STUDY AND DESIGN A STEP UP DC-DC CONVERTER FOR RENEWABLE ENERGY APPLICATION

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APPROVAL

"I hereby declare that I have read through this report entitled "STUDY AND DESIGN A STEP UP DC-DC CONVERTER FOR RENEWABLE ENERGY APPLICATION" and found that it has complies partial fulfilment for awarding the Bachelor of Electrical Engineering"

Signature : ……

Supervisor's name : ……

Date : ……

DECLARATION

I declare that this report entitled "STUDY AND DESIGN A STEP UP DC-DC CONVERTER FOR RENEWABLE ENERGY APPLICATION" 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 : ……

DEDICATION

To my beloved mother and father

ACKNOWLEDGMENT

Firstly, thanks to ALLAH for giving me strength to finish my final year project 1. I like to express my special appreciation to my supervisor, Dr. Azziddin Bin Mohamad Razali for the guidance and supervision during progress of this project. I also give my appreciation to my beloved family for their supports, understanding and inspirational to complete this final year project 2. Lastly, I want to thank all my friends that help me during the working progress and a special appreciation for those that involve directly and indirectly with me to complete the project.

ABSTRACT

In this era of globalization, the used of power electronics have increase widely due to high demand and applications of technology. On the other hand, the renewable energy sources become more important to the world with the depletion supply of oil and gas, coal and others. The renewable energy such as solar energy has its own speciality and can converts to electricity with the uses of the power electronics devices. The step up DC to DC converter is one of the popular devices in recent years. The main objective of this project is to study, simulate, analyse and design a step up DC to DC converter with 12V dc supply which is from the PV panel and produces a high voltage output which in range of 600V to 700V. The high output voltage will then be connected to multilevel inverter in order to converts DC to AC voltage for the transmission grid system. The step up DC to DC converter used in this project is Full-bridge converter. The software used to design, simulate and analyse the circuit simulation model is MATLAB/Simulink software. The open loop and close loop simulation circuits have been designed in the MATLAB/Simulink software. The close loop system uses the Proportional Integral (PI) as a controller to control the duty cycle of the Metal Oxide Semiconductor Field Effect transistor (MOSFET) to get the constant output voltage.

ABSTRAK

Dalam era globalisasi ini, penggunaan kuasa elektronik meningkat secara meluas kerana permintaan yang tinggi dan penggunaan teknologi. Sebaliknya, sumber tenaga boleh diperbaharui menjadi lebih penting kepada dunia dengan bekalan minyak dan gas, arang batu dan lain-lain. Tenaga boleh diperbaharui seperti tenaga solar mempunyai keistimewaan tersendiri dan boleh ditukar kepada elektrik dengan menggunakan alat elektronik kuasa. Langkah penukar DC ke DC adalah salah satu peranti yang popular dalam beberapa tahun kebelakangan ini. Objektif utama projek ini adalah untuk mengkaji, mensimulasikan, menganalisis dan merancang langkah DC ke DC penukar dengan bekalan 12V dc yang dari panel PV dan menghasilkan output voltan tinggi yang antara 600V hingga 700V. Voltan keluaran yang tinggi akan disambungkan kepada penyongsang bertingkat untuk menukar DC ke AC voltan untuk sistem penghantaran grid. Langkah penukar DC ke DC yang digunakan dalam projek ini ialah penukar Jambatan penuh. Perisian yang digunakan untuk merekabentuk, mensimulasikan dan menganalisis model simulasi litar ialah perisian MATLAB / Simulink. Litar simulasi gelung terbuka dan litar simulasi telah direka bentuk dalam perisian MATLAB / Simulink. Sistem gelung dekat menggunakan Integral Proportional (PI) sebagai pengawal untuk mengawal kitaran tugas dari Metal Oxide Semiconductor Field Effect transistor (MOSFET) untuk mendapatkan voltan keluaran tetap.

LIST OF TABLE

LIST OF FIGURE

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1 Research Background

In this era of technology, the use of power electronics in our daily life has grown drastically due to its wide range of applications. Power electronics circuit are widely used in renewable energy applications. One of the renewable energy is solar energy. Photovoltaic technology transforms the solar energy in sunlight into electrical and thermal energy. Malaysia still depends on the hydropower to generate more of its electricity.

Basically, DC-DC converter is one of the most popular power electronics circuit. A DC-DC converter converts an input dc voltage to a different dc output voltage level and it provides a regulated voltage output. A DC-DC converter also has its own disadvantages such as the electrical connection between the input and output. If the input supply is grounded, the output will be grounded as well. Therefore, a transformer can be use as a device to electrically isolate the output from the input electrically.

Transformer has two basic functions such as to provide electrical isolation and to step up or step down the voltage. Furthermore, transformer will improve design flexibility in relationship between input and output of converter with it turns ratio.

On the other hand, renewable energy resources such as solar energy will produces unregulated voltage and the DC-DC converter is used to regulate the voltage output for the load. Open loop and close loop systems are used to regulate the voltage. Open loop system produces unregulated dc output voltage. Therefore, to get a good regulated voltage, feedback controller is implemented in a close loop system. PI controller is used in DC-DC converter to regulate dc output voltage. The project designed DC-DC full-bridge converter topologies to regulate the voltage from the PV panel. A full-bridge DC-DC converter is designed in this project to step up and regulated the voltage from 12V solar panel.

1.2 Problem statement

First of all, for renewable energy such as photovoltaic (PV) system produce low voltage and unregulated voltage output and it is not suitable for dc application. Then, DC to DC full-bridge converter should be designed to surpass this problem. Therefore, this full-bridge converter mainly selected because it is needed to produce high output voltage from the low voltage input. On the other hand, in order to achieve the specification from the other part of the project, Proportional integral (PI) controller needs to be design and connects to the full-bridge converter. To design and control the PI controller is hard because it needs to fill the requirement for the chopper selected.

1.3 Objectives

The objectives of this project are:

1. To develop the simulation circuit of open loop and close loop of full-bridge converter.
2. To produce high output voltage such as 900V from 12V dc supply.
3. To develop a hardware of DC-DC converter for grid system application.

1.4 Scope of project

This project mainly focuses on analysis and development of DC-DC full-bridge converter for Grid system application. Basically, the single phase grid system requires around 340V ac voltage which is generate from the multilevel inverter. This project use PV panel as the voltage supply. Therefore, chopper is used to convert the low dc voltage to high voltage output which is 700V. The voltage requirement for multilevel inverter is around 700V. The simulation consists of designing open loop and close loop full-bridge converter in order to generate fixed output value. The simulation is performed using MATLAB/Simulink software. To develop the hardware, a microcontroller will be used to control the output voltage. Figure 1.1 shows the flow of process in this project. The focussing area for this project is in the dotted line box.

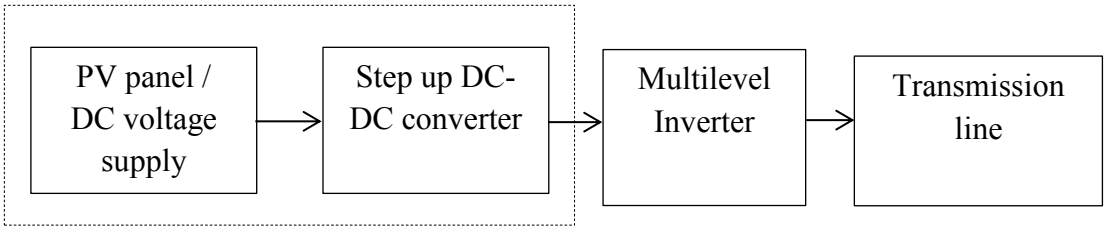

Figure 1.1: Block diagram of project

1.6 Report outline

This report consists of 5 chapters which are investigates about DC-DC full-bridge converter for PV system application.

Chapter 1 consists of the introduction of DC-DC full-bridge converter and overview of the studies. This chapter will discuss about the research background, problem statement full-bridge converter, objective and scope of project.

Chapter 2 consists of literature review about the chopper. The literature review in this chapter states the fundamental theory and basic principles of DC-DC full-bridge converter.

Chapter 3 consists of the design methodology based on fundamental theory and basic principles of the open loop and close loop DC-DC full-bridge converter. The design approach will be explained such methodology process for this project.

Chapter 4 will discuss about an early simulation result of the project which consist of open loop and close loop from the MATLAB/Simulink. The result is shown in waveform. Hardware progress will also be included.

Chapter 5 will discuss about future work and conclusion about project in this semester.

CHAPTER 2

LITERATURE REVIEW

2.1 THEORY AND BASIC PRINCIPLES

2.1.1 Solar Panel

Solar energy is one of the renewable energy that most popular usage these day because of its environment friendly (also known as eco-friendly) and does not cause air pollution or noise. Solar energy can generates electrical power besides other renewable energy such as hydroelectric and wind turbine. Solar power is crucial to human nowadays because it can be use everywhere and it is free. Furthermore, solar power is suitable usage for rural area and area that not served by the conventional grid connection. PV system has the basic element which is solar cell[1]. This solar cell converts the energy of the sunlight into electricity. It has three type of cell which are monocrystalline, polycrystalline and amorphous. There are three types of the PV power system which are stand-alone, hybrid and grid connected.

Stand-alone PV power system requires battery to meet the energy demand during low solar irradiation and night time. Hybrid power system combines multiple sources to deliver the non-intermittent electric power. Then, for grid connected system, the PV panel is connected to power conditioning and control before it connects to the grid.

2.1.2 DC-DC full-bridge converter

In power electronics field, there are various types of DC-DC converter. Each type of converter has its own specific function and application. Those types of converter can be classified to a few groups. There are DC-DC converters that are suitable to step up and step down the input voltage. Some DC-DC converters are suitable for step down voltage and also some can be used for both applications. DC to DC converter or chopper is an electronic circuit that converts fixed direct current (DC) voltage from one level variable dc output voltage. Full-bridge converter is an isolated converter. Next, full-bridge converter is mainly used in switching power supplies and suitable for high power application. Full-bridge converter consists of four switching devices.

This converter is used to improve efficiency as high as possible with smaller size[10]. As stated earlier, DC to DC converter mainly used in switch mode power supplies (SMPS), DC motor control (battery-supplied vehicles) and more other application. Full-bridge converter circuit consists of four power switch which is MOSFET, transformer, two diodes, inductor, capacitor and load resistance. Thus, full-bridge converter will step up the input dc voltage value. Full-bridge converter also can operate in high frequency.

2.1.3 DC-DC push-pull converter

Push-pull converter is an isolated DC-DC converter that can step up and step down the voltage because it has a transformer in the circuit. The difference between push-pull converter and the full-bridge converter is push-pull converter has two windings transformer in both primary and secondary side while full-bridge only has one winding at primary side and two windings at secondary side. Push-pull converter has less switching devices which is only two while full-bridge has four. However, the switching control will be difficult because both switches cannot be activated simultaneously, resulting low impedance and high shoot through current potentially damaging and destroying the switch[10].

2.1.4 DC-DC boost converter

Boost converter is a converter that operates as a step up converter. It is because the output voltage will be higher than the input voltage and it is non-isolated converter[10]. Boost converter can operate while the switch is open and closed. Literally, it can operate with two conditions. The function of DC-DC boost converter is to convert the unregulated dc input voltage to a controlled dc output voltage. The boost converter circuit consist of inductor, capacitor, one power switch which is, diode and load resistance. In boost converter circuit, the capacitor generally added to output to perform the function of reducing the voltage ripple.

2.1.5 MOSFET

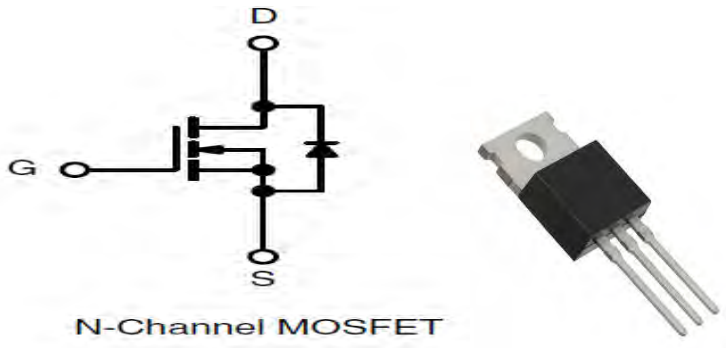

Figure 2.1: MOSFET

MOSFET or metal oxide silicon field effect transistor is a common switch and it is very fast device. The switching frequency of the MOSFET is higher than 100 kHz besides its frequency may go up to MHz range. Next, it comes up with two types which are n-channel and p-channel. It has three terminals which are drain, source and gate[2]. Furthermore, MOSFET are suitable for low voltage rather than IGBT which are suitable for high voltage application such as for multilevel inverter.

2.1.6 IGBT

IGBT or insulated gate bipolar transistor is one of the power switches that popular in electronic devices. IGBT is suitable for many applications in power electronics especially in pulse width modulation (PWM)[3]. Next, IGBT also suitable for three-phase drives requiring high dynamic range control. Then, IGBT has a very low-on state voltage drop because of its conductivity modulation and it also has low driving power with simple drive circuit.