DESIGN AND DEVELOPMENT OF PYRAMIDAL MICROWAVE ABSORBER USING AGRICULTURAL WASTE

by

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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 (℧m)
ρ	bulk resistivity values (Ωm)
ω	angular frequency of the radiation
A_O	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	experlenced 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
Rfr	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

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 polistrerina 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 menggunkan 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 kajian 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 ethiyl 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

& Fayyadh, 2009).

The microwave spectrum in the Electromagnet spectrum, near to radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-Rays and gamma rays (Gupta & Eugene., 2007). Figure 1.1 shows the Electromagnetic Spectrum. Microwaves are electromagnetic waves with wavelengths ranging from as long as one meter down to as short as one millimeter. In reality, most applications of microwave technology today are telecommunication system, radar system, environmental remote sensing, and medical system. In telecommunication, there are many applications of microwave that affects us in the daily life such as Wireless Local Area Network (LAN), Bluetooth, Global System for Mobile communication (GSM), Global Positioning Satellite (GPS), microwave radio, Ultra Wide Band (UWB) radio, satellite communication, and Worldwide Interoperability for Microwave Access (WiMAX). Most of the microwaves frequencies are reserved for the government sector (e.g military) thus leaving only limited range of frequencies for domestics and commercial usages. The common electric equipment used basically operates at the unregulated industrial, scientific and medical (ISM) band of 915 MHz, 2.45 GHz and 5.8 GHz.

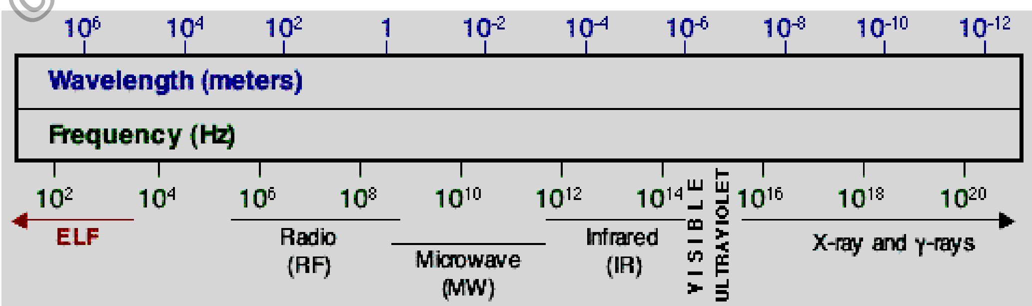

Figure 1.1: The location of microwaves in Electromagnetic Spectrum