Faculty of Electrical and Electronic Engineering Technology

DESIGN AND DEVELOPMENT OF VARIABLE POWER SUPPLY BASED ON BUCK-BOOST CONVERTER USING SLIDING MODE TECHNIQUE

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Bachelor of Electrical Engineering Technology (Industrial Power) with Honours

2021

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A project report submitted
in partial fulfilment of the requirements for the degree of
Bachelor of Electrical Engineering Technology (Industrial Power) with Honours

Faculty of Electrical and Electronic Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI TEKNOLOGI KEJUTERAAN ELEKTRIK DAN ELEKTRONIK

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek: Design and Development of variable Power Supply based on Buck-Boost Converter Using Sliding Mode Technique

Sesi Pengajian: 2021

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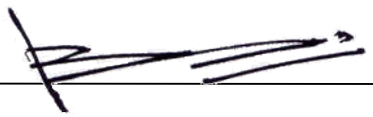

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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

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DEDICATION

To my beloved mother, thank you for believing in me, supporting at every situation that I go through, and to my father, who has motivated me to be a better person and helping in my financial support in my education, and Who have been gave strength when I thought of giving up, who continually provide their moral, spiritual, emotional, and financial support. I want to say thank you very much. To my brothers, sisters, lectures, friends, and classmates who shared had share their words of advice to help me like give me moral support, believe in me, and encouragement to finish this study.

ABSTRACT

Most of electronic equipment operates in range 1.5V to 24V and it always be powered from batteries. However, batteries have specific voltage value to deliver power for equipment, thus making it less flexible. For some cases, an adjustable power supply is needed for various reason, for example, a repair technician uses an adjustable power supply to troubleshoot a faulty component. Most universal power supplies that are available at market are designed by using step-down transformer, rectifier, and filter circuit. Thus, a desired voltage output at a constant value cannot be produced under different load due to open loop control configuration. To overcome this limitation, a variable power supply device is designed based on buck-boost converter circuit. The device will be equipped with closed loop control of sliding mode control (SMC) algorithm to enable constant output voltage under different load. SMC is used in this project since it can control the output voltage under various load conditions by using the same controller gain. The device will be developed by combination of Arduino microcontroller, buck-boost converter circuit, seven segment display and potentiometer, where the input of this device will be taken from 12VDC source.

ABSTRAK

Kebanyakan peralatan elektronik beroperasi di antara 1.5V hingga 24V dan ia selalunya dikuasakan oleh bateri. Walau bagaimanapun, bateri mempunyai nilai voltan yang tertentu untuk menyediakan kuasa kepada peralatan, menyebabkan ia kurang fleksibel. Dalam sesetengah kes, bekalan kuasa boleh dilaras diperlukan untuk pelbagai kegunaan, sebagai contohnya, juruteknik menggunakan bekalan kuasa boleh dilaras untuk mengesan komponen yang rosak. Kebanyakan bekalan kuasa biasa yang terdapat di pasaran direka dengan menggunakan alat pengubah, penerus, dan litar penapis. Oleh itu, keluaran nilai voltan yang malar tidak dapat dihasilkan untuk beban yang berbeza kerana konfigurasi kawalan gelung terbuka. Untuk mengatasi kekurangan ini, peranti bekalan kuasa pembolehubah direka berdasarkan litar *'buck-boost'*. Peranti ini dilengkapi dengan kawalan gelung tertutup algoritma *'Sliding Mode Control (SMC)'* untuk memastikan keluaran voltan yang malar di bawah beban yang berbeza. SMC digunakan dalam projek ini kerana ia dapat mengawal voltan output di bawah pelbagai keadaan beban dengan menggunakan *'gain'* pengawal yang sama Peranti ini akan dibangunkan oleh gabungan mikrokontroller Arduino, litar penukar buck-boost, paparan tujuh segmen dan potentiometer, di mana input peranti ini akan diambil dari sumber 12VDC.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Dr. Mohd Badril bin Nor Shah for the precious guidance, words of wisdom and patient throughout this project.

I am also indebted to Universiti Teknikal Malaysia Melaka (UTeM) and parents for the financial support which enables me to accomplish the project. Not forgetting my fellow colleague, Arif hasyimi bin ali and Muhammad Syahir Mohamed Sallehulldin for the willingness of sharing his thoughts and ideas regarding the project.

My highest appreciation goes to my parents and family members for their love and prayer during the period of my study. An honourable mention also goes to my supervisor for all the motivation and understanding.

Finally, I would like to thank all the fellow colleagues and classmates, the faculty members, as well as other individuals who are not listed here for being co-operative and helpful.

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LIST OF SYMBOLS

A	-	Ampere (current unit)
C	-	Capacitor
D	-	Duty Cycle
Hz	-	Frequency unit
H	-	Henry (inductor unit)
T	-	Period
V	-	Voltage
Vin	-	Voltage input
Vout	-	Voltage Output

LIST OF ABBREVIATIONS

SMC Sliding Mode Controller

PID Proportional Integral Derivative

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CHAPTER 1

INTRODUCTION

1.1 Project background

A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load. As a result, power supplies are sometimes referred to as electric power converters. Some power supplies are separate standalone pieces of equipment, while others are built into the load appliances that they power.

A buck boost converter is a type of DC-to-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. It is equivalent to a flyback converter using a single inductor instead of a transformer. The magnitude of output voltage of the buck boost converter is relying upon the duty cycle of PWM (Pulse Width Modulation) signal.

A sliding mode control (SMC) is a nonlinear control technique featuring remarkable properties of accuracy, robustness, and easy tuning and implementation. The state-feedback control law is not a continuous function of time. Instead, it can switch from one continuous structure to another based on the current position in the state space. Hence, sliding mode control is a variable structure control method.

1.2 Problem Statement

The number and variety of electronic devices has dramatically increased in the few years and currently there is growing interest in electronic devices with flexible, thin, and large-area form factors. Most electronic devices work in the 1.5V to 24V range and usually be powered from equipment. The batteries, on the other hand, have a specific voltage value to deliver power for equipment, making it less flexible. In certain situations, an adjustable power supply is needed for a various of reasons, such as when a repair technician uses an adjustable power supply to troubleshoot a faulty component.

Most universal power supply adapter devices on the market are built with a step-down transformer, rectifier, and filter. As a result of its open-loop control, a desired voltage output at a constant value cannot be powered under different loads.

Photovoltaic is another DC source that converts light energy to electrical energy through the photovoltaic effect. One benefit of using a photovoltaic device is that it does not rely on chemical reactions to generate electricity, instead relying on natural energy sources. Uncertain light intensity in natural energy sources, on the other hand, frequently results in unstable DC voltage output. Weather, either gloomy or bright, can be one of the factors that lead to irregularity in light intensity. The use of a closed loop buck boost converter allows to produce constant output voltage.

1.3 Project Objective

a) To design DC power supply circuit based on buck boost converter where the input is taken from any batteries or other DC sources.

b) To design a closed-loop control of buck boost converter by using sliding mode controller algorithm to form 1.5V to 24V adjustable DC power supply circuit.

c) To develop a hardware prototype of the designed power supply circuit

1.4 Project Scope

The explanation of the scopes in this project are consist of circuit design, controller design and hardware:

a) Circuit Design

The fundamental theory of the buck boost converter will be used to design a circuit that consists of capacitor, inductor, resistor, MOSFET, and diode. Arduino Microcontroller based circuit will connect to buck boost circuit is also included in the design.

b) Controller Design

Design of closed loop control to provide the desired output of DC voltage that set by user based on sliding mode algorithm.

c) Hardware

The buck boost converter circuit designed combined with an Arduino microcontroller and other interfacing device to develop a hardware prototype of this project thus forming an adjustable output power supply circuit from 1.5 to 24V.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter involves literature reviews to obtain idea and information for developing the project of power supply design based on Arduino microcontroller based buck boost converter. Throughout this chapter will provides the literature review on buck boost converter, Sliding mode control, power supply circuit, and related previous work.

2.2 Buck Boost Converter

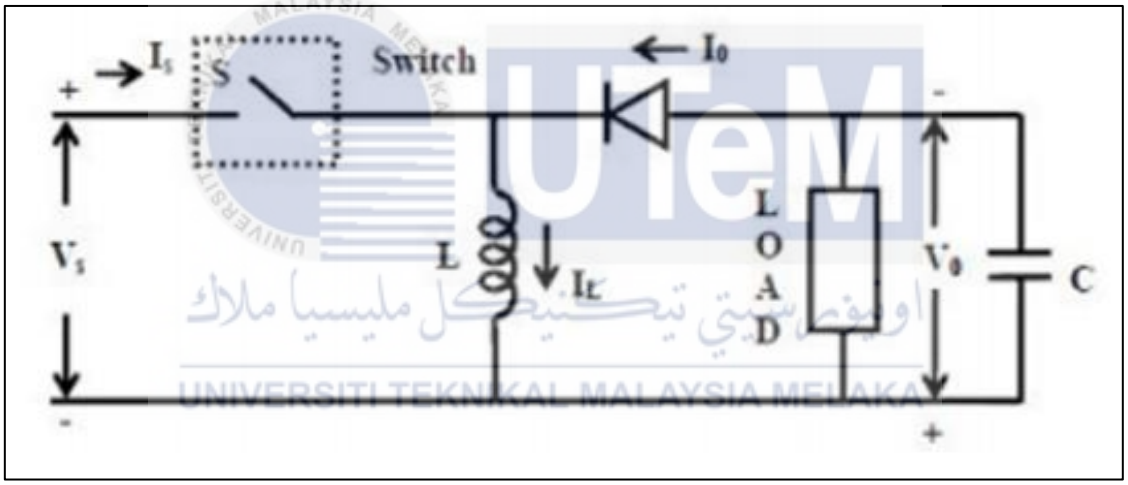

Figure 2. 1 Buck Boost Converter Circuit

The buck boost converter is a DC-to-DC converter. The output voltage of the DC-to-DC converter is less than or greater than the input voltage. The output voltage of the magnitude depends on the duty cycle (Elprocus, 2013). These converters are also known as the step up and step down transformers and these names are coming from the analogous step up and step down transformer. The input voltages are step-up/down to some level of more

than or less than the input voltage. By using the low conversion energy, the input power is equal to the output power. The following expression shows the low of a conversion.

Input power (Pin) = Output power (Pout) (2.1)

For the step-up mode, the input voltage is less than the output voltage (Vin < Vout). It shows that the output current is less than the input current. Hence the buck booster is a step-up mode.

Vin < Vout and Iin > Iout (2.2)

In the step-down mode the input voltage is greater than the output voltage (Vin > Vout). It follows that the output current is greater the input current. Hence the buck boost converter is a step-down mode.

Vin > Vout and Iin < Iout (2.3)

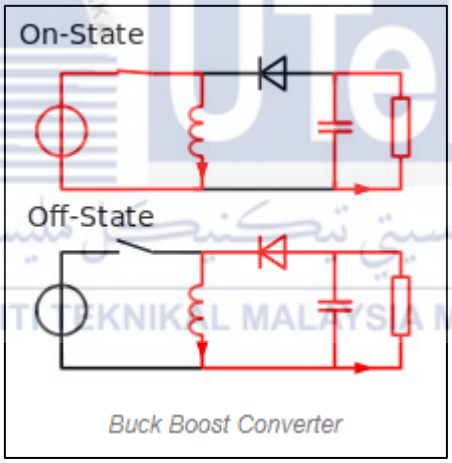

Figure 2. 2 Demonstrates a circuit of buck boost.

Figure 2.2 demonstrates a circuit of buckboost and the working principle of buck boost converter can be explained as follows:

The working operation of the DC-to-DC converter is the inductor in the input resistance has the unexpected variation in the input current. If the switch is ON, then the inductor feed the energy from the input and it stores the energy of magnetic energy. If the switch is closed it discharges the energy. The output circuit of the capacitor is assumed as

high sufficient than the time constant of an RC circuit is high on the output stage. The huge time constant is compared with the switching period and make sure that the steady state is a constant output voltage Vo(t) = Vo(constant) and present at the load terminal.

2.3 Arduino Microcontroller

Arduino microcontroller is an easy source platform utilized for building electronic papers. (Harshika, 2017). It is made up of a physical programmable circuit board with a microcontroller and software, known as an IDE (Integrated Development Environment), that runs on a computer. IDE is a programme that allows you to write and upload computer code to a physical board.

Arduino is a well-known platform because, unlike most programmable circuit boards, it does not require an isolated piece of hardware (programmer). A USB cable can be used to stack a modern circuit onto the board. Furthermore, the Arduino IDE employs C++ programming, which has been reorganised to make it easier to memorise.

Arduino could be an ATmega8-based microcontroller board. There are 14 advanced if input and yield pins on this device. Six PWM output pins, six analogue input pins, a 16 MHz ceramic resonator, a USB connection, a control jack, an ICSP header, and a reset button are all available. To begin started, Arduino can connect to a computer through USB or be controlled using an AC to DC adaptor or a battery.

The Uno differs from other boards in that it does not include an FTDI USB-to-Serial driver chip. SDA and SCL pins are close to the AREF stick on the Uno, while two additional contemporary pins are close to the RESET pin. The name "Uno" means "one" in Italian, and it was chosen to commemorate the imminent release of Arduino 1.0. The Uno is the most recent in a series of USB Arduino boards, as well as the platform's reference model. (Harshika, 2017)