MITTAL ENTER PRISES

AN ISO 9001:2015 Co.

Manufacturers & Exporters of Laboratory and Research Equipments

INSTRUCTION MANUAL

DIELECTRIC CONSTANT KIT For Solids
MODEL FR-4
(Sl. No.: 2122132)

2151/T-7C,New Patel Nagar,New Delhi- 110008

Telefax:+9101125702784, Mobile:+91-9810681132

Email : info@mittalenterprises.com Web:http://www.mittalenterprises.com

DIELECTRIC CONSTANT KIT For Solids

Model FR-04

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 with the dielectric to the capacitance C_0 of the evacuated condenser i.e.

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

FRONT PANEL DESCRIPTION:

Front panel comprises of

i) Digital Volt meter (DVM), that measures the voltage across the dielectric cell (DC) or standard capacitor (SC).

ii) Switch S_1 to select di-electric cell or standard capacitor.

iii) Switch S_2 to select one of the standard capacitors SC_1, SC_2, SC_3

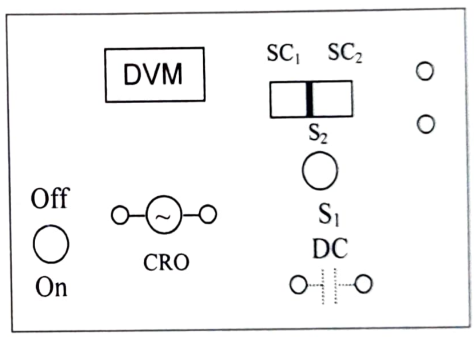


Fig. 1

DIELECTRIC CELL

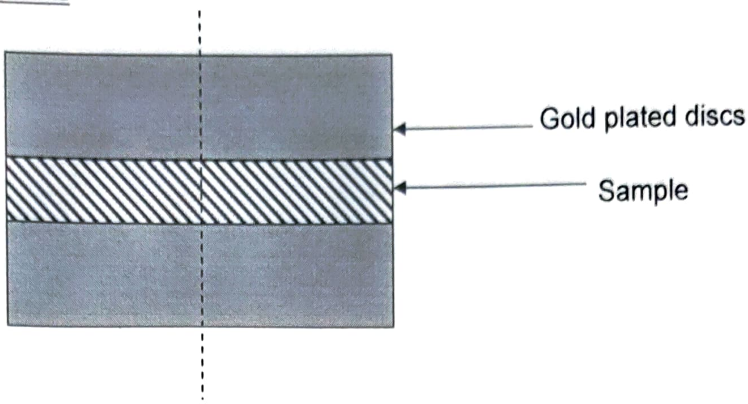


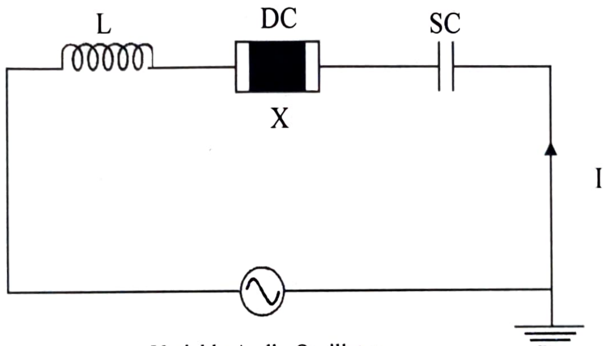
Fig.2

(i) Dielectric cell –1 having two Gold plated brass discs (75 mm. each)
(ii) Dielectric Cell-II having two Gold plated brass discs (25mm. each)
Keep the sample in between the metal plates.

IMPORTANT: Dielectric cell (metal discs) and sample should be coaxial.

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 below:



Variable Audio Oscillator
Figure 3

DC : Dielectric cell
SC : Standard capacitor
L : Inductor
X : Sample

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.

$$\frac{V_{SC}}{I} = \frac{1}{\omega C_{SC}} \qquad ...(1)$$

$$\Rightarrow \quad I = \omega V_{SC} C_{SC} \qquad ...(2)$$

The same current I passes through the dielectric cell.

$$\frac{V_{DC}}{I} = \frac{1}{\omega C_{DC}} \qquad ...(3)$$

$$\Rightarrow \quad C_{DC} = \frac{I}{\omega V_C} = \frac{\omega C_{SC} V_{SC}}{\omega V_{DC}} = \frac{C_{SC} V_{SC}}{V_{DC}} \qquad ...(4)$$

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

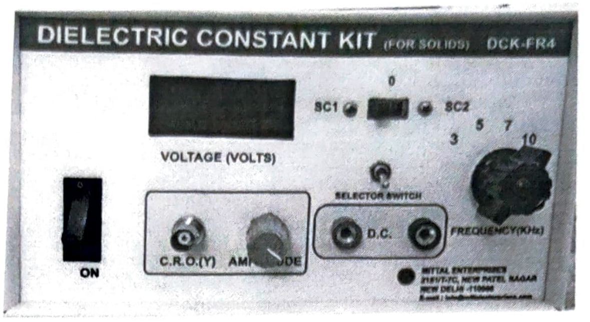
If C_0 represents the capacitance of the dielectric cell without the sample and the plates separated by air gap whose thickness is the same as the thickness of the sample then C_0 is given by

$$C_0 = \frac{\varepsilon_0 A}{d} = \frac{r^2}{36d} \text{ nf.} \qquad ...(5)$$

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

$$\varepsilon_r = \frac{C}{C_0} \qquad ...(6)$$



INSTRUMENT FRONT PANEL

PROCEDURE

1) Connect C.R.O. to the terminals provided on the front panel of main unit. Amplitude of the sinusoidal waveform (say 4 Vpp) can be adjusted using "AMPLITUDE" knob.

2) Connect the dielectric cell assembly DC to the main unit and insert the sample in between the dielectric plates.

IMPORTANT: Do not put extra pressure, as PZT sample and Glass samples are brittle and may be damaged.

3) Switch ON the unit. Select the frequency to 3 KHz using the rotary switch provided on the panel.

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 samples). Mid position marked "0" is open and should be skipped.

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 V_{SC}. Calculate the capacitance C using relation

$$C = \frac{V_{SC}}{V_{DC}} \times C_{SC}$$

NOTE : DIAMETER OF THE SAMPLES SHOULD NOT BE LESSER THAN THE GOLD PLATED DISCS.

6) Measure thickness of the sample and calculate the value of C_0(air) using relation (5).

7) Determine the dielectric constant of the sample using the relation

$$\varepsilon = \frac{C}{C_0(air)}$$

8) Repeat above procedure with different frequencies.

COMPONENT VALUES (S.NO. 2122132)

L = 25 mH

$SC_1 = 204pf$

$SC_2 = 23\ nf$

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 (big bakellite sheet provided with the setup) to avoid any humidity.
3. Least pressure should be exerted on the brittle samples.

PARTS LIST

1.	MAIN UNIT	☐
2.	DIELECTRIC CELL (2 Nos)	☐
3.	SAMPLES	☐
4.	BNC-BNC cable (1 no)	☐
5.	INSTRUCTION MANUAL	☐

SAMPLE READINGS/CALCULATIONS

1. PLYWOOD:

SC = 55.5 pf
V_{DC} = 0.75 V
V_{SC} = 1.51 V
d = 2.8 mm
r = 3.8×10^{-2} m.

$$\therefore \quad C = \frac{V_{SC}}{V_{DC}} \times SC = 107.91 pf$$

$$C_0 = \frac{r^2}{36d} = \frac{(3.8 \times 10^{-2})^2}{36 \times 2.8 \times 10^{-3}} = 14.3 pf$$

$$\varepsilon = \frac{C}{C_0} = \frac{107.91}{14.3} = 7.546$$

2. GLASS:

V_{DC} = 1.75 V
V_{SC} = 1.62 V
SC = 55.5 pf
d = 4.66 mm

$$\therefore \quad C = \frac{V_{SC}}{V_{DC}} \times SC = 51.37 pf$$

$$C_0 = \frac{r^2}{36d} = \frac{(3.8 \times 10^{-2})^2}{36 \times 4.6 \times 10^{-3}} = 8.6 pf$$

$$\varepsilon = \frac{C}{C_0} = \frac{51.37}{8.6} = 5.97$$

3. PZT-SAMPLE:

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

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

$$C_0 = \frac{r^2}{36d} = \frac{(12 \times 10^{-3})^2}{36 \times 1.08 \times 10^{-3}} = 3.7 \times 10^{-3} nf$$

$$\varepsilon = \frac{C}{C_0} = \frac{11.57}{3.7 \times 10^{-3}} = 3127$$

NOTE: These readings are of particular samples and may vary for sample to sample.