



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**DEVELOPMENT OF 10.5 GHZ FIXED WIRELESS ACCESS  
ANTENNA USING CST**

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

by

**MOHD FARID BIN ASMIR**

**B071510161**

**931101-14-5475**

FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING  
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## APPROVAL

This report is submitted to the Faculty of Electrical and Electronic Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering Technology (Telecommunication) with Honours. The member of the supervisory is as follow:

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Supervisor : FAKHRULLAH BIN IDRIS

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## ABSTRACT

Antenna is an electromagnetic transducers designed to transmit and receive electromagnetic wave depending on the applications, shape, size and frequency range. Antenna has a wide range application includes mobile communication, remote sensing, navigation (GPS), wireless LAN, biomedical, radio broadcasting, radar and satellite communication. The antenna involved in the application such as in Fixed Wireless Access required an antenna to be operated in X band region and the resonant frequency is selected at 10.5 GHZ. The antenna was designed in microstrip patch using CST Microwave Studio. This antenna is using FR-4 dielectric substrate with specified information include dielectric constant ( $\epsilon_r = 4.3$ ) and substrate height ( $h=1.6$  mm). The main antenna parameters mainly focused on resonant frequency, return loss, VSWR and gain. The antenna then will be fabricated and measurement will be carried out and compared with the simulation result.

## ABSTRAK

Antena adalah transduser elektromagnet yang direka untuk menghantar dan menerima gelombang electromagnet bergantung kepada aplikasi-aplikasi, bentuk, saiz dan jarak frekuensi. Antenna mempunyai pelbagai aplikasi termasuk komunikasi mudah alih, penderiaan jarak jauh, navigasi (GPS), LAN tanpa wayar, biomedikal, penyiaran radio, radar dan komunikasi satelit. Antena yang terlibat dalam aplikasi seperti '*Fixed Wireless Access*' (FWA) memerlukan antena untuk dikendalikan dalam rantau band X dan frekuensi resonan dipilih pada 10.5 GHZ. Antena mikrojalur ini direka menggunakan CST Microwave Studio. Antena ini menggunakan substrat dielektrik FR-4 dengan maklumat yang ditentukan termasuk pemalar dielektrik ( $\epsilon_r = 4.3$ ) dan ketinggian substrat ( $h = 1.6 \text{ mm}$ ). Antena utama parameter terutamanya tertumpu pada frekuensi resonan, kehilangan kembali, VSWR dan keuntungan. Antena kemudiannya akan direka dan pengukuran akan dilakukan dan dibandingkan dengan keputusan simulasi.

## **DEDICATION**

Special dedication to my beloved parents,

**ASMIR BIN DJANAS**

**&**

**NETTY BINTI KHATAB**

My family members and my friends

Thank you for all your care and support



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# TABLE OF CONTENT

	<b>PAGE</b>
<b>DECLARATION</b>	<b>iv</b>
<b>APPROVAL</b>	<b>v</b>
<b>ABSTRACT</b>	<b>vi</b>
<b>ABSTRAK</b>	<b>vii</b>
<b>DEDICATION</b>	<b>viii</b>
<b>ACKNOWLEDGEMENT</b>	<b>ix</b>
<b>TABLE OF CONTENT</b>	<b>x</b>
<b>LIST OF TABLES</b>	<b>xiii</b>
<b>LIST OF FIGURES</b>	<b>xiv</b>
<b>LIST OF ABBREVIATION, SYMBOLS AND NOMECLATURE</b>	<b>xvi</b>
<b>CHAPTER 1          INTRODUCTION</b>	<b>1</b>
1.0    Introduction	1
1.1    Project Background	1
1.2    Problem Statement	2
1.3    Objective	2
1.4    Project Scope	3
1.5    Thesis Outlines	3
<b>CHAPTER 2          LITERATURE REVIEW</b>	<b>5</b>
2.0    Introduction	5
2.1    Theory of Antenna & Operation	5
2.2    X Band Frequency Spectrum	6
2.3    Fixed Wireless Access (FWA)	7

2.4	Antenna Types	9
2.5	Parameters of Antenna	12
2.5.1	Return Loss	12
2.5.2	VSWR	13
2.5.3	Gain	14
2.6	Introduction to Microstrip Antenna	14
2.7	Shape of Patch in Microstrip Antenna	17
2.7.1	Rectangular and Circular Shape	17
2.7.2	Spanar Shape	18
2.7.3	U-Slot Shape	19
2.7.4	Patch-Array Shape	20
2.8	Feeding Technique of Microstrip Patch Antenna	21
2.9	Application Comparison Table	24
2.10	Summary	25
<b>CHAPTER 3            METHODOLOGY</b>		<b>26</b>
3.0	Introduction	26
3.1	Project Methodology	26
3.2	Project Flow Chart	27
3.3	Project Gant Chart	30
3.4	Project Overview	32
3.4.1	CST Microwave Studio	32
3.4.2	Dielectric Substrate	33
3.4.3	Patch and Ground Plane	34
3.4.4	Feeding Method	35

3.4.5	Connector Jack	38
3.4	Project Testing	39
3.5.1	Network Analyser	39
3.5.2	Gain Measurement	40
3.5.3	Radio-frequency Anechoic Chamber	41
3.6	Preliminary Finding- Antenna Design Dimensions	42
3.7	Expected Outcome	43
3.7	Summary	44
<b>CHAPTER 4</b>	<b>RESULT AND DISCUSSION</b>	<b>45</b>
4.0	Introduction	45
4.1	Single Rectangular Microstrip Patch Antenna	45
4.2	1 × 2 Rectangular Microstrip Patch Array Antenna	47
4.3	Fabrication Process	49
4.4	Return loss	50
4.5	VSWR	53
4.6	Gain	55
4.7	Radiation Pattern	57
4.8	Summary	60
<b>CHAPTER 5</b>	<b>CONCLUSION AND RECOMMENDATION</b>	<b>61</b>
5.0	Introduction	61
5.1	Conclusion	61
5.2	Future work	63
<b>REFERENCES</b>		<b>64</b>

## LIST OF TABLES

NO	TITLE	PAGE
2.1	Application Comparison Table	24
3.1	Gantt Chart for Final Year Project 1	30
3.2	Gantt Chart for Final Year Project 2	31
3.3	Properties of FR-4 Glass Epoxy	33
3.4	Patch and Ground Plane Theoretical Formula	34
3.5	Calculated Design Dimensions of MPA	42
3.6	Expected Outcome	43
4.1	Dimension of single rectangular MPA before and after optimization	46
4.2	Dimension of 1×2 rectangular array MPA after optimization	48
4.3	Return Loss for Simulation and Measurement of the MPA	53
4.4	Simulation Result of VSWR	54

## LIST OF FIGURES

NO	TITLE	PAGE
2.1	Antenna as Transducer Device	6
2.2	FWA Topology	7
2.3	FWA Frequency Spectrum provided to Service Provider in Malaysia	9
2.4	Microstrip Patch Antenna	10
2.5	Waveguide Slotted Antenna	11
2.6	S-Parameters Testing	12
2.7	Basic Microstrip Antenna Configuration	15
2.8	Fringing Fields within the Microstrip Antenna	16
2.9	Rectangular and Circular Shape of Microstrip Patch Antenna	18
2.10	Spanar Shape of Microstrip Patch Antenna	19
2.11	U-Slot Microstrip Patch Antenna	20
2.12	1 x 4 Array Microstrip Patch Antenna	21
2.13	Contacting Method of Feeding Technique	22
2.14	Non- Contacting Method of Feeding Technique	23
2.15	Microstrip Patch Array with Corporate Feeding Network with Line Inset Feed	23
3.1	Block Diagram of Project Methodology	27
3.2	Flow Chart on development of 10.5 GHz FWA antenna	29
3.3	CST Microwave Studio	32
3.4	FR-4 Glass Epoxy Structure	33
3.5	Corporate Feeding Line Network	37

3.6	RP SMA Female (Jack) Connector	38
3.7	Vector Network Analyser	40
3.8	Radio-Frequency Anechoic Chamber	41
4.1	Front view of rectangular MPA	46
4.2	Back view of rectangular MPA	46
4.3	Front View of $1 \times 2$ Rectangular Microstrip Patch Array Antenna	48
4.4	Fabricated of Single Rectangular MPA	49
4.5	Fabricated of $1 \times 2$ Rectangular MPA	50
4.6	Simulation result of return loss for Single Rectangular MPA	51
4.7	Simulation result of return loss for $1 \times 2$ Rectangular Array MPA	51
4.8	Measurement of Return loss for Single Rectangular MPA	52
4.9	Measurement of Return Loss for $1 \times 2$ Rectangular Array MPA	52
4.10	Simulation result of VSWR for Single Rectangular MPA	54
4.11	Simulation result of VSWR for $1 \times 2$ Rectangular Array MPA	54
4.12	Simulation result of gain for single rectangular MPA	55
4.13	Simulation result of gain for $1 \times 2$ array rectangular MPA	55
4.14	Gain Measurement Setup	56
4.15	Simulation result of Radiation Pattern for Single Rectangular MPA	57
4.16	Simulation result of Radiation Pattern for $1 \times 2$ Array Rectangular MPA	58
4.17	Radiation Pattern of Single Rectangular MPA	59
4.18	Radiation Pattern of $1 \times 2$ Array Rectangular MPA	59

## **LIST OF ABBREVIATION, SYMBOLS AND NOMECLATURE**

FWA	-	Fixed Wireless Access
GHZ	-	Gigahertz
MPA	-	Microstrip Patch Antenna
FR-4	-	Flame Retardant 4
MCMC	-	Malaysia Communications and Multimedia Commission
IEEE	-	Institute of Electrical and Electronics Engineers
VSWR	-	Voltage Standing Wave Ratio
SFH	-	Super High Frequency
UV	-	Ultra violet
S11	-	Return loss



# CHAPTER 1

## INTRODUCTION

### 1.0 Introduction

This chapter provides the introduction of the project background, problem statement and objectives of this project entitled “Development of 10.5 GHz Fixed Wireless Access (FWA) Antenna using CST”.

### 1.1 Project Background

An antenna is electrical component that radiate and receive the electromagnetic waves which solely purpose is to provide communication without having physical connection such as cable or wire. Generally the antenna is a necessary component in all radio equipment in order to provide transmission and reception of radio waves. The implementation of FWA require antenna that works in point-to-multipoint or broadcast communication in which many nodes or subscribers to receive information that being transmitted by one node that comes from a base station or fixed tower. On this project, the suitable antenna will be designed to be operate in X-band spectrum.

## 1.2 Problem Statement

In 2012, MCMC of Malaysia already allocate the frequency band from 10.15 GHz to 10.30 GHz and 10.50 GHz to 10.65 GHz to be used in FWA and classified to the operators that are available in Malaysia such as Maxis, Digi, Celcom and The Time. Along the development of 5G in Malaysia, this FWA services will be deploy on this country. Before this, a high speed internet connection can be get it by using physical connection transmission such as fiber optic. The high speed internet is usually delivered from the operators which comes from the central office to residential or premises area through the cable implanted underground alongside the road and also using infrastructure on the street. This physical connection will be sometimes limited to the area that are far away from central office and the expansion of fiber optic cable infrastructure will be cost expansive and required high maintenance. Therefore, the development of FWA will be implement to deliver high speed internet connection as the antenna will be designed to be part of necessary device in the FWA system.

## 1.3 Objective

The main objectives of this project are deeply concentrated on aspects as listed

- I. To design a 10.5 GHz antenna for Fixed Wireless Access (FWA).
- II. To archive targeted parameters of antenna such as return loss, VSWR and gain in the simulation.
- III. To fabricate the antenna and perform testing to determine the antenna performance.

## **1.4 Project Scope**

In this project, the antenna will be developed in microstrip patch that will resonant at 10.5 GHz. This resonant frequency is selected as the MCMC already allocate the frequency spectrum to be used in FWA. Therefore, the frequency of 10.5 GHz is lies between the frequency allocations. The antenna is designed and simulated by using Computer Simulation Technology Microwave Studio (CST) until the antenna achieved the required parameters.

Then, the process will continued to fabricate the designed antenna on the FR-4 substrate and undergoes hardware testing and measurement by using Vector Network Analyser and Anechoic Chamber to analyse the performance of the antenna. In the end, the result from both simulation and measurement is compared and analysed.

## **1.5 Thesis Outlines**

This report consist of three chapters which are introduction, literature review and methodology.

### **I. Chapter 1 – Introduction**

This chapter provides the brief introduction to the project and problem statement, list of objectives to be achieved and scope of the project. This chapter will provides the reason on why this project is being implemented.

## **II. Chapter 2 – Literature Review**

This chapter describes the review based previous literature, case study and research journals on development of the antenna that include type of antenna, shape of patch, fabrication process and improvement on the microstrip patch antenna that resonant in X Band spectrum. The antenna parameters such as return loss, VSWR, radiation pattern and etc were were analysed and discussed in this chapter.

## **III. Chapter 3 – Methodology**

This chapter provides the selected method in determining the antenna dimension which include patch dimension and feed line based on properties of dielectric substrate such as dielectric constant and substrate height to ensure the antenna is resonant at 10.5 GHz. The software and equipment used to measure antenna parameters were discussed in this chapter.

## **IV. Chapter 4 – Result & Discussion**

This chapter will show the result of the designed antenna based on simulation and measurement. The antennas were first designed in CST and undergoes optimization before being fabricated. The result between simulation and measurement were discussed in this chapter.

## **V. Chapter 5 – Conclusion & Recommendation**

This chapter will summarized up the overall project and suggesting a several method as improvement on antenna parameters.

## CHAPTER 2

### LITERATURE REVIEW

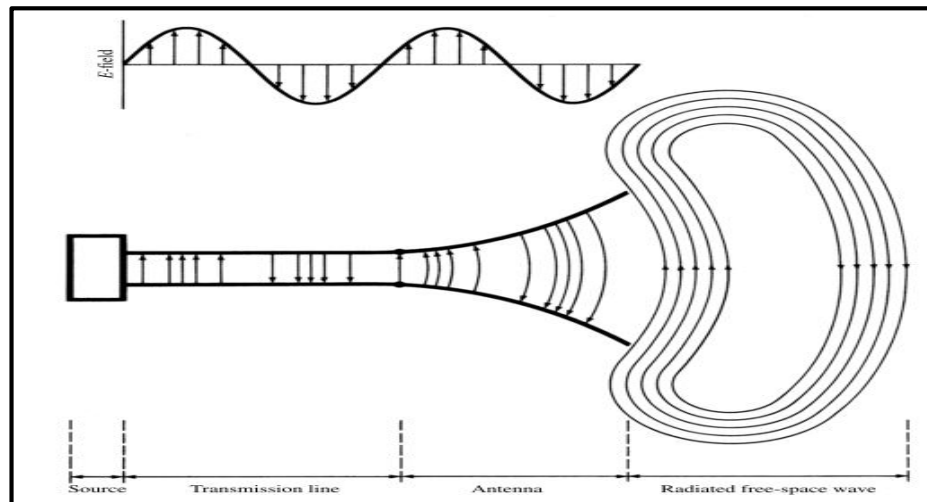
#### 2.0 Introduction

This chapter provided review on previous study and research which closely related to development of antenna working on X Band Frequency. All information is obtained from journal, books and internet. This literature review will discussed about types of antenna used, details explanation about microstrip antenna, shape of microstrip antenna and feeding technique. The variation of antenna type and its feeding technique is compared and analysed so that the development of antenna in 10.5 GHz can be designed in fixed wireless access system.

#### 2.1 Theory of Antenna & Operation

As defined by (Balanis, 2012) antenna is a transducer that specialized to radiate and receive electromagnetic waves which the main purpose is to convert guided waves in form of electrical signal inside the transmission line to radiated free space waves in form of electromagnetic waves for the transmission mode while in the receiving mode is to convert back the free-space waves` back to guided wave forms. This statement is supported by (Graf, 1999), define the antenna as the device used with a transmitter and receiver that create the interface between electromagnetic wave propagating through space the and the electrical waves moving in the metal conductors.

Figure 2.1 shows the basic concept of how the antenna is working which the electrical signal from the source is converted to free-space electromagnetic wave. Generally, antennas will be designed with suitable dimensions, shapes and sizes to efficiently and effectively deliver a desired transmission and reception of electromagnetic energy (El-darymli, 2017).



**Figure 2.1 Antenna as Transducer Device (Balanis, 2012)**

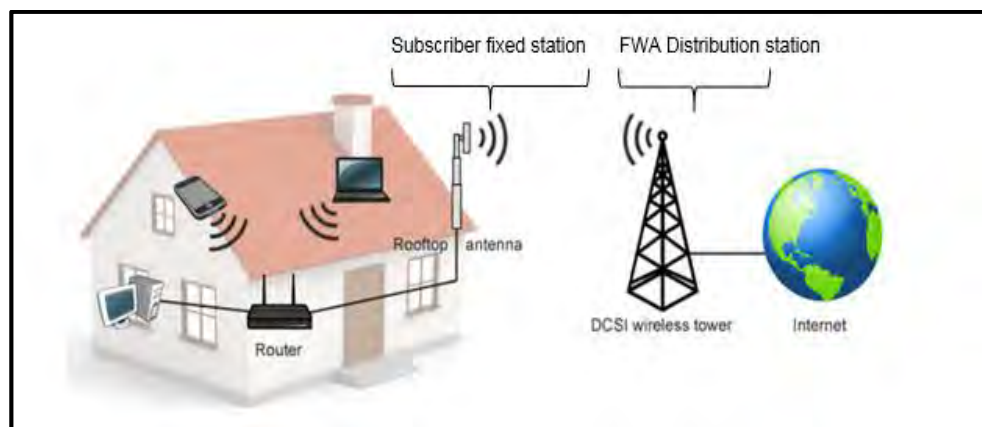
## 2.2 X Band Frequency Spectrum

The X Band frequency spectrum is the classification for a band of frequencies in radio microwaves in Super High Frequency (SHF) region. The portion frequencies in X-Band is assigned by the International Telecommunications Union (ITU). In the communication engineering, the frequency operation for the X Band indefinitely set at approximately 7.0 GHz to 11.2 GHz while in radar engineering the frequency operation that be specified by the IEEE at 8.0 GHz to 12.0 GHz. The X Band usually utilized in radar communication, space communication involving satellite and in wireless access network.

### 2.3 Fixed Wireless Access (FWA)

Fixed Wireless Access (FWA) sometimes known as Fixed Wireless Broadband is one of communication infrastructure platform that provide internet access to the home or premises that use wireless network connection rather than the fixed lines that usually be physically connected through infrastructure on the street. The FWA systems provides connection between two-way points in point-to-multipoint radio systems consisting of FWA distribution station, subscriber fixed stations and router shown in Figure 2.2. The FWA have a long history that are already been used for voice and data communication generally in backhaul networks operates by phone companies, cable TV companies, utilities, railways, paging companies and government agencies, and now will be used in commercial communication purpose.

Therefore, FWA services can serve the same function as wireline interconnecting private network, bypassing a local exchange carrier or connecting to the internet wirelessly in many areas where fixed broadband such as DSL, Cable and FTTx are limited (Rysavy, 2008).



**Figure 2.2: FWA Topology**

In Malaysia, the FWA system is in beginning of assignment and discussion along with the development of 5G network governed by Malaysia Communications and Multimedia Commission (MCMC). This FWA services are planned for providing furthest mile broadband connectivity to subscriber and can include applications such as voice, video, images, interactive multimedia and high-speed data. The MCMC provides a Standard Radio System Plan (SRSP) in 2006 for requirement for Fixed Wireless Access (FWA) System operating in frequency band 10.15 GHz to 10.30 GHz and 10.50 GHz to 10.65 GHz. In requirements for usage of spectrum stated by MCMC in the SRSP to use these frequency spectrum from Fixed ML35 for radiolocation, amateur-satellite, earth-exploration satellite for radio astronomy and space research to FWA service. Then, in 2012 the MCMC officially allocate the frequency spectrum for FWA to available service operators in Malaysia as shown in Figure 2.3. The spectrum allocation is divided into two bands, lower and upper band as the lower band is from 10.154 GHz to 10.3 GHz and the upper band is from 10.5 GHz to 10.65 GHz (MCMC, 2012).