print name (first last): ______________________

course: ECET 337 2025/07/26

Series RLC Circuit

Prelab Design Calculations ____

Performance Checks

			In lab	or	Late
_____	1.	Transient responses	(30%	or	15%)
_____	2.	Frequency responses	(30%	or	15%)

Lab Performance Scoresheet

Prelab initial submission (on time, with calculations, complete) … (10%)→ __________

All required signed ***Performance check offs*** ……………………………… (60%)→ __________

Total→ (out of 70%) __________

Prelab Activity:

1. Draw the schematic for an RLC circuit that outputs a step (eventually) in response to an input step (i.e. low pass). Is the output taken across the resistor, the inductor, or the capacitor? Include and label r_{inductor}, the internal resistance of the inductor.

2. Derive the transfer function for your circuit, in terms of R, L, and C. You may assume that r_{inductor} is included in R.

3. The standard second order transfer function is $\frac{A\omega_n{}^2}{s^2+2\xi\omega_n s+\omega_n{}^2}$ Equate coefficients from your transfer function and determine the equation for A, ω_n, and ξ in terms of R, L, and C.

A = ____________ ω_n = ____________ ξ = ___________

4. Rearrange these equations, assuming a given L, to solve for C and R.

C = _______________ R = _______________

5. Pick L = 33 mH. Calculate the value of C and R for
f_n = 8.8 kHz => ω_n = ________ ξ set to produce *critical* damping = ________

C = _______________ R_{total} = _________ What R goes in the circuit? ______

6. Build this circuit, arranged on your breadboard with the output across the capacitor.

_____________ Instructor's initals

Objectives

Investigate the performance of a series RLC in response to a step input with different damping.
Determine the frequency response of the voltage across each of the components.

Approach and Results

1. **$A = 1, f_n = 8.8$ kHz, Varied Dampings**
   - **a.** Measure the values of the components. R = ________ L = ________ C = ________
   - **b.** Arrange the RLC circuit with the output **across C**. This is from step 6 of the prelab circuit.
   - **c.** Set the function generator to 2 kHz, square wave, 0 V (**base**), to 1 V(**top**), then connect it to the oscilloscope.
   - **d.** Adjust CH1 of the oscilloscope so that it will display one to two cycles of the input signal across the *center* of the screen. A **Time** setting of **100 μsec/div** should be about right. Set the **V/div** so about 2/3 of the vertical area of screen is covered.
   - **e.** Connect the output of the function generator to the input of the RLC circuit.
   - **f.** Connect CH1 to the function generator, the circuit input.
   - **g.** Tweak the High level and the Low level from the function generator to get the correct signal into the circuit as displayed by the CH 1 **base** and **top** measurements
   - **h.** Place CH3 across the capacitor. Adjust the oscilloscope to produce a display that aligns well with and is similarly scaled to the input on CH 1.
   - **i.** Damping is to be critical, so the voltage across the capacitor should rise quickly and smoothly to its final value without ringing. When the circuit is responding correctly, capture the oscilloscope display.

     Photograph this display on your live oscilloscope for the report.

   - **j.** Disable the generator, then change the resistor to produce a damping of 0.5. Remember to account for the inductor's internal resistance when you install the new resistor. Show your calculations below.

     $R_{\text{damping} = 0.5} =$ ________

   - **k.** With the new resistor installed, enable the generator's square wave.
   - **l.** What should this transient response be? When the circuit is responding correctly, capture the oscilloscope display.

     Photograph this display on your live oscilloscope for the report.

   - **m.** Disable the function generator's output.

Demonstrate the oscilloscope display, screen capture and discuss the damping with your lab instructor.

2. Frequency Responses

Theory

The output wave shape of the RLC circuit depends on the input wave shape. In the preceding section you explored the transient response of the RLC circuit to a square wave, and the effect of changing the damping.

Driven with a *sine wave*, this circuit outputs a sine wave, regardless of the critical frequency, gain, damping, or across which component the output is taken. However, the *magnitude* of the output sine wave depends on A, f_o, ξ, and the frequency of the input. This effect is demonstrated by providing a sine wave input, measuring the output magnitude, then changing the frequency and measuring the output magnitude again. To get a good understanding of the circuit's performance, this must be done for a range of frequencies, starting below f_o and continuing well above f_o. At each frequency the gain is calculated, and then those gains are plotted versus the frequencies. It is traditional that the horizontal axis be scaled logarithmically. This is called a *frequency response* plot.

The circuit's response is different for the voltage across the resistor, across the inductor, and across the capacitor. So, at each frequency the magnitude of the voltage across each component is measured with the AC voltmeter and tabulated. Then three plots are produced.

Measurements

a. Open the Frequency Response Excel seed file from this lab's module on the course website.

- **1)** The frequencies have been chosen to approximate the notes in the upper part of the audio range.
- **2)** The three gain columns have been setup to automatically calculate the gain at the frequency being measured.
- **3)** The plots then automatically display the gain versus log frequency as you enter the measured voltages.

b. Change the circuit's damping back to *critical*.

c. Connect the oscilloscope across the capacitor (that is still connected to common). As you make the measurements below, at every frequency, verify that the waveform across the capacitor is still a sine wave, i.e. that the circuit is not misbehaving by distorting the shape.

d. Configure your voltmeter to measure V_{RMS}, and arrange it so that you can clip *both* ends into the circuit. Do *not* hold either probe while making the measurement.

e. Connect the voltmeter's negative probe to common and positive probe to the circuit's input (left end of the resistor).

f. Set the generator to output a sine wave, **Ampl** = $1V_{RMS}$ = 2.8 V_{pp}, **Offset** = 0 VDC, **High Z output**, **Freq** = 1 kHz.

g. Connect the generator to the input of the circuit (the resistor), and its common connection to the circuit's ground bus.

h. Enable the output of the generator.

i. Verify that the wave shape across the capacitor is an undistorted sine wave.

j. Verify that the input voltage is about 1 V_{RMS}. Record this input voltage in the table.

k. Disable the generator. Move the voltmeter's negative probe from common and connect it to the other side of the resistor, so that the voltmeter is measuring the voltage *across* the resistor.

l. Enable the generator. Allow the voltage to stabilize, then record the voltage *across* the resistor at that frequency.

m. Disable the generator. Move the voltmeter's probe, so that the voltmeter is measuring the voltage *across* the inductor.

n. Enable the generator. Allow the voltage to stabilize, then record the voltage *across* the inductor at that frequency.

o. Disable the generator. Move the voltmeter's probe so that the voltmeter is measuring the voltage *across* the capacitor.

p. Enable the generator. Allow the voltage to stabilize, then record the voltage *across* the capacitor at that frequency.

q. Disable the generator. Change the frequency to the next on the table. Repeat steps 2g-2p to obtain the voltages *across* each component.

r. Disable the generator. Enter the value of the resistor in the table, then save this file.

Demonstrate a measurement and both sets of frequency response measurements and plots to your lab instructor.

Analysis and Conclusions

Write two paragraphs. In the first, describe the effect on the transient response of changing the damping. In the second, suggest a name and a use for the circuit made when taking the voltage across the capacitor, and a name and a use for the circuit made when taking the voltage across the inductor.
Hint, "______-pass filter"