MICROSTRIP PATCH ANTENNA

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Specially dedicated to
My beloved parents, brother, sister, friend and my lover who have encouraged, guided and inspired me throughout my journey of education

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ABSTRACT

This project is about to design of a microstrip patch antenna on the non-conductive textile substrates at the operating frequency 2.45 GHz which is for wireless local area network (WLAN) application. There are certain fabric materials in the market that can be use to patch the microstrip antenna such as Nora, felt, fleece and etc. Those fabric materials have relative permittivity characteristics that make it suitable for wearable antenna. The main objective of this project is to design, simulate, fabricate and analyze the microstrip patch antenna at frequency 2.45 GHz using textile as the substrate. The proposed fabric material for this project is felt fabric. The felt fabric is selected because it has constant thickness and stable relative permittivity. The 2.45 GHz unlicensed band is utilized for the development of this wearable antennas. The used of FR4 as the substrate in conventional antenna is not suitable for wearable system because of limited body movement problem. To overcome this problem is by changing FR4 substrate with textile substrate. The measurement results for fabricated antenna have a slightly different with the simulation result. The frequency of the simulation result is 2.45 GHz, but the frequency of measured result has shifted to 2.6 GHz. However, some recommendation was made in order to improve the performance of the antenna.

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ABSTRAK

Projek ini adalah untuk merekabentuk Antena Tompok Jalur Mikro yang menggunakan tekstil bukan pengalir sebagai substrat. Antena ini beroperasi pada frekuensi 2.45 GHz yang mana bertujuan untuk aplikasi WLAN. Terdapat beberapa jenis kain tertentu yang berada di pasaran yang boleh digunakan sebagai substrat untuk Antena Tompok Jalur Mikro. Contohnya ialah Nora, felt fleece dan lain-lain. Tekstil ini mempunyai ciri-ciri ketelusan relatif (ε_r) yang menjadikan ia sesuai untuk antena boleh dipakai. Objektif yang utama dalam projek ini adalah untuk merekabentuk, simulasi, fabrikasi dan analisis Antena Tompok Jalur Mikro pada frekuensi 2.45 GHz yang menggunakan tekstil sebagai substrat. Kain yang dicadangkan dalam projek ini adalah kain *felt.* Kain ini dipilih kerana mempunyai ketebalan dan ketelusan relatif yang stabil. Penggunaan FR4 sebagai substrat pada antenna yang sedia ada tidak sesuai untuk sistem yang boleh dipakai kerana menyebabkan masalah pergerakan badan terhad. Langkah untuk mengatasi masalah ini adalah dengan menggantikan FR4 dengan tekstil sebagai substrat. Terdapat sedikit perbezaan diantara hasil ujian untuk fabrikasi antena dengan hasil untuk simulasi antena. Frekuensi yang diperoleh dari hasil simulasi ialah 2.45 GHz, tetapi frekuensi yang diperoleh dari hasil ujian untuk fabrikasi antenna ialah 2.6 GHz. Walaubagaimanapun, cadangan telah dibuat untuk penambahbaikan prestasi Antena Tompok Jalur Mikro ini.

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CHAPTER I

INTRODUCTION

1.1 Introduction

This project discussed the design of microstrip patch antenna using the textile substrates for mobile wireless communications which is wireless local area network (WLAN). The 2.45 GHz unlicensed band is utilized for the development of this wearable antennas. In the last decade, electronic devices have become gradually more mobile, portable, and accessible, both in their physical form and in their application scenarios. This has produced the potential for constant or pervasive computing access for the user, mostly through handy technologies like pocket-sized phones, palm-top computers, clip-on radios and music players. Nowadays, academic researchers as well as commercial developers of technology have begun to explore the design of wearable devices, technologies which are integrated directly into a garment (smart clothing)[1], or body-worn accessories which are intended for constant or situation-appropriate accessibility and use.

Therefore, antennas play a paramount role in an optimal design of the wearable or hand-held units used in these services. There are various types of antenna that can be used for wearable system, but the primary concern type in this project is microstrip patch antenna. 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. This type of antenna consists of dielectric substrate, radiated patch and the ground plane. However, microstrip antenna also has disadvantages which narrow bandwidth and low gain.

1.2 Problem Statement

The textile-based antenna will be able to monitor the wearer's vital signs and activity and also capable of observing environmental conditions, in a comfortable and unobtrusive way while supporting the operability. Antenna parameter like directivity, gain, radiation patterns, and efficiency must be optimized. The used of FR4 as the substrate in conventional antenna is not suitable for wearable system because of the limited body movement problem. To overcome this problem is by changing FR4 substrate with textile substrate.

1.3 Objectives

The objective of this project is to design, simulate, fabricate and analyze the microstrip patch antenna at frequency 2.45 GHz using textile material as the substrate. This project involved the study on the how the microstrip antenna can be implement into wearable system, measurement of textile relative permittivity and also fabrication technique for textile antenna. In order to design textile-based antennas, the dielectric properties and performance characteristics of the materials must be known at the operational frequency bands.

1.4 Scope of Work

This project will cover the review on antenna like characteristic, application, previous work regarding antenna design. Design antenna and analyze the simulated result will be done by using software like CST simulation tools in terms of antenna properties such as return loss in 2.45 GHz frequency range, radiation pattern, gain and bandwidth. Design and simulation, do performance and characteristic analysis for the fabric materials and parameter of the antenna. Lastly, this project will cover the fabrication and measurement of the antenna and comparison between simulation and measurement.

1.5 Report Structure

This report consists of five chapters. These chapters will explain and discuss more details about this project. The first chapter gives a brief explanation about Microstrip Patch Antenna. This chapter also gives an introduction about the overall process of project.

Then, for the second chapter is about the literature review of the project. The literature review covers the background knowledge of Microstrip Patch Antenna and the previous work of the patch antenna with textile substrate. The literature review helps to understand the basic fundamental of this project.

The third chapter will explain about the project methodology. In this chapter, the details about the methods used and all the process involved in this project are explained.

The fourth chapter is about the result and discussion of this project, finding the analysis throughout the research and also the progress of project. All the data and results that obtained during this project will be documented in this chapter.

Lastly, fifth chapter is about the conclusion and recommendation of this project. This chapter rounds up the attained achievement of the whole project and reserves suggestions for possible future research and improvement.

1.6 Methodology

At the beginning, deep researches about the microstrip patch antenna and fabric materials will be required to get this project well done. A work flow will be made from the beginning to make sure the project is done on time. The research via internet, books, and IEEE paper will be done on properties of antenna and the fabric.

This is to further understanding about fundamental, theory and properties of the antenna and the fabric. An experimental study will be required in order to investigate the antenna on its performance characteristics like resonant frequency, return loss, impedance bandwidth, gain and the radiation patterns.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Antenna is basic component of any electronic system which depends on free space as a propagation medium. Antenna is a means to transfer the electrical signal at a certain operating frequency to electromagnetic waves into the air. Then, a guiding device or transmission line may take the form of a coaxial line or the waveguide, and it is used to transport electromagnetic energy from the transmitting source to the antenna or from the antenna to the receiver. According to [2], this antenna can be mounted on the surface of high performance aircraft, spacecraft, and also the satellites. There are several types of antenna that popularly used:

i. Wire antenna
ii. Aperture antenna
iii. Microstrip antenna

iv. Reflector antenna

v. Lens antenna

Among all these types of antenna, microstrip antenna has been one of the most variations design in term of feeding method, shapes and architectures.

2.2 Microstrip Patch Antenna Basic

Since the development of the first practical antenna by Howell and Munson, the extensive research and development of microstrip patch antennas which aimed at exploiting its numerous advantages have led to diversified applications and to the establishment of the topic as a separate entity within the broad field of microwave antennas. Figure 2.1 show the common shapes of microstrip patch antenna.

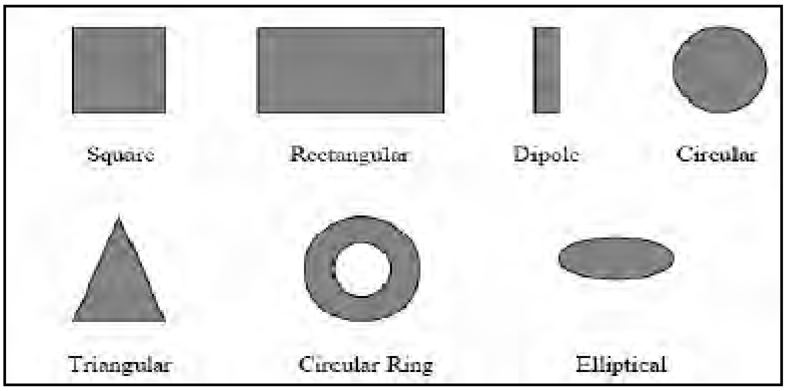

Figure 2.1: Common Shape of Microstrip Patch Antenna

Microstrip patch antenna is a simple antenna which consists of radiated patch component, dielectric substrate and the ground plane. The radiated patch and ground plane usually is a thin layer of copper or gold which is a good conductor. The radiating element is an electrically conductive material imbedded on the intermediate layer and is generally exposed to free space. Depending on the characteristics of the transmitted electromagnetic energy desired, the radiating element may be square, rectangular, triangular, or circular and is separated from the ground plane layer as shown in figure 2.2.

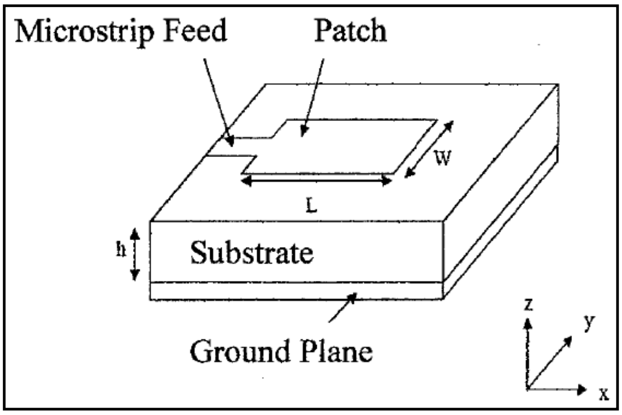

Figure 2.2: Structure of Microstrip Patch Antenna

Each dielectric substrate has its own dielectric permittivity value. This value is very important in designing antenna and also has great influence to the size of the antenna. Besides, the thickness of substrate also can influence the antenna performance. It can increase the bandwidth and efficiency if the antenna, but unfortunately it will generate surface wave with low propagation that cause lost of power. Microstrip antenna is a low profile antenna, conformable to planar and non-planar surfaces, simple and inexpensive to manufacture. In term of wearable system, the crumpling of fabric material is does not affect much on performance of the microstrip patch antenna[3].

Microstrip patch antennas have several advantages compared to conventional microwave antennas, and therefore many applications cover the broad frequency range from 100MHz to 100GHz. A few principal advantages of microstrip patch antennas compared to conventional microwave antennas are light weight, thin profile configurations, robust nature, low fabrication cost, dual-frequency and dual-polarization antennas can be easily made and can be easily integrated with microwave integrated circuits. However, microstrip patch antenna also have some limitations compared to conventional microwave antennas which is narrow bandwidth, lower gain, lower power handling capability, excitations of surfaces waves, and also difficult to achieve the purity of polarization. As the primary concern of this project is it conformability, low cost and integration with microwave integrated circuits, microstrip patch is chosen despite the inherent limitations possessed by this technology.

2.3 Microstrip Patch Antenna Properties

Performance of an antenna can be described based on the definitions of various parameters like return loss, radiation pattern, bandwidth, and polarization. There are some parameters are interrelated and not at all of parameters need to be specified for complete description of the antenna performance.

2.3.1 Radiation Pattern

Radiation pattern is defined as a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates[2]. The radiation pattern usually is determined in the far-field region and represented as a function of the directional coordinates. Antenna radiations consist of several properties such as power flux density, radiation intensity, field strength, and directivity phase or polarization. Patterns must be observed in the far field region as it is considered by the independence of the relative angular distribution of the field with varying distance consequently making the pattern is essentially independent of distance.

An important parameter of the radiation pattern is the two (2D) or three dimensional (3D) spatial distribution of radiated energy as a function of observed position. There are two pattern in antenna radiation which is power pattern and amplitude field pattern. Power pattern is define as a trace of the power received at a constant radius while an amplitude field pattern is the trace of the variation of electric or magnetic field along a constant radius. Most antennas have certain symmetrical features, thus in reality, the most important patterns are the radiation patterns in the two main planes: the E-plane and the H-plane. The E-plane is the plane that the electric field $\boldsymbol{E}$ lies on, while the H-plane is the plane that the magnetic field $\boldsymbol{H}$ is on. For the ideal current element case, the electric field is E_θ and the magnetic field is H_φ, thus the E-plane pattern is the field E_θ measured as a function of θ when the angle φ and the distance are fixed, while the H-plane pattern is the field E_θ measured as a function of φ when the angle θ and the distance are fixed.

There are various part of a radiation pattern which is called as lobes. These lobes can be sub classified into major or main, minor, side and back lobes. A radiation lobe is portion of the radiation pattern bounded by regions of relatively weak radiation intensity[2]. Radiation patterns may be plotted in a symmetrical three dimensional (3D) polar patterns and linear two-dimensional pattern where the same patterns characteristics are indicated. The plotted radiation patterns are as illustrated in Figure 2.3.

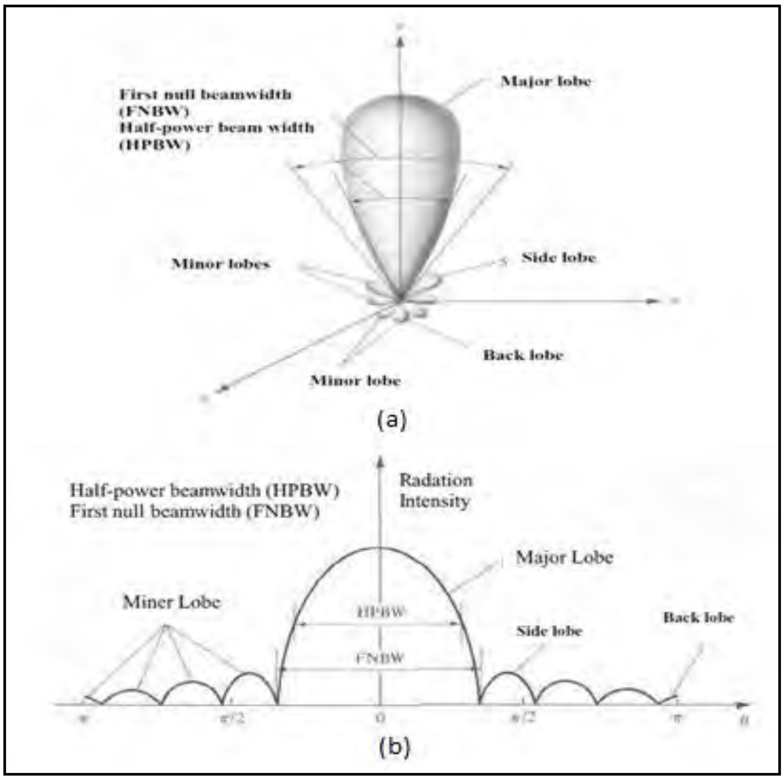

Figure 2.3: (a) 3D and (b) 2D Antenna Radiation Pattern[2].