MODELING STAND ALONE PHOTOVOLTAIC-WIND HYBRID SYSTEM FOR 100W MOTOR

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Bachelor of Electrical Engineering

July 2012

" I hereby declare that I have read through this report entitle "*Modeling Stand Alone Photovoltaic-Wind Hybrid System for 100W Motor*" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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Supervisor‟s Name : .....

Date : .....

MODELING STAND ALONE PHOTOVOLTAIC – WIND HYBRID SYSTEM FOR 100W MOTOR

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Power Electronic & Drive

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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I declare that this report entitle "*Modeling Stand Alone Photovoltaic-Wind Hybrid System for 100W Motor*" is the result of my own research except 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 : .....

Name : .....

Date : .....

To my beloved mother and father

ACKNOWLEDGEMENT

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ABSTRACT

Hybrid system of Photovoltaic (PV) - Wind turbine (WT) generation has more advantages compared to PV or wind turbine alone. The main objective of this project is to study the characteristic of the hybrid system of PV-WT besides supplying 100W permanent-magnet dc motor with this type of sources. The aim of this project also is to design a hybrid system of PV-WT for the source of 100W permanent-magnet dc motor. To achieve the objective, both of PV and WT are connected to converter in order to get the same source of DC supply. Then both source are combine or hybrid and straightly connected to 100W permanent-magnet dc motor. All the works in this project is only apply in circuit simulator of Matlab Simulink. The output source from each converter is expected to be suit to the motor specification. The value of the output source from each renewable energy system is expected to be high as it can support the motor if one of them is breakdown.

ABSTRAK

Sistem kombinasi hibrid daripada tenaga solar (PV) – kincir angin (WT) mempunyai lebih banyak kelebihan berbanding PV atau kincir angin yang dijalankan secara tunggal. Objektif utama projek ini adalah untuk mengkaji ciri-ciri sistem kombinasi hibrid PV-WT selain membekalkan 100W motor arus terus dengan menggunakan tenaga ini. Tujuan projek ini juga adalah untuk mereka bentuk satu sistem kombinasi hibrid PV-WT untuk sumber 100W motor arus terus. Bagi mencapai matlamat tersebut, kedua-dua PV dan WT disambungkan kepada penukar untuk mendapatkan sumber bekalan yang sama iaitu sumber arus terus. Kemudian kedua-dua sumber tersebut digabungkan atau dihibrid dan seterusnya disambungkan kepada 100W motor arus terus. Semua kerja-kerja dalam projek ini hanya dijalankan pada simulasi litar iaitu Matlab Simulink. Sumber keluaran daripada setiap penukar dijangka menjadi sesuai kepada spesifikasi motor. Nilai sumber keluaran dari setiap sistem tenaga boleh diperbaharui ini dijangka menjadi tinggi sehingga ia boleh menyokong motor jika salah satu daripada mereka mengalami kerosakan.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background

The World Energy Forum has predicted that natural sources such as oil, coal and gas reserves will be exhausted in less than another 10 decades. Petroleum account for over 79% of the primary energy consumed in the world, and 57.7% of that amount is used in the transport sector and are extremely reduced. The exhaustion of natural resources and the increasing demand towards the conventional energy have forced planners and governor to look for alternative sources. Renewable energy is energy derived from resources that are regenerative, and do not deplete over time. Based on the development of such applications, renewable energies have been increased markedly in recent years. This is proven with the approach taken by each governor and education institute, where all the renewable energy is being study in order to implement the application for their future.

1.2 Problem Statement

Nowadays, the natural resources are unlimitedly dissipated. This is because the demand towards these types of sources is become higher in each consecutive year. If this situation is last for many years ahead, our world will see the extreme decreasing in natural sources and leading to the problem for each governor to make their people life better. As a result, many new form of energy which is potentially renewable is extensively examined and developed. Then the newly form of energy such as solar system, wind turbine and diesel generator finally revealed and used. But another issue is come out which is the stand alone renewable energy has low reliability and flexibility such as the maintenance and the surrounding application. So by having hybrid system (combined renewable energy), as the intention of this project, the energy resources is become more flexible and reliable.

For example the hybrid system of solar and wind turbine. This is because solar system is applicable during sunny day and the wind turbine greatly functions during a windy night. This eventually would make our life better as the natural sources could be greatly reserved.

1.3 Objectives

The aims of this project are as follow:

1. To study the characteristic of PV, WT and hybrid system of PV-WT.
2. To supply and operate 100W permanent-magnet dc motor with hybrid system of PV-WT.
3. To design a hybrid system of PV-WT for the source of 100W permanent-magnet dc motor.
4. To analyze the performance PV, WT and hybrid system of PV-WT.

1.4 Scope

This project primarily focuses on several parts. The first part is the source of the renewable energy which is only consisting of PV and WT system. Second part is the motor. In this project the motor used is only permanent-magnet dc motor and the rated power is 100W DC supply. Other than this type of motor or higher rated specification is not included in this project. And the most important thing is the primarily supply is only from the renewable energy of PV and WT. Last, but not least all the works in this project is only apply in circuit simulator of Matlab Simulink and no hardware to be constructed.

CHAPTER 2

THEORY AND LITERATURE REVIEW

2.1 Introduction

For this project, simulation and analysis will be done. But literature review is needed to have more understanding for the ongoing project. The literature review is on the related topic and subject from various sources of information such as technical paper report, books, and journal. In this section, the theory or basic principle of component used in this project are discussed. This includes their general characteristic, basic function, advantages and many more. For this projects system, the component or system developed are photovoltaic system, wind turbine system, buck converter and DC motor.

2.2 Photovoltaic system

2.2.1 Definition

PV can be describe as a kind of technique or method of generating electrical power by transforming solar radiation into direct current electricity using semiconductor [6]. Since solar energy is the most abundant energy source on the planet, photovoltaic system can be classified as a vital technology that needs to be explored extensively in order to preserve our planet.

2.2.2 Operation

A PV cell is basically a semiconductor diode whose *p–n* junction is exposed to light [1]. Basically photovoltaic cell is made from several types of semiconductor such as monocrystalline and polycrystalline silicon cells. Silicon PV cells are composed of a thin layer of bulk Si or a thin Si film connected to electric terminals. One of the sides of the Si layer is doped to form the *p–n* junction. A thin metallic grid is placed on the Sun-facing surface of the semiconductor [2].

The incidence of light on the cell generates charge carriers that originate an electric current if the cell is short circuited [3]. Charges are generated when the energy of the incident photon is sufficient to detach the covalent electrons of the semiconductor. This phenomenon depends on the semiconductor material and on the wavelength of the incident light.

Basically, the PV phenomenon may be described as the absorption of solar radiation, the generation and transport of free carriers at the *p–n* junction, and the collection of these electric charges at the terminals of the PV device [4]. Figure 2.1 illustrates the physical structure of a PV cell [2].

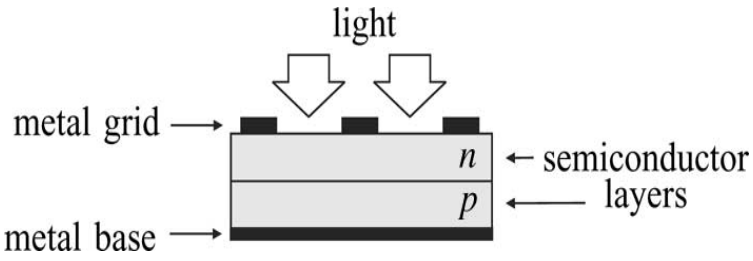

Figure 2.1: Basic physical structure of PV cell [2].

The rate of generation of electric carriers depends on the flux of incident light and the capacity of absorption of the semiconductor. The capacity of absorption depends mainly on the semiconductor band gap, on the reflectance of the cell surface (that depends on the shape and treatment of the surface), on the intrinsic concentration of carriers of the semiconductor, on the electronic mobility, on the recombination rate, on the temperature, and on several other factors [2].

The solar radiation is composed of photons of different energies. Photons with energies lower than the band gap of the PV cell are useless and generate no voltage or electric current. Photons with energy superior to the band gap generate electricity, but only the energy corresponding to the band gap is used. And the rest of the energy is dissipated as heat in the body of the PV cell. Semiconductors with lower band gaps may take advantage or a larger radiation spectrum, but the generated voltages are lower [5].

In order to increase the amount of generated electricity, the PV cell can be connected each other to form a PV module. Then if the PV module is wired or connected together whether in series or parallel, the amount of the electricity can be multiple. This formation or structure is called PV array. Figure 2.2 [10] show the PV cell, PV module and PV array.

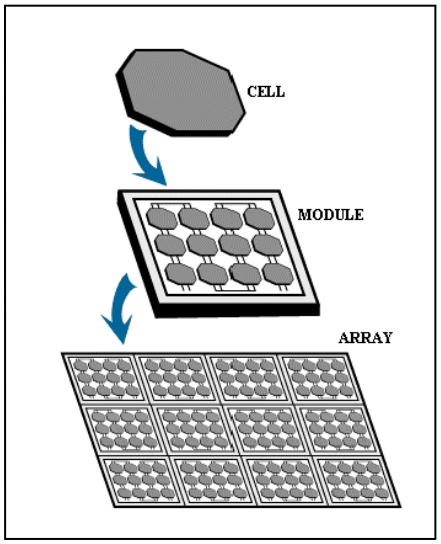

Figure 2.2: PV cell, PV module and PV array [10].

2.2.3 Equivalent circuit model

A simplified equivalent circuit of a solar cell consists of a diode and a current source which are connected in parallel. The photocurrent generated when the sunlight hits the solar cell can be represented with a current source and the P-N transition area of the solar cell can be represented with a diode. The shunt and series resistances represent the losses due to the body of the semiconductor and the contacts respectively [8-9]. Such an equivalent circuit of the solar cell is shown in Figure 2.3[2].

The voltage and current relationship in the simplified solar cell model can be derived from Kirchhoff's current law. According to Kirchhoff's current law, all currents entering and leaving a node add up to zero.

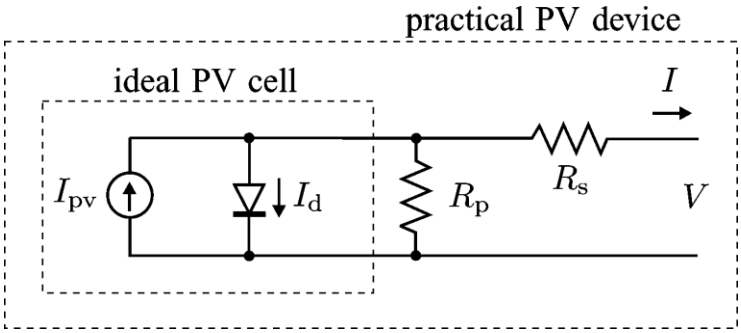

Figure 2.3: Solar cell equivalent circuit model [2].

Practical PV system usually is already formed in small array structure which means a module. As stated before, the PV array is consisting of several PV module and PV cell. So to determine the model parameter especially the output is based on the I-V characteristic curve which originated from following equation.

$$I = I_{pv} - Io\left[exp\left(\frac{V+RsI}{V_{ta}}\right) - 1\right] - \frac{V+R_SI}{R_P} \quad (2.1)$$

Where;

I_{pv} = Photovoltaic current

I_o = Saturation current

R_s and R_p = Series and shunt resistance

V_{ta} = $NskT/q$ = Thermal voltage

N_s = Cell connected in series

q = Electron charge, 1.6 x 10-19 C

k = Boltzmann"s constant, 1.38 x 10-23 J/K

In electrical principle, loads that connect in series would increase the output voltage while loads connect in parallel increase the output current. And same goes to PV system which constructed in array formation. This equation originates the I-V curve seen in Figure 2.4 [2], where three are highlighted which is short circuit (0,Isc), maximum power point (Vmp, Imp) and open-circuit (Voc, 0). For the power output, the P-V characteristic curve is shown in Figure 2.5 [2].

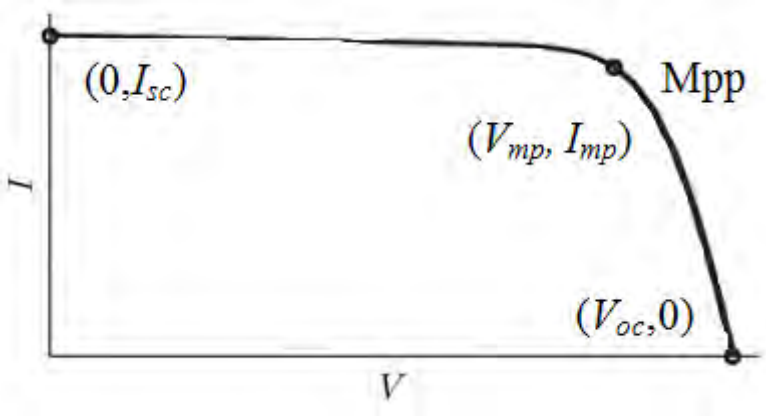

Figure 2.4: Characteristic I–V curve of a practical PV device and the three remarkable Points: short circuit (0, Isc), MPP (Vmp, Imp), and open circuit (Voc, 0) [2].

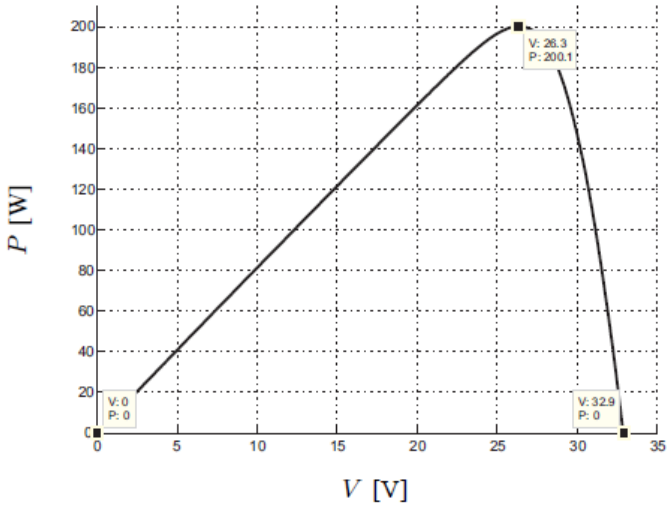

Figure 2.5: The P-V characteristic curve.

Some advantages of PV system [1]:

- Simple installation and long life (30 years)
- Low maintenance and light weight
- Silent and clean
- No moving parts and environmentally friendly

Some disadvantages are [1]:

- Limited power and Inefficient on cloudy days
- Drastic power reduction if any part of panel is shade
- Renewable energy production is dependent on natural cycles, i.e. PV does not work at night
- Initial cost of these systems is higher than comparably sized conventional generators
- They unable to handle peak loads well without energy storage

2.3 Wind turbine system

2.3.1 Definition

Wind turbines are used to generate electricity from the kinetic power of the wind. Historically they were more frequently used as a mechanical device to turn machinery [12]. In other words wind turbine is a device that changes kinetic energy from the wind source to generate mechanical energy. In windmills, wind energy is used to turn mechanical machinery to do physical work, such as crushing grain or pumping water. Wind power is used in large scale wind farms for national electrical grids as well as in small individual turbines for providing electricity to rural residences or grid isolated locations. Wind energy is plentiful, renewable, widely distributed, cleans, and reduces toxic atmospheric and greenhouse gas emissions if used to replace fossil-fuel derived electricity.

The wind energy is change through friction into diffuse heat throughout the Earth's surface and the atmosphere. The Earth is unevenly heated by the sun resulting in the poles receiving less energy from the sun than the equator does. Also the dry land heats up and cools down more quickly than the ocean do. The differential heating powers a global atmospheric convection system reaching from the Earth's surface to the stratosphere which acts as a virtual ceiling. There are some advantages and disadvantages of wind power on the surrounding environment, and the general reliability of wind turbines [13].

The advantages of wind energy:

1. Wind energy is very friendly to the surrounding environment because there are no fossil fuels are burnt to generate electricity from wind power.
2. WT takes up less space than the average power station.
3. WT is a suitable resource to generate electricity in remote locations, such as mountain and countryside communities.
5. If this type of source is combined with solar electricity system, this energy source is good for a country in order to provide a steady, reliable supply of electricity.

The disadvantages of wind energy:

1. The main disadvantage of wind power system is down to the winds unreliability factor. If the wind speed is too low, then the WT would be considered as inefficient type of power source.
2. A WT can only support a specific population. WT aren't like power stations, where you can just burn a bit more fuel to generate more energy when you need it.
3. The noise pollution from commercial wind turbines is on a par with a small jet engine.
4. Vast protests and/or petitions usually confront any proposed wind farm site. People feel the countryside should be left intact for everyone to enjoy its beauty.

2.3.2 System component

Designing a WT require numerous component of electrical and mechanical such as rotor blade, nacelle, transmission, generator and many more as shown in Figure 2.6. But this report would only discuss about the main component of WT which are rotor blade pitch angle, transmission and generator, since only these component are being used to develop the model.

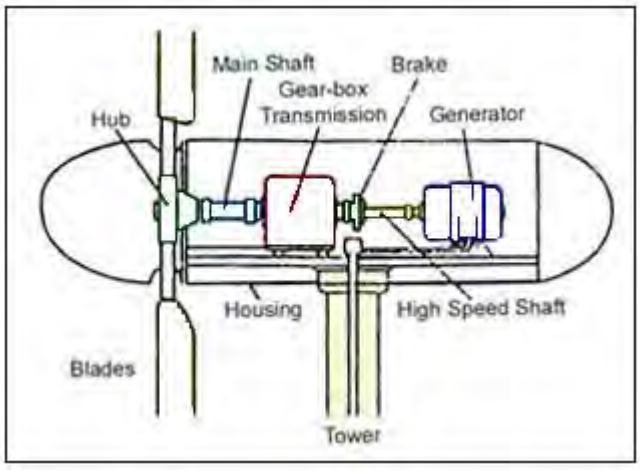

Figure 2.6: General construction of WT [20].