Faculty of Electrical and Electronic Engineering Technology

DESIGN AND DEVELOPMENT OF A FLEXIBLE PLANAR 5G FOUR ELEMENT MIMO ARRAY FOR SMARTPHONES

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Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

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DESIGN AND DEVELOPMENT OF A FLEXIBLE PLANAR 5G FOUR ELEMENT MIMO ARRAY FOR SMARTPHONES

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DEDICATION

I have a deep desire to honour and thank my kind and encouraging parent Encik Zulkapli bin Abdul Wahid and my mother Ummi kalthom binti Ramly by devoting this work to them, as they have been my primary source of motivation and support all the way through the process of bringing this project to fruition. I would also want to dedicate my effort to my siblings, who never fail to inspire me to grow as a person and pursue better opportunities in the years to come. My compassionate and good-hearted supervisor, DR. A K M ZAKIR HOSSAIN, is the source of much of my motivation and inspiration, and I have the deepest respect for him for the counsel and support he has provided. In conclusion, I would want to show my appreciation to Allah, the Most High, for rewarding my life in a way that is well above what I deserve.

ABSTRACT

Here 4×4 MIMO configuration array with polarization diversity on a flexible substrate for smartphones. To propose and simulate a single element planar antenna on flexible substrate for 5G communication. Planar antennas, like microstrip antennas and printed circuit board antennas, have both active and passive parts on the same plane. This makes them two-dimensional (2D). The idea behind the planar antenna is to make it easier to connect and use with other antennas or communication systems. Because of this, the planar antenna fits the goals of this report because of how it works. The design for the proposed planar antenna was made with the software CST Studio Suite and a specific spectrum of less than 6 GHz. The sub-6 GHz spectrum band is a standard frequency for fifth-generation (5G) communication and a fairly new feature and compatibility for smart phones. The results of the simulation showed that the proposed antenna design works at a frequency of 3.5 GHz with an acceptable level of radiation efficiency. MIMO (multiple input, multiple output) technology is also built into the antenna, which improves its performance. This project will make 5G smart phones more useful to their users by making them better at what they can do.

ABSTRAK

Di sini 4×4 tatasusunan konfigurasi MIMO dengan kepelbagaian polarisasi pada substrat fleksibel untuk telefon pintar.Untuk mencadangkan dan mensimulasikan antena planar elemen tunggal pada substrat fleksibel untuk komunikasi 5G.Antena Planar, seperti antena microstrip dan antena papan litar bercetak, mempunyai kedua-dua bahagian aktif dan pasif pada satah yang sama.Ini menjadikan mereka dua dimensi (2D). Idea di sebalik antena planar adalah untuk memudahkan untuk menyambung dan menggunakan dengan antena atau sistem komunikasi lain.Oleh kerana itu, antena planar sesuai dengan matlamat laporan ini kerana bagaimana ia berfungsi.Reka bentuk untuk antena planar yang dicadangkan dibuat dengan perisian CST Studio Suite dan spektrum tertentu kurang daripada 6 GHz.Jalur spektrum sub-6 GHz adalah frekuensi standard untuk komunikasi generasi kelima (5G) dan ciri dan keserasian yang agak baru untuk telefon pintar.Hasil simulasi menunjukkan bahawa reka bentuk antena yang dicadangkan berfungsi pada frekuensi 3.5 GHz dengan tahap kecekapan radiasi yang boleh diterima.Teknologi MIMO (multiple input, multiple output) juga dibina ke dalam antena, yang meningkatkan prestasinya.Projek ini akan menjadikan telefon pintar 5G lebih berguna kepada pengguna mereka dengan menjadikannya lebih baik pada apa yang mereka boleh lakukan.

TABLE OF CONTENTS

PAGE

CHAPTER 5 CONCLUSION AND RECOMMENDATION

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

$\boldsymbol{\delta}$	-	Voltage angle
℃	-	Temperature
[ ]	-	Brackets
%	-	Percent
π	-	Pi Constant
∝	-	proportional to
∑	-	sigma
ε	-	epsilon
∫		Intergal
i		imaginary unit
| z |		absolute value/magnitude of a complex number
∞		Infinity
Δ		Increment
$\boldsymbol{\beta}$		Beta
$\boldsymbol{\theta}$		theta
$\boldsymbol{\sigma}$		Sigma
$\boldsymbol{\mu}$		mu
$\boldsymbol{\omega}$		omega

LIST OF ABBREVIATIONS

MIMO	-	Multiple input, multiple output
AC	-	Alternating current
CPW	-	Coplanar waveguide
CST	-	Computer simulation technology
DG		diversity gain
EEC		envelope correlation coefficient
EHF	-	extremely high frequency
EIRP	-	effective isotropic radiated power
ELF	-	extremely low frequency
EMC	-	electromagnetic compatibility
FEM	-	finite elements method
FIT	-	finite integration technique
GSM	-	Global System for Mobile
HF	-	high frequency
HFSS	-	high frequency structure simulator
IEEE	-	Institute of electrical and electronics engineers
IDE	-	Integrated Development Environment
IFA	-	inverted F antenna
TARC	-	Total active reflection coefficient
SRMA	-	sequentially rotating monopole antenna
VSWR	-	voltage standing wave ratio

CHAPTER 1

INTRODUCTION

1.1 Background

5G technology will result in increased connection, high speed, and data throughput, all while maintaining exceptionally low latency. In terms of frequency of operation, 5G has two bands: sub-6 GHz (below 6 GHz bands) and millimetre wave. The millimetre wave band is found in various places of the world between 24 and 30 GHz. In the sub-6 GHz 5G spectrum, there are several subbands, including the lower band (700 MHz), mid band (3.4–3.6 GHz), and high band (4.8–6 GHz). Various nations and regions have selected unique sub-6 GHz bands for their projected 5G rollout activities. As a result of the shuttle's change in operating frequencies, all essential gear linked to base transceiver stations (BTS), handphones/smartphones, and other user equipment (UE) must be updated or tuned to match those chosen frequencies. Among the several components of such equipment, the antenna is one of the most crucial. The antenna acts as the primary gateway for any wireless interface by converting electrical impulses to electromagnetic radiation. As a result, a well-designed antenna will put less burden on other components such as power amplifiers (PAs), low noise amplifiers (LNAs), and so on Recently developed multiple input multiple output (MIMO) array methods and designs for smartphones allow for decreased crosstalk, excellent signal selectivity, and channel capacity in wireless signal transmission and reception. Furthermore, it has higher directivity, enhanced beamforming, and beam-steering capabilities by default. However, designing a MIMO antenna array that fits inside a smartphone along with the other circuitry elements without compromising the overall system's performance to cover the entire mid-range sub-6 GHz frequency range while maintaining MIMO performance in terms of port isolation, envelope correlation coefficient (ECC), diversity gain (DG), and SAR remains a challenge.

1.2 Problem Statement.

Due to the increased demand for wireless and mobile technologies, wired communication systems have gradually been superseded as the present communication system advances and evolves. In this transition phase, antennas, which are metallic devices that capture signals in the air, serve a critical function. Users all throughout the world require a variety of wireless apps. Aside from that, today's electronics are more likely to be mobile. As a result, the built-in antenna must be small enough to fit into the mobile device. Telecommunication devices are designed to function in a range of nations throughout the world. The purpose of this study is to create a small 2 2 MIMO array for cellular communication by employing a sequentially rotating monopole antenna (SRMA). An antenna is shown to have multiband features if it can operate in various frequency bands, such as the IEEE Bluetooth/ WLAN/ISM range of 2.4-6 GHz and the WLAN range of 5.15-6 GHz. The return loss criterion has been established at 10 dB, which corresponds to 95% of the antenna's matching efficiency.

1.3 OBJECTIVES.

The aim of the study is:

1. To propose and simulate a single element planar antenna on flexible substrate for 5G communication.

2. To simulate a 4×4 MIMO configuration array with polarization diversity on a flexible substrate for smartphones

3. To fabricate the proposed 4×4 array and measure in real environment using VNA and anechoic chamber.

4. Benchmark the outcome with the current trends.

1.4 SCOPE OF PROJECT.

The idea of this project is to design illustrate the qualities and capabilities of planar antennas, and its scope includes doing so. More over i will design 4 element antenna arrays it for the with a bandwidth 5GHz. For this project I will use flexible material and Rogers when designing it. Beside that i will show the specification of each material the will be use for this project. The software CST Studio Suite is used to complete the design of the antenna, and it is also capable of simulating the performance of the created antenna in the form of graphical data. In addition to this i will show some important parameter such as S-parameters, farfields both 2D and 3D , voltage standing wave ratio (**VSWR**) . Next, will also calculate the bandwidth, Envelope Correlation Coefficient (**EEC**), Directive Gain (**DG**), Total active reflection coefficient (TARC) . In conclusion, the scope of this research is limited to the mobile communications industry, namely the practical use of antennas.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION.

The latest technology for civilization of human intelligent was wireless communication .The term that been use wireless communication system is called 5G. It provides lower latency in conjunction with enhanced connection, quick speed, and an exceptionally high data throughput .As we known that the 5G based on OFDM (Orthogonal frequency-division multiplexing) that fall into several type of band that have been categories high band , middle band ,lower band .Most of countries agree and have set benchmark or basic guideline on the range frequencies for each band .For high band the parameter is between 4.G to 6.Ghz, for middle band was between 3.4G to 3.6Ghz and lastly for lowest band is 700 Mhz. All this band was under category sub 6Ghz frequencies. Hardwires that are essential to interface to wireless digital networks, such as Base Transceiver Stations (BTS), handphones, and other similar devices, must be developed to meet the frequencies that are used in each country since each country uses a unique set of frequencies. As we known when talking about wireless communication system they were several main components that been used but the most basic is antenna. Antenna was a device that receives and/or sends radio electromagnetic waves. Most antenna designer using MIMO for their basic based when build their antenna. This is because MIMO may also be utilized to extend transmission range at a given data rate, a feature that has enormous practical significance. This type design been used on the latest technology in mobile phones communications.

To meet the essential requirements for 5G communication, the antenna arrays at both the base-station and mobile-station ends of the link must be designed appropriately. The most complex aspect of design is fitting a MIMO antenna array into the narrow area of a mobile device. This is true of every mobile device. Current observations of the state of the art classify MIMO antennas for sub-6 GHz 5G mobile phones into four distinct categories. These classes are determined by the mode of operation, number of antenna components, isolation circuitry used, and antenna layout. As a result, the majority of academics and antenna engineers feel that it is impossible to develop a MIMO array with few components, a broad bandwidth, little separation, and a simple design. It is recommended that 5G phones use a two-element reconfigurable MIMO. To create frequency diversity at 2.4 or 3.5 GHz, the single element is comprised of two radiating arms with meander lines that may be connected to or decoupled from the 50 feedline. The envelope correlation coefficient (ECC) values for 2.4 GHz and 3.5 GHz are 0.0056 and 0.0009, respectively. The antenna array provides at least 12 dB of minimum isolation. Apparently, a smartphone antenna with a two-element MIMO array may cover more than 400 MHz for two sub-6 GHz mid-bands running concurrently at 3.5 and 4.3 GHz.

2.2 PREVIOUS PROJECT RESEARCH.

This chapter will review previous research and existing projects created using reference sources and guidelines such as journals, the internet, article writing, blogs, and scientific studies to gain an understanding of project design, conception, and any information that may be useful in improving the project. Several scholars have created and produced projects based on various concepts and designs. This chapter also discusses the research pertinent to this project.

2.2.1 Geometry of Microstrip (Printed) Antenna

A microstrip antenna is a form of antenna that may be manufactured on a printed circuit board (PCB) by the use of a photolithographic method. This type of antenna is also known as a printed antenna. The vast majority of microstrip antennas are made up of numerous patches that are arrayed in a two-dimensional pattern. The microstrip antenna that is most often seen is known as the patch antenna. A patch antenna is a narrowband antenna with a wide beam that is created by etching the pattern of the antenna elements into a metal trace that is attached to an insulating dielectric substrate, such as a printed circuit board, and then coupling a continuous metal layer to the other side of the substrate, which acts as a ground plane. Aside from that, microstrip antennas that are square, rectangular, circular, and elliptical in shape are typical, although any continuous design is acceptable. Some patch antennas are made up of a metal patch that is placed on top of a ground plane using dielectric spacers rather than a dielectric substrate. The structure that is produced by this method has a lower level of robustness but a greater bandwidth. Due to the fact that such antennas have a low profile and are sturdy, they are typically included into mobile radio communications equipment.

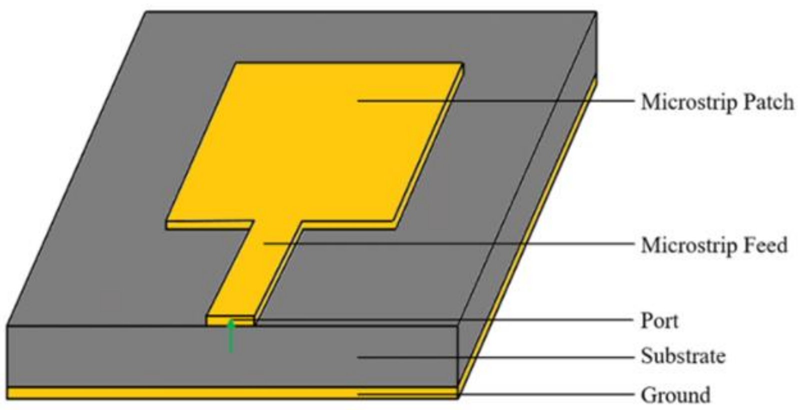

Figure 2.1: The main key design of microstrip antenna

2.1.1 Planar antenna in sub-6 Ghz applications

As a result of the fast development of technology for wireless communication, the standards for 2G, 3G, and 4G have gained widespread adoption. Therefore, in order to expand the bandwidth of mobile phone antennas, a few different methods have been suggested. These methods include the use of matching networks with lumped components, the multimode resonance approach, and the frequency reconfigurable methodology. Additionally, for use in mobile device applications, a broadband antenna that had a number of different resonant modes was designed; nevertheless, the design called for a very wide clearing space. As a result, reducing the clearance area may be accomplished by advocating for a basic planar antenna and putting restrictions on its designs, such as folding the antenna into three-dimensional structures.

Table 2.1: Dimensions of the antenna (unit: mm). [1]

Parameters	L1	L2	L3	L4	L5	L6
Values	12.9	28.7	4.4	21	6.5	5.5
Parameters	L7	L8	L9	L10	L11	L12
Values	14.5	3	7.5	12.5	1.7	15
Parameters	L13	L14	L15	L16	w1	w2
Values	29.9	5	4	11	1	1.5
Parameters	w3	w4	w5	Ls1	Ls2	
Values	0.5	1	1	0.5	1	