DESIGN A HIGH PERFORMANCE ABSORBER TO IMPROVE AN ANECHOIC CHAMBER PERFORMANCE

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Bachelor of Engineering with Honors
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Date

DESIGN A HIGH PERFORMANCE ABSORBER TO IMPROVE AN ANECHOIC CHAMBER PEFORMANCE

CHAI CHOK HUNG

This project is submitted in partial fulfilment of
The requirements for the degree of Bachelor of Engineering with Honours
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Dedicated to my dearest friends and family

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ABSTRAK

Projek ini memperkenalkan cara menghasilkan penyerap gelombang mikro yang berharga rendah, berkeupayaan tinggi dan mempunyai prestasi yang baik untuk digunakan pada ruang tanpa gema atau lebih di kenali sebagai “Anechoic Chamber”. Penyerap gelombang mikro yang dihasilkan akan digunakan pada julat frekuensi 3GHz ke 15GHz. Banyak kaedah dan cara telah dikaji ke atas keupayaan penyerapan gelombang mikro pada penyerap ini. Penyerap gelombang mikro ini diperbuat menggunakan polistrene di mana ia di potong dalam bentuk piramid. Untuk meningkat pretasi penyerap ini, serbuk arang telah dicampurkan dengan cat air. Sebelum model penyerap gelombang mikro ini dibuat, pada mulanya direkacipta dan disimulasi dengan menggunakan perisian “Computer Simulation Technology” di mana pretasi dan keupayaannya dikaji. Akhir sekali, keputusan pretasi penyerap buatan ini dibandingkan dengan penyerap gelombang komersil yang terdapat di Makmal Antenna, Fakulti Kejuruteraan UNIMAS. Penyerap yang telah dihasilkan diberi nama penyerap gelombang mikro kos rendah. Ciri utama penyerap gelombang mikro ini adalah kadar penyerapan yang tinggi terhadap gelombang mikro dan mudah difabrikasi dengan kos yang rendah.

ABSTRACT

This project presents the design of low cost, reliable and good performance microwave absorber for application in anechoic chamber. The absorber is designed to be functioning at frequency range from 3GHz to 15GHz. Different methods were investigated in term of signal absorption of the absorber. The absorbers are made from polystyrene, which were cut into pyramidal shape. The absorber is coated with charcoal mixed with water based paint where it can increase the absorption capability of the absorber. Before the real absorbers are fabricated, the absorber is first designed and simulated using Computer Simulation Technology software to monitor their performances. The measurement of the pyramidal absorber was done to determine its performance. Lastly, the results are compared with commercialized absorber available in the Antenna's Laboratory of Faculty of Engineering, UNIMAS. The absorber that has been developed is called low cost absorber. The major feature of the anechoic chamber absorber in this project is high absorptions rate of microwave signal and easy to be fabricated using low cost materials.

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LIST OF ABBREVIATIONS

AL	-	Aluminum
CAD	-	Computer Aided Design
CST	-	Computer Simulation Technology
Cu	-	Copper
dB	-	Decibel
EMR	-	Electromagnetic Radiation
Fe2O3	-	Ferrite Oxide
G	-	Gram
GHz	-	Giga Hertz
IEC	-	International Electrotechnical Commision
MHz	-	Mega Hertz
MIG	-	Metal Inert Gas
NRL	-	Naval Research Laboratory
PBT	-	Poly-p-phenylene-benzonis-thiazole
RCS	-	Revision Control System
RF	-	Radio Frequency
VSWR	-	Voltage of Standing Wave Ratio

CHAPTER 1

INTRODUCTION

1.1 Introduction

Mobile telecommunication market is one of the most rapid growing markets around the world. Mobile telecommunication has makes the life of the society much easier and faster. For example mobile phone can get a person in touch wherever that person is as long as there is coverage. Nevertheless, for mobile telecommunications system, there are weakness of their own such as the reflection, distortion and scatterings which come from the environment.

Nowadays, telecommunication devices become more complex and need a high frequency in transferring the information. The instruments such as the antenna need to be tested without being affected by the wave reflection [1]. To get a best performance of a telecommunication system, it is better to have an antenna that is working perfectly. Before a good antenna can be manufactured, it must be tested for their performances. The antenna performance is best to be tested in a space which is isolated and the performance of the antenna is not influence by any of the internal reflection or external interference. Antenna measurements are extensively conducted

throughout industry and government test facility. Thus the most suitable place for this testing is the anechoic chamber.

An anechoic chamber is a shielded room designed to attenuate sound or electromagnetic energy. Anechoic chambers were originally used in the context of absorbing acoustic (sound) echoes caused by internal reflections of a room, but more recently anechoic chambers have also been used to provide a shielded environment for radio frequency (RF) and microwaves. Anechoic chambers range from small compartments to ones as large as aircraft hangars [2]. The size of an anechoic chamber depends on the size of the objects to be tested and the frequency range of the radio or microwave signals used. Anechoic chamber is also used in aerospace industry where missiles, aircraft or similar weapon platform are tested for their radar cross section [3].

There are a few type of anechoic chamber such as, acoustic anechoic chambers, semi-anechoic chambers, radio-frequency anechoic chambers and etc. For the anechoic chamber to work effectively, all internal surfaces of the anechoic chamber such as the back wall, the side-wall, the floor and corner of the chamber must be entirely covered with radiation absorbent material which is also known as absorber. Usually, in sound testing, porous and fibrous materials are used which are composed of many fibers or cells, for example glass or mineral-wool, cocos fiber, felt, wood-shaving or porous cellular foam [4].

Two most common absorbing materials that normally are used in electromagnetic wave are the dielectric absorber and the ferrite absorber. They are

used in microwave frequency range and lower frequency range respectively [1]. This project focused on the absorbing characteristics of the absorber. The absorber will be tested with different height, width, and tips. Carbon acts as a lossy material absorbing electromagnetic radiation (EMR) [2]. Before the absorber design and testing is conducted, the absorber is first design using Computer Simulation Technology (CST) software and the characteristic will be analyzed.

Absorbers are design using expanded polystyrene. Expanded polystyrene is a kind of plastic which is made of normally white expanded beads. This polystyrene is very useful in our life such as for protecting the fragile item. This type of polystyrene can be easily obtained from the market and the price is affordable. After the absorber is design in the desired shape and size, it will be painted with the mixture of charcoal and water based paint.

1.2 Objective

The main objective of this project is to produce a simple, cheap and easy to fabricate polystyrene absorber, analyzed with the effect of different height, width, tips and several materials that are to be added to the absorber within the frequency range of 3GHz to 15GHz.

To achieve this objective, there are many procedures and works that will be taken into consideration such as:

1.3 Scope of works

I. Understand the different type of absorber that is used.

II. Design the model that is used for the experiment with the absorber that has different dimension parameter, and material that is mixed.

III. Collect data and info of the absorber and the hazard that is concerning.

IV. Learn some basic knowledge of mobile communication concept.

V. Design the testing area for the experiment to be conducted.

VI. Discuss the best dimension parameter of an absorber.

To perform the experiment, computer, transmitting and receiving antenna, and appropriate absorber will be used. In the experiment, the absorber is supposed to absorb as much as possible the signal energy that is transmitted. Roughly the stage in this experiment is mentioned bellow:

I. Design models using CST with different type of material.

II. Measure the signal absorption of the model with different dimensions parameter.

III. Collect and discuss the result.

IV. Graph will be plotted and analyzed.

V. Result will be analyzed and compared with other researchers findings.

1.4 Project Outline

Chapters 1 give an overview of the project and the objective of the project. Chapter 2 consist of the literature review where it cover the scenario involved in mobile communication especially signal propagation and absorbing properties of the absorber. This chapter also includes the fundamental of absorber material such as polystyrene that are coated and mix with other material together with plywood. This chapter provides the knowledge about absorbing materials that are used and its characteristics towards signal absorption, where the designed parameters of the absorber are also discussed. Chapter 3 discussed the methodology of the project. Experiment and result are explained in Chapter 4. Chapter 5 includes discussions and Chapter 6 covers the conclusion and recommendation after conducting this project.

CHAPTER 2

LITERATURE RIVIEW

2.1 Introduction

This chapter describes a study on several types of chamber, absorber and type according to the purpose of the facility and frequency of operation. Each different type of chamber will use different type of absorber in order to develop a comprehensive absorption of the signal. Two most common type of absorber are the dielectric absorber used in microwave frequency and the ferrite absorber used in the lower frequency range. After working on these of chamber and absorber, many method and ideas raised.

2.2 Anechoic Chamber

"Anechoic chamber" is a place where the whole room has been covered with material that scatters or absorbs much of incident energy in such a way that it can stimulate free space environment. Its origin can be traced to efforts that build aircraft which absorb or scatter radar signal during Second World War [5]. Shielded

anechoic chamber are widely used to provide RF isolated test region to stimulate free-space test environment for measuring antenna. Anechoic chamber provide a controlled environment which is not influence by weather and ambient condition. Anechoic chamber are widely used to measure antennas from various telecommunication links, remote sensing and radar signature [6].

2.3 Anechoic Chamber Design

The design of microwave anechoic chamber began drastically in 1950s. The commercial high performance anechoic absorber became available in 1960s after the concept of microwave anechoic chamber become more practical. In the 1980s, new class of chamber has evolved [1].

2.3.1 Near-field Anechoic Chamber Design

The most important consideration in near-field anechoic chamber is to ensure that the radiating aperture is fully terminated. In other words, the main beam of the antenna must see a load termination of sufficient attenuation that the energy reflected is very much lower with respect to the directed energy [1]. Although there is some other extraneous energy, sampling method must remain.

2.4 Anechoic Chamber Enclosure

The purpose of shielding is to prevent interference and electronic eavesdropping. Type of shielding is depending on the purpose or type of the equipment that are used. For anechoic chamber, moderate shielding would be enough to control the electromagnetic environment. In some other application, high performance shielding is required to protect sensitive equipment from interference. There are a few types of commonly used shielding material such as [1]:

I. Plywood/particleboard panels, copper foil or screen are laminated on one or both sides with various grades of galvanized sheet metal are commonly used for prefabricated enclosure.
II. Metal sheet of various thickness are welded into place on a steel supporting structure.
III. Copper screening mounted to spot soldered and wooden studs.
IV. Contact adhesive is installed with aluminum foil, or moisture-proof sheetrock, which has aluminum foil bonded to one face of the board.
V. Plywood is mounted with galvanized sheet metal that become single-shielded system.

2.5 Electromagnetic Shielding Of Anechoic Chamber

The purpose of shielding the chamber is to prevent outside interference that would disturb the measurement accuracy. There are three types of shielding such as