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Speed Control on AC Induction Motor Using PWM Controlled Voltage Source Inverter

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Abstract

Induction motors were widely used in industries as a load along with the power electronic controlled device however induction motors were used as constant and variable speed motors In this article a speed control is made on induction motors in such a way that is suitable for the consumers. Several conventional control strategies like voltage, frequency, V/f control methods were implemented to limit the speed of the induction motor however it is complex in real time applications to overcome such issues the article introduces a simple design structure is offered using a MOSFET based voltage source inverter (VSI) which is controlled using a sinusoidal Pulse width modulation (SPWM). The investigations were made for different load conditions. Simulation results show the performance of the voltage source inverter and it is effectiveness were verified using an experimental set up. The experimental set up shows the performance of the voltage source inverter which is controlled with the help of an arduino.

***Keywords*:**Voltage source inverter, Induction motors, Sinusiodal pulse width modulation Arduino

1 INTRODUCTION

The Power semiconductors were used as switching devices that are combined together to make inverters. Ac loads requires variable voltage at input end. When ac loads are energized by inverters. It is essential that output voltage control to provide a required power supply. This involves with the change input dc voltage for a voltage regulation of the inverters and for the constant voltage/frequency requirement. Since two types of inverters were available. Voltage source inverters (VSI) and current source inverters. Based on the supply we classify the inverters as 1 phase inverter and 3 phase inverter [1].

When the power semiconductor switches were switched ON, if frequency affect and preexisting voltage distortion will affect the quality power. A well tuned filter is able to suppress those effects. A filter design incorporate an isolating transformers and the designed complimentary controller by rejects the voltage distortion and offer the good power quality[2].LCL filters is designed to mitigate harmonic issues. Which are predominantly used to eliminate harmonics with small size and weight [3].

Small signal linear models were presented for variable frequency, constant on time and variable frequency constant off time those modulation methods were used to control a switching action of the power semiconductor switches [4]. A Quasi Z-source cascaded multilevel inverters is used with a photovoltaic power system that overcomes the demerits of conventional cascaded multilevel inverters by a balanced DC-Link voltage [5]. A modernized control using pulse width modulation technique (PWM) was applied for inverters that may act as custom power devices like dynamic voltage restorer [6]. Gate signals to the switches for the semiconductor switches determine the harmonic substance of the output. Various types of gating signals have been used in the literature; most primitive of them has been Pulse Width modulation schemes. Joachim Holtz has carried out a comprehensive analysis of the various types of PWM techniques such as carrier based PWM and non-carrier based PWM, various parameters namely harmonic spectrum, torque harmonics and dynamic performance for analyzing the performance for different PWM techniques have been discussed [7] [8].Since inverters were applied in distributed generation due to the lack of fossil fuels the distributed power generation made a makeable concentration in which the role of inverters is very important several topologies of inverters [9].

In this work a sinusoidal pulse width modulation is used to control the inverter. Section II describes the theory background of PWM controlled inverter .Section III describes the simulation results of an inverter connected with an induction motor and section IV describes the experimental results.

2 Theory of Pulse Width Modulation

Pulse Width Modulation (PWM) techniques for two level inverters have been used extensively during the past decades. Many different PWM techniques have been used to achieve the following objectives; wide linear modulation range, reduced switching loss, lesser total harmonic distortion in the spectrum of switching waveform and simple implementation. The two most widely used PWM schemes for inverters are the carrier based PWM (sine-triangle PWM or SPWM) techniques and the space vector based PWM techniques. These modulation techniques are widely studied.

The SPWM schemes are flexible and simple to implement, however the maximum peak of the fundamental component in the output voltage is limited to 50% of the DC link voltage. A voltage source inverter with a MOSFET semiconductor switch is as shown in Fig. 1. In the simplest approach, the top switch is turned on If turned on and off only once in each cycle, a square wave waveform results. However, if turned on several times in a cycle an improved harmonic profile may be achieved

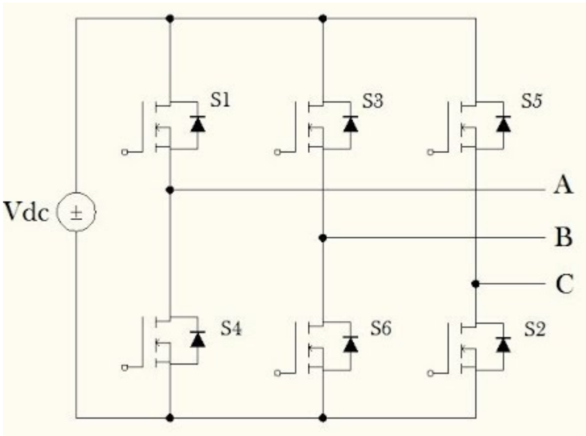


Fig.1. Schematic diagram of a Voltage source inverter

In the most straight forward implementation, generation of the desired output voltage is achieved by comparing the desired reference waveform (modulating signal) with a high-frequency triangular carrier wave as depicted schematically in Fig.2.

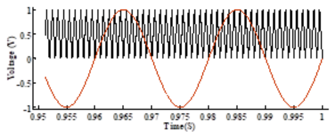


Fig.2.Reference source with carrier signal

Depending on whether the signal voltage is larger or smaller than the carrier waveform, either the positive or negative dc bus voltage is applied at the output. Note that over the period of one triangle wave, the average voltage applied to the load is proportional to the amplitude of the signal during this period. The resulting chopped square waveform contains a replica of the desired waveform in its low frequency components, with the higher frequency components being at frequencies of an close to the carrier frequency. The resultant waveform is as shown in fig.3.

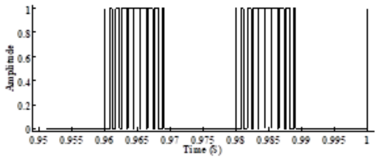


Fig.3.Generated sinusoidal Pulse Width Modulation

3 Simulation Study

A voltage source inverter is connected with a load that is driven with the help of a controller. The inverter is made up of semiconductor switches (MOSFET). The systemic Setup is implemented in MATLAB Simulink which is as shown in Fig.4

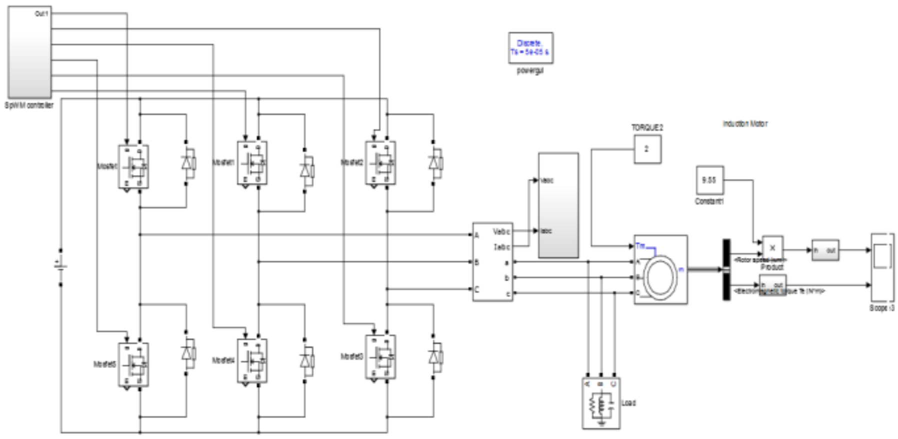


Fig.4. MATLAB Simulink diagram of a MOSFET Controlled VSC with an induction motor

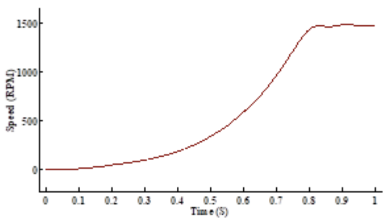


Fig.5.(a) Speed of the induction motor with a constant load

The output speed and torque of an induction motor is shown in fig.5.(a-c)

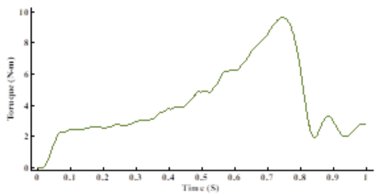


Fig.5.(b) Torque produced by the induction motor

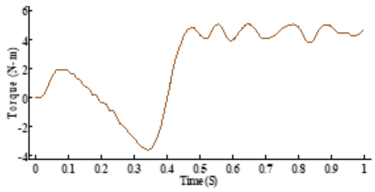


Fig.5.(c)Torque produced by the induction motor for a step load change

4 Experimental Setup

The block diagram of the above simulation circuit is modeled in a hardware setup which is as shown in fig.6. The block diagram setup consists of a DC source a MOSFET based inverter along with a adrunio controller that generates the SPWM signal.

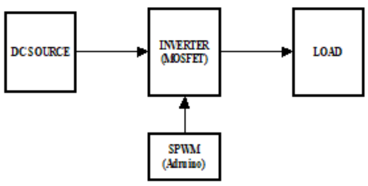


Fig.6. Block diagram of the proposed work

The arduino is used to generate the pulse of 5 V. The pulse generated is fed as input to the gate terminal of the MOSFET. The

MOSFET is operated under 1800 conduction mode. Six MOSFETs were used in this inverter. The output of the inverter is used to control the speed and the direction of the ac squirrel cage motor.

The arduino Uno R3 is an open source, low cost device used to interface the sensor output. It Consist of a Type B USB pin, a power port, Micro Controller Unit, Six Analog input pins (A0 to A5), Six Digital I/O pins, Six PWM pins and a Reset button.

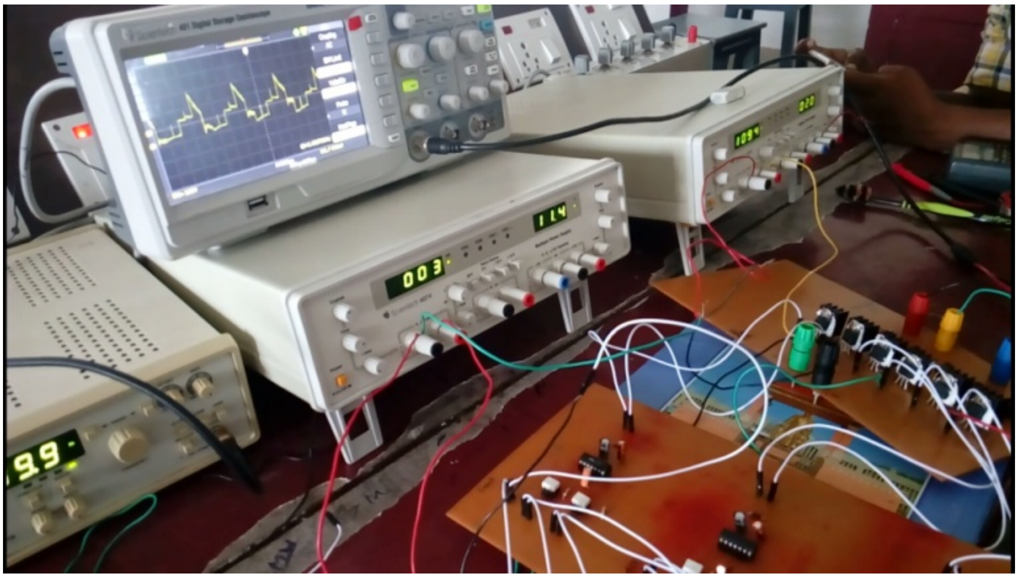
The MOSFET based inverter operates under 180o conduction mode the switching sequence of the inverter is shown in the table.1

State No	Switching states						V_{ab}	V_{bc}	V_{ca}
	S1	S2	S3	S4	S5	S6			
1.	ON	ON	OFF	OFF	OFF	ON	V_s	0	$-V_s$
2.	ON	ON	ON	OFF	OFF	OFF	0	V_s	$-V_s$
3.	OFF	ON	ON	ON	OFF	OFF	$-V_s$	V_s	0
4.	OFF	OFF	ON	ON	ON	OFF	$-V_s$	0	V_s
5.	OFF	OFF	OFF	ON	ON	ON	0	$-V_s$	V_s
6.	ON	OFF	OFF	OFF	ON	ON	V_s	$-V_s$	0
7.	ON	OFF	ON	OFF	ON	OFF	0	0	0
8.	OFF	ON	OFF	ON	OFF	ON	0	0	0

Fig: 5 Hardware setup with three phase inverter with arduino board

An induction motor is connected with the MOSFET based inverter the prototype setup is as shown in fig.5.

Table.1. Switching States of Three-phase Full-Bridge Inverter for 180o Conduction mode



5 CONCLUSION

In this article, a speed control on induction motors is made with a MOSFET based VSI. The control offered to the inverter through an arduino board it holds a good performance change under variable loading conditions. Simulation results shows the performance change and the effectiveness of the system is realized in hardware prototype model. As an extension of the work it will be applicable with the observation of power quality issues

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