INVESTIGATION OF MICROSTRIP SIERPINSKI-GASKET FRACTAL ANTENNA FOR GPS APPLICATIONS

MOHD SHAHRIL BIN ALI

This report is submitted in partial fulfillment of requirements for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) with honours

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UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

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ABD SHUKUR B JA'AFAR
Pensyarah
Fakulti Kej Elektronik dan Kej Komputer (FKEKK),
Universiti Teknikal Malaysia Melaka (UTeM),
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Tarikh: 8/05/07

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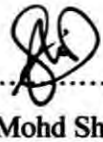
Signature : 

Name : Mohd Shahril Bin Ali

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To All My Lovely Family ...

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ABSTRACT

Nowadays, fractal antenna became more familiar to investigate their behavior to apply in our daily life application, either in internal or external application. It have already proved in many years ago that the fractal shape have their own unique characteristics that improved antenna achievement without degrading antenna properties. This project is about Sierpinski-Gasket patch fractal antenna. This antenna start with equilateral triangular microstrip antenna and then apply the iteration on it geometry structure, maximum iteration that applies to this antenna is three. The behavior of the antenna like return loss, number of iteration, bandwidth and radiation pattern investigated. These antennas usually can't operate to the operating frequency and some modification needed to make sure the antenna resonant close to the operating antenna. Fractal antennas are design to get the multiband frequency, and it is very useful for the daily life application.

ABSTRAK

Pada zaman sekarang, kajian tentang sifat antenna *fractal* untuk diaplikasikan dalam aplikasi harian kita, samada ada untuk aplikasi dalaman atau luaran. Sejak dahulu lagi kajian tentang pencapaian keunikan sifat antenna *fractal* ini telah dibuktikan dan tidak kehilangan ciri-ciri antena. Projek yang dijalankan adalah tentang antena mikrojalur *Sierpinski-Gasket* (antenna tampal). Antena ini disegmenkan sehingga ke iterasi yang ke tiga. Sifat seperti dari segi perubahan kehilangan kembali, bilangan iterasi yang dilaksanakan dan corak sinaran dikaji. Kebiasanya antena tidak dapat beroperasi pada frekuensi operasi dan memerlukan sedikit modifikasi untuk memastikan antena ini dapat resonan pada frekuensi operasi. Antena *fractal* ini direkabentuk untuk menghasilkan pelbagai jalur frekuensi dan ia sangat berguna untuk aplikasi harian kita

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Z_0	-	**Characteristic impedance**
εr	-	**Dielectric constant**
h	-	**Thickness of substrate**
λ_0	-	**Air waveguide**
λ_g	-	**Substrate waveguide**
a	-	**Side length**
aeff	-	**Side length efficiency**
V_n^-	-	**Amplitude of voltage wave incident**
V_n^+	-	**Amplitude of voltage reflected**
[S]	-	**Scattering parameter**
fr	-	**Frequency response**
RL	-	**Return Loss**
BW	-	**Bandwidth**
dB	-	**Decibel**

CHAPTER I

INTRODUCTION

1.1 Introduction

This project presents the Sierpinski Gasket fractal patch antenna where the antenna behaviors are investigated. All the numerical calculation and theoretical design was performed using Moment of Methods (MoM) software (Microwave Office) to obtain design parameters such as size of patch and feeding location. The antennas have been fabricated and tested to see the behaviors.

1.2 Problem statement

Usually antenna only can operate in single band but for the Sierpinski-Gasket fractal antenna it can operate in multiband frequency. This project presents the Sierpinski gasket patch antenna where these famous shapes, the antenna behaviors like return loss, frequency response and radiation pattern will be investigate.

Objective

- To design Fractal Sierpinski-Gasket patch antenna at GPS frequency 1.575 GHz.
- To investigate antenna behavior like multiband, return loss, radiation pattern and etc.

Scope of Project

- Fractal patch antenna (Sierpinski-Gasket).
- The operating frequency for this antenna will operate at 1.575GHz (GPS application).
- Microwave Office software will be used for simulation and expected result, Mathcad for calculation and AutoCAD software for fabrication (etching) process.
- Substrate FR4 their dielectric constant is 4.7, loss tangent 0.019, and thickness 1.6 mm.
- Measurement and testing the antenna properties.
- Comparison between expected and measurement results.

Methodology

This project will start with the understanding of basic Microstrip antenna technology include the property such as radiation pattern, input impedance and operating frequency. The journal, article reviews and reference books include understanding the Sierpinski-Gasket shape for patch antenna type. Start with an equilateral triangle as an initiator with operating frequency at 1.575 GHz (GPS application) it will determine the size of the patch before iteration need to apply. The next step is to choose the relevant material such as RF4. Calculate the characteristics and performance of the antenna. The artwork preparation for fabrication as well as connecting the appropriate connector is the practical implementation carried out after the simulation process. CoralDRAW 12 software being used to get the actual size to print to transparent for design layout antenna for the etching process.

Chapter II

GPS SYSTEM

2.1 GPS (Global Positioning System)

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS. [6]

Figure 2.1: 24 satellite GPS [6]

2.1.1 The GPS satellite system

GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. Essentially, the GPS receiver compares the time a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is. Now, with distance measurements from a few more satellites, the receiver can determine the user's position and display it on the unit's electronic map. A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude). Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time and more.

The 24 satellites that make up the GPS space segment are orbiting the earth about 12,000 miles above us. They are constantly moving, making two complete orbits in less than 24 hours. These satellites are traveling at speeds of roughly 7,000 miles an hour. GPS satellites are powered by solar energy. They have backup batteries onboard to keep them running in the event of a solar eclipse, when there's no solar power. Small rocket boosters on each satellite keep them flying in the correct path.

Here are some other interesting facts about the GPS satellites (also called NAVSTAR, the official U.S. Department of Defense name for GPS) [6]:

- The first GPS satellite was launched in 1978.
- A full constellation of 24 satellites was achieved in 1994.

- Each satellite is built to last about 10 years. Replacements are constantly being built and launched into orbit.
- A GPS satellite weighs approximately 2,000 pounds and is about 17 feet across with the solar panels extended.
- Transmitter power is only 50 watts or less.

2.1.2 What's the signal?

GPS satellites transmit two low power radio signals, designated L1 and L2. Civilian GPS uses the L1 frequency of 1575.42 MHz in the UHF band. The signals travel by line of sight, meaning they will pass through clouds, glass and plastic but will not go through most solid objects such as buildings and mountains. A GPS signal contains three different bits of information a pseudorandom code, ephemeris data and almanac data. The pseudorandom code is simply an I.D. code that identifies which satellite is transmitting information.

Ephemeris data tells the GPS receiver where each GPS satellite should be at any time throughout the day. Each satellite transmits ephemeris data showing the orbital information for that satellite and for every other satellite in the system. Almanac data, which is constantly transmitted by each satellite, contains important information about the status of the satellite (healthy or unhealthy), current date and time. This part of the signal is essential for determining a position. [6]

CHAPTER III

BACKGROUND STUDY

3.1 Microstrip

Microstrip is one of most popular of planar transmission lines, it because it can fabricate by photolithographic and also can integrated with other passive and active microwave device.

3.1.1 Microstrip basic structure

Microstrip structure is a conductor of width W is printed on a thin, grounded dielectric substrate of thickness d and relative permittivity εr. The thickness and type of substrate give a difference results, the thickness of substrate layer can increase the bandwidth and efficiency, but unfortunately it will generate surface wave with low propagation that cause lost of power [2]