DESIGN AND DEVELOPMENT OF AN ANTENNA AT 900MHz FOR SHORT RANGE WIRELESS COMMUNICATIONS

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"In the Name of Allah, the Most Beneficent, the Most Merciful"

I dedicate this thesis to my family, especially Abah En. Mohammad Zaidi bin Abdullah Zawawi, Ummi Puan Zakarinah binti Mohamad and siblings who have always been so close to me that I found them with me whenever I needed. Their unconditional love that motivate me to act higher targets. I also dedicate this thesis to my friends who always give moral supports and never lets any sadness enter inside.

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ABSTRACT

This project discussed about the performance of designed Microstrip Patch antenna and Microstrip Patch antenna with Split Ring Resonator (SRR) for a Short Range Device (SRD). Both antenna has been designed at 900MHz frequency which satisfied with short range standard in Malaysia. The main things in this project is to determine the maximum distance can be covered by both antennas in transmit and receive data. Besides that, the performance of parameter that has been studied were return loss, gain and radiation pattern. FR4 with thickness 16 mm has been used as the substrate and copper with thickness 0.035 has been used as patch material. The design was developed and simulated by using CST Studio Suite software. From the simulation results, for Microstrip Patch antenna, the return loss is -28.22dB, gain 2.32 dB, radiation pattern Omni-directional pattern and bandwidth 9.08 MHz. For Microstrip Patch antenna with SRR, the return loss is -15.38 dB, gain 0.98, radiation pattern Omni-directional pattern and bandwidth 9.64 MHz. Both antennas have been measured after the fabrication process. For Microstrip Patch antenna, the return loss is -16.168 dB at 920.5 MHz, gain 1.234 dB, radiation pattern Omni-directional pattern and bandwidth 10 MHz. while for Microstrip Patch antenna with SRR, the return loss is -24.5 dB at 909.5 MHz, gain 0.352 dB, radiation pattern Omni-directional pattern and bandwidth 14 MHz. After the measurement process, both antennas have been tested by doing the field test at UTeM Sport Complex. From the field test, the Microstrip Patch antenna has the maximum distance 0.11 km in transmit and receive data, while Microstrip Patch antenna with SRR the maximum distance can be covered in receive and transmit data was 0.16 km.

ABSTRAK

Projek ini membincangkan mengenai prestasi direka antena Microstrip Patch dan Microstrip Patch antena dengan Split Ring Bahantara (SRR) bagi Peranti Jarak Dekat (SRD). Kedua-dua antena telah direka pada frekuensi 900MHz yang berpuas hati dengan standard jarak dekat di Malaysia. Perkara-perkara utama dalam projek ini adalah untuk menentukan jarak maksimum boleh dilindungi oleh kedua-dua antena dalam menghantar dan menerima data. Selain itu, prestasi parameter yang telah dikaji ialah pulangan kerugian, keuntungan dan corak radiasi. FR4 dengan ketebalan 16 mm telah digunakan sebagai substrat dan tembaga dengan ketebalan 0.035 telah digunakan sebagai bahan tampalan. reka bentuk ini telah dibangunkan dan simulasi dengan menggunakan perisian CST Studio Suite. Dari hasil simulasi, untuk Microstrip Patch antena, kehilangan pulangan adalah -28.22dB, mendapat 2.32 dB, corak sinaran corak Omni-arah dan jalur lebar 9.08 MHz. Untuk Microstrip Patch antena dengan SRR, kehilangan pulangan adalah -15,38 dB, mendapat 0.98, corak corak sinaran Omni-arah dan jalur lebar 9.64 MHz. Kedua-dua antena diukur selepas proses fabrikasi. Untuk Microstrip Patch antena, kehilangan pulangan adalah -16,168 dB pada 920,5 MHz, mendapat 1,234 dB, corak corak sinaran Omni-arah dan jalur lebar 10 MHz. manakala bagi Microstrip Patch antena dengan SRR, kehilangan pulangan adalah -24.5 dB pada 909,5 MHz, mendapat 0,352 dB, corak corak sinaran Omni-arah dan jalur lebar 14 MHz. Selepas proses pengukuran, kedua-dua antena telah diuji dengan melakukan ujian lapangan di Kompleks UTeM Sport. Dari ujian lapangan, antena Microstrip Patch mempunyai maksimum jarak 0.11 km dalam menghantar dan menerima data, manakala Microstrip Patch antena dengan SRR jarak maksimum boleh dilindungi dalam menerima dan menghantar data adalah 0.16 km.

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CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

This chapter will briefly discuss the background of the project that has been chosen to design and simulate. In this chapter will also discuss the problem statement, main objective and scope of the project.

Recently, short range wireless has been widely used in industry of telecommunication to transmit the information because of its low capability of causing harmful interference and believed to be one of the vital and preferred medium for the future. The term “short range” connotes a signal travel from a few centimeters to several meters. SRD has a large demand these days by the end user and consumer due to its compatibility with most of the device such as Bluetooth, infrared, Zigbee and near field communication.

Short range device (SRD) is a general term applied to several of designed radio devices to operate on a license exempt basis, over short range and at low power levels. Some of the devices which have been used SRD such as alarms, telemetry and telecommand devices, radio microphones, radio local area network and anti-theft devices with maximum power up to 500 mW.

Antenna is a transducer designed to transmit, send and receive data in the term of electromagnetic wave. It transforms the electromagnetic radiation in space into electrical current or conversely depends on whether it is used for receiving or transmitting respectively. There are three types of antenna which is Omni-directional antenna, directional antenna and semi-directional antenna [12]. Omni-directional antenna can propagate in all directions and it is widely used in rural areas. This type of antenna can radiate with equal power in all horizontal direction. While in vertical plane, these antennas can radiate uniformly across all azimuth angles and have a main beam with upper and lower side lobes. Directional antenna has a narrow beam which allows highly directional propagation and these antennas are mostly used in mobile cellular system to get higher gain compared to Omni-directional antenna. Semi-directional antenna will propagate in a constricted fashion which is defined by a specific angle.

Antenna is a vital part of all supplies that uses radio. They are utilized as a part of framework, for example radio television, two-way radio and show TV. Normally an antenna consists of an arrangement of metallic conductors (component), electrically associated to be collector or transmitter. An oscillating present of electrons constrained through the radio wire by a transmitter will make a wavering attractive field around the antennas components, while the charge of the electrons likewise makes an oscillating electric field along the components.

1.2 SHORT RANGE DEVICES (SRD)

Short Range Devices (SRD) are wireless devices that offer a low risk interference with other radio services, usually because their transmitted power, and hence their range is low. The choice of the communication frequency of SRD wireless system is limited to those that allow license-free operation. Most popular wireless technologies operate in the unlicensed ISM band. ISM band operates on different frequencies: 433MHz, 868MHz (in Europe, Africa), 915MHz (Americas) and 2.4GHz (World-wide) [13]. SRD is generally an unlicensed band for wireless low data rate transmission as a signaling, remote control and warning system.

SRD are essentially low power radio communications systems. SRD technologies can include wireless links such as, data, audio, video or telemetry, sensors and actuators through to low power radar systems. Typically, the range of SRD is a few centimeters up to 100 meters [13]. Car key alarms are examples of SRDs, as are Bluetooth and Wi-Fi devices. RFID systems are also SRDs.

Generally, SRDs operate license free in Europe. To be allowed freedom of use, SRDs must inherently be devices that have a low capacity to cause interference to other radio communications. This is ensured by conformance to the relevant ETSI standards [14]. The low capacity to cause interference allow SRDs to coexist with other radio communications services. Consequently, SRD are permitted to operate in a number of bands across the radio spectrum.

ETSI is one of the world's leading standards development organizations for Information and Communication Technologies (ICT). It is founded initially to serve European needs, ETSI has grown rapidly to become highly-respected as a producer of technical standards for worldwide use. ETSI is independent of all other organizations and structures, a key feature for ensuring neutrality and trustworthiness. That brings benefits not only in the acceptance of standards and other publications, but also in growing range of ancillary services, such as interoperability testing [14].

1.3 PROBLEM STATEMENT

The existing antenna in the market only can covered a very short range. In order to have a higher gain which at the same time can covered in a range over 1000 meter, we need to use high directive antenna.

1.4 OBJECTIVES

The main objective of this project is to modified the RF module provided by adding the designed antenna at 900MHz for a short range wireless communication and to measure the distance can be covered by the antenna. The antenna design's performance will focus on return loss, directivity, gain, radiation pattern and it will be simulated and tested by using CST Studio Suite software.

1.5 SCOPE OF WORK

i. To design Microstrip Planar antenna and simulate an efficient antenna which will work at 900MHz by using CST Studio Suite software.
ii. To fabricate and validate the designed antenna at 900MHz and convenient with the RF module.
iii. To measure the distance can be covered by the antenna to transmit data by doing the field work.

1.6 BRIEF EXPLANATION ON METHODOLOGY

Many research on the project need to be done in order to ensure that the project will run seamlessly. Firstly, need to learn a lot of theoretical concept regarding antenna and short range device (SRD). From the reading, identify the type of antenna and method can be used to design that type of antenna. After that, synthesize the physical parameter of the antenna and proceed with the designing by using CST

Studio Suite. Next, simulate the antenna model, if the model did not fulfill all the expected parameter, need to design the new model. When the model optimizes all the expected parameter, the process can be proceeding with the fabrication and testing the antenna either it can produce the expected parameter. If it can produce the expected output, the design can be analyzing and validate. Else, need to fabricate the new one.

1.7 THESIS PLAN

Chapter 1 – In this chapter, briefly explain about the introduction of the project. Some of the information and explanation about the antenna and short range device (SRD). This chapter also included the problem statement, objectives and scope of the project.

Chapter 2 – In this chapter, the literature is where the explanations of past research and journal which related with this project. Past research included the results, formulas used and calculation.

Chapter 3 – Methodology is a guideline to complete and run the project smoothly. Start with the research on the related antenna and SRD which fulfils all the requirement in order to get the desired results.

Chapter 4 – In this chapter, it will present all the data and results from the simulation. There will also a discussion about the results.

Chapter 5 – There are suggestion and future work plan based on this project. As well as, the explanation of overall conclusion for the whole project.

CHAPTER II

LITERATURE REVIEW

This chapter will explain on the fundamental concept and theory of the antenna and short range device. The overall parameters will be discussed as well as each of its contribution to an antenna performance adding with the technique used in the preparation and designation of the antenna.

2.1 ANTENNA DEFINITION

IEEE Standards Association defines the antenna as "a part of transmitting or receiving system that is designed to radiate or to receive electromagnetic waves"[10]. Webster's 1913 Dictionary defines antenna as "a metallic device, variously shaped, designed for the purpose of either transmitting or receiving radio waves, as for radio or television broadcasting, or for transmitting communicating signal's [11]. In the other word, antenna is an electrical devices designed to sends and receives signal.

2.2 ANTENNA CONCEPT

Two important antenna parameters are the gain and the impedance bandwidth. The gain describes the directional property of an antenna while the impedance bandwidth describes the range of frequencies within which the voltage standing wave ratio is below a certain value. This value is usually taken as 2 in academia and 1.5 in industry. The abbreviation for voltage standing wave ratio is VSWR or SWR. Table 2.2.1 shows the typical values of these two parameters for the conventional antenna elements.

One method of obtaining high gain antennas is to use an array of fed elements, all of which are connected to a source. A linear array is one with the elements arranged in a straight line. The elements can also be arranged in a plane, resulting in a planar array. The element spacing is usually about half a wavelength. In theory, for a given spacing, the gain can be made as high as one wishes by increasing the number of elements. Another method of obtaining high gain antennas is to use a parabolic reflector, with the feed antenna at the focus. This antenna is also known as a dish. For a given frequency, the gain is proportional to the diameter of the dish. In the theory, the gain can be made as high as one wishes by increasing the dish diameter

The simplest forms of antenna polarization are vertical and horizontal because they both fall into a category which known as linear polarization. Most of antennas radiate either in linear or circular polarization. Linear polarized antenna radiates wholly in one plane containing the direction of propagation. While circular polarization is more difficult to visualize compare to linear polarization. In circular polarized antenna, the plane of the polarization will rotate in a circle to make one complete revolution during one period of the wave. The rotation will be in clockwise or counterclockwise. If the rotation is in clockwise, the sense is called as right-hand-circular (RHC) and if it is rotate in counterclockwise the sense is called as left-hand-circular (LHC). There is another form of polarization which known as elliptical

polarization. Elliptical polarization occurred when there is a mix of linear and circular polarization.

An antenna is a passive device which it does not offer any external power to the signal. Instead, an antenna simply redirects the energy it receives from the transmitter. The redirection of this energy will effect of providing more energy in one direction and less energy in all other directions.

Element	Typical gain	Typical bandwidth (VSWR < 2)
Half-wave dipole/Folded dipole	2dB	8 – 16%
Quarter-wave monopole	5dB	8 – 16%
One wavelength loop	4dB	10%
Yagi (Dipole + parasitics)	12dB	5%
Dipole + corner reflector	12dB	8 – 16%
Helical antenna	16dB	70%
Horn antenna	20dB	20%

Table 2.1: Typical gain and bandwidth of conventional antenna elements[6]

2.3 BASIC CHARACTERISTICS OF MICROSTRIP PATCH ANTENNA [6]

Microstrip antennas have a large number of applications despite their limitations. In some cases, pattern or bandwidth requirements can only be met with planar antennas which are not a traditional microstrip configuration. We will generally refer to these as a printed or planar antennas. In some cases, microstrip transmission line may be integrated with an antenna and so it is often still called a microstrip antenna.

Microstrip antennas received considerable attention starting in the 1970s. The general structure of a microstrip is illustrated in figure 2.1. A conducting strip (microstrip line) with a width W and a thickness t is on the top of a dielectric substrate that has a relative dielectric conctant ε_r and a thickness h, and the bottom of the substrate is a ground (conducting) plane.

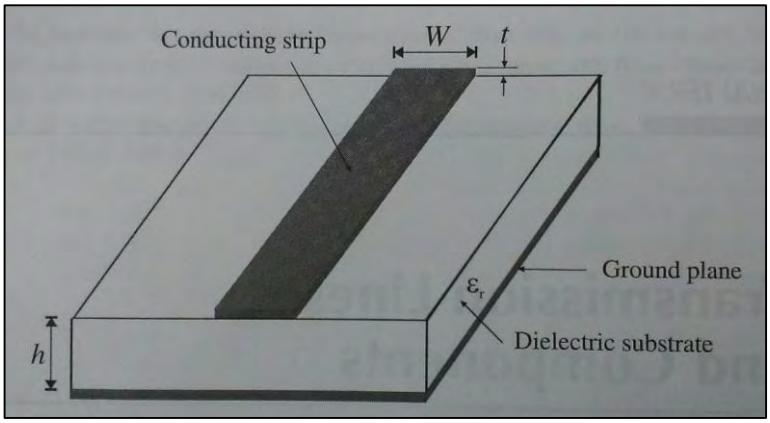

Figure 2.1: General microstrip structure

There are numerous substrate that can be used for the design of microstrip antennas, and their dielectric constants are usually in the range of $2.2 \leq I_r \leq 12$. The most desirable for good antenna performance are thick substrate whose the dielectric constant is in the lower end of the range because they provide better efficiency, larger bandwidth, loosely bound fields for radiation into space, but at the expense of larger element size. The thin substrate with higher dielectric constants are desirable for microwave circuitry because they require tightly bound fields to minimize undesired radiation and coupling, and lead to smaller element sizes. However, because of their greater losses, they are less efficient and have relatively smaller bandwidths. Since the microstrip antennas are often integrated with other microwave circuitry, a compromise has to be reached between good antenna performance and circuit design. Microstrip antennas are also referred to as patch antennas. The radiating elements and the feed lines are usually photo etched on the dielectric substrate. The radiating patch may be square, rectangular, dipole (thin strip), circular, elliptical, triangular, disc sector, circular ring and ring sector. All those shapes of microstrip patch element is shown in figure 2.2.