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

ETTIE ATHIRA BINTI HADLIN

This Report Is Submitted In Partial Fulfillment 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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Sedang Pengajian: 14/15

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Signature: [Signature]

Supervisor’s Name: Dr. Mohd Azdishah 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.
ACKNOWLEDGEMENT

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 conduct to reduced the large RCS of conventional antenna by using stealthy design. Many methods have been proposed to reduces 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 reduces the RCS and analyzed 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 cover the frequency in C-band range (4-8GHz) and the resonant frequency at 6GHz. Antenna performances that will discuss in this report is the value of gain, return loss, bandwidth, and radiation pattern.
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<td>CDMA</td>
<td>Code Division Multiple Access</td>
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<tr>
<td>CST</td>
<td>Computer Simulation Technology</td>
</tr>
<tr>
<td>EBG</td>
<td>Electronic Band Gap</td>
</tr>
<tr>
<td>FR4</td>
<td>Fire Retardant 4</td>
</tr>
<tr>
<td>FSS</td>
<td>Frequency Selective Surfaces</td>
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<td>HPBW</td>
<td>Half Power Beamwidth</td>
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<tr>
<td>PCB</td>
<td>Printed Circuit Board</td>
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<tr>
<td>PEC</td>
<td>Printed Electronic Circuit</td>
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<tr>
<td>PSS</td>
<td>Phase Switched Screen</td>
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<tr>
<td>RAM</td>
<td>Random Access Memory</td>
</tr>
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<td>RCS</td>
<td>Radar Cross Section</td>
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<td>VSWR</td>
<td>Voltage Standing Wave Ratio</td>
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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, the detection and stealth technology is rapidly growth and cause the attention to the reduction of radar cross sectional area. However, 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 frequency 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 analyze 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 theoretically 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 recommendation 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].
2.2 Method to reduce RCS of an Antenna

From the several research from the technical journal, there are a few methods that can be used to reduce RCS. Those following below are listed methods to reduce the RCS:

2.2.1 A novel stealth design

This method is based on the current distribution and scattering analysis. The metal was modified to achieve maximally 19.2 dBsm RCS reduction [2]. Two
symmetrical ellipses was cut out from the metal patch to reduces the RCS. However, when the ellipses was 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 place. This method is an effective method to reduces RCS for Vivaldi antenna. However, this method also 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 improve by impedance matching.

2.2.2 Half mode substrate integrated waveguide

This design method is the first design method use for Vivaldi antenna to reduce the RCS. The method can reduces the RCS as much as 24 dB compare to traditional method. This method modified the vivaldi antenna by making a hole. The holes is make between the two rows of the metallic patch [3]. The advantages by using this technique is, 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 bandwith produces bt this method also more wider.

2.2.3 A novel wideband radar with absorbing material

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