THE DESIGN OF ANTIPODAL VIVALDI ANTENNA USING GRAPHENE

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This Report is submitted in Partial Fulfilment of Requirements for The Bachelor Degree of Electronic Engineering (Wireless Communication)

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APPROVAL

This report is submitted to the Faculty of Electronic and Computer Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronic Engineering (Wireless Communication). The member of the supervisory committee is as follow:

Signature : ……

Supervisor‟s Name : MR. AZMAN BIN AWANG TEH

Date :

DEDICATION

"In the Name of Allah, the most Beneficent, the Most Merciful"

Special dedication to my family, especially my father and mother

(Hasim Bin Brahim and Jaa'rah Binti Sahider)

Thank you for your endless love, support and believe in me.

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ABSTRACT

This thesis is focused on the design of Antipodal Vivaldi antenna (APVA) by compared the performance of the Ultra Wideband antenna (UWB) using two type of material which is graphene and copper as the patch of the antenna. The parameters to be improved in this thesis are included reflection coefficient (S11), gain, radiation pattern, realized gain and directivity of the antenna. The results of the performances of APVA are only covered by the simulation of the design using CST Studio Suite Software. Two APVA with different materials are designed using CST software with the ranges of operating frequency between 1 to 15 GHz. The change in performances between the two types of material will be discussed in this thesis. From the simulation results, the value of return loss is achieving the aim which to be less than -10 dB, as both graphene and copper based APVA obtain the S11 with the value of -25.704 dB and -25.535 dB respectively. The gain of the APVA is 4.915 dB (graphene) and 4.882 dB (copper) which also achieving the goals of more than 4.5 dB gain to be achieved. Besides that, both of the antennas are radiate at directional radiation pattern with the value of the realized gain of 4.903 dB for graphene and 4.870 dB for copper based APVA. The value of directivity is 5.882 dBi is recorded via simulation for both materials used in the design of APVA. At the end of the project, an optimized APVA are design with the respected desired results.

ABSTRAK

Tesis ini memfokuskan kepada reka bentuk antenna Antipodal Vivaldi (APVA) yang membandingkan prestasi Ultra Jalur Lebar (UWB) yang menggunakan dua jenis bahan material iaitu graphene dan tembaga. Parameter utama yang dipertingkatkan dalam tesis ini adalah pekali pantulan (S11), keuntungan, corak radiasi, keuntungan direalisasikan, dan keuntungan, direktiviti. Keputusan prestasi APVA hanya merangkumi simulasi Reka bentuk menggunakan perisian PC Suite Studio CST. Kedua-dua antenna ini direka berdasarkan teknik kajian parametrik yang beroperasi pada julat frekuensi 1 hingga 15 GHz. Berdasarkan keputusan simulasi, nilai pekali pantulan untuk kedua-dua APVA berjaya mencapai sasaran iaitu kurang daripada -10 dB dimana antenna menggunakan material graphene mencapai keputusan -25.704 dB sementara untuk antenna yang menggunakan tembaga memperoleh sebanyak -25.535 dB. Selain itu, keputusan bagi keuntungan juga berjaya mencapai matlamat melebihi nilai 4.5 dB dimana graphene memperoleh 4.915 dB manakala 4.882 dB untuk material tembaga. Justeru, kedua-dua antenna yang dicipta melalui perisian CST ini turut berjaya menghasilkan corak sinaran secara direksional dengan nilai keuntungan direalisasikan 4.903 dB (graphene) dan 4.870 dB (tembaga). Nilai bagi direktiviti yang direkodkan melalui simulasi adalah 5.882 dBi bagi kedua-dua material yang digunakan. Pada akhir projek ini, satu APVA yang dioptimumkan berjaya direka berdasarkan nilai-nilai yang dijangkakan.

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LIST OF ABBREVIATION

Abbreviation	Description
APVA	Antipodal Vivaldi Antenna
AUT	Antenna Under Test
BW	Bandwidth
c	Velocity of Light in a vacuum
CST	Computer Simulation Technology
dB	Decibel
dBi	Decibel per isotropic
e_c	Conduction efficiency
e_d	Dielectric efficiency
e_r	Radiation efficiency
e_t	Total Radiation Efficiency
E	Electric
EIRP	Equivalent Isotropic Radiated Power
FCC	Federal Communications Commission
FNBW	First Null Beamwidth
FR4	Flame retardant 4
GHz	Gigahertz
H	Magnetic
HPBW	Half Power Beam Width
THz	Terahertz
UWB	Ultra- WideBand

CHAPTER I:

PROJECT INTRODUCTION

1.0 Introduction

In developing of communication system nowadays, ultra-wideband (UWB) antennas are widely designed and developed for medical and military purposed. The antennas usually being proposed in radar application for detect the images in greater accuracy and more efficient. Referring to the Federal Communications Commission (FCC) standards, an antenna is known as UWB antenna as it is reaching the range of spectrum from 3.1- 10.6 GHz [1][8][15][24]. Therefore, such antenna must be compact in size as well as less weight for portability at both transmitter and receiver [2].

The Antipodal Vivaldi Antenna (APVA) is having the suitable features suit the characteristics of the UWB design characteristics as it is classified as Tapered Slot Antenna (TSA). It is explained as an endfire travelling wave antenna which exhibits a wide beam width and moderately high directivity [3]. Besides that, antipodal Vivaldi antenna has some other advantages such as low lobe level, high gain and adjustable beam width. The stripline tapered notch is the first TSA presented in the industry.

1.1 Problem Statement

Antenna is an integral component of a radio communications system. An antenna connected to a transmitter is the device that releases RF energy (in the form of an electromagnetic field) to be sent to a distant receiver [3]. Therefore, an improvement

on the parameter of antenna required to obtain the optimized value of the reflection coefficient, gain, beamwidth, realized gain and directivity are required. However, the improvements in the parameter leads to manufacturing complexity by the used of dielectric rod in order to increase gain and increase the substrate layer for directivity which will also leads to the increments of cost of the production of an antenna.

In the other hand, the capabilities of APVA antenna that built from copper are required to be improving by using graphene. Graphene is a material which has the ability of a better conductivity compared to copper. With such characteristic, the process of data transfer could be upgrade up to terahertz (THz) [2] [4] [24].

1.2 Objective:

a) To simulate the Antipodal Vivaldi antenna (APVA) by using CST Studio Suite software.
b) To analyze the reflection coefficient, gain, radiation pattern, realized gain and directivity over the parameter of APVA.
c) To observe the variance in performance of 2 type of materials used in the design of antenna (copper and graphene).

1.3 Scope

The scope of this project is covered the design of antipodal Vivaldi antenna by varying the dimension of the antenna.. Since the antenna is used for radar communication system, so it is focusing at the range of frequency from 1 to 15GHz. Thus, the project is focusing on Tapered slot Antipodal antenna (TSA) type. To compare the performances between copper and graphene materials, the design of different range of antenna dimension such as the minor tapered length, antenna length, thickness of patch, width of wings and stripline width are varied as parametric study. It is crucial so that a different number of results could be obtained for better materials presentations. Therefore, before proceeding with the project a

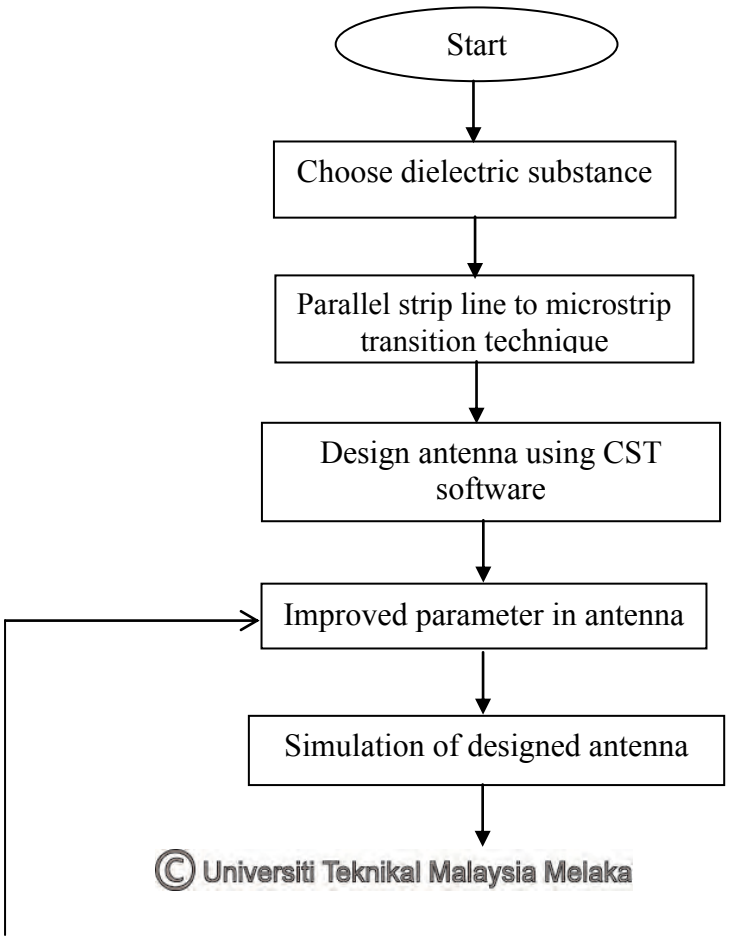
parametric study is made to get the optimize design of the antenna. These projects only cover on CST software simulation.

1.4 Methodology

The methodology are stated the flow of process use in the thesis. The flow of this thesis is started with making a literature review of the related topics. The literature are done by referring various types of sources such as books, technical journal, articles, website as well as the technical reports related to the following topics of AVPA. The literature review is done so that the researcher getting the idea and knowledge of the design and the parameter of the antenna so that the processes of designing are easier to understood.

Then, the designs related were simulated so that the antenna parameters could be observed and measured. The dimension of the antenna will later be modified accordingly so that it meets the specification of this thesis. The designs of the antenna are completely using CST Microwave Studios.

1.5 Flowchart of the project



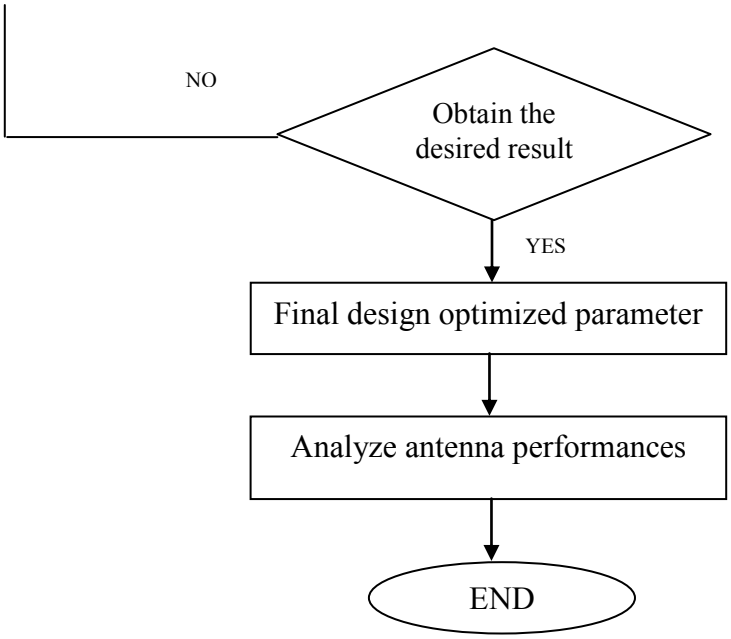


Figure 1.1 Flowchart of the project

1.6 Thesis Outline

Thesis outline is stating contains of the thesis. This thesis is consisting of five chapters that covered all the research works of the design of APVA.

a) Chapter I are introducing the surface of the project. This is including a brief introduction of the APVA design. At this part of the thesis, the problems statements, objectives of the project, scope of works, methodology, and flow chart of the methodology used in the project are also stated.

b) Chapter II came along after chapter I is completed. Chapter II briefings the literature review of design concerning about the study for the research and the design technique that is related of this project. Then, encloses of Chapter II will be implemented at the next chapters of the thesis.

c) Chapter III is describing the complete methodology that be used in the project implementation. The methodology is discussing about the design and simulation of the APVA by using CST Software. The related

parameter such as gain, realized gain and directivity will be discussed thoroughly in this chapter.

d) The findings of the final design of APVA are deliberated at chapter IV. All of the results of simulation will be observed and discuss in this chapter. The results will also be recorded and explained at the chapter.

e) Lastly, Chapter V will sum up the conclusion of the process occurs along the thesis. Hence, this part will also conclude and provide the suggestion for the future development of the research of the related project.

CHAPTER II

LITERATURE REVIEW

2.0 Introduction

Antennas are the main component of most of the wireless communication system. Antenna allows the process of sending and receiving signal within the devices at certain distance. Referring to the IEEE Standards, the term of the antenna are define as means for the purposed of radiating or receiving of the radio waves at free space [6] [14]25] [26]. There are a lot of antenna parameter that can be measured such as return loss, gain, radiation pattern, Half-Power Beamwidth (HPBW), First-null Beamwidth (FNBW), directivity, and efficiency. This parameter is very important as they are used to characterize the types and the performance of an antenna. There are various types of antenna that commonly used in the industry. Each of the antennas is design for different types of application. The antenna can be classified in two main families which is microstrip and planar antennas structure. Figure 2.1 below shows the types of antenna structures.

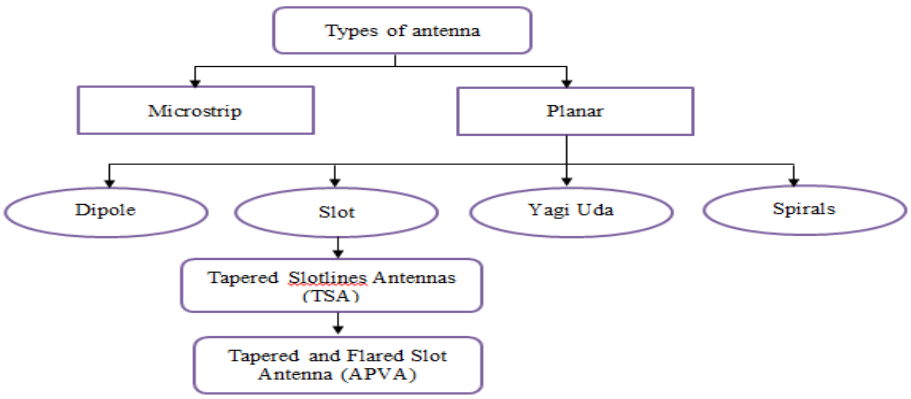


Figure 2.1 Types of antenna

2.1 Category of Vivaldi Antenna

APVA is the antenna that born from the improvement of Conventional Vivaldi antenna which is invented by Peter Gibson in the year of 1978, in United Kingdom [4]. TSA are having the Transverse Electromagnetic (TEM) stripline mode where a number of voltages are excites across the gap of the notch of the antenna. Figure below are illustrating the patent images of the three types of Vivaldi antenna:

2.1.1 Conventional Vivaldi antenna

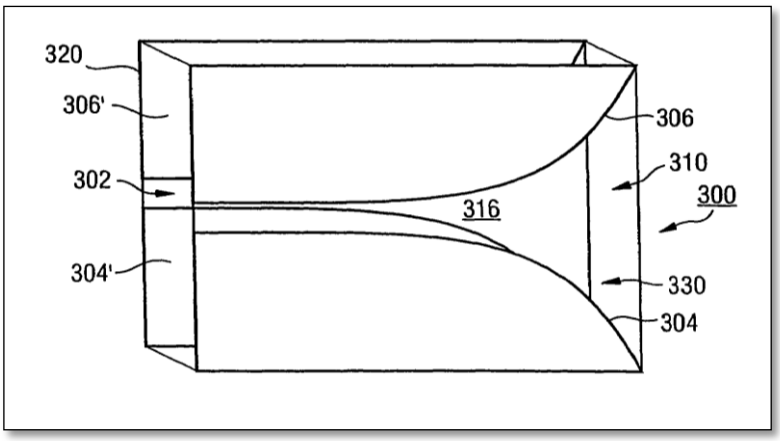


Figure 2.2 Conventional Vivaldi antenna

The design of the Conventional Vivaldi antenna is basically smoothly flaring from a narrow slot over the center conductor transition region to a wide aperture at the board edge. An open circuit terminated at the center of the conductor by some distance beyond the slot. The antenna is stimulates by a slot line and the taper shape are design by using the equation:

$$x = (az + b)\, e^{mz} \quad \text{.... (Eqn 2.1)}$$

Where the value of a, b and m are constant. The equation can also be used to design the Antipodal Vivaldi and Balanced Antipodal Vivaldi antenna.

2.1.2 Antipodal Vivaldi antenna (APVA)

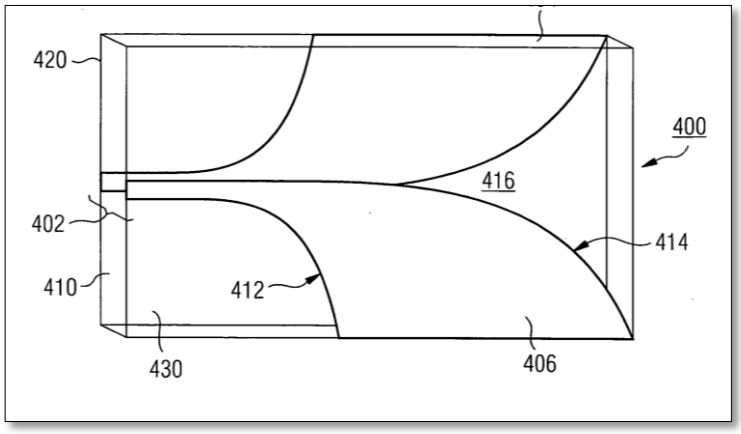


Figure 2.3 Antipodal Vivaldi antenna

To solve the feeding problems in the Conventional Vivaldi antenna, APVA are being introduced and studied by W. Nester in 1985 and the effort continued by E. Gazit in 1988 [6]. In the design, APVA is formed on a symmetric tapered radiating slot is formed by two arms printed on opposite surfaces of a dielectric substrate. Based on "Ultra-wideband Antennas and Propagation for Communications, Radar and Imaging" *(*2007) written by Allen, APVA is formed by exponentially tapering the inner and outer edges of the slot line conductors of the radiator. The antipodal Vivaldi antenna comprises tapered radiating slot and feeding transition. The feeding transition consists of a 50Ω microstrip line exponentially tapered to a parallel strip line to feed the tapered slot radiator, whereas the ground trace is exponentially tapered [5].

2.1.3 Balanced Antipodal Vivaldi antenna

Lastly, Balance Antipodal Vivaldi antenna was introduced by Langley, Hall and Newham in the year of 1996 [7]. The improvement in this radiator is by adding one layer of metallization, to balance the stripline structure. As the result, the cross polarization could be reduced by using this method. Besides that, the radiation of the radiator feed can possibly be reduced by the creation of triplets‟ stripline in the