East West University
Department of Computer Science and Engineering

Course: CSE109 Electrical Circuits
Expt No.: 8
Title: Experimental Study of Sinusoids and Their Characteristics

Objectives:
1. To observe the sinusoids in the oscilloscope using a simple RC circuit.
2. To read characteristics of the sinusoid from the oscilloscope and match the values with their corresponding measured values.

Theory:
Any sinusoid (voltage or current) is a periodic function of time and has positive value for half of the period and negative value for the rest half of the period. It is characterized by three parameters: (i) amplitude, (ii) frequency, and (iii) phase. A voltage sinusoid with amplitude V_m, period T $(f = 1/T)$, and phase θ is shown in Figure 1. This can be mathematically expressed as $v(t) = V_m \sin(\omega t + \theta)$, where $\omega = 2\pi f$. The RMS value of the voltage sinusoid is $V = \sqrt{\frac{1}{T}\int_0^T v^2 dt} = \frac{V_m}{\sqrt{2}}$. Using AC voltmeter and ammeter, we can measure the RMS value of a sinusoid.

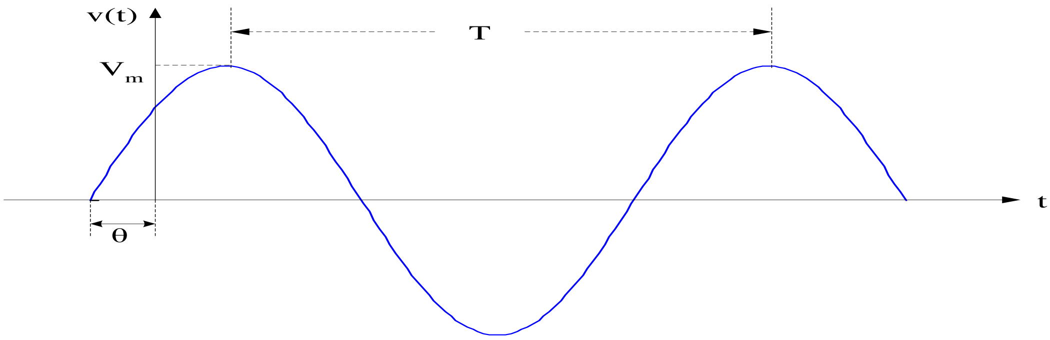

Figure 1. A sinusoidal voltage waveform.

Measurement of Phase Difference in Oscilloscope
The phase difference between two sinusoids (like voltage and current) can be measured in the oscilloscope by observing them in the dual mode. For this, observe one sinusoid in channel-1 and the other in channel-2. Turn on the cursor that measure ΔT and place them between the adjacent peaks of the two sinusoids as shown in Figure 2. Measure Δt as shown in Figure 2. Now turn off either channel-1 or channel-2 and observe one sinusoid. Measure the time period T as shown in Figure 1. Calculate the phase difference in degree between the two sinusoids from $\Delta\theta = \Delta t * 360^0/T$ or $\Delta\theta = \Delta t * 360^0 * f$.

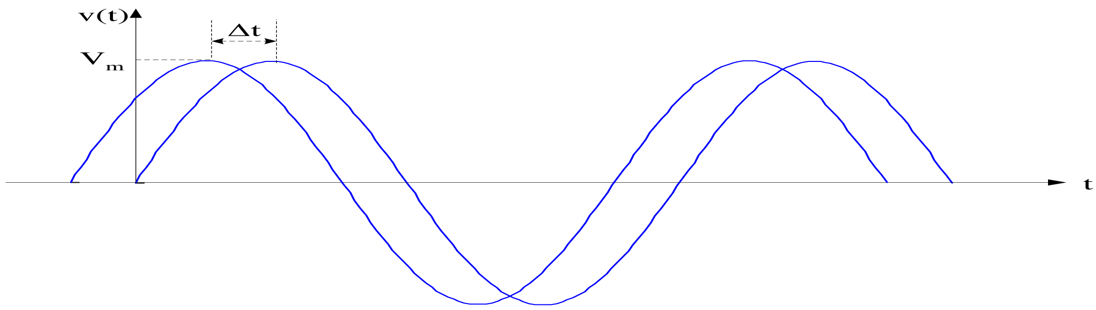

Figure 2. Illustration of how to measure the phase difference between two sinusoids.

Impedance

Once you measure the amplitudes of the voltage and the current sinusoids and the phase difference between them, you can calculate the impedance of the circuit from $Z = \frac{V_m}{I_m}\angle\theta$.

Circuit Diagram:

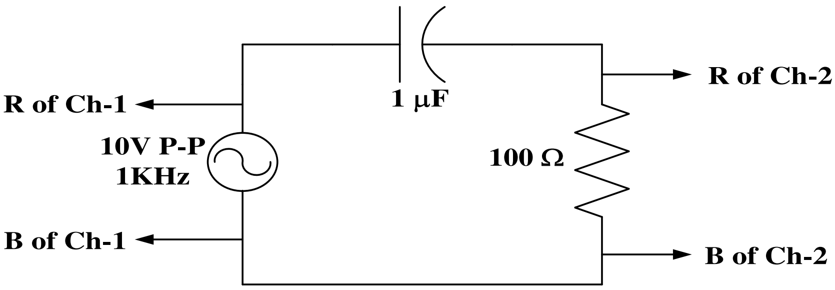

Figure 3. Circuit diagram for experiment.

Pre-Lab Report Question:

1. Theoretically calculate the amplitude of the current flowing through the circuit shown in Figure 3 and the phase difference between the current and the input voltage.

Equipments and Components Needed:

1. Resistance (100 Ω)
2. Capacitance (1 μF)
3. Multimeter
4. Connecting Wires
5. AC Voltmeter (0-3V range)
6. Signal generator
7. Oscilloscope

Lab Procedure:

1. Measure the resistance value using multimeter and write it down in Table 1.
2. Turn on the oscilloscope. Turn on channel-1 and turn off channel-2. Push the GND button and set up the channel to reference ground by tuning the horizontal and vertical knobs.
3. Turn on the signal generator, change the signal to sine wave, and connect its output to the channel-1 of the oscilloscope.
4. Change the GND of channel-1 of the oscilloscope to DC mode and observe the signal.
5. Turn on the ΔV cursor of the oscilloscope and set the peak-to-peak value of the sinusoid to 10V by changing the AMPL knob of the signal generator.

6. Turn on the ΔT cursor of the oscilloscope and set the frequency of the sinusoid to 1KHz or the time period T to 1mS by changing the FREQUENCY knob of the signal generator.
7. Connect the circuit shown in Figure 3 on the trainer board. The source of the circuit is the sine wave from the signal generator that you have set up in steps 4, 5, and 6.
8. Turn off channel-1 of the oscilloscope and turn on channel-2. Push the GND button and set up the channel to reference ground by tuning the horizontal and vertical knobs.
9. Connect channel-2 of the oscilloscope across the resistance as shown in Figure 3.
10. Change the GND of channel-2 of the oscilloscope to DC mode and observe the signal. This is the voltage sinusoid across the resistance. Measure the peak value and divide it by the measured value of the resistance. This is the amplitude of current. Write it down in Table 1.
11. Connect channel-1 of the oscilloscope as shown in Figure 3 and observe both the channels in dual mode. Measure the phase difference and write it down in Table 1. Also write which signal leads.
12. Using the AC voltmeter, measure the voltage across the resistance, across the capacitor, and across the source and write them down in Table 2.
13. Divide the voltage across the resistance by the measured value of the resistance. This is current through the resistance. Write it down in Table 2.

Table 1. Experimental Data from Oscilloscope.

Measured value of resistance (Ω)	Set peak-to-peak value of source voltage (V)	Set source frequency (KHz)	Measured peak value of current through resistance (mA)	Measured phase difference between voltage and current (deg)	Which signal is leading?

Table 2. Experiemntal Data from Meter Reading.

Measured RMS value of source voltage (V)	Measured RMS value of voltage across capacitor (V)	Measured RMS value of voltage across resistance (V)	RMS value of current through resistance (mA)

Post-Lab Report Questions:

1. Divide the amplitude of the signal generator voltage measured by the oscilloscope by √2 and compare it with the measured RMS value by voltmeter.
2. Divide the amplitude of the current measured by the oscilloscope by √2 and compare it with the measured RMS value.
3. Calculate the impedance by the measured values of voltage and current from the oscilloscope. Also calculate the impedance from $Z = R-jX_C$.
4. Calculate the impedance angle from the expression $\tan^{-1}(X_C/R)$ and compare it with the phase difference measured from the oscilloscope.