

# INVESTIGATION OF SIERPINSKI CARPET FRACTAL ANTENNA

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*To My loving and caring family and also to BENT pioneer student..*

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## ABSTRAK

Antena pecahan sebenarnya menarik banyak minat dan perhatian ramai penyelidik and ahli sains untuk mengkaji dan mencipta antena pecahan ini kerana karakter antenna yang unik yang dikaitkan dengan sifat geometri pechan dan untuk applikasi banyak frekuensi. Kebiasaannya antenna yang berbeza digunakan frekuensi yang berbeza tetapi antenna pecahan ini di cadangkan untuk mengatasi masalah ini menggunakan saiz antena yang kecil untuk beroperasi pada banyak frekuensi. Dalam projeck ini konsep pecahan diaplikasi kepada antena tampalan segiempat sama untuk mencapai operasi banyak frekuensi dan dikenali juga sebagai antena pecahan Sierpinski dari skala lebar jalur 1 GHz hingga 10 GHz. Proses pecahan ini dekenali sebagai pembahagian. Proses reka bentuk antena ini dilakukan menggunakan perisian gelombang mikro dengan mengambil kira teknik pepadanan rintangan dengan pemancar tampalan mikro. Kemudian membuat simulasi untuk melihat kehilangan kembali dan bentuk radiasi antena tersebut. Akhir sekali, melakukan proses membuat antena tersebut menggunakan teknik pembuangan kuprum dan membuat pengukuran antena tersebut menggunakan penganalisa rangkaian di makmal untuk melihat kehilangan kembali.

## ABSTRACT

The fractal antenna has got an intention and interest of many researcher and scientist because of its unique characteristics that are linked to the geometrical properties of fractals. Usually different antennas are needed for different frequency band but study fractal antennas suggest some attractive solution for using a single small antenna operating several frequency bands. In this project the concept of fractal has been applied to the geometry of a square microstrip patch antenna to obtain multi band frequency also know as Seirpinski carpet fractal antenna. This project is to investigate the behavior of the Sierpinski fractal antenna in range of bandwidth 1 GHz ad 10 G GHz. And process has divided into few parts or knows as iteration. The design process of the antenna is using microwave office where it considers on impedance matching network with the micro-strip transmission line feeding. Then make a simulation to see the return loss and radiation patterns of the antenna. Lastly, proceed to hardware development by fabricate this antenna on using etching technique.



## TABLE of CONTENTS

CHAPTER	TITLE	PAGE
	PROJECT TITLE	i
	VERIFYING FORM	ii
	STUDENT CONFESSION	iii
	SUPERVISOR APPROVAL	iv
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTRAK	vii
	ABSTRACT	viii
	TABLE OF CONTENTS	ix
	LIST OF TABLE	xiii
	LIST OF FIGURE	xiv
	LIST OF NOMENCLATURE	xix
	LIST OF APPENDIX	xxi
I	INTRODUCTION	
	1.1 Project Synopsis	1
	1.2 Objectives	2
	1.3 Scope of Work	2
	1.4 Problem Statement	3
	1.5 Project Methodology	5

<b>II</b>	<b>FRACTAL BACKGROUND</b>	
	<b>2.1 Introduction</b>	<b>7</b>
	<b>2.2 Fractal in Nature</b>	<b>8</b>
	<b>2.3 Fractal Dimension</b>	<b>10</b>
	<b>2.4 Fractal Antenna Elements</b>	<b>11</b>
<b>III</b>	<b>ANTENNA THEORY</b>	
	<b>3.1 Introduction</b>	<b>16</b>
	<b>3.2 Antenna Definition</b>	<b>16</b>
	<b>3.3 Types Of Antenna</b>	<b>17</b>
	<b>3.3.1 Wire Antenna</b>	<b>18</b>
	<b>3.3.2 Aperture Antenna</b>	<b>18</b>
	<b>3.3.3 Microstrip Antenna</b>	<b>19</b>
	<b>3.4 Antenna Properties</b>	<b>20</b>
	<b>3.4.1 Input Impedance</b>	<b>20</b>
	<b>3.4.2 Voltage Standing Wave Ratio (VSWR)</b>	<b>21</b>
	<b>3.4.3 Gain</b>	<b>22</b>
	<b>3.4.4 Radiation Pattern</b>	<b>23</b>
	<b>3.4.5 3dB Beam width (half power beam width, HPBW)</b>	<b>24</b>
	<b>3.4.6 Directivity</b>	<b>25</b>
	<b>3.4.7 Bandwidth, BW</b>	<b>26</b>
	<b>3.4.8 Return Loss</b>	<b>27</b>
	<b>3.4.9 Polarization</b>	<b>28</b>

<b>IV</b>	<b>MICROSTRIP ANTENNA</b>	
	<b>4.1 Introduction</b>	<b>30</b>
	<b>4.2 Basic Mirostrip</b>	<b>30</b>
	<b>4.3 Basic Mircostrip Antenna</b>	<b>33</b>
	<b>4.4 Feed Technique</b>	<b>34</b>
	<b>4.4.1 Microstrip Line Feed</b>	<b>34</b>
	<b>4.4.2 Coaxial Feed</b>	<b>35</b>
	<b>4.4.3 Aperture Coupled Feed</b>	<b>37</b>
	<b>4.4.4 Proximity Coupled Feed</b>	<b>38</b>
	<b>4.5 Analysis of Microstrip Antenna</b>	<b>39</b>
<b>V</b>	<b>SIERPINSKI CARPET FRACTAL MICROSTRIP ANTENNA</b>	
	<b>5.1 Introduction</b>	<b>41</b>
	<b>5.2 Sierpinski Carpet Fractal Antenna Design</b>	<b>43</b>
	<b>5.2.1 Determine Antenna Dimension</b>	<b>45</b>
	<b>5.3 Matching Technique</b>	<b>46</b>
	<b>5.4 Design Sierpinski Carpet Fractal Antenna Using Microwave Office</b>	<b>47</b>
	<b>5.5 Sierpinski Carpet Fractal Antenna With First Iteration</b>	<b>58</b>
	<b>5.6 Sierpinski Carpet Fractal Antenna With Second Iteration</b>	<b>61</b>
<b>VI</b>	<b>ANTENNA FABRICATION</b>	
	<b>6.1 Introduction</b>	<b>64</b>
	<b>6.2 Antenna Fabrication Steps</b>	<b>64</b>
	<b>6.3 Return Loss Measurement Equipment</b>	<b>69</b>

<b>VII</b>	<b>RESULT, ANALYSIS, AND DISCUSSION</b>	
	<b>7.1 Introduction</b>	<b>70</b>
	<b>7.2 First Section</b>	<b>70</b>
	<b>7.3 Second Section</b>	<b>74</b>
<b>IX</b>	<b>FUTURE WORK AND CONCLUSION</b>	
	<b>9.1 Conclusion</b>	<b>83</b>
	<b>9.2 Future Work</b>	<b>83</b>
	<b>References</b>	<b>85</b>
	<b>Appendix A</b>	<b>88</b>
	<b>Appendix B</b>	<b>91</b>
	<b>Appendix C</b>	<b>93</b>
	<b>Appendix D</b>	<b>94</b>

**LIST of TABLE**

<b>TABLE</b>	<b>TITLE</b>	<b>PAGE</b>
1	Table VSWR Vs Return Loss	22
2	Comparing the Different Feed Techniques	39
3	The Zero Iteration Result For Simulation and Measurement	71
4	The First Iteration of Return Loss Between The Simulation And Measurement	73
5	The Second Iteration of Return Loss Between The Simulation And Measurement	74
6	Show the Result for Zero Iteration	76
7	The table is summarized radiation pattern for first iteration	78
8	The table is summarized radiation pattern for second iteration	82

## LIST of FIGURE

<b>FIGURE</b>	<b>TITLE</b>	<b>PAGE</b>
1	Sierpinski Carpet Fractal Antenna Zero Stage to Second Iteration	4
2	Project Methodology	5
3	This Landscape Scene Was Created Mathematically Using Fractals	9
4	These Mathematically Generated Plants, Created Using Fractint, Are Good Examples Of How Fractals Can Be Used To Model Complex Geometries Found In Nature	9
5	A Fern Is Example Geometry in Nature That Is Easily Modeled Using Fractal	10
6	Several Stages in the Construction Of A Sierpinski Gasket Fractal	12
7	The First Few Stages in The Construction of a Koch, Snowflake	13
8(a)	Some Common Fractal Geometries Found In Antenna Applications: Koch Snowflakes/Islands. These Are Used In Miniaturized Loop Antennas and Miniaturized Patch Antennas	14

8(b)	Some Common Fractal Geometries Found In Antenna Applications: Koch Curves and Fractal Trees Used In Miniaturized Dipole Antennas	14
8(c)	Some Common Fractal Geometries Found In Antenna Applications: Sierpinski Gaskets and Carpets, Used In Multi Band Antennas	15
9	Antenna Basic Operation	17
10	Wire Antenna Configuration	18
11	Aperture Antenna Configuration	19
12	The Dimensions of the (A) Circular Patch Antenna and (B) Rectangular Patch Antenna	19
13	A Radiation Pattern for Antenna	24
14	Directivity of an Antenna	25
15	Vertical and Circular Polarization in 3-D	28
16	Microstrip Transmission Line (A) Geometry (B) Electric and Magnetic Field Lines	31
17	Equivalent Geometry of Quasi-Tem Microstrip Line	32
18	Microstrip Line Feed	35
19	Probe fed Rectangular Microstrip Patch Antenna	36
20	Aperture-coupled feed	37
21	Proximity-coupled Feed	38
22	Cavity model of a microstrip patch antenna	40
23	Show the Sierpinski carpet fractal antenna from Stage 0 to stage 2	42
24	Design methodology for antenna dimension	44
25	Sierpinski carpet antenna dimension	46
26	Feed using quarter-wave transmission line	47
27	Creating EM structure	48

28	The square patch antenna in Microwave Office Environment	48
29	The box dimension and cell size of the antenna	49
30	The dielectric layer parameter for the antenna	49
31	The boundaries of the antenna	50
32	Determined load at that point using via port	51
33	The line impedance was converting to length and width	52
34	The quarter-wave impedance was converting to length And width	52
35	The actual dimension with quarter-wave transmission line Feeding	53
36	After changing length and width of quarter-wave transmission line	53
37	The square patch antenna in Microwave Office environment	54
38	The square patch antenna in 3-D view	54
39	Creating new graph	55
40	Adding measurement to the graph	55
41	Setting project option	56
42	Analyze the EM structure	57
43	Created the antenna plot graph	57
44	Adding measurement to the graph	58
45	Sierpinski carpet with first iteration	59
46	Sierpinski carpet fractal antenna with first iteration in Microwave Office environment	60
47	The Sierpinski carpet fractal antenna in 3-D view	60
48	The second stage of Sierpinski carpet fractal antenna	62
49	Sierpinski carpet fractal antenna with second iteration in Microwave Office environment	
50	The Sierpinski carpet fractal antenna in 3-D view	63
51	The antenna dimension in CorelDraw Suite 12 Graphic	65



52	The actual antenna size on transparency paper	65
53	Ultra Violet Ray Exposed Equipment in PSM lab	66
54	Show the develop process	66
55	The etching tank in PSM lab	67
56	The actual antenna size from zero iteration to second Iteration	68
57	R3767CG network analyzer	69
58	The simulation and measurement result for zero iteration	71
59	The simulation and measurement result for first iteration	72
60	The simulation and measurement result for second iteration	74
61	Show the radiation pattern cutting at $\Phi = 0^\circ$ and $\Phi = 90^\circ$ at 1.8 GHz for zero iteration	74
62	Show the radiation pattern cutting at $\Phi = 0^\circ$ and $\Phi = 90^\circ$ at 1.6298 GHz for first iteration	75
63	Show the radiation pattern cutting at $\Phi = 0^\circ$ and $\Phi = 90^\circ$ at 3.99 GHz for first iteration	76
64	Show the radiation pattern cutting at $\Phi = 0^\circ$ and $\Phi = 90^\circ$ at 5.6 GHz for first iteration	76
65	Show the radiation pattern cutting at $\Phi = 0^\circ$ and $\Phi = 90^\circ$ at 7.96 GHz for first iteration	77
66	Show the radiation pattern cutting at $\Phi = 0^\circ$ and $\Phi = 90^\circ$ at 8.81 GHz for first iteration	78
67	Show the radiation pattern cutting at $\Phi = 0^\circ$ and $\Phi = 90^\circ$ at 1.63 GHz for second iteration	79
68	Show the radiation pattern cutting at $\Phi = 0^\circ$ and $\Phi = 90^\circ$ at 4.99 GHz for second iteration	79
69	Show the radiation pattern cutting at $\Phi = 0^\circ$ and $\Phi = 90^\circ$ at 5.45 GHz for second iteration	80
70	Show the radiation pattern cutting at $\Phi = 0^\circ$ and $\Phi = 90^\circ$ at 7.68 GHz for second iteration	80

71	Show the radiation pattern cutting at $\Phi = 0^\circ$ and $\Phi = 90^\circ$ at 8.68 GHz for second iteration	81
72	Show the radiation pattern cutting at $\Phi = 0^\circ$ and $\Phi = 90^\circ$ at 9.99 GHz for second iteration	81
73	Sierpinski carpet fractal monopole antenna	83
74	Dual thickness (with metal block) edge-fed patch antenna structure	84

## LIST of NOMENCLATURES

$E$	-	Euclidean space
$r$	-	Ruler
$D$	-	Hausdorff dimension
$Z_{in}$	-	Input impedance
VSWR	-	Voltage Wave Standing Ratio
$G$	-	Gain
$D$	-	Directivity
dB	-	decibel
HPBW	-	Half Power Beamwidth
FNBW	-	First Null Beamwidth
BW	-	Bandwidth
$f_H$	-	High Frequency
$f_L$	-	Low Frequency
$f_0$	-	Resonant Frequency
$Z_L$	-	Load impedance
$Z_0$	-	Input Impedance
$v_0$	-	Light Velocity ( $3 \times 10^8 m$ )
$\epsilon_r$	-	Relative permittivity
$d$	-	Substrate thickness
$\tan \delta$	-	Tangent Loss of Substrate
$W$	-	Antenna Width
$\epsilon_{eff}$	-	Effective dielectric constant
$\Delta \ell$	-	The fringing filed

$L$	-	Antenna Length
$N_n$	-	The number of box
$L_n$	-	The ratio for the length
$A_n$	-	The ratio for the fractal area after the $n^{\text{th}}$ iteration
$n$	-	The iteration stage number

**LIST of APPENDICES**

- APPENDIX A - Antenna Dimension Calculation
- APPENDIX B - Matching Technique Using Smith Chart
- APPENDIX C - First Iteration Calculation
- APPENDIX D - Second Iteration Calculation

## CHAPTER I

### INTRODUCTION

#### 1.1 Project Synopsis

With the advanced of wireless communication system and increasing importance of other wireless applications, wideband and low profile antennas are in great demand for both commercial and military applications. Multi-band and wideband antennas are desirable in personnel communications system, small satellite communication terminals and other wireless application. Actually the fractal antenna has got an intention and interest of many researcher and scientist to discover and develop this fractal antenna because of its unique characteristics that are linked to the geometrical properties of fractals and multi band application. Usually different frequency band needs a different antenna, means that one antenna can operated at single frequency band. So fractal antennas suggest in this project for some attractive solution for using a single small antenna operating several frequency bands. In this project the concept of fractal has been applied to the geometry of a square microstrip patch antenna to obtain multi band frequency also know as Seirpinski carpet fractal antenna. The objective of this project is to investigate the behavior of the Sierpinski fractal antenna in range of bandwidth 1 GHz ad 10 GHz. Due to the theoretical; the antenna parameters such as size can be calculated using software (MATLAB). Then using software (Microwave Office) to do design

procedure such as patch and feeding technique and the return loss must be below -10dB to consider as a good antenna. The antenna has been fabricated and tested using network analyzer and spectrum analyzer.

## 1.2 Objectives

- To study concept of fractals and can be applied to the design of Sierpinski carpet fractal antenna.
- To study and analyze antenna behavior between ranges 1 GHz till 10 GHz by changing certain parameters such as number of iteration, scaling factor and the element sizes.

## 1.3 Scope of Work

During this project there are several progresses that have to do:

### 1<sup>st</sup> phase: Literature Review

- Gather the information about the project via Internet, journals, magazines, published work and reference books that are related to the Sierpinski carpet fractal antenna and understand the Sierpinski fractal antenna concept.
- Study of the software implementation (Microwave Office)

### 2<sup>nd</sup> phase: Calculation and analysis

- Analyzed and calculated all the parameters that related in designing the Sierpinski carpet fractal antenna such as the antenna size.

### 3<sup>rd</sup> phase: Software Implementation development

- Used software (Microwave Office) to design the Sierpinski carpet fractal antenna for microstrip at 1.8 GHz including feeding technique and fractal it until 2<sup>nd</sup> iteration and simulated it. The simulation result has been record.

### 4<sup>th</sup> phase: Hardware Development

- Proceed to fabricate the Sierpinski carpet fractal antenna on microstrip board (FR4) and feed it with SMA connector. Test the antenna and record all the result. Due to the result, do the comparison of the simulation and measurement.

## 1.4 Problem Statements

Traditionally, a wideband antenna in the low frequency wireless bands can only be achieved with heavily loaded wire antenna, which usually means different antennas are needed for different frequency bands. So in this project, the concept of a fractal has been applied to the geometry of a square microstrip patch antenna to obtain multiband frequency operation. Fractal antenna are antennas that have the shaped of fractal structures. The fractal antenna consists of geometrical shapes that are repeated. Each ones have a unique attributes. So the Sierpinski carpet is constructed using squares geometries. In order to start these types of fractal antenna it begins with a square in the plane and divided into nine smaller congruent squares where the open central is dropped. Figure 1 [5, 6, 7] below is illustration of iteration of Sierpinski carpet fractal antenna till second iteration.