MINIATURIZED FRACTAL PATCH ANTENNA FOR WIRELESS APPLICATIONS

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Supervisor's Name : MADAM NORBAYAH BINTI YUSOP

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To My Loving and Caring Family

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ABSTARCT

The study of microstrip patch antennas has made great progress in recent years. Compared with conventional antennas, microstrip patch antennas have more advantages and better prospects. They are lighter in weight, low volume, low cost, low profile, smaller in dimension and ease of fabrication and conformity. Moreover, the microstrip patch antennas can provide dual and circular polarizations, dual-frequency operation, frequency agility, broad band-width, feedline flexibility, beam scanning omnidirectional patterning.

This thesis proposes a miniaturized fractal antenna using Koch curves. The structure of the proposed antenna is the result of the modifications made with the basic fractal square curves and using Rogers RO4003 as substrate. The design and simulation have been performed using a full-wave 3-dimensional electromagnetic simulator. The antenna can be used for most handheld devices and thus finds wide applications in the field of wireless and mobile communication.

ABSTARK

Kajian mikrostrip antena patch telah mencapai kemajuan besar dalam tahun-tahun kebelakangan ini. Berbanding dengan antena konvensional, antena mikrostrip patch mempunyai lebih banyak kelebihan dan prospek yang lebih baik. Mereka lebih ringan dalam berat badan, jumlah yang rendah, kos rendah, profil rendah, dimensi yang lebih kecil dan kemudahan fabrikasi dan pematuhan. Selain itu, antena mikrostrip patch boleh menyediakan polarisasi dual dan pekeliling, operasi dua frekuensi, kekerapan ketangkasan, luas band-lebar, fleksibiliti feedline, rasuk imbasan pencorakan omnidirectional.

Tesis ini mencadangkan satu antena fraktal bersaiz kecil menggunakan keluk Koch. Struktur antena yang dicadangkan itu adalah hasil daripada pengubahsuaian yang dibuat dengan keluk persegi fraktal asas dan menggunakan Rogers RO4003 sebagai substrat. Reka bentuk dan simulasi telah dilakukan dengan menggunakan simulator elektromagnet gelombang lengkap 3 dimensi. Antena itu boleh digunakan untuk peranti yang paling pegang tangan dan dengan itu mendapati permohonan yang luas dalam bidang komunikasi tanpa wayar dan mudah alih.

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LIST OF ABBREVIATIONS

LAN	-	Local Area Network
PSM	-	Projek Sarjana Muda
CST	-	Computer Simulation Technology
MSA	-	Microstrip Antenna
WLAN	-	Wireless Local Area Network
MPA	-	Microstrip Patch Antenna
EDC	-	Effective Dielectric Constant
IFS	-	Iterative Function System
DS	-	Similarity Dimension
DH	-	Hausdorff Dimension
DB	-	Box-counting Dimension
EM	-	Electromagnetic
FEM	-	Finite Element Method

CHAPTER I

INTRODUCTION

In this chapter, a summary of this project is presented. The objective of this project is explained briefly. The dissertation overview of this thesis also provided in this chapter.

1.1 BACKGROUND

Wireless communication assumes a major part to our daily existence, with antennas being of ceaselessly expanding importance. Microstrip antennas are a type of antennas that is popular with wireless communication equipment. This is because of its outstanding physical properties. Microstrip antennas are light weight, low profile, low production cost, conformability, reproducibility, reliability, also simplicity in fabrication and integration with solid state devices and wireless technology equipments [1]. However, the size of a conventional microstrip antenna is normally large when composed in microwave frequency regime creating issues for mounting on transmitter/receiver and repeater systems. These antenna types also bring impediments as far as their narrow bandwidth, low gain, and weak radiating patterns. The gain reduction is brought about by the general diminishment in the antenna size. It might additionally make attributed to the substrate characteristics which might prompt surface wave excitation and hence a reduction in gain. Therefore, it is trying to outline microstrip antennas to have better transmitting properties and in the same time have a smaller size. There are several techniques used to diminish the size of the radiating patch which prompts to a smaller antenna size, for example: using super-substrates to produce high dielectric constant [2], incorporating a shorting pin in a microstrip patch [3], using short circuit [4], cutting slots in radiating patch [5, 7], by in part filled high permittivity substrate [8], or by fractal microstrip patch configuration [1, 9, 10]. Still, it remains entirely hard to miniaturize microstrip antennas since these endeavours by and large clash for electrical limitations or cost considerations [1]. The main goal of this thesis is to propose a size reduction technique for microstrip antennas by using a novel fractal radiating patch.

1.2 PROBLEM STATEMENT

Antenna miniaturization is an important aspect in modern communication system design. With developing requirement for compact and small sized transceiver, manufacturers find it hard to design smaller antenna. For this, few techniques have been considered to reduce the antenna size, for example, the use of shorting pins, material loading and geometry optimization. Thusly in this project, the idea of a fractal has been applied to reduce the size of antenna. The minimization is the issue that should be focus on.

1.3 SIGNIFICANCE OF PROJECT

The microstrip patch antennas are well known for their execution and their robust design, fabrication and their extent usage. The benefits of this microstrip patch antenna are to conquer their demerits such as simple to design, light weight and so on, the applications are in the different fields for example in the medical applications, satellites and obviously even in the military systems just like in the rockets, aircrafts missiles and so on. The usage of the microstrip antennas are spreading broadly in all the fields and areas. Now they are booming in the commercial aspects because of their low cost of the substrate material and the fabrication. It is also expected that due to the increasing usage of the patch antennas in the wide range this could take over the usage of the conventional antennas for the maximum applications. Thus, it is expected to provide a smaller in size, better compact and multi-frequency antennas which suitable for low powered devices like cellular phones. The same design approach can also be used for designing antennas for other applications such as multi-frequency wireless LAN and maritime antennas.

1.4 OBJECTIVES OF PROJECT

The aim of this project is to provide solution to the antenna requirements mainly for wireless communication systems ensuring size reduction and multiband characteristics. In order to achieve this, some of objectives need to be as accomplished.

i. To modify and stimulate microstrip fractal patch antenna for wireless application.

ii. To study and analyze antenna parameters for antenna miniaturization.

iii. To investigate a square patch antenna using fractal geometry.

1.5 SCOPE OF PROJECT

The scope of project regarding title is by developing the antenna using fractal patch technique. The scope itself has divided into two parts which is Projek Sarjana Muda 1 (PSM 1) and Projek Sarjana Muda II (PSM II).

As for PSM I, the literature review should be able to do before initiate the project. Literature review needs to be done in order to understand the concept and theory, as well as the applications, characteristics, operations, specifications and design procedures of an antenna. It is also including the research of the antenna calculation. The formula in order to make sure the output will best meet the specification required. The software used for the simulation is CST Microwave Studio Suite. The parameter should be study to get familiar when applying to the project.

As for PSM II, the scope of project is focusing on modifying and analyzing the antenna. When modifying the antenna, the parametric study methods that have been made are applied. Later, the analyzing needs to be performed. The analyzing is important in order to assure the output of frequency response is in meet the requirement, which are 2.4GHz and 5GHz.

1.6 THESIS OUTLINE

For the thesis outlines, it will be cover on the whole thesis. This report is divided into a certain part. Each part will cover on a topic required.

Chapter 1 presents the introduction of the project. A little bit of explanation will be done due to the project. It also includes the objectives, problem statement, scope of project and the thesis outline of the project.

Chapter 2 presents the basic theory of MSAs, including the basic microstrip patch geometries, features and different feeding methods describing their characteristics. This chapter also deals about fractal geometry. Fractal antenna engineering represents a relatively new field of research that combines attributes of fractal geometry with antenna theory. Chapter presents basic theory of fractals describing its features, classes, and dimensions and explained about Iterative function schemes (IFS).

Chapter 3 presents the methodology of the project. Flow chart of project will be presented in this chapter with description as well.

Chapter 4 deals with the design and stimulation of the antenna. It also presents a discussion on its simulated results.

Chapter 5 presents the conclusion of this project after all the theoretical and analysed result is achieved. The future work also involved in this chapter.

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, an investigation of the microstrip antenna has been presented. This includes the basic geometries, feeding techniques, features and applications of these antennas. The fractal geometry also has been studied in this chapter.

2.2 MICROSTRIP ANTENNA (MSA)

The concept of microstrip antenna was traced in 1953 [11] and a patent in 1955 [12], but it received considerable attention in the start of 1970s. It used in aircraft, spacecraft, satellite and missile applications which to obtain result in high performance. Microstrip antenna can be used in order to meet size, weight, cost, performance and ease of integration, low profile antenna [13]. The antennas discussed earlier are 3-dimensional antennas which are bulky and need more space to be deployed. MSA are the modern generation of antennas having attractive features as low profile, low cost, light weight and simple to fabricate. These features make them ideal components of modern cellular and WLAN applications [14].

The interest for compact and low-cost antennas has conveyed the MSA to the forefront because of expanding necessities for personal and hand-held mobile communications. A MSA in its simplest form comprises of a radiating patch on front side of a dielectric substrate and a ground plane on the back side. The top and side views of a rectangular MSA (RMSA) are shown in Figure 2.1. The microstrip antennas are likewise alluded to as patch antennas. The radiating elements and feed lines are generally photoetched on the dielectric substrate. The radiating patch may be square, circular, triangular, semi-circular, sectoral, and annular ring shapes illustrated in Figure 2.2.

Besides, evaluation of the basic properties of microstrip patch antennas (MPA) has been numerously discussed in literature [15, 16]. There are essentially two sorts of radiator: broadside and end-fire radiator. Broadside radiators are those whose maximum pattern is normal to the patch or axis of the antenna. For end-fire radiators, they are those whose maximum is along the axis of the antenna. The strip and ground plane are separated by a dielectric sheet as demonstrated in Figure 2.1.

(a) Top view (b) Side view

Figure 2.1 Microstrip antenna, (a) top view (b) side view [15]

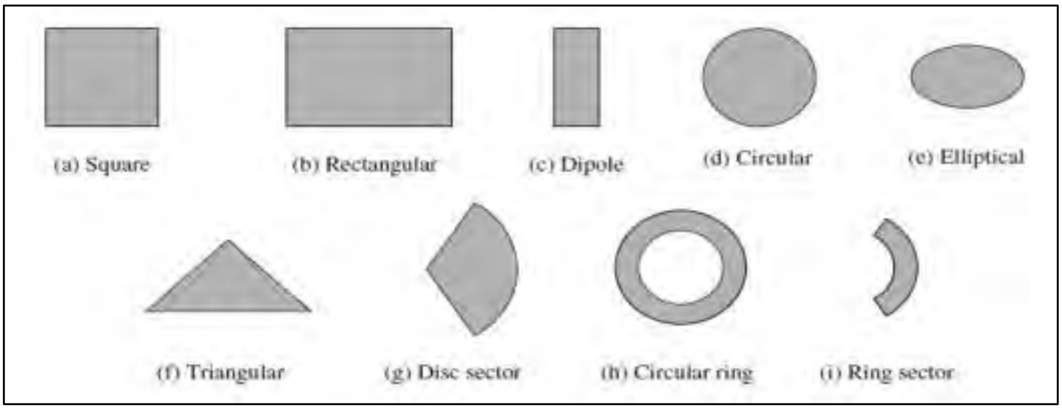

Figure 2.2 Different shapes of microstrip patches [16]

There are few substrates that can be used for the design of microstrip antennas. The dielectric constants are commonly in the range of $2.2 \leq \varepsilon_r \leq 12$. A good antenna performance can be produced by using thick substrates with dielectric constant which is low because they provide better efficiency, larger bandwidth, loosely bound fields for radiation into space. However, it will cost us in larger element size. For thin substrates with higher dielectric constants, they are also used for the microwave circuitry as they require tightly bound fields to minimize undesired radiation and coupling which lead to smaller element sizes, but they are less efficient and have relatively smaller bandwidths on account of greater losses [17].

2.2.1 Feeding Methods

There are few feeding techniques employed to feed the microstrip antennas. The most popular techniques are microstrip line, coaxial probe, aperture coupling and proximity coupling [13]. The microstrip feed line is also called conducting strip, which is much smaller width compared to the patch. The microstrip line feed is easy to fabricate and simple to match by controlling the inset position and rather simple to model. However as the substrate thickness increases surface waves and spurious feed radiation increase, which for practical designs limit the bandwidth (typically 2-5%). A typical microstrip feed line and its equivalent circuit are demonstrated in Figure 2.3 and Figure 2.4 respectively.