I. Determination of Capacitance

Background

It is known that capacitors play a significant role in the electrical circuits. There are several methods of measurements of the capacitance of a capacitor. In this experiment you are required to perform the experiment in order to determine the capacitance of an AC capacitor using a simple electrical circuitry.

In Fig. 1.1 (a), a capacitor of capacitance C and a resistor of resistance R are connected in series to the alternating voltage source of mains frequency. The electrical power which is dissipated at the resistor R depends on the values of $\mathcal{E}_0$, C, R and frequency of the mains f. Graphical analysis of this relationship can be used to determine C.

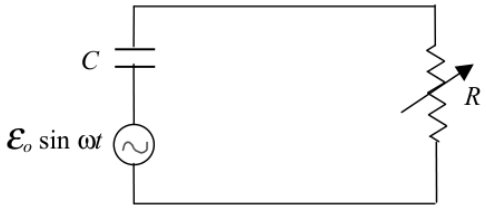


Fig. 1.1 (a): AC Circuit for determination of capacitance C

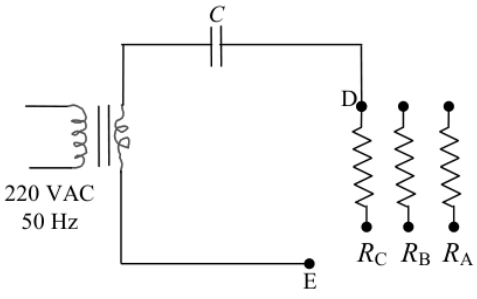


Fig. 1.1 (b): A schematic diagram of the equipment used

Materials and apparatus

1. capacitor
2. three resistors of known values with ±5% errors ($R_A = 680\,\Omega$, $R_B = 1500\,\Omega$ and $R_C = 3300\,\Omega$) as shown in figure 1.1 (b).
3. step-down isolation transformer for alternating voltage source of $f = 50\,\text{Hz}$
4. digital voltmeter
5. electrical connectors
6. linear graph papers

Warning: The digital multimeter in this experiment will be used for measuring the rms voltage ($\tilde{V}$) across R only. Do not use it to measure in other modes.

Instructions

a) Derive the expression for the average power dissipation $\overline{P}$ in resistor R in terms of $\mathcal{E}_o$, R, C and ω. (1 point)

b) Deduce the condition for which $\overline{P}$ is a maximum. (1 point)

c) Convert the dependence found in a) into a linear dependence of certain quantities $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$. (1 point)

d) Measure the root mean square (effective) voltage V across R for each of all possible combinations of R_A, R_B and R_C. (2.5 points)

e) Plot $\overline{P}$ versus R and from this graph compute the value of capacitance C. (2 points)

f) From c), draw the graph of $\boldsymbol{\alpha}$ versus $\boldsymbol{\beta}$ and determine capacitance C. (2 points)

g) Estimate the uncertainties in the values of C obtained in e) and f). (0.5 point)