DESIGN OF DC-DC BUCK-BOOST NON-INVERTING CONVERTER USING PIC MICROCONTROLLER

AHMED KHUDHAIR ABBAS

SCHOOL OF ELECTRICAL SYSTEM ENGINEERING
UNIVERSITI MALAYSIA PERLIS

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By

AHMED KHUDHAIR ABBAS

(1432221154)

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DECLARATION OF THESIS

Author's full name : AHMED KHUDHAIR ABBAS

Date of birth : 14 NOVERMBER 1989

Title : Design of DC-DC Buck-Boost Non-Inverting Converter using PIC Microcontroller

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LIST OF ABBREVIATIONS

DC	Direct Current
FSW	Switching Frequency
PWM	Pulse Width Modulation
V	Voltage
I	Current
R	Resistance
L	Inductor
C	Capasitance
E.M.F	Electro Magnetic Field
PCB	Printed Circuit Board
PIC	Programmable Intelligent Compute
IDE	Integrated Development Environment
MCU	Microcontroller Unit
CCM	Continuous Current Mode
ESR	Equivalent Series Resistance
BJT	Bipolar Junction Transistor
IGBT	Insulated-Gate Bipolar Transistor
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
ISIS	Intelligent Schematic Input System professional
Ω	Ohm
%	Percentage

LIST OF SYMBOLS

d	Duty Cycle
d_1	Duty Cycle Of Buck Converter
d_2	Duty Cycle Of Boot Converter
D_1	Diode Of Buck Converter
D_2	Diode Of Boost Converter
S_1	Switch Of Buck Converter
S_2	Switch Of Boost Converter
R_L	Resistive Load

Rekabentukkan Penukar DC- DC Buck-Boost Tidak-Songsang Menggunakan PIC Pengawal Mikro

ABSTRAK

Suis penukar MOSFET DC-DC telah digunakan secara meluas dalam pelbagai jenis peranti mudah alih dan bukan mudah alih elektronik. Tujuan utama kajian ini adalah voltan masukan, yang terhasil dari sumber yang dinamik. Ia diperlukan untuk mengawal model Buck-Boost bukan penyongsang penukar pengawal oleh kitaran penuh isyarat dalam PWM. Objektif kajian ini adalah untuk mereka bentuk, simulasi dan menganalisis litar penukar untuk mengawal voltan keluaran dengan menggunakan PIC Microcontroller (16F877A). Dalam merekabentuk litar, kekutuban voltan keluaran harus tidak berubah. Selain itu, litar ini harus boleh bertindak secara automatik untuk mengubah dari satu mod ke mod yang lain untuk penukar Buck-Boost. Sebelum ini, dua penukar digabungkan bersama-sama telah digunakan, iaitu di dalam keluaraga Buck dan Boost. Litar ini akan melaksanakan operasi dua langkah, mod menaik dan mod menurun, yang bergantung kepada keadaan input masukan. Perisian simulasi dan perkakasan pelaksanaan model telah siap dibina. Proteus Software telah digunakan sebagai alat perisian simulasi. PIC Microcontroller telah digunakan dalam litar ini untuk menjana PWM. Litar ini telah mencapai voltan keluaran 12VDC walaupun voltan masukan berubah-ubah dengan pelbagai tahap voltan masukan di antara (6-18) VDC. Litar ini telah dipilih dalam projek disertasi ini kerana ia mempunyai spesifikasi terbaik seperti induktor dan kapasitor tunggal untuk kedua-dua penukar, jumlah komponen elektrik yang kurang, tekanan yang lebih rendah, dan membawa kepada mengurangkan jumlah kos kerugian, kos dan juga meningkatkan kecekapan litar . Lebih-lebih lagi, ia telah mencapai voltan keluaran bekalan dengan kutub positif. Daripada keputusan ujian, kecekapan purata penukar yang dicadangkan itu mencapai pada 82%. Satu alternatif yang baru boleh digunakan untuk meningkatkan prestasi bukan menyongsang penukar Buck-Boost pada simulasi untuk aplikasi yang berkuasa tinggi dan telah dicadangkan berkaitan dengan penukar konvensional DC-DC ini telah dibahagikan dengan modaliti selari dalam penukar Multi-Modular. Oleh itu, tekanan yang tinggi semasa suis semikonduktor adalah dapat diatasi. Ia adalah satu penyelesaian yang optimum untuk keperluan semasa bagi beban tinggi dalam penukar DC.

Design of DC-DC Buck-Boost Non-Inverting Converter using PIC Microcontroller

ABSTRACT

Switching MOSFET of DC-DC converters were widely used in different types of portable and non-portable electronic devices. The main aim of this research is the input voltage, which comes from a varaible sources. It is required to control model of Buck-Boost non-inverting converter controller by a duty cycle of PWM signal. The objective of the research is to design, simulate and analyze circuit converter to regulate the output voltage by using PIC Microcontroller (16F877A). In the circuit design, the polarity of the output voltage should be not changed. Moreover, the circuit is required to act automatically from one mode to the other mode of Buck-Boost converter. Conventionally, two converters combined together were utilized, a Buck and Boost family of converters. The circuit were perform the dual operations of step-down and step-up modes, which relies on input conditions. The simulation software and the implementation hardware were completed. Proteus Software has been adopted as a simulation tool. The PIC Microcontroller was used in this circuit to generate PWM. The circuit was achieved the output voltage at 12VDC even the input voltage a variable with a range of input voltages was between (6-18) VDC. This circuit was selected in this dissertation project because it has the best specifications such as single inductor and capacitor for both of converters, less number of electrical components, lower stresses, which leads to reduce the total losses, cost and increase the efficiency of the circuit. Moreover, it was achieved supply output voltage with positive polarity. From the collected data, the average efficiency of the proposed converter was reached at 82%. A new alternative for improving the performance of Buck-Boost non-inverting converter on simulation for high power application was proposed with respect to conventional DC-DC converter, current was divided by parallel modality in Multi-Modular converters. Therefore, the high current stress on the semiconductor switches were overcame. It was an optimal solution for high load current requirements in a DC converter.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This research presents the technique that used for controlling Buck-Boost non-inverting converter. It is a beneficial application in the domain of renewable energy, a topic that covers subjects such as energy acquired from wind turbine and sun-light energy (Kjaer, et al., 2005). Another application when a battery voltage dropped and we need to maintain the constant voltage load (Liou., 2008), (Zhou., 2006). Therefore, for any practical reasons, these kinds of resources are always dynamic resources of energy.

The hybrid energy such as solar energy and wind energy are categorized as varied voltage due to the fact that solar power is dependent on sunlight and the wind energy depends on the wind. For that reason, DC-DC converter is used to regulate output voltage to be steady. That is utilized for supplying the electrical appliances.

Buck-Boost non-inverting converter is a circuit that convert a variable input voltage into a fixed output voltage. The output voltage of this circuit is controlled by using a duty cycle (Syed., 2004). Which is able to be the output voltage (greater, less or equal) to the input voltage.

1.2 Background

There are many typologies were used for converting the DC-DC voltage. They have been commonly used in the power supply appliances for the majority of electronic systems. Such as Buck converter, Boost converter and Buck-Boost converter. (Yao., & Lee., 2002), (Chakraborty, 2006). The basic principle of DC-DC Buck-Boost non-inverting converter is to convert DC input voltages to DC output voltages. The output voltage can be less than input, which is during Buck converter (step down), higher than the input during Boost converter (step-up) converter. It also could be same as the input. In recent years, DC-DC converters have been grown to be a popular subject matter, which has a lot of requirements for best specification such as less costly, smaller size, lighter in weight and less power loses towards a high efficient power conversion. Moreover, pulse width modulation (PWM) have been growth of DC electronic devices.

1.3 Problem Statement

The major focus of this thesis are:

i. The dynamic input voltage, which is come from a renewable energy source. It is order to step up or step down the output voltage to supplied steady levels.
ii. In high power applications the problem with high current of DC-DC power converter.
iii. The power semiconductor is always stressed by high current so the high current will be affected on the efficiency.

iv. Buck-Boost non-inverting converter can be improved to control a DC voltage, which is controlled by duty cycle of PWM signal which that generated by using PIC Microcontroller.

1.4 Objectives

The major objectives of this research program are:

i. To design, simulate, analyze and implement circuit of Buck-Boost non-inverting converter to regulate the output voltage which drives by Pulse Width Modulation (PWM) that generated by using PIC microcontroller (16F877A).

ii. Construct the circuit without changing the polarity of the output voltage related to the input voltage.

iii. To simulate a reliable design circuit of Buck-Boost non-inverting converter with Multi-Modular converter of high power application with two relays protection.

1.5 Scopes of Project

There are plenty ranges of electrical power switches. During this project, the metal-oxide-semiconductor field-effect transistor (MOSFET) power switching is chosen while it has many positive aspects over the insulated-gate bipolar transistor (IGBT) and thyristors, which is generally, faster and has better gate turn off capability (Jack., 2000). As well as the MOSFETs are easier to drive and to utilize.

With an improvement, DC-DC converter requires PWM signals with a higher switching frequency to quickly response to compensate the required level of DC output voltage. Buck-Boost non-inverting converter circuit can improve the control of DC voltage, which is controlled by duty cycle of PWM. The PIC Microcontroller is selected to generate PWM pulses because the characteristic of this IC is good for producing optimal DC-DC converter. The PIC enables to re-programmable flash-memory, high efficient, low price, and small size. The PIC Microcontroller can do more than one operations at the same time. Proteus software is used throughout for this project to simulate the circuit of Buck-Boost non-inverting converter. Additionally to development the work to use on electric power management, utilizing this topology hybrid automobile, electric grid and diversified renewable power resources.

1.6 Thesis Outline

This thesis report consists five chapters' introduction, literature review, methodology, results and finally conclusion. In chapter one, the overview of the idea and the whole system especially in Buck-Boost non-inverting converter is presented. Including the problem statements, objectives, and research scope.

Chapter two covers the literature review of previous cases of analysis based on Buck-Boost non-inverting converter background and development. Furthermore, general information about DC-DC converter control method and power switching design. In addition, some other techniques has been completed based on this research.

Chapter three presents the methodology utilized to design Buck-Boost converter with PIC Microcontroller. All the components that have been used are explained well in this chapter. Methodology can be divided into several parts that consist of schematics simulation software, hardware implementation, component selection etc.

Chapter four, explain and discuss about all the results and evaluations of performance of the circuit. A result analysis is given. The results are display the comparison of output voltage between software and hardware results with helps of set of Figures and Tables.

Lastly, chapter five is the conclusion of overall all chapters. In addition, the results have been discussed, analyzed and been used for comparison between simulation software and implemented hardware. At the end, a discussion about future works and new trends in the field of DC-DC converters.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents the overview of Buck-Boost converter with a positive output voltage reviewed and analyzed by other researchers. In these days, the applications of DC-DC converters have been improved and increased dramatically since they commonly used in renewable energy systems such as fuel cells, hybrid electric vehicles, battery chargers, and solar systems etc. (Restrepo., 2011), (Erickson., 1997).

There are two modes of operation in DC-DC converters based on inductor current.

i) Continuous Conduction Mode (CCM).

ii) Discontinuous Conduction Mode (DCM).

2.2 Continuous Conduction Mode (CCM)

The difference between the CCM and DCM is that in CCM the current in the inductor does not fall to zero. A converter operates in continuous mode if the current through the inductor never falls to zero during the commutation cycle. Basically for high power application, Conduction Continues Made (CCM) has lower conduction losses an smaller current stress on the semiconductor device. The current flows continuously in the inductor during the entirely switching cycle (Lynch, B. T., 2008). During CCM is ON state, the switch is closed, which makes the input voltage appear across the inductor and cause a change in current flowing through the inductor. In addition, the current in inductor increased at the end of ON state. As shown in Figure 2.1.

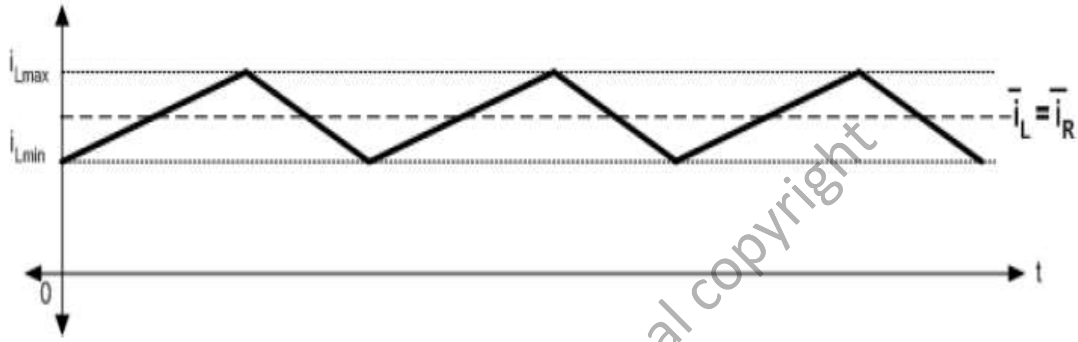

Figure 2.1: Continuous Conduction Mode (CCM) waveform (Lynch, B. T., 2008).

2.3 Discontinuous Conduction Mode (DCM)

In discontinuous mode operation, the duty cycle is a nonlinear function of the output current, in the load, and it cannot secure the maximum power output. Because of the converters operating in this mode have lower power efficiency compared to the continuous mode conduction. The converter is operate in CCM in exactly the same way as a synchronous converter (Lynch, B. T., 2008). The diode will prevent the inductor current from reversing its polarity. The inductor will charge energy through the high-side switch. When the high-side switch is off, the inductor will discharge the stored energy to the capacitor until the current drops to zero. Figure 2.2 shows the inductor current on DCM made. The current will be held at zero until the end of the cycle. This discontinuity in the inductor current defines the discontinuous conduction mode (DCM).

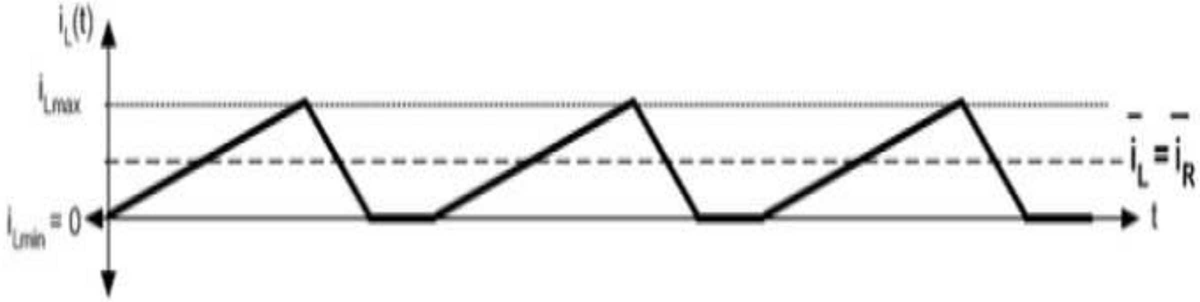

Figure 2.2: Discontinuous Conduction Mode (DCM) waveform (Lynch, B. T., 2008).

2.4 Pulse Width Modulation (PWM)

Pulse-Width Modulation (PWM) are used for controlling analog circuits with a processors digital output. PWM uses a square wave whose duty cycle is modulated resulting in the variation of the average value of the waveform. PWM can be used to reduce the total amount of power delivered to a load without losses normally incurred when a power source is limited. The average power delivered is proportional to the modulation duty cycle. With a sufficiently high modulation of duty cycle (d). With a sufficiently high modulation rate, passive electronic filters can be used to smooth the pulse.

High frequency PWM power control systems are easily realizable with semiconductor switch. The discrete on or off states of the modulation are used to control the state of the switch, which correspondingly controls the voltage across or current through the load. The product of the current and the voltage at any given time defines the power dissipated by the switch, thus no power is dissipated by the switch. Realistically, semiconductor switches such as MOSFETs or BJTs are non-ideal switches, but high efficiency controllers can still be build (Prodic, A., 2001).