DIELECTRIC SHEET PERTURBATION TO THE METALLIC AIR-FILLED CAVITY- Technique of Microwave Non-Destructive Testing

INSTITUTE of RESEARCH, DEVELOPMENT and COMMERCIALISATION (IRDC)
UNIVERSITI TEKNOLOGI MARA
40450 SHAH ALAM, SELANGOR
MALAYSIA

BY :

ENCIK MOHD TARMIZI ALI

ENCIK MOHD KHAIRUL MOHD SALLEH

PROF. MADYA MD MAHFUDZ MD ZAN

FEBRUARY 2006

Acknowledgement

The Author would like to acknowledge the help and support given by the following persons for successful completion of this research project; they are :

Associate Prof. Dr Yusof Md Salleh
(Dekan Fakulti Kejuruteraan Electrik)

Associate Prof. Dr. Norlida Buniyamin
(Koordinator Penyelidikan Fakulti Kejuruteraan Elektrik

I especially appreciate the financial support University of Technology Mara. With out it, this project would not have taken place.

Abstract

Dielectric sheet perturbation to the dominant TE111 mode resonant frequency of a circular cavity is studied and presented in this project. The dielectric sheet is placed at the middle of the air-filled cavity, introduces discontinuities and disturbs the configuration of electromagnetic fields in the cavity. For fixed dimensions of cavity and fixed thickness of the loading dielectric, the dominant resonant frequency varies quite linearly with the permittivity of the dielectric, in the range of frequency and permittivity value studied. This quasi linear relationship is plotted using Maple software and verified using 3D simulations. Two probes are used in the simulation for wave excitation into and from the cavity. The best length of probe is found to be 3 mm, giving the closest resonant frequency to the one calculated using Maple. A total of fourteen different dielectrics of permittivity varying from 1 to 12.9 are tested one by one in the simulation. The works show very close agreement between the results from Maple and the simulation. A constant difference of 0.04 GHz is found between the resonant frequencies collected during simulation and the ones from Maple. The success of this project leads than to the possibility of using the middle loaded cavity at TE111 mode as a microwave non-destructive testing of materials.

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Chapter I

Introduction

I.1 Background

Uniform cross sectional cavities are simply short circuited waveguides at both ends. Representing a very important group of microwave components, their applications are vast and range from the use as frequency meters and filters, to tools for material characteristics measurements. The use of cavity for measuring properties of dielectric materials has been reported in 1968 by Stinehelfer and it has been improved by Itoh in 1974 [1]. The simplicity of cavity design has been applied in microwave filtering even in a complex synthesis of elliptical filter [2]. The use of dielectric of high permittivity as a resonator is advised in reducing the loss and the dimensions of the filter. It is then interesting to analyze the dependency of the cavity on a dielectric perturbation as this can be used in the filtering application and the microwave non-destructive testing of materials.

Nowadays electromagnetic cavity has been one of the most popular tools in measuring materials' properties. Various techniques have been invented in using cavities for this purpose in the last 30 years and yet the more and more models and improved methods are presented. This is mainly due to the existence of infinity of resonance frequencies in a single cavity, representing every one of them its own mode. The mode with the lowest resonance frequency is called the fundamental mode and the rest are called the higher modes. Every single mode of the cavity has in general its own distribution or form of fields in the cavity, giving birth to infinity of possibilities in introducing the material whose properties are to be measured. One of the most popular approaches is by using the bottom loaded cavity, where the material to be tested is inserted at one end of the cavity [3 – 15]. Open resonator/Cavity has been used in the precision permittivity and loss-tangent measurement at very high frequencies [8-9]. An even more interesting technique is to use a coaxial resonator cavity where properties of liquid materials have been measured by Raveendranath et