# 60 GHz ANTENNA FOR WIRELESS COMMUNICATIONS

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# APPROVAL

"I acknowledge that I have read this report and in my opinion this report is sufficient in term of scope and quality for the award of Bachelor of Electronic Engineering (Industrial Electronics/ Computer Engineering/ Electronic Telecommunication/ Wireless Communication)* with Honours."

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# DEDICATION

This project and research work is dedicated to my beloved parents. I hope that this achievement will complete the dream that you had for me all those many years ago when you chose to give me the best education you could

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# ABSTRACT

The 60GHz short-range wireless communication system has gained a lot attention because it is believed to have a high rate data communications with free licensed frequency band. Thus, development of the 60 GHz antenna is a crucial issue in the system. This thesis is focused on the design of antipodal vivaldi antenna (APVA) at 60GHZ for wireless communications.the antenna is designed by compared the performance by using three different types of material substrates which are Silicon, Ferro A6s, and Duroid 5880. The parameters to be observed in this thesis included return loss, gain, radiation pattern, directivity and bandwidth of the antenna. The performance of the antenna is simulated by using CST microwave studio with the ranges frequency between 50GHz to 70GHz. The changes in performance between three different types of material substrate is discussed further in this thesis. From the simulation results, the value of return loss is as the desired results where it need to be less than -10dB for three different types of substrate used. Out of these three substrate used, Ferro have a better antenna performance where it has -19dB return loss, directional radiation pattern, and wider bandwidth which make it suitable to be used as 60GHz antenna for wireless communication

# ABSTRAK

60GHz jarak dekat sistem komunikasi tanpa wayar telah mendapat perhatian banyak kerana ia dipercayai mempunyai komunikasi data kadar tinggi dengan percuma jalur frekuensi berlesen. Oleh itu, pembangunan 60 GHz antena adalah satu isu yang penting di dalam sistem. Tesis ini memberi tumpuan kepada reka bentuk vivaldi antipodal antena (APVA) di 60GHz untuk komunikasi tanpa wayar. Antena wayarles direka dengan membandingkan prestasi dengan menggunakan tiga jenis substrat bahan yang Silikon, Ferro A6s dan Duroid 5880. Parameter untuk dilihat dalam karya ini termasuk "return loss", "gain" corak radiasi, "directivity" dan lebar jalur antena. Prestasi antena simulasi dengan menggunakan CST studio gelombang mikro dengan kekerapan frekuensi di antara 50GHz untuk 70GHz. Perubahan dalam prestasi antara tiga jenis bahan substrat dibincangkan dengan lebih lanjut di dalam tesis ini. Dari hasil simulasi, nilai "return loss" adalah seperti hasil yang diingini di mana ia perlu kurang daripada -10dB untuk tiga jenis substrat digunakan. Daripada ketiga-tiga substrat digunakan, Ferro mempunyai prestasi antena yang lebih baik di mana ia mempunyai -19dB "return loss", "directional radiation pattern", dan lebar jalur yang lebih luas yang menjadikan ia sesuai untuk digunakan sebagai 60GHz antena untuk komunikasi tanpa wayar

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| ABBREVIATION | DESCRIPTION |
|---|---|
| APVA | Antipodal Vivaldi Antenna |
| TSA | tapered Slot Antenna |
| BW | Bandwidth |
| CST | Computer Simulation Technology |
| dB | Decibel |
| dBi | Decibel per isotropic |
| FNBW | First Null Beamwidth |
| HPBW | Half Power Beamwdith |
| VSWR | Voltage Standing Wave Ratio |
| UWB | Ultra-Wideband |

# CHAPTER 1

# INTRODUCTION

## 1.0 Introduction

This chapter will give an overview of the project such as project introduction, project problem statement, and project objective, and project scope, project important and summary of this project. This chapter will explain briefly about the work from the beginning until the project is implemented.

## 1.1 Wireless Communication

Wireless technology is a fast growing technology in a communications industry where all people all over the world nowadays are using it without any doubt. Basically, wireless communication is transferring of data or information from one place to another via any electronic devices that was connected to it without the help of any wire. By using this communications system, people can get connected to internet everywhere and anywhere. There are many advantages of wireless communications. First, it is global coverage where communications can be reach where wiring is invisible or costly for example in rural area. Old buildings or even in outer space. Furthermore, there is a roaming in wireless communications system to allow the

flexibility to stay connected anywhere anytime. With all of this criteria, it really show that wireless communication is having a great demand in public for it mobility and flexibility. [33][47]

Antenna is very important component in communication systems. Antenna or less likely known as aerial is a metallic structures that is used to radiates and receive electromagnetic waves between the transmission line and free space. According to IEEE, they defines the antenna as the transmitting and receiving system that radiate and receive radio waves. The electrical signals of the antenna will be feeding into an electronic devices system such as radio, television, and telephone. Then the electrical signals turns into radio waves where it can travel up to thousand kilometers until it receive to its suitable receiver appliances or user. Antenna need to be tuned to a certain frequency where the frequency must be the same with the radio system which it is connected with. [15][46]

## 1.2 Project Background

The purpose of this project is to design Antipodal Vivaldi antenna for 60 GHz wireless communications. Design of antenna is using microstrip technology since it is beneficial as low weight antenna configurations. The size of antenna is design to be operate at the frequency of 60 GHz. The design antenna and the chosen parameter to manufacture the proposed antenna will be simulate using the Computer Simulation Tools (CST) software.

## 1.3 Problem statement of the project

Antenna is a mandatory equipment for transferring the information and data in wireless communications. For modern wireless communications, it is required to be in small in size, low weight, directivity pattern and the most important is wide bandwidth. [9] Nowadays, 2.4GHz and 5GHz or known as Wi-Fi is rapidly starting running out of spectrum because of the traffic or user who connected to it. The congestion issue occurred because mostly one person will have one or more than two devices connected to the internet. Even, IEEE expected that by the year of 2018, there will be more than

10 Exabyte of traffic which means it is almost exceed the bandwidth of the current antenna for wireless communications.[17] Furthermore, there is also the mutual interference problem in the ultra-wide band where the 2.4 GHz frequency is overlaid with the 5GHz frequency. [40] Thus people nowadays are demanding for the better and higher data rate for wireless communications.

Thus, it is indeed to implement a 60GHz antenna for better wireless communication because 60GHz antenna can works better where it have a higher data rates. It can deliver unprecedented data rates from 7Gbps up to 28Gbps. With the higher data rates, it can allow the uncompressed HD media transfer and allow the instantaneous access to massive libraries of information. With all of these importance, it is expected to replace the books, paper media and also computer hard drive. Furthermore, with the very small size of antenna, it is easy to be use as on chip even in to be used in our smartphone and other small electronic appliances.[2][18]

## 1.4 Objectives of the Project

a) To design and simulate Vivaldi antenna by using CST Studio Suite Software.
b) To analyze the performance of antenna when using different type of substrate.

## 1.5 Scope of the project

The main purpose of this project is to design Antipodal Vivaldi antenna for wireless communication at 60GHz. The design focusing on the directional antenna. The efficiency of the antenna will be focusing on simulation of radiation pattern, gain, bandwidth, and return loss. The project design is simulated and tested by using CST Studio Suite Software.

I. To design and simulate antipodal Vivaldi antenna of wireless communication at the frequency of 60GHz.

II. To evaluate the performance on antenna :

- Directional radiation pattern
- Gain more than 2dB
- Bandwidth more than 1GHz
- Return loss less than -10dB

III. To analyze the performance of antenna when using different type of substrate which are:
- Silicon
- Duroid 5880
- Ferro A6s

## 1.6 Brief Explanation on Methodology

Methodology is the methods used in collect the data and the flow of process use in the thesis to ensure the project run successfully. In primary stage, it started with literature review of the related topics. In one project, literature review is important to discuss all the project's information in a particular subject area so that the researcher get the idea on how their project is going to work as well as gaining knowledge. All the information of literature review is being extracted from the journals from IEEE, books, articles and from the established website.

Then, the designing and simulation process will be done by using CST Software in order to observe and measure the antenna parameters. The dimension of antenna will later be modified so that it will meet the specifications of this project. Lastly, analyze the results in term of the performance of the antenna.

## 1.7 Thesis Outline

Chapter 1 – briefly explains about background of project and antenna design. This part including problem statements, objectives of the project, scope of works, methodology and flow chart used in completing the project.

Chapter 2 – came along after chapter 1 is completed. In this chapter, it discusses on the literature review where it includes all the research and technical papers related with this project. Past research included the results, formulas and antenna parameters based on antenna design. Then, enclosed of chapter 2 will be implemented in the next chapter.

Chapter 3 – describing the complete methodology that is used in project implementation. Methodology part discussed about the formulas related to the antenna design so that it will meet all the desired specifications.

Chapter 4 – the presentation of all the data and results get from the simulation using CST software. All of the results and finding will be detailed observed and discussed in this chapter. The results also will be recorded.

Chapter 5 – suggestions and future works based on the completed project. This will sum up all the conclusion of the process occurs throughout completing this thesis report.

# CHAPTER 2

# THEORY AND LITERATURE REVIEW

## 2.0 Introduction

The literature review is one of the developer's methodologies to enhance the understanding of the field research for the developer. Besides that, literature reviews are made for the support of the arguments that are made during this research. Apart from that, the literature review is carried out in order to enable the reader to refer to this section if there is confusion and misunderstanding of some of the terms that are found throughout this research

## 2.1 Antenna Definition

Antenna is a must component used in a communications system as without the antenna, the user are not able to receive any information needed. Basically, antenna is a metallic structures that radiates and receives electromagnetic waves between the transmission line and free space. IEEE has defined antenna is a transmitting and receiving system that radiate and receive radio waves. In order for the antenna to work efficiently, it need to be tuned to a specific frequency according to their applications that it wish to work for or the radio waves can neither be emitted nor captured effectively. At the transmission part, a radio transmitter will applies a tuned radio

frequency to the terminals of the antenna. Then, the antenna will radiates the electromagnetic waves in the form of energy from the antenna itself. While in the receiver part, the antenna will deflects electromagnetic wave power to produce a radio frequency at its terminal that is applied to the receiver for amplifying and demodulating the signals. Somehow, the antenna can be used for both transmitting and receiving or neither receiving only nor transmitting only. In a simple understanding, the signal will turn to electrical energy, then the electricity will flow into the transmitter of antenna and this makes the electrons wiggle up and down where will produce radio waves. The radio waves then will travels at the speed of light through the air. When the waves reached at the receiver antenna, the electrons inside it will vibrate which produces an electric current that turns to its original signal.[4][11][15]

There are various type of antenna that commonly used in the industry and each of the antenna is designed for its specific applications. Antenna can be classified into certain categories such as their applications, operating frequency, design or according to their parameter performance of the antenna. Usually, the antenna is categorized into directional and non-directional antennas. Directional antenna are basic dipoles and monopoles while non directional antenna consists of arrays of elements or use one active elements and several passive element such as Yagi antenna. Somehow, with modern technology nowadays, antenna being developed in many designs and pattern due to their response to direction of transmitting and receiving signals.

## 2.2 Category of Vivaldi antenna

Vivaldi antenna are categorized into three types which are conventional Vivaldi antenna, unbalanced antipodal Vivaldi antenna, and balanced antipodal Vivaldi antenna. These three type of Vivaldi antenna is the improvement from one type to another type. It was invented by Gibson in 1978 in UK. Then, he proposed a paper entitled 'The Vivaldi Aerial' that was first discussed in 1979 IEEE European Microwave Conference paper. Peter Gibson believes Vivaldi antenna is easy to fabricate and can provide a wide bandwidth which is suitable for high frequency antenna. Figure below illustrate the patent images of three types of Vivaldi antenna.

### 2.2.1 Conventional Vivaldi Antenna

Vivaldi antenna also known as Tapered Slot Antenna (TSA). The design of Vivaldi antenna is basically smooth flaring from a narrow slot over the center conductor transition region to wide aperture at the board edge. Conventional Vivaldi antenna were constructed by conventional microwave lithographic thin film technique on the substrate that having a high dielectric constant such as alumina. (us). Basically, the old invented Vivaldi antenna were tapered notch having notches which open in an exponential flare shape. The exponential flare shape is used to maintain a requirement for a constant beamwidth antenna. However, using the other types of curves such as sinusoidal, parabolic, hyperbolic and polynomial curves is being implemented for approximations to constant beamwidth antenna.

Notch is a slot open at one end formed in the conductive layer and the gap between the sides of the slot widens from minimum at closed end of the slot to maximum at the open end. Closed end of the slot also known as "stub" where the stub can be designed in a circular shape with a diameter one quarter wavelength of center frequency in order to increase the bandwidth on the antenna. The antenna are fed by a transmission line such as microstrip line, stripline and fin lines at the closed end of the notch. The gap in the antenna is mirror symmetrical about an axis through the center of the slot. The flared is very important in this antenna design since it act as an effective radiating element.[48]]

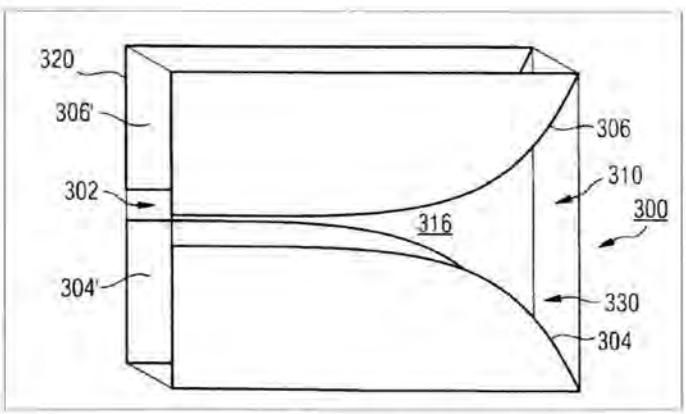


Figure 2.1: Conventional Vivaldi antenna [48]

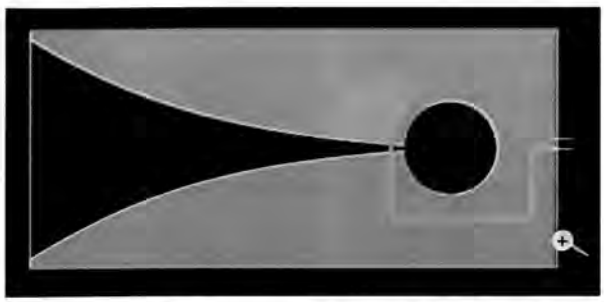

Figure 2.2: Conventional Vivaldi antenna [48]

### 2.2.2 Antipodal Vivaldi Antenna

Antipodal Vivaldi antenna was being implemented and studied by W. Nester in 1985 and continued by E. Gazit in 1988. This type of antenna was implemented in order to solve the feeding problem in the conventional Vivaldi antenna where it is fed from a twinline. One of the layers or wing of Vivaldi antenna is printed on top while the other one which is tapered in opposite direction is printed on the bottom of the substrate. Due to the arrangement of the first and second wings, from a point of view right angles to the plane of substrate, we can see there is a flare shaped slot as shown in figure 2.3. [48]

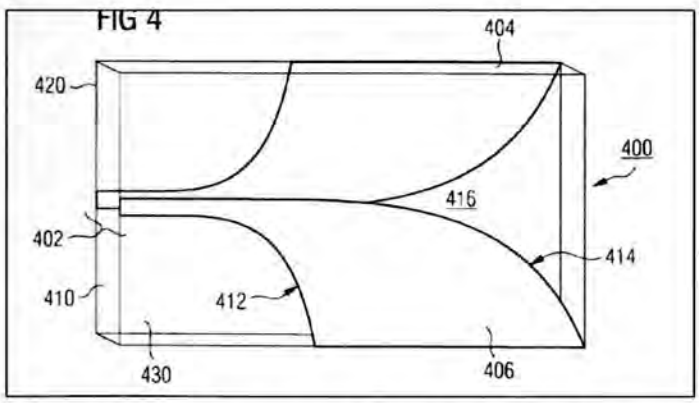


Figure 2.3: Antipodal Vivaldi antenna [48]