Resonance and Q in Electric Circuits

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28/03/24

1. Summary

2. Introduction

Electrical resonance occurs in electrical circuits at a specific input frequency at which the impedance is zero. At this frequency, the impedance of the capacitive and inductive components of the circuit are equal in magnitude but are 180 degrees out of phase with each other. Resonating circuits can generate higher peak voltages than the input and reach higher peak currents. Resonant RLC circuits are used commonly in wireless communications, as they are effective at selectively “blocking” frequencies other than the resonant frequency.

This report and experiments will be investigating RLC series circuits and their behaviour at different frequencies. Our aim is to estimate the resonant frequency using known measured values as well as finding it experimentally.

3. Theory

4. Method

4.1. Frequency response of an RLC circuit

The capacitance of the 3.3uF capacitor and resistance of 33 ohm resistor are recorded with a Digital Multimeter (DMM) and are recorded for use in calculations. The resistor, capacitor, and a 0.1 ± 0.01 H are connected in a circuit as shown below.

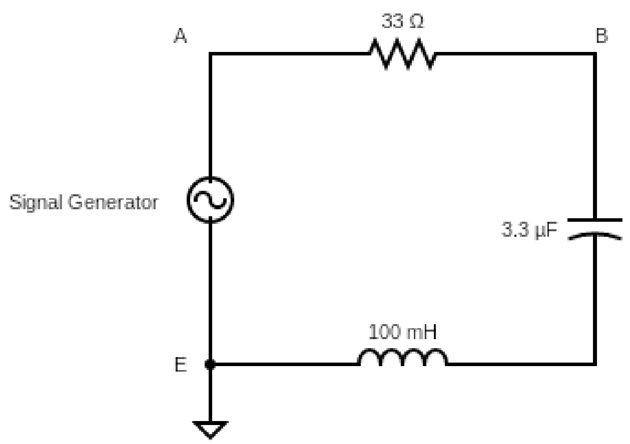

Figure 1: Circuit diagram for frequency response experiment.

The signal generator peak voltage is set to 0.57V. A digital multimeter is connected across the terminals temporarily to verify the RMS value of the AC signal is 0.4V. Channels 1 and 2 are connected to points A and B respectively, the oscilloscope is grounded at point E. To verify the setup, the frequency is quickly swept on the signal generator. Channel A is observed to be constant while Channel B is observed to change with frequency. Two DMMs are connected to the circuit in figure 1; one between point A and point B to measure V_R ; and one between A and E to measure V_0. Measurements are taken at a range of frequencies from 100Hz to 500Hz, including at the expected resonant frequency. Results are recorded in [REFERENCE]

4.2. Determining resonance using an oscilloscope

The experimental setup remains unchanged from the previous experiment. Channel A is adjusted such that the waveform crosses zero on the centre line of the display, and the volts/division is turned down such that the lines appear nearly vertical. Channel B is shifted until the peaks of the waveform are close to the centre line. The frequency on the signal generator is adjusted until peaks of channel B line up with the points channel A crosses zero. This indicates a phase difference of $\frac{\pi}{2}$ between the voltage at the input and the voltage over the inductor. The frequency on the signal generator is recorded and contributes to the previous exercise. Results are recorded [REFERENCE]

4.3. Measuring Quality Factor $(\boldsymbol{Q})$

The 33 ohm resistor is removed from the circuit, the new circuit is set up as below.

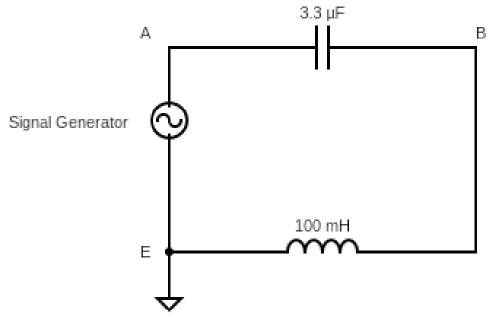

Figure 2: Circuit diagram for Quality Factor experiment.

Using the oscilloscope method described above, the resonant frequency of the circuit was measured and recorded. Voltage measurements were taken using a DMM across the capacitor, inductor, and signal generator at the resonant frequency and recorded. The frequency on the signal generator is lowered until $V_L(f) = 0.707\, V_m$. This frequency is recorded as f_-. The frequency is raised until the same relationship is true, this frequency is recorded as f_+.

4.4. Measurement of Equivalent Resistance $(\boldsymbol{R_e})$

5. Results and Uncertainties

6. Analysis of Results

7. Conclusion

8. Acknowledgements

9. References