ANALYSIS ON 40 KHZ ACOUSTIC ENERGY TRANSMISSION SYSTEMS THROUGH METAL PROPAGATION MEDIUM

NUR FATIN HAZIQAH BINTI AZHARI

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NUR FATIN HAZIQAH BINTI AZHARI

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DEDICATION

Special dedication to my loved family, Encik Azhari Bin Junit and Puan Suryani Binti Jamil. Their encouragement and motivation has always be an inspiration to me along journey of education and finish my Bachelor.

ABSTRACT

This project is analysed of energy transmission using ultrasonic wave which can propagate wave based on Acoustic Energy Transfer (AET) system through a couple of ultrasonic transducer to convey energy by eliminate wires and cables to increase the reliability of the critical system. The project is designed an efficient AET system using Class E zero voltage switching (ZVS) inverter by reducing or eliminating switching amplifier losses at the transmitter unit. The metal is used as a medium that propagate waves from the transmitter to receiver. A standard receiver unit is developed at the receiver unit to verify the energy transmission efficiency between the transducers which load is used to demonstrate the functionality of the system. The project to determine the performance of the AET system based on ZVS conditions, input power, and output power and transmission efficiency. Based on the 40kHz is analysed the efficient of 1W AET system using Class E ZVS inverter to increase the efficiency.

ABSTRAK

Projek ini mengenai penghantaran tenaga menggunakan gelombang ultrasonik yang boleh menyebarkan gelombang berdasarkan Sistem Pemindahan Tenaga Akustik (AET) melalui dua transduser ultrasonik untuk menghantar tenaga dengan menghilangkan wayar dan kabel bagi meningkatkan ketahanan di sistem yang kritikal. Projek ini direka untuk meningkatkan kecekapan dalam sistem AET menggunakan inverter Kelas E (ZVS) dengan mengurangkan atau menghapuskan losses penguat suis di unit pemancar. Logam digunakan sebagai medium untuk menyebarkan gelombang dari pemancar ke penerima. Unit penerima direka untuk menentukan kecekapan penghantaran tenaga antara transduser dengan load digunakan untuk menunjukkan sistem berfungsi. Projek ini dapat menentukan prestasi sistem AET berdasarkan keadaan ZVS, kuasa input, dan kuasa keluaran serta keberkesanan penghantaran. Dengan menggunakan ultrasonik transducer 40kHz dapat menganalisis kecekapan 1W sistem AET menggunakan inverter Kelas E ZVS untuk menghantar tenaga dan meningkatkan kecekapan sistem.

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LIST OF SYMBOLS AND ABBREVIATIONS

AC	:	Alternating current
AET	:	Acoustic Energy Transfer
CPT	:	Capacitive Power Transfer
DC	:	Direct current
IPT	:	Inductive Power Transfer
MOSFET	:	Metal oxide semiconductor field effect transistor
PWM	:	Pulse Width Modulation
PZT	:	Piezoelectric Transducer
WPT	:	Wireless Power Transfer
ZCS	:	Zero Current Switching
ZVS	:	Zero Voltage Switching

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays, most of the devices and systems such as implantable devices, mobile phone, and others need a power supply to activate them. The technology of wireless power transfer (WPT) systems is the technique by transfer the power source in transmitter to the load in receiver by eliminates the wires or cables. WPT system is more effective usable compared to a wired charger because to development a system more flexible, portable and convenient in order to run the system. In WPT have three types of energy transfer such as Acoustic Energy Transfer (AET), Capacitive Power Transfer (CPT) and Inductive Power Transfer (IPT).

The AET system is the one of an emerging technology which used the ultrasound waves to transfer energy. In AET system consists of transmitter and receiver part which both of part have a couple of ultrasonic piezoelectric transducer and it separated by a transmission through any medium.

Each of the types of wireless power transfer has advantage and limitation in the system. For example, CPT has the limitation on the distance and plate to transfer the power based on the medium. So, the requirement in the limited distance must have the high frequency and high voltage to obtain the high efficiency energy transfer [8]. IPT has the limitation on the transfer the energy in metal and water. For the IPT system, metal unsuitable uses as medium to transfer the energy for the IPT system because of the high losses occur in the electromagnetic fields and induce eddy current around the metal surface [4],[18].

This study aim to analysis the efficient power transfer using the AET system through metal propagation medium. Thus, the efficiently method to transmit energy from transmitter to the receiver in terms of gap distance and propagation medium is AET system method. In order to achieve this, a high frequency power amplifier was proposed to be used at the transmitter side of AET system.

1.2 Problem Statement

The innovative technology of wireless power transfer (WPT) systems is to supply the any device with electrical energy to the load by reduce number of cables. The problem that to transfer power in critical system and application which to increase the reliability of the applications such as aerospace, biomedical, robotic and multisensory. This problem can be overcome by using AET methods approach that utilizes the ultrasonic transducer as energy converter. The ultrasonic transducer is used to transfer energy by propagate through vibration wave in the any transmission medium. However, a major problem with the AET method is the low efficiency power during the power transfer process especially in air and metal medium [8],[9]. This project aimed to study the viability of AET through metal as a medium of propagation. In order to design high efficient AET system, the Class E ZVS inverter will be designed as a driver for the ultrasonic transducer at the transmitter side. By having the high efficiency of the Class E ZVS, it is achieved that an efficient power transmission can be achieved.

1.3 Objectives

1. To design an efficient AET system using Class E ZVS inverter at the transmitter unit in order to reduce or eliminate switching amplifier losses.
2. To validate experimentally the designed model of transmitter to receiver unit of the AET system using ultrasonic transducer through metal applications.
3. To determine the performance of the AET system based on ZVS conditions, input power, output power and efficiency.

1.4 Scope of Project

1. The design of power amplifier to drive 40 kHz ultrasonic transducer that using Class E ZVS inverter due to its ability to achieve high performance based on the switching condition.
2. The passive matching network that easily incorporated with the Class E ZVS inverter is chosen in order to reduce the acoustic impedance mismatch.
3. The passive high frequency rectification is develops at the receiver unit so that the capture power can be regulated and usable to the dedicated 1W load.
4. The project focuses on investigate of the energy transmission between the transmitter and receiver based on several thickness of metal medium.
5. The simulation using the MATLAB software.

1.5 Thesis Outline

Chapter 2 describes about WPT systems and detail of the background study and previous project. The review of the working principles and previous works on AET system are discussed in this chapter. Furthermore, this chapter discusses the application, operation and factor affect the performance of AET systems.

Chapter 3 explains a flow process method use of the project from the transmitter to receiver. Next, this chapter presents the Class E Zero Voltage Switching (ZVS) inverter in the AET system as a power amplifier. In general, the Class E Zero Voltage Switching (ZVS) inverter is also known as a driver circuit converter direct current (DC) to alternating current (AC). So, this chapter is discussed the method to design the circuit Class E Voltage Switching (ZVS) inverter that consists of MOSFET, series capacitor and inductor circuit and also shunt capacitor. The data of the calculation and simulation of the circuit design is analysed and used to build the hardware circuit.

Chapter 4 describes the analysis performance of the AET system in Class E ZVS inverter, ultrasonic transducer and adding impedance matching to achieve the maximum power transfer. The performance results of the proposal approach is given and discussed by using the simulation study and experiment implementation.

Chapter 5 concludes overall this thesis. A few future works can be improve related to this analysis is this chapter. Basically, its summary of the research about and the element related to it.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction

The development of technology advances for the most appliances that apply it become portable and smaller. In addition, the appliances unnecessary that practically to energize from power supply using wires to power outlet. However, to energize the system of the technology of wireless power transfer will have the other impacts by consumers on the usage. By the researches, M. G. L. Roes found that using the wires or cables to transfer power in the applications is exposed to hazardous and difficult to install [10]. Because of that, different types of Wireless Power Transfer (WPT) technique are analyzed which without using the cable able to transfer electrical energy to the receiver which stated by the H. F. Leung, B. J. Willis, and A. P. Hu [4] . However, before WPT can be utilized in daily lives, there