

AN ANALYSIS OF VIVALDI RCS ANTENNA AT 6GHZ FOR SATELLITE
COMMUNICATION

ETTIE ATHIRA BINTI HADLIN

This Report Is Submitted In Partial Fufillment Of Requirement For The Bachelor of
Degree of Electronic Engineering (Wireless Communication)

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka

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June 2015

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DECLARATION

I hereby, declared this report entitled 'An Analysis of Vivaldi RCS Antenna at 6GHz for Satellite Communication' is the results of my own research except as cited in references.

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Signature



Supervisor's Name : Dr. Mohd Azlishah Othman

Date

17/6/15

To my beloved parents and family, Supervisor, and all my friends for their continuous support, advice, and guidance to complete this final year project.

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

All praises are due to ALLAH SWT who had given blessing, strength, and knowledge in finishing this final year report entitled “ An Analysis of RCS Vivaldi Antenna at 6GHz for satellite communication system”.

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ABSTRACT

This project is conducted to reduce the large RCS of conventional antenna by using stealthy design. Many methods have been proposed to reduce the radar cross section (RCS). However, the reduction of RCS will increase the complexity of an antenna system or degrade the antenna performance. The main objective for this project is to develop the Vivaldi RCS Antenna by using the suitable method to reduce the RCS and analyze these antenna performance in simulation and measurement fabrication. To obtain the simulation result, the antenna was designed on the CST 2014 Software. While, FR-4 was used to implement the hardware fabrication. This project only covers the frequency in C-band range (4-8GHz) and the resonant frequency at 6GHz. Antenna performances that will be discussed in this report are the value of gain, return loss, bandwidth, and radiation pattern.

ABSTRAK

Projek ini dijalankan untuk mengurangkan keratan rentas radar (RCS) dengan menggunakan teknik bentuk. Banyak kaedah telah dicadangkan untuk mengurangkan keratan rentas radar (RCS). walau bagaimanapun, pengurangan RCS akan meningkatkan kerumitan sistem antena atau menjejaskan prestasi antena. Objektif utama projek ini adalah untuk membuat Vivaldi RCS Antena dengan menggunakan kaedah yang sesuai untuk mengurangkan RCS dan dianalisis prestasi antena ini dalam simulasi dan pengukuran fabrikasi. Untuk mendapatkan hasil simulasi, antena telah direka pada perisian CST 2014. Walaupun FR-4 telah digunakan untuk melaksanakan fabrikasi perkakasan. Projek ini hanya meliputi frekuensi dalam julat C-band (4-8GHz) dan frekuensi salunan pada 6GHz. Antena yang dihasilkan akan membincangkan nilai keuntungan, kehilangan gelombang semasa menghantar data, dan corak sinaran.

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LIST OF ABBREVIATIONS

CDMA	-	Code Division Multiple Access
CST	-	Computer Simulation Technology
EBG	-	Electronic Band Gap
FR4	-	Fire Retardant 4
FSS	-	Frequency Selective Surfaces
HPBW	-	Half Power Beamwidth
PCB	-	Printed Circuit Board
PEC	-	Printed Electronic Circuit
PSS	-	Phase Switched Screen
RAM	-	Random Access Memory
RCS	-	Radar Cross Section
VSWR	-	Voltage Standing Wave Ratio

CHAPTER I

INTRODUCTION

1.1 Introduction

Antenna is an electrical devices that convert the electric power into a radio waves and vice versa. There are many type of antenna such as wire antenna, long periodic antenna, travelling wire antenna, aperture antenna, reflector antenna, microstrip antenna and other antenna. Vivaldi antenna is the planar antenna that can provide the ultra wide bandwidth. Vivaldi antenna was firstly invent by P.J Gibson and was discussed in IEEE European Microwave Conference paper on 1979 [2]. Sometime, vivaldi antenna are known as tapered slot antenna (TSA) or vivaldi notch antenna. This antenna are type of fire control system and widely used in remote sensing, wireless communication, ground penetrating radar, and microwave imaging. Vivaldi antenna was classified into three main categories which is coplanar vivaldi antenna, antipodal vivaldi antenna and balanced antipodal vivaldi antenna [9]. Vivaldi have an broadbandwith and small physical dimension. Thus, the stealth design of an antenna is recommended

As a development of the detection technology today, a reduction of a low radar cross has gain an interests. There are many technique can be used to reduces

RCS, but the reduction of the RCS can cause degradation of the radiation antenna and make antenna more complex. This effect from the degradation can cause

the shifting of the resonance frequency, the value of the gain decreased and narrow for the frequency bandwidth[2].

1.2 Objective of the Project

The main objectives of this research is to design and analyze the vivaldi RCS antenna at frequency of 6 GHz for the satellite communication, to develop the vivaldi RCS antenna by using the suitable method to reduces the RCS and to analyze the performance of Vivaldi RCS antenna at 6GHz.

1.3 Problem Statement

Recently day, the detection and stealth technology is rapidly growth and cause the attention to the reduction of radar cross sectional area. However, the the RCS reduction will lead to the degradation of an antenna performances and increase the complexity of an antenna. The effect by the degradation of antenna performances is narrow bandwidth, the value of the gain decrease and shifting the resonance frequency. In addition, antenna is a special scatter and difficult to balance the reduction of RCS simultaneously with the good of antenna radiation performances.

1.4 Scope of Project

The scope of this project is to design and analysis of the RCS Vivaldi antenna at 6 GHz (range in the C-band frequency). Those following below are scope of this project:

- i. Literature review

Firstly, to start this project all the theory and related information like antenna parameter, design process, design structure of the RCS vivaldi antenna was studied

by referring to various type of source such as journals, letters, articles, books, and technical report that regarding to the fundamental of the antenna.

ii. Calculation

Some calculation and equation are needed to find the parameter of this antenna. This is important before the designing the antenna in simulation part.

iii. Simulation and design process

The simulation process was done by using the Computer Simulation Technology (CST) Microwave Studio Suite 2014 [7]. The operated frequency of RCS antenna at 6 GHz (in the range of freuency in the C-band which is in the range 4GHz-8GHz).

iv. Fabrication

The optimum design of RCS Vivaldi antenna was fabricate on the FR4 printed circuit board by using the technique of chemical etching.

v. Test analysis and measurement

Transient Solver was used for conduct simulation to anlyze the antenna performances. The antenna parameter like gain, return loss, and radiation pattern was measured. To get the desired antenna performances, some modification such as, the length and tapered slot of the antenna have been make [7].

1.5 Thesis Outline

For the part of the thesis outline, it will covered five chapter. Chapter 1 is an introduction. In this chapter, it will include the background of this project, the objective of project, problem statement, and scope of the project in terms of planning schedule.

In chapter 2, topic that will be discuss is literature review. This is a theoritically part and explained about the basic of Vivaldi antenna and method that can be used to reduce the RCS.

For chapter 3, it covered the design of the Vivaldi antenna. It includes the design structure, design parameter, design process, and measurement process.

Next is chapter 4, in this chapter it discussed and explain about the result obtain, analysis of the result and discussion. The last last chapter for this report project is chapter 5. This chapter will conclude all about this project and give some rcommendation for the future work

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

This chapter about the literature review, which is the first step before conduct this project. All the data of the performances antenna that get from the various type of source like journal, technical report, and letter was analyze. There are several method that can be used to reduces an RCS Vivaldi antenna. For an example, a novel stealth design, half mode substrate integrated waveguide, a novel wideband radar with absorbing material, using a Phase switched screen (PSS) boundary, and use EBG structure [2]-[6]. All of the method were analyzed according to the result that had published in each of the individual paper that include the antenna parameter and reduction of a RCS.

The outcome from the literature review give an idea how to reduce the RCS antenna with the best method that can be use. In addition, from the literature review it give knowledge about the antenna especially for RCS antenna. Figure below show the organization chart for category of antenna[11].

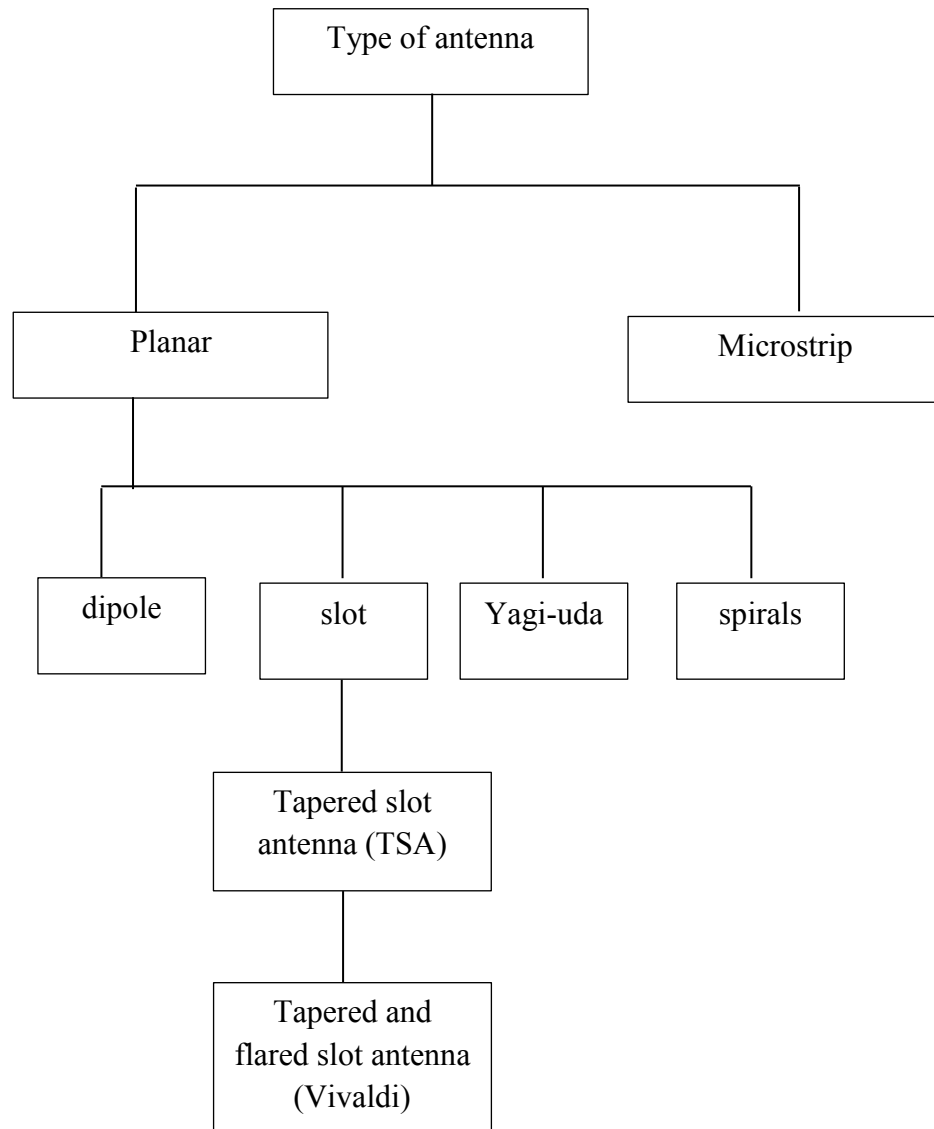


Figure 2.1: Organization chart for category antenna

2.2 Method to reduces RCS of an Antenna

From the several research from the technical jurnal, there are a few method can be used to reduces RCS. Those following below are listed method to reduces the RCS:

2.2.1 A novel stealth design

This method is based on the current distribution and scatering analysis. The metal was modified to achieved maximally 19.2 dBsm RCS reduction [2]. Two

symmetrical ellipses was cut out from the metal patch to reduce the RCS. However, when the ellipses were cut too big from the metal patch it can cause high side lobe and dispersive gain in wide frequency range. To overcome this problem a rectangle strip is placed. This method is an effective method to reduce RCS for Vivaldi antenna. However, this method also has potential for another type of antenna such as microstrip antenna. Besides that, the gain achieved by using this method is 4 dB and the return loss is only slightly larger and can be further improved by impedance matching.

2.2.2 Half mode substrate integrated waveguide

This design method is the first design method used for Vivaldi antenna to reduce the RCS. The method can reduce the RCS as much as 24 dB compared to traditional methods. This method modified the Vivaldi antenna by making a hole. The holes are made between the two rows of the metallic patch [3]. The advantages of using this technique are, no degradation on the antenna performances and more easy to design it on bilateral Vivaldi antenna without the degradation on antenna performances. In addition, from the voltage standing wave ratio (VSWR) the bandwidth produced by this method is also wider.

2.2.3 A novel wideband radar with absorbing material

Another method that can be used to reduce RCS for Vivaldi and Yagi-Uda antenna is by using absorbing material with frequency selective surfaces (FSS). FSS are widely used to reduce the RCS for narrowband antenna but rarely used for a wideband antenna. To reduce the RCS, wideband RAM was integrated at the ground plane of an antenna [4]. This method is rarely used for wideband. However, substantial reduction of an antenna gain may be produced by lossy ground with RAM. This technique can maximally reduce the RCS to 16 dB at the operating frequency 7.9 GHz. Even though this method is efficient and more easy to implement for end fire antenna, it can degrade the antenna performances like decreasing the value of the gain [3]. In addition, according to Hong Kyu Jang [2] another weakness of using this method is the operating band is almost unchanged.