Faculty of Electronic and Computer Engineering

INVERSE PHI SLOTTED ANTENNA DESIGN FOR RFID APPLICATION

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DECLARATION

I declare that this thesis entitle “Inverse Phi Slotted Antenna design for RFID application” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : NORAZURA BINTI MD NOR

Date : 22 NOVEMBER 2013

APPROVAL

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering

Signature : .....

Supervisor Name : DATO' PROF DR MOHAMAD KADIM BIN SUAIDI

Date : 24 NOVEMBER 2013

DEDICATION

To my supervisor Dato' Prof Dr Mohamad Kadim Suaidi;

To my mentor Imran bin Mohd Ibrahim who teaches me from zero;

To my husband Mohd Izwan bin Abu Bakar who always behind me,

To my daughter Irdeena Nurzara binti Mohd Izwan,

and my family who always support me

ABSTRACT

In RFID application, the antennas are the most paramount components required to engender a communication link between tag and reader. Dual band or multiple band antennas is designed to prevent excessive radiation effects due to the use of various sets of reader antenna in a system. Dual-band antenna is designed to operate at a frequency of 900MHz and 2.45GHz to meet the needs of RFID applications. Accordingly, these antennas help reduce the amount of RFID reader antennas in the RFID system. Planar monopole antennas are the most suited for indoor and mobile applications because of their low profile, light weight and omnidirectional characteristics. With the omnidirectional radiation pattern characteristic, this antenna will suit for portable RFID reader application. The major consideration for antenna design for handheld/ portable reader RFID reader applications is the compact size, while the antenna gain and bandwidth are not critical issues. Planar monopole can be designed in a variety of shapes in order to obtain enhanced bandwidth, dual band and ultra-wideband operation. Inverse Phi Slotted Antenna has been introducing based on planar antenna concept and able to provide a dual-band bandwidth for RFID application. This thesis provides a detailed study of the design of Inverse Phi Slotted Antenna to facilitate linear polarized and dual band operation. The design parameters of the antenna have been calculated utilizing the transmission line model. The effect of antenna dimensions on the performance of antennas has been discussed. This antenna is designed to use the technique of reactive load for the operation of dual- band RFID reader. The center frequencies of these bands are controlled by the electrical length of slots. A moderate gain has successfully achieved.

ABSTRAK

Dalam aplikasi RFID, antena merupakan komponen penting yang diperlukan untuk mewujudkan hubungan komunikasi antara tag dan pembaca. Dwi jalur atau pelbagai jalur antena direka untuk mencegah kesan radiasi ekoran penggunaan pelbagai jenis pembaca RFID didalam sebuah sistem. Bagi memenuhi keperluan aplikasi RFID masa kini, dwi jalur antena ini telah direka untuk beroperasi pada frekuensi 900MHz dan 2.45GHz. Sehubungan itu, antena ini membantu mengurangkan jumlah penggunaan set antena dalam sistem RFID. Antena Satah Kutub Tunggal begitu sesuai digunakan untuk aplikasi dalaman dan bersifat mudah alih kerana ciri-cirinya yang rata, ringan dan memiliki corak sinaran serata tumpuan. Dengan ciri-ciri ini, antena ini sesuai untuk aplikasi RFID pembaca mudah alih. Pertimbangan utama bagi reka bentuk antena untuk pembaca RFID mudah alih adalah bersaiz padat, manakala gandaan antena dan jalur lebar tidak begitu penting. Antena Satah Kutub Tunggal Planar *boleh direka dalam pelbagai bentuk untuk mendapatkan jalur lebar yang dipertingkatkan, dwi-jalur dan operasi jalur ultra-lebar.* Inverse Phi Slotted Antenna *direka berdasarkan konsep antena* planar *dan ia mampu menghasilkan dwi jalur lebar untuk aplikasi RFID. Tesis ini menyediakan kajian terperinci reka bentuk* Inverse Phi Slotted Antenna *untuk menghasilkan operasi jalur dwi frekuensi dan berpengutuban sesatah. Parameter rekabentuk antena telah dikira dengan menggunakan teknik talian penghantaran. Kesan saiz antena terhadap prestasi turut dibincangkan. Antena ini direka dengan menggunakan teknik beban reaktif untuk operasi pembaca RFID dwi-jalur. Pusat jalur frekuensi ini dikawal oleh saiz slot. Gandaan sederhana telah berjaya dicapai.*

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AC	Alternating current
AF	Antenna factor
AM	Amplitude modulation
AR	Axial ratio
AUT	Antenna under test
BER	Bit error rate
CAD	Computer-aided design
CDF	Cumulative distribution function
CEM	Computational electromagnetics
CP	Circular polarization
CPW	Coplanar waveguide
DC	Direct current
DCS	Digital cellular system
DRA	Dielectric resonant antenna
DUT	Device under test
EAS	Electronic article surveillance
EIRP	Effective isotropic radiated power
EM	Electromagnetic
EMC	Electromagnetic compatibility
ERP	Effective radiated power

FCC	Federal communication
FDTD	Finite-difference time domain
FEM	Finite element method
FNBW	First null beamwidth
GPS	Global positioning system
GSM	Global system for mobile communications
HF	High frequency
HPBW	Half-power beamwidth
IEEE	International
IFF	Interrogate friend of foe
IPA	Inverse phi antenna
ISO	International standard organization
LF	Low frequency
RF	Radio frequency
RFID	Radio frequency identification
TEM	Transverse electromagnetic (mode/field)
TX	Transmit
UHF	Ultra high frequency
UWB	Ultra wideband
VHF	Very high frequency
VSWR	Voltage standing wave ratio
WLAN	Wireless local area network
WWII	World war 2

LIST OF PUBLICATIONS

The research papers produced and published during the course of this research are as follows:

1. Nor, M.N., Ibrahim, I.M., Suaidi, M.K., Abu, M., 2011. Inverse Phi Antenna for RFID Application. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, vol.3 no 1. ISSN NO: 2180-1843
2. Nor, M.N., Ibrahim, I.M., Suaidi, M.K., Abu, M., 2011. A Study on Dual-Band Slotted Planar Antenna Design for RFID Application. *4th International Symposium on Broadband Communications (ISBC 2010)*, Equatorial Hotel, Melaka, Malaysia, 11-14 July 2010.
3. Nor, M.N., Ibrahim, I.M., Suaidi, M.K., Abu, M., 2011. Dual-Band Slotted Planar Antenna for RFID Application. *4th International Conference on Postgraduate Education (ICPE-4)*, Cititel Mid Valley, Kuala Lumpur, Malaysia, 26-28 November, 2010.

CHAPTER 1

INTRODUCTION

1.0 Research Background

Springing up with the demand for wireless communications has changed the life style of today's society. These developments urge to increase capacity broadband antennas for communication systems. This is because the antenna is a very important component of the communication system, such as the Radio Frequency Identification (RFID) systems application. The reader antenna plays a significant role in the communication between reader and tag. Without a suitable antenna design, signal generated by the Radio Frequency (RF) system will not be rendered and no signal can be detected at the receiver (RFID Tag) (Finkenzeller, K., 2003).

1.1 Problem Statement

More recently, an Ultra-High Frequency (UHF) band passive RFID system has attracted much attention (Finkenzeller, K., 2003). It is generally accepted that the UHF RFID systems can revolutionize various commercial applications such as supply chain management (Kim, D.Y., 2008). Several major supply chain companies like Wal-Mart and Tesco plans to enforce the use of UHF RFID in their supply chain, which operates in the 860-960MHz band. (Leong, K. S., 2006). These developments have a huge impact if dozens or hundreds of reader antenna began operating in close proximity to each other. As a result, it can cause serious disorders.

The communication between readers and tags created by irradiation tags with RF energy from the reader and recovers data from RF radiation reflected back from the tag to the reader. In order to ward off the influence of the other existing radio system, many countries have earned the same regulation limits the maximum power output of the RFID system. Under the restrictions reader output power, distance reading RFID system is related to the size of the reader antenna and the magnetic field emitted by the reader antenna. Reader antenna design is one element that contributes to the complexity as the reader antenna can vary in size and dimensions, depending on the specific application requirements. As a channel for data communication between the chip-based RFID tags and readers, antenna design and location are important in determining the zone coverage, and reliability of data communication networks.

Many types of antennas have been designed to meet their needs. Most of UHF RFID reader is kind of planar antennas. Planar antennas have larger variations than any type of antenna. Due to its advantages such as low profile and ability to use printed circuit assembly technology, antenna manufacturers and researchers can come out with a novel antenna design in-house will reduce development costs. Planar antennas are also relatively inexpensive to produce and are designed for the physical geometry of a simple 2-dimensional. They usually work at UHF and higher frequency as the antenna size is directly related to the wavelength of the resonant frequency (Sweeney, P.J., 2005).

In the ultra-wideband planar antenna, it has been found that the presence of V-slot and U-slot introduce the band position, and this has been used to reduce interference. However, for the microstrip patch antenna, V-slots are used primarily to increase bandwidth and instead of introducing the band position (Lee, K. F., 2011). In this study, the structure of inverse phi slots will be utilized for the development of dual-band frequency. Dual band antenna design using features of simple structure is a very

challenging task. In this thesis, the proposed antenna is known as Inverse Phi Slotted Antenna (IPSA).

1.2 Objective

The primary aim of this work is to design, simulate and fabricate antenna for RFID Reader application. Antenna design must fulfill the following criteria;

1. To design an antenna that can operate in two frequency bands in the frequency of 900MHz and 2.45GHz with a simple structure.
2. To analyze the performance of this antenna
3. To compare the performance of the IPSA antenna with real RFID measurement system.

1.3 Contribution of Project

From the research work, an IPSA has managed to reduce the interference by minimizing the set of RFID reader antennas. Other contributions from this study, the IPSA can operate a dual frequency band. The IPSA is compact, simple to design and easy to fabricate. This antenna can also be applied to the multiple side coverage area of the advantages omni directional characteristics.

1.4 Scope of project

This study focuses to the development of IPSA for RFID reader application that meets the satisfying performance of the RFID system. The antenna was designed to operate at a dual-band frequency of 860-960MHz and 2.45GHz. Firstly, in this study concept of communication between RFID reader and tag has been explored. Secondly, the type of antenna commonly used for RFID reader for the 860MHz-960MHz antenna and 2.45GHz

antenna are explored and compared. Thru the selected design parameter, antenna was designed to satisfy the objective of the research. Performance of antenna design will investigates by performing a parametric study using CST software.

1.5 Organization of thesis

This thesis consists of five chapters that will explain all the work carried out during the research project progresses. The organization of the thesis is generally described as follows:

This chapter summarizes the background to the issues related to the application of RFID systems. Through the issues arising problems, the best solution will be proposed in the research objective. The important contribution of this study will be explained more clearly. Followed by the main scope of this study that relate to the objectives of the study. The second chapter focused on the literature review on RFID technology. Where RFID research background will be explored so that the reader more clearly about the early history of the presence of RFID technology. The author also explains about basic introduction to RFID technology including its key components, and standard operating frequency regulation involved in the use of RFID systems. This chapter also summarizes the early studies of RFID reader antenna with basic techniques to make a dual - band frequency.

Chapter three focuses on the development of antenna design methods. Starting with the selection of design parameters, the necessary software to simulate the design, the equations needed to design an antenna, this chapter also notes the procedures to be considered further. The results of measurement and analysis will be presented in chapter four for comparing the performance of an antenna designed by the design parameters. Parameter to be compared is the return loss, radiation patterns and antenna gain. The final chapter will highlight the overall research conclusions and future work recommendations

to improve the antenna design. These studies are summarized in this thesis with aims to share knowledge and future upgrades can be established by other researchers in the future.

CHAPTER 2

LITERATURE REVIEW ON RFID TECHNOLOGY

2.0 Introduction

Chapter 2 will discuss the history of the beginning of RFID and RFID key components. Then, brief introduction of operating frequency, types of RFID applications was included in this chapter. In addition, this chapter also presents a brief initial study related to the reader antenna. Conventional techniques to get a dual band will be drawn in the final section.

2.1 RFID Research Background

The last half of the 19th century witnessed many advances in our understanding of electromagnetic energy. By the turn of that century, the works of Faraday, Maxwell, Hertz, and others had yielded a complete set of laws describing its nature. Beginning in 1896, Marconi, Alexanderson, Baird, Watson, and many others sought to apply these laws in radio communications and radar. The work done in this era forms the building blocks upon which many technologies have been built, including RFID. World War 2 (WWII) brought about more advancement in radio frequency communications and radar. Following the war, scientists and engineers continued their research in these areas and increasingly sought civilian uses for it. The idea of RFID of objects and remote control of devices was first introduced in late 1948 (Stockman, H., 1948). In October of 1948, Harry Stockman published a paper titled "Communications by Means of Reflected Power," in the