TEXTILE ANTENNA

MOHD NAZRY BIN MOHAMMAD

This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) With Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

April 2010

UNIVERSTI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek : TEXTILE ANTENNA

Sesi Pengajian : 2009/2010

Saya……………………………………………**MOHD NAZRY BIN MOHAMMAD**…………………………………………… mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√) :

☐	**SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	**TIDAK TERHAD**	

Disahkan oleh:

__________________________ ___________________________________

(TANDATANGAN PENULIS) (COP DAN TANDATANGAN PENYELIA)

Alamat Tetap: 280-2, KM13, JALAN SURAU BATU,

PAYA DALAM, 75460 MELAKA.

Tarikh: ……………………………………… Tarikh: …………………………………………

"I hereby declare that this report is the result of my own work except for quotes as cited in the references."

Signature	:……………………………………………….….
Author	: Mohd Nazry bin Mohammad
Date	:……………………………………………………..

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) With Honours."

Signature :…………………………………………………….

Supervisor's Name : Cik Siti Normi bte Zabri@Suhaimi

Date :……………………………………………………..

For my beloved father and mother……………………

ACKNOWLEDGEMENT

In the name of the almighty ALLAH, the most gracious and merciful, with his gracing and blessing had led to success be upon this thesis.

Firstly, I would like to express my sincere thanks to Cik Siti Normi bte Zabri for her supervision, patience and guidance in correcting my mistakes and in giving constructive criticism so that I can improve for the better. Beside I would like to thank my family member who gave me moral support and encouragement.

I would like to extend my gratitude to Mr. Zoinol Abidin bin Abdul Aziz and Mr. Azahari for their assistance, interest and consultations for enabling this work. Thanks to all my friends who help me significantly.

Thank you very much.

ABSTRACT

This project is to design a dual band textile antenna for a short range communication operating in the 2.45GHz and 5.5GHz frequency. This project also to investigate the performance of such antenna, since the development of wearable system has opened possibilities to incorporate antennas into clothing. The development of *textile systems* has altered the concept of clothing. Additionally, the introduction of these textiles has uncovered the need for wireless communication systems that are unnoticeably integratable into clothing. New generation garments are capable of monitoring the wearer's vital signs and activity as well as the environment. A textile antenna is proposed for operating in the 2.45 GHz and 5.5GHz for short communication range to transmit the wearer's life signs to a nearby base station. The outer fleece fabric was chosen as antenna substrate. This antenna substrate possesses a permittivity, εr and a loss tangent. A fleece fabric is chosen because its piled structure yields a permittivity close to 1 and its hydrophobic characteristic results in a low loss-tangent. These are excellent properties for optimal antenna design. The fleece fabric has a thickness of 2.55 mm, which provides an adequate bandwidth. The simulation of the design can be carried out by using CST software.

ABSTRAK

Projek ini adalah untuk merekabentuk 2 jalur frekuensi untuk jarak yang dekat iaitu 2.45GHz dan 5.5GHz. Projek ini juga bertujuan untuk menyiasat prestasi sesebuah antenna semenjak penghasilannya daripada tekstil. Selain itu, pengenalan tekstil ini telah menemui keperluan untuk sistem komunikasi wayarles yang tanpa disedari boleh diubah suai kepada pakaian. Pakaian generasi baru mampu memantau tanda vital si pemakai dan aktiviti serta persekitaran. Selain itu, pada frekuensi ini juga, ia bertujuan untuk menerima atau menghantar isyarat pada stesen pemancar yang terdekat. Kain jenis fabric digunakan untuk projek ini. Ini adalah kerana kain ini mempunyai tahap keelutan hampir dengan 1 dan dapat menghasilkan satu keputusan yang tepat dan jitu dalam mengesan kehilangan sesuatu isyarat. Ini merupakan salah satu cirri- cirri penting dalam penghasilan atau merekabentuk sesebuah antena. Kain yang digunakan mempunyai ketebalan 2.5mm dimana ianya sudah memadai untuk menghasilkan lebar jalur yang besar. Simulasi reka bentuk boleh dilakukan dengan menggunakan software CST.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

1.1 Background

Textile antennas are becoming attractive, since the development of wearable system has opened possibilities to incorporate antennas into clothing. This project will design and investigate the performance of such antenna and also designed to be integrated into protective clothing since it is made out of a high performance fleece fabric. The development of *textile systems* has altered the concept of clothing. New generation garments are capable of monitoring the wearer's vital signs and activity as well as the environment. The fact that this is done in a –for the wearer- comfortable and unobtrusive way, makes these garments quite exceptional. Additionally, the introduction of these textiles has uncovered the need for wireless communication systems that are unnoticeably integratable into clothing. Data concerning the operator's health status and surrounding environmental risks .Therefore, a wireless link is established where the antenna on the operator's side is a textile antenna to be integrated into the garment. A textile antenna is proposed for operating in the 2.45 GHz and 5.5GHz for short communication range to transmit the wearer's life signs to a nearby base station.

1.2 Problem Statement

Textiles antenna emerged as promising materials for an antenna substrate and its conductive part in wearable applications. In the future, this allows complete freedom to design textile antenna in smart clothes. Some people require additional protection against occupational hazards during the professional activities high performance materials are used to make this special class of protective clothing.

Small and unobtrusive antennas continuously gain in importance in the today's world of cellular phones and wireless network. Range of coverage, directionality and efficiency need to be adjusted and optimized considering application whereby limitations are given due to physics. 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 the following properties:

- a flat planar structure such that it can be comfortably worn
- almost arbitrary large area coverage
- a drapable textile substrate
- a substrate with inhomogeneous physical parameters
- Irregular ground plane

1.3 Objectives

The aim of this project is to:

1. Design and investigate the performance of such antenna and also designed to be integrated into protective clothing since it is made out of a high performance fabric.
2. Proposed for operating in the 2.45GHz ISM (2.4-2.485 GHz) and 5.5GHz for short range communication in body and personal area networks for Bluetooth, Wifi and Zigbee.
3. To design a dual band textile antenna operating in the 2.45GHz and 5.5GHz.

1.4 Scope of Work

The basic assumption of my project is to design a textile antenna for a short range communication operating in the 2.45GHz and 5.5GHz frequency. 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. The outer fleece fabric was chosen as antenna substrate. This antenna substrate possesses a permittivity, εr and a loss tangent. A fleece fabric is chosen because its piled structure yields a permittivity close to 1 and its hydrophobic characteristic results in a low loss-tangent. These are excellent properties for optimal antenna design. The fleece fabric has a thickness of 2.55 mm, which provides an adequate bandwidth.

The simulation of the design can be carried out by using CST software.

1.4 Project Methodology

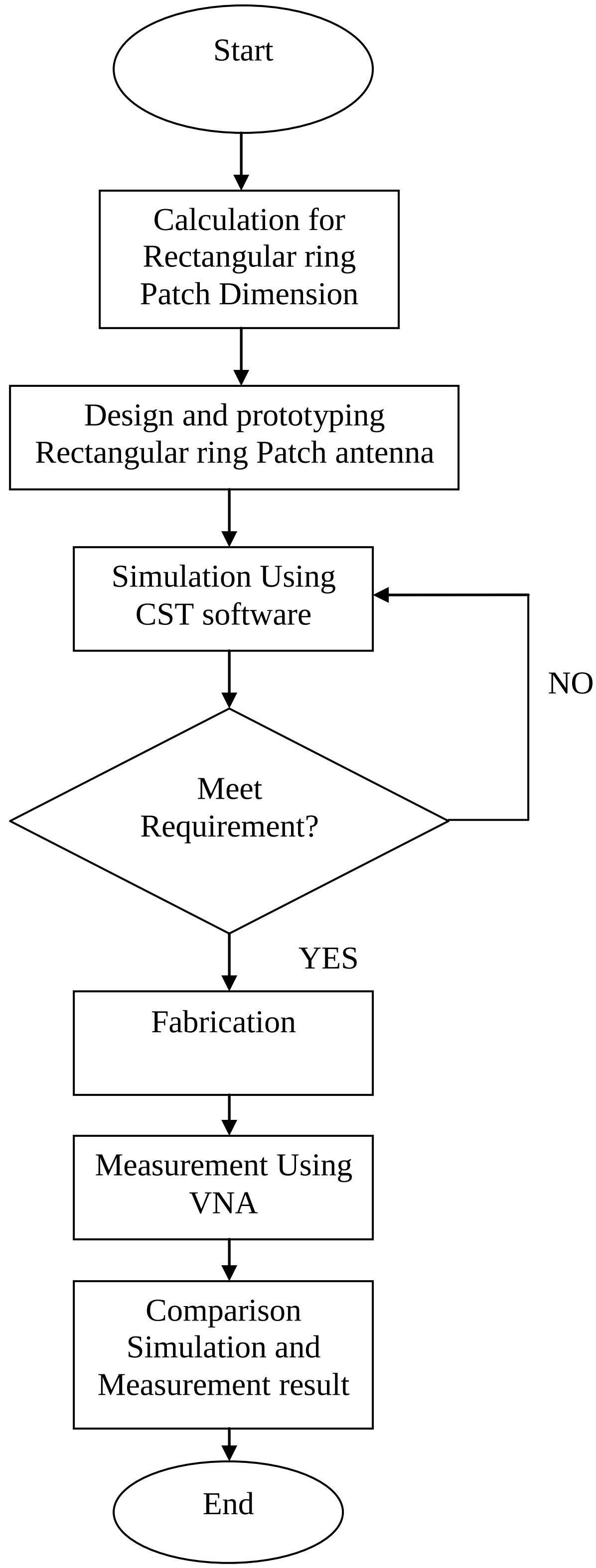

Figure 1.1: Flow chart

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.

Textile antennas available so far were designed with rectangular patches with probe feed (C.f. P. Salonen and H. Hurme, IEEE Antennas and Propagation Society International Symposium vol. 2, June 2003, pp. 700-703; and M. Tanaka and J.H. Hang, IEEE Antennas and Propagation Society International Symposium vol. 2, June 2003, pp. 704-707). Such antennas provide a linear polarization. However, it has been found that for some applications relating to wearable computing, the orientation of the textile antenna may vary as a function of time, for example if the person wearing the textile antenna moves. Linear polarization brings about a dependence of the antenna's efficiency on the relative orientation of transmitting (Tx) antenna and receiving (Rx) antenna. In addition, the probe feed causes elements to stick up from an antenna plane, so that it is not practical for wearable computing.

It is an object of the invention to provide a textile antenna overcoming disadvantages of prior art textile antennas, and especially to provide a textile antenna that would be suitable for the frequency ranges between around 1.8 to 1.9 GHz (GSM standard frequencies), about 2.4 GHz (Bluetooth frequency), and other frequencies between 400 MHz and 20 GHz in order to be operable to communicate using already available communication technologies, to provide a textile antenna that is also suitable for being posed on moving objects, and to provide a textile antenna that has a design that makes it cost effective to manufacture and that makes possible to contact it without parts protruding from the plane defined by the antenna, i.e. that may be contacted without parts sticking up from the textile[1]. A microstrip feed line in this context is a strip-shaped conductor structure for feeding the radiating part of the antenna with an AC voltage, being provided on the textile substrate, and meeting the radiating main part of the antenna patch. In a plane configuration, the microstrip feed line is in the same plane as the antenna patch main part.

Textiles have emerged as promising materials for an antenna substrate and its conductive parts in wearable applications. In the future, this allows complete freedom to design body-worn antenna systems embedded in, e.g. smart clothes. Smart clothes may find their place in our everyday living. Within couple of years they will emerge as various sports outfits, emergency workers' outfits, military, medical, and space applications etc [4]. The wireless communication is mandatory requirement for smart clothes. In addition, the wireless data communications allows also entertainment features for smart clothes. Since then the research on wearable antennas has received growing interest among university and industry researchers. The wearable antenna can be defined as an antenna which is designed and meant for part of clothing. The antenna requirements are given by the particular specification, hut common to all applications are light weight, inexpensive, zero maintenance, no set-up requirements, and no damage from obstacles.

Previous work was primarily focused on dual band frequency operation of wearable textile antennas. The fleece fabric and copper tape used for conducting elements enable the antenna to be flexible, low profile and lightweight. Hence, the proposed antenna structure is easy to attach to clothing and the structure does not limit the possible antenna placements. Conventionally, antennas that are inflexible and high profile have limited amount of places they can be attached to without being uncomfortable to the user. In addition, these materials are inexpensive and therefore the proposed antenna can also be considered suitable for commercial products. In this paper, details of the proposed antenna design are described, and the experimental results of a prototype are presented.

Wearable computing is a fast growing field in application-oriented research. Steady progress in miniaturization of microelectronics along with other new technologies enables integration of functionality in clothing that allows entirely new applications. The vision of wearable computing describes future electronic systems as an integral part of our everyday clothing. Such equipped clothing represents a wearable computer that could serve as intelligent personal assistants. A wearable computer is always on, does not restrict the user's activities, and is aware of the user's situation. It features easy-to-use interfaces and supports the user unobtrusively with ad hoc information.

There is currently much interest in body-worn communication systems whether for on-body communication or communication off body to fixed and mobile networks. Such systems are of interest for detecting motion on the body during exercise, monitoring functions such as heart rate and blood pressure, use by the emergency services, and for general network connection. Consequently, antennas for applications such as airwave at 400 MHz, mobile telephones 800–2200 MHz and network communications at 2.45 GHz and 5–6 GHz are of interest. Body-worn antennas may be made from textiles and attached on body or into clothing, or may be worn as a button antenna. Later, dual frequency band designs have emerged allowing mobile network connection[3].

In this paper, we provide further results from a study of a dual-band textile antenna. This antenna can be worn within clothing and covers the 2.45 GHz and the 5.5 GHz wireless networking bands. Construction of the antenna is based on a coplanar stripline feeding a coplanar patch antenna, giving a much wider operating bandwidth and more flexible band spacing than is possible from a dual-band patch antenna while maintaining the front to back ratio[5]. These antennas are to be placed against the body and hence it is desirable to reduce the backward scattered radiation as much as possible. The antennas are conformal and manufactured from flexible materials that are readily hidden or sewn into items of clothing. The materials used are commonly found in clothing products and range from felts and cloths to leather fabrics.

The conducting components, coplanar feed line, patch antenna, and ground plane, are manufactured from a cooper .At this prototype stage, the antenna was constructed by hand cutting the conductive material accurately and attaching the components to a layer of thin felt material 2.55 mm thick with Er = 1.17 and tan d = 0.035 either by stitching them together or by using a very thin layer of adhesive.

The antennas were designed and simulated using CST Microwave studio software and measurements were carried out to verify the results. Results are reported for the antenna bent around two formers in the E-plane and H-plane of the antenna and for the antennas placed on the human body. Specific absorption rate measurements and simulations were also carried out.

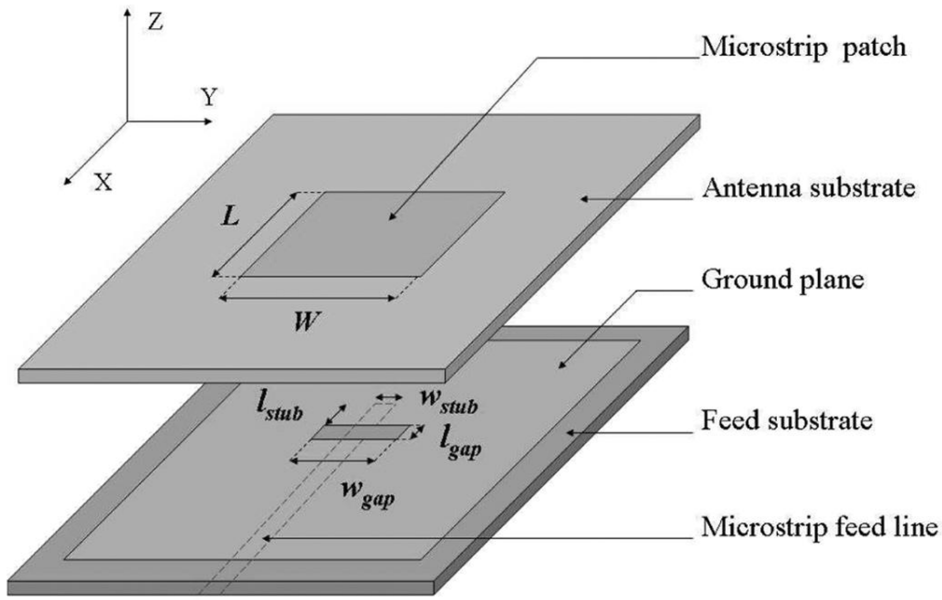

Figure 2.1: Aperture Coupled Patch Antenna

The so-called "*wearable textile systems*" aim at improving our quality of life by enhancing the functionalities of clothing through a combination of textiles and electronics. This new generation of garments has the ability to monitor the wearer's biosignals and communicate these data with the environment in order to provide continuous information about a person's state of health. But a wireless communication link between the garment and a base station requires antennas. Optimal integration of an antenna into a garment can be achieved by making the antenna itself out of textile material. The availability of conductive textile materials, known as electrotextiles, enables the manufacturing of textile antennas and makes them an unobtrusive part of the wearable textile system.

However, most of the presented prototypes consist of a dual layer design and often a coaxial feed is used to connect the antenna to the transceiver. This kind of feeding structure is rigid and thus quite disturbing to a person wearing a textile antenna. Likewise, feeding the antenna through a microstrip feed line *on* the antenna plane is no solution since parasitic radiation by the feed line and parasitic electromagnetic coupling between the antenna, the feed line and the transceiver can occur. Yet, this situation can be prevented by placing.

2.2 Fabric Characterization

In order to design textile-based antennas the electromagnetic properties of the materials must be known at the operational frequency bands. In this project, the dielectric properties of some common textile and leather materials were measured through a transmission/reflection waveguide method. The measurement setup was based on an HP 8720D network analyzer and a rectangular waveguide10 system (two identical waveguide cavities with transition parts, a shorting plate and a waveguide sample holder). The operating frequency range of the waveguide 10 system was 2.60–3.95 GHz. Six fabric samples and two reference solid samples (Perspex and PTFE) were measured. All the fabrics were purchased from a department store and are very commonly used in clothing. The samples were cut to fit the waveguide aperture tested as single layers and in multiple layers.

Table 2.1: Average result of the dielectric constant for each material

Material	Silk	Tween	Panama	Moleskin	Felt	**Fleece**	PTFE	Perspex
Single layer thickness (mm)	0.58	0.685	0.347	1.17	1.1	**2.55**	11.66	11.67
Permittivity	1.75	1.69	2.12	1.45	1.38	**1.17**	2.05	2.57
Loss Tangent	0.012	0.0084	0.018	0.05	0.023	**0.0035**	0.0017	0.038