INVESTIGATE AND OPTIMIZE THE VIVALDI ANTENNA FOR ULTRA-WIDEBAND APPLICATIONS

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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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Universiti Teknikal Malaysia Melaka

JUNE 2016

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : INVESTIGATE AND OPTIMIZE VIVALDI ANTENNA FOR ULTRA-WIDEBAND APPLICATION

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To my beloved friends and family. Thank you my supervisor and all lecturers who guide me, and to all my friends for giving me mentally and moral support during process of finish final year project.

ACKNOWLEDGEMENT

I would like to express my deepest appreciation to all those who provided me the possibility to complete this report. A special gratitude I give to my supervisor, Madam Norbayah Binti Yusop and co-supervisor, Dr. Mohd Azlishah Bin Othman who had given me many learning opportunities throughout the preparation of this report. Besides giving me suggestions, they had also helped me to coordinate my project, especially in writing this report. I am highly indebted to Madame Norbayah for her guidance and constant supervision as well as for accessing my progress and also for her support in completing this report.

Furthermore, I would also like to acknowledge with much appreciation of my friends for providing decent suggestions and necessary information during the completion of this report.

I have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals. I would like to extend my sincere thanks to all of them. Last but not least, I would like to thank my parents and family for their support financially and emotionally.

ABSTRACT

An exponentially tapered slot line antenna named the Vivaldi is studied in this thesis. This antenna has Ultra-Wideband (UWB) characteristics and is used in applications ranging from feeds reflectors to microwave imaging. In this project, a Vivaldi antenna with different dimensions of feedline and substrate are designed and presented. The optimization of Vivaldi antenna used to improve the basic antenna parameters. Besides that, the Antipodal Vivaldi antenna is studied and modified in order to improve the return loss and gain of the antenna. The Computer Simulation Technology (CST) software is used in design the antenna. The proposed antenna will cover the frequency range from 3.1 GHz to 10.6 GHz. The characteristics of UWB antenna will be proved from the radiation pattern of the proposed antenna.

Keywords: Ultra-Wideband, Antipodal Vivaldi Antenna, return loss, gain

ABSTRAK

Dalam tesis ini, antena jenis garis slot tirus yang bernama Vivaldi telah diperkenalkan. Antenna tersebut mempunyai ciri-ciri Ultra Wideband (UWB) dan digunakan dalam aplikasi antara julat frekuensi UWB contohnya dalam pengimejan microwave. Pelbagai jenis dimensi dari segi feedline dan substrat untuk antena Vivaldi telah direka dan dibentangkan dalam tesis tersebut. Antena Vivaldi yang telah beroptimum tersebut untuk meningkat asas parameter antena dari segi return loss dan gain. Selain itu, perisian Computer Simulation Technology (CST) telah digunakan dalam mereka antenna tersebut. Antena yang telah dicadangkan meliputi julat frekuensi dari 3.1 GHz ke 10.6 GHz. Ciri-ciri antena UWB telah dibukti dari segi corak radiasi bagi antena tersebut.

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LIST OF ABBREVIATION

UWB	**-**	**Ultra-Wideband**
FCC	**-**	**Federal Communications Commission**
PSD	**-**	**Power Spectral Density**
CST	**-**	**Computer Simulation Technology**
HPBW	**-**	**Half Power Beamwidth**
VSWR	**-**	**Voltage Standing Wave Ratio**
TSA	**-**	**Tapered Slot Antenna**
BAVA	**-**	**Balanced Antipodal Vivaldi Antenna**

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

In this chapter, Vivaldi antenna for Ultra Wideband (UWB) application will be discussed. The Ultra Wideband technology also will be briefly explained. A summary and the aim of this project will also be presented and discussed in this section.

1.2 BACKGROUND

Nowadays, the speed of expanding technology in this generation become faster compare to pass decade. The limitation of frequency spectrum become the factors in expanding of technology due to the innovation of new applications. The Ultra Wide Band is introduced to overcome this problems. UWB is a technology which transfer the data at low spreading of radio energy. The transmission of data has very low power spectral densities over the wide band frequencies. This low power spectral densities is useful in the limitation of interference between the radio systems. Due to the higher or wider bandwidth, a very high data throughput is allowed for the communication devices with high precision for location or imaging devices [1]. Ultra Wideband radio transmission is a revolutionary approach in wireless communication field in the sense that it transmits and receives pulse based waveforms compressed in time domain rather than frequency domain like traditional radio transmission. Figure 1.1 briefly explained the difference between traditional narrow band systems which usually uses periodic sinusoidal signal for communication to an UWB system which uses narrow time domain pulse which spans over a very wide frequency band.

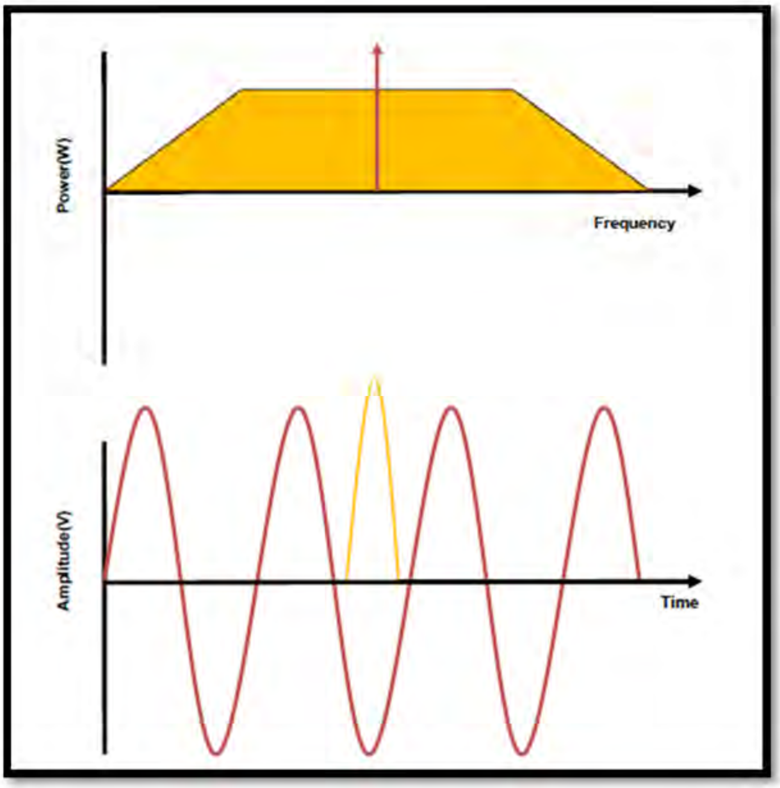

Figure 1.1 Difference between compressed signals in time domain

to the one expanded in time domain [2]

Due the introduction of UWB technology, the frequency spectrum allocation become the important factor to the vendors. Thus, the Federal Communications Commission

(FCC) has allocated the unlicensed frequency band in the range of 3.1 GHz to 10.6 GHz for UWB applications in February 2004. The allocation of the unlicensed band giving benefits to the UWB technology. Due to this factor, there is a lot of investors being attracted from various fields and opened the doors for the development of numerous daily life applications based on the UWB technology.

In addition, the UWB technology is referred to the application which has an absolute bandwidth more than 500 MHz. In other words, it can be said the system has a relative bandwidth of greater than twenty five percent. For example, an UWB signal centred at 2 GHz would have a minimum bandwidth of 500 MHz and minimum bandwidth at 4 GHz would be 1 GHz. This large spread in frequency domain results in low level of power spectral density (PSD) as depicted in Figure 1.2. This low level of PSD ensures the peaceful coexistence of UWB systems with narrowband systems operating in the same frequency range [3].

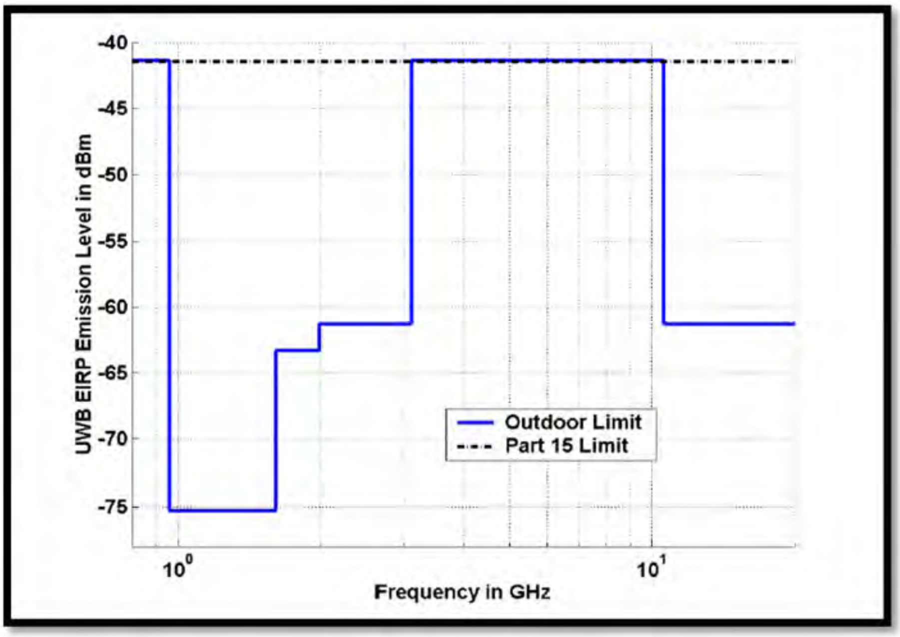

Figure 1.2 FCC spectral masks for outdoor unlicensed UWB emission [3]

UWB system has wide impedance bandwidth, steady directional or omnidirectional radiation pattern, constant gain in desired direction, constant desired polarization, high radiation efficiency, linear phase response, Small size, low profile and embeddable, low cost and low complexity (installation, fabrication, materials and maintenance). UWB systems operate at low power transmission levels; channel capacity is proportion to the bandwidth.

Due to the characteristics of the UWB antennas, this project had been focused on Antipodal Vivaldi antennas. Antipodal Vivaldi antenna is one of member of taper slot antenna which functioning as end fire and traveling wave antenna to produce a directive radiation or omni-directional radiation pattern. The wider pattern bandwidth and impedance will make the Vivaldi antenna as a traveling wave antenna. Besides that, the Printed Vivaldi antennas are easy to fabricate, having no highly sensitive dimensional tolerances. In theoretical, the Vivaldi antenna can be said has an infinity absolute bandwidth, but it will limits by its physical size and the fabrication capability. In practice, one of the main bandwidth limitations is the microstrip feeding technique.

1.3 PROBLEM STATEMENT

There are a few types of UWB antenna that widely used in wireless application. P.J. Gibson was the first introduced Vivaldi antenna since 1979. There are 3 main categories of Vivaldi antenna: Coplanar, Antipodal and Balanced antipodal that common use in UWB application. After few years, the researchers were modified the co-planar Vivaldi antenna by using different methods. The aim of the modification antenna was to improve and optimize the antenna parameters. Besides, the shape and the dimension of exterior surface of antenna will effect on the radiation field. In order to achieve the UWB frequency, a larger size of antenna will be used. The S11 parameter known as reflection coefficient or return loss is represents how much power is reflected from the antenna. If S11 is 0 dB, all power is reflected from the antenna and there is no radiated power. However, S11 is -10 dB, this implies that 3 dB of power is delivered to the antenna while -7 dB is reflected power. [8] Thus, it is important to improve the return loss more than -10 dB in order to get greater antenna gain. In other words, the lower gain of antenna will bring to the increase rate of losses during transmission. The narrower bandwidth is due to the weakness of microstrip patch antenna. Further, the radiation field of the antenna depends on the shape and dimension of exterior surface. In order to achieve UWB frequency, larger size antenna will be used.

1.4 SIGNIFICANCE OF STUDY

The Vivaldi antenna is a member of the class of aperiodic, continuously scaled and end-fire travelling wave antenna structures. It has the advantage of infinite operating bandwidth due to its exponentially flares. In practice, it can provide multioctave operation and is therefore designed under class of UWB antennas. These antennas are used for several applications such as satellite communication systems, radio astronomy, microwave imaging, feeds for reflectors and wide-band phased array systems. Due to its smaller size, low cost, ease to fabricate and no highly sensitive dimensional tolerance, it has been widely explored in UWB technology. In future, the antennas of wireless applications in UWB will replace with Vivaldi antenna because of its advantages. It can be further explore to achieve higher frequency band and the applications.

1.5 OBJECTIVES OF STUDY

The aim of this project is to investigate and optimize the Vivaldi antenna for UWB applications. In order to achieve this, some of the objectives need to be an accomplished:

i. To identify the limitation of key parameters for conventional Vivaldi antenna.

ii. To improve the return loss and gain of antenna.

iii. To analyse the simulation results at specific frequencies.

1.6 SCOPE OF PROJECT

The objective of this project is to optimize the Vivaldi antenna for UWB application. Before design an optimization antenna, firstly we have to do the research on the Vivaldi antenna in UWB technology. The research is based on the journals from the internet and library. The focus of this project is to design, simulate, analyse and compare the simulation results in order to produce an optimize antenna. The software will be used in design and simulation the antenna is Computer Simulation Technology (CST). There is few types of Vivaldi antenna is determined through journals from previous researchers. From the journals, the shape of slot antenna, type of substrate and antenna parameter will be analysed. Besides that, the improvement technique that used for the antenna parameter is determined from the journals. A parametric study is applied to design the optimization of Antipodal Vivaldi antenna in higher gain with miniature size of the antenna. In addition, Roger RT 5880 is chosen as a substrate with dielectric constant of 2.2.

1.7 THESIS OUTLINE

This thesis introduces the investigation and optimization of Vivaldi antenna for UWB application. This overall project will be discussed in five chapters.

In Chapter 1 describes the general idea of the project which includes the problem statement and project background. The objectives and the scopes of the project are listed. A short and precise methodology also describes so that objectives can be achieved.

In Chapter 2 introduces the literature review about the previous research of UWB technology and Vivaldi antenna. The theories of the antenna will be discussed in this chapter.

In Chapter 3 describes a flow of the steps and methodology based on the time frame. The modified antenna is designed using CST software. A different dimensions of feedline and substrate are used in the designed which to differentiate from previous researchers.

In Chapter 4 describes the simulation results will be analysed at specific frequencies. In the simulation results, a comparison between the changes of designed antenna will be discussed.

In Chapter 5 describes the project outcome. The overall conclusion on the project achievement will be mentioned in this chapter. The recommendation for the future work also will be described.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this section, the related previous work done by the researcher will be analysed and discussed. Besides, the related theoretical part is being explained in detail. This will help to enhance the understanding of this project and contribute towards the completion of the project. The previous works done by researchers is one of the factors for design this project.

2.2 BASIC ANTENNA PARAMETER

Antenna is a device which radiates or receives electromagnetic waves. The antenna is the transition between a guiding device and free space and it is used to convert the energy of guided wave as efficiently as possible or vice versa. Basically, the antenna parameters are concerned on radiation pattern, impedance bandwidth, directivity, efficiency and gain.

2.2.1 RADIATION PATTERN

Radiation pattern is provided the information of how an antenna is directing the energy. In far-field region, the researcher can indicate the properties of antenna through its propagation pattern. The propagation pattern of the radiated wave is illustrated in radiation pattern. The position of any particular point in this region has its own direction and can determine the directivity of the radiated wave. In radiation field, electric field and magnetic field are used in determined the pattern. The magnitude of both fields can be expressed in dB scale.

In Figure 2.1, the shapes and direction of the lobes are shown in three dimensional coordinates system. The x-z plane is indicated the elevation plane whereas the x-y plane is indicated the azimuth plane.