MICROCONTROLLER BASED SINGLE AXIS SOLAR RADIANT TRACKING SYSTEM

This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Engineering Robotic & Automation) (Hons.)

by

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DECLARATION

I hereby, declared this report entitled “Microcontroller Based Single Axis Solar Radiant Tracking System” is the result of my own research except as cited in reference.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Robotics & Automation) (Hons.). The members of the supervisory committee are as follow:

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Dr. Syamimi Binti Shamsuddin

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Encik Mahasan Bin Mat Ali

ABSTRAK

Pada masa kini, penggunaan tenaga elektrik semakin berkembang dengan pesat kerana populasi manusia yang semakin meningkat. Terdapat pelbagai cara alternatif untuk menjana tenaga elektrik, khususnya penjanaan tenaga solar photovoltaic (PV) menjadi lebih popular kerana ia boleh diperbaharui dan bebas pencemaran. Kajian ini dilakukan bertujuan untuk merekabentuk dan membangunkan sistem pengesanan sinaran suria paksi tunggal automatik yang mampan dalam iklim Malaysia. Sistem pengesanan mengawal orientasi panel solar untuk sentiasa berserenjang ke arah matahari. Ini adalah untuk mewujudkan penyerapan kuasa dengan potensi maksimum oleh panel solar tersebut. Penjejakan input akan dilakukan oleh sensor yang menghantar isyarat masuk kepada pengawal mikro. Seterusnya pengawal mikro akan menyediakan isyarat keluar kepada penggerak untuk menyelaraskan panel solar agar sentiasa sejajar ke arah matahari. Hasilnya meningkat prestasi pengesanan thesingle paksi berbanding statik sistem panel solar. Kecekapan sistem tersebut memanfaatkan penghasilan tenaga diukur dalam unit arus litar pintas (Isc). Koleksi data telah dijalankan pada selang setiap jam selama dua belas hari bermula jam 8.00 pagi hingga 6.00 petang di padang terbuka di sebelah Pusat Bahasa dan Pembangunan Insan (PBPI) UTeM. Keputusan keseluruhan menunjukkan bahawa sistem pengesanan radiasi solar tunggal paksi automatik mendapat kecekapan yang lebih tinggi dalam memanfaatkan tenaga berbanding dengan persediaan statik konvensional dengan 31.35%. Ini membuktikan bahawa pengesanan paksi tunggal mempunyai prestasi yang lebih baik berbanding statik sistem panel solar dalam iklim Malaysia. Produk ini diletakkan di padang ujian selama dua bulan dan masih mampu untuk menjalankan mod pengesanan radiasi cahaya dengan baik dan ini membuktikan bahawa sistem tersebut mampan beroperasi dalam iklim yang dinyatakan.

ABSTRACT

Presently, consumption of electricity is rapidly increasing due to the growing human population. Alternative ways to generate electricity, specifically solar powered photovoltaic (PV) cells are becoming more popular as it is renewable and pollution free. This study aims to design and develop a single-axis automated solar radiation tracking system that is sustainable in Malaysia climate. The tracking system controls the solar panel orientation to be always to perpendicular towards the sun. This is to establish maximum potential power absorption by the solar panel. Tracking direction input will be provided by pilot sensors which send an input signal to the microcontroller. The microcontroller then will provide an output signal to the actuator to align the solar panel perpendicularly towards the sun. The efficiency of the system in harnessing energy is measured in unit of short circuit current (Isc). The data collections were conducted on hourly interval for twelve days starting from 8.00 am until 6.00 pm at the open field beside Pusat Bahasa dan Pembangunan Insan (PBPI) UTeM. Overall results show that the single-axis automated solar radiation tracking system gained a higher efficiency in harnessing energy compared with conventional static setup by 31.35%. This shows that the single-axis tracking has better performance compared to static solar panel system in Malaysia climate. The tracker was put into field for two months and still able to perform tracking mode, proving its sustainability in the said climate.

DEDICATION

Only for

my beloved father, Muhammad Syams Baskaran Bin Abdullah

my appreciated mother, Poonia Binti Abdul Rahman

my adored sister, Nur Farhana Binti Muhammad Syams Baskaran

for giving me moral support, financial support, cooperation, encouragement and also understanding

Thank You So Much & Love You All Forever

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In the name of ALLAH swt, the most gracious, the most merciful, with His blessed I manage to complete this Final Year Project (Projek Sarjana Muda) in time and successfully without facing any major difficulty.

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Last but not least, I would like to thank my family and friends for their support and encouragement with full trust in me to complete this project successfully. They had given their thought and provide me with valuable information that helps in my research. Thanks for your kind help and guide.

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LIST OF ABBREVIATIONS

PV	-	Photovoltaic
CSP	-	Concentrated Solar Power
MBPIV	-	Malaysia Building Integrated Photovoltaic
Isc	-	Current Short Circuit
Voc	-	Voltage Open Circuit
Si	-	Silicon
a-Si	-	Amorphous Silicon
CdTe	-	Cadium Telluride
CIGS	-	Copper Indium Galium di-Selenide
PSC	-	Polymer base Solar Cells
CPV	-	Concentrated Photovoltaic
LDR	-	Light Dependent Resistor
PLC	-	Programmable Logic Controller
MCU	-	Microcontroller Unit
ALU	-	Arithmetic-Logic Unit
I/O	-	Input/Output
PC	-	Portable Computer

LIST OF SYMBOLS

cm	-	Centimetre
m	-	Metre
%	-	Percent
g/cm^3	-	Grams per centimetre cube
mm	-	Millimetre
MPa	-	Mega Pascal
GPa	-	Giga Pascal
°C	-	Degree Celsius
W/mK	-	Watt per metre per Kelvin
nm	-	Nanometre
kg.cm3	-	Kilogram centimetre cube
kg	-	Kilograms
rpm	-	Revolution per minute
g	-	Gram
KB	-	Kilo Byte
mA	-	miliampere
V	-	Voltage
A	-	Ampere
°	-	Degree

CHAPTER 1
INTRODUCTION

1.1 Background of Project

One of the most important natural energy available in an abundant in this world is solar radiation. This is due to the fact it drives all environmental processes on earth. For example energy radiate from the sun is stored in the sea and will be disperse at night in order to maintain the balance of earth temperature. There are many ways that solar radiation can be exploited into producing electricity to fulfil society needs. The method is varies but it is not widely implement around the world. Despite the downfall of sun which is not constantly available during the day, there is ways can be done to overcome it (Foster, *et al.*, 2010).

In the past, solar energy has been long used by human, to power the area where normal power supplies unable to reach the area. For example, solar energy is used to heat water in home usage, drying agricultural product such as fruits and fishes. In 1830s, an astronomer named John Herschek used a solar collector box for cooking purpose during his expedition to Africa (Ghosh and Prelas, 2011).

Electric generation company now trying photovoltaic (PV), which the process of converting solar radiation energy into electricity being done directly. The energy source is free and the installation can be made at anyway, as long as it can receive sunlight. Thus, the solar energy system is an inexpensive energy source and environment friendly (US Energy Information Administration, 2006).

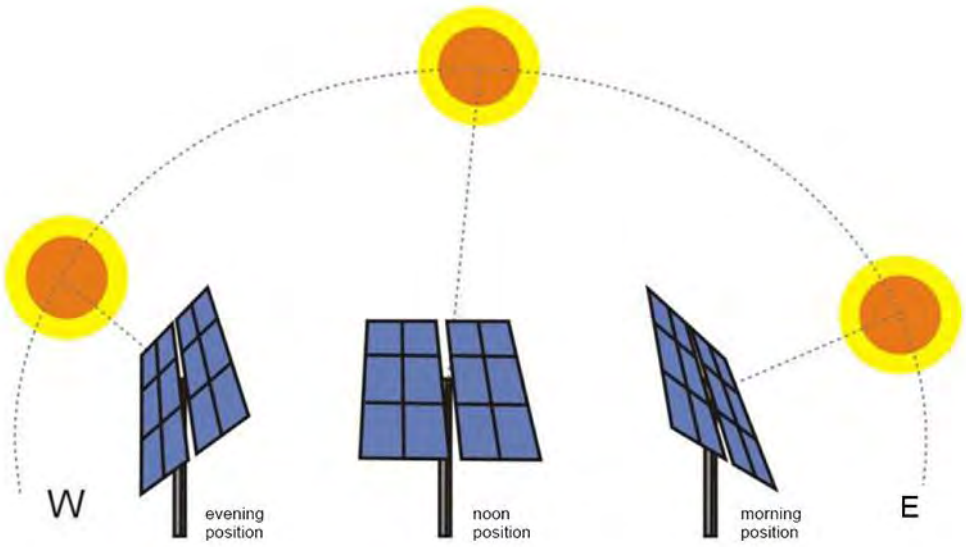

Figure 1.1: Solar radiation tracking system concept (Taleb, 2016)

1.1.1 Definition of Solar Energy

Every day, the sun radiates an enormous amount of energy which is called solar energy. It radiates more energy in one day than the world uses in one year. The energy generated within the Sun itself. The Sun is particularly made up mostly of hydrogen and helium gas. The energy created by the Sun is known as nuclear fusion. The nuclear fusion process graphical illustration as shown in Figure 1.2. The Sun's energy only required not more than eight minutes to travel 149.6 million km to Earth. It travels at the speed of light, which is $3.0\ x\ 10^8$ Meters per second. Due to the great distance between Earth and Sun, only a small amount of the visible radiant energy ever reaches the Earth, but it is more than enough to fulfil all of our energy needs. For every hour solar energy radiates to the Earth, it is enough to supply our nation's energy needs for a year. That is why solar energy is considered as a renewable energy (Garg and Parkash, 1997).

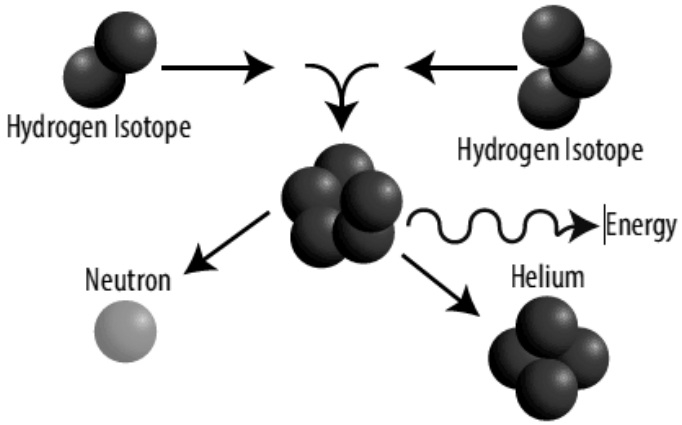

Figure 1.2: Nuclear fusion process (Imamzai, Aghaei Hanum and Forouzanfar, 2012)

1.1.2 Solar Electricity

There are two ways of producing electricity by harnessing the power from the Sun which is:

(a) Photovoltaic Electricity

Photovoltaic words originated from the word photo, meaning light, and volt, a measurement of electricity. Photovoltaic is also known as PV cells or solar cells for short. Solar cells usually are made up of silicon whereby it is the most common substance on Earth (Kettani, 1977).

Electricity is generated when the solar radiation energy from the Sun transmit the energy to the solar cells, causing the electron to move around. The action of the electrons starts an electrical current. The conversion of sunlight radiation into electricity takes place in silence and almost instantly (Kettani, 1977).

Figure 1.3: Solar panels (Photovoltaic Cells) in Narita, Japan

(b) Solar Thermal Electricity

Solar thermal systems, also known as concentrated solar power (CSP), use solar energy to produce electricity. Unlike photovoltaic panels, most solar thermal system used a solar collector with a mirrored surface to focus sunlight onto a receiver that heats a liquid. The super-heated liquid is used to make steam, which the drive a turbine to generate electricity. This method required a large area to be constructed (Kettani, 1977).

Figure 1.4: Solar thermal electric facility in Seville, Spain (Caldés *et al*., 2009)

1.1.3 History of Solar Energy

From the beginning of human modernization, the general idea of implementing Sun heat and radiation energy has become society generation of idea. This theory can be proven when the civilization such as Greeks, Romans, and Chinese harness the power of the Sun to provide light in the premises, and also heat and cool for agricultural purpose. Pliny the Younger built summer home in northern Italy that incorporated thin sheets of transparent mica as windows in one room. The room got warmer than others and saved on short supplies of wood. To converse firewood, the sixth century, sunrooms on private houses and public building were common that the Justinian Code introduced "sun rights" to ensure access to the Sun (Zumerchik, 2001).

Many further solar energy developments and demonstrations took place in the first half of the twentieth century and it is continually year by year. The invention of solar cell originated from a physicist named Antoine-Cesar Becquerel in 1839. He discovered the photovoltaic (PV) effect when conducting an experiment using solid electrode in an electrolyte. Approximately half a century later, Charles Fritts manage to create the first true solar cells using polarity is achieved by coating the semiconductor selenium with an ultra-thin, which is nearly a transparent layer of gold. Despite the new finding, the device found to be inefficient because it anly able to convert less than one percent of the absorbed solar radiation into electrical energy (Kolagirou, 2009)

Another semiconductor-junction cell made from copper and semiconductor copper oxide had been performed in 1927. During 1930s, both semiconductor being integrated into light-sensitive devices. Despite the constant development, the energy conversions are still lack of efficiency. The wall finally being broken by Russell Ohl in 1941 through the invention of silicon solar cells. This finding than was perfected by three researchers, G.L Pearson, Daryl Chapin, and Calvin Fuller where they manage to obtain higher energy conversion as much as six percent when using direct sunlight. A much higher efficiency was then fabricated in 1980s using gallium arsenide which able to achieve twenty percent. This improvement has leaded to vary efficiency and cost available in the market (Curly, 2012).

1.1.4 Implementation of Commercial Photovoltaic (PV) Solar in Malaysia

Solar energy is the most potential renewable energy available today that enable us to solve the world lack of energy resource. In Malaysia, the climate conditions provide us with abundant sunshine around the year. The average daily solar radiation received is between 4.21 to 5.56 kWh/m². The highest solar radiation received is in August and November which is 6.8 kWh/m² whereby the lowest is in December which is 0.61 kWh/m². Currently in Malaysia, solar energy are mostly for domestic used such as hot water system, drying agricultural produce and water pumping. Estimated that are over 10,000 units of solar power domestically used in Malaysia while large scale are insignificant (Syahrul *et al*., 2012).

In Malaysia, solar energy always referred as an extremely expensive for mass power generation. Currently the market value of a PV panel system is about RM 28.00/Wp. This is due to the fact that Malaysia are not manufacturing solar cell locally and most of the solar cell used are imported from other countries such as Germany and Japan. This imported technology resulted in high cost thus reducing the interest of Malaysian society (Syahrul *et al*., 2012).

In 1995, the Ministry of Energy, Water and Communications in Marak Parak, Sabah implemented demonstration photovoltaic (PV) project with a 100-kilowatt peak (kWp) indirectly creating a good milestone for a more efficient and reliable transfer of PV power generation technology in Malaysia (Syahrul *et al*., 2012).

To reduce the cost of PV systems, Malaysian government had implemented a program called Malaysia Building Integrated Photovoltaic (MBIPV) project. The global environment facility was distributed using the United Nation development program (UNDP/GEF) and also many private investors. During the lifetime of the project, the energy generated will prevent 65,000 tons of CO_2 emission from the power sector. Using 2005 as a baseline, it is expected with increasing of BPIV up to 330%. This indirectly reduces the cost of BPIV compared to 2005 costs as shown in Figure 2.4 (Syahrul *et al*., 2012).

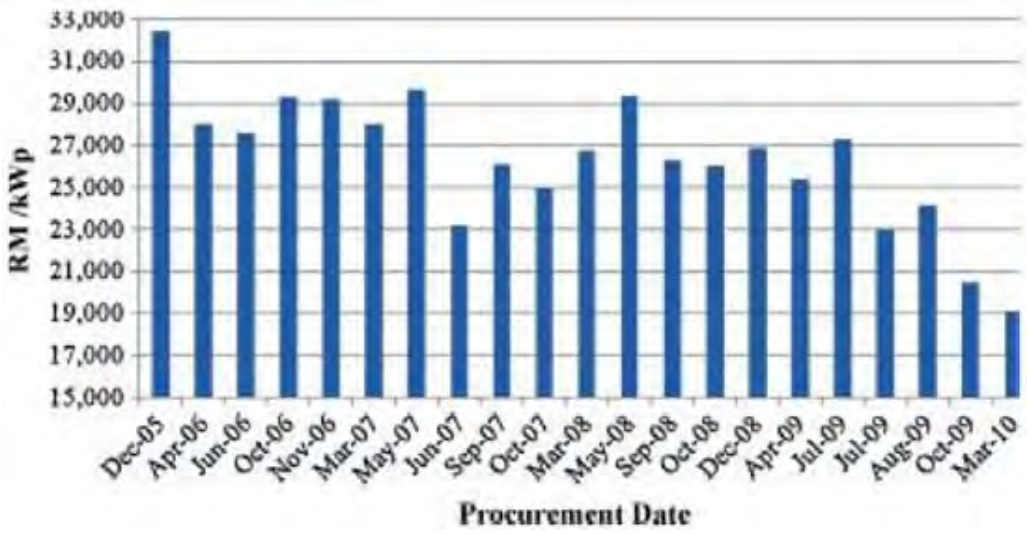

Figure 1.5: Average BIPV price/kWp from 2005 to 2010 in Malaysia (Syahrul *et al*., 2012).

Other than BPIV program, there are also implementation of SURIA 1000 the program which the main objective is priorities on residential and commercial sectors that will combine the new BPIV market. This initiative was taken to create collaboration between public and industry in involvement of renewable energy and environmental awareness (Syahrul *et al*., 2012).

Only a few number of grid-connected solar PV systems had been offered to public through auction in 2007. Adding to that only a minimum BIPV capacity is provided which is 3 kWp per application. Throughout this program, it is expected to reduce the solar cell prices until it is equal to the price in Japan and Europe. Currently in Malaysia, the price of 5 kWp BIPV turn-key roof top systems estimated around RM27,000/kWp resulting in RM 135,000 for 5 kWp BIPV. Yearly, the system will be able to generate roughly 6,000 kWh of energy (Syahrul *et al*., 2012).

1.2 Problem Statement

A photovoltaic (PV) cell or commonly known as a solar cell, is a device that converts sunlight directly into electricity. Recently, there has been an increase solar harnessing activity and also the applications of PV solar energy. Thus, there is a need to improve the current methods and materials being used in harnessing this type of power source. Major influences on overall efficiency of PV solar energy are the solar cell efficiency (semiconductor material and PV cell technology) and the intensity of the source radiation (The Sun).

Conventional designs have limitation in maximizing the absorption of sunlight radiation due to the static orientation of the solar panel itself. The Sun rises from the east to the west, but some of the sunlight radiation is unable to be optimally captured by the solar panel. Blockage by surrounding buildings also influences the sunlight radiation absorption as well as the clouds.

1.3 Objectives

The objectives of this project are:-

a) To design and develop an automated solar radiation tracking system that is sustainable in Malaysia climate
b) To analyze the efficiency of the solar panel with tracking system in harnessing power compared to static solar panel in Malaysia climate