DUAL BAND CIRCULARLY POLARIZEDMICROSTRIP PATCH ANTENNA FOR GPS APPLICATION

FAIZ HAFIZUDDIN BIN MAZLAN

This Report is Submitted in Partial Fulfillment of the Requirement for the Award of Bachelor of Degree Electronic Engineering (Telecommunication Electronic) With Honors

Faculty of Electronic Engineering & Computer Engineering
Universiti Teknikal Malaysia Melaka

May 2011

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Dual Band Circular Polarized Microstrip patch Antenna for GPS Application

Sesi Pengajian :

1	0	/	1	1

Saya FAIZ HAFIZUDDIN BIN MAZLAN
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 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:

_____ (TANDATANGAN PENULIS)

_____ (COP DAN TANDATANGAN PENYELIA)

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

Signature :

Author : FAIZ HAFIZUDDIN BIN MAZLAN

Date : 4 MEI 2011

"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 of Bachelor of Electronic Engineering Telecommunication with Honors'."

Signature	:
Supervisor's name	: ENCIK AZAHARI BIN SALLEH
Date	: 2 MEI 2010

For the most beloved and supporting parents,

MAZLAN BIN WANDI
NORYANA BINTI PONIN

Dedicated, in thankful appreciation for the support, encouragement, love and understanding.

ACKNOWLEDGMENT

Alhamdulillah, all praise to Allah SWT, God Almighty, Most Merciful for His guidance, blessing and by his will the project is successfully finished. A million thanks to my beloved family, who gives me encouragement and loved throughout the project. Without the encouragement and loved, the project will not be succeeded. Their trust and conviction towards me will always inspire me to become a better man than I am now and their good deeds towards me are the debt that I cannot pay in my lifetime. It is to them that I dedicate this work.

I would like to personally and sincerely express my gratitude to my supervisor; Mr. Azahari Bin Salleh. His wide knowledge and critical thinking has helped me in a lot of way in completing this project. This project is done by his guidance and supervision and he has helped me understand the task at hand that has to be done.

Finally, I would like to say my thanks to my friends especially Marina binti Mohamad and all the people who have helped me intentionally or unintentionally with my work and for their cooperation, support and encouragement.

ABSTRACT

This project proposed to study the antenna operation in Global Positioning System (GPS). The GPS is a system that able to determine the location of human and object that moving or static everywhere on the earth. GPS lately has been widely used and has become a vital global utility, indispensable for modern navigation, as well as an important tool for land surveying and map making. An extremely precise time reference, velocity and position provide that required for telecommunications and some scientific research are all provide by GPS including the study of nature phenomena such as earthquakes and tsunami that lately have been reported occur at many place around the word. The widely used frequency for GPS application is 1575 MHZ. The main objective of this project is to design and fabricate dual frequencies antennas that operate at 1575 MHz and 1227 MHz with circular polarization operation. Microstrip antenna method are been using due to its low cost, lightweight and other advantages. The microstrip technology which are used for defense and commercial application, are replacing many conversional antennas. However these types of antenna are limited to its bandwidth as it can generate a narrow bandwidth. A 2x2 array microstrip patch antenna is proposed for dual frequency operation and a square patch with a corner truncated is design to generate a circular polarization signal. A coaxial probe is used to provide current into the patch along the transmission line. Return loss, gain and bandwidth are investigated in this project. The antenna is required to have a return loss below than -10 dB, at least 40 MHz bandwidth and gain higher than 2 dB respectively.

ABSTRAK

Projek ini dicadangkan untuk mengkaji tentang pengoperasian antena di dalam sistem kedudukan sejagat (GPS). GPS adalah sistem yang boleh menentukan lokasi manusia dan benda yang bergerak atau statik di mana-mana di bumi. GPS akhir-akhir ini telah banyak digunakan dan telah menjadi sebuah kemudahan sejagat, alat mencari arah yang moden, serta alat penting untuk tinjauan tanah dan pembuatan peta. GPS juga memberikan maklumat tentang waktu rujukan, kelajuan dan kedudukan yang tepat untuk sistem telekomunikasi dan beberapa kajian saintifik termasuk kajian mengenai fenomena alam seperti gempa bumi dan tsunami yang akhir-akhir ini telah dilaporkan berlaku di banyak tempat di seluruh dunia. Frekuensi 1575 MHz digunakan untuk aplikasi GPS. Tujuan utama projek ini adalah untuk mereka bentuk antena yang beroperasi pada 1575 MHz dan 1227 MHz dengan operasi polarisasi melingkar. kaedah mikrostrip telah dicadangkan kerana kos rendah, ringan dan lain-lain. Teknologi mikrostrip yang digunakan untuk sistem pertahanan dan aplikasi komersil, menggantikan kebanyakan antenna yang lama. Namun jenis antena akan menghasilkan jalur lebar yang terhad. 2x2 susunan mikrostrip antena dicadangkan untuk operasi dua frekuensi dan antena segi empat sama dengan sudut yang dipotong direka untuk menghasilkan isyarat polarisasi melingkar. Sebuah probe koaksial digunakan untuk membekalkan arus ke antena sepanjang saluran penghantaran. Return loss, gain dan bandwidth yang dikaji dalam projek ini. Antena ini diperlukan untuk memiliki return loss bawah dari -10 dB, sekurang-kurangnya 40 MHz bandwidth dan keuntungan lebih tinggi dari 2 dB masing-masing.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

LIST OF ABBREVIATIONS

GPS	–	Global Positioning Syatem
PDA	–	Personal Digital Assistant
RHCP	–	Right Hand Circular Polarize
LHCP	–	Left Hand Circular Polarize
MIC's	–	Microwave Integrated Circuits
CST	–	Computer Simulation Technology
UTC	–	Universal Time Coordinated
TOA	–	Time of Arrival
CDMA	–	Called Code Multiple Access
PPS	–	Precise Positioning Service
SPS	–	Standard Positioning Services
RF	–	Radio Frequency
ISA	–	Industry Standard Architecture
RL	–	Return Loss
S-parameter	–	Scattering Parameter
MWO	–	Microwave Work Office
MSA	–	Microstrip Antenna

LIST OF SYMBOLS

$\mathbf{Z_L}$	-	Impedance load
$\mathbf{Z_o}$	-	Characteristic Impedance 50Ω
GHz	-	GigaHertz
MHZ	-	MegaHertz
dB	-	Decibel
mm	-	Millimeter
Hz	-	Hertz
Ω	-	Ohms
V	-	Voltan
λ	-	Wavelength
ε_{eff}	-	Effective Dielectric Constant

CHAPTER I

INTRODUCTION

1.1 Project Background

Global Positioning System (GPS) technology has been widely used as a navigation system to determine the locations, mapping, tracking devices, and surveying. In terms of public used, GPS receiver requires compact, lightweight, low power, low cost, high reliability and with mobility capability [1]. For our daily life, GPS also provide us with position, timing, and velocity information that can implement in many applications. GPS is a dual system. That is, it's providing separate services for civil and military users. GPS was initially developed for military uses, but has since been adopted for both civil and military users. With the rapid growth of the wireless communication, the uses of GPS functionalities are becoming more ubiquitous. Handheld terminals with GPS functionality are becoming common. Mobile phones, laptop computers, and Personal Digital Assistant (PDA) may are also have GPS functionality. So, in terms of public use, GPS receiver requires compact, lightweight, low power, low cost high reliability and with mobility capability. Furthermore, in order to satisfy the demanded precision and reliability, a high performance GPS antenna must be capable to operate at two or more frequencies at the same time.

Microstrip antennas are the subject of much research activity among scientists and engineer due to their unique advantages, especially their low weight,

low electromagnetic coupling to the human head, increased mechanical reliability, low cost fabrication and capability to maintain high performance over wideband of frequencies. Although in early implementations they suffered from narrow bandwidth, several approaches have been proposed to improve the bandwidth. The latest approach resulted in antennas with excellent bandwidths include the double layer structure, slotted antennas, shaped patch antennas and so on [2].

For GPS application, a circularly polarized microstrip antennas is widely been used due to its advantages in receiving signal capability and broad receiving pattern. Other advantage of circular polarized antennas is, it can reduce the multi-path effect around the GPS receiver. Furthermore, the antenna having broad receiving pattern in the upper hemispherical coverage is beneficial to receive the GPS signal from satellites [3]. It also has advantage in terms of its attractive physical properties and polarization. Several method of design has been investigated to achieve circular polarized polarization. A truncated corner method is the most design been use. A circular patch with a slot also been investigated. In general, there are many methods to design a circular polarized antenna.

In GPS application, a dual band with circularly polarized design has been the most popular among the engineer. GPS antennas that can cover for dual band operation enable to give more accurate information. There are many method have been proposed to achieve the dual band operation for circular polarized antennas. A stacked microstrip patch antenna for precise GPS application was design [4]. The truncated corner square patch is stacked without air layer and feed with a coaxial probe on the patch. Antenna with four slots on the patch also been reported have been investigated and design which use a single layer microstrip patch [5]. A single-feed slotted patch antenna is proposed that can operate for circular polarization at two resonance frequency [6]. A dual band circularly polarized stub loaded microstrip antenna also been presented in [7, 8]. The design enables it to reduce the frequency ratio of the two bands.

1.2 Problem Statement

For most current GPS receivers, it only operates at L_1 frequency of 1575MHz with right hand circular or left hand polarization (CP). L_1 frequency of 1575MHz is the standard band that been used for civilian GPS receiver such as Garmin. For more accurate information receive signal, a dual frequency operation of the GPS is require to get more information and less signal loss receive can be achieved. Less signal loss can be advantage as it increase the data receive capability of the antenna. Some applications also employ differential GPS whose antenna covers both L_1 and L_2 (1227 MHz) bands [7]. The antenna of a special GPS transmitter is, also, required to cover the two bands. Generally, dual frequency operation is preferred for its diversity capabilities.

A quadrafillar, dipole and helical type of antenna are the most general type of antenna that been implemented for GPS application. But in terms of more mobility and small size, microstrip antennas have been put in consideration for the design method. Microstrip patch antenna generally has a radiating conducting patch on a grounded microwave substrate and has many attractive features such as low profile, lightweight, easy to fabricate, low cost, can be easily integrated with microwave integrated circuits (MICs), capable of dual or triple frequency operation and allowing both linear and circular polarization.

However, microstrip patch antennas also suffer from a number of disadvantages' compare to conventional antenna. Some of their major disadvantages are narrow bandwidth, low gain, and low power handling capabilities, extraneous radiation from feed and junctions, and low efficiency. A narrow bandwidth is a main disadvantage of microstrip patch antenna in practical application typically a few per cent around 2% - 3%. Therefore, many methods have proposed to enhance the bandwidth of microstrip patch antenna. However there are many method have been proposed to overcome this problem such as slot, stacked and air layer design method [2, 7, 10, 11].

1.3 Objectives

The main objective of this project is to design, simulate and fabricate a Microstrip Patch Antenna for GPS application which can operate for dual frequency with circular polarized operation. The antenna design must satisfy this parameter to operate:

a. Frequency L1 (1.575GHz) and L2 (1.227GHz).
b. Bandwidth >20MHz.
c. Right hand circular polarized (RHCP) for both bands.
d. Return Loss ≤ -10dB.
e. High Gain

.

1.4 Scope of Project

The scopes of this project are to focus on design method for GPS antenna. In this project, a dual frequencies/band with circular polarization microstrip patch antenna for GPS application which can operate at frequency L_1 (1575MHz) and L_2 (1227MHz) is design. The designs of the antenna are using calculation and parametric study method. CST Studio suite software is used to simulate the designed antenna to obtain the return loss, radiation pattern, gain, bandwidth, and input impedance. For fabricating process, FR4 material with dielectric constant of 4.4, tangent loss of 0.019, and thickness of 1.6mm is used. Etching method has used to fabricate this antenna. Network analyzer and antenna trainer are used for measurement to measure return loss, bandwidth, radiation pattern and gain of the design patch antenna. A matching network analysis is used to matching the design at desire frequency.

1.5 Thesis Outlines

For the thesis outlines, it will be cover on the whole thesis. This thesis is divided into a certain part. Each part will cover on a topic required.

As for Chapter I, it will be cover on the introduction of the project. A little bit of explanation is done which related to the project. Specification parameter of the project and the problem statement of the project are also discussed and mention in this chapter. It also includes the objectives, and scope of work, methodology and the thesis outline of the project.

Chapter II and III will cover the literature review of the project. Each literature review was obtained from references book, journal paper, and technical paper. The literature review includes the review of GPS operation and microstrip technology and its characteristics. It also included the basic antenna parameter and specification of the design. Comparison of other proposed design also been discuss in this chapter.

Introduction and basic operation of GPS are briefly discussed in chapter II. The characteristic and the function of GPS receiver and operation of antenna in the GPS are been cover with help of diagram and explanations.

The microstrip technology and antenna parameter are briefly discuss in chapter III. Advantages and the disadvantages of microstrip is list down to compare with other design method. Basic antenna parameter is also been discuss in this chapter with the aid of figure and easy explanations.

In chapter IV, project methodology is fully covered which explain and discuss the method of design of the antenna. The first step of design until the project is finished is explained in detail in this chapter. All equation and parameter is state in detail.

The result from the simulation and measurement is compared and explain in very detail statement in chapter V. Besides it also give the detail on analysis of the results of the fabrication and followed by measurement.

The last chapter is the chapter VI, where it is an overall conclusion for the project. It also includes the future works of the project. The conclusion is related to the objective. It is important in order to assure that this project objective is achieved.

CHAPTER II

GLOBAL POSITIONING SYSTEM (GPS)

2.1 GPS Overview

Presently, GPS is fully operational and meets the criteria established in the 1960s for an optimum positioning system. The system provides accurate, continuous, world-wide, three dimensional position and velocity information to users with the appropriate receiving equipment. GPS also disseminates a form of Coordinated Universal Time (UTC). The satellite constellations normally consist of 24 satellites arranged in 6 orbital planes with 4 satellites per plane. A worldwide ground monitoring network monitors the status and health of the satellites. Navigation and other data also were uploaded time by time into the network. Since the GPS user receivers are working passively, GPS can provide service to an unlimited number of users at one time. One–way time of arrival (TOA) ranging concept is demonstrated in the system for better signal transfer.

The satellite broadcast ranging codes and navigation data on two frequencies using technique called code division multiple access (CDMA) that is, there are only two frequencies in use by the system, called L1 (1575 MHz) and L2 (1227 MHz).each satellite transmits on these frequencies, but in different ranging codes than those employed by other satellites. These codes were selected because they have low cross-correlation properties with respect with one and another. Each satellite

generates a short code referred to as the course/acquisition or C/A code and a long code denotes as the precision code P(Y) code.

The navigation data provide the means for the receiver to determine the location of the satellite at the time of signal transmission, whereas the ranging code enables the user's receiver to determine the transit time of the signal and thereby determine the satellite to user range. This technique required the user receiver also contain clock. Utilizing this technique to measure the receiver's three dimensional location requires that TOA ranging measurements be made to four satellites.

If the receiver clocks are synchronized with the satellites clocks, only three range measurements are required. However, a crystal clock is usually employed in a navigation receivers system to minimize the cost, complexity, and size of the receiver. Thus, four measurements are required to determine user latitude, longitude, height, and receiver clock offset from internal system time or height is accurately known. Less than four satellites are required [15,16].

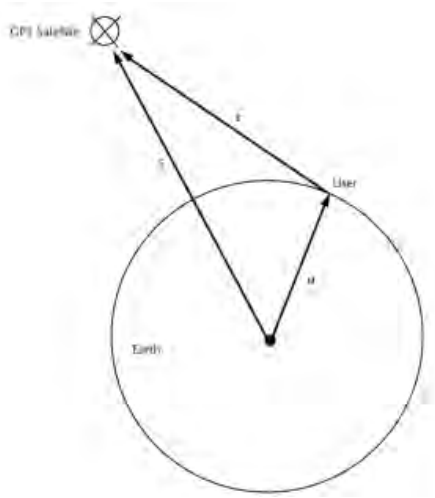

Figure 2.1 Determining Satellite-to-User Range [15]

GPS is a dual-use system. That is, it provides separates services for civil and military users. These are called the Standard Positioning Services (SPS) and the Precise Positioning Service (PPS). The SPS is designated for the civil community, whereas the PPS is intended for U.S authorized military and cryptography. Initial operating capability (IOC) for GPS was attained in December 1993, when