EFFICIENCY IMPROVEMENT OF PHOTO VOLTAIC PANELS USING A SUN TRACKING SYSTEM CONTROLL BY PLC

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18 NOVEMBER 2005

"I am accepting that have been read this work of report. In my opinion this report is suppose in the scope and quality for purpose to award the Degree of Bachelor Of Electric Engineering (Industry Power)"

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Date	: 18 November 2005

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This Report Is Submitted In Partial Fulfillment Of Requirement For The Degree of Bachelor In Electric Engineering (Industry Power)

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NOVEMBER 2005

"I admit this report is producing by me except the summary and extraction for each I have been clearly presented."

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Thank you Allah for my beloved mother and father, my family,
my teachers and friends.

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First of all I would like to express my gratitude to my supervisor, Miss. Chong Shin Horng for her guidance and advise throughout the development of this project.

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ABSTRACT

Nowadays, people are concern about energy resources. Although it still available but the price is increasing and some of the sources are toward its end. Due to the problem, researchers are doing some research to gain or to get new energy recourses. Solar energy was one of the renewal energy that still undiscovered well. So, scientists were still doing research on how to get the most energy from the sun. Besides that, solar energy is free and available everywhere in this planet. Project on sun tracking system still in research in some develop country. But still they couldn't solve the problem on how to get the most energy from the sun. That why, I choose this project so that I could gain a lot of information about the latest invention. Besides that, this project is about designing and build a sun tracking system. It is a mechatronic's project where it is a combination of mechanical, electrical and electronic knowledge. The objectives of this project were design and build a sun tracking system that control by PLC. The PLC would control all the activities. The input devices like push buttons and limit switch send signal to PLC and PLC will make a respond. The respond will move the panel to the desire position where the panel was perpendicular to sun position. This project would be useful for power generation in the future where all the resources such as oil and gas have been come to an end.

ABSTRAK

Pada masa kini, manusia sentiasa mengambil berat berkenaan sumber tenaga. Walaupun sumber tenaga tersebut masih wujud tetapi harga semakin meningkat dan sebahagiannya akan menemui penghujungnya. Daripada masalah tersebut, para penyelidik telah melakukan penyelidikan untuk memperolehi sumber tenaga baru. Tenaga solar merupakan salah satu sumber tenaga yang boleh diperbaharui dan masih belum ada penemuan terbaru. Oleh itu, para saintis masih menjalankan penyelidikan berkenaan tenaga solar. Tenaga solar merupakan sumber tenaga yang percuma dan boleh didapati dimana –mana di dunia ini. Projek berkenaan tenaga solar giat dijalankan di negara-negara maju. Tetapi mereka masih belum menjumpai penyelesaian terhadap masalah tersebut. Oleh kerana itu, saya memilih projek berkenaan kerana saya boleh mendapatkan informasi terkini berkenaan rekaan terkini. Disamping itu, projek ini adalah berkenaan mereka dan membina pengesan matahari atau penjejak matahari. Ia merupakan projek mekatronik dimana ia menggabungkan ilmu dari bidang mekanikal, elektrikal dan elektronik. Objektif projek ini adalah untuk mereka dan membina penjejak matahari yang dikawal oleh PLC. PLC akan mengawal semua aktiviti yang terlibat. Peranti input seperti punat tekan dan suis penghad akan menghantar isyarat ke PLC dan PLC akan memberikan tindakbalas. Tindakbalas tersebut akan menggerakkan panel ke arah yang dikehendaki dimana panel terletak bertentangan dengan kedudukan matahari. Projek ini berguna untuk penghasilan kuasa pada masa akan datang dimana sumber seperti minyak dan gas telah habis.

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CHAPTER 1

INTRODUCTION

1.1 Objective

The objective of my project is to understand the function of the solar panel and sun tracking system. Beside that, it is about to design a sun tracking system that can detect the sun position by using mathematical method.

The other objective is to design the Programmable Logic Control (PLC) for controlling the direct Current (DC) motor that move the solar panel. Finally, my goal is to develop the most effective sun tracking system and this could be achieve by ensuring that the solar panel are perpendicular with the sun.

1.2 Scope

The project scope is design a sun sensor or use a mathematical method to detect the sun position. Other than that is to develop PLC for controlling the motor that move the solar panel.

1.3 Problem Statement

I'm choosing solar system as a project because solar energy is a renewable resource and sun light is free. Beside of that, Malaysia climate is well suite solar energy.

To produce or generate the energy, we won't produce any pollution because we use the direct sun light as source energy before convert it into electricity energy. When the project succeeds, we can use the system to rural areas that were away from the national grid.

I'm choosing PLC as a tool for my project because I can use PLC as a controller to control the motor movement that turns the solar panel. Other than that is to improve the reliability of the system. This is because the PLC will be automatically control the system.

CHAPTER 2

LITERATURE RIVIEW

2.1 Introduction

Photovoltaic term comes from the Greek *photos* meaning light and the name of the Italian physicist, Volta after whom the voltage are named.

A solar cell, or photovoltaic cell, is a semiconductor device consisting of a large area p-n junction diode which in the presence of sunlight is capable of generating useable electrical energy. This conversion is called photovoltaic effect. The field of research related to solar cells is known as photovoltaic.

Solar cells have many applications. They are particularly well suited to and historically used in situations where electrical power from the grid is useable such as in remote area power system, satellites water pumping applications and many more.

2.2 Photovoltaic History

Table 2.1: Year and event in photovoltaic development

Year	Event
1839	Nineteen-year-old Edmund Becquerel discovered the photovoltaic effect while experimenting with an electrolytic cell made up of two metal electrodes.
1873	Willoughby Smith discovered the photoconductivity of selenium
1876	Adams and Day observed the photovoltaic effect in solid selenium.
1883	Charles Fritts, an American inventor, described the first solar cells made from selenium wafers.
1904	Hallwachs discovered that a combination of copper and cuprous oxide was photosensitive. Einstein published his paper on the photoelectric effect.
1914	The existence of a barrier layer in PV devices was reported.
1918	Polish scientist Czochralski developed a way to grow single-crystal silicon.
1923	Albert Einstein received the Nobel Prize for his theories explaining the photoelectric effect.
1951	A grown p-n junction enabled the production of a single-crystal cell of germanium.
1954	The PV effect in Cd was reported; primary work was performed by Rappaport, Loferski and Jenny at RCA. Bell Labs researchers Pearson, Chapin, and Fuller reported their discovery of 4.5% efficient silicon solar cells; this was raised to 6% only a few months later (by a work team including Mort Prince).
1958	Hoffman Electronics achieved 9% efficient PV cells. Vanguard I, the first PV-powered satellite, was launched in cooperation with the U.S. Signal Corp. The satellite power system operated for 8 years.
1959	Hoffman Electronics achieved 10% efficient, commercially available PV cells

1960	Hoffman Electronics achieved 14% efficient PV cells.
1963	Japan installed a 242-W PV array on a lighthouse, the world's largest array at that time
1974	Japan formulated Project Sunshine. Tyco Labs grew the first EFG, 1-inch-wide ribbon by an endless-belt process.
1977	The Solar Energy Research Institute (SERI), later to become the National Renewable Energy Laboratory (NREL), opened in Golden, Colorado. Total PV manufacturing production exceeded 500 kW
1979	Solenergy was founded. NASA's Lewis Research Center (LeRC) completed a 3.5-kW system on the Papago Indian Reservation in Schuchuli, Arizona; this was the world's first village PV system. NASA's LeRC completed a 1.8-kW array for AID, in Tangaye, Upper Volta, and later increased power output to 3.6 kW.
1981	A 90.4-kW PV system was dedicated at Lovington Square Shopping Center (New Mexico) using Solar Power Corp. modules. A 97.6-kW PV system was dedicated at Beverly High School in Beverly, Massachusetts, using Solar Power Corp. modules. An 8-kW PV-powered (Mobil Solar), reverse-osmosis desalination facility was dedicated in Jeddah, Saudi Arabia.
1982	Worldwide PV production exceeded 9.3 MW. Solarex dedicated its 'PV Breeder' production facility in Frederick, Maryland, with its roof-integrated 200-kW array. ARCO Solar's Hisperia, California, 1-MW PV plant went on line with modules on 108 dual-axis trackers.
1983	The JPL Block V procurement was begun. Solar Power Corporation completed the design and installation of four stand-alone PV village power systems in Hammam Biadha, Tunesia (a 29-kW village power system, a 1.5-kW residential system, and two 1.5-kW irrigation/pumping systems). Solar Design Associates completed the stand-alone, 4-kW (Mobil Solar), Hudson River Valley home. Worldwide PV production exceeded 21.3 MW, and sales exceeded $250 million.

1984	The IEEE Morris N. Liebmann Award was presented to Drs. David Carlson and Christopher Wronski at the 17th Photovoltaic Specialists Conference, "for crucial contributions to the use of amorphous silicon in low-cost, high-performance photovoltaic solar cells."

[8]

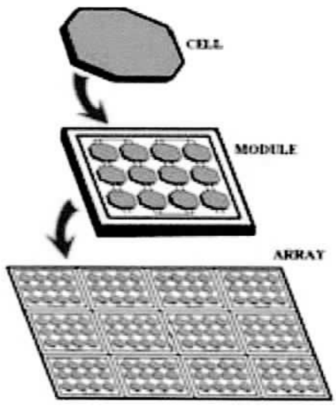


Figure 2.1: Solar cell, Solar Module and Solar Array

2.3 Materials and efficiency Of Photovoltaic

From the first time of photovoltaic development, various materials have been investigated to improve it. There are two main criteria in photovoltaic development, the efficiency and cost. Efficiency is a ratio of the electric power output to the light power input. Ideally, near the equator at noon on a clear day, the solar radiation is approximately $1000W/m^2$. So a 10% efficiency module of one square meter can power a 100W light bulb. Normally, costs and the efficiencies vary greatly.

The most common material for solar cells is crystalline silicon. Crystalline silicon solar cells come in three primary categories, single crystal or mono crystalline wafer, Poly or multi crystalline and ribbon silicon.

i. Single crystal or mono crystalline wafer made using the Czochralski process. Most commercial mono crystalline cells have efficiencies on the order of 14%. The Sun Power Company cells have high efficiencies around 20%. Single crystal cells tend to be expensive and because they are cut from cylindrical ingots, they cannot completely cover a module without a substantial waste of refined silicon.

ii. Poly or multi crystalline made from cast ingots. It is a large crucibles of molten silicon carefully cooled and solidified. These cells are cheaper and less efficient than single crystal cells. Although these cells are less efficient than the single crystal but it can easily be formed into square shape that cover a great fraction of a panel than mono crystalline cells and balance its lower efficiencies.

iii. Ribbon silicon formed by drawing flat thin films from molten silicon and has a multi crystalline structure. These cells are typically the least efficient but not expensive because there are very little waste silicon since this approach does not required sawing from ingots.

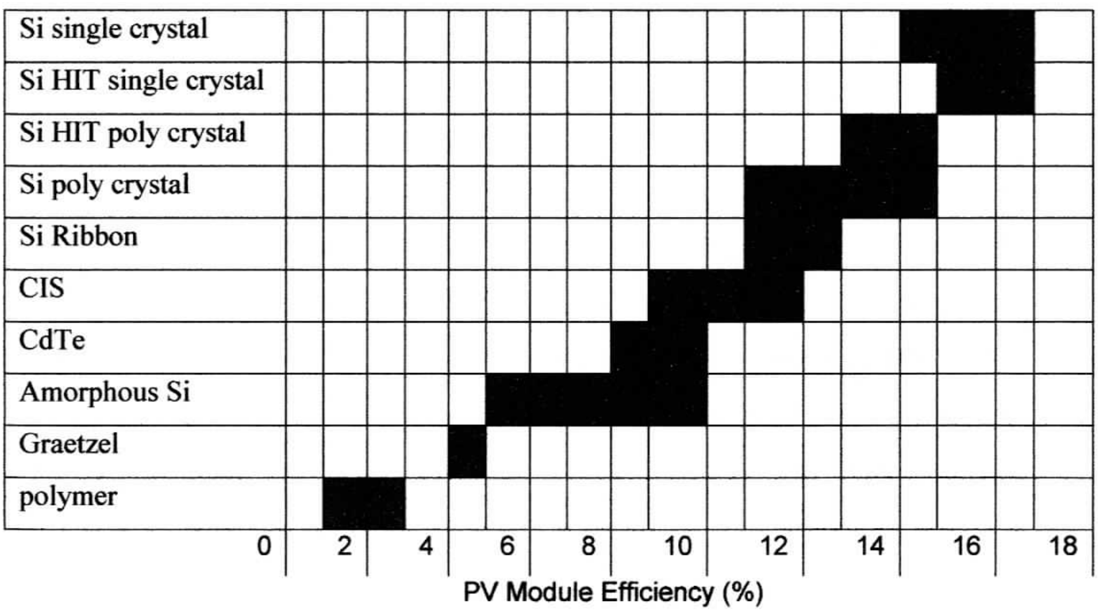
These technologies are wafer based manufacturing. In other words, in each of above approaches self supporting of 300 micrometers thick is fabricated and soldered together to form a module. Thin film approaches are module based. The entire module substrate is coated with the desired layers and a laser scribe is then used to delineate individual cells. Two main thin film approaches are amorphous silicon and CIS.

i. Amorphous Silicon film are fabricated using chemical vapor deposition techniques typically plasma enhanced (PE-CVD). These cells have low efficiency about 8%.

ii. CIS stands for chalcogenide film of Cu(InxGal-x)(SexS1-x)2 and these film can achieve about 11% efficiency but the costs is still too high.

Besides above, there are also additional materials and approaches. For examples, Sanyo has pioneered the HIT cells in this technology, amorphous silicon films are deposited onto crystalline silicon wafers. The table below shows the various commercial large area module commercial large area module efficiencies obtained for various materials and technologies.

Table 2.2: PV Materials and efficiencies



2.4 Photovoltaic Theory

Silicon (Si) is a group 14 atom. This means that each Si atom has four valence electrons in its outer shell. Silicon atoms can covalently bond to other Silicon atoms to form a solid. There are two basic types of solid silicon, amorphous and crystalline. Beside that, there are various other terms for the crystalline structure of silicon. They were poly crystalline, micro crystalline, nano crystalline and many more. These refer to the size of the crystal small pieces which make up the solid. Solar cells can be made from each of these types but the most commonly used is poly crystalline.

Silicon is a semiconductor. This means that in solid silicon, there are curtain bands of energies which the electrons are allowed to have, and other energies between these bands which are forbidden. These forbidden energies are called the "band gap". The allowed and forbidden bands of energy are explained by the theory of quantum mechanics.

At room temperature, pure silicon is a poor electrical conductor. In quantum mechanics, this explains by the fact that the Fermi level lies in the forbidden band gap. To make silicon a better conductor, it is doped with very small amounts of atoms from either group 13 (III) or group 15 (V) of the periodic table. These "dopant" atoms take the place of the silicon atoms in the crystal lattice, and bond with their neighboring Si atoms in almost the same way as the other Si atoms do.

However, because group 13 atoms have only 3 valence electrons and group 15 have 5 valence electrons, there is either one too few or one too many electrons to satisfy the four covalent bonds around each atom. Since these extra electrons or known as holes are not involved in the covalent bonds of the crystal lattice, they are free to move around within the solid. Silicon which is doped with group 13 atoms (aluminum and gallium) is known as p-type silicon because the majority holes carry