MODELING AND SIMULATION OF SPACE VECTOR PULSE WIDTH MODULATION FOR THREE PHASE VOLTAGE SOURCE INVERTER

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(Power Electronic And Drives)

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" I hereby declare that I have read through this report entitle "Modeling and Simulation of Space Vector Pulse Width Modulation for Three Phase Voltage Source Inverter" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Power Electronic and Drive) "

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A report submitted in partial fulfillment of the requirement for the degree of Bachelor in Electrical Engineering (Power Electronic and Drive)

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I declare that this report entitle "Modeling and Simulation of Space Vector Pulse Width Modulation for Three Phase Voltage Source Inverter " is the result of my own research except as cited I the reference. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

Various Pulse Width Modulation(PWM) techniques are developed for industrial application [3] to increase performance of industrial power inverter in term of efficiency and output voltage. The research has produce the advancement of Voltage Source Inverter to be flexible AC drive control to obtain variable magnitude and frequency. The most popular technique in controlling voltage source inverter is Space Vector Pulse Width Modulation. Research findings declare that the efficiency of SVPWM technique can be improve by implementing Discontinous Space Vector Pulse Width Modulation (DSVPWM) technique. SVPWM technique has lower efficiency due to high switching losses as this technique uses all three phases quantities while DSVPWM only use two out three phase quantities. Thus, this thesis performed comparative studies of SVPWM and DSVPWM techniques utilizing MATLAB tools. The objectives of this research to analyse the implementation of SVPWM and DSVPWM by using MATLAB/Simulink, to analyse efficiency improvement of DSVPWM over SVPWM as well as to analyse Total Harmonis Distortion for both technique. The research methode is simplified into implementing procedure for modeling and simulating the both technique. Both of the techniques following the implementing procedure but the only difference is at the last three step. The results obtained proved that DSVPWM improved efficeincy of SVPWM but does not improve Total Harmonic Distortion. THD of voltage for both technique is quite similar but in term of THD of current,DSVPWM has slightly higher than SVPWM.

ABSTRAK

Terdapat pelbagai teknik Permodulan Lebar Denyutan (PWM) yang dibina untuk aplikasi industri [3]bagi meningkatkan prestasi penyongsang kuasa perindustrian . Penyelidikan telah menghasilkan pembaharuan kepada penyosang jenis voltan sumber iaitu dengan menghasilkan voltan berubah-ubah dan kekerapan masa berubah-ubah. Teknik yang paling popular digunakan untuk mengawal penyongsang jenis voltan sumber adalah Modulasi Ruang Vektor Lebar Denyutan.Hasil kajian mendapati bahawa kecekapan teknik SVPWM boleh ditingkatkan dengan melaksanakan teknik Modulasi Ruang Vektor Lebar Denyutan Tidak Berterusan (DSVPWM). Oleh itu , tesis ini memaparkan kajian perbandingan antara SVPWM dan DSVPWM teknik menggunakan siasatan alatan MATLAB. Objektive kajian yang dijalankan adalah untuk menganalisis pelaksanaan SVPWM dan DSVPWM dengan menggunakan MATLAB / Simulink , untuk menganalisis peningkatan kecekapan DSVPWM lebih SVPWM dan juga untuk menganalisis Jumlah Penyelewengan Harmonis untuk kedua-dua teknik.Kaedah penyelidikan dipermudahkan dengan melaksanakan prosedur untuk pemodelan dan prosedur simulasi bagi kedua-dua teknik. Proses perlaksaanaan kedua-dua teknik tersebut melalui prosedur sama tetapi perbezaan bermula pada langkah tiga terakhir. Keputusan yang diperolehi membuktikan bahawa DSVPWM membaiki kecekapan SVPWM tetapi tidak memperbaiki Jumlah Penyelewengan harmonik . Jumlah Penyelewengan Harmonic bagi voltan untuk kedua-dua teknik ini agak sama tetapi dari segi Jmlah Penyelewengan Harmonic bagi arus, DSVPWM lebih tinggi sedikit daripada SVPWM .

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MI	Modulation Index
SVPWM	Space Vector Pulse Width Modulation
DSVPWM	Discontinuous Space Vector Pulse Width Modulation
VSI	Voltage Source Inverter
CSI	Current Source Inverter
DC	Direct Current
PWM	Pulse Width Modulation
THD	Total Harmonic Distortion
IGBT	Insulated-gate bipolar transistor
UPS	Uninterrupted Power Supply
IEGTs	Injection Enhanced Gate Transistor
AFD	Adjustable Frequency Drives
HVDC	High Voltage Direct Current

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CHAPTER 1

INTRODUCTION

1.1 Research Overview

For this project, discontinuous space vector pulse width modulation (DSVPWM) technique is used to improve the efficiency of space vector pulse width modulation (SVPWM) for voltage source inverter (VSI). SVPWM technique is depends on the representation of the inverter output as space vector. Space vector represent the output voltages of the inverter is realized for the implementation of SVPWM [1]. This PWM technique is the most popular technique in controlling voltage source inverter. This report is intended to introduce information about implementation of DSVPWM technique in order to improve the efficiency of SVPWM technique. Description of implementation steps and simulation findings is explained in this report.

1.2 Research Motivation

In the age of globalization era, the great demand in high efficiency industrial applications lead to development of high performance drives technology. The demand urged the researchers to undertake research extensively. The researches discover a technique to improve efficiency of voltage source inverter. Conventionally, space vector pulse width modulation (SVPWM) is the best technique used to control voltage source inverter. A new technique known as discontinuous pulse width modulation (DSVPWM) propose to improve SVPWM technique. The propose technique also famous as two-phase SVPWM. The analysis of these two techniques is focus on efficiency improvement and total harmonic distortion.

1.3 Problem Statement

Space pulse width modulation simultaneously symbolizes three-phase quantities as one rotating vector. This technique is popular due to higher output voltage when compared with Sinusoidal Pulse Width Modulation as well as easy digital realization. Regardless of these two advantages, SVPWM is analyses in term of its efficiency. The researchers found that the efficiency of this technique can be improved by implementing a technique call discontinuous pulse width modulation. In this technique, only two out of three-phases quantities used in a rotating vector. One of the phases is tied to positive or negative DC bus which represents zero voltage vector (000) elimination and zero voltage vector (111) elimination respectively.

1.4Objectives

i. To simulate and explain space vector pulse width modulation (SVPWM) and discontinuous space vector pulse width modulation (DSVPWM) technique for three phase voltage source inverter by using MATLAB/SIMULINK.
ii. To analyses the improvement in efficiency of discontinuous space vector pulse width modulation (DSVPWM) over space vector pulse width modulation (SVPWM).
iii. To analyses the Total Harmonic Distortion (THD) for both space vector pulse width modulation (SVPWM) and discontinuous space vector pulse width modulation.

1.4 Scope of Research

There are two approaches in implementation of DSVPWM which is zero voltage (000) eliminated and zero voltage (111) eliminated. Only zero voltage (000) eliminated approach enclosed in this research project. This research project also analyses Total Harmonic Distortion for both SVPWM and DSVPWM technique. This research project focus on the implementation of SVPWM and DSVPWM technique for three-phase voltage source inverter using the software MATLAB/SIMULINK includes:

i. Focus on development of MATLAB/SIMULINK model of SVPWM and DSVPWM step by step.
ii. Investigation on the improvement of SVPWM's efficiency by using DSVPWM technique.

1.6 Report Outlines

Chapter 1 Introduction

In this chapter, the brief idea about the project is discuss in overview. The idea is then elaborated in research motivation, objectives, scope as well as contribution of research.

Chapter 2 Literature Review

The review of basic principle PWM technique and the topologies of voltage source inverter are explained in detail. Besides, this chapter summed up the research information in related previous work and summary of review. The software used for simulation is described.

Chapter 3 Methodology

The overall flow of the project is explain and illustrated in flow chart. In addition, the detail of involved step is provided in analogical approach.

Chapter 4 Results and Analysis

The results, analysis and discussion of three-phase VSI using SPWM will be discuss in this chapter.

Chapter 5 Conclusion

Summation of ideas in the report will be concluded.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will justify and discusses the source or articles that are associated with the project. It consists of the theoretical information about the technique used. The derivation of Space Vector Pulse Width Modulation (SVPWM) is additionally express in this chapter.

2.2 Voltage source inverter (VSI)

A power inverter is an electronic device that converts Direct Current to Alternating current. It converts the DC power obtained from power supply or batteries and rectifier to AC power at the desired output voltage and frequency. There are two dominant types of inverter known as voltage source inverter (VSI) and current source inverter (CSI)[7]. In industrial market, voltage source inverter (VSI) design has greater advantages over current source inverter (CSI) as it is competent for running motor without reducing the power rating of the motor. Basically, a voltage source inverter (VSI) is one in which has small or negligible impedance at the DC source.

Voltage source inverter made up of power transistors and their controlled turn ON and turn OFF is generated from self-commutation with base signals. Each power switch of the inverter is insulated gate bipolar transistor (IGBT) with anti-parallel diodes. There are other possible choices of transistor to replace IGBT such as insulated gate commutated thyristors (IGCTs) and injection enhanced gate transistors (IEGTs) but IGBT is widely used in VSI drives market. The IGBT switches create a PWM voltage output that regulates the voltage and frequency to the motor [2].

Inverters industrial applications are for adjustable frequency drives (AFDs), HVDC transmission line, uninterruptable power supply (UPS) and electric vehicles [7]. Adjustable frequency drives (AFDs) consist of converter, DC link, inverter and motor as shown in Figure 2.1. Diode rectifiers are usually used as converter to converts line AC voltage between 50Hz-60Hz to DC voltage. The DC link transmits the DC voltage to the inverter. By storing energy, it provides ride-through capability as well as some isolation from utility. Motor as the AC loads requires adjustable voltage and frequency at their input terminals. Thus, they are fed by inverters as to fulfill the requirement load.

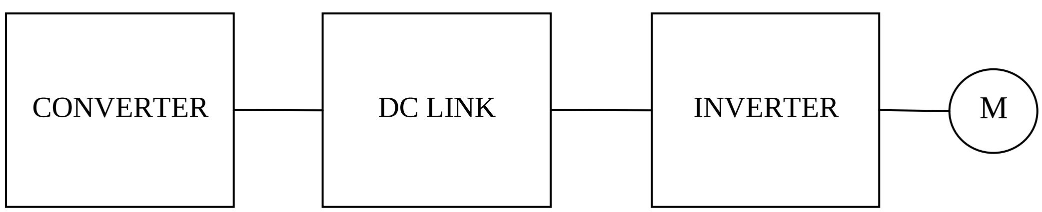

Figure 2.1: Block diagram of adjustable frequency drive (AFD)

2.2.1 Three-Phase Voltage Source Inverter

As shown in Figure 2.2, three- phase voltage source inverter (VSI) is composed with DC supply and pair of switch in each leg. Each switch is made up of fully controllable semiconductor, IGBT and diode. Upper and lower switch in each leg are complimentary in operation. If the lower switch is ON, the upper switch must be OFF in order to protect the circuit. The DC voltage at the input terminal is assumed as being constant. Symbols of (a, b, c) are donated as the inverter outputs, while (A, B, C) refer to the points connection of the outputs legs. The three-phase voltage source inverter (VSI) is developed assuming the commutation is ideal and zero forward voltage drop, six-step mode and phase delay between firing of two switches in any subsequent two phases is equal to $360°/3 = 120°$.

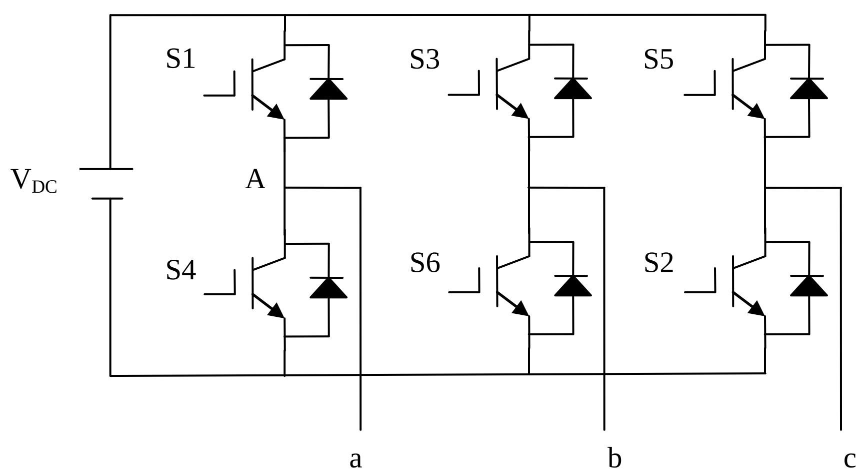

Figure 2.2: Power circuit topology of a three-phase voltage source inverter

The driving control gate for six-step mode operation of inverter in Figure 2.2 is illustrated in Figure 2.3. This driving control gate generates signal to inverter. One complete cycle is divided into six operation mode. Each of operation modes carries $360°/6 = 60°$. At