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Relay and Timer Based Automatic Star-Delta Starter

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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 Automatic Star- delta starter in the particular applications. The delta- star module is interfaced with the existing star-delta starter. When starting a motor creates some problem to solve these issues, star – delta starter comes into use. The project is designed to provide low voltage start to induction motor, using relays in star mode first and then to delta mode. This paper concentrates on the design, simulation and practical realization of an electronic based starter.

Keywords: star delta starter, timer, relay, inrush current

1. INTRODUCTION

In recent years, most Induction motors are started directly on line, but when large motors are started directly, they cause disturbance of voltage on the supply lines due to large starting current surges. Induction motors when operated on weak systems is a highly dynamic process that can cause motor and load damage as well as electrical network fluctuations. Mechanical damage is caused due to high starting current drawn by ramping induction motor. In order to compensate the load increase the voltage is reduced. To limit the starting current surge, large induction motors are started at reduced voltage and then have fully supply voltage reconnected when they run up to near rotated speed. There are many arrangements for starting an Induction motor. The choice of method is done keeping in mind the system robustness, efficiency, equipment cost, machine lifetime.

2. PARAMETERS WHICH ARE OF CONCERN DURING STARTING

2.1. Inrush current: Defined as the initial current which is the cause of mechanical stress of the bearings and belts on the motor load. This current also causes copper loss which affects efficiency. This loss is dissipated as heat causing thermal stress thus affecting the machine life.

2.2. Voltage dip: The voltage dip is caused by the load torque characteristics as torque is proportional to the square of voltage. The allowable voltage dip ranges from 80% to 90% of the rated voltage.

2.3. Frequency dip: To maintain the system stability it is very necessary to maintain fundamental frequency.The frequency dip is though not as important as the voltage dip.

2.4. Acceleration time: It is the approximate time required to achieve the rated speed of the motor. It is a measure of of other parameters such as torque and current.

2.5. Torque: The speed-torque curve is used to represent the required torques of the motor for different speeds. The initial rotor starting torque meets the necessity of potential energy at stand still and acceleration torque should increase in order to maintain acceleration or the motor will stall.

2.6. Reactive power and starting power factor: The rating of the equipment may be required to be rated higher than the rated value as the reactive power consumption by the motor is high. The reactive power during start is closely related to the voltage dip. Typical values of power factor are about 0.20 for motors under 1000HP.

2.7. Robustness: The ability of an induction motor to perform consistently.
2.8. Cost: The installation and operation cost.

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 face some difficulties at the starting time of the motor. The proposed system will overcome these situations.

3. AUTOMATIC STAR DELTA STARTER

The star 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 automatically operated. This is first achieved by connecting the stator winding in star connection, after the motor attains the certain speed the contactor switches to the stator winding to delta connection.

4. CALCULATION IN STAR AND DELTA CONNECTION

Suppose VP be the supply voltage per Phase. So the line voltage of the supply will be VL = Line current = $\sqrt{3}$ V_P.
For star connected load:
$I_{stY\ p}$= starting current per phase in star
$I_{stY\ l}$= starting line current in star
$I_{stY\ p}$= $I_{stY\ l}$, V_p=(V_l/$\sqrt{3}$)
For delta connected load:
$I_{st\Delta p}$= Starting current per phase in delta
$I_{st\Delta l}$= starting line current in delta
$I_{st\Delta p}$= ($I_{st\Delta l}$/$\sqrt{3}$) and V_p = V

5. PROPOSED STAR-DELTA STARTER

It is an equipment automatic star – delta starter for three phase induction motor. This is mainly relay based circuit. The three phases are connected in star. One way is to use star delta motor starter. So, it is where starter if simply connected in STAR , the starting current would be huge.
Normally motors run in star mode. Full voltage is applied to the motor. So by making motor to run in delta mode after consuming (50-60)%. Current sensor continuously monitors the current variations and provides the necessary feedback as per the design. Based on the feedback from current sensor the star - delta module performs. Start in star and change over to delta and then operate in star or delta, based on load. Changeover from star to delta based on current instead of time. 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.

6. WORKING PRINCIPLE

This is the reduced voltage starting method. Voltage reduction during star delta starting is physically reconfiguring the motor windings. During starting the motor windings are connected in star configuration and this reduces the voltage across each winding. This reduces the torque by a factor by three. After a period of time the windings are reconfigured as delta and the motor runs normally. At first the DC generator is coupled to the induction motor shaft and gives DC output. The values of threshold voltage are provided to the Zener diode. A filter circuit is connected in the path which filters the noises and the output is further send to OP-AMP input. A reference value is provided to the other end of OP-AMP for comparing with reference input. The desired value current passes through a resistor to the transistor base. When it reaches the base, the emitter current flows via the collector, and as a result the relay will be operated from NC mode to NO mode. It will also operate the 3CO relay. As soon as this is done, the star connection gets shifted to delta connection.

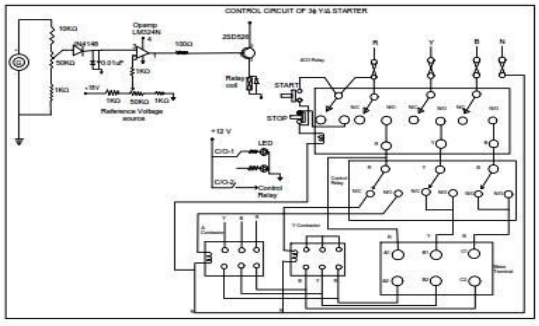

Figure 1 Circuit diagram of the starter.

7. SIMULATION RESULTS

The simulation of the proposed system is done in the Multisim. In Multisim software, it is difficult to show the star and delta winding connections of the induction motor. Thus the control of the supply voltage was done with the help of the electronics devices which receives its input from the power block output. Thus reduced voltage is given as supply to run the motor in the initial mode. And when motor attains the 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. The simulation helped in getting an idea of the voltage and current at different stages and thus realise the circuit practically.

8. ADVANTAGES OVER THE CONVENTIONAL METHOD

The other conventional methods are:

a. Direct-On-Line method- Direct connection of terminal voltage to motor stator with no additional components. Most economical in terms of installation cost and ease of use.
b. It produces highest inrush current, about 6-8 times of rated current. It is most commonly used for small motors. The mechanical stress on load is more; efficiency is low due to high reactive power consumed at start.
c. Shunt Capacitors- A capacitor is connected in parallel to the motor which compensates the reactive demand from motor during starting by supplying a loading current and thus improves power factor while still achieving high starting torque because of full voltage.
d. Electromechanical reduced Voltage techniques- Implementing through conventional circuitry, such as resistors and transformers. In this method of reduced voltage starting methods the thermal capability should also be considered.
e. Star and Delta- Initially the three windings are connected in star to provide line voltage reduced by a factor of 57.7% and current reduced to 1/3rd of the current at rated voltage. The starting torque is but 1/3rd to 1/5th of starting torque by DOL starter.
f. Autotransformer- Uses tap changes to reduce low voltage as required. Current can also be reduced. However torque also reduced as square of voltage & needs to be considered.
g. Primary Resistor or Reactor- Switchable primary series resistor or reactor bank connected at motor terminals to limit current or change in current.
h. Soft Starter Techniques- Solid state electronic circuit based device that manipulates the supply voltage as required.

Timer and Relay based – This is the approach taken in this paper.

It is dependent on time and also depends on the load current. The feedback from load characteristics decides whether to switch the mode or to continue. It makes the system application oriented thus enhancing the accuracy and efficiency. And also helps to optimise the actions required in the starting of an Induction motor.

9. CONCLUSION

Thus it is seen that if the motor can 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. The other advantages which were achieved are:

a. Power factor is better in star mode.
b. Usage of capacitor banks to improve power factor is reduced.
c. The size of the conductor can be reduced.
d. Reduced stress on power grid when starting.

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