RLC Circuits

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***Abstract*—**
THE purpose of this experiment...

CONTENTS

I. THEORY

The following expressions were used in the analysis of this circuit:

$$\omega = 2\pi f$$

$$\omega_0 = \sqrt{\frac{1}{LC}} \Rightarrow f_0 = \frac{1}{2\pi\sqrt{LC}}$$

$$X_L = \frac{V_L}{I}$$

$$X_C = \frac{V_C}{I}$$

$$Z = \frac{V_s}{I}$$

$$L = \frac{X_L}{2\pi f}$$

$$C = \frac{1}{2\pi f X_C}$$

$$\theta = 360^\circ f \Delta t$$

$$P = I_{\text{rms}} V_{\text{rms}} \cos\theta$$

$$Q = \frac{\omega_0 L}{R}$$

$$Q = \frac{f_0}{\Delta f} = \frac{\omega_0}{\Delta\omega}$$

Δf is the width of the resonance peak between the points where $V = \frac{1}{\sqrt{2}} V_{\text{max}}$

II. METHODOLOGY

1) A simple RLC series circuit was constructed. DMMs were wired to measure ΔV_L, and ΔV_C, the voltages of the inductor L and the capacitor C respectively.
2) An ammeter was wired in series with the previous elements to measure I, and an oscilloscope was wired to measure ΔV_s and ΔV_R, the voltages across the source and the resistor R respectively.
3) The resistance of R was measured in order to determine phase difference between the source voltage V_s and the current I. Δt between these two signals was recorded.
4) The potential difference of the supply was set to a constant 2.0 V (rms), and the ammeter was set to the 430 mA scale.
5) The expected resonance frequency f_0 was calculated, and a range of frequencies symmetric about f_0 were chosen for measurement.
6) For each frequency f, the following quantities were measured:
   a) I_{rms}
   b) V_L
   c) V_C

   Extra data points were taken at frequencies approaching f_0.
7) The data was then placed into a spreadsheet to calculate various variables, which were used in the analysis section.

III. RESULTS

A. Average Inductance/Capacitance Values

$\bar{L} = n \pm d$
$\bar{C} = n \pm d$

B. Impedance vs. Frequency

$Z_{\text{min}} = n\Omega$
$f_{\text{res,meas}} = n$ Hz

Why is R_{meas} not the same as the value of the resistor used in the circuit?

C. Current vs. Frequency

The data was fitted to the function

$$I_{\text{rms}} = \frac{V_{\text{rms}}\omega}{\sqrt{(R\omega)^2 + L^2(\omega^2 - \omega_0^2)^2}} \tag{1}$$

$R_{\text{fit}} = n\Omega$
$f_{\text{res, fit}} = n$ Hz

D. Difference between measured and fitted values

What is the percent difference between R (measured) and R (fit)? Is R (measured) within the uncertainty of R (fit)?
Percent Difference: $x\%$

E. Theoretical Resonant Frequency

The resonant frequency, calculated from the mean values of L and C from step 1 is given by

$$f_{\text{res,theor}} = \frac{1}{2\pi\sqrt{L_{\text{avg}} C_{\text{avg}}}}. \tag{2}$$
$$\Rightarrow f_{\text{res,theor}} = nHz$$

Comparing this to the values determined in Steps 2 and 3 above, we have
% Difference, Step 2: $x\%$
% Difference, Step 3: $x\%$

F. Voltage vs Frequency

What does this graph tell you?

G. Phase Angle vs. Frequency

Does this curve agree with theory? Explain.

H. Power vs. Frequency

Δf = x Hz

I. Quality Factor

The calculated quality factor is given by

$$Q_{\text{calc}} = \frac{f_{\text{max, meas}}}{\Delta f} \tag{3}$$

Calculated Quality Factor: $Q_{\text{calc}} = x \pm d$
The theoretical Quality factor is given by

$$Q = \frac{\omega_0 L}{R_{\text{meas}}}, \tag{4}$$

where ω_0 is given by $2\pi f_{\text{res,meas}}$ from Step 2 and L is L_{avg} from Step 1.
Theoretical Quality Factor: $Q = x \pm d$

IV. Analysis and Conclusion