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Signature : .....

Supervisor’s Name : .....

Date : .....

**OPTIMIZATION OF SOLAR PANEL POSITIONING FOR MAXIMUM ENERGY  
CONVERSION**

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

**Faculty of Electrical Engineering**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**APRIL 2010**

“I declare that this report entitle Optimization of Solar Panel Positioning for Maximum Energy Conversion 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 of any other degree”

Signature : .....

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Date : 22 APRIL 2010

To my beloved mother Amisah binti Talib and father Mamat bin Yusoff

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## ABSTRACT

Solar power is a conversion from the sunshine into electricity. The purpose of this project is to find the angle of the solar panel that will produce most optimum output power. This project also will be discussing about the relationship between the positions of the solar panel with the power that will be absorbed. A few factors that could be an effect for output power also will be discussed and considered. This research will be undergoing a repeated experiment in order to find the maximum output power with the variation of solar panel angle and also the facing direction.

## ABSTRAK

Projek ini adalah berkisarkan mengenai sistem kuasa solar. Kuasa solar adalah perubahan atau penukaran dari cahaya matahari kepada tenaga elektrik. Tujuan projek ini adalah untuk mencari sudut panel kuasa solar yang akan menghasilkan kuasa keluaran yang paling optimum. Projek ini juga akan membincangkan mengenai hubungkait antara kedudukan panel solar dan juga kuasa yang akan diserap. Terdapat beberapa faktor yang akan memainkan peranan penting dalam eksperimen ini juga turut akan dibincangkan. Kajian ini akan dilakukan berulang-kali untuk mendapatkan kuasa keluaran yang tertinggi dengan mempelbagaikan sudut panel solar dan juga arah panel solar akan menghadap.

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

Nowadays the main sources of generating power system like oil, gas, nuclear power are going more expensive than ever. Besides the price, the amount of non-renewable resources is decreasing and starting to run out while the demands of the world keep rises. If this situation still could not be solved, it can cause a trouble to the world if this is still continuing for a next decade. Besides that, burning fossil can produce greenhouse gases and this gases can make a global warming become faster. In Malaysia, the majority of energy source is from oil. The percentages of the energy sources in Malaysia are 71.4% petroleum, 11.6% hydroelectric power, 8.8% natural gas, 7.6% coal, and 0.5% biomass. Since the world is consuming the energy sources and try to protect the environment, renewable energy are the alternatives in solving this problem. So the main objective is to find a good replacement for such a problem. Renewable energy can be defined as an energy that has been generated from the natural resources such as sun, wind, tidal and others.

Most of renewable energy is free and it has literally no emissions released when being used. So it is basically saving money and helping the environment. One of the renewable energy is come from sunlight. Sunlight can be converted into electricity and called solar power system. It is believed that the true history of solar energy began in the

1883 when Charles Fritz created the first solar cell and began turning solar power into electricity. This was marked as an important moment in the history of solar energy. On 1949 William Grylls Adams had discovered that when light were shined upon selenium, the material shed electrons thereby creating electricity. At Bell Laboratories, Gerald Pearson, Daryl Chapin and Calvin Fuller make a progress about solar cell and on 1953 they developed the first silicon solar cell that works as a semiconductor is capable of generating a measurable electric current.

## **1.2 Problem Statement**

Sunlight position is not static and the position is keep changing from east in the morning and moving to west in the evening before sunset. Since the position of the sunlight is not static, so the sunlight that will produce electricity using PV cells will give a variety output power. This variety of the output power not only depends on the sunlight condition, it also depends on solar cell angle position. Based on this condition, the output power of solar panel will give a different value and not be optimized.

## **1.3 Project Objectives**

The objective of this project is to study about a solar system and the output. However, the main focus is to find the right position for the solar panel in facing the sun. The objectives can be listed as below:-

- i) To determine the solar panel angle that can produce the optimum output power.
- ii) To develop calculation methods for determining the solar panel angle based on the solar panel height.
- iii) To find the relation between the solar panel angle with output power.

## **1.4 Scope**

This project will be based on determining the output power from solar cell panel. Besides that, it also will be focused on how to find the suitable solar panel angle in producing the most optimum output power. There are a few solar cell panels at Faculty of Electrical Engineering (FKE) UTeM, so the experiment will be conducted here. The experiment will be done repeatedly hence it will produce a variety of output power.

## **1.5 Conclusion**

In a conclusion, in this chapter of introductions defines the subject of the project to developing. It is also outlines the purpose and objectives for the project to be carried out. As a result, the readers will be able to understand the basic information about solar power.



## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

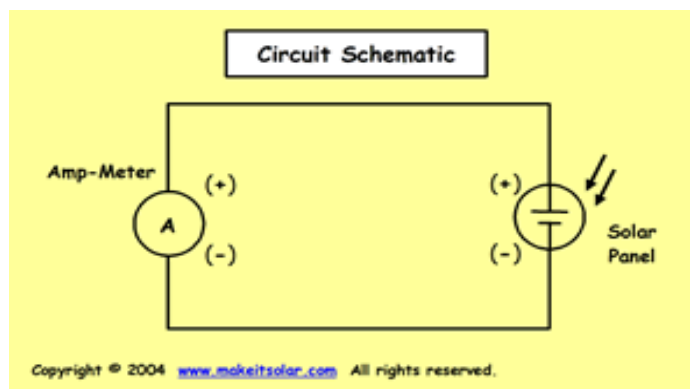
In writing the literature review, the main purpose is to convey to the reader about the ideas that is want to be established in this project. As a piece of writing, a literature review must be defined by as a guiding concept and the all of the information in it is not only a descriptive list of the material available, or a set of summaries. It must contain all of the important information that will be used in this project.

Literature review is the phase where all the processes happen such as searching, collecting, and analyzing that has been done or published by another researcher. All of the process can be completed through relevant sources such as book, journal, and technical report, proceeding conferences, web pages and others. Literature review could be main references guidance in the process of making this project.

Another definition for literature review is that it can be a simple summary of the sources, just it is usually has an organizational pattern and combines both summary and synthesis. A summary is a recap of the important information of the source, but a synthesis is a shuffling of the information. It might give a new interpretation of the old material or it also can combine it with the new interpretations.

## 2.2 Solar power

Solar power is energy which comes from the sun. This energy is very powerful and even with the tiny percentage of sunlight that touches the earth will produces plenty of the energy and the power needs of the entire human population more than 8,500 times over. The purpose of solar energy collection is for the output of power, measured in Watts ( $P= V \times I$ ,  $V$ =voltage,  $I$ =current). However, in order to study how factors affect this output, it is crucial to understand how this performance is evaluated. In Figure 2.1, it shows the basic circuit diagram of solar power system.



**Figure 2.1 Circuit Diagram for Solar System**

Solar power is produced by collecting sunlight and converting it into electricity. The conversion process will be through a solar cell panel that based on the principle of photovoltaic effect where as conventional cells, converts chemical energy into electrical energy. Our primary source of clean, abundant energy is the sun. The core of the sun is a series of constant nuclear explosions that turn hydrogen into energy. The temperature in the core of the sun reaches almost 27 million°F, and the sun produces  $3.8 \times 10^{26}$  watts (W) of power and  $1.4 \times 10^{31}$  joules (J) of energy every hour. The sun deposits 120,000 TW of radiation on the surface of the Earth, far exceeding human needs even in the most aggressive energy demand scenarios. The sun provides energy to the Earth in the form of radiated heat and light. The energy that the Earth receives is called insolation and it is the

rate of delivery of solar radiation per unit of surface. Insolation can be expressed in the units of watts per square meter ( $\text{W}/\text{m}^2$ ) or kilowatt-hours per square meter ( $\text{kWh}/\text{m}^2$ ) per day. However, not all the insolation that arrives at the earth's upper atmosphere will be absorbed in earth but half is reflected back into space. In this condition, there is more than enough free solar energy available to power human energy needs. Insolation is affected by Earth's atmosphere and the angle of incidence of sunlight on the atmosphere. On a clear day at sea level, when the sun's rays hit perpendicular to the earth's surface, we receive  $1000 \text{ W}/\text{m}^2$  of insolation. Because Earth is round, the Sun strikes the surface at different angles, from 0 degrees to 90 degrees. At lower degrees, the insolation travels longer through the atmosphere and becomes scattered and diffuse, whereas at higher degrees there are fewer atmospheres to travel through, so more of the sun's energy hits the earth. (Lewis, N. 2005)

Solar power has its own advantage and disadvantage. Since it is come from sun, it is known as a clean renewable energy. Besides that the cost of the source is free and it is also an infinite source. The maintenance for solar power also less rather than other energy source like fossil. However, even the cost of the source is free but the cost for construction the whole solar system is very high. Photovoltaic cells and battery is the main part of the system and because of that it needs a huge space to place all the equipment. In future, if we want to use solar energy as a main source for power system in Malaysia, a very huge placed is needed.

### **2.3 Solar system component**

To make a complete solar system, it depends on a few important components and every part has it own functions. Photovoltaic cells are the most important things that cannot be missed in solar system. However, besides photovoltaic cells there are other components like storage battery, blocking diode, control charger, and inverter.

The primary material which is photovoltaic cells used in the modern collection of solar energy is silicon. Even though it takes 100 times more surface area of silicon than that of other solid-state materials to collect the same amount of energy, silicon was already

developed and in mass production when solar energy collection technology was developed, and so it was the practical choice.

### 2.3.1 Photovoltaic cell

“Photovoltaic” is a Greek word which has its own meaning. The meaning of “Photo” is light and “Volt” is the voltage we can get after we make it in a circuit. The photovoltaic effect is the basic principal process by which a PV cell converts sunlight into electricity. When light shines on a PV cell, it may be reflected, absorbed, or pass right through. The absorbed light generates electricity.

Since the mid 1980s there have been dramatic increases in the efficiencies of laboratory demonstration cells. These came from improvements in current, significant increases in voltage, and splitting the sunlight among solar cells of differing bands gaps that waste less of sunlight input power. The higher voltages directly resulted from increases in the density of minority carriers generated by absorbed light.

A photovoltaic device or solar cell is a semiconductor device that can be used to convert light into electricity at the atomic level. Solar cells are made of the same kinds of semiconductor materials, such as silicon, used in the microelectronics industry. For solar cells, a thin semiconductor is specially treated to form an electric field, positive on one side and negative on the other. Semiconductors are not good at conducting electricity and that is what makes them semiconductors. Silicon, for example, forms a crystalline structure. Each molecule is bonded to the electrons of its neighbors, leaving no free floating electrons to move around and create a current. The photovoltaic cells are usually connected in series and parallel to construct a PV module. (Lafferty, K.,1998)

Solar cell panel produce an electrical current when sunlight feeds through a control unit into the batteries. It is used when a packet of light, called a photon, hits the surface of the solar cell and it will be absorbed by the semiconductor. When the photon is absorbed, it creates electrons and holes in the semiconductor. The movement of electrons is electrical current. The amount of electrical current created depends on the amount of the insolation, or the number of photons, that hits the surface of the solar cell. Electrical current is

proportional to the power that the solar cell delivers. The amount of energy that will be kept is depends the size of PV cells. There are a few types of PV cells such as, amorphous silicon, multicrystalline silicon ribbon silicon and others. PV cells can be made of many different semiconductors but crystalline silicon is the most widely in industry.

At FKE, there are a few solar panels that will be used in the research. In Figure 2.2 show the solar panel at FKE that will be used in this research. This is a few details about the solar cell panel:-

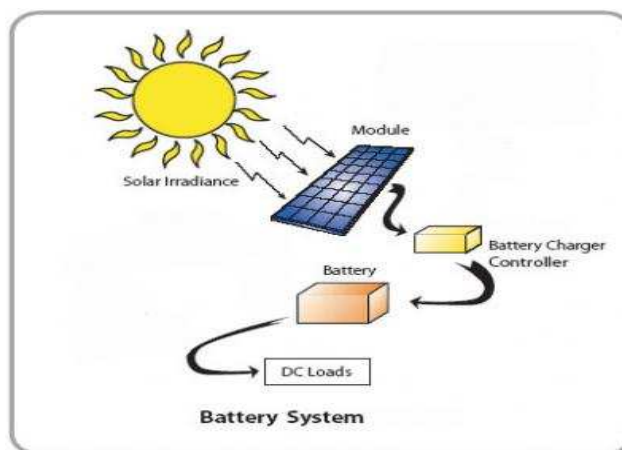
- Module type = BP 275 f
- Nominal peak power = 75.0 W
- Peak power voltage = 17.0 V
- Peak power current = 4.4.5 A
- Short circuit current = 4.75A
- Open circuit voltage = 21.40 V
- Minimum power = 71.25W



**Figure 2.2: Solar panel at FKE**

### 2.3.2 Storage battery

Backup battery charging is essential to most renewable energy systems because there are likely to be occasions when the natural energy supply is insufficient. In solar system, this is another important element that can't be missed. Many people might confuse and think that at night solar system will not be function. It is not true because solar system has this component that named storage battery. In Figure 2.3 shows the position of the storage battery in solar power system. The batteries are necessary to store the power once the sun does not supply an electrical charge anymore for an example at night or on a cloudy day. During that time, the photovoltaic modules will charges the batteries. Hence the batteries will supplies power to the load as needed.



**Figure 2.3: Battery in solar system**

The important factor about the storage battery is about the capacity. Their capacity is proportional with the period of the energy that will be kept. The amount of electricity that can be used after sunset or on cloudy days is determined by the output of the nature of the battery bank and also PV modules. The specifications that relate to battery charging systems include maximum charging rate (amps) and AC input power requirements. In Figure 2.4 shows one of the examples of solar storage battery.



**Figure 2.4: Solar Storage Battery**

Another important thing to be considered is about the process when discharge the batteries. There is one method named Depth of Discharge (DOD). This method is related with the voltage drop before the next charge cycle. Most battery ratings talk about 50% or so, but they will last longer if you keep them as charged as possible. For lead acid batteries is like to be fully charged. They will last much longer if not discharge it too deeply. This is known as shallow cycling and greatly extends their life. However, they can withstand discharges down to 20%.

### **2.3.3 Blocking diode**

In solar system, there is a diode that called blocking diode. In Figure 2.5 shows the example of the blocking diode. Basically there are two functions of blocking diode. The first function is to control the current that flows inside of the photovoltaic systems. This device is used to prevent reverse electrical currents from flowing back from a specified battery bank through solar panels and this is usually occur at night. When there is no sun, the solar panel would stop producing the electricity. The battery will start to give up its stored energy as current flows from the battery back into the solar panel. However, blocking diode can prevent this kind of situation. It makes sure that a current from one power supply does not find entry into another.

Another function is to block the reverse flow down damaged modules from parallel modules during the day. Blocking diodes placed at the head of separate series wired strings in high voltage systems can perform yet another function during daylight conditions. If one string becomes severely shaded, or if there is a short circuit in one of the modules, the blocking diode prevents the other strings from losing current backwards down the shaded or damaged string. The shaded or damaged string is “isolated” from the others, and more current is sent on to the load. In this configuration, the blocking diodes are sometimes called “isolation diodes”. (Anon, 2003)



**Figure 2.5: Solar Blocking Diode**

#### **2.3.4 Charge controller**

Most solar power systems will need a charge controller. The role of the control charger is to regulate the voltage and current from the solar cells before it is stored in the battery. It monitors the condition of the battery and makes sure that the batteries are always fully charged and prevents it from overcharging and being completely drained. The effect of overcharging is the lifetime of the battery could be reduced. Besides that, the charge controller will also protect the battery from being discharging below its lowest acceptable