CIRCULARLY POLARIZED MIMO ARRAY ANTENNA FOR 5.8 GHZ POINT-TO-POINT COMMUNICATION

by

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Specially dedicated to my beloved wife, parents, brothers, sisters and friends

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POLARASI BULATAN MIMO ARRAY ANTENNA UNTUK 5.8 GHZ TITIK KE TITIK KOMUNIKASI

ABSTRAK

Tiga rekabentuk yang berbeza dan konsep pengeluaran sirkuler terpolarisasi pelbagai masuk pelbagai keluaran (CP-MIMO) antena untuk komunikasi point-to-point telah dibentangkan dalam tesis ini. Seluruh antena dibangunkan oleh unsur-unsur MIMO dua liang yang setiap reka bentuk yang digunakan elemen memancar yang berbeza. Semua reka bentuk yang menggambarkan gabungan tiga kaedah, termasuk sistem MIMO, reka bentuk dan konfigurasi CP array ke satu antena. Gabungan tiga teknik di dalam satu antena adalah sangat mencabar dan banyak kajian telah dibuat untuk menyelesaikan rekabentuk ini. Ketiga-tiga reka bentuk menggunakan tatarajah yang sama yang mempunyai empat elemen radiasi, tetapi masing-masing mempunyai reka bentuk yang berbeza. Rekabentuk pertama dibangun dari empat bentuk persegi dipotong di penjuru petak dan diukir di Taconic TLY-5 substrat dengan 2.2 dan 1.575 mm pemalar dielektrik dan ketebalan masing-masing. Sementara itu, rekabentuk kedua dan ketiga adalah berdasarkan kepada bentuk elemen pemancar bulat dan diukir pada FR4 dengan pemalar dielektrik 4.7 dan 1.6 ketebalan substrat. Rekabentuk pertama yang direka menggunakan kaedah yang mudah untuk menghasilkan kemampuan CP yang telah menghasilkan 2.24 dB paksi catuan, rekabentuk kedua dan ketiga adalah lebih kompleks yang digunakan 90 ° peralihan secara berperingkat untuk menghasilkan 1.9 dB dan 1.94 dB nisbah paksi. Konvergensi kemampuan CP dalam jenis antena MIMO berjaya diwujudkan dengan dua susunan empat pekeliling-bersegmen pelbagai patch unsur radiasi. Selain itu, frekuensi salunan antena 5.8 GHz sesuai untuk point-to-point sistem tulang belakang komunikasi. Semua pengukuran pekali ruang dan refleksi anechoic bersetuju juga dengan keputusan penyelakuan. Gabungan MIMO antena dengan ciri-ciri polarisasi pekeliling akan bertambah banyak keuntungan dari pemancar untuk mencapai kinerja batu terakhir pada masa yang sama mengelakkan isyarat dilemahkan penting di bawah keadaan atmosfera yang buruk. Gabungan dua liang antena akan meningkatkan keuntungan sebanyak pemancar untuk mencapai kinerja batu terakhir pada masa yang sama mengelakkan isyarat dilemahkan penting di bawah keadaan atmosfera yang buruk. Kertas kerja ini memberi tumpuan lebih pada sistem MIMO yang digunakan dalam aplikasi 5.8 GHz.

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ABSTRACT

Three different design of circularly polarized multiple input multiple output (CP-MIMO) antenna for point-to-point communication is proposed in this thesis. All design involves with combination of three type of technique which are MIMO, CP and array in single antenna. The first design is constructed from four truncated patch etched on Taconic TLY-5 substrate with 2.2 and 1.575 mm of dielectric constant and thickness respectively. Meanwhile, second and third design is based on circular shape radiating element and fabricate on FR4 with 4.7 dielectric constant and 1.6 substrate thickness. Rectangular truncated circular polarized antenna (RTCPA) was designed using a simple technique to produce CP capability 2.24 dB axial ratio, while 90° phased shifted dual and tripled coupled CP-MIMO used 90° phased shifting element to produce 1.9 dB and 1.94 dB axial ratio. Convergence of CP capability within the MIMO array antenna is successfully realized by two arrays of four circular-segmented patch array radiating element. Apart from that, the antenna resonant frequency of 5.8 GHz is suitable for point-to-point backbone communication system. All anechoic chamber's and reflection coefficient measurements agrees well with the simulation result. The combination of MIMO array antenna with circular polarization characteristics will multiply the gain of transmitter to achieve a last mile performance while simultaneously avoiding significant attenuated signals under adverse atmospheric conditions. The combination of two-port array antenna will enhance the gain of transmitter to achieve a last mile performance while simultaneously avoiding significant attenuated signals under adverse atmospheric conditions (bad weather). This thesis focuses more on MIMO system that are used in 5.8 GHz point-to-point communication.

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LIST OF SYMBOLS

θ	Theta
Γ	Reflection Coefficient
Π	Phi
Ω	Ohm
η	Efficiency
ε	Permittivity
Δ	Loss Tangent

LIST OF ABBREVIATIONS

CAD	Computer Aided Design
CST	Computer Simulation Technology
dB	Decibel
dBm	Decibel of Measured power referenced to 1 mille watt (mW)
GHz	Giga Hertz
GPS	Global Positioning System
ICNIRP	International Commission on Non-Ionizing Radiation Protection
ISM	Industrial, Scientific and Medical
mm	Millimeter
PAN	Personal Area Network
PCPTF	Pure Copper Polyester Taffeta Fabric
RF	Radio Frequency
SAR	Specific Absorption Rate
SNR	Signal Noise Ratio
VSWR	Voltage Standing Wave Ratio
WBAN	Wireless Body Area Network
WLAN	Wireless Local Area Network
MIMO	Multiple Input Multiple Output
CP	Circular Polarized

ARMSA	Annular-Ring Microstrip Antenna
CST	Computer Simulation Technology

CHAPTER 1

INTRODUCTION

1.1 Introduction

In Malaysia, point-to-point wireless local area network (WLAN) is functioning in the upper Unlicensed National Information Infrastructure (UNII) band of 5.725 to 5.875 GHz. A point-to-point wireless communication usually fails to distribute the threshold signal strength of -71 dBm. It also fails to stabilize the data rates in severe climate conditions (R. A. Saed & S. Khatun, 2005). Failing to comply such meshold leads to the slow internet connection or even disconnected. A high efficiency, gain, and circular polarized (CP) microstrip patch antenna will provide an appropriate solution to avoid major signal attenuation during such conditions (William H. Hayt & Jr. John A. Buck, 2001; M. Rahmani et al., 2009). Instead of CP antenna, two-port MIMO techniques to increase channel capacity for higher data rate and better link stability of a system. Consequently, convergence between CP technique, array antenna configuration and MIMO antenna techniques are studied to deliver effective trustworthy point-to-point communication. One simple technique that has been widely used among researcher to produce CP is by using a single feed CP microstrip antenna (Wen Shyang Chen, Chun Kun & Kin Lu Wong, 1998). By using only single feed, the antenna should have two modes and necessity excited with equal amplitude and 90° out of phase. Usually, a basic microstrip patch antenna produces a linear polarization. However, in order to obtain a CP feature, there must be some techniques applied in the patch design. For example, in order to divide the field into two orthogonal modes with equal magnitude and 90° phase shift the perturbation segments are necessary. Thus, producing a circular polarization.

In this thesis, a circularly polarized two port array antenna is designed using the truncated edge patch and 90° phase shifted technique basically construct based on the inner and outer ring model (William H. Hayt & Jr. John A. Buck, 2001; Tso-Wei Li, Cheng-Liang Lai & Jwo-Shiun Sun, 2005; Mohamed A. Abdelaal & Hussien Hamed Mahmoud Ghouz, 2014). Instead of rectangular truncated edge patch and external polarizer, dual-coupled and triple-coupled 90° phased shifter has been designed as internal polarizer to each circle-segmented element to generate CP signals. Such design acts like shunt inductors and leads the E-field component function in 90° phase difference.

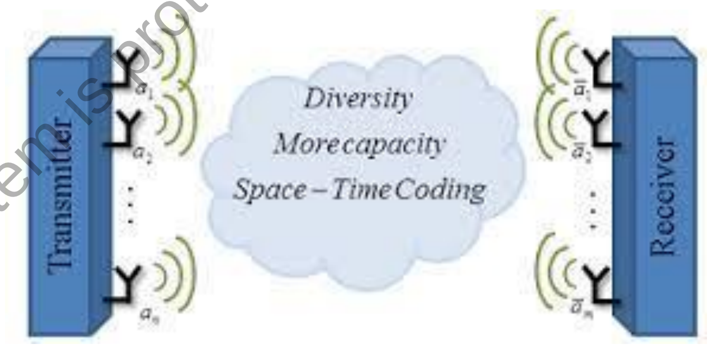

Figure 1.1: MIMO System [Claude Oestgates & Bruno Clerckx, 2007].

In wireless communication nowadays, Multiple input multiple output (MIMO) technology has concerned the considered by researchers to explore and analyze its capabilities. Figure 1.1 illustrates the MIMO antenna operating system with include the transmitter and receiver antenna. Significant increases in channel capacity are realized without the requirement of extra bandwidth or transmit power by positioning several antennas for transmission to attain an array gain and diversity gain, thereby improving the spectral efficiency and reliability. MIMO antenna methods oblige high decoupling amongst antenna ports and a compact size for application in handy devices. MIMO techniques are divided into several methods including single input single output (SISO), single input multiple output (SIMO) and multiple input single output (MISO) according to its application (Claude Oestgates & Bruno Clerckx, 2007). The MIMO system used numerous antennas for both transmitter and receiver. They have dual competency of integrating the SIMO and MISO technologies. They can also significantly increase capacity by using Spatial Multiplexing (SM). The MIMO technology has several advantages over Single-input, Single-output (SISO) technology. The declining is extremely eradicated by spatial diversity. Furthermore, MIMO required small power consumption paralleled to other techniques.

1.2 Problem Statement

Point-to-point communication deliberated as the backbone for the antennas subsequently they are expectable to deliver the wireless transmission amongst those devices. Moreover, presence capable to attain respectable signal to noise ratio and immunity to noise, they should have depicted compact structure, and can be simply fabricated and attached to numerous devices. A certain point-to-point application that's required high performance of the antenna such as high gain, good directivity with a low profile antenna including the lightweight, compact size, low cost and ease of installation are constraints. Based out of those demands, Microstrip antenna is one solution to satisfy all these requirements.

In early 1953, the microstrip antenna has been classified among one of the better technique and has several advantages over conventional microwave antenna, thus widely used in communication system nowadays (Deschamps & G. A, 1953; James, J. R. & P. S. Hall, 1989). However, from the viewpoint of another researcher that have investigate the microstrip antenna it also claim that microstrip antenna has some weaknesses containing small gain, low efficiency, and weak power handling ability (Kumar, G. & K. P. Ray, 2003). Currently, various techniques have been exposed by investigators to overwhelm the weaknesses of microstrip antenna by consuming an array structure. The array microstrip antenna has been extensively established and used among researcher to enhanced performance of the antenna such as gain, efficiency and beam scanning directivity (D. M. Pozar & D. H. Schaubert, 1995; A. AdyaPramudita, Lydia Sari & V. WindhaMahyastuti, 2012; Ada S. Y. Poon, David H. C. Tse & Robert W. Brodersen, 2006). For point-to-point wireless communication applications, it is necessary that the antenna has a narrow beam width, which is inflexible to accomplish by using a single element antenna. For that array antenna can achieve such goals, where array antenna beam width and side lobes generally depends on the numeral of elements and arrangement among them.

Point-to-point works with limited quality and stability signal strength under adverse at morphemic condition such as humidity, hot and rainy. Moreover, the complex geographical condition leads to the physics propagation issues (e.g scattering, diffraction, reflection of incident waves). Consequently, users experience a show internet connection and even worse losing the connection. It is significant for an antenna to have a better directivity (dBi) while simultaneously mitigating propagation issues and geographical. Circular polarization characteristics within a MIMO array structure is capable to decrease those problems as its wave, radiant energy in both horizontal and vertical planes and all planes in between. CP characteristic also more resistant to signal degradation due to severe weather circumstances throughout the ranges (Luxul, 2011).