Exp. 9: Oscilloscope and AC Circuits

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Physics 2410 Lab

November 3 2023

Abstract

A study was done to use an oscilloscope to determine the values of two capacitors and an inductor and the resonant frequency of an RLC circuit. This was done by connecting the capacitors and inductor in RC and RL circuit configurations, respectively, and using the oscilloscope to determine the phase angle difference of the circuit. The values for the 4.4 µF capacitor, the 1 µF capacitor, and the 1 mH inductor were 6.7 µF, 1.3 µF, and .87 mH, respectively. The resonant frequency of the RLC circuit was measured on the oscilloscope to be 4904 Hz, while the calculated resonant frequency was 4712 Hz.

Introduction

The frequency of an AC circuit is equal to the number of times the circuit oscillates in one second, otherwise known as 1 Hz. The period of the circuit is how long it takes to oscillate once. Thus, the frequency can be represented as , where *T* is the period of the circuit. Also, the phase angle of an AC circuit (φ) is equal to the difference between the applied voltage of the circuit and the voltage across a particular resistive element, such as a capacitor or inductor. For an RC circuit, which contains a resistor and a capacitor, the phase angle can be represented by the formula , where *R* is the value of the resistor, *f* is the frequency of the circuit, and *C* is the value of the capacitor. For an RL circuit, which contains a resistor and an inductor, the phase angle can be represented by the formula , where *L* is the value of the inductor. By determining the phase angle, the capacitance or inductance can be solved for and calculated. Additionally, an AC circuit’s resonant frequency can be described as the frequency at which the circuit’s phase angle equals zero. By altering the frequency of an RLC circuit (which contains a resistor, capacitor, and inductor) until the phase angle equals zero, the resonant frequency of the circuit can be found with the formula .

Procedure

For this experiment, a function generator was used to supply an AC current through various circuit configurations connected to an oscilloscope to determine the period, frequency and phase angles of the circuits. To start, the function generator was connected directly to the oscilloscope, and the current was set to 100 Hz and 5000 Hz. After taking the measured period and frequency of these two settings from the oscilloscope, the amplitude level of the function generator was set to half of its travel and then to its maximum. The peak voltage for each case was then measured. After this, an RC circuit was configured, with a 4.4 µF capacitor and the resistor box (set to 25 ohms) connected in series. This circuit was then connected to the oscilloscope. By using the oscilloscope with the function generator set to a frequency of 1000 Hz, the phase angle was visually measured and used in the formula to calculate the 4.4 µF capacitor’s capacitance. This test was repeated four more times, each time increasing the frequency by 500 Hz. This setup was used twice more: once with a 1 µF capacitor in place of the 4.4 µF capacitor, and again in an RL circuit with a 1 mH capacitor in place of the 4.4 µF capacitor. For the last case, the frequency of the circuit started at 3000 Hz and increased in 500 Hz increments for each test. Additionally, the formula was used to measure the 1 mH inductor’s inductance. After this, an RLC circuit was set up using the resistor, capacitor, and inductor. The frequency was then adjusted on the function generator until the graphs for the applied voltage and the voltage across the resistor were in phase. This frequency was then recorded as the resonant frequency, and the formula was used to calculate the resonant frequency manually.

Results

When the frequency of the function generator was set to 100 Hz and 5000 Hz, the measured frequencies were 100 Hz and 5005 Hz, respectively. These values match up nearly identically to the displayed values. The values for the 4.4 µF capacitor, the 1 µF capacitor, and the 1 mH inductor were 6.7 µF, 1.3 µF, and .87 mH, respectively. While not exact, these three values are all reasonably close to the manufacturer values for the various implements. The resonant frequencies of the RLC circuit with *R* set to 15 and 80 ohms were measured to be 4904 ±200 Hz and 4870 ±200 Hz and calculated to be 4712 Hz, which is with the bounds of uncertainty.

Questions to be Answered

1. The value for the 4.4 µF capacitor is off by about 52%, which does not match its stated value. The value for the 1 µF capacitor is off by about 30%, which does not match its stated value. The value for the 1 mH inductor is off by about 13%, which does match its stated value.
2. Average inductance: 0.66 mH. The value is much less accurate when ignoring the inductor resistance.

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| frequency | Φ (degrees) | Inductance |
| 3000 Hz | -26.5 | 0.66 mH |
| 3500 Hz | -24.8 | 0.53 mH |
| 4000 Hz | -28.8 | 0.55 mH |
| 4500 Hz | -40.9 | 0.77 mH |
| 5000 Hz | -43.9 | 0.77 mH |

1. The measured resonant frequencies are nearly identical to each other. The calculated resonant frequency is within the bounds of uncertainty of both measured frequencies.
2. The magnitudes are identical at the resonant frequency, but vary from each other more the higher and lower the frequencies are out of resonance.