UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF MICROSTRIP MICROWAVE SENSOR FOR LIQUID CHARACTERIZATION USING SPLIT RING RESONATOR (SRR)

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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I hereby, declared this report entitled Development of Microstrip Microwave Sensor for Liquid Characterization using Split Ring Resonator (SRR) is the results of my own research except as cited in references.

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APPROVAL

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

Signature: ……………………………………………….

Supervisor : PUAN AZIEAN BINTI MOHD AZIZE

ABSTRAK

Pemahaman yang tepat terhadap antena tampalan mikrostrip dan resonator cincin terbelah adalah penting untuk membangunkan pengesan mikrostrip mikrostruktur untuk pencirian cecair menggunakan resonantor cincin terbelah (SRR). Oleh itu, dalam projek ini, satu kaedah untuk membangunkan keuntungan dan bandwidth yang lebih baik dengan struktur resonator cincin terbelah (SRR) untuk meningkatkan prestasi keseluruhan antena. Antena tampalan mikrostrip (MPA) telah menjadi salah satu antena yang paling popular digunakan kerana sifatnya yang padat berbanding dengan tampalan segi empat tepat. Resonator cincin terbelah (SRR) adalah sejenis struktur tiruan yang tidak terdapat dalam sifatnya. Struktur ini menjadi minat di kalangan ramai kerana tindak balas yang luar biasa terhadap gelombang elektromagnetik. Resonator cincin terbelah adalah contoh struktur metamaterial yang mempunyai potensi untuk meningkatkan prestasi komponen dalam gelombang mikro tanpa mengubah bahan atau dengan pemancar tambahan. Segi empat tepat antena tampalan microstrip dengan resonator cincin terbelah telah direka untuk aplikasi perindustrian dan pengesan untuk menguji dalam sampel cecair, di mana frekuensi operasi adalah pada 2.1 GHz. Projek ini dibahagikan kepada beberapa bahagian. Pertama, mereka bentuk antena dengan menggunakan CST Microwave Studio di mana ia melibatkan rangkaian yang hampir sama dengan saluran pemancaran mikrostrip. Kemudian, simulasi dilakukan untuk melihat corak kehilangan, jalur lebar, dan corak radiasi antena. Akhirnya, projek ini akan diteruskan dengan fabrikasi antena menggunakan cecair sebagai sampel dan membuat perbandingan antara simulasi dan pengukuran.

ABSTRACT

Proper understanding of microstrip patch antenna and split ring resonator is important to develop a microstrip microwave sensor for liquid characterization using split ring resonantor (SRR). Therefore, in this project, a method for developing a better reflection loss performance by split ring resonator (SRR) structure in order to increase the overall performance of the antenna. Microstrip patch antenna (MPA) has become one of the most popular antennas is used due to their compact in nature compared to rectangular patches. Split ring resonator (SRR) is a type of artificial structure that is not found in the nature. This structure has become an interest among many due to its extraordinary response to electromagnetic waves. The split ring resonator is an example of a metamaterial structure which has the potential to improve the performances of components in microwave without changing the material or with additional radiators. The rectangular of microstrip patch antenna with split ring resonator has been designed for industrial and sensing application in order to test in the sample of liquid, where the operating frequency is at 2.1 GHz. This project was divided into a few parts. Firstly is designing the antenna using CST Microwave Studio where it involves a matching network with microstrip transmission feeding line. Then, simulations were done to observe the return loss, bandwidth, and radiation pattern of the antenna. Lastly, this project will be proceeding with fabrication the antenna using liquid as the sample and compare between the simulation and measurement.

DEDICATION

To my beloved parents JOHAN BIN ABDUL KADIR and BUKINAH BINTI PAIDI

Supervisor PN. AZIEAN BINTI MOHD AZIZE

&

Dear friends

NOOR SYAZWANI BINTI AHMAD RAZANI,

NUR HIDAYAH BINTI MOHD YUSOFF,

SYAFIQ AI'MULLAH BIN SABARUDDIN,

MUHAMMAD HAZIM BIN MOHD RAZIF,

MUHAMMAD FAHMI IZZAT BIN ABDUL LATIFF

and

MUHAMMAD MUTHANNA BIN JUMADIL.

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w	-	Width
l	-	Length
ε	-	Electric Permeability
μ	-	Magnetic Permeability
ε_r	-	Dielectric Constant or Permittivity
h	-	Substrate thickness
tan δ	-	Loss tangent
G	-	Gap between transmission line and S-SRR
Ω	-	Ohm
dB	-	Decibel
MHz	-	Mega Herts
GHz	-	Giga Herts
T_x	-	Transmitter
R_x	-	Receiver

LIST OF ABBREVIATIONS

MPA	Microstrip Patch Antenna
SRR	Split Ring Resonator
S-SRR	Single Split-Ring Resonator
RL	Return Loss
SNG	Single Negative
MNG	Mu-Negative
ENG	Epsilon-Negative
VNA	Vector Network Analyzer
CST	Computer Simulation Technology
FR4	Flame Retardant 4
UV	Ultra Violet
PCB	Printed Circuit Board
SMA	SubMiniature version A

CHAPTER 1

INTRODUCTION

1.1 Introduction

In this chapter, the short insight of a development of microstrip microwave sensor for liquid characterization the usage of split ring resonator (SRR) has been discussed. This encompasses as what issues arises that triggers the motivation for the project improvement primarily based on widespread specifications, scope of project and also expected outcome at the of this project.

1.2 Project Background

An antenna is a device designed used to radiate or receive electromagnetic waves, corresponding this sources of radio frequency signal on conductor into the electromagnetic waves. However, an antenna is a vital instrument to transport electromagnetic energy from transmitting source to the antenna or from the antenna to the receiver, it additionally frequently called radiant system. A good antenna design is an antenna that can fulfill system requirements and enhance overall system performance. The actual knowledge is modified which it can be seen by a few sort of modulation, and still carried or conducted with the aid of a cable to the antenna.

The proposed microstrip antenna was being launched in the year of 1950's. Eventually, inside the year of 1970's it received an important and was utilized in several of application of that time. The microstrip patch antennas have conformal and planar structure, compactness, low-profile, a directive with high transmission efficiency, low profile, light-weight, low cost and simplicity of integration with microwave circuit and portable communication equipment, this is because it reveals an area in such applications since 1970's. Microstrip antenna is characterized with the aid of a large number of physical parameter rather than is conventional microwave antennas. Microstrip antenna also can be designed with different geometrical shapes and dimensions, as an instance as proven in Figure 1.1 below (Sulaim, 2012).

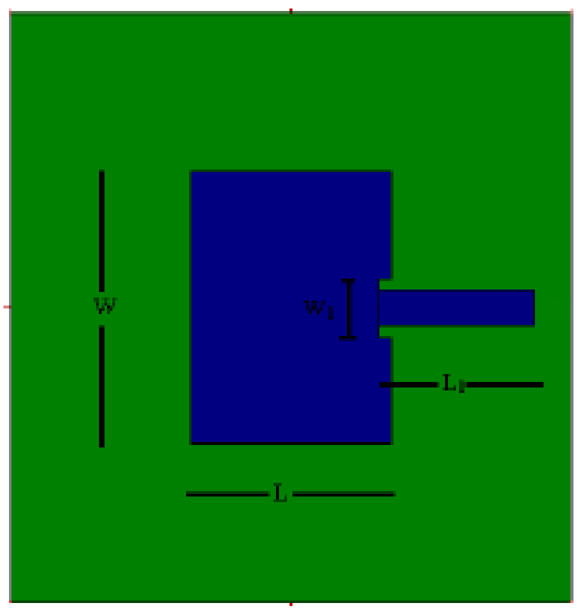

Figure 1.1: Example of rectangular shape microstrip patch

This project is that specialize in designing a development of microstrip microwave sensor for liquid characterization using split ring resonator (SRR) to determine the dielectric properties inside the materials primarily based on specific design for a high sensitivity and accuracy of the sensor capable to detect a liquid as a material (Rahman, Zakaria, Rahim, Dasril, & Mohd Bahar, 2017). The split-ring resonators (SRRs) structure is used to produce the positive permittivity or/and negative permeability as shows in Figure 1.2. This structure may be applied in many applications including antenna, oscillator, radio frequency (RF) switch, microwave absorber, filter, amplifier, and frequency selective surface (FSS). The split- ring resonator's integration into the components of microwave can improve the performance of the device, together with industrial application and sensing application. In the year of 1999, John Pendry has analyzed a realistic way to create left-handed metamaterials (LHM) which no longer followed the right-hand rule. Surprisingly, both Smith and Shelby had proven the work of Veselago before this. In the year of 2000, there has been the primary left-hand medium (LHM) become developed with both negative permittivity and positive permeability by using combining this structure with the array of strip wires (SW).

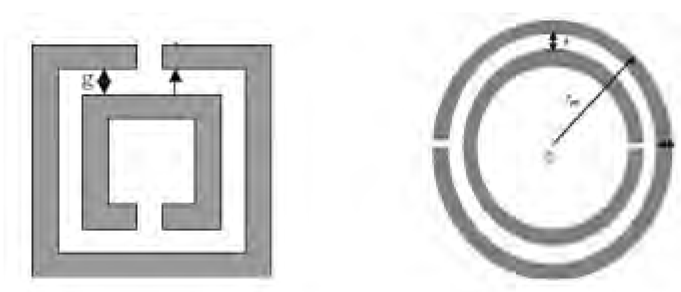

Figure 1.2: The antenna design for split-ring resonator structure

In fact, split ring resonator has become a popular topic and between the researchers since 1999. The split ring resonator's integration onto the components of the microwave that can be increase the performance of the system or device, such as industrial and sensing application.

1.3 Problem Statement

This work examined the importance of the components in sensing applications such as biomedical with standard specification and to obtain a good performance result. There are having difficulties for detecting of the different of liquids through the sensing area. One of the main components that have been embedded in the sensing applications is the antenna. At present, antenna must have the ability or capable to work with detection on liquid characterization to the sensing application. This is due to the demanding of technologies, the development of technology requires some specifications such as compact size which is low profile antenna need to be improved. The microstrip patches antenna has been getting more attention because of the simple design and smooth fabrication process. This microstrip patch antenna provides a sample of microtsrip patch sensor for testing and monitoring liquid materials characterization by the resonant frequency. This is because of the additional element that is used as a metamaterial structure in creating different frequency modes between the microstrip transmission line and split ring resonator (SRR).

There are not many specifications for designing that can be apply based on liquid sensor. Hence, the split ring resonator has the capability to prevent the fabrication of larger sized antenna by means of reducing the resonant frequencies inside the antenna. The split ring resonator also can be used to control the location of the resonance frequency that depends on size and location configuration without affecting other resonance frequencies.

1.4 Objectives

The objectives of the project are determined as within the following:

1. To study microstrip microwave sensor for liquid characterization.
2. To develop a microstrip microwave sensor for liquid characterization by using a new structure of single split ring resonator (S-SRR) at frequency 2.1 GHz.
3. To analyze the measurement on the simulation results and fabricated antenna.

1.5 Scope of Project

The scope of project is to develop a microstrip microwave sensor for liquid characterization using split-ring resonator (SRR) that operating at frequency 1.9 GHz to 2.5 GHz. The single split ring resonator (S-SRR) will be used as a unit cell in this project. All antenna designed work is simulated with the aid of the usage of CST software in order to analyse basic parameters along with return loss, gain, radiation pattern, directivity and efficiency. Then, the fabrication method goes to be done by using exploitation chemical etching technique. This microstrip patch antenna will be fabricated at Flame Retardant 4 (FR-4) board that has material constant of substrate 4.3, tangent loss of substrate 0.019, thickness of substrate 1.6mm and thickness of copper 0.035mm. After the fabrication method, measurement of antenna parameter consisting of return loss, radiation pattern, gain, and directivity are going to be measured by means of the usage of network analyzer, signal generator, spectrum analyzer, and anechoic chamber that are provided within the laboratory.