UNIVERSITI TEKNIKAL MALAYSIA MELAKA

AN ANALYSIS OF DS-UWB VIVALDI ANTENNA WITH LOW RADAR CROSS SECTION (RCS) FOR STEALTH PURPOSES

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering (Wireless Communication)

by

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This report submitted in partial fulfilment of the requirements for the award of Bachelor of Electronic Engineering (Wireless Communication) With Honours

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PROJEK SARJANA MUDA II

Tajuk Projek : AN ANALYSIS OF DS-UWB VIVALDI ANTENNA WITH LOW RADAR CROSS SECTION (RCS) FOR STEALTH PURPOSES

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I hereby, declared this report entitled "AN ANALYSIS OF DS-UWB VIVALDI ANTENNA WITH LOW RADAR CROSS SECTION (RCS) FOR STEALTH PURPOSES" is the results of my own research except as cited in references.

Signature	:	………………………………………………
Author's Name	:	WAN NUR AQILAH BINTI WAN AHMAD KHAIRUDDIN
Date	:	5TH JUNE 2014

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	:	DR. MOHD AZLISHAH BIN OTHMAN
Date	:	5^{TH} JUNE 2014

DEDICATION

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

Special Dedication to my family and especially my parents
(Wan Ahmad Khairuddin Bin Wan Abdullah and Madznah Binti Yaacob)

To my supervisor Dr. Mohd Azlishah Bin Othman

,

My friends, my fellow bosses and my colleagues

Thank you for all your care, support and believe in me.

ACKNOWLEDGEMENT

Alhamdulillah, apart from this effort, the project entitled "An Analysis of DS-UWB Vivaldi Antenna with Low Radar Cross Section (RCS) for Stealth Purposes" is successfully done within the time given for the course of Bachelor in Electronic Engineering of Wireless Communication as eligible for the Bachelor. I would like to take this opportunity to express my sincerest gratitude to the people who have been given their support in accomplishing this project. First and foremost I am grateful and would like to acknowledge expose my gratitude to my project supervisor, Dr. Mohd Azlishah Bin Othman for tirelessly providing me guidance and advice in accomplishing my project and thesis. I am indebted to all the lecturers who has teach me since I entered to Universiti Teknikal Malaysia Melaka for giving me a stimulating and pleasant environment in which to learn and grow. I also would like to thanks Universiti Teknikal Malaysia Melaka for providing me facilities to carry out my project and to complete this work. My utmost thanks to my families who have gave me support throughout my academic years for their blessings, love, dream and sacrifice throughout my life. I acknowledge the sincerity of my family who consistently encouraged me to carry on my studies until this level. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals. Not to forget to all my friends and course mates that has provided whether an idea or support, I tremendously acknowledge their direct or indirect supports and help. Last but not least, special thanks to all individuals who have directly or indirectly offered help, suggestions and support in bringing towards the completion of this project. Thank you so much.

ABSTRACT

This project was executed in order to design DS-UWB Vivaldi Antenna with Low Radar Cross Section (RCS) for Stealth Purposes at frequency between 6 GHz-10 GHz. The antenna was designed by considering the ideal requirements of a wireless antenna which is lightweight, small in size, low profile and can be used off-ground for the ease of mobility. Vivaldi antenna is a planar travelling wave antenna with endfire radiation which antenna consists of radiating and feed structure. Various types of radiating structure have been discussed included tapered slot Vivaldi antenna, antipodal Vivaldi antenna and balanced antipodal Vivaldi antenna. For the final design, the radiating structure was designed by using antipodal Vivaldi antenna. In the last part of this work, the optimum designs of Vivaldi antenna were fabricated and measured. The antenna were simulated by using CST Microwave Studio and fabricated on FR4 board. From the simulation and measurement results obtained, both antennas could operate efficiently at the designated frequency with return loss less than -10dB. The gain of Vivaldi antenna are 4.747dB respectively.

ABSTRAK

Projek ini dijalankan bertujuan untuk merekabentuk DS-UWB antipodal Vivaldi antena untuk Low Radar Cross Section (RCS) untuk aplikasi sistem stealth yang beroperasi pada 6 GHz hingga 10 GHz. Rekabentuk antenna ini mengambil kira ciri-ciri seperti ringan, kecil, dan sengang dibawa kemana-mana bagi memenuhi spesifikasi yang diperlukan untuk di integrasikan pada alatan yang mengaplikasikan wayarles. Vivaldi antena adalah sejenis antena yg berstruktur planar dan menguluarkan radiasi pada arah slot runcing antena tersebut. Di dalam tesis ini, beberapa struktur radiasi antena termasuk Taper Slot Antenna, Antipodal Vivaldi Antenna, dan Balanced Antipodal Vivaldi Antenna. Antena ini direka bentuk menggunakan perisian CST Micwave Studio dan di fabrikasikan ke atas papan FR4. Daripada keputusan simulasi dan pengukuran antena tersebut, dapat beroperasi dengan baik pada frekuensi yang telah ditetapkan dengan kehilangan balikan yang kurang dr -10dB. Kuasa penambahan untuk Vivaldi antena yang berstruktur planar adalah 4.747dB.

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LIST OF ABBREVIATION

RCS	–	Radar Cross Section
AUT	-	Antenna Under Test
BW	-	Bandwidth
c	-	Velocity of Lights In a Vacuum
CSWA	-	Constant Width Tapered Slot Antenna
CST	-	Computer Simulation Technology
D	-	Directivity
dB	-	Decibel
dBi	-	Decibel per isotropic
E	-	Electric
e_c	-	Conduction Efficiency
e_d	-	Dielectric Efficiency
EIRP	-	Equivalent Isotropic Radiated Power
e_r	-	Radiation Efficiency
e_t	-	Total Radiation Efficiency
FNBW	-	First-Null Beamwidth
FR4	-	Flame Retardant 4
G	-	Plane Ground Size
Gp	-	Power gain
GTest	-	Gain of Antenna Under Test
GHz	-	Gigahertz
H	-	Magnetic
h	-	Substrate Thickness

HPBW	-	Half-power Beamwidth
IEEE	-	Institute of Electrical & Electronics Engineers
ISM	-	Industrial, Scientific and Medical
L	-	Length of Antenna
mm	-	Milimeter
MHz	-	Megahertz
MwS	-	Microwave Studio
NT	-	Navigation Tree
p	-	Magnification Factor
PR	-	Power Receive
PRad	-	Radiation Power
PRef	-	Reference power
PTest	-	Power receive by Antenna Under Test
RF	-	Radio Frequency
RFID	-	Radio Frequency Identification
SMA	-	SubMiniature version A
SW	-	Slot Width
$\tan\delta$	-	Dissipation Factor
T	-	Metallization Thickness
TSA	-	Tapered Slot Antenna
U	-	Radiation Intensity
U_o	-	Radiation Intensity at Maximum
Vph	-	Phase Velocity
VTSA	-	Vivaldi Tapered Slot Antenna
W	-	Width of Antenna
W_A	-	Slot width at radiating area
W_E	-	Input Slot Width
W_o	-	Output slot width
WiMAX	-	Worldwide Interoperability for Microwave Access
W_S	-	Slotline Width
x	-	Length parameter

y	-	Half separation Distance
Z_o	-	Characteristic Impedance
ε_r	-	Substrate Dielectric Thickness
λ_o	-	Free space wavelength
Ω	-	Ohm
^{o}	-	Degree
%	-	Percent

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CHAPTER I

INTRODUCTION

1.0 Introduction

Vivaldi antipodal antenna is used for Direct-Sequence Ultrawide Band (DS-UWB) frequencies, which is from 6 GHz to 10 GHz. The advantages of a Vivaldi antenna such as simplicity, wide bandwidth, and high gain at microwave frequencies. This Vivaldi antenna is a planar travelling wave antenna with endfire radiation. P.J.Gibson in 1979 was first proposed this types of antenna [1]. The origin of the name "Vivaldi" is not really known but the name was commonly associated with Antonio Vivaldi, a composer from the Baroque period.

It is believed that Gibson named it after Antonio Vivaldi as he listened to Vivaldi's "Four Season" when he designed the antenna. The improvements to the initial design have been introduced in later years by E.Gazit in 1988 which he utilized an antipodal structure [2], and followed by balanced antipodal structure by Langley, Hall and Newham in 1996 [3].

Nose cone of the aircraft is to treat areas of radar detection, the distribution of electromagnetic antenna system's fire control in this area is normally very strong, which is a result of the importance of stealth antenna designs. Vivaldi antennas are widely used in the fire control system for wide bandwidth and small physical dimensions. Therefore, stealth Vivaldi antenna design is highly desirable in many airborne applications [4].

This is when Vivaldi antenna comes into view in which it have unlimited operating frequency range with constant beamwidth over broadband which could be used as a future antenna for the next generation high-speed wireless networks. Being a directional antenna, it could improve the capacity of wireless system and co-channel interference and also reduce multipath effects.

Moreover, it also possess a characteristics that is perfect for multifunction communication devices such as excellent impedance matching, low interference, do not require tuning elements, low profile, and unobtrusive [5].

The basic form of the antenna as shown in the figure. 1.1. The antenna consists of a feedline, stripline or microstrip normally, the transition from the feedline to a balanced stripline and slotline or radiating structure. Radiating expo-mental structures are tapered, the examples of the parabolic curve, hyperbolic or elliptical can be seen in [6].

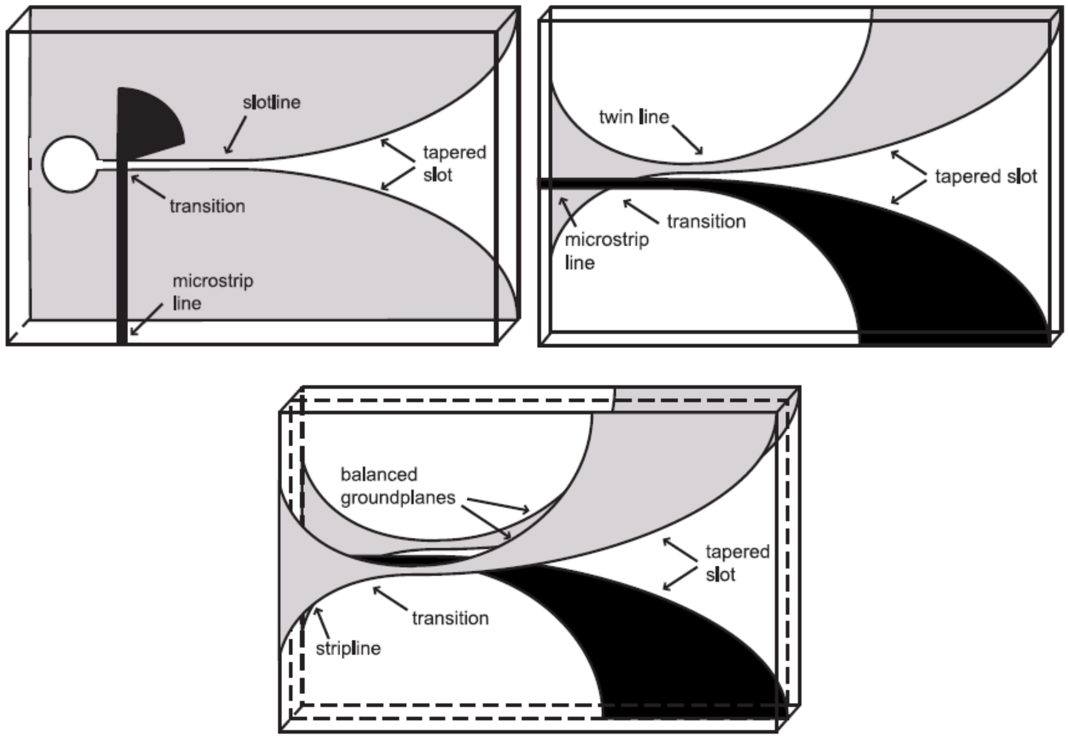

Figure 1.1 Types of Vivaldi Antenna [37]

1.1 Problem Statement

In general, high signal attenuation may results at higher operating frequencies; thus, a costly power amplifier will be needed to improve the Equivalent Isotropic Radiated Power (EIRP) [4]. Alternatively, a directive antenna like Vivaldi antenna can also be used to improve the EIRP instead of power amplifier. As the size of antenna increases with directivity and operating frequencies, a solution is seek as to design Vivaldi antenna that could operate at higher frequencies but smaller in size, lightweight and can be used off-ground for the ease of mobility.

Radar cross section (RCS) of a conventional antenna can be very large making it an easy target to pick on the basis of radar systems. If the antenna is placed in the stealth