Sinusoidal PWM Inverter fed Induction Motor Drive

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Abstract: *Recent developments in power electronics and semiconductor technology have lead improvements in power electronic systems. A three-phase voltage source inverter provides variable voltage and frequency supply required by ac drives. For obtaining variable voltage supply pulse width modulation technique proves to be useful. Sinusoidal pulse width modulation is one of the popular techniques used for obtaining controlled output from inverters. In ac motor drives using SPWM inverters one can control both frequency and magnitude of the voltage and current applied to a motor. As a result, PWM inverter-powered motor drives are more variable and offer in a wide range better efficiency and higher performance when compared to fixed frequency motor drives. Three phase voltage-fed PWM inverters are gaining importance in various industrial applications. Sinusoidal Pulse Width Modulation variable speed drives are preferred in applications demanding superior performance .In this paper simulation and analysis of sinusoidal PWM Inverter fed Induction motor is carried out. The THD and fundamental voltage is measured at varying modulation indexes.*

Keywords — *Matlab, Spwm, IGBT, Induction Motor Drive.*

I. INTRODUCTION

Induction motors are widely used in industrial applications as they are simple, rugged and easy to maintain. They run at constant speed but as its speed is frequency dependent, it can be controlled with the help of power converters that provide variable frequency output. The different power converters available are rectifiers, inverters, cycloconverters and choppers. An inverter converts dc power into variable ac power. Thus they can be used in inaccessible areas where ac power is not easily available. In such case ac power can be obtained with the help of inverters. An ideal inverter should produce sinusoidal output voltage. But practical inverters output waveforms are non-sinusoidal as they contain harmonics. The harmonic contents can be reduced with the help of pulse width modulation techniques. By using these modulation techniques we can control the switching electronic device in order to obtain the desired amplitude and frequency with the desired quality [2]. Pulse Width Modulation based firing of inverter provides the best constant V/F control of an induction motor. Output of an inverter can be controlled using either internal control or external control. Pulse width modulation is a method of controlling output of inverter which comes under internal control. In this method, a fixed dc input voltage is supplied to the inverter and a controlled ac output voltage is obtained by adjusting the on and off periods of inverter devices.PWM switching techniques helps in reducing THD, and achieving effective dc bus utilization. Three phase electronic power converters controlled by pulse width modulation have a wide range of applications for dc to ac power supplies and ac machine drives [1]. Modulation techniques are classified in two types i.e. carrier less modulation and carrier based modulation. Carrier based modulation, includes: Sinusoidal pulse width modulation (SPWM), Modified pulse width modulation (MPWM), 3rd harmonic injection PWM and Space vector modulation (SVM). Carrier less modulation consists of Delta modulation (DM), Specific harmonic elimination (SHE) and Wavelet modulation (WM) [2].

II. SINUSOIDAL PWM

Sinusoidal PWM technique is a popular method of controlling the output of inverters. This method is easy to implement and control. Also it is compatible with almost all the modern digital applications [2]. In this technique a high frequency triangular carrier wave is compared with the sinusoidal reference wave which determines the switching instant. When the modulating signal is a sinusoidal of amplitude A_m, and the amplitude of triangular carrier wave is A_c, then the ratio $m=A_m/A_c$ is known as the Modulation index. By controlling the modulation index we can control the amplitude of applied output voltage. A three phase Sine-PWM inverter requires a balanced set of three sinusoidal modulating
Signals along with a triangular carrier signal of high frequency.

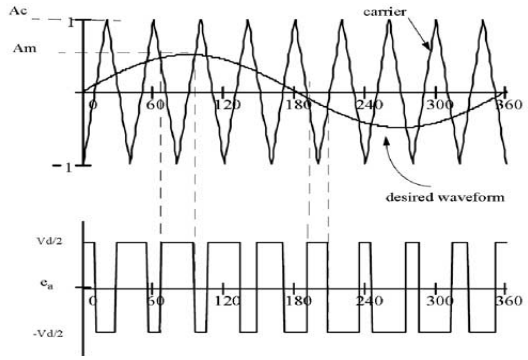

Fig.1: Sinusoidal PWM

III. THREE PHASE INVERTER

A circuit diagram of a three phase inverter is shown in fig. (a) below. A three phase inverter consists of six semiconductor devices which are arranged in three legs, each leg consisting of two devices. It is fed from a dc supply or a rectifier circuit. It converts the input dc supply into three phase ac. These inverters are normally used for high power applications. In order to control the output voltage of inverters it is necessary to deal with the variations in dc input voltage and also to regulate the voltage of inverters as well as satisfy the constant volts and frequency control requirement. This ac output can be utilized for three phase load such as inductive load or three phase ac motor. In Sine-PWM inverter the widths of the pole-voltage pulses, over the output cycle, vary in a sinusoidal manner [3].

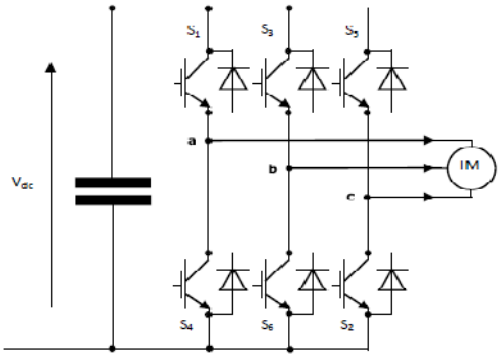

Fig.2: Three phase inverter Circuit

IV. THREE PHASE INDUCTION MOTORS

The three-phase induction motors are the most widely used electric motors in industry. They run at essentially constant speed from no-load to full-load. However, the speed is frequency dependent and consequently these motors are not easily adapted to speed control. Prior to the development of semiconductor devices, dc motors were preferred for large speed variations. But with the development in power electronics field, various power converters became available for motor control. An inverter can be used to provide variable frequency input to an induction motor. The 3-phase induction motors are simple, rugged, low-priced, easy to maintain and can be manufactured with characteristics to suit most industrial requirements.

V. SIMULATION OF SPWM INVERTER FED IM DRIVE

The Simulink model of SPWM inverter consists of a three phase supply, rectifier, filter circuit, inverter and an induction motor. Initially the three phase ac is converted into dc with the help of diode rectifier circuit. The dc output voltage of rectifier is filtered using LC filter. The switching frequency is set to 2.1 KHz. This filtered voltage is supplied to the three phase inverter which converts it into ac and supplies it to the induction motor. The parameters of induction motor used for simulation are as follows: 3 Hp, 2 pole, 1460 rpm, 3-phase with parameters: Rs = 1.115 ohm, Rr= 1.083 ohm, Ls= Lr = 0.005974 H, Lm= 0.2037 H, J= 0.02 Kg.m2, F= 0.005752 N.m./s The dc link filter parameters are L=200μH and C =5000 μF. Inverter switching frequency is 2.1 KHz and dc link voltage is 393.5 V.

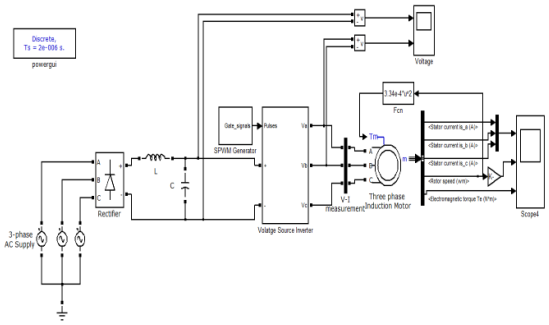

Fig.3: Simulink Diagram of SPWM inverter fed IM drive

VI. SIMULATION RESULTS

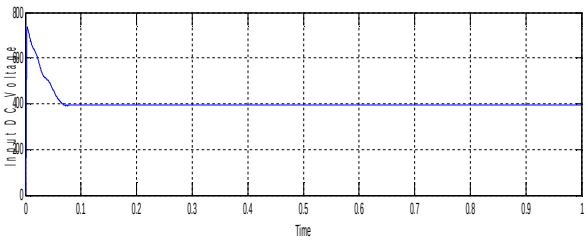

Fig.4: Input dc voltage of Inverter

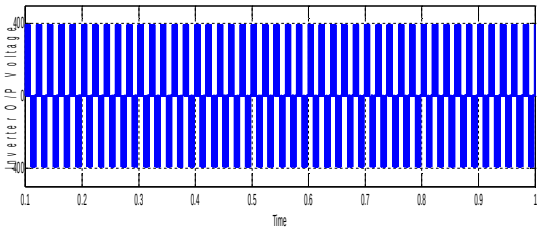

Fig.5: Output ac voltage of Inverter

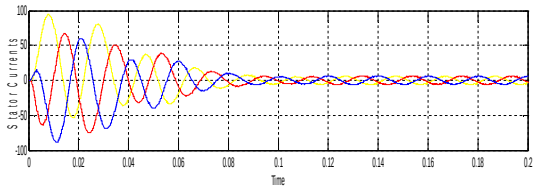

Fig.6: Stator Currents waveform of Induction Motor

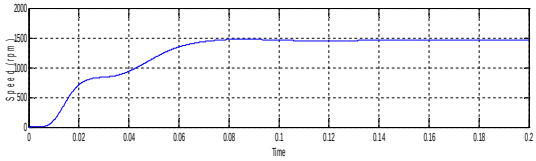

Fig.7: Speed of Induction Motor in rpm

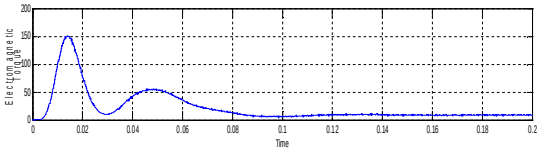

Fig.8: Electromagnetic torque of Induction Motor

The table below represents the changes in line voltage and total harmonic distortion according to different modulation indexes.

Table 1 Fundamental line voltage and THD for various modulation indexes

Modulation Index	Fundamental Line Voltage (Volts)	Total harmonic distortion (THD) %
0.4	214.3	165.45
0.8	274.4	92.17
1	342.3	68.3

VII. CONCLUSION

This paper has presented an analysis of the sinusoidal pulse width modulation technique applied to three phase inverter driven IM drive. Sinusoidal pulse width modulation is a popular technique used for the control of output voltage of inverter. From the results it has been observed that the induction motor attains steady state at t= 0.1 s approximately and also as the modulation index increases the fundamental line voltage increases while the total harmonic distortion decreases. Thus THD can be reduced by increasing modulation index.

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