

WIRELESS POWER TRANSFER IN NEAR-FIELD COMMUNICATION  
USING A CURRENT-CONTROLLED MULTI LOOPS WITH A  
LOADED CAPACITANCE

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WIRELESS POWER TRANSFER IN NEAR-FIELD COMMUNICATION USING  
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CAPACITANCE

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**DEDICATION**

To my beloved Mother and Father, who supported me all the time and  
To my lovely Wife and Son “Rayyan”, all my Brothers and Family members.

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## ABSTRACT

Wireless power transfer (WPT) in near-field communication (NFC) using current-controlled multi loops with a loaded capacitance is demonstrated in this work. The proposed multi loops antenna design gave low mutual inductance and transfer efficiency required within the operating distance of 1cm to 3cm. The ratio of the current between the loops was done by varying the value of loaded capacitor used in between loops, due to that mismatch of impedance between antennas was observed. Initially antennas were matched at 1cm but after optimization of simulation, it was decided at 3cm performance has improved and resulted as reduced mutual inductance within communication distance of NFC. The proposed loop design has better transfer efficiency for WPT up to 3cms within NFC operating modes. In this project, receiving antenna is placed in different close proximity from 1cm to 5cm with respective to transmitting antenna. The results of conventional loop and single current controlled loop and proposed multi loop antenna show that transfer efficiency of the proposed multi loop antenna is better and satisfactory than others.

## ABSTRAK

Tanpa wayar kuasa pemindahan (WPT) berhampiran bidang komunikasi (NFC) dengan pelbagai kawalan semasa gelung kemuatan dimuatkan ditunjukkan dalam kerja-kerja ini. Rekabentuk antena gelung pelbagai cadangan memberikan seragam inductance bersama yang diperlukan dalam jarak operasi. Nisbah perubahan semasa antara gelung tersebut adalah berbeza dengan nilai kapasitor yang digunakan di antara mereka, kerana itu ketakpadanan impedans antara antena telah berubah. Pada mulanya antena dipadankan pada 1cm tetapi setelah pengoptimuman simulasi, ia telah diputuskan untuk perlawanan pada 3 cm. yang dikurangkan bersama inductance dalam komunikasi jarak dari NFC. Reka bentuk cadangan gelung mempunyai kecekapan pemindahan lebih baik WPT sehingga 3cms dalam mod operasi NFC. Dalam projek ini, menerima antena diletakkan di berbeza dari 1cm ke 5cm dengan masing-masing untuk antena pemancar. Keputusan gelung konvensional dan tunggal semasa kawalan gelung [1] dan Arkib antena fabrikasi menunjukkan bahawa kecekapan pemindahan antena gelung yang dicadangkan adalah memuaskan.

## TABLE OF CONTENTS

<b>CHAPTER</b>	<b>TITLE</b>	<b>PAGE</b>
	<b>DECLARATION</b>	ii
	<b>DEDICATION</b>	iii
	<b>ACKNOWLEDGEMENT</b>	iv
	<b>ABSTRACT</b>	v
	<b>ABSTRAK</b>	vi
	<b>TABLE OF CONTENTS</b>	vii
	<b>LIST OF TABLES</b>	x
	<b>LIST OF FIGURES</b>	xi
	<b>LIST OF SYMBOL</b>	xiii
	<b>LIST OF ABBREVIATIONS</b>	xiv
<b>1</b>	<b>INTRODUCTION</b>	
	1.1 Introduction	1
	1.2 Problem statement	1
	1.3 Objectives of project	2
	1.4 Scopes of project	2
	1.5 Thesis Outlines	2
<b>2</b>	<b>LITERATURE REVIEW</b>	
	2.1 Introduction	4
	2.1.1 Commerce	4
	2.1.2 Bluetooth and Wi-Fi connections	5
	2.1.3 Social networking	5
	2.1.4 Identity and Accessing	5
	2.1.5 Smartphone automation through NFC tags	6
	2.2 Near-Field Communication Antenna	7
	2.3 Loop Antenna	8

2.4	Radiation Pattern of Loop Antenna	9
2.5	Impedance Matching of Loop Antenna	10
2.5.1	Series Inductor	11
2.5.2	Series Capacitor	12
2.5.3	Loop Inductance Calculation of Various Shape	14
2.6	Q-Factor and efficiency calculation	17
2.7	Operation of Loop Antenna through Magnetic Resonance	19
2.7.1	Oersted's law	19
2.7.2	Lenz's Law and Faraday's Lay	20
2.7.3	Magnetic Induction	21
2.7.4	Mutual Inductance	22
2.8	Summary	25
<b>3</b>	<b>METHODOLOGY DESIGN</b>	
3.1	Introduction	26
3.2	Design Methodology	26
3.3	Design Parameter of Loop Antenna	28
3.4	Design Specification	28
3.5	Single Loop Simulation	29
3.6	Multiple Loop Simulation	29
3.7	Summary	29
<b>4</b>	<b>DESIGN OF LOOP ANTENNAS</b>	
4.1	Introduction	30
4.2	Design of Single Loop Antenna	30
4.2.1	Design Loop Antenna	31
4.2.2	Simulation Review	32
4.3	Simulation of Loop Antenna in paper	33
4.3.1	Design Antenna	33
4.3.2	Simulation Review	35
4.4	Design of Proposed Loop Antenna	37
4.4.1	Design of antenna	38



4.4.2	Simulation review	39
4.5	Optimization of antenna parameters	43
4.5.1	Simulation review with optimization	43
4.6	Design of Impedance Matching circuit	47
4.7	Fabrication of proposed antenna design	49
4.7.1	Step 1	49
4.7.2	Step 2	49
4.7.3	Step 3	50
4.7.4	Step 4	50
4.7.5	Step 5	50
4.8	Comparison of measured result for selected design loop	51
4.9	Summary	54
<b>5</b>	<b>CONCLUSION AND DISCUSSION</b>	
5.1	Conclusion	55
5.2	Future Work	56
	<b>REFERENCES</b>	57

## LIST OF TABLES

<b>TABLE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	K1 & K2 values according to layout [2]	16
3.1	Design specification of Loop antenna	28
3.2	Substrate specification	28
4.1	Result of Single Loop antenna at 1cm	32
4.2	Transfer efficiency results of Loop antenna [1] at 1cm with various loaded capacitors	35
4.3	Mutual inductance of Loop antenna [1] at 1cm with various loaded capacitors	35
4.4	Transfer efficiency results of proposed loop antenna at 1cm with various loaded capacitors	39
4.5	Transfer efficiency results of proposed loop antenna at 1cm with various loaded capacitors	39
4.6	Transfer efficiency results after optimization of proposed loop antenna at 3cm with various loaded capacitors	43
4.7	Mutual Inductance results after optimization of proposed loop antenna at 3cm with various loaded capacitors	44
4.8	Capacitor values computed and standard value equivalent	48
4.9	Transfer efficiency results comparison between simulated and measured results	52
4.10	Mutual Inductance results comparison between simulated and measured results	52

## LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Illustration of device get charged through NFC	7
2.2	Small loop antenna. [8]	8
2.3	Field orientation of electrically small loop antenna is the dual antenna to the electrically short dipole antenna [13]	10
2.4	Series Inductor and load impedance ZL. [8]	11
2.5	Series Capacitor and load impedance ZL. [8]	12
2.6	Shape of circular loop [2]	15
2.7	Different shape of loop antenna [2]	16
2.8	Equivalent Schematics of the Small Loop Antenna [3]	17
2.9	Efficiency of Small Loop Antennas for 5% Tolerance [3]	19
2.10	Magnetic field lines around a current-carrying wire [8]	20
2.11	Magnetic field lines around a current carrying wire [11]	21
2.12	Two idealized resonating coils with magnetic fields place at distance D. [11]	22
3.1	Flow chart of project	27
4.1	Design shape of Single Loop antenna to be simulated	31
4.2	Simulation Scenario of two single loop antennas in CST	31
4.3	Mutual Induction of Single Loop with various distances	32
4.4	Transfer Efficiency of Single Loop and various distances	33
4.5	Design shape of Loop antenna [1] to be simulated	34
4.6	Simulation Scenario of two single loop antennas in CST	34
4.7	Transfer efficiency results of Loop antenna [1] at 1cm with various loaded capacitors	36
4.8	Mutual inductance results of Loop antenna [1] at 1cm with various loaded capacitors	37

4.9	The front (left) and back (right) of the proposed multi loop antenna design proposed for simulation	38
4.10	The simulation scenario of proposed antenna design	38
4.11	Transfer efficiency results of proposed loop antenna at 1cm with various loaded capacitors	40
4.12	Mutual Inductance results of proposed loop antenna at 1cm with various loaded capacitors	41
4.13	Return loses (S11) results of proposed loop antenna at 1cm with various loaded capacitors	42
4.14	Return loses (S22) results of proposed loop antenna at 1cm with various loaded capacitors	42
4.15	Transfer efficiency results after optimization of proposed loop antenna at 3cm with various loaded capacitors	45
4.16	Mutual Inductance results after optimization of proposed loop antenna at 3cm with various loaded capacitors	45
4.17	Return loses (S11) results after optimization of proposed loop antenna at 3cm with various loaded capacitors	46
4.18	Return loses (S11) results after optimization of proposed loop antenna at 3cm with various loaded capacitors	46
4.19	Schematic diagram of antenna as two port network	47
4.20	Modified impedance matching circuit	48
4.21	Fabricated Antenna design chosen after optimized simulation	51
4.22	Impedance Matching Circuit at 3cm with SMD capacitors	51
4.23	Transfer efficiency results comparison between simulation and measured results	52
4.24	Transfer efficiency results comparison between simulation and measured results	53

## LIST OF SYMBOL

$\lambda$	-	Wavelength
$E_{\phi}$	-	Electric field angle
$H_{\phi}$	-	Magnetic Field angle
$Z_{in}$	-	Input Impedance
$Z_0$	-	Output Impedance
$Z_{IND}$	-	Inductor Impedance
L or $L_{int}$	-	Inductance
C	-	Capacitance
$Z_C$	-	Capacitor Impedance
$R_r$	-	Radiation Resistance
R	-	Radius
$\mu_0$	-	Permeability
d	-	Mean coil diameter
c	-	Thickness of the winding
N	-	Number of turns
$\sigma$	-	Stefan–Boltzmann
$R_{att\_trans}$	-	Transformed attenuation resistance
$R_{loss}$	-	Loss Resistance
$R_{att}$	-	Attenuating resistor
$\eta$	-	Efficiency
f	-	Frequency
$M_{21}, M$	-	mutual inductance
v1	-	Voltage cross the inductor
$A_{loop}$	-	Area of loop
dB	-	Decibel
FR	-	Flame Retardant,

## LIST OF ABBREVIATIONS

NFC	-	Near Field Communication
Wi-Fi	-	Wireless Fidelity
WPT	-	Wireless Power Transfer
MHz	-	Mega Hertz
CST	-	Computer Simulation Technology
RFID	-	Radio Frequency IDentification
S-beam	-	Samsung Beam
MAC	-	Media Access Controller
IP	-	Internet Protocol
Q	-	Quality Factor
e.m.f.	-	electromotive force
AC	-	Alternating Current
VNA	-	Vector Network Analyzer

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Introduction**

In recent few years, the Near Field Communication (NFC) technology has been expanding very rapidly and most electronic devices are being launch in market are now integrated with NFC. Near field communication (NFC) is a set of communication standards for devices such as smartphones and other similar devices to establish radio link between devices, the link is created by making physical contact (touching) with each other or bringing them into near proximity, usually not more than a few centimeter. Presently, most anticipated applications include contactless transactions, data exchange, and simplified setup of more complex communications such as Wi-Fi [24].

#### **1.2 Problem statement**

The NFC standard is designed to make data transfer within near distance device. The standard doesn't serve purpose of transferring the power wirelessly. It is required develop an antenna to maximize power transfer received at given distance without effecting NFC data transfer capabilities.

### **1.3 Objectives of project**

This project's objective is to design, develop and fabricate multi loop antenna using loaded capacitor to control current flow, which will result to have low mutual inductance at given distance and show better transfer efficiency to support Wireless Power Transfer (WPT) in NFC system.

### **1.4 Scopes of project**

This project began with studying the concept of antenna design that supports NFC's operation frequency i.e. 13.56 MHz and following that understanding effects of variation in mutual induction effecting WPT.

This project has been focused on different methods of wireless near-field energy transfer by making different antenna designs, which can get better energy transfer efficiency with possible low mutual induction.

Consequently, this lead to the design and simulated the various antenna design with CST Microwave Studio. Antenna design parameters were termed by return loss, mutual induction with distance and current controlled through different values of capacitors. Finally, the proposed antenna was fabricated and the project was complete with comparing simulation results with measured results.

### **1.5 Thesis Outlines**

Five chapters are considered for this report, which each of them will explain on the different aspects of the project. The outlines of the project for each 5 chapter are shown as below:

Chapter 1 introduces the introduction and overview of the project, problem statements, objective, scope of project, and methodology of project.



Chapter 2 explains the theory of loop antennas, antenna properties, magnetic resonance, mutual induction and wireless power transfer theories. In addition, it consists of the literature review to help the project.

Chapter 3 discusses about the methodology and basic loop antenna design along with modified antenna design is demonstrated. Furthermore, performance measurement processes are also illustrated.

Chapter 4 it can be seen that the various antenna designs are simulated and measured results are demonstrated. Consequentially the only antenna is fabricated having better results compare to other designs. In the end comparisons between simulated and measured results is presented of the fabricated antenna.

Chapter 5 gathers final discussion and concludes this project with the work carried out for it and suggests possible future work to be done.

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