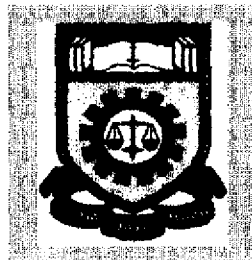


**MICROWAVE NONDESTRUCTIVE EVALUATION OF
TIMBER USING A METAL-BACKED REFLECTION
TECHNIQUE**

**Thesis presented in partial fulfilment for the award of the
Bachelor of Electrical Engineering (Hons)
of
MARA INSTITUTE OF TECHNOLOGY**



**RAZIMAH BINTI ABDUL RAHIM
SCHOOL OF ELECTRICAL ENGINEERING
MARA INSTITUTE OF TECHNOLOGY
40450 Shah Alam, MALAYSIA.**

APRIL 1998

ABSTRACT

Dielectric properties of timber are determined by its moisture content, slope-of-grain and density. So, they can be used for nondestructive evaluation of timber. Dielectric properties will be deduced from complex reflection coefficient measurements of metal-backed Malaysian timber specimens. A free-space microwave measurement system is used for reflection coefficient measurements in the frequency range of 7.5-14.5 GHz. The key components of the measurement system are a pair of spot-focusing horn lens antennas, the microwave network analyser and computer. The inaccuracies in free-space measurements due to diffraction and multiple reflections are minimized by the use of spot-focusing antennas and free-space LRL (Line, reflect and line) calibration technique. Experimental results will be reported for dry and wet specimens of different types of Malaysian timber. Also, dielectric constant and loss tangent values will be measured when the electric field is parallel and perpendicular to the grain direction.

ACKNOWLEDGEMENT

In the name of Allah , Beneficent and the Merciful , I would like to thank Allah for giving me the health and strength to conduct the experiment and study in my major project and thus enable me to prepare this thesis for the benefit of those who are interested.

I would like to express my deepest thanks to my major project advisor , Dr. Deepak Kumar Ghodgaonkar for his continuous guidance and encouragement during the one year. Especially , I would also like to express my sincere thanks and wishes to acknowledge with gratitude , Professor Dr. Wan Mahmood B. Wan A. Majid kindness , consideration and patience . Appreciation is also gratefully to the workshop staff of school of Civil Engineering En. Suhairi Mohammed for giving cooperation , the workshop staff of school of Mechanical Engineering En. Ramli and also to CADEM staffs for their full cooperation and Project Co-ordinator , Puan Rosnani Yahya for her continuous information and support.

Finally , I wishes to thank to my parent and family at Rembau Negeri Sembilan , for their support.

**MICROWAVE NONDESTRUCTIVE EVALUATION OF TIMBER USING A
METAL-BACKED REFLECTION TECHNIQUE.**

Contents	Page No.
Abstract	i
Acknowledgment	ii
Contents	iii
CHAPTER 1	
1.0 Introduction	1
1.1 Introduction of Microwaves	3
CHAPTER 2	
2.0 Microwave Nondestructive Testing Method	5
2.1 Dielectric Plates	7
CHAPTER 3	
3.0 Reflection and Transmission Waves	8
3.1 Introduction	8
3.2 Polarization of Planes Waves	8

CHAPTER 1

1.0 INTRODUCTION

There has always been a great deal of interest in nondestructive testing (NDT) of material such as timber, metals, composites etc. The field of NDT of materials covers many areas of science. When electromagnetic (EM) waves are used to nondestructively evaluate properties of materials media, an accurate theoretical model which describes the interaction of EM waves with the material must be developed.

Timber is a natural material with a complex structure and composition. Interaction between the alternating electromagnetic field and timber makes it possible to elucidate specific properties of this material. Timber is highly variable material with some properties, such as strength, varying by a factor of more than 10:1 within the same tree. The two important structural properties are strength and stiffness. The strength and stiffness properties are much greater along the fiber direction than in the cross direction. As timber is semi-transparent at microwave frequencies, the loss, phase shift and polarization of microwaves transmitted through timber can be measured. Timber is also strongly anisotropic both in its physical strength and in its electrical properties.

Under the action of an alternating electric field, the timber reveals its dielectric properties, which more often are characterized by two main indices: by the relative dielectric constant (ϵ') and by the dielectric loss tangent (δ).