrush current is reduced by root three times the value of the delta mode inrush current and also the windings will receive the line voltage across it. Since the torque developed by the induction motor is proportional to the square of the applied voltage, star-delta starting reduced the starting torque by one-third obtainable by direct delta starting.

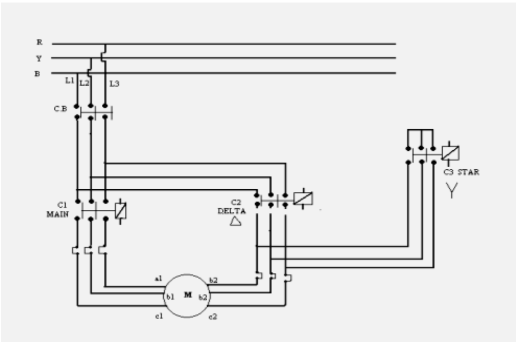

Fig1. Power circuit diagram of automatic star delta starter for 3 phase induction motor

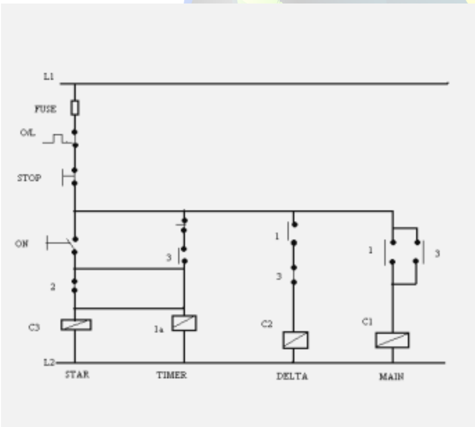

Fig2. Control circuit diagram for automatic star delta starter for 3 phase induction motor

From L_1 the phase current flows to thermal overload contact through fuse, then OFF push button, ON push button interlocking contact 2, and then C3. This way, the circuit is completed and it results:

- Contactor coil C3 and Timer coil (I_1) is energised at once and the motor winding then connected in star. When C3 is energised, its auxiliary open links will be closed **and** vice versa (that is close links would be open). Thus C1 contactor is also energised and three phase supply will reach to the motor. Since winding is connected in star, Hence each phase will get √3 times less than the line voltage i.e. 230 volts. Hence motor starts safely.
- The close contact of C3 in the delta line opens because of which there would be no chance of activation of contactor 2(C2). After leaving the push button, timer coil and coil 3 will receive a supply through timer contact (I_a), holding contact 3 and then close contact 2 of C2.
- When contactor 1 (C1) is energized, then the two open contacts in the line of C1 and C2 will be closed.
- For the specific time (generally 5-10 seconds) in which the motor will be connected in star, after that the timer contact (I_a) will be open (We may change by rotating the timer knob to adjust the time again) and as a result
- Contactor 3(C3) will be off, because of which the open link of C3 will be closed(which is in the line of C2)thus C2 will also energize. Similarly, when C3 off, then star connection of winding will also open. And C2 will be closed. Therefore, the motor winding will be connected in delta. In addition, contact 2(which is in the line C3)will open, by which, there would not be any chance of activation of coil 3 (C3).
- Since the motor is connected in delta now, therefore, each phase of the motor will receive full line voltage (400V) and, motor will start to run in full motion.

III.POWER RELATIONSHIP IN STAR AND DELTA CONNECTION

Let's suppose V_s be the supply voltage per phase. So the line voltage of the supply will be $\sqrt{3}\ V_s$.

For delta connected load:

Power per phase, $P_D=I^2R=\sqrt{3}V_s/R$ {as line voltage of the supply is directly applied to the phase of the delta load}.

$P_D = (\sqrt{3}V_s/R)^2\ R=3V_s^2/R$ watts per phase.

For 3 phases:

$P_{3D} = 3P_D = 3*3V_s^2/R = 9\ V_s^2/R$ watts.

For star connected load:

$P_s=I^2R = (V_s/R)^2R = V_s^2/R$ watts.

For 3 phases:

$P_3s = 3Ps = 3Vs\ ^2/R$

So we can see that the power in the delta connection in 3 times greater than that of the star connection.

IV. PROPOSED STAR-DELTA-STAR STARTER

It is an equipment to save energy during variable load conditions in three phase induction motor. About 25-30 % of energy gets saved by incorporating delta star conversion module. This is carried out by using ATMEGA 328 Microcontroller. The three phase winding inside the motor can be connected in star or delta. During motor star-up a way must be found to make the connections change over from star to delta at the right time. One way is to use star delta motor starter.

The starting current of any heavy electric motor can be 10 times more than the normal load current it draws. When it gains speed and has reached its normal running output power and temperature. So, it is where starter simply when connected in DELTA, the starting current would be huge. So we would require large circuit breakers, big enough to allow the start-up surge current to pass without immediately shutting it off. If the windings of a 3 phase motor are connected in star the voltage applied to each winding is reduced to only (1/√3) of the voltage applied to the winding when it is connected directly across two incoming power service line phases in DELTA. The current per winding is reduced to only (1/√3) of the normal running current taken when it is connected in DELTA

So, because of the Power Law V[in volts]* I[in amps] = P[in watts], the total output power when the motor is connected in star is :

$P_S = [V_L*(1/\sqrt{3})]*[I_D*(1/\sqrt{3})] = P_D*(1/3)$[one third of the power in DELTA]

Where,

V_L- the line-line voltage of the incoming 3-phase power service

I_D- the line current drawn in DELTA.

P_S-the total power the motor can produce when running in STAR.

P_D-the total power it can produce when running in DELTA.

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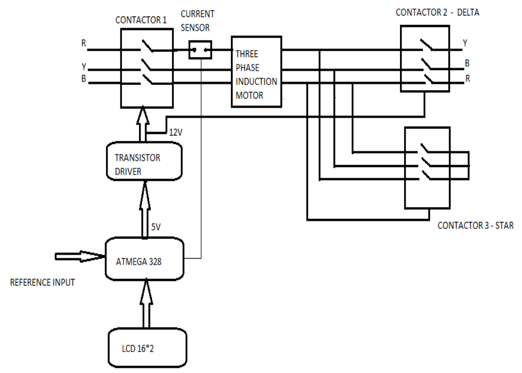
Another disadvantage when the motor is connected in STAR is that the total output torque is only 1/√3 of the total torque it can produce when running in DELTA.



During partial load or no load period motor is supplied with 400 or 440 volts as that much power is not required in that load condition. So by reducing the voltage applied during partial load condition power can be saved. Normally motors run in delta mode. Full voltage is applied to the motor. So by making motor to run in star mode during these no load periods only 1/√3 time's line voltage is applied which reduces power input to the motor. Current sensor continuously monitors the current variations and provides the necessary feedback as per the design. Based on the feedback from current sensor the delta-star module performs as an energy saver to avoid the frequent unwanted switching's the output from the sensor will be monitored by using an additional timer and this period can be varied manually as per the requirement. Start in star and change over to delta and then operate in star or delta, based on load. Start in delta and changeover to star when the load is less than 50 % (for motors with high starting torque requirement). Changeover from star to delta based on current instead of time.(It is likely that the motor is started with different loads at different times and the timing set in the timer may not be always suitable for these differing loads. It may be too high or too small.

V. SIMULATION RESULTS

The simulation of the proposed system is done in the MATLAB.

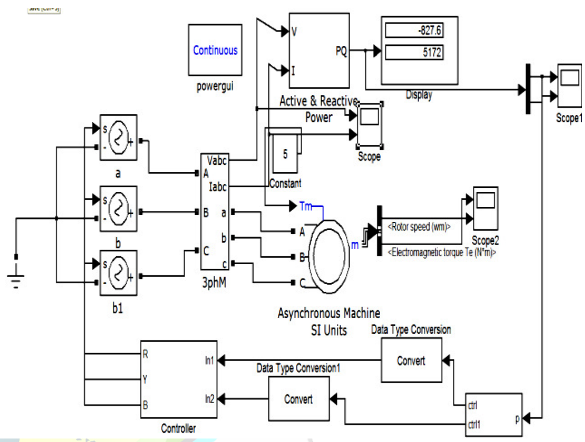


Fig4. Block diagram for Simulation

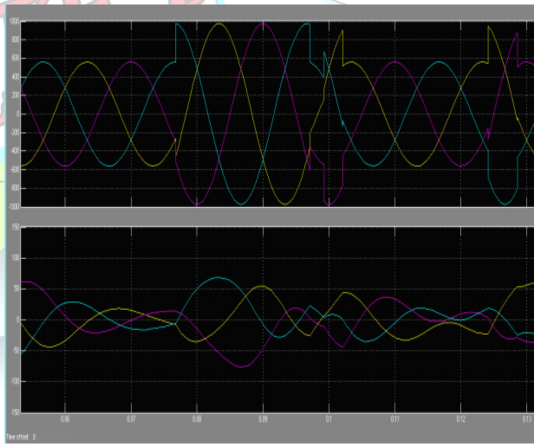


Fig5. Simulation result of current and voltage measurement

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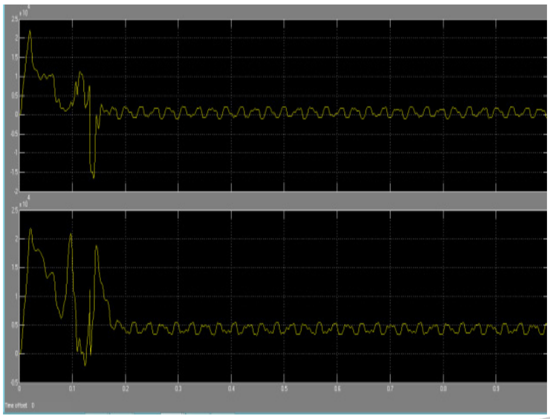

Fig6. Simulation result for active and reactive power

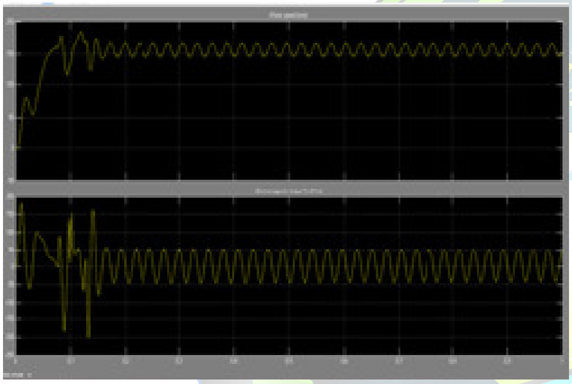

Fig7. Simulation results for speed and electromagnetic torque

In MATLAB software, it is difficult to show the star and delta winding connections of the squirrel cage induction motor. Therefore we are controlling the supply voltage with the help of the controller which will receive its input from the active reactive power block output. Thus reduced voltage is given as a supply to run the motor to initially in star mode. And when motor attains the rated speed at full load, motor is provided with full supply voltage to run in delta mode. Inside the controller reference load rating is given as a reference depending on which the voltage should be controlled.

VI. ANNUAL RUNNING DETAILS OF STAR DELTA STARTER

MOTOR RATING	WINDING	POWER OUTPUT	KVA	CURRENT DRAWN	POWER FACTOR
11KW	STAR	6.98	7.94	11.3	0.87
	DELTA	7.12	10.62	15.3	0.66
15KW	STAR	13.12	14.9	17.3	0.88
	DELTA	13.21	19.13	22.1	0.69
22KW	STAR	16.87	19.39	22.7	0.87
	DELTA	17.12	26.31	32.4	0.65

VII. CONCLUSION

If the motor can be meet the torque requirement in star mode then we can always run the motor in star mode. This can save 25% of power when compared to delta mode.

1. Power factor is better in star mode.
2. Usage of capacitor banks to improve power factor is reduced.
3. The size of the conductor can be reduced.
4. Reduced stress on power grid when starting.

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