DESIGN MULTIBAND E-SHAPED FRACTAL MICROSTRIP PATCH ANTENNA WITH DEFECT GROUND STRUCTURE (DGS) BY USING GRAPHENE

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ABSTRACT

To have small, compatible and affordable antennas is the need of today's mobile devices. Microstrip antennas are the best choice for wireless devices because of characteristics like low weight, ease of fabrication and low cost. But on the other hand, microstrip antenna also suffers from disadvantages like they have less bandwidth and gain. So, measure issues for consideration are a multiband and wideband operation of the antenna. In order to obtain multiband and wideband characteristics, different techniques can be used such as cutting a slot in the patch, fractal geometry and DGS (Defected Ground structure). In order to increase bandwidth, DGS can be used. It is to be noted that within a particular area of ground different DGS can produce different resonant frequencies and different bandwidth. In this thesis, the use of fractal geometry with three iterations has been proposed. This results in multiband operation of the antenna with added advantage of size reduction. Further, the wideband characteristic of the antenna is improved by applying DGS. Nowadays, graphene has attained a great demand from the device community. In this project, graphene is an element that preferred in replacing the copper as patch material to improve the performance of the antenna. This is because of its advantages for instance light weight, strong, transparent and good conductor of heat and electricity. From this project, the best optimization design is using the third iteration with DGS antenna. The antenna is designed and simulated by using Computer Simulation Studio 2011 (CST) software.By applying the concept of fractal geometry on a rectangular patch, a self-similar E-Shaped structure has been obtained. Also, by using FR-4 epoxy (Fire Retardant-4) as substrate antenna resonates at 5.6GHz,7.3GHz, 8.4GHz ,and 9.6GHz respectively with bandwidth 233MHz, 462MHz, 341MHz and 396MHz at corresponding frequencies. Graphene material shows a better performance compare to copper as the patch material in term of return loss, bandwidth and gain have also been proved in this thesis.

ABSTRAK

Antena yang kecil, sesuai dan mampu milik adalah antara ciri yang diperlukan oleh peranti mudah alih. Mikrostrip antena adalah pilihan yang terbaik untuk peranti tanpa wayar kerana cirinya yang ringan, mudah untuk di reka dan murah. Walaubagaimanapun, mikrostrip antena mempunyai kekurangan seperti kurang kelebaran jalur dan rendah gandaan. Jadi, ciri yang akan dititikberatkan adalah ciri pelbagai jalur dan jalur lebar. Untuk mendapatkan ciri pelbagai jalur dan jalur lebar, pelbagai teknik boleh digunakan seperti memotong slot di tampalan, fraktal geometri dan teknik DGS (Defect Ground Structure). Untuk meningkatkan kelebaran jalur, DGS boleh digunakan. Untuk diambil perhatian, keluasan tapak DGS yang berbeza boleh menghasilkan pelbagai frekuensi dan kelebaran jalur**.** Di dalam tesis ini, sebanyak tiga pengulangan fraktal geometri telah direka. Hal ini menghasilkan operasi pelbagai jalur di tampalan antena dengan tambahan pengurangan saiz. Selain itu, ciri jalur lebar unutk antenna telah ditingkatkan dengan mengunakan DGS. Pada masa kini, graphene telah mendapat permintaan yang tinggi dalam kalangan komuniti peranti. Dalam projek ini, unsur graphene telah dipilih untuk mengantikan tembaga unutk meningkatkan prestasi antena. Hal ini adalah kerana, kelebihannya seperti ringan, kuat, telus dan konduktor haba dan elektrik yang baik. Dalam projek ini, reka bentuk optimum yang terbaik adalah antena ulangan ketiga dengan ciri DGS. Antena ini direka dan disimulasi menggunakan perisian Computer Simulation Studio 2011 (CST). Dengan menggunakan konsep fraktal geometri di tampalan segi empat tepat, kesamaan sendiri bentuk E telah diperolehi. Juga dengan menggunakan FR-4 (Fire Retardant-4) sebagai substrat antenna resonansi di 5.6GHz,7.3GHz, 8.4GHz and 9.6GHz masing-masing dengan kelebaran jalur 233MHz, 462MHz, 341MHz and 396MHz di frekuensi tersebut. Di dalam tesis ini membuktikan bahawa unsur graphene menunjukkan prestasi yang lebih baik berbanding tembaga sebagai patch dari segi kehilangan balik, kelebaran jalur dan gandaan.

TABLE OF CONTENTS

CHAPTER	SUBJECT	PAGE
	PROJECT TITLE	**i**
	STATUS REPORT DECLARATION FORM	**ii**
	STUDENT DECLARATION	**iii**
	DECLARATION SUPERVISOR	**iv**
	DEDICATION	**v**
	ACKNOWLEDGMENT	**vi**
	ABSTRACT	**vii**
	ABSTRAK	**viii**
	CONTENT	**ix**
	LIST OF TABLE	**xii**
	LIST OF FIGURE	**xiii**
1	**INTRODUCTION**	
1.1	Project Background	2
	1.1.1 Graphene	2
1.2	Problem Statement	3
1.3	Objectives	4
1.4	Scope of Project	4
1.5	Brief Explanation of Methodology	5
1.6	Thesis Plan	5

2		**LITERATURE REVIEW**	
	2.1	Antenna definition	7
	2.2	Microstrip Antenna	8
	2.3	Fractal Geometry	9
	2.4	Feeding technique	11
	2.5	Defect Ground Structure	12
	2.6	Antenna Parameter	13
		2.6.1 Radiation Pattern	13
		2.6.2 Directivity	14
		2.6.3 Bandwidth	14
		2.6.4 Gain	15
		2.6.5 Polarization	15
		2.6.6 Antenna efficiency	16
	2.7	Graphene	16
3		**METHODOLOGY**	
	3.1	Overview of Methodology	19
	3.2	Substrate Material	20
	3.3	Designing Antenna	21
		3.3.1 Calculation of Patch dimension	21
		3.3.2 E-shaped Fractal Microstrip Antenna Design	22
	3.4	Introduction to CST 2011 Studio Suite Software	26
	3.5	Flowchart	27
4		**RESULT AND DISCUSSION**	
	4.1	Comparison of different iterations	28
		4.1.1 First Iteration	28
		4.1.1.1 Return Loss	29
		4.1.1.2 Bandwidth	29

	4.1.1.3 Gain	30
	4.1.2 Second Iteration	31
	4.1.2.1 Return Loss	31
	4.1.2.2 Bandwidth	32
	4.1.2.3 Gain	32
	4.1.3 Third Iteration	35
	4.1.3.1 Return Loss	35
	4.1.3.2 Bandwidth	36
	4.1.3.3 Gain	37
4.2	Effect on Defected Ground Structure (DGS) on Antenna	40
4.3	Comparison for Overall Result	47
5	**CONCLUSION AND RECOMMENDATION**	
	5.1 Conclusion	50
	5.2 Recommendation	51
6	**REFERENCES**	52

LIST OF TABLES

NO	TITLE	PAGE
2.1	Conductivity of material	17
3.1	Parameter of substrate material	21
4.1	Bandwidth for the first iteration	29
4.2	Gain for the first iteration	30
4.3	Bandwidth for the second iteration	32
4.4	Gain for the second iteration	32
4.5	Bandwidth for the third iteration	36
4.6	Gain for the third iteration	37
4.7	Comparison table of the third iteration	41
4.8	Overall result	47

LIST OF FIGURES

NO	TITLE	PAGE
2.1	Electric and magnetic wave produced by RF	8
2.2	Type of patch antenna	9
2.3	(a) Fractal geometry shape: Miwonski island	10
	(b) Fractal geometry shape: Koch loop	11
2.4	Feeding technique: Microstrip feed and coaxial feed	12
2.5	Example of antenna with DGS	12
2.6	Radiation pattern	14
2.7	Type of polarization	15
2.8	Reflection, conduction, and dielectric losses	16
2.9	Structure of graphene	17
3.1	Basic Rectangular Geometry Microstrip Antenna	20
3.2	Miwonski Fractal Geometry	23
3.3	Basic rectangular patch	23
3.4	First iteration of rectangular geometry	24
3.5	Second iteration of rectangular geometry	24
3.6	Third iteration of rectangular geometry	25
3.7	Dumb bell-shaped DGS	25
3.8	CST Studio Suite Software	26
3.9	Flow chart	27
4.1	Return loss for the first iteration	29
4.2	Gain for the first iteration for copper 3.4 GHz	30
4.3	Gain for the first iteration for graphene 3.4 GHz	31
4.4	Return loss for the second iteration	31
4.5	Gain for the second iteration for copper at 3.7 GHz	33

4.6	Gain for the second iteration for graphene 3.7 GHz	34
4.7	Gain for the second iteration for copper at 6.4 GHz	34
4.8	Gain for the second iteration for graphene 6.4 GHz	35
4.9	Return loss for the third iteration	35
4.10	Gain for the third iteration for copper at 5.8 GHz	37
4.11	Gain for the third iteration for graphene at 5.8 GHz	38
4.12	Gain for the third iteration for copper at 7.4 GHz	38
4.13	Gain for the third iteration for graphene at 7.4 GHz	39
4.14	Gain for the third iteration for copper at 8.2 GHz	39
4.15	Gain for the third iteration for graphene at 8.2 GHz	40
4.16	Return loss with DGS and without DGS	42
4.17	Gain for the third iteration with DGS for copper at 5.6GHz	42
4.18	Gain for the third iteration with DGS for graphene at 5.6 GHz	43
4.19	Gain for the third iteration with DGS for copper at 7.3GHz	43
4.20	Gain for the third iteration with DGS for graphene at 7.3 GHz	44
4.21	Gain for the third iteration with DGS for copper at 8.4GHz	44
4.22	Gain for the third iteration with DGS for graphene at 8.4 GHz	45
4.23	Gain for the third iteration with DGS for copper at 9.6GHz	45
4.24	Gain for the third iteration with DGS for graphene at 9.6 GHz	46

CHAPTER 1

INTRODUCTION

This chapter will explain about the background of the project. Besides, this chapter will discuss the problem statement, objective, and scope of the project that have been chosen to design and simulate.

An antenna is defined by Webster's Dictionary as "a usually metallic device (as a rod or wire) for radiating or receiving radio waves." The IEEE Standard Definitions of Terms for Antennas (IEEE Std 145–1983) defines the antenna or aerial as "a means for radiating or receiving radio waves."[1]. On the other word, the antenna is the medium of transition between free-space and guiding device. The transmission line such as coaxial line or waveguide is used to transport electromagnetic energy from the source to antenna or vice versa. There are numerous sorts of the antenna, for example, wire antennas, horn antennas, microstrip antennas, array antennas, lens antennas. Diverse sorts of the antenna have distinctive sorts of use.

With the demand for high-performance aircraft, spacecraft, satellite, and missile application where the size, weight and performance are limited, low profile antenna is required. As well as wireless communications, they also want similar specification. To meet this increasing demand, microstrip antennas can be used. By the progression of time, microstrip antenna got to be one of the quick developing

sections in the business of telecom and accepted to be the indispensable and favored medium for what's to come. Nowadays, this sort of antenna has a substantial interest by the end client and purchaser for a coordinated remote computerized application.

1.1 Project Background

This project has been proposed to design multiband E-shaped fractal microstrip patch antenna with Defect Ground Structure (DGS) by using Graphene. The fractal patch design with DGS at the ground plane technique will be done and simulated by using Computer Simulation Tool (CST) software. The property of self-similarity of fractal geometries is used to achieve multiband operations from fractal antennas and their space-filling property is used for the antenna miniaturization[2]. Antenna miniaturization is an important task in achieving the optimal design for wireless communication[3]. This design will compare the performance of the antenna by using copper and graphene as patch material. The graphene could potentially lead to very interesting features such as miniaturization, dynamic tuning and even optical transparency and mechanical flexibility[4][5]. The performance of the designed antenna was also compared with three iterations of fractal geometry in term of return loss,bandwidth and gain. There are also some aspects need to reconsider such that selection of resonant frequency, type of substrate, feeding technique, the thickness and dielectric constant of the substrate to meet a good result with DGS for wireless application by using graphene[6].

1.1.1 Graphene

During the last years, the interest in graphene experienced impressive growth due to its extraordinary mechanical, electronic and optical properties of the latter. Graphene is a thin layer of pure carbon; it is a single, tightly packed layer of carbon atoms that are bonded together in a hexagonal honeycomb lattice. Graphene is so special because of it atomic thickness. Although it is very thin but it also very strong material.

It was hypothetically asserted that two-dimensional substances neglected to exist in view of the absence of warm strength when isolated. Still, after graphene was disconnected, clearly that it appeared to be really conceivable, and it set aside analysts a touch of time to find the right way. After suspended graphene sheets were dissected by transmitting electron microscopy, specialists expressed that they found a justifiable reason of slight undulating in the graphene, modifying arrangement of the material. Indeed, even thus, later on, exploration suggests that it is entirely due to the carbon to carbon bonds in graphene are so reduced furthermore solid that they maintain a strategic distance from warm changes from destabilizing it.

In general, the conductivity of graphene is very frequency-dependent, and can have completed different behavior. Though graphene is known as best conductor known for electric and heat. By injecting energy to graphene, the Fermi level can be shift and modify its electrical properties. Moreover, when the Fermi-level moves into the valence or conduction band, the hole or electron conduction begins to dominate the current transport and hence the resistance becomes low. This energy can be provided by an external electric field . The gate-induced carriers can be seen as resulting from an electrical doping, analogous to the chemical doping typically used for semiconductor devices. The huge difference is that the semiconductor doping is an irreversible process, while the graphene electrical doping is completely reversible. Then, in graphene, the electrons and holes are electrically induced by applying a positive or a negative voltage with respect to a reference electrode.

Tests have demonstrated that the electronic portability of graphene is high. It is said that graphene electrons act like photons in their portability because of their absence of mass. Graphene likewise contains versatile properties, having the capacity to hold its beginning size after strain. [7] [8]

1.2 Problem Statement

The microstrip antenna is preferred due to some advantages for example low weight, low cost, ease of fabrication and versatility in terms of resonant frequency, polarization, pattern and impedance[6][9]. However, there are some limitations in

microstrip antenna such that low return loss, less bandwidth and low gain[9]. These disadvantages can be overcome by constructing fractal patch antenna with DGS.[6][9][10]. This project also is done to improve the antenna performance by replacing patch material of the antenna from copper to graphene. Graphene is the best conductor known, it is mono-atomic and thus, the surface resistance is very high compared to metals[11]. The conductivity of graphene is very frequency-dependent and can have completed different behavior[11]. Furthermore, graphene is going through impressive growth due to the extraordinary mechanical, electronic and optical properties [4][8]. So, the improvement needs to be simulated by CST Studio Suite to prove that graphene is better than copper in term of performance.

1.3 Objectives

The main objective of this project is to design multiband E-shaped fractal microstrip patch antenna with DGS by using Graphene. The design's performance will be more focus on return loss, bandwidth, and gain, and will be simulated and tested by CST Studio Suite software.

1. To design and simulate multiband E-shaped fractal microstrip patch antenna with DGS by using CST software.

2. To evaluate the performance between the three iterations of fractal geometry with DGS microstrip antenna.

3. To identify the performance of the Graphene replaced copper as patch material.

1.4 Scope Project

The antenna will be applying the concept of fractal geometry which is Miwonski shape for antenna patch. Three iterations are performed and results are compared in terms of antenna parameters. FR4 epoxy (Fire Retardant-4) is chosen as a substrate

for the antenna. The designed antenna will be developed for multiband operations for radar, satellite, and long range radio telecommunication applications . Coaxial feed has been used as the feeding method for microstrip antenna design. The proposed antenna will be inserted with DGS to improve various parameters such as return loss, bandwidth, and gain. Besides, two types of patch material have been used which are graphene and copper to identify and compare the performance.

1.5 Brief Explanations on Methodology

Numerous exploration on the task should be done to guarantee that the project will run easily. Essential stage, need to learn hypothetically the idea of microstrip patch antenna and graphene to actualize it in the recommended antenna. Next step, the planning and reenactment process by utilizing the CST programming. To wrap things up, break down the outcomes in term of performance of three iterations of fractal geometry and comparison of graphene and copper.

1.6 Thesis Plan

Chapter 1 - In this section, quickly clarify about the introduction of the project. A brief explanation about the definition of antenna and sorts of antenna additionally clarified. This section additionally including the project background, problem statement, objective, and scope of projects.

Chapter 2 - In this section, a literature review is a place the clarifications of past research and journal that related with this task. Past research incorporated the final results, formula and calculation of the antenna and the graphene.

Chapter 3 - Methodology is a rule to finish and runs the project easily. Begin from the research on the related antenna and graphene with the goal that it satisfies every one of the prerequisites so as to meet sought results.

Chapter 4 - In this part, it will display all the organization information and results. As the outcomes have been organized, the investigation of information should be possible. There will likewise discussion about the results.

Chapter 5 - There will a proposal and future work in light of this project. And in addition, the clarification of general conclusion for the entire project.

CHAPTER 2

LITERATURE REVIEW

This chapter survey hypothetically to get a thought that related with this undertaking so it can plans and reenact the project by utilizing a fitting idea. From the gathered data, it can be a rule in this project to enhance the proposed project with the goal that it works effectively.

2.1 Antenna definition

Antenna is an important terminal device in all type of communication and radar system. If the antenna is well designed it can transmit signal from one place to various place on the globe. If the antenna is not well designed the signal is impossible to send a signal even beyond the premises. All communication and radar system require and antenna in one form or the other. If there is no antenna, there would be no communication and radar system. The antenna acts as both source and sensor for electromagnetic waves. The behavior of the electromagnetic wave is between transmitter and receiver is important because receive power depends on propagation characteristics.[12]

An antenna is basically a transducer that converts radio frequency(RF) electric current into electromagnetic(EM) wave at the same frequency. The antenna can produce electric and magnetic fields that eventually produce an electromagnetic field. This field will obtain the transmission and reception of EM energy. It forms both the transmitter and receiver circuit. The equivalent circuit features resistance, inductance, and capacitance. The currents produce

the magnetic field and charge produce electrostatic field. These two in turn create induction field. When RF is applied to the antenna both electric and magnetic field produced as shown in figure 2.1.[12]

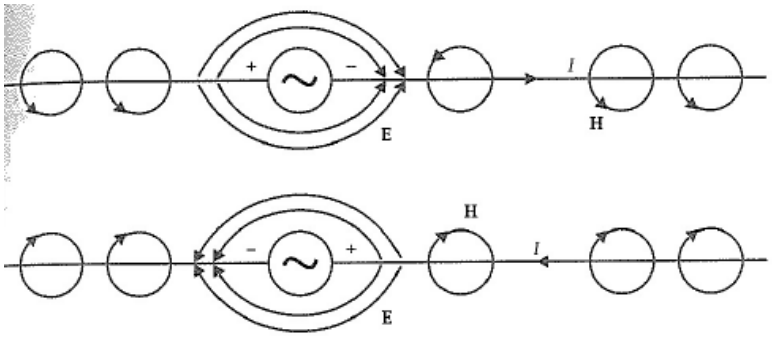

Figure 2.1: Electric and magnetic wave produced by RF

Moreover, getting or transmitting vitality, an antenna in a propelled remote framework is generally required to streamline or emphasize the radiation vitality in some headings and smother it in others. Accordingly the antenna should also serve as a directional gadget and examine gadget. It should then take different structures to meet the specific need close by, and it might be a bit of directing wire, an opening, a patch, array (exhibit), a reflector, a lens, et cetera[1].

2.2 Microstrip antenna

To have small, compatible and affordable antennas is the need of today's mobile devices. Microstrip antennas are the best choice for wireless devices because of characteristics like low weight, ease of fabrication and low cost [6]. The major disadvantages of the microstrip antenna are low efficiency, low gain, poor polarization, narrow bandwidth and spurious feed radiation [9][20]. Starting from 1970, microstrip antenna receives huge attention. Microstrip antenna consists of a very thin metallic strip or patch above the ground plane. For a rectangular patch, the length L of the element usually $\lambda 0/3 < L < \lambda 0/2$. The patch and ground plane is separated by dielectric known as substrate[12].

There are various substrates that can be utilized for the configuration of microstrip antenna also, their dielectric constants are as a rule in the scope of $2.2 \leq Ir \leq 12$. The ones that are

most alluring for good antenna execution are thick substrates whose dielectric consistent is at the lower end of the extent in light of the fact that they give better proficiency, bigger data transfer capacity, inexactly headed fields for radiation into space, however to the detriment of bigger component size. Slim substrates with higher dielectric constants are attractive for microwave hardware in light of the fact that they require firmly bound fields to minimize undesired radiation and coupling, and prompt littler component sizes; on the other hand, due to their more noteworthy misfortunes, they are less productive and have generally littler data transmissions. Since microstrip antenna are frequently coordinated with other microwave hardware, a trade-off must come to between great antenna execution and circuit outline.[12]

Besides microstrip antenna, it also is known as patch antenna. Basically, radiating element and feed line was placed or etched on a dialectric substrate. There is various type of patch such as square, rectangular, dipole, circular, elliptical, triangular and any other configuration. These are shown in figure 2.2.

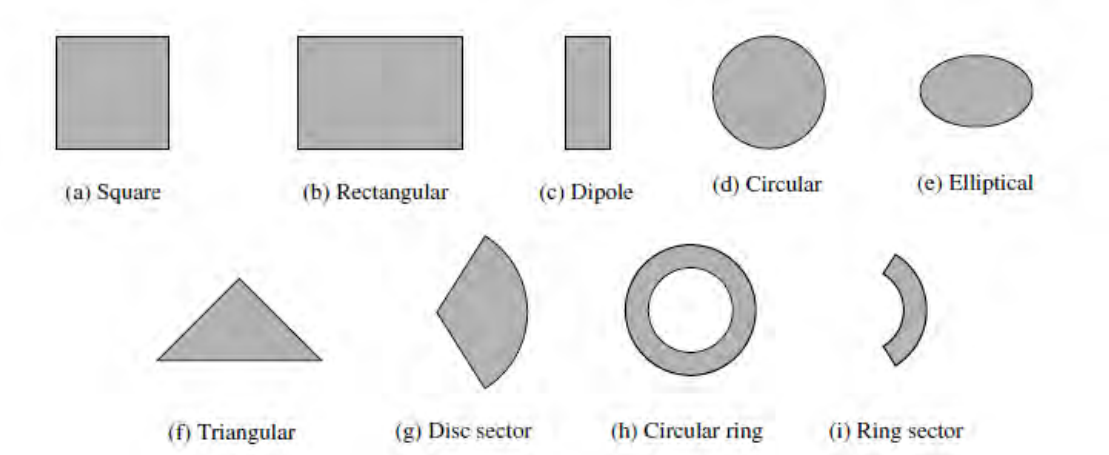

Figure 2.2: Type of patch antenna

2.3 Fractal Geometry

Fractal antennas are based on the concept of a fractal, which is a recursively generated geometry that has fractional dimensions, as pioneered and advanced by Benoit B. Mandelbrot [12]. He was able to show that fractal exist in nature and can be used to accurately model

certain phenomena. Moreover, he also introduced into a more complex structure including trees and mountain that has self-similarity and self- affinity in their geometrical shape.

There are two categories that can describe fractal geometry which is deterministic and random. Deterministic such as von Koch snowflake and Seiperski Gaskett are those generated by scaled down and rotated copies. This fractal can be generated using computer graphic by requiring particular mapping that is repeated over and over sing a recursive algorithm. Meanwhile, random fractal can obtain through randomness over the natural phenomenon.

Fractal geometry is used for miniaturization of the antenna which it can reduce the antenna size[22]. There are very different from Euclidean geometry which they have two common properties;space filling and self-similarity. The property of space filling is for size reduction and self-similarity is to achieve multiband operation [2]. It has been shown that a limited number of iteration of fractal geometry can make an antenna multiband. Based on their interesting properties, there have been used in radiating systems and microwave device. Fractal configurations iterative procedure allow them to achieve long linear dimensions and high surface areas in limited volume.

There are a number of fractal shapes like Sipernski Gasket, Minkowski,Hilbert Curve and Koch Curve, Fractal Arrays [6]. The example of the shape was shown in Figure 2.3(a,b). Figure 2.3(a) exhibits what is referred to as the Minkowski island fractal, while Figure 2.3(b) illustrates the Koch fractal loop.

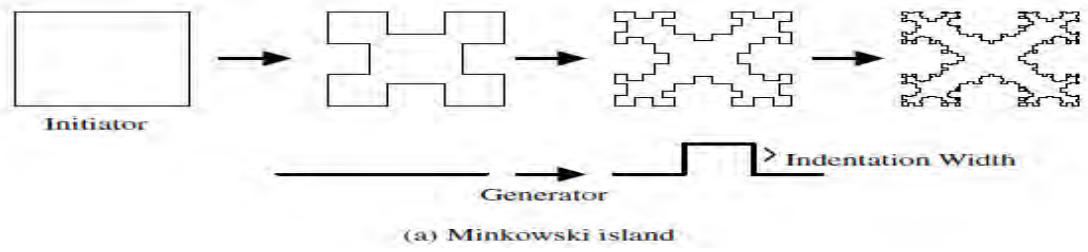

Figure 2.3(a): Fractal geometry shape: Miwonski island