THE RESPONSE ANALYSIS OF SPACE VECTOR PWM CONTROL BASED INDUCTION MOTOR DRIVE

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ABSTRACT

Pulse Width Modulation variable speed drives are increasingly applied in many new industrial applications that require superior performance. In this paper three-phase voltage source inverter which is based on vector control with power IGBTs is described. In ac motor drives, Space vector PWM inverters make it possible to control both frequency and magnitude of the voltage and current applied to a motor. The simulation and analysis of vector control based Induction motor is carried out. A voltage source inverter is commonly used to supply a three-phase induction motor with variable frequency and variable voltage for variable speed applications. In this paper first a model for Space vector PWM is made and simulated using MATLAB software and its performance is analyzed. The simulation study reveals that Space vector PWM utilizes the voltage more effectively.

Keywords: 3-Φ Induction Motor, Space Vector Pulse Width Modulation Technique, Voltage Source Inverter.

I INTRODUCTION

The induction machine is used in wide variety of applications as a means of converting electric power to mechanical power. Pump steel mill, hoist drives, household applications are few applications of induction machines. Induction motors are most commonly used as they offer better performance than other ac 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. We usually prefer dc motors when large speed variations are required. Nevertheless, the 3-phase induction motors are simple, rugged, low-priced, easy to maintain and can be manufactured with characteristics to suit most industrial requirements. An IM drive employing V/F method with application of Space Vector Pulse Width Modulation (SVPWM) is better to understand. By using 3-level inverter, ripples in speed and torque will reduce. The reference voltage vector is then realized using a voltage vector modulator.[1] The comparative performances of three phase induction motors using space vector pulse width modulation (SVPWM) and hysteresis current controller. The simulation results demonstrate that the

SVPWM can improve the quality of the stator current and reduce the torque ripple while maintaining the other performance characteristics of the system.[2] The control of IM number of Pulse width modulation (PWM) schemes are used to for variable voltage and frequency supply and main objective of this paper is analysis of Induction motor with SVPWM fed inverter and harmonic analysis of voltages & current. There is an increasing trend of using space vector PWM (SVPWM) because of it reduces harmonic content in voltage, Increase fundamental output voltage by 15% & smooth control of IM.[3] Voltage source inverter type SVPWM based speed control of an induction motor using a fuzzy PI controller enables us to adjust the speed of the motor by controlling the frequency and amplitude of the stator voltage; the ratio of the stator voltage to the frequency should be kept constant. A space vector PWM technique is also developed based on the vector space decomposition. The techniques developed in this paper can be generalized for the control of an induction machine with an arbitrary number of phases.[4-6] In space vector PWM method for a three-level inverter fed induction motor drive, a number of Pulse Width Modulation (PWM) schemes are used to obtain variable voltage and frequency supply from an inverter. There is an increasing trend of using SVPWM because of their easier digital realization and better dc bus utilization.[7]

II PRINCIPLE OF OPERATION

SVPWM technique was originally developed as a vector approach to pulse width modulation for three-phase inverters. The SVPWM method is frequently used in vector controlled applications. In vector controlled applications this technique is used for reference voltage generation when current control is exercised. It is a more sophisticated, advanced, computation intensive technique for generating sine wave that provides a higher voltage with lower total harmonic distortion and is possibly the best among all the pulse width modulation techniques. It confines space vectors to be applied according to the region where the output voltage vector is located. Because of its superior performance characteristics, it is been finding wide spread applications in recent years. The main aim of any modulation technique is to obtain variable output voltage having a maximum fundamental component with minimum harmonics. Many PWM techniques have been developed for letting the inverters to posses various desired output characteristics to achieve the wide linear modulation range, less switching losses, lower harmonic distortion.

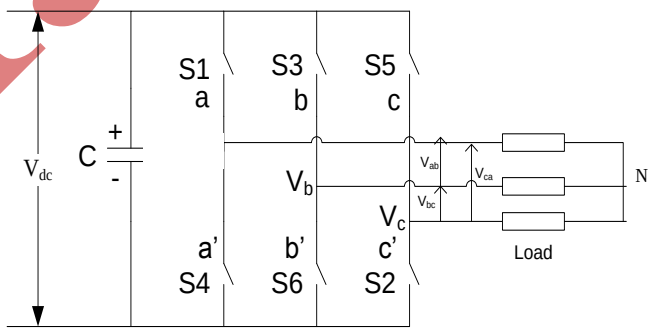


Fig.1 Power Circuit of a Three-Phase VSI.

The SVPWM technique is more popular than conventional technique because of more efficient use of DC supply voltage, 15% more output voltage then conventional modulation, lower Total Harmonic Distortion (THD) and prevent un-necessary switching hence less commutation losses. Firstly model of a three-phase inverter is presented on the basis of space vector representation. The three-phase VSI is reproduced in Fig.1. There are six power switches that shape the output, which are controlled by the switching variables and therefore, the on and off states of the upper switches can be used to determine the output voltage.

SVPWM refers to a special switching sequence of the upper power switches of a three-phase power inverter. It has been shown to generate less harmonic distortion in the output voltages and/or currents applied to the phases of a power system and to provide more efficient use of supply voltage compared with other modulation technique. To implement SVPWM, the voltage equations in the abc reference frame can be transformed into the stationary reference frame that consists of the horizontal (d) and vertical (q) axes as depicted in fig. 2.

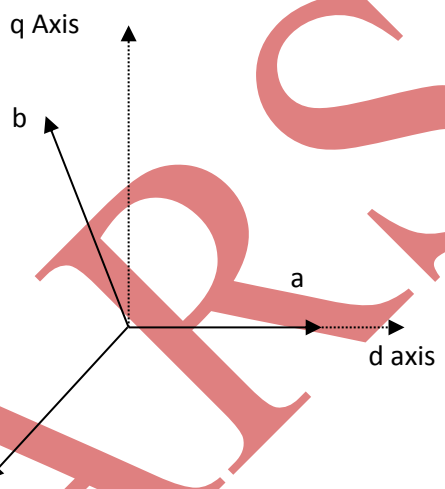


Fig.2 The Relationship of a-b-c Reference Frame And Stationary d-q Reference Frame

III SIMULATION RESULTS

Variable voltage and frequency supply to ac drives is invariably obtained from a three-phase voltage source inverter. Here is used three-phase voltage source inverter which is carrier-based sinusoidal PWM (Sinusoidal PWM) with power IGBTs is described. In ac motor drives, SPWM inverters make it possible to control both frequency and magnitude of the voltage and current applied to a motor. The simulation results before and after speed change are shown and various outputs are obtained like as rotor current waveform, rotor speed waveform, electromagnetic torque waveform. The Simulink Model of Vector control based Induction motor drive is shown in fig. 4. This model is simulated for the different speeds from 50 rpm to 250 rpm at the input voltage of 400V and the different responses of rotor current; rotor speed and electromagnetic torque are obtained which are shown in figures from fig. 4 to fig. 17. The different values of the parameters are shown in table 1.

Table 1: The Response Analysis of Rotor Current, Rotor Speed and Electromagnetic Torque

S.No	Input Voltage(V)	Ref. Speed (rpm)	Rotor Speed (rpm)	Rotor Current (A)	Torque(N-m)
1	400	50	50	35	40
2	400	100	100	38	35
3	400	150	150	42	25
4	400	200	200	44	20
5	400	250	220	52	35

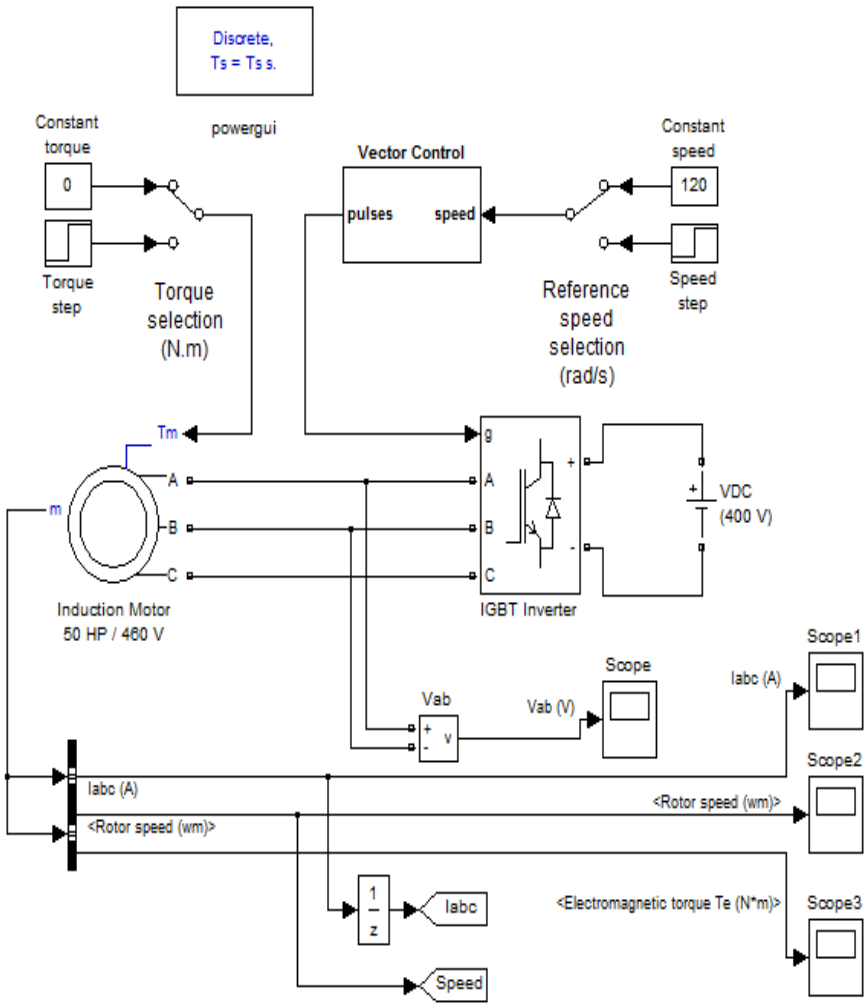
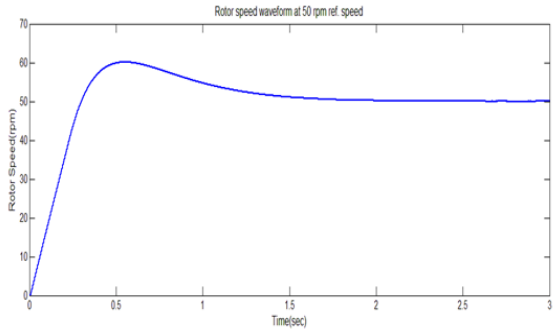


Fig.3 Simulink Model of Vector control based Induction motor



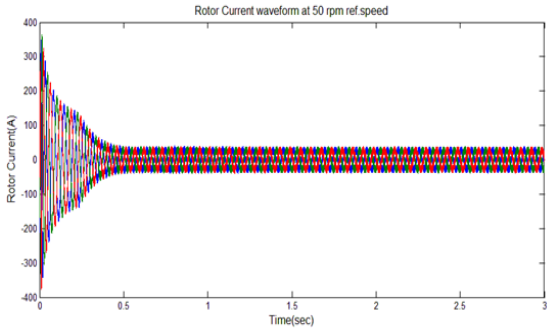
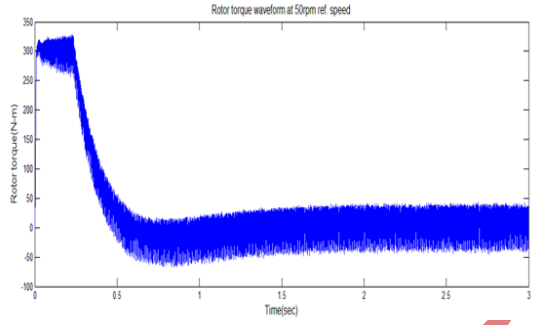


Fig.4 Rotor speed waveform at 50 rpm reference speed

Fig.5 Rotor current waveform at 50 rpm reference speed



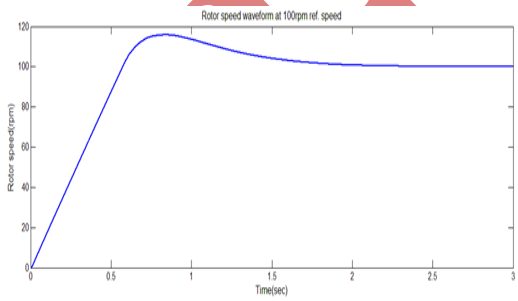
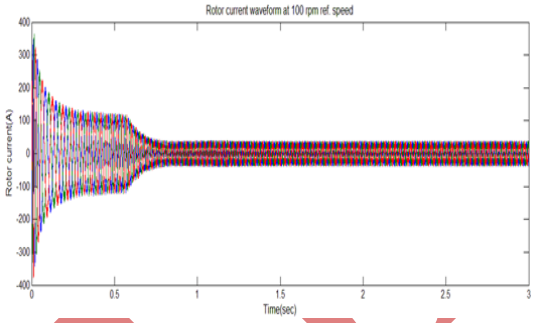


Fig.6 Rotor torque waveform at 50 rpm reference speed

Fig.7 Rotor speed waveform at 100 rpm reference speed



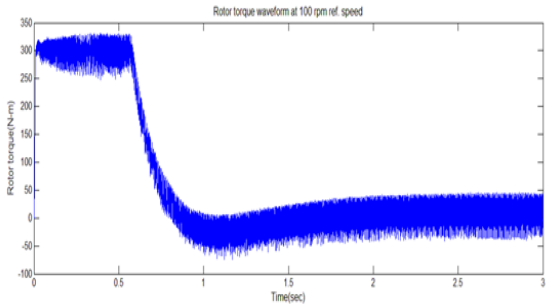
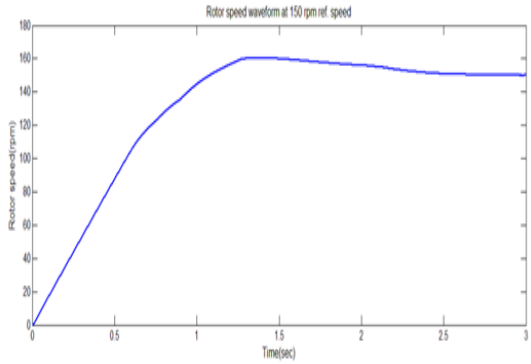


Fig.8 Rotor current waveform at 100 rpm reference speed

Fig.9 Rotor torque waveform at 100 rpm reference speed



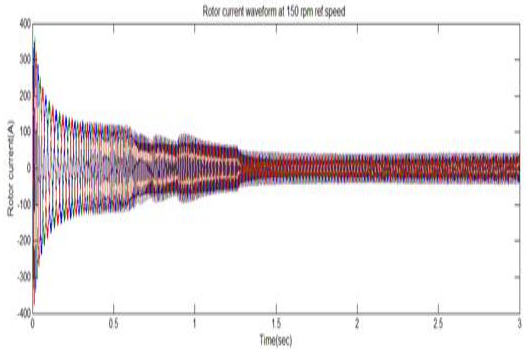
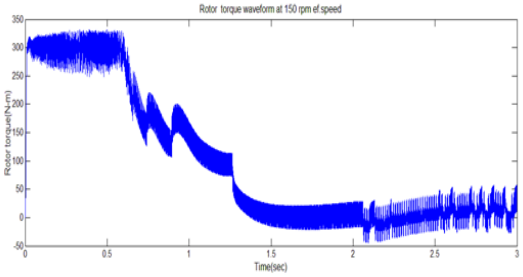


Fig.10 Rotor speed waveform at 150 rpm reference speed

Fig.11 Rotor current waveform at 150 rpm reference speed



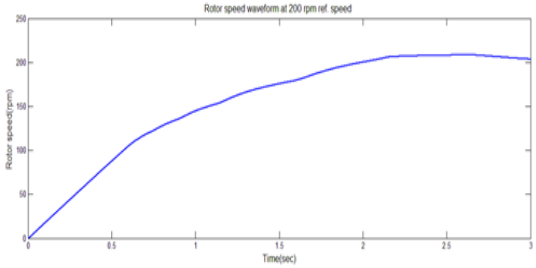
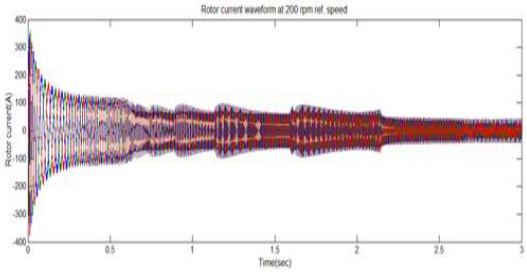


Fig.12 Rotor torque waveform at 150 rpm reference speed **Fig.13 Rotor speed waveform at 200 rpm reference speed**



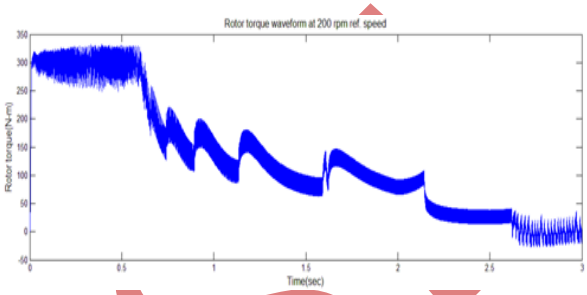
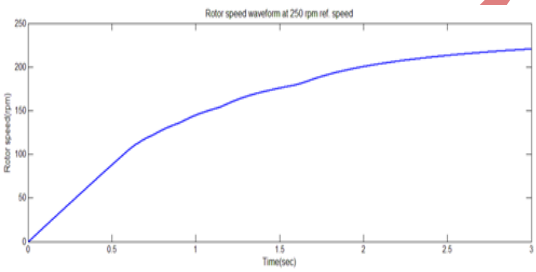


Fig.14 Rotor current waveform at 200 rpm reference speed **Fig.15 Rotor torque waveform at 200 rpm reference speed**



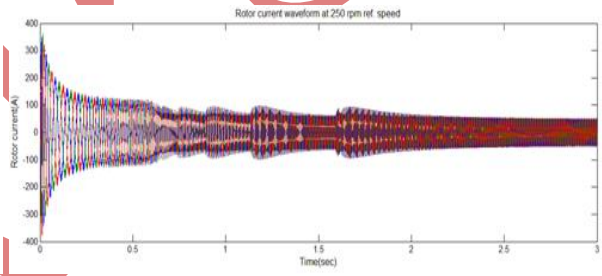


Fig.16 Rotor speed waveform at 250 rpm reference speed **Fig.17 Rotor current waveform at 250 rpm reference speed**

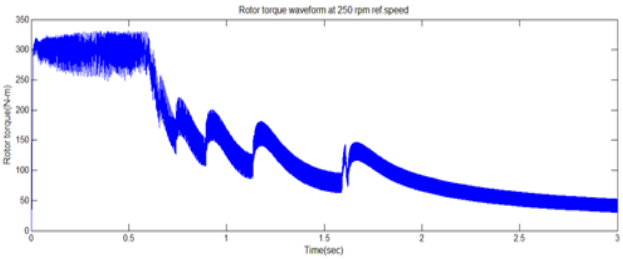


Fig.18 Rotor torque waveform at 250 rpm reference speed

IV CONCLUSIONS

The Space vector based induction motor drive is analyzed and designed with MATLAB simulink model which is suitable for wide speed range. A suitable pulse width modulation (PWM) technique is employed to obtain the required output voltage in the line side of the inverter. Space Vector Modulation (SVM) Technique has become the important PWM technique for three phase Voltage Source Inverters for the control of AC Induction Motor.

The different speeds from 50 rpm to 250 rpm at the input voltage of 400V and the different responses of rotor current, rotor speed and electromagnetic torque are obtained. The simulation study reveals that Space vector PWM utilizes the voltage more effectively.

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