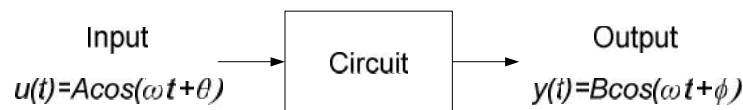


10.6.2: Passive RC Circuit Response

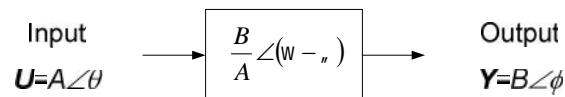
Overview:

In this lab assignment, we will be concerned with the steady-state response of electrical circuits to sinusoidal inputs. Figure 1(a) shows a block-diagram representation of the system. The input and output signals both have the same frequency, but the two signals can have different amplitudes and phase angles.

The analysis of the circuit of Figure 1(a) can be simplified by representing the sinusoidal signals as *phasors*. The phasors provide the amplitude and phase information of sinusoidal signals. By comparing the phasors representing the input and output signals, the effect of the circuit can be represented as an amplitude gain between the output and input signals and a phase difference between the output and input signals, as shown in Figure 1(b).



(a) Physical circuit



(b) Phasor representation of circuit input-output relationship.

Figure 1. Steady-state sinusoidal circuit analysis

In this lab assignment, we will measure the gain and phase responses of a passive RC circuit and compare these measurements with expectations based on analysis. These measurements will be used to estimate the impedance of the overall RC circuit.

Before beginning this lab, you should be able to:

- Represent sinusoidal signals in phasor form
- Determine electrical circuit steady-state sinusoidal responses in phasor form

After completing this lab, you should be able to:

- Measure phasor form of circuit steady-state sinusoidal response
- Measure input impedance of electrical circuit

This lab exercise requires:

- Analog Discovery module
- Digilent Analog Parts Kit
- Digital multimeter (optional)

Symbol Key:

- DEMO** Demonstrate circuit operation to teaching assistant; teaching assistant should initial lab notebook and grade sheet, indicating that circuit operation is acceptable.
- ANALYSIS** Analysis; include principle results of analysis in laboratory report.
- SIM** Numerical simulation (using PSPICE or MATLAB as indicated); include results of MATLAB numerical analysis and/or simulation in laboratory report.
- DATA** Record data in your lab notebook.

General Discussion:

In this lab assignment, we will determine the input impedance of the passive RC circuit shown in Figure 1. The input impedance of a circuit is defined as the ratio of input voltage to input current. Thus, for the circuit of Figure 1, the input impedance is represented in phasor form as:

$$\underline{Z}_{IN} = \frac{\underline{V}_{IN}}{\underline{I}_{IN}} \quad (1)$$

where \underline{V}_{IN} is the phasor representation of the circuit input voltage and \underline{I}_{IN} is the phasor representation of the input current to the circuit.

The cutoff frequency for the circuit of Figure 1 is:

$$f_c = \frac{1}{RC} \quad (2)$$

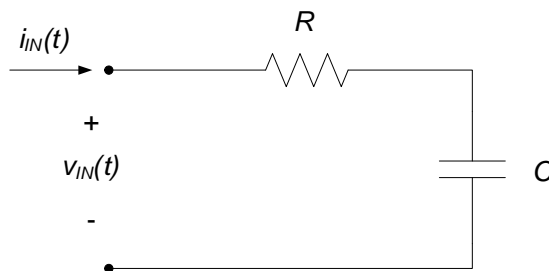


Figure 1. Passive RC circuit.

Pre-lab:

ANALYSIS

- a. Determine an expression for the input impedance of the circuit of Figure 1 in terms of R , C , and

ANALYSIS

- b. If $R = 100\Omega$ and $C = 1\mu\text{F}$, determine the cutoff frequency for the circuit. Also determine the input impedance for frequencies of:

- $= \frac{c}{10}$ (low frequency input)
- $= 10 c$ (high frequency input)
- $= c$ (corner frequency input)

ANALYSIS

- c. Check your low and high frequency results in part (b) relative to your expectations based on the capacitor's low and high frequency behavior.

Lab Procedures:

Construct the circuit of Figure 3, using $R = 100\Omega$ and $C = 1\mu\text{F}$.

DATA

- a. Measure the input voltage amplitude, the input current amplitude, and the time delay between the input voltage and the input current for the following frequencies:

- $\approx \frac{c}{10}$ (low frequency input)
- $\approx 10 c$ (high frequency input)
- $\approx c$ (corner frequency input)

Use your data to calculate the input impedance (magnitude and phase) of the circuit for the above frequencies. Create a table providing the measured data and the calculated input impedances at the above frequencies.

ANALYSIS

- b. Compare your measured results with your expectations based on the analysis you did in the pre-lab.

DEMO

- c. Demonstrate operation of your circuit to the TA and have them initial the appropriate page(s) of your lab notebook and the lab worksheet.

Hint:

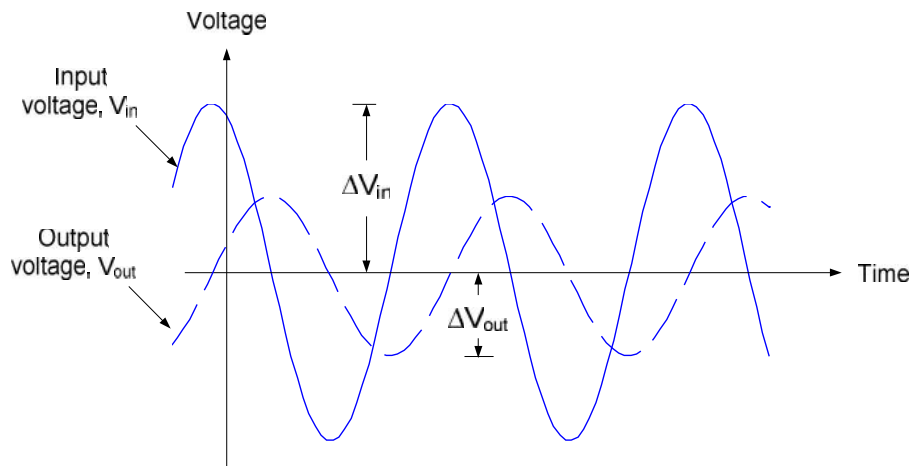
The process to perform the above lab procedures is comparable to the process performed in lab assignment 10.6.1. Be sure to record all necessary data and any calculations you perform to obtain your results in your lab notebook. Appendix A of this lab assignment provides tips relative to gain and phase measurement of sinusoidal signals.

Appendix A – Measuring Gain and Phase:

The gain of a system at a particular frequency is the ratio of the magnitude of the output voltage to the magnitude of the input voltage at that frequency, so that:

$$\text{Gain} = \frac{\Delta V_{out}}{\Delta V_{in}}$$

where ΔV_{out} and ΔV_{in} can be measured from the sinusoidal input and output voltages as shown in the figure below.



The phase of a system at a particular frequency is a measure of the time shift between the output and input voltage at that frequency, so that:

$$\text{Phase} = \frac{\Delta T}{T} \times 360^\circ$$

where ΔT and T can be measured from the sinusoidal input and output voltages as shown in the figure below.

