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PROJEK SARJANA MUDA II

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WIRELESS POWER TRANSFER FOR CELL PHONE CHARGING APPLICATION

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Bachelor of Electrical Engineering
(Control, Instrumentation and Automation)
May 2011

"I hereby declare that I have read through this report entitle "*Wireless Power Transfer For Cell Phone Charging Application*" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation & Automation)"

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Supervisor's Name : MR. LIM WEE TECK

Date : 8th JUNE 2012

WIRELESS POWER TRANSFER FOR CELL PHONE CHARGING APPLICATION

SOO ENG KUAN

A report submitted in partial fulfilment of the requirements for the degree of Electrical Engineering (Control, Instrumentation & Automation)

Faculty of Electrical Engineering

UNIVERSITY TEKNIKAL MALAYSIA MELAKA

JUNE 2012

I declare that this report entitle "*Wireless Power Transfer for Cell Phone Charging Application*" 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 : SOO ENG KUAN

Date : 8th JUNE 2012

DEDICATION

I dedicate this study to my family, especially…

to Father and Mother for instilling the importance of hard work and higher education;

to late grandmother, late grandfather for encouragement;

to my sisters—may you also be motivated and encouraged to reach your dreams.

ACKNOWLEDGEMENT

I would never have been able to finish my project without the guidance of my lecturers, help from friends, and support from my family members.

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Finally, I would also like to thank my parents, and three elder sisters. They were always very supportive and stood by me through the good times and bad.

ABSTRACT

Nowadays, hand phones are essential in our daily life and play as one of the most important communication devices. Hand phone chargers that available in the market are usually connected with USB cables or adapter and normally are not universal which in another word, different brand of hand phone will need its specific kind of charger. Wireless power transfer has been studied over years since Nikola Tesla demonstrated wireless illumination of phosphorescent lamp in 1893AD.Since then, magnetic induction has been studied and hence produced wireless chargers for devices these days. Nonetheless, the efficiency of the transmission has always been an issue for wireless applications and what was available in the market is also non-universal. Thus, the aim of this research will be focused on applying a wireless charger for cell phones. Prior laboratory testing, several simulation were conducted. Through simulations and designed laboratory testing, data is collected and analysed. Construction of a prototype and the complete schematic of the prototype are presented in this thesis. The performance of the charging device is analysed. Although the charging of hand phone is not able to be demonstrated, the transfer of power wirelessly was exhibited. Future works will focus on the study on coils in attempt to improve the capability of wireless power transfer.

ABSTRAK

Pada masa kini, telefon bimbit adalah penting dalam kehidupan harian kita dan ialah sebagai salah satu alat komunikasi yang paling penting. Pengecas telefon bimbit yang terdapat di pasaran sekarang biasanya berkabel dan jenama telefon bimbit yang berbeza akan memerlukan jenis pengecas yang khusus. Pemindahan kuasa tanpa wayar(*wireless power transfer*) telah dikaji sejak tahun 1893M. Selama ini, aruhan magnet sering dikaji, sehingga terhasil pengecas telefon bimbit tanpa wayar. Akan tetapi, pengecas tanpa wayar yang ada dalam pasaran dihasilkan untuk jenama dan model telefon bimbit tertentu dan khususnya yang baru dalam pasaran. Oleh itu, projek ini bertujaun untuk menghasilkan pengencas telefon bimbit tanpa wayar untuk semua model termasuk model telefon bimbit yang lama. Kaedah yang terlibat dalam projek ini, termasuk simulasi-simulasi yang dijalankan untuk membuktikan teori-teori yang ada. Data simulasi dikumpulkan untuk penghasilan prototaip pengecas tanpa wayar. Skema electrik sambungan prototaip juga terkandung dalam laporan ini. Analisa dijalankan atas fungsi prototaip ini. Walaupun prototaip ini tidak berjaya untuk mengecas telefon bimbit, tetapi, perpindahan kuasa tanpa wayar dapat diperhatikan melalui prototaip ini. Dalam penyelidikan seterusnya, gegelung-gegelung yang digunakan untuk perpindahan kuasa tanpa wayar perlu diberi perhatian.

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LIST OF ABBREVIATIONS AND SYMBOLS

AC	Alternating Current
DC	Direct Current
PWM	Pulse-Width-Modulation
SPWM	Sinusoidal Pulse-Width-Modulation
PF	Power Factor
THD	Total Harmonic Distortion

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CHAPTER 1

INTRODUCTION

1.1. Introduction

Wireless power transfer has been studied over years since Nikola Tesla demonstrated wireless illumination of phosphorescent lamp in 1893AD.Since then, magnetic induction has been studied and hence produced wireless chargers for devices these days. Nonetheless, the efficiency of the transmission has always been an issue for wireless applications.

1.2. Project Statement

Technological advancement has led to a scenario where most individuals own multiple portable devices. However, charging these devices at the same time has turned into an annoyance, as all these will require multiple power outlets with plenty of wires entangling each other; besides, travelling with plenty of different chargers for multiple devices proof to be troublesome. Wireless power transfer studies have devised chargers capable of charging portable devices wirelessly. The wireless transmission is done by applying the concept of power transformers while removing its iron core; we aimed to replicate the transmission efficiency as compared to conventional chargers.

1.3. Objectives

1.3.1. To study the current cell phone charger and come out with a similar charging signal.

1.3.2. To design power converters system that can be used to charge cell phone.

1.4. Scopes

This research will discuss the wireless power transfer application in cell phone charging inclusive of:

1.4.1. The study on Nokia phone chargers.

1.4.2. The method of wireless transmission.

1.4.3. The construction of circuit to demonstrate wireless transmission.

1.4.4. The construction of power converters to replicate charging signal.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

There are several methods of wireless power transmission known to human, however without proper configuration, immense loss of energy as other form is susceptible to occur. In order to improve efficiency of wireless power transfer, studies are to be performed on different configurations of power converters.

Oxford Dictionaries defines the term 'converter' as a person or a thing that converts something; hence power converters are devices that converts power. In terms of electrical engineering, power comes in basic form as alternating current (AC). It is then converted to meet the requirements of loads in terms of current and voltage, frequencies and duty cycle. The process of power conversion does not necessarily be a single step process. A multistep application such as AC-DC-AC conversion will require multiple converters [1].

2.2. Theoretical Background

Converters are mainly classified in 4 categories which can be easily distinguished through the relationship between input and output [2]:

- AC Input DC Output
  An ac-dc converter, also named as rectifier is used to yield dc output from an ac input.

- DC Input AC Output
  A dc-ac converter is classified as an inverter as it converts DC to AC using switching and control circuits

- DC Input DC Output

  When a load requires regulated DC voltage or current, dc-dc converter is used to optimise unregulated DC source

- AC Input AC Output

  The ac-ac converter is used to alter the amplitude and the frequency (whichever is needed) of the source ac signal.

Conventional cell phone chargers available in the market operate at AC input ranging from 100 Volts to 240 Volts and 110 miliampere at 50-60 Hertz producing DC output of 5 Volts and 890 miliampere. Figure 1 illustrates the process of conversion to yield the required output. AC input is rectified; then, voltage limiter is employed to clamp voltage. Finally, rectified output is then feed into filter to minimize ripple from the resultant output.

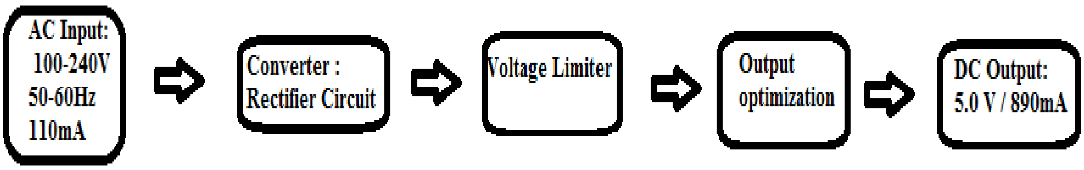

Figure 1 : Block Diagram of Mobile Phone Charger

Conceptual wireless power cell phone chargers derived after complying with selected wireless power transfer method is depicted in Figure 2. AC supply is fed into converter to obtain a suitable signal to be transmitted wirelessly to its receiver. Through wireless transmission, output from receiver is fed into converter to obtain a signal similar to the output requirement of cell phone charging signal.

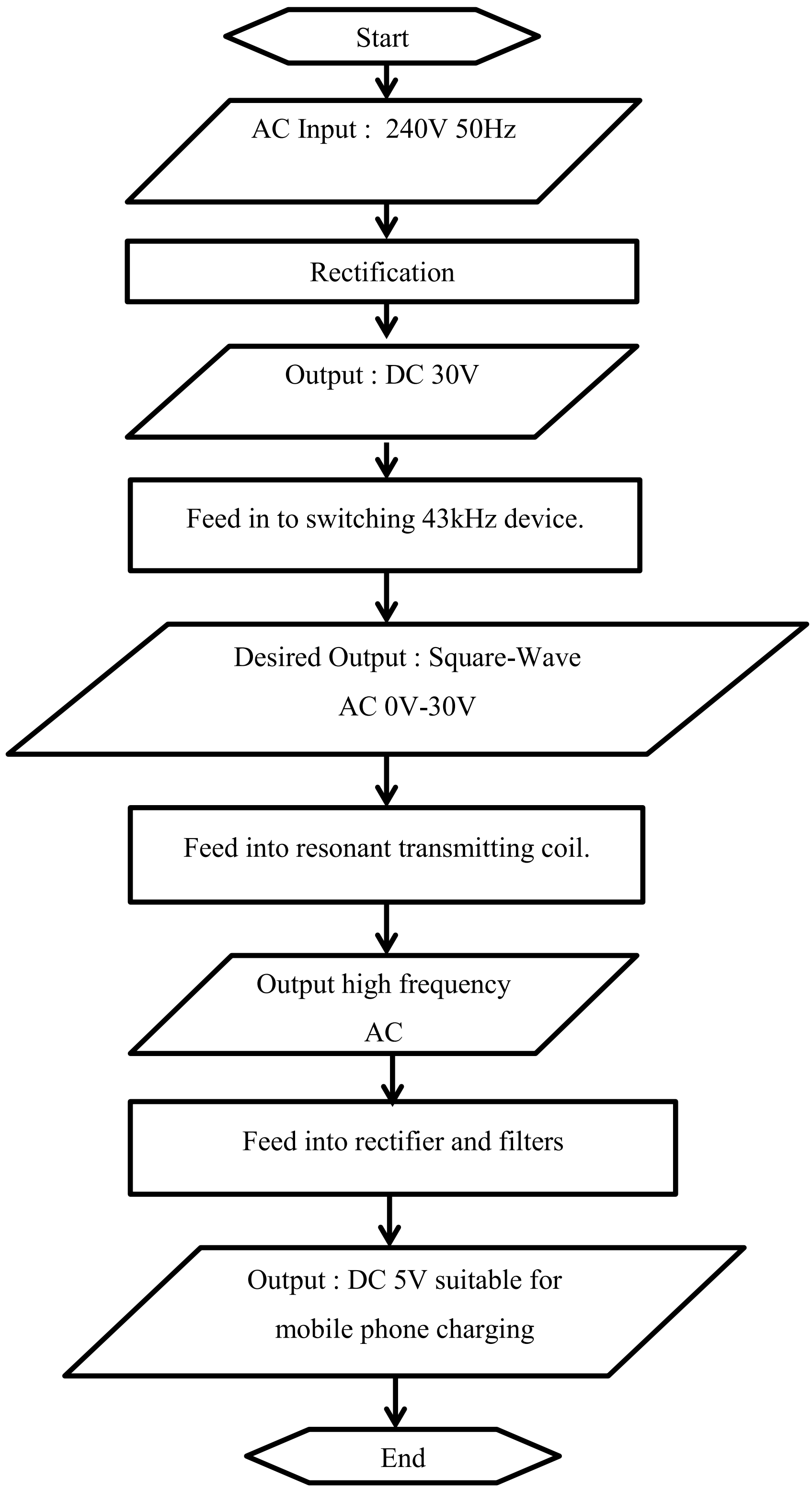

Figure 2 : Block Diagram of Wireless Mobile Phone Charger

Generally, the requirement of load will determine the yield of converters. Thus, a study on the output of required converter is reviewed.

2.2.1. Rectifiers

[3] stated, in general, there are 2 main types of rectifiers, namely the Half-Wave Rectifiers and the Full-Wave Rectifiers.

A half-wave rectifier circuit is depicted in Figure 3. Circuit consists of 1 diode fed with transformer secondary voltage. During positive half of power cycle, diode D conducts. Diode D blocks away the negative half of the power cycle.

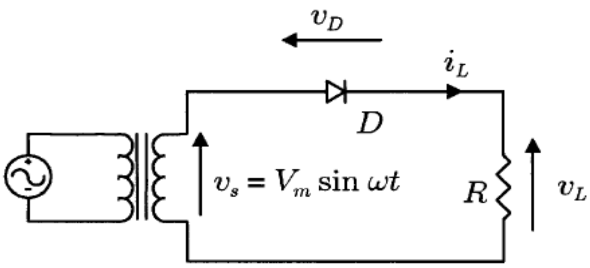

Figure 3 : Half-Wave Rectifier with resistive load. [3]

Figure 4 depicts the voltage and current waveforms of the half-wave rectifier with resistive loads. It is noticeable the half of a power cycle is lost in the rectification process. Thus, the resultant output will greatly reduce the efficiency of the rectifier.

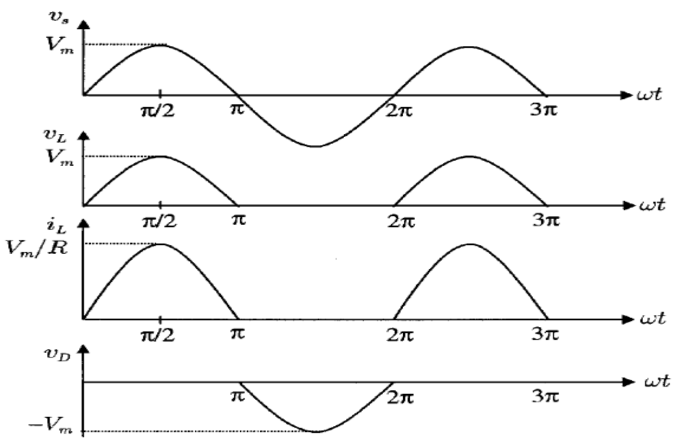

Figure 4 : Voltage and current waveforms of the half-wave rectifier with resistive load. [3]

A full-wave bridge rectifier is illustrated in Figure 5. Full-wave bridge rectifier employed four diodes in the rectification process. The positive half cycle of the transformer secondary voltage, diodes D_1 and D_2 conduct, whereas the negative half cycle, current flows through D_3 and D_4. Figure 6 illustrates the voltage and current waveforms of full-wave bridge rectifiers.

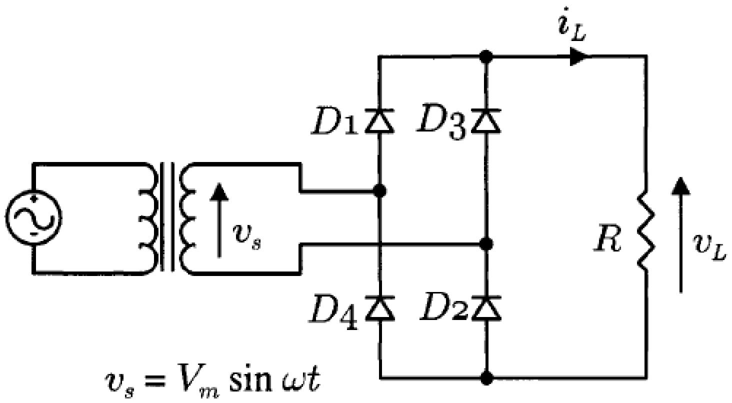

Figure 5 : Full-Wave Bridge Rectifier with resistive load. [3]

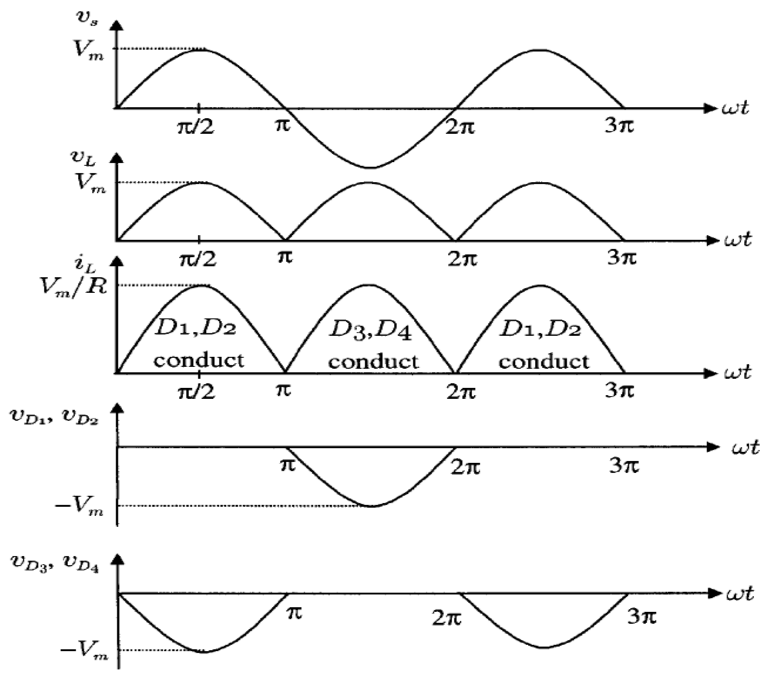

Figure 6 : Voltage and current waveforms of full-wave bridge rectifier. [3]

In order to select an appropriate rectifier to be used, several performance parameters are evaluated and compared.

Table 1 shows the comparison of performance parameters between half-wave rectifier and full-wave bridge rectifier with resistive loads. Judging from these parameters, full-wave bridge rectifier provides higher power efficiency throughout the rectification process.

Table 1 : Comparison of performance parameters between half-wave rectifier and full-wave bridge rectifier with resistive loads. [3]

Performance Parameters	Half-Wave Rectifier with Resistive Load	Full-Wave Bridge Rectifier with Resistive Load
Average load voltage, v_L	$v_L = V_{dc} = \frac{V_m}{\pi} = 0.318V_m$	$v_L = V_{dc} = \frac{2V_m}{\pi} = 0.636V_m$
RMS load voltage, V_L	$V_L = \frac{V_m}{2} = 0.5V_m$	$V_L = \frac{V_m}{\sqrt{2}} = 0.707V_m$
Average load current, i_L	$i_L = I_{dc} = \frac{0.318V_m}{R}$	$i_L = I_{dc} = \frac{0.636V_m}{R}$
RMS load current, I_L	$I_L = \frac{0.5V_m}{R}$	$I_L = \frac{0.707V_m}{R}$
Rectification ratio,σ	$\sigma = \frac{(0.318V_m)^2}{(0.5V_m)^2} = 40.5\%$	$\sigma = \frac{(0.636V_m)^2}{(0.707V_m)^2} = 81.0\%$
Form Factor, FF	$FF = \frac{0.5V_m}{0.318V_m} = 1.57$	$FF = \frac{0.707V_m}{0.636V_m} = 1.11$
Ripple Factor, RF	$RF = \sqrt{1.57^2 - 1 = 1.21}$	$RF = \sqrt{1.11^2 - 1 = 0.482}$
Transformer Utilization Factor,TUF	$TUF = \frac{0.318^2}{0.707 \times 0.5} = 0.286$	$TUF = \frac{0.636^2}{0.707 \times 0.707} = 0.286$