MINIATURIZATION OF RECTANGULAR MICROSTRIP ANTENNA

MUHAMAD HAFIZ BIN BAHARUN

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Saya MUHAMAD HAFIZ BIN BAHARUN ....

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BDR BARU UDA , TAMPOI

81200 JOHOR

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Special dedication to my loving parents, Baharun Bin Maulud and Rohana Binti Ahmad, my kind-hearted supervisor, Mr. Abd Shukur Bin Ja'afar, and last but not least, to all dearest friends.

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ABSTRACT

An antenna is a backbone to a wireless communication system. The main objective of this project is to design a microstrip antenna operating at ISM band which is 2.4 GHz. A simple rectangular microstrip antenna is already small in size and to miniaturize it many techniques can be used. Some of the techniques are by using different substrate or different layout design. Layout design that can be used is the design which use fractal concept. In this project, Minkowski fractal concept is selected because it is proven that the operation frequency can be decreased and hence, contributes in the miniaturization of the antenna size. The iteration process is done until 2^{nd} iteration. All the designing and simulation process is carried out using ADS software. Next, the antenna is fabricated and measurement is carried out.

ABSTRAK

Antena merupakan tulang belakang bagi sesebuah sistem komunikasi tanpa wayar. Objektif utama projek ini adalah untuk merekabentuk sebuah antena mikrojalur yang beroperasi pada jalur ISM iaitu 2.4 GHz. Sebuah antena mikrojalur bersegi empat tepat yang biasa sememangnya bersaiz kecil dan untuk mengecilkannya terdapat pelbagai teknik yang boleh digunakan. Antara teknik tersebut adalah dengan menggunakan substratum atau rekabentuk bentangan yang berlainan. Rekabentuk bentangan yang boleh digunakan adalah rekabentuk yang menggunakan konsep *fractal*. Di dalam projek ini, konsep *Minkowski fractal* telah dipilih kerana telah terbukti dapat membantu dalam penurunan operasi frekuensi dan seterusnya menyumbang kepada pengecilan saiz antenna. Proses pengulangan semula dibuat sehingga tahap ke dua. Semua proses merekabentuk dan simulasi dijalankan menggunakan perisian ADS. Kemudian antenna tersebut akan difabrikasi dan pengukuran dijalankan.

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LIST OF ABBREVIATION

ADS	Advance Design System
BW	Bandwidth
dB	Decibel
FNBW	First Null Beamwidth
HPBW	Half Power Beamwidth
ISM BAND	Industrial, Scientific, and Medical Band
RMSA	Rectangular Microstrip Antenna

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CHAPTER 1

INTRODUCTION

This topic consists of the introduction to the project, the background, project objective, problems statement, the scope of works covered.

1.1 Background

An antenna is a transducer designed to transmit or receive electromagnetic waves. It usually works in air or outer space, but can also be operated under water or even through soil & rock at certain frequencies for short distance. The most common uses of antenna can be found in Radio & Television broadcasting, point-to-point radio communication, wireless LAN, radar, and space exploration. There are many types of antenna such as smart antenna, horn antenna, parabolic antenna, Yagi-Uda beam antenna and etc.

Physically, an antenna is an arrangement of conductors that generate a radiating electromagnetic field in response to an applied alternating voltage and the associated alternating electric current, or can be placed in an electromagnetic field so that the field will induce an alternating current in the antenna and a voltage between its terminals. Therefore antenna has a wide area of application and is very important in our everyday life.

1.2 Project Objectives

There are three main objectives of this project which are:

a) To design and simulate Minkowski fractal antenna that will operate at 2.4 GHz within ISM band by using ADS.
b) To fabricate RMSA on the FR4 board by using etching technique.
c) To compare the analysis results obtained from simulation and fabricated RMSA.

1.3 Problem Statement

Nowadays, every gadget or equipment is necessarily to be mobile so that it is easy to access or use. The thing about mobile is, it comes in small in shape or compact. The challenge is to design the gadget or equipment's component in miniaturized. The easiest example is in wireless communication. An antenna is a very significant part that can be found in wireless communication system. Type of antenna that is commonly used for this purpose is microstrip antenna. Rectangular microstrip antenna is already small in size and to miniaturize it different substrate or layout design has to be used.

1.4 Scope of Work

There are several areas that have been identified or considered that need to be work out. There are:

a) Calculate the specification of the RMSA with the aid of MathCAD

   Calculation on the width and length of the radiating patch

b) Design, simulate, and analyze the RMSA and Minkowski fractal patch using ADS software. From simulation the antenna properties that can be analyzed such as return loss, radiation pattern, and so on.

c) Fabricate on the FR4 board using etching technique

d) Compare analysis results of simulation and experimental

1.5 Methodology

There are 5 important phases involved in order to achieve the objective of this project which are:

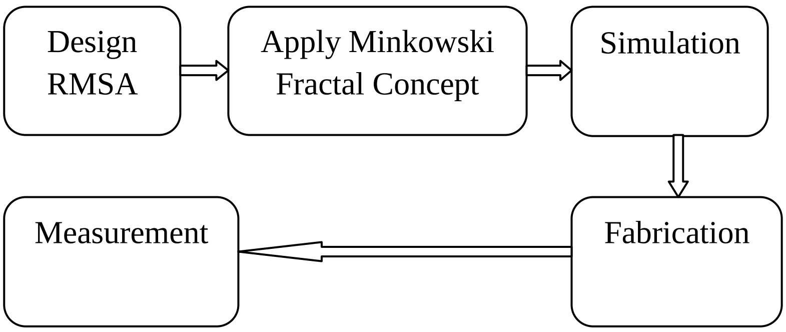

Figure 1.1 Phase flow

Further explanations of these phases will be discussed later on in chapter 3.

1.6 Report Structure

This thesis consists of five main chapters. The following are the outline of each chapter.

Chapter 1: This chapter is brief overviews of the project consist of introduction, background, project objective, problems statement, and scope of the project.

Chapter 2: This chapter discuss the research and information regarding the project. Facts and information gathered from journals and other resources is used to select the best methods for this project.

Chapter 3: This chapter is about the project methodology used for this project.

Chapter 4: This chapter discuss the project findings including results and discussions.

Chapter 5: Conclusion and suggestions for future work is presented in this chapter.

CHAPTER 2

LITERATURE REVIEW

This chapter will discuss precisely about the project, including the factors that should be considered before choosing a substrate, method for miniaturizing the antenna, configuration of an array antenna, and the antenna properties.

2.1 Microstrip Antenna

2.1.1 Basic Characteristic

A simple microstrip antenna consists of a radiating patch on one side of a dielectric substrate ($\epsilon_r \leq 10$), which has a ground plane on the other side [1]. There are numerous substrates that can be used for the design of microstrip antennas, and their dielectric constants are usually in the range of $2.2 \leq \varepsilon_r \leq 12$. The ones that are most desirable for good antenna performance are thick substrates whose dielectric constant is in the lower end of the range because they provide better efficiency, larger bandwidth, loosely bound fields for radiation into space, but at the expense of larger element size. Thin substrates with higher dielectric constants are desirable for microwave circuitry because they require tightly bound fields to minimize undesired radiation and coupling, and lead to smaller element sizes; however, because of their greater losses, they are less efficient and have relatively smaller bandwidths [2].

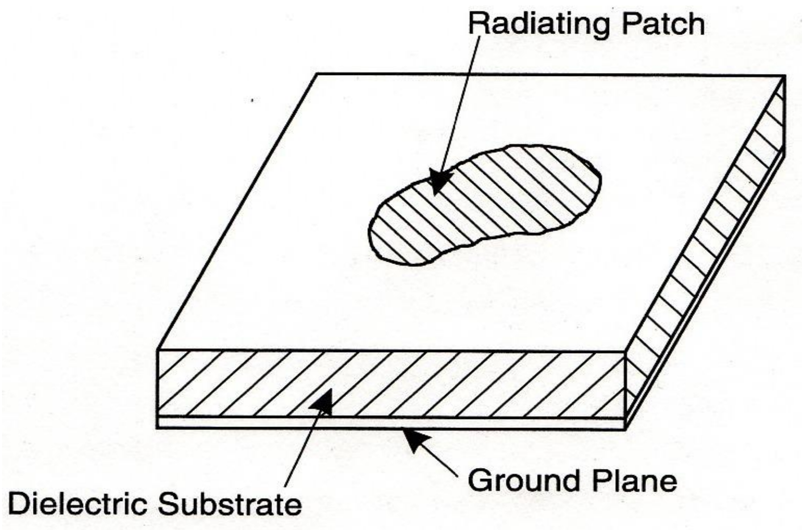

Figure 2.1 Microstrip Antenna Configurations

The patch conductor is usually copper or gold. Microstrip patch antenna possibly can have various shapes, but regular shapes are commonly used to simplify analysis and to predict performance[1]. Below are the principle advantages of the microstrip antennas over conventional microwave antennas[1]:

- Light weight, low volume, and thin profile configurations, which can be made conformal;
- Low fabrication cost; readily amenable to mass production;
- Linear and circular polarizations are possible with simple feed;
- Dual-frequency and dual-polarization antennas can be easily made;

- No cavity backing is required;
- Can be easily integrated with microwave integrated circuits;
- Feed lines and matching networks can be fabricated simultaneously with the antenna structure.

The microstrip antenna is small in size, so it can be used in many area of application. Some of the applications are [4]:

Table 2.1 Application of Microstrip Antenna

Platform	**System**
Aircraft	Radar, communications, navigation, altimeter, landing systems
Missiles	Radar, fuzing, telemetry
Satellites	Communications, direct broadcast TV, remote sensing radars and radiometers
Ships	Communications, radar, navigation
Land vehicles	Mobile satellite telephone, mobile radio
Other	Biomedical systems, intruder alarms

2.1.2 Fringing Effects

Because the dimensions of the patch are finite along the length and width, the fields at the edges of the patch undergo fringing. This is illustrated along length in Figure 2.2 (a, b) for the two radiating slots of the microstrip antenna. The same applies along the width. The amount of fringing is the function of the dimensions of the patch and the height of the substrate. Fo r the principle *E*-plane (xy-plane)