Experiment 10
Sinusoidal AC Analysis

Introduction

The students learnt how to use the function generator and oscilloscope in the previous experiment. In this experiment they will learn to build and take measurements in ac circuits. The circuit will be simulated on *Multisim Electronics Workbench*. Then they will build it with hardware components and check the accuracy of the measurements comparing with the simulation results. Consider the circuit given in Figure 1.

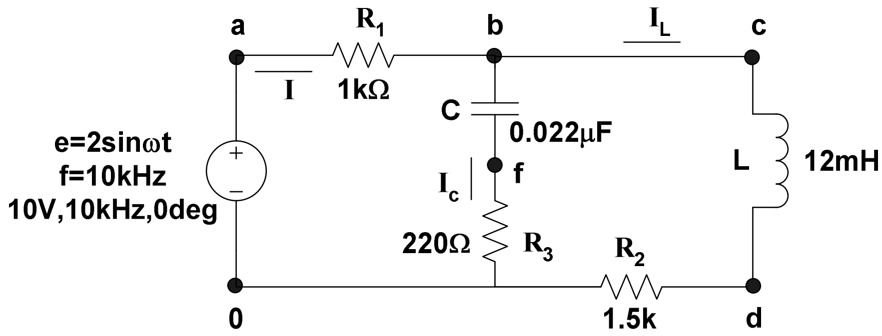
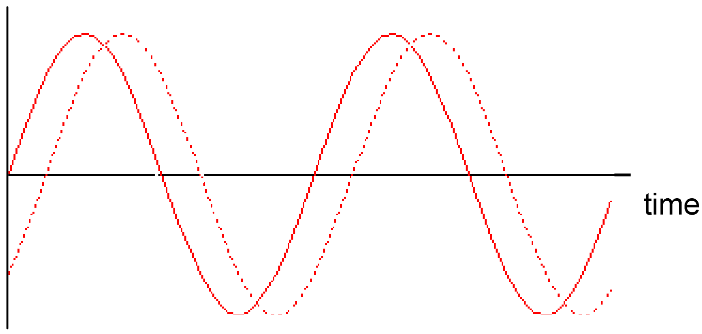


Figure 1: RLC circuit

The equations for sinusoidal current is written in the form,

$$i = I_m \sin (? t-?) \qquad (1)$$

where, i is the instantaneous value of current, I_m is the peak value, ? is the angular frequency and ? is the phase angle of the current with respect to the source voltage. Phase angle can be measured by using the two traces of a dual trace oscilloscope and measuring the time difference between two waveforms, as shown in Figure 2.



Time shift = t
Phase shift = ? = wt
Phase shift = ? = 360 (t/T**)**
where T = time period

Figure 2: Phase angle measurement

The RMS or effective value of the sinusoid is given as $I_m/v2$. The power dissipated can be computed by using,

$$P= E_{rms} I_{rms} \cos ? \qquad (2)$$
$$P= I^2_{rms} R= V^2_R/R \qquad (3)$$

Objectives

1. Measure currents in each branch of the circuit of Figure 1 using oscilloscope
2. Verify KCL for ac circuit
3. Calculate the power dissipated in the resistor.

Materials

Dual trace oscilloscope
Signal generator
Resistors (470Ω, 5Ω, 5Ω)
Inductor, 1mH (iron core)
Capacitor, 3300pF

Procedure

1. Construct the circuit of Figure 1. Connect Ch A of the oscilloscope to the output of signal generator at point 'a'. Oscilloscope ground and circuit ground should be the same. Set the oscilloscope to AUTO sweep, and use Ch A as the TRIGGER source. Adjust the output of the signal generator to provide a sinusoidal voltage with an amplitude (peak value) of 5V (10 Vp-p) and frequency of the function generator at f=10 KHz.
2. Use Ch B of the oscilloscope to observe the voltage at point d. This is the voltage across resistor R_2. Measure the peak (half of peak to peak) voltage V_2 (across R_2). Determine phase angle $?_2$ of voltage V_2 with respect to generator voltage 'e'. Determine the amplitude I_L (V_3/R_3) and enter time domain expression for i_L below.

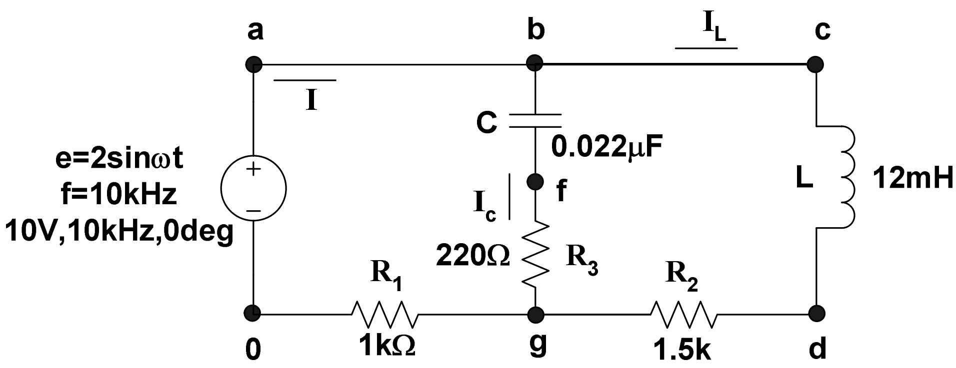
Table 1: Sinusoidal expressions for voltage (v_2) and current (i_L)

	V_2 (amplitude)	$?_2$ (phase, deg)	Expression v_2	Expression i_L
Workbench				
Hardwired				

4. Move Ch B of the oscilloscope to observe the voltage at point f. This is the voltage across R_3. Measure the amplitude V_3 and phase angle $?_3$ with respect to 'e'. Determine the amplitude I_C (V_3/R_3) and enter time domain expression for i_C below.

Table 2: Sinusoidal expressions for voltage (v_3) and current (i_C)

	V_3 (amplitude)	$?_3$ (phase, deg)	Expression v_3	Expression i_C
Workbench				
Hardwired				



5. Change the position of resistor R_1 to that shown in Figure 2. This change will not affect the circuit. Connect Ch A to point 'a' and Ch B to point 'g'. Measure amplitude of the voltage across R_1 (V_1) from Ch B. Determine phase angle ?$_1$ of voltage V_1 with respect to generator voltage 'e'. Determine the amplitude I (V_1/R_1) and enter time domain expression for i below.

Table 3: Sinusoidal expressions for voltage (v_1) and current (i)

	V_1 (amplitude)	?$_1$ (phase, deg)	Amplitude I	Expression i
Workbench				
Hardwired				

Questions

1. Convert the measured values of currents i_R, i_L and i_C obtained in steps 3-5 into phasor form (example, $I = 5\angle 30^0$ Amp). Compare these values with the ones obtained through simulation.

<u>Hardwired Experimental Values</u> <u>Simulation Values</u>

2. Use complex algebra to show that the data in step 1 (above) satisfies Kirchhoff’s current law.

3. Use the phasors E and I to calculate total power delivered to the circuit by the voltage source (equation 2).

   P_T=

4. Now use the rms values of I_R and V_R to determine the power dissipated by the resistor (equation 3). How does this value compare with the total power dissipated by the source? Offer an explanation for any variation.

   P_R=

Any other observations or comments