"I hereby declare that I have read through this report entitle "Evaluation of Grid Connected Solar PV System Under Malaysia Environment" and found that it has complied the partial fulfillment for awarding the Bachelor in Electrical Engineering (Industrial Power)

Signature : ....

Supervisor's Name : PROF. MADYA DR. GAN CHIN KIM

Date : ....

EVALUATION OF GRID CONNECTED SOLAR PV SYSTEM UNDER MALAYSIA ENVIRONMENT

NORAZWANI BINTI OMAR

A report submitted in partial fulfillment of the requirements for the Bachelor in Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering
(UNIVERSITI TEKNIKAL MALAYSIA MELAKA)

2016

I declare that this report entitle "*Evaluation of Grid Connected Solar PV System Under Malaysia Environment*" 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 the candidature of any other degree.

Signature : ....

Name : NORAZWANI BINTI OMAR

Date : ....

To my beloved mother and father

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Thank You.

ABSTRACT

This project is conducted at the main campus of Universiti Teknikal Malaysia Melaka (UTeM), Melaka. The changes of weather and passing cloud may caused variation of solar irradiation that contributed to variation of PV output power . Unfortunately, the variation of PV output will cause energy losses and harmonic distortion. Thus, the aim of this project is to study the correlation between solar irradiance and Total Harmonic Distortion (THD) contributed from PV inverter and investigate the efficiency of PV inverter with variation of solar irradiance. Fluke 43B meter and Automatic Weather Monitoring System(AWS) were used to record the required data. The data was collected for 3 to 6 months in order to analyse the data. In addition, the value of THDi, current, solar irradiance, output and input voltage have been recorded for 8 hours a day for 30 days. From the collected data, its shown that the variation of solar irradiance effects the THDi and current profiles. When the solar irradiance is high the value of current also increase. However, THDi increases when the solar irradiance is low. This implies that, in order to get high power quality of output, the value of solar irradiance should be high. Based on the result, it shows that the average value of THDi fulfil the requirement from TNB Technical Guidebook. Furthermore, the inverter efficiency is high when the DC power output is high. Low and fluctuating DC power output cause the value of inverter efficiency to decrease. In addition, the value of solar irradiance give impact to inverter efficiency. The finding shows that the of solar irradiance, DC power output and efficiency have the same behavior.

ABSTRAK

Projek ini dijalankan di kampus utama Universiti Teknikal Malaysia Melaka (UTeM), Melaka. Perubahan cuaca dan pergerakan awan mungkin menyebabkan perubahan sinaran suria yang menyumbang kepada perubahan keluaran kuasa PV. Malangnya, perubahan keluaran PV akan menyebabkan kehilangan tenaga dan herotan harmonik. Oleh itu, tujuan kajian ini adalah untuk mengkaji hubungan antara sinaran suria dan Jumlah Herotan Harmonic (THD) dihasilkan dari PV penyongsang dan menyiasat kecekapan PV penyongsang dengan variasi dari sinaran suria. Meter Fluke 43B dan Sistem Pemantauan Cuaca Automatik (AWS) digunakan untuk merekodkan data yang diperlukan. Data dikumpul selama 3 hingga 6 bulan untuk dianalisa. Oleh yang demikian, nilai THDi, arus, keamatan cahaya, keluaran dan kemasukan voltan telah dicatatkan selama 8 jam sehari. Data yang dikumpulkan menunjukkan bahawa perubahan sinaran suria memberi kesan kepada THDi dan profil arus. Apabila bacaan sinaran suria tinggi, nilai arus juga meningkat. Walau bagaimanapun, THDi meningkat apabila sinaran suria rendah. Dalam usaha untuk mendapatkan kualiti keluaran kuasa yang tinggi, nilai sinaran solar juga perlu tinggi. Bedasarkan keputusan, ia menunjukkan nilai purata THDi memenuhi syarat dari Buku Panduan Teknikal TNB. Kemudian, kecekapan penyongsang adalah tinggi apabila keluaran kuasa DC adalah tinggi. Pengeluaran kuasa DC yang rendah dan turun naik menyebabkan nilai kecekapan inverter rendah. Dapatan kajian menunjukkan bahawa sinaran suria, keluaran kuasa DC dan kecekapan mempunyai tingkah laku yang sama.

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AC	-	Alternating Current
AWS	-	Automatic Weather Monitoring System
CSI	-	Current Sourse Inverter
DC	-	Direct Current
GCPV	-	Grid Connected Photovoltaic
P	-	Power
PCC	-	Point of Common Coupling
PQ	-	Power Quality
PV	-	Photovoltaic
STC	-	Standart Test Condition
THDi	-	Total Harmonic Distortion of current
THDv	-	Total Harmonic Distortion of voltage
V	-	Voltage
I	-	Current

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Research Background

Recently, because of the increase in energy demand, the needs of alternative energy sources are also increasing. Rapidly in 1950s, the negative effect from fossil fuel inspire scientist and engineers to growth other alternative energy that benefits the people and environment. Thus, the renewable energy have been promoted because of it free pollution . The solar energy is the one of clean renewable energy resources. The Photovoltaic (PV) system directly convert light energy to electricity. However, the PV system produce Direct current (DC) output which is not suitable for the most electrical appliances. Hence, the PV inverter used to convert DC to AC output. Unfortunately, the major power quality problem is Total Harmonic Distortion (THD) that contributed by the PV inverter. Hence, this project is conducted to study the THD levels contributed by PV inverters under various irradiance levels.

1.2 Problem Statement

Electrical energy is very important in our daily life. Most of the electrical energy is produced by fossil fuels and the nuclear energy. Since the these kinds of energy source are exhaustible, many countries start to promote the renewable energy. Grid Connected Photovoltaic (GCPV) is a very clean system that generates electric energy from solar energy . To operate this system solar PV panels and PV inverter are needed . The generated electric energy is in direct current output. However, to fed into the grid, the output need to convert to alternating current (AC) by using an PV inverter . The changes of weather and passing cloud may caused variation of solar irradiation that contributed to variation of PV output power . Unfortunately, the variation of PV output will cause energy losses and harmonic distortion. This project is conducted to investigate the PQ behavior of GCPV and and also PV inverter efficiency. Under different weather conditions, analyses produced from this study may provide information on how weather condition may effect the output quality of PV inverter

1.3 Objective

The objective of this project are:

1) To evaluate the correlation between solar irradiance and total harmonic distortion contributed from the GCPV inverter.
2) To investigate the efficiency of GCPV inverter under different solar irradiance levels.

1.4 Scope of Work

The scope of this project focuses on GCPV system located at the Faculty of Electrical Engineering (FKE), Universiti Teknikal Malaysia Melaka (UTeM), Melaka. The PV systems include mono crystalline silicon (Mono), thin film (TF), heterojunction with intrinsic thin layer (HIT) and poly crystalline silicon (Poly) . The main aim of this project is to investigate the PQ behavior of GCPV under Malaysia climate condition in addition of PV inverter efficiency. This project focuses on total harmonic distortion for current and efficiency of GCPV inverter. Data are collected for the duration of between 3 to 6 month by using suitable appliances such as Fluke meter and instrument Automatic Weather Monitoring System (AWS).

CHAPTER 2

LITERATURE REVIEW

This section will discuss about the book and other reading materials that are used as reference in order to understand and develop the project. The articles review, book and other research material were review in order to get main idea about the project conception and any information that related to conduct the project. Besides that, this chapter also reviews the project that have been done by other researchers with different concepts and design. By doing the review will provide a better understanding of the system. Furthermore, this chapter will discuss the overall theories and concept of the project. Finally this chapter also explains the theories used in order to implement the project.

2.1 Theory and basic principles

2.1.1 Photovoltaic system

Edmund Bequerel is the first person reported the effect photovoltaic in 1839. He was discover that the action of light on silver coated platinum electrode immersed in electolyte produce electric current.[1] And then, in 1887 German physicist Heinrich Hertz has refined the finding.

The PV system can supply electric for small or large application. This sytem already apply around world in individual homes, offices and small or large building. Most of electrical appliances used alternating current . However, the PV system produce direct current which is not suitable for most equipment and appliances design for alternating current. Due to this problem,inverter is used to convert the direct current to alternating current. The solar panel and inverter are the main component of PV system. Basicly the

PV system design in storage and direct system.[2]The system called as on-grid (Grid Connected) and off-grid (stand alone) system. Grid connected PV system are linked to grid, while stand alone system operated without grid.

2.1.2 Solar panel

The basic of solar cell is an electrical device that converts the light energy into electric energy by the reaction of photovoltaic. The solar cell has been design as two terminal device which operate like diode when there is no light and produces a photovoltaic in present of light. However, the generated DC voltage is too small for the most application which is o.5 to 1Vdc. [3]

To generated acceptable DC voltage, the solar cell is linked together in series to form PV module as shown in Figure 2.1. The PV module usually connected into 28 to 36 cell in series to produces 12Vdc in standard illumination condition. [4] To produce larger voltage and current output, the PV module separately or linked in series and parallel to form an array.

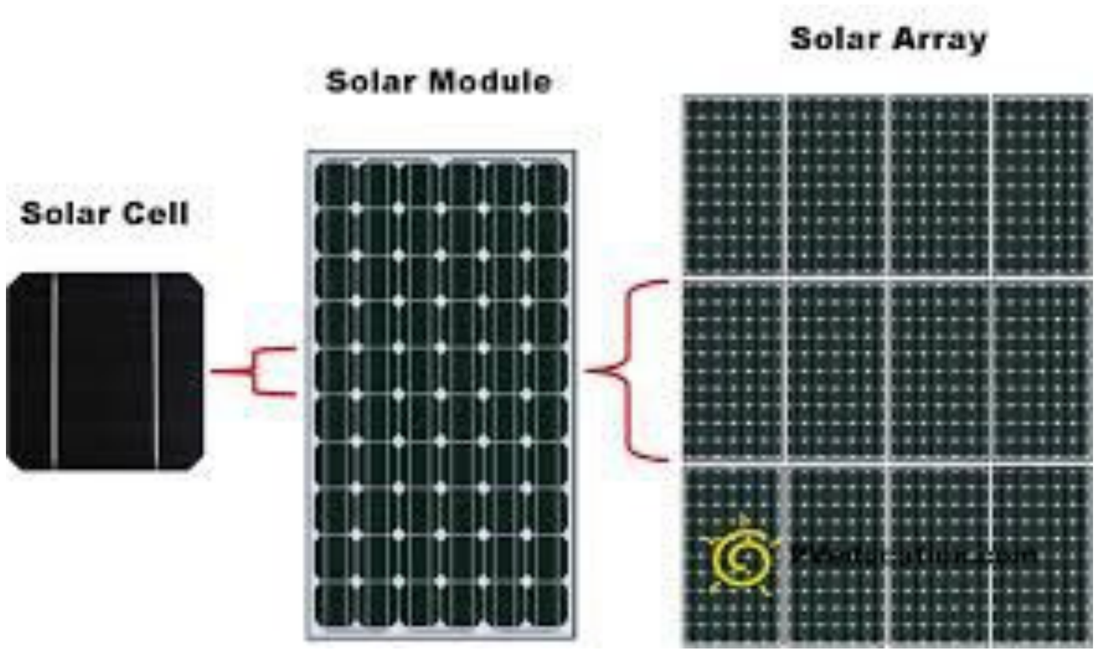

Figure 2.1: The cell, module and array [5]

2.1.3 PV inverter

Converter is power electronic device, its can divided into 3 types which is rectifier, chopper and inverter [6]. The inverter are device that convert direct current (DC) to Alternating Current (AC). The DC current that provide by PV system is not suitable for the most of electrical appliances. Inverter have two main type which is single phase inverter and three phase inverter. For low to medium voltage the single phase inverter is applied. Then, for high voltage load the three phase inverter is used.

2.1.3.1 Single phase inverter

Basicly, single phase inverter divided into 2 categories which is Voltage Source Inverter (VSI) and Current Source Inverter (CSI). The type of VSI include the Square Wave Inverter, Quassi Square Wave Inverter and Sinusoidal PWM Inverter (bipolar switching scheme). The Figure 2.2, Figure 2.3 and Figure 2.4 show Voltage Source Inverter (VSI).

A. The Square - Wave Inverter

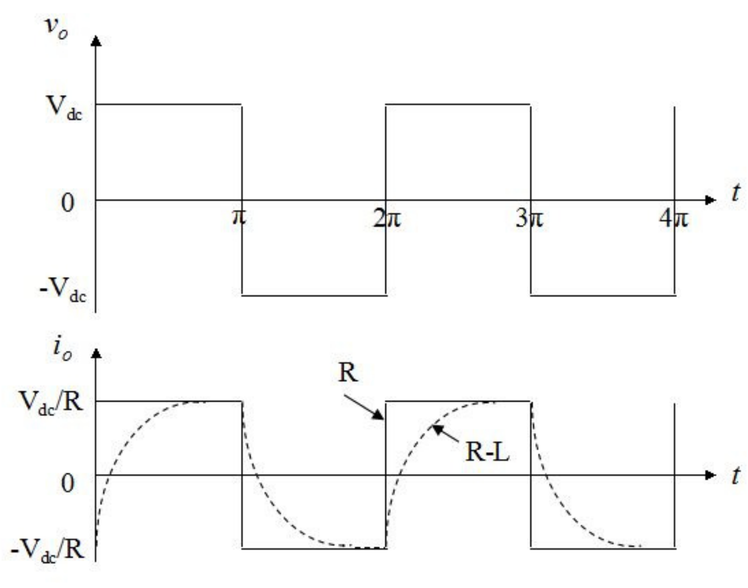

Figure 2.2: The Square - Wave Inverter [7]

B. Quassi Square Wave inverter

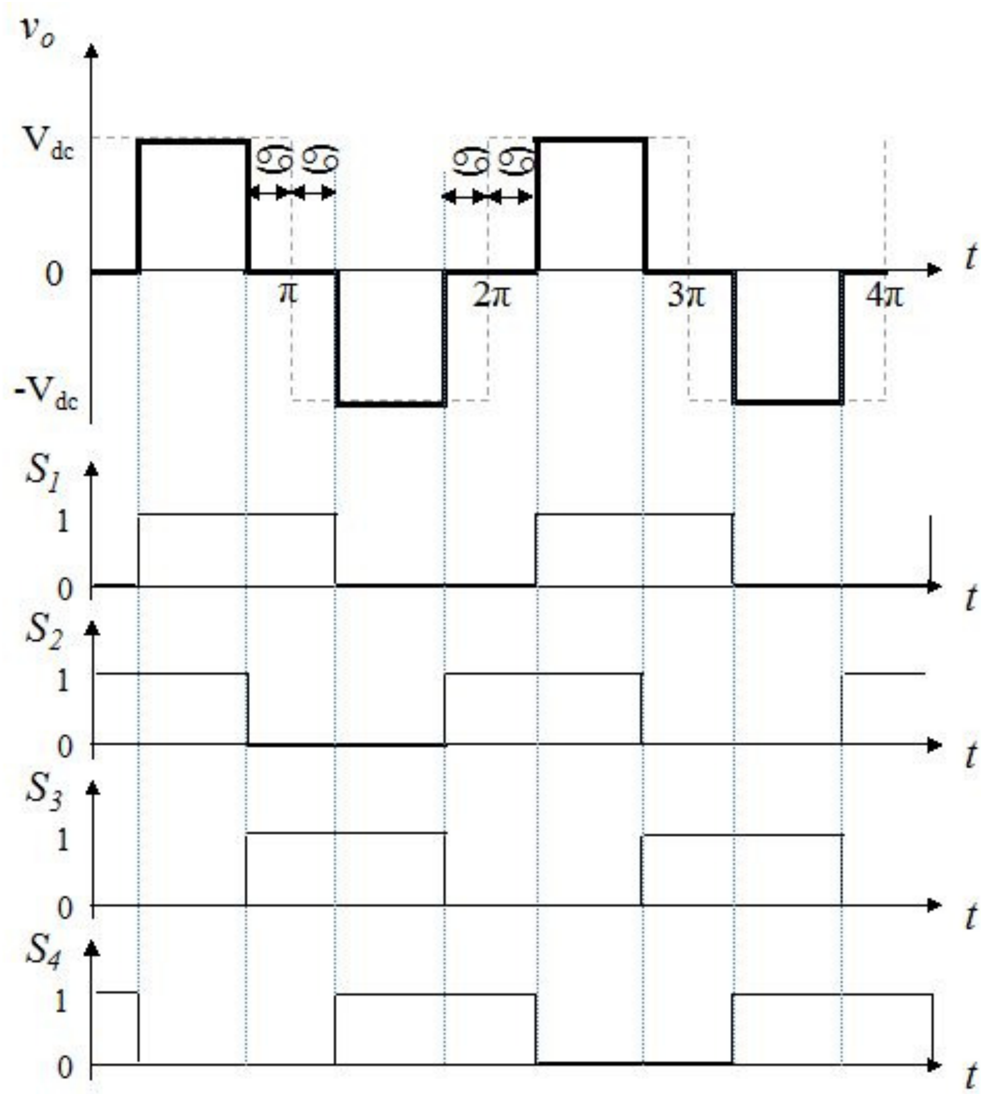

Figure 2.3: Quassi Square Wave inverter [7]

C. Sinusoidal PWM Inverter (bipolar switching scheme)

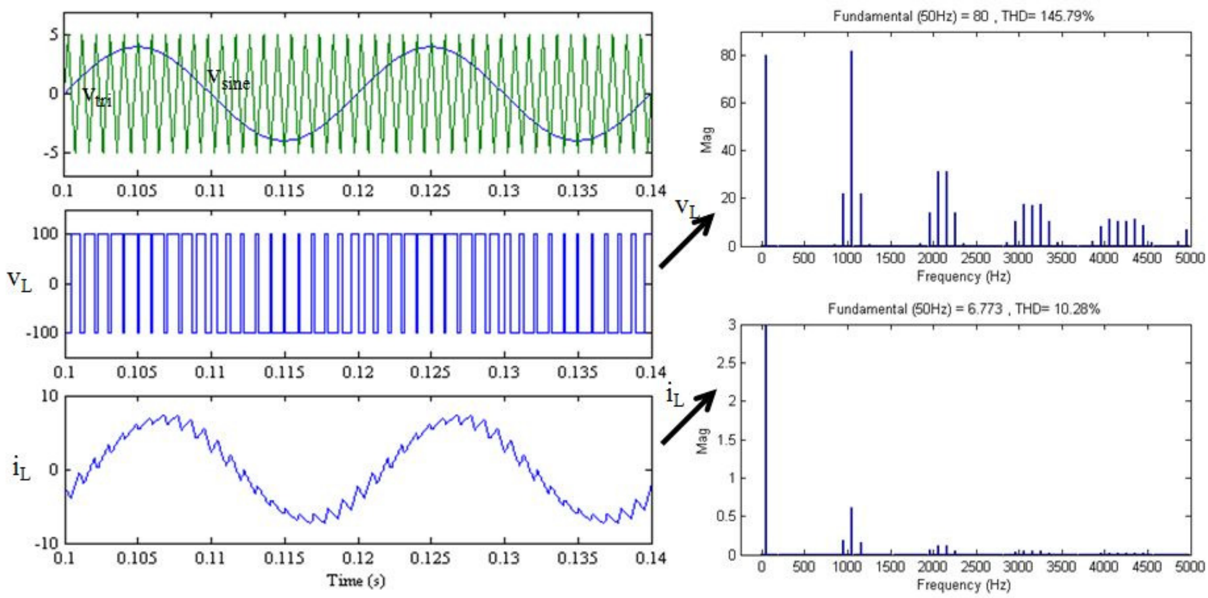

Figure 2.4: Frequency spectrums of output voltage and load current [7]

The type of CSI include Hysteresis-based current control and Carrier based current Control. The Figure 2.5 and Figure 2.6 show the CSI type.

The type of CSI is:

A. Hysteresis-based current control

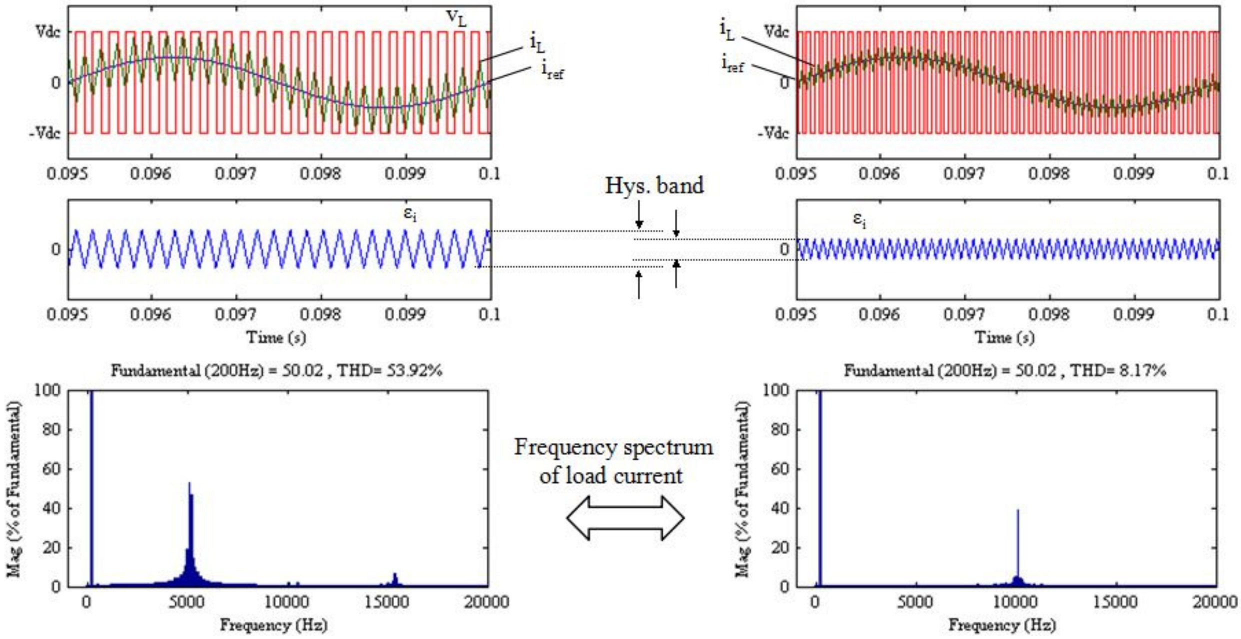

Figure 2.5: Hysteresis bandwidth [7]

B. Carrier based current Control

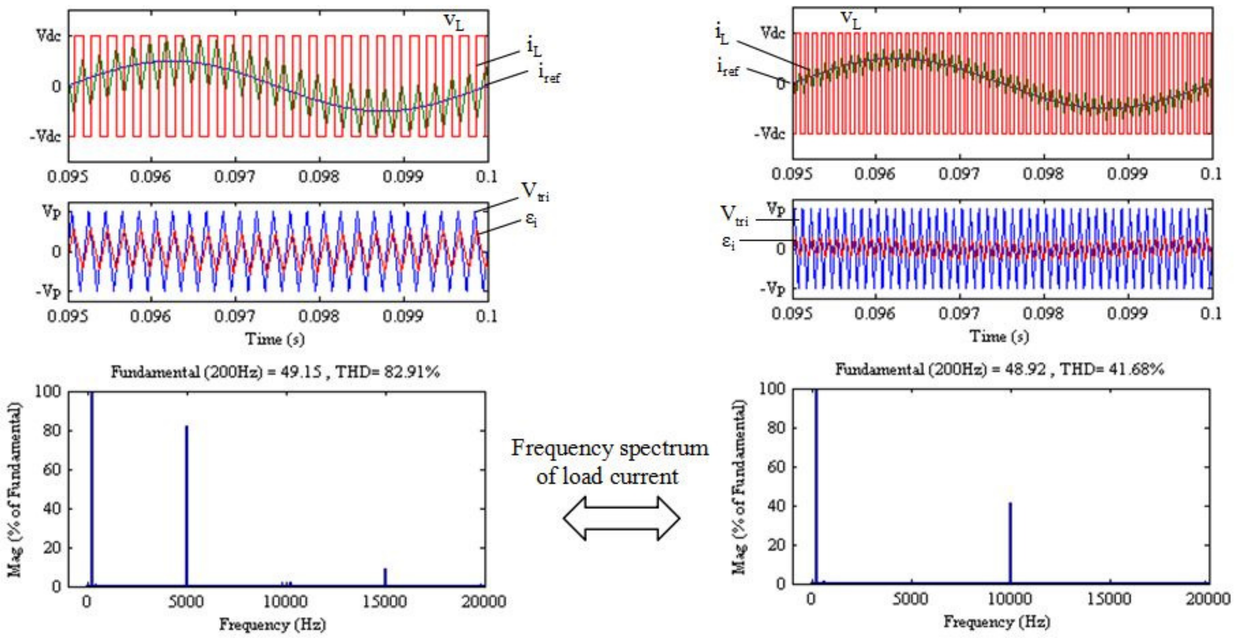

Figure 2.6: Constant frequency triangular waveform [7]

2.1.3.2 Three phase inverter

The three phase inverter divided into two categories which is Six step inverter and Sinusoidal Pulse-Width Modulation (SPWM) Inverter. The Figure 2.7, Figure 2.8 and Figure 2.9 show the three phase inverter type.

A. Six step inverter

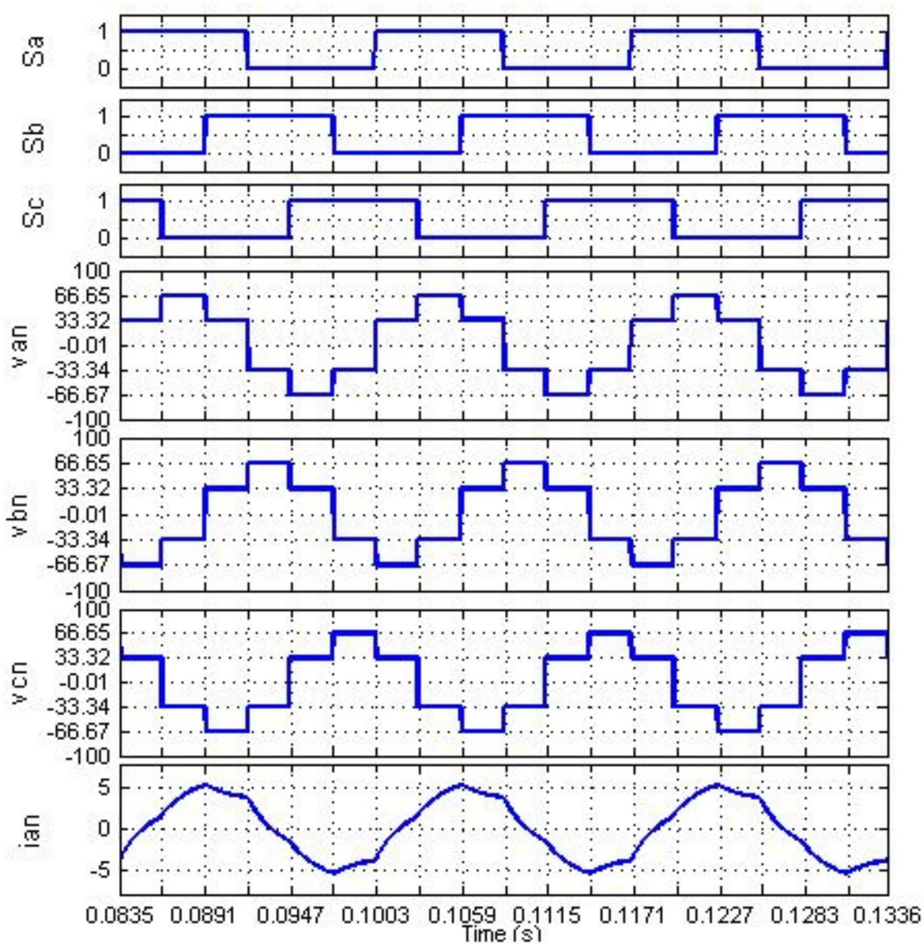

Figure 2.7: Six step inverter waveform [8]

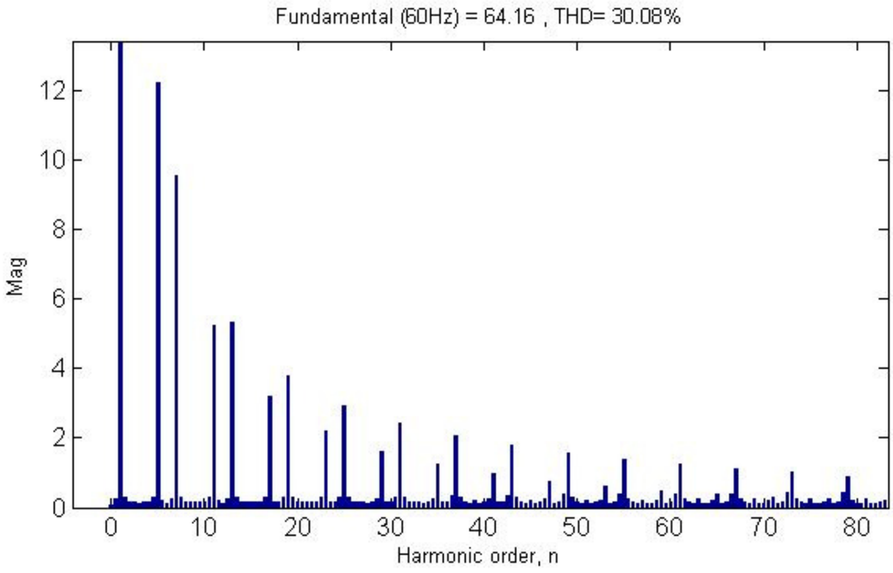

Figure 2.8: Frequency spectrum for Van [8]