UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OF ROUND SHAPE KAPTON BASED FLEXIBLE ANTENNA FOR FREQUENCY 3.5 GHZ

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering Technology (Telecommunications) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Telecommunications) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Projek ini menerangkan kajian tentan reka bentuk antena fleksibel berdasarkan Kapton bentuk bulat yang mampu beroperasi pada jalur frekuensi 3.5 GHz (3.4 GHz hingga 3.6 GHz) untuk aplikasi 5G. Antena tampalan bentuk bulat dicadangkan dalam projek ini dengan menggunakan bahan substrat Kapton dengan ketelusan relatif 3.5, substrat ketebalan adalah 0.025 mm. Kapton adalah substrat yang hebat kerana menghasilkan sifat RF dan termal yang baik, ia dapat berkembang pada julat suhu yang luas (-73 hingga + 400 ° C), ia juga tahan tinggi terhadap banyak pelarut kimia (Yang, 2017). Kapton juga dikenali sebagai Filem Polyimide. Lebih-lebih lagi, dalam (Dahalan et al., 2019) Kapton cenderung lebih fleksibel dibandingkan dengan substrat lain. Ini dapat diterapkan pada antena langsung dan bergantung pada frekuensi dan aplikasi antena. Substrat polimid Kapton dipilih untuk reka bentuk antena fleksibel bentuk bulat. Teknologi baru memerlukan antena menjadi ringan, fleksibel dan lebih sesuai untuk aplikasi digital di mana bahan Kapton membuat substrat yang menarik kerana fakta bahawa batu mereka biasanya digunakan pada industri elektronik kerana perniagaan beralih ke bahan tambahan yang lebih kecil, lebih ringan dan lebih cepat. Antena yang direka perlu disimulasikan menggunakan perisian CST untuk menganalisis hasilnya dapatannya

ABSTRACT

In this project presents the design of a round shape Kapton based flexible antenna that capable to operates at 3.5GHz (3.4GHz until 3.6GHz) frequency for 5G application. The circular shape patch antenna is proposed in this project by using Kapton substrate materials with relative permittivity of 3.5, thickness substrate is 0.025mm. Kapton is a great substrate as it produced good RF and thermal properties, it can developed at wide temperature range (-73 to +400°C), it is also high in resistant to many chemicals solvent in (Yang, 2017). Kapton is also known as Polyimide Film. Moreover, in (Dahalan et al., 2019) the Kapton is tend to be more flexible compare to other substrate. It can be applied to a direct antenna and depends on the frequency and application of the antenna. Kapton polyimide substrates was chosen for the design round shape flexible antenna. New technology needs that the antenna become lightweight, flexible and more suitable for digital applications whereby Kapton materials make an interesting substrates because of the fact that their miles are commonly used on the electronic industry as businesses shift to smaller, lighter and faster additives. The proposed antenna need to be simulated using the CST software to obtain and analyse the result.

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DEDICATION

I dedicate this thesis to my beloved families, supervisor and co-supervisor, senior, and those who involved in a process completing this thesis.

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CHAPTER 1

INTRODUCTION

1.1 Background

In the past decade, wireless communication technology has been a field which has intensively improved and has progressed. Since the first- generation communications networks up to today 4G LTE networks, rapid progress has taken place and it is important to move not only voice and text but also video, GPS data, and much more between transmission and reception device. In the near future, the priority will be on the specific demand for faster communication. Global mobile data traffic increased 74% in 2015 and third-generation (4G) traffic exceeded 3G for the first time in 2015 according to Cisco Visual Networking Index (VNI), (Hakanoglu, B.G. and Turkmen, M., 2017). Furthermore, there was an rise in demand for higher data rates and need to move from the current generations to a higher-frequency band within a couple of years is expected. 5G used higher frequency ranges for its applications, where the best options are the microstrip patch antennas. In addition, the patch microstrips are inexpensive, light and simple to produce. The increasing frequency reduces the size of the device. The antennas can be compact and miniatured to be used in different hand-held devices, (Sahoo, A.B., Patnaik, N., Ravi, A., Behera, S. and Mangaraj, B.B., 2020,). The spectrum constitutes the life-line of any communications. There had three groups which are low frequency, medium frequency and high frequency. 5G network technology used in the medium and high frequency for networking purposes with faster data speeds and high network efficiency in dense networks based on different specifications and networks. In india there are three pioneering 5G technology bands that have been targeted or allocated. The numbers range from 700 MHz, 3.5 GHz and 26/28 GHz (Sahoo, A.B., Patnaik, N., Ravi, A., Behera, S. and Mangaraj, B.B., 2020,). For these three pioneer frequencies, the antenna proposed in this project is 3.5 GHz. Furthermore, Kapton polyimide substrates was chosen for the design round shape flexible antenna. New technology needs that the antenna become lightweight, flexible and more suitable for digital applications whereby Kapton materials make an interesting substrates because of the fact that their miles are commonly used on the electronic industry as businesses shift to smaller, lighter and faster additives. Kapton material is typically performed on an instantaneous antenna designed to suit the antenna frequency and application.

1.2 Problem Statement

Round shape antennas have recently become increasingly significant in the wireless communication system because it has provided a decent advantage. A round shape flexible antenna is purpose in this project. Most of the previous research designated round shape patch antenna can work well with other common substrate such as textile materials which is jeans and polyester. Nowadays, most application need flexible antenna and the market for flexible antenna devices are increasing fast, mostly due to demands for wearable and implantable devices for health monitoring systems and wireless daily life devices. Besides, for the square shape is also mostly used in terms of design. In order to do another analysis, Kapton based material is chosen as a substrate for round patch antenna. The design of microstrip antennas as low-cost radiators for mobile communications can be challenging. According to the observation, student is desire to measure the antenna efficiency by measuring its radiation pattern. Typically, for flexible antenna, the substrate material chosen is Kapton.

In response to this problem, the study purpose is to design a round shape flexible antenna for using at 3.5 GHz frequency for application. The aim for this project is to have high gain and efficiency to ensure maximum data transfer.

1.3 Objective

- To design a round shape flexible antenna that operates at 3.5 GHz frequency using CST software
- To simulate round shape patch antenna for using at 3.5 GHz frequency for 5G application.
- To analyze the performance of antenna in term directivity, gain, return loss and VSWR of round shape patch antenna at 3.5 GHz frequency.

1.4 Scope Study

CST software is used to design and simulate the round shape flexible antenna. Besides, this design use Kapton for substrate with range frequency starting at 3.5GHz band. This paper focuses on the design of a round shape flexible antenna. The nominal operating frequency band of the antenna is 3.4 GHz to 3.6 GHz. The main antenna requirements which are low profile and small size, minimize radiation absorption by human body, operation guaranteed even under the cover of wet clothing and mud, sufficient structural integrity for the survival of near-disturbed circumstances. This challenging issue comes with a design solution. Simulations and effects of various antenna curvatures are discussed. Finally, the antenna performance was measured with references to return loss and distant radiation gain pattern.

1.5 Thesis Outline

Based on this report, it consists of five chapters in order to complete the full report. All the idea, process, flow and the concepts of project will be discussed in the chapter required. Initially, for the first chapter briefly describe the introduction of this project. The review about the basic platform of project concisely explained. This chapter also clarify the background of the project, problem statement, objective to achieve and the scope of project.

In the second chapter, literature review is done by reviewing journals, books and article which is related to Round Shape Flexible Antenna for 5G Application. Other than that, this chapter will make a summary for all the journals that have been review. This chapter also will cover about the study and idea based on round shape flexible antenna as well as the concept.

For chapter 3, the overall process and method used for designing the antenna are discussed. It starts from antenna design specification of parameters, dielectric substrate, feeding method of antenna were determined. Then, the software development and measurement using CST are addressed from this chapter. The Kapton that act as substrate for this antenna also will be discussed in this chapter.

For chapter 4, there will be an explanation for the data collection, taken decision, result for simulation and hardware. The comparison for performance of the antenna between simulation and hardware are also discussed in this chapter.

Lastly, the final chapter will conclude the overview of overall project process. The recommendation for future work also will be discussed in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss several similar previous work, related articles, and research which is the design of an antenna for the completion of this project. Literature review is an essential part before beginning any project because it provides all required data related to the project. Based on that, the correct direction in developing the project can be performed proficiently. In this chapter, topic that will be explained are system that going to be implemented and previous related work.

2.2 Type of material substrate for flexible antenna.

Flexible antenna are advanced for the use of substrates that can easily be inserted in abnormal surfaces without removing their functions. New substances with very specific chemical houses and a new process of production have resulted in the developing of dielectric substrates which guarantee a suitable result in terms of flexibility, efficiency, weight and antenna reproducibility.

The choice of the dielectric on which the conductor is installed affects the behavior of the antenna with respect to impedance bandwidth, radiation efficiency and gain. Thickness, dielectric permittivity, loss tangent of antenna substances must be measured and controlled that allows to attain the specifications of the distinct packages. Several experimental techniques such as coplanar waveguide approach (Dib, N.I. and Katehi, L.P., 1992), differential open resonator method (Dudorov, S.N., Lioubtchenko, D.V., Mallat, J.A. and Raisanen, A.V., 2005.) and microstrip linear method can be used to characterize the electromagnetic properties of dielectric substrates.

2.2.1 Kapton Polyimide

This substrate is known for its excellent and occasionally high losses. Several research groups have suggested antennas on this substrate consisting of the CPW-fed monople antennas UWB with 2.2 GHz and 5.3 GHz (El Maleky, O., 2018) resonance frequencies and a two-band 2.45 GHz and 5 GHz, (Hamouda, Z.,2017), which are correct for use by portable, flexible telemedicine and WLAN applications.

The use of microfabrication strategies suggested throughout Y.H. Jung et al. is a fully-insulated dual-band WiFi antenna with a 10-um thick Parylene C biocompatible film on a 0.127-mm thick Kapton polyimide substrate (Jung, Y.H.,2015). The Implantable application can be used, (Haj-Omar, A.,2016). The IFA antennas for biomedical substrates and computer applications are good examples of this group of flexible antennas.

Kapton is a great substrate as it produced good RF and thermal properties, it can developed at wide temperature range (-73 to +400°C), it is also high in resistant to many chemicals solvent in (Yang, 2017). Kapton is also known as Polyimide Film. Moreover, in (Dahalan et al., 2019) the Kapton is tend to be more flexible compare to other substrate. It can be applied to a direct antenna and depends on the frequency and application of the antenna. The author in (Rabobason et al., 2016) classify that there are three types of Kapton depending on the application which is HN, VN and FN. Generally, the HN type is suitable for project with 5.8 GHz due to its dielectric properties and thermomechanical stabilities criteria. The dielectric constant is 3.6 and the loss tangent of the Kapton is 0.031 as referred to the datasheet from manufacturer.

2.2.2 Textile Antenna

Textile materials are interesting for flexible and wearable applications as they are suitable for easy integration in clothing and other wearable devices. Structures for textile antennas can be classified. The antenna substrate in the first category is made of a non-conductive material, whereas copper foils are the conducting layers and floor plans. In the second group of the antennas, the substrates and the conductive layer are made from textiles completely textile composed.

Table 1.1 displays dielectric residential areas in some regular textiles, in which the total permittivity range of 1.22 to 2.12 can be seen, and their loss tangent is additionally small (0.01 to 0.05) because the materials are porous and air-filled. (Dhupkariya, S., Singh, V.K. and Shukla, A., 2015), Some typical metal deposition techniques of these substrates include the use of liquid adhesive with a liquid cloth, a conductive spray method, sewing technology, ironing layer and copper tape technique. Furthermore, monitor printing and inkjet printing can be introduced. Several publications on this problem have been published, consisting of several antennas and digital components designed for textiles, of which only a few in this section are selected. Selective frequency surfaces are frequently used for a variety of purposes in antenna design, including increasing the gain or bandwidth. In standard form, the use of copper classified on an electrical material acting as filter with the band prevents between 10 and 12GHz for on body communications programs. Another periodic shape operating at millimeter-wave frequencies is supplied in (Ghebrebrhan, M., 2017).

Table 1.1. Dielectric properties of some normal textile fabrics (Dhupkariya, S., Singh, V.K. and Shukla, A., 2015).

Table 2.1: Dielectric Properties

Non-conductive Fabric	ε_r	Tan δ
Felt	1.22	0.016
Cordura	1.90	0.0098
Cotton	1.60	0.0400
100% Polyester	1.90	0.0045
Quartzel Fabric	1.95	0.0004
Silk	1.50	0.012

Tween	1.69	0.0084
Jeans	1.7	0.025
Moleskin	1.45	0.05

2.3 Microstrip Antenna

The microstrip antenna includes radiating patches on one side of a dielectric substrate that has a floor plane on the other side of the substrate. Copper or gold are typically the conductors of patches. The radiation patch and feeding lines are normally graved on the dielectric substrate (Saad, A. 2013). Figure 1.1 shows the patch antenna structure for microstrips.

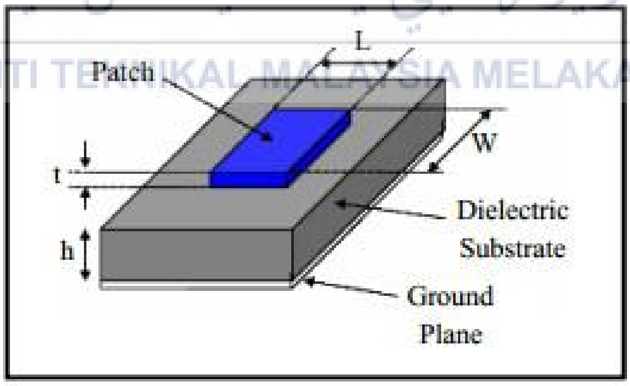

Figure 2.1: Microstrip Patch Antenna