DESIGN OF MICROSTRIP TRI-RING ANTENNA

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Tajuk Projek :
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Special dedication to my beloved family especially my late father…

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ABSTRACT

An antenna is a transducer designed to transmit or receive electromagnetic waves. A microstrip antenna is defined as an antenna which consists of radiating patch on one side of a dielectric slab and a ground plane on the other side. A Microstrip Tri-ring Antenna(MTA) is designed in order to obtain the mutli-frequency antenna that can operates at frequency 2.4 GHz, 5.2GHz and 10GHz. Method of analysis that used in this project is parametric study. This MTA is fed by coaxial probe feed and FR4 board is used as a substrate with the specified information include the dielectric constant of substrate ($\epsilon_r = 4.9$), substrate height (h=0.035mm) and loss tangent ($\delta = 0.019$). The antenna has been design using CST Microwave Studio software. The main parameters concerned are return loss (S_{11}) and resonant frequency. A prototype of this MTA has been built and tested by Vector Network Analyzer (VNA). Then the measurement result obtained would be compared to the simulation result. Troubleshooting process is carried out regarding to the difference between both of them and would be discussed in the result part.

ABSTRAK

Antena merupakan satu transduser yang dicipta untuk menghantar dan menerima gelombang elektromagnetik. Antena mikrojalur didefinasikan sebagai antena yang mengandungi radiasi patch pada salah satu sisi ‘slab’ dielektrik dan satah bumi pada permukaan yang lain. Antena microjalur tiga gelung ini di cipta untuk menghasilkan antenna pelbagai frekuensi yang dapat beroperasi pada frekuensi 2.4GHz, 5.2GHz dan 10GHz. Kaedah analisis yang digunakan dalam projek ini adalah pengajian parameter. Antena mikrojalur tiga gelung ini menggunakan teknik ‘coaxial probe feed’ dan papan FR4 diguna sebagai substrate dengan informasi yang khusus termasuk pemalar dielektrik($\epsilon_r = 4.9$), tinggi substrate(h=0.035mm) dan kehilangan tangent($\delta = 0.019$). Antena ini dicipta dengan menggunakan perisian computer, CST Microwave Studio. Parameter utama yang diberi perhatian adalah S_{11} dan frekuensi resonan. Prototaip antenna mikrojalur tiga gelung ini dibina dan diukur menggunakan Vector Network Analyzer (VNA). Kemudian keputusan pengukuran dibandingkan dengan keputusan simulasi. Proses mengenalpasti masalah dibuat berikutan terdapatnya perbezaan diantara kedua-duanya dan akan dibincangkan di bahagian keputusan,

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ABBREVIATIONS LIST

Γ	-	Reflection Coefficient
S_{11}	-	Return Loss
ϵ_r	-	Dielectric Constant
BW	-	Bandwidth
CP	-	Circular Polarization
CST	-	Computer Simulation Technology
dB	-	Decibel
dBd	-	Decibels Over Dipole
dBi	-	Decibels Over Isotropic
EM	-	Electromagnetic
FDTD	-	Finite-Different Time Domain
FEM	-	Finite-Element Method
GPS	-	Global Positioning Satellite
h	-	Substrate height
l	-	Length
LAN	-	Local Area Network
Lavg	-	Average Circumferential Length
LHCP	-	Left Hand Circularly Polarized
MIC	-	Microwave Integrated Circuit
MoM	-	Method of Moments
MTA	-	Microstrip Tri-ring Antenna
Q	-	Quality Factor
R1	-	Outer Radii
R2	-	Inner Radii
RF	-	Radio Frequency
RHCP	-	Right Hand Circularly Polarized

TV	-	Television
UV	-	Ultraviolet
VNA	-	Vector Network Analyzer
VSWR	-	Voltage Standing Wave Ratio
W	-	Width
Zin	-	Input Impedance
Zo	-	Characteristic Impedance
λ	-	Wavelength
δ	-	Loss tangent

CHAPTER 1

INTRODUCTION

This chapter provides the introduction of the project, objectives, scope of work and problem statements of this project.

1.1 Overview of Antenna

An antenna is a transducer designed to transmit or receive electromagnetic waves. In other words, antennas convert electromagnetic radiation into electrical current, or vice versa. Antennas generally deal in the transmission and reception of radio waves, and are a necessary part of all radio equipment. Antennas are used in systems such as radio and television broadcasting, point-to-point radio communication, wireless LAN, cell phones, radar, and spacecraft communication. Antennas are most commonly employed in air or outer space, but can also be operated under water or even through soil and rock at certain frequencies for short distances.

Physically, an antenna is an arrangement of one or more conductors, usually called elements in this context. In transmission, an alternating current is created in the elements by applying a voltage at the antenna terminals, causing the elements to radiate an electromagnetic field. In reception, the inverse occurs: an electromagnetic field from another source induces an alternating current in the elements and a corresponding voltage at the antenna's terminals. Some receiving antennas (such as parabolic and horn types)

incorporate shaped reflective surfaces to collect the radio waves striking them and direct or focus them onto the actual conductive elements.

The IEEE Standard Definitions of Terms for Antennas defined antenna as means for radiating or receiving radios waves. In other words the antenna is the transitional structure between free-space and a guiding device. Antenna which can work in more than one frequency region either for transmitting or receiving electromagnetic (EM) waves are termed as Multiband Antenna [1].

1.2 Objective

The main objective of this project is to design a tri-ring antenna that can operates at three frequencies which are 2.4GHz, 5.4GHz and 10GHz. The other objectives of this project are to get higher bandwidth and gain.

1.3 Scope of Works

In this project, the tri-ring microstrip antenna is designed which have opportunity can operate at multiple frequency which are 2.4GHz, 5.4GHz and 10GHz. The simulation is carried out until the result obtained meets the required specifications. Computer Simulation Technology (CST) software is used for simulation to measure the parameters (i.e. frequency, gain, bandwidth and return loss) of antenna.

Then, the process continued by fabrication process using etching technique on FR4 board, where the actual dimension is fabricated. Vector Network Analyzer is used for measurement to measure the parameters (i.e. frequency, gain, bandwidth and return loss) of antenna. Finally, the comparison between the simulation and measurement results is investigated.

1.4 Problem Statement

With technology advancement, wireless transmission system has become prevalent amongst electronic products. However, the traditional antenna can no longer satisfy the needs for the transmission process of large data volume, such as the multi-media files; therefore, an antenna with a multiple frequency is needed [16].

Microstrip patch antennas patch antenna have a disadvantage of narrow bandwidth typically 1-5 % impedance bandwidth, dielectric and conductor losses can be large for thin patches resulting in poor antenna efficiency and sensitivity to environmental factors such as temperature and humidity [1].

1.5 Methodology

Appendix A represents the flow of works involved in constructing the tri-ring antennas that can operates at multiple frequencies. Firstly, study about parameters of antenna such as matched impedance, gain, frequency, bandwidth, return loss, amplitude of radiation pattern and feeding technique must be taking into considerations when designing the antenna. These parameters determine the performance of the antenna designed.

The tri-ring antenna is designed using the parametric study method. The dimension of the ring antenna such as width and the location of the coaxial probe feed is analyzed. The initial dimension of ring antenna is obtained from the existing ring antenna.

Then, the simulation of the design is carried out by using Computer Simulation Technology (CST) Microwave Studio software. The effect of width, radius and location of coaxial probe feed with return loss and frequency is analyzed. This antenna used coaxial probe as a feeding method because the ease of matching the characteristic impedance to that antenna.

After that, the flow of work continues with the fabrication process. This process begins with the layout printed of tri-ring antenna. After that, the etching process is carried

out accordingly to the antenna layout print out from the simulation. At this point, the etching is implemented accordingly to the actual dimensions of the printed layout.

Finally, the antenna is measured using a Vector Network Analyzer (VNA) to compare the simulations results with the measurements results.

CHAPTER 2

LITERATURE REVIEW

This chapter explained the theory of antenna such as types of antenna, explanation about microstrip antenna, types of feeding technique and others. This chapter also included the review of the various ring antenna types.

2.1 Introduction of Microstrip Antenna

A microstrip antenna is defined as an antenna which consists of radiating patch on one side of a dielectric slab and a ground plane on the other side. Figure 2.1 shows a basic configuration of the microstrip antenna.

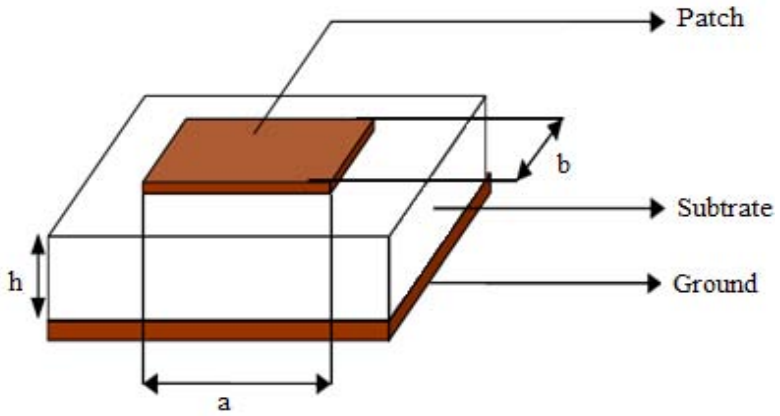

Figure 2.1: Basic Microstrip Antenna Configuration [1]

Microstrip antennas are used in a broad range of applications from communication systems such as radars, telemetry and navigation field due to their simplicity, conformability, low manufacturing cost, and very versatile in terms of resonant frequency, polarization, pattern and impedance at the particular patch shape and model [1].

Microstrip antennas have been used in various configurations such as square, rectangular, circular, triangular, trapezoidal, elliptical etc. In microstrip antenna designs, it is depends strongly on the dimensions of the patch, the location of the feed point, the excitation frequency, the permittivity of the substrate and its thickness.

Microstrip antennas radiate due to the fringing fields between the patch and the ground plane. Figure 2.6 shows the fringing fields in a microstrip patch antenna [1].

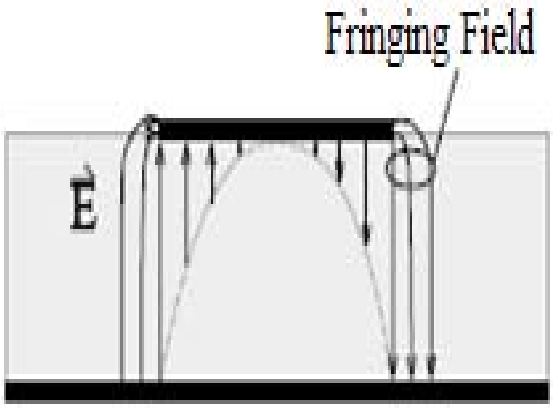

Figure 2.2: Fringing Fields within the Microstrip Antenna [1]

The fields at the end of the patch can be splited into tangential and normal components with respect to the ground plane. The normal field components are out of phase because the length of the patch is approximately $\lambda/2$. Therefore their contribution to the far field in broadside direction cancels each other. The tangential field components, which are in phase, combine to give the maximum radiated field normal to the surface of the patch [2].

Due to the fringing fields between the patch and the ground plane, the effective dimensions of the antenna are greater than the actual dimensions. For example the radius effective of the patch is greater than the physical radius. In this case fringing effect makes the radius effective look larger due to the fact that some of the waves travel in the substrate and some in the air [1]. Besides that, if the frequency of the wave is at a resonant point then the electric fields around the edges have the maximum amplitude. Thus, the radiated electric fields will be at a maximum at resonant frequencies.

2.2 Basic Microstrip Antenna Properties

In microstrip antenna, there several important properties that need to be considered including resonance frequency, bandwidth, input impedance, radiation pattern, return loss, directivity, gain and polarization.

2.2.1 Resonance Frequency

The resonant frequency and electrical resonance is related to the electrical length of the antenna. The electrical length is usually the physical length of the wire multiplied by the ratio of the speed of wave propagation in the wire. Typically an antenna is tuned for a specific frequency, and is effective for a range of frequencies usually centered on that resonant frequency. Antennas can be made resonant on harmonic frequencies with lengths that are fractions of the target wavelength. Some antenna designs have multiple resonant frequencies, and some are relatively effective over a very broad range of frequencies [31].

2.2.2 Bandwidth

The bandwidth of an antenna is the range of frequencies over which it is effective, usually centered around the resonant frequency. The bandwidth of an antenna may be increased by several techniques, including using thicker wires, replacing wires with cages