International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 04, April-2015

Speed Control of Three Phase Squirrel Cage Induction Motor

Akhil G Augustine Alvin Valantine Athul S Chandran Bibi Banerji
[1]Mar Athanasius College of Engineering, Department of Electrical and Electronics,
Kothamangalam, Ernakulam, India

***Abstract*— The paper describes the open loop control of the 3 phase induction motor at variable speed using a 3 phase inverter. The 3 phase inverter is supplied from a 400V DC supply. The 3 phase inverter with 3 legs use IGBTs as switches for the generation of 3 phase output. The switches are controlled by pulses created by the PIC microcontroller. The PWM technique used in this project is sinusoidal pulse width modulation. PIC mi crocontroller is used to generate PWM signals. These low voltage signals are given to opto-couplers. The opto-coupler isolates the controller from high voltage level circuit and raises the voltage level of output. The output is fed to the driver circuit for a half bridge of IGBT. For the protection of IGBTs against the over voltages and from short circuiting we have used bootstrapping arrangement. The PIC microcontroller is used to generate PWM signals at variable frequencies. The frequency can be varied using a manual input to the controller.**

Keywords*— PWM, Opto-coupler, IGBT, LCD Display

I. INTRODUCTION

Induction motors are the most widely used electrical motors due to their reliability, low cost and robustness. However, induction motors do not inherently have the capability of variable speed operation. Due to this reason, earlier dc motors were in most of the electrical drives. But the recent development in speed control method of the induction motor have led to their large scale use in almost all electrical drives. out of the several methods of speed control of an induction such as pole changing, frequency variation, variable rotor resistance, variable stator voltage, constant V/F control, slip recovery method etc., constant V/F speed control method is most widely used. In this method, the V/F ratio is kept constant which in turn maintain the magnetizing ux constant so that maximum torque remain unchanged[1]. Thus, the motor is completely utilized in this method. This project is concerned with Microcontroller based speed control of Sinusoidal PWM Inverter fed three phase Induction Motor. The work involves design and fabrication of a variable frequency PWM inverter using IGBT, operating from a DC source[2]. The objective is to implement variable frequency sinusoidal PWM inverter in order to control the speed of the induction Motor using Microcontroller. When it is required to provide wide range of speed control covering up to motor rated speed, normal three phase supply at 50Hz with voltage control alone is not successful due to the unstable region in Torque-Slip characteristics of the motor. Hence it is necessary to go in for variable voltage and variable frequency mode of operation. The main focus of this project is the design and fabrication of variable voltage and variable frequency sinusoidal PWM inverter for speed control operation of Induction Motor.

II. SPEED CONTROL BY V/F METHOD

The torque developed by the motor is directly proportional to the magnetic field produced by the magnetic field produced by the stator. So the voltage applied to the stator is directly proportional to the product of stator flux and angular velocity. This makes the flux produced by the stator proportional to the ratio of applied voltage and frequency supply. By varying the voltage and frequency by the by the same ratio, flux and hence, the torque can be kept constant throughout the speed range. This makes constant V/F the most common speed control of an induction motor[1]. The Fig 1 shows the relationship between the voltage versus frequency. The voltage and frequency being increased up to base speed. At base speed, the voltage and frequency reach at the rated values. We can drive the motor beyond the base speed by increasing frequency further. However the voltage applied cannot be increased further. Therefore only frequency can be increased, which results in weakening and the torque available being reduced.

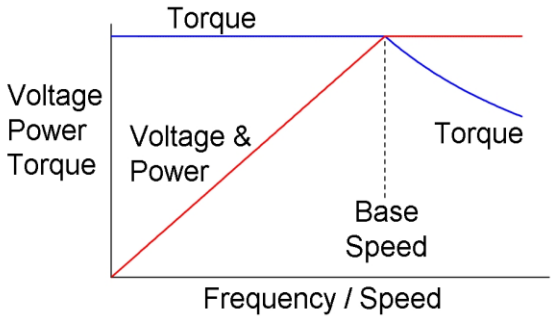

Fig 1. Torque-Speed characteristics

A. SINUSOIDAL PULSE WIDTH MODULATION

In single pulse and multiple pulse modulation techniques the width of all pulses are same but in sinusoidal pulse width modulation the width of each pulse is varied in proportion to the amplitude of a sine wave. In this technique the gating signals are generated by comparing a sinusoidal reference signal with a triangular carrier wave. The commutation of the modulated pulse and intersection of sine and square waves

determines the switching instant. This is described in Fig 2. When the modulating signal is a sinusoidal of amplitude Am, and the amplitude of the triangular carrier is Ac, the ratio =Am/Ac is known as the modulation index[3]. With a sufficiently high carrier frequency, the high frequency components do not propagate significantly in the AC network (or load) due to the presence of inductive elements.

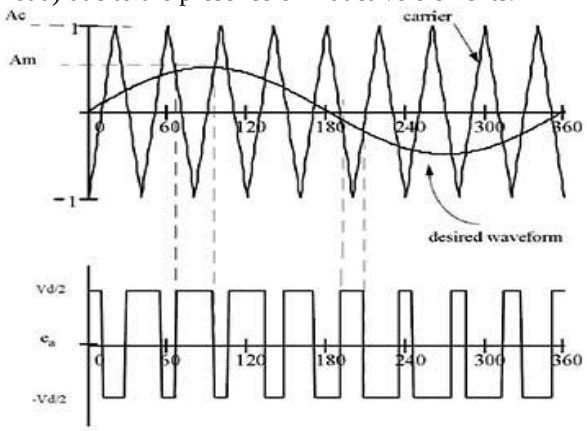

Fig 2. Sinusoidal PWM curve

III. OPERATING PRINCIPLE

The generalised block diagram for the hard ware implementation of the project has been shown Fig 3. The three phase rectifier denotes the 6 diodes connected so as to get a 440V ac supply. The capacitor filters the ripple in the DC bus. This DC bus is used to generate a variable voltage and variable frequency power supply. A voltage source power inverter is used to convert the DC bus to the required AC voltage and frequency. In summary, the power section consists of a power rectifier, filter capacitor and power inverter. The pulses generated by the PIC microcontroller are given into the opto-coupler and we get a high level voltage pulses which is necessary for triggering the IGBTs in the three phase Inverter.

Thus the speed of motor is controlled by varying the frequency of the output of inverter.

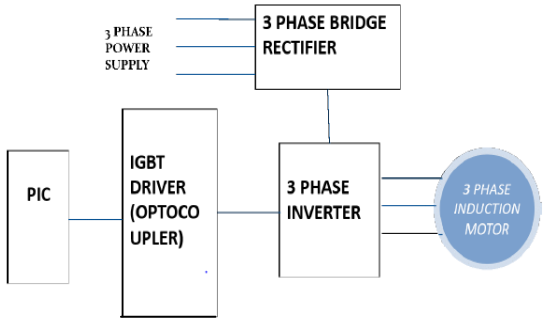

Fig 3. Block Diagram

A. *Circuit Diagram*

The auxiliary supply to the PIC microcontroller is given using a 5VDC supply and the auxiliary supply to opto-coupler is given using 12V supply. Frequency can be varied using a manual input(trim pot) to the controller. Program code generate gate pulses for the IGBT according to external trim pot. The complete circuit diagram is given in Fig 4. It consist of a controller side and a power side.

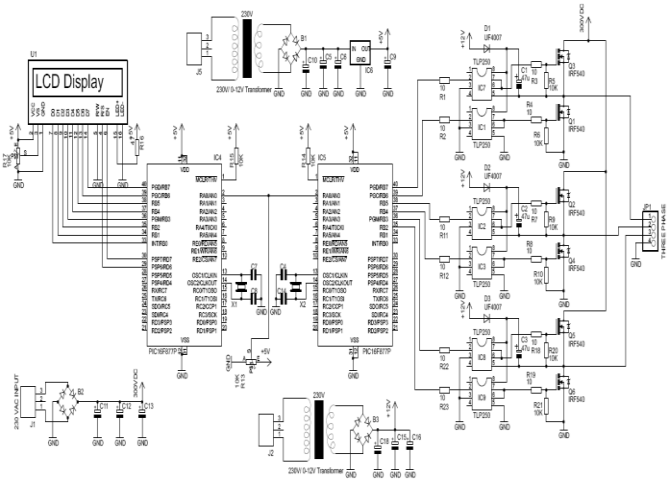

Fig 4. Circuit Diagram

B. *Program Algorithm*

Flow chart of the micro controller program is given in Fig. 5. The program algorithm is explained below.

1. Value of trim pot is detected by the ADC of PIC 1 & PIC 2.
2. PIC 1 creates the gate pulse (PWM) according to the output of ADC.
3. Gate pulse are send to the IGBT through opto-coupler
4. PIC 2sends data to the LCD display according to the output of ADC and speed is displayed.
5. Go to step 1.
6. End.

C. *Working*

The frequency of the output of the inverter is controlled by the trim port. By varying the trim pot, we can vary the output of the PIC. The frequency of the inverter is controlled by the gate pulses to the opto-coupler from the PIC.As the trim pot varies, the triggering pulses from the PIC changes and the output frequency of inverter changes. Hence, the speed is controlled.

Program is done in such a way that PIC always produces PWM pulse and the V/F ratio is kept constant .The value of v/f can be varied by varying values timers in the micro controller.

The second microcontroller is used to control the LCD display. The output of the of trim pot is also given to the second microcontroller and it will show the speed according to the calibration, in the LCD display.

IV. CONCLUSION

Speed control of three phase squirrel cage induction motor using V/F method is implemented. The implementation is done using a rectifier and an inverter, where the PWM triggering pulses were generated by using PIC micro controller for switching the IGBTs of the inverter. The speed is controlled using a trim port and speed control in the range 0 to 630 RPM is made possible. The flow code programming made the implementation easier and the accessibility towards PIC was made more convenient. This method of speed control has got wide range of application in industries. Speed can be varied from zero to synchronous speed keeping the torque constant.

ACKNOWLEDGMENT

The authors would like to thank Prof. Radhakrishnan, Head of the Department, Electrical and Electronics Engineering, MACE, Prof. Daissy Kutty Abraham and Asst. Prof. Jeena Joy for their help and support in preparing this paper.

REFERENCES

[1] Mrs.Deepali S. Shirke, Prof.Mrs.Haripriya, H.Kulkarni, "Microcontroller based speed control of three phase induction motor using v/f method", International Journal of Scientific and Research Publications, Volume 3, Issue 2, pp. 1-6, February 2013

[2] Madivalappa.B , M. S. Aspalli, "Speed Control of Three Phase Induction Motor by Variable Frequency Drive", International Journal of Advanced Research in Computer Science and Software Engineering, pp. 411-412, 2013.

[3] Amer Bellil, Abdelkader Meroufel, "VS PWM inverter feed induction machine using Volts per Hertz Control Scheme", Przegld Elektrotechniczny, pp. 59-62, 2012

[4] Nazmul Islam Raju, Md. Shahinur Islam, Ahmed Ahsan Uddin, "Sinusoidal PWM Signal Generation Technique for Three Phase Voltage Source Inverter with Analog Circuit and Simulation of PWM Inverter for Standalone Load and Micro-grid System", International journal of renewable energy research, vol 3, pp. 647-658.