EELE 250 Circuits, Devices, and Motors

Lab #4: RL and RC Circuits and Signals

Scope:

- Study the steady-state (DC) and transient RL and RC responses.
- Use of the signal generator and the oscilloscope.

Home preparation:

- Review sections 3.1 - 4.3 of the Hambley text.
- Read through the experiment and plan out each step.
- Prepare the calculated results for the circuits you will be measuring in the lab, and fill out the **prelab sheets**.
- Create tables in your notebook with the calculated values and space to enter the measured results for the experiment.

Laboratory experiment:

1. RL Circuit at DC

Breadboard the DC circuit shown in Figure 4.1. (DC = '*direct current*,' meaning that nothing is changing as a function of time)

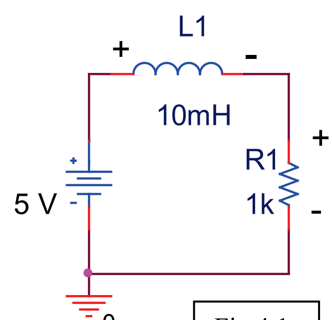


Fig 4.1

- Actual inductors have a small but non-zero resistance at DC, so start by measuring the DC resistance of the inductor using the DMM. *<u>Remember</u>: you need to remove the component from the circuit before measuring its resistance.*
- Measure the DC current through the inductor.
- Measure the DC voltage across the resistor.
- Verify that KVL is satisfied for this DC circuit.

2. RL Circuit with time-varying (AC) source

Now replace the 5VDC source with the signal generator, set to produce a square wave signal with VMAX = 5V, VMIN = 0 V, and a frequency of **10 kHz**, as shown in Fig. 4.2. Set the square signal to 5 volts peak-to-peak and adjust the DC offset of the signal until VMIN is achieved.

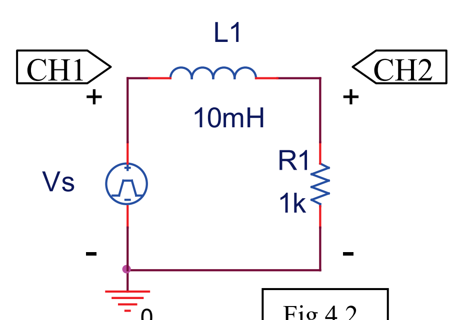


Fig 4.2

- Connect Channel 1 of the oscilloscope (set to DC coupling) to record the voltage across the source, and connect Channel 2 to record the voltage across the resistor. Use the MATH function of the oscilloscope to display CH1 – CH2, which is the voltage drop across the inductor.
- Carefully make *detailed* hand sketches in your notebook of the three voltage signals v_s, v_{R1}, and v_{L1}. Also, if your oscilloscope is equipped with a USB port, you may save the oscilloscope display as an image file to a USB memory stick, print the image, and paste it into your notebook.
- From the 'scope display, determine the time constant for this circuit. Detail the procedure used to find the time constant in your notebook, and compare your measurement to the theoretical time constant calculation.
- Present the results of these experiments. Highlight the important features. Comment on the results.

3. RC Circuit at DC

Breadboard the circuit shown in Figure 4.3

- Measure the DC voltage across the capacitor.
- Measure the DC current through the resistor.
- Describe what this information means.

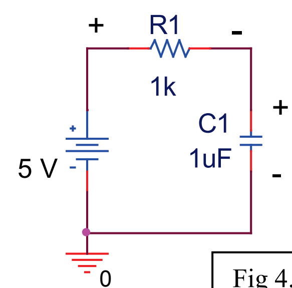


Fig 4.3

4. RC Circuit with time-varying (AC) source

Now replace the 5VDC source with the signal generator, set to produce a square wave signal with VMAX = 5V, VMIN = 0 V, and a frequency of **50 Hz**, as shown in Fig. 4.4.

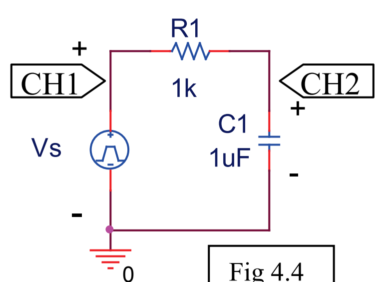


Fig 4.4

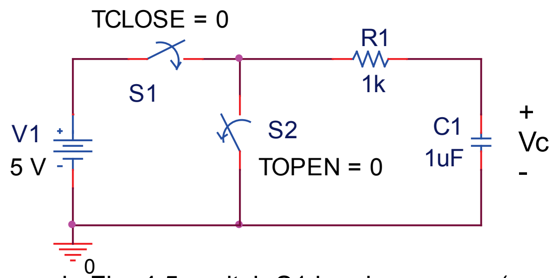
- Connect Channel 1 of the oscilloscope to record the voltage across the source, and connect Channel 2 to record the voltage across the capacitor. As before, use the MATH function of the oscilloscope to display CH1 – CH2, which is the voltage drop across the resistor.
- Carefully make *detailed* hand sketches in your notebook of the three voltage signals v_s, v_{C1}, and v_{R1}.
- From the 'scope display, determine the time constant for this circuit and compare to your theoretical expectations.
- Comment on the results.

Before leaving the lab, turn off the lab equipment, return cables and probes to the rack, carefully collect your belongings, straighten up your lab area, and don't forget to check-out with your TA.

PRELAB SHEETS

Perform the calculations before coming to lab, and show a summary of your work. Your lab TA will collect this sheet at the start of the lab period for grading.

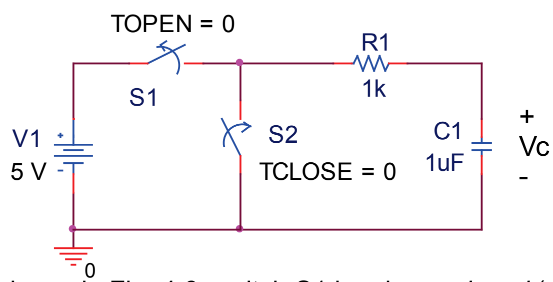
Fig. 4.5:



For the circuit shown in Fig. 4.5, switch S1 has been *open* (open circuit) for a long time and switch S2 has been *closed* (short circuit) for a long time. Then at time t = 0 seconds, S1 closes and S2 opens. Determine the voltage $v_c(t)$ across the capacitor for t just before zero (t = 0-), t an instant after zero (t = 0+), and as t goes to infinity. Also specify the *time constant* (τ), and give the mathematical expression for $v_c(t)$ for $t \geq 0$ seconds.
Recall: $v_c(t) = v_c(\infty) + \{v_c(0) - v_c(\infty)\} \cdot \exp(-t / (RC))$

v_c(0-)	
v_c(0+)	
$v_c(\infty)$	
Time Constant	
$v_c(t)$ for t>0	

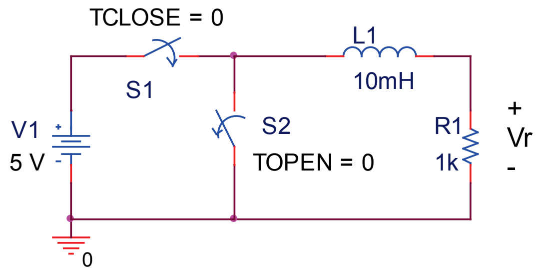
Fig. 4.6:



For the circuit shown in Fig. 4.6, switch S1 has been *closed* (short circuit) for a long time and switch S2 has been *open* (open circuit) for a long time. Then at time t = 0 seconds, S1 opens and S2 closes. Determine the voltage v_c(0-), v_c(0+), and $v_c(\infty)$, and specify the *time constant* (τ), and the mathematical expression for $v_c(t)$, for $t \geq 0$ seconds.

v_c(0-)	
v_c(0+)	
$v_c(\infty)$	
Time Constant	
$v_c(t)$ for t>0	

Fig. 4.7:

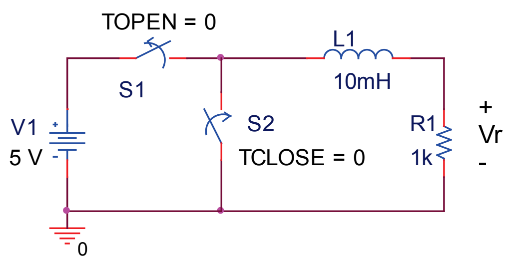


For the circuit shown in Fig. 4.7, switch S1 has been *open* (open circuit) for a long time and switch S2 has been *closed* (short circuit) for a long time. Then at time t = 0 seconds, S1 closes and S2 opens. Determine the initial and final conditions, and write an expression for the current through the inductor $i_L(t)$ and an expression for the voltage $v_r(t)$ across the resistor, for $t \geq 0$ seconds.
Recall: $i_L(t) = i_L(\infty) + \{i_L(0) - i_L(\infty)\} \cdot \exp(-t / (L/R))$

$i_L(0-)$	
$i_L(0+)$	
$i_L(\infty)$	
Time Constant	
$i_L(t)$ for t>0	

$v_R(0-)$	
$v_R(0+)$	
$v_R(\infty)$	
$v_R(t)$ for t>0	

Fig. 4.8:



For the circuit shown in Fig. 4.8, switch S1 has been *closed* (short circuit) for a long time and switch S2 has been *open* (open circuit) for a long time. Then at time t = 0 seconds, S1 opens and S2 closes. Determine the initial and final conditions, and write an expression for the current through the inductor $i_L(t)$ and an expression for the voltage $v_r(t)$ across the resistor, for $t \geq 0$ seconds.

$i_L(0-)$	
$i_L(0+)$	
$i_L(\infty)$	
Time Constant	
$i_L(t)$ for t>0	

$v_R(0-)$	
$v_R(0+)$	
$v_R(\infty)$	
$v_R(t)$ for t>0	