RADIO-FREQUENCY IDENTIFICATION (RFID) TEXTILE TAG ANTENNA

MOHAMAD AMIN BIN ABU ZAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

RADIO-FREQUENCY IDENTIFICATION (RFID) TEXTILE TAG ANTENNA

MOHAMAD AMIN BIN ABU ZAKA

This report is submitted in partial fulfillment of the requirement for the award of Bachelor of Electronic Engineering (Wireless Communication) with Honors.

Faculty of Electronic and Computer Engineering

Universiti Teknikal Malaysia Melaka

June 2012

UNIVERSTI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek : RADIO FREQUENCY IDENTIFICATION (RFID) TEXTILE TAG ANTENNA

Sesi Pengajian :

1	1	/	1	2

Saya MOHAMAD AMIN BIN ABU ZAKA mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hak milik UniversitiTeknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓) :

☐	**SULIT***	*(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD****	**(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi / badan di mana penyelidikan dijalankan)
☐	**TIDAK TERHAD**	

Dr. Maisarah Binti Abu
Pensyarah Kanan
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Disahkan oleh:

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)

"I confess this report is all my own work except the certain passage that I have clarified each of their sources."

Signature:.....

Prepared by: Mohamad Amin Bin Abu Zaka

Date: 12 JUNE 2012

"I confess that I have read this report and for my opinion I think this report is sufficed in partial fulfillment of requirements for the Bachelor of Electronic Engineering with Honors (Wireless Communication)."

Signature:.....

Supervised by: Dr. Maisarah Binti Abu

Date.....15/6/2012

Special dedication to my family, my kind hearted supervisor, Dr. Maisarah Binti Abu
and to all my dearest friend

ACKNOWLEDGEMENT

I wish to express my deep sense of gratitude to my supervisor**,** Dr. Maisarah Binti Abu for her able guidance and useful suggestions, which helped me in completing the project work, in time.

Great deals appreciated go to my fellow friends and all Faculty of Electronic and Computer Engineering (FKEKK) that patient in helping me complete this project either directly or indirectly. Thank you very much.

Finally, yet importantly, I would like to express my heartfelt thanks to my beloved parents for their blessings, my friends/classmates for their help and wishes for the successful completion of this project.

ABSTRACT

This project entitled radio-frequency identification (RFID) textile tag antenna enabled a tag antenna mount on a jeans as the substrate. The jeans textile has a permittivity of 1.7. Nowadays, plenty of the transponders in the market still using the unfold materials such as Flame Retardant #4 (FR-4) board and PET. Using textile as the substrate of the tag antenna making the tag antenna versatile and can operate at the condition where ordinary FR-4 board cannot operated. This project consists of two parts which is simulation of the tag antenna using different types of textiles materials and development of the antenna itself. This combination of two parts will produce a textile antenna that can be used at Microwave frequency (MWF) bands for any types of applications demanding for versatile RFID tag antenna.

ABSTRAK

Ini projek yang bertajuk pengenalan frekuensi radio (RFID) tekstil tag antena membolehkan tag antena digunakan tekstil kain jenis jeans sebagai substrat. Tekstil jeans mempunyai ketelapan sebanyak 1.7. Pada masa kini, banyak transponder di pasaran masih menggunakan bahan Unfold seperti yang papan rencat api # 4 (FR-4) dan PET. Menggunakan tekstil sebagai substrat antena tag membuat antena tag serba boleh dan boleh beroperasi pada keadaan di mana papan FR-4 yang biasa tidak boleh dikendalikan. Projek ini terdiri daripada dua bahagian yang merupakan simulasi antena tag menggunakan jenis bahan tekstil dan pembangunan antena itu sendiri. Ini gabungan daripada dua bahagian akan menghasilkan antena tekstil yang boleh digunakan pada jalur gelombang mikro frekuensi (MWF) bagi mana-mana jenis aplikasi yang ingin menggunakan teknologi antena tag RFID ini.

TABLE OF CONTENT

CHAPTER	MATTER		PAGES
	PROJECT TITTLE		**i**
	PSM STATUS VERIFICATION FORM		**ii**
	DECLARATION		**iii**
	SUPERVISOR VERIFICATION FORM		**iv**
	DEDICATION		**v**
	ACKNOWLEDGEMENT		**vi**
	ABSTRACT		**vii**
	ABSTRAK		**viii**
	TABLE OF CONTENT		**ix**
	LIST OF FIGURES		**xiii**
	LIST OF TABLES		**xiv**
	LIST OF ABBREVIATIONS		**xv**
I	**INTRODUCTION TO PROJECT**		1
	1.1	INTRODUCTION	2
	1.2	PROBLEM STATEMENT	3
	1.3	OBJECTIVE	3
	1.4	SCOPE OF WORKS	4

	1.5	METHODOLOGY	4
	1.6	THESIS OVERVIEW	5
II	**LITERATURE REVIEW**		7
	2.1	RFID HISTORY	8
	2.2	RFID WORKING CONCEPT	9
	2.3	RFID SYSTEM ARCHITECTURE	10
		2.3.1 RFID Tag	11
		2.3.1.1 Passive RFID Tag	11
		2.3.1.2 Active RFID Tag	13
		2.3.1.3 Semi-active RFID Tag	14
		2.3.2 RFID Reader	15
		2.3.3 Host and Software System	16
		2.3.3.1 Edge Interface/System	16
		2.3.3.2 Middleware	16
	2.4	BASIC CONSIDERATION OF RFID TAG	17
		2.4.1 Antenna Types	18
		2.4.2 Impedance Matching	18
		2.4.3 Radar Cross Section (RCS)	20
		2.4.4 Size of Tag Antenna	20
		2.4.5 Surface Material Properties	21
		2.4.6 Radiation Pattern and Antenna Polarization	21
	2.5	IMPEDANCE MATCHING	22
		2.5.1 Delta Match	22
		2.5.2 Quarter Wave Transformer	23

2.5.3 LC Network Match 25

2.5.4 Transformer Matching 25

III METHODOLOGY 27

3.1 PROJECT IMPLEMENTATION 27

3.2 ANTENNA PARAMETERS 30

3.2.1 Radiation Pattern 30

3.2.2 Directivity 31

3.2.3 Gain 32

3.2.4 Polarization 32

3.2.5 Return Loss 33

3.3 PROJECT DESIGN 34

3.4 FABRICATE PROCESS 37

3.5 TESTING PROCESS 38

IV RESULT AND DISCUSSION 39

4.1 CHAPTER OVERVIEW 39

4.2 RFID CONCEPT IN STORES 40

4.3 TEXTILE PERMITTIVITY 40

4.4 SIMULATION RESULTS 42

4.5 PARAMETRIC STUDY 45

4.6 RFID TEXTILE TAG ANTENNA 54

V	**CONCLUSION AND RECOMMENDATION**		55
	5.1	CONCLUSION	55
	5.2	RECOMMENDATIONS	56
	REFERENCES		57

LIST OF FIGURES

FIGURES	TITTLE	PAGES
1.1	Block Diagram of RFID System	2
2.1	Passive RFID Tag System	12
2.2	Active RFID Tag System	13
2.3	Delta Match Technique	23
2.4	The Quarter Wavelength Impedance Matching	24
2.5	List of Matching Method	25
2.6	Transformer Type Impedance Matching	26
3.1	Flow Chart for PSM 1 Activities	28
3.2	Flow Chart for PSM 2 Activities	29
3.3	Design of RFID Textile Tag Antenna in Simulation	36
3.4	RFID Transponder Equivalent Circuit	36
4.1	RFID Technology Applied in Store	40
4.2	Permittivity of Jeans Measured in Laboratory	41
4.3	The Front View of Tag Antenna in Simulation	42
4.4	The Back View of Tag Antenna in Simulation	43
4.5	The 3D View of Gain of Antenna	44
4.6	The Polar View of The Antenna Radiation (theta & phi)	44

4.7	The Matching Between Tag Antenna and Chip	45
4.8	The Parameters Used in Parametric Study	46
4.9	The Simulated Return Loss with Different Value of L_1 for textile Tag antenna.	46
4.10	The Simulated Return Loss with Different Value of L_2 for textile Tag antenna.	47
4.11	The Simulated Return Loss with Different Value of L_3 for textile Tag antenna.	48
4.12	The Simulated Return Loss with Different Value of L_4 for textile Tag antenna.	49
4.13	The Simulated Return Loss with Different Value of W_1 for textile Tag antenna.	50
4.14	The Simulated Return Loss with Different Value of W_2 for textile Tag antenna	51
4.15	The Simulated Return Loss with Different Value of W_3 for textile Tag antenna	52
4.16	The Simulated Return Loss with Different Value of W_4 for textile Tag antenna	53
4.17	The Front View of Fabricated Tag Antenna	54
4.18	The Back View of Fabricated Tag Antenna	54

LIST OF TABLES

TABLE	TITTLE	PAGES
4.1	List of Textile and Its Permittivity	41
4.2	The Simulation Result of RFID Textile Tag Antenna	43
4.3	Results of Impedance Matching	45
4.4	Results of L_1 Slot	47
4.5	Results of L_2 Slot	48
4.6	Results of L_3 Slot	48
4.7	Results of L_4 Slot	49
4.8	Results of W_1 Slot	50
4.9	Results of W_2 Slot	51
4.10	Results of W_3 Slot	52
4.11	Results of W_4 Slot	53

LIST OF ABBREVIATIONS

RFID	-	Radio-frequency Identification
LOS	-	Line of sight
RCS	-	Radar cross-section
MW	-	Microwave
FR-4	-	Flame Retardant #4
CST MWS	-	Computer Simulation Technology Microwave Studio
IFF	-	Identify Friend or Foe System
LF	-	Low frequency
HF	-	High frequency
UHF	-	Ultra-high frequency
SR	-	Shortening radio
PSM 1	-	Projek Sarjana Muda 1
PSM 2	-	Projek Sarjana Muda 2
EMC	-	European Muon Collaboration
MPA	-	Microstrip Patch Antenna
UTeM	-	Universiti Teknikal Malaysia Melaka
RTLS	-	Real-time locating syste

CHAPTER I

INTRODUCTION TO PROJECT

Chapter I give an overview of Radio-frequency Identification (RFID) textile tag antenna. The objective of the project will be stated clearly in this chapter. There are few problems statements that explain about the existing problems which are eventually lead to this project development. The methodology explains briefly about the project flow. The scope of works which consisting software and hardware is being discuss in this chapter as well.

1.1 INTRODUCTION

Radio-frequency identification (RFID) is a generic term that is used to describe a system that transmits data from an electronic tag through a reader for the purpose of identifying and tracking the objects using radio waves. RFID is in use all around us. It has been used in a toll booth, supermarket and even in your house. Some tags can be read from several meters away and beyond the line of sight (LOS) of the reader.

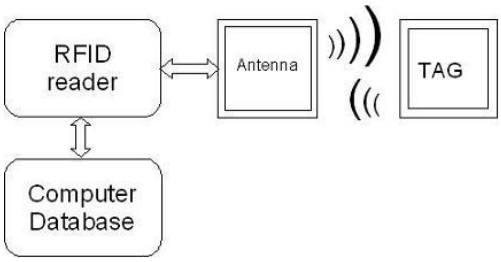

Figure 1.1: Block Diagram of RFID System

Figure 1.1 shows the block diagram of RFID system. Most RFID tags contain at least two parts. The integrated circuit for storing and processing information, modulating and demodulating a radio waves signal and the antenna for purposes of receiving and transmitting the signal. Plus, a technology called chip less RFID allows for discrete identification of tags without an integrated circuit, thereby allowing tags to be printed directly onto assets at lower cost than traditional tags.

To design a RFID tag antenna is one of the challenges in RFID system. The antenna itself must follow a few considerations and limitation especially for passive-type antenna. The considerations included antenna types, impedance matching between chip and designed antenna, radar cross-section (RCS), antenna sizes, surface material

properties and radiation pattern and antenna polarization. All this will be evaluated to ensure the designed antenna work properly.

1.2 PROBLEM STATEMENT

RFID system nowadays is widely used in various applications from simple application to advance tracking application. Most of the RFID tag antenna used in that system operates in single band frequency which limit it operation. Plus, the tag itself used Flame Retardant #4 (FR-4) boards as the material for the antenna to mount. The tag antenna will be more versatile and apply in applications that previous tag cannot be.

1.3 OBJECTIVE

The main objective of this project is to design, fabricate and measure single radio-frequency identification (RFID) textile tag antenna that operate at 2.45 GHz. The designed antenna will be used into various types of application mainly in textile industry.

1.4 SCOPE OF WORKS

This project covers several scopes in accomplishing the project objectives. Basically this project is about designing an antenna for a transponder using new material as the substrate of antenna. In order to design the antenna, the understanding of the RFID architecture is vital to make the antenna work. It can be achieved through analysis and understand the related documentation of structured antenna types and any related research regarding antenna design. The next scope of works is to measure the permittivity of the textile used as the substrate of the antenna. This measurement is important to use in antenna simulation processes. Moreover, the works also include the determination of parameters that will be used in designing the antenna. The next crucial part is the simulation of the antenna. This is the part where the tag antenna's design to meet the specifications using Computer Simulation Technology (CST) Microwave Studio software. After the simulation successfully conducted, the following works is to fabricate and test the antenna designed in real life environment and validate the results with existing research.

1.5 METHODOLOGY

The project planning and development is divided into three parts which are research and finding, software and simulation and development of the antenna. The research part includes study the RFID technology, it components, RFID operation system, and the most crucial part is basic knowledge about RFID tag. Before begin the simulation process, the permittivity of the substrate is measured. For the software and simulation part, it involves plenty of testing into designing a new single band RFID textile tag antenna. If the design does not meet the specification, the step will be repeated till the promising results obtained. During this part implementation, the

searching for the chip is going to begin. The last part is RFID tag textile antenna development where involve a lot of laboratory works. In this part, the process of patching the antenna to the textile and compare its result to the simulated results and verified the outcomes of the project.

1.6 THESIS OVERVIEW

Chapter I gives an overview of dual band textile RFID tag antenna system and design. The objective of the project is stated clearly. There are few problem statements that explain about the existing problems which eventually lead to this project development. The scope of work explains details about what necessary to be done during period of this project development. The methodology explain briefly about the project flow from the beginning which is the background study, the textile's permittivity examined, the simulation of the tag antenna and the development of the tag antenna in laboratory.

Chapter II consists of theories and background study on RFID system especially RFID tag antenna. This is followed by the history of the RFID system, the working concept of the RFID system, the architecture of the RFID system and design consideration and parameters of the textile RFID tag antenna.

The overview of the methodology used in this project is described in Chapter III. The details from the beginning if the projects till the end of this project explain in this chapter. The project started with literature review about the RFID system then followed by the determination of the permittivity of each textile going to be used in this project and its parameters. Once it is done, the steps proceed to simulation process and lastly the

RFID tag antenna development. After it is done, the integration between designed tag antennas with RFID reader is done to ensure the system capability.

Chapter IV discusses of the output of the projects. The results are divided into two parts which are the simulation result using CST Microwave Studio and testing result using Network Analyzer. In this process, the impedance matching between the chip and designed antenna is the important part to ensure the designed tag antenna works at the demand frequency band.

Chapter V consists of conclusion and recommendation of the project for future development. The suggestion for future works is also included in this chapter.

CHAPTER II

LITERATURE REVIEW

Chapter II consists of theories and background study on the RFID system especially RFID tag antenna. This is followed by a brief explanation about the antenna structure and Computer Simulation Technology (CST) Microwave Studio software. Other than that, the advantages and disadvantages of the RFID and its application in daily routine are being discussed. The facts about the ordinary RFID tag antenna and RFID tag textile antenna also being discussed too. A few parameters also included and discussed.