MULTI INPUT ZVS CONVERTER FOR RENEWABLE ENERGY

WONG JIAN LOONG

BACHELOR OF ELECTRICAL ENGINEERING WITH HONOURS
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

MULTI INPUT ZVS CONVERTER FOR RENEWABLE ENERGY

WONG JIAN LOONG

A report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electrical Engineering with Honours

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

DECLARATION

I declare that this thesisentitled “MULTI INPUT ZVS CONVERTER FOR RENEWABLE ENERGYis the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that Ihave checked this reportentitled “MULTI INPUT ZVS CONVERTER FOR RENEWABLE ENERGY” and in myopinion, thisthesisit complies the partial fulfillment for awarding theaward of the degree of Bachelor of Electrical Engineering with Honours

Signature : .....

Supervisor Name : .....

Date : .....

DEDICATIONS

To my beloved mother and father

ACKNOWLEDGEMENTS

I was conducted many researches from online journals, articles and internet sources in order to get information about my project title to improve my understanding about the title in order to design and analyse the product. Besides, the researches also provide some information to me in order to write and prepare this report which present all the information about the product which include how to design, analyse and comparison about what components will be suitable for the product and what methods will be suitable to analyse and design the product. .Moreover, I'm also very thankful to my supervisor PROFESOR MADYA DR KASRUL BIN ABDUL KARIM for his guidance , advices and motivation. He gives some ideas and information to me when I face some problems such as simulation problems. He also put full attention to check my progress works and my report. Without his support and interest, this project would not have been same as presented here.

ABSTRACT

This report discussed about the design and the simulation of a multi input ZVS phase shift full bridge DC to DC converter to overcome the problem that face by renewable energy by using MATLAB/ SIMULINK software. The first problem that need to solve is the unstable and overload output voltage produce by renewable energy that cause load disturbance. So, to solve this problem, firstly phase shift full bridge DC to DC converter have designed to overcome it by using phase shift modulation of the pulse signal of the lagging leg switches respect to leading leg switches. The second is apply ZVS technic to solve the switching losses due to PSM of the pulse signal of the switches to regulate the output voltage. The third is develop a close loop phase shift full bridge DC to DC converter by using PI controller to overcome the fluctuate of the input voltage from the renewable energy that cause load disturbance. The full bridge phase shift ZVS DC to DC converter will choose because it can handle high power and high voltage. The high frequency operation for the use of MOSFET switches also allow the system operate in high frequency in order to reduce the conduction loss hence improve system efficiency. The three objectives have been achieved by using MATLAB/ SIMULINK software which the first objective where design a single phase phase shift full bridge DC to DC converter which can regulate the output voltage by PSM of the pulse signal of the switches when load disturbance occur. Second, the ZVS technic have been carry out to apply in this converter to improve the system efficiency during PSM of the pulse signal of the MOSFET switches and third a controller have been apply to regulate the output voltage automatically by undergo PSM at the pulse signal of the switches when there is fluactuate of the input voltage from the renewable energy.

ABSTRAK

Laporan ini dibincangkan mengenai reka bentuk dan simulasi input pelbagai ZVS fasa peralihan jambatan penuh DC ke DC converter untuk mengatasi masalah yang dihadapi oleh tenaga boleh diperbaharui dengan menggunakan perisian MATLAB / SIMULINK. Masalah pertama yang perlu diselesaikan adalah voltan keluaran yang tidak stabil dan dihasilkan oleh tenaga boleh diperbaharui yang menyebabkan gangguan beban. Jadi, untuk menyelesaikan masalah ini, peralihan fasa pertama jambatan penuh DC ke DC converter telah direka untuk mengatasinya dengan menggunakan modulasi peralihan fasa isyarat denyut suis kaki ketinggalan berkenaan dengan suis kaki terkemuka. Yang kedua adalah menggunakan teknik ZVS untuk menyelesaikan kerugian beralih disebabkan oleh PSM isyarat denyut suis untuk mengatur voltan keluaran. Yang ketiga adalah mengembangkan fasa gelung jarak pergeseran jambatan penuh DC ke DC converter dengan menggunakan pengawal PI untuk mengatasi turun naik voltan input dari energi terbarukan yang menyebabkan gangguan beban. Fasa fasa jambatan penuh ZVS DC ke DC converter akan dipilih kerana ia boleh mengendalikan kuasa tinggi dan voltan tinggi. Operasi frekuensi tinggi untuk penggunaan suis MOSFET juga membolehkan sistem beroperasi dalam frekuensi tinggi untuk mengurangkan kehilangan konduksi dan seterusnya meningkatkan kecekapan sistem. Tiga objektif telah dicapai dengan menggunakan perisian MATLAB / SIMULINK yang objektif pertama di mana mereka bentuk fasa fasa tunggal beralih sepenuhnya jambatan DC ke DC converter yang dapat mengawal voltan output oleh PSM dari isyarat nadi suis apabila gangguan beban berlaku. Kedua, teknik ZVS telah dilaksanakan untuk digunakan dalam penukar ini untuk meningkatkan kecekapan sistem semasa PSM isyarat denyut suis MOSFET dan ketiga pengawal telah digunakan untuk mengawal voltan keluaran secara automatik dengan menjalani PSM pada isyarat nadi suis apabila terdapat voltan masukan dari tenaga yang boleh diperbaharui.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

D	-	Duty Cycle
PSM	-	Phase Shift Modulation
PWM	-	Pulse width Modulation
DC	-	Direct Curent
AC	-	Alternating Current
V	-	Voltage
	-	
	-	

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Project Overview

The title of this project is multi input zero voltage switching converter for renewable energy. Nowadays, the world have changed to use renewable energy as the alternative source for the electrical appliances. There are few types of renewable energy that use as the alternative source such as solar energy, wind energy, biomass energy and also fuel cell. By using these renewable energy as the alternative source for the electrical appliances, there allow to save the cost of electrical bill but sometimes there will faced some problems such as unstable output voltage produce due to the weather conditions. For example, for solar system, the voltage accumulated depends on the sunlight. If the sunlight is unstable the voltage accumulate will be unstable and load disturbance will occur. So it is not suitable to supply for the electrical appliances and sometimes will cause the load burn.

To overcome this problem, a converter is designed to regulate the output voltage from the renewable energy source before supply to the load. There are various types of converters such as DC to AC converter (inverter), AC to DC converter and DC to DC converter (chopper). For this project, a DC to DC converter use because the voltage supply from renewable energy is DC. There are two types of DC to DC converter which are isolated and non-isolated DC to DC converter. The three main types of non-isolated DC to DC converter are buck converter, boost converter and buck-boost converter. These three types of converters have limitation which buck converter only can step down the input voltage, boost converter only can step up the input voltage and for buck-boost converter it can either step up or step down the input voltage but the output voltage produce is always in negative. For isolated DC to DC converter, such as fly back and forward converter, there can step up or step down the input voltage by using the transformer and use transformer to

store energy compare to non-isolated DC to DC converter that use inductor to store energy. The output voltage produce by isolated converter is in positive and the phase shift of the pulse signal of the switches of the converter also can apply to step down the input voltage when overload occur.

So, for this project, an isolated DC to DC converter which is a phase shifted full bridge DC to DC converter will be use. The DC input voltage must be convert to AC before the transformer going to step up or step down the input voltage to a specific value. Then it will convert to DC back before supply to the load. The construction of the circuit of the converter will be discuss in the literature review at chapter 2. Inside the converter it consist of transformer to step up or step down the DC source input voltage which use to supply single phase load. Not only that, the converter consists of switches which use for switching mode and what types of switches and transformer use will be discuss in the literature review later. Below figure 1.1 shows the basic topology of phase shift full bridge DC to DC converter.

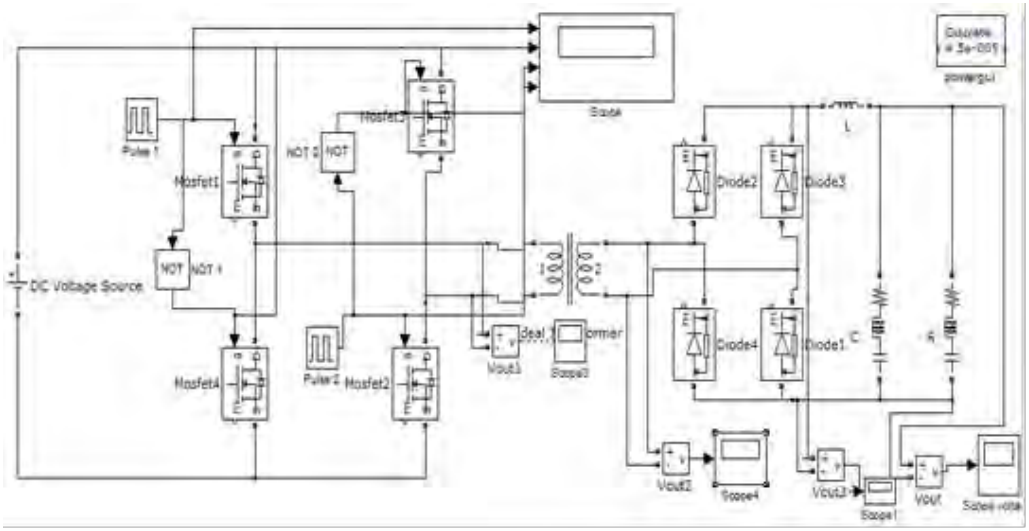

Figure 1.1: the basic topology of phase shift full bridge DC to DC converter

Besides, the second problem which faced when using renewable energy as alternative source is sometimes switching and conduction loss will occur during convert and regulate the output voltage by undergo pulse width modulation (PWM) and phase shift modulation (PSM) for the pulse signal at the switches of the DC to DC converter [1].

To overcome this problem, there is need to apply zero voltage switching (ZVS) which state at the title of this project. The zero voltage switching phase shifted full bridge DC to DC converter is apply to overcome this problem. Zero voltage switching phase shifted full bridge DC to DC converter mostly use in high power and voltage applications. This converter able to handle high power and voltage with low switching and conduction loss [1]. The phase shift feature of the control signal allow ZVS and it able to eliminate the switching loss during FET device transition and this can increase the system efficiency also. ZVS on the phase-shifted PWM control signal can also minimize the parasitic effect so that the conduction loss will be reduced because the converter operate at high switching frequency.

Phase shifted PWM full bridge converter consists of two parts. The first part consists of the DC to AC H bridge converter and the high frequency transformer, and the second part is the AC to DC part. For the first part, the input DC voltage from the renewable energy will be convert to AC by using the DC AC H bridge before going to step up or step down to a desire output voltage that need for the load. The phase shift application of the converter is use to regulate the desire output voltage when there is load disturbance occur due to unstable input voltage which phase shift the pulse signal of the lagging leg switch S2 respect to leading leg switch S1 as shown in figure 1.1. After the AC voltage have been step up to a desire output voltage need for the load and the AC voltage will convert back to DC by using the second part which is AC to DC part.

Besides, to improve the input voltage and power in order to produce enough output voltage and power to supply for the load, a multi input from different sources or same sources of renewable energy can be apply at the input. For multi input, it is easier to achieve the desire output voltage and power need compare to single input. This is because more voltage and power store at the input for multi input.

1.2 Motivation

Nowadays, renewable energy such as solar energy, biomass, wind energy and fuel cell are popular in the world and many place such as residential and industries had applied to reduce the use of electrical energy from govournment to safe the

electrical bills. Not only that, renewable energy also environment friendly which conserve the environment by saving the use of energies. However, there are some problems that faced when use renewable energy to generate electricity which is the unstable output voltage produce due to unstable input voltage. Hence, this is the point that motivated to carry out this project to design a converter to regulate the input voltage from renewable energy in order to achieve the desire output voltage.

Besides, if the output voltage is regulated by using phase shift modulation of the pulse signal of the switches of the converter, the efficiency of the system will be decrease. So, this also motivated to undergo this project to carry out to apply zero voltage switching technic (ZVS) to the switches of the converter in order to improve the system efficiency.

1.3 Problem Statements

The purpose that construct a multi input ZVS converter for renewable energy is to overcome the following problems.

Firstly, the voltage accumulate from the renewable energy is unstable and the voltage is not suitable to supply for the load. This is because the voltage accumulate for the renewable energy such as solar panel use is depends on the weather condition. If the weather condition is change, the voltage accumulated will be unstable and this will cause the output voltage that supply to the load will be unstable or load disturbance will occur.

The second problem is the conduction and switching loss occur in the converter during convert and regulate the output voltage from the source of renewable energy by undergo pulse width modulation (PWM) or phase shift modulation(PSM) for the pulse signal of the switches due to unstable input voltage from the renewable energy. Sometimes there is unstable or overload voltage accumulate at the source of renewable energy during bad weather conditions.

These unstable output voltage from the source of renewable energy will not regulate by the converter because the input voltage and the ratio for the transformer

have been set and fix. For example the input voltage have been set to 24 V and the ratio is 1:10 so the output regulate voltage will be 240. So if there is unstable input voltage, the converter cannot be control and the PWM or PSM for the pulse signal of the switches is need to solve this problem. During PWM or PSM for the pulse of the switches, the conduction loss and switching loss will occur, so ZVS for the pulse signal of the switches after PWM modulation is use to solve this problem.

1.4 Objectives

i) To overcome the problem of unstable output voltage produce from the renewable energy, a ZVS full bridge phase shift DC to DC converter is designed to overcome this problem by undergo PSM or PWM on the pulse signal of the switches.

ii) To overcome the problem of switching and conduction loss on the switches when undergo PSM or PWM on the pulse signal of the switches. A ZVS operation for the phase shifted full bridge DC to DC converter is apply to overcome the problem of switching and conduction loss in the MOSFET switches of the converter due to PSM of the pulse signal of the switches to regulated the input voltage.

iii) To design a controller to auto regulate the pulse signals of the switches to achieve the desire output voltage need when the input voltage is fluctuated. The controller will responsible to determine the amount of phase shift that need for the pulse signal of the switches in order to reach the desire output voltage need to supply to the load by varies input voltage.

1.5 Scope

In this report, a phase shift full bridge ZVS DC to DC converter is design only for single phase load by using MATLAB/ SIMULINK software. The load that suitable for this converter is small DC motor such as DC water pump that use to pump water. Not only that, to undergo ZVS for this converter, it has the limit of input

voltage range in order to produce the reference output voltage. The range of input voltage from 350 V DC to 400V DC in order to produce the reference output voltage of 150 V DC . ,If the input voltage is out of the range, the ZVS operation to reduce the switching losses due to PSM of the pulse signal of the switches unable to carry out. The output voltage also unable to maintain at 150V reference voltage. To overcome the problem of fluctuated of the input voltage, the PI controller is use.