UNIVERSITI TEKNIKAL MALAYSIA MELAKA

POWER SUPPLY DESIGN USING MICROCONTROLLER-BASED BUCK-BOOST CONVERTER

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Electrical and Electronics Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

Signature: …….

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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 berasaskan pengawalmikro direka berdasarkan konfigurasi buck-boost. Peranti ini dilengkapi dengan kawalan gelung tertutup algoritma PID untuk memastikan keluaran voltan yang malar di bawah beban yang berbeza. Peranti ini dicipta dengan gabungan pengawalmikro Arduino, litar buck-boost, paparan tujuh ruang dan meter upaya. Untuk mengesahkan keberkesanannya, peranti ini disambungkan kepada beban 510 Ω, 1000 Ω dan 2000 Ω, dan didapati ia mampu menghasilkan keluaran voltan julat di antara 1.5V hingga 24Vdengan nilai-nilai gandaan PID yang telah ditala dengan sewajarnya.

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 divide 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 microcontroller-based power supply device is designed based on buck-boost configuration. The device is equipped with closed loop control of PID algorithm to enable constant output voltage under different load. The device is developed by combination of Arduino microcontroller, buck boost converter circuit, seven segment display and potentiometer. To verify its efficacy, the device is connected to 510 Ω, 1000 Ω and 2000 Ω, and it is found the device capable to produce output voltage ranging from 1.5V to 24V providing the PID gain values are appropriately tuned.

DEDICATION

To my beloved parents

To my kind supervisor

To my irreplaceable family

Thank you for all their love, sacrifice, and encouragement throughout my life.

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A	-	Ampere (current unit)
C	-	Capacitor
D	-	Duty Cycle
Hz	-	Frequency unit
H	-	Henry (inductor unit)
L min	-	Inductor minimum
Kp	-	Proportional Gain
Ki	-	Integral Gain
Kd	-	Derivative Gain
T	-	Period
Td	-	Derivative Time
V	-	Voltage
Vin	-	Voltage input
Vout	-	Voltage Output

LIST OF ABBREVIATIONS

PWM	Pulse Width Modulation
PID	Proportional Integral Derivative
CCM	Continuous Current Mode
PV	Process Variable
SP	Set Point
PSU	Power Supply Unit
SMPS	Switch Mode Power Supply
BDC	Bidirectional DC Converter
GAPID	GA-based PID Controller
CSPID	Cuckoo search based PID Controller
PSOPID	PSO based PID Controller
LED	LED Light Emitting Diode
ADC	Analog to Digital Converter
PIC	Peripheral Interface Controller
ROM	Read-Only Memory

LCD	Liquid Crystal Display
IDE	Integrated Development Environment

CHAPTER 1

INTRODUCTION

1.1 Background

DC sources are broadly utilized as a power supply that can be obtained either from battery or rectified AC source. It is quiet mainstream which supply to most miniature electric appliances such as clocks, radios, cell phones, toys and to name a few.

Battery is an example of DC source. In brief, battery perform electrochemical reaction which result in electrical difference between anode and cathode terminal. The battery has many virtues over other energy sources which are ability to store energy for a long time and capable to deliver energy more effectively compared with a thermal engine. But the battery has major limitations that lack on longevity and quite costly. This constraint can be covered by using a rectified AC sources that produce DC voltage by converting AC voltage to clean DC voltage.

A buck boost converter is utilized to control output voltage produced by battery supply or another DC source. The buck boost converter can be changed in accordance with deliver output voltage either larger or lower than input voltage value (Maniktala, 2012). An aim of this project to produce a voltage output with range 1.5 to 24V. The magnitude of output voltage of the buck boost converter is relying upon the duty cycle of PWM (Pulse Width Modulation) signal.

In order to control the PWM signal, a microcontroller will be used. The controller that can used for buck boost converter to produce the output desired voltage is PID (Proportional Integral Derivative) controller (Dinniyah, et al., 2017). The popularity

of PID controller in industry environment if prominent since it can perform a wide range of operating conditions and it has simple structure (Bista, 2016).

1.2 Problem Statement

Most of electronic equipment operates in range 1.5V to 24V and always be powered from batteries. However, the batteries have specific voltage value to provide power for equipment, thus making it less flexible. For some cases, an adjustable power supply it needed for various reason, for example, a repair technician uses an adjustable power supply to troubleshoot a faulty component.

Most universal power supply adapter device that is available in the market is designed by using step-down transformer, rectifier, and filter. Thus, a desired voltage output at a constant value cannot be powered under different load due to it is open-loop control (Farahani, 2016).

Photovoltaic is another DC sources where change over the light vitality to electrical vitality via photovoltaic impact. An advantage utilizes the photovoltaic system is not use chemical reaction to produce electric power while it is natural energy sources. However, often found uncertain light intensity in the natural energy sources leads to unstable DC voltage produced. Weather may be one of the factors that contributes to irregularity light intensity whether the weather are gloomy or sunny. With utilize of closed loop buck boost converter can be enables to produce constant output voltage (Dinniyah, et al., 2017).

1.3 Objective

This project is conducted:

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 PID 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. 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 PID algorithm.

c) Hardware

The buck boost converter circuit designed combined with a 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 microcontroller based buck boost converter. Throughout this chapter will provides the literature review on buck boost converter, PID controller, power supply circuit, microcontroller and related previous work.

2.2 Buck Boost Converter

The buck boost converter is a kind of DC to DC conversion or called as a chopper. The output voltage of this converter either be larger or smaller than input and the output voltage also can be equivalent to the input.

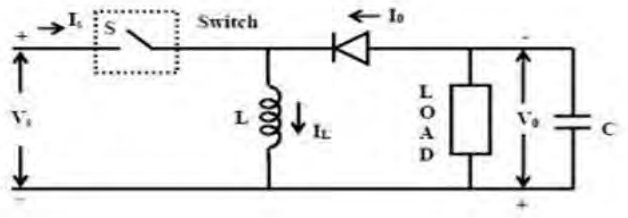

Figure 2.1: Buck-Boost converter circuit

Figure 2.1 demonstrates a circuit of buck boost. According to Maniktala (2012) the properties of buck boost is can be explained as follows:

When the switch is closed, energy is delivered only into the inductor by the input DC source via the switch and none of it passes through to the output. Meanwhile, when