

ANALYSIS AND DESIGN OF HIGH GAIN AND LESS LOSS FOR
MULTIBAND MICROSTRIP ANTENNA USING DEFECTED GROUND
STRUCTURE (DGS)

NUR NABILA BINTI PILI

This Report Is Submitted In Partial Fulfillment of Requirement for the Bachelor
Degree of Electronic Engineering (Wireless Communication)

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka

JUNE 2015



UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEDRUTERAAN ELEKTRONIK DAN KE-DRUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : ANALYSIS AND DESIGN OF HIGH GAIN AND LESS LOSS FOR
MULTIBAND MICROSTRIP ANTENNA USING DIELECTRIC GROUND
STRUCTURE (DGS)

Sesi Pengajian :

4	R	E	N	W
---	---	---	---	---

Saya **NUR NABLA BINTI PILI**
mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan
syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan () :

SULIT*

* (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang terdiktub di dalam AKTA RAHSIA RASMI 1992)

TERHAD**

** (Mengandungi maklumat terhad yang telah diterbitkan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

(TANDATANGAN PENULIS)


Disahkan oleh:

(TOP DAN TANDATANGAN PENYELIA)

TARIKH: 23/6/2015

TARIKH: 23/6/2015

"I hereby declare that this report is the result of my own work except for the quotes
as cited in the references"

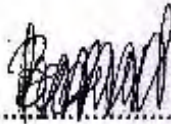
Signature : 

Author : NUR NABILA BINTI PILI

Date : 23 June 2015

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award Bachelor Degree of Electronic Engineering (Wireless Communication) with Honours"

Signature



Supervisor's Name : PM DR BADRUL HISHAM BIN AHMAD

Date : 23 June 2015

*Special dedication my lovely mother, Fauziah Binti Tetel, my father, Pili Bin Poying
and my family.*

ACKNOWLEDGEMENT

This research paper is made possible through the help and support from everyone, including the supervisor, parents, and friends. Especially, please allow me to dedicate my acknowledgment of gratitude toward the following significant advisor. I would like to thank PM Dr Badrul Hisham Bin Ahmad for his most support and encouragement. He kindly read my paper and offered invaluable detailed advices on organization, and the contents of the paper.

Secondly, I would like to thank the panels for PSM 1 and PSM 2, Dr Ho Yih Hwa and Encik Nor Azlan Bin Mohd Aris for comments that greatly improved the project and also the research paper. Not forgetting, a lot of thanks to my family for the moral and financial support until I manage to complete this project.

Last but not least, I would to thank to all my friends for their help, knowledge and assistance to accomplish my project. The product of this research paper would not be possible without all of them.

ABSTRACT

In this thesis, a few design of a high gain and less loss of multiband microstrip antenna using defected ground structure (DGS) are proposed. Total of three shape of DGS with number unit of 2, 4 and 6 DGS are proposed and only one best shape and number of unit DGS is selected to proceed with the next process which is the fabrication process. The measurement result show that the antennas have operating frequencies of 4.65 GHz, 6.871 GHz and 9.723GHz with return loss $S_{11} < -10\text{dB}$. The gain of the proposed antenna also in range of 1dB – 6dB. Comparison of return loss and gain between simulation and fabricated antenna also be done in this project paper.

ABSTRAK

Dalam tesis ini, beberapa reka bentuk antena yang mempunyai gandaan simulasi tinggi dan kehilangan balikan yang kurang dengan menggunakan teknik kerosakan struktur belakang telah dicadangkan. Sebanyak tiga bentuk kerosakan struktur belakang dengan jumlah unit 2, 4 dan 6 kerosakan struktur belakang dicadangkan dan hanya satu bentuk dan unit kerosakan struktur belakang terbaik dipilih untuk meneruskan proses berikutnya iaitu proses fabrikasi. Hasil pengukuran menunjukkan bahawa antena telah beroperasi di frekuensi 4.65 GHz, 6,871 GHz dan 9.723GHz dengan kehilangan balikan $S_{11} < -10\text{dB}$. Gandaan antena yang dicadangkan juga dalam lingkungan 1dB - 6dB. Perbandingan kehilangan balikan dan gandaan antara simulasi antena dan fabrikasi antena juga dilakukan dalam kertas projek ini.

TABLE OF CONTENT

CHAPTER	CONTENT	PAGE
	PROJECT TITLE	i
	DECLARATION	iii
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTRACT	vii
	ABSTRAK	viii
	TABLE OF CONTENT	ix
	LIST OF TABLES	xiii
	LIST OF FIGURES	xiv
I	INTRODUCTION	1
	1.1 PROJECT BACKGROUND	2
	1.2 PROBLEM STATEMENT	2
	1.3 OBJECTIVES	3
	1.4 PROJECT SCOPES	3
	1.5 BRIEFLY EXPLANATION ON METHODOLOGY	4
	1.6 METHODOLOGY	4
	1.7 THESIS PLAN	6

II	LITERATURE REVIEW	
	2.1 Introduction	7
	2.2 Basic Operation of Microstrip Antenna	8
	2.3 Feeding Technique	9
	2.4 Important Parameter of Antenna	10
	2.4.1 Return Loss	10
	2.4.2 Gain	10
	2.4.3 Bandwidth	11
	2.4.4 Radiation Pattern	11
	2.4.5 Directivity	12
	2.5 Advantages and Disadvantages of Microstrip Antenna	12
	2.5.1 Advantages of Microstrip Antenna	12
	2.5.2 Disadvantages of Microstrip Antenna	13
	2.6 Defected Ground Structure (DGS)	13
	2.7 Basic Ideas and Geometries	14
	2.8 Past Work Research	15
III	METHODOLOGY	
	3.1 Introduction	18
	3.2 A Multiband Microstrip Antenna Design	18
	3.2.1 Design Specification	19
	3.3 Designs by Calculation	20
	3.4 Simulation Process	22

IV	RESULTS AND DISCUSSION	
4.1	Original Design	24
4.1.1	Return Loss Original	25
4.1.2	Gain Original	26
4.2	Design with Circle DGS	27
4.2.1	Return Loss with circle DGS	27
4.2.2	Gain with circle DGS	29
4.3	Design with Dumbbell DGS	32
4.3.1	Return Loss with Dumbbell DGS	32
4.3.2	Gain with dumbbell DGS	34
4.4	Design with Square DGS	37
4.4.1	Return Loss with circle DGS	37
4.4.2	Gain with square DGS	39
4.5	Fabricated Antenna	42
4.6	Measurement	42
4.6.1	Return Loss	42
4.6.2	Gain	44
4.7	The Comparison between the Simulated and Fabricated Antenna	44
4.7.1	Return Loss	45
4.7.2	Gain	46

V CONCLUSION AND RECOMMENDATION

5.1 Conclusion	47
5.2 Future Work	48
REFERENCES	49

LIST OF TABLES

NO	TITLE	PAGE
4.1	Return Loss for Original Antenna	25
4.2	Comparison of return loss with two, four and six circle DGS	28
4.3	Comparison of return loss with two, four and six dumbbell DGS	33
4.4	Comparison return loss with two, four and six square DGS	38
4.5	Measured return loss for original antenna	43
4.6	Measured return loss for antenna with six circle DGS	43
4.7	The Comparison of original return loss between simulation and measurement result	45
4.8	The Comparison of return loss with six circle DGS between simulation and measurement result	45
4.9	The Comparison of original gain between simulation and measurement result	46
4.10	The Comparison of gain with six circle DGS between simulation and measurement result	46

LIST OF FIGURES

NO	TITLE	PAGE
1.1	Flow chart of the project	5
2.1	Basic structure of a microstrip patch antenna	7
2.2	A side view of microstrip patch antenna	8
2.3	Inset feed line	9
2.4	Spherical coordinate systems for antenna analysis	11
2.5	Various type of DGS geometries	14
3.1	Design for multiband antenna (front view)	19
3.2	Shapes for DGS	19
3.3	Background properties	22
3.4	Substrate material properties	23
3.5	Monitor Setting	23
4.1	Original design (a) front (b) back	24
4.2	Graph of Return Loss for Original Antenna	25
4.3	Gain for original design at frequency of 4.65GHz	26
4.4	Gain for original design at frequency of 6.871GHz	26
4.5	Gain for original design at frequency of 9.723GHz	26
4.6	Design with 2, 4 and 6 Circle DGS	27
4.7	Return loss of two circle DGS	27
4.8	Return loss for four circle DGS	27
4.9	Return loss for six circle DGS	28
4.10	Comparison of return loss with two, four and six circle DGS	28

4.11	Gain for design with 2 circle DGS at frequency of 4.65GHz	29
4.12	Gain for design with 2 circle DGS at frequency of 6.871GHz	29
4.13	Gain for design with 2 circle DGS at frequency of 9.723GHz	29
4.14	Gain for design with 4 circle DGS at frequency of 4.65GHz	30
4.15	Gain for design with 4 circle DGS at frequency of 6.871GHz	30
4.16	Gain for design with 4 circle DGS at frequency of 9.723GHz	30
4.17	Gain for design with 6 circle DGS at frequency of 4.65GHz	31
4.18	Gain for design with 6 circle DGS at frequency of 6.871GHz	31
4.19	Gain for design with 6 circle DGS at frequency of 9.723GHz	31
4.20	Design with 2, 4 and 6 Circle DGS	32
4.21	Return loss of two dumbbell DGS	32
4.22	Return loss of four dumbbell DGS	32
4.23	Return loss of six dumbbell DGS	33
4.24	Comparison of return loss with two, four and six circle DGS	33
4.25	Gain for design with 2 dumbbell DGS at frequency of 4.65GHz	34
4.26	Gain for design with 2 dumbbell DGS at frequency of 6.871GHz	34
4.27	Gain for design with 2 dumbbell DGS at frequency of 9.723GHz	34
4.28	Gain for design with 4 dumbbell DGS at frequency of 4.65GHz	35
4.29	Gain for design with 4 dumbbell DGS at frequency of 6.871GHz	35
4.30	Gain for design with 4 dumbbell DGS at frequency of 9.723GHz	35
4.31	Gain for design with 6 dumbbell DGS at frequency of 4.65GHz	36
4.32	Gain for design with 6 dumbbell DGS at frequency of 6.871GHz	36
4.33	Gain for design with 6 dumbbell DGS at frequency of 9.723GHz	36
4.34	Design with 2, 4 and 6 Square DGS	37
4.35	Return loss of two square DGS	37
4.36	Return loss of four square DGS	37

4.37	Return loss of six square DGS	38
4.38	Comparison of return loss with two, four and six square DGS	38
4.39	Gain for design with 2 square DGS at frequency of 4.65GHz	39
4.40	Gain for design with 2 square DGS at frequency of 6.871GHz	39
4.41	Gain for design with 2 square DGS at frequency of 9.723GHz	39
4.42	Gain for design with 4 square DGS at frequency of 4.65GHz	40
4.43	Gain for design with 4 square DGS at frequency of 6.871GHz	40
4.44	Gain for design with 4 square DGS at frequency of 9.723GHz	40
4.45	Gain for design with 6 square DGS at frequency of 4.65GHz	41
4.46	Gain for design with 6 square DGS at frequency of 6.871GHz	41
4.47	Gain for design with 6 square DGS at frequency of 9.723GHz	41
4.48	Fabricated antenna with and without DGS	42
4.49	Measured return loss for original antenna	42
4.50	Measured return loss for antenna with six circle DGS	43

CHAPTER 1

INTRODUCTION

This chapter will discuss briefly about the background the problem statement, objectives and scope of the project that have been chosen.

Multiband antenna is an antenna designed to operate on several bands. A multiband antenna may have lower than average gain or may be physically larger in compensation.

DGS is realized by introducing a shape defected on a ground plane which disturbs the current distribution of the antenna [7]. The disturbance at the shielded current distribution will influence the input impedance and the current flow of the antenna. Shapes and number of DGS also affect the performance of the antenna.

The gain of an antenna is defined as the ratio of the power intensity radiated by the antenna in a given direction. Gain requirements may vary according to different applications of mobile communication. This report will present about the design of a high gain and less return loss antenna with multiband operation frequencies.

1.1 Project Background

This project proposed to analysis and design of high gain and less loss for multiband microstrip antenna using defected ground structures (DGS). Recently there has been much interest in microstrip patch antenna because of its simplicity and compatibility. Because of their advantages in simplicity and compatibility with printed circuit technology, microstrip antennas are widely used in the wireless telecommunication systems [2]. These types of antennas are attractive in antenna applications for many reasons such as they are easy and cheap to manufactured and also light in weight.

While using microstrip patch antenna the other problems which will occurs are high loss and surface wave in substrate layer, as the losses will always occurs in radiation as the antenna is transmitting the signals. Due to surface wave radiation excitation losses occur that will cause decrease in the antenna efficiency, gain and bandwidth because the surface wave occurs, it extract total available power for radiation to space wave [3].

1.2 Problem Statement

Microstrip patch antenna has been studied extensively over the past years because of its low profile, light weight, low cost and easy fabrication. Based on literature review studies, it is found that there is still a need for antenna to be improved in term of gain and return loss. One of the solutions proposed to improve these two parameters is to design an antenna by using Defected Ground Structure (DGS). With implement of DGS, it can increase the gain of the antenna and also reduce the return loss.

1.3 Objectives

The objectives of the project are:

1. To study the effect of different number and shapes of DGS toward improvement of gain and return loss in antenna
2. To design an antenna with implement of DGS at three operating frequency range from 3GHz to 10GHz
3. To fabricate the proposed antenna and conduct the experiment test on it.

1.4 Project Scopes

This project is about high gain and less loss antenna. The antenna design operates at three operating frequency between 3GHz to 10GHz. The proposed antenna should be simpler in design but the circuit must be able to receive high gain and has less return loss. The least cost also took into consideration since FR-4 substrate is used. The result of high gain antenna through simulation will be compared with the experiment result. Even though the experiment only focusing on the improvement of high gain and less loss, the other parameters such as bandwidth, radiation pattern, efficiency and directivity will be analyse using CST Microwave Studio.

1.5 Brief Explanation on Methodology

The suitable software is the first thing needed consideration in order to design the antenna. CST Studio Suite Software is the most common and user-friendly software to design antenna. The software enables users to design the desired antenna in 3D version that will give a clearer vision about the sooner fabricated antenna. By using this CST software, the users are able to do the simulation after designing the antenna. The simulation result will measure and display the various parameters such as gain, return loss, directivity bandwidth and so on. After getting the desired simulation result, the next step which is fabrication step will be proceed. In the fabrication step, the designed antenna will be fabricated on the FR4 substrate. After finish the fabrication step, then the test will be held upon the antenna by using the facilities and equipment provided in the lab at Universiti Teknikal Malaysia Melaka.

1.6 Methodology

This project will begin by determine the objectives of the project. Next is finding information on the antenna design by doing literature review. Next, the project will be continued by designing an antenna with DGS that operates in multiband by using CST Software. Then the simulation will be carried out to find out the desired value on gain and return loss. After achieve all desired parameter, process of fabrication the antenna will be done. Experiment test will be conduct and if the results differ from simulation, process of software will be repeated. Finally both experimental and simulation result will be compared and included in the final report.

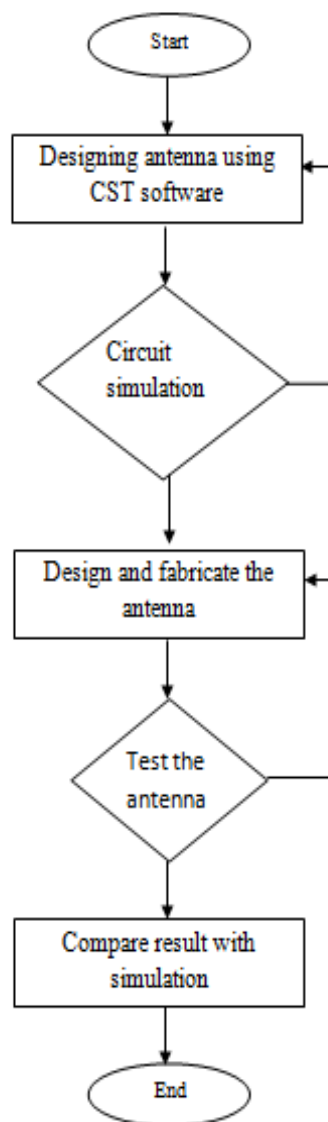


Figure 1.1: Flow chart of the project

1.7 Thesis Plan

This thesis will be divided into five chapters.

Chapter 1- This chapter will briefly explained about the introduction and the background of the project. Some information about the type of antenna used is also mentioned. This chapter also includes the problem statement, objectives and project scope and brief explanation on methodology.

Chapter 2- This chapter is about the literature review about this project will be reviewed. It includes the explanations of the past work research related to this project. The past research will be based on the high gain and less loss multiband antenna.

Chapter 3- This chapter is about methodology. It will explain in details the methods and procedures as the guideline to complete and run the project perfectly from the beginning till the end.

Chapter 4- This chapter will present all the tabulation data and results. The discussion about this project will be included in this chapter instead.

Chapter 5- This chapter will be presenting the overall conclusion of this project. Apart from that, the recommendation for the future work will be clarified.

CHAPTER 2

LITERATURE REVIEW

This chapter will explained on the fundamental concept and theory of multiband antenna with DGS base on past work research. The information gathered in this literature review chapter can be a guideline in designing and simulating the proposed antenna in the correct way so it may work perfectly according to plan. Most of the past study discussed about almost the same good features of multiband antenna that will achieve in a way desired.

2.1 Introduction

A microstrip patch antenna is a narrowband wide beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which form a ground plane [4]. The conducting patch can take any shape but rectangular and circular shapes are commonly used.

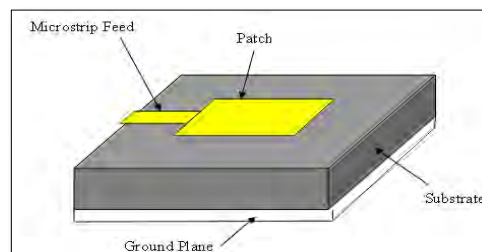


Figure 2.1: Basic structure of a microstrip patch antenna

2.2 Basic Operation of Microstrip Antenna

The figure below shows a patch antenna in its basic form which consist a flat over a ground plane. The center conductor of a coax serves as the feed probe to couple electromagnetic energy in and/or out of the patch. The electric field distribution of a rectangular patch excited in its fundamental mode is also indicated [5].

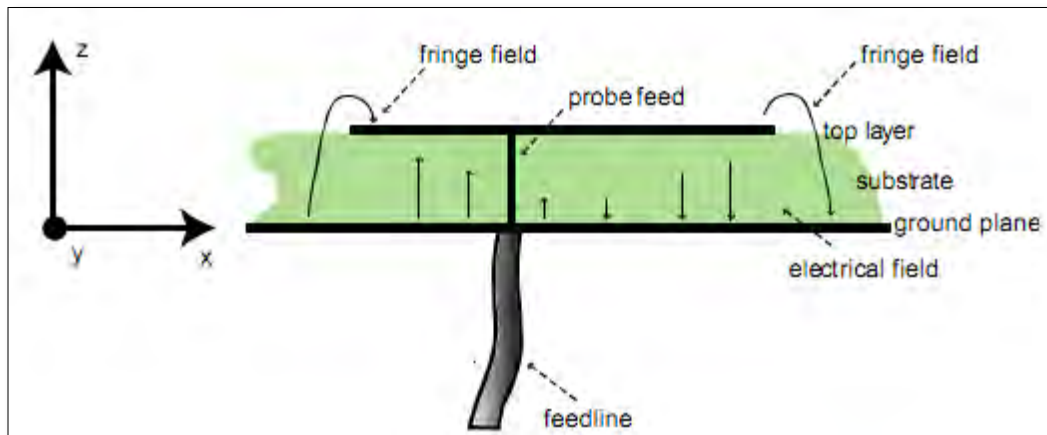


Figure 2.2: A side view of microstrip patch antenna

The electric field is zero at the center of the patch, maximum at one side, and minimum on the opposite side. It should be mentioned that the minimum and maximum continuously change side according to the instantaneous a cavity. Rather, the fields extend the outer periphery to some degree. These field extensions are known as fringing fields and cause the patch to radiate. Some popular analytic modeling techniques for patch antennas are based on this leaky-cavity concept. Therefore, the fundamental mode of rectangular patches often denoted using cavity theory as the TM₁₀ mode.

TM stands for transversal magnetic field distribution. This means that only three field components are considered instead of six. The field components of interest include the electric field in the z direction and the magnetic field components in x and y direction using a Cartesian coordinate system, where the x and y axes is parallel with the ground plane and the z axis is perpendicular.