PATTERN AND FREQUENCY RECONFIGURABLE ANTENNA FOR WIRELESS APPLICATIONS

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A project report submitted in partial fulfilment of the

requirements for the award of the degree of

Master of Engineering (Electrical-Electronics and Telecommunications)

Faculty of Electrical Engineering

Universiti Teknologi Malaysia

JUNE 2014

To God Almighty for his favor, my family and my country Rwanda for their endless support and encouragement.

ACKNOWLEDGEMENT

First of all, I would like to thank God for his unconditional love upon my life; more especially during my studies in UTM, he strengthened me with special encouragement which pushed me until the completion.

With a sincere heart, my profound gratitude goes to my supervisor Dr Mohamad Rijal bin Hamid for his patience, kindness and for his limitless advice during this project work. He indeed guided me and helped me to build a strong background in antenna design. It was an honor to be under his supervision.

I wish to thank also Husna Idris for her kindness and help during the antenna fabrication process in the laboratory. I also appreciate Igbafe Orikumhi, Ali Obadiah whose encouragement, ideas and help where vital in making this project a success. I would like to appreciate all my friends and classmates, especially Ning, Ayu, Rossi and Skudai Joy Chapel members who stood by me during my masters' degree programme.

Finally my special thanks be conveyed to my beloved mum, siblings my uncle, his wife and Richard Ikuesan Adeyemi for their love, counsel, support through my master's degree programme, though it was difficult but they never fade up to carry this heavy weighted burden. Thanks be to the government of Rwanda, UTM and department of electrical and electronics engineering. May God bless you all.

ABSTRACT

In general, equal gain in all direction is needed as the system moves in wireless applications such as body area network. Reconfigurable radiation pattern antennas have contributed a lot in solving this problem due to the potential features offered by these types of antennas. In addition wideband operation to narrow band operation reconfigurable antenna is also needed to provide high antenna efficiency in communication systems. The aim of this project is to design an antenna which quantifies the potential gain of the pattern and frequency control in order to suit the requirement of wireless applications such as body are networks. Therefore a new concept of a pattern and frequency reconfigurable antenna is proposed. The proposed antenna uses two types of feedings (CPW and slotlines) for controlling the radiation pattern and the same time, ring resonators were integrated in order to switch from a wideband operation to a narrow band operation while maintaining the same polarization. The antenna ranges from 3 to 6 GHz for wideband operation and operates at 3.5GHz for a narrowband operation with good radiation pattern reconfigurability. The proposed antenna was designed and simulated in CST microwave studio and printed on a Taconic board and the analysis yielded a well behaved radiation pattern and a good agreement of return loss between measured and simulated results. Hence the proposed antenna is suitable for use in pattern and frequency reconfigurable for wireless applications such as body area network

ABSTRAK

Secara amnya gandaan sama rata pada semua arah adalah diperlukan bagi sistem bergerak tanpa wayar seperti rangkaian ruang badan. Antena bolehubah polaradiasi telah banyak membantu dalam menyelesaikan masalah ini kerana ciri-ciri yang berpotensi yang ditawarkan oleh antena jenis ini. Selain itu, antena boleh ubah frekuensi jalur lebar ke frekuensi jalur sempit juga diperlukan bagi menyediakan kecekapan antena yang tinggi di dalam sistem komunikasi. Tujuan projek ini adalah untuk mereka sebuah antena yang mempunyai kawalan radiasipola dan frekuensi supaya dapat memenuhi keperluan aplikasi tanpa wayar seperti rangkaian kawasan badan. Oleh itu, satu konsep antena bolehubah semula radiasipola dan frekuensi yang baru adalah dicadangkan. Antena yang dicadangkan menggunakan dua jenis suapan talian (CPW dan baris slot) bagi mengawal polaradiasi dan pada masa yang sama, gelang resonator telah diintegrasikan supaya dapat mengubah operati jalur lebar ke operasi jalur sempit sambil mengekalkan pengutuban yang sama. Julat antena antara 3 ke 6 GHz untuk operasi jalur lebar dan 3.5 GHz untuk operasi jalur sempit dengan polaradiasi bolehubah yang baik. Antena yang dicadangkan direka dan disimulasi menggunakan perisian CST Microwave Studio dan dicetak di atas papan Taconic dan analisa menghasilkan keputusan polaradiasi dan kehilangan balik yang baik antara pengukuran dan simulasi. Oleh itu, antena yang dicadangkan sesuai digunakan di dalam konfigurasi semula pola dan frekuensi untuk aplikasi tanpa wayar seperti rangkaian ruang badan.

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LIST OF SYMBOLS

BW	-	Bandwidth
c	-	Velocity of light
dB	-	decibel
f_C	-	Center Frequency
f_L	-	Lower Frequency Band
f_H	-	Upper Frequency Band
p	-	Maximum directivity
Hz	-	Hertz
tan δ	-	Loss Tangent
W	-	Width of the slot line
λ_o	-	Free space Wavelength
η	-	Efficiency
E	-	Electric Field
H	-	Magnetic Field
ε	-	Permittivity
ε_r	-	Relative Permittivity
ε_{eff}	-	Effective Relative Permittivity
η_r	-	Radiation Efficiency
η_t	-	Total Efficiency
λ	-	Wavelength
Z	-	Impedance
T	-	Actual thickness of substrate
Γ	-	Reflection Coefficient
υ_{ph}	-	Phase Velocity

S_{11}	-	Return Loss
D	-	Directivity

LIST OF ABBREVIATIONS

MEMS	-	Micro Electro Mechanical system
UV	-	Ultra Violet
4G	-	Fourth Generation
EIRP	-	Effective Isotropic Radiated Power
VSWR	-	Voltage Standing Wave Ratio
HPBW	-	Half Power Beam width
RHCP	-	Right Hand Circular Polarization
LHCP	-	Left Hand Circular Polarization
CPW	-	Coplanar Waveguide
RL	-	Return Loss
RF	-	Radio Frequency
EBG	-	Electromagnetic Band Gap
MMICs	-	Microwave Monolithic Integrated Circuits
EM	-	Electromagnetic

CHAPTER I

INTRODUCTION

1.1 Introduction

Although wireless communication systems are designed to perform optimally, this isn't really the case. As it rarely maximizes the obstacles it encounters along its part. The propagating signals are degraded by reflection and scattering in a multipath environment. As a result diffraction from buildings, land forms and also nearby objects occurs hence this cause the fluctuations in the signal strength.

One of the techniques which have been proposed for the purpose of solving the multipath effect is by applying diversity technique. The diversity technique includes spatial diversity, pattern diversity as well as polarization diversity which aim at improving the signal to noise ratio and hence improves the overall performance. This can be achieved by the use of an antenna with reconfigurability ability. This means that the antenna is able to alternate using switches between several predetermined states for diversity purpose.

A reconfigurable antenna can be referred to as an antenna with the ability of achieving diversity in wireless system; this diversity may be in terms of spatial, temporal, pattern as well as polarization depending on the goal of the design as well as the application.

There are three major categories of reconfigurable antenna; these can be frequency, polarization or pattern reconfigurable which play a major role in integrated system with a purpose of using a single multifunctional antenna for different services [1].

For the frequency reconfigurable antenna, only the frequency is reconfigurable while o the radiation pattern of this antenna remains principally unchanged as the operating frequency switches. For the pattern reconfigurable antenna over the frequency band of interest, concentrate its energy in a particular direction hence minimizing the gain in further directions exclusive of affecting the impedance bandwidth of the antenna [2]. The reconfigurable antenna in terms of its polarization is designed in order to switch the antenna polarization states either in linear polarization or right hand circular (RHCP) and left hand circular polarization (LHCP).

Various studies have been carried on some pattern and frequency reconfigurable antenna structure by applying switching PIN diodes and dc bias network on the antenna topology [3]-[4]. Therefore, this project is aimed at designing a pattern and frequency reconfigurable antenna fed by a coplanar wave guide (CPW) of a wideband (3 to 6 GHz) and narrowband (3.5GHz) antenna with the capability of controlling the radiation pattern but in the same time with ability of handling frequency reconfigurable where switches are used to obtain polarization in different direction. It could be also applied in order to switch the wideband to the narrowband for wireless applications.

1.2 Problem statement

Most of the projects nowadays are focused on wideband reconfigurable antenna for WLAN/WIMAX applications due to broadband demands. A general realistic indication has shown that the wireless link quality varies hastily in some wireless applications such as body area networks, hence this raised a permanent transmit power results in either misused energy (when the link is decent) or low consistency (when the link is corrupted).

Therefore, this project seeks to quantify the potential gain of pattern and frequency control in order to maintain an upright external radiating antenna gain through most of the system (body) to avoid problems with an outstanding gain over a certain direction as the system (wearer) moves or turns.

1.3 Project Objective

- To design and fabricate pattern and frequency reconfigurable antenna by means of switches.
- To switch wideband (3-6 GHz) operation to narrowband (3.5 GHz) operation.
- To control beam direction from -180^0 to 0^0 and $+180^0$.

1.4 Scope of work

- The project involves the design and simulation of a wide band frequency (3 – 6GHz) and a narrowband (3.5 GHz) antenna.
- Fabrication of the reconfigurable antenna implementing ideal and real switches.
- Testing, measurement and analyzing the performance of both the simulated and measured results.

1.5 Thesis Outlines

This thesis is divided into six chapters. Each chapter will discuss on different issues of the project. Following are the outlines of the project for each chapter. Chapter 1 begins with the introduction and overview of the project, problem statements, objective, scope of project, and methodology of project to carry out the work.

The second chapter describes the theory behind reconfigurable antenna, antenna properties, Feeding methods, polarization types. It also includes the literature review to assist the project.

The third explains in detail about the design process and methodology of this

Project. Additionally, the fabrication process and measurement process are also presented.

The fourth provides the simulated and measured results. Discussions for these results are also being attached. Comparisons are being made between the simulated results and measured results for the fabricated antennas.

The fifth provides the results obtained by Implementing real switches and the comparison made between ideal switches and real switches in terms of return loss.

The sixth concludes this thesis with the work carried out for this project and the future work that can be further study.

1.6 Summary

This chapter provides introduction of the project, followed by a brief explanation about the chosen type of antenna. This chapter also covers the objective of the project, as well as scope of work that involved.

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