UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ACTIVE SOLAR TRACKER

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

By

AFDZAL RIDZUAN BIN KHALID

B071110029

880329-08-5133

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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 Bachelor's Degree in Electrical Engineering Technology (Industrial Automation and Robotics) (Hons.) The member of the supervisory is as follow:

……

(Miss Suziana Binti Ahmad)

ABSTRAK

Tenaga suria merupakan tenaga yang paling sedia ada di bumi kita. Tenaga matahari digunakan sejak zaman purba. Dengan perkembangan yang pesat, alam sekitar menghadapi risiko termasuk perubahan iklim. Penjanaan kuasa boleh diperbaharui menjadi isu hangat. Tenaga solar telah menjadi jawapan yang terbaik bagi kuasa boleh diperbaharui sejak beberapa dekad dahulu. Walau bagaimanapun, kuasa keluaran sel papan solar adalah dipengaruhi oleh sudut tuju cahaya matahari. Dengan menjejaki papan solar terhadap matahari, ia akan sentiasa menunjuk pada sudut yang optimum untuk memperoleh tenaga solar yang maksimum sepanjang hari atau setahun. Dalam projek ini, satu kaedah baru alat pengesanan solar telah dibentangkan. Pergerakan matahari dikaji sebelum mereka-bentuk prototaip alat pengesanan dan papan solar bergerak tersebut. Dengan menggunakan susunan enam (6) fotodiod dan satu (1) silinder, prototaip alat pengesan menunjuk matahari direka. Alat pengesan tersebut berfungsi dengan menentukan lokasi bayang-bayang silinder supaya dapat mengesan kedudukan matahari dalam arah bertentangan. Mekanisme dwi-paksi penggerak itu akan membolehkan sistem untuk bergerak berdasarkan elevation dan azimuth matahari. Penggerak yang akan gunakan adalah DC motor tanpa berus. Kedua-dua motor akan diletakkan pada pan-miring. Pergerakan tracker solar akan meliputi latitud dan azimut. Selain itu, potensiometer juga digunakan untuk membaca kedudukan elevation papan solar. Kaedah projek ini dibincangkan di sini adalah operasi automatik yang merangkumi kaedah pengesanan, bekalan kuasa sendiri, pengawal pintar, mikropengawal dan penggerak aktif.

ABSTRACT

Solar energy is the most readily available energy available on earth. The energy of the sun is used since ancient times. With fast growing environmental concerns over the climate change risks associated with power generation with non-renewable energy, solar power has been the best answer over the decades. However, the output power of the solar cell panel is highly affected by the sunlight incident angle. By tracking the solar panel to the sun, it can always be pointing at the optimum angle to harvest the maximum solar energy throughout a day or a year. In this project, a new method of solar tracking is presented. The sun movements are studied to design the prototype of sensor and the solar tracker. By using arrangement of six (6) Photodiode and one (1) solid cylinder, a prototype sun-pointing sensor is designed. The sensor works by determining the location of solid cylinder's shade and tracker would track the sun position in opposite direction. The dual-axis mechanism of the tracker would enable the system to track based on the sun azimuth and altitude. The actuators that will use are stepper motor brushless. Both motors will mount at the pan-tilt. The movement of solar tracker will cover latitude and azimuth. Also, a potentiometer is also used to read the solar panel elevation position. The method is discussed here for an automatic operation of the system which includes an intelligent tracking method, self-sufficient power supply; using microcontroller and active tracker.

DEDICATION

To my beloved parents

To my kind lecturers

And not forgetting to all friends

For their

Love, Sacrifice, Encouragement, and Best Wishes

ACKNOWLEDGEMENT

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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CHAPTER 1
INTRODUCTION

The solar energy is the renewable energy that the popular during this day. Now day, every country is developing solar tracking to harvest the radiation of the sun energy.

1.1 Background

Solar tracker is invented to make the solar panel move towards to sunlight. A solar tracker is a device for operating a solar photovoltaic panel or concentrating the panel forward sun-concentrates, require high degree of accuracy to ensure that the concentrated sunlight is dedicated precisely to the panel. Solar tracking enables to the generated energy because this system able to maintain the panel perpendicular to the sun. To make solar energy more efficient, the solar tracking system must be maximized.

1.2 Problem Statement

Traditional fixed static solar panel is unable to harvest the maximum solar energy of the sun because of different position in azimuth and elevation of the sun at day time. The sun light is either reflected or diffused away when the panel is in shallow angle. If the cloud is blocking the solar panel, it will be minimize the energy harvest time. The harvest of solar energy is depending on the amount of light projected on the cell. The solar panel is the main tool that must have to convert radiation of the sun to electrical energy. Now day, renewable energy is imported because to overcome problem of the oil and gases that have been almost exhausted.

1.3 Objectives

Project Objectives are to;

a) Develop a prototype tracking sensor.
b) Understand a mechanism for moving the solar penal by used pan-tilt.
c) Analysis the voltage, current and power of active solar tracker.

1.4 Work Scopes

The scopes of this project are;

a) One solar panel connected to the system for store the energy.
b) Operating system involving microcontroller Arduino Uno.
c) Development of solar tracker using two stepper motor for moving pan-tilt for controlling the solar tracker system.
d) Photo resister sensor (shadow sensor) is used to detect the sun and move forward.

CHAPTER 2
LITERATURE REVIEW AND PROJECT BACKGROUND

This section 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

Figure 2.1: Microcontroller Arduino MEGA

Microcontroller is the important part of the most. It like heart of the project, all part of the component is connecting to the microcontroller. The systems are running and process is in this controller. All the journals are mention important of the controller for every each project. The controllers that have been used in the previous research are Programmable Logic Control (PLC) [Salsabila Ahmad et al. (2012) and Wang Wei et al. (2012), arduino uno controller N.Othman et al. (2013), Microcontroller PIC 18F4560, M. Amir Abas (2010) , ATmega81 microcontroller Guangyu liu et al. (2013), ATmega32 microcontroller Md. Tanvir Arafat Khan (2010), microcontroller

(MCU) tracking system data base S.B Elagib et al. (2013), and MPPT controller S. Kalika et al. (2012) and Loredana Cristaldi et al. (2014).

Salsabila Ahmad et al. (2012) in a journal titled ‘A high Power Generation, Low Power Consumption Solar Tracker shows that a solar tracker has controlled by a Programmable Logic Controller (PLC). The controller can pre-calculate the altitude and azimuth of the sun by inserting the formula that has been created. The controller can also can controls the motor in which follows the position of the sun. It can be seen that the power consumption of using the controller is very high. Salsabila ahmad et al. (2012).

N. Othman et al (2013) in a journal titled ‘Performance Analysis of Dual-axis Solar Tracking System’ mention that arduion UNO controller has more advantages which are the language used easy to understand for programming and to interface with the hardware is more flexible. The controller can sense the environment by receiving input from a variety of sensor that can affect its surrounding. Arduio projects can be stand-alone and can communicate with software running on the computer. N. Othman et al. (2013).

Loredana Cristaldi et al. (2014) in journal ‘An Improved Model-Based Maximum Power Point Tracker for Photovoltaic Panel’ have stady about the using model – based (MB) MPPT give batter performent that is because the system is easy to maintain an accurate model of the single PV panel. Loredana Cristaldi et al. (2014).

2.2 Solar Panel

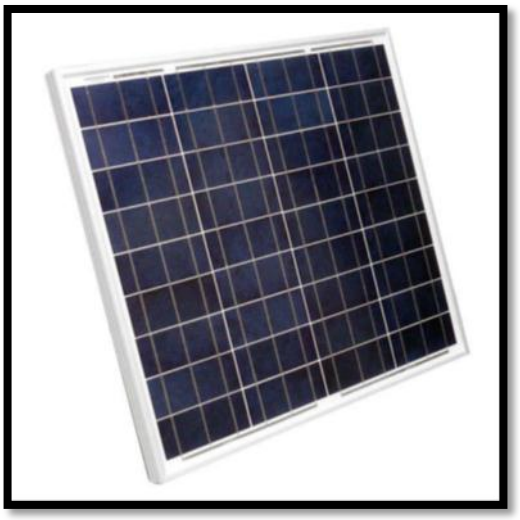

Figure 2.2: Solar Panel

A solar panel is a connected assembly of solar cell which also known as photovoltaic (PV) cell. Solar panel can be used to generate and supply electricity in commercial application by converting radiation sun light to the electricity energy. They have several type of the panel that has been used in the last paper project and they are monocrystalline, polycrystalline and thin film. N. Othman et al. (2013).

In marked, solar panel can be divided into three types:

a) Monocrystalline silicon solar cell
b) Polycrystalline silicon solar cell
c) Thin-film Solar Cell (TFSC)

Based on website from Mathias Aarre Maehlum,(2013) mentions the advantages and the disadvantages of the solar panel.

2.2.1 Monocrystalline Silicon Solar Cell

Monocrystalline solar cell is made out of silicon ingots, which are cylindrical in shape. It can give this type of solar their characteristic look. The advantages of the Monocrystalline Silicon Solar Cell are:

a) This type of solar panel has the highest efficiency rates since they are made out of the highest-grade silicon. The efficiency rate of monocrystalline solar panel is typically 15-20%.
b) Monocrystalline silicon solar panels are space-efficient.
c) Monocrystalline solar panel lives the longest. Most solar panel manufacturers put a 25-year warranty.
d) Tend to perform better at low-light condition.

The disadvantages of the Monocrystalline Silicon Solar Cell are:

a) Monocrystalline solar panel is the most expensive.
b) If the solar panel is partially covered with shade, dirt or show, the entire circuit can break down.
c) The czochralski process is used to produce monocrystalline silicon. It result inlarge cylindrical ingots. Four sides are cut out of the ingots to make silicon wafers. A significant amount of the original silicon ends up as waste.
d) The solar panels tend to be more efficient in warm weather.

2.2.2 Polycrystalline Silicon Solar Cell

The first solar panel based on polycrystalline silicon, which also is known as polysilicon (p-Si) and multi-crystalline silicon (mc-Si). This type of solar panel does not require the czochralski process. Raw silicon is melted and poured into square mold, which is cooled and cut into perfectly square wafers. The advantages of the polycrystalline-base solar panel are:

a) The process used to make polycrystalline silicon is simple and cost less.
b) Polycrystalline solar panel tends to have slightly lower heat tolerance then monocrystallline solar panel.

The disadvantages of the silicon solar cell are:

a) The efficiency of polycrystalline-based solar panel is typically 13-16%.
b) Lower space-efficiency.
c) The polycrystalline silicon have uniform look like less aesthetically between other solar panel.

2.2.3 Thin-film Solar Cell (TFSC)

Thin-film solar cell also known as thin-film photovoltaic cell (TFPV). The manufactured is by depositing one or several thin layers of photovoltaic material onto a substrate is the basic gist. Thin-film model prototypes have reached efficiencies between 7-13% and production modules operate at about 9%. The different type of thin-film solar cell can be categorized by which photovoltaic material is deposited onto the substrate:

a) Armorphous silicon (a-Si).
b) Cadmium telluride (CdTe).
c) Copper indium gallium selenide (CIS/CIGS).
d) Organic photovoltaic cell (OPC).

The advantages of the thin-film solar panel are:

a) Mass-production is simple. Potentially cheaper to manufacturing.
b) Their homogenous appearance makes them look more appealing.
c) Can make flexible, which open many new potential application.
d) High temperatures and shading have less impact on solar panel performance.
e) Space is not an issues, thin-film solar panel can make sense.

The disadvantages of the thin-film solar panel are:

a) Thin-film solar panels are in general not very useful for in most residential situation.
b) Low space-efficiency also means that the costs of PV-equipment.
c) Thin-film solar panel tends to degrade faster than mono and polycrystalline solar panel that is why the warranty is shorter.

2.3 Motor as actuator

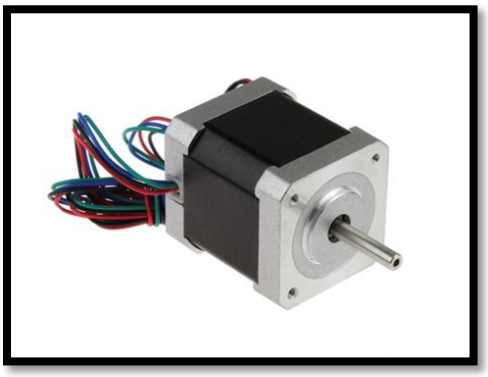

Figure 2.3: Motor

Motor is an actuator that has been used to perform movement of the solar tracker. The part of motor is assembled as a mechanism of movement to track the position of the sun. From the review of study, the journals have been a lot of motor are used such as DC motor. Salsabila et al. (2012), Stepper motor as the actuator M. Amir Abas(2010), S. Kalika et al. (2012), Wang Wai et al. (2012) and Md. Tanvir Arafat Khan (2010),and using servo motor. S.B.Elagib et al. (2013) and N.Othman et al. (2013).

M.Amir Abas et al. (2010) in a journal titled 'improved structure of solar tracker with microcontroller based control'. The used of stepper motor can be considerably not heavy to the force the shaft at the motor. The advantage of using this type of motor is which has X-Y turning position to make movement of solar tracker more flexible. M.Amir Abas et al. (2010).

S.B Elagib et al. (2013) in a journal titled ‘Design and implementation of dual axis solar tracker based on solar maps’ shown that using servo motor mechanism is an automatic device that uses error sensing feedback to correct the performance of the mechanism. S.B Elagib et al. (2013).

Salsabila ahmad et al. (2012) in a journal titled ‘A high power generation, low power consumption solar tracker is mention using dc motor where the cylindrical base is able to rotate 360˚, clockwise and counter clockwise for azimuth and can upper holder is able to rotate up and down within a 90˚. Salsabila ahmad et al. (2012).

2.4 Sensor

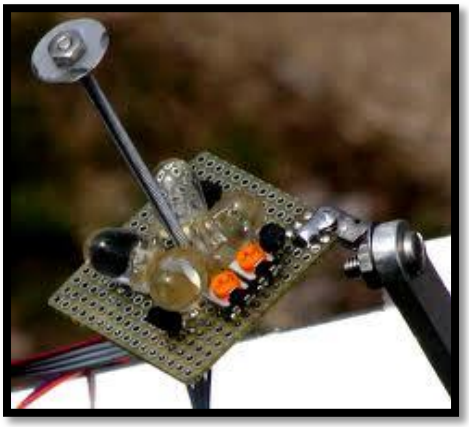

Figure 2.4: Photodiode sensor

Sensor is a component in which it is sending a feedback to the microcontroller to give signal that to changes of the position at active solar tracker. They are many kind of sensor that been used from past study. The previous study have used such as photodiodes Guangyu Liu et al. (2013), photo resistor Md. Tanvir Arafat Khan et al (2010), sun position algorithm, S.B.Elagib et al. (2013) , ultra violet sensitive device known as pyranometer M. Amir Abas et al. (2010), and light dependent resister (LDR) N.Othman et al. (2013).

Guangyu liu et al. (2013) in a journal titled ‘Principles, design, and calibration for genre of irrafiation angle sensor ’. Advantage of the sensor with its linear regression model, yielded an accuracy of up to ±0.3˚. Draw back, the sensor is not sensitive to different irradiation level is supported. Guangyu liu et al. (2013).

Md Tanvir Arsfat Khan et al. (2010) in a journal titled ‘Design and Construction of an Automatic Solar Tracking System’. The advantage of using photo resister is it can automatically detect the starting position itself. The sensitivity of the photo resister is between 500mm to 700mm of wave length. Md Tanvir Arsfat Khan et al. (2010).

S.B.Elagib et al. (2013) in a journal titled ‘Design and Implementation of Dual Axis Solar Tracker based on Solar Map’. This solar tracker working solution for maximizing solar cell output by positioning a solar panel at the point of maximum light intensity. The system has low equipment cost in large plants. S.B.Elagib et al. (2013).

2.5 Summary of Literature Review

From the literature studied, it was proven that the solar panel with active solar tracker is better in efficiency compare to the fixed panel. No need to spend times adjusts the solar tracking since the solar just only need to place at the certain location and then the solar tracking will moved automatic based on the light source of the sun. The solar tract the sun by its own and the energy absorb by the solar panel is maximizing.

Due to the last study from the journal, the actuator that been used was stepper motor. There is because of its advantages such as the motor have full torque at standstill, precise position and repeatability. The entire projects have their own purpose by chosen the stepper motor which follows the requirement of the projects.