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

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λ	-	Wavelength
$E_{\emptyset}$	-	Electric field angle
$H_{\emptyset}$	-	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
μ_0	-	Permeability
d	-	Mean coil diameter
c	-	Thickness of the winding
N	-	Number of turns
σ	-	Stefan–Boltzmann
R_{att_trans}	-	Transformed attenuation resistance
R_{loss}	-	Loss Resistance
R_{att}	-	Attenuating resistor
η	-	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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