EXPERIMENT NO. 4

OBJECTIVE: TO DETERMINE DIELECTRIC CONSTANT OF GIVEN SAMPLES.

INTRODUCTION:

A dielectric is a material having electrical conductivity low in comparison to that of a metal. It is characterized by its dielectric constant. Dielectric constant is measured as the ratio of the capacitance C of an electrical condenser filled (as shown in figure (1)) with the dielectric to the capacitance C_0 of the evacuated condenser i.e.

$$\varepsilon = \frac{C}{C_0} \tag{1}$$

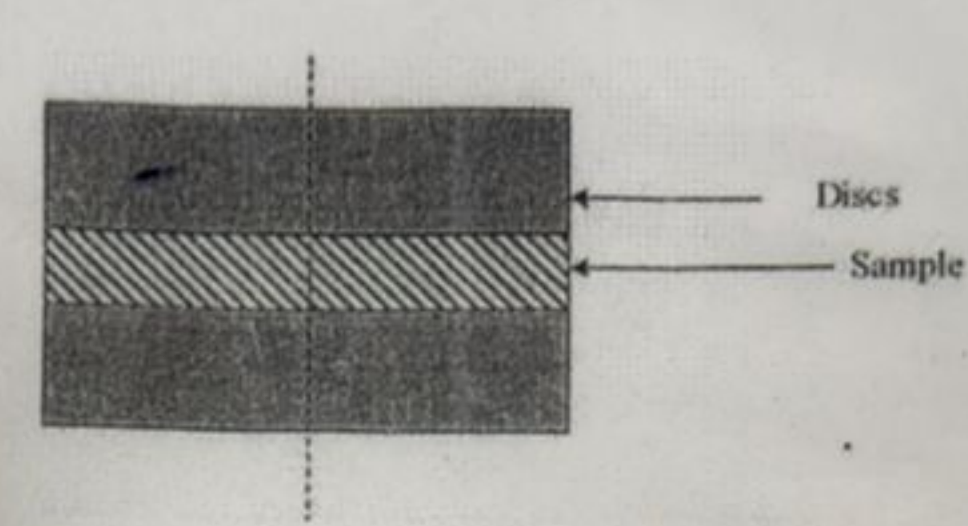

Figure 1 Schematic of a dielectric sample cell with two gold coated brass plates.

THEORY:

In this experiment an LC circuit is used to determine the capacitance of the dielectric cell and hence the dielectric constant. The circuit details are shown in figure (2)

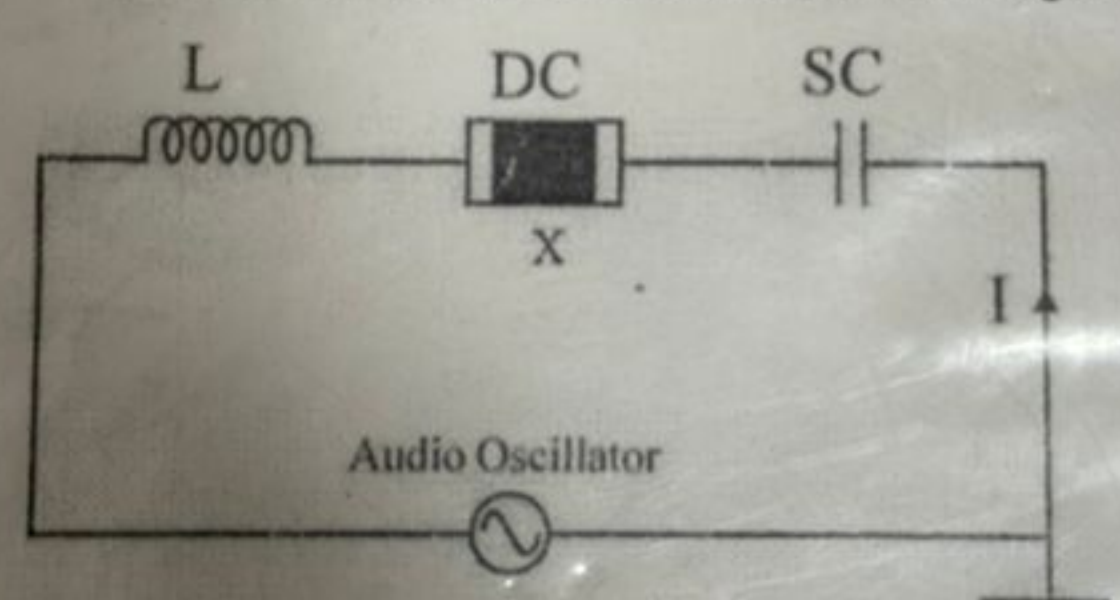

Figure 2: Circuit used to measure the dielectric constant.

Where,

DC	Dielectric cell
SC	Standard capacitor
L	Inductor
X	Sample

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The audio oscillator is incorporated inside the instrument. If C_{SC} and C_{DC} represents the capacitances of the standard capacitor and dielectric cell respectively and if V_{SC} and V_{DC} are the voltages across SC and DC then.

$$\frac{V_{SC}}{I} = \frac{1}{\omega C_{SC}} \tag{2}$$

$$I = \omega V_{SC} C_{SC} \tag{3}$$

The same current I passes through the dielectric cell.

$$\frac{V_{DC}}{I} = \frac{1}{\omega C_{DC}} \tag{4}$$

$$C_{DC} = \frac{I}{\omega V_{DC}} = \frac{\omega C_{SC} V_{SC}}{\omega V_{DC}} = \frac{C_{SC} V_{SC}}{V_{DC}} \tag{5}$$

By measuring V_{SC} & V_{DC} and using the value of Csc we can determine the capacitance of the dielectric cell containing the sample.

If C_0 represents the capacitance of the dielectric cell without the sample and the plates separated by air gap whose thickness is the same as the thickness of the sample then C_0 (air) is given by

$$C_0 = \frac{\varepsilon_0 A}{d} = \frac{r^2}{36d} nf \tag{6}$$

Where r represents the radius of the gold plated discs and d represents thickness of the sample in meters.

The dielectric constant of the sample is given by

$$\varepsilon_r = \frac{C_{DC}}{C_0} \tag{7}$$

EXPREIMENTAL PROCEDURE:

1) Connect CRO to the terminal provided on the front panel of main unit. If no sinusoidal waveform appears on CRO then adjust "CAL" such that waveform appears.
2) Connect the dielectric cell assembly to the main unit and insert the sample in between the metal discs. Important: Do not put extra pressure, as Glass samples is brittle and may be damaged.
3) Switch ON the unit.
4) Choose the standard capacitor (with the help of switch S_2) SC_1 for materials having low dielectric constants (like Bakelite, Glass, Plywood samples) or SC_2 for material having high dielectric constant (PZT sample).

5) Throw S_1 towards DC to measure the voltage across dielectric cell, say V_{DC} and towards SC to measure voltage across standard capacitor, say Vsc. Calculate the capacitance C using equation (5).

6) For samples, other than provided with the kit, measure the capacitance of the sample placed in between the Dielectric Cell with the help of any capacitance meter available. If measured capacitance value is not comparable to either of SC_1 or SC_2 put capacitor having value near to that measured value in between the plugs provided at SC_3 and throw switch S2 to SC_3 and repeat step 4.

7) Measure thickness of the sample using the cell holder and calculate the value of C_0(air) using equation (6).

8) Determine the relative dielectric constant of the sample using equation (7).

COMPONENT VALUES

$SC_1 = 47\ pf$

$SC_2 = 20\ nf$

TABLE:

I.

Sr. No.	Materials	Diameter (m)	Thickness (m)	C_0 (*nf*)

II.

Sr. No.	Sample Name	SC	Vsc (V)	V_{DC} (V)	C_{DC} (*nf*)	C_0 (*nf*)	ε_r

PRECAUTIONS:

1. Sample surface must be flat so that there is no air gap between the sample and the disc.
2. Dielectric cell should be placed on insulating surface in humid weather conditions.
3. Least pressure should be exerted on the brittle samples.
4. Diameter of the samples should not be lesser than the gold plated discs.
5. Dielectric cell (metal discs) and sample should be coaxial.

Conclude your report by answering the following questions:

1. Can we modify the set-up to compare dielectric constant of different solids? Can we determine dielectric constant of liquids by this procedure? (In particular of water.)

2. Which is the prime source of error in this experiment? Which is the next important factor?

3. Why it is necessary to have diameter equivalent or more than the gold plated brass electrodes?

SAMPLE CALCULATION:

$V_{SC} = 1.83$ V
$V_{DC} = 1.74$ V
$SC = 11$ nf
$d = 1.08$ mm
$r = 12$ mm

$$\therefore \quad C = \frac{V_{SC}}{V_{DC}} \times SC = 11.57nf$$

$$C_0 = \frac{r^2}{36d} = \frac{(12\times10^{-3})^2}{36\times1.08\times10^{-3}} = 3.7\times10^{-3}nf$$

$$\varepsilon = \frac{C}{C_0} = \frac{11.57}{3.7\times10^{-3}} = 3127$$

Note: The above readings are of particular samples and varies for sample to sample.

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