

AC CIRCUITS

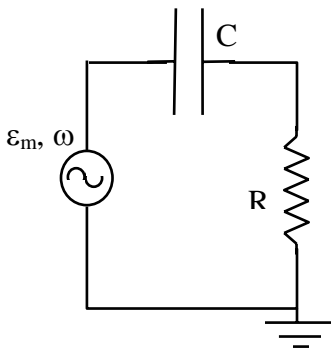
Purpose: To gain familiarity with AC measurements by working with various circuits involving capacitance, inductance, and resistance.

Apparatus: Oscilloscope, function generator, decade resistance box, capacitor, inductance, digital multimeter, connecting wires

Introduction: Remember that in AC circuits, the voltage and current at different points in the circuit are not necessarily in phase. For example, the current through an inductor lags the voltage by 90 degrees, and the current "through" the capacitor leads the voltage by 90 degrees. Because of this, we cannot simply add voltages across series elements as we do with DC circuits. We can combine voltages, however, by using a phasor diagram as discussed in class and in your text. Or, equivalently, we can use the phasor diagram to determine the combined impedance of two or more elements in the circuit.

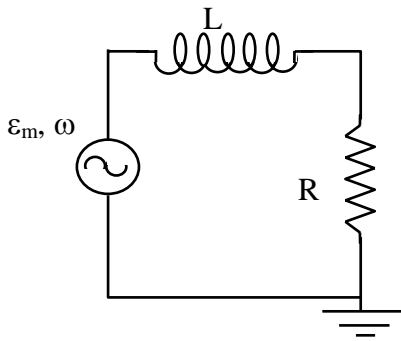
In this experiment, we will be making some voltage measurements with the oscilloscope and will thus be obtaining peak values for these voltages. If instead we were using a voltmeter, the voltages obtained would be the rms values. Using an oscilloscope has the advantage of seeing the actual shape and phase relationships of the various waveforms. On the other hand, voltage measurements can be made much more accurately with a digital voltmeter. By measuring the voltage across a resistance, we can see how the current in the circuit varies in time since the voltage and current are in phase for a resistance.

Procedure: Part I: RC Series Circuit



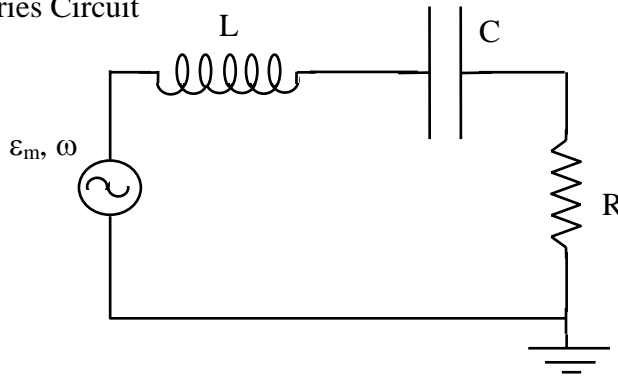
1. Set $R = 50$ ohms and $C = 0.22 \mu\text{F}$ and then accurately measure these values with an ohmmeter and capacitance meter. Set up the circuit shown and connect channel 1 of the oscilloscope across the resistance. Be sure that the oscilloscope ground is in common with the ground on the signal generator. Connect channel 2 of the scope across the source voltage (signal generator).
2. Adjust the signal generator for a sinusoidal voltage with a frequency of 10 kHz and a peak voltage of about 2.0 volts as measured on the scope. Select a suitable time base on the scope to display one or two cycles of the signal and use a vertical sensitivity of 0.5 v/cm for both channels 1 and 2. Set the scope for viewing both channels simultaneously (dual) with the triggering on channel 1.
3. Using the digital voltmeter, accurately measure the voltage (rms) across the resistor and calculate the rms current in the circuit using Ohm's law. Now, measure the rms voltage across the entire circuit and find the impedance ($Z = V/I$) of the circuit.
4. Make a phasor diagram showing the resistance and capacitive reactance, and the impedance of the circuit. Calculate, from this diagram, the impedance and compare with the value found in part 3 above by finding the percent difference.
5. Determine the phase difference between the current and the voltage supplied to the circuit by observing the two waveforms on the oscilloscope. Is the current leading or lagging the voltage? Also, calculate the phase difference from the phasor diagram constructed in part 4 above and find the percent difference between the two values. Record all results in a neat table.

Part II: RL Series Circuit



1. Accurately measure the inductance, L , and the resistance of the inductor, R_L , and then set up the circuit shown using the same resistance, R , used in part I.
2. Repeat the above five steps (in part I) doing the various calculations, measurements, and phasor diagram this time of course with inductive reactance instead of capacitive reactance. Don't forget to include R_L as part of the resistance in your phasor diagram.

Part III: RLC Series Circuit



1. Using the above values for R , L , and C set up the circuit shown and repeat steps 1-5 again. This time, of course, the impedance refers to the series RLC combination. Vary the frequency of the source and observe the change in the phase difference between the current in the circuit and the voltage source. Adjust the frequency until the phase difference goes to zero. This should be the resonant frequency of the circuit. Compare this value with the theoretical resonant frequency,

$$\omega_0 = \frac{1}{\sqrt{LC}}$$