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Supervisor's Name : ....IR DR ROSLI B OMAR....
Date : ....19/6/13....

SPACE VECTOR PULSE WIDTH MODULATION FOR INDUSTRIAL APPLICATION USING DSP TMS320F2812

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A report submitted in partial fulfillment of the requirement for the degree Of Electrical Engineering (Industrial Power)

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JUNE 2013

I declare that this report entitle " Space Vector Pulse Width Modulation for Industrial Application using DSP TMS320F2812" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : AFIQAH BINTI SABARI

Date : 20/6/2013

To my beloved mother and father

ACKNOWLEDGMENT

All praises be to Allah S.W.T, The Most Gracious, The Most Merciful for Guidance and Blessing. Alhamdulillah, after facing all challenges and obstacles throughout Final Year Project (FYP), I able to finish and complete a report entitle "Space Vector Pulse Width Modulation for Industrial Application Using DSP TMS320F2812".

I would like to express my gratitude and special thanks to my final year project guide or supervisor Ir.Dr. Rosli Bin Omar, who had helped me in completing the project and solving problem in which I faced during project. It has a great pleasure for me to get an opportunity to learn some knowledge under him and finally completes this project successfully. Finally, I feel a deep sense of gratitude to my parents, Sabari Bin Siraj and Siti Marpungah Bt Sipon because for their encouragement and moral support during my studies at Universiti Teknikal Malaysia Melaka (UTeM).

Last but not least, I would like to take this opportunity to express my gratitude to the people who have given me support in the successful to complete of this project. I hope this report will give a better knowledge about the SVPWM for industrial application using DSP TMS320F2812 due my final project.

ABSTRACT

Sinusoidal Pulse Width Modulation, also called Pulse Width Modulation Sine coded is very much applied in the industry. Nowadays, the three phase inverter has drawn tremendous interest for high voltage and high power application. The general structure of three phase inverter is to synthesize sinusoidal voltage waveform from several levels of voltages. Digital control of inverter using DSP TMS320F2812 is preferred due their dynamic controlling property. This project focuses on the Space Vector Pulse Width Modulation (SVPWM) for industrial applications using DSP TMS320F2812. In addition, this project emphasizes the indirect vector control strategies that place the inverter as a leading role in the drive system. Pulse Width Modulation controller is used to generate a pulse inverter switching pattern. Therefore, Space Vector Pulse Width Modulation (SVPWM) is used to pulse width modulation scheme for three phase voltage source.Ultimately, Space Vector Width Modulation is befitting for high power load application especially to alternate current motor in term of lower frequency.

ABSTRAK

Sinusoidal nadi modulasi lebar (SPWM), juga dikenali sebagai sin nadi modulasi lebar dikodkan, banyak digunakan dalam industri.Pada masa kini, tiga fasa penyongsang telah menarik minat yang besar untuk voltan tinggi dan penggunaan kuasa yang tinggi. Struktur umum tiga fasa penyongsang adalah untuk mensintesis gelombang voltan sinusoidal dari beberapa tahap voltan. Kawalan digital penyongsang menggunakan DSP TMS320F2812 adalah pilihan kerana harta mengawal dinamik mereka. Projek ini merupakan projek ruang vektor nadi modulasi lebar (SVPWM) untuk aplikasi industri yang menggunakan DSP TMS320F2812. Di samping itu, projek ini secara tidak langsung menekankan strategi kawalan vektor yang meletakkan penyongsang sebagai peranan utama dalam sistem pemacu. Nadi modulasi lebar (PWM) pengawal digunakan untuk menjana denyut penyongsang corak bertukar. Oleh itu, untuk projek ini menggunakan ruang vektor nadi modulasi lebar (SVPWM) kepada denyut skim modulasi lebar untuk tiga fasa sumber voltan. Dari segi kekerapan yang lebih rendah, ruang vektor nadi modulasi lebar (SVPWM) kawalan sesuai untuk kuasa tinggi beban permohonan terutamanya kepada motor arus alternatif.

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CHAPTER 1

INTRODUCTION

1.1Background

This section focuses on what is expected to be done during the Space Vector Pulse Width Modulation for industrial applications using DSP TMS320F2812 project period. In addition, this project also emphasizes the indirect vector control strategies that place the inverter as a leading role in the drive system. Pulse Width Modulation controller is used to generate a pulse inverter switching pattern. Therefore, for this project use the Space Vector Pulse Width Modulation to pulse width modulation scheme for three phase voltage source inverter.

Space Vector Pulse Width Modulation technology (SVPWM) gained wide applications in power electronics and electrical drives as it reduces motor axis pulsation and current waveform distortion. Moreover, DC voltage utilization ratio has improved very much which is 70.7% of the DC link voltage(compared to the conventional SPWM's 61.2%), in the linear modulation range, thus making it more convenient for digital realization[2].

In recent years, the three phase inverter has drawn larger benefit for high voltage and high power applications. Generally,the structure of a three-phase inverter is to synthesize a sinusoidal voltage waveform from several levels of voltages. Hence, a three phase voltage source inverter using TMS320F2812 DSP has been selected for the dynamic controlling property.

1.2 Problem Statement

There are a lot of issues occurring in electrical power system. One of these problems is harmonic distortion. Harmonic distortion appearing in the industry can be divided into two which is currents and voltages. Voltage and current harmonics within electrical power system will cause power line carrier disorder which leads to long distance operation of switching devices, load control and metering to be less precise. Especially in microprocessor systems, interference signal and the relay would not work. In addition, interference in large motor controllers and system excitation the power station will also cause motor output to be inconsistent.

There are several modulation techniques that are used to meet the output variable that have maximum base component with minimum harmonic [9] in order to make the motor operates smoothly. Space Vector Pulse Width Modulation is one of the technique that increases the direct current bus and reduces switching losses [1].

Based on Space Vector Pulse Width Modulation using DSP TMS320F2812, creating and encoding Space Vector Pulse Width Modulation program which has been applied to DSP TMS320F2812. With this, the pulses generated have been used for the inverter. Output waveform of the connected to loop as an example is a loop with induction motor.

1.3Objectives

Based on problem statement section, there are two objectives identified for this project as follows:-

1. To understand and develop conventional Space Vector Pulse Width Modulation technique and applied for industrial applications.
2. To study and use applications of DSP TMS320F2812.

1.4 Project Scope

The scope of this project is to generate pulses by using DSP TMS320F2812 based on Space Vector Pulse Width Modulation. These pulses would be applied to the inverter. The output of the inverter can be used for motor application. An example is for motor movement. Design the implementation of the Space Vector Pulse Width Modulation technique using DSP TMS320F2812. The controller has been developed for open loop system and the controller was encoded into the DSP TMS320F2812.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of pulse width modulation (PWM)

Pulse Width Modulation (PWM) as it applies to motor control, is a means of delivering energy pulses through substitution rather than analogue signals varies.There are several definitions and considerations when using the PWM should be specified.

a. From equation (1.0),the frequency modulation ratio, m_f is defined the ratio of the frequencies of the carrier and reference signals. By increasing the carrier frequency will increase m_f. Therefore, it increases the frequency at which the harmonic happens. A disadvantage is the high switching frequency to higher losses in the switches is used to implement the inverter.

$$m_f = \frac{f_{carrier}}{f_{reference}} = \frac{f_{tri}}{f_{sine}} \tag{1.0}$$

b. From equation (1.1), the amplitude modulation ratio m_a is defined the ratio of the amplitudes of the references and carrier signals,

$$m_a = \frac{V_{m,reference}}{V_{m,carrier}} = \frac{V_{m,sine}}{V_{m,tri}} \tag{1.1}$$

If m_a is less and equal than one, the amplitude of the fundamental frequency of the output voltage V_1 is linearly proportional to $m_a$from equation (1.2)

$$V_1 = m_a V_{dc} \tag{1.2}$$

c. The switches in the full bridge circuit must be capable of carrying current either direction for pulse width modulation (PWM) switch to do the same as for square wave operation. Another result is that no actual switch on or off instantly. Therefore, it is necessary to allow for the change in the time switch control just as it is for square wave inverter.

d. The sinusoidal reference voltage must be generated within the control circuit of the inverter or taken from external references. Power is supplied to the load provided by the dc power source and this is the intended purpose of the inverter.

2.2Space Vector Pulse Wave Modulation

Typical structure of a three phase power voltage source inverter is shown in Figure 2.1. S_1 through S_6 are six power with transistors switches and antiparallel diodes that form the output, which is controlled by a, a', b, b', c, c'. Induction motor control for alternating current, when the transistor is turned ON and one example is when the condition a, b, or c is 1. Moreover, when the transistor is turned OFF matching lower and one example is the same when the condition a', b', or c' is 0. State ON and OFF the transistors$S_1, S_{3,}$ and S_5above, or similar, where a, b, and c, are literally enough to assess the output voltage [2].

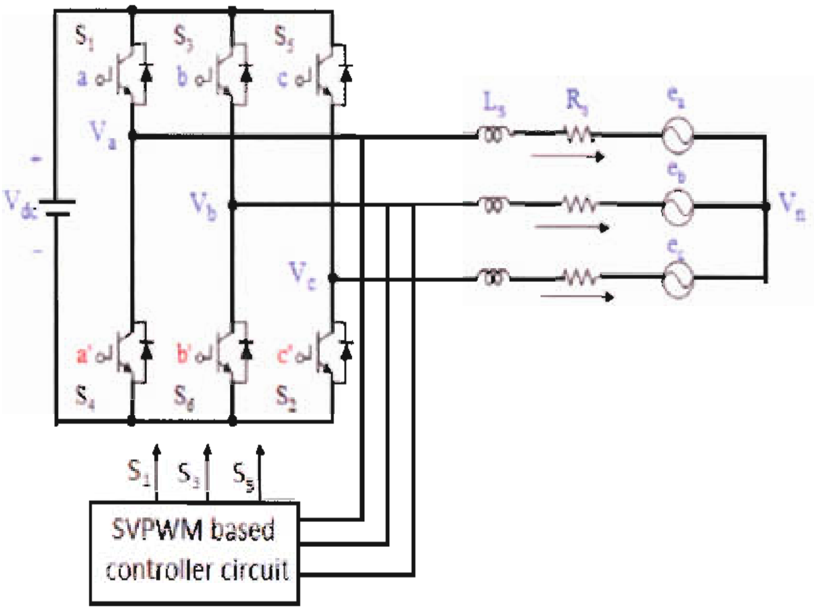

Figure 2.1: A three phase power source inverter circuit [3]

Modelling two levels in terms of voltage source inverter switching function given by equation (1.3) and (1.4) as follows which determines the relationship the switching variable vector with the phase voltage$[\mathrm{Va},\mathrm{Vb},\mathrm{Vc}]^t$ and the line to line voltage vector$[\mathrm{Vab},\mathrm{Vbc},\mathrm{Vca}]^t$ where Vdc is the supply voltage.

$$\begin{bmatrix}\mathrm{Van}\\ \mathrm{Vbn}\\ \mathrm{Vcn}\end{bmatrix} = \frac{V_{dc}}{3}\begin{bmatrix}2 & -1 & 2\\ -1 & 2 & -1\\ -1 & -1 & 2\end{bmatrix}\begin{bmatrix}a\\ b\\ c\end{bmatrix} \tag{1.3}$$

$$\begin{bmatrix}\mathrm{Vab}\\ \mathrm{Vbc}\\ \mathrm{Vca}\end{bmatrix} = \mathrm{Vdc}\begin{bmatrix}1 & -1 & o\\ 0 & 1 & -1\\ -1 & 0 & 1\end{bmatrix}\begin{bmatrix}a\\ b\\ c\end{bmatrix} \tag{1.4}$$

Eight combination and the output lines and phase voltage in the direct current voltage V_{dc}supply, according to equation (1.3), shown in Figure 2.2. Space Vector Pulse Width Modulation refers to a switching sequence on three phase source inverter power transistors. It has been shown to generate less harmonic distortion in voltage or current output and used for single-phase alternating current motors and provide the use of a more efficient supply voltage in comparison with direct sinusoidal modulation technique [3].

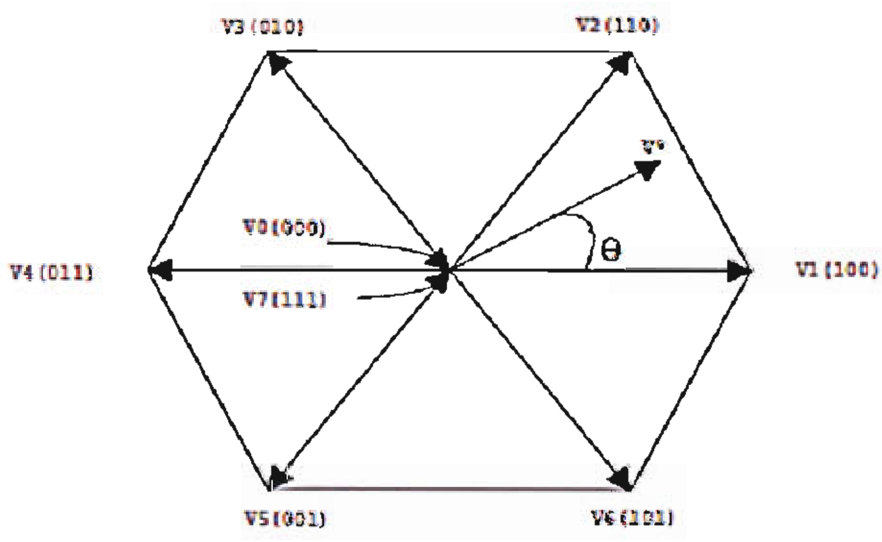

Figure 2.2: Inverter output voltage space vector [3]

To determine the values of Vd, Vq, Vref, and angle (α), coordination transformation which is abc to dq is used. The relation is given in the equation (1.5) and equation (1.6). The voltage space vector and its components dq plane are shown in Figure 2.3

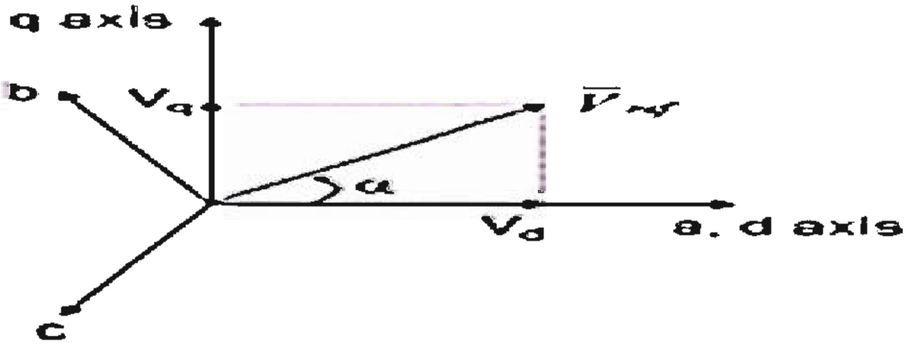

Figure 2.3: The voltage space vector and its components dq plane [6]

$$V_d = V_{an} - V_{bn}.\cos60 - V_{cn}.\cos60 = V_{an} - \frac{1}{2}V_{bn} - \frac{1}{2}V_{cn} \tag{1.5}$$

$$V_q = 0 - V_{bn}.\cos30 - V_{cn}.\cos30 = V_{an} - \frac{\sqrt{3}}{2}V_{bn} - \frac{\sqrt{3}}{2}V_{cn} \tag{1.6}$$

Therefore,

$$\begin{bmatrix} V_d \\ V_q \end{bmatrix} = \frac{2}{3}\begin{bmatrix} 1 & -\frac{1}{2} & \frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix}\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} \tag{1.7}$$

$$|\overline{V}_{ref}| = \sqrt{V_d^2 + V_q^2} \tag{1.8}$$

$$\alpha = \tan^{-1}\left(\frac{V_d}{V_q}\right) = \omega_s t = 2\pi\pi_s t \tag{1.9}$$

(Where, f_s= fundamental frequency)

The reference vector rotates in 360° and each 60° contributes a sectorin the *αβ* axis. When the reference vector lies in between 0° to 60°, then it is first sector. The PWM pattern for the six sectors is evaluated.The on and off of the states are lower power of devices contrary to the one above and so easily defined power states on transistor is determined. According to equation (1.3) and (1.4), eight switching vectors, output phase to neutral voltage and voltage output phase to phase where the respective voltage is multiplied by Vdc, [5] are given in Table 1.

Table 1: Switching vector pattern, phase voltages and output line to line voltages

Voltage Vectors	Switching Vectors			Line to neutral voltage			Line to line voltage		
	a	b	c	Van	Vbn	Vcn	Vab	Vbc	Vca
V_0	0	0	0	0	0	0	0	0	0
V_1	1	0	0	2/3	-1/3	-1/3	1	0	-1
V_2	1	1	0	1/3	1/3	-2/3	0	1	-1
V_3	0	1	0	-1/3	2/3	-1/3	-1	1	0
V_4	0	1	1	-2/3	1/3	1/3	-1	0	1
V_5	0	0	1	-1/3	-1/3	2/3	0	-1	1
V_6	1	0	1	1/3	-2/3	1/3	1	-1	0
V_7	1	1	1	0	0	0	0	0	0

Particularly inverter can move to eight unique states. Modulation is achieved by changing the state inverter. Space vector pulse width modulation treat as a sinusoidal voltage of constant amplitude vector rotating at a constant frequency. This technique PWM match reference voltage Vref by a combination of eight exchange patterns (V0 to V7). Vectors (V1 to V6) divide the plane into six vectors; Vref generated by two adjacent non-zero vectors and two zero vectors [3]. SVPWM treat inverter as a single reference voltage. With a single reference voltage, this will make it flexible to be implemented for advanced vector-controlled drives.