PHY322: Electronic Devices & Circuits
Lab 3

Report due date: Wednesday, October 8, 2025

AC circuits: Amplitude and Phase Relationships

In a purely resistive circuit the current and voltage will change in the same way at the same time, they are said to be *"in phase"*. However, if there are capacitors or inductors in the circuit then the current and voltage in these devices, and therefore in the circuit as a whole, will not be in phase. For a capacitor, the current leads the voltage by $^{\pi}/_{2}$ as it charges/discharges, while for an inductor, the current lags the voltage by$-^{\pi}/_{2}$ due to the induced back emf caused by the changing magnetic field in the inductor. For the circuit as a whole the phase difference between the current and voltage will depend on the relative sizes of the resistance R and the reactances X_C and X_L .

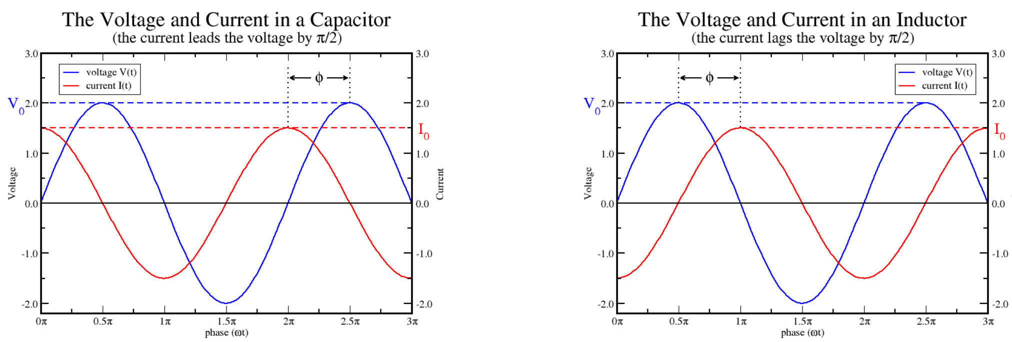


Figure 1: The voltage and current in a capacitor (left) and an inductor (right) as a function of time for a sinusoidal signal with angular frequency ω. The phase difference between the current and voltage is labeled ϕ.

1. **Current/Voltage Phase Difference for a Capacitor**

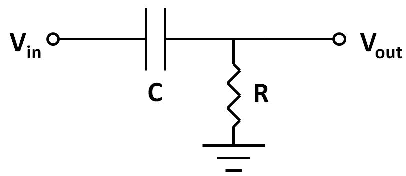
   (a) Design a series RC circuit that will allow you to measure, with a scope, the phase difference between the current to a capacitor and the voltage across the capacitor. Please have the lab. instructor check your circuit schematic before you build it.
   Hint #1: The scope measures voltage. What voltage will has the same phase as the current flowing to the capacitor?

   (b) Construct this circuit with R = 1 kΩ and C = 0.02μF and connect the appropriate signals to the scope channels.

   (c) Using the scope, confirm that the current to the capacitor leads the voltage across the capacitor by $\pi/2$. Remember to save a screen image for your report.
   Hint #2: The correct triggering of the scope is essential for this measurement.

2. **RC Time Constant**

(a) Consider the following RC series circuit



Derive the relationships for the ratio V_{out}/V_{in} and the phase difference between the input and output signals, defined as

$$\frac{V_{out}}{V_{in}} = \frac{V_R}{V_{series\,RC}}$$

Note that both relationships will be a function of the signal frequency ω and the component values R and C.

(b) Construct the circuit with R = 1 kΩ and C = 0.02μF. Carefully measure the component values. Set the signal generator to produce a sinusoidal waveform as V_{in} with V_{pp}[1] = 6 V. Connect V_{in} and V_{out} to the scope.

(c) Measure and record the signal voltages V_{in} and V_{out} and the time difference between V_{in} and V_{out} for sinusoidal waveforms with frequencies of approximately 100 Hz, 1 kHz, 10 kHz and 1 MHz. Ensure you measure the actual frequency, do not rely on the value the signal generator is set to.

f (set)	V_{in}	V_{out}	Δt	T	f (actual)
(Hz)	(V)	(V)	(s)	(s)	(Hz)
100					
1 k					
10 k					
1 M					

(d) Calculate the ratio V_{in}/V_{out} from your data. Compare these values with the predicted values for this ratio at each input frequency.

(e) The phase difference ϕ between the input and output signals can be calculate using the time difference Δt you measured and the signal period T, with $\phi = (2\pi)\Delta t/T$. Calculate the phase difference for your measurements. Compare these with the predicted values for the phase difference at each input frequency.

[1] V_{pp} refers to the peak-to-peak voltage. This is the voltage difference between the signal maximum and minimum. For a symmetric waveform, this will be $2V_0$.