DESIGN OF SIMPLE SOLAR TRACKING SYSTEM TWO AXIS FOR RESIDENTIAL APPLICATION

MANJIT SINGH A/L GURMAIL SINGH

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DEDICATION

Special dedicated to my beloved mother Dilbinda Kaur and father Gurmail Singh, who had encouraged and inspired me endlessly in my journey to pursue my studies in this field. And to my associate Ms. Norfae`zah Mohammad, thanks for the patience towards my behavior and never lack of understanding in giving me full support and encouragement in order for me to complete this project. I treasure it very much.

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ABSTRACT

Solar energy is a very notable and unlimited source of energy. The usage of solar energy main issue is the difference in readiness of solar energy happens day-to-day due to the sun's movement changes throughout the year. The dissimilarity in accessibility arises daily as of the cycle of night and day and the season change due to the earth’s rotation with our star which is the sun. In order to achieve the maximum sun irradiation, the solar panel has to be positioned correctly throughout the day. Creation of a simple, low cost solar tracking system with emphasizing on a two-axis solar tracking system with automatic detection using Light Dependent Resistor (LDR). The system is to track the sunlight and switch its location appropriately to exploit the maximum power yield. Comparison of the efficiency on the two-axis system with a fixed solar panel system will be probed into. Tracking system consists of Light Dependent Resistor, Arduino Nano microcontroller to drive the direct current servo motors and gearing positioning with supports structure. The direct current servo motors are employed in order to position the solar panel to ensure the solar irradiation is able to be maintained aligned with the solar panel throughout the day. Water spray system is used for cooling system that employs DC pump with the help of RTC sensor which detects the panel temperature with ambient air temperature. The difference will allow the pump to send the water onto the panel.

ABSTRAK

Tenaga solar adalah sumber tenaga yang sangat ketara dan tidak terhad. Isu utama penggunaan tenaga solar adalah perbezaan dalam tenaga suria yang berlaku setiap hari akibat perubahan pergerakan matahari sepanjang tahun. Perbezaan dalam akses berlaku setiap hari sebagai kitaran malam dan siang dan perubahan musim disebabkan putaran bumi dengan matahari. Untuk mencapai penyinaran cahaya maksimum, panel solar harus diposisikan dengan betul sepanjang hari. Penciptaan sistem penjejakan solar yang mudah dan murah dengan sistem penjejakan solar dua paksi bagi pengesanan automatik menggunakan resistor bergantung cahaya (LDR). Sistem ini adalah untuk mengesan cahaya matahari dan menukar lokasinya dengan tepat untuk mengeksploitasi kuasa yang maksimum. Perbandingan kecekapan pada sistem dua paksi dengan sistem panel solar tetap akan disiasat. Sistem penjejakan terdiri daripada resistor bergantung cahaya, mikrokontroler Arduino Nano untuk memacu motor servo dan kedudukan gearing dengan struktur sokongan. Motor servo digunakan untuk meletakkan panel solar dan memastikan sinaran solar dapat dikekalkan sejajar dengan panel solar sepanjang hari. Sistem semburan air digunakan untuk sistem penyejukan yang menggunakan pam DC dengan bantuan sensor RTC yang mengesan suhu panel dengan suhu udara ambien. Perbezaannya suhu akan membolehkan pam menghantar air ke atas panel..

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

A	-	Ampere (amp)
AC	-	Alternating Current
AVR	-	Alf and Vegard's RISC
BSC	-	Base Station Controller
BIPV	-	Building-Integrated Photovoltaic
CNC	-	Computer numerical control
CPU	-	Central Processing Unit
CV	-	Circuit Voltage
DC	-	Direct Current
DPBT	-	Discounted Payback Time
EA	-	External Access
ESS	-	Energy Storage System
FC	-	Ferric Chloride
FOCV	-	Fractional Open Circuit Voltage
FSCC	-	Fractional Short Circuit Current
FYP	-	Final Year Project
GND	-	Ground
HSATS	-	Horizontal Single Axis Tracking System
IS	-	Idyllic Spot
IAM	-	Incidence Angle Modifier
IDE	-	Integrated development environment
IRR	-	Internal Return Rate
I/O	-	Input & Output

IEEE	-	Institute of Electrical and Electronic Engineering
kW	-	kilowatt (1,000 Watts)
kWh	-	kilowatt-hours (1,000 Watts-hours)
LCD	-	Liquid Crystal Display
LCOE	-	Levelized Cost of Energy
LDR	-	Light Dependent Resistor
MPI	-	Modified Profitability Index
MPPT	-	Maximum Power Point Tracking
MWh	-	megawatt-hours (million Watts-hours)
NPC	-	Net Present Cost
PI	-	Profitability Index
PV	-	Photovoltaic
PCB	-	Printed Circuit Board
PTC	-	PVUSA Test Conditions
PWM	-	Pulse Width Modulation
RAM	-	Random Access Memory
RM	-	Ringgit Malaysia
RMS	-	Root-Mean-Square (power measurement)
ROI	-	Return of Investment
ROM	-	Read Only Memory
RST	-	Reset
RTC	-	Real Time Clock
RX	-	Receiver
SSA	-	Sub-Sahara Africa
SMC	-	Sliding Mode Control

TX	-	Transmitter
USB	-	Universal Serial Bus
VSATS	-	Vertical Single Axis Tracking System

LIST OF SYMBOLS

γ	-	Temperature Needs of Different Materials
°C	-	Celsius
µF	-	Micro Farad
A	-	Area of Surface
B	-	Constant Non-Temperature Variant
C	-	Capacitor
D	-	Marginal Carrier – Silicon
E_{G0}	-	Band Gap Which Is Deduced To Complete Zero
f	-	Frequency
h	-	Standard Constant
Hz	-	Hertz Frequency
I_O	-	Output Current
K	-	Standard Constant
K	-	Kilo
L	-	Marginal Carrier Length
m	-	Electron and Hole Mass
M	-	Mega
n_i	-	Intrinsic Carrier Cluster for Silicon
N_D	-	Doping
P	-	Power
R	-	Resistor
T	-	Current Temperature
q	-	Electronic Charge

V	-	Voltage
V_{CC}	-	Incoming Voltage Supply
V_{OC}	-	Voltage Open Circuit
V_{in}	-	Voltage Input
V_{out}	-	Voltage Output
W	-	Watt

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of the project

The worry and key issue of the world now is global warming which as been in sight of many government around the world in present-day. Due to this raising issue, many methods were introduced and are being implemented strongly in some nations. One of the methods is the green technology introduction and advancement which now receiving prodigious consideration in the national plan of energy management. Particularly, the huge let go of the excess heat and carbon dioxide from numerous energy process of fossil fuel during the manufacturing, giving out, transmission, conversion and usage were involved with strong standing to globally, and have remained to be controlled in the Kyoto Protocol, 1997. The research of the green technology bases or root is then has become a concentrating part of exploration, equally for scholastically and technologically. The source of solar radiation from the mother nature is clean and infinite, with comparatively reciprocated technologies, which heads the solar energy to develop into one of the hopeful green power contributors.

The position of the slope is between -90 ° after dawn and + 90 ° before evening passes with 0° during the midday. This allows the solar radiation that is brought together to be 0% at dawn and evening and 100% during the midday. The reason the for the photovoltaic panels loses the energy is due to the difference in solar irradiation which can be in range from 30% up to 40% in total of energy collection.

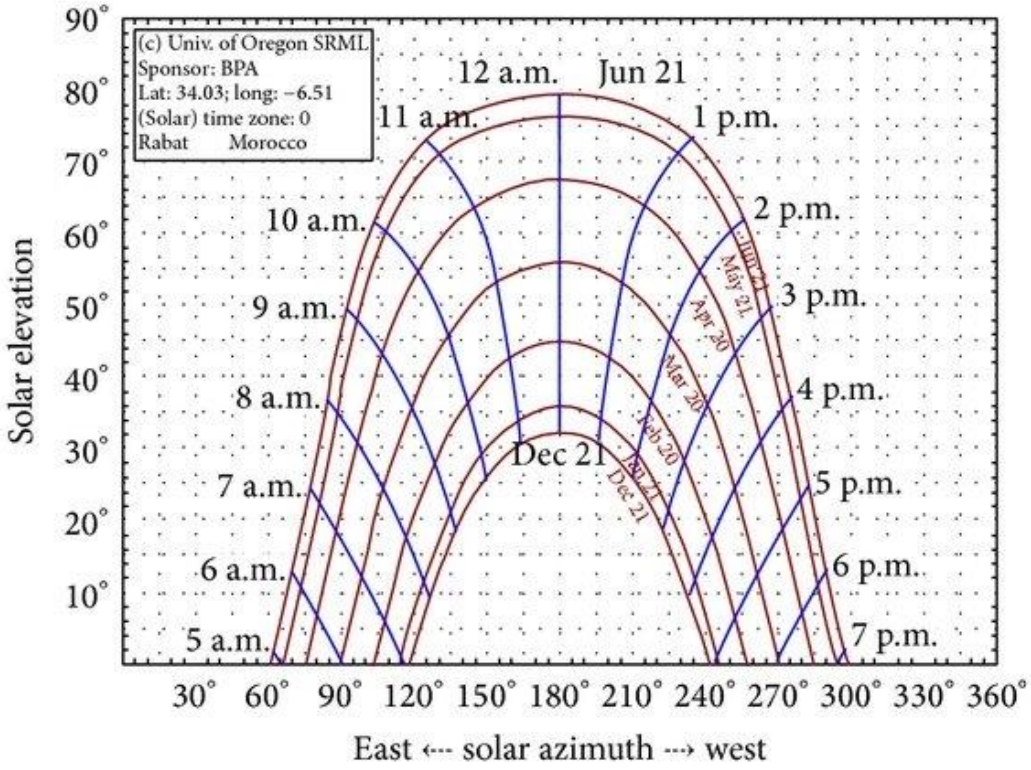

Figure 1.1 Annual sun path in Rabat, Morocco

Figure 1.1 shows our star the sun annual path at latitude 35° and longitude of -6.51° for Rabat, Morocco. Based on figure 1.1, The precise location of the sun can be estimated every month and at any period given in a day. The location is determined at between two crisscrossing lines or surfaces at or nearby to the point anywhere they meet in spherical coordinates. The solar elevation is represented in the vertical plane and the horizontal panel indicates the movement of the sun from east to west.

The output of the photovoltaic system is determined by the angle of the sun and photovoltaic panel location. This is commonly known as Incidence Angle Modifier (IAM). There are two type of incidence angle modifier which are transversal and longitudinal. Transversal is used to measures the variation in performance when the angle between the sun and the photovoltaic panel changes on daily basis where else longitudinal is used to measures the variation in performance when the angle between the sun and the photovoltaic panel changes on annual basis. Figure 1.2 shows the transversal and longitudinal incidence angle modifier.

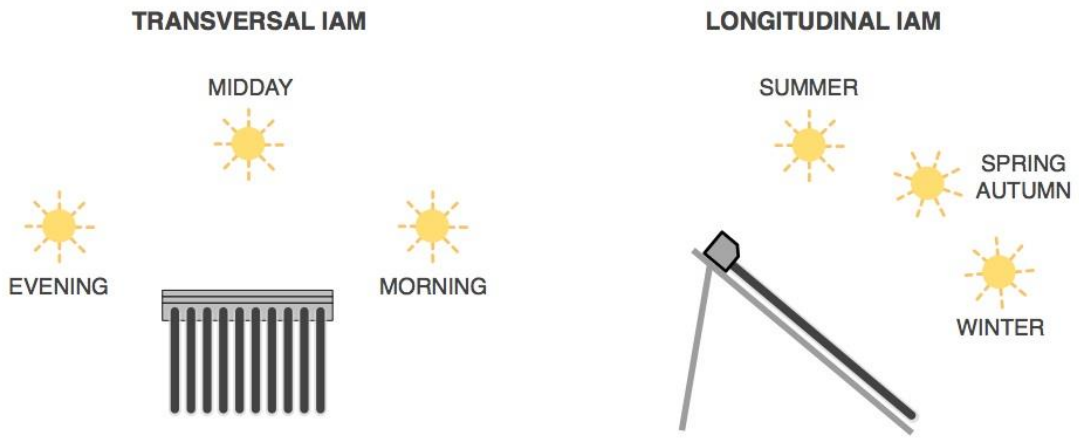

Figure 1.2 Transversal and longitudinal incidence angle modifier

Temperature plays the crucial role in the energy generation from the photovoltaic panel. This is due to, when the temperature increases, the overall output generation decreases proportional. The dust accumulation also causes the deep drop of energy output from the solar panel. More dust is accumulated on the panel surface, less energy produced. Therefore, considering the temperature and dust accumulation, the best source of cooling and cleaning is by using water. Water is abundant, cheap and it is clean as well.

The essential element in solar power system is the photovoltaic panels, which design of the solar panel is followed either fixed and tracking system. Dual axis tracking system provides the best tracking solution for areas with lower altitude. Due to shading at lower altitude areas, the tracking system is able to position itself at the best position facing the sun in order to be at 0° at all possible time to achieve the maximum power. Figure 1.3 shows the basis concept of the dual solar tracking system against fixed type solar panel.

Currently there are many industrial dual-axis tracking system for solar energy is available in the market. But there is no similar system is available for residential or home use with affordable rate. The project will utilize the Arduino microcontroller for the control system for the dual tracking solar system with temperature sensor to detect the temperature at the photovoltaic panel. The temperature sensor will indicate to the system when to cool the panel accordingly.

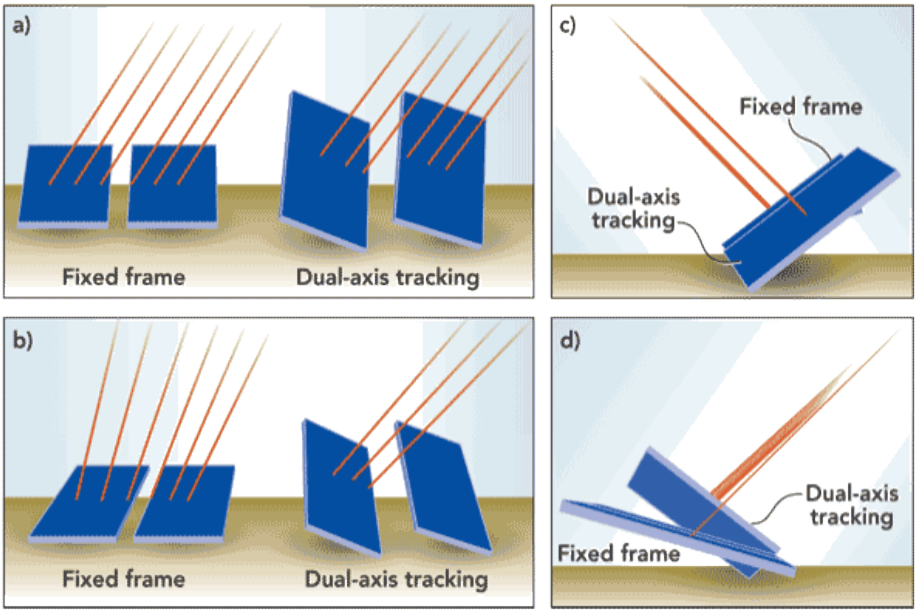

Figure 1.3 Dual axis tracking system against fixed panel type

1.2 Problem statement

The usage of solar energy main issue is the difference in readiness of solar energy happens day-to-day due to the sun's movement changes throughout the year.

The dissimilarity in accessibility arises daily as of the cycle of night and day and the season change due to the earth’s rotation with our star which is the sun. In order to achieve the maximum sun irradiation, the solar panel has to be positioned correctly throughout the day.

Normally, photovoltaic system is made to produce the highest power from the sun ray at the lower design cost. Solar energy system producers are exploring to develop a more coherent solar system. It is believed that twenty to thirty percent more solar energy can be capture and able to work more efficiently in locations with lower altitudes compared to fixed or titled angle solar panels.

Referring to study that was conducted by Chong Li and Dequn Zhou in 2017 on off-grid residential solar photovoltaic power systems, the study showed that the

fixed solar panel system, with the zenith angle of 25° against the dual axis tracking solar system was producing less than 20.1% in energy generation compared to the later [10]. This was also support afterwards by Chiemeka Onyeka Okoye in 2018 regards to the study on evaluating the solar resource potential on different tracking surfaces in Nigeria [17]. The author study also found that the best trackers are dual-axis and single-axis and the worst performing are fixed optimal and panel facing north-south position only.

Temperature plays the crucial role in the energy generation from the photovoltaic panel. This is due to, when the temperature increases, the overall output generation decreases proportional shown in Figure 1.4. Dust accumulation also causes the deep drop of energy output from the solar panel shown in Figure 1.5.

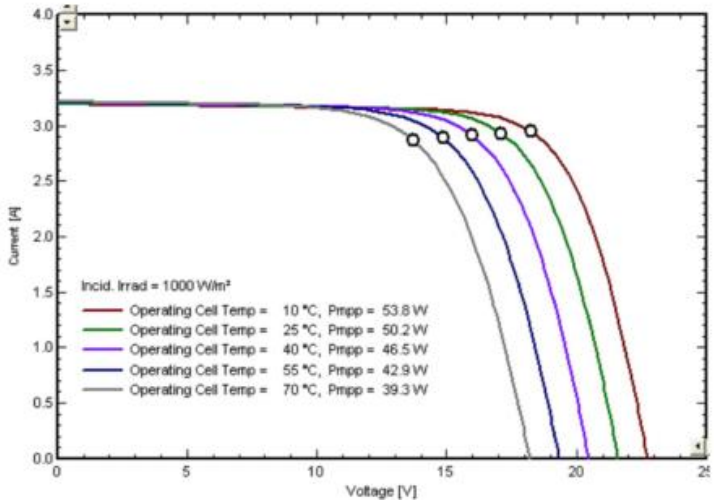

Figure 1.4 Temperature effect on the solar panel output

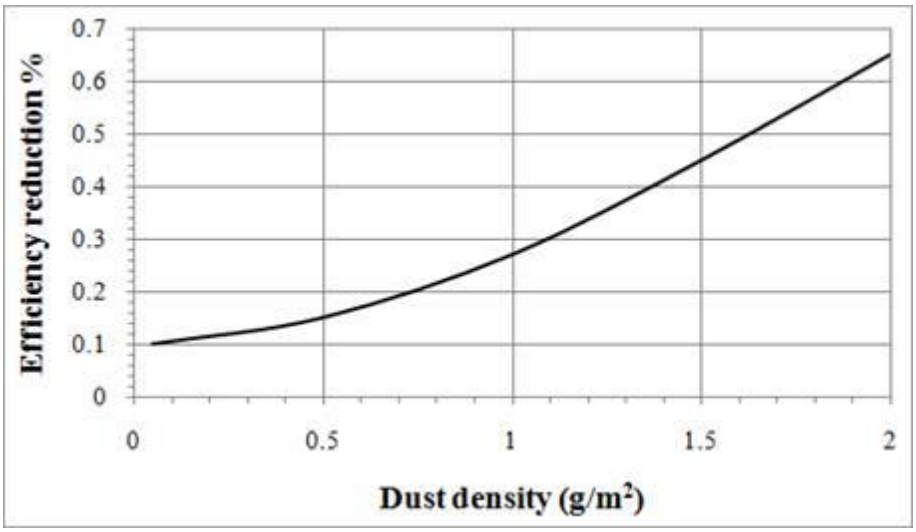

Figure 1.5 Dust density against efficiency of solar panel

This study is focused on dual axis solar tracking system for residential usage. It is required to be at lower cost in order to allow the return of investment (ROI) for this dual axis solar tracking system to be achieved. The dual axis solar tracking system design will also be compared to the fixed panel design with same photovoltaic panel.

1.3 Objective of Project Proposal

1. To design a simple, solar tracking system with emphasizing on a two-axis solar tracking system with automatic detection using Light Dependent Resistor (LDR) with water cooling system.
2. To develop a system to track the sunlight and switch its location appropriately to exploit the maximum power yield.
3. To show the efficiency on the two-axis system with a fixed solar panel system.

1.4 Scopes of Project

There are two main scopes in this project which is study development and analyse development. These are the designing and output simulation. Below are the scopes that need to be built according to the objectives:

i. To use the Arduino microcontroller as the control system for the dual-axis solar tracking system.

ii. The system is limited for the residential and stand-alone purpose. It is not for commercial, industrial purpose and not grid connected and project data is based on day time but limited to the weather condition such as raining and cloudy day.

iii. To compare the output of power generated with and without cooling system for the dual-axis solar tracking system. Cooling agent to be used is water.

1.5 Project Schedule

Project schedule is based on the Gantt chart which consist of the Semester II 2018/2019 session. This is to warrant that project meets the deadline. It is also to ensure the project objectives are meet. Gantt chart is used to display the overall process flow of project and manage the timeline of each process. The Gantt chart for the project proposal as per Appendix A.

For the project proposal, there are several tasks to be followed. The project starts from the idea or proposal that will ensure the project title to be accepted by the supervisor. The title then is acquiesced to supervisor for verification and approval. Confirmation from the supervisor is important before the next step is able to be taken whereby the literature review is formed and the collection of information or data which is closely related to the project is compiled before the proposal report is finalized and sent for submission.

1.6 Proposal Outline

This report was separated in five chapters. Respectively each chapter will deliberate on the various topics. The frameworks of the project are as the following:

i. Chapter 1 covers the introduction and overview of the project, describes the background, problem statement, objectives and scope of the project proposal.

ii. Chapter 2 discusses about the literature review of this project which includes the overview theory of solar energy system and dual axis tracking system, with critical review of other studies done.

iii. Chapter 3 intensive on methodology of the project which contains the design specification and flow process procedure.

iv. Chapter 4 presents the data, measurement and testing results from theoretical result. The results obtained are analyzed and discussed.

v. Chapter 5 The final chapter concludes the report and provide recommendations for additional enhancement on this project.

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