UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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DESIGNING A BOOST CONVERTER FOR SOLAR ENERGY HARVESTING SYSTEM

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree in Electrical Engineering Technology (Industrial Power) (Hons.)

by

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Designing a Boost Converter for Solar Energy Harvesting System**

SESI PENGAJIAN: **2014/15 Semester 1**

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I hereby, declared this report entitled "Designing a Boost Converter for Solar Energy Harvesting System" is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree Bachelor of Electrical Engineering Technology (Industrial Power) with Hons. The member of the supervisory is as follow:

....

(Project Supervisor)

ABSTRAK

Tujuan projek ini adalah untuk memperkenalkan reka bentuk dan pembangunan kaedah untuk penukar dc-dc *boost* dengan penukar voltan output malar. Penukar dc-dc *boost* adalah dipilih kerana keupayaannya untuk meningkatkan voltan input yang rendah kepada voltan keluaran yang tinggi. Dari yang turun naik atau voltan input yang berubah-ubah, penukar *boost* dapat meningkatkan voltan input untuk voltan keluaran yang tetap lebih tinggi. Untuk mendapatkan kawalan prestasi tinggi model yang baik penukar dc-dc diperlukan. Beban biasanya memberi kesan dinamik dan satu cara untuk membawa kira adalah untuk menganggap beban sebagai sebahagian daripada penukar. Beban ialah sering bahagian yang boleh berubah-ubah dalam sistem ini. Penukar dc-dc terdiri daripada suis tunggal semikonduktor iaitu MOSFET, diod, induktor dan kapasitor. Proses yang terlibat dalam projek ini adalah mereka bentuk litar penukar *boost* oleh beberapa pengiraan (teori), simulasi litar penukar *boost*, merekabentuk susun atur litar di papan donat, menguji dan membuat penyelesaian masalah bagi litar dan akhir sekali menganalisis data berdasarkan teori pengiraan, simulasi dan pembangunan litar. Kajian simulasi dijalankan dalam perisian OrCAD PSpice. Proses pemantauan kemajuan projek pula dijalankan oleh pensyarah yang ditugaskan sebagai penyelia projek.

ABSTRACT

The purpose of this project is to introduce a design and development method of a dc-dc boost converter with constant output voltage. A dc-dc boost converter was choose because of its ability to step up the low input voltage to a high output voltage. From a fluctuating or a variable input voltage, boost converter is able to step up the input voltage to a higher constant dc output voltage. To obtain high performance control of a dc-dc converter, a good model of the converter is needed. The load usually affects the dynamics and one way to take this into consideration is to regard the load as a part of the converter. The load is often the most variable part of this system. This converter is consist of a single semiconductor switch that are mosfet, a diode, an inductor and a capacitor. The process involved in this project are designing the boost converter circuit by several calculation (theoritical), simulating the boost converter circuit, designing the circuit layout on donut board, testing and troubleshooting the circuit and last but not least analysing the data based on the theoritical calculation, simulation and hardware development. The simulation studies are carried out in OrCAD PSpice software. The process of monitoring project progress is conducted by the lecturer which entitled as a project supervisor.

DEDICATION

This dedication is dedicated to show my gratitude and appreciation especially to

My beloved parents, Sulaiman Bin Mohd Tahir

& Hazmah Binti Hj Razali

My supervisor, Mr. Syahrul Hisham Bin Mohamad

My panels, Mr Ab Wafi Bin Ab Aziz

& Miss Suziana Binti Ahmad

My friends,

Lecturers involved

And every individual

Who have help me a lot throughout this long journeys

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Vs	-	Voltage Source
Vo	-	Voltage Output
Io	-	Current Output
Po	-	Output Power
PWM	-	Pulse Width Modulation
CCM	-	Continuous Conduction Mode
DCM	-	Discontinuous Conduction Mode
L	-	Inductor
C	-	Capacitor
R	-	Resistor
D	-	Duty Cycle
PV	-	Photovoltaic

CHAPTER 1

INTRODUCTION

1.1 Background

Due to the continuous growth of the global energy demand for developing industry, it increases society awareness of environmental impacts from the widespread utilization of fossil fuels, leading to the exploration of renewable energy sources. Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat. Renewable energy replaces conventional fuels in four distinct areas that are electricity generation, hot water/space heating, motor fuels, and rural (off-grid) energy services.

Solar energy is one of the most popular sources, which is clean, quiet, and maintenance-free. The power generation using solar power had increased dramatically because it is pollution free as compare to power generation using fossil fuel. Besides, it needs low maintenance and no noise and wear due to the absence of moving parts which make solar power attractive to the people. Solar power uses solar panel to convert sun irradiation into electric energy using photovoltaic (PV) effect. Photovoltaic principles are used to produce electricity. A solar panel (PV panel) is made of the natural element, silicon, which becomes charged electrically when subjected to sunlight. The output voltage of a solar panel is varying depending on sun irradiation and temperature.

However, due to the instability and intermittent characteristics of PV arrays, it cannot provide a constant or stable power output. As the sun irradiation and temperature changes, output voltage changing as well. Since the voltage produced is fluctuating, a lot of electronic equipment are unable to be directly connected. Therefore, a DC-DC boost converter with constant output voltage is needed. The boost converter will step up the solar panel voltage to the suitable voltage required by electronic equipment.

1.2 Problem Statement

In the current century, DC-DC converter plays a vital role in industrial areas. DC-DC boost converter is used widely with low power battery applications, and is aimed at the ability of a boost converter to 'steal' the remaining energy in a battery. This energy would otherwise be wasted since the low voltage of a nearly depleted battery makes it unusable for a normal load. 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 it in other applications, we should have a DC output at a certain required voltage level.

Another one problem was the electricity from the sun that generated through the solar photovoltaic modules comes in various power output to meet the load. However, the output power of a PV panel is largely determined by the solar irradiation and the temperature of the panel. At a certain weather condition, the output power of a PV panel depends on the terminal voltage of the system. To maximize the power output of the PV system, a high efficiency, low-cost DC/DC converter with a voltage feedback signal is commonly employed to control the terminal voltage of the PV system at optimal values in various solar radiation conditions.

1.3 Project Objective

The main purposed of the project is to develop DC-DC Boost Converter that converts the unregulated DC input to a controlled DC output with desired voltage level. Furthermore, the objectives are to:

a) To design a boost converter for solar energy harvesting system.

b) To simulate the design of the boost converter.

c) To conduct the experimental work to test the efficiency of the boost converter.

1.4 Scope of the Project

This project concentrates on DC-DC Boost Converter.

a) Designing a boost converter for solar energy harvesting systems that have a rating voltage between 10V to 14V voltage input and have a constant voltage output of 24V.

b) Simulate the design of the Boost Converter using OrCAD Pspice software.

c) Conducting the experimental work to test the efficiency of the Boost converter using the suitable electrical equipment provided at the laboratory.

1.5 Report Outline

This report is divided into five chapters;

Chapter 1 offers an introduction of the background of the study about power electronic converters focusing on the boost converter itself. This chapter also included the objectives of the project, the scope of the project and lastly the problem statement.

Chapter 2 provides the literature review based on the journals, papers, books, articles and other sources that related to this project. After finish reading the references based on variety of sources, the key points of each of the sources was compile and discuss on this chapter. This chapter focus more on the dc-dc boost characteristics and circuit analysis.

Chapter 3 explained on the methods implement to carry out the design and analysis of the dc-dc boost converter. This chapter also included the flowchart, milestones and gantt chart so the project can flow smoothly with the sequences of the project operation itself. Besides that, this chapter also discussed on the components selection, the simulation and hardware implementation of the project.

Chapter 4 discussed about the results of analysis on the theoretical, simulation and hardware. Its represents the design analysis of the dc-dc boost converter using different approaches. The results was then compared.

Chapter 5 concluded the overall achievement of the dc-dc boost converter project. This chapter concluded based on the data that have been gathered and collected. A recommendation was also provided in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this section, the literatures are divided into three sections. The first one is on the Renewable Energy, the second is on the Solar PV System and another one is on the DC-DC Boost Converter. The literatures review is collected from different journals, conference papers, articles and books have been reviewed as follows

2.2 Renewable Energy

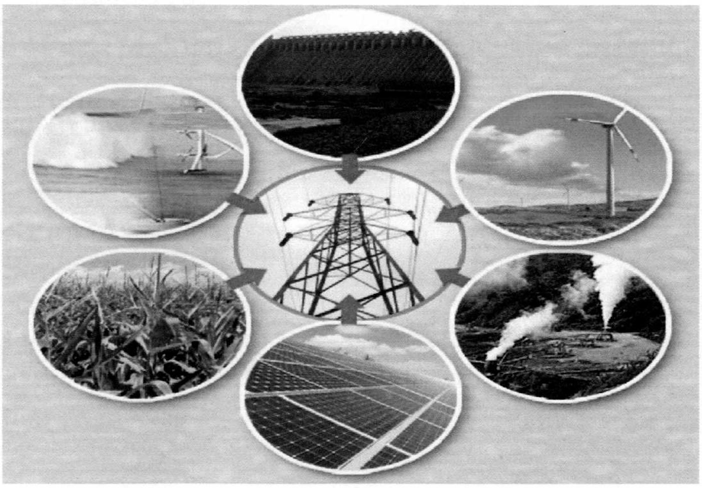

Figure 2.0: Types of renewable energy

Figure 2.0 shows the type of renewable energy. Musall. F. D and Kuik, O. (2011) state that, energy is a necessity for human beings, but current energy resources are forecast to be limited in the coming years with apparent destructive consequence to the environment. While according to St. Denis, G and Parker, P. (2009), renewable energy is emerging as a solution for a sustainable, environmentally friendly and long term, cost-effective source of energy for the future. Renewable energy alternatives are capable of replacing conventional sources of energy in most of their applications at competitive long term prices (Wolsink, M. 2007).

Recently, renewable energy is the targeted solution for energy crises. In addition, it is a friendly solution which is free from any pollution (R.C. Campbell, 2007: p.97). According to P. Sathya and Dr. R Natarajan (2013), renewable energy play an important role in electricity generation. People are finding the benefits of having their own renewable energy system more attractive than they ever had before. Specially, energy from the sun is the best option for electricity generation as it is available everywhere and is free to harness. Due to the continuous growth of global energy demand for developing industry, it increases society awareness of environmental impacts from the widespread utilization of fossil fuels, leading to the exploration of renewable energy sources, such as PV-arrays, wind energy and so on (Sheng-Yu Tseng and Cheng-Tao Tsai , 2012) on their paper.

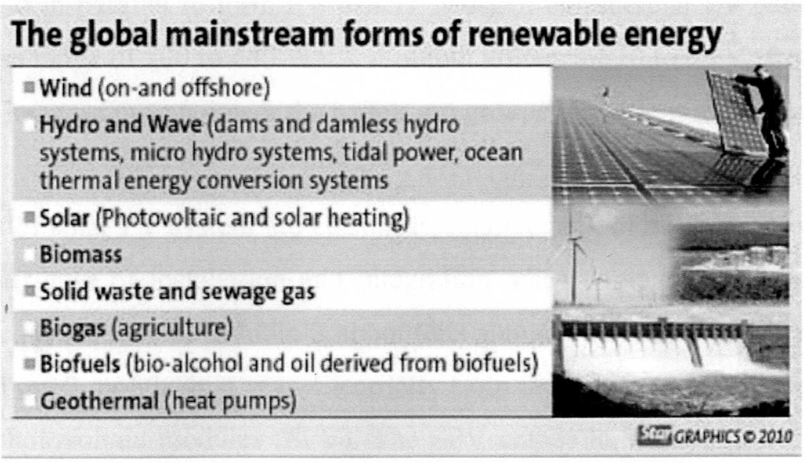

Figure 2.1: The global mainstream forms of renewable energy

2.3 Solar Photovoltaic System

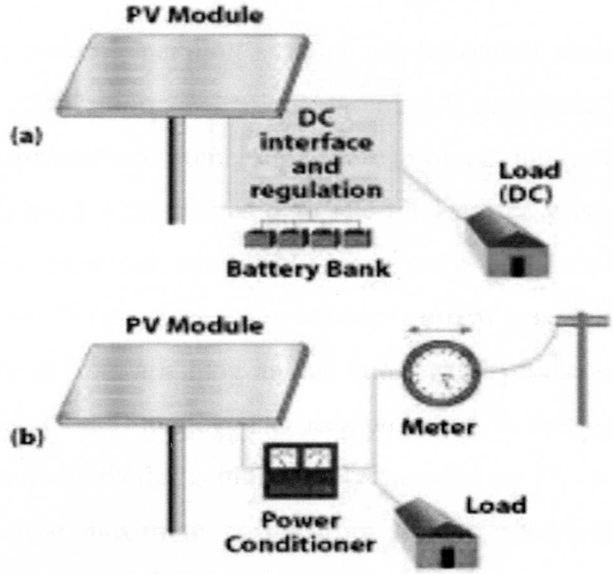

Figure 2.2: Two type of solar PV system

Solar photovoltaic system can be divided into two types that are off-grid system and on-grid system as shown in figure 2.2. According to R.C. Campbell, (2007) the main parts of a photovoltaic system (PV) are photovoltaic panels (also called photovoltaic cells), DC/DC and/or DC/AC converters, energy storage and control systems and control-measuring devices. A single PV cell without load produces output voltage up to 0.6 V. To increase the output voltage and output current single cells are connected in series and in parallel to form PV panels. Most of commercial PV panels deliver power in the range of 100 to 400 Watts at output voltage of 20 to 45 V (from a single panel). To increase output power the panels are grouped in strings and arrays.

The merits of solar PV system are cleanness, relative lack of noise or movement, as well as their ease of installation and integration when compared to others. On an average the sunshine hour in India is about 6hrs annually also the sun shine shines in India for about 9 months in a year. Electricity from the sun can be generated through the solar photovoltaic modules (SPV). The SPV comes in various power output to meet the load. However, the output power of a PV panel is largely determined by the solar irradiation and the temperature of the panel. At a certain weather condition, the output power of a PV panel depends on the terminal voltage of the system (A. M. Subiyanto and S. Hussain, 2012).

Photovoltaic (PV) power-generation systems are becoming increasingly important and prevalent in distribution generation systems. A conventional centralized PV array is a serial connection of numerous panels to obtain higher dc-link voltage for main electricity through a dc–ac inverter. The total power generated from the PV array is sometimes decreased remarkably when only a few modules are partially covered by shadows, thereby decreasing inherent current generation, and preventing the generation current from attaining its maximum value on the array. To overcome this drawback, an ac module strategy has been proposed. In this system, a low-power dc–ac utility interactive inverter is individually mounted on PV module and operates so as to generate the maximum power from its corresponding PV module (M. G.Villalva, J.R.Gazoli, and E.R.Filho. 2009).

Based on the paper of entitle "Design of High Efficiency DC-DC Converter for Photovoltaic Solar Home applications" (2009) states that the power capacity range of a single PV panel is about 100W to 300W, and the maximum power point (MPP) voltage range is from 15V to 40V, which will be the input voltage of the ac module in cases with lower input voltage, it is difficult for the ac module to reach high efficiency. However, employing a high step-up dc–dc converter in the front of the inverter improves power-conversion efficiency and provides a stable dc link to the inverter (Syafrudin Masri and Pui Weng Chan 2010).

2.3.1 The PV Cell Circuit Model

The PV cell can be approximated by a current source and a p-n junction similar to that of a diode, thus its equivalent circuit is shown in Figure 2.3. The model includes also series and shunt resistors where the series resistor Rs is usually very small that could be neglected and set to zero, while the shunt resistor Rsh is very large and could be considered as an open circuit.