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IMPACT OF FLUCTUATING INPUT OF PV TO HARMONIC DISTORTION

Akmal Fuad Bin Yusuf
B011110338

Bachelor of Electrical Engineering
(Industrial Power)

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"I hereby declare that I have read through this report entitle "Impact of fluctuating input of PV to harmonic distortion" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature : .....

Supervisor's Name : DR. Aida Fazliana Binti Abdul Khadir

Date : 18 June 2014

IMPACT OF FLACTUATING INPUT OF PV TO HARMONIC DISTORTION

AKMAL FUAD BIN YUSUF

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

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"I declare that this report entitle "Impact of fluctuating input of PV to harmonic distortion" 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 : Akmal Fuad Bin Yusuf

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ABSTRACT

The photovoltaic (PV) solar system is one of the alternative and green energy used for generating the electricity. Several beneficial offered by the PV system are reduce gas emissions into atmosphere, lower operating and maintenance costs, easy to install and no noise pollution without using any moving part. However, some issues arise due to installation of PV to the distribution system such as power quality problems. Thus, this project aims to study the impact of PV on harmonic distortion. Two type of PV are considered in this project, which are Mono-Crystalline and Heterojunction (HIT) PV system. These two PV systems were installed at the Universiti Teknikal Melaka Malaysia (UTeM) area. All the measurement of the impact PV fluctuation and harmonic distortion has been conducted by using the Power Quality Analyzer 435 Fluke Meter and aided with solar monitoring system data lodge. This process provides the necessary results for solar irradiation, voltage, current and power generated profiles. The outcomes of this project show that the power generates and the current profile of the PV system will always depends on the solar irradiation. Meanwhile, for the voltage and harmonic profiles of the PV system are not reflecting much with the solar irradiation fluctuates. The value of the voltage and current harmonic output from both PV are complies with IEEE standard.

ABSTRAK

Sistem fotovolta adalah salah satu tenaga alternatif dan hijau digunakan untuk menjana elektrik. Beberapa kebaikan dan faedah yang ditawarkan oleh sistem fotovolta adalah mengurangkan pelepasan gas ke atmosfera, kos operasi dan penyelenggaraan yang lebih rendah, mudah untuk dipasang dan tiada pencemaran bunyi juga tanpa menggunakan mana-mana bahagian yang bergerak. Walau bagaimanapun, beberapa isu timbul akibat pemasangan fotovolta kepada sistem pengagihan seperti masalah kualiti kuasa. Oleh itu, projek ini bertujuan untuk mengkaji kesan fotovolta pada herotan harmonik. Dua jenis fotovolta dipertimbangkan dalam projek ini, Mono-Crystalline dan Heterojunction (HIT) sistem fotovolta. Kedua-dua sistem fotovolta ini dipasang di kawasan Universiti Teknikal Melaka Malaysia (UTeM). Semua ukuran impak turun naik fotovolta dan herotan harmonik telah dijalankan dengan menggunakan Power Quality Analyzer 435 Fluke Meter dan juga dibantu oleh sistem persinggahan pemantauan data suria. Proses ini memberi keputusan yang diperlukan untuk penyinaran suria, voltan, arus dan kuasa profil yang dihasilkan. Hasil projek ini adalah kuasa dan arus profil yang dihasilkan oleh sistem fotovolta akan sentiasa bergantung kepada jumlah penyinaran suria. Sementara itu, bagi voltan dan harmonik profil sistem fotovolta tidak bergantung terlalu banyak oleh turun naik penyinaran suria. Keputusan nilai voltan dan harmonik yang diperolehi dari kedua-dua sitem fotovolta ini telah menepati piawaian yang dirujuk pada harmonik IEEE standard.

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Chapter 1

Introduction

1.1 Research Background

Technological advancement nowadays has resulted in high demand for electricity. Hence the demand of the production of electricity has led to global warming and polluted environment [1]. Therefore, many of the clean and renewable energy sources were created and introduced to concern the environmental issues and together sustained the electricity demand [2]. This photovoltaic (PV) systems is one of the most renewable energy system that been focus due to clean the environments and also meet future demands [3].

This PV technologies are comes from the source of sunlight, this PV system may convert the light energy to the form of electricity energy. During the conversion process there was no pollution produced, no moving part used and very little maintenance needed [4]. In Malaysia the government takes an initiatives to support the goods of the PV system approved and started the enactment of renewable energy law 2011. The users that installing the fit-in-tariff (FiT) PV system will be awarded at the certain rates Ringgit Malaysia (RM) per kWh for duration of 21 years [5]-[8].

There are many researcher studied the PV analysis. Some of the investigations were focusing on modeling and the simulation of the PV system [9], the harmonic distortion with harmonic resonance effect [10], and PV systems with problem of voltage rise causes by the high penetrations of solar PV [11].

However, this report focuses on the impact of fluctuating input of PV on harmonic distortion with certain weather condition. Cloud and weather changes may cause variation in solar radiation and produce variation in PV output power. The variation will lead to harmonic distortion to the power system. By such, the performance of the 6.12kW Mono-Crystalline grid connected PV and the performance of the 5.64kW

Heterojunction with intrinsic thin layer (HIT) grid connected PV has been investigated on the harmonic distortion.

1.2 Problem Statement

The application of the inverters in the PV solar systems will contribute harmonic distortion to the system because of the electronic component used in the inverter itself. This harmonic distortion will affect both of the voltage grid and also the current waveform. The generated output of PV solar will depend on the weather and the efficiency of the PV solar itself. Different type of PV may contribute different propagation of harmonic. The significant findings will contribute useful information to power quality research area. There are two types of the PV solar systems have been considered in this report. The two types of the PV solar systems; namely Mono-Crystalline cell system and HIT cell system. Each of the system will generate different values of voltage, current and power.

1.3 Objectives

The objectives of this research:

1. To measure the voltage harmonic and current harmonic distortion with two weather condition and the different various types of PV systems.
2. To analyze the harmonic impact of the two different type of the PV solar systems.

1.4 Scope

The research work will be focused on the following scopes which are:

1. The study will focus only in Faculty of Electrical Engineering (FKE), Universiti Teknikal Malaysia Melaka (UTeM) area.
2. The study focus on the two types of the photovoltaic solar system which are Mono-Crystalline cell system and Heterojunction with intrinsic thin layer (HIT) cell system.

1.5 Report Structure

Here were the overall preview of the research report that start from the beginning until the end. Here the explanation about each of the topic discussed

Introduction

The first chapter is all about the introduction of this research. Explain about base and the background of what was the idea of this research. This chapter also explains about the objectives and also about the scope of this research as well. This research was focus on the study and analyze of voltage, current and harmonic behavior with the two weather condition for various types of PV systems.

Literature Review

On chapter two, the explanation is all about the basic principles that used for this research. Papers, journals or books found with related topic to become as a source for researcher. From that the current knowledge including substantive findings, as well as theoretical and methodological can be review.

Methodology

Next, this chapter will explains more about the methodology of this research. Explains the sequence from the beginning till to the end of the research and also the method to collect data and complete the research. Further explanation will be in chapter three.

Results

The measurements data of this research will be discuss in this part. All the graphical figures and value will be explained further in this topic. Some discussion also will be involves together to strengthen the information.

Conclusion

All the related found will be conclude in this chapter and show what thus this research achieves with the findings. Recommendation also will be part of this chapter.

Chapter 2

Literature Review

2.1 Basic Principles

This PV technology actually converts energy from sunlight to electricity energy by using no moving parts, consuming no conventional fossil fuels, creating no pollution, and lasting for decades with very little maintenance [4]. In the real life the solar cells that you see that attached on the calculators and satellites are also called PV cells. PV cells are made of special materials called semiconductors such as silicon, which is currently used commonly.

Figure 2.1shows that, photovoltaic cells are made up of at least 2 semi-conductor layers. The first layers containing the positive charge while the second layer is negative charge. At the negative layer side contained electrons that are free to move. As the cell is exposed to the sunlight, the sunlight consists of the little particles of solar energy that known as photons. Photons from the sunlight are absorbed by the negative layer. Then, when the photons fills the layer are absorbed by the negative layer of the cell, the freed electrons will migrate to move to the positive layer and creating the voltage differential, similar to a household battery. If the layer connected to an external load, the electron flows through the circuit and create electricity [12]-[14].

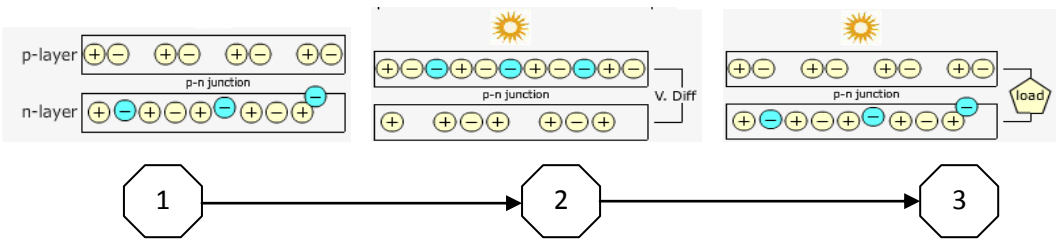

Figure 2.1: The flow of the PV cell basic operation [14].

These cells are enough to generate power if the small amount of direct sunlight is attached. Groups of cells are mounted together in panels or modules. The power of a PV cell is measured in kilowatts peak (kWp). That's the rate at which it generates energy at peak performance in full direct sunlight during the summer. PV cells come in a variety of shapes and sizes design criteria [15] [16].

2.2 Type of PV Solar Cell

In this research, there are two types of semiconductor that is used for solar cells with the differences lie in the atomic structure. The semiconductor is consists of Mono-Crystalline PV System and HIT PV System.

2.2.1 Mono-Crystalline

Mono-Crystalline silicon has an orderly atomic structure. This makes the material predictable, with an efficiency rate of less than 15 to more than 21 percent. It's also easier to work with. The downside of Mono-Crystalline silicon is that it is expensive to make. To create predetermined and orderly cell structure, the manufacturing process is slow and precise. The development of Mono-Crystalline silicon begins with the production of crystals of silicon, made from molten silicon. This silicon is very pure. The thickness of the molten silicon was 0.2 to 0.3 mm. The edge of the round wafers is cut off, creating hexagonal shape, allowing more wafers to be placed on a module [17] [18]. Figure 2.2 shows the shape and figure of Mono-Crystalline panel.

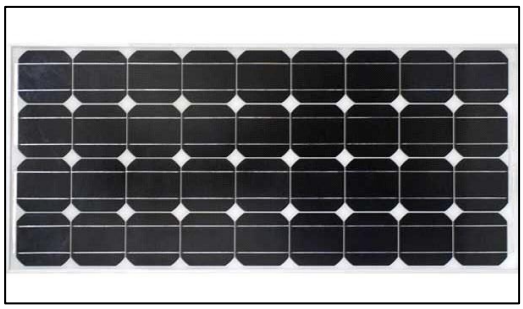

Figure 2.2: The panel of Mono-Crystalline PV

For this research, the model of this panel module is SW255 Mono-crystalline Solar World from Germany was used. This Mono-crystalline PV model consists of 24 units of panels. The system consists of 3 arrays and each of the arrays had 8 units of panel and all the 3 arrays are connected to each of the 3 inverters. Inside each of this panel contain 60 cells per module that was bond together. The Table 2.1 shows the performance under standard test condition for each of this Mono-crystalline panel module that was stated in the data sheet. The overall total size of this system was 6.12kW. The SW255 Mono-crystalline further data sheet detail is attached at Appendix A.

Table 2.1: The Mono-crystalline PV performance under standard test conditions (STC)*

Maximum Power, (Pmax)	255Wp
Open Circuit Voltage, (Voc)	37.8V
Maximum Power Point Voltage, (Vmpp)	31.4V
Short Circuit Current, (Isc)	8.66A
Maximum Power Point Current, (Impp)	8.15A

*STC: 1000 W/m^2, 25^{0}C, AM1.5

2.2.2 Heterojunction with Intrinsic Thin Layer (HIT)

The HIT solar cell is a combination of a crystalline and thin-film solar cell. Heterojunction with intrinsic thin layer (HIT) refer to the structure of these hybrid solar cells. This comprises crystalline an amorphous silicon that is bonded with an additional undoped thin-film (intrinsic thin layer). In HIT solar cells this occurs between the two structurally different semiconductors. The HIT cell is distinguished by greater energy yields at a higher temperature and utilization of a wider spectrum. Here, for each degree Celsius increase in temperature, the performance worsens by only 0.33 per cent compared with 0.45 percent of crystalline silicon. The required deposition temperature is just 200^{o}C (392^{o}F). With a 100 cm^2 (15.50 square inches) laboratory cell an efficiency of 23 per cent was achieved. However, in series production modules efficiencies of only 17.4 percent were reached [19]-[22].

Figure 2.3: The panel of HIT PV

Figure 2.3 shows the shape and figure of HIT panel. The model of this panel module is HIT VBHN235SJ18 Panasonic brand Japan. This HIT PV model is consists of 24 units of panels. The system consists of 3 arrays and each of the arrays had 8 units of panel and all the 3 arrays are connected to each of the 3 inverters. The table 2.2 shows the performance under standard test condition for each of this HIT panel module that was stated in the data sheet. The overall total size of this system was 5.64 kW. The HIT VBHN235SJ18 further technical data detail is attached at Appendix B.

Table 2.2: The HIT PV performance under standard test conditions (STC)*

Maximum Power, (Pmax)	235Wp
Open Circuit Voltage, (Voc)	51.8V
Maximum Power Voltage, (Vmp)	43.0V
Short Circuit Current, (Isc)	5.84A
Maximum Power Current, (Imp)	5.48A

*STC: 1000 W/m^2, 25^0C, AM1.5

2.2.3 The PV Solar Systems that Used at FKE UTEM

The table 2.3 shows that there are two different types of PV solar systems that install around Faculty of Electrical Engineering (FKE).

Table 2.3: The PV solar systems that used for this research

System	1	2
Panel Type	Mono-crystalline (SW 255)	Heterojunction (VBHN235SJ18)
Brand	Solar World Germany	Panasonic Japan
Quantity of panels	24	24
Max power	6.12 kW	5.64kW
Location at FKE	Admin Rooftop	Admin Rooftop
Technical reference	APPENDIX A	APPENDIX B

2.3 Type of PV Connection

PV power systems are generally classified according to their functional and operational requirements, their component configurations, and how the equipment is connected to other power sources and electrical loads. For this research, system that only has been applied was the grid-connected system.

In Malaysia, the Grid-connected or utility-interactive PV systems are designed to operate in parallel with and interconnected with the electric utility grid which is Tenaga Nasional Berhad (TNB) supply. The primary components in grid-connected PV systems are the inverter, or power conditioning unit (PCU). The PCU converts the DC power produced by the PV array into AC power consistent with the voltage and power quality requirements of the utility grid.

The major components of a grid-connected PV system include the PV array, inverter and the metering system. In addition to these major components are the necessary cables, combiner boxes, protection devices, switches, lightning protection and signage. The connection of these systems must follow the requirements that made by a MS 1837:2005 Malaysian Standards on Installation of Grid Connected Photovoltaic System [23].

2.4 The Model of the Inverters

The model of SMA sunny boy 2000HF was used for these two solar systems. Figure 2.4 show the inverter installation for this solar PV system. Each of this Mono-crystalline and HIT PV systems was used three inverters each. The performance of the inverter is depends on it operation efficiency behavior. These inverters were imported from USA. The further technical information will be at Appendix C.

Figure 2.4: The SMA SUNNY BOY 2000HF inverter.

2.5 Reviews of previous related works

These reviews of the previous related works were to come out what the method that the researcher used to get the results. From the result, the advantages and disadvantages of the method can be obtained and evaluated.