BUCK-BOOST SINGLE-STAGE INVERTER INTEGRATED WITH BATTERY CHARGING FOR RENEWABLE ENERGY HARVESTING

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2021

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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

2021

DECLARATION

I declare that this thesis entitled "BUCK-BOOST SINGLE-STAGE INVERTER INTEGRATED WITH BATTERY CHARGING FOR RENEWABLE ENERGY HARVESTING is the result of my research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature : 

Name : MUHAMMAD HAZWAN BIN HASBOLLAH

Date : 5 / 7 / 2021

APPROVAL

I hereby declare that I have checked this report entitled "BUCK-BOOST SINGLE-STAGE INVERTER INTEGRATED WITH BATTERY CHARGING FOR RENEWABLE ENERGY HARVESTING" and in my opinion, this thesis complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature : .....

Supervisor Name : DR. MAASPALIZA BINTI AZRI

Date : 5 / 7 / 2021

DEDICATIONS

To my beloved mother and father

ACKNOWLEDGEMENTS

Many thanks to the lecturer, colleagues and teaching assistants for their help in carrying out this project. They have contributed to my understanding and thought. I wish to express my sincere appreciation to my main project supervisor, Dr. Maaspaliza Binti Azri, for encouragement, guidance critics, and friendship. It was a great pleasure to have this opportunity to have her as my supervisor for completing this project.

ABSTRACT

Conventional energy generation affected our earth and something needs to be done to reduce the effect of the greenhouse defect. Renewable energy has been one of the best alternatives to counter this problem before it getting worse. Solar energy is the most abundant source on the earth. With the increase of the renewable energy demand, the need for the inverter is very common in solar energy harvesting to get an AC load per household application. The buck-boost, a single-stage inverter integrated with a battery topology is introduced in this project. Buck-boost single-stage inverter also improves the efficiency of the system for the stand-alone solar system because of the topology proposed only one conversion stage. With this implementation, hoping that the output of the inverter can improve the stability and reliability of the system. A method that is used in this system is by eliminated the transformer and reduce the multiple stages that involve the common inverter. The desired output of the inverter is 240 Vrms in phase with low noise and disturbance in the system. The topology used in the inverter is a buck-boost single-stage inverter that implements a modified PWM technique to get the desired output. Integrated with battery also utilized and increase the usage of sources to the maximum. The system will be simulated in the MATLAB Simulink and the performance of the inverter is observed. The THD of buck-boost single stage output voltage is produced sinusoidal waveform with 6.51%.

ABSTRAK

Penjanaan tenaga konvensional mempengaruhi bumi kita dan ada yang perlu dilakukan untuk mengurangkan kesan kerosakan rumah hijau. Tenaga boleh diperbaharui telah menjadi salah satu alternatif terbaik untuk mengatasi masalah ini sebelum menjadi lebih teruk. Tenaga suria adalah sumber yang paling banyak di bumi. Dengan meningkatnya permintaan tenaga yang boleh diperbaharui, keperluan penyongsang sangat umum dalam pengambilan tenaga suria untuk mendapatkan output dan kecekapan sistem yang baik. Dengan inverter tahap tunggal buck-boost yang disatukan dengan bateri dapat meningkatkan kecekapan sistem kerana inverter topoloji yang diperkenal hanya menggunakan satu tungkat pertukaran sahaja. Dengan pelaksanaan ini, diharapkan output penyongsang dapat menghasilkan keluaran penyongsang yang stabil dan berkualiti kepada sistem tenaga matahari penyendiri kerana kebiasaan penyonsang ada beberapa peringkat penyonsang yang mampu mengurangkan kecekapan kepada sistem. Keluaran inverter yang diinginkan adalah 240 Vrms dalam fasa dengan kebisingan rendah dan perbezaan dalam sistem. Topologi yang digunakan dalam penyongsang adalah penyongsang tahap tunggal yang meningkatkan pengukuhan PWM untuk mendapatkan output yang diinginkan. Bersepadu dengan bateri juga digunakan dan meningkatkan penggunaan sumber ke maksimum. Sistem akan disimulasikan dalam simulink MATLAB dan tahap prestasi penyongsang diperhatikan. Maka THD daripada buck-boost single stage inverter dapat menghasilkan sinusoidal dengan 6.51%.

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LIST OF SYMBOLS AND ABBREVIATIONS

DC	-	Direct Current
AC	-	Alternate Current
SoC	-	State of Charge
PV	-	Photovoltaic
MPPT	-	Maximum Power Point Tracking
PWM	-	Pulse Witdth Modulation
MOSFET	-	Metal–Oxide–Semiconductor Field-Effect Transistor
I-V characteristic	-	Current-Voltage characteristic

Vd	-	Voltage Diode
L	-	Inductor
C	-	Capacitor

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CHAPTER 1

INTRODUCTION

1.1 Overview

An inverter is a type of converter that is commonly used in this present world. There was any type of inverter that has in our world depend on their functionality. The solar farm is a rising industry that needs an inverter to charge their battery and their research to improve the efficiency of the inverter are still has a lot more room that needs to be done.

Two types of inverter that are single-stage and multistage inverter are commonly used in the solar industry because of its need to change DC supply to AC supply. Each of the topologies has its own advantageous on the efficiency of the inverter, their cost, and the controllability of the inverter of the entire system. These advantages can determine the best maximum power point tracking (MPPT) of the inverter so that the inverter can produce the optimum output to feed the grid.

1.2 Motivation

The rapid growth of renewable energy technology has gave a big impact on our energy system[1]. Abundant sources of renewable energy such as wind, geothermal, solar, biomass, and hydropower that yet not fully utilize have brought a big room to reduced the high consumption of sources in conventional energy generation that bring much pollution compare to renewable energy.

Due to the highly effective economic progress from conventional energy base on coal and natural gas, the demand for energy sources has increase 1.8% in 2012[2]. Many organization has encouraged for the research in green energy and its efficiency and since environmental concerns increase made the world invest on renewable energy for better future[2]. The main goals of shifting into renewable energy are focusing on reducing greenhouse gas emission and climate impacts, reliability, and cost effusion upon delivering the energy[2].

Table 1.1 shows that the growth of renewable energy dependability increasing sharply over the past 10 years and this shows the positive sign of the optimum usage of renewable energy resources. Focusing on these resources also has increased the confidence in the technologies, reduced cost, and opened up new opportunities for a future generation[2].

Table 1-1 Renewable energy usage by type[2]

	2010	2020	2035
Electricity generation (TW h)	**4206**	**6999**	**11,342**
Bioenergy	331	696	1,487
Hydro	3431	4513	5,677
Wind	342	1272	2,681
Geothermal	68	131	315
Solar PV	32	332	846
Concentrating solar power	2	50	278
Marine	1	5	57
Share of total generation	**20%**	**25%**	**31%**
Heat demand (Mtoe)	**337**	**447**	**604**
Industry	207	263	324
Buildings and agriculture	131	184	280
Share of total production	**10%**	**12%**	**14%**
Biofuels (mboe/d)	**1.3**	**2.4**	**4.5**
Road transport	1.3	2.4	4.4
Aviation	–	–	0.1
Share of total transport	**2%**	**4%**	**6%**

Solar photovoltaic is a renewable energy that has the most sources in the world. The basic system of the solar photovoltaic is it supply DC supply and change it to an AC source that can be connected to the grid. The efficiency of the solar system is the best improvement that can be made as a researcher due to the reliability of the availability of sunlight. Therefore, in this research, the single-stage inverter having buck-boost operation topology is proposed to improve the efficiency and the controllability of the system to supply AC sources to the grid. Also the charging the battery capability are proposed in this project.

1.3 Problem Statement

Renewable energy harvesting inverter has a multiple power stage that increases the losses and causes low efficiency of the entire system. The improvement that focusing the charging capabilities also needs to be considered as solar energy can be optimized in the daylight. The multiple stages also increase the component of the inverter that makes the inverter more costly. Multiple switching involves simultaneous switching therefore it increases losses between the switching occurs.

A new configuration of DC to AC single-phase transformerless inverter topology with the single-stage operation plus battery charging capability introduced will perform a better performance in terms of efficiency and reduces the losses. The common inverter doesn't optimum the usage of the sources. With the buck-boost inverter, it will use solar energy in optimum condition to improve the inverter system. With the aid of buck-boost circuit configuration without a transformer to handle the input and the output, the size of the inverter will reduce and increase the rate of renewable energy resources. Therefore, the drawbacks of the previous project are overcome by this research.

1.4 Objective

The objective of this research are:

- To model and design the single-stage inverter with a charging battery solar energy system.
- To design the switching algorithm for buck-boost inverter
- To analyze the performance of the single-stage inverter in term of THD, amplitude of fundamental and efficientcy of the inverter.

1.5 Scope

This project aims to study the performance of the single-stage inverter system. This research only covers the single-stage inverter integrated with a battery for renewable energy harvesting. The circuit configuration for this research is a buck-boost circuit and the switching technique is using PWM switching technique. MATLAB Simulink is used to model and analyzed the output of the converter and the step of charge of the battery. For simulation, the voltage source is used as the source of the inverter. In modeling the inverter system, MOSFET for switching and resistor for the load used for this research. This research only covers the simulation and showed that the usage rate can be increased by uncooperating the battery charging with the inverter.

1.6 Outline

This report consists of five chapters which are started with chapter 1 which is explained the introduction of the project. Chapter 2 is discussed the literature review of the previous research. In chapter 3, the methodology of the project is explained. For chapter 4, results and discussions of the project are discussed. In chapter 5, the conclusion and recommendation are discussed.

For chapter 1, there is an explanation of the project overview, problem statement and motivation, objective, and scope of the project.

For chapter 2, there is some literature review based on the previous research such as photovoltaic/solar module characteristics, type of the inverter, type of the inverter topologies, PWM switching technique, and Single-stage inverter topologies with battery charging.

For chapter 3, there is a flowchart of the project, project milestone, project Gantt chart,

For chapter 4, the simulation result of the proposed

For chapter 5, the conclusion is discussed, and the recommendation of the research is suggested for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is a chapter review created to get ideas about the project design, concepts, and any relevant information to improve the project. This chapter also describes and discusses resources or articles related to the project and giving the point about the research. This chapter also consists some basic idea for the circuit topology, the photovoltaic module, and type of inverter that have in our world.

2.2 Photovoltaic/Solar Module Characteristic

Solar energy is a source of energy that has been harnessed by human time by time since ancient times that radiates light and produces heat. Solar energy is the most available energy on earth but only a minuscule fraction of solar can be used such as on electricity and heater [3].

2.2.1 Solar Cell

The electrical device introduced to our world name solar cell or photovoltaic cell. It converts solar energy into and electrical energy by the photovoltaic effect when it is exposed to the light either from sunlight or artificial light. The maximum voltage that can be produced by the solar cell approximately about 0.5 to 0.6 volts.[4]

There is 3 basic attribution on the operation of the solar cell, first is The absorption of light, generating either electron-hole pairs or excitons. The second is The separation of charge carriers of opposite types. Lastly is The separate extraction of those carriers to an external circuit.[4]

2.2.2 Solar Module

A solar module is a combination of a pack of solar cells that can produce high wattage of power. This module is more efficient than the solar cell that produces very low voltage. It is connected with a series bunch of solar cells to produce higher voltage output to perform maximum efficiency. The range of energy output of the solar module is about 100-365 watts of dc voltage. The higher the wattage output, the bigger energy production producing by the solar module.[4]

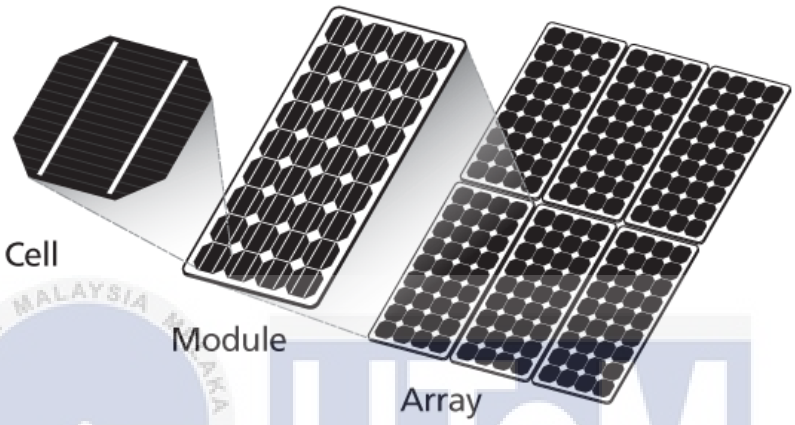

Figure 2-1: Difference Between Cell, Module, and Array [4]

2.2.3 Construction of Solar Module

The most solar module is still created by the series of element crystalline cells sandwiched between a front glass plate and a rear compound plastic back-sheet supported inside an aluminum frame [5]. The lifespan of a solar module if it's installed perfectly, can last about up to 20 years with the help of scheduled maintenance and good care of the solar module [5].

A solar cell is made up of silicon crystalline wafers that are similar to the computer chip on the processor making [5]. It can be polycrystalline or monocrystalline and the most efficient is monocrystalline and which costs way higher than polycrystalline due to the manufacturing process that expensive [5].

Figure 2-2 Solar Cell Manufacturing Process [5]

There is 6 main component on making a solar module that is solar photovoltaic cells, toughened Glass - 3 to 3.5mm thick, extruded Aluminum frame, encapsulation - EVA film layers, polymer rear back-sheet and lastly junction box that consist diodes and connectors [5].

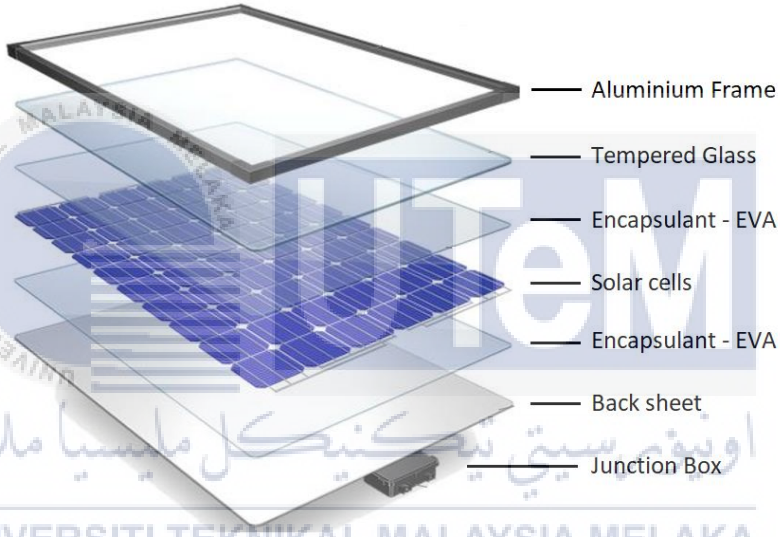

Figure 2-3 Construction of The Solar Module[5]

2.2.4 Type of Solar Module

There is 3 type of solar panel for commercial and the residential purpose. All 3 type has their own advantageous and disadvantageous. So let break this three type shortly for the review. Firstly, there is the monocrystalline type. This type is the most efficient and expensive in our market available right now[6]. Due to high efficiency versus cost, mostly the application of it is a residential area that can give maximum electrical output for the customers[6].

The second one is the polycrystalline solar panel. This is the opposite side of the monocrystalline type that is less efficient and more affordable. This type is commonly used on solar farms due to its cost and its build structure is the same as the