ECE 0101 – Linear Circuits and Systems
Laboratory # 9 – AC Phasor Circuit Analysis

Objectives:

- Analyze circuits through phasor circuit analysis.
- Observe the phase and amplitude changes as frequency changes in RC, RL, and RLC circuits.

Introduction

A phasor is a complex number representing the amplitude and phase of a sinusoidal voltage or current signal, e.g.

$$\mathbf{V} = V_A e^{j\emptyset} \text{ or } \mathbf{V} = V_A\angle\phi \text{ or } \mathbf{V} = V_A cos\phi + jV_A sin\phi$$

In phasor circuit analysis, the relation between the phasor voltage and phasor current is

$$\mathbf{V} = Z\mathbf{I}$$

where *Z* is the impedance of the element or the circuit. The impedance of the three basic elements are:

$$\text{Resistor: } Z_R = R$$
$$\text{Inductor: } Z_L = j\omega L$$
$$\text{Capacitor: } Z_c = \frac{1}{j\omega C}$$

For example, the combined impedance of a 100Ω resistor with a 1mH inductor in series as in the following circuit at 16kHz is Z=100+j101, or $Z = 141.8\angle 45.1°$. Assuming the voltage signal from the function generator has 1V amplitude and zero phase, then the current through the inductor and resistor is

$$\mathbf{I} = \frac{\mathbf{V_S}}{Z} = \frac{1\angle 0°}{141.8\angle 45.1°} = 7\angle -45.1° \text{ mA}$$

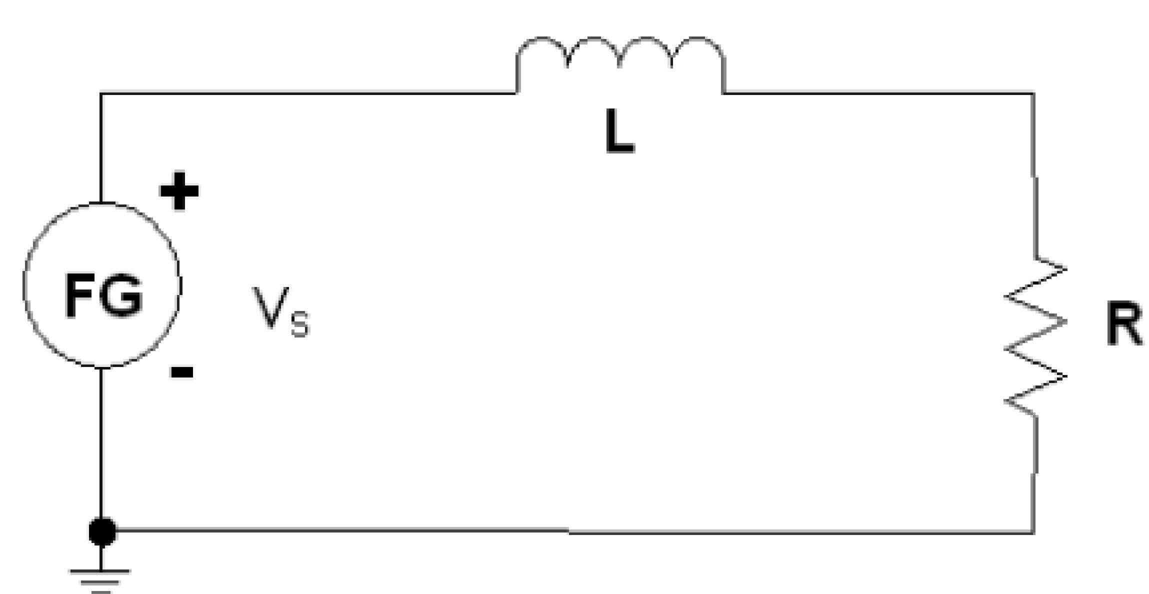

Fig. 1

Homework

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1. (16 points) In the following RC circuit, assuming Vs is a sinusoidal voltage with amplitude of 1V, the resistor is 1kΩ, and the capacitor is 0.1 μF, then determine the total impedance and phasor current at 1.6kHz.

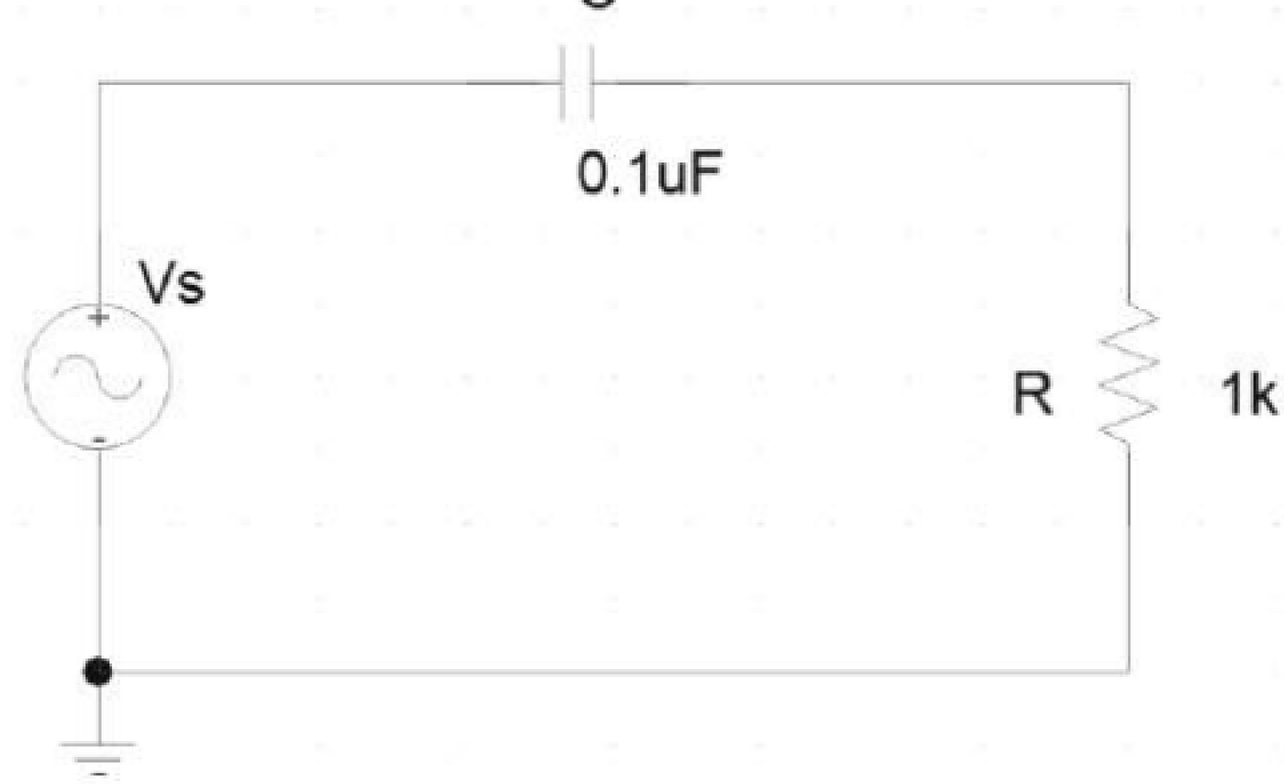


Fig. 2

Z= $1000 - j994.7\Omega$ $(1410 \angle -44.85^\circ)$

I= $0.709 \angle 44.9^\circ$ mA ~~(1418∠45.15°)~~

2. (16 points) In the following RL circuit, assuming Vs is sinusoidal voltage with amplitude of 1V, the resistor is 1kΩ, and the inductor is 1 mH, then determine the total impedance and the phasor current at 160kHz.

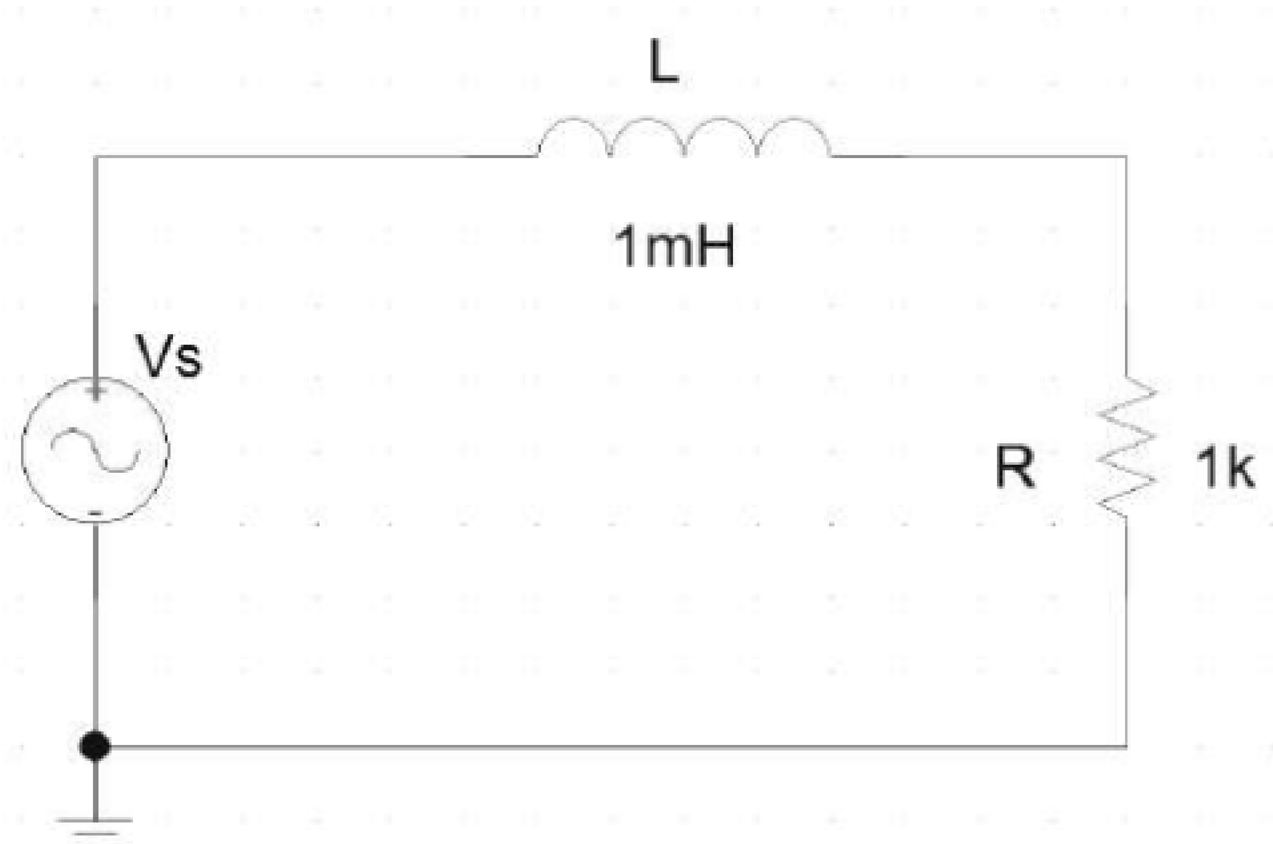


Fig. 3

Z= $1000 + j1005.3\Omega$ $(1418 \angle 44.7^\circ)$

I= $0.705 \angle -45.1^\circ$ mA

Laboratory Procedure

1. On your breadboard, build the RC circuit as shown in Fig. 2 using R=1 $k\Omega$ and C=0.1 μF.

2. Configure the function generator to output a sine waveform with the following characteristics:

- Amplitude = 2 Vpp with 0 DC offset.
- Frequency = 1.6 kHz
- Phase = 0°

3. Connect the function generator to oscilloscope channel 1 as well as to the circuit; connect the voltage output of the circuit across the resistor $v_R(t)$ to oscilloscope channel 2. Simultaneously display at least 4 periods of the input sine wave $v_s(t)$ and the output voltage across the resistor $v_R(t)$ as in Fig. 2. Now $v_R(t)$ can also be used to represent the current in the circuit as a single current flowing in the circuit and $i(t)= v_R(t)/R$. Since R=1$k\Omega$, the current will be the same waveform as the $v_R(t)$ but with a unit of mA instead of V.

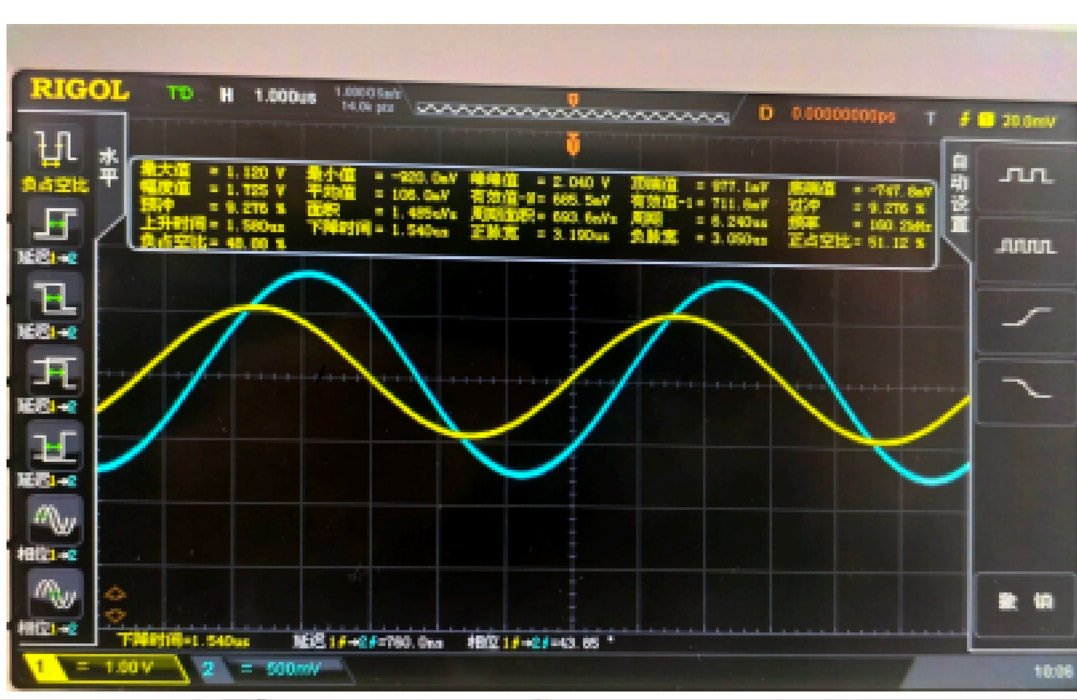
4. Measure the amplitude of $v_R(t)$ using the oscilloscope and calculate the amplitude of the current using $I= V_R/R$. Note the value for current in the table below.

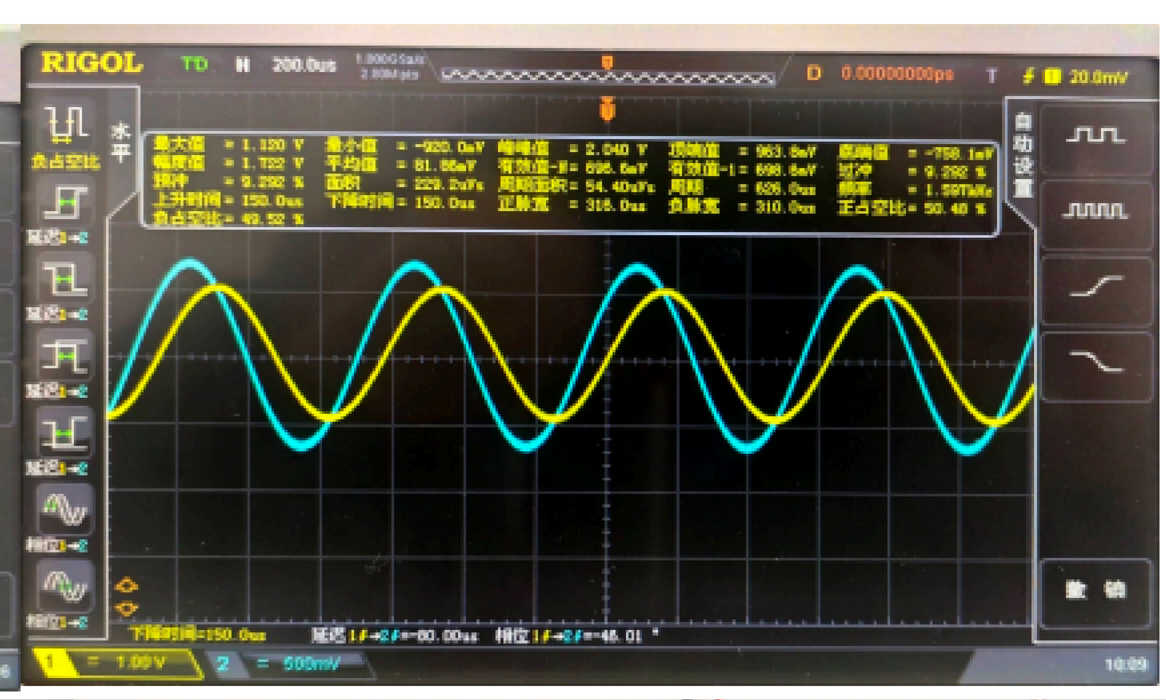
5. Measure the time delay between the $v_R(t)$ and $v_S(t)$. Calculate the phase of $v_R(t)$ relevant to $v_S(t)$, which is also the phase of the current $i(t)$ relevant to $v_S(t)$. Note your value in the table below.

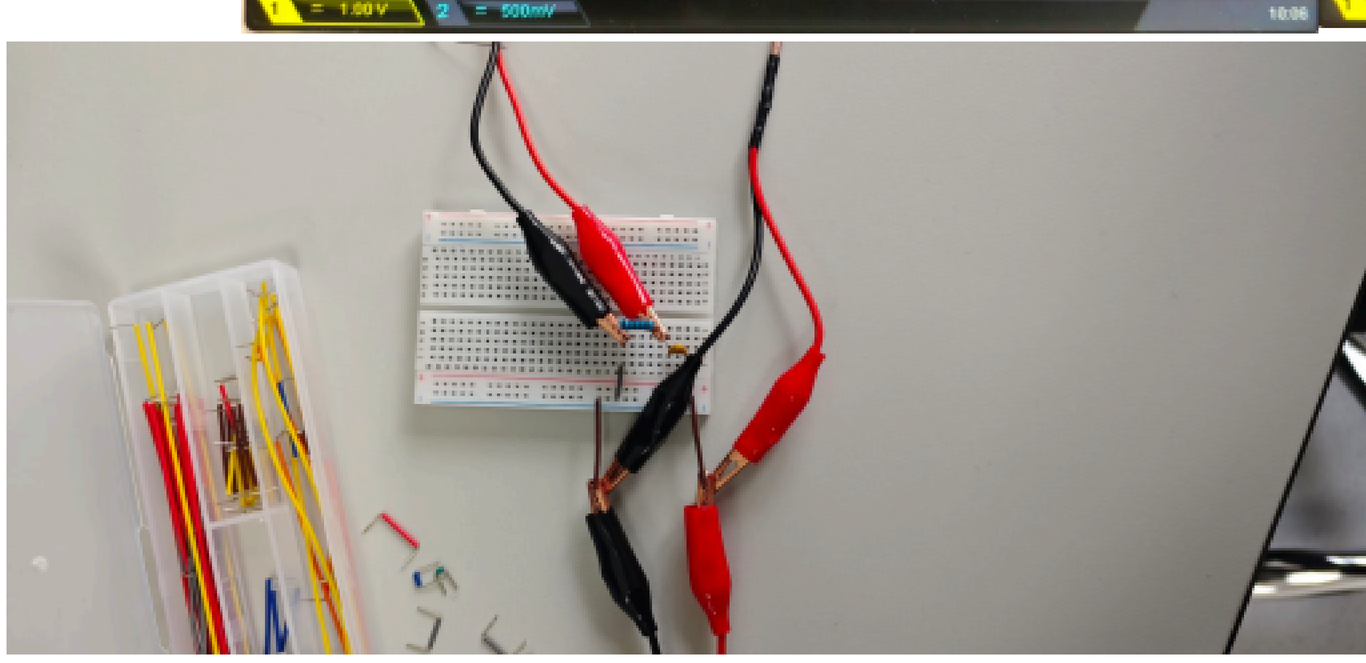
6. Repeat for a frequency of 160 kHz.

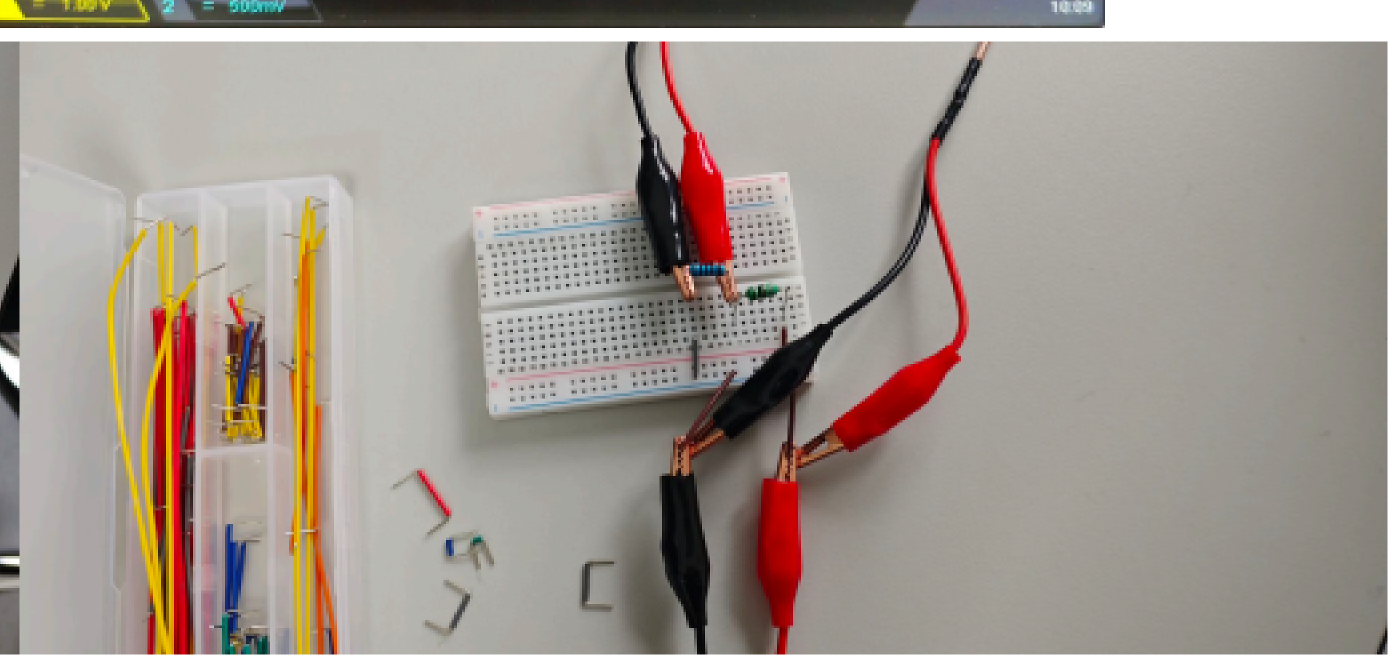
7. On your breadboard, build the RL circuit as shown in Fig. 3 using R=1 $k\Omega$ and L=1 mH.

8. Repeat step 3-6 to find the current amplitude and phase.









Results and Analysis

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Report your results in the following table and attach your captured screen results from the oscilloscope for each measurement

(6 points per entry = 48 points)

Circuits	Frequency (Hz)	Current Amplitude (mA)		Current Phase (°)	
		Measured	Calculated	Measured	Calculated
RC	1.6k	0.72mA	0.709	43.85	44.9
RL	160k	0.86mA	0.705	-46.01	-45.1

Answer the following questions:

(a) (10 points) How do the measured and calculated values compare with one another? Explain any differences.

The measured value is close to the calculated value, the Small diffierences may be component tolerances measure error or others.

(b) (10 points) Explain why the current phase relevant to the voltage is delayed in RL circuit while is advanced in RC circuit.

For inductor, a changing current produces voltage, so V_L is +90° ahead of I, So for R, current lags the source Voltage.

For capacitor, the capacitor current is ahead. So for R-C series, current leads the source voltage.