EXPERIMENT # 6

FREQUENCY DOMAIN ANALYSIS

OBJECTIVE:

1. To experimentally verify frequency domain calculations using the phasor method.
2. Experimentally measure the phase difference between two sinusoidal signals.

Pre-Lab Assignment:

For the circuit shown in Figure 2:

1- Assume that the inductor has an internal resistance of 51 Ohms.
2- Add 1 K Ohm resistor with the inductor.
3- Let the source voltage V_s have a peak amplitude of 10 V and frequency f = 20 kHz. Assume that V_s has a zero phase angle.
4- Use phasor method to calculate all voltages and currents shown.

Enter your results in Table 2.

APPARATUS: Signal Generator.
Digital Multimeter.
Oscilloscope.
Capacitor 0.022 μF.
Inductor 8.2 mH
Resistor: 100 Ω, 1 KΩ, and 1.5 KΩ.

THEORY:

In the frequency domain (phasor domain), the currents and voltages are represented by complex numbers whose magnitudes are equal to the maximum values of the sinusoidal time-domain quantities, and whose angles are equal to the phase angles of the time-domain functions expressed as cosines.

In terms of voltage and current phasors and the complex impedance $\overline{Z}$, Ohm's law becomes:

$$\overline{V} = \overline{I}\,\overline{Z} \qquad (1)$$

Where $\overline{Z} = R$ for a resistance
$= jL$ for an inductance
$= \dfrac{1}{j\omega C}$ for a capacitance

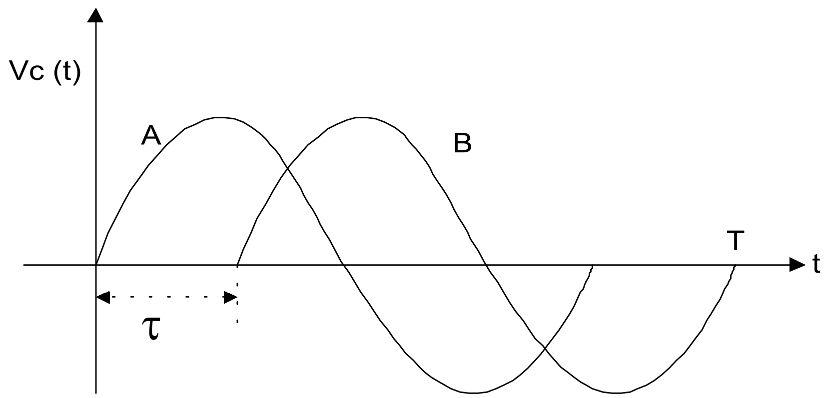
where $\omega = 2\pi f$ is the angular frequency of the source . The bar indicates a complex quantity.

In general, for $\overline{V} = V\angle\alpha$ and $\bar{I} = I\angle\beta$, the impedance $\overline{Z} = \dfrac{V}{I}\angle\alpha - \beta$

Analytically, frequency-domain circuits are treated by the same method as used in DC circuits, except that the algebra of complex numbers is used.

Experimentally, the frequency-domain phasors can be measured on the oscilloscope. The magnitudes can be measured by means of calibrated vertical scales. Phase difference can be measured by using the dual traces and measuring the time difference between two waveforms, as illustrated in Figure 2.

IMPORTANT NOTE: When measuring the phase difference between two signals, make sure that the control knobs in the oscilloscope are set properly such that the signals are not relatively inverted.



Time shift = τ

Phase shift = $360\ (\frac{\tau}{T})$ degrees

Figure 1

Signal B lags signal A.

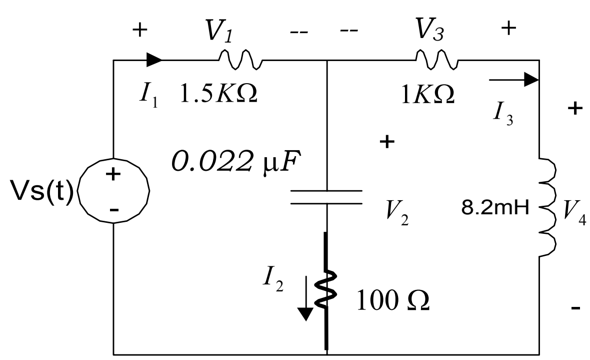


Figure 2

PROCEDURE:

1. Measure the resistor values and the internal resistance of the inductor, using an Ohmmeter.

2. Connect the circuit of Figure 2. Adjust the source voltage to 10 V peak at 20 kHz, while it is connected to the circuit.

3. Use the oscilloscope to measure the magnitudes and phases of all voltages and currents and record the values in Table 2.

IMPORTANT NOTE:

1. When measuring the phase difference between two signals, make sure that the control knob of the oscilloscope are set properly such that the signals are not relatively inverted.

2. Whenever two signals are to be displayed simultaneously on the oscilloscope, they should have one common node as a reference. Therefore, you may have to change the position of some elements to be able to measure two signals simultaneously.

3. To find I_2, measure the voltage on the 100 Ω resistor.

REPORT:

1. Draw the circuit of Figure 2 in the frequency domain (in the phasor representation).
2. Record the theoretical and experimental values in Table 2.
3. Draw the phasor diagram, showing all the voltages and currents, based on the experimental values.
4. Discuss the sources of discrepancies between the theoretical and experimental values.

QUESTIONS:

1. For a resistance and capacitance in series with a voltage source, show that it is possible to draw a phasor diagram for the current and all voltages from magnitude measurement of these quantities only. Illustrate your answer graphically

2. The equivalent impedance of a capacitor in series with an inductor is equivalent to a short circuit (i.e. equal to zero) at a certain frequency. Derive an expression for this frequency.

3. The equivalent impedance of a capacitor in parallel with an inductor is equivalent to an open circuit (i.e. equal to infinity) at a certain frequency. Derive an expression for this frequency.

TABLE 1

Resistor	R1	R2	R3
Nominal Value (Ohm)	100	1k	1.5k
Ohmmeter Reading			

Internal resistance of the inductor = Ohms

TABLE 2

		V_1	V_2	V_3	V_4	I_1	I_2	I_3
Theoretical Values	Magnitude (Volts)							
	Phase Shift (Degree)							
Experimental Values	Magnitude (Volts)							
	Phase Shift (degrees)							
% Error	Magnitude (Volts)							
	Phase Shift (degrees)							

CIRCUIT IN FREQUENCY DOMAIN

PHASOR DIAGRAM