print name (first last): ______________________

course: ECET 337 2025/07/26

RL Transient Response

Perlab Calculations

_____ 1. RL Ramp Generator (5%)

_____ 2. RL Pulse Shaper (5%)

Performance Checks

		In lab	or	Late
_____ 1.	RL Ramp Generator	(30%	or	15%)
_____ 3.	RL Low Pass Filter	(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. Design an RL circuit that will shape a 50% duty cycle square wave into an exponential rise, (a ramp). Select the time constant to allow a complete rise, from the table below, based on your birthday.

Month of your birthday	Time constant, τ, (µsec)
January & February	20
March, April, May	25
June & July	30
August, September, October	35
November, December	40

Your birth month _________ Your time constant = ____________

Use a 33 mH inductor. Its internal resistance, $R_{internal} = 55\ \Omega$.
The resistance of the function generator, $R_{generator} = 50\ \Omega$ Calculate the needed $R_{circuit}$.

$$\tau = \frac{L}{R_{\text{internal}} + R_{\text{generator}} + R_{\text{circuit}}}$$

Find the inductor and $R_{circuit}$. You may need to build $R_{circuit}$ by placing two resistors in series.

The inductor looks like a blue or gray thimble – from ECET 277. If you do not have this inductor, one will be available for loan from your lab instructor.

L = ________ $R_{circuit}$ = ________

Draw the schematic below.

2. Design an RL circuit that will shape the 50% duty cycle square wave into positive and negative pulses that just complete their fall back to 0 V by the end of the pulse-width. As in problem 1, use the 33 mH inductor and your personal time constant, $R_{internal}$ and $R_{generator}$ to calculate $R_{circuit}$ that produce the desired time constant.

L = ________ $R_{circuit}$ = ________

Draw the schematic below.

Objectives

Verify the design of two RL pulse shapers, and an RL low-pass filter.

Approach and Results

1. RL Ramp Generator – Square to Exponential Ramp

a. Measure and record the value of the inductor and the resistances.

$L =$ ________ $R_{\text{internal}} =$ ______ $R_{\text{circuit}} =$ ________

b. Connect the generator's output to the input of your circuit.

c. Also connect the oscilloscope CH 1to the output of the generator.

d. Set the function generator to provide a square wave, 50% duty cycle, 1.5 kHz. Adjust the amplitude and offset to create a 0 V to 2 V signal.

e. Enable the output of the generator, then adjust the oscilloscope controls as necessary to provide a good display. Refer to the preceding lab for help setting up the oscilloscope and the function generator.

f. Display this signal to nearly fill the oscilloscope display, going from 2 divisions up from the bottom to two divisions down from the top (the middle 4 divisions).

g. Add measurements of the signals V_{top}, V_{base}, and f to the oscilloscope display.

h. Tweak the **Amplitude Lolevel, Amplitude Hilevel**, and **frequency** to provide the correct input to the circuit.

i. Move the oscilloscope to the circuit's output.

j. Adjust the oscilloscope controls as necessary to provide a good display.

k. When the circuit is providing the correct shape, enable and position the cursors to measure the time constant.

l. Measure your circuit's time constant. Capture this display.

$\tau_{\text{measured}} =$ _______ $\tau_{\text{calculated}} =$ ________

m. Increase the resistor's value by about a factor of 3. Record the effect on the output's waveshape. Capture this waveform with the cursors properly measuring τ.

n. Lower the resistor's value to about 1/3 of the original value. Record the effect on the output's waveshape. Capture this waveform with the cursors properly measuring τ.

o. Return the original resistor to the circuit and verify that the circuit still works.

Demonstrate the oscilloscope display, screen capture and explain the effects to your lab instructor.

2. RL Pulse Shaper – Square to Spikes

a. *Disable* the signal from the generator.

b. Build a circuit to shape the signal into positive and negative *spikes*.

c. Connect the generator's output to the input of your circuit.

d. Connect the oscilloscope to the output of your circuit.

e. Adjust the CH 1 *position* potentiometer to place ground across the center of the screen. This allows both the positive and the negative spikes to be displayed.

f. Enable the output of the generator, then adjust the oscilloscope controls as necessary to provide a good display, filling the screen vertically, and showing one positive and one negative spike.

g. When the circuit is providing the correct shapes, use the cursors to measure the circuit's time constant. Place **Cursor 1** at the top of the positive spike. Then use **Cursor 2** to measure the time it takes for the spike to *fall* 63.2 %. Capture the oscilloscope's display to be included in your report.

$\tau_{\text{measured}} =$ _______ $\tau_{\text{calculated}} =$ ________

h. Increase the resistor's value by a factor of about 3. Record the effect on the output's waveshape.

i. Lower the resistor's value to about 1/3 of the original value. Record the effect on the output's waveshape.

j. Return the original resistor to the circuit and verify that the circuit still works.

3. RL Low-pass Filter

a. Build the circuit in Figure 1. The lab instructor can loan you the op amp if you do not have one of your own. Its purpose is to isolate the circuit from the 50 Ω internal output impedance of the generator. The op amp can provide much more current to the load. The circuit also lets us look at the performance of an LR low pass filter for a switching power supply or Class D audio amplifier without having to build the switches.

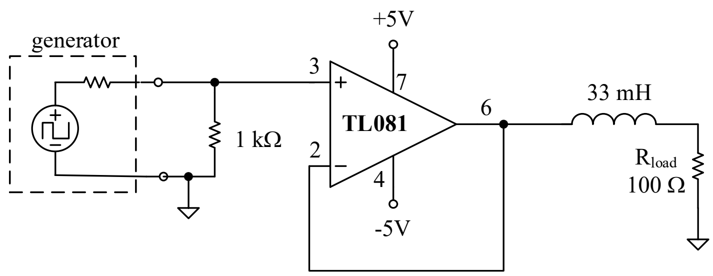

Figure 1 Switching LR filter emulation

b. With the generator's output disabled, connect Channel 1 of the oscilloscope and the multimeter to the output of the op amp and then apply power to the op amp.

c. Verify that the op amp's output is DC (not oscillating) and < 100 mV_{DC}.

d. Set the generator to produce a 0 V to 2 V square wave, 50% duty cycle, 100 kHz, then apply it to the input (pin 3) of the op amp voltage follower.

e. Verify that the output of the op amp is a proper square wave.

f. Connect the digital multimeter and the oscilloscope's across R_{load}. Verify that the voltage across the load is ~ $\frac{duty\ cycle \times 2\ V \times 100\Omega}{R_{L\ internal} + 100\Omega}$, and *nearly* steady.

g. Alter the generator's duty cycle and verify that $V_{load\ DC}$ alters appropriately.

h. Tabulate the duty cycle, theoretical $V_{load\ DC}$ and the measured $V_{load\ DC}$ for 30%, 40%, 50%, and 60% duty cycle.

Demonstrate the oscilloscope display to your lab instructor.

i. Disable the output of the function generator. Then, turn the power off.

Analysis and Conclusions

1. Write a paragraph that explains the effect and the cause of *each* of the changes you made to the RL Pulse Shaper. Use terms such as “sluggish”, “rapid”, “fully charged”, “barely charged”.

2. Explain the difference in the circuit for section 1 and section 2.

3. For the low pass RL filter:

- **a.** What is the relationship of the signal’s duty cycle to the DC voltage across the load?

- **b.** What has happened to the 100 kHz signal at the filter’s output?