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RE: EE 2210, Laboratory Project 5

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Summary

A second-order circuit was designed with a 5 kΩ resistor in series with a 20 mH inductor and a 10 nF capacitor in parallel. The circuit was designed to have an underdamped response to an input voltage with a square waveform. The theoretical response of the circuit was simulated in B2 Spice and compared with the actual response of the circuit.

Design

A second-order circuit was designed with a resistor with a theoretical value of 5 kΩ and a real value of 5.11 kΩ in series with an inductor with a theoretical value of 20 mH and a real value of 20.16 mH and a capacitor with a theoretical value of 10 nF and a real value of 10.12 nF in parallel, as seen in figure 1. Using these theoretical values, the time constant, τ was calculated to be 75 µs, with an oscillation frequency, f_c, of 13333.33 Hz and a corner frequency, ω_o, of 70710.68 rad/sec.

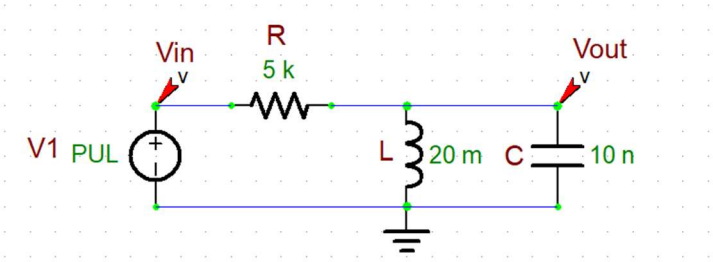

Fig. 1. Circuit diagram

The circuit was first constructed on a breadboard to test and ensure the response was correct. A function generator was used to generate a square voltage waveform with an amplitude of 3 V and a frequency of 1 kHz. The circuit was then placed on a perfboard and soldered onto the perfboard.

Results

The theoretical circuit was simulated in B2 Spice, producing an underdamped response as seen in figure 2. This response starts at the peak of the waveform and decays to 0 V.

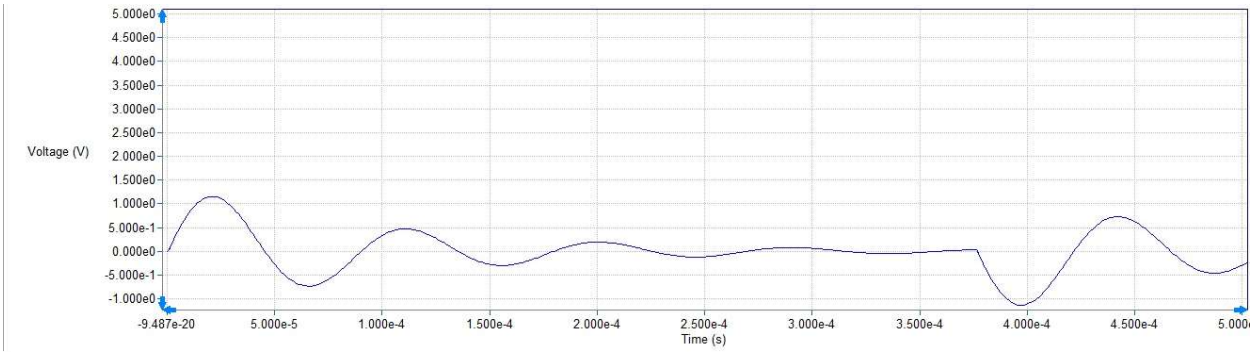

Fig. 2. Theoretical response of circuit simulated in B2 Spice

When the circuit was tested on the breadboard, the circuit had a response as seen in figure 3, with the input voltage forming a square waveform with a peak of 5 V, as seen in blue, and the response of the circuit being underdamped, as seen in pink.

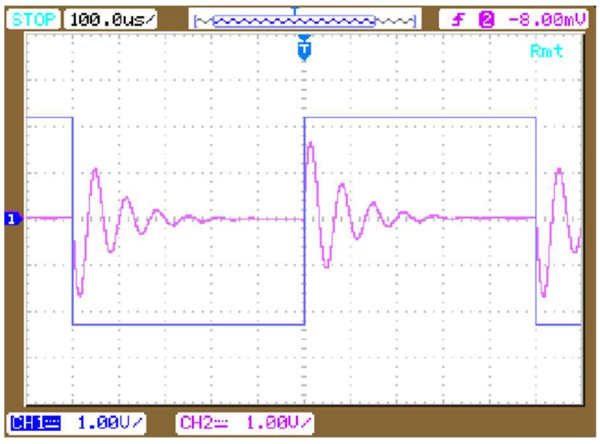

Fig. 3. Actual response of the circuit

Using the oscilloscope, the transient-decay time constant was found as follows. First, the peak of the response was found at 1.64 V. This was multiplied by 0.63 to find how much the response decayed in one time constant. The time between when the waveform began and where 63% of the waveform has decayed is the transient-decay time constant, as seen in figure 4. This value was measured to be 66 µs.

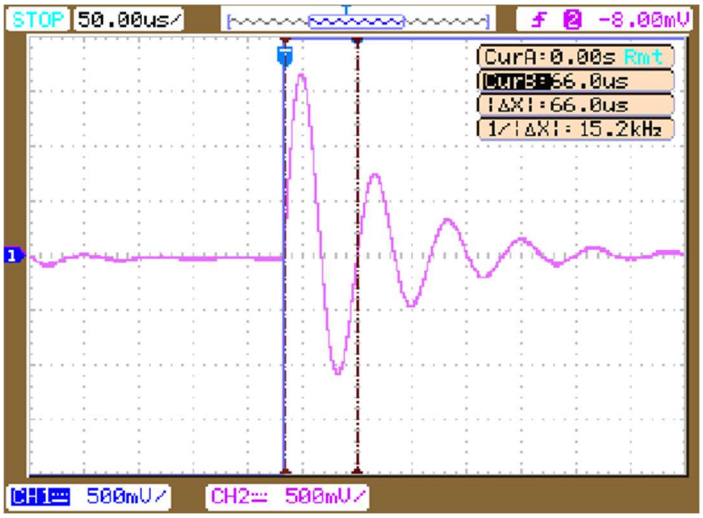

Fig. 4. Calculation of τ

Additionally, using the oscilloscope, the oscillation frequency was found. The time for one period of the response, T_d, was found using the time cursors to be 64 µs. From this, the oscillation frequency was calculated to be 15625 Hz.

When comparing the results from the actual circuit and the calculated values in the prelab, the transient-decay time constant, τ, had a percent error of 13.6%, with the calculated value being 9 µs larger than the actual value in the lab. This could be due to the actual element values differing from the theoretical values and the parasitic resistance in the inductor and capacitor. Additionally, the oscillation frequency had a percent error of 14.6%, with the calculated frequency being 2291.67 Hz smaller than the actual value. This variation could also be due to the same reasons τ was off.

The actual circuit was simulated in B2 Spice using the actual values for each element and the same input voltage of a 5 V square waveform with a frequency the same as the oscillation frequency found in the lab. The response of the simulated circuit can be seen in figure 5. The response simulated in B2 Spice matches the response found in the actual circuit, with the waveform decaying from the peak of the waveform to 0 V.

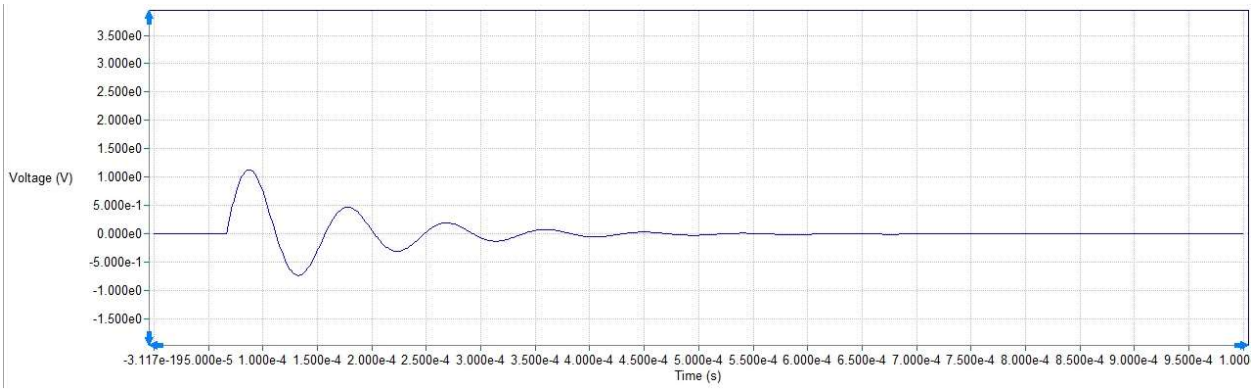

Fig. 5. Actual response of the circuit simulated in B2 Spice

Additionally, the circuit was soldered onto a perfboard and also tested. This circuit produced a response the same as when the circuit was tested on the breadboard, with a τ of 66 μs and an oscillation frequency of 2291.67 Hz.