Computer Simulation of SPWM-VSI for Minimizing the starting torque and current in Asynchronous Motor Drive

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Abstract

The paper involves the speed control of three phase induction motor by using the PWM fed VSI. Speed can regulate by varying the external resistance in series with rotor circuit but this method is not so efficient. Therefore this paper is focused on frequency control method for which a three phase induction motor drive fed by Pulse width modulation Voltage source inverter. PWM is most reliable and efficient way to regulate the output voltage of VSI. There are several ways to modulate the pulse width but this paper deals with sinusoidal pulse width modulation technique. By varying the modulation index of SPWM then vary the voltage of VSI. This technique minimizes the lower order harmonics and improves the response of VSI. The transient rotor current, electromagnetic torque and rotor speed of the Induction Motor will improve. Proposed model of open loop PWM Inverter fed induction motor drives in MATLAB/Simulink software.

Keywords:

PWM Inverter, MATLAB/Simulink, Induction motor.

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I. Introduction

Induction Motor is very popular and extensively used in industry. It is simply excited ac machine which have a very good speed regulation and high starting torque [1]. To maintain the speed of the Induction motor there is need an electrical drive system [2]. In the past, the application of Induction motor was limited with constant speed because conventional method was used, but due to the evolution in inverter we can regulate the speed of Induction motor very easily[1,2]. There are various ways to control the speed of 3-φ Induction Motor. For this purpose PWM fed VSI electrical drive system is taken because the harmonic content is very low and it improves the performance of 3-φ Induction motor. In inverter six switches of bridge network is made of IGBT instead of SCR because of high switching frequency of VSI. The gate terminal of IGBT is fixed with pulses of PWM generator are the function of reference sine wave which has lower order harmonics are eliminated from the PWM fed VSI which makes the operation of 3-φ Induction motor smooth and noiseless[3].

II. 3-φ AC Drive System

3-φ electrical drive system plays an important role in speed control of 3-φ Induction Motor.
The speed of 3-φ Induction Motor can be given as:-

$$\omega_r = \omega_s(1-s)$$

$$\omega_r = 4\Pi\frac{f_s}{P}(1-S)$$

Where,

ω_r = Rotor speed in radian/second
f_s = Supply frequency in Hertz
S = Slip
P = no. of poles/phase

Mathematical expression shows by varying frequency, slip or number of poles/phase. Speed of 3-φ Induction Motor can be controlled. The main function of the drive system is to maintain constant v/f ratio at the input of 3-φ Induction Motor when frequency is varied [4].

III Pulse Width Modulation Inverter

3-φ inverter consists of a bridge network in which six IGBT's but each IGBT is gated for 180˚ [5]. The output of VSI is non-sinusoidal and consists of harmonics. These harmonics raises the current harmonic due to machine impedance. The harmonic in the output voltage of VSI causes losses in the m/c winding. The quality of inverter depends upon the amount of harmonics [6].

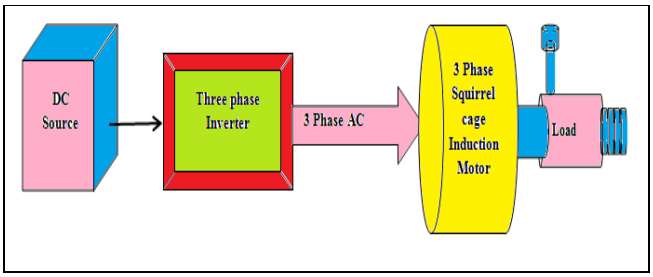

Figure 3.1 Block diagram of VSI fed Induction motor Drive .

There are several techniques are available for eliminating or minimizing the harmonics such as:–

(a)External control of sinusoidal voltage
(b) External control of dc voltage
(c) Internal control of inverter.

Internal control of inverter is better than external control methods [8].

SPWM technique is adopted because of variation in modulation index & it can vary the output voltage. Modulating index is V_r / V_c and it controls the harmonic content. The magnitude of fundamental component of output voltage is proportional to the Modulation Index (MI) and it cannot be more than 1[9].

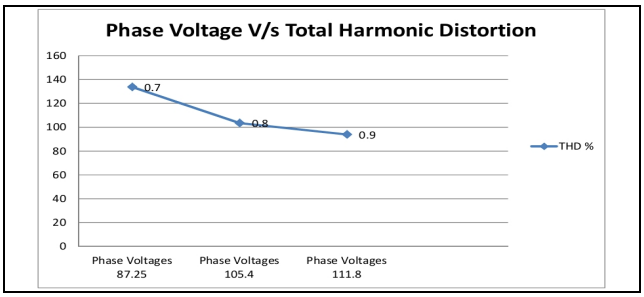

Figure. 3.2: Phase voltage and Total harmonic distortion graph.

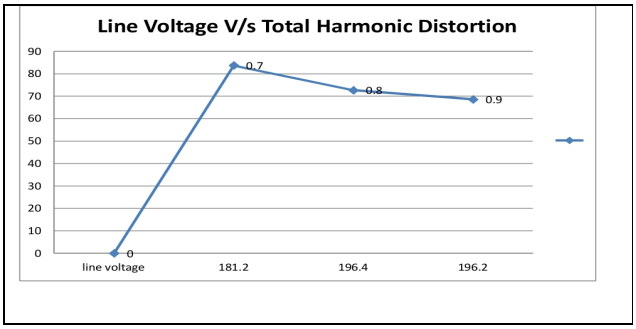

Figure. 3.3: Line voltage and Total harmonic distortion graph

IV. Implemented VSI Fed Induction Motor Drives

The MATLAB Simulink based three phases VSI fed induction motor drive system shown in figure. 4.1. In this 180˚ conduction mode is applied. It consists of six IGBT switches S1 to S6 are used to operate in six different modes. Main purpose of this topology is to provide three phase voltage source so that we can easily control the magnitude, phase, voltage and frequency [7].

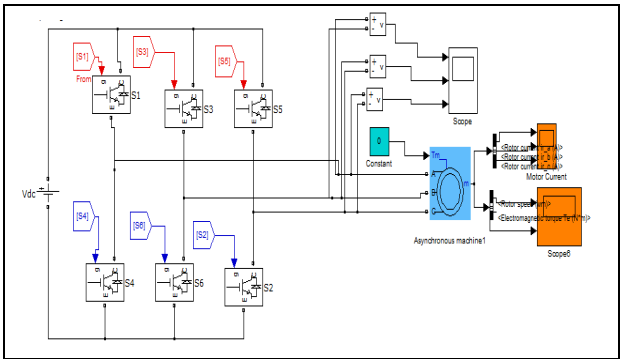

Figure. 4.1: Implemented VSI fed induction motor drive

V. Simulation Results:

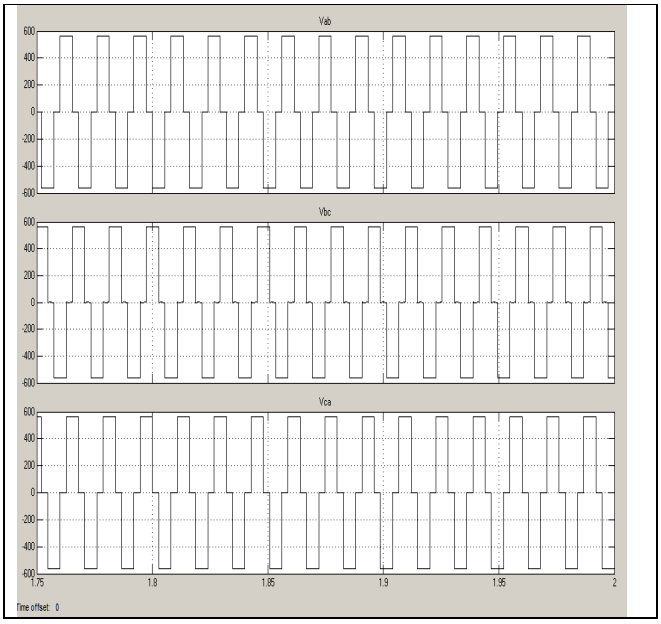

Figure. 5.1: Output voltage of VSI

In figure 5.1 shows the output voltage V_{ab}, V_{bc} & V_{ca}.

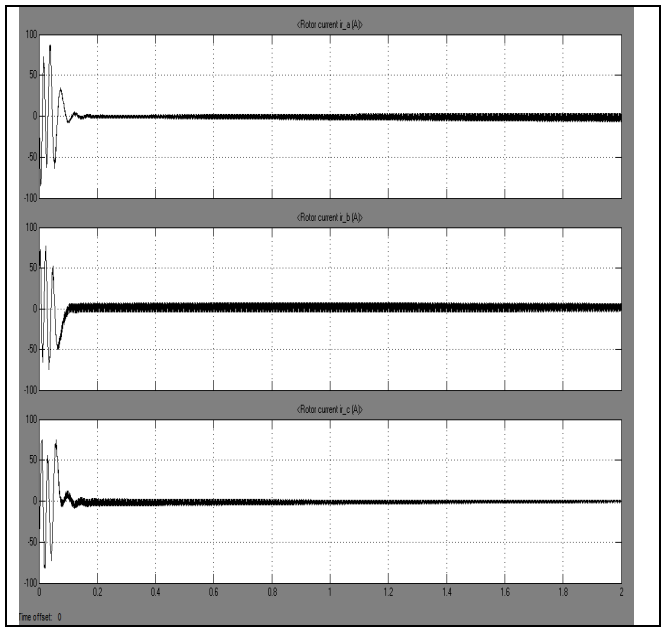

Figure. 5.2: Rotor Current waveform

In figure 5.2 shows the magnitude of rotor current is initially high and after 0.1 Sec it settles down.

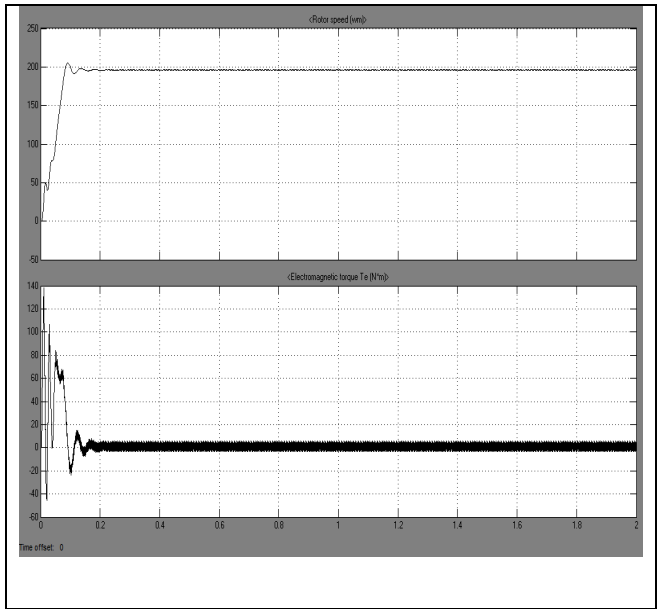

Figure .5.3 Electromagnetic torque and Rotor speed of induction motor

Torque is inversely proportional to slip at the time of starting and after the breakdown torque it becomes proportional to the Slip.
In figure 5.3 shows Rotor speed of the induction motor rises initially and then after 0.1 sec it becomes constant.

In figure 5.4 shows the proposed pulse width modulation inverter fed induction motor model in MATLAB/Simulink.

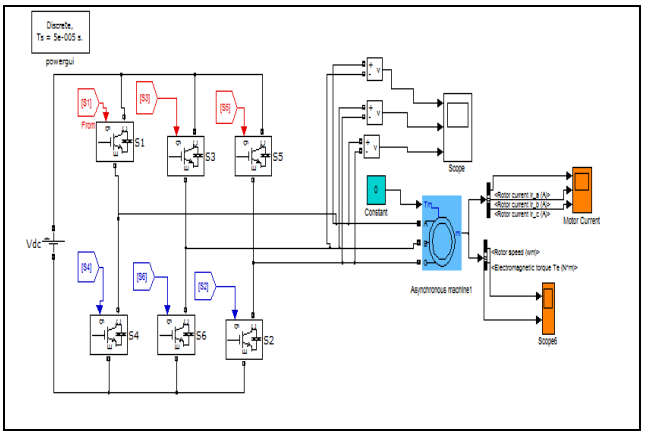

Figure .5.4 Simulink model of Proposed PWM inverter fed Induction motor

VI. Simulation Results

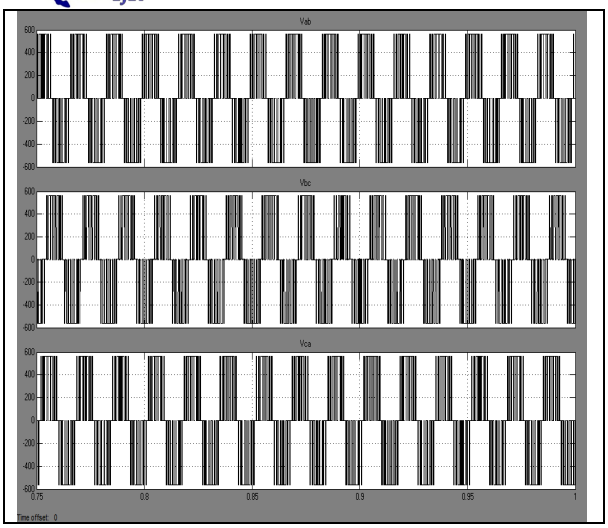

Figure.6.1 Output voltage of PWM fed VSI

In figure 6.1 shows the elimination of lower order harmonic the output voltage becomes smooth (behaves like sine wave).

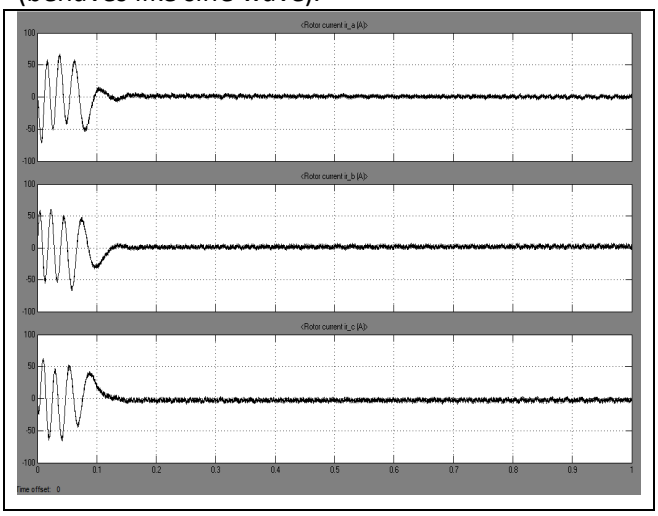

Figure.6.2 Rotor Current waveform

The rotor current fluctuates between 0 to 0.1 sec and after 0.1 sec its magnitude becomes 5 amps. In VSI fed induction motor drive the starting current magnitude is high (approximately 80 amps), as compared to PWM fed inverter modeling where current magnitude is approximately 60 A.

It can easily observe by using the PWM fed inverter; the starting current value goes to minimize.

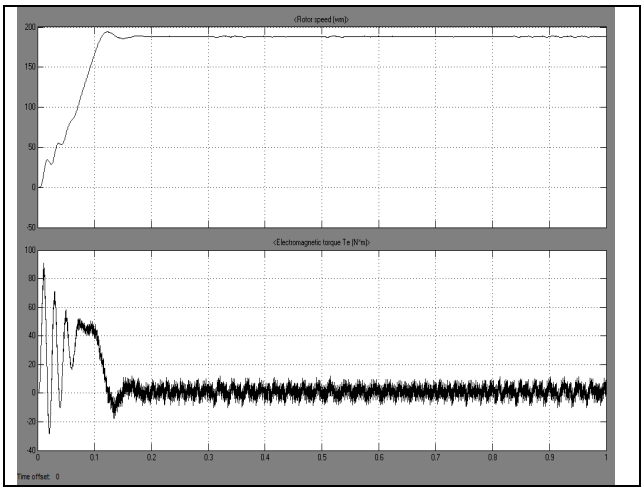

Figure.6.3 Electromagnetic Torque and Rotor Speed

Here magnitude of starting torque rises as compared to inbuilt VSI model. Due to elimination of lower order harmonic the pulsation in torque also minimizes.

VII. 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.

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