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UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**LAPORAN PROJEK  
SARJANA MUDA**

**DESIGN AND SIMULATION OF DC-DC SWITCHING BOOST CONVERTER FOR  
CURRENT RIPPLE REDUCTION**

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**Bachelor of Electrical Engineering**

**June 2013**

“I hereby declare that I have read through this report entitle “Design and Simulation of a DC-DC Switching Boost Converter For Current Ripple Reduction” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)”

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**DESIGN AND SIMULATION OF DC-DC SWITCHING BOOST CONVERTER FOR  
CURRENT RIPPLE REDUCTION**

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**A report submitted in partial fulfilment of the requirements for the degree of Electrical  
Engineering (Industrial Power)**

**Faculty of Electrical Engineering  
UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2013**

I declare that this report entitle “Design and Simulation of a DC-DC Switching Boost Converter for Current Ripple Reduction” 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 : .....

To my beloved family,

*Abah*

*Mama*

*Along*

*Ana*

*Apit*

*Baby*

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## ABSTRACT

This project is to simulate and to design a DC-DC switching boost converter for current ripple reduction. Step up converter is also referred to boost converter where its characteristic is to have a voltage at the output that is larger than the voltage at the input. The converter operates by opening and closing an electronic switch such as a power MOSFET, IGBT's or thyristors periodically. Ripple exist during the switching process in the DC-DC converter where the change or switching from the ON state and OFF state produces current ripple in the inductor. By reducing the current ripple in the DC-DC switching boost converter, the efficiency of the DC-DC switching boost converter will increase. Methods that is available for current ripple reduction includes by increasing the value of the inductor, by using soft-switching techniques and also by the adaptation of interleaving technologies. The method of varying the value of inductance to reduce the current ripple in the DC-DC boost converter is presented in this paper.

*Keywords: DC-DC converter, boost converter, current ripple, reduction*

## ABSTRAK

Projek ini adalah bertujuan untuk mensimulasi dan mereka bentuk satu arus terus peningkatan pensuisan arus terus penukar untuk pengurangan riak arus. Meningkatkan penukar juga dirujuk kepada peningkatan penukar di mana biasanya mempunyai nilai voltan di output yang lebih besar daripada nilai voltan di input. Penukar beroperasi dengan kondisi di mana suis elektronik di buka dan di tutup secara berkala oleh suis elektronik seperti MOSFET, IGBT atau thyristor. Gelombang atau riak ini wujud dalam proses pensuisan dalam arus terus penukar di mana perubahan dari kondisi buka kepada kondisi tutup menghasilkan riak dalam pengaruh. Dengan mengurangkan riak arus dalam arus terus peningkatan pensuisan arus terus penukar, kecekapan arus terus peningkatan pensuisan arus terus penukar dapat ditingkatkan. Cara yang tersedia ada untuk mengurangkan riak arus terus termasuklah dengan menambahkan nilai pengarus, dengan menggunakan teknik penukar lembut dan juga oleh penyesuaian pengantara lembaran teknologi. Kaedah mempelbagaikan nilai aruhan untuk mengurangkan riak arus dalam arus terus peningkatan arus terus ini akan dibentangkan di dalam kertas tulis ini.

*Kata kunci: Dc penukar DC, penukar peningkatan, riak arus, pengurangan*



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**LIST OF ABBREVIATIONS**

AC	-	Alternating Current
DC	-	Direct Current
SEPIC	-	Single Inductance Converter
IGBT	-	Insulated Gate Bipolar Transistor
DSP	-	Digital Signal Processing
MOSFET	-	Metal Oxide Semiconductor Field Effect Transistor
CCM	-	Continuous Current Mode
DCM	-	Discontinuous Current Mode
$L_{min}$	-	Minimum Inductance
V	-	Voltage
$V_s$	-	Voltage source
D	-	Duty cycle
f	-	Frequency
R	-	Resistance
CCS	-	Code Composer Studio
PCB	-	Printed Circuit Board

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

As the world evolves to an era where the parameters of a device or component in terms of size, weight, and performance of technologies are concerned, the power electronic industry escalates to rise. With the advantage of having a compact system with low losses, high efficiency, availability, and reliability, new switching circuit topologies, high speed of response, power electronic operates with digital or analog electronic control circuits with the conjunction of semiconductor device circuit. Power electronics is the combination of three important elements which are power, electronics and control. Power electronic device allows the conversion of voltage and current to a specified output without the need of a transformer. There are six types of power electronic circuits which includes diode rectifier, AC-DC converters (controlled rectifier), AC-AC converters (AC voltage controller), DC-DC converters (DC choppers or switching regulator), and static switches. Each type can be divided into a broader range of implementation depending on its function. In line with the topic of the project, the scope is directly focused to the DC-DC converter. Based on the industrial demand, fixed voltage DC source are required to be converted into a DC voltage source that is variable while maintaining the system to have acceleration control that is smooth, high efficiency and also to have fast dynamic response. The types of converters can be divided to buck converter (also known as the step down converter), boost converter (as step up converter), buck-boost converter, cuk converter, single inductance converter (SEPIC) and also interleaved converter (multiphasing). The boost converter or also known as the step up converter is a switching converter that uses semiconductor devices such as diode, thyristor, IGBT and transistor as switches that is periodically open and closes.

The boost converter has the characteristic of having an output voltage higher than the input voltage. A problem exists in the converter as it is a switching converter. The interrelation between the ON and OFF state of the semiconductor devices as switches (diode, thyristor, and transistor) causes current ripple at the inductor. This project consist of the pulse generated from a program from the digital signal processing (DSP), a gate drive to drive the IGBT of the boost circuit, and the boost circuit itself.

## **1.2 Problem Statement**

Current ripple reduction in a DC-DC boost converter is crucial in order to cater the escalating demand of electronic devices that faces challenges in designing in terms of battery life, power dissipation and many more. Ripple exist during the switching process in the DC-DC converter. The change or switching from the ON state and OFF state produces current ripple in the inductor. The converter will suffer from efficiency reduction as the higher the switching frequency, the more losses it would have. By reducing the current ripple of the DC-DC boost converter; it would overcome the problem faced as the DC-DC converter will improve its efficiency, dynamic response and provides smooth acceleration control. Therefore, this project simulates and designs the DC-DC switching boost converter for current ripple reduction.

## **1.2 Objectives**

The objectives of the project includes

1. To design and to obtain the correct parameters of a DC-DC switching boost converter for current ripple reduction
2. To understand the effect of switching to current ripple
3. To model, simulate and analyze the DC-DC switching boost converter for current reduction designed using MATLAB software
4. To develop a hardware prototype of the DC-DC converter

## **1.4 Scope of Project**

The scope is limited to simulate, design and to analyze an open loop DC-DC switching boost converter with a continuous current mode operation. MATLAB is used to simulate the DC-DC switching boost converter in terms of the relationship of related parameters that would affect the current ripple in the DC-DC switching boost converter which includes by varying the value of frequency and by varying the value of duty cycle. The pulse width for the switching controller is generated by using programming developed by DSP TMS320F2812. And the hardware implementation of the DC-DC switching boost converter is based on the simulation done in the MATLAB software.

## **1.5 Chapter summary**

This chapter states the background or motivation of this project, the problem statement, the objectives that are identified that needs to be accomplish throughout the project and the scope that is to limit the research area and what to focus on. The next chapter which is chapter 2 will discuss regarding the literature to show a brief overview regarding the projec

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

In this chapter describes the general overview of components and criteria's or software involved in the process of developing this project. The literature review part is to provide a general overview regarding the DC-DC boost converter. It is also to supports theoretically regarding the implementation of this project.

#### 2.2 Common Methods for Current Ripple Reduction

##### 2.2.1 By increasing the value of the inductance

As stated in [4] the value of the inductance used in a converter holds a huge significance to the existence of current ripple in a circuit thus affecting the efficiency or performance of the circuit. [4] States that if the load current in the converter increases, the inductance reduces as it is forced towards saturation. In [11] states that the higher the value of the inductor, the slower the start up time. [11] Describes that the inductance that is to be used in the circuit must be based on the maximum current ripple that is allowed during the minimum duty cycle,  $D$  at the maximum input voltage.

### 2.2.2 Frequency control

Micro-technology forces manufacturers to produce miniature products. The voltage needed for a microprocessor requires low voltage but increasing current rating. With little amount of inductance in the circuit, large current ripple will result during the switching process. Research in [8] states that the peak to peak current and conduction mode of the converter will be affected by the changes of switches.

### 2.2.3 Interleaved technologies

In an interleaved boost converter, the phase number, the size of inductance, the amplitude of switching frequency, the input voltage, the desired output voltage and the load that is connected to the circuit effects the current ripple in the circuit of the DC-DC boost converter. Based on research [7] that uses the method of interleaved DC-DC boost converter, the research that is conducted results that the inappropriate usage of components (inductors, input voltage source and MOSFET) would cause effect to the input current amplitude during the interval of the switching process, the current in the inductor is not equal to zero as resonance exist in the circuit. Research [7] includes optimal control, components selection and input filter as techniques to reduce the input current ripple. For optimal control high consideration are given upon selecting optimal base angle and phase shift angle. The input current ripple will be minimized as the switching frequency increases but the downside is that it would produce high power dissipation. The second technique introduced in [7] includes components selections (MOSFET and inductance). High inductance causes smaller current ripple but it would impact the speed response, power density and also efficiency. [7] States that other parameters such as the temperature rise, saturation current and magnetic core material characteristic should be taken into consideration. The third technique introduced by [7] is the input filter. To minimize the input current ripple, a series of damped filter (output impedance of the input filter must be less than input impedance of the converter) is attached to the circuit thus causing it to affect its stability to be better.

### 2.3 Overview of Boost Converter

DC-DC converters are invented to cater the need of industrial application as the demand of a variable voltage source is needed. DC-DC boost converter or also known as step-up converters are converters where the output voltage is higher than the voltage at its input. It operates by periodically opening and closing an electronic switch. The information and details on the DC-DC switching boost convert includes the discussion on its mode of operation, the Figure 2.1: illustrates the basic structure of a DC-DC boost converter.

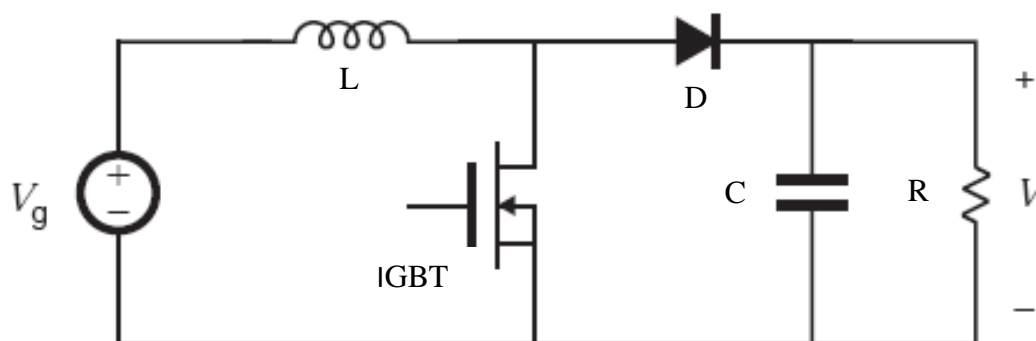


Figure 2.1: Boost converter [4]

The basic component of a DC-DC boost converter is a voltage source, inductor, diode, capacitor, resistor and a switching device which can be any semiconductor device such as MOSFET, IGBT or thyristor as can be seen in figure 2.1 above. Based on research conducted by previous researchers, current ripple can be reduced by several methods which includes by increasing the value of inductance, through frequency control, by varying the value of inductance and by using interleaving technologies. In this project only two methods are implemented which is through varying the value of frequency and by varying the value of its duty cycle.