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CASCADED DC-DC BOOST CONVERTER FOR FUEL CELL APPLICATIONS

FOR

FINAL YEAR REPORT 2

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"I hereby declare that I have read through this report entitle "Cascaded DC-DC Boost Converter for Fuel Cell Applications" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Power Electronics and Drives)

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CASCADED DC-DC BOOST CONVERTER FOR FUEL CELL APPLICATIONS

SHAZREDZUAN BIN QASIM

A thesis submitted

in partial fulfillment of the requirements for the degree of

Bachelor of Electrical Engineering (Power Electronics & Drives)

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2015

I declare that this report entitle "Cascaded DC-DC Boost Converter for Fuel Cell Applications" is the result of my own research except as cited in the references. The report has not been accepted any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

Nowadays, step up power conversion is popularly used in many applications around the world. One of the famous power conversions right now is fuel cell (FC). Fuel cell is a good power conversion because it is a renewable power conversion. However the main issue is FC is provide a small output. Therefore, suitable devices need to be proposed to step-up the voltage output from the FC. One of the compatible devices to step-up the voltage output of FC is boost converter. In this thesis, a new approach of boost converter has been proposed by combining interleaved boost converter with three-level boost converter on cascade structure. These two types of converter had been recognized as stage 1 converter and stage 2 converter. Besides to analyze the performance of proposed converter the comparison between proposed converter and conventional boost converter was carried out. All the converters is modeled and simulated by using Matlab Simulink. The simulation results are recorded and presented to authenticate the proposed scheme.

ABSTRAK

Pada masa kini, penaik pengubah kuasa popular digunakan dalam perbagai aplikasi di seluruh dunia. Salah satu pengubah kuasa yang terkenal kini adalah fuel cell (FC). Fuel cell adalah pengubah kuasa yang baik kerana ianya boleh diperbaharui. Walaubagaimanapun, isu utama adalah FC menyediakan keluaran yang kecil. Oleh itu, peranti yang sesuai perlu dicadangkan untuk menaikkan voltan keluaran daripada FC.Salah satu peranti yang sesuai untuk menaikkan voltan keluaran adalah perangsang pengubah. Di dalam tesis ini, pendekatan baharu rangsangan pengubah telah dicadangkan dengan menggabungkan antaralembar rangsangan pengubah dengan tiga-tahap rangsangan pengubah dalam struktur lata pengubah. Kedua-dua jenis pengubah ini dikenali sebagai pengubah peringkat 1 dan pengubah peringkat 2. Selain itu, untuk menganalisa prestasi pengubah yang dicadangkan, perbandingan antara pengubah yand dicadangkan dengan pengubah konversional telah dijalankan. Kesemua pengubah dimodel dan disimulasi menggunakan Matlab Simulink. Keputusan simulasi direkodkan dan dibentangkan untuk mengesahkan skema yang dicadangkan.

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LIST OF ABBREVIATIONS

FC	Fuel Cell
DC	Direct Current
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
IGBT	Insulated-Gate Bipolar Transistor
BJT	Bipolar Junction Transistor
MDIBC	Multi-device Interleaved Boost Converter
SIMLBC	Switched Inductor Multilevel Boost Converter
PWM	Pulse Width Modulation
PID	Proportional Integral Derivative

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CHAPTER 1

INTRODUCTION

1.1 Motivation

A fuel cell (FC) is a device that produces electricity by undergo chemical reaction process. In the structure of the FC, it consist two electrodes, positive and negative electrodes. The electrodes are called anode and cathode. Besides, FC also consist an electrolyte that carries electricity charged particles from one electrode to another electrode, and also a catalyst to boost the reactions at the electrodes. To generates the FC, hydrogen is the main material, however FC also need an oxygen. The benefit of the FC is produce electricity with very little pollution. This is caused by the combination of hydrogen and oxygen that used in producing electricity produce a byproduct, namely water. Each of a FC produces a small amount of direct current (DC). Each FC just provide a voltage around $0.7V - 1.6V$. So, in real life, FC usually assembled into a stack [1]. The basic working concept of fuel cell are shown in Figure 1.1.

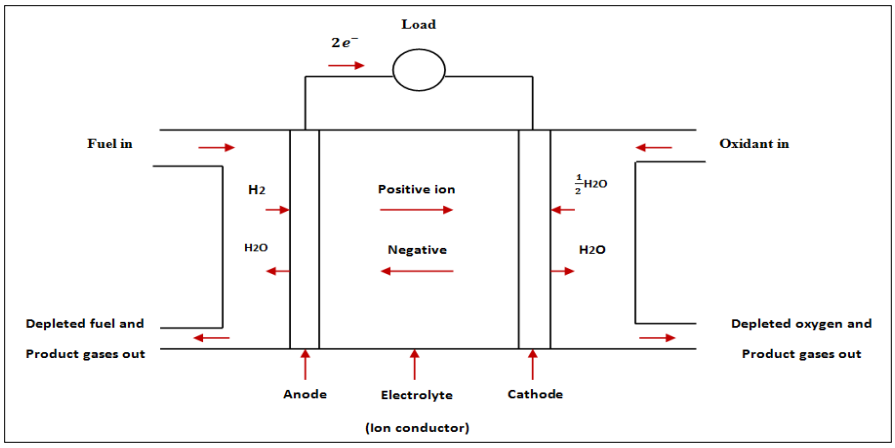

Figure 1.1: Basic working concept of fuel cell

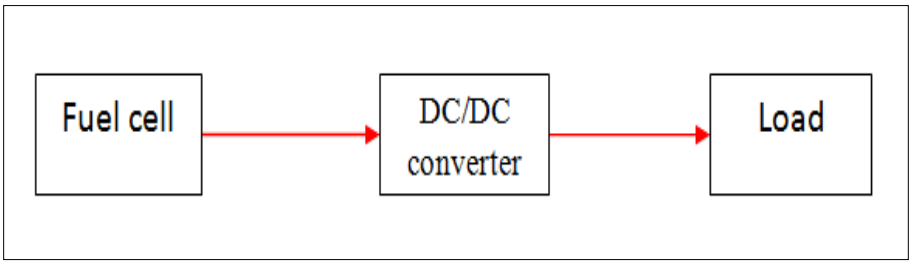

Figure 1.2: Block diagram of connection between fuel cell, converter, and load

Because of fuel cell basically provided a small output voltage, a converter is required to step up the voltage. DC-DC boost converter is the suitable device to convert the unregulated DC input to a controlled DC output as shown in Figure 1.2 [2]. Power electronics nowadays has focusing to meet the characteristic such as high reliability, efficiency, and low cost. DC-DC boost converter consist some component inside the structure. It consist a basic component such as diode, inductor, capacitor and adding of switch such as MOSFET. But, other semiconductor switches like IGBT's and BJT's can be proposed too. For the boost converter, it is a switching converter that operates by periodically opening and closing an electronic switch. This is named boost converter because the output voltage is bigger than the input voltage ($V_o > V_i$). Therefore,this project combination of interleaved boost converter and three level boost converter with a cascade

converter structure leads to a high voltage gain output. It is because the proposed converter structure is constituted by a cascade of two sub-converters in order to obtain the desired voltage [3].

1.2 Problem Statement

Nowadays, the DC-DC boost converter is the typical step up power converter applied in many applications because it may convert from low input voltage to high output voltage by controlling a duty cycle of the power switch. However, the conventional DC-DC boost converter just provide voltage output twice as input voltage of the converter. In order to achieved high voltage and low output current ripple, the design of the converter need to be improved to get a high efficiency. In this project, DC-DC boost converter is designed by using the combination of interleaved boost converter with three-level boost converter in cascade structure. However other challenges arise because cascade structure is difficult to synchronous. The converter should be designed properly to get the desired results.

1.3 Objective

i. To design a cascade converter structure consists of interleaved boost converter and three-level boost converter using Matlab Simulink simulation approach.
ii. To analyze the performance of adopted cascaded converter and cascaded conventional converter in term of voltage output, current output, output ripple of voltage and current and efficiency.

1.4 Scope

The scope of the research is to model and simulate the dc-dc boost converter that designed by combining the interleaved boost converter with three-level boost converter by using cascade structure approach. The modeling and simulation process was conducted by using software Matlab Simulink.

1.5 Report Outlines

The following chapters investigate about DC-DC converter that becomes the main part of this project.

Chapter 1 provides about the introduction of dc-dc converter and the overview of the studies. This chapter also explains about the project motivation as a problem statement to the DC-DC converter. Besides, the objective and the scope are included in this chapter.

Chapter 2 provides an introduction to literature review about high voltage DC-DC converter. The literature review in chapter 2 also develops the fundamental theory and basic principles of the DC-DC converter. At the end of this chapter, summary and discussion of the review will be discussed.

Chapter 3 provides the design methodology based on the fundamental theory and basic principles of the DC-DC converter. The design includes the methodology process and approach for this project to get the results.

Chapter 4 provide about the expected result of high voltage DC-DC converter that collected from Simulink drawing in MATLab Simulink. The results will be shown in waveform.

Chapter 5 will provide the expected conclusion of this project. The objectives of this report will be discussed whether the objectives is achieved or not.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this section, it will be discussed about previous related work that associated with field of this project. The summarization of the work will be shown in this section.

2.1 Basic Principles of fuel cell

Fuel cell is electrochemical devices that use oxygen and hydrogen as a fuel. This devices converting both oxygen and hydrogen into water in the process that produce electricity. Use of the fuel cell as an energy source has received a positive reaction among researchers to make it as one of a new primary energy source in the future. It is because fuel cells provide the maximum criteria that meeting the requirements of zero emission vehicles, expected to be the main model users of hydrogen in future [4].

Fuel cell work similarly like a baterry. In both batteries and fuel cells two electrodes consisting of an anode and a cathode are seperately by an electrolyte. The principle of fuel cell operation are shown in Figure 2.1. Whereas a storage battery contains all the substances in the electromechanical oxidation reduction ractions involved. Thus, a limited capacity, a fuel cell is supplied with its reactants outwardly and works continously as long as it is provided with fuel cell. Besides, the limitation of fuel cell because of low input voltage making it unstable. Basically, each stack of fuell cell just provide $0.7V - 1.6V$ of voltage output [5].

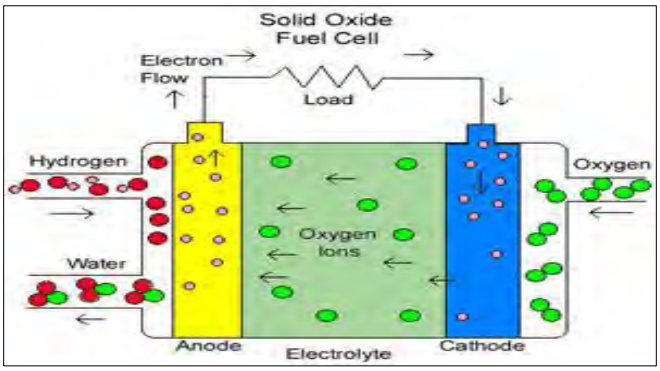

Figure 2.1: Basic principle of fuel cell

2.2 Review of previous related works

Due to low output voltage of fuel cell, the DC-DC boost converter is needed. This section will discuss several types of DC-DC Boost converter.

2.2.1 Conventional boost converter

A boost converter is functioning as a converter that convert low input voltage to high output voltage. Conventional boost converter is operating regularly opening and closing an electronic switch. The conventional boost converter has four external components. It is inductor, switch, diode and output resistor. The switch of the converter need to have fast turn on and off. The