DESIGN OF GEOMETRICAL ARRAY MICROSTRIP ANTENNA

SHAH ERAWATI BINTI MOKHTAR

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Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
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MOHAMAD ZOINOL ABIDIN B ABD AZIZ

Pensyarah

Fakulti Kej Elektronik dan Kej Komputer (FKEKK)

Universiti Teknikal Malaysia Melaka (UTeM)

Karung Berkunci 1200

Ayer Keroh 75450 Melaka

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Supervisor's Name : Mohamad Zoinol Abidin Bin Abd Aziz

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To My Loving and Parents

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ABSTRACT

Wireless communication has experienced an enormous growth since it allows users to access network services. WLAN is the most rapid evolution and wide popularity in standard developed by IEEE (Institute of Electrical and Electronics Engineers). The 2.4 GHz and 5.2 GHz frequency is user in WLAN network. This project presents the design of geometrical array using microstrip antenna. The special of requirements microstrip antenna required it for designing the array concept. It is also one of the fastest growing segments in the telecommunication industry. It have proved that the microstrip antenna have their own unique characteristics that improved the telecommunication industry. Design geometrical array microstrip antenna can achieve the higher gain and broader bandwidth. The project design using three types of geometrical antenna, such as rectangular patch, triangle patch and circular patch antenna. The antenna is designed at the frequencies 2.4 GHz, 5.2 GHz, and 5.8 GHz. The behavior of each type antennas are investigate such as return loss, radiation pattern, bandwidth, half power bandwidth (HPBW), first null bandwidth (FNBW) and gain. The project are includes the simulation process, fabrication process and testing. According to the single element, triangle shapes show the efficiency of return loss of -27.02 dB and largest percentage of bandwidth. Circular shape shows the higher of gain. In array configuration, the 2 x 4 array of rectangular shows higher of return loss compare to 1 x 2 and 1 x 4 array configuration. The 1 x 2 and 1 x 4 array configuration shows that circular shape shows the good of return loss, higher in gain and percentage of bandwidth.

ABSTRAK

Komunikasi tanpa wayar mula berkembang sejak perkhidmatan rangkaian *access* diperkenalkan. Perkhidmatan Rangkaian Tempatan (WLAN) berkembang pesat dan meluas selaras dengan Institut Kejuruteraan Elektrik dan Elektronik (IEEE). Frekuensi yang digunakan dalam WLAN adalah 2.4 GHz, dan 5.2 GHz. Tajuk projek ini adalah rekabentuk *array* geometri menggunakan microstrip antenna. Keistimewaan microstrip antenna adalah dimana ia boleh direkabentuk dalam konsep *array*. Teknik ini merupakan teknik yang berkembang luas digunakan dalam industri telekomunikasi. Rekabentuk geometri *array* antenna boleh meningkatkan gandaan dan menghasilkan *bandwidth* yang luas. Rekabentuk projek ini menggunakan tiga bentuk geometri antenna iaitu bentuk segiempat tepat, segitiga dan sfera. Antenna ini di rekabentuk pada frekuensi 2.4 GHz, 5.2 GHz, and 5.8 GHz. Setiap antenna akan dikaji dari segi *return loss, radiation pattern, bandwidth, half power bandwidth (HPBW), first null bandwidth (FNBW) and gain*. Projek ini mengandungi proses simulasi, proses fabrikasi dan ujikaji. *Single element antenna* menunjukkan bentuk segitiga menghasilkan kehilangan kuasa paling minimum iaitu pada -27.02 dan peratus lebar jalur paling tinggi (*bandwidth)*. Bentuk sfera menghasilkan gandaan paling tinggi. Rekabentuk segiempat tepat gabungan 2 x 4 menghasilkan kehilangan yang minimum iaitu pada -17.5 dB berbanding bentuk gabungan 1 x 2. Rekabentuk segitiga gabungan 2 x 4 menghasilkan kehilangan paling minimum berbanding dengan rekabentuk struktur 1 x 2. Rekabentuk circular gabungan 1 x 2 dan 1 x 4 menghasilkan kehilangan yang minimum, gandaan yang tinggi dan peratus lebar jalur paling tinggi.

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LIST OF ABBREVIATIONS

SYMBOLS	DESCRIPTION
w	Width
h	Dielectric thickness
t	Copper thickness
ε_r	Dielectric Constant
Z_o	Characteristics impedance
ΔL	Dimensions of the patch along its length
w/h	Width-to-height ratio
ℓ	Inset feed
a	Radius
fr	Frequency
IEEE	(Institute of Electrical and Electronics Enginerring)
WLAN	Wireless Local Area Network
MW2004	Microwave Office 2004
FR4	Frame Resistance 4

CHAPTER 1

INTRODUCTION

1.1 Introduction

This project discussed the design of geometrical array antenna using microstrip technology. The microstrip antenna is one of the fastest growing segments in the telecommunication industry. Microstrip antennas are low profiles, conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology. Microstrip antenna consists of dieletric subtsrate, radiated patch and antenna ground plane. The microstrip antennas have disadvantage which narrow bandwidth and low gain.

1.2 Objectives

The objective of this project is to study the concept of the basic geometrical array microstrip antenna. This project involved the designed and fabrication of the three geometrical shapes such as rectangular, triangle and circular. Each geometrical shape will be designed in single element and array technique. The antenna is design to have higher gain and broader bandwidth.

1.3 Scopes of work

The first scope of the project is to study the concept of microstrip array antenna of broad band communication. The calculation of the parameter for rectangular, triangle and circular patch antenna will be studied. The simulation processed has been done by using microwave 2004. Then, the comparison between calculation and simulation will be investigated. The calculation has been done at frequency 2.4 GHz, 5.2 GHz, and 5.8 GHz. Then, the antenna is designed at 1 x 2, 1 x 4 and 4 x 4 array. Finally, the characteristics of the antenna such as return loss, gain, bandwidth and radiation pattern will be investigated.

CHAPTER II

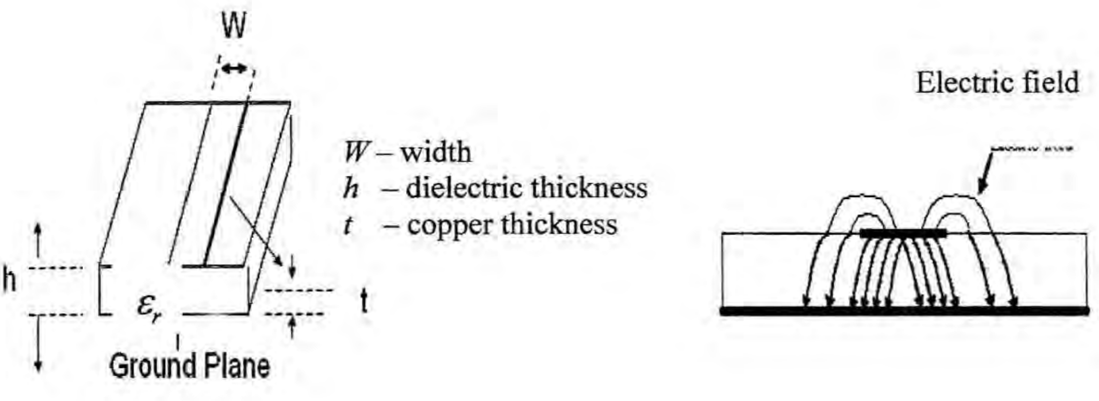
BACKGROUND OF STUDY

2.1 Introduction

Microstrip antenna was a simple antenna that consists of radiated patch component, dielectric substrate and ground plane. The radiated patch and ground plane is a thin layer of cuprum or gold which is good conductor. Each dielectric substrate has their own dielectric permittivity value. This permittivity will influence the size of the antenna. Microstrip antenna is a low profile antenna, conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology. They have several advantages light weight, small dimension, cheap, conformability and easily to integrate with other circuit make it is chosen in many applications [6].

2.2 Basic Microstrip Antenna

Microstrip antennas received considerable attention starting in the 1970s, although the idea of a microstrip antenna can be traced to 1953 [1] and a patent in 1955 [2]. Figure 2.1 and Figure 2.2 show the basic structure of microstrip structure. Bottom layer of dielectric substrate is fully covered by conductors that act as a ground plane. The thickness of substrate layer can increase the bandwidth and efficiency, but unfortunately it will generate surface wave with low propagation that cause lost of power. It is consists of a very thin metallic strip (patch) placed a small fraction of a wavelength above a ground plane [6].



(a) (b)

Figure 2.1 : (a) Basic structure of microstrip and (b) Electric field on microstrip line

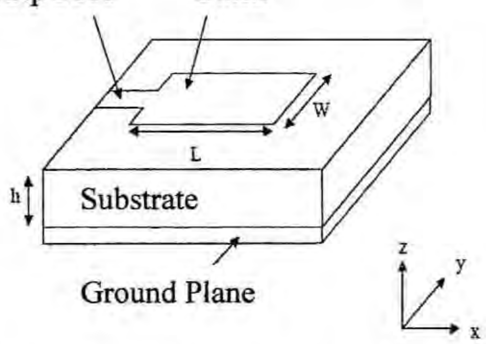


Figure 2.2 : Structure of Microstrip Patch Antenna

There are numerous substrates that can be used for the design of microstrip antennas, and their dielectric constants (ε_r are usually in the range of $2.2 \le \varepsilon_r \ge 12$. The ones that are most desirable for antenna performance are thick substrates whose dielectric constant is in the lower end of the range because they provide better efficiency, larger bandwidth, loosely bound fields for radiation into space, but at the expense of larger element size [7].

Thin substrates with higher dielectric constant are desirable for microwave circuitry because they require tightly bound fields to minimize undesirable radiation and coupling, and lead to smaller element sizes. However, because of their greater losses, they are less efficient and have relatively smaller bandwidths [7]. Often microstrip antennas are also referred to as patch antennas. The radiating elements and the feed lines are usually photoetched on the dielectric substrate. The radiating patch may be square, rectangular, thin strip (dipole), circular, elliptical, triangular or any other configuration as shown in Figure 2.3.

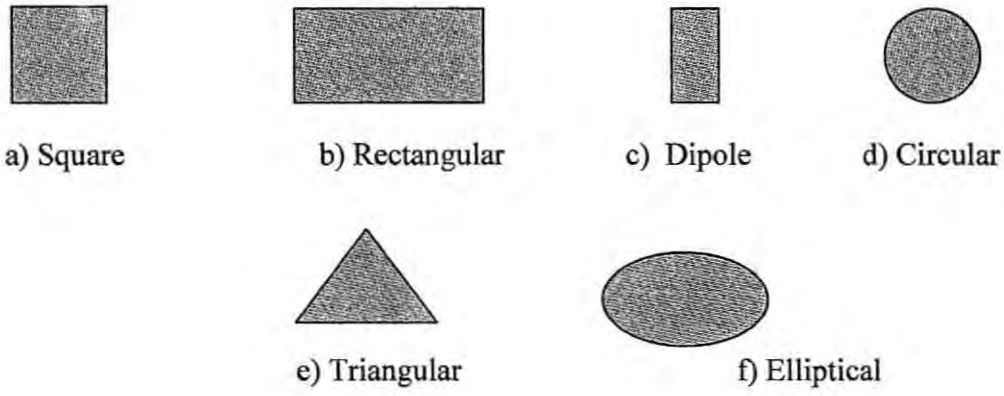


Figure 2.3 : Representative shapes of microstrip patch antenna

Square, rectangular, dipole (strip), and circular are the most common because of ease of analysis and fabrication, and their attractive radiation characteristics, especially low cross-polarization radiation. Microstrip dipoles are attractive because they inherently possess a large bandwidth and occupy less space, which makes them attractive for arrays [8], [9]. Linear and circular polarizations can be achieved with either single elements or arrays of microstrip antennas. Arrays of microstrip elements with single or multiple feeds, may also introduce scanning capabilities and achieve greater directivities.

The effective dielectric constant (ε_r), of a microstrip line is given approximately by[10]

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(\frac{1}{\sqrt{1+12\left(\frac{d}{w}\right)}}\right) \qquad 2.1$$

The effective dielectric constant (Er) can be interpreted as the dielectric constant of a homogeneous medium that replaces the air and dielectric regions of the microstrip given the dimensions of the microstrip line. The characteristics impedance (Z_o) can be calculated as [10];

$$Zo = \begin{cases} \dfrac{60}{\sqrt{\varepsilon_{eff}}} In\left(\dfrac{8h}{w} + \dfrac{w}{4h}\right) & \text{For w/h < 1} \\ \dfrac{120\pi}{\left[\dfrac{w}{h} + 1.393 + 0.667 In\left(\dfrac{w}{h} + 1.444\right)\right]\sqrt{\varepsilon_{eff}}} & \text{For w/h > 1} \end{cases} \qquad (2.2)$$

2.2 Feeding Techniques

Feeding techniques are important in designing the antenna to make sure antenna structure can operate at full power of transmission. Designing the feeding techniques for high frequency, need more difficult process. It is because of input loss on feeding increase depending on frequency, and finally given huge effect on overall design. There are a few techniques that can be used. The technique is used in this project is microstrip line feed. It is easy to fabricate, simple to match by controlling the inset position and rather simple to model. However as the substrate thickness increases surface waves and spurious feed radiation increase, which for practical designs limit the bandwidth (typically 2-5%) [7], [11], [12].

2.3 Analysis of Microstrip Antenna

There has several approached to analyze microstrip antenna. Among the favorite are transmission-line, cavity model, and full-wave analysis. Transmission line model are simple to analysis. It gives good interior behavior even though less precisely. In this project, the transmission line is used. The transmission line model is easiest of all, it gives good physical insight, but is less accurate and it is more difficult to model coupling [7], [8], [12].

2.4.1 Rectangular Patch

The rectangular patch is by far the most widely used configuration. It is easy to analyze using both the transmission-line and cavity models, which are most accurate for thin substrates [6], [13].

2.4.1.2 Transmission-Line Model

a) Fringing Effects

The dimensions of the patch are finite along the length and width so, the fields at the edges of the patch undergo fringing. Fringing process is making the microstrip line look wider electrically compared to its physical dimensions. Since some of the waves travel in the substrate and some in air, an effective dielectric constant is introduced to account for fringing and the wave propagation in the line.