DESIGN OF TRI-POLARIZED ANTENNA

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Tajuk Projek : Design of Tri-Polarized Antenna

Sesi Pengajian : 1 6 / 1 7

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DEDICATION

Special Dedicated To

My beloved father and mother,

My supervisor,

My family,

And all my friends

For their Love, Encouragements and Best Wishes.

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ABSTRACT

Nowadays, people demands for high quality communication system such as high-quality video call, voice call and data. In order to achieve that, Multiple-Input Multiple-Output (MIMO) system is a must as conventional communication such as Single-Input Single-Output (SISO) communication system is incapable of providing high transfer speed and high capacity. In order to exploit the potential of MIMO system to maximum, polarization diversity method is preferred where multiple polarization antenna is used to overcome the mutual coupling problem among the huge number of antennas. In this project, a tri-polarized antenna that operate at frequency 2.4GHz with a dual circular polarization and a linear polarization is proposed. Circuit Simulation Tool (CST) software is used to design and construct the designed antenna. Investigation on single polarized antennas are carried out first where different feeding methods such as orthogonal feed are used to achieve circular and linear polarization. A dual circular polarized antenna is then designed by combining two single polarized antenna in a single antenna structure with two independent ports to generate dual polarization. The final stage of this project is the combination of the dual circular-polarized antenna and a linear polarized antenna in single antenna structure to realize tri-polarization.

ABSTRAK

Pada masa kini, sistem komunikasi yang berkualiti tinggi seperti panggilan video berkualiti tinggi, panggilan suara dan data amat diperlukan. Untuk mencapai matlamat tersebut, Multiple-Input Multiple-Output sistem (MIMO) adalah satu kemestian sebab komunikasi konvensional seperti Single-Input Single Output (SISO) tidak mampu menawarkan kelajuan hantaran yang tinggi dan berkapasiti tinggi. Dalam usaha untuk mengeksploitasi potensi sistem MIMO sistem, kaedah kepelbagaian polarisasi lebih diutamakan di mana antena dengan pelbagai polarisasi digunakan untuk mengatasi masalah gandingan bersama di kalangan sebilangan besar antena. Dalam projek ini, antena tri-polarisasi yang beroperasi pada frekuensi 2.4GHz dicadangkan.dan perisian litar Simulasi Tool (CST) digunakan untuk mereka dan membina antena direka dan nisbah paksi digunakan untuk menentukan polarisasi antena di mana nisbah paksi lebih daripada 3 adalah polarisasi linear sementara nisbah paksi kurang daripada 3 adalah polarisasi bulat. Siasatan antena polarized tunggal dijalankan di mana kaedah pemakanan yang berbeza digunakan untuk mencapai polarisasi bulat dan linear. Dual antena kemudiannya direka dengan menggabungkan dua single antena dalam struktur antena tunggal untuk menjana dua polarisasi. Peringkat akhir projek ini adalah gabungan antena dual polarisasi dan antena tunggal polarisasi dalam satu struktur antena tunggal untuk merealisasikan tri-polarisasi.

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AUT	-	Antenna Under Test
CST	-	Computer Simulation Technology
dB	-	Decibel
GHz	-	Gigahertz
MIMO	-	Multiple-Input Multiple-Output
WLAN	-	Wireless Local Area Network

CHAPTER 1

INTRODCUTION

1.1 Project Overview

Multiple input multiple output (MIMO) is one of the smart antenna technology implemented in current wireless communication system where multiple antennas are used to maximize data speed and channel capacity. In conventional wireless communications, an antenna is used at both the source and the destination but this method brings multipath effects and it is not efficient enough. The idea of using multiple antennas is then raised to overcome these problems. In order to further improve the performance of MIMO system in wireless communications, polarization diversity is preferred where multiple polarized antennas are used. By introducing tri-polarized antenna in MIMO system, the number of antennas can be reduced and space limitation in MIMO system can be solved. Therefore, in this project, a tri-polarized antenna which operates at frequency 2.4GHz is proposed, designed, simulated and fabricated.

1.2 Problem Statement

Wireless communication plays an important role and impacted human life in many ways. People demands high quality communication system for technologies like voice calling, video calling and data where high data transmission rate is required. In order to achieve improvement in communication system, the transfer speed of information need to be upgraded by increasing the data capacity where it can be achieved through the

implementation of Multiple Input Multiple Output (MIMO) system. MIMO system technology has been considered as a significant foundation to build the next and future generation of wireless network due to its advantages of high capacity and spectral efficiency.

The efficiency of MIMO system can be proportionally increased according to the number of antennas. In realizing the MIMO system, single polarized vertically arranged spatial array configurations is usually implemented where the antennas are separated in space. This system requires adequate space between antennas to achieve significant gain. When the spacing between antennas is nearer, lower degree of isolation between radiating ports is obtained and hence mutual coupling occurred. Therefore, polarization diversity is preferred as multi polarized diversity antenna make use of the vector electromagnetic field and have greater potential in space limited MIMO system. Polarization diversity plays an important role in combating the multipath propagation effects and it is capable of increasing the channel capacity.

The use of multi polarized antennas help to overcome space limitation in implementing MIMO system due to large number of antennas. Dual polarized antenna is important in polarization diversity in order to improve the system performance and reduce the multipath effect in wireless communication. Arrays of dual polarized antennas are used in most of the conventional polarization diversity system because it has the ability to generate arbitrary polarization. However, this ability of dual polarized antenna leads to cross polarization or polarization distortion at large scanning angles in diagonal plane. In order to fully utilize the polarization diversity, triple polarized antenna is introduced to exploit additional degree of freedom for wireless communication.

1.3 Objective

The objective of this project is to design, simulate and fabricate a tri-polarized antenna with combination of a dual circular polarization and a linear polarization that operates at frequency 2.4GHz for wireless MIMO system.

1.4 Scope of Project

The scope of work in this project are:

i. Design of a tri-polarized antenna with combination of a dual circular polarization and a linear polarization for wireless MIMO system. For this project, the focus is on WLAN system with frequency 2.4GHz.

ii. The 3D structure of antenna designed is simulated by using CST Studio Suite 2015 software. The antenna parameters such as return loss, gain, axial ratio, directivity and efficiency are simulated.

iii. The fabrication method is chemical etching and FR4 with dielectric constant of 4.4, substrate thickness of 1.6mm, conductor thickness of 0.0035mm and tangent loss of 0.019 is chosen as the substrate.

iv. The antenna parameters such as return loss, gain and radiation pattern are measured and observed by using equipment such as signal generator, spectrum analyzer and network analyzer.

1.5 Thesis Outline

Chapter 1 presents the introduction to this project through the objectives, problem statement, and scope of work of the project.

Chapter 2 presents the literature review on the antenna polarization, multi-polarized antenna, microstrip antenna and information on the basic antenna parameters.

Chapter 3 presents the overall project methodology and the design methodology of the antenna.

Chapter 4 discusses the simulation and measurement results by analyzing through comparison.

Chapter 5 concludes the project's findings or outcomes and suggestions for project's future works.

CHAPTER 2

LITERATURE REVIEW

2.1 Antenna Parameters

Definitions of various parameters are needed in order to describe the performance of the antenna. Typical parameters of antenna are return loss, gain, radiation pattern, polarization and directivity. All these parameters will be discussed and explained in detail.

2.1.1 Gain

Gain of antenna is a measure of efficiency of the antenna as well as its directional capabilities and it is closely related to directivity. More precisely, gain of antenna is defined as the ratio of intensity in a given direction to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotopically and the equation is expressed in. However, relative gain is used most of the time where it is defined as the ratio of power gain in a given direction to the power gain of reference antenna in referenced direction. A lossless isotropic source is used as the reference antenna most of the time and it is expressed in equation.

$$Gain = 4\pi \frac{radiation\ intensity}{total\ input\ (accepted\ power)}$$

$$= 4\pi \frac{U(\theta, \varphi)}{P_{in}}$$

$$Gain = \frac{U(\theta, \varphi)}{P_{in}(lossless\ isotropic\ source)}$$

2.1.2 Directivity

Directivity of an antenna is defined as the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions and the direction of maximum radiation intensity is implied if the direction is not specified. As for antennas with orthogonal polarization components, the partial directivity of the antenna for a given polarization in a given direction is defined as part of the radiation intensity corresponding to a given polarization divided by the total radiation intensity agreed over all directions [1].

$$D = \frac{U}{U_O} = \frac{4\pi U}{P_{rad}}$$

If the direction is not specified, it is expressed as

$$D_{max} = D_O = \frac{U_{max}}{U_O} = \frac{4\pi U_{max}}{P_{rad}}$$

D = directivity

Do = maximum directivity

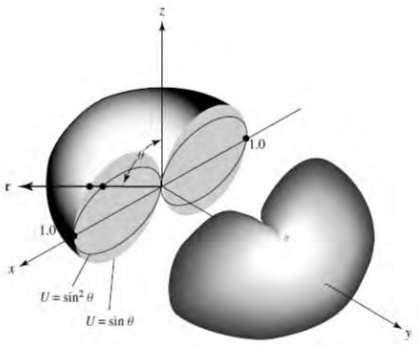

Figure 1.1: 3D radiation intensity pattern [1].

2.1.3 Radiation Pattern

An antenna radiation pattern is a mathematical function or graphical representation of antenna radiation properties such as power flux density, radiation intensity, field

strength, directivity or polarization as a function of space coordinates. However, radiation pattern is represented as a function of directional coordinates most of the time when it is determined in far field region [1]. For an antenna, field pattern typically represents a plot of the magnitude of the electric or magnetic field as a function of angular space while the power pattern usually represents a plot of square of the magnitude of the electric or magnetic field as a function of angular space .

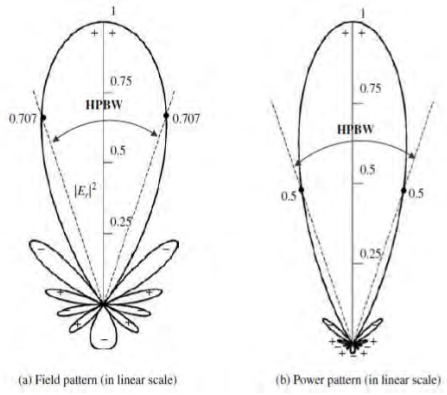

Figure 1.2: Two-dimensional normalized field pattern and power pattern [1].

2.1.4 Polarization

Polarization of an antenna in a given direction is the polarization of wave radiated by the antenna. Polarization of radiated wave is defined as the property of an electromagnetic wave describing the time-varying direction and magnitude of the electric-field vector. There are three type of polarizations which are linear, circular and elliptical polarization.

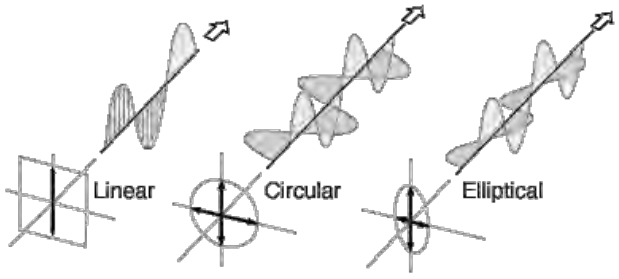

Figure 1.3: Type of polarization.

2.1.4.1 Linear Polarization

A field is considered linearly polarized if the vector that describes the electric field at a point in space as a function of time is always directed along a line. Linear polarization is widely used in early system due to the simplicity and low cost of feed antennas [14]. Linear polarization occurred when a time-harmonic wave is linearly polarized at a given point in space if the electric or magnetic field vector at that point is always oriented at the same straight line at every instant of time. This is achieved when the field vector possesses only one component or two orthogonal components that are in time phase or 180 degrees out of phase [1].

2.1.4.2 Circular Polarization

The generation of circular polarization in wireless communication systems does not require polarization alignment between transmitter and receiver and it is more robust against multi-path effects. These advantages make it feasible to receive linear polarization at any angle and can easily penetrate through obstacles [3]. Besides, circular polarization helps to overcome the difficulty with linear polarization in satellite communication due to variable or unknown orientation of linear polarized antenna because the electric field of circular polarization is varied in two orthogonal planes which are x and y direction and it can radiate in either RHCP or LHCP [4].

2.2 Multiple Input Multiple Output (MIMO)

Multiple Input Multiple Output (MIMO) system is one of the methods to significantly improve the performance of wireless system. MIMO system employs two or more antennas at both the transmitting and receiving ends where this helps to reduce the multipath wave propagation effects, delay and packet loss. Employment of multiple antennas provides additional paths where this paths provides helps improve signal to noise ratio and increase the link data capacity [2]. Therefore, antenna selection is the important element in MIMO system because it can exploit the diversity benefits of MIMO