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RESEARCH ARTICLE

SPEED CONTROL OF SINGLE PHASE INDUCTION MOTOR USING SINGLE MOSFET

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ABSTRACT

Phase angle controlled converter using back to back Thyristors or Triacs are being widely adopted to control the speed of voltage controlled single phase Induction Motor used for domestic Fan / Blower loads. This method suffers from the disadvantages of low input power factor at lower speeds due to low power factor. The fan draws more current than the required one. This leads to higher I^2R Cu losses occurring in the stator of the single phase motor. The proposed techniques of High Frequency PWM Controlled are proposed. This motor is expected to draw lesser current at higher input power factor as compared to the existing firing angle controlled speed controlled techniques. In this way, the motor would operate at higher efficiency, yielding a low Cu loss, high input power factor, reduced low order harmonics and reduced torque pulsation.

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INTRODUCTION

Power saved is the power generated and hence there is an urgent need to save the power wherever possible. Demand for energy is rising in the whole world at an unsustainable rate. Energy efficiency is the only way to manage and restrain the growth in energy consumption. If it delivers more services for the same energy input than it is more energy efficient, or the same services for less energy input. In all industries due to increase in the energy tariff, the need for energy efficiency is essential. Improved energy efficiency has many potential benefits. The optimal investment in power efficient technologies is not taking place due to a variety of obstacles. Some of the obstacle is overcome in the proposed research work. Electric drive manufacturers are trying to maximize the efficiency and input power factor of AC motors suitable for all classes of industrial and domestic drives for both single phase and three phase AC supply. Induction motors are the widely used AC motor in domestic and industrial purpose. They are very simple, extremely rugged, requires a minimum of maintenance. Hence, Low power Single phase Induction motors are widely used for domestic utility fan motor applications, e.g. Ceiling fans, table fans, air coolers, blowers which are required to run continuously for a long time and also need speed control provision. In the previous techniques, the variable speed drives had various limitations such as larger space, poor efficiencies, lower speed and etc.

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But, the new advanced technology of power electronics devices is changing the scenario. Efforts are being made to obtain variable speed drives with smaller size, high efficiency and high power factor and lower losses (Nabil Ahmed and Emad El-Zohri, 2004). Now a day, in the U.S., an approximately 1 billion motors exists which is used 64% of the electrical energy or roughly 1700 billion kWh/yr. 90% of the motors are less than 1 HP in size, and account for approximately 10% of the electricity consumed by the electric motor population. These fractional horsepower motors are primarily single phase induction motors used primarily due to their low production cost despite their poor efficiency. A mere 1% improvement of efficiency in the fractional horsepower market translates to 1.7 billion kWh/yr of energy saved (Daut *et al.,* 2011).

Proposed techniques: This research carried out as High frequency PWM technique in AC freewheeling action for induction motor which is Only one semiconductor switch instead of two numbers of semiconductor switches and high efficiency and high power factor of fan, air coolers and blower coupled to single phase induction motor. This is Simple and Economical control circuit and Power saving device as shown in Fig.1. Phase angle controlled converters using back to back Thyristors or Triacs are being adopted to control the speed of voltage controlled single phase Induction Motor used for Fan / Blower loads. This method suffers from the disadvantages of low input power factor, especially at lower speeds. The motor draws discontinuous current at lower speeds which leads to torque oscillation. The overall r.m.s. current in the motor is higher than that required due to low power factor at lower speeds.

Phase angle controlled AC voltage controller using SCR and Triacs are in use till date which suffer from the dis-advantage of lower power factor operation in the lower speed range. The motor draws more than the required current from the source at low power factor causes a voltage drop in line because the numbers of such motors are very large in number leads to increase in stator copper loss. The operation of fans in low power factor region therefore has two ways disadvantageous effects, one for the user and the second for the power supply Distribution Company. In-order to minimize the above mentioned dis-advantages of low power factor and higher copper loss in the motor, a high frequency pulse width modulation control is proposed. In above Fig.2. a capacitor is performing the freewheeling action in place of conventionally used additional freewheeling switch. The RMS output voltage of the motor and thereby the speed of the induction motor would be controllable by fixed High frequency PWM control. The source current waveform, therefore, remains in the same phase with the source voltage giving rise to high input power factor. The controllable switch therefore always remains in a Forward bias condition On application of the gate pulse to the power semiconductor switch the motor terminals at the input bridge rectifier get short circuited and the motor therefore draws current from the AC source whose path is completed through bridge rectifier and power semiconductor switch.

Principal of operation of proposed drive: The modes of operation are divided into four modes, i.e. conduction and freewheeling mode for Positive half cycle, conduction and freewheeling mode for the negative half cycle. The load current conducts through the input and output sides, providing energy to the load as shown in Fig.3.

Conduction Mode: In conduction mode, current flows from source to the motor, diode D_1, MOSFET, diode D_2 and then back to the source for positive half cycle and current flows from source to the motor, diode D_3, MOSFET, diode D_4 and then back to the source for negative half cycle.

Free Wheeling Mode: In Free Wheeling Mode, Current circulates in the motor and parallel connected capacitor C_{fw} in the same direction as per their respective positive and negative half cycle. Mode 1 and mode 2 are repeated a number of times in positive half cycle. Mode 3 and mode 4 are repeated a number of times in the negative half cycle. The number of switching intervals depends on applied switching frequency. In Controller Circuit, the High Frequency oscillator generates the triangular wave whose magnitude varies in between Vcc which is shown in fig.4 then outputs given to the non inverting input of the duty ratio controller. In the duty ratio controller, i.e. PWM controller, which is generating the inverting High Frequency PWM wave and then this inverting wave gives driver fed to gate pulses. The control circuit of the drive consists of various ICs used for generation of gate pulses in a continuous manner. The control circuit of the proposed drive has been designed using an analog based circuit. The circuit includes different integrated circuits (ICs) for generation of pulses. +/- 12V regulated power supply is procured through transformer (9-0-9V, 500mA) for the control circuit. The proposed scheme uses a controlled power semiconductor switch which is power MOSFT depending on their power handling capability. The frequency of pulses ranging up to 2 kHz for main switch. The pulses used in the proposed drive are complimentary to each other.

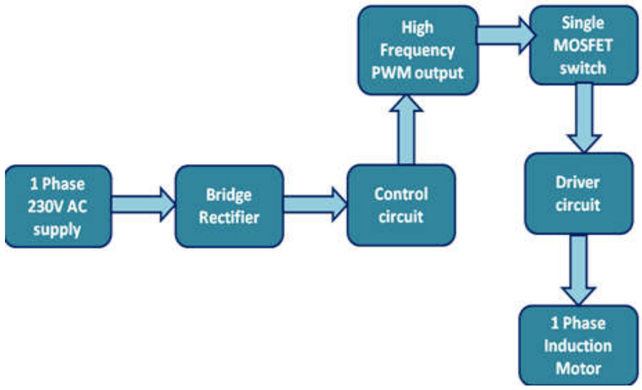

Fig. 1. Block diagram of proposed drive

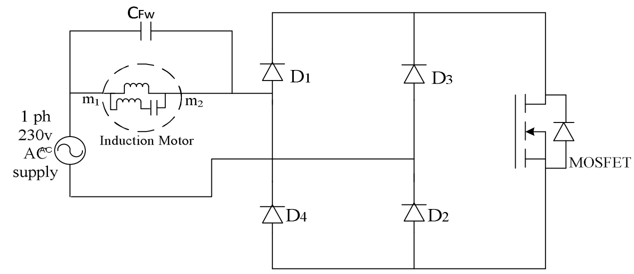

Fig. 2. Power Circuit of Proposed Drive

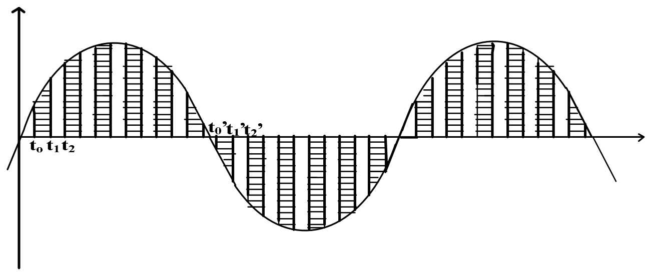

Fig. 3. PWM controlled Motor Stator Voltage waveform

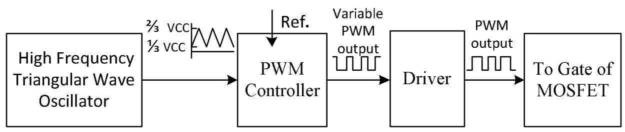

Fig. 4. Block Diagram of Controller Circuit

EXPERIMENTAL RESULTS

Fig.5. shows the measured variation of the total harmonic distortion factor (THDF) of the input current versus the rms output voltage for different load conditions. In this Figure, when THD is minimum then duty ratio 25%. Second curve shows the duty ratio is at 75%, then THDF is High on 50% and third curves shows the duty ratio is 50% then THDF is higher than 50%.. That means it is in the same load condition, which is increasing in the THDF with the input power factor goes from lag to lead as well as displacement factor. Although the increase in THDF will reduce the value of the supply power factor, however, it will not affect its leading nature. The experimental results in Fig.6. are the improvement in the input power factor with the Speed in RPM which gives a nearly unit power factor at 700 RPM speed of the single phase induction motor and lagging input power factor at full speed of the motor.

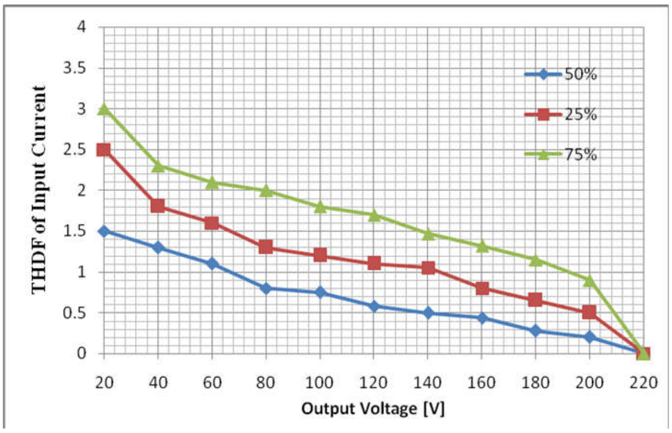

Fig. 5. Variation of THDF of Input current with the output voltage

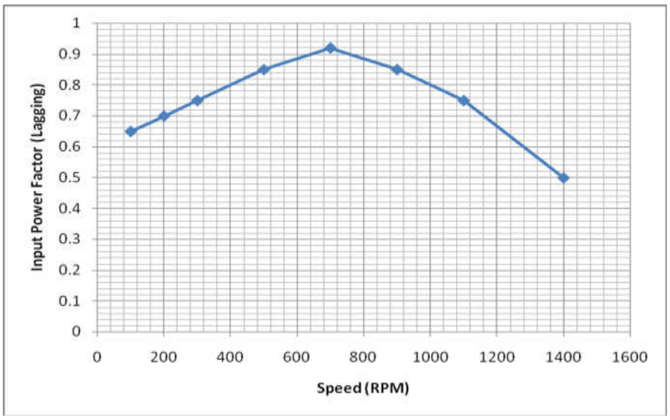

Fig. 6. Variation of Input Power Factor with the Speed in RPM

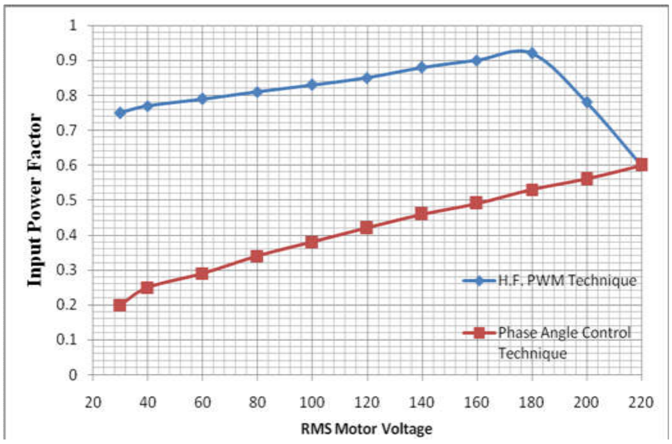

Fig. 7. Variation of the Input power factor with the motor voltage

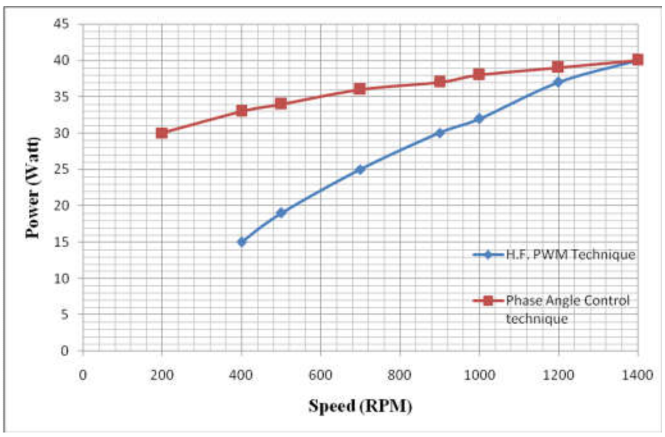

Fig. 8. Variation of the Power with the Speed in RPM

A signification of improvement in the input power factor with the rms voltage is shown in Figure.7. Which is given the variation of the THDF of the input current with the motor applied voltage and compare with phase angle control techniques as shown in figure.7. The significant improvement in power output with the speed in RMS and compare with the phase angle control technique as as shown in figure.8.

Conclusion

Based on experimental results, it is observed that the proposed topology of the drive is unique. It provides independent control over power factor and speed of the single phase induction motor by the combination of High Frequency PWM control technique is used in the project. High input power factor range is obtained during running condition. Since input power factor is high, current intake of the motor is less and corresponding stator copper losses (I^2R) are also reduced. The efficiency of the motor is effectively improved. Proposed topology offers AC freewheeling. The Proposed project is useful for speed control of induction motor for blower and fan load application. The source current is observed to be reduced for the same speed of motor and thereby for the same power output. The THD of the input current seems to be low. The Scheme is also applicable to loads of torque proportional to Speed. Approximately 20% Energy Saving – For Fans / Blowers at Reduced Speed. The Proposed scheme is economic and have simplicity of control over various parameters.

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