Series RC circuit

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1. Introduction and Aim

The aim of this experiment is to investigate the frequency-dependent behavior of a series RC circuit, specifically the relationship between the voltage, current, and impedance at different frequencies.

2. Theory

The series RC circuit is a fundamental electronic circuit that consists of a resistor (R) and a capacitor (C) connected in series. The impedance of the circuit is frequency-dependent, as the capacitor's impedance decreases with increasing frequency.

Quantities Under Investigation 1. **Total Impedance (Z_T)**: The total impedance of the series RC circuit is given by:

$$Z_T = \sqrt{R^2 + \left(\frac{1}{2\pi fC}\right)^2}.$$

Here, f is the frequency in Hz, and C is the capacitance in Farads.

2. **Voltage Relationships**: The voltage across the resistor (V_R) and capacitor (V_C) is calculated using the voltage divider rule:

$$V_R = \frac{R}{Z_T} V_S, \quad V_C = \frac{\frac{1}{2\pi fC}}{Z_T} V_S,$$

where V_S is the supply voltage.

Principles Under Investigation The experiment explores how the voltage and current in the circuit vary with frequency. Specifically, it demonstrates the physical principle that capacitive reactance (X_C) decreases with increasing frequency, affecting the impedance and voltage distribution.

3. Experimental Method and Results

a. Circuit Diagram Below is the circuit diagram for the series RC circuit. It consists of a resistor, a capacitor, a signal generator, and a cathode ray oscilloscope (CRO). (Include diagram or Multisim representation here)

A photo of the physical circuit setup is also provided:

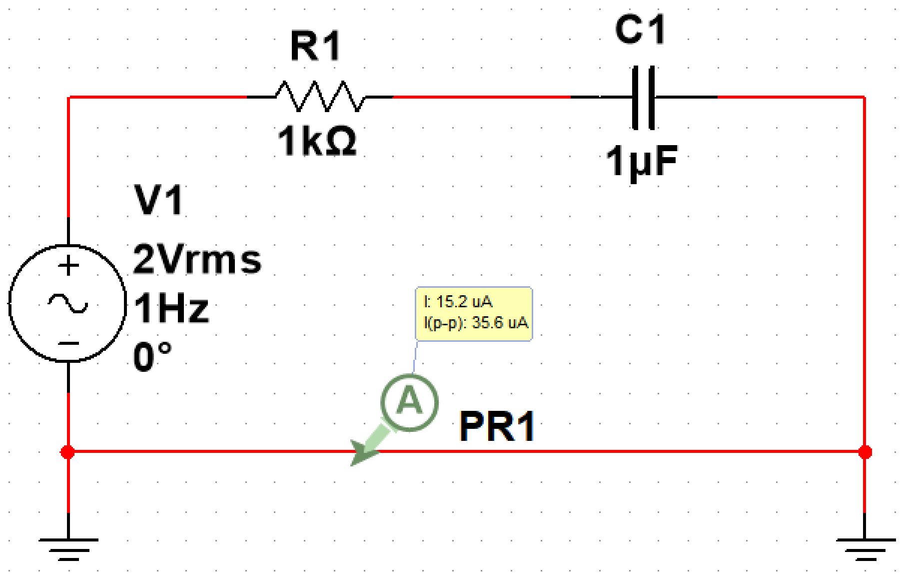

Figure 1: Enter Caption

b. Experimental Method The experiment was carried out as follows: - The circuit was assembled according to the provided diagram, ensuring all connections were secure. - The signal generator was set to an initial frequency of 1 kHz with a peak-to-peak voltage of 2 V. - Channel 1 of the CRO was used to measure the supply voltage (V_S), while Channel 2 measured the voltage across the resistor (V_R). The time delay between the two signals was also recorded. - The same procedure was repeated to measure the voltage across the capacitor (V_C). - The frequency was increased to 5 kHz, and all measurements were repeated.

c. Results and Discussion The measured data are shown in the table below:

f(Hz)	V_S(V)	V_R(V)	V_C(V)	τ_R(ms)	τ_C(ms)	T(ms)
1000	2.0	1.2	1.6	0.3	0.5	1.0
5000	2.0	1.8	0.9	0.1	0.2	0.2

Table 1: Experimental Measurements

Discussion: The results demonstrate that as frequency increases: 1. The voltage across the resistor (V_R) increases, while the voltage across the capacitor (V_C) decreases. This behavior aligns with the theoretical relationship, as X_C decreases with frequency, causing the resistor to account for a larger share of the voltage drop. 2. The time delays (τ_R and τ_C) decrease with increasing frequency, reflecting the faster oscillation of the signal.

Error Analysis: - Measurement errors may have occurred due to limitations in the CRO resolution. - Component tolerances (e.g., resistor and capacitor values) might deviate from their nominal values, introducing discrepancies between theoretical and experimental results.

Suggestions for Improvement: - Use higher-precision measurement instruments to reduce uncertainty. - Calibrate all equipment before conducting the experiment to ensure accurate results.

4. Conclusion

This experiment successfully demonstrated the frequency-dependent behavior of a series RC circuit. The results showed that capacitive reactance decreases with increasing frequency, leading to a redistribution of voltage across the circuit components. These findings align with theoretical predictions, although minor measurement inaccuracies were noted.