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Model and Simulate Three-Level Inverter-Fed Induction Motor Using MATLAB Simulink

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Abstract: The decrease in Total Harmonic Distortion (THD) in multilevel inverter-fed induction motor drive is the focus of this paper. The results of modelling and simulating a multi-level voltage source inverter-fed induction motor drive using MATLAB/ Simulink are presented. For the purpose of researching the decrease in harmonics, the FFT spectra for the outputs are examined. The hardware is put into use, and the outcomes are shown. The simulated results are compared with the experimental outcomes.

Keywords: ***Voltage source inverter, multilevel inverter, Total Harmonic Distortion***.

I. INTRODUCTION

Adjustable Speed Drives (ASDs) play a prominent role in controlling the speed of conveyor systems, blower speeds, and machine tools that requires adjustable speeds in various industrial applications. They have a larger influence and are playing a significant part in revolutionizing control systems for multiple industrial operations. Due to their superior speed and torque action, DC motors have traditionally been the work horses for adjustable speed drives. However, they have the inherent disadvantage of commutator and mechanical brushes, which wear and tear over time. AC motors are generally favored over DC motors, particularly induction motors, due to their low cost, low maintenance, smaller weight, higher efficiency, improved robustness, and durability.

The existence of large harmonics in a standard two-level inverter fed induction motor drive system causes the induction motor to suffer from extreme torque and speed changes, especially at low speeds, which could result in shaft cogging. Harmonics also induce electromagnetic interference and unwanted motor heating. To lower the magnitude of harmonicas, huge sized filters are required. As a result, the driving system is bulkier and more expensive.

Harmonics, also known as harmonic distortion, play an important part in degrading power quality. Due to the expanding use of non-linear loads, harmonic distortion in electric distribution systems is increasing. Large quantities of these demands have the potential to generate harmonic voltage and currents in a power supply that rise to unacceptable high levels, causing the system to fail. The amount of harmonics in electrical systems is one of the most serious challenges in terms of power quality. Any repeating waveform can be demonstrated to be a superposition of fundamental and harmonic components. Each harmonic component frequency is an integral factor of its basic frequency. The concept of a harmonic is commonly used to describe waveform components with frequencies different than the fundamental.

A non-sinusoidal and distorted waveform comprises anything other than the basic frequency. The odd orders are the most commonly observed harmonics in 3 phase distribution networks. Harmonic amplitudes typically decrease as frequency rises. Harmonics are minimal above order 50, and measures are no longer useful. Measuring harmonics up to order 30 yields sufficiently accurate measurements. Harmonic orders 3, 5, 7, 11, and 13 are monitored by utilities. Harmonic filtering of the lowest orders (up to 13) is generally sufficient. In the electric power system, harmonics mix with the basic frequency to produce distortion. The level of distortion is proportional to the harmonic current's frequencies and amplitudes. The contribution of all harmonic frequency currents to the fundamental current is referred to as "Total Harmonic Distortion" or THD.

Voltage and current harmonics are the two types of harmonics. They can be generated from either the load or the source side. Load side harmonics are caused by nonlinear switching devices, arc furnaces, gas discharge lighting devices and transformer core and motor overheating. Non-sinusoidal voltage waveforms in the power supply are primarily responsible for the generation of source harmonics.

The most common electric motor type utilized in industry and by utilities is a 3-phase squirrel cage induction motor. The induction motor appeal originates from various characteristics, including its ruggedness and simplicity of construction, which makes it a reliable, long-lasting, easy-to-maintain, and low-cost option, as well as its ability to start and function straight from the grid, which is unique. Adjusting the frequency of the supply voltage, which is often done with a frequency converter, allows for energy-efficient speed regulation of the induction motor. The most popular sort of frequency converter first rectifies the line voltage into DC voltage, which is subsequently converted into an adjustable AC voltage employing PWM techniques.

2. BACKGROUND

Power Electronics and semiconductor technology advancements have prompted the creation of extremely powerful and high-speed semiconductor devices to produce a smooth, continuous, and stepless variation in induction motor speed. The usage of solid-state converters/inverters for variable speed induction motor drives is beneficial in a wide range of industrial systems. Feng, 2000 compares basic and high frequency carrier-based approaches for NPC inverters. Golubev, 2000 discusses the effect of the number of stator windings on motor parameters. Gopukumar (1984) describes an enhanced current source inverter-fed induction motor drive. Zhang (2000) describes multilevel inverter modulation techniques for eliminating common mode voltages. Mohapatra (2002) provides a modulation strategy for a six-phase induction motor.

The presence of harmonics alters the final voltage waveform and causes the motor to experience severe torque pulsations, particularly at low speeds, which show as shaft cogging. In addition, it will generate unwanted motor heating and electromagnetic interference (Shivakumar et al., 2001). A decline in harmonics necessitates the use of large-sized filters, which increases the system's size and expense.

Multilevel inverters are now the most cost-effective and promising option for achieving good output power quality in high voltage and high-power motor drive operations [5]. The power handling ability of the system can be increased in a scientific and powerful manner by using the Multilevel inverter structure [6]. The word multilevel is derived from the three-level inverter proposed by Nabae Et Al [7]. By increasing the inverter's level count, the output voltage waveform comprises more steps, resulting in a staircase waveform with lower harmonic distortion. The performance of multilevel inverters improves as the number of inverter levels increases.

3. RESULTS

Figure 1 depicts a VSI-fed induction motor drive. The voltage source is a diode rectifier with a capacitive filter. The induction motor drive is fed by a three-phase inverter running in 1200 mode. Figure 2 depicts the phase voltage waveforms, whereas Figure 3 depicts the stator phase currents. Figure 4 depicts the variation in speed. The speed rises until it reaches 1120 rpm. The current is subjected to FFT analysis, and the resulting spectrum is depicted in Figure 5. The magnitude of the fundamental current may be shown to be 28 Amperes. The THD (Total Harmonic Distortion) is 12.87 percent.

Fig. 1 VSI-Fed Induction Motor Drive System

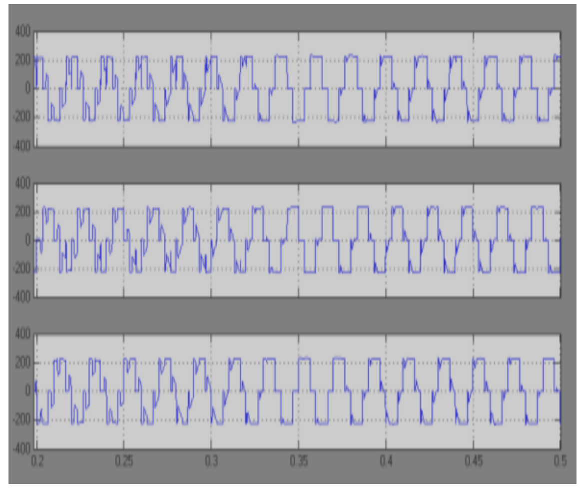

Fig. 2 Phase voltage waveforms of VSI-fed IM drive

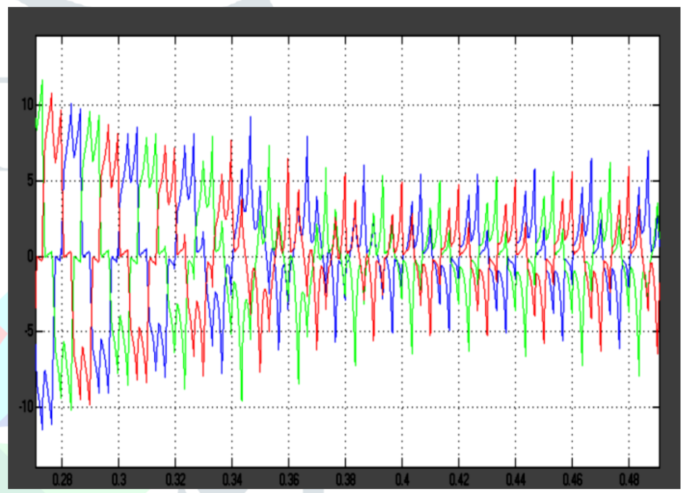

Fig. 3 Stator current waveforms of VSI-fed IM drive

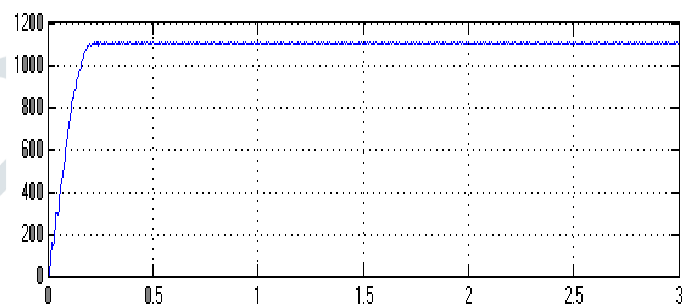

Fig. 4 Rotor speed of VSI-fed induction motor drive

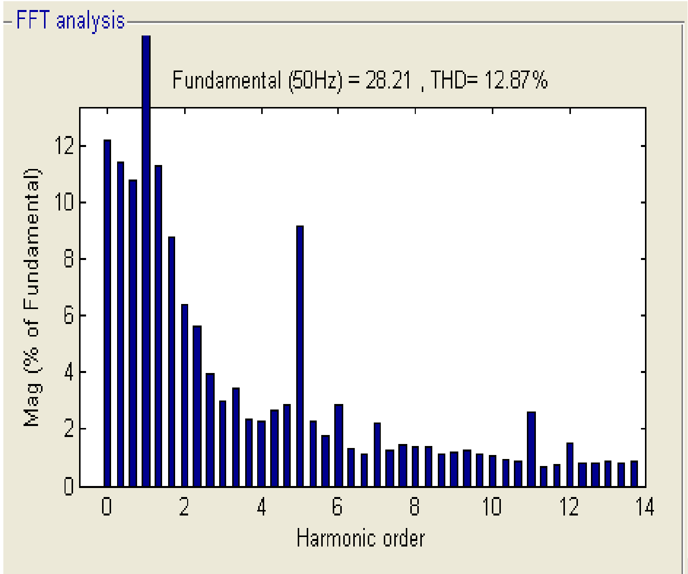

Fig. 5 FFT analysis for stator current of VSI-fed IM drive

4. CONCLUSION

MATLAB Simulink is used to model and simulate a three-level inverter-fed induction motor system. Voltage, current, speed, and FFT spectrum simulation data are examined. Speed variations are also observed. The speed rises until it reaches 1120 rpm. The current through the stator of the induction motor drive is subjected to FFT analysis. The matching spectrum shows that the fundamental current has a magnitude of 28 Amperes and a Total Harmonic Distortion (THD) of 12.87 percent.

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