DESIGN OF TRIPLE BAND MICROSTRIP PATCH ANTENNA FOR MULTIPURPOSE APPLICATION

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To my beloved parents, thank you.

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ABSTRACT

A multipurpose triple-band microstrip patch antenna with frequencies of 2.45 GHz, 3.66 GHz, and 4.46 GHz has been constructed. The proposed antenna is fed by 50 ohm microstrip feed lines. Inserting five rectangular slots in the patch improves the impedance bandwidth, gain, and reflection coefficient. The antenna was constructed on FR 4 substrate of (ε_r=4.3) with a loss tangent of 0.035. The overall dimensions of the antenna are 29 × 38 × 1.6 mm. The simulation results were generated using CST Microwave Studio. The reflection coefficient (S11) operates at –26.7 dB at 2.45 GHz, -24.1 dB at 3.66 GHz, and -54.9 dB at 4.46 GHz. The gain of the design is 4.08 dB, 3.49 dB and 3.49 dB at 2.45 GHz, 3.66 GHz and 4.46GHz, respectively, with a VSWR of less than 2.0. The proposed antenna covers a large section of the ISM-S and C bands. Because of its tiny size, narrow bandwidth, and appropriate gain can be incorporated in mobile devices for mobile WiMAX, Wi-Fi, Bluetooth, and WLAN operations. It can also be used for surveillance and communication by weather radar, surface ship radar, and some communications satellites. As a result, the presented microstrip rectangular patch antenna could be helpful for ISM, S, and C bands applications.

ABSTRAK

Antena tampalan jalur mikro ganda tiga pelbagai guna dengan frekuensi 2.45 GHz, 3.66 GHz dan 4.46 GHz telah dibina. Antena yang dicadangkan disuap oleh saluran suapan jalur mikro 50 ohm. Lima slot segi empat tepat dimasukkan dalam tampalan bagi meningkatkan lebar jalur impedans, gandaan dan pekali pantulan. Dimensi antena ialah (29 × 38 × 1.6) mm, dengan substrat FR 4 (εr=4.3) dan tangen kehilangan (0.035). Perisian gelombang mikro CST digunakan untuk menjana hasil simulasi. Pekali pantulan (S_{11}) beroperasi pada –26.7 dB pada 2.45 GHz, -24.1 dB pada 3.66 GHz dan -54.9 dB pada 4.46 GHz. Gandaan reka bentuk ialah 4.08 dB, 3.49 dB dan 3.49 dB pada 2.45 GHz, 3.66 GHz dan 4.46GHz, masing-masing, dengan VSWR kurang daripada 2 dB. Antena yang dicadangkan meliputi sebahagian besar jalur ISM-S dan C. Oleh kerana saiznya yang kecil, lebar jalur yang sempit dan keuntungan yang sesuai boleh digabungkan dalam peranti mudah alih untuk operasi mudah alih WiMAX, Wi-Fi, Bluetooth dan WLAN. Ia juga boleh digunakan untuk pengawasan dan komunikasi oleh radar cuaca, radar kapal permukaan dan beberapa satelit komunikasi. Secara keseluruhan, antena tampalan segi empat tepat jalur mikro yang dibentangkan boleh membantu untuk aplikasi jalur ISM, S dan C.

CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

WLAN	Wireless Local Area Network
GPS	Global Positioning System
RFID	Radio Frequency Identification tags
CW	Clock wise
CCW	Counter clock wise
RHCP	Right hand circular polarization
LHCP	Left hand circular polarization
CPMA	Circular polarized microstrip Antenna
LP	Linear polarization
CP	Circular polarization
TM	Transverse magnetic
VSWR	Voltage standing wave Ratio
AR	Axial Ratio
PTFE	Poly Tetra Fluor Ethylence
ARSA	Annual Ring Slot Antenna
ACMAS	Annual Circular Microstrip Patch Antenna
WSN	Wireless Sensor Network
HPBW	Half power Beam Width
RMS	Root Mean Square
IEEE	Institute of Electrical & Electronic Engineering
MOM	Method of Moment
FEM	Finite Element Method
SDT	Special Domain Technique
PLF	Polarization Domain Technique
E field	Electrical field
H field	Magnet field
MNM	Multipoint Network Model
PCB	Printed Circuit Board

ADSB	Automatic Department Surveillance Broadcast
UVAS	Unmanned Aerial Vehicles
VTS	Vessel Traffic Service

CHAPTER 1

INTRODUCTION

1.1 Introduction

The world has irreversibly switched to wireless networks, and their usage is growing enormously. Wireless systems have been widely accepted among consumers due to their convenience and mobility. The rise of wireless technology has brought a tremendous application that all rely on radio waves. Those applications include (Surface Ship) (Satellite Communications), Wi-Fi (Wireless Fidelity), WLAN (Wireless Local Area Network), and many more. On the other hand, the number of devices using those applications has also skyrocketed for the last decade. From well-known devices such as mobile phones, GPS navigators, wireless routers, printers to the newest devices such as Apple's AirTag, a tiny tracking device that uses Bluetooth signal to detect the lost items, they all communicate through radio waves. To transmit or receive a radio waves, these devices are equipped with antennas. Antennas play a huge role in receiving or transmitting radio waves,

However, the above-mentioned wireless applications usually operate in different frequency ranges thus, requires the implementation of different antennas. A single device for instance, a mobile phone, can be used for different wireless technology such us Wi-Fi, Bluetooth and GSM have imposed tremendous challenges. To avoid using three antennas in a single device, the need for small and multiband antennas has grown. Antenna, which can work properly in more than one frequency region for transmitting or receiving electromagnetic waves, is termed multiband antennas[1]. These antennas have gained popularity due to their multiband frequency capability. There is a growing demand for a multiband terminal antenna that is capable of receiving multiple services introduced by different wireless technology networks

[2]. In wireless systems, the alignment between the transmitter and receiver antenna is imperative. Mobile and portable wireless applications where wireless devices frequently change their location and orientation make it nearly impossible to maintain that alignment. The microstrip antenna is one of the most commonly used antennas in applications that require of triple band antenna. Microstrip antennas attract the attention of researchers because of its attractive merits such us low profile, conformal nature, low weight and ease of fabrication [3]. They are also known for their ability to integrate with electronic devices. Due to these advantages these antennas are used and developed in wireless communications [4]. The previous works have proposed many designs with different multiband frequencies depending on their intended applications.

This project will present the design of a microstrip patch antenna that operates triple-band frequencies for wireless applications. These three frequency bands are 2.45(ISM) , 3.66GHz(S- band), and 4.46 GHz(C-band). First, chapter two will briefly present the previous works related to multiband patch antennas Then, the methodology of this work is discussed in Chapter three, while Chapter four presents the results and discussion. Finally, the conclusion is given in Chapter five.

1.2 Problem statement

For shrouded space and microelectronics, modern telecommunication devices require multiple frequencies for communication and operation, as well as a smaller physical size. A triple band antenna is an excellent choice for applications requiring three frequencies. Compact and miniaturized efficient antennas are required for triple-band applications. Moreover, wireless devices such as modems usually use an internal microstrip patch antenna that has small gain so that the reception of the signal is not efficient [5].

The low gain is one of the biggest disadvantages of microstrip patch antenna as it is detrimental to the antenna's performance. Triple-band antenna is attained by modifying the structure utilizing slots inside the patch. However, cutting inside the patch shape does not expand the size of the antenna [6]. The use of triple band type antennas has increased greatly in recent times. this is the mostly due to its high speed in radiating frequencies. However, researchers face extremely difficult challenges in proposing a compact-size antenna with sufficient gain, narrow bandwidth and a multiband frequency. To overcome these challenges, new inventions, and techniques for designing an efficient microstrip antenna that considers all of these factors are required. In this study, a triple-band microstrip patch antenna for multipurpose applications will be designed, and the design should alleviate these issues.

1.3 Objectives

The objectives of this project are:

I. To design a triple-band rectangular slot antenna that operates three frequencies bands for 2.45GHz (ISM) ,3.66GHz (S-band) ,and 4.46GHz(C-band) applications.

II. To analyze the performance of the design.

1.4 Scopes of study

The scopes of the research are:

I. Design and simulate a triple band rectangular slot antenna which operates desire frequency bands for different applications.

II. Utilizing FR4 material as substrate to design the antenna.

III. Analyze the simulated result using CST Microwave Studio in terms of antenna properties such as reflection coefficient, radiation pattern and VSWR and gain.

1.5 Organization of thesis

Chapter 1 begins with an introduction followed by problem statement and objective and scope description and the organization of thesis is shown in this chapter.

Chapter 2 gives an overview of this project and introduction multiband antenna is given. Particularly, the introduction to microstrip patch antenna and its characteristics are to discuss in this chapter. Chapter 3 contains the project’s design technique the design overview , as well as all of the tools and modules utilised in this project are presented The antenna design parameters and calculation also discussed in this chapter.

Chapter 4 focuses on the simulation and testing outcomes the key properties are also evaluated such as reflection coefficient, radiation pattern and gain.

Chapter 5 concludes the thesis and makes some suggestions for future work and project development.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of the microstrip patch antennas, antenna properties, polarization, multiband antennas and a summary of previous researches on designing triple band microstrip patch antennas for multiband frequencies.

2.2 Microstrip Patch Antenna

Microstrip patch antennas have been very promising antennas, especially in the telecommunication field. They are easy to design, implement, and cheap to manufacture, and they are very compact with the mobile phone's design profile. The performance of these antennas has demonstrated a promising future in mobile communication and distributed antennas over the last decade. Furthermore, a single patch antenna is much simpler to execute in a mobile device than multiple patch antennas. The most basic form of a microstrip patch consists of two conducting materials separated by a dielectric material, known as substrate.

The two conducting materials operate as a ground plane and a patch or a radiating element, as indicated in Figure 2.1 [7]. Once the upper patch is excited with an electromagnetic signal, considering the operating frequencies of the patch, an electromagnetic signal is de-latched normal to the surface of the patch, creating a microstrip patch antenna. As these antennas' research and development progressed, different and varied shapes, structures, feeding methodologies, materials, fabrication methods, and principles were employed.

In this study, a microstrip patch antenna for GSM and ISM is explored. The possibilities are to combine the operation frequency bands of the mobile cellular networks and the local networks in one compact, easy to fabricate antenna.

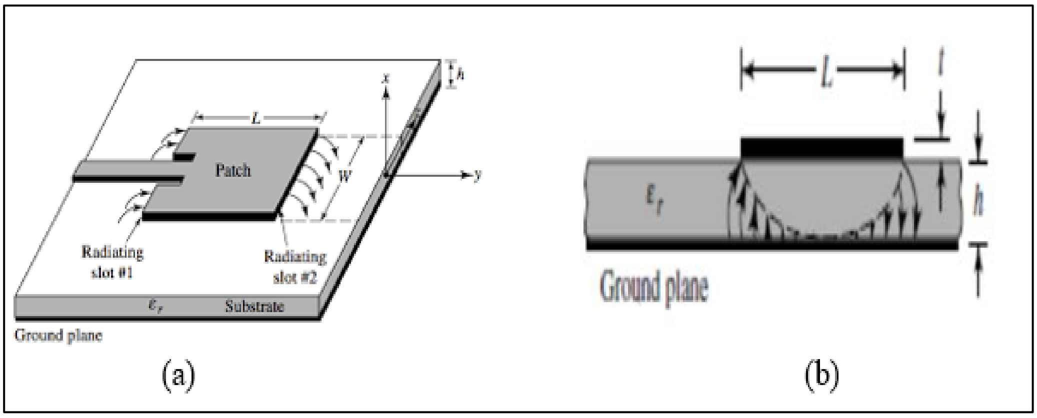

Figure 2.1**:** Microstrip patch antenna (a) radiating element, (b) side view, ground plane [7].

2.3 Different Types of Microstrip Patch Antennas

Microstrip patch antennas May be categorised according to similar physical characteristics.different kinds of patches are used for various purposes. There is square rectangular polarity round published and 12 indirect conformations. Nearly of the conformations are shown in Figure 2.2. Here really are various slots available. in patch antenna configuration such as A-slot, U-slot, H-slot, E- patched antennae with slots. They're employed in a variety of frequencie.

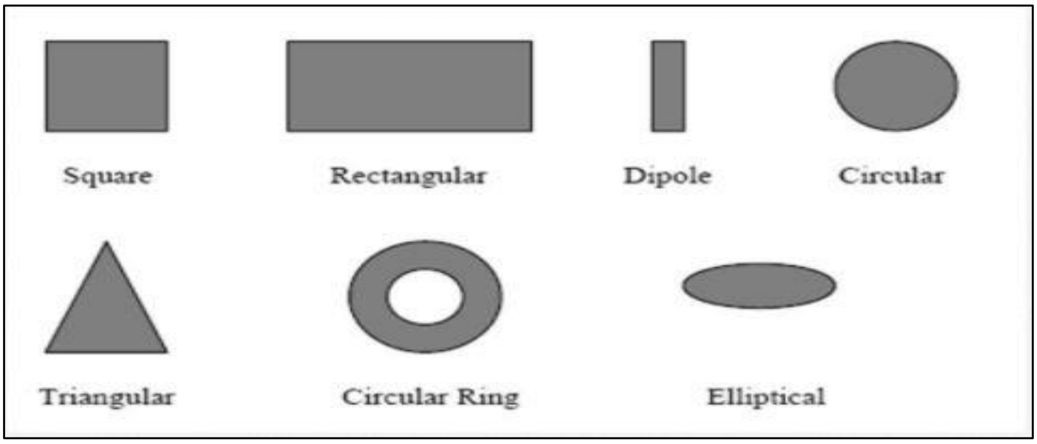

Figure 2.2: Different shapes of microstrip patch antenna [8].

2.4 Advantages and disadvantages of microstrip antennas

Microstrip patch antennas are growing in acceptance for the use in wireless applications owed to their little-shape building. Hence, They work well with integrated antennae in transportable wireless devices like mobile telephones and pagers (which are only used during messages). On missile, monitoring and telecommunication antennae must be thin and conformal, and are frequently made of carbon fiber. go hand in hand with microstrip patch antennas. Another area where they have been used successfully is in GSM and ISM applications [9]. Some of the major advantages of microstrip patch antennas are:

I. Small capacity and compact size.
II. Small plane design that conforms well to the host surface.
III. Small fabrication charge, henceforth may could be industrial in great quantity.
IV. Facilitates equally, linear as glowing as circular polarization.
V. Can be simply united with microwave united circuits (MICs).
VI. Skilled of some frequency processes.
VII. Automatically hearty once equestrian on unbending surfaces.

Microstrip patch antennas smart from weaknesses related to conservative antennas. Some of their major disadvantages are:

I. Narrow bandwidth
II. Low efficiency
III. Low Gain
IV. Extraneous radiation from feeds and junctions
V. Low power handling capacity.
VI. Surface wave excitation

2.5 Methods for Designing Multi-band Patch Antennas

A multiband antenna is one that can operate across many frequency bands. Multiband antennas have a design that allows one section of the antennae to be active for one band while the other part is active for just another. The multiband functioning of cell devices is fast expanding, thanks to the extensive applications of the Gsm network, which uses double radio frequencies of 900 and 1800 MHz.

As effects opinion nowadays, the application of the multiband organisations through several frequency band mixtures is quickening. World-wide drifting is systematic universally, the infrastructures volume is growing and different purposes are presence supplementary, counting GPS (1.57 GHz) and Bluetooth (2.4 GHz). Consequently, it is normal that all the handsets will probably become compatible with multiband in the near future. A multiband antenna is one of the key devices in such multiband systems since it is compatible with all the frequency bands without resort to multiple antennas [10]. A suitable patch structure can be made to operate at different frequencies wide apart while avoiding the use of multiple antennas [11]. As a result, a variety of strategies have just been developed. and implemented for constructing antenna for multiband performance including slotted shape, fractal shape and stacked configuration of patches. Some of these techniques are discussed briefly in the next subtopics.

2.5.1 Defected Ground Plane Structure (DGS)

This technique is quite popular among printed microstrip antennas. The ground plane is modified by integrating with defects or slots. These slots are mainly created in the form of an etched-out pattern in the ground plane. Currently, DGS is in request widely on behalf of several applications due to its benefits. it takes remained used in microstrip antennas to enhance the bandwidth and gain of microstrip but most importantly for achieving multiband performance [12]. The disruption in the recent owing to spaces allocation on the ground horizontal and the vitality connection among the slots products a several ringing frequency.

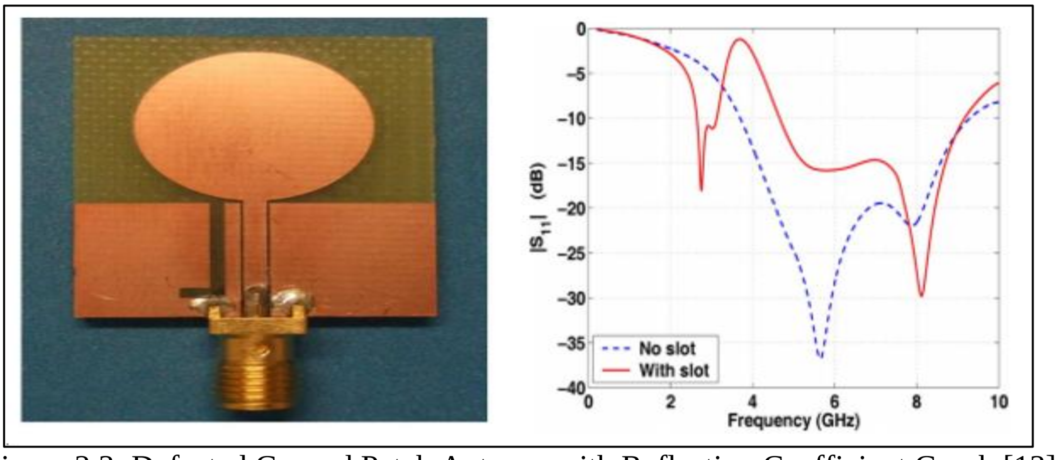

Figure 2.3: Defected Ground Patch Antenna with Reflection Coefficient Graph [13].

The antenna shown in Figure 2.3, L- The curved slot being adopted in order to accomplish a longer useful slot duration while increasing the grounding pilot's thickness. The results of the replicated reflection coefficient of the deserted-ground-plane monopole antenna with the circular disc monopole antenna are compared [13]. It can be observed that inserting the L-shaped slot in the ground plane results in two additional low-frequency resonances around 3 GHz while retaining the original high-frequency resonances around 5.6 and 8 GHz.

2.5.2 Slots Loaded Patch

To modify the resonance properties of the patch antennas, slotted means burning out a region first from patch in a precise manner. Removing gaps allows the major rivers on the metallic patch antennas to disperse, resulting in multi-banding. [11]. It also offers compression, bi-directional radiation patterns and multiband performance. Slots are embedded in the printed patch, with their dimensions and positions being properly selected. The slots would be of several shapes as toothbrush [14], double bend [15], cross [16], or U-shape.

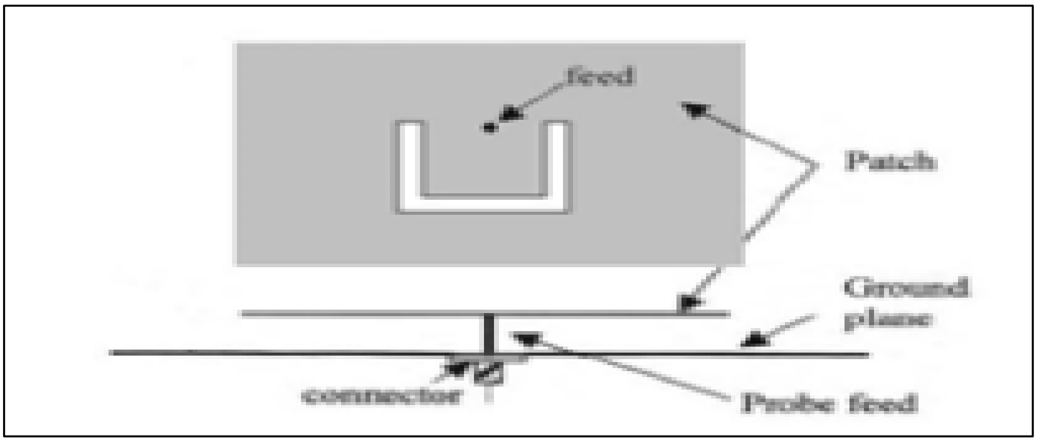

Figure 2.4: A Microstrip Patch with U Slot [17].

The U-slot technique is one of the popular microstrip techniques for obtaining multiband operations. They have been proved to be versatile radiating elements and can be designed not only for wideband applications but also for dual- and triple-band circular polarization operation [17]. Figure 2.4 shows a U-slot microstrip antenna consisting of two parallel vertical rectangular slots and a horizontal rectangular one [17]. The strictures that affect the broadband presentation antennae of such patches seem to be the slot's lengths, as well as its location. in order to get more than two bands of frequencies such as a triple band, it is reported in [18] that by introducing two U-slots as the radiating patch, it can be achieved the multiband characteristics. The inner U slot of the antenna shown in Figure 2.7, produces two resonant frequency at 1.2 and 2.4 GHz, while the outer U slot produces the 3.4GHz resonant frequency [18].

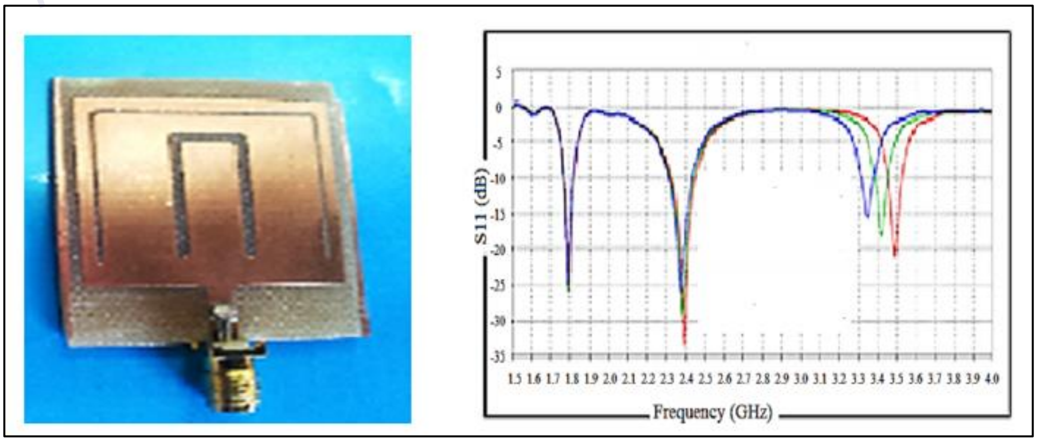

Figure 2.5: Double U Slot Patch Antenna with Reflection Coefficient [18].

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