



DESIGN AND DEVELOPMENT OF PYRAMIDAL
MICROWAVE ABSORBER USING AGRICULTURAL
WASTE

by

NORNIKMAN HASSAN
(0730810214)

A thesis submitted
In fulfillment of the requirements for the degree of
Master of Science (Communication Engineering)

**School of Computer and Communication Engineering
UNIVERSITI MALAYSIA PERLIS**

2011

UNIVERSITI MALAYSIA PERLIS

DECLARATION OF THESIS

Author's full name :

Date of birth :

Title :

Academic Session :

I hereby declare that the thesis becomes the property of Universiti Malaysia Perlis (UniMAP) and to be placed at the library of UniMAP. This thesis is classified as :

- CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)*
- RESTRICTED** (Contains restricted information as specified by the organization where research was done)*
- OPEN ACCESS** I agree that my thesis is to be made immediately available as hard copy or on-line open access (full text)

I, the author, give permission to the UniMAP to reproduce this thesis in whole or in part for the purpose of research or academic exchange only (except during a period of _____ years, if so requested above).

Certified by:

SIGNATURE

SIGNATURE OF SUPERVISOR

(NEW IC NO. / PASSPORT NO.)

NAME OF SUPERVISOR

Date : _____

Date : _____

NOTES : * If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentiality or restriction.

ACKNOWLEDGMENTS

I am indebted and grateful to many people, who have helped me during the course of this research project in one way or another. In particular I would like to acknowledge and express my deepest gratitude to my supervisor, Dr. Mohd Fareq Abd Malek to whom I am greatly indebted, for giving me the opportunity to undertake the research in UniMAP, for his supervision and for his encouragement throughout the course of the research.

I also would like to express my deep and sincere thanks to my co-supervisors, Mr Soh Ping Jack and Mr Azremi Abdullah Al-Hadi for their guidance, support and encouragement. Their door has always been opened and I could always talk to them no matter how busy they were. I can only feel flattered for the confidence that always show in me. Fortunately, I have benefited from his extraordinary motivation, great intuition and technical insight.

A special gratitude to Dr R. Badlishah Ahmad (Dean of School of computer and Communication, UniMAP), Hj Hasnain Hj Abdullah @ Idris (Lecturer of UiTM Penang), Dr Supri A. Ghani (Lecturer of School of Material, UniMAP), Shaiful Aziz Rashid Ali (Lecturer of School of computer and Communication, UniMAP), Saidatul Norlyana Azemi (Lecturer of School of computer and Communication, UniMAP), Ismahayati binti Adam (Lecturer of School of computer and Communication, UniMAP), Ir Anuar Mat Safar (Lecturer of School of computer and Communication, UniMAP), Abdul Hafiizh Ismail (Lecturer of School of computer and Communication, UniMAP), Muhammad Ezanuddin Abd Aziz (Master student), Wee Fwen Hoon (PhD student), Mohd Rashidi Che

Beson (Master student), Nurul Husna Mohd Rais (Master student), Manjur Ahmed (Master student), Muhammad Solihin bin Zulkifli (Master student), Mohd Hafizuddin b Mat (Master student), Fredy Novriandy (practical student), Amira Eleza Azemi (practical student) for many useful discussion and suggestions during the course of my research.

Last but not least I would like to thank my postgraduate's friends, my siblings and my parents for their patience, understanding, love and constant encouragement. Finally, I would like to thank everyone that has been involved in this project directly or indirectly for their help and contribution. Thank you very much!

© This item is protected by original copyright

TABLE OF CONTENTS

	Page
APPROVAL AND DECLARATION SHEET	ii
ACKNOWLEDGMENT	iii
TABLE OF CONTENTS	v
LIST OF TABLES	ix
LIST OF FIGURES	xi
LIST OF SYMBOLS	xvii
LIST OF ABBREVIATIONS	xx
ABSTRAK (BAHASA MELAYU)	xxii
ABSTRACT (ENGLISH)	xxiii
CHAPTER 1 INTRODUCTION	
1.1 Overview	1
1.2 Problem Statement	3
1.3 Research Objective	4
1.4 Research Scope	5
1.5 Thesis Outline	6
CHAPTER 2 LITERATURE REVIEW	
2.1 Overview	8
2.2 Anechoic Chamber	9
2.3. RF Absorber	
2.3.1 Lower Frequency Absorber	13

2.3.2	Microwave Frequency Absorber	14
2.4	Types of Microwave Absorber	
2.4.1	Layer Type Absorber	15
2.4.2	Pyramidal Absorber	16
2.4.3	Wedge Absorber	17
2.4.4	Oblique Absorber	18
2.4.5	Convolutd Absorber	19
2.4.6	Flat Absorber	19
2.4.7	Broadband Walkway Absorber	20
2.4.8	Hybrid Absorber	20
2.4.9	Other Type of Absorbers	21
2.5	Microwave Properties for Absorbing Material	
2.5.1	Reflection Coefficient	22
2.5.2	Reflection Loss	23
2.5.3	Dielectric Constant	23
2.5.4	Wavelength	25
2.5.5	Loss Tangent	25
2.5.6	Skin Depth	26
2.6	Components of a Microwave Absorber	
2.6.1	Agricultural Waste	28
2.6.2	Resins	29
2.6.3	Hardener Agent	30
2.7	Parameters of the Microwave Absorber	
2.7.1	Differential Shape	30
2.7.2	Dimension of Absorber	34
2.7.3	Angle of Incidents	37
2.8	Dielectric Constant Measurement Technique	
2.8.1	Free Space Measurement Technique	39
2.8.2	NRL Arch Free Space Technique	40
2.8.3	Resonant Cavity Technique	40
2.8.4	Transmission Line Technique	41

2.9	Reflection Loss Measurement	
2.9.1	Radar Cross Section Measurement	42
2.9.2	AVSWR Measurement	44
2.10	Specification of Microwave Absorber	
2.10.1	Clean Room Rating	45
2.10.2	Fire Retardant	45
2.10.3	Tensile Stability	46
2.10.4	Power Density	47
2.10.5	Product Life	48
2.10.6	Humidity Resistance	48
2.11	Critical Review of Pyramidal Microwave Absorber	49
2.12	Summary	50

CHAPTER 3 METHODOLOGY

3.1	Overview	51
3.2	Flow Chart	51
3.3	Collecting of Agricultural Waste	53
3.4	Fabrication of Particle Board	53
3.5	Measurement of Dielectric Properties	57
3.6	Microwave Absorber Simulation Design in CST MWS	
3.6.1	Pyramidal Microwave Absorbers in CST MWS	61
3.6.2	Different Dimension of Pyramidal absorber	63
3.6.3	Different Resin Percentages	63
3.6.4	Different Carbon Coating Thickness	64
3.6.5	Different Distances of Signal Source	64
3.6.6	Different Angle of Signal Sources	65
3.7	Absorber Mould Fabrication	66
3.8	Microwave Absorber Fabrication	66

3.9	Measurement of the Pyramidal Microwave Absorber	
3.9.1	The Measurement Calibration	68
3.9.2	Reflection Loss Performance using RCS Method	69
3.9	Summary	72

CHAPTER 4 RESULTS AND DISCUSSIONS

4.1	Overview	73
4.2	Simulation Result	
4.2.1	The Different Shapes	73
4.2.2	Different Dimensions	76
4.2.3	Different Resin Percentages	80
4.2.4	Different Coating Thickness	83
4.2.5	Different Distances of the Source Signal	85
4.2.6	Different Angle of Signal Source	86
4.2.7	Different Polygonal Sides	89
4.2.8	Radar Cross Section Result (Simulation)	90
4.3	Measurement Result	
4.3.1	Dielectric Properties Measurement Results	92
4.3.2	Radar Cross Section Measurement Results	94
4.4	Summary	101

CHAPTER 5 SUMMARY AND FUTURE WORK

5.1	Overview	102
5.2	Contributions	103
5.3	Future Work	103

REFERENCES	105
-------------------	-----

APPENDIX

List of Publication and Exhibition	114
Data Sheet	117

LIST OF TABLES

Table		Page
2.1	Dielectric constant of several materials based on Clipper Control	23
2.2	The connection of dielectric constant and wavelength, frequency at 2 GHz	25
2.3	Skin depth with different frequency	27
2.4	Element percentages in rice husks	29
2.5	Shape of Microwave Absorber Design	32
2.6	Dimensions, side angle and open surface area of the polygonal based pyramidal microwave absorber	34
2.7	Comparisons of dimensions of commercially available pyramidal microwave absorber	34
2.8	Dimension of the pyramidal and truncated pyramidal microwave absorber	35
2.9	Dimensions of normal, truncated wedge microwave absorber	36
2.10	General guidelines for microwave absorber reflection loss	42
2.11	Comparison of tensile strength of several materials	47
2.12	Several research on pyramidal microwave absorber	50
3.1	Agricultural wastes used for particle board fabrication	55
3.2	Resin percentages with rice husks (for parametric study)	55
3.3	Dimensions of the pyramidal microwave absorbers	63
3.4	Parametric study for different dimensions of the pyramid microwave absorber	64
3.5	Location of the 10 point for the RCS Method	71
4.1	The reflection loss of the different shape of the pyramidal Microwave absorber (simulation)	75
4.2	The reflection losses of different pyramidal width, PW of the microwave absorber (simulation)	76
4.3	The reflection losses of different P_H for the pyramidal microwave	78

	absorber (simulation)	
4.4	The reflection losses of the different B_H for the pyramidal microwave absorbers (simulation)	80
4.5	The reflection losses of the different UF percentages in the pyramidal microwave absorber (simulation)	81
4.6	The reflection losses of the different PF percentages in the pyramidal microwave absorber (simulation)	83
4.7	The reflection losses of the different coated carbon thicknesses for the pyramidal microwave absorber ($t =$ thickness) (simulation)	84
4.8	The reflection losses of the different distances for the pyramidal microwave absorber ($d =$ distance) (simulation)	86
4.9	The reflection loss of the different angle between the signal sources and the pyramidal microwave absorber (simulation)	87
4.10	The reflection losses of the polygonal pyramid and cone-cylinder microwave absorber (simulation)	90
4.11	Dielectric constants of different resin percentages	92
4.12	Dielectric constants of different types of agricultural waste particle board with different sample distance	93
4.13	Average reflection losses of simulation and fabricated at different point for rice husk pyramidal microwave absorber (measurement)	99
4.14	Average reflection losses of commercial absorber and fabricated for rice husks pyramidal microwave absorber	100

LIST OF FIGURES

Figure		Page
1.1	The location of microwaves in Electromagnetic Spectrum	2
1.2	Scope of work	6
2.1	Type of absorber (a) For evaluating the radiation noise and the immunity of an automobile, (b) For antenna evaluation/EMI 10-meter/ EMS testing (multi purpose), (c) For microwave evaluation and antenna testing, (d) For VHF, UHF and SHF evaluation and testing	10
2.2	The side view of RF anechoic chamber	12
2.3	Ferrite absorber	14
2.4	A single-layer tuneable microwave absorber using an active FSS	15
2.5	Salisbury screen absorber from ARC Technologies	16
2.6	Square based pyramidal microwave absorber: (a) <i>TDK ICT 030</i> , (b) <i>Eccosorb VHP-8-NRL</i>	17
2.7	Wedge Microwave Absorber: (a) <i>TDK IP 045C</i> (b) <i>AEW-18</i>	18
2.8	Oblique Microwave Absorber from TDK	18
2.9	Convoluted microwave absorber: (a) <i>C RAM FAC 4.0</i> (b) <i>AEC-4</i>	19
2.10	The common placement location of flat absorber in the anechoic chamber	19
2.11	Commercial walkway absorber a) <i>AEMI</i> b) <i>Siepel Hyral API</i>	20
2.12	Pyramidal ferrite absorber	21
2.13	Corrugated absorber (Choo <i>et al.</i> , 2001) and Chebyshev Multilevel Absorber with curve wedge design (Gau, <i>et al.</i> , 1997)	21
2.14	Higher dielectric constant can make signal travel slower than free space	24
2.15	Skin depth	26
2.16	Mixed material that use for microwave absorber	28
2.17	Agricultural waste used: (a) rice husk, (b) rice straw, (c) kenaf	28
2.18	Polygonal based pyramidal microwave absorber	33

2.19	Dimensions of (a) the pyramidal microwave absorber and (b) the truncated wedge microwave absorber	35
2.20	Dimensions of the wedge microwave absorber and (b) the truncated pyramidal microwave absorber	36
2.21	Angle of incident at pyramidal microwave absorber (a) normal incident (b) oblique incident	38
2.22	Free Space Measurement Technique setup	39
2.23	NRL Arch Free Space Technique setup	40
2.24	Resonant Cavity Technique	41
2.25	Transmission Line Technique: (a) rectangular waveguide transmission (b) coaxial air line	41
2.26	Radar Cross Section Measurement Method	41
2.27	(a) empty room measurement setup (b) reference target measurement setup	43
2.28	AVSWR measurement setup	44
3.1	Flow chart of research project	52
3.2	Rice husk that taken from BERNAS office	53
3.3	Fabrication of particle board process	54
3.4	Mixture materials for the fabrication of agricultural waste particle board	54
3.5	(a) UF resin (white) and PF (purple-black) resin. (b) Resin is mixed with the rice husks (c) The mixture are transfer to the square mould	56
3.6	The view of hot press machine (a) the whole view (b) the upper part (c) the lower part (cooling part)	57
3.7	Three samples of agricultural waste particle board. From left: Kenaf, rice straw and rice husk	57
3.8	Process of measuring the dielectric constant of agricultural waste particle board	58
3.9	Free Space Measurement technique to determine the dielectric constant of rice husks in Communication Advance Laboratory,	59

UniMAP

3.10	Time gating setting at the PNA network analyzer	61
3.11	Dimensions of (a) the pyramidal microwave absorber and (b) the Truncated pyramidal microwave absorber	62
3.12	Simulation setup for pyramidal microwave absorber using CST Microwave Studio	62
3.13	Pyramidal microwave absorber (a) normal (b) coated with carbon	64
3.14	Different distances between the signal source (Point $X_1 = 35$ cm, $X_2 = 50$ cm, and $X_3 = 65$ cm) and the pyramidal microwave absorber. The constant parameter is angle = 0^0	65
3.15	Different angles between signal source (Point $Y_1 = 0^0$, $Y_2 = 30^0$ and $Y_3 = 45^0$) and the surface of the pyramidal microwave absorber. The constant parameter is distance = 35 cm	65
3.16	The mould of pyramidal microwave absorber	66
3.17	(a) transparency plastic is placed into mould, (b) the mixed materials in the plastic cup, (c) the mixture in the absorber mould	67
3.18	Hand press machines	67
3.19	Microwave absorber measurement testing method	68
3.20	Two ports measurement setup	68
3.21	One port measurement setup	69
3.22	(a) RCS Method setup with reference signal (b) Define the best distance between	70
3.23	RCS Method setup with the commercial available VHP-NRL pyramidal microwave absorbers	71
3.24	RCS Method setup with the fabricated rice husk pyramidal microwave absorbers	71
3.25	24 different points on the pyramidal microwave absorber	71
4.1	The reflection losses of the different shape of the rice husks microwave absorbers (simulation)	75
4.2	The reflection losses of the different pyramidal widths, P_w for the pyramidal microwave absorber (simulation). The constant	77

- values are: pyramid height, $P_H = 13$ cm, base height, $B_H = 2$ cm, source signal distance, $d = 35$ cm, angle of source signal = 0^0
- 4.3 The reflection loss of the different pyramidal heights, P_H for the pyramidal microwave absorber (simulation). The constant values are base width, $B_W = 5$ cm, base length, $B_L = 5$ cm, base height, $B_H = 2$ cm, source signal distance, $d = 35$ cm, angle of source signal = 0^0 78
- 4.4 The reflection losses of different base heights, B_H for the pyramidal microwave absorber (simulation). The constant values are base width, $B_W = 5$ cm, base length, $B_L = 5$ cm, pyramid height, $P_H = 13$ cm, source signal distance, $d = 35$ cm, angle of source signal = 0^0 79
- 4.5 The reflection losses of the different UF percentages in the pyramidal microwave absorber (simulation). The constant values are base width, $B_W = 5$ cm, base length, $B_L = 5$ cm, base height, $B_H = 2$ cm, pyramid height, $P_H = 13$ cm, source signal distance, $d = 35$ cm, angle of source signal = 0^0 81
- 4.6 The reflection losses of the different PF percentages in the pyramidal microwave absorber (simulation). The constant values are base width, $B_W = 5$ cm, base length, $B_L = 5$ cm, base height, $B_H = 2$ cm, pyramid height, $P_H = 13$ cm, source signal distance, $d = 35$ cm, angle of source signal = 0^0 82
- 4.7 The reflection losses of the normal and the coated carbon thickness for the pyramidal microwave absorber ($t =$ thickness) (simulation). The constant values are base width, $B_W = 5$ cm, base length, $B_L = 5$ cm, base height, $B_H = 2$ cm, pyramid height, $P_H = 13$ cm, source signal distance, $d = 35$ cm, angle of source signal = 0^0 84
- 4.8 The reflection losses of the different distances for the pyramidal microwave absorber (simulation). The constant values are base width, $B_W = 5$ cm, base length, $B_L = 5$ cm, base height, $B_H = 2$ 85

	cm, pyramid height, $P_H = 13$ cm, angle of source signal = 0^0	
4.9	The reflection losses of the different angles between the signal sources and the pyramidal microwave absorber (simulation). The constant values are base width, $B_W = 5$ cm, base length, $B_L = 5$ cm, base height, $B_H = 2$ cm, pyramid height, $P_H = 13$ cm, source signal distance, $d = 35$ cm	87
4.10	The average reflection losses of the pyramidal microwave absorber over degrees (simulation). The constant values are base width, $B_W = 5$ cm, base length, $B_L = 5$ cm, base height, $B_H = 2$ cm, pyramid height, $P_H = 13$ cm, source signal distance, $d = 35$ cm	88
4.11	The reflection losses of the polygonal pyramid and cone-cylinder microwave absorber	89
4.12	The reflection losses of the pyramidal microwave absorber at different points (simulation)	91
4.13	The fabricated pyramidal microwave absorber using rice husk (a) single unit (without base), (b) 4x4 array unit absorber	91
4.14	The reflection losses of the pyramidal microwave absorber at different point The constant values are base width, $B_W = 5$ cm, base length, $B_L = 5$ cm, base height, $B_H = 2$ cm, pyramid height, $P_H = 13$ cm, source signal distance, $d = 35$ cm, angle of source signal = 0^0	95
4.15	The reflection losses at the lowest peak point (between 4 absorbers) for simulation and fabricated pyramidal microwave absorber. The constant values are base width, $B_W = 5$ cm, base length, $B_L = 5$ cm, base height, $B_H = 2$ cm, pyramid height, $P_H = 13$ cm, source signal distance, $d = 35$ cm, angle of source signal = 0^0	96
4.16	The reflection losses at the random point (Between 2 Absorbers) for the fabricated pyramidal microwave absorber. The constant values are base width, $B_W = 5$ cm, base length, B_L	96

- = 5 cm, base height, $B_H = 2$ cm, pyramid height, $P_H = 13$ cm,
source signal distance, $d = 35$ cm, angle of source signal = 0^0
- 4.17 The reflection losses at the highest peak point for the fabricated 97
pyramidal microwave absorber. The constant values are base
width, $B_W = 5$ cm, base length, $B_L = 5$ cm, base height, $B_H = 2$ cm,
pyramid height, $P_H = 13$ cm, source signal distance, $d = 35$ cm,
angle of source signal = 0^0
- 4.18 The reflection losses at the lowest peak point (between 2 97
absorbers) for the fabricated pyramidal microwave absorber. The
constant values are base width, $B_W = 5$ cm, base length, $B_L = 5$
cm, base height, $B_H = 2$ cm, pyramid height, $P_H = 13$ cm,
source signal distance, $d = 35$ cm, angle of source signal = 0^0
- 4.19 The reflection losses between the highest and lowest peak point 98
for the fabricated pyramidal microwave absorber. The constant
values are base width, $B_W = 5$ cm, base length, $B_L = 5$ cm, base
height, $B_H = 2$ cm, pyramid height, $P_H = 13$ cm, source signal
distance, $d = 35$ cm, angle of source signal = 0^0
- 4.20 The comparison of the reflection losses between the commercial 100
microwave absorber and the fabricated rice husks pyramidal
microwave absorber

LIST OF SYMBOLS

α	attenuation constant
β	phase constant of the propagation function
δ_s	skin depth
ϵ	absolute permittivity
ϵ_0	permittivity of free space
ϵ_r	relative permittivity or dielectric constant
ϵ_r''	imaginary of relative permittivity
μ	permeability
γ	complex propagation functions of the material in waveguide
λ	wavelength
λ_0	free space wavelength
λ_c	cut-off wavelength
χ	susceptibility
σ	electrical conductivity of the metal ($\Omega^{-1}\text{m}^{-1}$)
ρ	bulk resistivity values (Ωm)
ω	angular frequency of the radiation
A_0	Open Surface Area
B_H	base height
B_L	base length
B_W	base width
c	speed of light
C	Carbon

D	flux
D	distance between horn antennas and reference metal
d	sample thickness
Emp	RCS of empty room measurement
f	frequency
G	power gain of antenna
H_a	height of antennas in the anechoic chamber
H_L	Hypotenuse Length
n	number of open surface side
NiZn	ferrite tiles
P	experienced in a material
P_H	pyramid height
P_i	power input to antenna
P_L	pyramid length
P_W	pyramid width
R	distance between horn antennas and microwave absorber
R_a	actual distance between two antennas
R_c	distance to center of radiation of antenna
R_{fr}	RCS of reference target measurement
S	power density
S_R	Point to Angle Length
S_L	Side Length
$\tan \delta$	loss tangent

T_L	top length
T_W	top width
v	velocity
X_L	Triangle Length
x_0	distance of first minimum position from the sample
W_H	wedge height
W_L	wedge length
W_W	wedge width

© This item is protected by original copyright

LIST OF ABBREVIATIONS

AUT	antenna under test
AVSWR	Advanced voltage standing wave ratio
BERNAS	Beras Nasional
CST	Computer Simulation Technolgy
EM	Electromagnetic
EMI	electromagnetic interference
EMC	electromagnetic compatibility
FSM	Free Space Measurement Technique
GPS	Global Positioning Satellite
GSM	Global System for Mobile communication
LAN	Local Area Network
LPA	Log periodic antenna
MDI	methylene diphenyl isocyanate
MEKP	methyl ethyl ketone peroxide
MUT	material under test
MWS	Microwave Studio
NRL	Naval Research Laboratory
OHP	overhead projector
OP-EFB	oil palm empty fruit bunch
PF	Phenol Formaldehyde
PNA	Programmable Network Analyzer
PSG	Personal Systems Group

QZ	quiet zone
RAM	radar absorbing material
RCS	radar cross section
RF	Radio Frequency
SHF	Super High Frequency
SOLT	Short – Open – Load – Trough
SAR	specific absorption rate
SRR	Split Ring Resonator
UF	Urea Formaldehyde
UHF	Ultra High Frequency
UWB	Ultra Wide Band
VHF	Very High Frequency
VSWR	voltage standing wave ratio
WiMAX	Worldwide Interoperability for Microwave Access

Rekabentuk dan Pembangunan Penyerap Mikrogelombang Berbentuk Piramid Menggunakan Sisa Pertanian

ABSTRAK

Sisa pertanian mempunyai potensi untuk digunakan sebagai bahan alternatif untuk penyerap mikrogelombang yang digunakan di dalam bilik anekoik. Berbanding kepada bahan yang digunakan pada masa ini dalam pasaran komersial seperti polistirena and poliuretina, sisa pertanian adalah bahan yang kos rendah dan mesra alam. Penyerap mikrogelombang berbentuk pyramid dari sekam padi berupaya untuk beroperasi secara efektif di dalam julat frekuensi mikro gelombang dari 7 GHz ke 13 GHz. Dalam kajian ini, sisa pertanian lain seperti jerami padi dan kenaf juga digunakan untuk membandingkan prestasi kehilangan pantulannya dengan penyerap sekam padi. Poliester digunakan sebagai pelekat yang dicampur dengan sisa pertanian dan pengeras metal etil keton peroksida (MEKP). Pelekat lain seperti Urea Formaldehida (UF) dan Fenol Formaldehida (PF) juga digunakan untuk membandingkan prestasi kehilangan pantulannya. Terdapat 6 peringkat utama dalam rekabentuk dan pembuatan penyerap mikrogelombang pyramid dari sekam padi. Peringkat perama adalah membina papan partikel dari pada sisa pertanian. Kediua, peringkat seterusnya disambung dengan pencarian nilai sifat dielektrik bagi papan partikel dari sisa pertanian menggunakan teknik pengukuran ruang bebas. Peringkat ketiga adalah mencari kehilangan pantulan terbaik bagi penyerap mikrogelombang pyramid menggunakan perisian simulasi CST Microwave Studio. Sifat dielektrik yang digunapakai dalam simulasi ini adalah diambil dari hasil teknik pengukuran ruang bebas yang dibuat sdebelum ini. Beberapa parameter yang dapat memberi kesan kepada prestasi penyerap mikrogelombang berbentuk pyramid telah disiasat di dalam sesi kajjian parametrik. Kajian Parametrik yang diambil kira di dalam simulasi ini adalah perubahan bentuk, dimensi, peratusan pelelat, ketebalan salutan karbon, jarak untuk sumber isyarat, sudut untuk sumber isyarat, dan sisi poligon. Selepas itu, ia diteruskan dengan proses fabrikasi bagi penyerap mikrogelombang dari sekam padi menggunakan mol berbentuk pyramid bertapak segiempat. Peringkat terakhir adalah untuk mengukur prestasi kehilangan pantulan bagi penyerap mikrogelombang dari sekam padi yang telah difabrikasi. Dalam sesi ini, hasil dari simulasi dan fabrikasi bagi penyerap mikrogelombang telah dibandingkan. Hasil pengukuran didapati mempunyai nilai yang hampir sama. Pada sisi yang lain, penyerap komersial dan yang telah difabrikasi juga telah diambil kira untuk dibandingkan kehilangan pantulannya. Didapati hasil kehilangan pantulannya (pengukuran) adalah melebihi - 30 dB dalam julat frekuensi 7 GHz dan 13 GHz.

Design and Development of Pyramidal Microwave Absorber using Agricultural Waste

ABSTRACT

Agriculture waste has potential to be used as an alternative material for the microwave absorber that used in the RF anechoic chamber. Compared to the current material that used in the commercial market such as polystyrene and polyurethane, the agricultural waste is low cost material and environmental friendly. This rice husk pyramidal microwave absorber can operate effectively in the microwave frequency range from 7 GHz to 13 GHz. In this research, agricultural waste of rice husks from paddy is used as the main material that mixed with resin and hardener agent for the pyramidal microwave absorber design. Other agricultural waste like rice straw and kenaf are also used to compare its reflection loss performance with rice husk absorber. Polyester is used as resin that mixed with agricultural waste and methyl ethyl ketone peroxide (MEKP) hardener. Other resin like Urea Formaldehyde (UF) and Phenol Formaldehyde (PF) are also used to compare its reflection loss performances. There are six main stages in designing and development of the rice husk pyramidal microwave absorber. The first stages are fabricating the agricultural waste particle board. Secondly, the stage is continuing with deriving the dielectric properties value of the agricultural waste mixture particle board using the free space measurement technique. The third stage is to define the best reflection loss result of the agricultural waste pyramidal microwave absorber using CST Microwave Studio simulation software. The dielectric properties that used in this simulation are taken from the free space measurement technique result that had been done before. Various parameters that affect the performance of the pyramidal microwave absorber are investigated in the parametric study section. The parametric study that taken care in this simulation are different shape, dimension, resin percentage, carbon coating thickness, distance of source signal, angle of source signal, and polygonal side. Then, it continued by fabrication process of the rice husk pyramidal microwave absorber using pyramidal shape with square base mould. The last stage is to measure the reflection loss performances of the fabricated rice husk pyramidal microwave absorber. In this section, the result of the simulation and fabrication of the pyramidal microwave absorber are compared. Measurement results show close agreement with the simulation result. In the other side, the commercial and fabricated absorber is also considered to compare it reflection loss. It show that the reflection loss performance is better than - 30 dB in the range between 7 GHz and 13 GHz.

CHAPTER 1

INTRODUCTION

1.1 Overview

In the real world, the agricultural waste is considered as not useful to the community. Agricultural Waste is waste produced at agricultural premises as a result of agricultural activity. Crop residues or field residues are materials left in an agricultural field or orchard after the crop has been harvested. These residues include stalks and stubble (stems), leaves, and seed pods. Good management of field residues can increase efficiency of irrigation and control of erosion. Agriculture waste has potential to be used as an alternative material for the microwave absorber used in the anechoic chamber. The example of the agricultural waste are rice husk, rice straw, oil palm empty fruit bunch, sugar cane bagasse, coconut shell charcoal, corn stover, citrus waste and others.

Rice husk is a waste product of the agriculture activity in most countries in Asia and in particular Malaysia. Rice husks are the natural sheaths that form on rice grains during their growth and removed as waste during the processing of rice in the mills (Adil & Farook, 2007). In Malaysia, around 350,000 tons of rice husks are produced annually (Padiberas, 2007). The source from The Malaysian Ministry of Agriculture's statistic shows that approximately one million ton of rice husk was generated in 1994 (Ministry of Agriculture, 1995). However, in the recent years, there are many researches about the potential of this agricultural waste. Nowadays, this material has been used in many sectors. For example, these materials are used in biomass fuel for generating power (Mohamad, *et al.*, 2008), (Ahiduzzaman & Islam, 2009) and also as rice husk-concrete mixture in building construction work (Habeeb