INSTRUCTION MANUAL

CAPACITANCE & PERMITTIVITY KIT

MITTAL ENTERPRISES

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CAPACITANCE & PERMITTIVITY KIT

1. INTRODUCTION :

When a quantity of charge, Q, is transferred to the unearthed plate of a capacitor, the potential of the plate rises by V volts. The charge is given by

$$Q = C\,V \qquad (1)$$

Where C is the capacitance in farads. If the capacitor is charged with a d.c. voltage V and discharged through a d.c. microammeter f times a second, the current passing through the ammeter is given in amperes by

$$I = f\,C\,V \qquad (2)$$

2. WORKING PRINCIPLE :

The working of this kit is based on the above principle (eqn.2). A reed switch is used to charge and discharge the capacitance 100 times a second. The resulting current is amplified electronically 500/3 times using a specially designed integrated circuit amplifier operating on 6 volt d.c. battery. The amplified current is read using a 0 –100 μa analogue meter.

The experimental arrangement is shown in Fig. 1

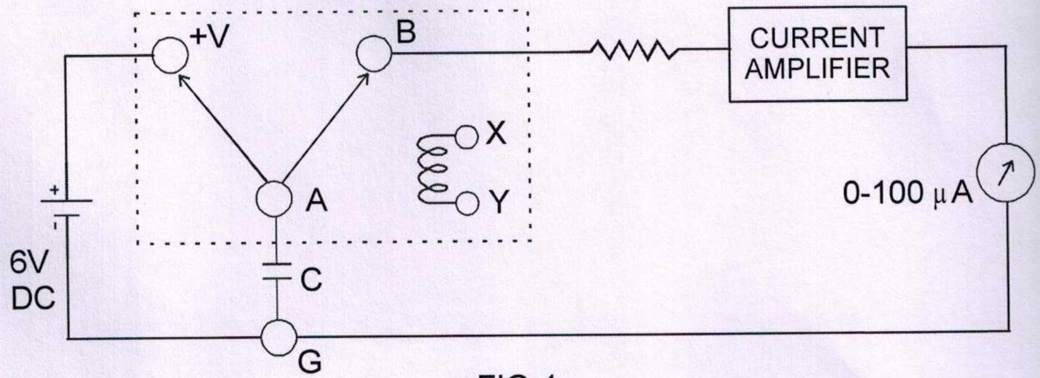

FIG-1

The components within the dotted box constitutes the reed switch. It is a changeover switch that charges the capacitor C through contact A and then discharges C through the electronic micrometer via the contact B. The charge discharge rate is double the frequency of the voltage applied to X, Y terminals of the coil of the reed switch. Since the mains frequency is 50 Hz, we should use a value f = 100 Hz in equation (2)

If I is the current as read by the microammeter, the discharge current

$$\mathrm{I} = \frac{i}{500/3} \qquad (3)$$

Then from eqn. (2)

$$C = \frac{I}{f.V}$$

$$= \frac{i}{500/3} \times \frac{1}{100 \times V} \quad (f = 100)$$

$$= \frac{60i}{1000000 \times V}$$

$$= \frac{60 \ \ i \times 10^{-6}}{V} \ \ farads$$

$$or \quad C = \frac{60 \ \ i}{V} \ \ \mu \, farads \qquad (4)$$

If i is expressed in microamperes and V = 6 volts in this kit, then

$$C = \frac{60 \ \ i}{V} \ \ \mu\mu\,\mathrm{f} \qquad (5)$$

$$or \ \ C = 10 \ \ i \qquad \mu\mu\,\mathrm{f}$$

The capacitance of a parallel plate capacitor is given by

$$C = \frac{\varepsilon_0 \ \ A}{d} \ farads \qquad (6)$$

Where A = area of overlap of the plates in metre^2

d = distance between the plates in meters

and ε_0, the permittivity of air which is very nearly equal to the permittivity of vacuum = 8.85 x 10^{-12} farad $meter^{-1}$.

3. DESCRIPTION

The kit consists of a reed relay switch with it's a.c. supply, integrated circuit Current amplifier and 0-100 micrometer housed in a cabinet. In addition a pair of capacitor plates 0.3m x 0.3m, a Perspex Sheet, one standard capacitor, and a set of perspex/polyethene spacers are provided with the kit.

4. EXPERIMENTAL PROCEDURE

(a) Factors determining capacitance

(i) Connect the parallel plate capacitor across the terminals A and G. Plate connected to G should be used as bottom plate and plate connected to A should be used as top plate. Side faces of plates are marked with black lines. Match the faces / lines.

(ii) Separate the two plates by placing 4 pieces of polyethene spacers at the four corners. The thickness of the spacer is t (marked on spacers). The distance 'd' between the plates can be varied by spacers of different thickness. Measure current i for each value of d.

Tabulate the results as shown below :

S.No.	Thickness of spacers in meter (d)	Current in uA
1	T	
2	2 t	
3	3 t	
4	4 t	

(iii) Draw a graph between i and (1/d). It should be straight line indicating that capacitance is inversely proportional to the separation between the plates. Does the graph pass through the origin ? explain.

The common area between the plates of the area of overlap can be varied by moving one of the plates sideways, observe the variation of i as the area of overlap is decreased. Your results should indicate that $C \propto A$.

(iv) Determine the current i_a through the ammeter with air as dielectric. Keep the distance between the plates d = t i.e the thickness of one spacer. Replace the air between the plates by completely filling the space with dielectric i.e. perspex or polyethene whose thickness is the same as the thickness of the spacer used. If i_d is the current with the dielectric, your results should indicate $i_d > i_a$ as the dielectric increase the capacitance.

(b) Permittivity of air

(i) Connect the parallel plate capacitor across terminal C and G on the front panel. Use one set of spacers between the plates. Let its thickness t be equal to the distance between the plates.

(ii) Determine the current (i) through the meter by switching on the unit.

(iii) The theoretical value of the capacitance is given by equation (6) $C = \frac{\varepsilon_o A}{d}$

From eqn. (5)

$$C = 10\, i\, \mu f = 10\, i \times 10^{-6} \text{ farads}$$

$$\frac{\varepsilon_o A}{d} = 10\, i \times 10^{-6}$$

$$\varepsilon_o = \frac{10\, i\, d \times 10^{-6}}{A} \quad farad\,/\,meter$$

(iv) Substitute the values of i, d & A in the above equation and evaluate ε_o

5. **Typical Results** (with another similar unit)

$A = 0.0625\ m^2$

$d = 1.65 \times 10^{-3} m$

$i = 40\ \mu A$

$\varepsilon_0 = 8.8 \times 10^{-12}$ farads/meter

6. **Precautions**

a) Periodically check the deflection in micro-ammeter with standard capacitor provided. If not getting the proper deflection, please check the 6V dc supply with multimeter. If voltage is less, please replace the cells.