DUAL BAND DIELECTRIC RESONATOR ANTENNA OPERATES AT 2.4 GHz AND 5.4 GHz

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Dedicated to my beloved Wife, Kids, Father, Mother and Family Members. Without their support, I'm nobody.

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ABSTRACT

This thesis explains about the design of dual band antenna by using a dielectric material. The antenna is made from a dielectric resonator antenna (DRA) with a permittivity, ε_r, is 10. Rectangular DRA is used to ease the fabrication process. The operating frequency chosen to be design is 2.4 GHz and 5.4 GHz. Notched DRA technique is used for dual band application purpose. In order to drive the antenna to function, it is placed on top of the ground plane. FR4 board is chosen as a ground plane for this research with a dielectric constant is 4.6. Alphabet "I" is used in this study for the aperture coupling at the substrate. Meanwhile, for the feeding line, microstrip line is used to match with 50Ω network. The simulation is run by using Computer Simulation Technology (CST) software. This software provides 3D design of the antenna and easier visualizes the antenna properly. The result is then compared to the actual result obtained by measurement. The fabricated product is attached to a network analyzer via SMA connector. S11 output obtained during simulation and measurement will be discussed thoroughly.

ABSTRAK

Tesis ini menerangkan tentang reka bentuk antena dwi jalur dengan menggunakan bahan dielektrik. Antena itu dibuat daripada antena resonator dielektrik (DRA) dengan ketelusan, ε_r ialah 10. Segiempat tepat DRA digunakan untuk memudahkan proses fabrikasi. Frekuensi operasi yang dipilih untuk reka bentuk adalah 2.4 GHz dan 5.4 GHz. Teknik takuk DRA digunakan untuk mendapatkan antenna dwi jalur. Bagi membolehkan antena berfungsi, ia diletakkan di atas satah bumi. Papan FR4 dipilih sebagai satah bumi untuk kajian ini dengan pemalar dielektrik ialah 4.6. Huruf "I" digunakan dalam kajian ini untuk gandingan "aperture" pada substrat. Sementara itu, bagi talian suapan, selaras mikrostrip digunakan untuk dipadankan dengan rangkaian 50Ω . Simulasi dijalankan dengan menggunakan perisian "Computer Simulation Technology" (CST). Perisian ini menyediakan reka bentuk 3D antena agar mudah membayangkan bentuk antena dengan betul. Hasilnya kemudian dibandingkan dengan hasil sebenar yang diperolehi oleh pengukuran. Produk yang direka dilampirkan kepada penganalisa rangkaian melalui penyambung SMA. Hasil keluaran S11 yang diperolehi semasa simulasi dan pengukuran akan dibincangkan.

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DRA	-	Dielectric Resonator Antenna.
ε_r	-	Permittivity.
CST	-	Computer Simulation Technology.

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CHAPTER 1

INTRODUCTION

1.1. Introduction.

Dielectric resonator antenna (DRA) study and application has been widely used for more than 25 years ago [1]. It was started in the early 1980's. The first study was conducted by Stuart Long and Liang Shen. Their investigation involved printed circuit radiators. These investigations sponsored by US Army Research Office. From their investigation, it was found that microstrip antenna is less efficient at high frequencies. It is due to high ohmic loss and increase in power consumption.

In summer 1981, Stuart Long proposed to study cylindrical dielectric resonator. In this study, he concludes that choosing a correct dimension and dielectric constant can produce an efficient antenna with a maximum radiation.

Stuart Long's study is then furthered by Mark McAllister. He studied rectangular and hemispherical DRA shape. Apart from that, he also varied the size and the materials used in DRA. The first paper that he studied was "The Resonant Cylindrical Dielectric Cavity Antenna" [2]. After that, he came out with his second paper title "Rectangular Dielectric Resonator Antenna" [3]. Even though this is his second paper, but so happen that this is the first paper to be printed out. From there, this is where the term "Dielectric Resonator Antenna" comes from. After several researches, this term is then standardized to avoid any misconception.

Over the years, the studies of DRA become famous throughout the whole world. People are more concern of its performance and try to fully utilize the DRA characteristics [4]. The

study involved design for compact DRA, wide impedance bandwidth, low profile and high gain antenna. Besides, the fabrication technique also has been studied.

DRA is basically made from dielectric material with no metallic loss [5]. It comes in various shapes [6] such as cylindrical, hemispherical, elliptical, pyramidal, rectangular and triangular as shown in Figure 1.1. These are common DRA shapes used in study. In order to make DRA radiates the signal, it needs a mechanism to excite it. Some of the techniques are coaxial probe, microstrip line or coplanar waveguide.

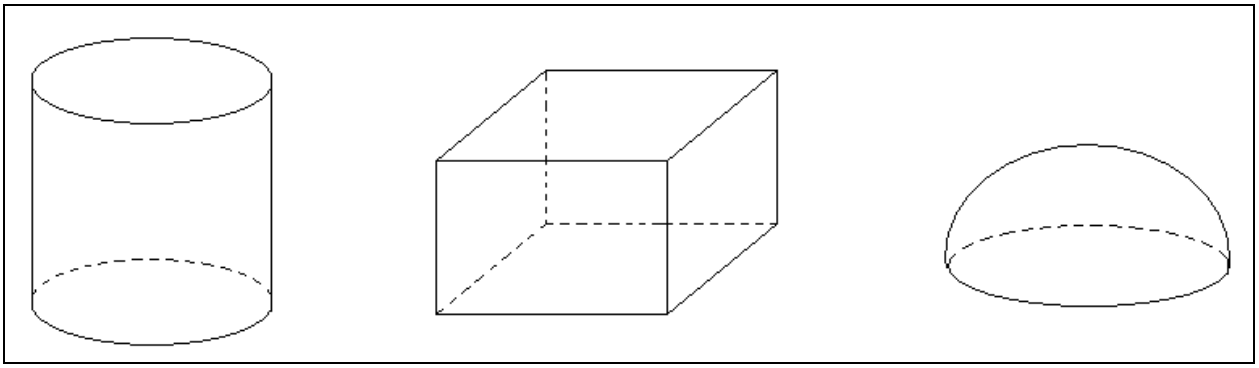

Figure 1.1 : DRA shapes – cylindrical, rectangular and hemispherical.

There are few points of interest DRA is preferred in the design compared to conventional antenna. Conventional antenna requires high power in order for it to operate. Differ with DRA which only requires small amount of power to operate. Besides that, size of the conventional antenna is big rather than DRA size which is small enough to radiate the same signal bandwidth. In terms of cost effectiveness, DRA is the cheapest to implement because of its material. Overall, DRA manage to get a wide impedance bandwidth as well as a high antenna gain.

DRA is an important element in antenna design. When DRA is placed in an open environment, power losses radiate the surrounding field [7]. Due to its size, lightweight and cost effectiveness, DRA become a popular choice in antenna and mobile design. In this project, DRA will be used to test the performance and compared with the simulation result.

1.2. Problem Statement.

Most of the antenna in the market can only cater for a single frequency application. It is using a conventional microstrip antenna. Thus, for application that needs a dual frequency, two separate antennas are needed.

Apart from that, microstrip antenna can only give small bandwidth which is less than 5%. Besides, it needs a large area for the antenna to operate.

Meanwhile, DRA have more advantages compared to microstrip antenna. It can give more than 5% bandwidth and can operate using a smaller size of antenna if compared to microstrip type antenna. Bandwidth enhancement will be emphasize in this paper.

1.3. Objective.

To design, fabricate and measure a high bandwidth rectangular DRA that operates at 2.4 GHz and 5.4 GHz.

1.4. Scope Of Project.

The scope of this project describes the design of a dual band antenna by using a dielectric resonator material. Frequency proposed is 2.4 GHz and 5.4 GHz. The simulation is run using Computer Simulation Technology (CST) software. A notched DRA technique will be used for dual band application. Apart from that, alphabet slot is used as an aperture. The effect of using adhesive when placing DRA on top of ground plane will be study as well.

1.5. Research Methodology.

There are two variables that will determine the size of DRA, which are free space wavelength, λ_0 and dielectric constant, ε_r. The relationship between those variables described in Equation 1.1 below:

$$\frac{\lambda_0}{\sqrt{\varepsilon_r}} \quad \text{… Eq. 1.1}$$

Dielectric constant (ε_r) plays an important role to determine the antenna size. The bigger the value of it, the smaller the size of the antenna would be. Normally, the value for dielectric constant (ε_r) is chosen in between 10 to 100. Figure 1.2 below summarizes overall processes that involved in the project.

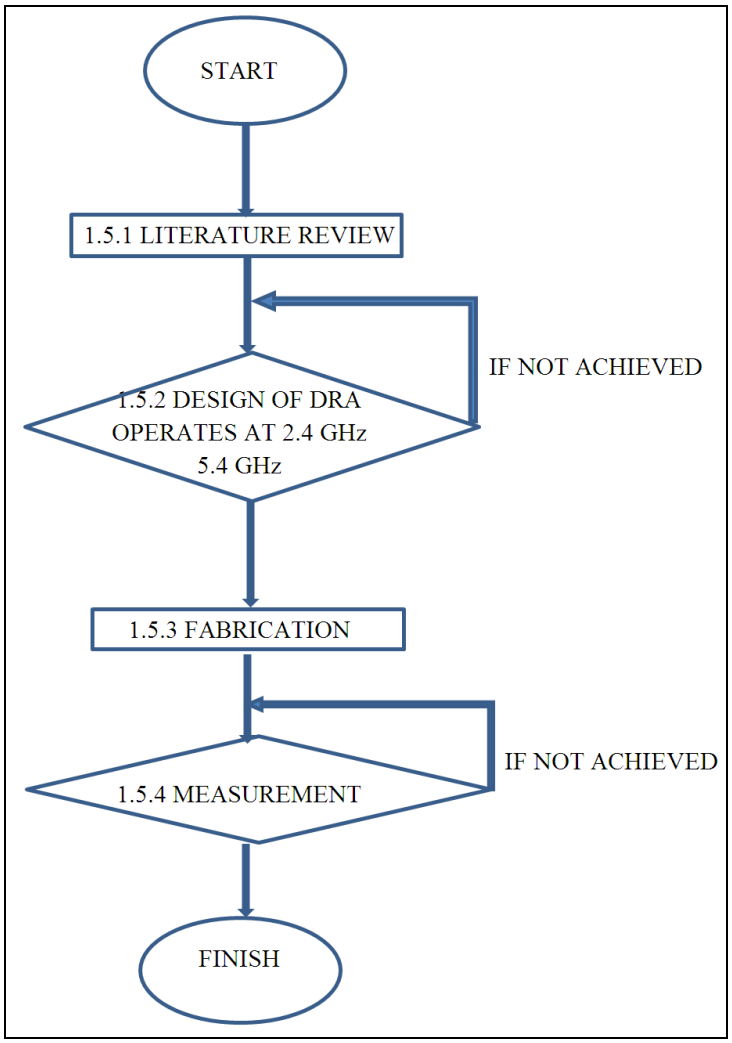

Figure 1.2 : Overall project processes.

1.5.1. Literature review.

In this stage, the basic antenna design has been distinguished. Below are the criteria:

a. Choosing DRA shape.

b. Calculate DRA size.

c. Choosing coupling technique.

d. Calculate the strip line width.
e. Choosing the substrate permittivity.

1.5.2. Design.

After all the necessary criteria have been finalized, the design is then tested by using a computer simulation first. “Computer Simulation Technology” (CST) software is used to verify the design. Simulation is needed to avoid wastage of time, material and others incurred during fabrication process. Return loss from the simulation is captured and verified. If so happen that the design is not according to the specification, the design process needs to be repeated. Should the simulation result satisfy with the specification, then next process can be proceed.

1.5.3. Fabrication.

Layout is then printed to substrate ground plane. Probe is then attached to the strip line to capture the result. Next, DRA is place on top of the ground plane.

1.5.4. Measurement.

The prototype is then place inside anechoic chamber to get accurate result. This chamber is specially design to prevent any noise from interfering the antenna radiation when it is operating. Actual result is then compared to the simulation result obtained from previous stage. The design is confirmed when the actual and simulation result matched with each other. Should the measurement result is differ, then the fabrication process need to re do again.

1.6. Specification.

From all the literature above, the DRA design that will be used in this project is as Table 1.1 below.

Table 1.1 : Design Specification.

DRA Type	Rectangular
Frequency	2.4 GHz / 5.4 GHz
DRA Configuration	Notched
Excitation Method	Microstrip Feed Line
DRA Coupling	Aperture Coupling

The expected result from these configurations would have a waveform similar like Figure 1.3 below. Even at 10dB return loss, the antenna still manages to give the frequency needed for the application. The result for the measurement is taken from the real antenna design. This case is for ideal case. Some noises and spikes should be expected in the real measurement.

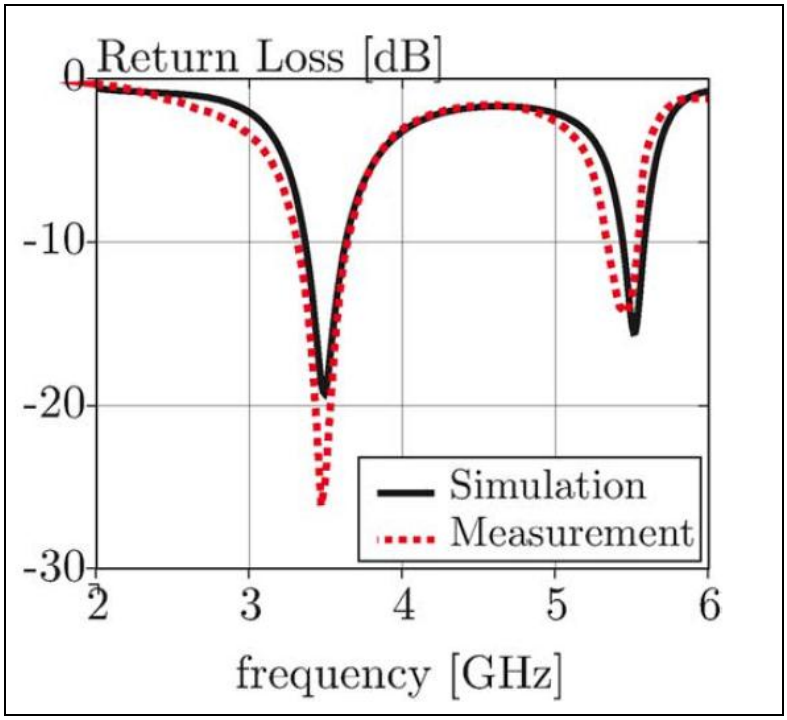

Figure 1.3 : Expected result.

1.7. Thesis Outline.

This thesis is divided into five (5) main chapters that cover research for Dual Band Dielectric Resonator Antenna.

Chapter 2 describes on literature review related to DRA. In chapter 3, it is discussed on methodology to realize the actual product. After that, in chapter 4 it is discussed on simulation and measurement result. Lastly in chapter 5, is a conclusion of the research as well as future work proposed.

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