ANALYSIS AND SIMULATION OF FRACTAL MULTIBAND ANTENNA FOR ON BODY APPLICATION

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BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : ANALYSIS AND SIMULATION OF FRACTAL MULTIBAND PATCH ANTENNA FOR ON BODY APPLICATION

Sesi Pengajian : 1 4 / 1 5

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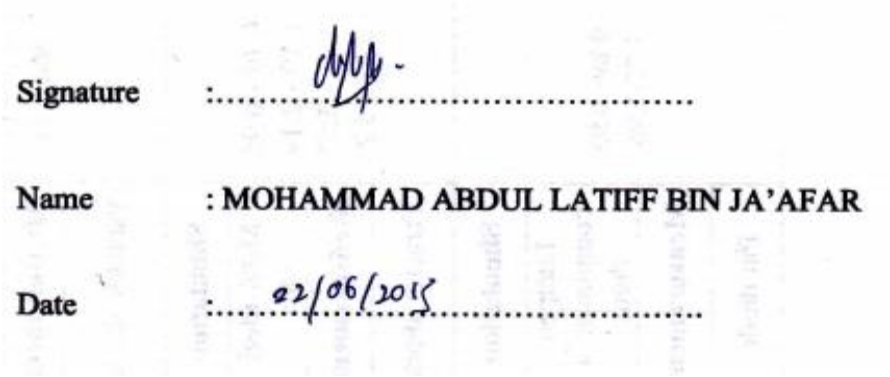

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Name : Mr. ADIB BIN OTHMAN

Date : 22/6/2015

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- To other lecturer who have given commitment throughout my study.

With humbly, thanks everyone. Let succeed in this world and hereafter.

ABSTRACT

Nowadays, any part of this world is surrounded by many wireless devices. Wireless application such as mobile phones, GPS or other wireless devices has become a part of modern society lives and works as it make our life easier. It means that we are always interacting with electromagnetic fields. Thus, it is very important scenario to be study due to the possible health effects that these electromagnetic fields can cause in humans. This project is focused on the study of the antenna parameters and radiation effects on the human arm model produced by the microstrip antenna. The microstrip antenna is a fractal multiband antenna. The special feature of this antenna is it wearable to any part of arm body which transmits signal within mobile communication applications (0GHz – 3 GHz). Three different fractal multiband antennas are used for this project. There are two conditions of observation which are antenna in free space condition and antenna attach to the human arm model condition. Both conditions were analysed, in term of antenna performances such as frequency, return loss, realized gain, directivity and efficiency. After that, the measurements are carried out in the proximity of human arm model which commensurate with the antenna field regions and the size of antenna's reactive near-field that is satisfied to be an important factor in the evaluation of an acceptable on-body operation. For instance, one fractal antenna result in free space condition is used as a parameter's proof. The resonant frequencies are 0.852 GHz, 1.8391 GHz and 2.3251 GHz. The return loss are -13.716 dB, -16.599 dB and -20.26 dB. The values of gain are 2.90 dB, 2.960 dB and 1.689 dB. Therefore, those parameters are satisfied. There is significant differences between different antennas were observed through investigations. The results of this study are helpful to engineers evaluating antennas for the use in fractal multiband antenna applications.

ABSTRAK

Pada masa kini, seluruh dunia dikelilingi dengan peranti-peranti tanpa wayar. Aplikasi tanpa wayar adalah seperti telefon bimbit, Global Positioning System (GPS), mahupun apa sahaja peranti tanpa wayar telah menjadi sebahagian daripada kehidupan moden dalam masyarakat kini dimana ia memudahkan kerja seharian kita. Ini bermaksud kita juga sering berinteraksi dengan medan elektromagnetik. Oleh itu, ia adalah senario yang sangat penting untuk dipelajari kerana kemungkinan medan elektromagnetik memberi kesan kepada kesihatan manusia. Projek ini tertumpu kepada kajian parameter daripada antenna dan kesan radiasi kepada model lengan manusia yang dihasilkan oleh antenna "microstrip" itu. Antenna tersebut adalah antenna fraktal pelbagai jalur. Ciri-ciri khas antenna ini adalah ia boleh dipakai dimana-mana bahagian lengan badan dengan isyarat penghantaran di dalam lingkungan aplikasi komunikasi mudah alih (0 GHz - 3 GHz). Terdapat tiga jenis antena yang berbeza digunakan. Penilaian dilakukan pada dua keadaan iaitu pada antenna sahaja dengan ruang udara bebas dan juga keadaan antena diletakkan bersama lengan badan manusia. Kedua-dua keadaan dianalisiskan dari segi keupayaan antenna seperti nilai "frequency", "return loss", "realized gain", "directivity", dan "efficiency". Selepas itu, penilaian dijalankan di kawasan berhampiran dengan model lengan badan yang setimpal supaya radiasi boleh diterima badan. Contohnya, salah satu hasil dapatan daripada tiga rekaan antenna digunakan untuk pembuktian nilai parameter. Nilai "frequency" adalah pada 0.852 GHz, 1.8391 GHz dan 2.3251 GHz. Nilai "return loss" adalah -13.716 dB, -16.599 dB dan -20.26 dB. Dengan nilai yang dijelaskan, kesemuanya adalah memuaskan. Terdapat perbezaan yang ketara ditunjukkan oleh ketiga-tiga antenna tersebut melalui penyiasatan ini. Keputusan daripada kajian ini boleh membantu para jurutera untuk menilai antenna untuk kegunaan pada aplikasi antenna fractal pelbagai jalur.

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LIST OF ABBREVIATIONS

c	- Velocity of light in free space
L	- Length of the patch antenna
W	- Width of the patch antenna
Lg	-Length of ground
Wg	- Length of ground
$\mathcal{E}reff$	-Effective relative permittivity
$\mathcal{E}r$	-Relative permittivity
fo	- Desired resonant frequency
h	-Substrate thickness
Zo	- Characteristic of impedance
BW	- Bandwidth
RF	- radio frequency
GSM	- Global short massage
WLAN	- Wireless local area network
Fr4	- Flame retardant 4
CST	-Computer simulation technology
SAR	-Specific absorption rate
GSM	-Global system for mobile communication

LTE -Long term evolution

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

This chapter will discussed about introduction fractal multiband antenna design for body application. Moreover this chapter also explains about problem statement, objective and scope of work.

1.1 Introduction

Recently, wireless communication is on demand all over the world as it is a new and convenient medium of communication. Wireless communication means a transfer of information between two points or many without any connected wired. There are changes in term of data rate. There are lots of wireless technologies used and the most common is radio. It encompasses various types of fixed, cellular telephones or even wireless networking. Meanwhile, antenna is a device used in wireless application that transform an electric power into a radio waves which means a radio transmitter supplies an electric current oscillating at radio frequency and the antenna radiates the energy as electromagnetic waves. Antennas consist of various types which are horn antenna, microstrip patch antenna, yagi uda antenna, dipole antenna and many more. Those antennas are differentiate with their own capabilities and usage for different type of application where each applications has their specific frequency for examples

frequency range for mobile application is 3.1 GHz to 10.6 GHz and frequency for Wireless Local Area Network is 2.4 GHz. All of the frequencies have been set up by the Federal Communication Commission (FCC) agency. In order to test the effectiveness of the design antenna, there are seven type of antenna parameters used to measure the antenna performances which are directivity, gain, radiation pattern, efficiency, resonant frequency, return loss and antenna polarization.

This final year project will be studies on the fractal multiband antenna on body application (arm body) parameter that will be observed are such as its gain, bandwidth, return loss and resonant frequency. A fractal antenna is a repetition of a motif design of the antenna with the same or different in sizes. Moreover, fractal antennas are light-weight, low profile, conformal and easy to combine with other circuit structures [1,2]. This type of antenna's self-similarity can be applied for multiband antenna design. It has been proved that fractal shapes can lead to antenna miniaturization as well as capable to operate at multiband frequencies [3,4]. Fractal shapes is divided into various types such as cantor set, Koch curve, Sierpinski gasket and Sierpinski carpet [5].

1.2 Problem Statement

Wireless communication have been exposed into our society and affecting our everyday life profoundly during the last decade. The facility of information exchange using wireless communication system has affected many aspect of the modern lifestyle. There are many application that are using wireless communication such as mobile phone, medical application, radar application and etc. Every application has specific operating frequency. General frequency band for medical applications is 400MHz until 460MHz [1]. However, must of on body wireless medical devices which used for data transmitting to monitoring devices have limitation in amount of data that can be transferred due to low frequency band usage. Therefore, this project will analyzed the higher frequency band which can be used for medical application purposes. Higher frequency band has an advantage of higher bandwidth. As a result, higher data rate can be achieved. The drawback of using higher frequency band is that it produces more radiation effect towards the biological tissue. Therefore, the importance of

determining which high frequency band suitable for on body application is crucial. This project considered the mobile frequency band due to each of implementation with current communication technology

This project will be analyzing which is the highest frequency band that can be used for medical application. It is because when the frequency is increases, the bandwidth also increases. Besides that, the antenna wavelength is smaller. Objective for these projects are to identify which operating frequency of mobile application has a less effect of power loss density on body application. This project consider the mobile frequency because implement antenna form medical application by follow changing of technology.

1.3 Objective

Objective of this project is to design and simulate multiband antenna (GSM1800, UMTS 2100, Wi-Fi/Bluetooth 2.4GHz, and LTE2600) by using fractal shaped techniques. Besides that, this project to Analysis effect of parameter (return loss, gain, directivity, total efficiency and radiation pattern) between antenna with free space and on human arm model condition. Next is to identify which operating frequency of mobile application has a less effect of power loss density on body application.

1.4 Project scope

In order to achieve the objective of the project, there are several scope had been outlined. This project focuses on frequencies that can be function ranging from 0 GHz – 3.0 GHz for mobile communication[6]. Frequency that can cover range for:-

1. GSM900/1800 (880MHz – 915MHz/1710MHz – 1879MHz)
2. UMTS 2100 (1920 MHz-2170MHz)
3. Wi-Fi/ Bluetooth (2400MHz-2495MHz)
4. LTE2600 (2500 MHz- 2690 MHz)

The scope of this project also focuses on Analysis effect of parameter between free space antenna and arm body without consider effect to the body.

1.5 Project Schedule

Table 1.1: Project Schedule for Final Year Project

<table>
<tr><th>PROJECT ACTIVITIES</th><th>SEMESTER 1</th><th>SEMESTER 2</th></tr>
<tr><td>Supervisor meeting</td><td colspan="2">Every weeks</td></tr>
<tr><td>Project title selection.</td><td>week 1 and week 2</td><td rowspan="4"></td></tr>
<tr><td>Project title registration.</td><td>Week 2</td></tr>
<tr><td>Producing project proposal.</td><td>Week 3 until week 5</td></tr>
<tr><td>Submission of project proposal.</td><td>Week 4 and week 5</td></tr>
<tr><td>Modeling multiband patch antenna will be conducted by CST software.</td><td>Week 7 until week 19 and also within semester break</td><td>Week 1 until week 5</td></tr>
<tr><td>The simulation procedure will be done for the patch antenna.</td><td rowspan="2">Week 12 until week 19 and also within semester break</td><td rowspan="2">Week 5 until week 9</td></tr>
<tr><td>Analysis the antenna parameters on free space condition and redesign.</td></tr>
<tr><td>Apply the antenna on human arm model in CST to analyze the suitable frequency body application. Then compare the parameters of antenna.</td><td></td><td>Week 7 until week 11</td></tr>
<tr><td>FYP 1 preparation.</td><td>Week 7 until week 10</td><td rowspan="3"></td></tr>
<tr><td>Producing Chapter 1, 2 and 3.</td><td>Week 8 until week 13</td></tr>
<tr><td>Submission of preliminary report</td><td>Week 14</td></tr>
<tr><td>Writing Chapter 4</td><td rowspan="3"></td><td>Week 8-week 10</td></tr>
<tr><td>Writing Chapter 5</td><td>Week 10 until week 12</td></tr>
<tr><td>Submission of full report</td><td>Week 12</td></tr>
</table>

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

The literature review is one of the developer's methodologies to enhance the understanding of the field research for the developer. Besides that, literature reviews are made for the support of the arguments that are made during this research. Apart from that, the literature review is carried out in order to enable the reader to refer to this section if there is confusion and misunderstanding of some of the terms that are found throughout this research.

2.2. Microstrip Antenna

Microstrip antenna [6,7] is low profile antenna that consists of 3 main parts which are ground plane, dielectric substrate and radiated patch component. Figure 2.1 shows the structure of microstrip antenna.

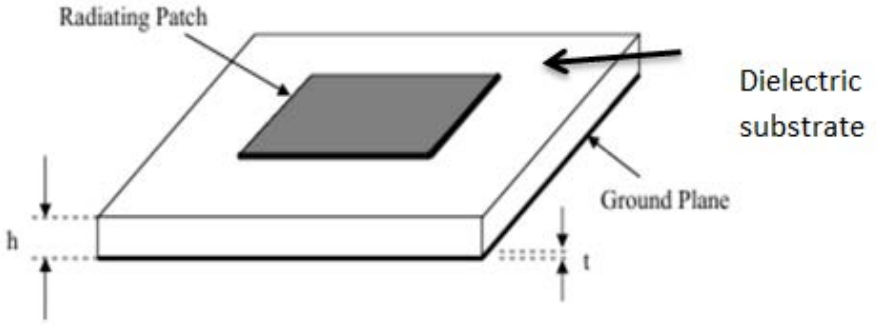

Figure 2.1: Parts of microstrip antenna

By referring to the figure 2.1, h represent the substrate thickness and t represent the thickness. The microstrip antenna is energized only when connected to a microwave ground plane. Then, the charge will arise on the upper patch, lower patch and surface on the ground plane to create a positive and negative charge into field.

Each of dielectric substrate already has their own dielectric permittivity values that will influence the antenna size. The thickness of substrate layer can improve and increase the bandwidth and efficiency but another effect from that, it will generate surface wave with low propagation that can cause loss of power. Both ground plane and radiated patch is a thin layer of copper that is a good conductor. Many application used microstrip antennas because of it has several advantages such as small in dimension, cheap, light weight and easy to integrate with other circuit. Microstrip antenna is popular due to their good characteristic but it also have several disadvantages like narrow bandwidth, low gain, surface wave excitation, low efficiency and low power handling capacity.

2.3. Antenna Properties

There are several factors that can determine the performance of the antenna. Those properties are listed:

2.3.1 Gain

The antenna's gain is a measurement of the antenna overall efficiency. There are many factors that can reduce the antenna overall efficiency. Those factors are impedance matching, material losses, network losses and random losses. In order to achieve acceptable gain performance, the antenna must overcome lot of optimization process obtained a good designed.

2.3.2 Input impedance

Basically, input impedance is to determine maximum power transfer between antenna and the transmission line. The transfer only succeeds when input impedance of the transmission line and antenna is matches otherwise the reflected wave will be generating at the antenna terminal and then flow back to the energy source. The impact of reflection of energy result causes a reduction in efficiency system.

2.3.3 Directivity

Directivity is the ratio of maximum radiated to radiate reference antenna where this kind of parameter capable to show the ability of the antenna focusing radiated energy. Reference antenna act like isotropic radiator as it radiated energy

the same in all direction and usually has directivity of 1. Directivity also can be defined as equation below:

$$D = F_{max} / F_0 \quad (2.1)$$

Where,

F_0 is a isotropic radiator radiated energy (Hz)

F_{max} is a maximum radiated energy (Hz)

2.3.4 Bandwidth

Bandwidth is defines as frequency range over a certain specification performance criteria. The performance tradeoffs between all of its performance properties should be important thing to be concern when it goes to bandwidth. An antenna is considered as a broadband if

$$F_H / f_L \geq 2 \quad (2.2)$$

$$BW_p = (f_H - f_l) / f_0 \ x\ 100\% \quad (2.3)$$

$$BW_b = f_H / f_l \quad (2.4)$$

Where,

f_0 is a operating frequency (Hz)

f_l is a lower cut off frequency (Hz)

f_H is a higher cut off frequency(Hz)

2.3.5 Radiation pattern

An antenna radiation pattern or antenna pattern is defined as "a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates. In most cases, the radiation pattern is determined in the far-field region and it is represented as a function of directional coordinates.

Radiation properties include power flux density, radiation intensity, field strength, directivity phase or polarization."[1]. Representation of the radiation properties of the antenna as a function of angular position:

- Power pattern: the trace of the angular variation of the received/radiated power at a constant radius from the antenna
- Amplitude field pattern: the trace of the spatial variation of the magnitude of electric (magnetic) field at a constant radius from the antenna.

Often the field and power pattern are normalized with respect to their maximum value, yielding normalized field and power patterns. The power pattern is usually plotted on a logarithmic scale or more commonly in decibels (dB). The have 3 type of radiation pattern:-

- Isotropic pattern is the pattern of an antenna having equal radiation in all directions. This is an ideal (not physically achievable) concept. However, it is used to define other antenna parameters. It is represented simply by a sphere whose center coincides with the location of the isotropic radiator.
- Directional antenna is an antenna, which radiates (receives) much more efficiently in some directions than in others. Usually, this term is applied to antennas whose directivity is much higher than that of a half wavelength dipole as shown in Figure 2.2.

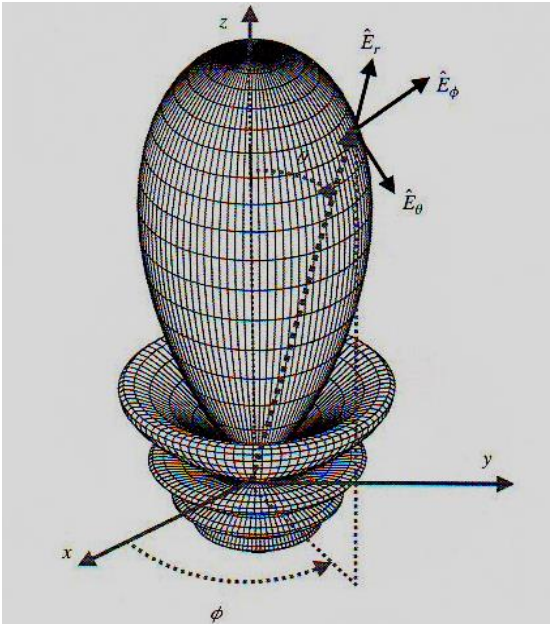

Figure 2.2: Directional antenna