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DUAL POLARIZATION MICROSTRIP ARRAY ANTENNA FOR WLAN APPLICATION

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DUAL POLARIZATION MICROSTRIP ARRAY ANTENNA FOR WLAN APPLICATION

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DECLARATION

I declare that this thesis entitled "Dual Polarization Microstrip Array Antenna for WLAN Application" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : 7-10-2011

DEDICATION

To my dearest mother, father and family for their encouragement and blessing

"You are always my inspiration to do better."

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ABSTRACT

The advantages of microstrip antennas have made them a perfect candidate for use in the Wireless local area network (WLAN) applications. Though bound by certain disadvantages, microstrip patch antennas can be tailored so they can be used in the new high-speed broadband WLAN systems. The design and development of a dual linearly polarized microstrip antenna operating at center frequency of 2.4 GHz is presented in this thesis by using one port with single layer. This design presents an array antenna from type of inset-fed microstrip patch antenna oriented at 45° and -45°. The antenna is capable to generate dual-polarization radiation pattern slanted at 45° and -45°. Combinations of two and more patches using quarter-wave impedance matching technique have been used to design the array antenna. The design were simulated using CST Studio Suite 2008 and were fabricated on FR4 substrate with a dielectric constant ε_r = 4.7, tan δ = 0.019 and thickness =1.6mm. Then, the fabricated antenna were measured by using network analyzer. The measurement show, the dual polarization microstip array antennas demonstrate larger bandwidth and increase the gain response compared to the single antenna. It provides an impedance bandwidth of 5% (from 2.412 to 2.484GHz) below 10dB and the gain of antenna achieve about 5.01 dBi, so that it easily covers the required universal 2.4GHz bandwidths for wireless local area network applications (WLAN).

ABSTRAK

Kelebihan antena mikrostrip telah membuatkan ia calon yang sempurna untuk digunakan dalam aplikasi Rangkaian Kawasan Tempatan Wayarles (WLAN). Walaupun terikat oleh kelemahan tertentu, antena mikrojalur tampalan boleh disesuaikan sehingga ia boleh digunakan dalam sistem baru WLAN broadband berkelajuan tinggi. Rekabentuk dan pembangunan antena dual linear polarisasi mikrojalur tampalan beroperasi pada frekuensi tengah 2.4 GHz dipersembahkan dalam tesis ini dengan menggunakan satu port dan lapisan tunggal. Rekebentuk tatsusunan antena ini dihasilkan daripada jenis sisipan suap antena mikrojalur tampalan terhala pada +45° dan -45°. Antena ini berkeupayaan untuk menghasilkan alunan radiasi dual polarisasi condong pada 45° dan -45°. Kombinasi dari dua dan lebih tampalan dengan teknik galangan padanan seperempat-gelombang telah digunakan untuk merekabentuk antena tersusun. Antena ini direkabentuk menggunakan perisian *CST Studio Suite 2008* di atas FR4 dengan pemalar dielektrik 4.7, tangen kehilangan 0.019, dan tebal 1.6 mm. Kemudian, antena dibuat diukur dengan menggunakan alat analisis rangkaian. Hasil pengukuran menunjukkan, antena mikrojalur dual polarisasi tersusun menghasilkan lebarjalur yang lebih besar dan meningkatkan reaksi kehilangan balikan dibandingkan dengan antena tunggal. Ia memberikan galangan lebarjalur sebanyak 5% (dari 2.412 hingga 2.484GHz) di bawah 10dB dan kehilangan balikan daripada antena mencapai sekitar 5.01 dBi, sehingga mudah merangkumi lebarjalur yang diperlukan umum 2.4GHz untuk aplikasi Rangkaian Kawasan Tempatan Wayarles (WLAN).

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LIST OF SYMBOLS

f	-	Frequency
f_r	-	Frequency resonant
G	-	Antenna gain
$\overrightarrow{E_x}$	-	Electric field in x-axis direction
$\overrightarrow{E_y}$	-	Electric field in y-axis direction
θ	-	Relative phase difference
H	-	Magnetic field
P_r	-	Total radiated power
P_a	-	Total input power
Z_0	-	Characteristic impedance
Z_L	-	Load impedance
Z_{in}	-	Input impedance
f_H	-	Upper frequency
f_L	-	Lower frequency
f_c	-	Center frequency
D	-	Directivity
h	-	Substrate height
c	-	Velocity of light in free space
ℓ	-	Length of patch antenna
λ	-	Wavelength
λ_g	-	Guided wavelength
ε_r	-	Dielectric constant
ε_{eff}	-	Effective dielectric constant
E	-	Antenna efficiency
Γ	-	Reflection coefficient
μ	-	Permeability
μ_r	-	Relative Permeability
dB	-	Decibel
dBi	-	Decibel (isotropic)
R	-	Radius (field region)

LIST OF ABBREVIATIONS

ABBREVIATION	DISCRIPTION
WLAN	Wireless Local Area Network
MCMC	Malaysian Communications and Multimedia Commission
IEEE	Institute of Electrical and Electronics Engineers
LOS	Line of Sight
FR4	Flame Retardant 4
SMA	SubMiniature version A
VSWR	Voltage Standing Wave Ratio
BW	Bandwidth
HPBW	Half Power Bandwidth
FNBW	First Null Bandwitdh
RL	Return Loss
RF	Radio Frequency
3D	3 Dimensional
EM	Electromagnetic
RHCP	Right Hand Circular Polarized
LHCP	Left Hand Circular Polarized

CHAPTER 1

INTRODUCTION

Antennas come in many forms of structures and classifications. It is often the case that system performance requirements determine the type of antenna necessary to meet the overall specifications. Some basic antenna considerations are radiation pattern, bandwidth, polarization, gain, and size limitations. Antennas are available in many designs including horn, lens, reflector, dipole and microstrip (John L. Volakis, 2007).

Each type of antenna has its advantages and disadvantages. For example, horn antenna has simplified structures and is easy to align, but this antenna tends to be large and difficult to fabricate. In some application, size limitation and appearance can be the key parameters. Due to this necessity, microstrip antennas, commonly called patch antennas, often provide a reasonable balance between physical structure and size.

The aim of this project is to design a dual polarization microstrip antenna at 2.4GHz frequency band which can be easily integrated into an existing wireless communication system such as Wireless Local Area Network (WLAN) and Wi-Fi. Indoor WLAN frequency band has been allocated at two frequency bands which are at 2.40 GHz to 2.48 GHz and 5.15 GHz to 5.25 GHz. In Malaysia, the frequency spectrum at 5.20 GHz is not allowed because it is reserved for aeronautical navigation and fixed satellite communication. The standard for the 2.40 GHz frequency band is Institute of Electrical and Electronics Engineers (IEEE) 802.11b has the data rates of 11 Mbps. IEEE 802.11b is the original Wi-Fi standards (MCMC, 2002). The spectrum allocation in Malaysia is shown in Appendix A.

The concept of dual polarization is becoming popular with the increasing demand for polarization diversity. A dual linear polarization is one that is capable of producing two orthogonal polarized electromagnetic waves. Consequently, the antenna is be able to transmit and receive double as much information using the same bandwidth.

This microstrip antenna consists of a radiating patch on one side of a dielectric substrate which has ground plane on the other side. There are various shapes that can be used as the radiating patch. For this project, rectangular patch with corporate feed network is designed. The selection of rectangular patch is made because it is simple to fabricate and easy to modify and customize.

This design of dual polarization was extended from (Wansuk & Joong, 2005) and (Joehoon & Taewoo, 2000) which are linear polarization at angles of ±45° using inset feed method. The ±45° polarizations instead of horizontal and vertical polarization are used by rotating the patch and feeding structures, for receiving an equal strength signal at each element. This antenna is a single layer using corporate feed network.

The microstrip antenna is simulated and using CST Studio Suite 2008. The fabricated of the antenna use Flame Retardant 4 (FR4) substrate and tested with network analyzer. Both simulated and measured results are compared.

1.1 Problem statement

Many existing antennas are usually large in size and some have only single polarization. In general, most antennas radiated either in linear or circular polarization rely on feed point. In some wireless systems, the transmitting and receiving sites are not in direct line-of-sight (LOS) contact. The majority of the signals either linear or circular polarization arriving at the receiving site are the multipath signals. If the received component is oriented such that not aligned with the polarization of the incident wave, the reflected wave is experience a polarization shift. The resultant or total signal available to the receiver at either end of the communications link is the vector summation of the direct signal and all of the multipath signals.

In many instances, there are a number of signals arriving at the receive site that are not aligned with the assumed standard polarization of the system antenna. As the receive antenna rotates from vertical to horizontal, it simply intercepts or receives energy from these multiple signals. In order to enhance system gain and improve signal reception, a dual polarization antenna is used at the receive site to take advantage of the fact that many linear polarization multipath signals, with different orientation, exist at the receiving site.

1.2 Research Objective

1. To design a dual polarization microstrip array antenna operating at 2.4 GHz for WLAN application.
2. To simulate and fabricate dual polarization microstrip array antenna using inset feed patch slanted at +45° and -45°.
3. To study very clearly an array technique in order to perform dual polarization.

1.3 Research Methodology

The design of the dual polarization microstrip antenna was started by designing the single elements that will cover the WLAN frequency band operating at frequency 2.4 GHz. Firstly, the dimension of single antenna was calculated using exiting formula such as width

(W), length *(L)* and inset (ℓ). The type of feeding technique that will be used is the inset feed technique (Pozar & Schaubert, 1995) to achieve the dual polarization.

Next, the design of single antenna was simulated using CST Studio Suite 2008. The antenna parameter such as return loss, bandwidth, gain, and radiation pattern was studied clearly during construction of a single antenna. An antenna with more patches was design by using array technique.

After determined the dimensions and parameters of the antenna, the design was fabricated using FR4 substrate and wet etching technique. The FR4 substrate has a dielectric constant, ε_r of 4.7 and a tangent loss, $tan\ \delta$ of 0.019. The thickness of the dielectric is 1.6 mm, while the thickness of the copper is 0.035 mm.

The design of dual polarization can be applied onto single layer with one port to cover the WLAN application. Apparently, there are some limitation exist in this design. First, the array network is constrained by the size selected for the initial patch (the array on the adjacent antenna sides should not overlap). Furthermore, the electrical performance of the antenna may degrade, as the array network increases, both in term of input return loss and port isolation. In additional, the slants of patchs antenna have a degrading effect on the impendence bandwidth.

1.4 Significant contribution of research

A dual polarization is designed by using two orthogonal transmitted signals. Since the orthogonal signal does not interface with each other, a double message can be transmitted at the same time, same space and same frequency band. A dual polarization antenna comes out together with applying polarization diversity to ensure channel fade is reduced and increases channel capacity.

Polarization diversity has been found to be nearly as effective as spatial diversity for base stations (Jukka & Jaana, 1998), (Lee & Yeh, 1972) and provides a great space and cost savings. Polarization diversity also compensates for polarization mismatch due to random antenna orientation. Diversity antennas provide two major benefits. The first benefit is improved reliability in multipath channels where interference from reflected signals causes fading of the received signal. Systems that use diversity combining can provide a 10 dB or greater diversity gain. The second benefit is the overall average received signal power is increased. Systems that use polarization or angle diversity automatically match the antenna characteristics to the received signal and increase the efficiency of the communication link (Cox, 1983).

1.5 Overview of Thesis

This thesis presents a dual polarize, slant +45° and -45° radiating element operating at WLAN application. The research material is presented within the chronological order that was followed during the development of the antenna. The final design being presented is a dual polarization radiating antenna that is completely slant ±45° polarization.

The theory of antenna, microstrip patch, array techniques on dual polarization and their applications in arrays is described in Chapter 2. Chapter 3 presents an the design of single polarize patch antenna in terms of +45° and -45° radiating that was used as the basic element for developing the final dual polarization solution. Also presented is an explanation of the feeding structure for the element such as series or corporate feed and how the array performance and enhancement can be improved by combining them into many elements. In this chapter also an experimental setup and theoretical proof is described very clearly.

The results are presented in Chapter 4 along with a discussion and analysis of those results. The comparison of the simulation and measurement results for each design of dual polarization microstrip antenna was also presented. Finally, the conclusion, recommendations and suggestions for future work were presented in Chapter 5.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Wireless Local Area Network (WLAN)

A wireless LAN (WLAN) is a flexible data communication system implemented as an alternative for, a wired LAN within a building or campus. Using electromagnetic waves, WLANs transmit and receive data over the air, minimizing the need for wired connections. Thus, WLANs combine data connectivity with user mobility, and, through simplified configuration, enable movable LANs (Long. K. Li *et. al.*, 2010).

WLANs have gained strong popularity in a number of vertical markets, including the health-care, retail, manufacturing, warehousing, and academic arenas. These industries have profited from the productivity gains of using hand-held terminals and notebook computers to transmit real-time information to centralized hosts for processing. Today WLANs are becoming more widely recognized as a general-purpose connectivity alternative for a broad range of many applications (Wei-Jun Wu *et. al.*,2011).

WLANs have data transfer speeds ranging from 1 to 54Mbps, with some manufacturers offering proprietary 108Mbps solutions. The 802.11n standard can reach 300 to 600Mbps. Because the wireless signal is broadcast so everybody nearby can share it, several security precautions are necessary to ensure only authorized users can access your WLAN. A WLAN signal can be broadcast to cover an area ranging in size from a small office to a large campus. Most commonly, a WLAN access point provides coverage within a 65-300 feet

(D. Parkash *et. al.*,2010). Tables 2.1 describe the specification of WLAN application follow by IEEE 802.11b standard.

Table 2.1: Design specification for WLAN application.

Parameters	**Specification**
Frequency	2.412-2.484 GHz
Bandwidth	25 MHz
Gain	2.14 dBi
Distance	65 to 300 feets

2.1.1 Applications for Wireless LAN

Wireless LANs frequently augment rather than replace wired LAN networks-often providing the final few meters of connectivity between a backbone network and the mobile user. The following list describes some of the many applications made possible through the power and flexibility of wireless LANs:

1. Doctors and nurses in hospitals are more productive because hand-held or notebook computers with wireless LAN capability deliver patient information instantly.
2. Network managers in dynamic environments minimize the overhead of moves, add, and changes with wireless LANs, thereby reducing the cost of LAN ownership.
3. Training sites at corporations and students at universities use wireless connectivity to facilitate access to information, information exchanges, and learning.
4. Network managers installing networked computers in older buildings find that wireless LANs are a cost-effective network infrastructure solution.