UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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DUAL BAND AND DUAL POLARIZED MICROSTRIP PATCH ANTENNA

This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Telecommunications) with Honours.

by

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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 Electronics Engineering Technology (Telecommunications) with Honors. The member of the supervisory is as follow:

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ABSTRAK

Mikrostrip antena dikenali sebagai empat segi tepat tunggal yang terdiri daripada substrat dieletrik yang ringkas dengan pelan tanah yang secara langsung menghubungkan ke talian penghantran yang bersesuaian. Oleh kerana masalah kapisiti dalam sistem komunikasi mudah alih, mikrostrip empat segi tepat antena telah dicadangkan untuk mengurangkan dan menyelesaikan masalah ini. Projek ini direka untuk mengukur prestasi dual frekuensi dan dual polarisasi mikrostrip empat segi tepat antena. Satu reka bentuk baru iaitu dual frekuensi dan dual polarisasi mikrostrip empat segi tepat antena dengan satu masukan telah dibentangkan. Kedua-dua 'Design 1' dan 'Design 2' telah direkabentuk, dibina dan diuji untuk digunakan dalam jalur frekuensi dual iaitu GSM900 dan 1800 band. Keputusan yang telah dikira disahkan oleh pengukuran pada prototaip. Dalam 'Design 1' antena kedua-dua reka bentuk antena boleh beroperasi pada julat frekuensi antara 924MHz-1790MHz untuk simulasi dan untuk mengukur 938MHz-1837MHz. Untuk antena frekuensi 'Design 2' boleh beroperasi antara 900MHz-1760MHz untuk simulasi dan ukuran antara 904MHz-1775MHz. Oleh itu, kedua-dua dual jalur dan operasi dual polarisasi telah berjaya digabungkan dengan segi empat tepat antena tunggal dengan satu masukan.

ABSTRACT

Microstrip antenna is known as single patch which consists of simple dielectric substrate with ground plan that directly contacting an appropriate transmission line. Due to capacity problems in mobile communications system, microstrip patch antenna is proposed in order to minimize and solve this problem. This project was designed to investigate the performance of dual band and dual polarized microstrip patch antenna. A new design of a simple dual band and dual polarized microstrip patch antenna was presented with single feeding. Both 'Design 1' and 'Design 2' was designed, fabricated and tested to be used in a dual frequency bands which is GSM900 and 1800 bands. The calculated results were confirmed by measurement on prototype. Both designs antenna can be operated at frequencies between range 924MHz-1790MHz for simulation and for measurement 938MHz-1837MHz in antenna 'Design 1'. For antenna 'Design 2' frequencies can operate between 900MHz-1760MHz for simulation and measurement between 904MHz-1775MHz. Therefore, both dual band and dual polarized operation has successfully incorporated with single patch and feeding.

DEDICATION

This research paper is solely dedicated to my family who have been my constant source of inspiration. They have given me endless drive in order for me to tackle this thesis with enthusiasm and determination. Without their love and support, this project would not have been made possible.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

BW	-	Bandwidth
CST	–	Computer Stimulation Technology
CuSO4	–	Copper Sulfate
FEM	-	Finite Element Method
FIT	–	Finite Element Method
GHz	–	Giga Hertz
GSM	–	Global System for Mobile
HCL	–	Hydrochloric corrosive
HFSS	–	High Frequency Structured based Simulator
HPBW	–	Half power beam width
LTE	–	Long Term Evolution
MHz	–	Mega Hertz
MRI	-	Magnetic Resonance Imaging
NaOH	–	Sodium Hydroxide
NH4	–	Ammonium
PC	–	Personal Computer
PCB	–	Printed Circuit Board
SNA	–	Scalar Network Analyzer
UV	–	Ultra Violet
USB	–	Universal Serial Bus
UHF	–	Ultra High Frequency
VNA	–	Vector Network Analyzer
VSWR	–	Voltage Standing Wave Ratio

CHAPTER 1

INTRODUCTION

2.0 Introduction

Matters discussed in this chapter include the project background, problem statement, objectives of the project, project limitation and the scope project.

1.1 Background

The first communications between humans was by sound through voice. In ancient times, they used visual method such as signal flags and smoke signals as their communications. Nowadays, communications are main key for survival in our world and the advancements in communication have changed our lifestyle to allow us to view the world from completely different view. To allow this type of communication, many technologies are necessary and one of those is the antenna technology. Antenna can work in more than one frequency region either for transmitting or receiving electromagnetic wave. In other words, an antenna is the device that provides resources for radiating and receiving the radio waves. Such antennas are usually used for dual-band, tri-band, and penta-band applications. Dual-band antenna is more complex than the single band antennas in design, structures and operations. Currently, the most famous antenna is microstrip patch antenna that is most rapidly developing field and have many features.

1.2 Problem Statement

As for today, due to capacity problems in mobile communication system such as GSM900 band, many operators acquired licenses for more bands as additional to accommodate the demands such as 1800bands. In addition, the demands on reducing the size and costs of antennas have emerged as well antenna is necessary part of wireless link. Furthermore, use of conservative microstrip antennas is limited because of their poor gain, low bandwidth and polarization purity. Dual band and dual polarized is suggested and created in order to increase the communication performance. That can help in maximize the performance that the usual antenna. This dual band and dual polarized microstrip patch antenna will include as additional information in the communication antenna.

1.3 Objectives

In order to accomplish the goal, this project embarked based on the following objectives:

(a) To understand the concept of the patch antenna.

(b) To simulate and fabricate a dual frequency and dual polarized microstrip patch antenna.

(c) To investigate the performance of dual-band and dual-polarized microstrip patch antenna including - parameter, radiation pattern, bandwidth, gain and directivity.

1.4 Scope of Work

This objective of this project is to microstrip patch antenna that facilitates dual polarized, dual band operation. This microstrip antenna helps to reduce space or size of antenna and also reduce costs for making antenna. On the other hand, the antenna project can be designed in a variety of shapes in order to obtain enhanced gain and bandwidth, dual band and circular polarization to even ultra wideband operation. The frequency that is used for the testing is between range 900MHz and 1800MHz which is for mobile phone communication. Microstrip antennas are suitable because of their low profile, light weight and low power handling capacity. This project is mainly focused on dual band and dual polarized operation of microstrip patch antennas. For the simulation process, CST software need to be used to do test-run simulation and design. The effects of antenna dimensions and substrate parameters on the performance of antenna also need to be included in the discussion.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter discusses the basic principle of microstrip patch antenna design, dual band antenna concept and some of the related works.

2.1 Dual Band Frequency

From the book written by Balanis (2005) the range of frequencies within which the performance of the antenna, with respect to some characteristic, conforms to a specified standard is defined as the bandwidth of antenna. The bandwidth can be considered to be the range of frequencies either the resonance frequency for a dipole of center frequency, where the characteristic is within an acceptable operation. The bandwidth typically expressed as the ratio of the upper-to-lower frequencies of acceptable operation for the broadband antennas. For narrowband antennas, the bandwidth is expressed as a percentage of the frequency difference upper minus lower over the center frequency of the bandwidth.

For the dual band frequency, the wireless operator and antenna real estate is used multiple frequency bands. The used of dual-band antennas often can be pursued. Dual-band antennas allow for the same antenna which is radome or to support two different frequency bands. Figure 2.1 illustrates of a dual band antenna shared by 850MHz and 1900 MHz systems. The radome in fact contains two antennas.

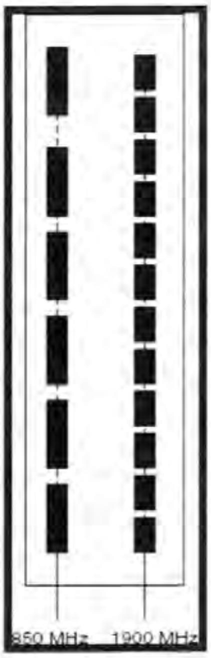

Figure 2.1: Dual-band antennas.

To reduce the number of feed lines, it is possible with a cross-band adaptor but as with multipurpose devices, compromises must be made. The design criteria for one system of GSM at 850MHz and UMTS at 1900 MHz are not same. Therefore, when using a dual band antenna system, performance may be sacrificed to overcome installation circumstance. In addition, dual-band antennas can be tailored for each band by employing a separate down tilt to each of the bands. A 3-degree down-tilt could have for the 850MHz while the 1900MHzband might have 0 degrees or no down-tilt.

The introduction of LTE can also lead to the desire to have a tri-band antenna. However, with any design involving multiple-frequency bands the potential for performance degradations and necessary trade-offs are always present. The kiss principle is always the preferred method since technology requirements constantly change regardless of your future planning vision and knowledge. Having an antenna system design which is overly complex will directly impact your ability to introduce technology changes, improvements, or modifications needed in the future, besides the obvious impact on performance-related activities and maintenance.

2.2 Microstrip Patch Antenna

In this section, the microstrip patch antenna background, characteristic and advantages of microstrip patch antenna was discussed because in the past few years microstrip patch antenna becoming increasingly useful in mobile communications.

2.2.1 Background of Microstrip Patch

Microstrip antenna is a standard configuration for a single patch of conductor supported above the ground plan by a simple dielectric substrate and directly contacting an appropriate transmission line in order to couple power between the resonant patch antenna and the transmitter or receiver circuit. It is relatively easy to fabricate and this is a simple configuration that is rugged but have limited in its functional capabilities. A microstrip device is the simplest form which is a structure that has layered with two parallel conductors can be separated by a thin dielectric substrate and has lower conductor acting as a ground plane. A thin metallic film bonded to ground which consists of microstrip, and has advantages of being lightweight, conformable, economical to manufacture and easily wedded to solid state devices. A microstrip transmission line is formed because of the upper metallization is a narrow strip. The device becomes a microstrip antenna as illustrated in Figure 2.2 when the upper conductor patch that is an appreciable fraction of a wavelength in extent (Stutzman and Thiele, 1998).

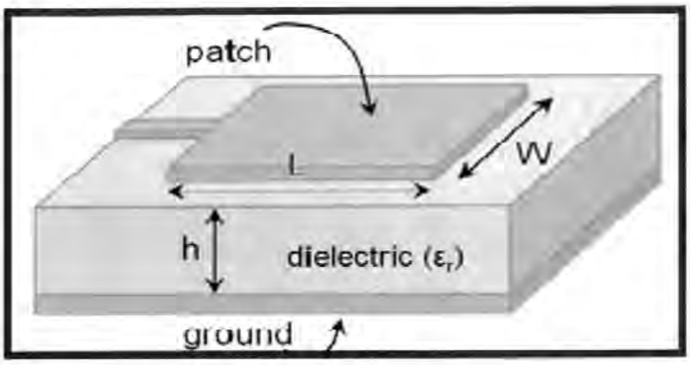

Figure 2.2: Geometry for analyzing the edge-fed microstrip patch antenna

Any of shape can be the patch, but the regular geometric shapes such as rectangles and circular are most commonly used. The class of resonant antennas belongs to the patch antenna and the main challenge in microstrip antenna because of its resonant behavior and need design to achieving adequate bandwidth. At the frequencies below UHF, the resonant nature of microstrip antennas also means and become excessively large. The tradeoff in microstrip antennas is to design patch with loosely bound fields extending into space while keeping the fields tightly bound to the feeding circuitry (Stutzman and Thiele, 1998) and (Elliott, 2003).

Feeding is succeeding either via use of coaxial line with an inner conductor that terminates on the patch or through microstrip patches (Elliott, 2003).The placement of the feed is important to the operation of the antenna. To carrying the energy along the microstrip or coax to the feed point they need guided waves. The region under the patch will spreads out the energy and some of it crosses the boundary of the patch to be radiated. For the permittivity of the dielectric layer is usually not great and its thickness t is small, so the region under the patch behaves like a portion of a parallel plate transmission line. Arrays are used to improve the efficiency but narrow-handedness puts a limitation on the applications (Elliott, 2003).

2.2.2 Basic Characteristics Microstrip Antenna

Microstrip antennas, as shown as Figure 2.2 consists of a very thin ($t \ll \lambda$, where λ is the free space wavelength) metallic strip patch placed a small fraction of a wavelength ($h \ll \lambda$, usually $0.003\lambda \leq h \leq 0.05\lambda$) above a ground plane. The microstrip patch is designed it is means the pattern maximum is normal to the patch (broadside radiator). By properly choosing the mode of the field configuration it can accomplish of excitation underneath the patch. By judicious mode selection help end fire radiation can also be accomplished. The length L of the element is usually $\lambda/3 < L < \lambda/2$ for rectangular patch antenna (Balanis, 2005).

For the design of microstrip antennas, there are several substrates that can be used and their constant is commonly in the range of $2.2 \leq \varepsilon_r \leq 12$. To get better efficiency, larger bandwidth, loosely bound fields for radiation into space there is ones that are most necessary for good antenna performance are thick substrates whose dielectric constant is in the lower end of the range, but at the expense of larger element size (Pozar and Schaubert, 1995). Thin substrates with higher dielectric constants need tightly bound fields to minimize undesired radiation and coupling, this may lead to smaller element sizes are necessary for microwave circuitry because of their greater losses, there are less efficient and have relatively smaller bandwidths (Pozar and Schaubert, 1995). Between good antenna performance and circuit design need to reach meanwhile microstrip antennas often integrated with other microwave circuitry, a compromise (Balanis, 2005).

Normally, microstrip antennas are also known to as patch antennas. To know the dielectric substrate is normally photo etched at the feed lines and the radiating elements. The pattern patch may be square, rectangular, thin strip (dipole), circular, elliptical, triangular, or any other shape (Balanis, 2005). Ease of analysis and fabrication, and their attractive radiation characteristics especially low cross-polarization radiation is the characteristics of square, rectangular,