LOG PERIODIC ANTENNA DESIGN

SITI NORHIDAYAH BINTI HJ. MOHAMED

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Saya SITI NORHIDAYAH BINTI HJ. MOHAMED

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Specially for my loving umi, abah and to all my sisters and brother.

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ABSTRACT

This project presents the design of microstrip Log Periodic Antenna. The antenna was designed at frequency between 2.0GHz and 2.4GHz for Wireless Area Local Network (WLAN) and International Mobile Telecommunication 2000 (IMT2000). The main problem of microstrip antenna is the narrowband characteristic up to 3% of bandwidth. The objective of this project is enhance the bandwidth of microstrip antenna. The constructing of this antenna including design, simulate and fabricate a log periodic antenna for broadband application. First, the single element for each frequency have been designed. Then, the three elements, five elements and seven elements have been designed with scaled by scaling factor of 1.05, 1.03 and 1.02. After that, the design antenna have been simulated by using Microwave Office software (AWR 2006) to performs the simulation of return loss, reflection coefficient, bandwidth and gain. The experimental validation to verify the performance of the designed antenna was done using the Advantest R3767 CG Network Analyzer and Spectrum Analyzer. The properties of antennas such as bandwidth, gain and half power beamwidth have been investigated and compared between simulation and measurements. The design provided the bandwidth better than -20.22% in the working bandwidth of five elements. Besides, the radiation pattern of three elements shows the HPBW at 63° for H-co polarization. Then, the five elements show the HPBW is 88° at frequency 2.31GHz for H-co polarization.

ABSTRAK

Projek ini bertujuan membina sebuah antena berkala log pada frekuensi 2.0 GHz dan 2.4GHz untuk *Wireless Area Local Network (WLAN)* dan *International Mobile Telecommunication 2000 (IMT2000)*. Masalah utama antenna mikrostrip ialah lebar jalur sempit dengan nilai 3%. Objektif utama projek ini adalah untuk membina antena yang dapat meningkatkan lebar jalur antena mikrostrip. Antena ini dibina dengan merekabentuk, simulasi and fabrikasi antenna berkala log untuk penggunaan lebar luas. Pertama, setiap elemen tunggal pada setiap frekuensi direka. Kemudian, tiga elemen, lima elemen dan tujuh elemen direka dengan penskalaan faktor 1.05, 1.03 dan 1.02. Kemudian, antenna yang direka disimulasi dengan menggunakan perisian *Microwave Office(AWR2006)* menghasilkan *return loss*, *reflection coefficient*, lebar jalur, gandaan. Eksperimen yang dijalankan untuk menilai prestasi antena ini dijalankan melalui Rangkaian Penganalisis dan Spektrum Penganalisis. Keputusan pengukuran antena berkala log adalah sepadan dengan keputusan simulasi seperti lebar jalur luas, gain yang tinggi adalah dijangka untuk penggunaan antenna dalam komunikasi mobil. Ia menyediakan penyesuaian yang lebih baik pada -20.22% dalam frekeunsi lebar jalur bekerja.

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LIST OF ABBREVIATIONS

w	Width
h	Dielectric Thickness
t	Copper Thickness
L	Length
L_{eff}	Effective Length of the Patch
f_r	Resonance Frequency
yo	Feed Line
λ	Wavelength
ε_r	Dielectric Constant
ε_o	Permittivity of Free Space
μ_o	Permeability of Free Space
Zo	Load Impedance
ΔL	Dimensions of the patch along its length
w/h	Width-to-height ratio
a	Radius
ℓ	Inset Feed
Q	Antenna Quality Factor
dB	Decibel
dBi	Decibel Isotropic
RL	Return Loss
G	Gain
Pr	Radiated Power
Pi	Input Power

Rin	Real Part
Xin	Imaginary Part
Cc	Coupling Capacitance
S	Distance
MPA	Microstrip Patch Antenna
EM	Electromagnetic
PCMA	Proximity Coupled Microstrip Antenna
IEEE	Institute of Electrical and Electronics Enginerring
WLAN	Wireless Local Area Network
MWO	Microwave Office
FR4	Frame Resistance 4
ξ	Tangent Loss
MMIC	Monolithic Microwave Integrated Circuit
TEM	Transverse Electric-Magnetic
TX line	Transmission Line
UI	User Interface
UV	Ultra Violet
EM	Electromagnetic
S_{11}	Input Port 1 to Output Port 1
VSWR	Voltage Standing Wave Ratio

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This report documents the design, simulate, fabricate and testing a log periodic antenna at frequency 2.4GHz for broadband application and at frequency 2.0GHz for IMT 2000 (International Mobile Telecommunication) band using Microwave Office. IMT 2000 consist two types that is core Frequency Band and Extension Band. Further, for IMT 2000-Core Frequency Band is operating in the FDD mode in the bands 1920-1980MHz paired with 2110-2170MHz with the mobile station transmitting [1].

The design is based on the log periodic antenna theory. The design guidelines as well as simulated, fabricated and measured results are represented. Log periodic technique is considered to be useful for improving the characteristics of a microstrip antenna which is narrow band in natural, without giving up the advantages of low profile and light weight.

At the end of this project, the objectives that will achieved. The expected result in this project is producing a log periodic antenna microstrip antenna operates at frequency 2.4GHz for WLAN and at frequency 2.0GHz for IMT2000. The narrowband

characteristic up to 3% of bandwidth can enhance using log periodic antenna technique. It is also provided the matching better than -10dB in the working bandwidth is ability to operate over wide frequency range and maximum gain at centre frequency is 4.5dB.

The radiating elements are coax-fed and arranged on one side of the common feed line behind the ground plane. This arrangement necessarily decreases the element spacing and increases the mutual coupling between elements. The coupling effect has acted to fill up the inactive frequency regions. Larger coupling between elements due to the necessarily dense arrangement enables obtaining wide band frequency characteristics. An example five element cases proves that present this technique is useful, giving gain of 6 to 10dBi over a bandwidth of about 20% [2].

1.2 Scope Of Projects

This project is divided to several phase. The first phase is to design the log periodic microstrip antenna at frequency 2.4GHz for WLAN and frequency 2.0GHz for IMT2000. A log periodic structure consists of the metal strip which is edges is specified by the angle α/2 [3]. The second phase is simulating the log periodic antenna using Microwave Office. Before this, the single element and multiple elements microstrip antenna for three, five and seven elements is design to produce a log periodic antenna structure. The radiating element is a square or rectangular of patch antenna. The input impedance of the patch is adjusted to the inset feed and matched at 50Ω impedance with quarter wavelength [4]. The third phase of my project is fabricating the log periodic antenna on FR4 board by using chemical etching technique. The fourth phase is testing and measuring the log periodic antenna by gain comparable to dipole. This phase is the last task for determine whether this project is successful or not.

1.3 Problem Statement

The most limitation of microstrip antenna technology is narrow bandwidth of basic element, lower gain and low power handling capability. Microstrip has narrow bandwidth, typically 1-5% which is the major limiting factor for widespread application of antenna [5]. The bandwidth of an antenna expresses its ability to operate over a wide frequency range. It is often defined as the range over which the power gain is maintained to within 3dB of its maximum value or the range over which the VSWR is no greater than 2:1, whichever is smaller [6].

Besides that, the log periodic antenna designs which have a good size where the values of width *(W)* are approximately same with the value of length *(L)*. So, the antenna design with be low profile and fulfill the weight characteristics [5]

1.4 Projects Objective

The objective of this project is to design, simulate and fabricate a log periodic antenna at frequency at 2.4GHz for broadband application. The antenna is design for single, three and five elements array of log periodic antenna at the certain frequency has been chosen.

Otherwise, this project is to analyze the characteristic impedance, return loss, VSWR and tangent loss of feed network. Besides that, this project provided design of broadband antenna structure which used the characteristic are vary periodically with the logarithm of the frequency are produced.

1.5 Project Methodology

The project methodology was beginning when the information of Log Periodic Antenna is gathering via IEEE Explorer, journals and references books and so on. All the related information that can be used in this project must be record. At the same time, the characteristic of log periodic antenna design are available which provide omni directional, bidirectional or unidirectional radiation patterns and either linear or circular polarization are recognized [7].

Besides, the Microwave Office software (AWR 2006) has to study. This software used for design and simulate the circuit of log periodic antenna. Before design the circuit, we need to calculate the parameter of log periodic follow the related formula such as return loss, reflection coefficient and so on. The simulation still be analyzing to checking wheatear the simulation is achieved the specification and matching. After the specification the antenna parameter and impedance matching is obtained. The periodic τ as 1.05, 1.03 and 1.02 has been chosen. The substrate also used is FR4 with dielectric constant of 4.7, height of 1.6mm and loss tangent of 0.019 based on data sheet specification. Additional, the components will be choosing including the SMA connector PCB Mounting Socket.

After that, the Log Periodic Antenna circuit to get substrate thickness, width *(W),* patch length *(L)*, spacing between *m+h* and *(m+1)th* element for scaling factor τ is designed and redesign until get the best optimization analysis. All planning of this project are monitoring by supervisor. The fully guided, support for doing this project in successfully progress is appreciated.

Next, the Log Periodic Antenna is fabricated on FR4 board by using chemical etching technique. Lastly, the Log Periodic Antenna circuit by using gain comparable to dipole is tested and measured. The result is verified with successfully.

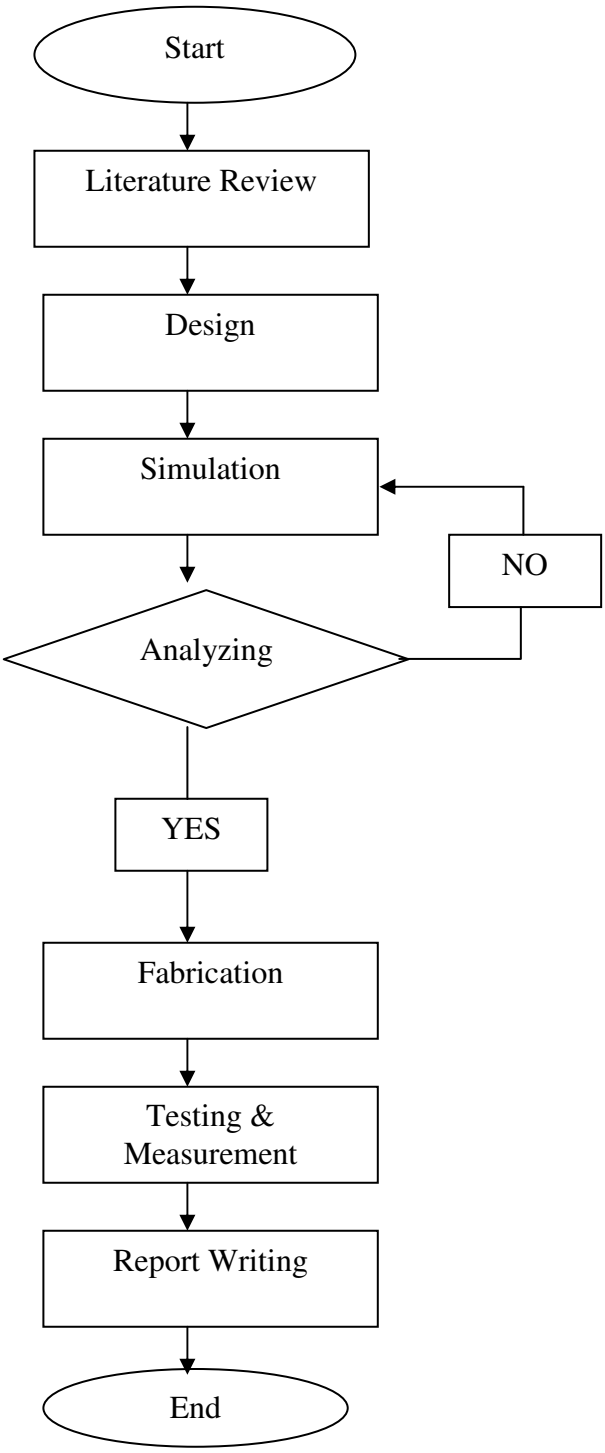

Figure 1.1: Project Methodology

CHAPTER II

LITERATURE REVIEW

2.1 Antennas Concept

An antenna is defined by Webster's Dictionary as "a usually metallic device (as a rod or wire) for radiating or receiving radio waves." The IEEE Standard Definitions of Terms for Antennas (IEEE Std 145-1983) defines the antenna or aerial as a means for radiating or receiving radio waves [8]. The purpose of and antenna is to transmit or receive radio frequency energy. The function of an antenna when used at a transmitter is to convert the radiated wave into useful radio frequency energy for the receiver [3].

In other words the antenna is the transitional structures between free-space and guiding device, as shown in Figure the guiding device or transmission line may take the form of a coaxial lie or a waveguide and it is used to transport electromagnetic energy from transmitting source to the antenna or from the antenna to the receiver. In the previous cases, we have a transmitting antenna and in the latter a receiving antenna.

In addition to receiving or transmitting energy, an antenna in an advanced wireless system usually required to optimize or accentuate the radiation energy in some directions and suppress it in others. Hence, the antenna must also serve as a directional