ANALYSIS OF MULTI LEVEL INVERTER FED INDUCTION MOTOR DRIVE SYSTEM USING MATLAB SIMULINK

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Abstract
This paper deals with analysis of voltage source multi level inverter fed induction motor drive system. A three level inverter fed induction motor drive system is modeled and the results are presented. The prototype of the system is also presented to compare the simulation results with experimental results. There is close agreement between simulation results and experimental results.
Keywords: Induction motor, Multi level inverter, Total harmonic distortion, Matlab Simulink.

1 INTRODUCTION

In a conventional two-level inverter fed induction motor drive system the presence of significant quantity of harmonics makes the induction motor to suffer from severe torque and speed fluctuations, especially at low speeds, which could result in cogging of the shaft. The presence of harmonic also causes electromagnetic interference and undesirable motor heating [1]. Large sized filters are required to reduce the magnitude of harmonics. This results in larger size and higher cost of the drive system.

Nowadays, in high voltage and high power motor drive applications, multilevel inverters provides the cost effective solutions and most promising alternative to achieve good quality of output power [2]. Using the Multilevel inverter structure the power handling capability of the system can be raised in a systematic and powerful way [3]. The term multilevel starts with the three-level inverter introduced by Nabae et al [4]. Increase in number of levels of the inverter, results in the output voltage waveform containing more steps generating a staircase waveform, which has a reduced harmonic distortion. The performance of multilevel inverter enhances with the increase in number of levels of the inverter.

The inverters are either Current Source Inverter (CSIs) or Voltage Source Inverters (VSIs) [5]. Current source inverters are widely used for the implementation of fully generative induction machine variable speed drives. An important and attractive feature of CSI is its good fault protection capability and the inherent regeneration capability. However, a CSI-fed induction motor suffers from severe torque pulsations, especially at low speeds, which manifest themselves in cogging of the shaft. The usual technique of overcoming such problems in voltage source inverters is to pulse width modulate the input voltage waveforms. Pulse width modulated voltage source inverters are invariably used for AC/DC/AC conversion to provide a variable ac voltages to the induction motor. However, inverter fed induction motor suffers from the presence of significant amount of harmonics which causes undesired motor heating, torque pulsation and electro-magnetic interference. In order to reduce the harmonics, large sized filters are needed, which results in larger size and increased cost of the system. However the advanced achievements in the field of industrial electronics and power electronics made possible to reduce the magnitude of

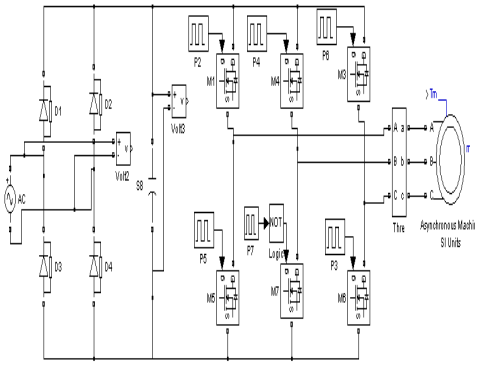
harmonics using multilevel inverter structures, in which the number of output voltage and current waveforms are increased without increasing the size of the filter. The performance of multilevel inverters will be better than a classical inverter. The THD (Total Harmonic Distortion) for multilevel inverters will be lower than that of a classical inverter.

The time harmonics in the output of inverter produces more heating in the stator of induction motor. The fifth harmonic produces opposing torque in the rotor. To reduce the harmonics and to improve the performance of induction motor, multilevel inverter is used. The proposed work deals with the study of a conventional VSI fed induction motor and a three level inverter fed induction motor drive. Matlab based simulation is carried out and the results are experimentally verified.

2. SIMULATION RESULTS OF THREE LEVEL INVERTER FED DRIVE SYSTEM

VSI fed induction motor drive is shown in Figure 1. VSI fed induction motor drive involves a diode rectifier with capacitive filter acts as the voltage source. Three phase inverter operating in 120^0 mode is used to feed the induction motor drive. Phase voltage waveforms are shown in Figure 2 and the stator phase currents are shown in Figure 3. Variation in speed is shown in Figure 4. The speed increases and settles at 1120 rpm. FFT analysis is done for the current and the corresponding spectrum is shown in Figure 5. It can be seen that the magnitude of fundamental current is 28 Amperes. The Total Harmonic Distortion (THD) is 12.87 percent.

Block diagram of three level inverter fed induction motor drive is shown in Figure 6. Its Phase voltage waveforms are shown in the Figure 7. The stator current waveforms are shown the Figure 8. The variation in rotor speed with respect to time is shown in the Figure 9. The magnitude spectrums for the stator current and voltage are shown in the Figure 10 and 11 respectively. It can be seen that the current THD value is 7.46 percent. The THD in three level inverter is reduced by 42 percent compared to the VSI fed induction motor. From the spectrum, it can be seen that the amplitude of low frequency components are higher than the high frequency components.



Rectifier Link filter PWM inverter

Figure 1. VSI-fed induction motor drive system

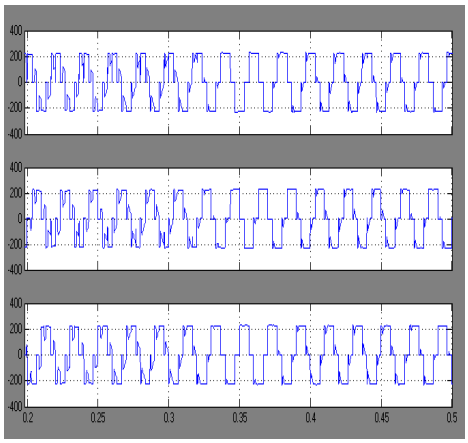


Figure 2. Phase voltage waveforms of VSI-fed IM drive

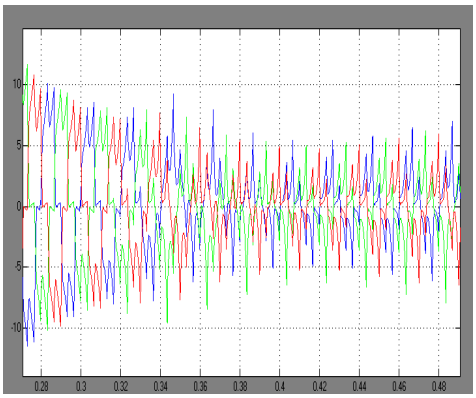


Figure 3. Stator current waveforms of VSI-fed IM drive

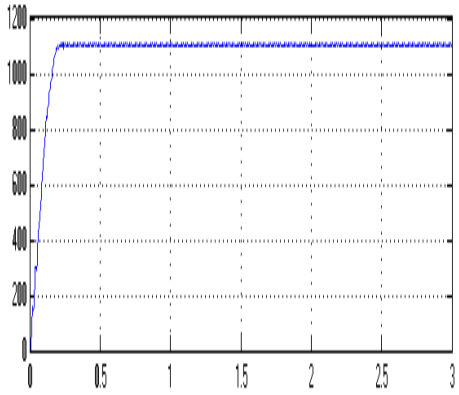


Figure 4. Rotor speed of VSI-fed induction motor drive

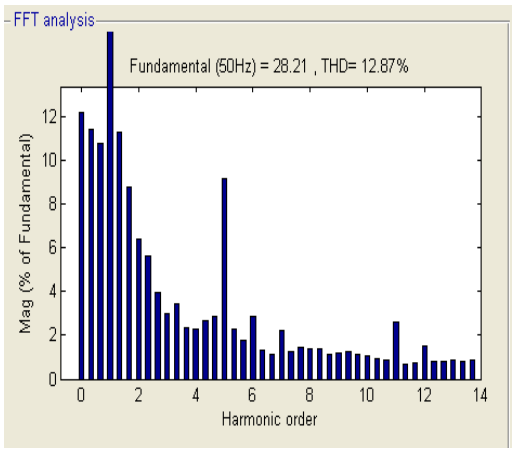


Figure 5. FFT analysis for stator current of VSI-fed IM drive

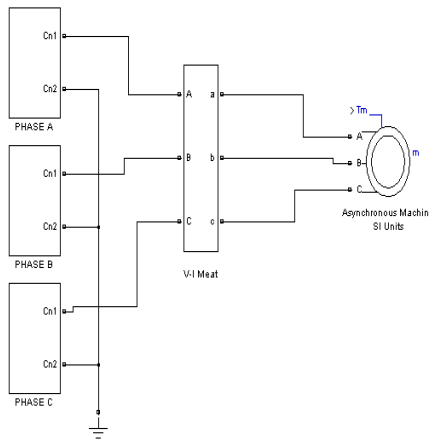


Figure 6. Block diagram of 3 phase multilevel inverter-fed IM

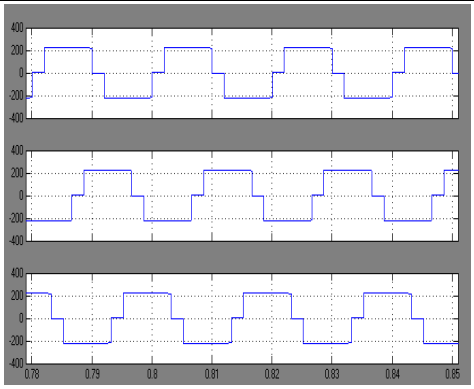


Figure 7. Voltages waveforms of 3 level inverter fed Induction motor

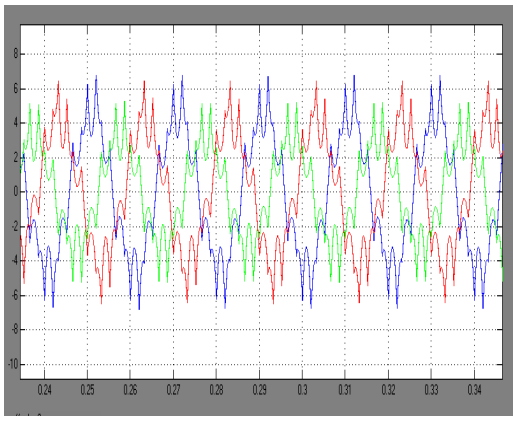


Figure 8. Stator current waveforms of three level inverter fed induction motor drive

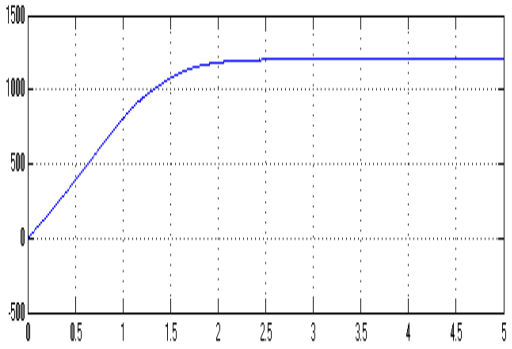


Figure 9. Rotor speed of three level inverter fed induction motor drive

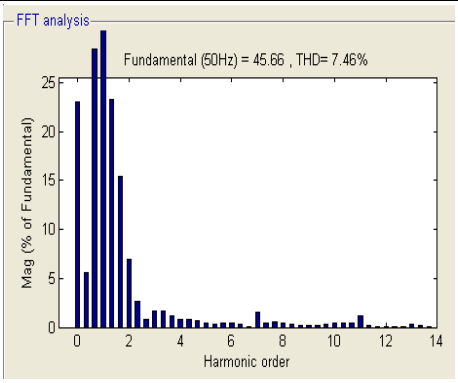


Figure 10. FFT spectrum for stator current of three level inverter fed IM drive

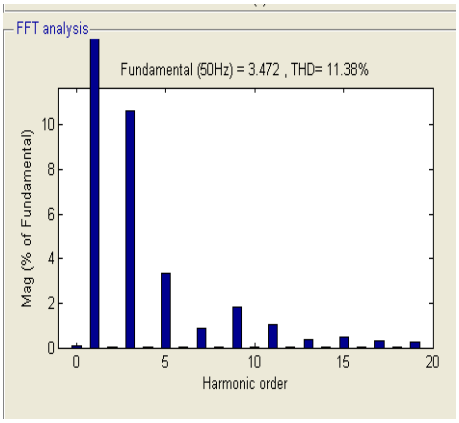


Figure 11. FFT spectrum for stator voltage of 3 level inverter fed IM drive

3. EXPERIMENTAL RESULTS OF THREE LEVEL INVERTER

Three level inverter fed induction motor drive system is fabricated and tested in the Power Electronics laboratory. The snapshot of the hardware is shown in Figure 12. Driving pulses to the MOSFETs are shown in Figure 13. The three level output voltage is shown in figure 14. The experimental value of current THD is 7.03 percent and voltage THD is 10.77 percent.

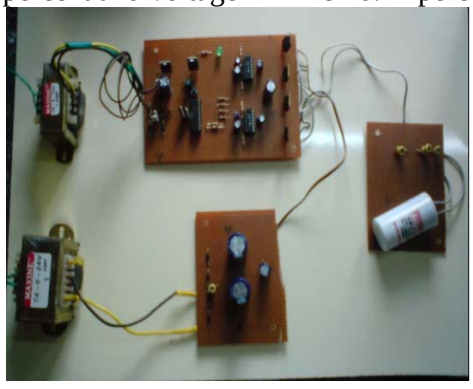


Figure 12. Hardware snap shot of three level inverter

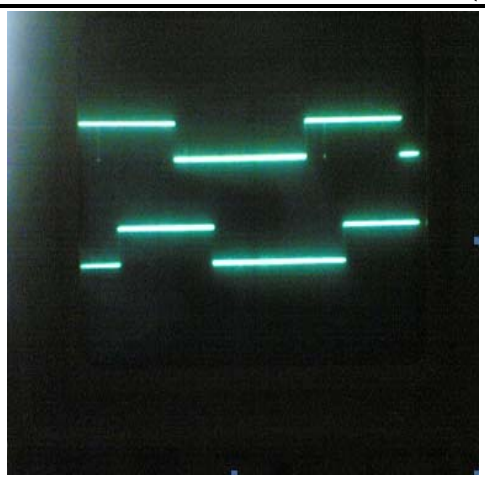


Figure 13. Driving pulses for three level inverter circuit

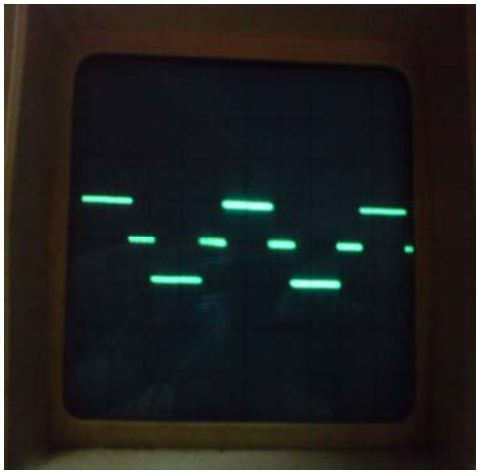


Figure 14. Output voltage of three level inverter.

4 CONCLUSION

Three level inverter fed induction motor system is modeled and simulated. The simulation results of voltage, current, speed and FFT spectrums are presented. Study of the results indicates that fifth harmonic is eliminated. This will eliminate the opposing torque in induction motor drive. Therefore the net torque developed in the motor is higher.

Three level inverter fed drive system is implemented successfully in the Power Electronics laboratory to validate the simulation results. By the laboratory tests, the efficiency of 3 level inverter fed induction motor is found to be 70.78 percent and rotor speed is found to be 1230 rpm. The experimental value of current THD is 7.03 percent and voltage THD is 10.77. There is close agreement between the simulation and experimental results.

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