National Anveshika Experimental Skill Test -2021

(NAEST – 2021)

Name:.....Class.....

Roll NO.....Mobile No.....

School/College Name.....

Date.....Time.....

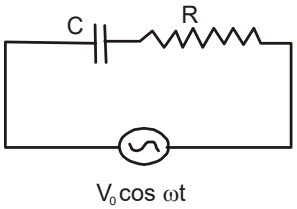
SF2- Temperature of a glowing bulb filament using R-C circuit

Introduction

When current is passed through a filament (usually tungsten) bulb, its temperature increases. If you keep on increasing the current, at a certain stage the bulb starts glowing. At a certain current the bulb glows with full intensity.

How to measure the temperature of the glowing bulb at different stages? In this experiment, you will get the resistance of the bulb at these stages and from that find the temperature using the temperature coefficient of tungsten.

To find the resistance of the bulb when a current is passed through it, we use AC circuit. When a voltage $V = V_0 \cos \omega t$ is applied on an R-C series circuit, the current is given by.



$$i = \frac{V_0 \cos(\omega t - \phi)}{\sqrt{R^2 + \left(\frac{1}{C\omega}\right)^2}}$$

where $\tan\phi = \frac{1}{C\omega R}$.

Because of this phase difference, the RMS voltage on R and C do not add to the applied RMS voltage. The meters measure the RMS voltage only. The RMS voltages on C, R and the source are related as

$$(V_s) = \sqrt{(V_c)^2 + (V_R)^2}$$

where V_s, V_c and V_R are the RMS values across the source, the capacitor and the resistor respectively. These RMS values are given by

$$V_R = i_{rms}.R$$

$$V_c = i_{rms}.\frac{1}{C\omega}$$

So $$\frac{V_R}{V_c} = RC\omega$$

Or $$R = \frac{V_R}{V_c}\frac{1}{C\omega}$$

Using $$R = R_0\left[1 + \alpha\left(T - T_0\right)\right]$$

you can get the value of temperature T. Here T_0 is the room temperature, R_0 is the resistance at the room temperature and $\alpha = 0.0045/K$ is the temperature coefficient of tungsten.

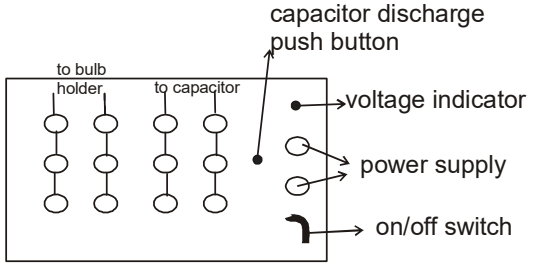
In this experiment you will get the value of resistance for different applied voltages and then estimate the temperature of the filament.

Materials

A board having sockets etc to make the circuit, two fan capacitors ($\square\ 2.5\mu F$), an electric bulb (60 W), a capacitance meter, a multimeter, a variac, a thermometer and connectors.

VARIAC: This is essentially a transformer which converts 220V AC to some other volt decided by the dial. You can choose the RMS value of voltage by rotating the dial at that value. The output of the variac is connected to the board.

Block Diagram of RC Board:



Process:

Study the board given to you and see the interconnections. A fan capacitor and a 60W electric bulb are fixed on the board. Check the connections between the terminals given.

Measure the capacitance C of the capacitors using the C-meter and the resistance R_0 of the bulb using the multimeter. Measure the room temperature T_0 using the thermometer.

Connect the two capacitors in parallel and the 60 W bulb in series using the connecting wires. Keep the multimeter ready in AC 600V range.

Connect the terminals of the variac to the board with the dial at 0. Switch on the mains power to the variac. Increase the variac voltage in steps of say 25 V up to 250 V. For each step measure the voltage V_R across the bulb, V_c across the capacitor and Vs across the bulb-capacitor combination. Note these RMS values in a tabular form.

Calculate the resistance R and temperature T for each applied voltage. Find the temperatures at which the bulb just shows red glow and when the glow is almost white. Also show the values of power $P = (V_R)^2 / R$ given to the filament. Plot P vs T.

Show all your data, calculations and results in a neat understandable form.

Your comments/observation/extensions