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MOTOR DRIVING USING FRONT END ACTIVE CONVERTER

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ABSTRACT

The paper addresses the issue of harmonics, hard switching and soft switching, speed control of a high power three phase motor used in industries. To analyze this problem in this paper, power electronics-based approach is used to drive a three-phase motor using a front end active converter. The technology presented in this paper uses power devices such as IGBT's and SCR's which has various benefits over BJT and MOSFET. To reduce harmonics power devices are used in rectifiers and inverters. Three phase motors are extensively used for various industrial applications because of their various advantages and using a power device-based technique to drive motor makes it more efficient. The design procedure for this proposed technique is briefly discussed with simulation results and calculations.

Keywords: Active front End converter, harmonics, motor encoder.

INTRODUCTION

An induction motor is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding. AC motors are highly flexible in many features including speed control and have a much larger installed base compared to DC motors. Three common motor speed control applications include constant speed, variable speed and torque (or position) control. Many applications only require the motor to run at constant speed with no need for acceleration and deceleration ramps. The variable speed drives have the ability to control acceleration and deceleration and may also help handle product better. Harmonics induction motor are generated due to the usage of non linear load. Some of the effects of harmonics on the performance of induction machine are: increase in core loss, reduction in motor torque, Electromagnetic interference and damage of the induction motor insulation. With analysis on various parameters these harmonics can be reduced to greater extent and efficiency of induction motor can be increased.

PROBLEM IDENTIFICATION

Harmonics in the power system are generated due to the usage of non-linear load. Some of the effects of harmonics on the performance of induction machine are: Core losses in the Induction machine increases Torque of the Induction motor reduces Increase in the Skin effect Damage of the induction motor insulation Electromagnetic Interference Deviation in the induction motor Torque-Speed curves cables overheating due to the extra current Capacitors enduring insulation damaging voltages due to resonance Uncontrolled noise and torque oscillations in motors that could lead to mechanical resonance and vibration and communication equipment or instruments providing incorrect readings due to signal interference.

Core loss in any machine constitutes both hysteresis loss and eddy current loss. Hysteresis loss of the induction machine is proportional to the applied frequency and eddy current loss is proportional to the frequency squared. Frequency of the harmonics will be in the order of the multiples of the fundamental frequency. Therefore, core loss is major concern at higher frequencies due to harmonics. Also, harmonic currents and voltages reduces the overall efficiency of the machine. Increase in the harmonics frequency results in increase in skin effect tending the current to flow on the surface of the conductor. Skin effect contributes the loss in the form of resistance to the flow of current.

Harmonics increase the Electromagnetic Interference (EMI). This EMI does not affect the motor; however, it affects the operation of nearby electronics, control and communication circuits. Fundamental frequency of the induction motor produces forward operating torque. However, it is observed that harmonics frequency will generate torque in both forward and in reverse direction. For example, 5th 7th and 11th harmonics produce torques in reverse direction and on the other hand 7th, 13th and 19th harmonics components produce torque in forward direction. 5th harmonic components will have higher magnitude compared to 7th harmonics. Hence harmonics torque will reduce the operating torque of the machine. Losses which occur due to Harmonics will cause the deviation in the torque speed characteristics of the motor from original and affects the performance of the motor.

ACTIVE FRONT END

An active front end (AFE) not only reduces harmonics, but also provides other benefits that can reduce costs for the end user. Rather than using diodes in the rectifier to convert the incoming AC power to DC, an active front end uses insulated gate bipolar resistors (IGBTs). IGBTs are devices whose switching is controlled electronically — hence the term “active” front end. The active front end monitors the input current waveform and shapes it to be sinusoidal, reducing total harmonic distortion (THD) to 5 percent or less. (Note that THD is only measured for lower-order harmonics. An LCL filter is necessary to reduce higher-order harmonics caused by the switching frequency of the IGBTs.)

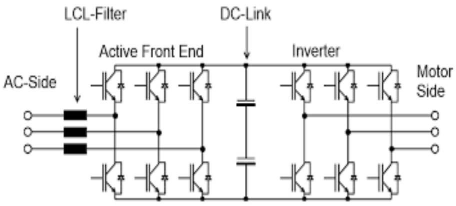

Fig. 1. Active Front End Converter

Another benefit of active front end drives is their ability to handle regenerative power. The IGBT rectifier design allows four-quadrant operation, meaning the motor can produce either positive or negative torque, during either the forward or reverse motor rotation. When torque and motor rotation are in different directions, the motor acts like a generator, and the power produced by the motor can be fed back into the electrical supply. This eliminates the need for large resistor banks to dissipate the regenerated energy and reduces costsby feeding the energy back to the line, where it can be reused.

PROPOSED METHODOLOGY

A three-phase induction motor uses a three-phase supply and its basic blocks consist of a rectifier and a three-phase inverter for the purpose of speed control and reduction of harmonics. The initial source is a three phase AC source which is converted to a DC supply using a rectifier. Like the half wave circuit, a full wave rectifier circuit produces an output voltage or current which is purely DC or has some specified DC component. A 12-pulse rectifier uses two 6-pulse rectifiers in parallel to feed a common DC bus. A transformer with one primary and two secondary windings creates a 30-degree phase shift between the two current waveforms, which eliminates the 5th and 7th harmonics and reduces current THD to between 10 and 15 percent. Disadvantages of a 12-pulse rectifier are cost due to the special transformer required.

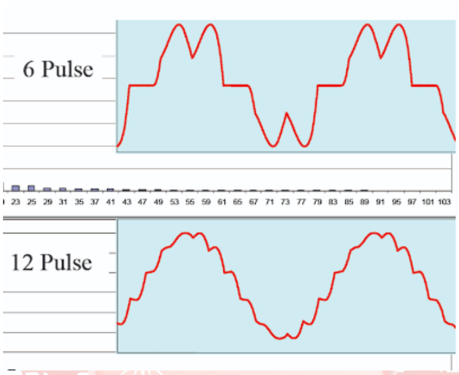

Fig. 2. Comparison of 6pulse and 12 pulse

Due to various advantages of power devices, SCR and IGBTs are used in construction of rectifiers and inverters. The DC output from rectifier is fed to a 3-phase inverter. A three-phase inverter converts a DC input into a three-phase AC output. Its three arms are normally delayed by an angle of 120 so as to generate a three-phase AC supply. The inverter switches each has a ratio of 50 and switching occurs after every T/6 of the time T. This 3-phase output from inverter is used to drive induction motors. In the case of three phase AC operation, the most widely used motor is a 3-phase induction motor, as this type of motor does not require an additional starting device. These types of motors are known as self-starting induction motors. When we connect the primary winding, or the stator to a 3 phase AC source, it establishes rotating magnetic field which rotates at the synchronous speed. According to Faradays law an emf induced in any circuit is due to the rate of change of magnetic flux linkage through the circuit. As the rotor winding in an induction motor are either closed through an external resistance or directly shorted by end ring, and cut the stator rotating magnetic field, an emf is induced in the rotor copper bar and due to this emf a current flow through the rotor conductor.

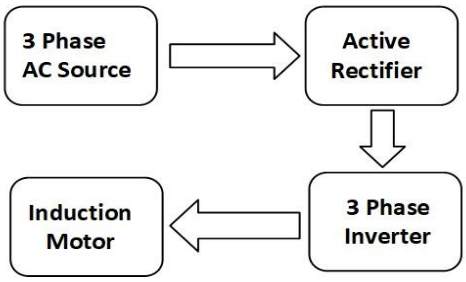

Fig. 3. Block Diagram

A Encoder is attached with the motor for controlling the speed of the motor. A motor encoder is a rotary encoder mounted to an electric motor that provides closed loop feedback signals by tracking the speed and/or position of a motor shaft.

CONCLUSION AND FUTURE SCOPE

Power electronics technology has found its way into many applications, from renewable energy generation (i.e., wind power and solar power) to Electrical Vehicle, biomedical and small appliances, such as laptop chargers. In a near future, electrical energy is provided by power electronics and is consumed by power electronics. This, not only intensifies the role of power electronics technology in power conversion processes, but also implies that power systems are undergoing a paradigm shift, from centralized distribution to distributed generation. The starting torque of induction motor is very high which makes motor useful for operations where load is applied before the starting of the motor. 3 phase induction motors will have self starting torque unlike synchronous motors. However, single-phase induction motors does not have self starting torque and are made to rotate using some auxiliaries. 3 phase induction motors are extensively used for various industrial applications because of their many advantages. They have very simple and rugged (almost unbreakable) construction. They are very reliable and have low cost, high efficiency, and good power factor. This circuit drives an induction motor whose speed can be controlled and due to the use of power devices harmonics are reduced.

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