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Elimination of Harmonics in Three Phase Inverter by Using Modifying Reference PWM Technique

KEYWORDS: Three Phase Sinusoidal-PWM inverter, Modified-Reference, Lower order harmonics, Fast Fourier Transform.

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ABSTRACT *This paper attempts to eliminate the dominant lower order harmonics present in three phase inverter by using Modified Reference PWM technique. The output voltage would result in a good quality sinusoidal voltage waveform of desired fundamental frequency and magnitude after some filtering. This is proposed in Matlab/simulink.*

I INTRODUCTION

An Inverter is an electrical device that converts DC to AC and are used in wide range applications, from small switching power supplies in computers, to large electric utility current applications that trans high-voltage direct current application that transport bulk power. Inverters are commonly used to supply AC power from DC sources such as solar panels or batteries. The inverters performs the opposite function of a rectifier. Among the different inverter control strategies used, Pulse Width Modulated (PWM) inverters are the most commonly used.

Pulse Width Modulation technology is used in inverters to give a steady output voltage of 230 or 110V AC irrespective of the load. The Inverter based on the PWM technology are more superior to the conventional inverters.

The quality of the output wave form the inverter determines its efficiency. The quality of the inverter output wave form is expressed using Fourier analysis data to calculate the Total Harmonic Distortion (THD). THD is the squares of the harmonic voltage divided by the fundamental voltage.

$$THD = \sqrt{V_2^2 + V_3^2 + V_4^2 + \dots\dots\dots + V_n^2}/V_1$$

The major issue with PWM is Presence of harmonics. The higher order harmonics around the carrier frequency are relatively easier to filter out, but the lower order harmonics, though smaller in magnitude, often cause problems in certain applications. A variety of techniques have been proposed to reduce the lower order harmonics to some percent. Based on the output waveforms, there are three types of Inverters. These are Sine Wave, Modified Sine Wave and Square wave inverters.

II TEST SYSTEM

A basic three-phase inverter consists of three single-phase inverter switches each connected to one of the three load terminals. For the most basic control scheme, the operation of the three switches is coordinated so that one switch operates at each 60 degree point of the fundamental output waveform.This creates a line-to-line output waveform that has six steps. The six-step waveform has a zero-voltage step between the positive and negative sections of the square-wave such that the harmonics that are multiples of three are eliminated as described above. When carrier-based PWM techniques are applied to six-step waveforms, the basic overall shape, or envelope, of the waveform is retained so that the 3rd harmonic and its multiples are cancelled.

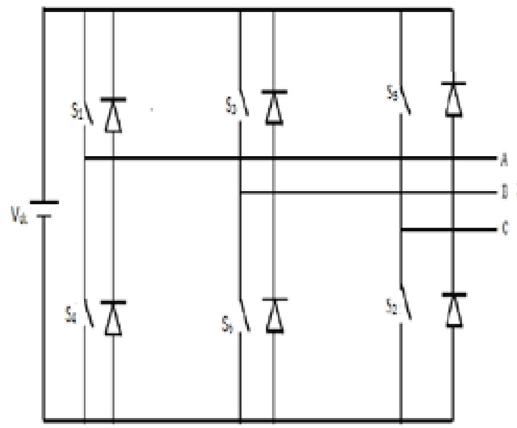

Fig 1: Three phase inverter

Table I
TEST SYSTEM PARAMETERS

Parameter	Symbol	value	Unit
DC link Voltage	V_{dc}	800	V
Modulating frequency	f_m	50	Hz
Carrier frequency	f_c	4000	Hz
Modulation index	M	0.8	-

The three phase inverter output voltage is shown in Figure 2.In three phase inverter directly the third harmonics and its multiples are reduced.

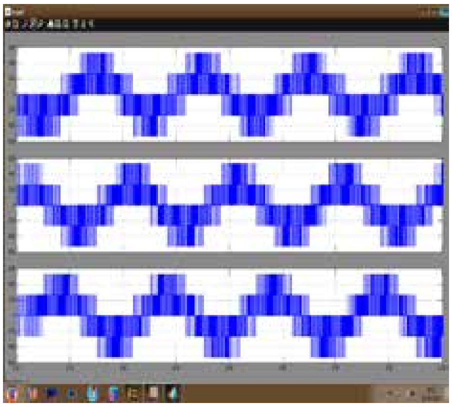

Fig 2: PWM Three Phase Inverter Output Voltage

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Hence, here we are reducing remaining lower order dominant harmonics i.e 5^{th}, 7^{th},11^{th}..........so on.

Figure 3 shows the basic third harmonic reduction in FFT analysis.

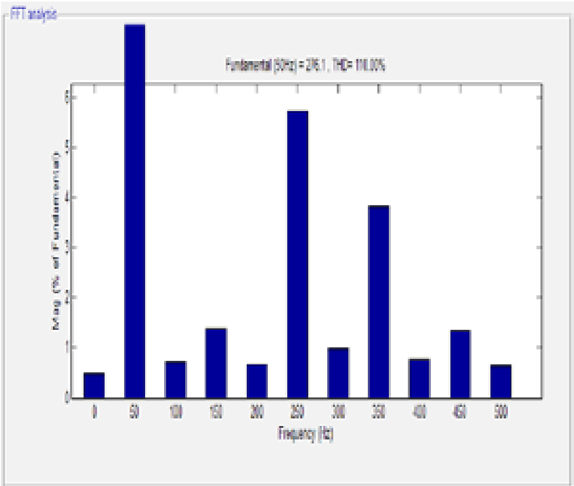

Fig 3: Harmonic Spectrum of PWM Three Phase Inverter Output Voltage

III CIRCUIT TOPOLOGY

Figure 4 shows the basic circuit configuration of three phase inverter . The circuit consists of 6 IGBT switches connected as shown in the figure below.

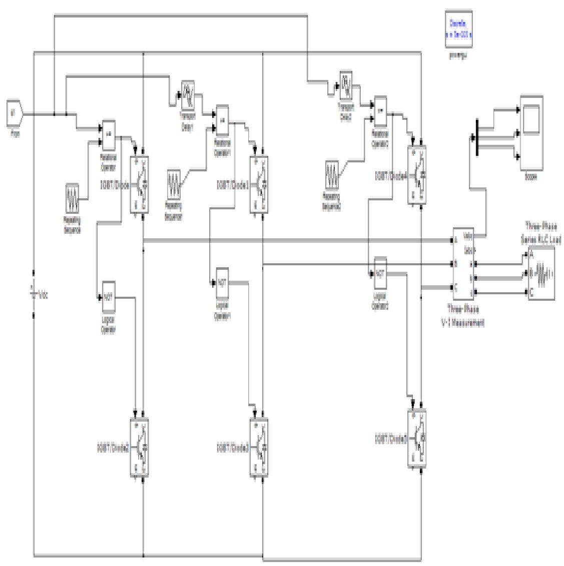

Fig 4: Matlab Circuit Diagram

IV CONTROL SCHEME

According to the elimination of harmonics a control scheme is proposed for modifying reference sine wave to the three phase inverter. Figure 5 shows the block diagram model of the scheme for n^{th} harmonics elimination i.e, 5^{th}, 7^{th},...... and so on will be eliminated.

The output voltage of the inverter V_{ab} is taken as α – component and is delayed by 90° to get the β – component . A phase locked loop is applied to the reference sine wave to get the angle information nθ, where n is the harmonic order to be eliminated. The transform shown in Eq. 1 converts the α – β to d_e – q_e quantities whereby the harmonic of interest becomes DC quantities.

$$V_{de}=V_\alpha \, X \sin(n\theta) - V_\beta \, X \cos(n\theta)$$

$$V_{qe}=V_\alpha \, X \cos(n\theta) + V_\beta \, X \sin(n\theta) \qquad (1)$$

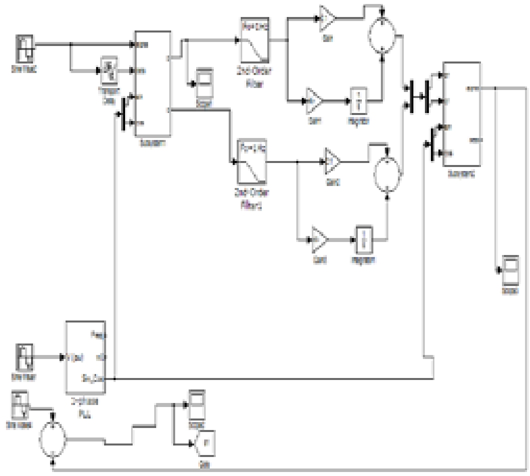

Fig 5: Control scheme for Modified Reference Technique

The low pass filters (LPF) having cut off frequency 1 Hz, is applied to extract the DC quantities. After passing through a suitable PI controllers, a reverse transformation as shown in Eq. 2 is done to get the α component of voltage.

$$V_\alpha = V_{de} \times \sin(n\theta) + V_{qe} \times \cos(n\theta) \qquad (2)$$

This signal is subtracted from the reference and compared with the carrier to generate the switching pulses (S_1). This block diagram shows elimination of 5^{th},7^{th},.....so on.

V SIMULATION RESULTS

The system shown in Fig 4 was simulated in MATLAB with the control scheme shown in Fig 5. The results for reduction of 5^{th} dominant harmonics with FFT analysis are shown in Fig.6 below.

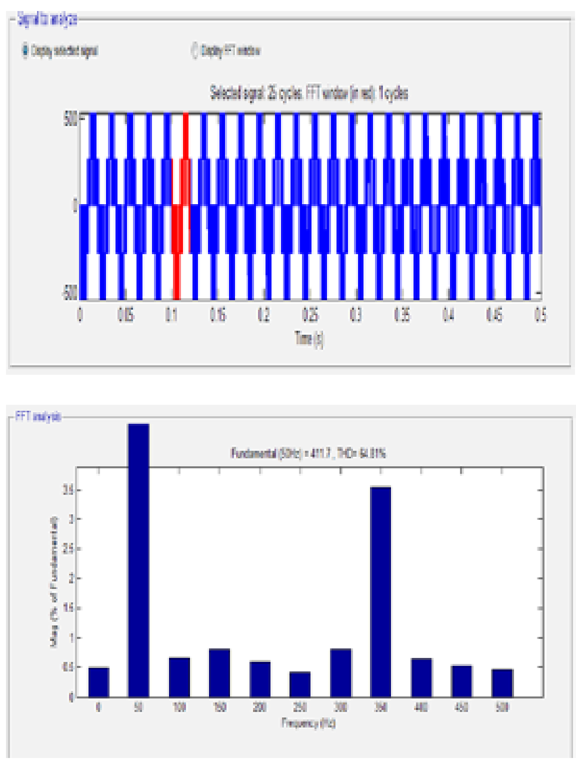

Fig 6: FFT Analysis Results for reducing 5^{th} harmonic

VI CONCLUSION

In this paper, to reduce the dominant lower order harmonics, the popular three phase sinusoidal PWM technique with a control scheme is proposed. Since there is no hardware requirement here, the scheme is reliable and economical. Here 5^{th} harmonic is reduced. Furthermore, by reducing 7^{th} harmonic the THD level is reduced. Also by using the multilevel inverters we can improve the THD in future.

VII. Acknowledgment

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