THE EFFECT OF TEMPERATURE, ANGLE AND IRRADIATION INTENSITY OF SOLAR PANEL ON POWER EFFIECIENCY

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Abstract

The objective of this paper is to determine the relationship between the power efficiency and the heat, intensity and angle effect. The data taken from these three effects are show by Microsoft excel graph. The IV (current voltage) curve shows the FF(fill factor) of PV(Photovoltaic) module is 0.77 graphically, while 0.76 was taken from the mathematical formula. It comes from first model of intensity effect. The resistance along the circuit of the first model is 233.16 Ω that includes shunt resistance and series resistance in the circuit. Graph 4.2 and 4.3 show Voc (open circuit voltage) increases logarithmically with the illumination, while the Isc (short circuit current) graph shows increase linearly. Furthermore, Isc is more sensitive illumination as compare. However, the output of the module increases at end. The second model of heat effect shows the temperature and output increase with the time. Unavoidable, the effective of the PV module become less effective at higher temperature. The last module determines the maximum point of the tilt angle. Orienting of the PV module is track maximum exposure of the sunlight. Hence, the result found that the best orientation is 0° with respect to the surface of the table as horizontal line.

KESAN SUHU, SUDUT DAN INENSITI IRRASIASI PENAL SOLAR KEPADA EFISIENSI TENAGA

Abstrak

Tujiuan kajian ini dilakukan untuk mengkaji kesan suhu,keamatan sinaran dan sudut terhadap keluaran panel solar fotovoltek. Data yang telah direkod telah ditukar kepada bentuk graf menggunakan perisian Microsoft Exell. Hasil mendapati Fill Factor*, FF adalah 0.77 manakala menggunakan formula adalah 0.76 dengan nilai rintangan selari dan shunt) 233.16Ω. Graf 4.2 dan 4.3 menunjukan Voc bertambah secara logaritma dan Isc bertambah secara linear. Peningkatan Voc terhadap penambahan keamatan sinaran adalah kurang berbanding Isc, namun kedua-duanya menyumbang kepada peningkatan kuasa. Kesan peningkatan suhu tidak memberi banyak perubahan yang besar, namun terhadap sedikit penurunan kuasa keluaran apabila suhu meningkat. Manakala sudut terbaik untuk kesan sudut adalah 0°*

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LIST OF SYMBOLS

+	addition
-	subtraction
×	multiplication
÷	division
=	equal to
≈	equivalent to
A	current
En	irradiation under nominal condition
FF	fill factor
IV	current-voltage
Isc	short-circuit current
Imp	short-circuit current at maximum power point
Rch	characteristic resistant
Ω	ohm
P	power
PV	photovoltaic
V	voltage
Vmp	open-circuit voltage at maximum power point
Voc	open-circuit voltage
Vocn	open-circuit voltage under nominal condition
W/m^2	watt per square meter

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The conversion of solar energy is categorized by two types, which are heat energy and electric energy. It is harnessed using a range of ever-evolving technologies such as solar heating, solar photovoltaic, solar thermal electricity, solar architecture and artificial photosynthesis. The solar electricity is electric power generated from sunlight using the devices called modules. Collecting and harnessing solar energy power has not been as easy or convenient as it has been for other energy sources. The solar energy is spread over a wide area in a relatively low energy form. Moreover, solar energy is not available at night and cloudy weather, and need another equipment to store the energy. In the past, the solar energy has often been overlooked because high price of the equipment utilized. However, as the prices of other energy sources such as petroleum fuel, biomass, and even coal-generated electricity rise. The functioning of the solar photovoltaic is considered again as a reusable energy for the daily usage.

There is a thermal technology to convert into heat that is called solar thermal technology, different from the solar electricity technology called photovoltaic system. Solar energy is fast becoming economically attractive. The mid-1990s, world production of the solar modules increased rapidly, largely because of demand for grid-connected system in Europe, the US and Japan (Hankins, 2010). Millions of rural off-grid homes are using solar photovoltaic system throughout the developed and developing world.

The scattered radiation defines the efficiency output of the solar technology. It contains two kinds of radiations, direct radiation and diffuse radiation. Direct radiation is transmitted into straight beam by focusing by lens or mirrors. Nevertheless, there is some radiation ion scatted by cloud, smog or dust and reflected by the atmosphere, reducing the amount reach to the surface of the earth. Solar energy arrives at the edge of the earth's atmosphere at a constant rate of about 1350 watt per square meter. Whereas, the amount to reach the surface when it is absorbed by the atmosphere is reduced about 1000W/m^2 of maximum (Hankins, 2012).

1.2 Background

1.2.1 The Solar Resource

The sun is the source of virtually all the earth's energy, producing 3.8x10^{23} kW of power in huge nuclear fission reactions. Some of the energy is lost in the space before reaching the surface of earth. Energy can also be harvested from the sun directly for heating, distilling, cooking, drying and generating electricity.

The solar energy is more stable, reliable and environmental friendly as compare to fossil fuel, particularly oil and gas, which are releasing vast quantity of carbon into atmosphere and is a cause of climate change. At the end of the twenty-first century, in only 400 years of industrial activity, humanity will have used up much of the fossil fuel which has been deposited in the crust of the earth over last 400 million years. The increasing of carbon and the effect of climate change is clearly measurable. The UN Intergovernmental Panel on Climate Change (IPPCC) predicts a temperature increase of between 1.4 Celsius and 5.8 Celsius over the next 100 years (Falk, 2013).

1.2.2 The Principle of Solar Electricity

The photovoltaic array, commonly called solar panel, is the key components used to convert sunlight into electricity. Solar modules are made of semiconductor that are very similar to those used to create integrated circuit for electronic equipment. The most common type of the semiconductor currently in use is made of silicon crystal, which is laminated into n-type and p-type layers, stacked on top of each other. The light striking the crystals induces photovoltaic effect that is generated of electricity in direct current (DC). It can be used immediately or stored in the battery, when it is been used into a home that will change to alternative current (AC).

The wafer process into photovoltaic modules contains four outermost valences electron in the silicon atom. By combining a small number of five outermost valence electrons, a negative charge will occur when light photon hits the atom. The electron is discharged from the origin atom to move around freely. This is called an n-type (negative) semiconductor, and is usually caused by having the silicon doped with the boron film. In contrast, 3 valence electrons are used that lack one electron result in a hole with an electron missing. This is called as p-type semiconductor.

A p-n junction is formed by placing p-type and n-type semiconductors next to one another. The p-type attracts the surplus electron from the n-type semiconductor to stabilize itself as shown in figure 1.1. Thus the electricity is displaced and generates a flow of electrons (www.mesmer.us).

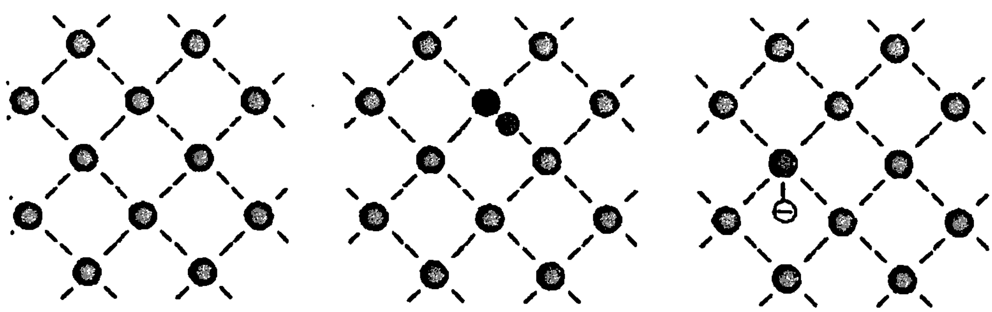

Figure 1.1 Formation of the p-type n n-type silicon crystal

When the sunlight hits the semiconductor, an electron springs up and is attracted toward the n-type semiconductor and more positive in the p-type then, thus generating a higher flow of electricity. This is the photovoltaic effect. The concept of semiconductor can be seen in the figure 1.2 (www.mesmer.us).

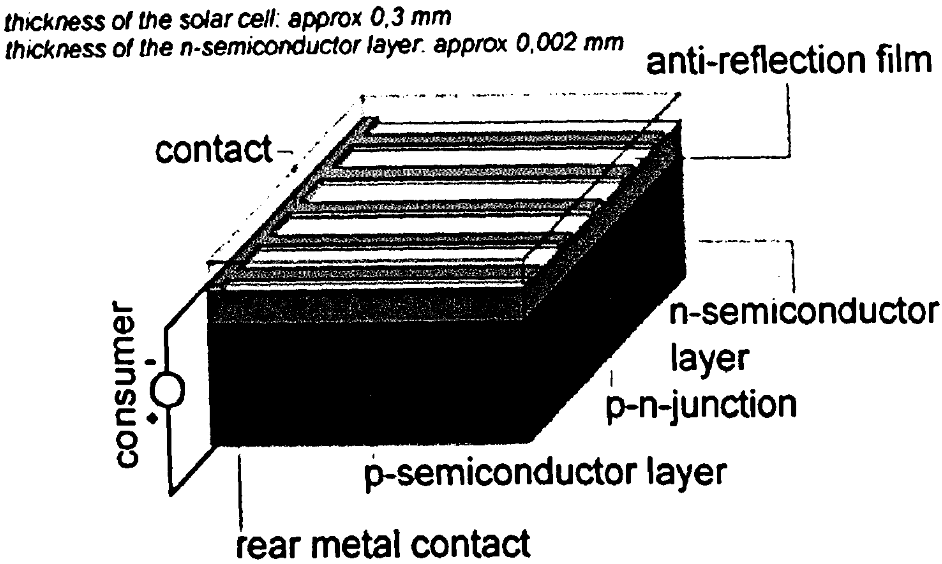

Figure 1.2 Structure of the processing wafer into photovoltaic modules

1.2.3 The Photovoltaic(PV) System

The PV system is categorized by 2 types, grid-tied system which is connected to the public electricity grid, and stand alone system. The grid-tied PV feed unused power directly into the grid and usually does not utilize battery storage. The off-grid PV system requires battery banks to store energy to use during cloudy period. It is generally more rural and found where there is no grid provide, such as telecom, remote home and building of holiday cottage, national parks, recreational vehicles. Stand alone PV in urban and suburban is also a significant.

The main component of the sand alone PV: solar modules, battery, controller and inverter. The solar panel is functioning as capture the solar energy to generate the electricity. The types of the panels used in this investigation are monocrystalline solar cells were the first to be developed for commercial purpose. Controller function is to controls the electric current flow in and out of the battery to prevent damaging the bank storage, during charging or discharging. The inverter is used for concentrating of the direct current to alternate current to the load (Boxwell, 2012).

1.3 Objectives

This study tends to determine the characteristic of to be solar photovoltaic (PV) system. In this study, the following objectives are to be achieved:

i) To determine the I-V curve for a particular PV panel,

ii) To determine relationship between temperature and the output power,

iii) To determine relationship between angle and efficiency of the PV panel,

iv) To determine solar intensity of the PV panel.

1.4 Problem Statement

The sunlight is unlimited to use as a source for functioning certain machines. It is able to overcome the environment problem and the scarcity of nature sources. From the user of the photovoltaic system have a mind set that system is not really good to use. Diffusion of the solar energy is hard to control but the probability usage of the off-grid solar electric system. The effect that influences maximum solar energy is a serious consideration in this system. Furthermore, the PV array will always show maximum output power when it is perpendicular to the sunlight incidence direction. Since the position of the sunlight is changing tilt angle of the PV modules with respect to the ground will change with the time. The ambient temperature and the inter-temperature, which occurs when the module is switch on for a long period, decrease the power efficiency through the shunt resistance.

1.5 Significance of Study

The stand alone solar electricity plays important rule in developing economy of Malaysia. But there are still many industries which are unaware of its contribution and benefit. Hopefully through this research, its value can be increased and more people will get to know the essential role of the off-grid solar system.

The off-grid PV system is environmental friendly and a source of renewable energy without polluting the surrounding. It helps to reduce the carbon monoxide, carbon dioxide, total unburnt hydrocarbon, and air toxics. This can improve the air quality and greenhouse gas mitigation and thus reduce the health care cost. With all these advantage, we should increasingly use the numbers of the off-grid photovoltaic systems in future.

This research can give an obvious result show to increase the efficiency of solar output may open a development about the off-grid PV system.

1.6 Scope of Study

The output power solar energy is critical for the stand alone solar electric system. To ensure that the efficiency output of system is consistent. There are some of measurable ways to determine the efficiency of the output of off-grid electric system. An I-V graph is plotted from a range of two data: voltage and circuit, which were taken by multimeter. At the same time, the humidity has been recorded for knowing the influence on power efficiency and the intensity value was also taken too. These factors are crucial for the power efficiency.

1.7 Limitation of the Study

The research source in this thesis is the light, the scattering of the sunlight is hard to control for data recording. And the electrical parameter of the PV system, involves the short-circuit resistance (Isc), open circuit voltage (Voc), fill factor (FF) and efficiency (η).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this study, the functioning of a solar cell is described along with the power efficiency of the solar panel. The energy output and characteristics of modules under various temperature, radiation and angle of tracking of sunlight are explained. The output of the solar modules can be determinates by using the data of the open-circuit voltage and short-circuit current and then plotting I-V curves. The importance of this chapter is that it will broaden the perspective on the subject and give us more understanding about the previous researches that were done in the subject. Lastly, through reading of previous studies, we can identify how effective previous research is and to develop the best method to finish the current project.

2.2 The Solar Cell

The manufacturing of a solar cell makes use of the silicon atom properties to act as conductor and semiconductor. The photovoltaic cell directly converts sunlight into electric energy by using the principle of the photo-electric effect. Briefly, the light strikes the silicon atom, knocking away the outermost valence electrons from the orbit around the nucleus, thereby freeing the electron to move into the electric field of the panel. When a load is connected to the positive and negative sides of the cell, the electrons flow as current.

The cell can be categorized by monocrystalline, polycrystalline and thin film. The utility of the solar cell has been demonstrated with large and consistent growth over several decades. The high production cost is in much consideration nowadays; monocrystalline solar cells have the best efficiency. But they do not perform as well as polycrystalline cell and thin firm under high temperature. Whereas, the thin film, or amorphous solar cells are made up of silicon atom in thin layer rather than a crystal structure. However, their portion in market is growing rapidly. It is expected the cost of the thin film will drop much faster than that of crystalline silicon technology. The changes and advancement in technologies, system or apparatus will increase the output efficiency of solar cells. Third generation tandem cell have recently been introduced (Corkish, 2013). In which an absorber layer with lower bandgap is added to absorb the lower energy light that is always pass through the high energy bandgap.

2.3 I-V Curve

The I-V curve describes the energy conversion capability of solar cell at certain irradiance and temperature values. The curve represents the combination of current and voltage at which the module can be operated or 'loaded', if the irradiance and cell temperature is held constant. Figure 2.1 (Pveduction.org) shows an I-V curve yielding a power- voltage or P-V curve.

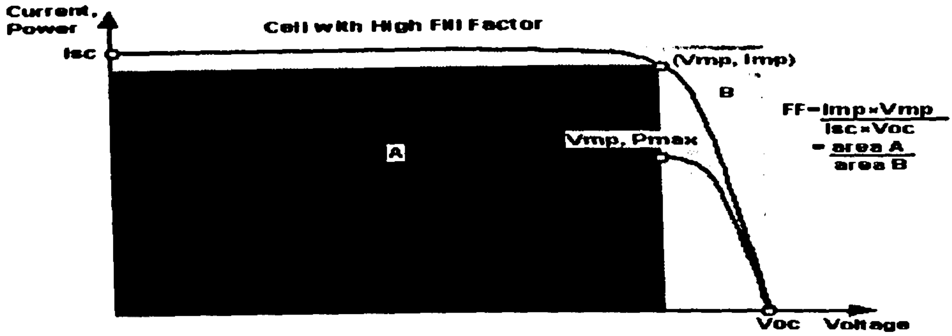

Figure 2.1 I-V curve contribute a P-V curve.

Refer from the Figure 2.1, it is shown that the short-circuit (Isc) at zero volt, to zero current at the open circuit (Voc). At the knee of a normal V-I has the maximum power point (Imp, Vmp), the point at which the cell generates maximum electrical power. In an operating PV system, inverter is added to constantly adjust the load, seeking out particular point on the I-V curve at which the array as a whole yields the DC power (Pisacane, 2005).

Imp is the flow of solar-generated electrical charge when external load is connected and is relatively independent of output voltage. Near the knee of the curve, this behavior starts to change. As the voltage increases further, an increasing percentage of the charges recombine internally. The maximum power point, located at the knee of the curve, is the (I,V) point at which the product of current and voltage reaches its maximum value.

The fill factor (FF) of a solar cell or a PV module is an important performance indicator. It represents the square ness or rectangularity of the I-V curve, and is the ratio of two areas defined by the IV curve, as illustrated in figure 2.1 Although physically unrealizable, an ideal PV module technology would produce a perfectly rectangular I-V curve in which the maximum power point coincided with Isc and Voc, for fill factor of 1. Fill factor is vital as reference for another PV module. If the Isc and Voc of another module have different value of the Isc and Voc, thus the impairment will reduce the filter factor associated with reduction of the output power. The formula of the FF shows into the figure 2.1.

Efficiency conversion of solar-generated electricity is defined to as the functioning of a

PV module as 100 % efficient. Another way to explain with ratio efficiency by comparing the maximum electrical power output (Pmax) to the solar power input (Pin) as show η

$$\text{Effieciency, } \eta = \frac{FF \times Isc \times Voc}{Pin}$$

2.4 The Output of Solar Cell Modules

The efficiency of a solar cell is independent of a number of factors and its performance can vary greatly depending on its location. PV modules work best in summer, as there is more sunlight for the module to convert into energy. It is impossible for utilizing all the energy of the sun and generating electricity. The losses occur if the energy is too weak to eject an electron from its shell. The energy might be absorbed by the internal circuit or resisted by the solar cell. Some energy might be absorbed by the internal circuit or resisted by the solar cell which will influence the output electricity generated.

2.4.1 Temperature

The I-V curve of a PV device under illumination is a strong function of temperature, which must be accounted for in performance measurement. Isc is smallest dependence, that is slightly increase by the decreasing of the bandgap associated with the more photon have enough energy to create e-h (electron-hole) pairs. The Voc and Pmax degrade rapidly with increasing temperature. It shown into Figure 2.2 (Pveducation. org)

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