# DESIGN OF A COMPACT MICROSTRIP ANTENNA AT 2.4GHZ

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*To all my loving family members,*

*especially to my beloved HUSBAND & my dearly loved*

*SON……*

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# ABSTRACT

With the recent advances in telecommunications, the need for compact antennas has greatly increased. Electronic equipment has rapidly reduced in physical size due to the development of integrated circuits, especially in mobile communications; the demand for the smaller antennas is quite strong. However, requirements on antenna performance on such small equipment are becoming increasingly severe, since the antenna performance should not be significantly degraded as the size become smaller.

The microstrip antenna is one of the most preferable for small equipment, especially when a built-in antenna is required. It has many advantages such as low profile and easy fabrication. However for low-frequency applications, the microstrip size becomes too large for practical implementation. One of the problems in microstrip antenna technology is the reduction of the antenna sizes. The aim of this project was to design, fabricate and test a compact microstrip patch antennas operating at 2.4GHz.

Three microstrip antennas operating at 2.4GHz was designed, fabricated and tested; a conventional rectangular microstrip antenna, a compact rectangular microstrip antenna with shorted wall method and a compact rectangular microstrip antenna with shorted pin method. Those designs were simulated with Microwave Office software and tested with the Marconi Scalar Analyzer. Both, simulated and measured data were compared and contrasted.

# ABSTRAK

Perkembangan yang pesat di dalam industri telekomunikasi telah menyebabkan keperluan terhadap penggunaan antena yang kecil dan mampat meningkat dengan begitu ketara. Peralatan elektronik telah pun mengalami satu perubahan yang drastik dari segi saiznya iaitu kepada yang lebih kecil. Ini adalah disebabkan oleh kemajuan pembangunan di dalam litar bersepadu terutamanya dalam industri telekomunikasi bergerak dan seterusnya menjadikan permintaan ke atas antena bersaiz lebih kecil adalah sangat tinggi. Walaupun permintaan ke atas antena ini meningkat dengan begitu ketara, namun prestasi antena tersebut tidak seharusnya terjejas.

Antena mikrojalur merupakan salah satu dari antena yang dicadangkan bagi peralatan yang bersaiz kecil. Terdapat banyak kelebihan pada antena tersebut seperti ianya berprofil rendah dan mudah difabrikasi. Walaubagaimanapun bagi applikasi berfrekuensi rendah, saiz mikrojalur akan menjadi terlalu besar untuk dilaksanakan secara praktikal. Ini merupakan salah satu masalah dalam penggunaan teknologi antena ini. Justeru itu, objektif utama projek ini adalah untuk merekebentuk, memfibrikasi dan menguji antena mikrojalur termampat yang beroperasi pada frekuensi 2.4 GHz.

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# LIST OF TERMINOLOGIES

| | | |
|---|---|---|
| PCS | - | Personal Communication System |
| GSM | - | Global System for Mobile Communication |
| DCS | - | Digital Communication System |
| WLAN | - | Wireless Local Area Network |
| ISM | - | Industrial Scientific and Medical |
| RF | - | Radio Frequency |
| DBS | - | Direct Broadcast Satellites |
| GPS | - | Global Positioning System Satellite |

## LIST OF SYMBOLS

| | | |
|---|---|---|
| mm | - | milimeter |
| dB | - | decibel |
| Hz | - | hertz |
| K | - | kilo |
| $d$ | - | diameter |
| $h$ | - | height |
| $L$ | - | length |
| $W$ | - | width |
| $\Gamma$ | - | reflection coefficient |
| $Z_0$ | - | characteristic impedance |
| $\lambda o$ | - | free-space wavelength |
| $\varepsilon_r$ | - | dielectric constant of the substrate |
| $t$ | - | patch thickness |
| $c$ | - | speed of light 3x $10^{-8}$ m/s |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

In modern mobile and wireless communications systems, there is an increasing demand for smaller low-cost antennas that can be easily integrated with packaging structures [1]. It is well known that planar antennas such as microstrip patch have a significant number of advantages over conventional antennas, such as low profile, lightweight and low production cost. Nevertheless in some mobile/wireless applications such as the *AMPCS/PCS, GSM/DCS, PDC/PHS, IMT 2000* or *WLAN* in the 2.4GHz Industrial Scientific and Medical (*ISM*) band, their physical size maybe too large for handheld terminals.

A number of techniques have been proposed to reduce the physical size of a conventional half-wave ($\lambda_0/2$, $\lambda_0$ is the guide wavelength in the substrate) patch antenna [2]. The most straightforward approach is to use a high dielectric constant substrate [2], however, it leads to poor efficiency and narrow bandwidth.

A shorting wall has been used to reduce the overall size of the patch antenna to $\lambda_0/4$, while a shorting pin near the feed can reduce the patch size even further [3].

## 1.2 Objectives

The objective of this project is to design and fabricate a compact rectangular microstrip antenna operating at 2.4GHz frequency using *FR4* substrate ($\varepsilon_r$ = 4.5) with dielectric loss tangent ($tan\delta$) of 0.019 and height ($h$) of substrate 1.6mm. The antenna is excited by a coaxial probe and the feed point is located at the distance ($dx$) away from the center of the patch.

## 1.3 Scope of Work

The scope of work of the project is to design a conventional rectangular patch antenna and two compact rectangular patch antennas (with shorting wall and shorting pin method) operating at 2.4GHz frequency.

The design is simulated with Microwave Office software. The antennas were then etched on a *FR4* substrate with dielectric substrate of 4.5 and height of 1.6mm. Network Analyzer was used to measure the antennas. Both, simulated and measured data are compared and contrasted.

## 1.4 Outline of the Thesis

The thesis comprises of five chapters and the overview of all the chapters are as below:

Chapter 1: This chapter provides the introduction, objective and scope of work involved in accomplishing the project.

Chapter 2: Chapter 2 presents the literature reviews on microstrip antenna, including the antenna basic parameters, the feeding methods and the methods of analysis that can be used for the microstrip antenna design.

Chapter 3: This chapter comprises the literature reviews on compact microstrip antennas and the description of the methods used in this project.

Chapter 4: The fundamental processes required in the design, fabrication and simulation of the microstrip antenna for this project are explained in this chapter.

Chapter 5: The simulation and measurement results obtained are discussed in this chapter.

Chapter 6: Conclusion of the project and suggestions for future work are presented in this final chapter.