

# **PLANAR YAGI ANTENNA DESIGN**

**MOHD SUPIAN BIN SULAIMAN**

**This report is submitted in partial fulfillment of the requirements for the award  
of Bachelor of Electronic Engineering (Telecommunication Electronics) With  
Honours**

**Faculty of Electronic and Computer Engineering  
Universiti Teknikal Malaysia Melaka**

**May 2008**



UNIVERSITI TEKNIKAL MALAYSIA MELAKA  
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN  
PROJEK SARJANA MUDA II

Tajuk Projek : PLANAR YAGI ANTENNA DESIGN

Sesi Pengajian : 2004/2008

Saya MOHD SUPIAN BIN SULAIMAN  
(HURUF BESAR)

mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (  ) :

SULIT\*

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

TERHAD\*

(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

  
(TANDATANGAN PENULIS)

Alamat Tetap: 1386-D, KG NIBONG  
JALAN PANJALAM,  
21100, KUALA TERENGGANU,  
TERENGGANU DARULIMAN.

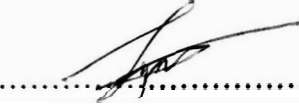
Tarikh: 09 MAY 2008

Disahkan oleh:  
  
(COP DAN TANDATANGAN PENYELIA)

**MOHAMAD ZOINOL ABIDIN BIN ABD AZIZ**  
*Lecturer*  
Faculty Electronics and Computer Engineering (FKEKK)  
Universiti Teknikal Malaysia Melaka (UTeM)  
Locked Bag 1200  
Ayer Keroh, 75450 Melaka.

Tarikh: 09 MAY 2008

“I hereby declare that this report is result of my own work except for quotes as cited  
in the references.”

Signature :  .....

Author : Mohd Supian B. Sulaiman .....

Date : 1.5.08 .....

“I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) With Honours.”

Signature : .....  
Supervisor's Name : .....  
Date : 9/5/08 .....

**MOHAMAD ZOINOL ABIDIN BIN ABD AZIZ**  
*Lecturer*  
Faculty Electronics and Computer Engineering (FKEKK)  
Universiti Teknikal Malaysia Melaka (UTeM)  
Locked Bag 1200  
Ayer Keroh, 75450 Melaka.

**To my beloved father and mother**

## ACKNOWLEDGEMENT

First, thanks to ALLAH SWT for helping me through this all the obstacles that I faced during this project.

I would like to express my appreciation to my supervisor, Mr Mohamad Zoinol Abidin Bin Abdul Aziz that for his guidance and support that help me finished my thesis. For his wisdom, insight and knowledge, the social grace with which he delivers his idea are a constant inspiration. He guided me so that I will continue to be in the correct path during the development of this draft. He provided a motivating and enthusiastic atmosphere during the many discussions we had. It was a great pleasure to do this thesis under his supervision.

Finally, I would to express my sincerely gratitude to my family and close friends. If not for their encouragement and support, I certainly will not be able to finish this thesis or even completed graduate school.

## ABSTRACT

This thesis is present the design of planar Yagi antenna for WLAN application at frequency 2.4 GHz .Now days designing conventional antenna is high cost due to the large size. There several step to design this antenna .The design and simulation of this antenna was completed using Microwave Office software. There are two designs of antenna was investigated. The first planar Yagi antenna with one director and the second planar Yagi antenna with three directors. For both prototype antenna were simulated. The optimized design was fabricated using chemical etching and UV ray. The both antennas and then tested. Compared to the simulation result the operating frequency for both planar Yagi antenna design is 2.4 GHz. The measurement result show that the operating frequency slightly shift to 2.5GHz and the bandwidth of both designs were 14.05% and 6.88% ,Compared to the simulation, the bandwidth of both designs are achieve about 11.88%. The measurement result slightly different from simulation.

## ABSTRAK

Thesis ini menunjukkan rekabentuk antenna planar Yagi untuk aplikasi WLAN pada frekuensi 2.4 Ghz .Kini merekabentuk antenna biasa memerlukan kos yang tinggi disebabkan oleh saiznya yang besar.Beberapa langkah digunakan untuk merekabentuk antenna ini.Proses rekabentuk dan simulasi diselesaikan dengan menggunakan perisian Microwave Office. Dua rekabentuk antenna yang diasasat,iaitu antenna planar Yagi pertama mempunyai satu pengarah dan antenna planar Yagi kedua mempunyai tiga pengarah.Kedua-dua antenna prototaip ini disimulasi dan reka bentuk terbaik antenna di fabrikasi menggunakan sinar UV dan teknik goresan kimia.Kedua-dua antenna ini diuji dan dibandingkan dengan keputusan simulasi dimana frekuensi operasi kedua-dua antenna ini pada 2.4GHz.Tetapi keputusan ukuran menunjukkan frekuensi operasi antenna beranjak kepada 2.5GHz.dan lebar jalur untuk kedua-dua antenna itu ialah 14.05% dan 6.88%.Jika dibandingkan dengan simulasi lebar jalur mencapai sebanyak 11.88%.Keputusan ukuran sedikit berbeza dari keputusan simulasi.



## TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	PROJECT TITLE	i
	REPORT STATUS RECOGNITION FORM	ii
	DECLARATION	iii
	SUPERVISOR DECLARATION	iv
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTRACT	vii
	ABSTRAK	viii
	TABLE OF CONTENTS	ix
	LIST OF TABLES	xiii
	LIST OF FIGURES	xiv
	LIST OF ABBREVIATIONS	xvii
	LIST OF APPENDIX	xix
	INTRODUCTION	
1.1	Introduction	
1.2	Problem Statement	
1.3	Objective	
1.4	Scopes of Project	

1.5	Methodology of Project	2
<b>II</b>	<b>LITERATURE REVIEW</b>	<b>4</b>
2.1	Microstrip Antenna	4
2.1.1	Introduction	4
2.1.2	Advantages of Microstrip Antenna	5
2.1.3	Disadvantages of Microstrip Antenna	5
2.1.4	Various Microstrip Antenna Configuration	6
2.2	Planar Antenna	6
2.3	Yagi-Uda Antenna	7
2.4	Feeding Technique	8
2.4.1	Microstrip Transmission Line	8
2.4.2	Coaxial Feed	9
2.4.3	Aperture Coupled Feed	10
2.4.4	Proximity Coupled Feed	11
2.5	Antenna Parameter	13
2.5.1	Resonant Frequency	13
2.5.2	Gain	13
2.5.3	Bandwidth	14
2.5.4	Impedence	15
2.5.5	Polarization	15
2.5.6	Efficiency	17
2.6	WLAN	17
2.6.1	Advantages of WLAN	18
<b>III</b>	<b>PLANAR YAGI ANTENNA DESIGN</b>	<b>20</b>
3.1	Introduction	20
3.2	Design Specification	21
3.3	Antenna Design Procedure	21
3.3.1	The Determination of Driven Element	24
3.3.2	The Determination of Spacing between Driven and	25

	Director	
3.3.3	The Determination of Director length	27
3.3.4	The Determination of the Number Director	28
3.3.5	The Final Design of Antenna	29
3.4	Fabrication Process	30
3.5	Measurement Setup	31
3.5.1	Return Loss Measurement	31
3.5.2	Radiation Pattern Measurement	32
3.5.3	Gain Measurement	32
<b>RESULT AND ANALYSIS</b>		<b>33</b>
4.1	Planar Yagi Antenna with One Director	33
4.2	Planar Yagi Antenna with Three Directors	36
4.3	Measurement Result	40
4.3.1	Radiation Pattern Planar Yagi Antenna with One Director	40
4.3.2	Radiation Pattern Planar Yagi Antenna with Three Directors	41
4.3.3	<i>HPBW</i> and <i>FNBW</i> for Planar Yagi Antenna with One Director	42
	4.3.3.1 For <i>E-plane</i>	42
	4.3.3.2 For <i>H-plane</i>	43
4.3.4	<i>HPBW</i> and <i>FNBW</i> for Planar Yagi Antenna with Three Directors	44
	4.3.4.1 For <i>E-plane</i>	44
	4.3.4.2 For <i>H-plane</i>	45
4.3.5	Return Loss	46
4.3.6	Compared Result between simulation and measure	47
4.4	Analysis of Planar Yagi antenna parameter	49
4.4.1	The Effect Adjusting Driven Dipole Length	49
4.4.2	The Effect Adjusting Spacing between Driven and	51

	Director	
3.3.3	The Determination of Director length	27
3.3.4	The Determination of the Number Director	28
3.3.5	The Final Design of Antenna	29
3.4	Fabrication Process	30
3.5	Measurement Setup	31
3.5.1	Return Loss Measurement	31
3.5.2	Radiation Pattern Measurement	32
3.5.3	Gain Measurement	32
<b>IV</b>	<b>RESULT AND ANALYSIS</b>	<b>33</b>
4.1	Planar Yagi Antenna with One Director	33
4.2	Planar Yagi Antenna with Three Directors	36
4.3	Measurement Result	40
4.3.1	Radiation Pattern Planar Yagi Antenna with One Director	40
4.3.2	Radiation Pattern Planar Yagi Antenna with Three Directors	41
4.3.3	<i>HPBW</i> and <i>FNBW</i> for Planar Yagi Antenna with One Director	42
4.3.3.1	For <i>E-plane</i>	42
4.3.3.2	For <i>H-plane</i>	43
4.3.4	<i>HPBW</i> and <i>FNBW</i> for Planar Yagi Antenna with Three Directors	44
4.3.4.1	For <i>E-plane</i>	44
4.3.4.2	For <i>H-plane</i>	45
4.3.5	Return Loss	46
4.3.6	Compared Result between simulation and measure	47
4.4	Analysis of Planar Yagi antenna parameter	49
4.4.1	The Effect Adjusting Driven Dipole Length	49
4.4.2	The Effect Adjusting Spacing between Driven and	51

	Reflector	
	4.4.3 The Effect Adjusting Director Element Length	53
	4.4.4 The Effect Adding Director	55
<b>V</b>	<b>DISCUSSION, CONCLUSION AND FUTUREWORK</b>	<b>57</b>
	5.1 Discussion	57
	5.2 Conclusion	58
	5.3 Future work	58
	<b>REFERENCES</b>	<b>59</b>

**LIST OF TABLES**

<b>NO.</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	Comparing the different feed techniques	12
3.1	Design specification	21
3.2	The change of $RL, f$ and $BW$ due to change driven length	24
3.3	The change of $RL$ and $BW$ due to change of spacing between reflector and driven	26
3.4	The change $BW$ and $RL$ due to change of director length	27
3.5	The change of $RL$ and $BW$ due to change of number of director.	28
4.1	The result of simulation and measurement	48
4.2	The result of simulation and measurement of $HPBW$ and FNBW	48

## LIST OF FIGURES

<b>NO.</b>	<b>TITLE</b>	<b>PAGE</b>
1.1	Methodology flow	3
2.1	Microstrip antenna configuration	5
2.2	Basic shape of patch antenna	6
2.3	The planar radiating element	6
2.4	Yagi antenna structure	8
2.5	Microstrip line feed	9
2.6	Coaxial feed	10
2.7	Aperture coupled feed	11
2.8	Proximity coupled feed	12
3.1	Planar Yagi antenna initial design	21
3.2	Dielectric layer setup	22
3.3	Boundaries setup	22
3.4	Dimension setup	23
3.5	EM layout setup	23
3.6	The layout of EM structures of driven element	25
3.7	The layout of EM structures of spacing between driven and reflector	26
3.8	The layout of EM structures of driven element when length of director is adjusted.	28
3.9	The EM layer of antenna with added director	29
3.10	The EM layout of final design antenna	29
3.11	The fabricated planar Yagi antenna	30
3.12	Network analyzer	31

4.1	The EM layout of planar Yagi antenna with one director	33
4.2	<i>RL</i> for planar Yagi antenna with one director	34
4.3	<i>VSWR</i> for planar Yagi antenna with one director	35
4.4	Radiation pattern of planar Yagi antenna with one director	35
4.5	Radiation pattern at <i>E-plane</i> for planar Yagi antenna with one director	36
4.6	Radiation pattern at <i>H-plane</i> for planar Yagi antenna with one director	36
4.7	The EM layout of planar Yagi antenna with three director	37
4.8	<i>RL</i> for planar Yagi antenna with three directors	36
4.9	<i>VSWR</i> for planar Yagi antenna with three directors	36
4.10	Radiation pattern for antenna planar Yagi with three directors	37
4.11	Radiation pattern at E-plane for planar Yagi antenna with three directors	39
4.12	Radiation pattern at H-plane for planar Yagi antenna with three directors	39
4.13	E-co	40
4.14	<i>E-cross</i>	40
4.15	<i>H-co</i>	40
4.16	<i>H-cross</i>	40
4.17	<i>E-co</i>	41
4.18	<i>E-cross</i>	41
4.19	<i>H-co</i>	41
4.20	<i>H-cross</i>	41
4.21	E-plane <i>HPBW</i> and <i>FNBW</i> for planar Yagi antenna with one director	42
4.22	H-plane <i>HPBW</i> and <i>FNBW</i> for planar Yagi antenna with one director	43
4.23	E-plane <i>HPBW</i> and <i>FNBW</i> for planar Yagi antenna with three directors	44
4.24	E-plane <i>HPBW</i> and <i>FNBW</i> for planar Yagi antenna with three directors	45
4.25	<i>RL</i> for planar Yagi antenna with one director	46
4.26	<i>RL</i> for planar Yagi antenna with three director	46
4.27	The result of simulation and measurement of <i>RL</i> for planar Yagi antenna with one director	47
4.28	The result of simulation and measurement of <i>RL</i> for planar Yagi antenna with three director	47
4.29	Driven element versus bandwidth	49
4.30	Driven element versus return loss	50



4.31	The return loss graph when length of dipole is adjusted	50
4.32	Spacing between driven and reflector vs. <i>BW</i>	51
4.33	Spacing between driven and reflector vs. <i>RL</i>	52
4.34	The simulation <i>RL</i> result when the spacing between driven and reflector is adjusted	52
4.35	Director Length vs. <i>BW</i>	53
4.36	Director Length vs. <i>RL</i>	54
4.37	<i>RL</i> when director length is adjusted	54
4.38	The number of director vs. <i>BW</i>	55
4.39	The number of director vs. <i>RL</i>	55
4.40	<i>RL</i> of antenna when director is added.	56

## LIST OF ABBREVIATIONS

<i>BW</i>	-	Bandwidth
<i>CAD</i>	-	Computed Aided Drawing
<i>dB</i>	-	Decibel
<i>dBi</i>	-	Decibel over isotropic
<i>dBm</i>	-	Power ratio in decibel of measured power
<i>E-plane</i>	-	Electric field plane
<i>f</i>	-	Frequency
<i>FNBW</i>	-	Full Null Beam Width
<i>FR4</i>	-	Flame Retardant 4
<i>GHz</i>	-	Gigahertz
<i>h</i>	-	Substrate height
<i>HPBW</i>	-	Half Power Beam Width
<i>H-plane</i>	-	Electromagnetic field plane
<i>L</i>	-	Length
<i>LAN</i>	-	Local Area Network
<i>mm</i>	-	Millimeter
<i>MoM</i>	-	Moment of Method
<i>MSA</i>	-	Microstrip antenna
<i>S</i>	-	Spacing
<i>SMA</i>	-	Sub Miniature version A
<i>SWR</i>	-	Standing Wave Ratio
		Copper thickness
<i>tan δ</i>	-	Loss tangent
<i>UV</i>	-	Ultra Violet

<i>VSWR</i>	-	Voltage Standing Wave Ratio
<i>W</i>	-	Width
<i>WLAN</i>	-	Wireless Local Area Network
$\epsilon_r$	-	Dielectric Constant
$\theta$	-	Angle in degree
$\lambda$	-	Wavelength

**LIST OF APPENDIX**

<b>NO.</b>	<b>TITLE</b>	<b>PAGE</b>
A	FR4 substrate	61

# CHAPTER I

## INTRODUCTION

### 1.1 Introduction

This project is about developing Planar Yagi antenna using microstrip that cost effective and lightweight at frequency 2.4GHz for WLAN application .The main problem of the microstrip antenna is narrowband characteristic up to 3% and low gain. Planar Yagi antenna design can offer wider bandwidth and more gain for antenna application.

### 1.2 Problem Statement

Nowadays, the antenna size is too large and high cost to design, by using microstrip this problem can be solved. The microstrip offers numerous advantages, such as low weight, small volume, low cost and easy fabrication using printed circuit technology. But using microstrip suffers some disadvantages compared to conventional antenna. The disadvantages of microstrip antenna is its narrowband characteristic which is the major limiting factor for widespread application .This disadvantage can be solved by implementing planar Yagi antenna design in this project to increase bandwidth and gain of this antenna design

### **1.3 Objective**

The objective of this project is to design, simulate and fabricate Planar Yagi antenna at frequency 2.4 GHz for WLAN application.

### **1.4 Scope of Project**

There is several scope of the project that has been determined. The first scope was to design Planar Yagi antenna at 2.4 GHz for WLAN application .The second scope was to simulate Planar Yagi antenna by using Microwave Office software to get the wanted properties or specification of the antenna. After design and simulation has been done .The antenna was fabricate on FR4 using UV ray and chemical etching technique. Lastly the antenna then measured and compared with the simulation

### **1.5 Methodology of Project**

The methodology of project started with literature review. During this stage all information and data about Planar Yagi Antenna is collected from books ,IEEE journal and web .Then the design process started when all data and parameter that has been selected during literature review .After that ,the antenna structure was designed and simulated in Microwave Office software environment .After simulation achieved the required parameter and properties ,The fabrication process was started .The antenna is fabricated on FR4 board using UV ray and chemical etching technique. The fabricated antenna measured and the simulation result compared with the measured result .Last, all data and literature review that collected since the project started is compiled together to make full report.

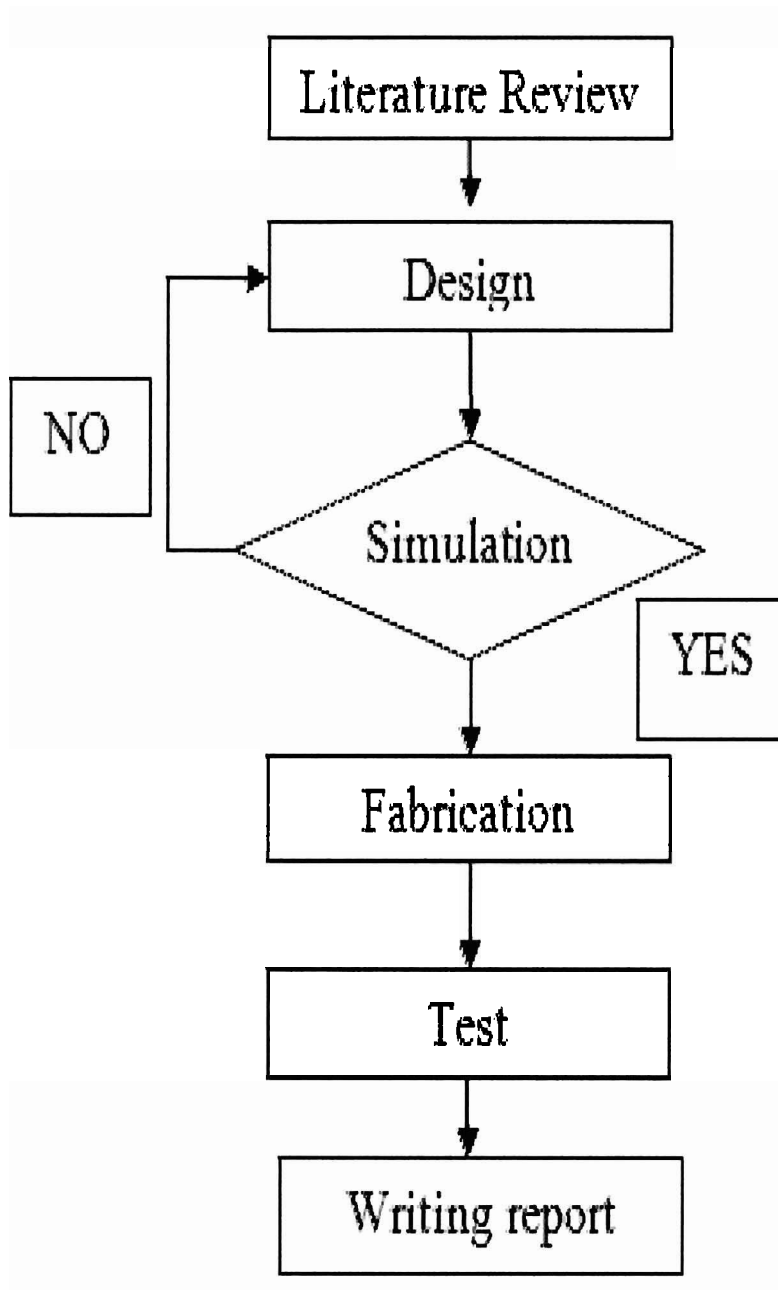


Figure 1.1: Methodology flow

## **CHAPTER II**

### **LITERATURE REVIEW**

#### **2.1 Microstrip Antenna**

##### **2.1.1 Introduction**

Deschamps first proposed the concept of the MSA in 1953 [1]. However, practical antennas were developed by Munson [2] and Howell [3] in the 1970s. The numerous advantages of MSA, such as its low weight, small volume, and ease of fabrication using printed-circuit technology, led to the design of several configurations for various applications [4]. With increasing requirements for personal and mobile communications, the demand for smaller and low-profile antennas has brought them MSA to the forefront. As shown in figure below figure 2.1 is the simplest configuration of a MSA .This antenna consists of a radiating patch on one side of the dielectric substrate and the ground plane on other side. The patch conductor, usually copper or gold is use. The MSA can be in any shape, but the regular shape is use to simplify and performance prediction.