UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND DEVELOPMENT OF SUB-6GHZ PLANAR ANTENNA FOR 5G APPLICATION

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

by

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TECHNOLOGY

2021

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Antena patch mikrostrip (MPA) adalah kelas antena rata yang selama empat dekad terakhir telah banyak dinilai dan dikembangkan. Dalam sistem komunikasi tanpa wayar, antenna ini menjadi pilihan pertama bagi pereka antena untuk digunakan di kebanyakan aplikasi. Walau bagaimanapun, sebahagian besar reka bentuk antena planar mikrostrip hanya dapat memberikan lebar jalur yang sempit dalam julat 500MHz. Terdapat juga beberapa reka bentuk antena planar mikrostrip yang rumit untuk mencapai lebar jalur lebar. Projek ini bertujuan untuk merancang dan mensimulasikan antena planar dengan lebar jalur lebar yang dapat digunakan dalam aplikasi 5G sub-6GHz dengan reka bentuk tampalan sederhana. The Rogers 3003 digunakan sebagai substrat dengan tinggi 1.55mm. Antena patch berbentuk-Z dirancang dan mensimulasikan hasilnya pada perisian CST untuk memastikan ia dapat dicadangkan. Lebar jalur lebar diperoleh dalam julat 3GHz hingga 6GHz. Corak radiasi stabil dan dapat digunakan dalam aplikasi 5G.

ABSTRACT

Microstrip patch antennas (MPA) are a class of flat antennas which in the past four decades have extensively been investigated and evolved. In the wireless communication system, they become the popular choice for those antenna designers to use in most applications. However, most of the design of the microstrip planar antenna can only provide a narrow bandwidth in the range of 500MHz. There also some design of microstrip planar antennas that are complicated to achieve wide bandwidth. This project aims to design and simulate a planar antenna with wide bandwidth that can be used in sub-6GHz 5G application with a simple patch design. The Rogers 3003 is used as the substrate with a high of 1.55mm. A Z-shape patch antenna is designed and simulates the result on the CST software to make sure it can be proposed. The wide bandwidth is obtained in the range of 3GHz to 6GHz. The radiation pattern is stable and can be used in 5G application.

DEDICATION

This thesis is dedicated to my parents and family member who give me many kinds of support and encouragement during completing this project. I also would like to dedicate my friends and supervisor that always possibly help me when I have trouble with this project

ACKNOWLEDGEMENTS

I would like to take this opportunity to express my deepest gratitude to all the outstanding people who have provided continuous support, guidance, experience, understanding and commitment to my successful project. In addition, I would like to express my heartfelt thanks to my supervisor, DR A.K.M ZAKIR HOSSAIN for his support, wiling to share his knowledge, suggestions and encouragement for helping me in completing the implementation and documentation of this project. I would like to thank every lecturer who has taught me, especially those who have given me all the knowledge, skills and tips for my research. These knowledge, skills and tips are very important for me to complete this project. In addition, I would like to thank all my friends for providing me with giving suggestions and improvements on my project. I really appreciate their guidance and cooperation. It is blessings and gracious encouragement of my parents, respected elders and my supporting colleagues that make me able to accomplish this project.

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LIST OF SYMBOLS

GHz	Giga Hertz
MHz	Mega Hertz
Mm	Milli-meter
A/m	Current per meter

LIST OF ABBREVIATIONS

MPA	Microstrip Patch Antenna
GSM	Global System For Mobile Communication
PCB	Printed Circuit Board
5G	Fifth Generation
LTE	Long-Term Evolution
WLAN	Wireless Local Area Network
3D	Three Dimensional
EM	Electromagnetic
ADS	Advanced Design System
RF	Radio Frequency
MMIC	Monolithic microwave integrated circuit
RFID	Radio-frequency identification
EMC	Electromagnetic compatibility
EMI	Electromagnetic interface
MWS	Micro-wave software
PET	Polyethylene

CHAPTER 1

INTRODUCTION

1.1 Background

Microstrip patch antennas (MPA) are a class of flat antennas which in the past four decades have extensively been investigated and evolved. In the wireless communication system, they become the popular choice for those antenna designers to use in most applications. Microstrip planar antenna was first developed in the early 1950s. However, in the 1970s, the idea was kept on almost 20 years only to be realized after the advancement of the Printed Circuit Board (PCB) technology. The microstrip patch antenna is a low-profile directional antenna. The microstrip patch antenna becomes familiar because it consists of some advantages for example low profile, inexpensive, simple, and can be fabricated easily in the circuit board.

According to (Balanis, 2005), due to the special characteristic of the antenna, it is popular for specific applications in satellite communications, mobile communication for Global System For Mobile Communication (GSM). The comprehensive research and evolution of microstrip antennas and arrays, leveraging the benefits, has led to the diversification of applications and the establishment of the subject as a separate entity within the broad field of microwave antennas. After many years of study, scientists had found a few ways to increase the efficiency of the microstrip planar antenna.

In Fifth Generation (5G) applications, there are two types of frequency bands which are Sub-6GHz frequency band and millimetre-wave spectrum bands. Sub-6GHz also called mid-band 5G is one of the frequency bands and it is widely used in 5G

technology. Sub -6 band can cover radio frequencies in the range of 2GHz to 6GHz. The most resonant frequency of the sub-6GHz is about 3.5GHz. Sub 6GHz can cover a greater area of 5G coverage but in another way, it cannot provide higher speed downlink compare to millimetre-wave.

1.2 Problem statement

The research and study on the microstrip planar antenna in the sub6GHz 5G application had been done by the antenna designers. There are many shapes of the patch antenna that had been developed or modified by the researcher to improve the uses of the microstrip planar antenna. However, most of the design of the microstrip planar antenna can only provide a narrow bandwidth in the range of 500MHz. Besides, some design of the microstrip planar antenna is complicated to achieve wide bandwidth. It may use a lot of time and cost to develop the design and expected result. Besides, some of the design of microstrip antennas are having low efficiency.

In this project, the simple design of the patch antenna will be proposed, and the proposed antenna can provide a wide bandwidth to increase the efficiency and can be used in many wireless communication systems.

1.3 Objective

The objectives of this project are:

1. To design and simulate the planar antenna on PCB with wide bandwidth that can be used in sub-6GHz 5G application
2. To design and simulate the antenna on different flexible substrates
3. To develop a prototype of planar antenna

4. To bench-mark of the existing work

1.4 Project Scope

This project mainly focuses on the designation of the microstrip planar antenna to works in a sub6-GHz 5G application. The CST Studio Suite is used as the microwave software to design the microstrip planar antenna and simulate the result. In this project, the dielectric constant of the substrate is not the variable of choice and depends on which dielectric material the antenna is designed. The Rogers 3003 substrate with dielectric constant 3 and a thickness of 0.51 mm has been used in the microstrip planar antenna. Next, the Polyimide substrate and PET substrate are used as flexible substrates to determine the stability of the antenna. The dielectric constant of the polyimide substrate is 3.5 and the height is 0.125 mm while the PET substrate with dielectric constant 3.2 and the thickness of the substrate is 0.125 mm. Bending technique is then apply on the flexible substrate to observe the effect on the antenna performance.

1.5 Expected results

In this project, there will be 2 sections of results to be observed, which is the simulation result and hardware result that fabricated on the PCB. The geometry of the microstrip planar antenna will be designed and the simulation result will be simulated by the microwave software. To make sure that the microstrip planar antenna able to works in the sub 6GHz 5G application, the result of the S-parameter should cover the wide bandwidth in the range of 3 to 4 GHz. The result of the directivity and gain must be good and stable. After that, the fabrication process is done according to the design of microstrip

planar antenna in the software. The S-parameters, radiation patterns, and directivity will need to be close to the simulated result to make sure that it is suitable to use in the sub 6GHz 5G application. Next, for the antenna designed on the flexible substrates which is Polyimide substrate and PET substrate, it can show the wide bandwidth that can cover from 3 to 4 GHz and show the higher efficiency compare to Rogers 3003 substrate. The proposed antenna that design on the flexible substrate will apply the bending technique to observe the result.

1.6 Thesis Organization

In this project, there will be 5 chapters provided. Chapter 1 will briefly explain the background of the project. The problem statement, objectives, and scope will be stated in this chapter. Chapter 2 will describe the related work of the project. The comparison between the previous paper will also be discussed and discuss the software to be used in this project. Next, the Chapter is the methodology of the project. In this chapter, the procedure, the materials have chosen to use and the parameters for the design will be stated to achieve the objectives of the project. Besides, Chapter 4 will show and discuss the results obtained based on the methodology step. The comparison results with the previous paper will also be discussed. Chapter 5 will conclude the overall result of the project. The suggestion to improve future research will also be discussed.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss the basic design of the microstrip planar antenna. Next, the related work from the previous research paper. Besides, the comparison table about the previous paper is provided. In addition, the comparison of software applications used to design and simulate the microstrip planar antenna. Overall, this chapter summarizes current information about the microstrip planar antenna including the main theoretical and methodological findings.

2.2 The geometry of microstrip antenna

The microstrip patch antenna used to provide high resonant frequency depends on the designation of the microstrip planar antenna. The single-layer design of the microstrip planar antenna can be divided into three parts which are patch, substrate, ground plane with feeding technique. A microstrip patch antenna contains either a planar or a non-planar geometry patch on the upper side of the substrate and a ground plane on the bottom side of the substrate (Singh, 2011). The rectangular patch is the normally used microstrip antenna and used for the simplest and most challenging applications. The basic structure of a rectangular patch antenna is shown in figure 1 below.