MODIFIED SUBOSCILLATION METHOD FOR INVERTER WITH THIRD HARMONIC INJECTION

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MEI 2007

"I hereby declared that I have read through this repot 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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This Report is submitted in Partial Fulfillment of Requirement for The Degree of Bachelor in Electrical Engineering (Power Electronic and Drives)

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DEDICATION

For my beloved parents, my brothers, my teachers and friends

ACKNOWLEDGEMENT

Alhamdulillah, all praise belongs to Allah S.W.T. for giving me the strength, patients and tranquility in completing my Bachelor's Degree project and my thesis before its due date. First of all, I want to thanks my parents, Abu Yamin b. Hj Mupit and Sutiah bte Hj Muhammad, and also my family for all their kindness, concern, and loyal support. Without of these supports, I would not have completed my project successfully. A special thanks to my project supervisor, Prof Madya Dr Zulkifilie b. Ibrahim and Mr Auzani b. Jidin who helped me a lot in my project and gave me motivation throughout this project. Also not forgotten, to whose people which effort contributed to the completion of this project. Their cooperation greatly enhances the authenticity and utility of my effort. Last but not least, thank you so much to all my friends especially batch 4BEKE 2006/07. Hope our friendship remains forever.

ABSTRACT

The power output and dynamic performance of PWM controlled ac drive can be improved by increasing the inverter output voltage through overmodulation. As a result this project is proposed to increase the output voltage in a continuously controllable fashion up to maximum possible value. This project presented the features of control method based on a modified suboscillation method with third-harmonic injection or well known as third-harmonic pulse-width modulation (THIPWM).This method is optimal in the following ways: increase maximize dc bus voltage utilization without overmdulation, better performance with low total harmonic distortion, THD of the line current and effectively eliminate the third harmonic component. The analysis and experimental results from thethird-harmonic pulse-width modulation (THIPWM) and fundamental (SPWM) method are shown through MATLAB simulation. Furthermore hardware implementation can be accomplished by uses op-amp 741 integrated circuit for the modulator circuit.

ABSTRAK

Kuasa keluaran dan keupayaan dinamik oleh pemacu arus terus kawalan PWM boleh diperbaiki dengan meningkatkan voltan keluaran penyongsang sehingga tahap modulasi yang lebih. Oleh yang demikian, projek ini diperkenalkan untuk meningkatkan voltan keluaran yang mana berterusan boleh dikawal sehingga nilai tertinggi yang boleh dicapai. Projek ini menerangkan kaedah kawalan berdasarkan kaedah pengubahsuaian cabang pengayun dengan suntikan harmonik ketiga atau lebih dikenali sebagai harmonik ke-3 PWM (THIPWM). Kaedah ini sangat berkesan pada perkara berikut: meningkatkan penggunaan voltan dc bus semaksima mungkin tanpa melebihi modulasi, keupayaan yang lebih baik dengan jumlah harmonik yang rendah pada arus talian dan juga berkesan untuk menghapuskan komponen harmonik ke-3. Keputusan analisa dan kajian tentang kaedah harmonik ketiga PWM (THIPWM) dan kaedah asas (SPWM) ditunjukkan melalui simulasi menggunakan perisian MATLAB. Tambahan lagi perlaksanaan perkakasan disempurnakan dengan menggunakan litar bersepadu 741 penguat operasi untur litar modulator.

TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	TITLE	i
	ADMISSION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	LIST OF FIGURES	x
	LIST OF TABLES	xiii
	LIST OF APPENDICES	xiv
1	**INTRODUCTION**	
	1.1 Introduction	1
	1.2 Objectives	2
	1.3 Scopes	2
	1.4 Problem Statements	3
2	**LITERATURE REVIEW**	
	2.1 Overview	4
	2.1.1 Power Section	4
	2.1.2 Control Strategy	5
	2.2 Pulse Width Modulation (PWM)	8
	2.3 Inverter	10
	2.4 Driver Circuit	12

		2.4.1 Power Switch Losses	12
	2.5	Power Line Disturbances	
		2.5.1 Types of Disturbances	12
	2.6	Harmonics	14
		2.6.1 Causes of Harmonics	15
		2.6.2 Symptoms of Harmonics	16
		2.6.3 Effects of Harmonics	16
		2.6.4 Eliminating Harmonics	17
	2.7	Introduction to Matlab	18
		2.7.1 Simulink	18
		2.7.2 Sim Power Systems	19
		2.7.3 Creating Models	20
		2.7.4 Running simulation	20
3	**THEORITICAL ANALYSIS**		
	3.1	Overview	21
	3.2	Industry Scenario	22
	3.3	Third-Harmonic modulation (THIPWM)	24
		3.3.1 Advantages	26
		3.3.2 Maximum Modulation Index	26
		3.3.3 Third Harmonic Component Elimination	28
4	**METHODHOLOGY**		
	4.1	Simplified Of Methodology	29
	4.2	Flow Chart	31
5	**SIMULATION AND RESULT**		
	5.1	Simulation	33
	5.2	THIPWM Circuit	34
		5.2.1 Result	35
	5.3	Sinusoidal PWM Circuit	39

		5.3.1 Result	40
	5.4	Six-step Circuit	44
		5.4.1 Result	45
	5.5	Result discussion	48
6	**DESIGN AND IMPLEMENTATION OF HARDWARE**		
	6.1	Introduction	50
	6.2	Operational Amplifier	50
	6.3	Three-phase generator	52
		6.3.1 Wein Bridge Oscillator	53
	6.4	Triangular Wave Oscillator	56
	6.5	Summing Amplifier	60
	6.6	Comparator	61
	6.7	Hardware	61
		6.7.1 Hardware limitation	63
	6.8	Hardware result	63
7	**CONCLUSION AND RECOMMENDATION**		
	7.1	Conclusion	64
	7.2	Recommendation	65
	LIST OF REFERENCES		67
	APPENDICES		69

LIST OF FIGURES

FIGURE	TITLE	PAGE
2.1	A PWM waveform	6
2.2	Fundamental output voltages versus Modulation index, *ma*	7
2.3	A PWM waveform for $ma = 0.3$	7
2.4	A PWM waveform for $ma = 1.0$	8
2.5	Output waveform for $ma \geq 1.0$	8
2.6	Three-phase inverter	9
2.7	Speed control drive	9
2.8	Driver Circuit Block Diagram	10
2.9	Possible distortions in input voltage: a) Chopped voltage waveform; b) Distorted voltage waveform due to harmonics	13
2.10	Harmonics	14
2.11	Normal sine curve and harmonic	15
2.12	Harmonic curve	15
3.1	Block Diagram of Speed Control	22
3.2	Fundamental output voltages versus modulation index	23
3.3	Third-harmonic modulation	24
3.4	Third-harmonic modulation with output voltage	25
3.5	Block diagram of 3rd harmonic elimination	28
4.1	Flow chart of methodology	27
5.1	Block Diagram of Project (THIPWM)	34

5.2	Third harmonic PWM modulation	35
5.3	Translation from SPWM to THIPWM for Modulating waveform	35
5.4	Line to line output voltage (THIPWM)	36
5.5	Phase output voltage (THIPWM)	33
5.6	Fundamental and THD for voltage (THIPWM)	37
5.7	Fundamental and THD for voltage (THIPWM) For $freq_{tri}$=5 kHz	37
5.8	THD for current (THIPWM)	38
5.9	Reference at space vector locus for THIPWM	38
5.10	Block diagram of sinusoidal PWM	
5.11	Sinusoidal PWM modulation	40
5.12	Line to line output voltage (SPWM)	41
5.13	Phase output voltage (SPWM)	41
5.14	Fundamental and THD for voltage (SPWM)	42
5.15	Fundamental and THD for voltage (SPWM) For $freq_{tri}$=5 kHz	42
5.16	THD for current (SPWM)	43
5.17	Reference at space vector locus for SPWM	43
5.18	Block Diagram of Six-step	44
5.19	Six-step modulation	45
5.20	Phase output voltage (Six-step)	46
5.21	Fundamental and THD for voltage (Six-step)	46
5.22	THD for current (Six-step)	47
5.23	Reference at space vector locus	48
6.1	741 Op-amp schematic and pin-out	51
6.2	Three-phase generator circuit	52
6.3	Wein bridge oscillator	54
6.4	Output from oscilloscope 50 hertz	55

6.5	Output from oscilloscope 150 hertz	55
6.6	Triangular wave oscillator circuit	56
6.7	Output from oscilloscope	59
6.8	Summing amplifier circuit	60
6.9	Comparator circuit	61
6.10	The whole view	61

LIST OF TABLES

TABLE	TITLE	PAGE
4.1	Project Gantt chart	32
5.1	The result comparison	48
6.1	The performance	56
6.2	The performance	59

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	OP-AMP 741	69
B	LF 353 JFET	73
C	Field Effect Transistor FET 2n3819	77

CHAPTER 1

INTRODUCTION

1.1 Introduction

Many three-phase loads require a supply of variable voltage at variable frequency, including fast and high-efficiency control by electronics means. Predominant applications are in variable speed ac drives, where the rotor speed is controlled through the supply frequency, and the machine flux through the supply voltage.

The power requirements for these applications range from fractions of kilowatts to several megawatts. It is preferred in general to take the power from a dc source and convert it to three-phase ac using power electronic dc-to-ac converters. The input dc voltage, mostly of constant magnitude, is obtained from a public utility through rectification, or from a storage battery in the case of an electric vehicle drive.

The conversion of dc power to three-phase ac power is exclusively performed in the switched mode. Power semiconductor switches effectuate temporary connections at high repetition rates between the dc terminals and the three-phase of the ac drive motor. The actual power flow in each motor phase is controlled by the on/off ratio, or duty-cycle, of the respective switches. The desired sinusoidal waveform of the currents is achieved by varying the duty –cycle sinusoid ally with time, employing techniques of pulse width modulation (PWM). The performance of pulse width modulation (PWM) is characterized by the modulation index and at given switching frequency by the harmonic distortion.

For this project we use third- harmonic injection PWM (THIPWM) method. In fact, the modulation index can be increased when this voltage is modified by addition third- harmonic component to the reference signal.

1.2 Objectives

There are several objectives that desired in this project. There are:

1. To investigate about the SPWM and THIPWM characteristic and operation.
2. To determine the suitable technique for analyzing ,designing and simulating modulator for inverters by using MATLAB
3. To investigate the performance parameters of inverter
4. To investigate how total harmonic distortion THD can be reduce
5. To investigate the modulation and built circuit three phase balanced signals.
6. To implement the PWM circuit based on modified suboscillation method for inverter

1.3 Scope

To realize this project, a few scopes were determined. The projects scopes are very important to make sure that the project is on the right rails. The scopes of this project are:

1. Investigate behavior of third-harmonic injection of PWM (THIPWM) based on simulation approach.
2. To utilized MATLAB simulation tools and its toolboxes.
3. Understanding the principles of THIPWM , concept ,topology and theory of control method, modulator, gate drive and power circuit

4. To study the effects of third harmonic injection in terms of: dc bus utilization, power produced and THD
5. To design the simple and low cost PWM circuit using conventional Op-Amp components.

1.4 Problem Statement

The analysis and simulation of third-harmonic injection of PWM (THIPWM) modulator model is developed to overcome the problems arise. The problems are:

1. Dc bus voltage is not fully utilize therefore insufficient power to drive high load (torque produce must be large)
2. Low total harmonic distortion THD requirement in voltage source inverter application.
3. Difficult to filter out harmonics due to low frequency harmonics contents.
4. Switching losses in high power application.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

A power converter has a power stage and a control stage. The power stage comprises the semiconductor switches and energy storage components. The power section converts the unregulated power at its input to regulated power at the load .The controller section is concerned with providing control signals to the power stage. This section can be implemented in analog or digital form

2.1.1 Power Section

The power stage basically consists of switched-mode semiconductor devices that are turned on and off periodically by waveforms from the control stage. A low pass filter with corner frequency considerably lower than the switching frequency is employed to remove the undesirable harmonics in the output. The duty cycle D of the switching waveform defines the fraction of time that the switch remains on. The output voltage is a function of the duty cycle and the input voltage in an ideal converter. In a real case, the parasitic resistances such as the inductor resistance, equivalent series resistance of the capacitor and on resistance of the switching devices also determine the output voltage.

2.1.2 Control Strategy

The control section of a converter deals with generation of switching signals for the semiconductor devices in the power section. Conventional techniques rely on comparison of a ramp waveform with a reference signal.

Conventional hysteresis control regulators produce rough output voltages due to high ripple current in the inductor caused by low switching frequency and sub-harmonic oscillation. The response time from the drain voltage of the switch to the converter output is also slow as the voltage information is used to regulate just the output voltage. Consequently, switching frequency is low and ripples current and conduction losses are high. In PWM control method, the switching frequency is easily adjustable and the ripple in the output voltage and ripple in the inductor current can made to be low by increasing the switching frequency. However, a complex compensation circuit around the error amplifier depending on the load and filter conditions is a serious shortcoming in this method

2.2 Pulse Width Modulation (PWM)

PWM is a switch–mode control method used to control motor voltages and current to obtained higher efficiency than linear control. PWM refers to variable on/off times or width of the voltage pulses applied to the switches. Voltage and frequency are maintained at a constant relationship at any motor speed to maintain a constant torque. Benefits to use PWM concept is:

1. Motors run smoothly at high and low speed (no cogging); however, they are current limited.
2. PWM drives can run multiple parallel motors with acceleration rate matched to total motor load.

3. At low speed, PWM drives may require a voltage boost to generate required torque.

Figure 2.1 shows amplitudes of the triangular wave (Carrier) and sine wave (modulating) are compared equivalent to generate PWM waveforms.

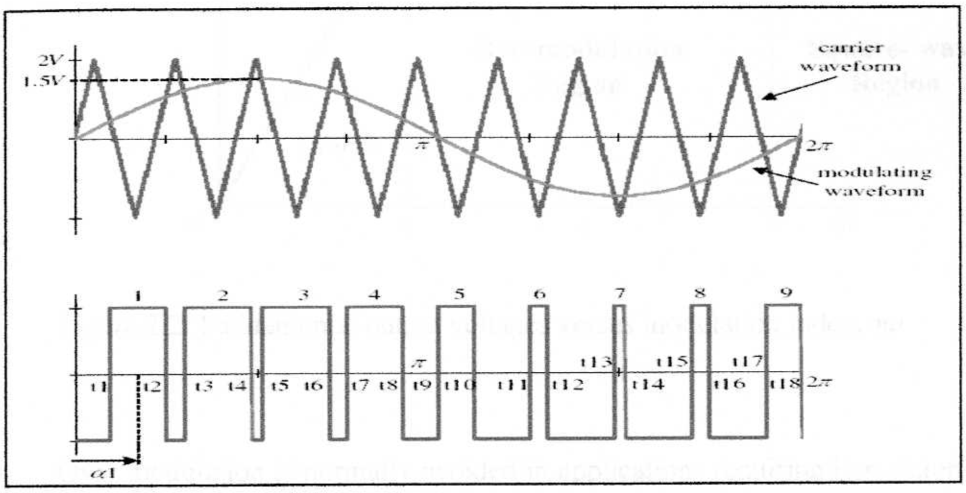

Figure 2.1: A PWM waveform

The peak fundamental output voltage for PWM control can be found approximately from:

$$Vm1 = dVs \qquad \text{for } 0 \le d \le 1.0 \tag{2.1}$$

For $d = 1$ Equation (2.1) gives the maximum peak amplitude of the fundamental output voltage as $Vm1(\max) = Vs$. $Vm1(\max)$ could be as high as $1.273\,Vs$ for a square-wave output. To increase the fundamental output voltage, d must increased beyond $d = 1.0$. The operation beyond $d = 1.0$ is called over modulation. Over modulation basically leads to square-wave operation and adds more harmonics as compared with operation in the linear range (with $d \le 1.0$).

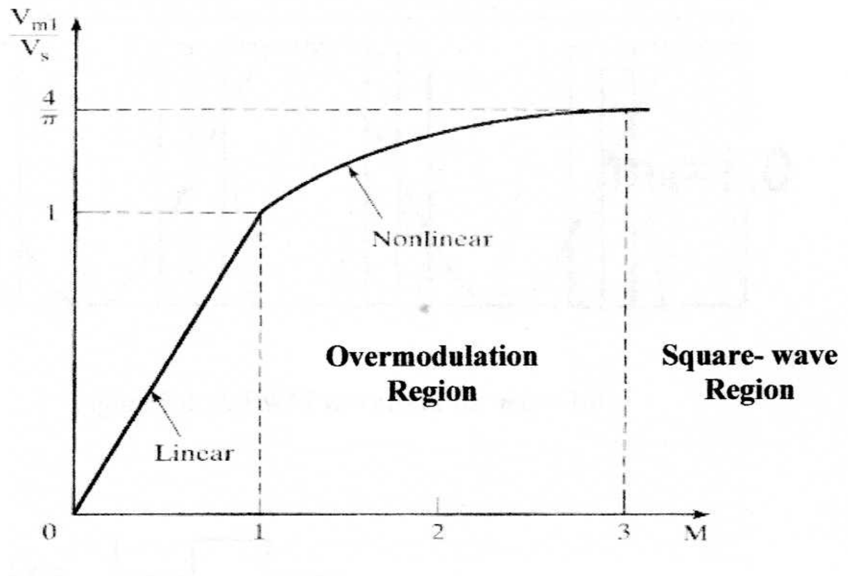

Figure 2.2: Fundamental output voltages versus modulation index, *ma*

Over modulation is normally avoided in applications requiring low distortion like UPS but used for high power level; in which case the magnitude of the dc input must be adjusted. Over modulation occurs for *ma* greater than one and could result in the inverter waveform degenerating into a square wave.

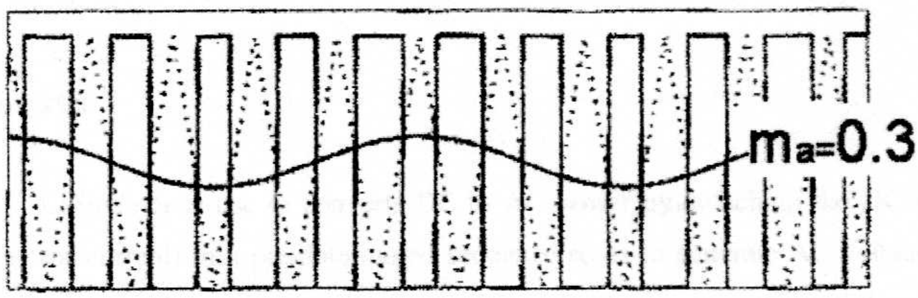

Figure 2.3: A PWM waveform for *ma* = 0.3

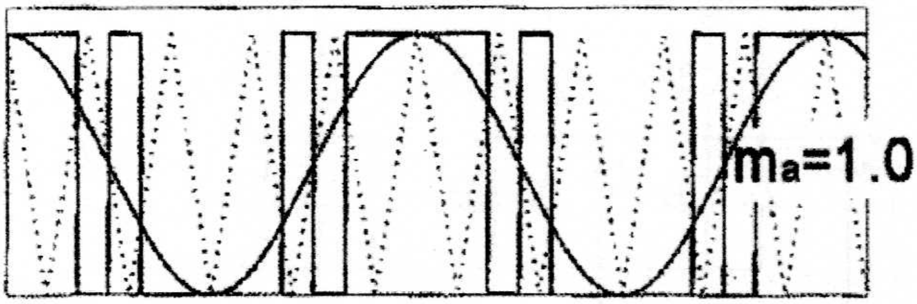

Figure 2.4: A PWM waveform for *ma* = 1.0

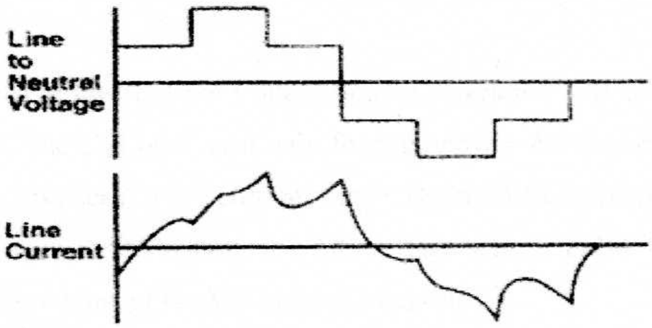

Figure 2.5: Output waveform for *ma* ≥ 1.0

2.3 Inverter

An inverter is use to converts DC to AC power by switching the DC input voltage (or current) in a pre-determined sequence so as to generate AC voltage (or current) output. The typical applications of inverters are in un-interruptible power supply (UPS), industrial (induction motor) drives, traction and HVDC. The main purpose of these topologies is to provide a three-phase source where the amplitude, phase, phase and frequency of the voltages should be controllable. Each leg normally is called by red, yellow; blue is delayed by 120 degrees. A three-phase inverter with star connected load is shown below: