UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MOBILE PHONE CHARGER DESIGN USING TELEPHONE LINE BASED ON BANG-BANG CONTROL OF BUCK 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 Automation and Robotics) with Honours

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelors of Electrical Engineering Technology (Industrial Automation and Robotics). The member of the supervisory is as follow:

……

(DR. MOHD BADRIL BIN NOR SHAH)

ABSTRAK

Mengecas telefon bimbit semasa ketiadaan kuasa elektrik amat menyusahkan kerana pengecas telefon tidak berfungsi dalam keadaan sedemikian. Selain bank kuasa, sumber kuasa alternatif yang ada adalah dari talian telefon. Walau bagaimanapun, voltan daripada talian telefon adalah agak tinggi dan tidak sesuai untuk mengecas telefon bimbit. Oleh itu, voltan yang perlu digunakan mestilah direndahkan dengan cara yang sesuai, iaitu penukar buck. Voltan talian telefon juga tidak konsisten kerana voltan yang berbeza diperlukan untuk keadaan mod memanggil, siap sedia dan mod deringan. Oleh itu kawalan gelung-tertutup litar untuk menurunkan voltan perlu direka bentuk bagi menyediakan voltan yang sesuai untuk mengecas telefon bimbit. Teknik kawalan tutup-buka dipilih sebagai kawalan gelung tertutup kerana ia adalah mudah untuk direka bentuk dan juga teguh kepada gangguan dan ketidaktentuan parameter. Penukar buck akan menurunkan voltan dari talian telefon dan pengawal tutup-buka akan mengawal voltan kepada voltan yang dikehendaki 5V untuk mengecas voltan. Pada akhir projek ini, peranti yang telah dibangunkan mampu mengecas telefon bimbit dengan menggunakan kuasa dari talian telefon dan juga mampu memberikan voltan pengecasan malar melalui kawalan gelung-tertutup yang telah direka.

ABSTRACT

Charging mobile phone during an event of utility power supply loss would be troublesome since the charger of the phone is not functioning in such situation. Beside power bank, the alternative power source available is from telephone line. However, the voltage from telephone line is quite high and not suitable for mobile phone charging. Hence, the voltage needs to be step down by appropriate means, i.e. buck converter. The voltage of telephone line also is inconsistent since different voltage is required for calling, standby and ringing mode. Therefore closed-loop control of step-down circuit needs to be designed to provide constant voltage for mobile phone charging. Bang-bang control technique is chosen as a closed-loop control since it is easy to design and also robust to disturbances and parameter uncertainties. Buck converter will step down voltage from telephone line and bang-bang controller will regulate the voltage to desired voltage of 5V for charging voltage. At the end of this project, the developed device is able to charge mobile phone by using power from telephone line and also able to provide constant charging voltage through designed closed-loop control.

DEDICATION

To my beloved parents

To my kind lecturers

And not to forget to all my fellow friends

Thank you for all their love, sacrifice, encouragement, and best wishes

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Before, while and after I doing my job to complete this project, I have received so many help from my supervisors, lecturers, researchers, family members and also my fellow friends.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AC	-	Alternating Current
DC	-	Direct Current
MOSFET	-	Metal-Oxide Semiconductor Field-Effect Transistor
PWM	-	Pulse Width Modulation
SMPS	-	Switch-Mode Power Supply
USB	-	Universal Serial Bus
VREF	-	Voltage Reference
VOUT	-	Output Voltage

CHAPTER 1
INTRODUCTION

1.0 Project Background

Mobile phone nowadays is very important in our life. Needless to say, mobile phones provide remote and distance communication, data transfer, entertainment, to name few. It is powered by batteries that can be recharged by another DC source, i.e. power bank or rectified AC source (charger adapter).

However, during power utility breakdown or power loss, the charging source is not available at power socket outlet. Beside portable power bank, the alternative source to obtain charging phone is from telephone line. Under this circumstance, telephone line is powered by backup battery or standby generator. Hence it is possible to harness the power from telephone line to charge our mobile phones.

The voltage of telephone line is quite high, this it is not suitable for mobile phone charging. A step-down circuit is required to bring the telephone line voltage at the suitable charging voltage. Buck converter is an appropriate circuit for this purpose. It is a switching-based circuit to step down DC voltage at desired level. A basic buck converter is consists of inductor, capacitor, resistor, diode and semiconductor switch. The magnitude of the output for buck converter is depends on the duty cycle of PWM signal that is supplied to semiconductor switches.

Bang-bang control is also known as on-off controller. It is the simplest basic form of controller and used in many applications such as temperature control and power supply control. The advantages of this controller are easy to design, robust to disturbance and parameter uncertainties.

The voltage from telephone line is not constant since different voltage is used for ringing, talking and standby mode. Hence buck converter need to be combined with a controller. Bang-bang controller is chooser since it is suitable to be adapted to buck converter.

1.1 Problem Statement

Charging mobile phone during an event of utility power supply loss would be troublesome since the charger of the phone is not functioning in such situation. Beside power bank, the alternative power source available is from telephone line. However, the voltage from telephone line is quite high and not suitable for mobile phone charging. Hence, the voltage needs to be step down by appropriate means, i.e. buck converter.

The voltage of telephone line also is inconsistent since different voltage is required for talking, standby and ringing mode. Therefore closed-loop control of buck converter circuit needs to be designed to provide constant voltage for mobile phone charging.

1.2 Objective

The objectives of this project are:

a) To design buck converter circuit to step down telephone line voltage to suitable voltage charging of mobile phone.
b) To design closed loop control of buck converter to provide constant charging voltage.
c) To develop hardware prototype to verify the efficiency of the designed closed-loop control of buck converter.

1.3 Project Scope

The scope of this project are:

a) **Circuit design**

Buck converter circuit need to be designed to obtain the correct parameter value of the circuit.

b) **Controller design**

Closed loop control design is required to provide constant charging voltage.

c) **Simulation**

The performance of the closed-loop control of buck converter will be evaluated through simulation using Matlab/Simscape.

d) **Hardware prototype**

A hardware prototype of this project will be developed to verify the real-time performance of the designed closed-loop control of buck converter.

1.4 Thesis Outline

This thesis consists of five chapters and are organized as the following. Chapter 2 provides a literature review on buck converter, bang-bang controller and the preview of related work.

Chapter 3 discusses the methodology of this project that covers circuit design and hardware development.

Chapter 4 explains the result of the designed bang-bang control of Buck Converter. The analysis of the circuit performance is also discussed in details.

Chapter 5 is the conclusion. Recommendation for future works is also included in this chapter.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

Literature review is an important to understand the fundamental ideas to develop the project of mobile phone charger design using telephone line based on bang-bang control of buck converter. In this chapter, the fundamental and related information on buck converter, bang-bang controller and microcontroller are presented. The previous project done by other researchers are also discussed.

2.1 Buck Converter

Buck converter is one of three principle sorts of DC-DC power converters. At the point when the circuit runs, it will bring about the circuit model containing unverifiable parameters due to load change. The resignation and feedback linearization are vital techniques for examining DC-DC power converters (Wei, 2012). In any case, these two techniques depend on the outline parameters and precise display generally, which restrains their applications. For the model of buck converter can be changed into strict parameters criticism structure, back stepping can be utilized to plan the controller of buck converter.

Controller plan incorporates three perspectives: the first is dynamic demonstrating of buck converter, the second one is versatile controller demonstrating and the last one is the security evidence. A buck converter (venture down converter) is a DC-to-DC power converter which ventures down voltage (while venturing up

current) from its information (supply) to its yield (load). It is a class of switched-mode power supply (SMPS) ordinarily containing no less than two semiconductors (a diode and a transistor, albeit current buck converters as often as possible supplant the diode with a second transistor utilized for synchronous rectification) and no less than one vitality stockpiling component, a capacitor, inductor, or the two in blend. To diminish voltage ripple, filters made of capacitors (once in a while in mix with inductors) are regularly added to such a converter's yield (load-side channel) and info (supply-side channel).

The exchanged mode DC-DC converters are the absolute most broadly utilized force electronic circuits which change over one level of electrical voltage into another level by exchanging activity. These converters have gotten an expanding arrangement of enthusiasm for some zones of uses because of keep up the voltage supplied to the heap steady from no heap to full load with high transformation proficiency (Wei, 2012). Buck converter is one of the least complex however most helpful power converters. It is a controlled stride down converter that changes over an unregulated dc information voltage to a directed dc yield at a lower voltage (Prabhu, 2015).

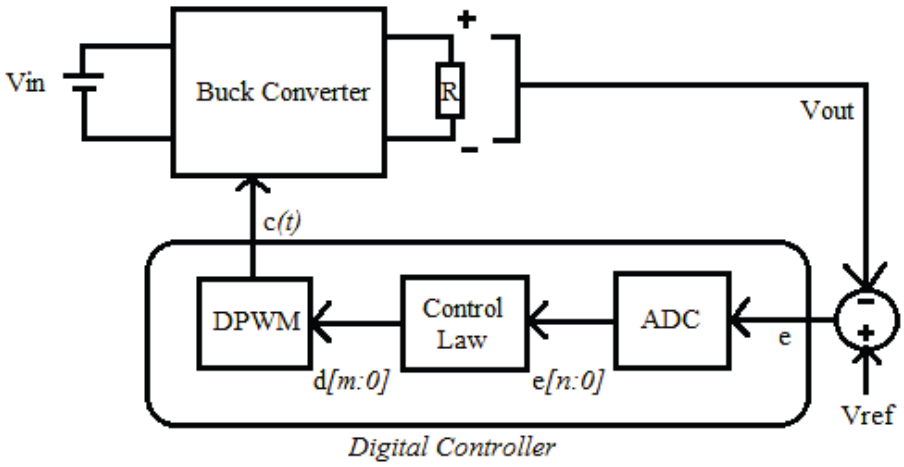

Figure 2.1a: Buck Converter regulated by digital controller

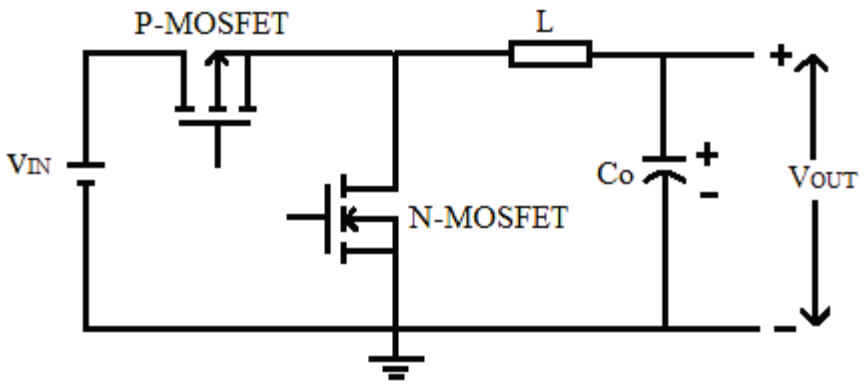

Figure 2.1b: Synchronous buck converter circuit

2.2 Controller

2.2.1 PID Controller

The most ordinarily utilized methodology for duty ratio control utilizes classical linear feedback, specifically, the surely well-known PID control. The controller outline is generally in view of the linear approximation of the nonlinear progression of the converter. A PI way to deal with SMC plan in changed frameworks connected to the Buck converter (Prabhu, 2015), altered-frequency pseudo SMC for Buck-Boost DC-DC converter (Seshagiri, 2016) and a robust adaptive feedback design for a Boost converter operating in DCM converters in portable applications with examinations with a straight PID controller (Seshagiri, 2016).

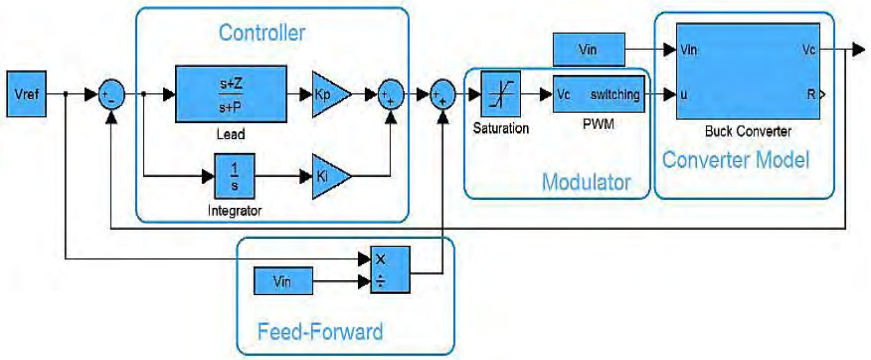

Figure 2.2a: Block diagram of closed-loop system with classical PID controller

2.2.2 Bang-Bang Controller

For an ideal control issue, a standout amongst the most widely recognized sorts of control capacity is the piecewise-steady capacity by which a succession of steady inputs is utilized to control a given framework with reasonable exchanging times. Furthermore, when the control is limited, a normally experienced kind of piecewise constant control is bang-bang, which switches between the upper what's more, lower limits of the control information. The ideal control issue is to minimize a cost utilitarian, characterized on the state direction, as an element of the exchanging parameters. Such ideal control issues emerge in different application spaces, counting workman, mechanical autonomy, power converters, generation control and so forth. In exchanging power converter control the controller yield has one of two states: "on" or "off". These applications are not well suited to standard direct control plan techniques. An exchanging procedure including hysteresis is ordinarily utilized for these sorts of force converters.

In control theory, a bang–bang controller (on–off controller), otherwise called a hysteresis controller, is a feedback controller that switches unexpectedly between two states. These controllers might be acknowledged regarding any component that gives hysteresis. They are frequently used to control a plant that acknowledges a twofold contribution, for instance a heater that is either totally on or totally off. Most basic private indoor regulators are

bang–bang controllers. The Heaviside step capacity in its discrete structure is a case of a bang–bang control signal. Because of the discontinuous control signal, frameworks that incorporate bang–bang controllers are variable structure frameworks, and bang–bang controllers are hence variable structure controllers.

2.3 Electrical Hardware Review

This section explains the review of the electrical hardware components that is used in this project. The fundamental components for buck converter which are inductor, capacitor, diode and resistor are discussion in the following subtopic.

2.3.1 Inductor

An inductor is a passive component intended to store vitality in its magnetic field. An inductor will oppose the adjustment in current coursing through it. The current through inductor can't change quickly. A perfect inductor does not dissipate energy. The energy put away in it can be recovered at a later time. The inductor takes power from the circuit while putting away vitality and conveys energy to the circuit while returning beforehand put away vitality. A practical non ideal inductor has a critical resistive part. This is because of the way that the inductor is made of a conducting material, for example, copper, which has some resistance. This resistance is known as the winding resistance, and it shows up in series with the inductance of the inductor. The nearness of winding resistance makes it both an energy stockpiling gadget and an energy dissipation gadget. Since the winding resistance is typically little, it is disregarded as a rule. The non-ideal inductor additionally has a twisting capacitance because of the capacitive coupling between the leading coils. Winding capacitance is little and can be disregarded much of the time, aside from at high frequencies.

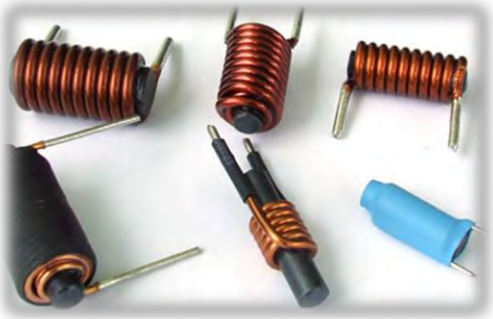

Figure 2.3a: Inductor

2.3.2 Capacitor

A capacitor is a detached component intended to store vitality in its electric field. The capacitor opposes an unexpected change in the voltage crosswise over it. The voltage on a capacitor cannot change suddenly. The perfect capacitor does not disseminate vitality. It takes power from the circuit while putting away vitality in its field and returns already put away vitality when conveying energy to the circuit. A genuine, noni deal capacitor has a parallel-model spillage resistance. The spillage resistance might be as high as 100 MQ and can be disregarded for most reasonable applications.

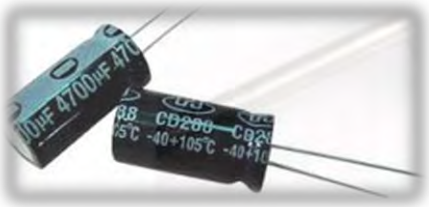

Figure 2.3b: Capacitor

2.3.3 Diode

Since the current in the inductor can't change momentarily, a way should exist for the inductor current when the switch is off (open). This way is given by the freewheeling diode (or catch diode). The motivation behind this diode is not to correct, but rather to direct current stream in the circuit and to guarantee that there is dependably a way for the current to stream into the inductor. It is likewise vital that this diode ought to have the capacity to kill generally quickly. In this way the diode empowers the converter to change over put away vitality in the inductor to the load.

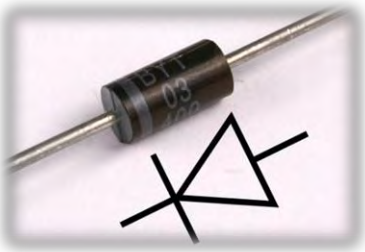

Figure 2.3c: Diode

2.3.4 Resistor

A resistor is a passive two-terminal electrical part that executes electrical resistance as a circuit component. Resistors might be utilized to diminish current stream, and, in the meantime, may act to lower voltage levels inside circuits. In electronic circuits, resistors are utilized to farthest point current stream, to change signal levels, predisposition dynamic components, and end transmission lines among different employments. High-control resistors, that can disperse numerous watts of electrical force as warmth, might be utilized as a major aspect of engine controls, in force appropriation frameworks, or as test burdens for generators. Altered resistors have resistances that lone change marginally with temperature, time or working voltage. Variable resistors can be utilized to alter circuit components, (for example, a volume control or a light dimmer), or as