UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OF COMPACT MULTIBAND ANTENNA

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Electronic Engineering Technology (Telecommunications) (Hons.)

by

Wan Zaura Azureen Binti Wan Zinal
B071110171
920619-05-5454

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2014

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DECLARATION

I hereby, declared this report entitled “Design of Compact Multiband Antenna” is the results of my own research except as cited in references.

Signature : .....

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Electronics Engineering Technology (Telecommunications)) (Hons.). The member of the supervisory is as follow:

.....

(Project Supervisor)

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ABSTRAK

Antena pelbagai jalur padat merupakan antena yang mempunyai dua ciri, iaitu bersaiz kecil dan boleh beroperasi pada beberapa frekuensi. Ia digunakan untuk aplikasi WLAN. Tujuan utama kajian ini adalah untuk mereka antena pelbagai jalur padat bagi menampung permintaan yang tinggi terhadap antena yang mampu beroperasi dalam banyak aplikasi selain dari menggunakan banyak antena untuk beroperasi pada banyak aplikasi. Dalam kajian ini, beberapa kaedah telah digunakan untuk mendapatkan dapatan kajian. Kajian terhadap jurnal-jurnal adalah salah satu kaedah yang digunakan untuk mereka antena ini. Aplikasi yang digunakan untuk mereka antena ini ialah *Computer Simulation Technology (CST) Studio Suite 2011*. Fabrikasi antena adalah dengan menggunakan papan FR4. Kaedah-kaedah yang digunakan untuk mendapatkan informasi tentang antena ini telah melahirkan idea untuk mereka antena jenis mikrostrip. Berdasarkan keputusan, antena pelbagai jalur padat beroperasi pada empat frekuensi untuk WLAN, dengan pulangan kehilangan kurang dari -10dB.

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ABSTRACT

Compact multiband antenna is an antenna comprised with two characteristics, that is compact or small size and multiband which means it can cover several frequency bands. It is mainly used for WLAN applications. The main aim of this research is to design a compact antenna with multiband characteristics to solve the demand for an antenna that can support many wireless applications instead of using several antennas to do so. In this research, several methods were implemented to obtain the outcomes of the project. Reviewing journals were one of the methods to obtain information on designing this type of antenna. Software used to simulate the antenna designing program is Computer Simulation Technology (CST) Studio Suite software. Fabrication of the antenna is by using FR4 board. Methods that were implemented in order to obtain information have brought several results which the design suggested for the antenna is microstrip planar antenna which is the common antenna being used in circuitry. Based on the results, this compact multiband antenna covers four frequencies for WLAN, with return loss of less than -10dB.

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DEDICATION

Dedicated to my beloved parents who supported me all the time, my supervisor for his encouragements and my friends for always by my side.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

WLAN	-	Wireless Local Area Network
CST	-	Computer Simulation Software
UV	-	Ultra Violet
FR4	-	Flame Retardant 4
HF	-	High Frequency
UHF	-	Ultra High Frequency
RF	-	Radio Frequency
FBW	-	Fractional Bandwidth
VSWR	-	Voltage Standing Wave Ratio
D	-	Directivity

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Design of Compact Multiband Antenna

Wan Zaura Azureen binti Wan Zinal
[#]*Faculty of Engineering Technology*
[*]*Bachelor Degree in Electronics Engineering Technology (Telecommunications) with Honours*
Universiti Teknikal Malaysia Melaka(UTeM),
Durian Tunggal, Melaka.

***Abstract*— A compact multiband microstrip square patch antenna with four resonant frequencies (quadband) is proposed in this paper. There are three stages of design (Design I, Design II and Design III) with different dimensions of patch width and substrate width. First, a rectangular shaped patch antenna is designed. The first design is the basic rectangular patch antenna. This rectangular patch antenna design is focusing at frequency 2.4 GHz because it is in the ISM band and it is one of the unlicensed bands. Then, the double C-shaped slot had been embedded in the rectangular patch antenna to obtained multiband characteristics in Design II. Design III considered as the optimization to get the right frequency bands. It is improved in terms of width of the patch and substrate.**

Keywords—patch antenna, C-shaped slot, return loss, gain, bandwidth

I. INTRODUCTION

Nowadays, wireless accesses to the Internet have becoming a necessity in life. There is such a great demand for this application to operate. In order for this application and devices to operate, they must have an important item or system that enables them to work properly. Basically, to connect wireless devices, signals or waves are being transferred. Each device must have something that receives this signals or waves from other devices or system.

Antenna is the most important aspect in this device to transmit and receive signals. It is a device for converting electromagnetic radiation in space into electrical currents in conductors and vice versa. In basic wireless communication system, it consists of a transmitter, a receiver and the transfer medium. Antenna is placed at the transmitter's end and the receiver site.

In the advancement of technology era, people need a device which is the antenna that can be multifunction, low cost and compact. As we know, the wireless system has undergoes a great development nowadays. This triggered the needs for the antenna to be operated in multiband so that it can cover more frequencies and can handle many applications.

Multiband antenna uses a design that one part of the antenna is active for one band, whereas another part is active for a different band. Basically multiband antenna has lower-than-average gains or be physically large compared to single band antenna in order to achieve multiple frequencies.

Microstrip patch antenna is the commonly used antenna. It consists of dielectric substrate with ground plane at the other side. It always been chosen because of its low fabrication costs, light weight and low profile planar configuration which suitable for wireless communication application and system [1].

II PROBLEM STATEMENT

Due to the rapid progress in wireless communication technology, there is a need for the antenna to cover more than a single frequency band in order to support more wireless applications. This is because each wireless application operates at specific frequency range. Instead of using several antennas to support the applications, there are high demands for an antenna that can operate in multiband.

At the same time, the size of the antenna must as compact as possible because some wireless applications require miniaturized antennas. As the space in telecommunication devices gets limited, a compact antenna is required to fulfill the requirements.

II. DESIGN TECHNIQUE

TABLE 1: DESIGN SPECIFICATIONS OF COMPACT MULTIBAND ANTENNA

Antenna Parameter	Design Specifications
Frequency bands	• 2.392 GHz • 4.824 GHz • 5.2 GHz • 5.564 GHz
Application	WLAN
Return loss	<-10dB

DESIGN I, II AND III

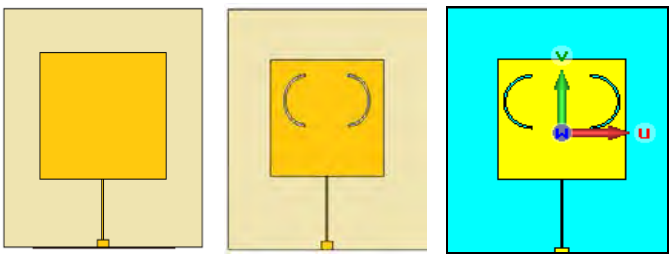

Figure 1: Three Design Of Antenna

The first design is the basic rectangular patch antenna. This rectangular patch antenna design is focusing at frequency 2.4 GHz because it is in the ISM band and it is one of the unlicensed bands. The patch and the ground plane consist of conducting material, which is copper. This antenna consists of three layers, which are patch, substrate and the ground plane at the back [2].

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. In Design II, there is double C-shaped slot that creates the second frequency. This makes the antenna as dual-band antenna. Slots are a helpful design which can brings the antenna to obtain multiband characteristic [3].

This design considered as the optimization to get the right frequency bands. It is improved in terms of width of the patch and substrate. The final design obtained is 31.5mm for patch width and 55.00mm for substrate width. This design brings four different resonant frequencies which are 2.392GHz, 4.824GHz, 5.2GHz and 5.564GHz.

III. RESULT

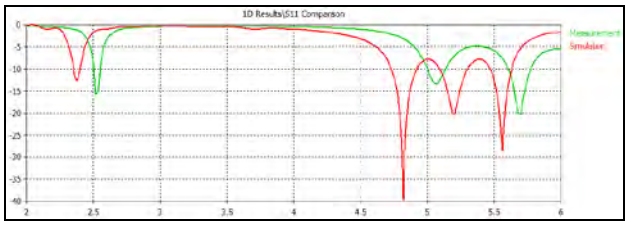

Figure 2: Comparison between Simulation and Measurement

It is observed that the measurement result is not as good as the simulation result. In simulation, four resonant frequencies were obtained. But, in measurement result, only three frequencies were obtained and the value of frequency is slightly different.

Although the antenna is said to be less efficient than the simulation one, it is still can perform multiband characteristics as it has three frequencies. This difference in output is due to many factors. Some of it may occur during fabrication process. The antenna output may changed if there is mishandling during the etching process. Besides that, the soldering process also may become part of the causes [4].

During soldering process, the port is hard to attach to the antenna and it causes the soldering process to be done many times until the port attached to antenna. The improvement can be done by fabricating the antenna multiple times until the best output is obtained.

Table 2: Performance of Design I [5].

Design	Resonant Frequency(GHz)	Return Loss(dB)	Gain(dB)
I	2.404	-30.974	3.357

Table 3: Performance of Design II.

Design	Resonant Frequency(GHz)	Return Loss(dB)	Gain(dB)
II	2.386	-18.176	3.751
	5.068	-32.025	2.971

Table 4: Performance of Design III [9].

Design	Resonant Frequency(GHz)	Return Loss(dB)	Gain(dB)
III	2.392	-11.609	2.906
	4.824	-39.714	4.036
	5.2	-20.342	4.254
	5.564	-28.555	0.9105

IV. CONCLUSION

A compact multiband antenna is successfully designed and fabricated. It achieved the objective to have multiband characteristic which is covers multiple resonant frequencies for WLAN applications.

This antenna consists of three layers which are patch, substrate, and the ground plane at the back [6]. The patch and the ground plane consist of the conducting material that is copper. It is found that the dimensions of the patch of the antenna are the part that controls the designed frequency which by means the width, W and length, L of the patch is the parameters that depends on the resonant frequency of the design.

The return loss of the antenna may be improved by improving the process of the fabrication so that the measurement is as good as the simulation. The frequency bands also can be increased more as the more the frequency bands, the more wireless applications the antenna can operate.

Some technique can be applied to obtain good multiband and compact antenna. The gain of the antenna also can be improved by increasing the substrate thickness or using air gap.

References

[1] F. Properties, “Fundamental Properties of Antennas,” pp. 1–32.

[2] J. Coonrod, “Understanding When To Use FR-4 Or High Frequency Laminates.”

[3] M. M. Saad, M. N. Husain, H. Nornikman, M. Z. A. A. Aziz, B. H. Ahmad, and F. Malek, “Design A Quadband Frequencies Microstrip Patch Antenna with Double C- Shaped Slot,” vol. 5, no. 2, pp. 1955–1961, 2013.

[4] W. L. Stutzman and G. A. Thiele, *Antenna Theory and Design*. John Wiley & Sons, 2012, p. 822.

[5] C. P. Narayan, *Antennas And Propagation*. Technical Publications, 2007, p. 291.

[6] *Modern Antenna Handbook*. John Wiley & Sons, 2011, p. 1704.

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CHAPTER 1
INTRODUCTION

This chapter introduces the background of antenna and how a compact multiband antenna is in demand nowadays. Followed after the background are the problem statement, objective, scope of work, project significance and summary of Chapter 1.

1.1 Background

Nowadays, wireless accesses to the Internet have becoming a necessity in life. There is such a great demand for this application to operate. In order for this application and devices to operate, they must have an important item or system that enables them to work properly. Basically, to connect wireless devices, signals or waves are being transferred. Each device must have something that receives this signals or waves from other devices or system.

Antenna is the most important aspect in this device to transmit and receive signals. It is a device for converting electromagnetic radiation in space into electrical currents in conductors and vice versa. In basic wireless communication system, it consists of a transmitter, a receiver and the transfer medium. Antenna is placed at the transmitter's end and the receiver site.

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Microstrip patch antenna is the commonly used antenna. It consists of dielectric substrate with ground plane at the other side. It always been chosen because of its low fabrication costs, light weight and low profile planar configuration which suitable for wireless communication application and system [1].

1.2 Problem Statement

Due to the rapid progress in wireless communication technology, there is a need for the antenna to cover more than a single frequency band in order to support more wireless applications. This is because each wireless application operates at specific frequency range. Instead of using several antennas to support the applications, there are high demands for an antenna that can operate in multiband.

At the same time, the size of the antenna must as compact as possible because some wireless applications require miniaturized antennas. As the space in telecommunication devices gets limited, a compact antenna is required to fulfil the requirements.

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1.3 Objective

To design, simulate and fabricate a compact multiband antenna using microstrip patch antenna for Wireless Local Area Network (WLAN) applications. The antenna must be able to operate in several frequency bands (quadband) as well as compact in size. The frequency is designed for 2.392 GHz, 4.824 GHz, 5.2 GHz and 5.564 GHz. The return loss must less than -10dB.

1.4 Scope of Work/Study

Scope of a project is the criteria that a project needs to accomplish. The scope of this project is to design a compact multiband antenna with four frequencies which are 2.392GHz, 4.824GHz, 5.2GHz and 5.564GHz which focused on WLAN applications. All antenna design works includes frequency, efficiency, return loss, bandwidth, realized gain and directivity will be done by using CST Studio Suite Software.

The fabrication process of this project is done by using etching technique. Etching technique is a process that uses strong acid to cut into the parts of metal surface to design in intaglio in the metal. The material used to design the antenna is FR4 board which undergoes UV lithography process before undergoes etching process. The FR4 board has thickness of 1.6mm and dielectric constant of 4.4 [2].

The last part is measurement part. The return loss of the antenna is measured by using network analyzer as it is used to measure the network parameters of electrical networks. The network analyzer can measure frequencies ranging from 300 kHz to 14GHz. The radiation pattern of the antenna is measured by placing the

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antenna in anechoic chamber where the distance is set within the far-field distance. The gain of the antenna is measured by using signal analyzer.

1.5 Project Significance

The research of the design of compact multiband antenna will benefit both society and technology aspect. In terms of technology, more wireless applications can be supported by one antenna. Users can change from using several antennas to one antenna that has multiband characteristic. The compact size increases the efficiency of the antenna as devices' demand and requirement nowadays is in miniature size. Hence, it may ease society a lot. Ease the society means that peoples can get easier and comfortable device due to its small size as well as effective in multiband characteristic.

1.6 Thesis Outline

This report consists of five chapters. Chapter 1 summarize the introduction and background of the antenna and why it is in demand nowadays. The specification and type of the antenna also stated in this chapter. It includes the background, problem statement, objective, scopes and project significance.

Chapter 2 is all about the literature review. Literature review means a text of scholarly papers which includes the knowledge to a particular topic. In this chapter, it comprises the background of the antenna along with the literature review. The various types of antennas and its characteristics also discussed here. The important aspect which is the antenna parameters and design also been stated here according to the literature review.

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Chapter 3 is about the methodology of the project. The methodology includes the steps carried out and action taken for the project as well as the flow of the project. In the methodology part, the design of the multiband antenna from Design I, Design II until Design III is discussed in this chapter. All the designs are from the simulation. The fabrication and measurement processes also stated here.

Chapter 4 is related to Chapter 3. As Chapter 3 is more to the results, Chapter 4 discussed the results and findings obtained and relate it to the theoretical, factual and simulation aspect. Chapter 5 is the Conclusion & Future Work. In this chapter, overall processes, findings, results and observations are summarized here. The future work part gives recommendation for future research of this project.

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CHAPTER 2
LITERATURE REVIEW

This chapter discussed about the types, design and structure of the antenna. Besides that, the basic parameter of antenna also will be discussed here such as radiation pattern, resonant frequency, return loss, directivity, gain, efficiency and bandwidth.

2.1 Antennas

There are many types of antenna. These include reflector antennas, horn antennas, lens antennas, helical antennas, phased array antennas, microstrip antenna and Yagi antenna. A reflector antenna is made with different shapes depending on the shape of the reflector and type of mechanism. It consists of a reflector and feed antenna. Usually the shape of the reflector is parabolic. It reflects electromagnetic waves. The feed mechanism includes the feed antenna placed at the parabolic focal point [3].

Horn antennas were very popular at UHF and higher frequencies. They often have directional radiation pattern and high antenna gain as well as wide impedance bandwidth. Lens antennas are used in radar and metering equipment which operates in centimetre wavelength range. It consists of a lens proper and a feed. It grouped based on the material used or shape of lens. They depend on refraction phenomenon [2].

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Helical antennas have a very distinctive shape. Its advantages include wide bandwidth, easily constructed, can produce circularly polarized field and has real input impedance. Phased array antenna is an antenna where the radiated beam is electronically steered without physical movement of the antenna.

Microstrip antenna is a famous antenna and very useful as they can be printed directly onto a circuit board. This antenna mostly used in cell phones. Patch antennas are low cost, low profile and are easily fabricated. Yagi-Uda antenna or Yagi antenna is the most useful one. It has high gain which greater than 10dB. It operates at HF to UHF bands.

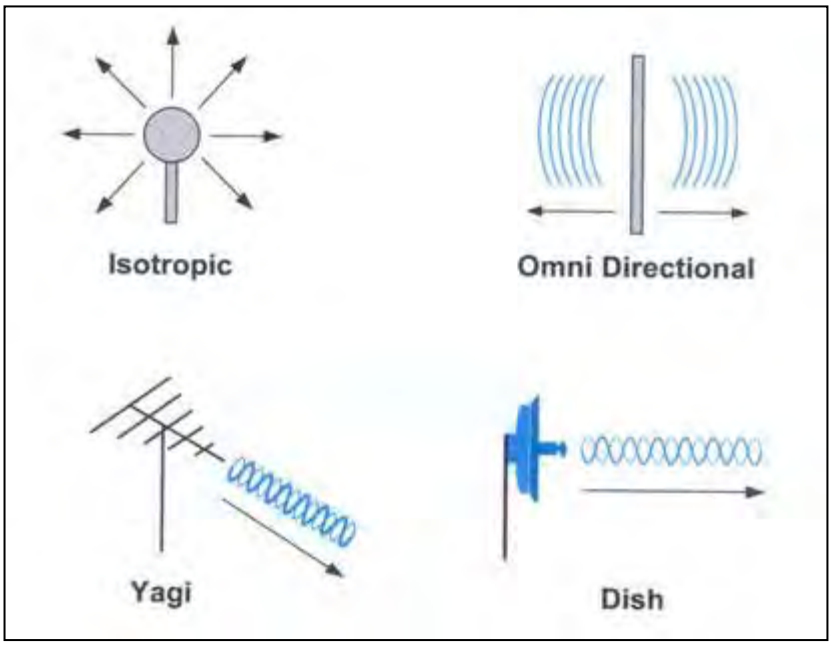

Figure 2.1: Several types of antennas

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2.2 Antenna Properties

In communication systems, antenna acts as transducer that couples energy from one electronic system to another location [4]. Three main properties of antenna include direction, gain and polarization. Antenna direction is the shape of the wireless signal after it leaves the antenna. Wireless antenna gain used for measuring the increase in signal power, as Decibels (dB). Noted that antenna with higher gain is said to be more effective in its radiation pattern [5].

Antennas are designed to raise the power in their wanted direction and reduce it in unwanted direction. Gain of antenna is the same for transmitting and receiving. In other words, it can be called reciprocal. Meanwhile, the polarization of an antenna is the orientation of wireless signal. The orientation can be circular, horizontal, vertical or combinations of these.

2.3 Basic Antenna Parameters

Antenna parameters are an important aspect in designing the best antennas. All the parameters need to be fully understood so that the objective of the design can be achieved. There are several parameters that will be discussed which are radiation pattern, resonant frequency, bandwidth, directivity, gain, efficiency and return loss.

2.3.1 Radiation Pattern

Radiation pattern of an antenna is a graphical representation of the radiation of the antenna against its direction. The radiation is in terms of field strength, E volts per meter, or power per unit solid angle. When it is expressed in terms of field

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