EE 220/220L Circuits I (Fall 2019)
Laboratory Project 12 Second-Order Circuits

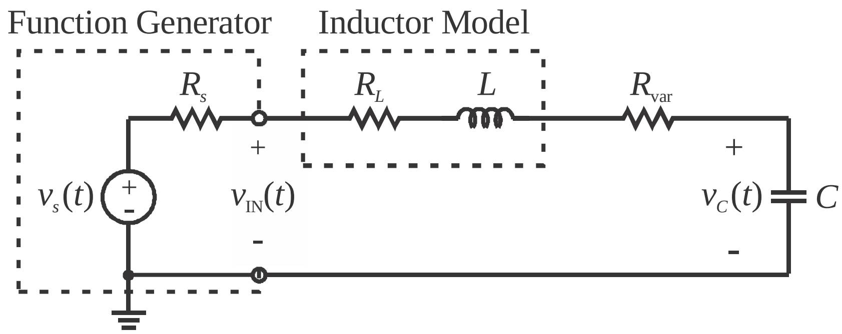

Figure 1 Series RLC Circuit

Preliminary

This laboratory will demonstrate how varying resistance changes the natural response of a series RLC circuit (Fig. 1). The function generator is modeled as an ideal voltage source $v_s(t) = 5\,u(t)$ V in series with source resistance $R_S = 50\ \Omega$. After measurements using an LCR meter, the inductor is modeled as an ideal $L = 70$ mH inductor in series with resistance $R_L = 600\ \Omega$. The capacitor is $C = 0.01\ \mu$F.

1) Calculate the roots of the characteristic equation and determine the **general form** of the <u>natural response</u> of the capacitor voltage $v_{C,n}(t)$ for $t \geq 0$ when the resistor R_{var} has values of: a) 15 kΩ (overdamped), b) 4641.50262 Ω (critically-damped, *make* roots equal), and c) 470 Ω (underdamped).
2) Find $v_C(0)$, $dv_C/dt|_{t=0}$, and $v_C(\infty)$ given no initial energy is stored in the inductor and/or capacitor.
3) Find equations for the <u>total</u> capacitor voltage $v_C(t)$ for $t \geq 0$ for each value of R_{var}.
4) Using Matlab, graph $v_C(t)$ for $0 \leq t \leq 0.6$ ms for all three cases. Put the traces for all three solutions on same plot using a vertical scale of 0 to 8 V. Use different line types and a legend to differentiate and identify the solutions. Add to comment lines of m-file & title of plot text including EE 220L, *lab number* & *title*, *your name*, and *date*. Insert m-file and graph in logbook.
5) Have the lab instructor sign your preliminary before you do the experiment.

Experiment

1) To set up $v_s(t)$, connect function generator directly to oscilloscope. Use a square wave with 5 V_{pp} amplitude, 2.5 V_{DC} offset (i.e., high level 5 V & low level 0 V), and 1.2 ms period (833.3 Hz). Adjust oscilloscope to view only initial half period ($0 \leq t \leq 0.6$ ms)- use 50 μs/div and 1 V/div with reference level(s) at **<u>bottom</u>** of screen. Save bitmap image of $v_S(t)$, print, label, and put in logbook.
2) Set-up circuit shown in Figure 1 (note: R_s is internal to the function generator) letting R_{var} have values of: a) 15 kΩ, b) 4641.50262 Ω, and c) 470 Ω. To implement R_{var}, choose resistors or resistor combinations that are within ±5% of the given values. Sketch resistor combinations (if applicable), <u>measure</u>, and record R_{var}. In each case, display $v_{IN}(t)$ (ch. 1) and $v_C(t)$ (ch. 2) on the oscilloscope, save bitmap image, print, and put in logbook with traces labeled. For underdamped case, place a 'Track' mode cursor on channel 2 on peak of $v_C(t)$ before saving bitmap.
3) Have your experimental data signed-off before tearing down last circuit.

Analysis and Conclusions

- Using PSpice, model circuit in Fig. 1 using nominal values and graph $v_{IN}(t)$ & $v_C(t)$ for $0 \leq t \leq 0.6$ ms for all three cases using a vertical scale of 0 to 8 V, print, and insert in logbook (label by response type). Also, insert PSpice circuits with text EE 220L, *lab number* & *title*, *your name*, and *date*. For underdamped case, place cursor on peak of $v_C(t)$ and record time and value.
- Discuss and summarize results. How do measured capacitor voltages compare to those calculated and simulated? Explain any differences. Is $v_{IN}(t)$ the same as $v_S(t)$? If not, account for differences.