PLANAR FRACTAL DIPOLE ANTENNA

FOR THE UHF BAND

MOHAMMAD IRFAN

UNIVERSITI TEKNOLOGI MALAYSIA

ACKNOWLEDGEMENT

In the name of Allah, Most Garceful, Most Merciful . With His permission I have completed this project report.

I have received a lot of assistance in doing the project and preparing this project report. First, I thank my supervisor, Dr. Mohd. Kamal A. Rahim, for his support and guidance. I am truly indebted to him for his mentorship during the entire process of this project. I would also like to extend greatest appreciation to Thelaha bin Masri and Mohd. Nazri Karim who had spent their valuable time to help me in this project and given me so much knowledge for the use of this project.

I would also like to thank my colleagues Siti Zuraidah Ibrahim, AlHasan Ali Moftah AlMahroug and Qi Xuefeng for all their help and support.

I am also grateful to my friends for their advices, guidance and motivation they offered. Finally, I thank my family whom, in many ways, has been involved in the inspiration and learning process leading to this thesis. Special appreciation to my beloved father, my loving mother, my dearly sisters, and someone special in my heart who was always there for me, in appreciation of their patience, sacrifice, support and encouragement.

Thank you all for your kindness and generosity. May Allah bless everyone.

ABSTRACT

The Ultra High Frequency (UHF) band has long been used for voice,data and video communication. The lower frequency band of the UHF which is the 470 – 890 MHz is used for terrestrial TV broadcast. The conventional UHF antennas for receiving TV signals are quite large and directional. It would be better to have a compact and omnidirectional antenna that can be easily fabricated, especially for portable devices such as portable televisions . Koch curve fractal structure is one of the fractal geometries used in antenna designs. One of the benefits of using fractals in the design of antenna structure includes miniaturization. The dipole antenna is one of the omnidirectional that can be easily designed. The planar type of antenna is one of the easiest to fabricate. This project report describes the design of the planar fractal antenna for the uhf band using the Koch curve structure. Different shapes of antenna using the truncated ground plane have been designed and simulated to investigate which is the one that gives the best performance. The simulation process was done using the Agilent ADS software.The antenna has been fabricated on the FR4 microstrip board with e_r = 4.6 and thickness of 1.6 mm using the photolitography and wet etching technique. The simulation result shows that the Koch curve can be used to minimize the length of the dipole. It also shows that the folded dipole configuration together with using Koch curve can increase bandwidth and minimize the length of the antenna. The bandwidth achieved for this antenna based on simulation is 5% and based on measurement is 7% which is quite small compared to the 470-890 MHz band but adequate to receive channel 57-62 UHF. The radiation patterns shows the characteristic of a dipole which is omnidirectional.

ABSTRAK

Jalur *Ultra High Frequency* (UHF) telah lama digunakan untuk komunikasi video, suara, dan data. Frekuensi jalur rendah daripada UHF iaitu diantara 470 – 890 MHz digunakan untuk penyiaran televisyen. Antena UHF yang sekarang banyak digunakan untuk penerimaan isyarat televisyen adalah agak besar dan terarah. Adalah lebih baik sekiranya dibuat sebuah antena yang lebih kecil dan semua arah yang dapat dengan mudah dibuat, terutamanya untuk alatan mudah alih seperti televisyen mudah alih . Struktur *fractal* lengkungan *Koch* adalah salah satu bentuk yang digunakan untuk merekabentuk antena. Salah satu kelebihan menggunakan *fractal* adalah mengecilkan saiz struktur. Antena *dipole* adalah salah satu antena semua arah yang mudah untuk direkabentuk. Antena jenis *planar* adalah salah satu bentuk antena yang paling mudah difabrikasi. Projek ini menerangkan tentang rekabentuk antena *planar fractal* untuk jalur UHF menggunakan struktur *Koch*. Pelbagai bentuk antena menggunakan satah *ground* terpenggal telah direkabentuk dan disimulasi untuk mengkaji prestasi yang paling bagus. Proses simulasi telah dilakukan menggunakan perisian Agilent ADS. Antena difabrikasi menggunakan board FR4 dengan e_r=4.6 dengan ketebalan 1.6 mm menggunakan teknik *photolitography* dan punaran basahan. Hasil simulasi menunjukkan bahawa panjang antena *dipole* boleh dikurangkan menggunakan lengkungan *Koch*. Ia juga menunjukkan konfigurasi lipatan *dipole* bersama lengkungan *Koch* boleh meningkatkan lebar jalur dan mengurangkan panjang antena. Lebar jalur yang dicapai berdasarkan hasil simulasi adalah 5% manakala hasil pengukuran adalah 7% yang mana agak kecil jika dibandingkan dengan lebar jalur 470-890 MHz, tetapi cukup untuk menerima saluran televisyen 57-62 UHF. Corak penyinaran daripada antena ini menunjukkan corak antena *dipole* iaitu corak semua arah.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

BW	-	Bandwidth
c	-	Speed of light in vacuum
E_q	-	Far electrical field of the radiated electromagnetic wave
f	-	Resonant frequency
f_{D}	-	Resonant frequency of the linear dipole
f_h	-	lower frequency that coincide with the -10 dB return loss value
f_{K}	-	resonant frequency of the koch curve dipole
f_l	-	upper frequency that coincide with the -10 dB return loss value
h	-	Thickness of the substrate
I_o	-	Input current
L_k	-	Length of koch curve dimension
L_{koch}	-	Total Length of koch curve
L_0	-	Length of initiator
ℓ	-	Dipole arm length (m)
n	-	Iteration of Koch curve
r	-	Distance from the doublet to the point where the electrical field is evaluated
v	-	Actual propagation speed on the dipole radials
w	-	width of the trace
Z_1	-	Impedance toward the source
Z_2	-	Impedance toward the load
e_{eff}	-	Effective dielectric constant

e_o	-	Permittivity of vacuum
l	-	Wavelength (m)
q	-	Angle of rotation

LIST OF ABBREVIATIONS

UHF	-	*Ultra High Frequency*
VHF	-	*Very High Frequency*
WLAN	-	*Wireless Local Area Network*

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

During the past ten years, the mobile radio communications industry has grown by orders of magnitude, fueled by digital and RF circuit fabrication improvements, new large-scale circuit integration, and other miniaturization technologies which make portable radio equipment smaller, cheaper, and more reliable. These trends will continue at an even greater pace during the next decade.

Wireless operations, such as long range communications, are impossible or impractical to implement with the use of wires. The term is commonly used in the telecommunications industry to refer to telecommunications systems (e.g., radio transmitters and receivers, remote controls, computer networks, network terminals, etc.) which use some form of energy (e.g.,radio frequency (RF), infrared light, laser light, visible light, acoustic energy, etc.) to transfer information without the use of wires.Information is transferred in this manner over both short and long distances. Applications may involve point-to-point communication, point-to-multipoint communication, broadcasting, cellular networks and other wireless networks.

Antenna is a very important component for the wireless communication systems using radio frequency and microwaves. By definition, an antenna is a device used to transform an RF signal, traveling on a conductor, into an electromagnetic wave in free space. 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". In other words it is a transitional structure between free space and a guiding device that is made to efficiently radiate and receive radiated electromagnetic waves. Antennas are commonly used in radio, television broadcasting, cell phones, radar and other systems involving the use of electromagnetic waves. Antennas demonstrate a property known as reciprocity, which means that an antenna will maintain the same characteristics regardless if it is transmitting or receiving.

One of the application of a one way wireless communication is the terrestrial television. Terrestrial television (also known as over-the-air, OTA or broadcast television) is the method of television broadcast signal (can be analog or digital) delivery by using radio waves from broadcast stations to televisions at homes using air as the medium . In terrestrial TV system, the transmitters (broadcast stations) are transmitting the TV signal with high power and a very tall antenna transmitters located on the ground to transmit radio waves to the surrounding area., Viewers can pick up the signal with a much smaller antenna. The main limitation of broadcast television is range. The frequency range used by the terrestrial television includes the very high frequency (VHF) and ultra high frequency (UHF). The most common antenna used for receiving TV signals are the the Yagi-Uda antenna (variation of the dipole antenna) which is traditionally placed on the roof of the house.

One of the other types of the antenna is the planar antenna. The planar antenna has the most variation compared to any other types of antenna. Due to its advantages such as low profile and the capability to be fabricated using the printed circuit technology, antenna manufacturers and researchers can come out with a novel design of antenna in-house which will reduce the cost of its development . Planar antennas are also relatively inexpensive to manufacture and design because of the simple 2-dimensional

physical geometry. They are usually employed at UHF and higher frequencies because the size of the antenna is directly tied to the wavelength at the resonant frequency.

Fractal geometries have been applied to antenna design to make multiband and broadband antennas. In addition, fractal geometries have been used to miniaturise the size of the antennas. However, miniaturization has been mostly limited to the wire (dipole and loop) antennas. The geometry of the fractal antenna encourages its study both as a multiband solution and also as a small (physical size) antenna. First, because one should expect a selfsimilar antenna (which contains many copies of itself at several scales) to operate in a similar way at several wavelengths. That is, the antenna should keep similar radiation parameters through several bands. Second, because the space-filling properties of some fractal shapes (the fractal dimension) might allow fractal shaped small antennas to better take advantage of the small surrounding space. The fractal antenna is formed by applying a generator shape repetitively at a constant scale factor and results in an antenna with log-periodic characteristics which is a multiband antenna and a miniaturization characteristic.

1.2 Problem Statement

Antenna elements are based on the size of the waves they're designed to receive, and the lower the frequency, the waves are longer, requiring a larger antenna surface to receive them. UHF TV antenna is significantly large and are intended for roof- or attic-mounting.

The use of big outdoor UHF antenna should be replaced with a compact, less expensive and easily manufactured dipole antenna. The fractal geometry combined with the planar dipole can produce an antenna that has the benefit of being compact ,low cost, and easily fabricated. The UHF band spanning from 470 MHz - 890 MHz is used for

terrestrial TV broadcast. It will be very useful if the planar fractal antenna can be utilised in this frequency band.

1.3 Objectives

The objectives of this project are as follows:

To design, simulate and fabricate a double sided planar dipole antenna based on the Koch curve fractal geometry and with truncated ground plane, that has operating frequency within the lower UHF band i.e. 470MHz-890MHz which is the terrestrial TV signal frequency band.

1.4 Scope of Project

(i) Design the antenna based on previous similar works in published journals using antenna design software ,

(ii) Simulate the proposed antenna using antenna design software (Agilent Advanced Design Systems),

(iii) Fabricate the antenna using the available materials.

1.5 Organisation of Project Report

This project report consists of five chapters describing all the work done in the project. The project report organisation is geneally described as follows.

The first chapter explain the introduction of the project and problem this project try to solve which describe the motivation of this project. This chapter sets the work flows according to the objectives and scope of project.

Chapter two discuss the types of antennas, theories of planar and microstrip antenna , dipole configuration, and the fractal structure for antennas. Also the equation needed to design the planar dipole antenna is discussed.

Chapter three discuss the steps on designing the planar fractal dipole antenna, the software used for design and simulation, the structure of the designed antennas, and the measurement techniques.

Result and analysis are presented in chapter four to compare the performance of all the designed antennas.

The last chapter highlights the overall conclusion of the project with future work suggestion to improve the design of the antenna. The project is summarized in this chapter to give general achievements and the future improvements can be made by other reserachers in the future.

1.6 Summary

This is an introductory chapter that defines the literature review, the objectives, and research background of the thesis. The project report structure is explained and highlighted. In the following chapters, the project work performed is reported.