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Research Paper :

New method for the determination of dielectric constant at microwave frequency using double ridge wave-guide

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ABSTRACT

This paper deals with introduction of the method of measurement of dielectric constant at microwave frequency. The variation of cutoff frequency of Step Ridge wave-guide was taken as a parameter for calibration of dielectric constant and a new method of dielectric constant is suggested. By placing the material sample at various locations, theoretically the changes in cutoff frequency of fundamental and first overtone are worked out and the location of maximum change was selected for further calculations. Using Finite Element Method (FEM) and sample of different dielectric constant located at the selected place, the variations in cutoff frequencies were calculated. Using these variations, a calibration curve was established and a new method of measurement of dielectric constant was suggested.

Key words : Dielectric constant measurement, FEM, Double Ridge Wave guide.

Many times physical quantities are measured indirectly using their effect on some other properties. Dielectric constant measurement is also an indirect measurement in which dielectric constant is measured from the changes its makes in various properties like resonance frequency of resonator(Andrade *et al.*, 1981), impedance of transmission line, VSWR in slot line (Van, 1935), S-parameter of a device (Abdulnour *et al.*, 1995; Tian and Tinga, 1994), refection coefficient in coaxial cable (Wong, 1998). How ever the use of cut off frequency for such measurement has not been made so far. Hence we proposed to introduce the possibility of establishing a method of dielectric measurement based on the cut off frequency variation of a double ridge wave-guide. To justify the validity of the method we have worked out cutoff frequency for various e values using Finite Element Method. It is shown that the cut off frequency variation with e is smooth and can be used as calibration curve for e measurement.

METHODOLOGY

Consider double ridge wave-guide (H-Shaped). Let the walls of wave-guide be perfectly conducting. The problem is analyzed for the air medium and dielectric medium. The Double Ridge wave guide (DRW) is as shown in Fig. 1. The dimension of DRW are a and b while h is the length of ridge and w be the width, symmetric ridges are used.In the process of calibration we firstly, find the cut off frequencies for different modes by placing the dielectric material sample at different locations in a double ridge wave-guide along the line. Then decide which location gives maximum change in which property. At the location of maximum change different dielectric constant value samples are placed and the value of property are evaluated by FEM .The choice of the ridge wave guide property, its variation calibration with dielectric constant enable us to suggest a new method for measuring dielectric constant .The use of FEM in establishing the method of characterization of permittivity of dielectric material has made by Deshpande and Reddy (1997) and Robertcoccioli *et al.* (1997), respectively.

Mathematical formulation :

The electric and magnetic fields, inside the wave guide will satisfy the Maxwell's equations and assuming the time dependence of the fields; as $e^{j\omega t}$ the Maxwell's equation are written as:

$$ď \times \mathbf{E} = - j\mu«_0\mathbf{H} \qquad (1)$$

$$ď \times \mathbf{H} = j\mu£_0£\ \mathbf{E} \qquad (2)$$

The magnetic field vector formulation (Koshiba *et al.*, 1985) is used for the solution of the problem. Therefore, Maxwell's equation (2) is expressed as

$$£^{-1}\ (ď \times \mathbf{H}) = j\mu£_0\mathbf{E} \qquad (3)$$

Taking the curl of equation (3) and using equation (1), equation (3) can be written as

$$ď \times (£^{-1}\ ď \times \mathbf{H}) = k_0^2\mathbf{H} \qquad (4)$$

where, $k_0^{\ 2} = \omega^2\mu_0\,\varepsilon_0$

Here, ω is the angular frequency, ε_0 and μ_0 are the permittivity and permeability of free space and ε is the