"Modeling and Simulation of Sine PWM VSI fed Induction Motor Drives"

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Abstract: *This study deals with simulation of Sine PWM VSI inverter fed induction motor drive. By varying the modulation index of SPWM then vary the voltage of VSI. This technique minimizes the lower order harmonics, heating and improves the response of VSI. The transient rotor current, electromagnetic torque and rotor speed of the Induction Motor will improve. The drive system is modeled using matlab simulink and the results are presented. Fixed AC is converted into DC and this DC is converted into variable voltage and variable frequency AC using Sine PWM inverter. The output of inverter is applied to the stator of induction motor. The FFT analysis shows that the current spectrum has reduced harmonics compared to the conventional system.*

***Keywords**: Induction motor, Matlab, VSI, Sine PWM, VVVF.*

1. Introduction

The three phase induction motor, which is most widely used AC motor type in the domestic, industry, has been favored because of its self starting capability, low inertia, simple & rugged structure, suitable to all applications, low cost, low maintenance cost, less weight per watt, high reliability and high efficiency. Along with variable frequency AC inverters induction motors are used in many adjustable speed applications, which do not require fast dynamic response. There are many possible PWM techniques like sinusoidal PWM, selected harmonic elimination PWM, space vector PWM etc used for speed control of induction motor.

The PWM inverters are very commonly used in adjustable AC motor drive loads, where one needs to feed the motor with variable voltage variable supply frequency. For wide variation in drive speed, the frequency of the applied AC voltage needs to be varied over a wide range. The applied voltage also needs to vary almost linearly with the frequency. The switches of the PWM inverters are turned on and off at significant higher frequencies than the fundamental frequency of the output voltage waveform.

In sine PWM Inverter, the width of the pole voltage pulses over the output cycle, vary in a sinusoidal manner. The scheme, in its simplified form, involves comparison of a high frequency triangular carrier voltage with a sinusoidal modulating signal that represents the desired fundamental component of the pole voltage waveform. The peak magnitude of the modulating signal should remain limited to the peak magnitude of the carrier signal. The comparator output is then used to control the high side and low side switches of the particular pole. Some of the following constraints for slow varying sinusoidal voltage be considered as the modulating signal are 1) the peak magnitude of the sinusoidal signal is less than or equal to the peak magnitude of the carrier signal. This ensures that the instantaneous magnitude of the modulating signal never exceeds the peak magnitude of the carrier signal. 2) The frequency of the modulating signal is several orders lower than the frequency of the carrier signal. A typical figure will be 50 Hz for the modulating signal and 20 KHZ for the carrier signal. Under such high frequency ratio's the magnitude of the modulating signal will be virtually constant over any particular carrier signal time period. 3) A three phase sine-PWM inverter would require a balanced set of three sinusoidal modulating signals along with a triangular carrier signal of high frequency. For a variable voltage- variable frequency (VVVF) type inverter, a typical requirement for adjustable speed drives of AC motor, the magnitude as well as frequency of the fundamental component of the inverters output voltage

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needs to be controlled. This calls for generation of three phase balanced modulating signals of variable magnitude voltage and frequency which it may be emphasized, need to have identical magnitudes and phase difference of 120 degrees between them at all operation frequencies. Generating a balanced three phase sinusoidal wave forms of controllable magnitude and frequency is a pretty difficult task for an analog circuit and hence a mixed analog and digital circuits is often preferred.

Effects of harmonics on PWM inverter fed induction machines are given by S.Ekram [1]. This method presents about the effects of harmonics upon current, torque & speed of PWM inverter fed induction machine. Harmonic elimination in three phase VSI inverters by particle swarm optimization is given by Mohamed Azad [2]. This paper presents accurate solutions for non-linear transcendental equations of the selective harmonic elimination technique used in three phase PWM inverters feeding the induction motor by particle swarm optimization. Control of voltage source inverters using SPWM strategy for adjustable speed drives is given by Sabrije.F. osmanaj[3]. This paper analysis the theoretical and modulation form for control strategy and simulation results of SPWM three phase VSI inverter are presented by the different switching conditions. Open Loop V/f Control of Induction Motor based on hybrid PWM With reduced torque ripple is given by M.Harsha Vardhan Reddy [4]. This paper compares the torque ripples of conventional space vector PWM with hybrid PWM techniques. Use of PWM techniques for power quality improvement is given by Mahesh.

A Variable Structure Controller Approach is given by Brahmananda *et al.* [5] for Sensor less Direct Torque Control of Induction Motor based on Hybrid Space Vector Pulse width Modulation to Reduce Ripples and Switching Losses. This scheme for direct torque control of induction machines using hybrid space vector PWM to reduce switching losses and the study state ripple in torque and flux. Zelechowski A. patel. [6] is paper discussed the effects of harmonics on the power quality of the power supply and also discussed the different configurations of PWM techniques for harmonic reductions and improvement of fundamental voltage. Compensation method eliminating voltage distortions in PWM inverter is given by H.Sediki[7]. The proposed method produces the same inverter output voltages by online compensation method. Control of single-phase-to-three –phase AC/DC/AC PWM converters for induction motor drives are given by Dong-Choon Lee [8]. This paper proposes a novel control scheme of single-phase-to- three –phase AC/DC/AC PWM converters for low power induction motor drives and also discussed on integrative control algorithm for a single phase half-bridge PWM rectifier and a two leg PWM inverter for three phase induction motor drives.

Voltage and current Harmonic Variations in Three-Phase Induction Motors with different Stator Coil Pitches is given by Yasar Birbir[9].This paper presents firstly a sinusoidal pulse width modulation (SPWM) inverter feeding five different chorded three phase induction motors were tested for low order odd harmonic voltage component and efficiently at different loads. Secondly the motors fed by sine voltage again were tested for low order odd harmonic voltage and current component and efficient at different loads. A review of three PWM techniques is given by Zhenyu Yu[10]. This paper presents with emphasis on implementation and shown the experimental results.

The above literature does not deal with simulink modeling of Sine PWM VSI fed three phase induction motor. This work deals with modeling and simulation of Sine PWM VSI fed three phase induction motor drive.

2. Sine PWM Based VSI Inverter Fed Induction Motor Drive.

Induction motor drive is modeled and simulated using matlab simulink. Sine PWM based VSI fed induction motor drive is shown in Fig1. Sine PWM generation block is shown in Fig2. Pulses are generated by comparing sine wave with high frequency triangular wave. Driving pulses are shown in Fig 3. Phase voltages are shown in Fig 4. The line currents are shown in Fig 5. Speed response is shown in Fig6. The speed increases and settles at 1480 RPM. FFT analysis for current is done and the spectrum is shown in Fig 7.The THD is 6.01%.

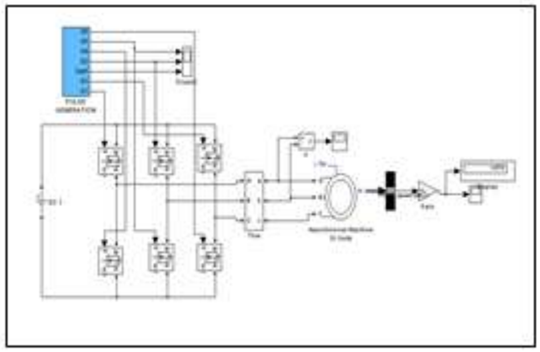

Fig 1: VSI fed Induction Motor Drive

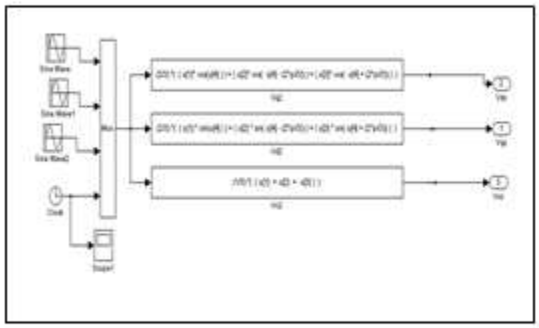

Fig 2: Sine PWM pulse Generation block

3. Generating Sinusoidal PWM Patterns

Due to the design historic aspect in AC-motor designs most of the motors used with power electronics are design to operate on sinusoidal supplies. Therefore the inverter output voltage should be as nearly sinusoidal as possible. Adjustable frequency operation of these motors requires a symmetrical set of three-phase sine modulated PWM waveforms, adjustable in both amplitude and frequency. The reference voltages (sine waves) should be adjustable in the full speed range, normally in the area from a couple of hertz to several hundred hertz. Accordingly, if the motor has to be controllable from very low-speed the voltage amplitudes have to follow the same range. In the past, this variable-voltage, variable-frequency voltage references were generated using analog electronics. The PWM patterns were typically generated by comparing these analog reference voltages with a high-frequency triangular carrier wave at the desired switching frequency (typically between 5 and 20 kHz).The desired output voltages are achieved by varying the frequency and amplitude of the reference voltage.

The results of the comparisons between the sinusoidal references and the carrier waveform are the PWM signals used to control the power devices of the voltage source inverter that is used to supply the motor. The variations in the amplitude and frequency of the reference voltages change the pulse width patterns of the voltages but keep the sinusoidal modulation, as shown in Figure 6.

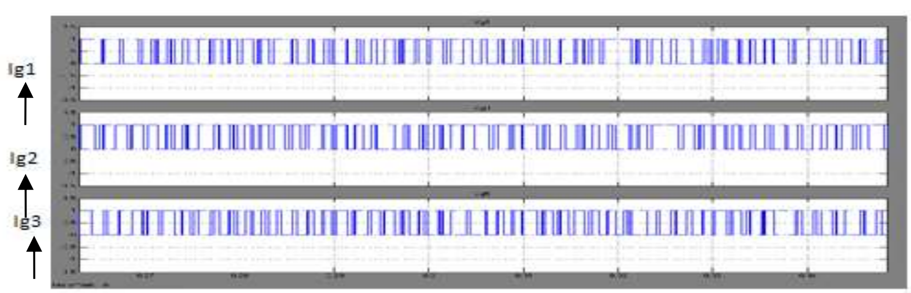

Fig 3: Driving pulses → time

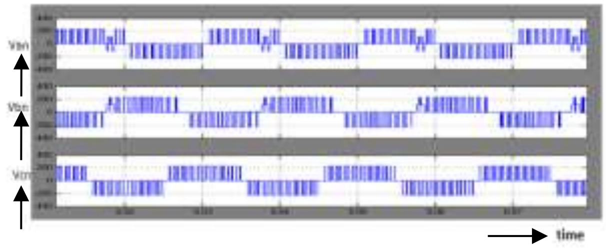

Fig 4: Phase voltages

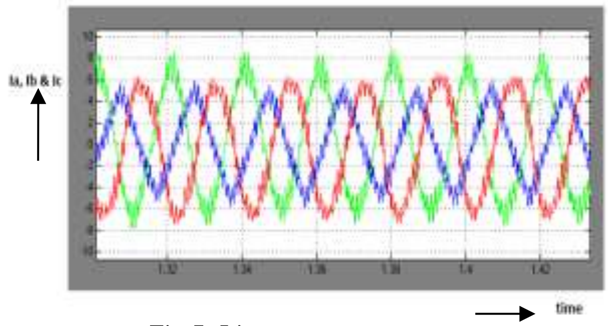

Fig 5: Line currents

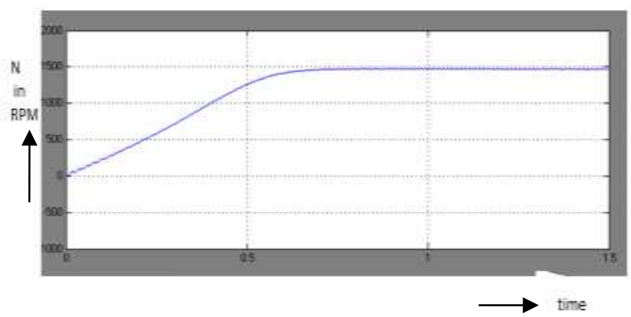

Fig.6 Rotor speed in RPM

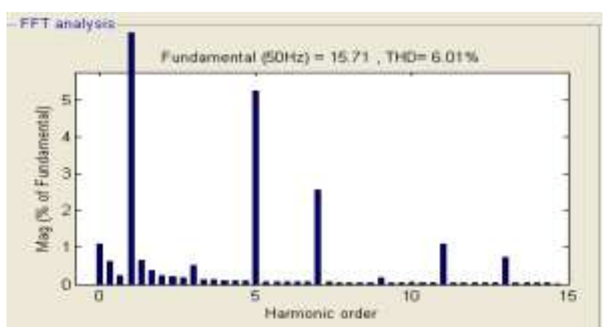

Fig 7: FFT analysis for current

4. Conclusion

The modeling, analysis and control of 3- Φ induction motor with performance analysis of VSI fed 3-Φ Induction Motor drive and PWM fed VSI AC Motor drive. For this purpose the proposed drive system is designed in MATLAB/Simulink. The two test results are implemented VSI fed and PWM fed asynchronous motor drive is shown. Control process of machine can be improved by PWM inverter. The Rotor current and electromagnetic torque is reduced by using PWM inverter in induction machine and speed will also be reduced in motoring mode. The harmonics content of PWM fed VSI drive has less as compared to square wave voltage inverter drives. SPWM makes the output voltage of VSI as a function of sine wave and by varying the modulation index it can vary the frequency of output voltage of VSI in such a way that v/f ratio remains same. The effect of modulation index on line voltage and phase voltage has been carried out which shows the Total Harmonic Distortion decreases with increase in modulation index.

5. References

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