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LAPORAN PROJEK SARJANA MUDA

MODELING AND ANALYSIS PERFORMANCE SIMULATION PERFORMANCE OF MULTILEVEL INVERTER USING BIPOLAR AND UNIPOLAR SWITCHING SCHEMES

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Bachelor of Electrical Engineering (Power Electronic and Drive)

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MODELING AND ANALYSIS PERFORMANCE SIMULATION OF MULTILEVEL INVERTER USING BIPOLAR AND UNIPOLAR SWITCHING SCHEMES

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

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YEAR 2014

I declare that this report entitle “Modeling and Analysis Performance Simulation of Multilevel Inverter Using Bipolar and Unipolar Switching Schemes” 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 : ………………………………………..

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Date : ………………………………………..

"I hereby declare that I have read through this report entitle "Modeling and Analysis Performance Simulation of Multilevel Inverter Using Bipolar and Unipolar Switching Schemes" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Power Electronic and Drive)"

Signature : ....

Supervisor's Name : En. Musa Yusup Lada

Date : ....

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ABSTRACT

Multilevel inverter is one of the popular converter topologies used in high power medium- voltage (MV) drives due to able operate at high direct current (DC) voltage which is achieved using series connection of power semiconductor switches. Multilevel inverter can generate output voltage with very low harmonic distortion and synthesis a staircase voltage output waveform by having multiple voltage level. Various topologies of multilevel inverters are introduced; however, in this project, the cascaded seven-level multilevel inverter will be discussed due to easy control method implementation. Unipolar and bipolar switching schemes are used to analyze the performance of seven-level cascaded H-bridge inverter. Both of these SPWM voltage modulation type are selected because these method able to double the switching frequency of the inverter voltage effectively. The major problem in designing multilevel inverter is to design filtering in order to filter the low harmonic which is very hard to eliminate. Bipolar switching PWM inverter is able to filter the low frequency harmonics compared to the unipolar switching schemes inverter. From the simulation results, it can be clearly seen that by using bipolar switching scheme, the total current harmonic distortion (THD_i) and voltage harmonic distortion (THD_V) for R, RL and RC loads are low compared to unipolar switching scheme. Therefore, the bipolar switching scheme is more suitable because the common domestic loads used are RL load. MATLAB Simulink is used to model the seven levels cascaded multilevel PWM inverter

.

ABSTRAK

Penyongsang berperingkat adalah salah satu topologi penukar kuasa arus terus yang popular dalam voltan sederhana kuasa tinggi dengan menggunakan penyambungan siri suis – suis semikonductor kuasa. Penyongsang berperingkat dapat menjanakan voltan yang berherotan harmonic yang sangat rendah dan bentuk gelombang voltan tangga yang berbilang. Pelbagai topologi penyongsang berperingkat telah diperkenalkan, walaubagaimanapun, dalam projek ini, tahap tujuh penyongsang melata berperingkat akan dibincangkan kerana pelaksanaan kaedah pengawalan lebih mudah. Pensuisan dwikutub dab ekakutub digunakan untuk menganalisi prestasi tujuh peringkat penyongsan berperingkat. Dua persuisan modulasi ini dipilih kerana kaedah ini mampu menggandakan frekuensi utama voltan penyongsang dengan berkesan. Masalah utama dalam mereka penyongsang berperingkat adalah menapis herotan harmonik yang rendah kerana herotan harmonik yang rendah sangat sukar untuk ditapis. Dwikutub persuisan lebih mudah menapis herotan harmonik ini berbanding dengan persuisan ekakutub. Keseluruhan keputusan simulasi, dengan jelasnya herotan harmonik arus dan voltan penggunaan R, RL dan RC muatan adalah rendah berbanding dengan persuisan ekakutub.Lantarannya, persuisan dwikutub adalah lebih sesuai digunakan kerana muatan-muatan domestik adalah RL muatan. Simulink Matlab digunakan untuk memperagakan tujuh tahap penyongsang berperingkat

.

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LIST OF ABBREVATIONS

AC – Alternating Current

APOD – Alternative Phase Opposition Dissipation

CSI – Current Source Inverter

DC – Direct Current

GTO – Gate Turn-Off Thyristor

MLI – Multilevel Inverter

PD – Phase Dissipation

POD – Phase Opposition Disposition

PWM – Pulse Width Modulation

THD – Total Harmonic Distortion

VSI – Voltage Source Inverter

CHAPTER 1

INTRODUCTION

1.1 Background

Inverters are circuits that convert direct current (DC) to alternating current (AC). More precisely, inverters transfer power from a DC source to an AC load. Since the main objective of the inverter is to use a DC voltage source to supply a load requiring AC, it is useful to describe the quality of AC output.

In the electrical power distribution system, there are many non-linear loads drawing non-sinusoidal current. The quality of a non-sinusoidal wave can be expressed in terms of total harmonic distortion (THD). If non-sinusoidal current passes through a different kind of impedance, it will produce voltage and current harmonics. The voltage and current harmonics can cause additional losses, overheating and overloading of the load.

Multilevel inverter has the advantages of generating better output quality by using pulse width modulation (PWM) technique. This is because PWM inverters are able to eliminate unwanted harmonic by using suitable design of PWM scheme such as bipolar and unipolar schemes.

1.2 Problem Statement

In the past, square wave inverters were widely used in independent wind or solar power systems and some industrial applications with lower requirement on power quality. In square wave inverter, the harmonics and output voltage amplitude could not be controlled by the user. In addition, in AC power distribution system, harmonics occur when the normal electric current waveform is distorted by non-linear loads such as computer equipment with switched-mode power supplies, variable speed motors and drive, fluorescent lamp ballasts and others.

Harmonic decreases significantly in power quality and live cycle of electrical equipment. Basically, harmonic distortion will increase resistive losses, voltage stresses and excessive voltage distortion on power distribution system.

Therefore, the multilevel inverter is used to produce multilevel-output voltages which are purely sinusoidal or synthesis a staircase voltage waveform and thus reduce harmonic content. Higher frequency harmonics are easier to filter than harmonics near the fundamental frequency. Bipolar and unipolar switching schemes are chosen because these methods able to double the switching frequency of the inverter. However, some of low frequency harmonics are formed due to non-linear loads, therefore, bipolar switched multilevel inverter is proposed due to able to filter the low frequency harmonics More number of levels of multilevel inverter will give better performance in term of total harmonic distortion.

1.3 Objective

The objectives of this project are:

1. To model there phase seven-level multilevel inverter using bipolar and unipolar switching technique by using Matlab Simulink Software.
2. To analyze and evaluate the simulation of seven-level of multilevel inverter by using bipolar and unipolar switching schemes.
3. To validate the THD for bipolar and unipolar switching schemes for multilevel inverter by using varieties of load testing.

1.4 Scope

This project focuses on the performance of seven-level multilevel inverter on minimizing the harmonics distortion. The Matlab Simulink is used to model the seven-level cascaded multilevel inverter. The multilevel inverter is used for various loads testing such as R, RL and RC load. The performance of seven levels cascaded inverter will be analyzed by using bipolar and unipolar switching schemes. Meanwhile, the simulation results are compared and validated that the bipolar seven-level cascaded inverter has the minimum harmonic distortion

.

1.5 Report Outline

This report contains five chapters and start with the introduction of project which is multilevel inverter. The following five chapters of this project are arranged as follows:

Chapter 1 covers the short explanation about this research project, problem statement, objective and scope.

Chapter 2 covers the theoretical background of this project including the detail about the types of inverter, the general topologies of multilevel inverter, multilevel inverter modulation control schemes, PWM consideration, power quality and total harmonic distortion definition.

Chapter 3 states about the research methodology. This chapter consists of the flowchart of project and the switching methods used in this project and the simulation results which are the designing Simulink block by using bipolar and unipolar switching schemes.

Chapter 4 discusses the simulation result by using different non-linear loads. Harmonic analysis for the non-linear loads will be discussed to evaluate the performance of the inverter.

Chapter 5 is the summary of this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Inverters are circuits that convert a DC power into an AC power at a desired output voltage and frequency. Figure 2.1 shows the block diagram of inverter. Inverters can be in single phase or multiphase and they deliver bipolar current waveform and allow for bi-directional power flow [1]. Inverters are widely used in various applications requiring variable voltage and variable frequency AC supply. Some important applications are adjustable-speed AC motor drives, DC motor drives; uninterruptible power supplies (UPS), induction heating, standby power supply and high voltage DC transmission systems [2].

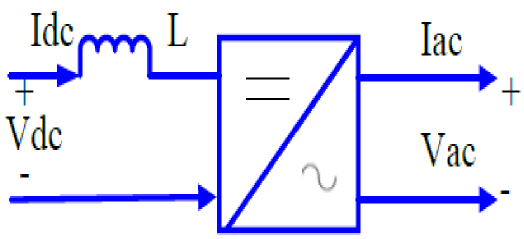


Figure 2.1: Block Diagram of Inverter

2.2 Classification of Inverter

There are different basis types of inverters. The two major types of inverters are current-source inverter (CSI) and voltage-source inverter (VSI). Their input sources are either a constant current or constant voltage.

2.2.1 Current-source Inverter (CSI)

Current-source inverter is fed by a 'current source' with an inductor in series with a dc source. Therefore, the supply current does not change quickly. Figure 2.2 shows the block diagram of CSI inverter. CSI inverters are in general constructed with gate-turnoff thyristor (GTO) and refer to high power levels. The load current is varied by controlling the DC input voltage to the current source inverter. CSI are used in a very high-power AC drives [3].

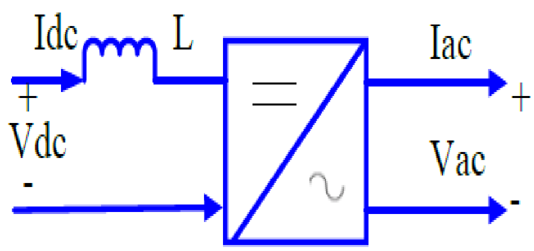


Figure 2.2: Circuit Configuration of CSI inverter

2.2.2 Voltage – Source Inverter (VSI)

Voltage-source inverter is fed by a DC source of small internal impedance. VSI inverters are constructed with insulated-gate bipolar transistor (IGBTs) or GTO. The AC terminal output voltage remains almost constant irrespective of the load current drawn. There are two types of VSI which are square wave inverter and PWM inverter [3].

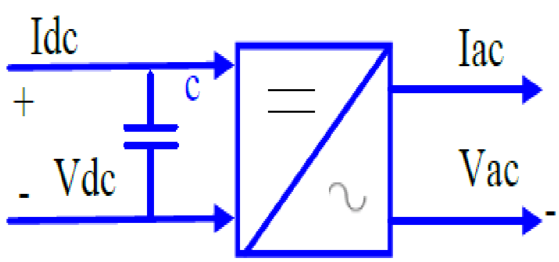


Figure 2.3: Circuit Configuration of VSI Inverter

2.2.2.1 Single-phase Half-bridge Inverter

The basic topology of a single-phase is half-bridge inverter fed by a DC voltage source as shown in Figure 2.4. S1 and S2 are gate-commutated power semiconductor switches. When closed, these switches conduct current flows. The gating signal of switches, S_1 and S_2 are shown in Figure 2.5. When S_1 is closed, the load voltage is Vdc/2. When S_2 is closed, the load voltage is –Vdc/2.Thus, a square wave or bipolar pulse width modulated output voltage can be produced. The output voltage of half-bridge is shown as Figure 2.6 too [3].

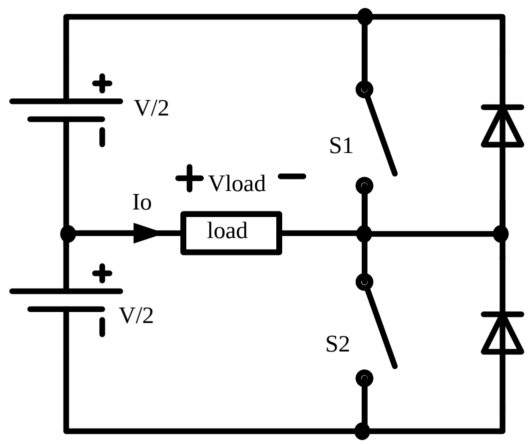
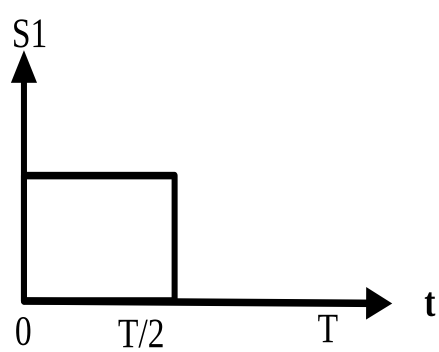
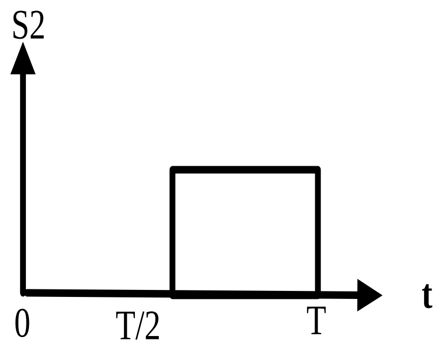


Figure 2.4: Circuit Configuration of a Single-phase Half-bridge Inverter



(a)



(b)

Figure 2.5: (a) Gating Signal for Switch S_1 (b) Gating Signal for Switch S_2

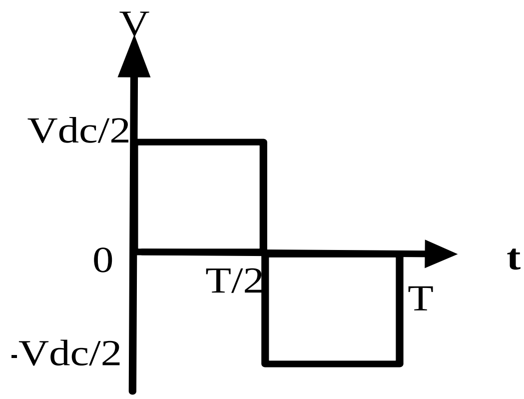


Figure 2.6: Output Voltage of Single phase half-bridge inverter

2.2.2.2 Single-phase Full- bridge Inverter

The basic topology of a single-phase is full-bridge inverter fed by a DC voltage source as shown in Figure 2.7. The inverter uses two pairs of controlled switches (S_1S_2 and S_3S_4) and two pairs of diodes (D_1D_2 and D_3D_4). The devices of one pair operate simultaneously. However, in reality, there must have switching transition time or blanking time to control the closing and opening of switches Overlapping opening of switches will result in short circuit or shoot-through fault. The gating signals of the switch-pairs S_1S_2 and S_3S_4 are shown in Figure 2.8.