RECONFIGURABLE DUAL POLARIZATION ANTENNA

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To my beloved family and friends

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ABSTRACT

Due to signals are not travels only line of sight, it reaches the destination through multipath and causes the multipath effect which might weaken the receive signal. Dual polarization antennas able to overcome this problem where it can combat multipath effect, enhance the system performance, reduce interference, and increase channel capacity. Besides, the feature of reconfiguration enable the polarization of the antenna can be chosen. The main objective of this project is to design, simulate and fabricate the reconfigurable dual polarization antenna. The antenna should be able to operate at the resonant frequency of 2.4GHz with the return loss of -10dB and the type of polarization can be switch by using PIN diode. The design process of the antenna started from single linear and circular polarization antenna, dual polarization antenna and lastly the reconfigurable antenna. Then, the design antenna will be simulated by using CST software and some of them go for fabrication and measurement. The simulation and measurement result show that the design antenna having the resonant frequency about 2.4GHz and is able to produced dual polarization which is left-handed and right-handed circular polarization. Furthermore, the type of polarization can be switch by external power supplied to the PIN diode to trigger the 'on' and 'off' state. This reconfigurable dual polarization antenna can be used for any device that operate at 2.4GHz and it can aid in reduce the multipath effect. On the other hand, it can even enhance the system performance.

ABSTRAK

Oleh kerana isyarat tidak bergerak hanya atas garisan penglihatan, ia sampai ke destinasi melalui pelbagai laluan dan menyebabkan kesan berbilang laluan yang mungkin melemahkan penerimaan isyarat. Dwi polarisasi antena dapat mengatasi masalah ini di mana ia boleh menangani kesan berbilang laluan, meningkatkan prestasi sistem, mengurangkan gangguan, dan meningkatkan keupayaan saluran. Selain itu, ciri konfigurasi membolehkan jenis polarisasi antena boleh dipilih. Objektif utama projek ini adalah untuk mereka bentuk, simulasi dan fabrikasi dwi polarisasi antena yang boleh konfigur. Antena ini boleh beroperasi pada frekuensi salunan 2.4GHz dengan kehilangan pulangan -10dB dan jenis polarisasi boleh tukar dengan menggunakan diod PIN. Proses reka bentuk antena bermula dari antena tunggal linear polarisasi dan antena tunggal polarisasi bulat, antena dwi polarisasi dan akhir sekali dwi polarisasi antena yang boleh konfigur. Kemudian, antena akan disimulasikan dengan menggunakan perisian CST, fabrikasi dan pengukuran. Keputusan untuk simulasi dan pengukuran menunjukkan bahawa antena direka bentuk mempunyai frekuensi salunan 2.4GHz dan mampu menghasilkan dwi polarisasi iaitu polarisasi membulat tangan kiri dan polarisasi membulat tangan kanan. Tambahan pula, jenis polarisasi dapat bertukar dengan adanya kuasa luar yang dibekalkan kepada diod PIN untuk mencetuskan keadaan ‘buka’ dan ‘tutup’. Antena dwi polarisasi yang boleh konfigur ini boleh digunakan untuk mana-mana peranti yang beroperasi pada 2.4GHz dan ia boleh membantu dalam mengurangkan kesan berbilang. Sebaliknya, ia juga boleh meningkatkan prestasi sistem.

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LIST OF ABBREVATIONS

AUT	-	Antenna Under Test
CPW	-	Coplanar Waveguide
CST	-	Computer Simulation Technology
dB	-	decibel
FET	-	Field-effect Transistor
GHz	-	Gigahertz
IEEE	-	Institute of Electrical and Electronics Engineers
LAN	-	Local Area Network
LTE	-	Long Term Evolution
MEMs	-	Microelectromechanical system
MHz	-	Megahertz
RF	-	Radio Frequency
WiMAX	-	Worldwide Interoperability for Microwave Access
WLAN	-	Wireless Local Area Network

LIST OF SYMBOLS

AR	-	Axial Ratio
BW	-	Bandwidth
c	-	Speed of light
D	-	Directivity
$\mathcal{E}r$	-	Dielectric Constant
ε_{reff}	-	Effective Dielectric Constant
E	-	Efficiency
f_r	-	Resonant Frequency
g	-	Gap
gstack	-	Gap between Stacked Patch and Circular Patch
G	-	Gain
h	-	Height of Copper
hs	-	Height of Substrate
hstack	-	Height of Stacked Patch
L_{eff}	-	Effective Length
Lf	-	Length of Feed Line
Lp	-	Length of Patch
Ls	-	Length of Substrate
Ltc	-	Length of Truncated Corner
Pc	-	Coordinate of Coaxial Probe
Pif	-	Position of Inset Feed Line
Rbs	-	Radius of Big Circular Slot
RL	-	Return Loss
Rp	-	Radius of Patch
Rss	-	Radius of Small Circular Slot

slit	-	Size of Square Slit
Sstack	-	Size of Stacked Patch
stub	-	Size of Square Stub
$tan\delta$	-	Tangential loss
Wf	-	Width of Feed Line
Wp	-	Width of Patch
Ws	-	Width of Substrate
ΔL	-	Length Extension of Rectangular Patch

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CHAPTER I

INTRODUCTION

This chapter is discussed about the introduction of the antenna design of reconfigurable dual polarization antenna. Moreover, this chapter also explains on the problem statement, objective, scope of work and methodology.

1.1 Introduction

Antenna is any conductor that can radiate signal. It is needed for systems and devices to transmit and receive signal. Hence, systems and devices can communicate with each other through the aid of antenna. There are a few types of antenna that will be often seen and used in daily life. They are the antenna built in the phone, router's antenna, antenna on the radio base station, yagi-uda antenna and Astro antenna used on television. Mobile phone communicate with Wi-Fi router to get the Wi-Fi service while communicate with radio base station to make or receive a phone call. All this can only be done through antenna.

Furthermore, every systems and applications have their own specific operating frequency. For example Bluetooth, Wi-Fi and Wireless Local Area Network (WLAN) are working on 2.4GHz. So, a device has to equip itself with an antenna which operates at the same resonant frequency. Otherwise, they might fail to communicate with each other.

There are several antenna parameters that are used to measure antenna performances such as radiation pattern, directivity, gain, resonant frequency, return loss, type of polarization and more. This project will be study on polarization of antenna. Polarization is divided into three main types. They are linear polarization, circular polarization and elliptical polarization. In linear type polarization it is further divided into vertical and horizontal polarization. Meanwhile circular polarization is further divided into right-handed and left-handed polarization. Type of polarization can be observed at the end of the antenna.

Antenna can only communicate with each other if they are in the same polarization which means a vertical linear antenna can only communicate with vertical linear antenna. So a single system with a dual polarization antenna will be able to communicate with more than one other system.

1.2 Problem Statement

Signals are not travelling in line of sight only. They might undergo reflection, diffusion and scattering. Hence, signals usually reach the destination in many ways and this phenomenon known as multipath effects. If the signal travelled from different path and reach the destination 90 degrees out of phase, the signal tends to cancel out each other. Thus, reduce the performance of the antenna. Thus, dual polarization antenna is used to combat the multipath effect [1-5]. If a dual polarization antenna is being used, there were two type of polarization signal travel from the same antenna. Then, these signals reach the same destination as two individual signals. So, they will not recognize each other and the cancellation of signal will not happen. At the same time, it is important in polarization diversity for enhances system performance; reduce the multipath effect and the interference [1-6]. Furthermore, dual polarization antenna can increase the effective channel capacity [6]. This is due to dual polarization antenna can used to communicate with more than one system without extra use of bandwidth or transmit power.

Reconfigurable antenna also known as smart antenna is the antenna with the special feature where the properties of the antenna can be change dynamically by

external control [7-12]. The properties of the antenna that can be change are polarization, feed, resonant frequency and other. In this project, the polarization of the antenna will be changed. For example the polarization can be change from right-handed polarization to left-handed polarization.

1.3 Objective

The main objective of this project is to design, simulate and fabricate the reconfigurable dual polarization antenna. The design antenna will be able to reconfigure the dual polarization which is consisting of linear polarization, right-handed polarization and left-handed polarization. Besides, the antenna will be operating at the resonant frequency of 2.4GHz. Furthermore, the designed antenna should meet the minimum requirement where the return loss of the antenna must be less than -10dB and the axial ratio of the linear polarization must be more than 3dB while less than 3dB for circular polarization.

1.4 Scope of Work

The scope of work for this project is divided into four parts which are design, simulation, fabrication and measurement. First is to design reconfigurable dual polarization antenna that can be operate at 2.4GHz where the return loss should be less than -10dB. The dual polarization can be the linear polarization and the circular polarization. The antenna designation will be simulated by using Computer Simulation Technology (CST) software on the parameters such as resonant frequency, polarization, return loss, gain directivity and efficiency. The material that used for fabrication is FR4 board by using the techniques of chemical etching technique. The FR4 board having the substrate with dielectric constant, $\varepsilon r = 4.4$, tangent loss, $\tan\delta = 0.019$. The thickness of the substrate of the FR4 board is 1.6mm while the thickness of the copper is 0.035mm. After that, the antenna parameters such as resonant frequency, return loss, gain and directivity will be measure by using Agilent Network Analyzer, Antenna Training Kit (Transmitter and Receiver) and Fieldfox RF analyzer.

1.5 Methodology

Figure 1.1 explains the methodology used to complete this project. The project started with doing the literature review by study on journals and books regarding the topics of reconfiguration, linear polarization, circular polarization and dual polarization. Then, start to design the antenna of single linear polarization, single right-handed polarization, single left-handed polarization, dual polarization and reconfigurable dual polarization. The dual polarization antenna could be design form combining two single polarization antennas. Then, simulate the entire designed antenna by using CST software. If the result is not desirable, optimization step will be needed; otherwise, move on the fabrication stage. After that, measurement will be made on the antenna prototype.

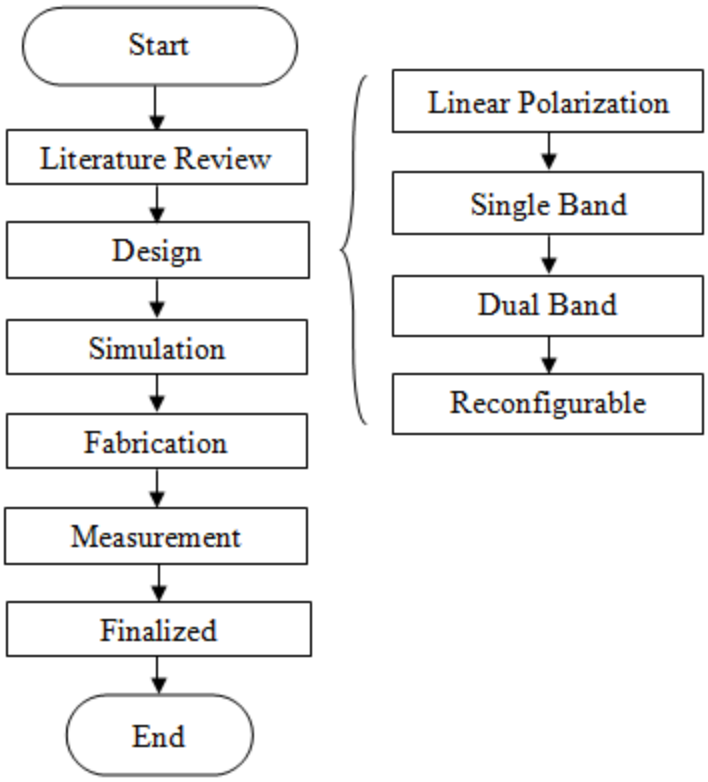

Figure 1.1: Project flowchart