SIERPINSKI GASKET PATCH AND MONOPOLE FRACTAL ANTENNA

ABD SHUKUR BIN JA'AFAR

UNIVERSITI TEKNOLOGI MALAYSIA

SIERPINSKI GASKET PATCH AND MONOPOLE ANTENNA

ABD SHUKUR BIN JA'AFAR

A thesis submitted in fulfilment
of the requirements for the award of the
Degree of Master of Engineering
(Electrical-Electronics & Telecommunications)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

MARCH 2005

To My Loving and Caring Family ...

ACKNOWLEDGEMENTS

My first thanks is for my supervisor, Dr. Mohamad Kamal A. Rahim, whose constant support, patience and unbounded enthusiasm were of invaluable help. His devotion to the needs of the students and the encouragements has made working with him a true delight.

My sincere appreciation to my fellow colleagues in the sharing the similar research interests. I value the camaraderie we share as well as the time they spent to share with me enriching ideas, as well as their concern. My gratitude especially goes to Lester Cheung, Mohd Zoinol, Azahari, Abd Hafizh, Mohd Fairus Yusof, and Asrul Izzam for many hours of discussions, as well as assistance during fabrication process.

My sincerest thanks to all those who have helped to make this thesis possible. Warmest regards to my mother, sister, both grandmother and grandfather for their seamless caring encouragement and moral support that has made this journey possible.

ABSTRACT

The use of fractal geometry in designing antenna has been a recent topic of interest. It have already proved that fractal shaped have their own unique characteristics that improved antenna achievement without degrading antenna properties. This dissertation tells about one of familiar geometry in fractal antenna, Sierpinski gasket. Here, two types of antenna are designed: Sierpinski gasket patch and Sierpinski gasket monopole. Maximum iteration that applies to these antennas is three. The behaviors of both type antennas are investigate such as return loss, number of iteration and radiation pattern. Simulation, fabrication and testing have been done. The entire antenna shows multiband in resonant frequencies. For Sierpinski monopole shows a pattern in return loss but not for Sierpinski patch. Monopole type shows the frequency band log-periodically spaced by two, same as the scale factor among the structure (sub-gasket). The self-similarity properties of fractal structure are translated into its electromagnetic behavior.

ABSTRAK

Penggunaan geometri *fractal* di dalam rekabentuk antenna menjadi satu tumpuan sejak kebelakangan ini. Kajian telah membuktikan rekabentuk *fractal* mempunyai sifat yang unik di mana ia membantu pencapaian sesuatu antena tanpa mngurangkan prestasi asal. Disetasi ini membincangkan mengenai salah satu rekabentuk *fractal* yang terkenal iaitu Sierpinski gasket. Di sini, dua jenis antenna direkabentuk berdasarkan geometri Sierpinski gasket iaitu mikrojalur (antena tampal) dan ekakutub. Antenna tersebut disegmenkan sehingga iterasi ketiga. Kelakuan antenna fractal ini dikaji dari segi perubahan kehilangan kembali, bilangan iterasi yang dilaksanakan, dan corak sinaran. Simulasi, fabrikasi dan pengukuran telah dilaksanakan. Kesemua antenna menunjukkan sifat multijalur frekuensi apabila *fractal* dilaksanakan. Bagi jenis ekakutub, kehilangan kembali mempamerkan corak yang boleh dijangka tetapi tidak pada jenis mikrojalur. Jenis ekakutub juga menunjukkan pengulangan berkala jalur frekuensi sebanyak 2 kali ganda , dimana boleh diakitkan dengan struktur rekabentuk gasket antena tersebut. Ini boleh dikatakan rekabentuk kesamaan pada antena tersebut di pindahkan ke kelakuan elektromagnetiknya.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

BW	-	Bandwidth
c	-	Velocity of light
D	-	Directivity
f	-	Frequency
f_o	-	Operating frequency
f_r	-	Resonant frequency
G	-	Gain
h	-	Substrates thickness
S_{11}	-	Return loss
t	-	Thickness of conductor
tanδ	-	Loss tangent
VSWR	-	Voltage standing wave ratio
w	-	Width of feed line
Z_{in}	-	Input impedance.
Z_o	-	Characteristic impedance
Z_L	-	Load impedance
ε_r	-	Relative permittivity
ε_{eff}	-	Effective relative permittivity
σ	-	Conductivity
λ_o	-	Free space wavelength
λ_g	-	Guided wavelength
π	-	3.142

η - Efficiency

LIST OF APPENDICES

LIST OF ABBREVIATIONS

SGFpe1 SGFpd1 SGFm1 SGFm2

S	-	Sierpinski
G	-	Gasket
F	-	Fractal
p	-	patch
m	-	monopole
e	-	edge feed
d	-	direct feed
#	-	version number

RF	-	Radio Frequency
VSWR	-	Voltage Standing Wave Ratio
HPBW	-	Half Power Beamwidth
dB	-	decibel

CHAPTER 1

INTRODUCTION

1.1 Project Background

In modern wireless communication systems and increasing of other wireless applications, wider bandwidth, multiband and low profile antennas are in great demand for both commercial and military applications. This has initiated antenna research in various directions, one of them is using fractal shaped antenna elements. Traditionally, each antenna operates at a single or dual frequency bands, where different antenna is needed for different applications. This will cause a limited space and place problem. In order to overcome this problem, multiband antenna can be used where a single antenna can operate at many frequency bands. One technique to construct a multiband antenna is by applying fractal shape into antenna geometry.

This project presents the Sierpinski gasket patch and monopole antenna where this famous shape, the antenna behaviors are investigated. In addition to the theoretical design procedure, numerical simulation was performed using Moment of Methods

(Mom) software (Microwave Office, ADS) to obtain design parameters such as size of patch and feeding location. The antennas have been fabricated and tested.

1.2 Objective

The objective of this project is to design, simulate and fabricate the Sierpinski gasket patch (microstrip) and monopole fractal antenna. The behavior and properties of these antennas are investigated.

1.3 Scope of Project

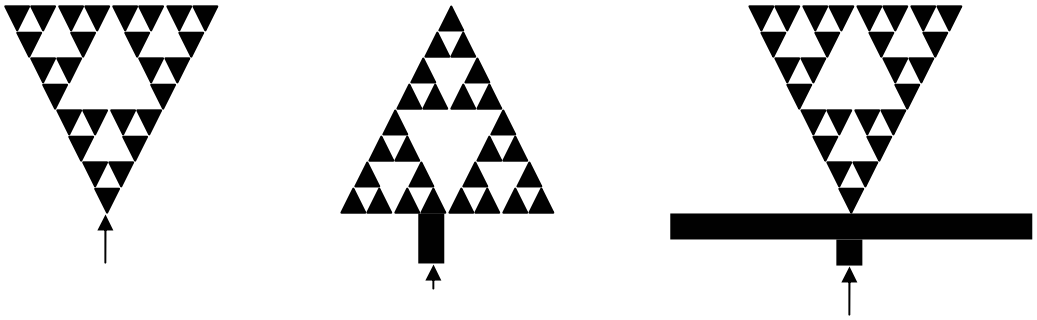
The scopes defined for this project are as follows:

- Understanding the antenna concept.
- Design the equilateral triangle for microstrip at 1.8GHz, and fractal it until 3rd iteration. The same structure will be used for monopole type.
- Performs numerical solution using Microwave Office V6 and Advance Design System (ADS) softwares.
- Practical implementation of the antennas.
- Measurement of the antennas properties.
- Comparison the measurement and simulation results.

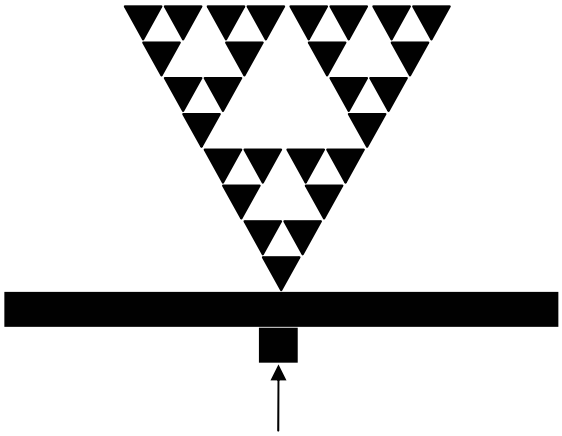
1.4 Project Methodology

The project begins with the understanding of the microstrip antenna technology. This includes the property studies such as the radiation pattern, input impedance and operating frequency. The related literature reviews includes understanding the Sierpinski gasket shape for monopole type. The design of the microstrip Sierpinski gasket starts with an equilateral triangle as an initiator with operating frequency at 1.8 GHz. This will determine the size of the patch before iteration need to apply. The next step is to choose the relevant material such as microwave laminate. The information is used to calculate the characteristics and performance of the antenna. The software used for numerical simulation are Microwave Office V6 and Advance Design System (ADS). The practical implementation is carried out after the simulation process. This involves the artwork preparation for the antenna fabrication as well as connecting the appropriate connector. The knowledge of AutoCAD software is very useful in fulfilling this task. AutoCAD software is chosen to print actual antenna size on transparency for fabrication process. Then the measurement was performed. Comparisons between simulation and experimental results are made.

In this project four antennas have been fabricated. For Sierpinski gasket patch two variations of feeding techniques have been constructed, which is the direct feed and the edge feed. The antennas are named as SGFdf1, SGFef1, SGFm1, and SGFm2. Figure 1.1 shows the geometry of each antenna.



a) SGFef1 b) SGFdf1 c) SGFm1



d) SGFm2

Figure 1.1: Geometry of each antenna.

1.5 Thesis Outline

The thesis is organized into 7 chapters. Chapter 1 presents the overall idea of this thesis including objective, scope of project and project methodology. Chapter 2 presents basic theory antenna theory and properties.

Chapter 3 presents the background or the idea of fractals dimension. The geometry of Sierpinski gasket also has been elaborate here.

Chapter 5 tells about simulation software, fabrication process and testing of the antennas. Chapter 6 presents the result and discussion in detail. The final chapter, Chapter 7 emphasizes on conclusion, recommendations and future works.