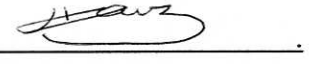
I confess that this project report is the result of my own works except for the statements/sentences and articles that been clearly cited in the references.

Signature :  .

Supervised by : **MOHD HAPEZ JOHARI**

Date : **4 APRIL 2006**

DEVELOPMENT OF A 2.4GHz ANTENNA ARRAYS USING MICROSTRIP TECHNOLOGIES

MOHD HAPEZ JOHARI

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Faculty of Electronics and Computer Engineering (FKEKK)
Kolej University Teknikal Kebangsaan Malaysia

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To my beloved parents:

Thank you for all that you have done.

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ABSTRACT

In this thesis, a 2.45GHz Array Microstrip Antenna was designed, simulate, fabricate and tested. Microstrip antennas consist of a very thin patch that placed a small fraction of a wavelength above a conducting ground plane. It was low profile, lightweight antennas that are suitable for aerospace, telecommunication and Bluetooth applications. A few prototypes were created to see which method will produce a better performance which includes bandwidth, return loss and also VSWR depth. Microwave Office was introduce as an effective tool for modeling electromagnetic structure. The antenna was fabricated based on simulation and measurement which focus on 2.45GHz center frequency.

ABSTRAK

Pada tesis ini, Antena Mikrojalur Dwisusunan yang beroperasi pada frekuensi kendalian 2.45GHz telah direkabentuk, disimulasi, fabrikasi dan diuji. Antenna Mikrojalur terdiri daripada logam tampal yang nipis diletakkan pada lingkungan pancaran gelombang diatas pengaliran yang dibumikan. Ia juga mudah dibentuk, ringan serta sesuai untuk aplikasi aeroangkasa, telekomunikasi dan Bluetooth. Beberapa prototaip telah direka bagi menganalisa kaedah terbaik yang dapat menghasilkan prestasi unggul termasuk dari segi lebar jalur, kehilangan balikan serta Nisbah Voltan Terhadap Gelombang (VSWR). Microwave Office diperkenalkan sebagai alat yang berkesan untuk membentuk struktur elektromagnetik. Antena telah difabrikasi berdasarkan pada simulasi dan ukuran yang tertumpu pada frekuensi kendalian 2.45GHz.

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LIST OF SYMBOLS

f_r	Center Frequency
VSWR	Voltage Standing Wave Ratio
ε_r	Relative Permittivity
ε_{eff}	Effective Relative Permittivity
L	Microstrip Actual Length
L_{eff}	Microstrip Effective Length
ΔL	Microstrip Extended Length
W	Microstrip Actual Width
h	Substrate Thickness
t	Thickness of Conductor (copper)
Ω	Ohms
V	Voltage
ρ	Charge Density
c	Velocity of electromagnetic waves in space (3×10^8)
λ_o	Free space wavelength
Z_{in}	Input Impedance
Z_o	Characteristic Impedance
Z_{new}	Characteristic Impedance using Wilkinson Power Divider
π	Phi Constant (3.1416)
S_{11}	S-Parameter that represent an input reflection.

CHAPTER 1

PROJECT OVERVIEW

1.1 OBJECTIVE

A fully operational 2.45GHz Microstrip Antenna Array is the objective of this project. Antenna that are using the Microstrip are also very small in size but capable to radiate an Ultra High Frequency (UHF). Designs are focuses on rectangular shape (Patch) with array radiating element and operates at 2.45GHz.

1.2 SCOPE OF WORKS

The antennas that will be design are operated in 2.45GHz of frequency. Deep understandings are necessary to support the overall view of the project. Antenna background knowledge is important to make sure all antennas' parameter is right and match with project specification. After all the parameters are well known, simulation process will be done. Manual calculation or with suitable software presence (Microwave Office) will help in the shape of designing. Calculation must be precisely correct that can support up to 2.45GHz. Fabrication is the final step whereas the real antenna can be implemented with proper component. Testing can be made to analyze the result and furthermore will be discussed. Below is the table of antenna scope parameters:

Table 1.1: Antenna Specifications

No	Parameters	Specifications
1	Center Frequency (f_r)	2.4 GHz
2	Bandwidth	> 1.5%
3	VSWR	< 2.00
4	Return Loss (dB)	< -10

1.3 PROBLEMS STATEMENT

The purpose of this design is to overcome several problems that occur with nowadays normal antennas. Importantly is to overcome the narrow bandwidth that the main problem of Microstrip Antenna. Antenna that are using the microstrip are also very small in size but capable to radiate an Ultra High Frequency (UHF). It's also build from a though substrate that makes it strong and stable from any high structure impact (e.g.: being drop from high places). Since it is small, it's also low in weight, low in cost and easy manufacturing.

1.4 METHODOLOGY

To archive a successful toward this project, a proper flow should be created, understand and followed. Steps of flow are as below:

1) Antenna background study.
    - Focus on Microstrip Antenna.

2) Defining major problem.
    - Method to solve.
3) Antennas main parameters
4) Simulation.
    - Microwave Office
5) Fabrication.
6) Measurement & testing.
    - Discussion.

The flows are as the next page:

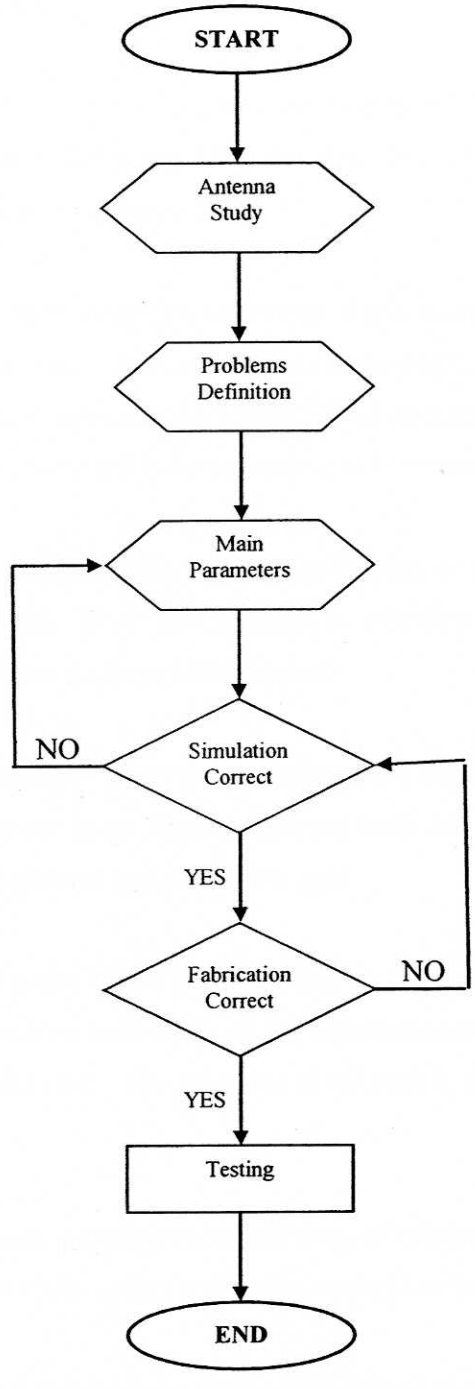

Figure 1.1: Overall Project Flows.

1.5 THESIS OUTLINE

Chapter 1 starts with project overview. Here the purpose of designing are stated and scope that will be covered. Other than that the flow through the overall project are expose so that it will be easier as a guideline.

Chapter 2 will touch on literature review on history of microstrip antenna and the aspect that build it. Introduction about microstrip antenna including the basis of microstrip line that will be used also are exposed. Not forget the advantages and disadvantages the microstrip antennas with their application nowadays are followed then.

Chapter 3 will review the microstrip antenna properties or parameters that will be consider on designing stage later. The method to calculate antenna dimension are explain here with help of certain theory that related.

Chapter 4 will provide on how to design an antenna and their others requirement that include components that are used also engineering tools for simulation. Each of the requirements is briefly explained including their spec.

Chapter 5 is the critical point where the designing begin. Calculation, simulation and preliminary result that archive from using all the information before are shown either it can be proceed to the next level. Several types of microstrip antennas are created here and analyze their output.

Chapter 6 concentrates only on fabrication. All steps of fabrications are explained here and here is the final steps of designing before real testing can be made.

Chapter 7 starts on after fabrication are finish. The overall measurements are discussed here and any matter that occurs will be discussed next.

Chapters 8 discuss any problem that occurs from the beginning to the end of the project.

Chapter 9 concludes this thesis with a summary of the work carried out for this thesis and the future prospects for microstrip array antenna. An overview of the topics covered in this thesis will be displayed. Subsequently, the future prospects of microstrip antennas, especially microstrip array antenna will be addressed.

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION TO ANTENNA

Antenna is the interface between transmission lines and space. The basic concept to understand regarding antennas is that they are passive devices. It's because, to operates, they require no supply voltage. Besides that, they do not alter nor process RF signals especially to amplify the energy of RF signals. In the other words, an antenna only converts an electromagnetic signal to an electrical signal at a receiver or electrical signal to an electromagnetic signal at a transmitter.

2.2 MICROSTRIP ANTENNA

This part provides information on the history, basic microstrip design and microstrip patch antenna. The basic geometry of the microstrip antenna is illustrated for easy understanding before proceed to the next chapter.

2.2.1 Historical

Microstrip antennas were first proposed by Deschamps on 1953, Gutton and Bassinot in 1955[7]. Only by early 1970, the first practical microstrip antenna was

fabricated by Munson and Howell. Howell first presented the design procedures for microstrip antennas whereas Munson tried to develop microstrip antennas as low-profile flushed-mounted antennas on rockets and missiles. In October 1979, the first international meeting devoted to microstrip antenna materials, practical designs, array configurations and theoretical models was held at New Mexico State University under co-sponsorship of the U.S. Army Research Office and New Mexico State University's Physical Science Laboratory [7]. By 1979, design idea of electromagnetically couple patch antenna has been proven experimentally by Hall that it cans posses' higher bandwidth while maintaining a simple fabrication process. Milestone in practical realism and manufacturing of the microstrip antennas crucially increase within early 1980s. Now, 'antenna array architecture' began to take interest by researchers which has emerged as a dominant approach to the Microstrip world.

2.2.2 Basic Microstrip Antenna

In today's aircraft and spacecraft applications where the antenna's size, weight, cost, performance, ease of installation and aerodynamic profile are of utmost consideration, the low-profile microstrip antenna is preferred over conventional antennas. The term 'Microstrip' actually refers to any type of opens wave guiding structure which is not only a transmission line but also used together with other circuit components like filters, couplers, resonators, etc. A microstrip antenna in its simplest configuration consists of a radiating patch on one side of a dielectric substrate, which has a ground plane on the other side. The patch conductors usually made of copper or gold can be virtually assumed to be of any shape. However, conventional shapes are normally used to simplify analysis and performance prediction. The radiating elements and the feed lines are usually photo etched on the dielectric substrate. Shown in Figure 2.1 is the basic configuration of a simple microstrip antenna.

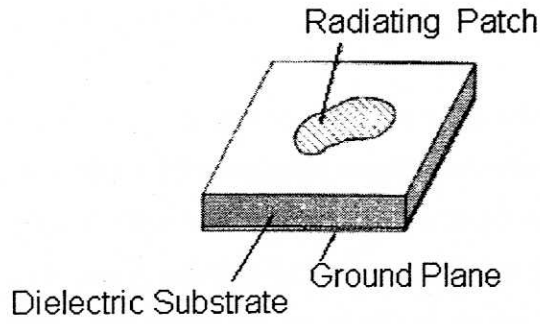

Figure 2.1: Basic Configuration of Microstrip Antenna

2.2.3 Microstrip Patch Antenna

A simple Microstrip Patch Antenna consists of a very thin patch that placed a small fraction of a wavelength above a conducting ground plane. The patch and the ground plane are separated by a dielectric. The patches are usually photo etched on the dielectric substrate, substrate usually non-magnetic and in rectangular shape. The relative permittivity (ε_r) of the substrate is an important parameter to consider. It is because relative permittivity will enhances the fringing fields that account for radiation. This type of antenna is characterized by its length L, width W, and thickness h, as shown in Figure 2.2.

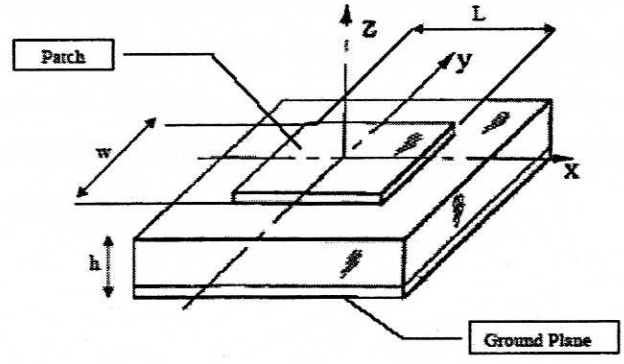

Figure 2.2: A rectangular patch antenna