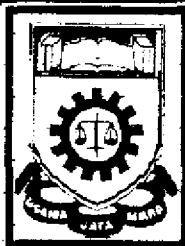


# **FREE SPACE MICROWAVE INTERFEROMETER TECHNIQUE FOR DIELECTRIC MEASUREMENTS**

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



**MUNAWIR BIN MOHAMMAD  
FACULTY OF ELECTRICAL ENGINEERING  
MARA INSTITUTE OF TECHNOLOGY  
40450 SHAH ALAM  
SELANGOR  
NOV 1998**

## **ACKNOWLEDGEMENT**

In the name of Allah, the Beneficent and the Merciful. It is with deepest sense of gratitude to Allah who has given the strength and ability to complete this project and the thesis as it today.

I would like to express my deepest gratitude to my project advisor, **Dr. Deepak Kumar Ghodgaonkar** and **Staffs of Electronic Communication Laboratory** for their support, guidance and assistance for the success of this project.

I would like to thanks to my classmates especially Mohd.Nor Hashim and Sanadi Zainol for their contribution in the completion of this thesis.

## **ABSTRACT**

In the past, a free-space techniques has been used for the measurement of dielectric constant and loss tangent using short-circuited line method and reflection and transmission coefficient method. A microwave interferometer technique is implemented on the free-space microwave measurement system consisting of transmit and receive spot focusing horn lens antenna, a network analyzer, mode transitions and a computer. The dielectric constants and loss tangents will be measured for standard materials such as Teflon and Polyvinyl-Chloride (PVC). A free-space measurement system operating in the 8 – 12.5 GHz frequency range is used to measure the reflection and transmission coefficients,  $S_{11}$  and  $S_{21}$  of the planar samples, sandwiched between composite reflectors.

<b>CONTENTS</b>	<b>PAGE</b>
Declaration	i
Acknowledgement	ii
Approval	iii
Abstract	iv
Contents	v
 <b>CHAPTER 1</b>	
1.0 Introduction to microwave	
1.1 Microwave Bands	1
1.2 Microwave Application	2
1.3 Energy associated with microwave	4
 <b>CHAPTER 2</b>	
2.0 Basic Theory Of Microwaves	
2.1 Properties Of Fields At Microwave Frequencies	6
2.2 Frequency Definition	7
2.3 Wavelength Definition	8
2.4 Conductivity	8
2.5 Complex permittivity	9
2.6 Complex permeability	12

# CHAPTER 1

## 1.0 INTRODUCTION TO MICROWAVE

Microwaves are electromagnetic waves of very short wavelength between 50 cm (600 MHz) and 1.0 mm (300 GHz). Since frequency is inversely proportional to wavelength, microwave frequencies are relatively high. Generally defines operations in the region where distributed constant circuits enclosed by conducting boundaries are used instead of conventional lumped-constant circuit elements. The wavelength and frequency of various kinds of electromagnetic wave are listed in table 1.1

**TABLE 1.1 The frequencies and wavelength of various bands of electromagnetic waves**

Electromagnetic wave	Frequency	Wavelength
Long waves	30 – 300 kHz	10 – 1 km
Medium waves	300 – 3000 kHz	1000 – 100 m
Short waves	3 – 30 MHz	100 – 10 m
Ultra short waves	30 – 300 MHz	10 – 1m
Microwaves	300 – 30000 MHz	100 – 0.1 cm
Ultra microwaves	30 – 300 GHz	10 – 0.1 mm
Infrared rays	300 – 416000 GHz	0.1 – 0.00072 mm

### 1.1 Microwave Bands

The frequency band between the higher range of UHF (Ultra high frequency) and the lower range of EHF (Extreme high frequency), is divided into many frequency ranges as shown in table 1.2. Because of much larger bandwidth (compared to the commonly used