UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A DUAL AXIS ACTIVE SOLAR TRACKING DEVICE

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Automation and Robotics) with Honours

by

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I hereby, declared this report entitled “A Dual Axis Active Solar Tracking Device” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Automation and Robotics) with Honours. The member of the supervisory is as follow:

……

(Project Supervisor)

ABSTRACT

The green energy also called renewable energy has gained much attention nowadays. Some renewable energy types are solar energy, hydro potential energy, wind energy, biomass energy and terrestrial heat. Among these, solar energy is effective that can be used. Nowadays, the solar panels are popular and are often used to convert solar energy into electricity. Mostly, solar panel that exists and used now is static, it cannot generates higher power. The solar panel should always be parallel to the sun in order to get more sunlight. This project attempts to generate more power from sunlight using solar panel tracking. If the solar panel is parallel to the sun, that the power generated from the solar panels will be maximum. Therefore, this project is concerned with the position of the solar panel. This system consists of hardware, electrical and software development. The stand was created and combine the stepper motor with the stand. A photoresistor have been used as a sensor to detect a sunlight. Then, the stepper motor and sensor circuit are connected with the microcontroller. Lastly, develop a program to control the sensor and stepper motor and burn the program in Arduino. The goal of this project is to develop a system of automatic sun tracking position. The system will move the solar panel angle to keep in parallel with the sun and generate maximum power at all times. In this project, a dual axis active solar tracking device is presented. A dual axis active solar tracking system changes both azimuth (horizontal) and altitude (vertical) angle of solar panel. It is believe that, A dual axis solar tracker system are more efficient and generates more power than fixed solar panels. There are a few recommendations for the future work of this project. The newly developed sensor can be reduced in size. Smaller sensor is useful if the sensor is going to be produced in higher quantity. The overall design can be improved for better and attractive appearance for the user.

ABSTRAK

Tenaga hijau juga dikenali sebagai tenaga yang boleh diperbaharui telah mendapat banyak perhatian pada masa kini. Beberapa jenis tenaga yang boleh diperbaharui adalah tenaga solar, tenaga keupayaan hidro, tenaga angin, tenaga biojisim dan haba daratan. Tenaga solar adalah antara yang berkesan yang boleh digunakan. Pada masa kini, panel solar adalah yang popular dan sering digunakan untuk menukar tenaga solar kepada tenaga elektrik. Kebanyakan panel solar yang wujud dan digunakan sekarang adalah statik, ia tidak boleh menjana kuasa yang lebih tinggi. Panel solar perlu sentiasa selari dengan matahari dalam usaha untuk mendapatkan lebih banyak cahaya matahari. Projek ini cuba untuk menjana lebih banyak kuasa daripada cahaya matahari dengan menggunakan panel pengesan solar. Jika panel solar adalah selari dengan matahari, kuasa yang dijana daripada panel solar akan menjadi maksimum. Sistem ini terdiri daripada pembangunan perkakasan, elektrik dan perisian. Tiang telah dicipta dan menggabungkan motor pelangkah dengan tiang. Foto perintang telah digunakan sebagai sensor untuk mengesan cahaya matahari. Kemudian, motor pelangkah dan litar sensor disambungkan dengan pengawal mikro. Akhir sekali, membangunkan satu program untuk mengawal sensor dan stepper motor dan memasukan program pada Arduino. Matlamat projek ini adalah untuk membangunkan satu sistem pengesan kedudukan matahari secara automatik. Sistem ini akan mengerakkan panel solar supaya selari dengan matahari dan menjana kuasa yang maksimum pada setiap masa. Dalam projek ini, peranti pengesan solar aktif dwi paksi dibentangkan. Sistem pengesan solar aktif dwi paksi menukar kedua-dua sudut panel solar iaitu azimut (mendatar) dan ketinggian (menegak). Pengesan solar aktif dwi paksi lebih cekap dan menjana lebih banyak kuasa daripada panel solar tetap. Terdapat beberapa cadangan untuk kerja-kerja masa depan projek ini. Saiz sensor yang baru dibangunkan boleh dikurangkan. Saiz sensor yang lebih kecil berguna apabila sensor dihasilkan dalam kuantiti yang lebih banyak. Reka bentuk keseluruhan boleh diperbaiki untuk penampilan yang lebih baik dan menarik untuk pengguna.

DEDICATIONS

To my beloved parents

To my kind lecturers

And not forgetting to all friends

ACKNOWLEDGMENTS

In completing this project, I have received a lot of helps from my supervisors, lecturers, researchers and family members and fellow friends.

First, I want to give my upmost thanks to my supervisor, Miss Suziana binti Ahmad who gave me an opportunity to do this project, for guiding and assisting me through the completion of this project. Without him guidance and persistent help, this project would not have been successful.

Next, I would like to express deepest appreciation to my parents in supporting me mentally and financially, for their encouragements and supports.

It is also my duty to record my thankfulness to my fellow friends that gave advice at some points and lent me a hand in completing the project. Also to a friend that offered this private space for field test and analysis of the prototype.

Finally, I also take this opportunity, my sense of gratitude to one and all that, directly or indirectly, have helped me in this project.

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INTRODUCTION

1.0 Introduction

This chapter will briefly discuss about the background study of the project. Besides that, objectives, problem statement and scope also have been discussed.

1.1 Background

Solar tracker is a device used to track the sun and generate power from sunlight. Solar tracker will move the solar panels to always parallel to the sun. Solar trackers require higher accuracy for detecting the sun and must maintain the incidence angle of 0° parallel to the sun in order to get the maximum energy from the sunlight (S. Ahmad et al., 2012). By using the solar tracking system, solar panels will receive a higher amount of solar energy and energy generated output is higher (Md. Tanvir et al., 2010).

1.2 Problem Statement

The sun will always change with the movement of the sun, the solar panel should always be parallel to the sun in order to get more sunlight. Mostly, solar panel that exists and used now is static, it cannot generates higher power compared with solar trackers. On overcast day, clouds will interfere fixed solar panels from tracking the more sunlight (S. Ahmad et al., 2012). In addition, the single-axis solar tracker only changes azimuth (horizontal) angle while two axis solar tracker changes both azimuth (horizontal) and altitude (vertical) angle (P. Bajpai et al., 2011). Thus, a dual

axis active solar tracking device in this project can generates higher power from solar panel.

1.3 Objectives

Project Objectives are to;

a) Study a mechanism for moving solar panel by using stand.
b) Develop a prototype tracking sensor for solar panel.
c) Analyze the voltage, current and power of active solar tracker.

1.4 Work Scopes

The scopes of this project are;

a) Polycrystalline Silicon Solar Cells is used to harvest the solar energy.
b) Photoresistor sensor is used to sending a feedback to the microcontroller to give signal that to changes of the position at active solar tracker.
c) All the part have to connected to Arduino Uno microcontroller for operate the system.
d) Two stepper motor is an actuator that has been used to perform movement of the solar tracker.

CHAPTER 2
LITERATURE REVIEW AND PROJECT BACKGROUND

2.0 Introduction

This chapter shows that the research that have been done. In this chapter, the review was to microcontroller, solar panel, motor, and the sensor to sense the position of the sun. Below are explanation about the previous study that they done.

2.1 Microcontroller

Microcontroller is important in a control system. All the parts have to connect to this microcontroller for operating the system. The system is for running process in this controller. Some of the journals are mentioned the important of the controller. The controllers that have been used in the previous research are ATmega328P microcontroller, [Salih Fadil et al. (2013)], ATMEGA32 microcontroller, [Md. Tanvir Arafat Khan et al. (2010) and Prabodh Bajpai (2011)], ATmega128 microcontroller [S.B.Elagib et al. (2013)], STM32F100C4T6B microcontroller [Oleksandr Veligorskyi et al. (2014)], PIC 16F84A [Lwin Lwin Oo et al. (2010), Tuton Chandra Mallick et al. (2014) and A.B. Afarulrazi (2011)], PIC16F877A microcontroller [Dimitrija Angelkov et al. (2014)], Arduino UNO microcontroller N.Othman et al. (2013)], Programming Logic Controller (PLC) [Salsabila Ahmad et al. (2012)].

N. Othman et al. (2013) in a journal titled 'Performance Analysis of Dual-axis Solar Tracking System', a solar tracker that controlled by Arduino UNO. Hardware and software of Arduino are easy to use and it is open-source electronics prototyping platform that is flexible. Programming languages are used in the Arduino software is a C programming. An Arduino can received input from a variety of sensors that

connected to the analog of Arduino and projects that used Arduino can operate independently or communicate with software on a computer.

Lwin Lwin Oo et al. (2010) in a journal titled 'Microcontroller-Based Two-Axis Solar Tracking System', study a solar tracker that control by PIC 16F84A. PIC 16F84A microcontroller is used to interface with two-axis system using a programming language and it is the main controller entire circuit. PIC 16F84A can decode written instructions and convert it to electrical signals.

Salsabila Ahmad et al. (2012) in a journal titled 'A High Power Generation, Low Power Consumption Solar Tracker', study a solar tracker that controlled by Programming Logic Controller (PLC). By using Programming Logic Controller (PLC), altitude and azimuth of the sun is pre-calculated using the formula and the input and output PLC connected in electromechanically. So, the microcontroller can control the motors that move the solar panels to follow the sun's position and always parallel to the sun.

2.1.1 Arduino Uno Microcontroller

Figure 2.1: Arduino Uno Microcontroller

Arduino Uno as shown in Figure 2.1 is a device for making computer that can sense and control. It is a simple microcontroller board because easy to writing software for the board. Arduino projects can communicate with computers or can

stand alone and it used to take input from various sensors, controlling a variety of motor and other physical outputs.

Advantages;

a) Simple and clear programming environment.
b) An USB interface, the board plugs straight into USB port on computer.
c) Open source and extensible software and hardware.

Disadvantages;

a) Arduino library needs to be improved to make it easier to resolve the issues.

2.1.2 Programmable Interface Controllers (PIC) Microcontroller

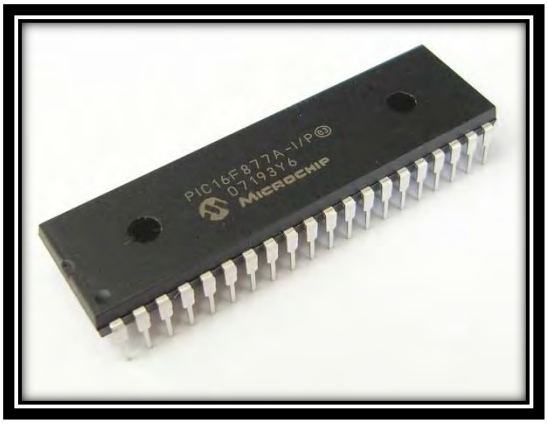

Figure 2.2: Programmable Interface Controllers (PIC) Microcontroller

PIC microcontrollers (Programmable Interface Controllers) as shown in Figure 2.2 is an electronic circuit that can be programmed to perform various tasks such as controlling.

Advantages;

a) Various types of electronic components and circuit can be replaced with PIC to controlling.
b) Increased product reliability through the use of less components.
c) Power conception is also very less when compared to other microcontrollers.

Disadvantages;

a) The length of the programming.
b) Programmable Interface Controllers require interfacing circuitry to drive because have a low power output.

2.2 Solar Panel

Md. Tanvir Arafat Khan et al. (2010) in a journal titled 'Design and Construction of an Automatic Solar Tracking System' had mentioned that the photovoltaic cell is the basic solar system that is used to convert sunlight into energy and it is very suitable to be used because a source of sunlight is the easiest and a lot of renewable to be energy. Time of the day, position the solar panel and season affect the power output because it depends on the amount of light received by the solar panel. Therefore, to get the maximum power, the solar panel should always be parallel to the sun.

N. Othman et al. (2013) in a journal titled 'Performance Analysis of Dual-axis Solar Tracking System'. Solar panel, which is also called 'photovoltaic' mentioned that it is a device that generates electricity from light. There are many types of solar panel distinguished by their efficiency, price and temperature coefficient that are available in the market.

Solar panel can be divided into three types;

a) Polycrystalline solar panel
b) Monocrystalline solar panel
c) Thin-film solar cell (TFSC)

2.2.1 Polycrystalline Silicon Solar Cell

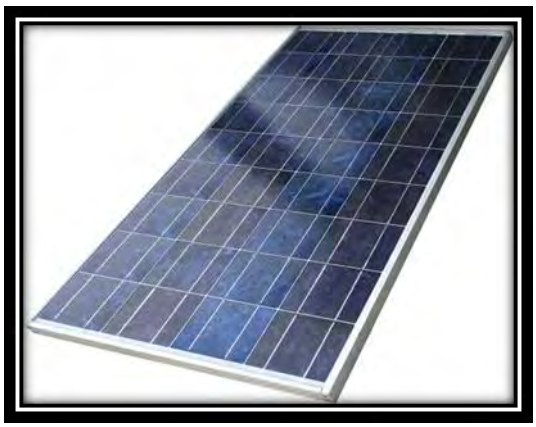

Figure 2.3: Polycrystalline Silicon Solar Cell

Polycrystalline panels as shown in Figure 2.3 are some of bits pure crystalline consists of silicon offcuts, which is formed using a block. It will not be efficient when individual crystals are not aligned together and there is a loss in the joints between it. However, in low light, the cells work better to light at all angles due to misalignment.

Advantages;

a) Its manufacturing cost is low and it is very simpler to produce.
b) The durability and longevity at least 25 years.
c) Environmental problems related to fossil fuels and rising greenhouse gases can be overcome by generating energy from sunlight.

Disadvantages;

a) Solar modules made of a single crystal is better and more effective compared with polycrystalline solar.
b) If heavy objects falling onto it or carried by the wind, it will damaged because it is fragile.

2.2.2 Monocrystalline Silicon Solar Cell

Figure 2.4: Monocrystalline Silicon Solar Cell

The solar cells in monocrystalline panels as shown in Figure 2.4 be produced from pure drawn crystalline silicon bars that cut in slices and the entire cell is aligned in one direction. It will be more effective when bright sunlight shines on it at the correct angle. It has a uniform blacker colour because it is absorbing most of the light.

Advantages;

a) Monocrystalline solar panels are longevity.
b) Although fixed solar panel, it able to convert the highest amount of solar energy into electricity.
c) The output of power will be less when the sun reaches temperatures of 50 degrees Celsius.

Disadvantages;

a) Manufacturing is expensive and complex.
b) If heavy objects falling onto it or carried by the wind, it will damaged because it is fragile.

2.2.3 Thin-film Solar Cell (TFSC)

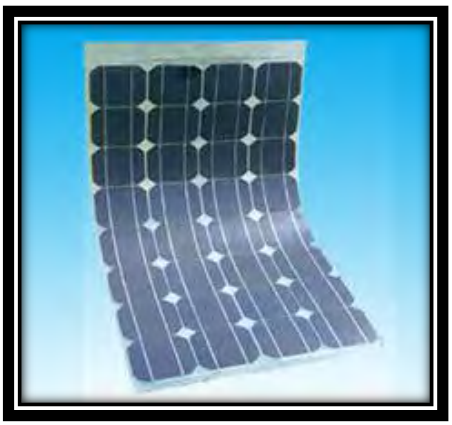

Figure 2.5: Thin-film Solar Cell

The thin film solar cells (TFSC) as shown in Figure 2.5 known as Thin Film Photo Voltaic cell (TFPV) contains many thin film layers of photo voltaic materials. If compared with the traditional P-N junction, the thickness is very thin because it in a nano meter. It can be divided into four types. Which are;

a) Amorphous silicon (a-Si) and other thin-film silicon (TF-Si)
b) Cadmium Telluride (CdTe)
c) Copper indium gallium Deselenide (CIS or CIGS)
d) Dye-sensitized solar cell (DSC) and other organic solar cells

Advantages;

a) It can be used in various forms of surfaces.
b) It is flexible for use anywhere.
c) If the temperature increases, the output does not decline.

Disadvantages;

a) Inefficient because a thin film decreased performance over time.
b) It can only produce half the power compared to polycrystalline and monocrystalline.

2.3 Motor

Motor is an actuator that has been used to perform movement of the solar tracker so that the solar panel is always parallel to the sun. In the previous studies, DC motor had been used in the solar tracker system, [Tuton Chandra Mallick et al (2014), Salsabila Ahmad et al. (2012) and Oleksandr Veligorskyi et al. (2014)]. Meanwhile, stepper motor in a solar tracker also had been used in the previous researches [Md. Tanvir Arafat Khan et al. (2010) and M. Amir Abas et al. (2010)] and servo motor also had been used in the previous studies [S.B.Elagib et al. (2013), Dimitrija Angelkov et al. (2014) and N.Othman et al. (2013)].

Md. Tanvir Arafat Khan et al. (2010) in a journal titled 'Design and Construction of an Automatic Solar Tracking System' stepper motors is the best for use in applications requiring precision positioning control and among the features of the stepper motor is brushless, open loop capabilities, load independent and excellent response.

S.B.Elagib et al. (2013) in a journal titled 'Design and Implementation of Dual Axis Solar Tracker based on Solar Maps' using servo motor . Motor drive is one of the most important aspects of the automatic solar tracker. It drives the solar panel to ensure always parallel to sunlight. To effectively use a servo motor for precise positioning a servo mechanism should be applied. A servo mechanism or servo is an automatic device that uses error sensing feedback to correct the performance of a mechanism. Servo motor is an automatic device that using sensors to sense feedback signal to correct the performance of a mechanism and servo mechanism must be proper position so that it can operate more effectively. Pulse-width modulation (PWM) is used to control the servo motor.

Salsabila Ahmad et al. (2012) in a journal titled 'A High Power Generation, Low Power Consumption Solar Tracker' using DC motor where it can rotate clockwise and anti-clockwise to detect an azimuth up to 360 ° and a motor that holds the solar panel can rotate up to 90 °.