

**CAPACITIVE POWER TRANSFER SYSTEM FOR AQUARIUM
APPARATUS**

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**CAPACITIVE POWER TRANSFER SYSTEM FOR
AQUARIUM APPARATUS**

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DEDICATION

This project is enthusiastically dedicated toward to my dearest family, friends and supervisor which had been help and support.

ABSTRACT

This project presents the design and development of Capacitive Power Transfer (CPT) system, which is one of the wireless power transfer (WPT) technology that offer many benefit than the other WPT technology. This is due to the CPT benefits of simple topology, fewer components that can help EMI perform better and robustness to surrounding metallic elements. In this work, CPT technology is proposed to provide contactless power supply for apparatus in an aquarium such as lighting and motor pump. Firstly, this project begins by analysing the Class-E inverter to generate high power frequency ac power source to drive the CPT system. Secondly, because of the sensitivity of the Class-E to the load variations, Class-E was combined together with LCCL impedance matching circuit to preserve ZVS condition for wider load-range changes. Thirdly, the performance of the proposed topology were analyses in term of switching losses, input power, output power and dc-dc efficiency. Lastly, a 10W power output for supplying power to apparatus aquarium was constructed to verify the proposed circuit. The best performance for this project has demonstrated 92% efficiency at 3mm working distance, which can be considered as an exceptional performance.

ABSTRAK

Projek ini membentangkan reka bentuk dan pembangunan pemindahan sistem Kapasitif Kuasa (CPT), yang merupakan salah satu teknologi pemindahan kuasa tanpa wayar yang banyak memberi manfaat daripada teknologi lain. Ini adalah kerana manfaat CPT yang mana topologinya mudah, komponen yang sedikit yang dapat membantu EMI dilakukan dengan lebih baik dan kukuh beroperasi dalam persekitaran unsur-unsur logam. Dalam kerja ini, teknologi CPT dicadangkan untuk menjana bekalan kuasa tanpa sentuhan untuk peralatan di dalam akuarium seperti lampu dan pam air. Pertama, projek ini dimulakan dengan menganalisis penyongsang Kelas-E untuk menghasilkan kuasa at berfrekuensi tinggi untuk memacu CPT sistem. Kedua, disebabkan oleh sensitiviti Kelas-E terhadap variasi bebanan, Kelas-E digabungkan bersama dengan litar padanan galangan LCCL untuk memelihara keadaan ZVS untuk perubahan jarak jauh yang luas. Ketiga, prestasi topologi yang dicadangkan adalah berdasarkan analisis dari segi kehilangan penguisan, kuasa masuk, kuasa keluar dan kecekapan at-at. Akhir sekali, kuasa keluaran 10W untuk menjana kuasa untuk radas akuarium direka bentuk untuk sahkan tujuan litar. Prestasi yang terbaik untuk projek ini adalah menunjukkan 92% kecekapan pada ketebalan jarak 3mm, dimana boleh dipertimbangkan sebagai prestasi luar biasa.

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TABLE OF CONTENTS

Declaration	
Approval	
Dedication	
Abstract	i
Abstrak	ii
Acknowledgements	iii
Table of Contents	iv
List of Figures	viii
List of Tables	xi
List of Symbols and Abbreviations	xii
List of Appendices	xiii
CHAPTER 1 INTRODUCTION	1
1.1 Project Background	1
1.2 Project Objective	2
1.3 Problem Statement	3
1.4 Scope of Project	3

1.5	Thesis Organization	4
CHAPTER 2 BACKGROUND STUDY		5
2.1	Introduction	5
2.2	Wireless Power Transfer Technology	6
2.3	Capacitive Power Transfer Topology	8
2.3.1	Class-E Topology	8
2.3.2	Capacitance of Coupling Plate	11
2.3.3	Impedance Matching Resonant Circuits	13
2.3.3.1	Series L Impedance Matching	14
2.3.3.2	LC Impedance Matching	15
2.3.3.3	LCLC Impedance Matching	16
2.3.4	Rectifier circuit	17
2.4	Summary	18
CHAPTER 3 METHODOLOGY		19
3.1	Introduction	19
3.2	Flowchart Methodology	20
3.3	CPT System Circuit Configuration	22
3.3.1	Class-E Configuration	22
3.3.2	Impedance Matching Configuration	25
3.3.3	Rectifier Configuration	27

3.4	Hardware Requirement	28
3.4.1	Layout Design	29
3.5	Implementation	31
CHAPTER 4 RESULTS AND DISCUSSION		33
4.1	Introduction	33
4.2	Simulation Result	34
4.2.1	Class-E 34	
4.2.2	LCCL Impedance Matching	37
4.2.3	Rectifier	38
4.3	Experimental Result	40
4.3.1	Class-E 40	
4.3.2	LCCL Impedance Matching	42
4.3.3	Rectifier	45
4.3.4	Implement in the apparatus	47
4.4	Comparison between Simulation and Experimental	49
4.5	Analysis	50
4.5.1	Analysis Load variation	50
4.5.2	Analysis Distance	54
CHAPTER 5 CONCLUSION AND FUTURE WORKS		58
5.1	Conclusion	58

	vii
5.2 Future work	59
REFERENCES	61
LIST OF PUBLICATIONS AND PAPERS PRESENTED	63
APPENDICES	64

LIST OF FIGURES

Figure 2.1: Block Diagram of the Proposed CPT System[3]	8
Figure 2.2: Class-E RF zero-current-switching amplifier Equivalent circuit[4]	10
Figure 2.3: Current Through Switch and Voltage Across Switch[6]	11
Figure 2.4:Capacitive coupling structure [1]	12
Figure 2.5: Impedance Matching circuit[4]	14
Figure 2.6: Circuit topology of a CPT system based on L impedance matching[1]	15
Figure 2.7: Circuit topology of a CPT system based on LC impedance matching[1]	16
Figure 3.1: Flowchart for Methodology	21
Figure 3.2: Flowchart of Class-E	23
Figure 3.3: Block Diagram of Proposed CPT System in the MATLAB[4]	24
Figure 3.4: Circuit topology of a CPT system based LCLC impedance matching	26
Figure 3.5: Flowchart Class-E LCCL Impedance Matching	26
Figure 3.6: Flowchart for Rectifier	28
Figure 3.7: Layout in Protues for Transmitter	30
Figure 3.8: Layout in Protues for Receiver	30
Figure 3.9: Prototype of CPT system for aquarium application layout	32
Figure 4.1: Class-E circuit	35
Figure 4.2: ZVS waveform	36

Figure 4.3: Waveform in MATLAB for voltage output and current output	36
Figure 4.4: LCCL Impedance Matching	37
Figure 4.5: Output voltage waveform	37
Figure 4.6: ZVS waveform without capacitor	39
Figure 4.7: Voltage output without capacitor waveform	39
Figure 4.8: Output voltage with capacitor waveform	40
Figure 4.9: ZVS condition with capacitor waveform	40
Figure 4.10: Circuit in Breadboard	40
Figure 4.11: ZVS and Driver waveform	41
Figure 4.12: Voltage Output waveform	42
Figure 4.13: Circuit in PCB	42
Figure 4.14: Voltage output waveform for LCCL impedance matching	43
Figure 4.15: ZVS condition waveform	43
Figure 4.16: Circuit with the capacitor plate medium air	44
Figure 4.17: Diode and the receiver part	45
Figure 4.18: Bridge diode full-wave waveform	46
Figure 4.19: Capacitive Plate and receiver part	46
Figure 4.20: Voltage output waveform for rectifier	46
Figure 4.21: Full circuit with capacitor	47
Figure 4.22: Value of the ZVS condition when implement the load waveform	48
Figure 4.23: Value minimum to on the apparatus	48
Figure 4.24: Graph output power versus load resistor	53
Figure 4.25: Graph output voltage versus load resistor	53

Figure 4.26: Graph Efficiency versus load resistor	53
Figure 4.27: Setup for the plate	55
Figure 4.28: Graph Distance versus output power	57

LIST OF TABLES

Table 4.1: Parameter For Calculation	34
Table 4.2: Parameter Class-E	35
Table 4.3: Parameter LCCL Impedance Matching	38
Table 4.4: Value of component	41
Table 4.5: Table comparison capacitor value 800pF	44
Table 4.6: Table comparison capacitor value 4580pF	45
Table 4.7: Table parameter for load	47
Table 4.8: Result both simulation and circuit	49
Table 4.9: Class-E	51
Table 4.10: Class-E LCCL impedance matching	52
Table 4.11: Table distance	54
Table 4.12: Table distance versus power	55
Table 4.13: Result when change the distance	56

LIST OF SYMBOLS AND ABBREVIATIONS

CPT	:	Capacitive Power Transfer
WPT	:	Wireless power Transfer
ZVS	:	Zero Voltage Switching
PCB	:	Printed Circuit Board
PIC	:	Programmable Intelligent Computer
AC	:	Alternating Current
DC	:	Direct Current
PWM	:	Pulse Width Modulation

LIST OF APPENDICES

Appendix A: MOSFET Datasheet	70
Appendix B: TC4422 Datasheet	71
Appendix C: Specification Apparatus	71

CHAPTER 1

INTRODUCTION

The first chapter of this thesis explain about project background, project objective, problem statement of the project, scope of project, overview of the methodology, and project outline.

1.1 Project Background

This project present Capacitive Power transfer (CPT), which is one of the wireless power transfer (WPT) technology that have many benefit than other technology. The CPT system is introduce as an attractive alternative rather than traditional inductive coupling method. This is due to the CPT benefits simple topology where the fewer components can help EMI perform better and robustness surrounding metallic elements. The main reasons using the CPT system want to prevent the limitation of the WPT, where the magnetic field cannot penetrate through a metal barrier exits in

between of power sources and load. Because of that, magnetic field and special shield are needed to prevent electromagnetic interfere, to increase the efficiency magnetic and to achieve a reliable coupling factor which can increase the size and cost. In this work, CPT technology is proposed to generate contactless power supply for apparatus in an aquarium. A Class-E inverter together with LCCL matching circuit is utilized to drive the CPT system because of its ability to perform the dc-to-ac inversion efficiently with significant in switching losses using MATLAB software and experimental. The performance of the proposed topology analyzes in term of switching losses, input power, output power and dc-dc efficiency. Apart from that, the design of CPT system for this system able to transfer 10W output power efficiently and thus power up the aquarium apparatus such as LED light and motor pump. With this contactless power supply to transmit electric energy by using the wireless power receiving instead of wiring, the appearance of the aquarium can have been enhanced.

1.2 Project Objective

In this study, there has been listed several important objectives were superbly set to be achieved after complete this task which were:

1. Design a CPT system based on Class-E resonant inverter topology CPT system based on Class-E for aquarium apparatus.
2. Optimize the efficiency of the CPT system using multistage impedance matching circuit that is capable of improving the ZVS conditions that are less sensitive to the load and coupling variation.
3. Analyses the performance of the developed CPT system based on ZVS condition, input power, output power and efficiency.

1.3 Problem Statement

The main popular of the WPT that use nowadays is Inductive Power Transfer (IPT) but due to the limitation, IPT cannot penetrate metal so to overcome this problem by using the CPT.

Beside that for CPT system usually use for low watt scale application because it exhibits the limited of output power and efficiency. The efficiency of this system will drop when increase the coupling gap distance and load variation. In order to overcome this limitations, the development of Class-E inverter with the impedance matching network has been utilized.

1.4 Scope of Project

This project covered few part, which is simulate Class-E inverter using MATLAB software until achieve condition of Zero Voltages Switching (ZVS). In this case, it consists of MOSFET as switch where to check the performances by analysing ZVS condition, input power and output power, and efficiency. After that, demonstrate the Class-E inverter circuit with impedance matching network which is LCCL type. The reasons using LCCL impedance matching because, it can establish resonance circuit and effective power transfer. Apart of that, CPT in this project use four plate know as Bipolar structure. The proposed of prototype of Capacitive Power Transfer for Aquarium Apparatus with desired parameter of:

- Input Voltage, $V_{DC} = 24V$
- Output power, $P_o = 10W$
- Frequency, $f = 1MHz$
- Efficiency, $\eta = \text{more than } 80\%$
- Duty cycle, $D = 0.5$

- Distance gap, $d = 1\text{mm}$

1.5 Thesis Organization

This thesis contains of five chapters. Each chapter had been organized as follows:

- i. Chapter 1 is about an introduction of the project which is consists of project introduction, objective, problem statement and scope of work.
- ii. Chapter 2 is about the literature review of the CPT based on previous research.
- iii. Chapter 3 is about the description of the project implementation.
- iv. Chapter 4 will explain the progress result of the project and discussion.
- v. Chapter 5 concludes the whole research and proposes the future progress of the project.

CHAPTER 2

BACKGROUND STUDY

This chapter discuss about the literature discourse and the review CPT system based on the information obtained from valid sources such as book, journal and any other appropriate sources. This chapter is regarding the background study about how the project perform, and documentation about the theoretical concept that applied to completed this project.

2.1 Introduction

In recently WPT is the most important system that people used now a day. Because of this, this knowledge of the WPT by using CPT system is important for an understanding and it reviewed in this chapter. There have been several studies in the literature reporting such as type of the WPT, capacitive coupling plate, advantage of the CPT and limitation of the CPT. In addition, in this chapter also explain the several