IMPLEMENTATION OF A BUCK BOOST CONVERTER IN MOTOR CONTROLLER FOR A SOLAR CAR

MOHD AZMI BIN AMAT MANIS

A report submitted in fulfillment of the requirements for the award of the degree of the Bachelor of Electrical Power System

Faculty of Electrical & Electronic Engineering
Universiti Malaysia Pahang

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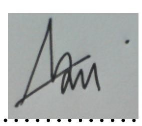

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Author : MOHD AZMI BIN AMAT MANIS

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ABSTRACT

The transport needs of our ever growing and evolving society is becoming increasingly stringent and more demanding. In order to combat this, more efficient transportation vehicles need to be developed which are faster and cleaner. Solar Power is excellent energy source from the universe that can be converted into electricity using photovoltaic's (PV) using the sunlight and less pollution which is also called renewable energy. The main problem from this energy is electricity produces by the PV is proportional with the sunlight radiation where the output voltage produces from PV can be increase or decrease depends on sunlight radiation. To solve this problem, buck boost converter is implemented to the system to maintain the output voltage at the desired value. When the PV get the maximum or minimum voltage from the sunlight, this converter will use to control the output voltage at the desired value to charging the battery. At the same time the PV collect a portion of the sun's energy and stores it into the batteries of the solar car that can be use in night day and cloudy condition. Pulse Width Modulation (PWM) is needed to control the switching frequency of semiconductor MOSFET in Buck Boost Converter circuit.

ABSTRAK

Pengangkutan yang terus berkembang di dalam masyarakat menyebabkan ia menjadi semakin lebih diperlukan. Untuk mengatasi hal sedemikian, kenderaan pengankutan yang lebih cepat dan lebih bersih serta cekap perlu dikembangkan. Solar power adalah sumber tenaga yang sangat baik dari alam semesta yang boleh ditukar menjadi kuasa elektrik dengan mengunakan fotovoltaik (PV) akibat radiasi daripada sinaran matahari. Tenaga ini juga dapat diperbaharui semula tanpa menghasilkan pencemaran alam sekiter. Masalah daripada tenaga ini ialah elektrik yang terhasil dari PV adalah berkadar langsung dengan radiasi sinaram matahari dimana voltan output yang dihasilkan dari PV adalah tidak tetap bergantung pada radiasi sinaran matahari. Untuk mengatasi masalah tersebut, Buck Boost Converter digunakan untuk menetapkan voltan output yang dikehendaki seterusnya disambungkan pada litar pengisian bateri. Ketika PV mendapatkan voltan maksimum atau minimum dari sinar matahari, penukar ini digunakan untuk mengawal voltan output pada nilai yang dikehendaki. Pada masa yang sama PV mengumpulkan sebahagian daripada tenaga matahari dan menyimpannya ke dalam bateri dari kereta suria yang boleh digunakan dalam hari mendung dan malam. Pulse Width Modulation (PWM) diperlukan untuk mengawal frekuensi switching dari MOSFET semikonduktor di litar Buck Boost Converter

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LIST OF ABBREVIATIONS

AC	- Alternating current
ADC	- Analog digital converter
C	- Capacitor
CCM	- Continuous Current Mode
D	- Duty Cycle
DC	- Direct Current
ESR	- Equivalent Series Resistance
F	- Frequency
G	- Irradiation
MOSFET	- Metal Oxide Semiconductor Field-Effect Transistor
MPPT	- Maximum power point tracker
NiCad	- nickel-cadmium
L	- Inductor
PIC	- Programmable integrated circuit
PV	- Photovoltaic
PWM	- Pulse Width Modulation
R	- Resistor
VRLA	- Captive electrolyte lead-acid

CHAPTER 1

INTRODUCTION

1.1 Background

For many years people have been interested with the automobile. Some people just enjoy using the automobile as transportation while others also enjoy the workings and operation of this fascinating machine. The automobile is not without its problems of pollution and energy consumption. Therefore, scientists and engineer are trying to solve these problems in different ways. Part of their efforts is directed towards limiting the use of fossil fuels, and replacing them with alternative sources of energy that do not cause any harm to our eco-system. Another problem is changing its design and construction for new clean energy sources are being analyzed and applied to power the modern automobile.

A space age energy source now being considered by some and used by others to power the automobile is photovoltaic (PV). Solar energy is the most non-conventional energy source gaining interest throughout the world which has no harmful environmental impact. There are a number of devices in the modern car that are electrically powered. PV is the direct conversion of sunlight to electricity**.** There has been a great deal of research in PV among energy experts. The automobile is known the world over in both use and operation. The merging of these two technologies will benefit mankind and without damaging the environment.

Solar energy is a continually advancing technology, and as PV solar cells are being made more efficient, solar power is finding widespread use in applications such as outback power supplies and grid connected PV arrays. A large contributor to the increasing level of pollution is the household car, so solar cars were developed with the vision that an ideal car could be built which could run solely from the sun for the lifetime of the car, and never require fueling up. This indeed is a futuristic dream however the technology is fast approaching this stage.

In this project, the electric powers that have been produces from the solar panel must be constant that can use to charging the battery using the PIC microcontroller and also Buck Boost Converter. The reason why these project use Buck Boost Converter because the output voltage produces from the solar panel is proportional with the radiation from the sunlight that why converter is needed to constant the output at range 13V to charging the battery.

1.2 OBJECTIVE

There are several objectives that have been recognized for this project. The project objectives are listed below

i. To generate the Pulse Width Modulation (PWM) using the Programmable integrated circuit (PIC).
ii. To apply the principle of buck boost converter for the system to charging the battery at the certain time.
iii. To develop battery charger using electric energy from solar panel as energy source.

1.3 SCOPE OF PROJECT

The works undertaken in this project are limited to the following aspects

i. Solar panel that have rating voltage at 17.5V and rating current at 4.58A
ii. This project concentrates on DC-DC Converter.
iii. The variable input voltage from PV was control using the PWM microcontroller to get the constant output voltage.
iv. PIC16F877 microcontroller will be used to generate PWM and also used to control charging and discharging of the battery.
v. 12V DC motor will be used as the load for the project.

1.4 PROBLEM STATEMENT

Cars were developed as a fast means of transport, and internal combustion engines soon found themselves in many applications ranging from cane harvesters to outback generator sets. As time progressed, most people had realized that although the internal combustion engine had provided a much easier lifestyle, there were a number of major drawbacks. Petrol, when combusted, forms a number of gaseous byproducts, consisting mainly of carbon dioxide, but also containing traces of other gases such as carbon monoxide and compounds containing lead. The potency and increasing levels of these gases and compounds are causing gradual damage to the ozone layer in the Earth's atmosphere. Such gases are commonly referred to as greenhouse gases.

Soon people began looking for alternatives to the internal combustion engine. The internal combustion engine still emits greenhouse gases, however only at a fraction of the amount. An alternative energy source which is very appealing is solar energy. Solar panels produce direct currents (DC), and to connect these panels to the load or use them in other applications, we should have a DC output at a certain required voltage level. That why Buck Boost Converter is use for this project.

1.5 THESIS OVERVIEW

This Implementation of a Buck Boost Converter in Motor Controller for a Solar Car final thesis is arranged into following chapter:

Chapter 1: Basically is an introduction of the project. In this chapter, provides the background of the project, objectives, scope of the project, problem statement, and also the thesis outline.

Chapter 2: Focuses on literature reviews of this project based on journals and other references.

Chapter 3: Mainly focused on methodologies for the development of Implementation of a Buck Boost Converter in Motor Controller for a Solar Car. Details on the progress of the project are explained in this chapter.

Chapter 4: Focuses more on result and discussion of the project. All information must be explained in detail in this chapter with the problem specification.

Chapter 5: Concludes overall about the project. Obstacle faces and future recommendation are also discussed in this chapter.

CHAPTER 2

LITERATURE REVIEW

Overview

There are lots of vehicles in the world where solar car is one of them. Solar car use solar energy to drive the motor. The uniqueness and wide application of this technology will help global warming campaign to change the energy of car. This part provides an insight and literature review on the current technology available to construct a solar car.

2.1 SOLAR CAR

U.S Department Energy, Richard J King [2] said that the propulsion system in a solar car is made up of four basic components. Solar cells convert sunlight directly into electricity. The electricity is used to power a variable-speed electric motor with direct drive to the wheels. Batteries allow the car to accelerate and travel at higher speeds when necessary. Electronics are used to maximize electrical power transfer between the solar cells, battery and motor.

From another paper research by Don Dunklee, April, 2005 [10] solar car is characterized by the ability to move using solar power with some speed. The basic idea for a solar car is drive the wheels using DC motor that get sources from battery that charger by solar energy. The car needed to be able self contained, that is all charging from sun, but still allow the factory charger to be used if needed). Don Dunkle has build Don's solar scooter that the technology advances in motors, controllers and related technology led largely by the solar industry, has made this possible.

Jiying shi and member, design a practical tracker for efficiently maximizing the output power of a solar array is presented. The power conversion stage is a pulse -width-modulated (PWM) buck-boost dc/dc converter operating in discontinuous inductor current mode, called loss-free resistor (LFR). The change of the duty cycle of the switch is adjusted to a value according to the incremental conductance tracking (ICT) algorithm [3]. In PV systems the energy from the sun is converted to electric energy by means of solar cells. They are the fundamental energy conversion component exhibit an extremely non-linear voltage-ampere characteristic, which varies with temperature and insulations at all, times. However, the present energy conversion efficiency of them is still quite low. Therefore, in order to enhance it, the technique, called maximum power point tracking (MPPT) control to extract the maximum possible power from the PV array, is essential one in the whole system. The objective is to make the solar arrays operate at an operating point corresponding to the maximum output power.

2.2 CHARACTERISTIC OF PV ARRAY

PV panel is a part of the system that converts sunlight to electricity. It can also be defined as a group of modules that is the basic building block of a PV array. PV cell is the fundamental of PV array that are built before creating a group of modules. PV cells are made of semiconductor materials (usually silicon), which are specially treated to form an electric field, positive on one side (backside) and negative on the other (towards the sun) . When solar energy (photons) hits the solar cell, electrons are knocked loose from the atoms in the semiconductor material, creating electron-hole pairs (Lorenzo, 1994) [4]. If electrical conductors are then attached to the positive and negative sides, forming an electrical circuit, the electrons are captured in the form of electric current *IL* (photo generated current) [4]. Figure 2.1 illustrates the circuit equivalent for a single PV cell.

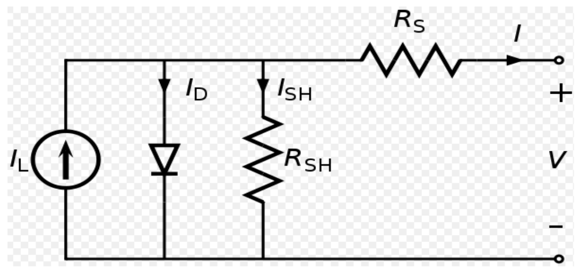

Figure 2.1: The circuit equivalent for a single solar cell

The circuit contains a current source. I_L diode is connected in parallel and resistance, R_S that are connected in series which represents the resistance inside cell and the connection between the cells. Based on the circuit above the following equation can be derived:

$$I = I_L - I_D = I_L - I_O \left(exp^{e(v + IRSH)}/_{aKTc} - 1\right) \qquad (2.1)$$

Where:

I = output current

I_D = diode current

a = idealinising factor

k = Boltzmann's gas constant,

Tc = the absolute temperature of the cell

e = electronic charge

V = the voltage imposed across the cell

I_0 = the dark saturation current and depending on temperature

Figure 2.2 portrait a typical I-V characteristic of the solar cell for a certain ambient irradiation *G* and a certain fixed cell temperature *T*. For a resistive load, the load characteristic is a straight line with scope *I/V*=1/*R*. It should be pointed out that the power delivered to the load depends on the value of the resistance only. However, if the load *R* is small, the cell operates in the region *M-N* of the curve, where the cell behaves as a constant current source, almost equal to the short circuit current. On the other hand, if the load *R* is large, the cell operates on the regions *P-S* of the curve, the cell behaves more as a constant voltage source, almost equal to the open-circuit voltage [5].

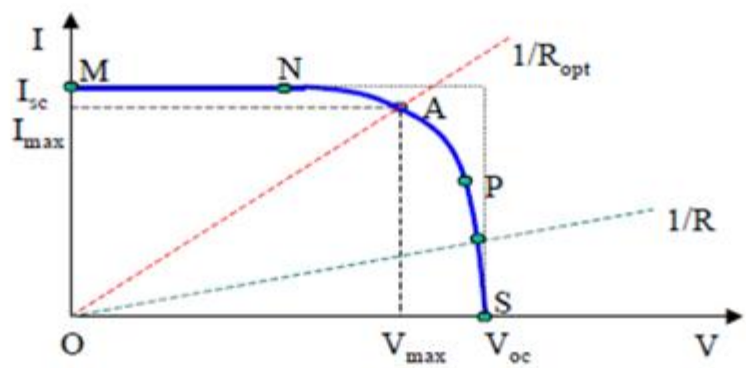

Figure 2.2: A typical current- voltage I-V curve for a PV cell

From the paper Gilbert M. Master's says solar cells produce direct current electricity from sunlight, which can be used to power equipment or to recharge a battery. The first practical application of photovoltaic was to power orbiting satellites and other spacecraft and pocket calculators, but today the majority of photovoltaic modules are used for grid connected power generation [6]. Figure 2.3 shows the example of the solar modules that convert sunlight into electricity which can be used immediately or stored in a battery. Solar cells do the work of making electricity.

Figure 2.3: Solar modules

Andrew James Reghenzani have do research about the Photovoltaic cells, module and arrays [7]. Photovoltaic cells are connected electrically in series or parallel circuits to produce higher voltages, currents and power levels. Photovoltaic modules consist of PV cell circuits sealed in an environmentally protective laminate, and are the fundamental building blocks of PV systems. Photovoltaic panels include one or more PV modules assembled as a pre-wired, field-installable unit. A photovoltaic array is the complete power-generating unit, consisting of any number of PV modules and panels as shown in Figure 2.4.

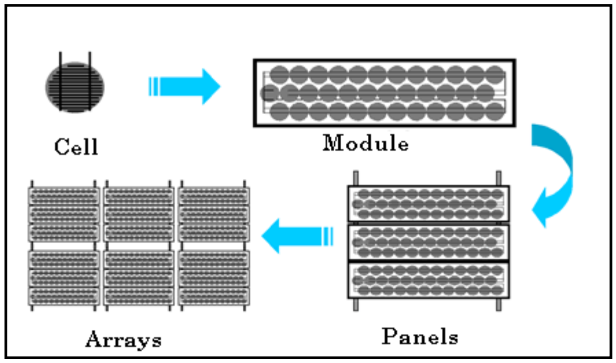

Figure 2.4: Transition of cell, module and arrays

There are three types array of electrical in electrical reconfigurations which are parallel, parallel-series and series as shown in Figure 2.5. The relationship between current and voltage of electrical array configuration as shown in Figure 2.6 indicates that the parallel types provides much current and low voltage, the parallel series provides moderate current and voltage and the series types provides low current but high voltage[7].

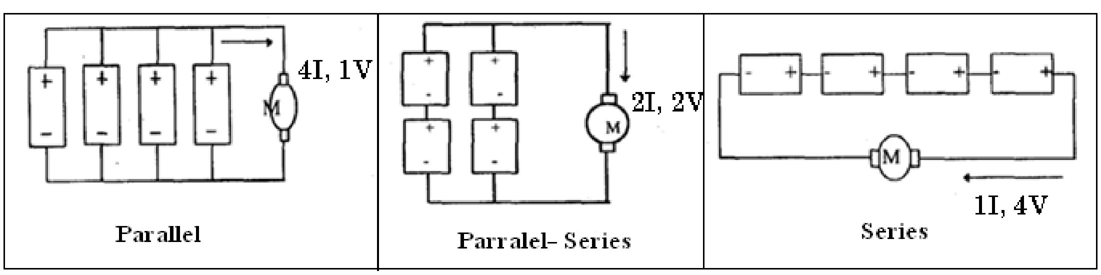

Figure 2.5: Three types of electrical array

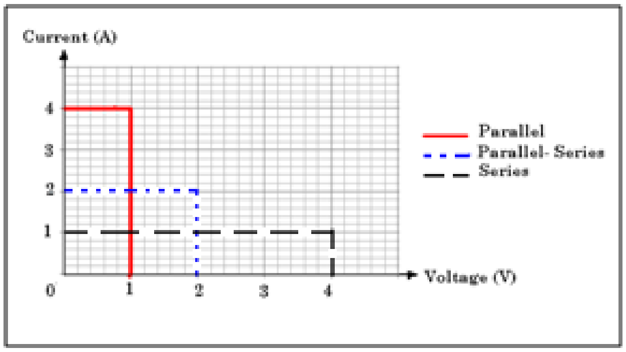

Figure 2.6: Relationship between current and voltage of electrical array reconfiguration

The advantages and its disadvantages of this project using PV also consider. Here are some advantages and disadvantages about the solar power system. Firstly, the sunlight reaching the earth's surface is plentiful compared to the average power consumed by humans. Secondly, solar power is no pollution during use. That means production end wastes and emissions are manageable using existing pollution controls. No bills to pay because customer buy solar powered equipment and after that the electricity is free. Another advantage using this PV are minimal or no maintenance because solar panels are guaranteed for 15 years and the Deep Cycle Batteries for 5 years. Finally, advantage of PV is the system operation quiet, benign, and compatible with almost all environments. Solar cell converts the solar radiation directly into electricity using photovoltaic effect without going through a thermal process.

Some disadvantages using the PV are solar electricity is almost always more expensive than electricity generated by other sources. Secondly, solar electricity is not available at night and is less available in cloudy weather conditions. Therefore, a storage or complementary power system is required. Limited power density and solar cells produce DC which must be converted to AC (using a grid tie inverter) when used in currently existing distribution grids. This incurs an energy loss of 4-12%.