UNIVERSITI MALAYSIA SARAWAK
UNIMAS

Faculty of Engineering

DESIGN AND DEVELOPMENT OF A PHOTOVOLTAIC (PV) SYSTEM WITH A SUN TRACKER

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Bachelor of Engineering with Honours
(Electronics and Computer Engineering)
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20/5/2010
Date

Design and Development of a Photovoltaic (PV) System with a Sun Tracker

CHAI KOH KIONG

This project is submitted in partial fulfilment of
The requirements for the degree of Bachelor of Engineering with Honours
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Faculty of Engineering
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Dedicated to my beloved family and friends

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ABSTRAK

Kajian adalah mengenai rekabentuk dan pelaksanaan fotovoltaic (PV) dengan sistem pengesanan matahari. PV adalah susunan sel-sel yang mengandungi bahan fotovoltaic yang menukarkan sinaran matahari kepada kuasa arus elekrik melalui kesan fotovoltaik. Pemasangan pengesanan matahari salah satu pendekatan untuk meningkatkan prestasi sistem photovoltaic. Pengesanan matahari adalah digunakan untuk berorientasikan panel photovoltaic terhadap matahari. Tujuan kajian ini adalah untuk menguji prestasi sistem photovoltaic dengan pengesanan matahari di Batu Lintang, Kuching, Sarawak (1°32'09.73''N, 110°20'32.70E). Sistem fotovoltaic yang direkabentuk dan dibangunkan dengan pengesanan matahari adalah dipamerkan. Sistem yang dibangunkan terdiri daripada lima modul, iaitu sistem sensor, sistem aktuator linear, mekanisme pengesanan, sistem simpanan bateri dan pengawal serta sistem mikro. Selain itu, prestasi sistem fotovoltaik dengan pengesanan matahari dan tanpa matahari pelacak telah dibanding, dianalisasi dan dinilai melalui eksperimen.

ABSTRACT

This thesis presents the design and implementation of solar photovoltaic (PV) system with a sun tracker. PVs are arrays of cells containing a solar photovoltaic material that convert radiation into direct current electricity via photovoltaic effects. Installation of a sun tracker is one of the approaches to improve the performance of a solar photovoltaic system. A sun tracker is a device for orientating photovoltaic panel towards the sun. The aim of this paper is to examine the performance of a solar photovoltaic system with a sun tracker in Batu Lintang, Kuching, Sarawak (1°32'09.73''N, 110°20'32.70E). A designed and developed solar photovoltaic system that is equipped with a sun tracker is presented. The developed system consists of five modules, i.e., a sensor system, a linear actuator system, a tracking mechanism, a battery storage system and charge controller, and a microcontroller system. Besides, the performance of the photovoltaic system with sun tracker and without sun tracker are compared, analyzed and evaluated with experiments. Concluding remarks is further presented.

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ABBREVIATIONS

3-D	3 Dimension
AC	Alternating Current
A	Ampere
ADC	Analog to Digital Converter
ASTS	Automatic Sun Tracking System
CdS	Cadmium Sulphide
CIS	Copper-Indium-Diselenide
δ	Declination Angle
^{o}	Degree
^{o}C	Degree Celsius
DC	Direct Current
I_0	Extraterrestrial Solar Irradiance
FPGA	Field Programmable Gate Array
GA	genetic algorithm
GPS	Global Positioning System
ω	Hour Angle
I/0	Input/Output
IC	Integrated Circuit
ISES	International Solar Energy Society
J	Joule

$\emptyset$	Latitude Angle
LDR	Light Dependable Resistor
LED	Light Emitted Diode
MW	Mega Watt
NPV	Net Present Value
PV	Photovoltaic
PLC	Programmable Logic Control
RAM	Random Access Memory
ROM	Read Only Memory
SA	Simulated-annealing
α	Solar Altitude Angle
I_{SC}	Solar Constant
θ_z	Solar Zenith Angle
VB	Visual Basic
V	Volt
W	Watt

CHAPTER 1

INTRODUCTION

1.0 Introduction

Solar energy is a clean, inexhaustible source of energy in everywhere of our world. The Sun provides approximately 4.3 x 10^{20}J per hour while the energy consumed on the earth is approximately 4.1 x 10^{20}J per year [1]. Thus, the amount of energy given by the sun is sufficient for the world electricity demand. Due to the shortage of fossil fuels, alternative source such as solar energy has become more important and increasingly popular around the world [2][3]. Besides, our environment is polluted during the process of energy production [4]. In Saudi Arabia, it was reported that average of 8182 tones of green house gases could be entering into atmosphere each year with each of 5 MW power plants [5]. These aspects have made environment-friendly and clean sources of renewable energy more important.

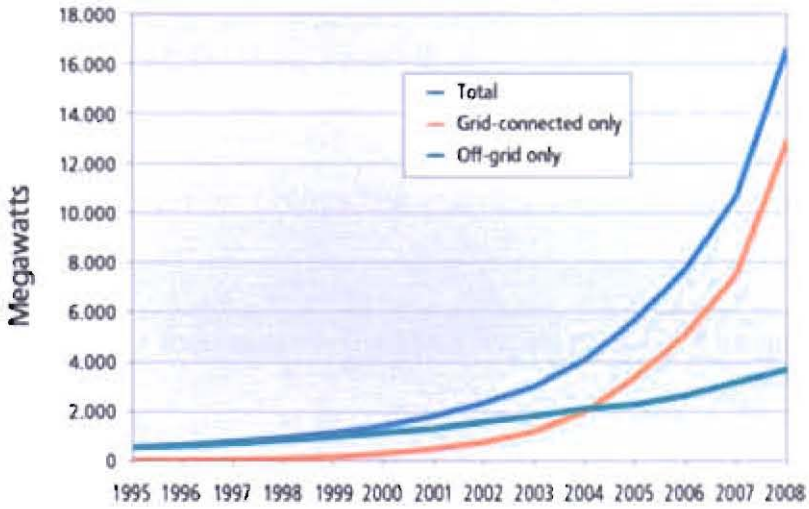

Fig. 1.1 Solar Photovoltaic (PV) energy capacity, 1995-2008

Fig. 1.1 shows the growth of Solar Photovoltaic (PV) energy capacity from year 1995 to 2008. In year 2008, ISES international Solar Energy Society [6] reported that the investment in Solar Photovoltaic (PV) energy has increased fourfold to record $120 billion. From end-2004 to end-2008, the total existing worldwide solar photovoltaic (PV) capacity has increased four times to more than 16gigawatts (GW). It shows that solar energy is drawing more attention from the worldwide due to its great potential in future renewable energy.

1.1 Project Objectives

The proposed project embarks in the following objectives:

i. To design and develop a controlling system to improve the power generation in solar panel.

ii. To analyze the irradiance in UNIMAS by using Solar time and geometrical coordinate.

iii. To analyze the performance of developed system.

1.2 Project Overview

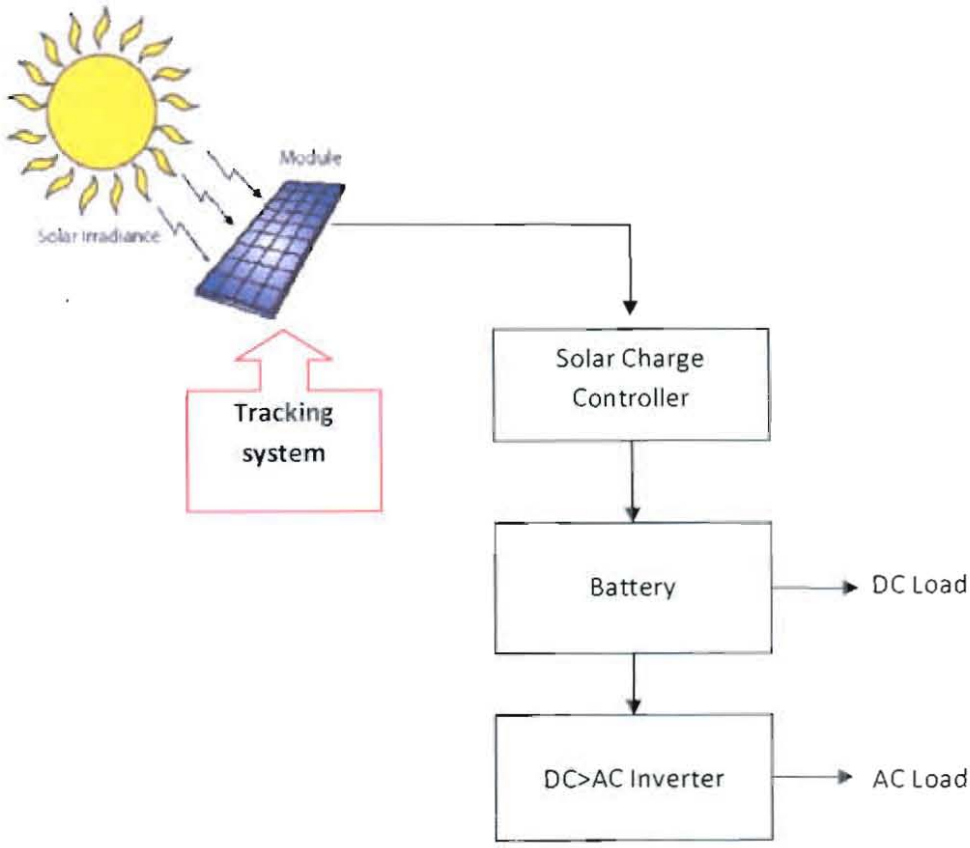

Fig. 1.2 Solar energy system with tracking control system

Fig. 1.2 shows a simple block diagram of the solar energy system with sun tracker. A solar charge controller would be connected between solar panel and battery for regulating the power generated from solar panel.

In this project, solar tracking system is implemented in solar energy system. The tracking mechanism would hold the solar panel and allows a 3-Dimension (3D) hemispheroidal rotation to track the sun's movement and allow all the light radiation is pointed perpendicularly to solar panel without any reflection. Therefore, the annual yield power generation can be improved.

1.3 Project Outline

Chapter 1: Introduction

In this chapter, an overview of the project, problem statement, project scope and thesis outline are presented. The aims and objectives of the project with the descriptions of the approach to the problems are clearly stated.

Chapter 2: Literature Review

In this chapter, earth-sun geometry, mathematical expression of solar irradiance, cost of generating energy with solar system, researches on strategies used to improve solar energy system are presented.

Chapter 3: Methodology

In this chapter, the developed solar tracking system which consists of solar sensor system, linear actuator system& motor controller, tracking mechanical system, battery storage system & charge controller and microcontroller system are presented.

Chapter 4: Result and Discussion

In this chapter, the developed solar tracking system is presented. The developed solar tracking system is divided into hardware (electronic circuitry and tracking mechanism) and software (Assembly programming code). Besides, the performance of solar tracking system and static solar system are compared and analyzed.

Chapter 5: Conclusion

In this chapter, the performance of solar tracking system and static solar system are summarized. Besides, the weaknesses of the developed system are discovered. Future works are commented and suggested.