EFFECT OF TILT ANGLE ON DUMMY SIGNAL POWERED BY SOLAR ENERGY

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in fulfillment of the requirements of the degree of
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DECLARATION

I declare that this project report entitled "Effect of Tilt Angle on Dummy Signal Powered by Solar Energy" is the result of my own work except as cited in the references.

Signature	:	…………………………………..
Name	:	……..……………………………
Date	:	…………………………………..

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluids).

Signature	:	…..…….………………………
Supervisor's Name	:	…..……..……………………...
Date	:	…...……………………………

DEDICATION

To my beloved Mother, Father, Along, Angah, Abang, and Adik.

ABSTRACT

The highway dummy signal currently operating based on battery consumption. The previous approach must be modified by applying the solar system which is one of the renewable energy to save the cost of the project evaluation. The solar system generally can generate electricity and providing light for various usage in daily life. This environmental friendly product is implemented to ease the contractors of road builder to place this highway dummy signal regardless of lack of energy in battery because the presence of solar energy in the dummy signal system. The dummy signal is tested to determine the best tilt angle of solar module that need to be applied on highway. In this project, the dummy signal is tested at Melaka, therefore, the tilt angle of solar module must be depends on the position of Sun in Melaka. Thus, the optimum tilt angle is determine by involving the performance of solar module which is by considering the power output of the solar module. As a results, power generated by the solar module is affected by tilt angle.

ABSTRAK

Patung isyarat lebuhraya yang sedia ada pada masa kini adalah beroperasi menggunakan bateri. Cara yang lama ini mesti diubah suai dengan mengaplikasikan sistem suria yang merupakan salah satu tenaga yang boleh diperbaharui untuk menjimatkan kos pelaksanaan projek. Secara umumnya, sistem suria ini boleh menjana tenaga elektrik dan membekalkan cahaya untuk pelbagai kegunaan seharian. Produk yang mesra alam ini dilaksanakan untuk memudahkan para kontraktor yang membina jalanraya untuk meletakkan patung isyarat lebuhraya ini tanpa keraguan dengan kekurangan tenaga di dalam bateri kerana adanya tenaga suria dalam sistem patung isyarat ini. Walau bagaimanapun, patung isyarat ini diuji untuk menentukan sudut kecondongan yang terbaik untuk diaplikasikan di atas lebuhraya. Bagi projek ini, patung isyarat lebuhraya ini diuji di Melaka, oleh itu, sudut kecondongan modul fotovoltaik bergantung kepada kedudukan Matahari di Melaka. Dengan itu, sudut kecondongan yang terbaik ditentukan dengan melibatkan prestasi modul fotovoltaik dengan mengambil kira kuasa keluaran yang dihasilkan oleh modul fotovoltaik. Kesimpulannya, penjanaan kuasa oleh modul fotovoltaik adalah dipengaruhi oleh sudut kecondongan.

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LIST OF ABBEREVIATIONS

PV	Photovoltaics
Si	Silicon
GaAs	Gallium Arsenide
CIS	Copper Indium Diselenide
CdTe	Cadmium Telluride
EMF	Electromotive Force
GC	Grid-connected Systems
SA	Stand-alone Systems
PV-GC	Photovoltaic grid-connected system
PV-SA	Photovoltaic stand-alone system
DC	Direct current
AC	Alternating current
IV	Current versus voltage
STC	Standard Condition

LIST OF SYMBOL

%	=	Percent
+	=	Holes
-	=	Electrons
G_{global}	=	Global solar irradiance
G_{direct}	=	Direct solar irradiance
$G_{diffuse}$	=	Diffuse solar irradiance
α	=	Solar altitude
θ	=	Specific solar altitude
β	=	Tilt angle
º	=	Degree
ºC	=	Degree Celcius
Pmax	=	Maximum power
V_{OC}	=	Open circuit voltage
I_{SC}	=	Short circuit current
V_{mp}	=	Voltage at maximum power
I_{mp}	=	Current at maximum power
W	=	Watt
V	=	Volt
A	=	Ampere
kWh/m^2	=	kilowatt hour per meter square
γ	=	temperature coefficient

CHAPTER 1

INTRODUCTION

1.1 Background

Solar energy is simply the light and heat from the Sun and one type of renewable energy which also categorised as the cleanest and most abundant energy. This solar energy can be converted into thermal or electrical energy. Other than that, this energy can be harnessed for various usages, such as generating electricity, providing light, and heating system for residential or industrial use. Nowadays, new technologies are created so that people can harness the energy directly from the Sun in different ways, such as, through photovoltaic cells, solar thermal technology, and passive solar heating. From these good benefits of our new technology, a study has been made by considering solar energy to replace the battery consumption in highway dummy signal. Previously, it is proven that solar energy is more economical than using battery consumption. The initial cost might be high, but in the long term this new system is beneficial. So, this study is based on effect of various tilt angle of dummy signal on current flow and power.

1.2 Problem Statement

The highway dummy signal that had been used currently is based on battery consumption. From previous studies, it shown that battery consumption is less economical than solar photovoltaic cell. Solar energy is environmental friendly, although the initial cost to install the photovoltaic cell is higher than using battery itself but it will be beneficial for a long term time. This research is about the effect of tilt angle on dummy signal powered by solar energy, which aims to gain the basic data in order data to find the performance of solar module that based on current flow.

1.3 Objectives

The objectives of this project that need to be fulfilled as follows:

1. To determine the best angle of solar panel which can gives the best performance to store the electricity generate by solar photovoltaic to the battery.
2. To determine the current stored in the battery from solar photovoltaics module.

1.4 Scope of Project

The scopes of this project are:

1. This experiment is carried out at Fasa B, Universiti Teknikal Malaysia Melaka within 2 hours which is at 10 a.m until 12 p.m.
2. Analyse the effect of generated current for various tilt angle.

CHAPTER 2

LITERATURE REVIEW

The contents of this literature review are obtained from research study and also different sources, including journals, books, articles, and internet web browsing which related to this research study. The topics that will be covered in this chapter are about the solar energy and its systems, the basic fundamental of photovoltaics, and the factors that affecting the photovoltaics output.

2.1 Solar energy

Solar energy is one of the renewable energy which is the world's most abundant and accessible energy. It is radiant energy that is produced by the sun. This solar energy can be harnessed in many different ways and used in daily life. According to (Goswami, 2008), this energy also can replace most of fossil fuels, which already stored sunlight over a million years.

People nowadays realise the important of renewable energy, so the usage of solar energy as renewable energy is increasing every year. This solar energy can be converted into heat energy and electrical energy but it need to be harnessed. There are two ways to harness solar energy which are the hybrid systems; the combinations of passive and active systems.

2.1.1 Passive Systems

Passive solar system is the conversion of solar energy into heat. For example, a house will just rely on windows and not to any special mechanical equipment to gain the solar energy (The Need Project, 2009). This system just relies on natural surrounding temperature. There are five elements as consideration in build a passive solar design which are windows, absorber, thermal mass, heat distribution, and control (U.S. Department of Energy, 2010). The five elements of passive solar system are illustrated as Figure 2.1.

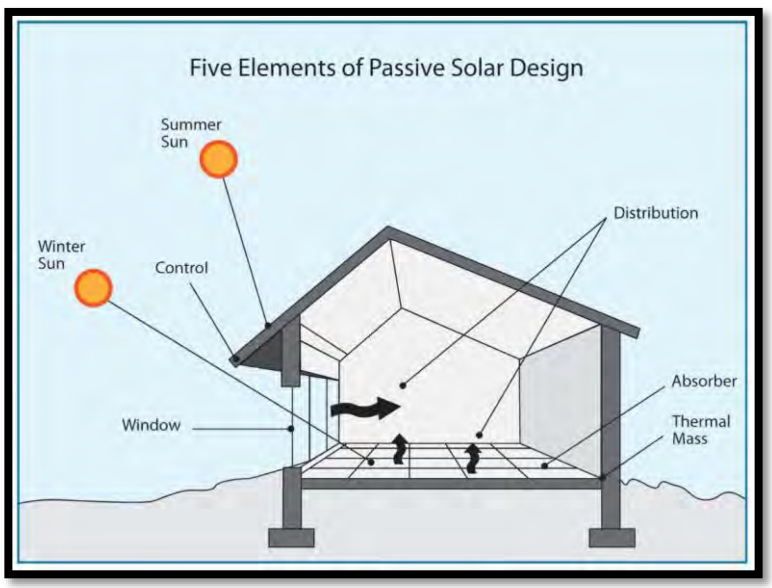

Figure 2.1: Elements of Passive Solar Design

(Source: U.S. Department of Energy, 2010)

Passive solar system is working when there is heat flow from hot to cold areas. This will apply the concept of heat transfer which are convection, radiation and also heat capacity. From (The Need Project, 2009) claims that, a passive system that applied at home usually can get 50-80% of solar energy to heat the home.

2.1.2 Active Systems

Active solar system is a contradiction with passive solar systems. This active system is usually operated with the help of mechanical equipment which are pumps and blowers or any source to supply the energy when there is lack of solar energy to heat the buildings (The Need Project, 2009). The solar collector which also known as photovoltaic (PV) cells is used to collect and distribute the heat. The PV cells used to generate the solar energy to electricity.

This system is usually applied to the buildings and water heating systems. By realising the importance of renewable energy nowadays, people are preferred to choose this technology to minimize their living costs. Figure 2.2 below shows the application of PV cells in a building.

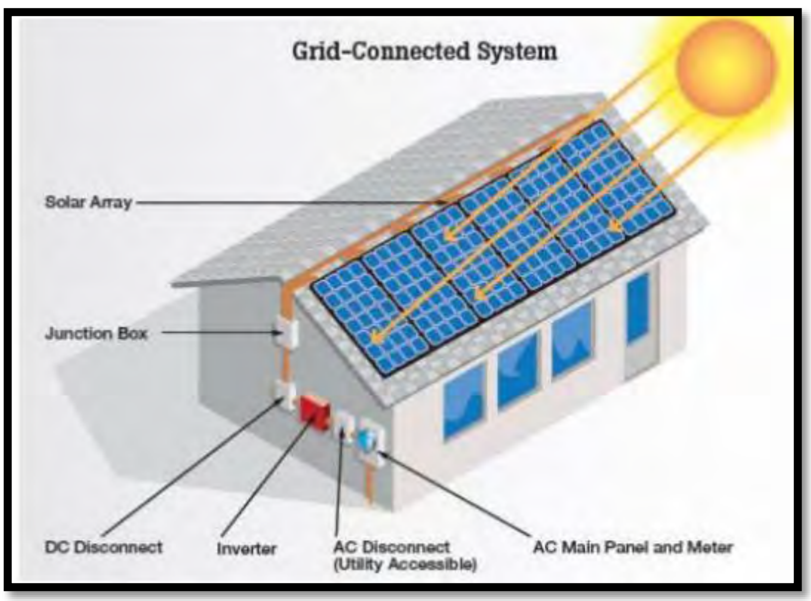

Figure 2.2: Application of PV cells as an Active Solar System

(Source: Eshkalak et al., 2014)

2.2 The Basic Fundamental of Photovoltaics

Photovoltaics (PV) is a technology that convert the light energy into electrical energy. A PV cell is made up from Silicon (Si), Gallium Arsenide (GaAs), Copper Indium Diselenide (CIS), Cadmium Telluride (CdTe), and other materials (Massenger et al., 2007). It is comprised with p-n junction that has built in the electromotive force (EMF). The n-layer which carry electrons (-) are freed and the p-layer which carry holes (+) are formed as light energy reached p-n junction then it will be driven by EMF to the sides of p-n junction. After all, the circuit is complete thus will generate electrical energy and power up the electrical load (Shaari et al., 2010). Figure 2.3 below shows the diffusion between the holes and electrons.

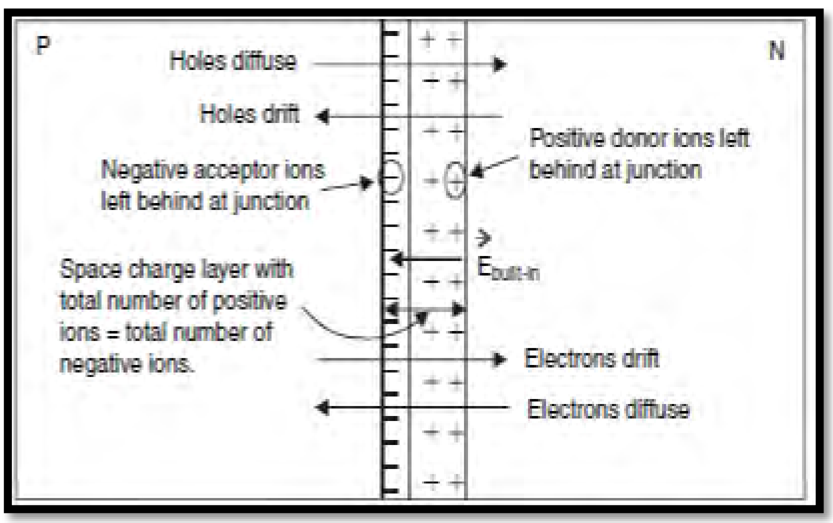

Figure 2.3: Diffusion of electrons and holes in p-n junction

(Source: Massenger et al., 2007)

The application of photovoltaics system can be divided by two broad areas which are:

1. Grid-connected systems (GC) – connected to the utility grid.
2. Stand-alone systems (SA) – not connected to the utility grid.

The PV-GC systems can be divided into two types which are distributed systems and centralised systems. According to (Shaari et al., 2010) the distributed systems supplied power directly to electricity network and also to the GC customers. While, for centralised systems, the power provided in bulk and do not relate to any customer.

In the meantime, PV-SA systems can be divided into 3 categories which are, PV direct using Direct Current (DC), PV and battery for DC and Alternating Current (AC) and lastly, PV, battery and auxillary genset which also known as PV hybrid system for DC or AC loads.

2.2.1 System Configurations

In this project, one system configuration had been applied which is DC system with battery backup. The system configuration is shown in Figure 2.4 below.

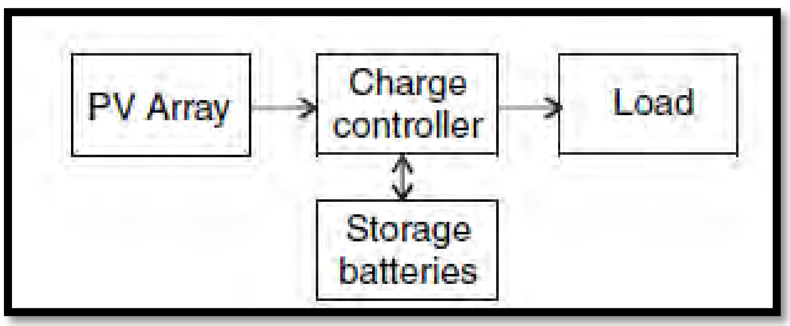

Figure 2.4: DC system with battery backup

(Source: Massenger et al., 2007)

This system used charge controller and storage batteries so that the energy could be produced during the day and used up the energy during day and night by the load. Besides, the function of charge controller is to prevent the battery from overcharge. Other than that, the charge controller also disconnects the load as the batteries become discharged and also to prevent it from overdischarge (Massenger et al., 2007). In addition, based on (Roos et al., 2009), the charge controller usually are selected based on 2 main things which are the PV array voltage and PV array current. For the PV array voltage, the DC voltage controller input must equivalent the nominal voltage of the solar array. Other than that, for PV array current, the controller should be suitable to handle the maximum current that could be produced by the PV array.

2.2.2 Factors Affecting the PV Output

The PV output is not constant throughout the day. This is because the PV output is depends on several factors which are irradiance effect, temperature effect, and tilt angle. These are the parameters that need to be considered during the experiment.

2.2.2.1 Temperature Effect

The temperature can give effect to the efficiency of PV output. This can be related when the PV module exposed to the Sun, the module temperature will get elevated (Shaari et al, 2010). According to (Bertolli et al., 2014), the power output will significantly drop as the temperature greater. Other than that, it will effect on IV curve. In order to have an efficient of PV output, the temperature has to be at suitable range which is not too high because theoretically it will increase the power output. The illustration of temperature effect on IV curve is as Figure 2.5.

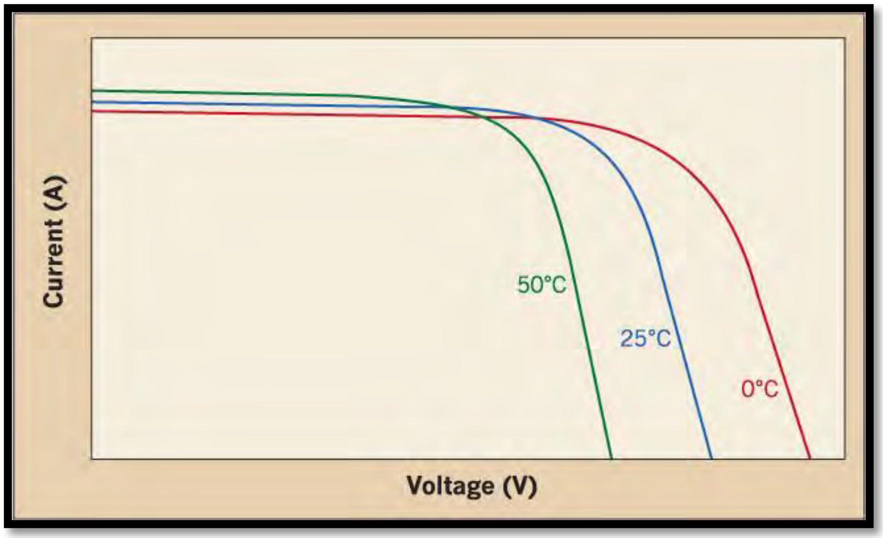

Figure 2.5: The temperature effect on IV curve

(Source: Mayfield, 2012)

However, the based on (Shaari et al., 2010) temperature coefficient is also an important thing in order to determine the corrected values of the solar module. The corrected values is determine by the following equation.

$$X_{corrected} = X_{\_stc} \times \{1 + [\gamma_x \times (T_{cell} - T_{stc})]\} \quad (2.1)$$

where X could be open circuit voltage (V_{OC}), short circuit current (I_{SC}), maximum power current (I_{MP}), maximum power voltage (V_{MP}), or maximum power (P_{MP}), while $X_{\_stc}$ is value of parameter X at STC, γ_x is temperature coefficient of parameter x for the module, T_{cell} is cell temperature and T_{stc} is cell temperature at STC.

2.2.2.2 Irradiance Effect

Solar irradiance is the intensity of solar power at a point of observation. The unit of irradiance is W/m^2. The solar irradiance can be calculated using below equation.

$$G_{global} = G_{direct} + G_{diffuse} \tag{2.2}$$

where G_{global} is the sum of all components of solar radiation, G_{direct} is the solar radiation that travelled in straight path and that will cast a shadow, and $G_{diffuse}$ is the solar radiation that come from effect of scattered due to clouds, dust or haze.

The irradiance effect is theoretically will affect the current output. The voltage output will change slightly and it is stable compared to the current (Shaari et al., 2010). The effect of irradiance variation on IV curve is shown in Figure 2.6. In order to improve the efficiency of PV output, the temperature should be lower and the higher irradiance on the PV panel.

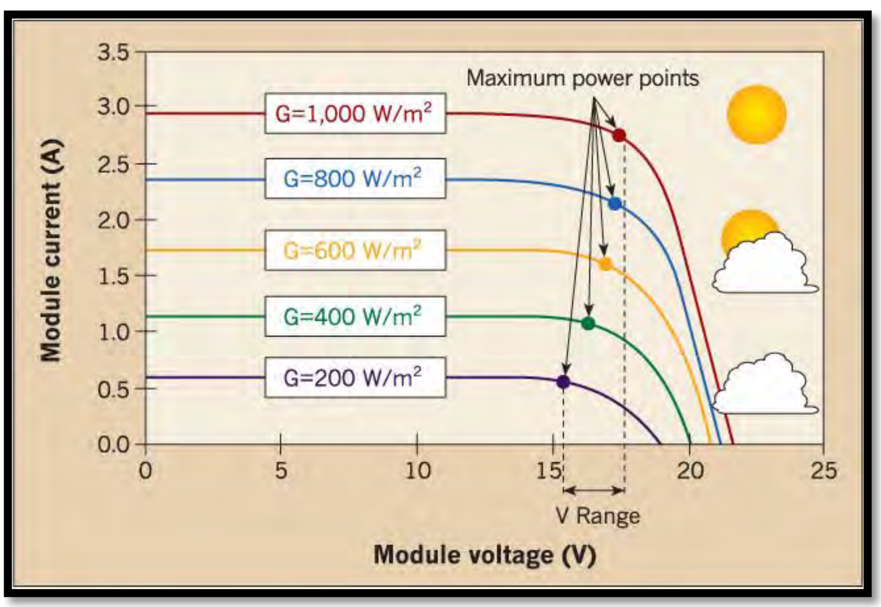

Figure 2.6: The effect of irradiance variation on IV curve

(Source: Mayfield, 2012)