

DESIGN A 3.5 ANTENNA FOR DUAL BAND APPLICATIONS

MAHFUZH BINTI MD. SHUKOR

This Report Is Submitted in Partial Fulfilment of Requirements for the Bachelor
Degree of Electronic Engineering (Telecommunication Engineering)

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka

June 2012



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek : MAHFUZAH BINTI MD. SHUKOR

Sesi Pengajian :

1	1	/	1	2
---	---	---	---	---

Saya MAHFUZAH BINTI MD. SHUKOR
(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

MOHAMAD ZAINOL ABIDIN BIN ABD. AZIZ


Pensyarah Kanan
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
8100 Durian Tunggal
Melaka

Disahkan oleh:

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)

"I admit that this report is the result of my own work except for the summary and the passage of each of which was me explain the source."

Sign : 

Student Name : MAHFUZAH BINTI MD. SHUKOR

Date : 22/6/2012

"I / we hereby declare that I have read this in my / our work is sufficient in scope and quality for the award of a Bachelor of Electronic Engineering (Telecommunication Electronics)."



Sign :

Supervisor Name : **MOHAMAD ZAINOL ABIDIN BIN ABD. AZIZ**
Pensyarah Kanan
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)

Date : **22/6/12**
Hang Tuah Jaya
8100 Durian Tunggal
Melaka

"I / we hereby declare that I have read this in my / our work is sufficient in scope and quality for the award of a Bachelor of Electronic Engineering (Industrial Electronics)."

Sign :

Supervisor Name :

Date :

To my mother and father

&

My brothers

For your infinite and unfading love, sacrifice, patience, encouragement and

best wishes

ACKNOWLEDGEMENT

All praises and thanks be to Allah (S.W.T), who has guided us to this, never could we have found guidance, were it not that Allah had guided us!(Q7:43)

Alhamdulillah, first of all, I would like to express my gratitude to Almighty for blessing me with strength and courage to complete this report. From the beginning till the end of this report, I have so many people who stand by me; given me guidance for every obstacle that stand in my way. Therefore, I would like to express my deepest appreciation to those involved in this report.

Words cannot express my gratitude towards my supervisor, Mr. Mohamad Zoinol Abidin Bin Abd. Aziz for the patience, humble supervision and fatherly advice I received from him in the course of his project. May the sky be your limits in all your future endeavors and may jannatul-firdaus be your abode in the hereafter.

Last but not least, I would like to express my appreciation to my beloved parents Mr. Md. Shukor Bin Masuod and Madam Khadijah Binti Talib for the unconditional love and support that let me through the toughest days in my life. To all my friends who shared ideas to make my report better, I hope we can have a good grade for our effort. For those whom not stated here, I would like to thank for their help, friendship and countless support to me. May Allah S.W.T. bless all of them for their support and kindness.

Thank you.

ABSTRACT

In the wireless world today, the antenna design facing many problems and issues those need to be solved immediately to fulfil the user needed. The problems involved in antenna design such as in some applications space is very limited so it need to be in compact size, challenges to make the antenna broadband and now dual band issues. To achieve the objective of this project, the design process is done such as calculation, simulation and fabrication. Firstly the basic shape structures are designed at frequency 2.4 GHz based on radiating structure 5 and 5.2 GHz based on radiating structure 3. Then both structures are combined to achieve the dual band. In this project, the technique that has been used to achieve dual band is by designing the 3.5 shaped by using microstrip, planar and coplanar waveguide structure. Then, the changes on the position of radiating structure 3 have been carried out to investigate the effect for dual band. After that, each antenna parameter such as return loss, bandwidth, gain, directivity and radiation pattern was simulated using CST Studio Suite software. The parametric study is done for each design parameter for all design aspect. Next the planar and coplanar waveguide designs are fabricated using chemical etching technique. Lastly the antennas that have been tested using the Network Analyzer, Field Fox Analyzer and antenna measurement systems to measure the antenna parameter such as return loss, radiation pattern and gain.

ABSTRAK

Dalam dunia tanpa wayar hari ini, reka bentuk antenna menghadapi banyak masalah dan isu-isu yang perlu diselesaikan dengan segera untuk memenuhi pengguna yang diperlukan. Masalah yang terlibat dalam reka bentuk antenna seperti dalam ruang aplikasi beberapa sangat terhad, jadi ia perlu berada dalam saiz yang kompak, cabaran untuk membuat antenna jalur lebar dan kini isu band dua. Untuk mencapai objektif projek ini, proses reka bentuk dilakukan seperti pengiraan, simulasi dan fabrikasi. Pertama struktur bentuk asas direka bentuk kekerapan pada 2.4 GHz berdasarkan terpancar struktur 5 dan 5.2 GHz yang berdasarkan terpancar struktur 3. Kemudian kedua-dua struktur digabungkan untuk mencapai dwi-jalur. Dalam projek ini, teknik yang telah digunakan untuk mencapai jalur dwi adalah dengan merekabentuk berbentuk 3,5 dengan menggunakan struktur mikrostrip, pandu gelombang satah dan sesatah. Kemudian, perubahan ke atas kedudukan struktur terpancar 3 telah dijalankan untuk menyiasat kesan untuk band dua. Selepas itu, setiap parameter antenna seperti kehilangan balasan, jalur lebar, keuntungan, 'directivity' dan corak sinaran simulasi menggunakan perisian CST Studio Suite. Kajian parametrik dilakukan untuk setiap parameter reka bentuk untuk semua aspek reka bentuk. Seterusnya reka bentuk pandu gelombang satah dan sesatah palsu menggunakan teknik punaran kimia. Akhir sekali antenna yang telah diuji menggunakan Analyzer Rangkaian, Field Fox Analyzer dan pengukuran sistem antenna untuk mengukur parameter antenna seperti kehilangan pulangan, corak sinaran dan keuntungan.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	PROJECT TITLE	i
	APPROVAL FORM	ii
	STUDENT’S DECLARATION	iii
	SUPERVISOR’S DECLARATION	iv
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTRACT	vii
	ABSTRAK	viii
	TABLE OF CONTENTS	ix
	LIST OF TABLES	xiii
	LIST OF FIGURES	xv
	LIST OF SYMBOLS	xvii
	LIST OF APPENDIXES	xxi
1	INTRODUCTION	1
	1.1 Background of the Project	1
	1.2 Problem Statements	4

		x
1.3	Objective	6
1.4	Methodology of the Project	6
1.5	Organization of the report	7
2	LITERATURE REVIEW	9
2.1	Definition of Antenna	9
2.2	Important Parameters of Antenna	10
2.2.1	Resonance Frequency	10
2.2.2	Antenna bandwidth	11
2.2.3	Input Impedance	12
2.2.4	Radiation Pattern	13
2.2.5	Directivity	14
2.2.6	Gain	16
2.2.7	VSWR	17
2.2.8	Efficiency	17
2.3	Antenna types	17
2.3.1	Microstrip Antenna	18
2.3.2	Planar Antenna	19
2.3.3	Coplanar Waveguide Antenna	20
2.4	Design Process	21
2.4	Dual band Antenna	22
2.4.1	Microstrip and Planar Antenna	22

2.4.2	Coplanar Waveguide	28
3	METHODOLOGY OF THE PROJECT	33
3.1	Antenna Design	33
3.1.1	Design Specification of the Antenna	33
3.1.2	Basic 3.5 Antenna	34
3.1.3	Design of 3.5 Antenna	35
3.2	Parametric Studies	39
3.3	Design Parameter	40
3.4	Design Process	41
3.4.1	Microstrip Antenna	41
3.4.2	Planar Antenna	43
3.4.3	Coplanar Waveguide	45
3.5	Fabrication Process	47
3.6	Measurement Process	50
3.4.1	Return Loss Measurement	51
3.4.2	Radiation Pattern Measurement	51
3.4.3	Gain Measurement	52
4	RESULT AND DISCUSSION	54
4.1	Microstrip Antenna	54
4.1.1	Design A1	54

4.1.1.1	Parametric Studies	57
4.1.2	Design <i>A2</i>	57
4.1.2.1	Parametric Studies	60
4.1.3	Comparison between design <i>A1</i> and design <i>A2</i>	60
4.2	Planar Antenna	61
4.2.1	Design <i>B1</i>	61
4.2.1.1	Parametric Studies	64
4.3	Coplanar Waveguide Antenna	65
4.3.1	Design <i>C1</i>	65
4.3.1.1	Parametric Studies	68
4.3.2	Design <i>C2</i>	69
4.3.2.1	Parametric Studies	72
4.3.3	Design <i>C3</i>	74
4.3.3.1	Parametric Studies	76
4.4	Comparison between design <i>C1</i> , design <i>C2</i> and design <i>C3</i>	78
4.5	Comparison between microstrip, planar and coplanar waveguide antenna	79
5	CONCLUSION	80
5.1	Conclusion	80
5.2	Suggestion	81

REFERENCES

82

APPENDIX

87

LIST OF TABLES

TABLE NO.	TITLE	PAGE
3.1	Design Specification	34
3.2	The material and height for substrate, patch and ground	35
3.3	Value for λ_g in mm for frequency of 2.4 GHz and 5.2 GHz	40
3.4	Dimension in mm of 3.5 Antenna	41
4.1	Comparison between return loss, gain, bandwidth, directivity and the radiation efficiency between design A1 and design A2	61
4.2	Comparison between simulation and measurement results	65
4.3	Comparison between simulation and measurement results	69
4.4	Comparison between simulation and measurement results	78
4.5	Comparison between return loss, gain, bandwidth, directivity and the radiation efficiency between design C1, design C2 and design C3	79

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	Methodlogy of the project	7
2.1	Impedance of RF antenna with frequency	11
2.2	S11 Graph (Return Loss)	12
2.3	The radiation pattern of antenna	14
2.4	The geometry of the microstrip (patch) antenna	18
2.5	The geometry of the planar antenna	19
2.6	The geometry of the coplanar waveguide (CPW) antenna	20
2.7	The geometry antenna	23
2.8	The geometry F shaped antenna	24
2.9	Geometry of curl F shaped antenna	25
2.10	Geometry of proposed antenna	26
2.11	Geometry of proposed antenna	26
2.12	The geometry of the bow tie antenna	27
2.13	Antenna configurations	28
2.14	The geometry of the antenna	28

2.15	Configuration of dual band unidirectional coplanar antenna	29
2.16	The geometry of the proposed antenna	30
2.17	The geometry of the proposed antenna	31
2.18	The proposed antenna structures	32
3.1	Antenna structure	35
3.2	Background properties	36
3.3	Boundary conditions	36
3.4	Waveguide Port	37
3.5	Field Monitor	38
3.6	Design A2	31
3.7	The line feed	39
3.8	Antenna geometry	40
3.9	Design A1	42
3.10	The waveguide port	42
3.11	Design A2	43
3.12	Basic structure planar	44
3.13	Design B1	44
3.14	Basic structure CPW	45
3.15	Design C1	46
3.16	Design C2	46
3.17	Design C3	47
3.18	Antenna Prototype of design B1	49
3.19	Antenna Prototype of design C1	49

3.20	Antenna Prototype of design <i>C3</i>	50
3.21	Flow chart of fabrication process	50
3.22	Measurement setup for return loss measurement	51
3.23	Measurement setup for radiation pattern measurement	52
3.24	Flow chart of measurement process	52
4.1	Design <i>A1</i>	54
4.2	Return loss of design <i>A1</i>	55
4.3	Surface current	56
4.4	Radiation pattern	56
4.5	Graph return loss when changing the length feed, LF	57
4.6	Design <i>A2</i>	58
4.7	Return loss of design <i>A2</i>	58
4.8	Surface current	59
4.9	Radiation pattern	59
4.10	Graph return loss when changing the length feed, LF	60
4.11	Design <i>B1</i>	61
4.12	Return loss of design <i>B1</i>	62
4.13	Surface current	63
4.14	Radiation pattern	63
4.15	Graph return loss when changing the length feed, LF	64
4.16	Design <i>C1</i>	65
4.17	Return loss of design <i>C1</i>	66
4.18	Surface current	67

4.19	Radiation pattern	67
4.20	Graph return loss when the length feed is changing	68
4.21	Graph return loss when the width of the ground is changing when length feed	68
4.22	Design C2	70
4.23	Return loss of the design C2	70
4.24	Surface current	71
4.25	Radiation pattern	72
4.26	Graph return loss when changing the length feed, LF	73
4.27	Graph return loss when width of slot is changing when length of feed, LF = 48 mm	73
4.28	Design C3	74
4.29	Return loss of design C3	74
4.30	Surface current	75
4.31	Radiation pattern	76
4.32	Graph return loss when length feed is changing	77
4.33	Graph return loss when width of slot is changing when length of feed, LF = 48.6mm	77

LIST OF SYMBOL

AMPS	-	Advanced Mobile Phone System
B_w	-	Bandwidth
c	-	Speed of Light
CPW	-	Coplanar Waveguide
CP	-	Circular Polarization
d	-	Thickness of Substrate
d	-	Distance between transmitter and receiver
dB	-	Decibel
dBd	-	Decibel Dipole
D	-	Directivity
DS-CDMA	-	Direct Sequence Code Division Multiple Access
DCS	-	Distributed Control System
EM	-	Electromagnetic
Eq.	-	Equation
f	-	Frequency
f_r	-	Resonant Frequency
Fig	-	Figure

FCC	-	Federal Communications Commissions
FM	-	Frequency Modulation
FNBW	-	First Null Beamwidth
G	-	Giga
G	-	Gain
G_r	-	Gain at Receiver
G_t	-	Gain at Transmitter
GPS	-	Global Positioning System
GPRS	-	General Packet Radio Service
GSM	-	Global System for Mobile
Hz	-	Hertz
HPBW	-	Half-Power Beamwidth
IEEE	-	Institute of Electrical and Electronics Engineers
IFA	-	Inverted-F Antenna
ISM	-	Industrial, Scientific and Medical
L	-	Length of patch or antenna layer
LAN	-	Local Area Network
MAN	-	Metropolitan Area Network
MB-OFDM	-	Multi-Band Orthogonal Frequency Division Multiplexing
Mbps	-	Mega bit per second
MHz	-	Mega
MMS	-	Multimedia Messaging Service

mm	-	millimetre
m/s	-	millisecond
PAN	-	Personal Area Network
PCB	-	Printed Circuit Board
PCS	-	Personal Communication System
PDA	-	Personal Digital Assistant
PIFA	-	Planar Inverted-F Antenna
P_r	-	Power Receive
P_{rad}	-	Power Radiated
P_t	-	Power Transmit
p'	-	Polarization of antenna
RF	-	Radio Frequency
RSW	-	Reduced-Surface Wave
\hat{S}	-	Closed Surface Containing Antenna
\hat{S}_{iso}	-	Power Density
SMA	-	SubMiniature version A
SMS	-	Short Message Service
SWR	-	Standing Wave Ratio
Tx	-	Transmitter
UHF	-	Ultra High Frequency
UWB	-	Ultra-Wideband
VHF	-	Very High Frequency
VSWR	-	Voltage Standing Wave Ratio

W	-	Width of strip
WLAN	-	Wireless Local Area Network
WLL	-	Wireless Local Loop
λ_0	-	Wavelength
λ_g	-	Wavelength
ϵ_r	-	Dielectric Constant
ϵ_{ff}	-	Effective Dielectric
Ω	-	ohm

LIST OF APPENDIXES

NO.	TITLE	PAGE
A	Input Impedance	67
B	Low Frequency	68
C	High Frequency	70
D	Efficiency	72