Experimental Competition

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 $\pm 5\%$ 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 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}) <u>across *R*</u> only. <u>Do not use it to measure in other modes.</u>

Instructions

a)	Derive the expression for the average power dissipation	\overline{P} in resistor	R	in terms of
	$\boldsymbol{\mathcal{E}}_{o}, R, C \text{ and } \boldsymbol{\omega}.$			(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 α and β . (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)
