AC analysis

This week we look at some (relatively) simple *AC* circuits.

In lab

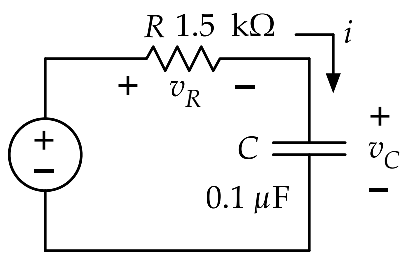
- Build each of the circuits shown below. In each case, the source is a sinusoid. Various amplitudes and frequencies will be used, as described for each circuit.
- Use the multimeter to measure AC voltages and currents.
- Use the oscilloscope to measure phase differences. One way to do this is to measure the lead or lag time between the source voltage and the voltage of interest. The cursors are handy for measuring time differences. Usually, it is more accurate to measure the differences at zero crossings rather than trying to use peaks or valleys.
- If you are adventurous, you can try to use the phase measurement capability built into the oscilloscope. (Look under the measurement menu.) However, you should note that this not always totally accurate.
- Be sure to bring a flash drive for recording oscilloscope traces.
- Be sure to measure the values of the resistors, inductors, and capacitors used in your circuits.
- Calculate the expected magnitude and phase for the voltages or currents of interest in each circuit and for each frequency. Include the calculated values in your report.
- Note: As seen in lecture, the inductors have some parasitic series resistance. (Use the ohm-meter to measure the resistance, if you haven't done it previously.) In some cases, the series resistance can have a noticeable effect on the voltages and currents in the circuit. In your calculations for the circuits with inductors, you might try including the inductor series resistance.

1. RC circuit

Set up the RC circuit shown in Fig. 1. Set the amplitude of the source at 5 V_{RMS} and the frequency at 1000 Hz.

- Use the multimeter to measure the amplitude of the resistor and capacitor voltages.
- Use the oscilloscope to observe the source voltage and the capacitor voltage simultaneously, and measure the phase difference between the source and the capacitor sinusoids. Save a trace for your report.
- Use the math functions to display the resistor voltage on the oscilloscope. Measure the phase difference between the resistor and source sinusoids. Then measure the phase difference between the resistor and capacitor sinusoids. (Note that the resistor waveform will be in phase with the current, so the phase difference between the resistor and capacitor voltages should be a familiar number.)
- Repeat all of the above measurements at frequencies of 250 Hz and 4 kHz.

Figure 1. $V_S = V_m \cos(\omega t)$



The table below may help you in collecting and organizing your data.

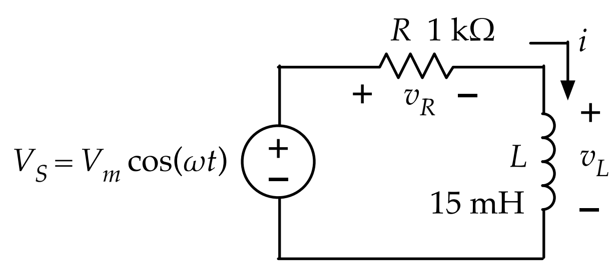
	$\lvert V_S \rvert$	$\lvert V_C \rvert$	$\lvert V_R \rvert$	θ_{SC}	θ_{SR}	θ_{RC}
250 Hz						
1 kHz						
4 kHz						

2. RL circuit

Set up the RL circuit shown in Fig. 2. Set the amplitude of the source at 5 V_{RMS} and the frequency at 10 kHz.

- Use the multimeter to measure the amplitude of the source, resistor, and inductor voltages.
- Use the oscilloscope to observe the source voltage and the inductor voltage simultaneously, and measure the phase difference between the source and inductor sinusoids. Save a trace for your report.
- Use the math functions to display the resistor voltage on the oscilloscope. Measure the phase difference between the resistor and source sinusoids. Then measure the phase difference between the resistor and inductor sinusoids.
- Repeat all of the above measurements at frequencies of 2.5 kHz and 40 kHz.

Figure 2.



The table below may help you in collecting and organizing your data.

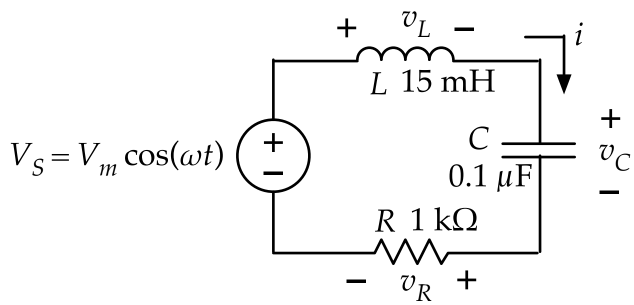
	$\|V_S\|$	$\|V_L\|$	$\|V_R\|$	θ_{SL}	θ_{SR}	θ_{RL}
2.5 kHz						
10 kHz						
40 kHz						

3. RLC circuit

Set up the RLC circuit shown in Fig. 3 Set the amplitude of the source at 5 V_{RMS} and the frequency at 4000 Hz.

- Use the multimeter to measure the RMS amplitudes of the source, resistor, capacitor, and inductor sinusoids.
- Use the oscilloscope to observe the source and resistor voltage waveforms simultaneously. Measure the phase difference between the source and resistor sinusoids. Save a trace for your report. (Note the resistor voltage is in phase with the current, so the resistor phase is the current phase.)
- Swap the capacitor and resistor in the circuit (so that the capacitor and source share a ground connection). Use the oscilloscope to observe the source and capacitor voltage waveforms simultaneously. Measure the phase difference between the source and capacitor sinusoids. Save a trace for your report.
- Repeat all of the above measurements at frequencies of 1.500 kHz and 12 kHz. In the phase measurements, be sure to note whether the resistor and capacitors sinusoids are leading or lagging the source voltage at each frequency.

Figure 3.



The table below may help you in collecting and organizing your data.

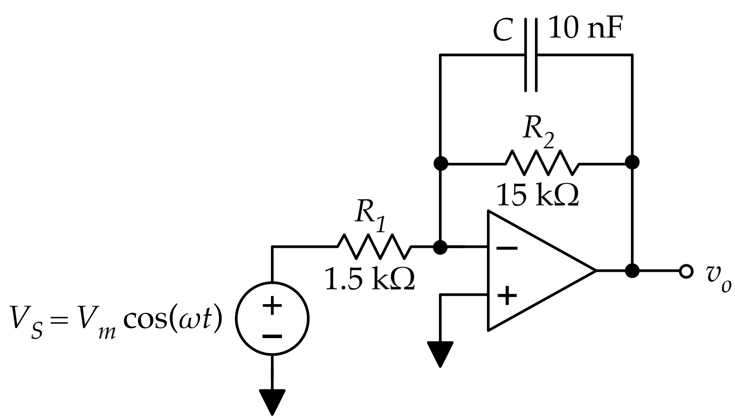
	$\lvert V_S \rvert$	$\lvert V_L \rvert$	$\lvert V_C \rvert$	$\lvert V_R \rvert$	θ_{SR}	θ_{SC}
1.5 kHz						
4 kHz						
12 kHz						

4. An op-amp circuit

Yes, op-amps work just fine in sinusoidal circuits. (And no, we will never get away from op-amps!) Build the op-amp circuit shown in Fig. 4 using an amp from the LM324 chip. Use ±15 V power supplies. Set the amplitude of the source at 0.5 V_{RMS} and the frequency at 1000 Hz.

- Use the multimeter to measure the amplitude of the source and output voltages. (As usual with op amps, the output is measured with respect to ground.) Calculate the gain of the amplifier at this frequency.
- Use the oscilloscope to observe the source and output voltage waveforms simultaneously. Measure the phase difference between the source and output sinusoids. Save a trace for your report.
- Repeat all of the above measurements at frequencies of 250 Hz and 4 kHz. (The phase measurements might be trickier at the higher frequency because the output amplitudes will be smaller. You can increase the amplitude of the source in order to make the output bigger, which should make it easier to make the phase measurement.)

Figure 4.



The table below may help you in collecting and organizing your data.

	$\lvert V_S \rvert$	$\lvert v_o \rvert$	$\lvert G \rvert$	θ_{SO}
250 Hz				
1 kHz				
4 kHz				

Reporting

Prepare a report discussing your calculations and measurements from each part of this lab. Be sure to include your calculations. (You may not know how to do the calculations today, but you will be able to do them within a couple of days.) The report is due at you next regularly scheduled lab time.