



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**TRI-POLARIZED ANTENNA FOR MULTIPLE INPUT  
MULTIPLE OUTPUT (MIMO) SYSTEM**

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering Technology (Telecommunication) with Honours.

by

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## ABSTRAK

Dalam tahun kebelakangan ini, sistem komunikasi wayarles seperti radar, sistem navigasi, persidangan video, aplikasi perubatan dan sebagainya telah berkembang dengan pesat yang memerlukan katar data dan kapasiti yang tinggi. Dengan provokasi ini, sistem Multiple Input Multiple Output (MIMO) telah diperkenalkan untuk membekalkan prestasi yang cekap dan menentang kesan pelbagai arah. Objektif projek ini adalah untuk mereka bentuk, mensimulasi dan menfabrikasikan antenna tiga-polarisasi yang padat untuk sistem MIMO dengan frekuensi yang beroperasi pada 2.4GHz. Mula-mulanya, polarisasi tunggal seperti linear polarisasi (Design A) dan polarisasi putaran (Design B) antenna direka.. Akhir sekali, antenna tigapolarisasi (Design C) yang padat direka dengan gabungan tiga jenis polarisasi, termasuk linear polarisasi, polarisasi putaran arah kiri dan polarisasi putaran arah kanan. Semua antenna yang direka adalah disimulasikan dengan menggunakan CST perisian. Polarisasi tunggal, dual-polarisasi dan tiga-polarisasi telah berjaya direka dan memenuhi spesifikasi reka bentuk. Berdasarkan keputusan simulasi dan pengukuran, antenna yang direka melingkungi frekuensi 2.4GHz dengan koefisien pantulan di bawah -10dB. Simulasi lebar jalur setiap port untuk antenna tiga-polarisasi yang padat adalah lebih daripada 200MHz untuk spesifikasi tiga-polarisasi. Secara keseluruhannya, koefisien pantulan, jumlah dan lebar jalur untuk antenna tri-polarisasi yang padat telah menunjukkan keputusan yang baik. Keputusan pengukuran juga hampir sama dengan keputusan simulasi. Oleh itu, antenna tiga-polarisasi yang padat dengan tiga polarisasi yang berlainan adalah sesuai untuk diaplikasikan dalam sistem MIMO yang memerlukan polarisasi diversiti.

## ABSTRACT

In recent years, wireless communication system such as radar, navigation system, video conferencing, medical application and others has been widely developed. Regardless of the application, most of the modern wireless communication systems require high data rate and channel capacity. With these provocations, Multiple Input Multiple Output (MIMO) system was introduced to provide efficient performance and combat multipath effect. The objective of this project was to study tri-polarized antenna for wireless MIMO communication system, design, simulate and fabricated a tri-polarized antenna that operates at frequency 2.4GHz and analyze the performance of the designed antenna. First of all, single polarizations for linear polarized (Design A) and circular polarized antennas (Design B) were designed. Lastly, a compact tri-polarized antenna (Design C) was designed with a combination of three different polarizations; including linear polarization, left-handed circular polarization (LHCP) and right-handed circular polarization (RHCP). All the antenna designs were simulated by using Computer Simulation Technology (CST) software. Single-polarized antenna, circular polarized antenna and tri-polarized antenna were successfully designed and achieved design specifications. Based on the simulation and measurement results, the designed antennas covered frequency of 2.4GHz with reflection coefficient below -10dB. The simulated bandwidths of the designed antenna were more than 200MHz for the tri-polarized specification. Overall, all the antenna specification of compact tri-polarized antenna showed good responses. The measurement results were almost similar to the simulation results. Therefore, this tri-polarized antenna that is capable of performing in three different polarizations is suitable to be applied in MIMO system that requires polarization diversity.

## **DEDICATION**

To my beloved family and friends.



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# TABLE OF CONTENT

<b>TABLE OF CONTENTS</b>	<b>x</b>
<b>LIST OF TABLES</b>	<b>xiii</b>
<b>LIST OF FIGURES</b>	<b>xiv</b>
<b>LIST OF APPENDICES</b>	<b>xvii</b>
<b>LIST OF SYMBOLS</b>	<b>xviii</b>
<b>LIST OF ABBREVIATIONS</b>	<b>xix</b>
<b>CHAPTER 1 INTRODUCTION</b>	<b>1</b>
1.1 Background overview	1
1.2 Problem statement	2
1.3 Objective	4
1.4 Scope of work	5
1.5 Overview thesis outline	5
<b>CHAPTER 2: LITERATURE REVIEW</b>	<b>6</b>
2.1 Introduction of Literature Review	6
2.2 Multiple Input Multiple Output (MIMO) Wireless Communication System	6
2.3 Antenna Parameters	8
2.3.1 Gain	9
2.3.2 Directivity	10

2.3.3	Radiation Pattern	11
2.4	Basic Microstrip Antenna	13
2.5	Antenna Polarization	14
2.5.1	Linear Polarized Antenna	14
2.5.2	Circular Polarized Antenna	16
2.5.3	Dual- Polarized Antenna	20
2.5.4	Tri-Polarized Antenna	22
2.6	Related Research Paper	27
2.7	Summary	31
<b>CHAPTER 3: METHODOLOGY</b>		<b>32</b>
3.1	Project Methodology	32
3.2	Design Specification	34
3.3	Design Process	35
3.4	Linear Polarized Antenna (Design A)	38
3.5	Dual Circular-polarized Antenna (Design B)	40
3.6	Tri-polarized Antenna (Design C)	41
3.7	Fabrication Process	43
3.8	Measurement Process	50
3.9	Summary	52

<b>CHAPTER 4: DISCUSSION AND RESULT</b>	<b>53</b>
4.1 Introduction	53
4.2 Return Loss	53
4.3 Bandwidth	59
4.4 Gain	60
4.5 Radiation Pattern	64
<b>CHAPTER 5: CONCLUSION AND FUTURE WORK</b>	<b>65</b>
5.1 Conclusion	65
5.2 Future Work	67
<b>REFERENCES</b>	<b>67</b>
<b>APPENDICES</b>	<b>70</b>

## LIST OF TABLES

TABLE	TITLE	PAGE
Table 3.1	Antenna's specification.	34
Table 3.2	Specification of materials	35
Table 3.3	Antenna parameter for Tri-Polarized antenna	42
Table 4.1	Simulation and measurement results of frequency and return loss	55
Table 4.2	Simulation results of bandwidth for Tri-polarized antenna	56
Table 4.3	Measurement results of bandwidth for Tri-polarized antenna	57
Table 4.4	Show the result bandwidth between simulation and measurement	58
Table 4.5	Simulation results of gain for Tri-polarized antenna	59
Table 4.6	Simulation and measurement results of gain for Tri-polarized antenna	60
Table 4.7	Show the simulation results of gain for Tri-polarized antenna	61
Table 4.8	Show the measurement results of gain for Tri-polarized antenna	62

## LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1	3D Radiation Intensity Pattern	10
Figure 2.2	Radiation pattern in spherical coordinates	12
Figure 2.3	Three-dimensional normalized field pattern and power pattern.	12
Figure 2.4	Top view and Side view of patch antenna	14
Figure 2.5	Polarized radiation patterns for three perpendicularly-oriented short linear antennas.	15
Figure 2.6	Linear Polarization	15
Figure 2.7	Rectangular Patch with Inset Feed	16
Figure 2.8	Geometry layout of annular-ring slot antenna	17
Figure 2.9	Geometry of the proposed microstrip antenna with single feed by electromagnetic coupling on the radiating face. (a) Square Patch. (b) Elliptic Patch	18
Figure 2.10	Diagonally fed microstrip patch antenna layout with its current distribution.	19
Figure 2.11	Geometry of CPW fed microstrip antenna	20
Figure 2.12	Geometry of dual-polarized antennas	21
Figure 2.13	Dual Circular-Polarized Antenna	22

Figure 2.14	Linear polarized antenna	23
Figure 2.15	Basic circular patch antenna	23
Figure 2.16	Combination of planar antenna with dual polarized circular patched	24
Figure 2.17	Linear polarized antenna	25
Figure 2.18	Half-slot antenna	26
Figure 2.19	Comb structure antenna	26
Figure 2.20	Geometry of tri-polarized antenna with capacitive coupling strip	27
Figure 2.21	Far-field patterns of the tri-polarized comb half-slot antenna compared to the half-slot antenna.	28
Figure 2.22	(a) Proposed dipole antennas (units in millimeters). (b) The 3-D view. Three port tri-polarized dipole antenna.	29
Figure 2.23	Broadband Tri-polarized antenna	30
Figure 3.1	Flowchart of process methodology	33
Figure 3.2	Flowchart of design process	37
Figure 3.3	Design A1	39
Figure 3.4	Design A2	39
Figure 3.5	Design A3	39
Figure 3.6	Design B1	40
Figure 3.7	Design B2	40
Figure 3.8	Design B3	41

Figure 3.9	Tri polarized antenna (Design C)	42
Figure 3.10	Flow chart fabricate process	44
Figure 3.11	UV Curing Machine	45
Figure 3.12	PCB Developer Machine	46
Figure 3.13	Etcher machine Mega Electronics model FAPC 3000	47
Figure 3.14	Etcher machine Mega Electronics model PA320	48
Figure 3.15	Soldering Process	49
Figure 3.16	Fabrication of Tri-polarized antenna	49
Figure 3.17	Vector analyzer for return loss measurement	50
Figure 3.18:	Signal generator	51
Figure 3.19	Anechoic chamber	52
Figure 4.1	Simulation results of the frequency and return loss for the Tri-Polarized antenna	54
Figure 4.2	Measurement results of the frequency and return loss for the Tri-Polarized antenna	54



## **LIST OF APPENDICES**

<b>APPENDIX</b>	<b>TITLE</b>	<b>PAGE</b>
Appendix1	Gantt chart	70

## LIST OF SYMBOLS

G - Gain

$\eta$  - Radiation efficiency

D - Directivity (dimensionless)

$D_0$  - Maximum directivity (dimensionless)

$U(\theta, \varphi)$  - Radiation intensity (W/sr)

$U_{\max}$  - Maximum radiation intensity (W/sr)

$U_0$  - Radiation intensity of isotropic source (W/sr)

$P_{\text{rad}}$  - Total radiated power (W)

L - Length

W - Width

r - Radius

## LIST OF ABBREVIATIONS

AUT - Antenna under Test

VNAs - Vector Network Analysts

CST - Computer Simulation Technology

mm – millimeter

SMA - SubMiniature version A

GHz –Giga hertz

WLAN - Wireless Local Area Network

SISO - Single Input Single Output

MIMO – Multiple Input Multiple Output

CPW - Coplanar Waveguide

dB - Decibels

LCHP - Left Hand Circular Polarized

RHCP - Right Hand Circular Polarized

# CHAPTER 1

## INTRODUCTION

### 1.1 Background overview

In this era, the wireless communication system is growing unexpectedly. The conventional wireless communication system is based on the single input single Output (SISO) system, which only transmits and receives one signal at the one time. Multiple input multiple Output (MIMO) system is one of the distinct ways within the wireless communication system that requires high data rate, channel capacity, and system reliability. Consequently, the concept of MIMO system has been introduced with multiple antennas at both transmitter and receiver of the communication link.

Multiple Input Multiple Output (MIMO) is one of the smart antenna technology implemented in the current wireless communication system wherein multiple antennas are used to maximize data speed and channel capacity. In conventional wireless communications, the antenna is used in both the source and destination but this had the effect of multiple and not efficient enough. The idea of the usage of multiple antennas is then raised to overcome these problems. As a way to further improve the overall performance of MIMO system in wireless communications, polarized diversity is preferred where multiple polarized antennas are used. By introducing tri-polarized antenna in MIMO system can be solved.

An antenna is an essential part of any wireless system. The antenna is described as a metal device used for transmitting or receiving radio signals. In this technology generation, the antenna is over with a very ordinary device and is required to receive or

transmit something. Each antenna has its own characteristics to determine its parameters. There are a several number of antenna parameters used to measure the performance of the antenna radiation pattern that includes the director, the benefits, the resonant frequency, return loss, polarization type, and others.

The design of compact antenna polarization for MIMO system is one of the topics of interest in the investigation of the antenna. Antenna with compact size is one of the key concerns in the design of wireless communication systems. The tri-polarized antenna is a combination of three different antenna polarization. Polarization is characterized through three main types. They are linear polarization, circular polarization, and elliptical polarization. Linear polarization categorized into vertical and horizontal polarization (RHCP) and left circular polar (LHCP).

## **1.2 Problem Statement**

The rapid development of the wireless communication system has led to a high demand for high data rates and high channel capacity to support new applications such as video conferencing, email and other services. The power transmission needs to be increased in order to improve the channel capacity of the wireless communication system. The transmission power can be increased by modifying the transmitter, however this increases the installation. Multiple Input Multiple Output (MIMO) system allowing multiple transmission is another appropriate solution for increasing transmission power. Therefore, the Multiple Input Multiple Output (MIMO) system improves the data rate and channel capacity significantly in order to improve the robustness of the wireless communication system.

Linear antenna polarization transmits signals, either vertically or horizontally, in one plane. However, signals do not only travel in a sight line. They could reflect, diffuse and spread. Signals normally reach the destination in many ways and this phenomenon is referred to as multipath effects. This phenomenon will reduce antenna performance. A single polarized antenna is not sufficient to perform efficiently in a modern wireless communication system. This is because single polarization does not make full use of the polarization resource. When dual-polarized and tri-polarized antennas are used, performance degradation is prevented. The dual-polarized and tri-polarized antenna can thus combat the multi-path effect, reduce interference and improve system performance. However, the tri-polarized antenna performs better than the dual antenna. This is due to the presence of three types of polarization signal that transmit over a wide field of view from the tri-polarized antenna to the same destination as three independent signals.

Compact antenna is important for most portable wireless devices such as mobile phones, laptops, global positioning systems (GPS), wireless internet and others. It is not necessary to install many antennas with different polarization in a wireless device. Thus, a compact tri-polarized antenna requires higher polarization diversity, which offers three independent transmission paths. Diversity of polarization can reduce the antenna size and number in wireless communication systems. This resulted in a higher transmission rate than the single polarized and dual-polarized antenna. Tri-polarized antenna with a compact size can be used to increase capacity without excessive bandwidth and transmission power. Nowadays, in practical wireless communication systems, broadband antenna has received great attention. Broadband antenna can provide a wide frequency range to support high-data communication. However, one of the biggest disadvantages of microstrip antennas is the limited bandwidth. Many approaches have been made to

increase the bandwidth of the antenna, such as increasing the thickness of the substratum, adding slot, stacked patch, layer of air gap and others. As a result, a compact, three-polarized broadband antenna is proposed, which is suitable for most modern telecommunications systems and plays an antenna role in Multiple Input Multiple Output (MIMO) systems.

### **1.3 Objective**

The objective of this project, as shown below:

1. To study tri-polarized antenna for wireless MIMO communication system.
2. To design, simulate and fabricated a tri-polarized antenna that operates at frequency 2.4GHz.
3. To analyze the performance of the designed antenna.

### **1.4 Scope of work**

The project scope of work is:

- I. Design of a tri-polarized antenna with combination of a dual circular polarization and a linear polarization for wireless MIMO system. For this project, the focus is on WLAN system with frequency 2.4GHz.
- II. The 2D structure of antenna designed is simulated by using CST Studio Suite software. The antenna parameters such as gain, return loss, directivity, axial ratio and efficiency are simulated.
- III. The fabrication method is chemical etching and FR4 with dielectric constant of 4.4, substrate thickness of 1.6mm, conductor thickness of 0.0035mm and tangent loss of 0.019 is chosen as the substrate.

- IV. The antenna parameters such as gain, return loss and radiation patterns are measured and observed using equipment such as signal generators, spectrum analyzers and network analyzers

## **1.5 Overview thesis outline**

Chapter 1 present an introduction to this project through objective, problem statement, and project scope.

Chapter 2 presents the literature review on the antenna polarization, multi polarized antenna, microstrip antenna and information on the basic antenna parameters.

Chapter 3 presents the overall project methodology and the design methodology of the antenna.

Chapter 4 discuss the simulation and measurement results by analyzing through comparison

Chapter 5 presents concludes the project finding or outcomes and suggestions project future work.