# THE DEVELOPMENT OF CAPACITIVE POWER TRANSFER FOR BIOMEDICAL IMPLANTABLE DEVICE

NUR FATIN AFIQAH BINTI AHMAD

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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**NUR FATIN AFIQAH BINTI AHMAD**

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# DEDICATION

This report is especially dedicated to my beloved parents, family and everyone who contributes to this journey

# ABSTRACT

Wireless power transfer using electric and magnetic near-fields has been used in many applications widely, and biomedical implants being one of them. The most commonly used method for powering power wirelessly to biomedical implantable device is using inductive coupling between two mutually-coupled coils. In this project, a consider new method will be proposed in transferring power for biomedical device which is capacitive power transfer (CPT). The simplicity in its design compared to inductive coupling make it more convenient to be used in biomedical implantable device. The main reasons of using this method are the low electromagnetic interference (EMI), can reduce power losses and the abilities to transfer power across metal barriers compared to the traditional method of inductive power transfer. To be specific, in this project, we have designed Class E circuit as an inverter to convert the 12VDC to AC with 1 MHz frequency. The prototype of the capacitive power transfer for implantable application has also been successfully developed with capacitive plate dimensions of 3cmx3cm width per length for receiver plate and 4cmx4cm for transmitter plate, respectively. The 5mm thickness of beef separation between the plates is used in this project. The design specification of this project is according to stimulator for peripheral nerve implantable device

which only needs 100 mW of power to operate in the CPT system. Overall, the developed CPT system for the biomedical device is able to deliver 76mWatt with 41.43% efficiency. To enhance the efficiency, the impedance matching circuit has been proposed in this project and the prototype is now able to deliver 140mWatt power to the DC load, achieving ZVS waveform and efficiency of 77.5%.

# ABSTRAK

Pemindahan kuasa tanpa wayar menggunakan elektrik dan medan magnet berhampiran telah digunakan dalam banyak aplikasi secara meluas, dan implan biomedikal adalah salah satu daripadanya. Kaedah yang paling biasa digunakan untuk menyalurkan kuasa tanpa wayar ke peranti implan biomedikal adalah menggunakan gandingan induktif antara dua gegelung yang saling dipasangkan. Dalam projek ini, pertimbangan kaedah baru akan dicadangkan dalam memindahkan kuasa untuk peranti bioperubatan yang merupakan pemindahan kuasa kapasitif (CPT). Keringkasan dalam reka bentuknya berbanding dengan gandingan induktif menjadikan ia lebih mudah untuk digunakan dalam peranti implant bioperubatan. Sebab utama menggunakan kaedah ini adalah gangguan elektromagnetik yang rendah (EMI), dapat mengurangkan kehilangan tenaga dan kebolehan untuk memindahkan kuasa merentasi halangan logam berbanding dengan kaedah tradisional pemindahan tenaga induktif. Secara spesifik, dalam projek ini, kami telah mereka litar Kelas E sebagai penyongsang untuk menukar 12VDC ke AC dengan kekerapan 1 MHz. Prototaip pemindahan kuasa kapasitif untuk aplikasi implan juga telah berjaya dibangunkan dengan dimensi plat kapasitif 3cmx3cm lebar kali panjang untuk plat penerima dan 4cmx4cm bagi plat pemancar. Ketebalan 5mm pemisahan daging lembu antara plat digunakan dalam projek ini. Spesifikasi reka bentuk projek ini adalah berdasarkan stimulator untuk alat implan saraf periferal yang hanya memerlukan 100 mW kuasa untuk beroperasi dalam sistem CPT. Secara keseluruhan, sistem CPT yang dibangunkan untuk peranti bioperubatan dapat menyampaikan 76mWatt dengan kecekapan 41.43%. Bagi meningkatkan kecekapan, litar pemadanan impedans telah dicadangkan dalam projek ini dan prototaip kini dapat menyampaikan kuasa 140mWatt kepada beban DC, mencapai bentuk gelombang ZVS dan kecekapan 77.5%.

# ACKNOWLEDGEMENTS

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| | | |
|---|---|---|
| WPT | : | Wireless Power Transfer |
| IPT | : | Inductive Power Transfer |
| APT | : | Acoustic Power Transfer |
| CPT | : | Capacitive Power Transfer |
| LPT | : | Light Power Transfer |
| MPT | : | Microwave Power Transfer |
| SAR | : | Specific Absorption Rate |
| MOSFET | : | Metal Oxide Semiconductor Field Effect Transistor |
| AC | : | Alternating Current |
| DC | : | Direct Current |

# LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

The first chapter of this thesis will explain about project background, project objectives, problem statement and lastly scope of the project.

## 1.1 Project background

The transmission of electrical energy without wires is called wireless power transfer (WPT). WPT can be accomplished by creating electric, magnetic or electromagnetic coupling between a device and its counterpart [1]. This innovation can be another option to control electrical gadgets while interconnecting wires are troublesome, unsafe, or are impractical. WPT framework are utilizing the fundamental idea as appeared in Figure 1.1. The essential side includes DC-to-AC resonant converter that will convert DC control supply to high frequency AC energy. An energy transfer medium will then transferred the AC energy to the auxiliary side of receiver. The auxiliary side is not associated electrically to the essential side. High frequency AC energy is then changed by an AC-to-DC converter to meet the requirements indicated by the load parameters [2].

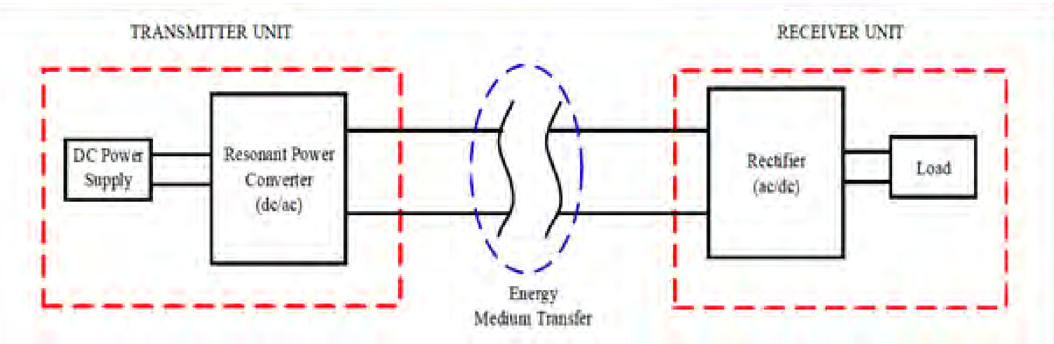


Figure 1.1: WPT system block diagram

Wireless power techniques have two categories which are near-field and far-field. As for far-field or radiative techniques, which is also called power beaming, power is transmitted by beams of electromagnetic radiation, corresponding to microwaves or laser beams. These methods can transmit energy in longer distances but must be aimed at the receiver. Solar power satellites and wireless powered drone aircraft are the examples of proposed applications for this kind of methods.

As for near field techniques as shown in Figure 1.2, power is transferred by magnetic fields using inductive coupling between coils of wire, or by electric fields using capacitive coupling between coupling plates. The power transferred in inductive coupling (electromagnetic induction or inductive power transfer, IPT), is occurring between coils of wire by a magnetic field. The transmitter and receiver coils together will act like a transformer. An alternating current (AC) through the transmitter coil produces an oscillating magnetic field (B) by Ampere's law. The magnetic field goes through the receiving coil, where it prompts an alternating EMF (voltage) by Faraday's law of induction, which generates an alternating current in the receiver. The induced alternating current may either powering up the load directly, or be rectified to direct current (DC) by a rectifier in the receiver, which drives the load. Inductive coupling is the oldest and most widely used wireless power technology that has been used in many commercial products.

In capacitive coupling (electrostatic induction), the conjugate of inductive coupling, energy is transmitted between electrodes such as metal plates by electric fields. The transmitter and receiver plates will act like a capacitor, with the intervening space as the dielectric. An alternating voltage generated by the transmitter is applied to the transmitting plate, and the oscillating electric field induces an alternating potential on the receiver plate by electrostatic induction, which causes an alternating current to flow in the rectifier circuit to be converted to direct current for powering up load.