PE
1

LAB BENCH REVIEW

A Practical Exercise

Name:_____

I. Purpose.

The purpose of this lab is to review your understanding of the oscilloscope, function generator and digital multimeter.

II. Equipment.

1 1 mH inductor
1 100-Ω resistor
1 0.1 μF capacitor
Standard Lab Bench setup

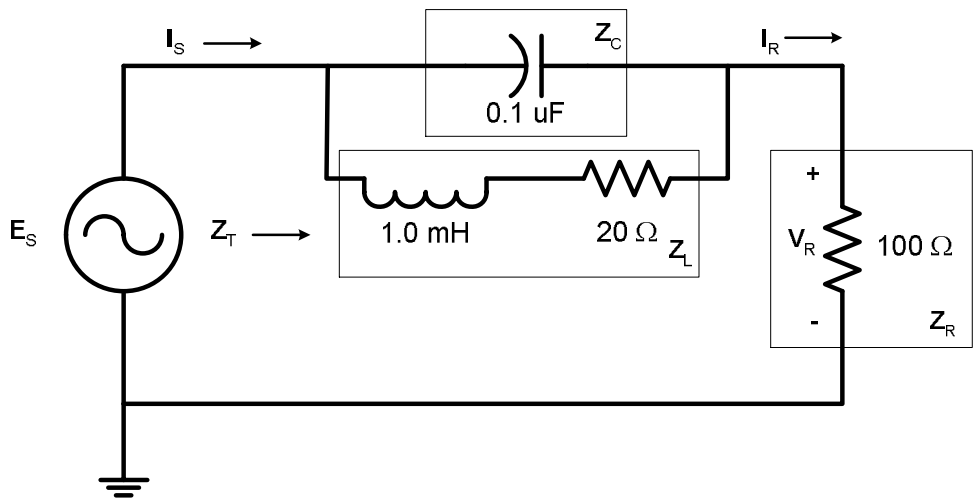


Figure 1

III. Preparation

For this lab we will be constructing the circuit in Figure 1. Prior to constructing the circuit, evaluate the impedances Z_C, Z_L, and Z_R assuming the frequency of the source E_S is 10,000 Hz. Note, the 20-Ω resistance is not a separate component, rather it represents the resistance of the wire used to construct the inductor. The impedance Z_L is composed of both the 1-mH inductor and a 20-Ω resistance.

Z_R = _____∠ _____

Z_C = _____∠ _____

Z_L = _____∠ _____

Using the calculated values of Z_C, Z_L, and Z_R, determine the total impedance Z_T of the circuit.

Z_T = _____∠ _____

If the source E_S has an amplitude of 1.00-V_{rms}, use the total impedance Z_T to determine the source current.

I_S = _____∠ _____

What will the amplitude and phase of the voltage V_R be? (Hint: What is true about the current through the resistor I_R and the source current I_S ? If you know I_R, you can find V_R using Ohm's law.)

V_R = _____∠ _____

IV. Lab Procedure.

Measuring resistance

Using the digital multimeter (DMM), measure and record the resistance of the 100-Ω resistor.

R = _____

What tolerance of the this resistor (note: indicated by the 4th band)? _____ %

Is this resistor within the indicated tolerance (quantify this) ?

Measure the resistance of the 1 mH inductor. $R_{inductor}$ = _____

Constructing the circuit
Construct the circuit depicted in Figure 1. For the source E_S, set the function generator to produce a 1-V_{rms}, 10-kHz sine wave.

Measuring voltage using the digital multimeter
The digital multimeter provides the most precise measurement of voltage.

Due to the loading of the circuit, the voltage E_S will not match what is indicated on the function generator. To compensate for this **you will need to increase the amplitude of the function generator until E_S is 1.00 V_{rms} as read on the digital multimeter**. (You will probably need to set the amplitude in the neighborhood of ~1.3 V_{rms}.)

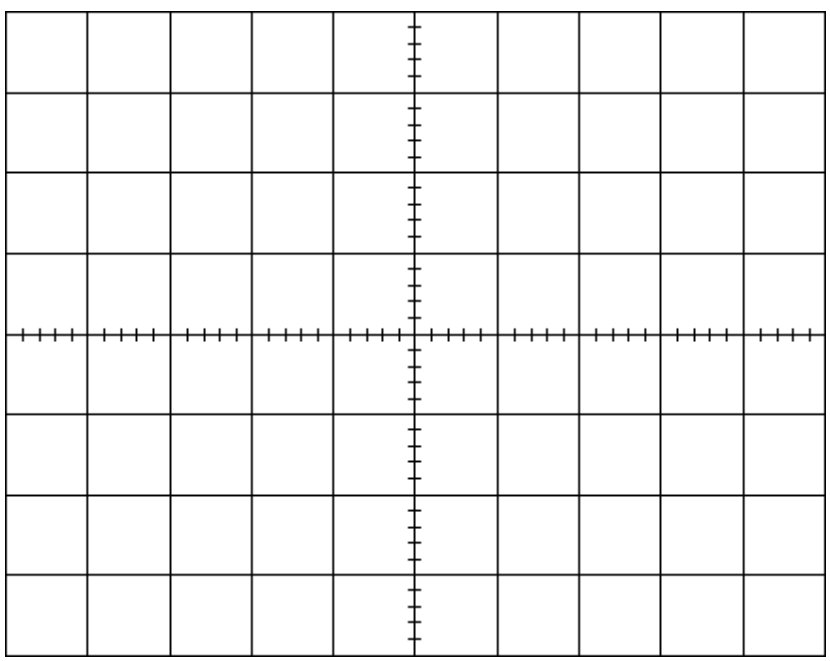
Measure E_S and V_R using the digital multimeter with **AC V** function selected.

	V_{rms}
E_S (ideally 1.00 V_{rms})	
V_R	

Connect CH1 of the oscilloscope to measure the source E_S and CH2 to measure V_R. Set the oscilloscope, as follows:

Vertical: CH1 and CH2 to 500 mV/div, adjust vertical position to 0.00V for both
Horizontal: 10 μs/div, adjust horizontal position so that CH1 crosses zero the center of the grid.
Acquire: Press the **Acquire** button then select **Average** from onscreen menu.

Carefully draw the two waveforms on the grid in Figure 2. Label E_S , V_R and record the scale.



CH1 _____ V/div Time: _____ s/div CH2 _____ V/div

Figure 2. Oscilloscope Display

Measuring the waveform on the oscilloscope
There are several different methods of measuring signal parameters using the oscilloscope.

Manual method
The first method is by counting the divisions of grid and applying the scale (volts/div or sec/div). Using the waveforms that you transcribed onto Figure 2, determine the peak-to-peak voltage of E_S and V_R. Determine the amplitude of the signal and express it as an rms value (recall that the rms value of a sinusoid is the amplitude times 0.707).

	Peak-to-peak	Amplitude	V_{rms}
E_S (CH1)			
V_R (CH2)			

Now, using the horizontal scale on Figure 2, determine the period of E_S and calculate its frequency. Also, measure the time delay between V_R and E_S.

	Period (μs)	Frequency (kHz)	Time delay (μs)
E_S (CH1)			
V_R (CH2)			

Is V_R leading or lagging E_S? _____

Calculate the phase difference between V_R and E_S. _____

Taking cursor measurements
The second method of measurement is through the use of the on-screen cursors. Press the **CURSOR** button to view the cursor menu, then cycle the top menu box button until **Voltage** appears under the cursor **Type**. Also, ensure that CH1 is selected as the **Source**. Adjust the **CURSOR 1** knob (same as the first VERTICAL POSITION knob) so that cursor 1 is at the peak voltage of the CH1 waveform. Adjust the **CURSOR 2** so that the cursor 2 is at the minimum voltage of the CH1 waveform. The peak-t0-peak voltage is indicated by the value under **Delta** on screen. Record this, change the **Source** to CH2, and repeat the measurements for V_R.

	Peak-to-peak	Amplitude	V_{rms}
E_S (CH1)			
V_R (CH2)			

Now, change the cursor **Type** to **Time** and repeat the measurements of period, frequency and time delay. Note, frequency can be read directly from the screen. It may be helpful to adjust the horizontal scale (sec/div) for more precise measurements.

	Period (μs)	Frequency (kHz)	Time delay (μs)
E_S (CH1)			
V_R (CH2)			

Calculate the phase difference between V_R and E_S. _____

Taking automatic measurements
The oscilloscope has the ability to take automated measurements of voltage, period and frequency. Press the **Measure** button to view the measurement menu then cycle the top menu box button to highlight **Source**. Select CH1 for the top two measurements and CH2 for the bottom two. Once the measurement sources are set, cycle the top menu box button again to highlight **Type** allowing you to specify the type of measurement desired. Note: if the measurements appear to be jumping around, ensure the **Average** is selected on the **Acquire** menu.

Cycle one CH1 menu box button to display **Pk-Pk** and record peak-to-peak voltage. Cycle it again to display **Cyc RMS** and record rms voltage. Repeat for CH2. Amplitude is not automatically measured but can still be calculated from the peak-to-peak voltage as before.

	Peak-to-peak	Amplitude	V_{rms}
E_S (CH1)			
V_R (CH2)			

Continue cycling the menu box buttons to measure period and frequency.

	Period (μs)	Frequency (kHz)
E_S (CH1)		
V_R (CH2)		

V. Conclusions.
Assuming that digital multimeter is the most precise, compute the percent error for our measurements of rms voltage for E_S.

	V_{rms}	Percent error
Multimeter		
Manual		
Cursors		
Automated		