CHAPTER 1
INTRODUCTION

1.1 Introduction

For wireless communication systems, the antenna is one of the most critical components. A good design of the antenna can relax system requirements and improve overall system performance. An antenna is the system component that is designed to radiate or receive electromagnetic waves. In other words, the antenna is the electromagnetic transducer which is used to convert, in the transmitting mode, guided waves within a transmission line to radiated free-space waves or to convert, in the receiving mode, free-space waves to guided waves. In a modern wireless system, the antenna must also act as a directional device to optimize or accentuate the transmitted or received energy in some directions while suppressing it in others [2]. The antenna serves to a communication system the same purpose that eyes and eyeglasses serve to a human. The history of antennas [3] dates back to James Clerk Maxwell who unified the theories of electricity and magnetism, and eloquently represented their relations through a set of profound equations best known as Maxwell's Equations. His work was first published in 1873 [4]. The origin of microstrip antennas can evidently be traced back to 1953, when Deschamps proposed the use of microstrip feed lines as a feed mechanism to feed an array of printed antenna elements [5]. Deschamps introduced the first type of planar printed circuit antenna, though these structures were nonresonant in nature, as opposed to the usual microstrip antenna, which operates as a lossy resonant cavity.

Byron published a symposium paper in 1970 [6], in which he described a rectangular microstrip type of element, but the element was several wavelengths wide for the nonresonant dimension, and was fed with a periodic arrangement of coaxial feeds along the two radiating edges. It was thus not exactly the rectangular patch antenna that is known today. microstrip patch antenna as known now it was evidently first introduced by Munson in a symposium paper in 1972 [7], which was followed by a journal paper that he had in 1974 [8]. These papers discussed both the wraparound microstrip antenna and the rectangular patch. The microstrip patch antenna was mainly viewed as an element that could be used in a discrete implementation of a planar version of the wraparound antenna, allowing for individual control of the element phases. Munson thus introduced the concept of a phased array of microstrip antennas, demonstrating a onedimensional phased array of microstrip antennas that utilized pin diode phase shifters [6].

Microstrip is probably the most successful and revolutionary antenna technology ever. Its success comes from very well known advantages such as; light weight, low profile, easy and low cost fabrication, planar but also conformal to non-planar geometries, mechanical robustness, easy integration of components (including active devices), easy association in arrays, and versatility in terms of electromagnetic characteristics (input impedance, radiation pattern, polarization). It can be used in very broad range of frequencies roughly from 1 to 100 GHz. Of course it also has some disadvantages, the most well known being the inherent narrow bandwidth and low efficiency. However even these drawbacks have been overcome. Several techniques have been developed to increase the bandwidth and very wideband microstrip antennas have been presented [9] [10]. The development of new technologies and process and the use of new materials have provided low loss microwave and milimetre wave substrates.

Wireless is evolving, driven by more devices, more connections, and more bandwidth-hungry applications. Future networks will need more wireless capacity and reliability. That's where the sixth generation of Wi-Fi comes in or as known as Wi-Fi 6. The emerging IEEE 802.11ax standard is the latest step in a journey of nonstop innovation. It builds on the strengths of 802.11ac, while adding flexibility and scalability that lets new and existing networks power next generation applications. IEEE 802.11ax couples the freedom and high speed of gigabit wireless with the predictability we find in licensed radio (LTE). IEEE 802.11ax allows enterprises and service providers to support new and emerging applications on the same Wireless LAN (WLAN) infrastructure, while delivering a higher grade of service to older applications. This scenario sets the stage for new business models and increased Wi-Fi adoption. IEEE 802.11ax lets access points support more clients in dense environments and provide a better experience for typical wireless LAN networks. It also powers more predictable performance for advanced applications such as 4K video, Ultra HD, wireless office, and IoT. Flexible wake-up time scheduling lets client devices sleep much longer than with 802.11ac, and wake up to less contention, extending the battery life of IoT [11].

The U.S. Federal Communications Commission (FCC) approved the opening of the 6-GHz band for unlicensed use in the United States in April 2020, with this move, the FCC freed 1200 MHz of bandwidth for use by Wi-Fi 6E devices, which feature an extra radio that lets them communicate in the 6-GHz band. The 6-GHz band offers more than twice as much Wi-Fi bandwidth as the 5-GHz band, the FCC extended Wi-Fi into the 6-GHz frequency band to help encourage wireless innovation and support smart homes and offices and the expanding IoT. Other countries and regulatory bodies, including Brazil, Chile, the European Union, Japan, Mexico, South Korea, Taiwan, the United Arab Emirates, and the United Kingdom, are also delivering 6-GHz unlicensed spectrum to their residents [12]. Unlike Wi-Fi 6, Wi-Fi 6E is not a standard. It is an extension of the Wi-Fi 6 standard into the 6-GHz spectrum that brings faster speeds, lower latency, and more security to the network. The additional spectrum of Wi-Fi 6E offers more non-overlapping channels. It can support a dense IoT environment with no degradation in performance. One of the biggest advantages is that by using the 6-GHz band, Wi-Fi 6E devices won't share spectrum with Wi-Fi 4 (802.11n) or Wi-Fi 5 (802.11ac) devices. Wi-Fi 6E will improve efficiency and performance, since all Wi-Fi 6E devices use highly efficient Wi-Fi 6 radios and won't be slowed down by older devices operating at lower data rates [13].

An important trend, IoT presents a significant challenge to enterprises: how to securely and easily connect hundreds or thousands of electronic devices to the corporate IT network congruent with their operational and engineering needs. In contrast with user devices such as laptops, IoT devices have either a need for deterministic wireless service (for example, poll me every 5 ms or I will shut down) or low-power service (that is, I don't talk unless I really need to). Traditionally, these needs have been met with proprietary, niche, or service provider-specific technology, but enterprise Wi-Fi has been increasingly chosen as the indoor IoT platform because of its significant economies of scale and ease of management by IT. To address these IoT operational needs, 802.11ax and its IoT capabilities such as low power and determinism are expected to accelerate this adoption [11].

The research in Microstrip antennas is already done by many scholars and many types of antennas that has been created, after reading many journals, paper, and scientific article for the Dual-Band antennas, there is almost no journals, paper, and scientific article that created a simple dual-band antenna using 5 and 6 GHz for the IoT devices, even though the 5 GHz is the standard and in the future the 6 GHz will become the future standard the closest thing that this thesis will research is from paper [14], after learning the paper of A Compact Dual-Band Antenna for loT Applications it using the 2.39-3.15 GHz, in this thesis the change to the antenna design is to make a more simple design and using a higher frequency that is 5 and 6 GHz and hope to get a good result.

1.2 Problem Identification

The increased usage in the IoT sectors that using high data transfer rate, low latency connection and huge bandwidth presents a significant challenge, in order to fulfil this needs, the standard of the wireless is evolving, from 802.11-1997 Standard to Wi-Fi 6 or 802.11ax Standard, the 5 and 6 GHz frequency is the best choice for an IoT devices, as it can transmit more data, has lower latency, and also has bigger bandwidth, by trading off the range of the connection, this thesis observed the addition of the dual-band for an important devices as IoT, if there is a problems with one of the band, the other band will be the secondary option, the chance for the IoT devices to lost a connection will be reduced,

1.3 Objectives and Contribution

To solve the problems described in Section 1.2, this thesis design and realization of Dual-Band Microstrip antenna using a 5 and 6 GHz frequency that fulfill the standard of Wi-fi 6 and Wi-fi 6E to achieve the best results to solve this problems, using the advantage of the high frequency to get a small patch size that can use newer modulation and transmit more data, while also has a moderate size of bandwidth and gain, this antenna will be very helpful to connect IoT nodes and become an antenna for IoT gateway. this thesis using the 3D model simulation software to simulate and to achieve a desired results before comes into the fabrication and the realization of the antenna, the design of the antenna will be very similar to this paper [14].

1.4 Scope of The Thesis

The scope of this Thesis is.

- The observation is done by simulation using 3D model simulation software and measurement in the antenna lab.
- To gain VSWR below 2.
- To gain huge value of bandwidth, for the 5 GHz the minimum is 80 MHz while for the 6 GHz the minimum is 160 MHz.
- the value of gain must be 1.5 dBi.
- The frequency range that was observed only from 5 to 6 GHz.

1.5 Research Method

This Thesis divided by six sections of *workpackages* (WP):

1. WP1: Literature Study this thesis, the author studies about Dual-Band antenna and the antenna in general from lecturer, textbooks, journals, and papers.

2. WP2: Calculating the antenna using the basic and given formula to create the basic of the antenna before created it in the simulation.

3. WP3: Simulation process is done to give a desired results and dimension to the antenna before Fabrication process to ensure the best performance of antenna.

4. WP4: Fabrication and Antenna measurement was done after the antenna finished the simulation process, after fabrication the next step is to calculate the parameters of the antenna that had been printed out.

5. WP5: Analysis after the simulation and measurement results were obtained, both were compared and analyzed to ensure that the results were in accordance with desired specifications.

6. WP6: Writing report, after all of the results and analysis were obtained, the next step was writing the report in the form of thesis.

1.6 Book Structure

The rest of this thesis is organized as follows:

- Chapter 1 INTRODUCTION
  This chapter contains a description, background, problem identification, objective and contribution, scope of this thesis, research method, and book structure of this thesis.

- Chapter 2 BASIC CONCEPT
  This chapter consists of the explanation and basic theory about antenna in general, Dual-Band antenna, and their parameters.

- Chapter 3 PROPOSED MODEL OF ANTENNA
  This chapter consists of the final antenna system model and design of Dual-Band Rectangular Microstrip Antenna of 5 and 6 GHz for this thesis.

- Chapter 4 RESULTS AND ANALYSIS
  This chapter discusses the analysis result of simulation and measurement of antenna parameters observed, such as gain, VSWR, and radiation pattern.
- Chapter 5 CONCLUSIONS AND SUGGESTION
  This chapter contains the conclusion from the analysis and suggestion.