UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BANDWIDTH ENHANCEMENT OF MULTIBAND MICROSTRIP PATCH ANTENNA FOR WIMAX APPLICATION

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

by

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FACULTY OF ENGINEERING TECHNOLOGY

2017

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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TAJUK: **BANDWIDTH ENHANCEMENT OF MULTIBAND MICROSTRIP PATCH ANTENNA FOR WIMAX**

SESI PENGAJIAN: **2017/2018**

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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 Degree in Electronic Engineering Technology (Telecommunication) with honors. The member of the supervisory is as follow:

………………………………
Adib Bin Othman

ABSTRAK

Antena patch microstrip (MPA) digunakan untuk aplikasi komunikasi kerana saiznya yang kecil dan kos rendah. Kelebihan yang lebih rendah dan jalur jalur sempit adalah kekurangan utama antena patch. Oleh itu, struktur slotting dan kecacatan tanah (DGS) digunakan untuk menjadikan antena dapat mencapai keuntungan yang lebih tinggi dan jalur lebar yang lebih besar. Selain itu, antena dapat beroperasi pada frekuensi multiband yang 2.4 GHz, 4.1 GHz dan 4.8 GHz. Antenna patch microstrip disimulasikan dalam perisian CST dan diikuti dengan proses fabrikasi. Hasilnya dibandingkan antara antena konvensional dengan simulasi dan hasil pengukuran antena patch microstrip multiband. Keputusan menunjukkan bahawa peningkatan jalur lebar (Bandwidth) dicapai jika dibandingkan dengan antena konvensional. Bandwidth untuk antena konvensional simulasi adalah bandwidth untuk frekuensi 2.4 GHz adalah 76 MHz dari 2.45 GHz ke 2.53 GHz, untuk frekuensi 4.1 GHz adalah 183.2 MHz dari 3.97 GHz hingga 4.15 GHz. dan untuk frekuensi 4.8 GHz adalah 246 MHz dari 4.75 GHz hingga 5.0 GHz. Jalur lebar untuk simulasi antena microstrip multiband simulasi adalah lebar jalur untuk frekuensi 2.4 GHz meningkat kepada 100.9 MHz dari 2.38 GHz hingga 2.49 GHz. Selain itu, kekerapan 4.1 GHz ialah 182.7 MHz dari 4 GHz hingga 4.18 GHz dan lebar jalur untuk frekuensi 4.8 GHz meningkat kepada 405.4 MHz dari 4.60 GHz hingga 5.01 GHz. Ganjaran kerugian pulangan (Gain) yang dicapai di bawah daripada -10 dB dengan penggunaan slot dan susunan struktur tanah pada antena. Akibatnya, antena boleh beroperasi dalam julat frekuensi WiMAX (2.5 GHz hingga 5.8 GHz) dan oleh itu sesuai untuk aplikasi WiMAX.

ABSTRACT

Microstrip patch antennas (MPA) are used for communication applications due to their small size and low cost. Lower gain and narrow bandwidth are the major drawbacks of a patch antenna. Therefore, slotting and defect ground structure (DGS) is used in order to make the antenna able to achieve higher gain and larger bandwidth. Furthermore, the antenna are able to operate at multiband of frequency which are 2.4 GHz, 4.1 GHz and 4.8 GHz. Microstrip patch antenna is simulated in CST software and followed with fabrication process. Result are compared between conventional antenna with simulation and measurement result of multiband microstrip patch antenna. Result show that enhancement of bandwidth is achieved if compared to the conventional antenna. The bandwidth for simulation conventional antenna is the bandwidth for frequency 2.4 GHz is 76 MHz from 2.45 GHz to 2.53 GHz, for frequency 4.1 GHz is 183.2 MHz from 3.97 GHz to 4.15 GHz. and for frequency 4.8 GHz is 246 MHz from 4.75 GHz to 5.0 GHz. The bandwidth for simulation multiband microstrip patch antenna is the bandwidth for frequency 2.4 GHz is increased to 100.9 MHz from 2.38 GHz to 2.49 GHz. Furthermore, the frequency 4.1 GHz is 182.7 MHz from 4 GHz to 4.18 GHz and the bandwidth for frequency 4.8 GHz is increased to 405.4 MHz from 4.60 GHz to 5.01 GHz. The return loss magnitude achieved below than -10 dB with application of slot and defect ground structure on the antenna. As a result, the antenna can operate in WiMAX frequency range (2.5 GHz to 5.8 GHz) and therefore suitable for WiMAX application.

DEDICATION

Dedicated To My Parents and Family with Love and Care.

ACKNOWLEDGEMENT

First and foremost, I would also like to convey my grateful and appreciations to my supervisor, Adib bin Othman. His supervision and support gave truly help on the progression and smoothness of complete this thesis. Your kindness, your leadership and your word of wisdom will keep close to my heart at all the times.

I also would like to extend my thankfulness to the most precious persons in my life, my family for their moral and financial support and also to my friends for always be with me with the ups and downs. At last, I would like to thanks all those persons who helped me in completing this report.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CMPA	-	Conventional Microstrip Patch Antenna
CST	-	Computer Simulation Technology
EM	-	Electromagnetic
EMC	-	Electromagnetic Compatibility
FR-4	-	Flame Retardant
GPS	-	Global Positioning System
IEEE	-	Institute of Electrical and Electronic Engineers
MMPA	-	Multiband Microstrip Patch Antenna
OFDM	-	Orthogonal Frequency Division Multiplexing
PCB	-	Printed Circuit Board
RFID	-	Radio Frequency Identification
SI	-	Signal Integrity
VSWR	-	Voltage Standing Wave Ratio
WiMAX	-	Worldwide Interoperability for Microwave Access
WLAN	-	Wireless Local Area Network

CHAPTER 1

INTRODUCTION

This chapter covers the introduction of the project, background study, the problem statement, and the project objective and the scope of work of this project.

1.1 Introduction

Nowadays, wireless communication systems require antennas that can operate at more than just one frequency while maintaining a small size. There is also an increasing demand for small low cost microstrip patch antenna that can be easily integrated with packaging structures. Communication has become the important things changes in the organization of businesses and industries.

Microstrip patch antenna has been used in wireless communication. It has features compact size and easy to fabricate use with multiband antenna operation. The basic slot technique on microstrip patch antenna can be done by applying variety of slot shape such as E slot, U slot, C slot and H slot. These methods are usually used to set the frequency of microstrip patch antenna.

1.2 Problem Statement

The main drawback of microstrip patch antenna is suffering from narrow bandwidth, low gain and only operate at one frequency. To overcome this problem, some technique such DGS and slotting can be applied at the antenna to operate multiband frequency and also increasing the bandwidth and gain.

1.3 Objectives

The objective of the research is:

a) To design a multiband microstrip patch antenna
b) To enhance bandwidth and gain of multiband microstrip patch antenna compare to the normal patch antenna.
c) To validate the result of fabricated multiband microstrip patch antenna

1.4 Work Scope

The scope of work this project is to design a microstrip patch antenna using low cost FR-4 substrate. FR-4 substrate is high loss, low gain antenna, cheap and easy availability. The feed technique proposed is microstrip line. Microstrip line is used as the feeding line fetched in the middle of structure. Slotting technique is used in the patch. The Computer Simulation Technology software is used as the tool for simulation. The frequency is design to operate in 2.4 GHz, 4.1 GHz and 4.8 GHz. The gain and bandwidth is measured using network analyzer in an anechoic chamber.

1.5 Thesis Organization

This study is presented in five chapter. The thesis begins with an introduction brief of the project. It focused on the overview of the project, detailing the objectives, the problem statement, and work scope of the project. Chapter 2 is basically literature review about past study on microstrip patch antenna. then, literature review contains the facts or other aspect that we need correspond to the project that will build. Methodology on how this study under taken is discussed deeply in chapter 3. This chapter include the design of CMPA and MMPA. Chapter 4 is focused on discussion of results obtained from simulation process and hardware process. Conclusion and future recommendation for this study were briefly stated in chapter 5.

CHAPTER 2

LITERATURE REVIEW

The characteristics and information of the equipment and materials being used in the project are discussed in this chapter. This chapter explains literature review based on current and exist technologies and work that has been done in order to create a specific research about this project.

2.1 CST Microwave Studio

CST Microwave Studio is a special tool for the 3D EM simulation of high frequency components. CST enables the fast and accurate analysis of high frequency (HF) devices such as antenna as shown in Figure 2.1. It also can simulate and analyze filters, couplers, planar and multi-layer structures and signal integrity (SI) and electromagnetic compatibility (EMC) effects. Exceptionally user friendly, CST quickly gives an insight into the electromagnetic (EM) behavior of high frequency designs [1].

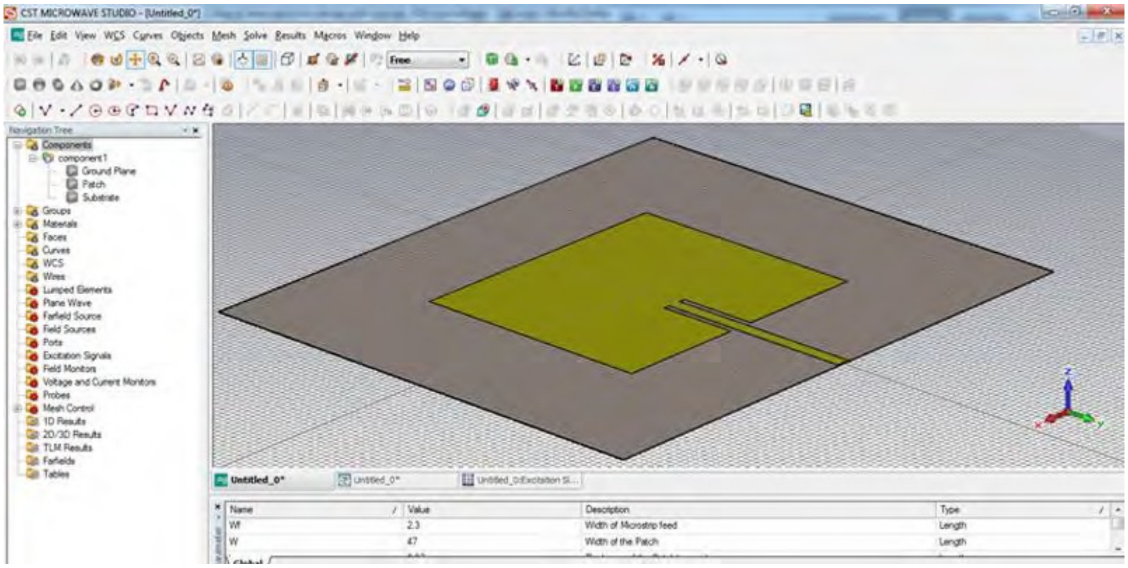

Figure 2.1: Software of CST Microwave Studio

2.2 Material Substrate (FR-4)

FR-4 is a grade designation assigned to glass-reinforced epoxy laminate sheets, tubes and rods. It also assigned to printed circuit boards (PCB) as shown in Figure 2.2. FR-4 is a composite material composed of woven fiberglass cloth with an epoxy resin binder that is flame resistant (self-extinguishing). FR-4 glass epoxy is a popular and versatile high-pressure thermoset plastic laminate grade with good strength to weight ratios. With near zero water absorption, FR-4 is most commonly used as an electrical insulator possessing considerable mechanical strength. The material is known to retain its high mechanical values and electrical insulating qualities in both dry and humid conditions. The attributes, along with good fabrication characteristics, lend utility to this grade for a wide variety of electrical and mechanical applications [2]. Detail parameters of FR-4 are as shown in Table 2.1.

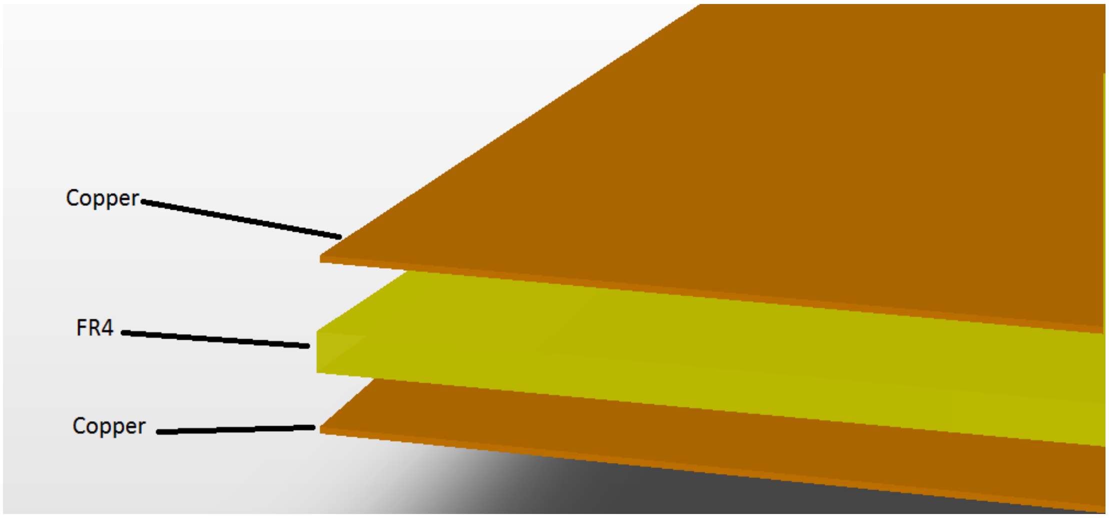

Figure 2.2: FR-4 substrate layout [2]

Table 2.1: Parameter for FR-4 substrate [2]

Parameter	Value
Dielectric constant	4.36
Loss tangent	0.013
Water absorption	< 0.25%
Tensile strength	< 310 mPa
Volume resistivity	8 x 10^7 Mohm cm
Surface resistivity	2 x 10^5 Mohm
Breakdown voltage	55kV
Peel strength	9N/nm
Density	1.850 g/cm^3 (3,118 lb/cu yd)

2.3 Antenna

Antenna is one of the critical components in any wireless communication system. The word ‘antenna’ is derived from Latin word ‘antemna.” Since the first demonstration of wireless technology by Heinrich Hertz and its first application in practical radio communication by Guglielmo Marconi, the antenna has been a key building block in the construction of every wireless communication system. IEEE defines an antenna as “a part of a transmitting or receiving system that is designed to radiate or receive electromagnetic waves” [3].

2.3.1 Wire Antenna

This is the basic type of an antenna as shown in Figure 2.3 are widely used on top of the buildings, automobiles, ships and spacecraft. This antenna is made into different shape such as a straight wire (dipole), loop and helix.

Figure 2.3: Wire antenna

2.3.2 Aperture Antenna

This antenna as shown in Figure 2.4 is in the form of a slot or aperture in a metal plate and commonly used at higher frequencies (3-30 GHz). Typical examples are slotted waveguide antenna and horn antenna. These antennas are very useful for aircraft and spacecraft applications, because they can be conveniently flush mounted on the surface of the aircraft or spacecraft.

Figure 2.4: Aperture antenna

2.3.3 Printed Antenna

A printed antenna as in Figure 2.5 is fabricated using standard photolithography technique. The most common version of printed antenna is microstrip antenna, which consists of a metallic patch above a ground plane. The shape and size of patch determine the frequency of operation of the antenna and its performance. This antenna is more popular because of their low cost and ease of fabrication, and easy integration with circuit technology, and are conformal to planar and non-planar surfaces. This antenna can be easily mounted on the surface of aircrafts, spacecraft, satellites, missiles and even on handheld mobile devices.

Figure 2.5: Printed antenna

2.3.4 Array Antenna

In an array antenna, several radiators separated from each other are geometrically arranged to give desired radiation characteristics that are not possible to achieve with a single independent radiating element. The arrangement of array elements is such that radiation from individual elements adds up to give the maximum radiation in a particular direction or directions and minimum radiation in other directions. An example of array antenna is shown in Figure 2.6.

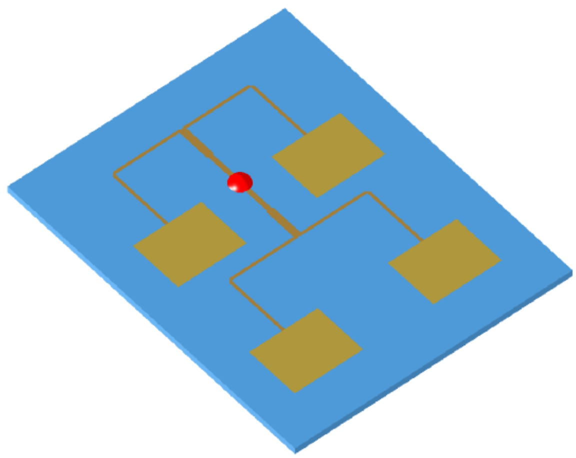

Figure 2.6: Array antenna