Development of PV and TEG Integrated Charging System for Rechargeable Lithium Ion Battery for Hybrid Car

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A report submitted in fulfillment of the requirement for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

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2015

I hereby declare that I have read through this report entitle “Development of PV and TEG Integrated Charging System for Rechargeable Lithium Ion Battery for Hybrid Car” and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)

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Date : 29/05/2015

I declare that this report entitle “Development of PV and TEG Integrated Charging System for Rechargeable Lithium Ion Battery for Hybrid Car” is the result of my own research excepts as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……

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Date : 29/05/2015

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ABSTRACT

Sales of hybrid and electric cars are rapidly gaining in the market nowadays. The factors these two vehicles production actually caused by two main reasons that are to reduce fuel consumption and reduce greenhouse gases emission. Generally the rate of air pollution can be reduced by using an alternative way which is generating renewable energy from clean energy sources. Hybrid and electric vehicles have within them an electrical source system such as braking system and rotation of tire that will produce electricity for charging the batteries car. Every windshield of a car will be exposed to 60% of solar irradiation, is highly recommended for hybrid or electric car to install transparent solar system by replacing the entire window's car. The installation of transparent solar system can be one of the electrical source systems in hybrid car. This report stated the outcome of investigation on the performance of solar panel with respect to the sun irradiation and its energy consumption for hybrid car in analysis part. An alpha version of prototype has been made for the experimentation on hardware and collection data. 3 major step of methodology has been describe to make this project complete and working well, that are planning, construct and analysis. Finally, the contribution of transparent solar panel for hybrid car is about 0.5761kwh energy consumption which is can make the vehicle travel about 3 to 4km after one day under sun emission and less of 565g carbon dioxide release compare to the others gasoline cars.

ABSTRAK

Kereta hibrid dan kereta elektrik semakin banyak dipasarkan hari ini. Faktor pengeluaran kereta jenis ini sebenarnya disebabkan oleh dua sebab utama, iaitu mengurangkan kadar penggunaan petrol dan mengurangkan perlepasan gas rumah hijau. Umumnya kadar pencemaran udara dapat dikurangkan dengan menggunakan jalan alternative iaitu menghasilkan tenaga boleh diperbaharui daripada sumber tenaga yang bersih. Terdapat sistem sumber tenaga elektrik dalam kereta hibrid seperti sistem brek dan pusingan tayar yang bertujuan untuk menghasilkan tenaga elektrik supaya dapat mengecas bateri kereta. Setiap cermin kereta akan terdedah kepada 60% daripada sinaran matahari, dan adalah sangat disyorkan bagi kereta jenis hybrid atau elektrik memasang sistem solar lut sinar dengan menggantikan semua cermin kereta. Pemasangan sistem solar lut sinar ini akan menjadi sebahagian daripada salah satu sistem sumber tenaga elektrik dalam kereta hibrid. Laporan ini menunjukkan hasil siasatan telah dibuat terhadap prestasi panel solar dengan keamatan sinaran matahari dan penghasilan tenaga daripada sistem solar untuk kereta hibrid dalam bahagian analisis. Sebuah model versi alpha telah di bina untuk tujuan ujikaji dan pengumpulan data. Langkah-langkah yang diambil bagi menyiapkan projek ini telah di terangkan secara lengkap, antaranya ialah step perancangan, pembinaan, dan analisis. Akhir kalam, sistem solar lut sinar dapat menyumbangkan sebanyak 0.5761kwh tenaga, yang mana boleh menggerakkan kereta sejauh 3 ke 4 km pada satu hari berada di bawah sinaran matahari.

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CHAPTER 1

INTRODUCTION

1.1.1 Introduction

Hybrid cars productions today are marketed by two major benefits, which are increased fuel economy and reduce greenhouse gases emission. Generally, hybrid cars produce 80% less harmful pollutants and greenhouse gases than comparable gasoline cars. This translates to eco-friendly system, and a cleaner earth. A hybrid car is driven by a hybrid engine, which is any engine that combines two or more sources of power, generally gasoline and electricity. Hybrid systems use batteries to store the sources of power to make the vehicle move, while braking system use to generate kinetic energy so that the batteries can recharged while driving [1]. In this report, the implementation of transparent solar panel to replace all windshield glass in hybrid car in order to be a part of electrical source system for charging the batteries.

Solar energy is a renewable energy, which has going to be progressively well known nowadays. It has noticeable healthy than non-renewable energy such as nuclear energy, coal and oil. It is can produce energy anywhere that there is sun shining and non-polluting, so its resources are not going to run out anytime soon. It also has advantages than other renewable energy such as water power and wind turbine. Sun power is generated using solar panel, no mechanical part are involve for generating an electricity like wind turbine. The mechanical parts produce noise or can be break down and cause maintenance issues. Both of these issues are virtually non-existent with solar panels. Beside, solar panels are also can last up to several decades without replacement. Because of these several reasons, it is better for hybrid car to install solar panel in its system for charging the batteries. This report will also discussed about selecting the best type of solar panel for windows, type of batteries, and calculation of energy consumption by solar cell and distance traveled by vehicle.

To begin the project, an alpha version of a prototype (hardware) needs to construct to study the performance of solar panel with respect to the sun radiation and its contribution (energy consumption).

1.2.1 Background

The sun is known to supply the world with a permanent and abundance clean energy source in the form of solar radiation. The measure of sun oriented radiation captured by the world's surface is 82×10^{15} W which is much higher compared to the annual global energy use [2]. Understanding this, researches have been widely done lately producing many promising technologies in order to extract the sun"s energy. Hybrid car have currently been introduced to the market. These hybrid cars have components such as a computer, inverters, a battery, and electric traction motors which can readily use photovoltaic generated electricity to produce propulsion.

In this chapter, there are discussing about the introduction of photovoltaic system in term of renewable energy and the improvement of electrical source system in hybrid car. The objective of the project is to understand in flow of the system. It started from, photovoltaic system, converter configuration, battery that can be used and compare to the recent hybrid car. Problem statement, objective and scope of the project will be explained in detail. Hybrid system, operation of photovoltaic will be explain and discuss deeply in Chapter 2.

1.3 Problem Statement

Energy policies and global warming have become a hot topic on the international issue. Advanced countries are trying to lessen their greenhouse gas outflows. Clean energy can be produce by a technological alternative such as renewable energy source. Over the renewable energy, photovoltaic system has received a big attention as it appears to be one of the most promising zero emission. Solar modules to vertical walls or facades had been widely used to produce energy. To avoid pollution caused by fossil fuels from the cars and to save fuel cost, hybrid system is the one of the best way to be installed for car. For construct model of the system, it required to understand the operation of solar system to meet the specification of hybrid car system. Lot of fundamental engineering knowledge is needed to begin this project.

1.4 Motivation

The car‟s windshield surface, which receives up to 60% of the solar radiation incident upon the vehicle glazing, is traditionally tinted, resulting in absorption but produce nothing. When solar radiation hits the car glass windows, 4% of radiation is reflected off the glass, another 3% absorbed by the glass, and 53% transmitted through the glass shows in figure 1.1.

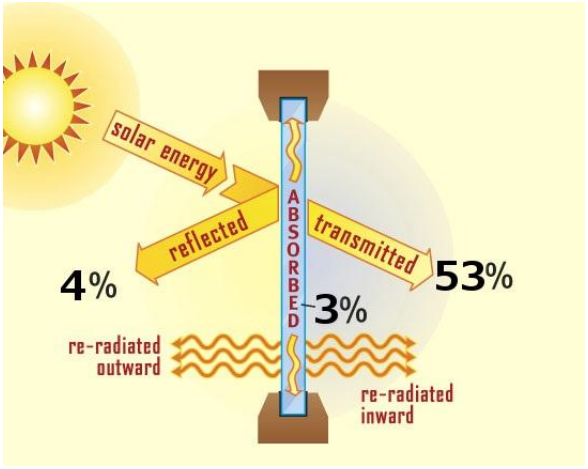


Figure 1.1: Windshield surface receives solar radiation

For these reasons, it is needed to design a PV integrated power source, to replace windshield glass so that it will utilize the wasted energy generated by sun to produce electrical energy to charge a battery of hybrid car. It is can be a new part of electrical source systems to improve the charging system in hybrid car. Before, hybrid car might have braking system to utilize kinetic energy or dynamo to generated electricity by rotation of tires or maybe solar panel on the roof top, but now then system will improved by installing the transparent solar panel for all glasses to optimize day light energy for charging the batteries during parked or driving under the sun. The motivation of this thesis, develop a photovoltaic solar panel in windshield glasses so that it will utilize the wasted energy produced by sun to produce electrical energy for charging a battery of hybrid car. It will be new part of electrical source system to improve the charging rate while generating clean electricity and eco-friendly system.

1.5 Objectives

Design and analysis of photovoltaic integrated charging system are the aims of the research. The photovoltaic integrated should be capable to meet specification of battery such as output power, voltage, and current. To achieve these aims, the objectives of this research are to:

I. Analyze the output value from model of solar charging system with using related theories and formula.

II. Analyze the operation of transparent solar panel that will be installing for charging system in hybrid car.

III. Investigate the performance of solar panel with respect to the sun radiation and its energy consumption.

1.6 Scope Of Projects

The scopes of this project are:

I. Developing a model of photovoltaic module that converts solar energy to electric energy.
   - Design a prototype of electrical system for charging batteries in small scale. Use batteries bank as a storage unit and solar panel as a generating system.

II. Determination type of photovoltaic cell that will be designed.
   - Study on the best type of photovoltaic cell for windows which are needs to be transparent and efficient. Understanding the suitable type of solar panel that can be selected.

III. Research on battery chemistries that suitable for hybrid car that can be able for solar panel to store the energy.
   - Investigate the suitable type of batteries used by electric motor of hybrid car. The percent of charged energy input by solar panel daily.

1.7 Project Conclusion

At the end of this project, the outcome to produce a charging system for hybrid car‟s battery which is powered via transparent solar panel is recommended to install. Hybrid vehicles are able to make effective use of solar energy. Replacing all windshield glasses in hybrid car to utilize the sun energy, hoped these alternative and more environmentally friendly technologies may be implemented. Finally, a conclusion will be concluded to summarize the overall project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Today, hybrid electric vehicles are chosen for the option of the day and many automobile companies have their interest and asset in this area. The main reasons for this are for the coming energy crisis, and significant increase of greenhouse gases. The proposed system can produce power, without polluting the air.

Thus this chapter will explain development an electrical source system for electric or hybrid car which includes the solar panel and batteries as its input energy sources and the power electronic devices as connecting and transforming part. The transparent solar which is mounted with windshield absorbs solar energy during the day time to supplement energy cost of battery.

Then, type of solar cell, such as crystalline silicon solar cell and thin-film solar cells is studied and explained clearly. Lastly, this chapter explain about the designing an electric vehicle with a thin-film silicon photovoltaic cells to charge battery of hybrid car as well as to utilize the wasted energy.

2.2 Overview of Photovoltaic System and Earlier Researches

Photovoltaic cells are available in the market with different semiconductor materials. The most popular semiconductor materials for PV are monocrystalline, polycrystalline, thin film and copper-indium selenide (CIS). The technologies involved of p-n junction diodes capable of generating electricity from light sources and usually have efficiencies of 6% - 20% in market use [1].

Making of Monocrystalline and polycrystalline silicon arrays are almost the same way. There are made up of individual 0.5 V cells connected together to achieve the required power [1]. Their weigh less than the amorphous and CIS arrays, and are about half the size of CIS arrays in which to produce the same power.

Microcrystalline silicon carbide (μc-SiC:H) thin film, CIS thin film and amorphous thin film are the most popular type of Thin Film PV technologies. Thin film be made up of a layer of silicon fabricate with glass and plastic [2].]. A laser scribe is then used to mark out individual cells. Thin film cell generate very good energy consumption on sunny days compare to other crystalline silicon cell. However thin film need to be bigger in size than other crystalline silicon cell in way to produce the same energy.

Basically one single cell can produces about 0.5 volt and then they are connected together to form modules (combination of 36 cells). Combination connected of modules can form larger units called arrays as shown by Figure 1.1.

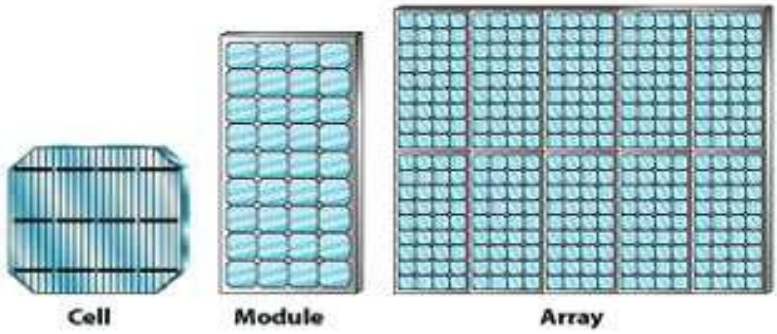


Figure 2.1: Arrangement of PV Cell, Module and Array [3]

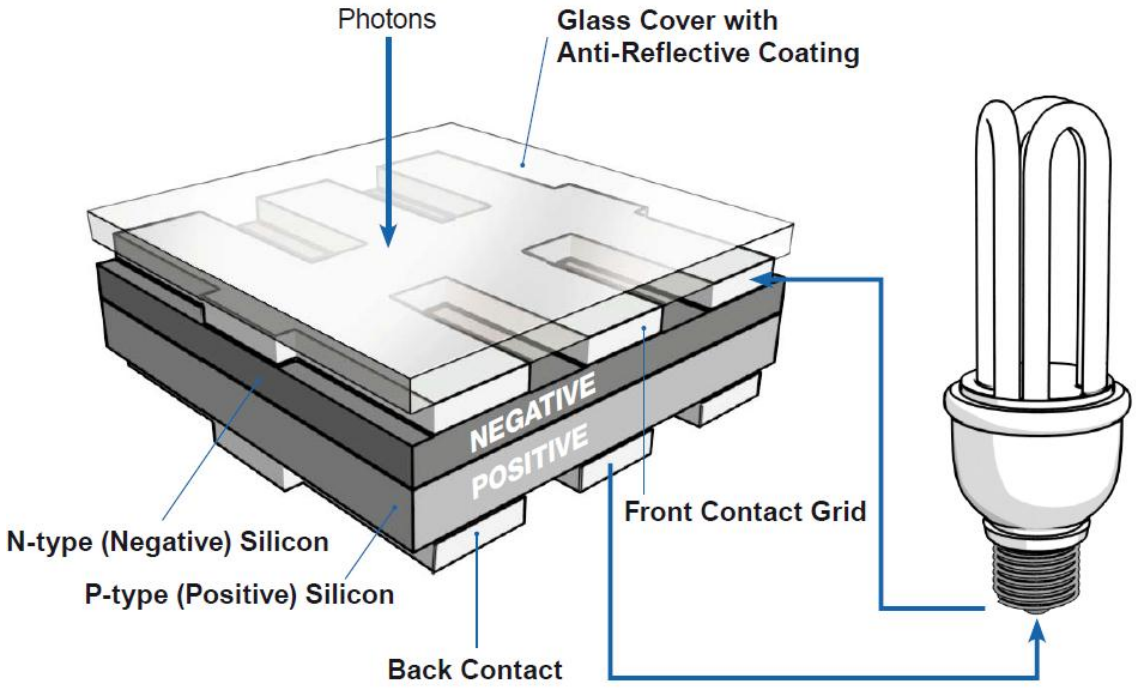
2.3 Principle of Solar Cell

A photovoltaic or solar panel is made up of several photovoltaic solar cells. A cell of photovoltaic normally generates about 1 or 2 watt of power [3]. Energy is generated when photons of light from the sun collides a solar cell and are captivated inside the semiconductor material. This energizes the semiconductor‟s electron, result in the electrons to discharge, and produce an electric current [3]. The electricity generated is direct current (DC) since the flow of charge is in one direction. To increase the output power of PV cells, they are connected together to form larger units. This joined cell is call array, and the combination between arrays are called module. Producing module is to produce more power, and so on. Therefore, photovoltaic systems can be built to meet all electric power need, small or large.

2.4 Structure of a Solar Cell

Solar panels, from the very small ones used in some calculators, to the much larger ones found on some suburban rooftops, are made up of various numbers of photovoltaic cells. These cells, also known as solar cells, make use of a natural energy source, the sun, to generate electrical power without any moving parts, noise, pollution, radiation or the need for maintenance [5]. A solar cell is formed by a composition of materials typically made up of the following layers:

I. Glass cover with anti-reflective coating
II. Front contact grid
III. N-type (negative) silicon
IV. P-type (positive) silicon
V. Back contact grid.



Picture 2.2: Typical Solar Cell Structure [4]

When photons that are light from the sun strike the cell, they give up their energy to electrons in the P-type layer causing them to jump to the N-type layer (positive to negative). This transfer of electrons forms a current which flows from the „back contact grid" through a circuit to the „front contact grid. A number of solar cells can be wired together into a solar panel to increase the voltage as may be required for different applications such as household hot water heaters and solar powered cars [6].

2.5 Crystalline Silicon (c-Si)

The popular choice of solar cell material is silicon because it"s inherent physical quantities. Silicon has 4 valence electrons from an 8 „holes". It will always attract to fill the other 4 „holes", thus the hole will sharing electrons with another silicon atoms [5]. A lattice type structure then created after the sharing proces, where every atom in the structure bonds with four other atoms in the structure.

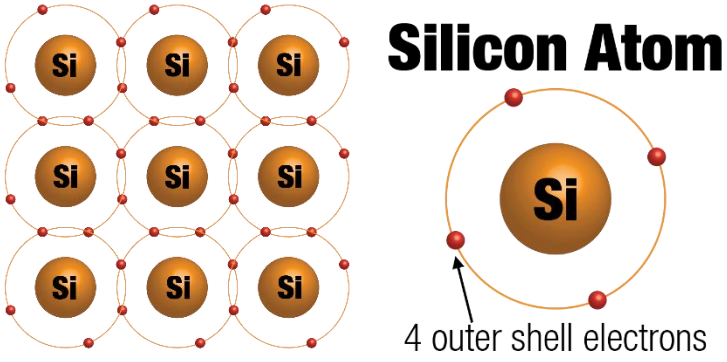


Figure 2.3: Structure of Silicon Atom bonds with four other atoms [5]

Under the sun emission days, energy is added to silicon material. Then the electron will be knock out and free from lattice structure, but this proces need a lot of energy and produce very few free electron. As the free electron release from lattice, there is small current flow. Therefore, some impurities are added to increase its current. The process of added impurities to the silicon is called doping process [5].

Atom consist of more electron is „doped" into the silicon materials to create negative charge of silicon or atom that consist of less electron is doped to create positive charge of silicon. These compounds are n-type and p-type [5].

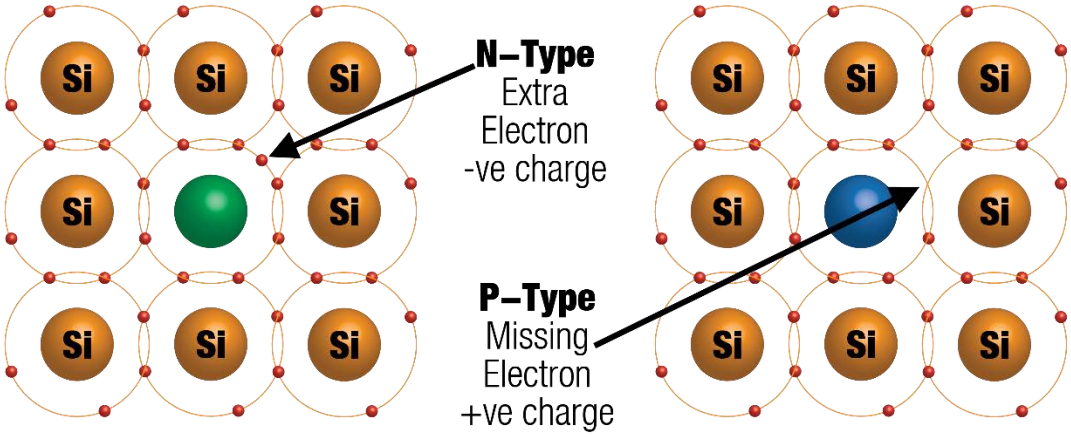


Figure 2.4: Number of P-type and N-type Silicon Atom Electron [5]

If the N-type get energy, there will be lot free electron produced in the structure. Then, this N-type silicon is placed next to the P-type silicon so that the free electron can get into the hole in P-type silicon, and then generate a current flow [5].

2.5.1 Mono-crystalline Silicon Solar Panel

Single silicon crystal can form a Mono-Crystalline panel. Silicon crystal can get either made in a laboratory of found naturally (hard to find). Process of create this crystal is called recrystallizing, which is tough to produced and then will make the Mono-crystalline panels more expensive. The interface of Mono-Crystalline is smoother than poly- Crystalline panel, as shown in figure 2.5. Normally Mono-Crystalline efficiency is around 15% at 25°C, and then drops at 50°C by 12% to 15% [7]. Therefore, the higher temperature of the panel gets, the lower the efficiency of the solar panel.

Figure 2.5: Mono-crystalline Silicon Solar [7]