

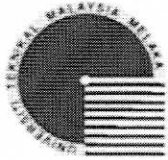
**A STUDY AND DESIGNING GPS ANTENNA USING MICROSTRIP
TECHNOLOGIES**

MOHD HAFIZUL B. MOHAMED @ ABU BAKAR

This report is submitted in partial fulfilment of requirement for the award of
Bachelor of Electronic Engineering (Industrial Electronics) with honours.

**Fakulti Kejuruteraan Elektronik dan Komputer
Universiti Teknikal Malaysia Melaka**

May 2007



UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

**BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II**

Tajuk Projek : A Study and Designing GPS Antenna Using Microstrip Technologies

Sesi Pengajian : 2-2006/2007

Saya ...MOHD HAFIZUL B. MOHAMED @ ABU BAKAR

(HURUF BESAR)

mengaku membenarkan laporan 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 (\checkmark) :

SULIT*

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

TERHAD*

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

TIDAK TERHAD

Disahkan oleh:

(COP DAN TANDATANGAN PENYELIA)
IMRAN MOHD B IBRAHIM

Pensyarah

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer (FKEKK),
Universiti Teknikal Malaysia Melaka (UTeM),
Kampus Berkunci 1200,
Ayer Keroh, 75450 Melaka

9/5/07


Tarikh:

(TANDATANGAN PENULIS)


Alamat Tetap: Lot 2949 Kg. Gual Badak,
17200 Rantau Panjang Kelantan.

Tarikh: 8/5/2007

“I hereby declare that this project is the result of my own work except for quotes as
cited in the reference”

Signature :.....
Author : Mohd Hafizul B. Mohamed @ Abu Bakar
Date : 4th May 2007

“I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of Bachelor of Electronics Engineering (Industrial Electronics) with honours”.

Signature : 
Supervisor's Name : Mr. Imran B. Mohd Ibrahim
Date : 4th May 2007

Dedicated to my beloved mother, father, families, supervisor, lecturers, technicians
and fellow friends.

ACKNOWLEDGEMENT

First of all, endless thanks to the Almighty, the source of my life, wisdom and hope for giving me the strength and patience to pursue this project.

My warmest appreciation especially to my supervisor, Mr. Imran Bin Mohd Ibrahim for his caring and cooperation towards his protégé. He is very keen in facilitating me during project execution. Also special gratitude for the kindness spending his precious time in supervising me even he was very busy. For that, thank you very much.

I would like to express my sincere appreciation to Mr. Mohammad Zoinol Abidin Bin Abdul Aziz that help me so much in completing this project. And also to all lecturers for their help and providing me with many positive remarks, which inspired me in becoming a well-rounded engineer. Deeply thanks for giving me the knowledge as well as guidance throughout project accomplishment and this knowledge is valuable in work field as a competence engineer.

My special thanks to panels Mr Zoinol Abidin Bin Abdul Aziz and Mr. Redzuan Abdul Manap for assessing my performance throughout the presentations.

Deepest thanks to my parents, colleagues and friends for giving me moral support and providing me with many comments and advices to become an excellent and well-rounded engineer.

ABSTRACT

This project proposed to study the antenna in GPS (Global Positioning System), designing the antenna and fabricate it. The GPS is a system that is able to determine the location of object and human on the earth. GPS has become a vital global utility, indispensable for modern navigation on land, sea, and air around the world, as well as an important tool for map-making, and land surveying. GPS also provides an extremely precise time reference, required for telecommunications and some scientific research, including the study of earthquakes. The frequency that use for GPS is 1575.42 Mhz. The main objective of this project is to design and fabricate a cheap GPS antenna. The best way to fabricate a cheap antenna is by using the microstrip antenna technology. The microstrip antennas are manufactured using printed-circuit technology, so that mass production can be achieved at a low cost. Microstrip antennas have several advantages, including that they are lightweight and small-volume and they can be conformal to the host-surface. Microstrip technology which are used for defense and commercial application, are replacing many conversional antennas. However, the types of applications of microstrip antennas are restricted by antennas inherently narrow bandwidth.

ABSTRAK

Tujuan projek ini adalah untuk mendapat maklumat dan mengkaji antenna yang digunakan di dalam sistem GPS '*Global Positioning System*', serta mereka bentuk dan membina antenna tersebut. GPS adalah sistem yang mampu menentukan kedudukan sesuatu objek ataupun manusia di atas bumi ini. GPS menjadi perkhidmatan global yang penting untuk navigasi moden yang di gunakan di darat, laut dan udara di seluruh dunia, serta penting di dalam sistem pemetaan dan peninjauan tanah. Sistem ini juga menyediakan rujukan waktu yang tepat, yang diperlukan oleh sesetengah kajian termasuk kajian gempa bumi. Frekuensi yang digunakan untuk sistem ini adalah 1575.42 Mhz. Objektif utama projek ini adalah untuk mereka bentuk dan membina antenna GPS yang murah. Penyelesaian terbaik untuk membina antenna yang murah adalah dengan mereka bentuk antenna yang menggunakan antenna microstrip. Antenna microstrip dihasilkan menggunakan teknologi '*printed-circuit*', maka pengeluarannya dapat dilakukan dengan kos yang rendah. Antenna microstrip mempunyai banyak kelebihan termasuk ringan dan kecil dimana boleh diletakkan dan disesuaikan dengan perumah. Antenna microstrip yang digunakan untuk pertahanan dan kegunaan komersial sedang menggantikan kebanyakan antenna biasa. Bagaimanapun, jenis-jenis aplikasi antenna microstrip adalah terbatas kerana sifatnya yang mempunyai jalur lebar yang sempit.

CONTENT

CHAPTER	ITEM	PAGE
	PROJECT TITLE	i
	VERIFICATION STATEMENT	ii
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTRACT	vii
	ABSTRAK	viii
	CONTENT	ix
	LIST OF TABLE	xiii
	LIST OF FIGURE	xiv
	LIST OF ABBREVIATION	xvi
	LIST OF APPENDIX	xvii
I	INTRODUCTION	
	1.1 Project Introduction	1
	1.2 Objective	1
	1.3 Project Statement	2
	1.4 Scope of Project	3
	1.5 Thesis Outline	3
II	LITERATURE RIVIEW	
	2.1 Introduction	5
	2.2 Antenna	6

2.2.1	Basic Antenna Operation	7
2.2.2	Polarization	8
2.3	Basic Parameters of Antenna	10
2.3.1	Impedance	10
2.3.2	Wavelength	10
2.3.3	Bandwidth	11
2.3.4	Voltage Standing Ratio	13
2.3.5	Gain	14
2.3.6	Return Loss	14
2.3.7	Half Power Beam Width	15
2.4	Antenna in GPS	16
2.4.1	Types of GPS antenna	16
2.5	GPS Antenna Design Requirement	17
2.6	Microstrip Technologies	17
2.7	Microstrip Antenna	19
2.7.1	Characteristics of Microstrip Antenna	21
2.7.2	Advantages	21
2.7.3	Disadvantages	22
2.7.4	Application of MSA _s	22
2.7.5	Size of the patch element	24
2.7.6	Resonant dimension of the patch element	24
2.7.7	Two resonant dimensions	24
2.7.8	The feed position	24
2.7.9	The feed position and resonant frequency	25
2.8	Transmission Line	25
2.8.1	Fringing Effect	26
2.8.2	Feeding technique	28
2.8.3	Method of analysis	30
2.9	The Equation Use for Antenna Design	31

III METHODOLOGY

3.1	Introduction	33
3.2	Designing Process	33
3.3	Material of The Dielectric Constant	35
3.4	Simulation	36
	3.4.1 Microwave Office	36
	3.4.2 Corel Draw 12	38
3.5	Antenna Specification From Calculation	39
3.6	Antenna Fabrication	44
	3.6.1 Layout printing	46
	3.6.2 Ultraviolet	46
	3.6.3 Developer	46
	3.6.4 Etching	46
	3.6.5 Stripper	47
	3.6.6 Soldering	47

IV RESULT AND DISCUSSION

4.1	Introduction	48
4.2	Network Analyzer	48
4.3	Return Loss Plot	49
4.4	Result of Simulation Using Microwave Office	50
	4.4.1 The result use original value refer to calculation	50
	4.4.2 The result after adjusted the dimension of the patch	51
	4.4.2.1 Return Loss	54
	4.4.2.2 Voltage Standing Ratio	54
	4.4.2.3 Bandwidth of the antenna	55
	4.4.2.4 Gain	55
	4.4.2.5 Half Power Beam Width	56
	4.4.2.6 First Null Beam Width	56

4.5	The result of measuring using fabricated antenna	57
4.5.1	Return Loss	58
4.5.2	Voltage Standing Ratio	58
4.5.3	Bandwidth of the antenna	59
4.6	The comparison of the dimension of the antenna and the result of simulation and fabricated antenna	60
4.7	Discussion	61
4.7.1	The reasons of the differences between simulation and measurement	61
4.7.1.1	Transmission Line Matching	62
4.7.1.2	Improper etching process	62
4.7.1.3	Effect of reflection and interferences from surroundings	62

V CONCLUSION

5.1	Introduction	63
5.2	Conclusion	63
5.3	Future Works	65

REFERENCE	66
------------------	-----------

APPENDIX A	68
-------------------	-----------

APPENDIX B	69
-------------------	-----------

APPENDIX C	70
-------------------	-----------

APPENDIX D	71
-------------------	-----------

LIST OF TABLE

NO.	TITLE	PAGE
2.1	The frequencies make up the GPS electromagnetic spectrum	6
2.2	VSWR and transmitted power table for antenna	13
2.3	Comparison between MIC and MSA	21
2.4	Typical Application of MSAs	23
3.1	The detail of FR4	
4.1	The comparison between the dimensions of the original value with adjusted value in simulation using Microwave Office	60
4.2	The comparison results of the simulation and fabricated antenna with specification antenna.	60

LIST OF FIGURE

NO.	TITLE	PAGE
2.1	Function of Antenna	7
2.2	The polarization of antenna	9
2.3	The location of lower frequency, centre frequency and upper frequency on the Return Loss vs Frequency graph.	12
2.4	Microstrip Line	18
2.5	Rectangular Patch Antenna	19
2.6	Shapes of Microstrip Patch Antenna	20
2.7	Structure of Microstrip Antenna	23
2.8	Microstrip Line Feed	25
2.9 (a)	Microstrip Line	27
2.9 (b)	Typical electric field line	27
2.9 (b)	Effective dielectric constant	27
2.10	Kinds of feed point in Rectangular Patch Antenna	29
3.1	Flow chart in designing the antenna	34
3.2	Rectangular patch antenna with microstrip line feed along radiating edge with quarter-wave transformer	35
3.3	The interface of the Microwave Office	37
3.4	The interface of the Microwave Office	38
3.5	The example of Smith Chart	41
3.6	The patch located with via port to find Z_L	42
3.7	The result of Z_L from Smith Chart	42
3.8	The fabrication process of the antenna	45
4.1	The Network Analyzer Model R3767CG	49
4.2	The dimension use the original value refer to calculation	50

4.3	The return loss chart of the antenna using original value	51
4.4	The dimension of the antenna after been adjusted	52
4.5	The return loss chart of the antenna after been adjusted	52
4.6	The result of radiation pattern	53
4.7	The fabricated antenna	57
4.8	The result from measurement of fabricated antenna	58

LIST OF ABBREVIATION

GPS	-	GLOBAL POSITIONING SYSTEM
GSM	-	GLOBAL FOR MOBILE COMMUNICATION
MSA	-	MICROSTRIP ANTENNA
MIC	-	MICROWAVE INTEGRATED CIRCUIT
RMSA	-	RECTANGULAR MICROSTRIP ANTENNA
BW	-	BANDWIDTH
VSWR	-	VOLTAGE STANDING RATIO
HPBW	-	HALF WAVE BEAM WIDTH
FNBW	-	FIRST NULL BANDWIDTH

LIST OF APPENDIX

NO	TITLE	PAGE
A	Microstrip Feed	67
B	Coaxial Feed	68
C	Example of testing procedure	69
D	Steps to design antenna using Microwave Office	70

CHAPTER I

INTRODUCTION

1.1 Project Introduction

This project covers on the designing and fabricates a GPS rectangular patch antenna with the frequency of 1.575 GHz using Microstrip Antennas Technology. The reason for using Microstrip Antenna Technology is because there are a lot of advantages, such as low cost antenna and others. The importance from this study is to increase the bandwidth of the microstrip antenna.

1.2 Objectives

The objective of this project is the antenna that will be built is able to pick and discriminate very weak signals. The frequency that used in this project is classified in weak signals that are about 1 GHz to 3 GHz.

The antenna also must operate at just L1 frequency, or both the L1 and L2 frequencies. For this project, the design of the antenna used L1 frequency 1.575 GHz. As the signals are circularly polarized, the GPS antenna must also be circularly polarized.

Besides that, the objective of this antenna is to design and fabricate a low cost GPS antenna using the Microstrip Antenna Technologies.

1.3 Problem Statements

The problems in GPS and Microstrip Antenna Technology are:

i) **The frequency used in this system**

In the GPS, there are about 5 bands of frequency that must be studied and for the fabricated of the antenna, these frequencies must be considered. The suitable frequency for public used is been selected.

ii) **The narrow bandwidth of the microstrip antenna**

The characteristics of microstrip antenna that got narrow bandwidth are the major limiting factors for the widespread application of these antennas. The bandwidth can be increased by using a thick substrate with low dielectric constant, planar gap-coupled and directly coupled multiresonator.

ii) **Shapes of microstrip antenna**

There are several shapes of the antenna in microstrip antenna. Among the shaped are square, circular, triangular, semicircular, sectoral and annular ring. The selection of the shaped is decided by considering the frequency and parameters.

1.4 Scope of Works

The scopes for this project are to understand the system of GPS and the antenna in the system. Before designing and fabricated the GPS antenna the specification in the system must be known first.

Then the characteristic of microstrip antenna must be understood. The characteristic of the microstrip antenna can be learning through research and also experiment.

The engineering tools use for this project, Microwave Office is learned. The designing of the antenna will be using this software. After designing the antenna, the fabricated antenna will used the exact dimension from design process.

1.5 Thesis Outline

This report is divided into five chapters. The following is the outline of this project, A Study and Designing of GPS Antenna chapter by chapter. Each part will cover on a topic required.

As for chapter 1, it will cover on introduction of the project. A little bit of explanation will be done due to the project. It also includes the objective and the problem statement of the project.

Chapter 2 is a chapter which covers on the literature review of the project. Each of the literature review is divided into a certain sub topic or explanation. The literature review begins with the introduction, followed by GPS antenna, microstrip antenna, rectangular patch, microstrip technologies and software use in antenna development.

Introduction is an explanation on the overview of the literature review. As for the antenna topic, it is about the general description of an antenna. It is also covered on the GPS and the basic principal of the antenna. Microstrip antenna is an

explanation regarding the microstrip antenna where it is slightly different from the general explanation of the general antenna.

The next explanation is on microstrip antenna, followed by the rectangular patch antenna itself. This topic is more specific where it is only explain on the microstrip antenna. It is also shows on designing an antenna. The design is focus on rectangular patch antenna. Besides, it also covers on the characteristics of antenna, the specifications and more.

Next, chapter 3 will be cover on project methodology where it is focusing on the method that used to completing the project accordingly. The methodology are presented in the flowchart. In addition, it is representing in details in the form of sentences.

As for the chapter 4, the preliminary result of the project will be discussed. The progress of the project is assigned into two parts which is the complete tasks and project in progress. The complete progress will be including the calculation regarding the patch antenna and the transmission line and the actual result. The project in progress is informing on the simulation for the design. This part also will discuss the comparison of the simulation result with the actual result.

The last chapter is chapter 5, where it is the conclusion part for the project. In this chapter, the analysis of the project accomplished and recommendation for next study after this project was made. The recommendation to improve the project and the contribution of the project to the university, faculty and the students itself also in this part.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The literature review will start with the introduction of the GPS. The GPS (Global Positioning System) is a system that is able to determine the location of object and human itself on the earth. In this system, a constellation of more than two dozen GPS satellites broadcasts precise timing signals by radio to GPS receivers, allowing them to accurately determine their location (longitude, latitude, and altitude) in any weather, day or night, anywhere on earth [1].

GPS has become a vital global utility, indispensable for modern navigation on land, sea, and air around the world, as well as an important tool for map-making, and land surveying. GPS also provides an extremely precise time reference, required for telecommunications and some scientific research, including the study of earthquakes. The frequency that use for GPS is divided into 5 bands as shown in table 2.1 below [2].

Table 2.1: The frequencies make up the GPS electromagnetic spectrum

Frequency	Description
L1(1575.42 MHz)	Carries a publicly usable coarse-acquisition (C/A) code as well as an encrypted precision P(Y) code.
L2 (1227.60 MHz)	Usually carries only the P(Y) code, but will also carry a second C/A code on the Block III-R satellites
L3 (1381.05 MHz):	Carries the signal for the GPS constellation's alternative role of detecting missile/rocket launches (supplementing Defense Support Program satellites), nuclear detonations, and other high-energy infrared events.
L4 (1841.40 MHz)	Being studied for additional ionospheres correction.
L5 (1176.45 MHz)	Proposed for use as a civilian safety-of-life (SoL) signal.

For this project, the frequency used for designing the GPS antenna is from the L1 band 1575.42 MHz. This frequency is used because the designing for this antenna is for the public user. Next, the introduction of the antenna will be explained.

2.2 Antenna

Antenna is a device, which is used for sending and receiving the electric wave for the communication. It is usually called an aerial. The antenna is a device which builds in the air of effectively radiating electric wave for the purpose of wireless communication. It is also effectively maintaining the electromotive force by the electric wave [3].

The transmission line in the wireless communication is not a wiring transmission line, but free space. It is the antenna that transmits and receives the signal in such free space as the terminal. The electric signal is transmitted as the flow of charges through a conductor. It will cause the charges cannot pass through a nonconductor such as free space. However, the electromagnetic wave cannot pass through a conductor and proceeds by forming the magnetic fields on a nonconductor [3].

Antenna is a device that will convert the electric signals, which can be expressed in terms of voltage and current. While for the electromagnetic wave, it can be expressed as electric field and magnetic fields. It is represented by the figure 2.1. By interconnecting the electric signal on a conducting line of the antenna and the electromagnetic field change outside the electric or electronic device can detect the electromagnetic signal in the air and vice versa [3].

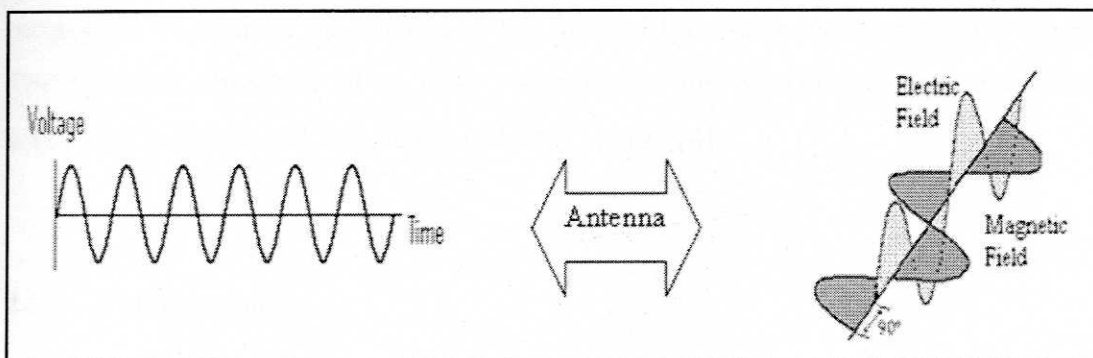


Figure 2.1: The wave radiated from antenna

2.2.1 Basic Antenna Operation

As for the basic operation of an antenna, it is apparent that the size of an antenna is inversely proportional to frequency. A relatively small antenna can efficiently radiate high frequency electromagnetic waves. As for the low frequency waves, it requires relatively large antennas. Each of an antenna has directional characteristics and radiates more energy in certain directions relative to other