SINGLE BAND TEXTILE ANTENNA

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For my beloved family and my true friends……………………

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ABSTRACT

This project is to design a single band textile antenna which operates at 2.4GHz frequency, which complies with IEEE802.15 (Bluetooth) standards. Since the development of wearable system has opened the possibilities to integrate antennas into clothing, the performance of the antenna is investigated whether it can be applied for Bluetooth applications. Furthermore, the introduction of these textile antennas has revealed the need for wireless communication systems that are unnoticeably integratable into clothing. A textile antenna is proposed to be operated at 2.4GHz for Bluetooth applications. The material of the substrate that has been chosen is fleece which possesses relative permittivity, ε_r of 1.2548 and thickness of 3.00mm. Copper is used as the radiator which also known as the antenna which has a thickness of 0.35mm. The fleece fabric is chosen because of the ε_r which is close to 1 and its piled structure that results hydrophobic characteristics. These are great in designing antenna into its optimum performance. The simulation of the design had been carried out by using Microwave CST Studio and the textile antenna had been fabricated. The fabricated antenna had been measured in term of the radiation patterns, the return loss (dB) and the bandwidth which has the return loss of -16.689dB and bandwidth of 450MHz.

ABSTRAK

Projek ini adalah bertujuan untuk merekabentuk satu jalur frekuensi tekstil antena untuk beroperasi pada frekuensi 2.4GHz sekaligus mematuhi piawaian IEEE802.15 (Bluetooth). Semenjak pengenalan tekstil antenna ini, ia telah membuka ruang untuk wayarless komunikasi system beroperasi dengan mengubahsuai antena tersebut supaya dapat digunakan pada kain atau pakaian. Prestasi tekstil antena tersebut telah disiasat supaya ia boleh digunakan untuk aplikasi Bluetooth. Kain yang digunakan untuk projek ini adalah dari jenis ‘fleece’, dimana ia mempunyai tahap keelutan, ε_r sama dengan 1.2548 dan ketebalannya sama dengan 3.00mm. Tembaga digunakan sebagai antenna yang mempunyai ketebalan sama dengan 0.35mm. Kain jenis ‘fleece’ dipilih kerana mempunyai tahap keelutan, ε_r yang hampir dengan 1. Ini merupakan ciri-ciri yang penting untuk menghasilkan sebuah antenna yang boleh beroperasi pada tahap yang optima. Simulasi reka bentuk yang dihasilkan adalah menggunakan Microwave CST Studio dan antenna yang telah disimulasi telah difabrikasi mengikut dimensi dalam simulasi. Antenna yang difabrikasi telah diukur dari segi bentuk-bentuk radiasi, kerugian pulangan dan lebar jalur yang mempunyai nilai kerugian pulangan sebanyak -16.689dB dan lebar jalur sebanyak 450MHz.

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CHAPTER I

INTRODUCTION

1.1 Background

Textile antennas are becoming attractive, since the development of wearable system has opened possibilities to incorporate / integrate antennas into clothing. The introduction of these textiles has uncovered the need for wireless communication systems that are unnoticeably integratable into clothing [1]. A textile antenna is proposed for operating in the 2.4 GHz for. Since most antennas have problems with limited placement or attachment, the proposed antenna structure is easy to attach to clothing and the structure does not limit the possible antenna placements. Antennas that are inflexible and high profile have limited amount of places they can be attached to without being uncomfortable to the user. The proposed antenna will cover or fulfill certain desired characteristics such as bendable structure, smaller in size compared to existed antenna and fully mobile.

1.2 Problem Statement

Some people need additional protection against occupational hazards during the professional activities. High performance materials are used to make this special class of clothing. Small and unobtrusive antennas continuously gain in importance in the today's world of cellular phones and wireless network. Ranges of coverage, directionality and efficiency need to be adjusted and optimized. New fields in this development are textile antennas. Integration of antennas in textiles introduces a bunch of additional design constraints. Compared with conventional antennas, textile antennas possess several advantages such as flexible or bendable textile substrate and have a flat planar structure such that it can be comfortably worn. It possesses smaller size than existed antennas and fully mobile.

1.3 Objectives

The objectives of this project are to design a single band textile antenna operating at 2.4GHz frequency. Secondly, to design and investigate the performance of such antenna and also designed to be integrated into clothing. And lastly, this project is proposed to operate in 2.4GHz frequency for short range communication application in body and area network such as Bluetooth and WLAN.

1.4 Scope of Work

The scope of this project is to design and investigate the performance of such antenna, since the development of wearable system has opened possibilities to incorporate antennas into clothing. To design a single band textile antenna that can be operated at 2.4GHz for Bluetooth applications.

1.5 Thesis Structure

This thesis consists of five chapters. The first chapter represents the overview of single band textile antenna. The objectives of this project have been stated clearly together with the problems statements. Next, the scope of work narrowed the details that need to be focused in this project based on the objectives of this project. Then, the methodology explains briefly about the steps or the flow of project from the early stages to the final stages.

Chapter two consists of the theories and the background study on textile antenna especially in single band textile antenna. This section discusses in detail about the fabric material selection, type of antenna that is going to be implemented and type of feeding techniques together with the textile transmission line. In addition, the last part of this chapter discusses the selected previous works that are really helpful and resourceful in completing this project.

For the third chapter, the details about the methodology are shown clearly from the early stages to the final stages of project. This project started with the literature reviews on the textile antenna especially in material selection aspect followed by the determination of the dielectric permittivity, ε_r of the fabric. Next, the antenna had been design for 2.4GHz frequency and all the related parameters had been calculated thoroughly. After that, simulation of the designed antenna had been done by using Microwave CST Studio. In order to achieve the design specifications that had been set, parametric study had been performed so that the antenna can be operated to its optimum performances.

Chapter four discusses the results or the output of this project. It starts with the simulation process by using Microwave CST Studio. Next, the final design of the antenna is fabricated and measured by using PNA-X Network Analyzer manufactured by Agilent Technologies.

For the last chapter, which is chapter five consists of discussion and conclusion of this project. Furthermore, the recommendations for future works are also included in this last chapter.

1.6 Project Methodology

Firstly, it all started with calculation of several related parameters. Then, start the design of the prototype. After that, use CST Microwave studio software to simulate. If the simulation results do not comply with the desired requirement, the simulation process will be repeated. If the simulation results comply with the desired requirement, the fabrication process will be initiated. After the fabrication process is done, the measurement of desired parameters or elements will be done. Lastly, the simulation and the measurement results will be compared.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Textile antennas are antennas that comprise a textile substrate with a conductive patch and ground plane and may be affixed to or integrated in clothing, furniture or other textile material. They are for example used in connection with wearable computing. Wearable computing is a new, fast growing field. Steadily progressing miniaturization in microelectronics along with other new technologies enables wearable computing to integrate functionality in clothing allowing entirely new applications. Medical prevention with continuously monitoring the patient's health condition is such an application necessitating sensing devices close to the patient's body. With wearable computing, it has become possible to integrate such sensing devices in the clothing, which offers unobtrusiveness and body proximity. As a next step, patients would benefit if a health condition can be directly communicated to a medical center. The implementation of antennas in textiles is therefore a logical next step. Further applications of textile antennas include applications in the automotive industry, namely antennas in seats of a car.

Compared with conventional antennas, textile antennas have to fulfill the additional requirement of being drapable. 'Drapability' means that something can be bent in all directions at the same time. A textile has this property in contrast to standard flexible substrates, which usually have a preferred bending direction. Additionally, in wearable applications, a textile antenna must have a flat and planar structure such that it does not affect wearing comfort.

2.2 Microstrip Antenna

A microstrip antenna which is also known as patch antenna possesses a metal patch on a substrate on a ground plane. There are different types of feeding techniques, they are aperture-coupled, and microstrip feed line and coaxial feed as shown in Figure 2.1.

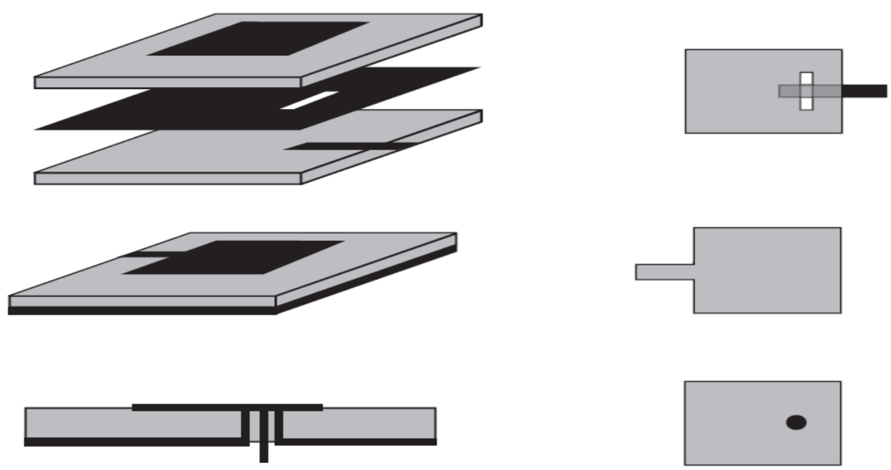

Figure 2.1: Three Feeding Configurations: Coupling Feed, Microstrip Feed and Coaxial Feed

Furthermore, the patch antenna can be mounted with various types of shapes [3]. The typical shapes are rectangular, square, triangular and circular as shown in Figure 2.2. The characteristics of microstrip antenna are low profile, comformable to planar and nonplanar surface, simple and cheap. Plus, it is very flexible in terms of resonant frequency, input impedance, radiation pattern and polarization.

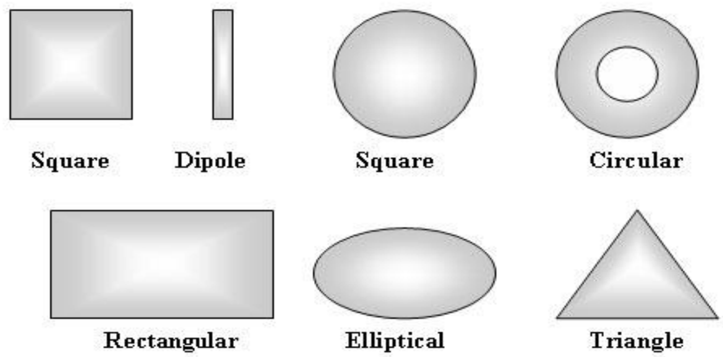

Figure 2.2: Shapes of Patch Antenna

Since the rectangular patch antenna is the most popular among the others, the following part will discuss about rectangular patch antenna. The design layout is as shown in Figure 2.3.

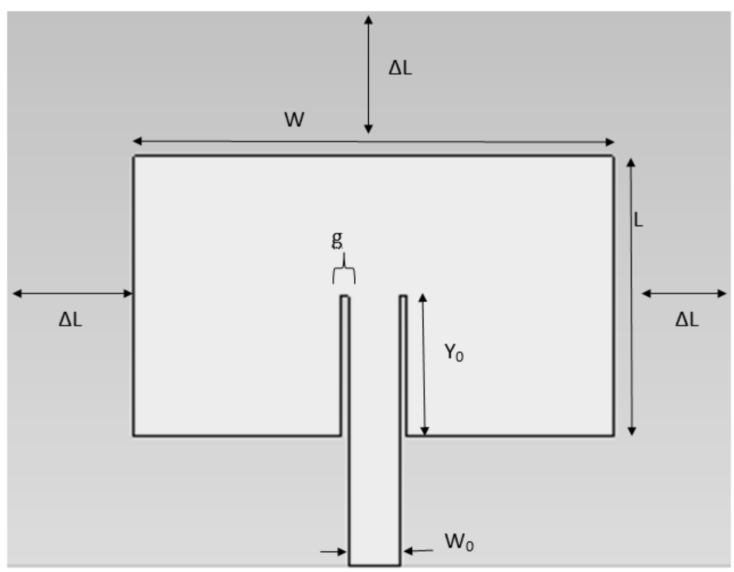

Figure 2.3: The Layout Design of Rectangular Patch Antenna

All the related parameters in the design can be determined by using the formulae in [3]. The typical radiation pattern of rectangular patch antenna is as shown in Figure 2.4.

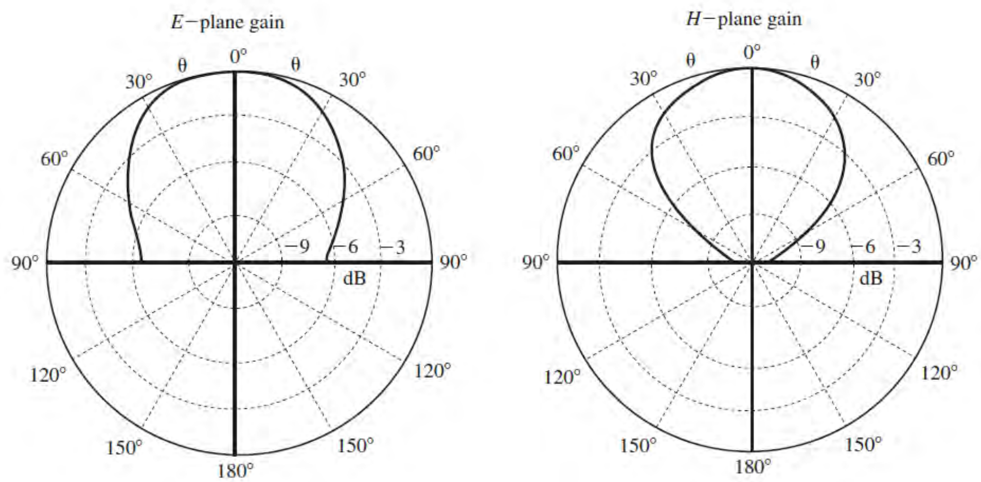

Figure 2.4: Typical Radiation Pattern of Rectangular Patch Antenna

2.3 Textile Transmission Line

Fundamental structures in electronic circuits are transmission lines. The electrical properties of their substrate, i.e., a fabric, can be determined by measurements of such lines. The goal of this section is to identify the limits of textile transmission lines regarding maximal signal frequency and line impedance. The higher the maximal signal frequency (bandwidth) of such lines is the higher and faster is the data throughput. The absolute value of the line impedance is not important in the first place, though 50Ω line impedance is a common standard in electronics. However, it is more important to have constant line impedance along the entire transmission line in order to avoid signal reflections. Such reflections can lead to signal attenuation and perturbed data transmission.

Textile transmission lines built from two variants of fabrics are investigated in this section. The first substrate features wires in warp direction only whereas the second variant embeds wires in warp and weft direction. In the second variant, the cross-running wires will be floating.

2.4 Antenna Placement

The proposed antenna is designed for integration into the outer fire fighter garment. Since this is a multilayer assembly, two types of positioning have to be determined: between what layers and where on the garment. The antenna will be wired to the monitoring system within the garment; therefore it was decided to locate it underneath the moisture barrier and the thermal barrier layer. Underneath the antennas' ground plane is the inner lining of the garment, as shown in Figure 2.5.

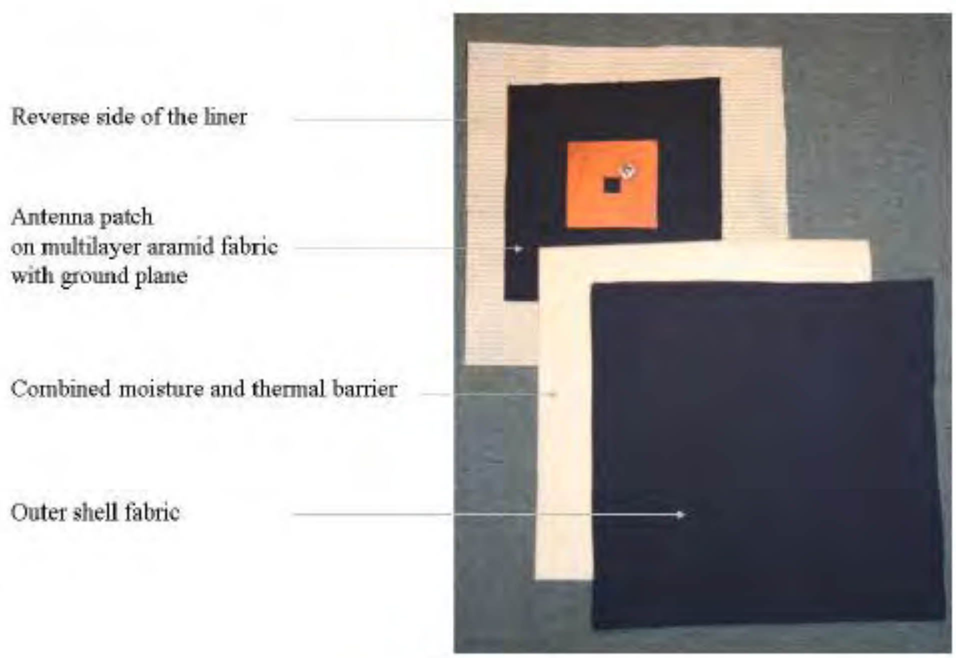

Figure 2.5: Positioning of the Antenna

The antenna placement on the garment was preferred in the area of the shoulders or the upper arm because of the minimal risk of creasing and wrinkling in these areas.

Figure 2.6: Possible Placement of the Antenna on the Suit

Given the required functionalities, a firefighter garment generally consists of three layers of fabric:

a) An outer shell layer of high-performance material, protecting the firefighter from harsh environmental conditions;
b) A waterproof layer avoiding any passage of water or dangerous liquids
c) An insulating layer.

Since the antenna is just one component in an entire system that includes sensors and other electronics, the decision was made to integrate it underneath the waterproof layer as in Figure 2.7 so that the moisture barrier does not protrude and cause leakage.