SMALL APERTURE RADIAL WAVEGUIDE SLOT ARRAY ANTENNA DESIGN AND DEVELOPMENT FOR WIRELESS LOCAL AREA NETWORK APPLICATION

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To my beloved father, mother and brother
Thanks for the joys and tears we shared,
Thanks for the love and encouragement,
Thanks for giving me strength to pursue my dream,
Thanks for being my inspiration.

To my dearest fiancé
Thanks for the smiles during the darkest days,
Thanks for the warmth during the coldest nights,
Thanks for standing by my side when I'm torn at the seams,
Thanks for understanding my wildest dreams.

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ABSTRACT

The Radial Waveguide Slot Array (RWSA) Antenna is known for its good characteristics such as low profile, low cost, aesthetically pleasing, ease of installation and simple structure. This research project involves the design and development of the novel linearly polarized small aperture Radial Waveguide Slot Array (RWSA) Antenna for indoor WLAN applications operating based on ISM frequency band standard, with frequency range of 2.4 – 2.4835 GHz. Zeland Fidelity 4.0, a FDTD based antenna simulation is utilized to estimate the input impedance and radiation pattern of the antenna design. The second part of this project includes the antenna prototypes fabrication and experimental evaluation. Finally, the measurement analysis is compared with the theoretical result. The small aperture linearly polarized 2.4GHz RWSA antenna is successfully designed and developed for indoor Wireless Local Area Network access point. From the experimental evaluation, the RWSA antenna has validated its potential to be operated on the WLAN system.

ABSTRAK

Antena Pandu Gelombang Berjejari Dengan Tatasusun Slot (RWSA) terkenal dengan ciri-cirinya seperti rata, murah, fizikal yang menarik, mudah dipakai dan struktur yang ringkas. Penyelidikan ini bertujuan untuk merekabentuk dan membina Antena Pandu Gelombang Berjejari Dengan Tatasusun Slot (RWSA) berkekutuban lelurus berdimensi kecil untuk kegunaan Rangkaian Kawasan Tempatan Tanpa Talian (WLAN) dalam bangunan yang beroperasi atas jalur frekuensi ISM dengan frekuensi berada dalam julat 2.4 – 2.4835 GHz. Zeland Fidelity 4.0 yang berasaskan kaedah Pembezaan Terhad Dalam Domain Masa (FDTD) telah digunakan untuk menjangka galangan masukan antenna dan bentuk radiasinya. Bahagian kedua projek ini meliputi penghasilan prototaip antenna dan ujikaji. Akhirnya, keputusan analisis dibandingkan dengan keputusan teori daripada simulasi. Antena RWSA 2.4GHz berkekutuban lelurus berdimensi kecil untuk kegunaan titik capaian WLAN dalam bangunan telah berjaya direkabentuk dan dihasilkan. Ujikaji dasar mengesahkan antenna RWSA ini boleh beroperasi pada system WLAN.

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ε_{eff}	Effective dielectric constant
ε_o	Dielectric constant of free space
ε_r	Dielectric constant / permittivity
λ	Wavelength
λ_g	Guided wavelength
λ_o	Free space wavelength
μ_o	Permeability of free space
c	Velocity of light
D	Directivity
dB	Decibel
f	Frequency
b	Radial cavity height
I	Current
IL	Insertion Loss
L	Inductance
P_i	Incident power
P_{max}	Peak handling capability
P_r	Reflected power
P_t	Transmitted power
R	Resistance
RL	Return Loss
TEM	Transverse electromagnetic
V	Voltage
ρ_a	Slot array radius

ρ_{sc}	Short circuit distance
ρ_c	Centre hole radius
ρ_w	Waveguide radius
l_s	Slot length
w_s	Slot width
Z_0	Characteristic impedance
2D	Two dimension
3D	Three dimension

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CHAPTER I

INTRODUCTION

1.1 Introduction

Intensive development of the Wireless Local Area Network (WLAN) standards and protocols has been witnessed in recent years. Affordable wireless home and public access points are clear signs of the growing popularity of the wireless solution for entering the sophisticated communication networks. 2.4GHz band, the free Industry-Scientific-Medicine (ISM) frequency bands and 5.2GHz bands are frequently deployed for the WLAN applications. Many WLAN standards have since being developed and employed such as IEEE 802.11b, IEEE 802.11a, and IEEE 802.11g [1]. IEEE 802.11a operating at 5.2GHz, with its advantage of higher throughput and less interference as compared to the more heavily utilised IEEE 802.11b which operate at 2.4GHz. Nevertheless it is still less popular due to its incompatibility issue with the widely used IEEE 802.11b products. Furthermore, the 5Gz spectrum is not license-free in every country. Therefore, the IEEE 802.11g standard is proposed to enhanced the 2.4GHz IEEE 802.11b technology and besides having the same throughput as IEEE 802.11a at 54Mbps in November 2001 and ratified on 13 June 2003.

Most of the WLAN Access Point (AP) available on the current commercial market commonly employed the quarter-wavelength monopole or dipole for WLAN antenna designs. It poses certain physical and network limitation due to its nature of easily susceptible to physical damage, hence affecting its performance and reliability.

Other alternative design includes the microstrip patch antenna. The limited choices reveal that the design of suitable antennas for AP has been largely overlooked [2]. This research work will investigate on the well known low profile and flat Radial Waveguide Slot Array Antenna, also known as Radial Line Slot Array Antenna as a potential alternative to the WLAN AP antenna.

1.2 Problem Statement

Current commercially available WLAN APs that use either the dipole antenna or monopole antenna exhibit some physical and network limitations. The movable dipole or monopole antenna itself has clear physical structure limitation as shown in Figure 1.1. The moving and tilting of the antenna pole changes the radiation pattern that requires frequent recalibration which will make maintenance support difficult. On top of that, it is susceptible to physical damage as the antenna pole is easily bent or broken. The monopole antenna generates an omnidirectional radiation pattern characteristic which can penetrate the wall as demonstrated in Figure 1.2. This may reduce the efficiency as the propagation envelope for a specific room or area is reduced. Both the physical limitation and the propagation envelope reduction will reduce the reliability of equipment and the wireless network.

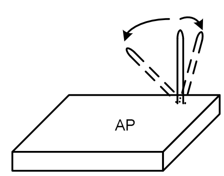

Figure 1.1: Limitation of the physical structure of the monopole/dipole antenna.

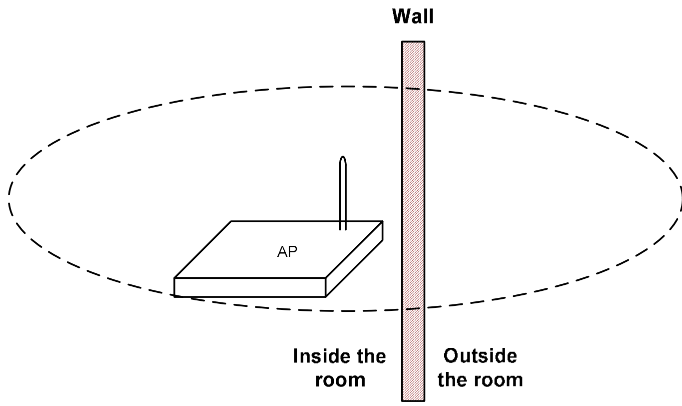

Figure 1.2 Propagation envelope reductions in a specific room/area.

WLAN products based on IEEE802.11a standard do not compliance with the existing IEEE802.11b Standards. High cost is involved to replace the existing IEEE802.11b with the IEEE802.11a standard. On the other hand, the IEEE802.11b operating at 2.4GHz suffers from network congestions and interference as many devices are operating at this range. The emergence of IEEE802.11g provides a solution to the problems as the standard is compatible to both standards while maintaining a high throughput.

1.3 Objective

The primary purpose of this research work is to design and develop a linear polarized small RWSA antenna as an external antenna for access point of WLAN indoor application. In this research, the WLAN is based on the IEEE 802.11g standard and the operating frequency range is 2.4GHz. The antenna shall be design according to the Federal Communication Commission (FCC) regulations.

1.4 Research Scope

The research scopes in order to accomplish the objectives are:

1. Theoretical investigations of the characteristic of the RWSA (or RLSA) antenna.
2. Familiarize with Zeland Fidelity software for simulation purposes.

3. Propose a linear polarized RWSA antenna.
4. Optimize the antenna design parameters.
5. Simulation of the radiation pattern.
6. Prototype development for the best antenna design performance from simulations.
7. Measurements of antenna performance.
8. Comparison of measured prototype with simulation.
9. Report/Thesis writing

1.5 Research Methodology

An interactive theoretical and experimental design approach will be utilized to optimise the structure of the antenna. The research methodology to simplify the design and development procedures in this research project includes:

1. **Pre-design Stage**
   - Literature review
   - Problem statement
   - Design conceptual understanding
2. **Design/Simulation Stage**
   - Slot pattern design for desired radiation pattern and polarization
   - Antenna input impedance optimization
3. **Prototype Stage**
   - Antenna fabrication
4. **Measurement Stage**
   - Return loss and Received Signal Strength Index (RSSI)
5. **Analysis Stage**
   - The measurement and simulation results comparison

The antenna fabrications need to fit within the cost constraints and the availability of the materials. The design and development steps are briefly summarized in the flow chart of Figure 1.3. In particular, this methodology provides an approximate chronological progress of the work performed to finally complete the full design cycle.

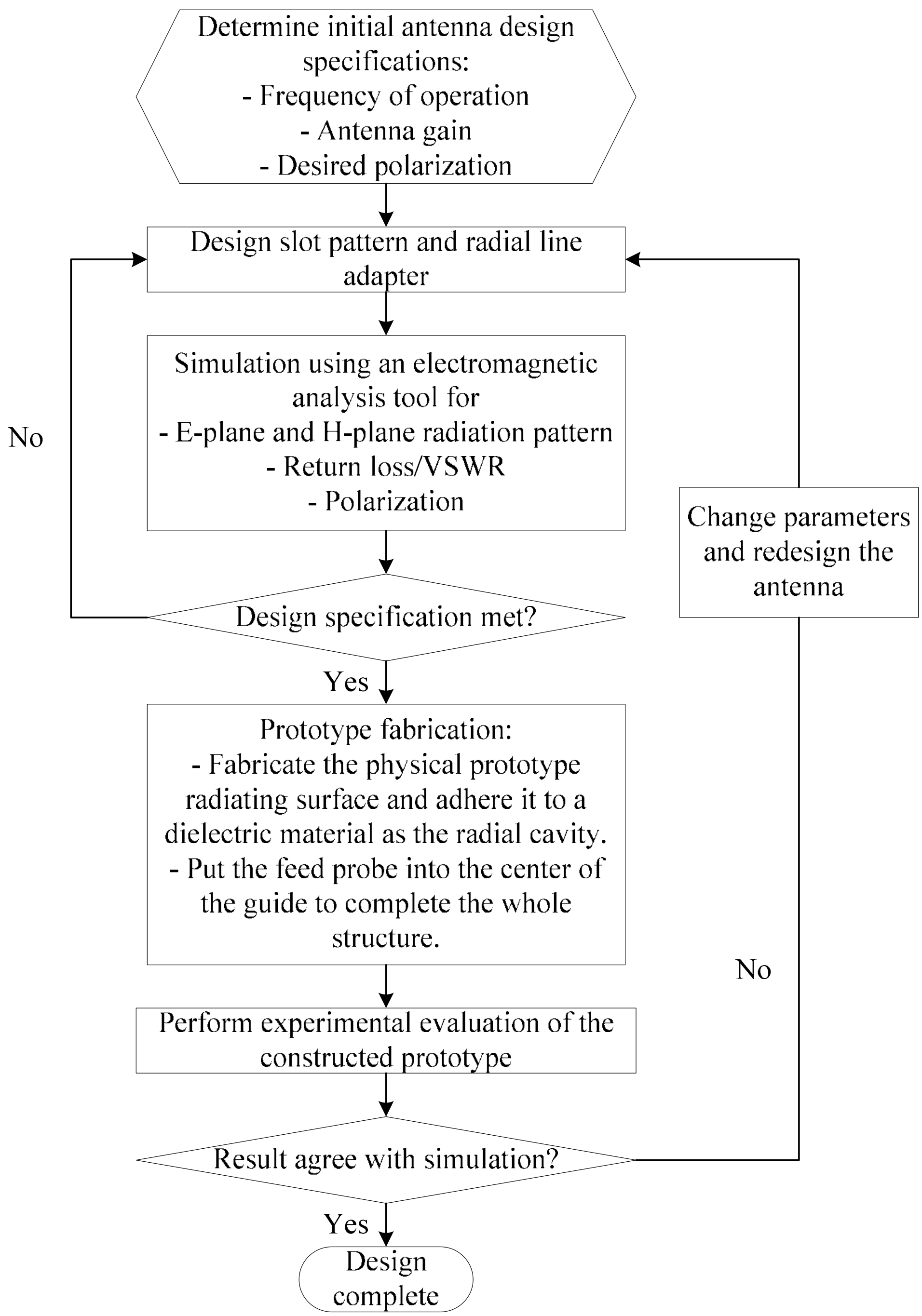

Figure 1.3: Research methodology flowchart.

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