PE
16

Introduction to AC Circuits

(Updated 09 Jun 2009)

A Practical Exercise Name:_____ Section: _____

I. Purpose.

1. Review the measurement of ac sinusoidal voltages with the oscilloscope.
2. Review the operation the function generator.
3. Review the graphing of impedances, voltages and current in the phasor domain.
4. Review the graphing of voltages and current as function of time.
5. Introduce the calculation of total impedance for AC series circuits.
6. Introduce the use of Ohm's law and the voltage divider rule in analyzing AC series circuits.
7. Review the determination and measurement of phase angle using the oscilloscope.

II. Equipment.

Agilent E3620A Dual DC Power Supply
Agilent 34401A Digital Multimeter (DMM)
Oscilloscope
Function Generator
220-Ω resistor
1-mH inductor

III. Preparation.

IV. Lab Procedure.

You must **read** and complete each step.

Step One: Total impedance

☐ Compute the total impedance as seen by the ac power source, $e(t) = 7.07 \sin\{2\pi (30\text{kHz})t\}$, of the ac series circuit in figure 1. Note: Use the DMM to determine the internal coil resistance of the inductor.

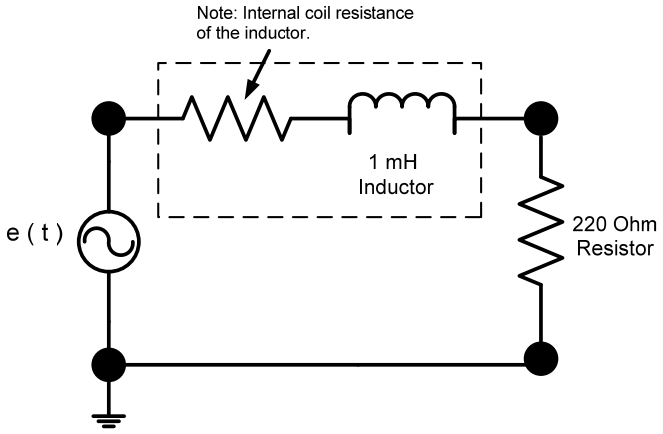
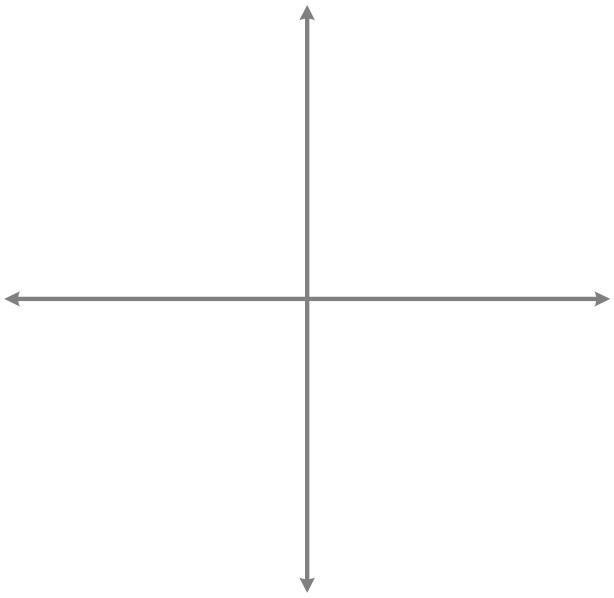


Figure 1

$\mathbf{Z_T} =$ _____

☐ On Figure 2, sketch the predicted impedances of the resistor ($\mathbf{Z_{R220\Omega}}$), the inductor ($\mathbf{Z_L}$), and the total impedance ($\mathbf{Z_T}$).



$Z_{R220\Omega}$= _____

Z_L = _____

Z_T = _____

Figure 2

Step Two: Voltage divider rule

☐ Given your source voltage e(t) = 7.07 sin{2 π (30kHz)t}, write your source voltage in phasor form.

$$\mathbf{E_{SOURCE}} = \_\_\_\_\_$$

☐ Using the voltage divider rule and your predicted total impedance ($\mathbf{Z_T}$), calculate the voltages across the 220-Ω resistor and across the inductor. Write your answers in phasor form.

$\mathbf{V_{R220\Omega}}$ = _____ $\mathbf{V_L}$ = _____

☐ Use Ohm's law to calculate the current in this series circuit.

$$\mathbf{I_S} = \_\_\_\_\_$$

☐ In Figure 3 sketch the phasors, $\mathbf{I_S}$ and $\mathbf{E_S}$., $\mathbf{V_R}$ and $\mathbf{V_L}$.

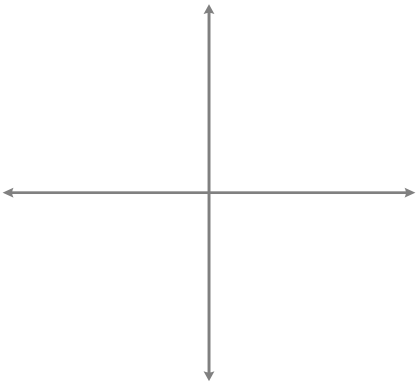


Figure 3

Question: In your above sketch, is $\mathbf{I_S}$ leading or lagging $\mathbf{V_L}$? _____
By how much?_____

Step Three: Construct an AC series circuit

☐ On a QUAD board construct the AC series circuit in Figure 1 and set the function generator to a sine wave with 14.14 V_{PP} at 30 kHz.

☐ Use a DMM to measure the output of the function generator. Adjust the function generator amplitude until the DMM displays 5.00 V_{RMS}.

> Note:
> The function generator voltage output decreases when it is attached to a circuit. The LED voltage indication on the function generator will not match the actual voltage output. You must adjust the function generator output based upon a DMM reading.

☐ Connect your oscilloscope so that CH 1 will measure the ac voltage source and CH 2 will measure the ac voltage across the 220-Ω resistor, as seen in Figure 4.

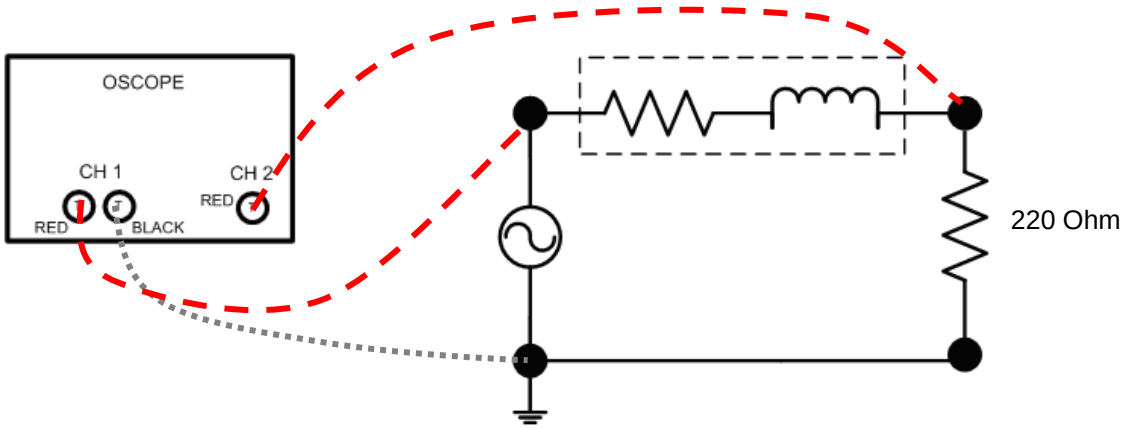


Figure 4

☐ Adjust the oscilloscope so at least **two full cycles** of both CH 1 and CH 2 are clearly displayed on the LCD.

Step Four: Determining phase difference

- AC voltage across an inductor will lead the AC current.
- AC voltage and current across a resistor will be in phase.
- Since we cannot measure ac current with our oscilloscopes, we will determine the phase difference between ac voltage source and the current in the series circuit by measuring the phase difference between the ac source voltage and the ac voltage across the 220 ohm resistor.

☐ Using the cursor function on the oscilloscope measure the time difference between CH 1 and CH 2, and their period, T.

$\Delta t =$ _____ $T =$ _____

☐ Calculate the phase difference.

$$\Theta = (\Delta t / T) \times 360^{\circ}$$

$\Theta =$ _____ **degrees**

☐ Using your oscilloscope determine the voltage across the resistor. Use this value to write the equation of the voltage across the resistor as a phasor.

$V_{R220\Omega} =$ _____

☐ Use Ohm's Law, the measured AC voltage across the 220-Ω resistor, and the determined phase angle to write the equation of AC current as a phasor and as a function of time.

$I_S =$ _____

$i(t) =$ _____

☐ Use Ohm's Law, your determined value for I_S immediately above, and Z_L to determine the voltage across the inductor.

$V_L =$ _____

☐ Sketch the phasors $\mathbf{I_S}$, $\mathbf{E_S}$, and $\mathbf{V_L}$. and $\mathbf{V_R}$ on Figure 5.

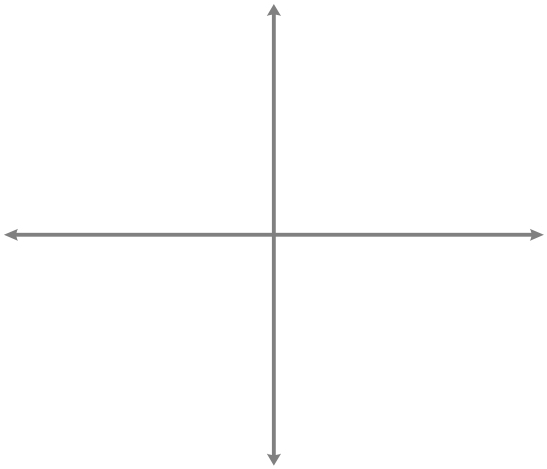


Figure 5

Your text indicates that the voltage across inductors will lead current by 90°. How does this compare to your measured phase difference? _____

What causes your measured phase difference to be less than 90°?

_____

_____