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Characterization of dielectric constant of solid materials (Leather belt) at X-Band

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Abstract: - This paper discusses the experimental measurement technique for dielectric constant (i.e. permittivity) of leather belt at X-band. This measurement play selection of dielectric constant for antenna substrate. This leather can be used as flexible substrate of wearable microstrip antenna. This measurement system consist of solid state klystron power supply, isolator, VSWR meter, frequency meter, solid dielectric cell (XC-501). This data may be interested in flexibility wearable microstrip antenna studies.

Keywords: - *Solis dielectric cell; leather belt, solid dielectric cell (XC-501).*

I. INTRODUCTION

Recently, as the number of system using high frequency electromagnetic wave has increased , serious electromagnetic compatibility (EMC) problem have become apparent. This has lead to search for electromagnetic wave absorbing material useful in microwave frequencies.

The permeability and permittivity of a Leather belt plays an important role to determine reflection properties. It is very essential to determine accurately the dielectric constant of Leather material. Such type of absorbing materials have varied application such as construction of wearable microstrip antenna , improvement of antenna pattern and improvement in wearable antenna performance.

II. MEASUREMENT U USING RECTANGULAR WAVEGUIDES X- BAND

A representative study was carried on leather belt . In this work the thickness of dielectric sample of leather 2.5 cm. [1]. The accuracy of sample largely depends upon smoothness of the sample in waveguide and care which has been taken to ensure that its surface are properly squared with respect to each other.[2]. The machine sample has taken very carefully for smoothness, the size and squared surfaces.

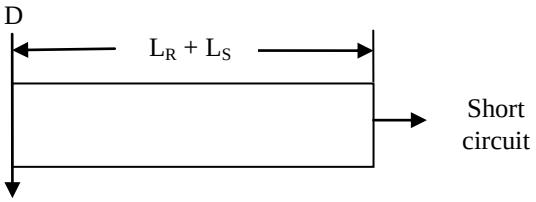
The figure 2(a) shows an empty short circuited waveguide with probe located at voltage minimum L_R Figure 2(b) the sample waveguide containing sample of length L_ε with a probe located at new voltage minimum D.

Factor affecting Dielectric Constant of Leather

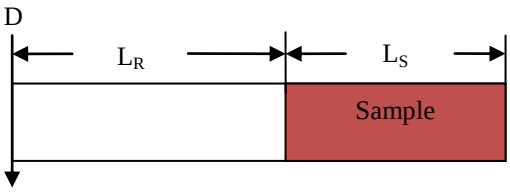
Electromagnetically a leather is, in general a four component dielectric mixture consisting of air , rawhide, bound water. Due to forces acting upon it the bound water molecule interacts with an incident electromagnetic wave in a manner dissimilar to that free water molecule, thereby exhibiting a dielectric dispersion spectrum, very different from that of free water molecule. Therefore, the dielectric constant of leather mixture is greatly influenced by a number of factors such as total water content due to humidity of environment ,frequency, temperature etc.[6].

Many of the studies on dielectric properties of leather have been carried out in laboratory conditions. In general, it has been observed that dielectric constant of leather primarily related to leather moisture content [7]. Dielectric constant of water is 80, hence variation in leather moisture content makes significant in dielectric properties of leather.

III. PROCEDURE



(a) Empty short circuited waveguide



(b) Wave guide containing sample

Where

L_R = empty cavity length

L_S = sample (i.e. dielectric material) length

Fig1. Figure shows waveguide with dielectric and without dielectric sample

The basic arrangement of equipment were connected as shown in Fig. 2.

1. Connect the equipment as shown in Figure 2 (c).
2. With no sample dielectric in the short circuited line, measure D_R position of the minimum in the slotted line with respect to arbitrary chosen reference plane (D = 0), was find out.
3. The guide wavelength (λg) was obtained by measuring distance between alternate in the slotted line.
4. The dielectric , i.e. the leather sample in this case was inserted in the short circuit in such a manner that it touches the end of the sample.
5. Measure D, the position of minima in the slotted with respect to the reference plane.

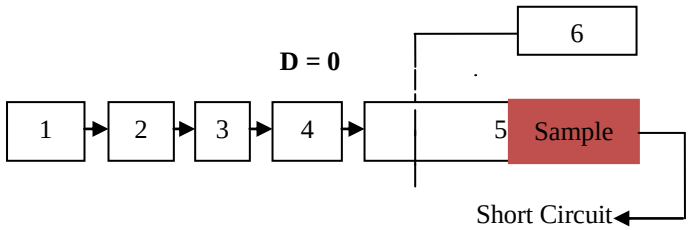


Fig. 2 Experimental Set Up for Dielectric Constant measurement

1. Microwave Source (Klystron power supply)
2. Isolator
3. Frequency meter
4. Variable attenuator
5. Wave containing sample
6. Detector

IV. WAVEGUDE INSIDE A DIELECTRIC

The wavelength in a dielectric medium is always smaller than free space wavelength. The wavelength in any unbounded dielectric medium λ_d is

$$\lambda_d = \frac{\lambda_0}{\sqrt{k'\mu'}}$$

Where

k' = dielectric constant of the medium (i.e. leather belt)

μ' = permeability of the medium
λ_c = cut-off wavelength of the waveguide
λ_0 = wavelength in vacuum
For most of the dielectric materials μ' = 1 and therefore

$$\lambda_d = \frac{\lambda_0}{\sqrt{k'}}$$

The wavelength λg in the air field rectangular waveguide is given by

$$\lambda_g = \frac{\lambda_0}{\sqrt{\left[1 - \left(\frac{\lambda_0}{\lambda_c}\right)^2\right]}}$$

Where
λ_c = cut-off wavelength of the waveguide.
If the waveguide is filled with a medium of dielectric constant k' the new wavelength λ'_g in the waveguide is given by

$$\lambda'_g = \frac{\lambda_0}{\sqrt{\left[k' - \left(\frac{\lambda_0}{\lambda'_c}\right)^2\right]}}$$

Where,

$$\lambda'_g = \frac{\lambda_g}{\sqrt{k'}}$$

and

$$\lambda'_c = \sqrt{k'}\lambda_c$$

after solving these equation we obtain dielectric constant of leather belt (i.e. k') of leather sample is 1.6587.

V. CONCLUSION

In this paper measurement of dielectric constant of leather belt determined. From the computed result it is conclude that dielectric constant depends on thickness of the sample and at lower frequency dielectric constant are high.

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