ECE 205: Lab 6

Filters and Op-Amps

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1 Statement of Purpose

The purpose of this lab is to gain familiarity with filters and OP-AMPs, and how they pertain to voltage regulation.

2 PreLab Deliverables

For the first prelab deliverable, we investigated the left side of the given circuit, which is encapsularized in the left box of the picture below:

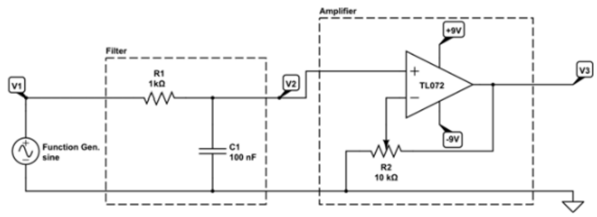

Figure 1: Circuit Diagram

For this circuit, the cutoff frequency is given as:

$$\omega_C = \frac{1}{RC} = \frac{1}{(1k\Omega)(100nF)} = 10,000\frac{rad}{s} = \frac{10,000}{2\pi}hz \tag{1}$$

and this filter is a low pass filter.

3 Procedure

To begin, to complete challenge 1 we constructed the simple circuit shown in Fig. 2. With this circuit we simulated the output voltage, the voltage at the top right corner node, as a function of the ac voltage frequency.

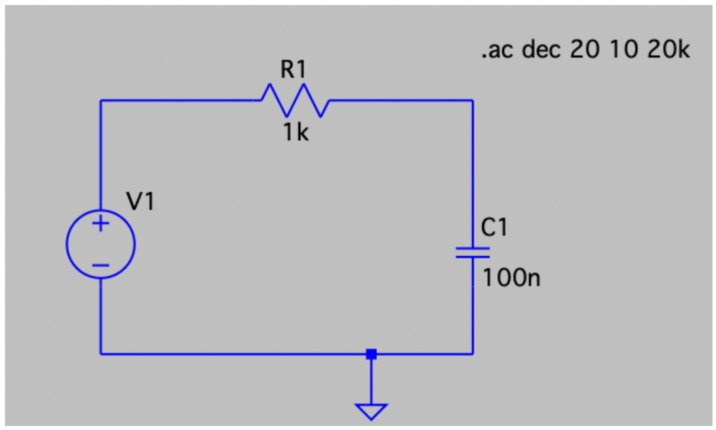

Figure 2: Schematic of challenge 1 circuit in LTspice

Next, to complete challenge 2 we constructed the much more complex circuit presented in Fig. 3. With this circuit we simulated the output and input voltage to the amplifier as a function of time. With this plot we are able to visualize the amplifier gain, and changing the resistance of $R_{2.1}$ and $R_{2.2}$ we can see the cut-off amplitude.

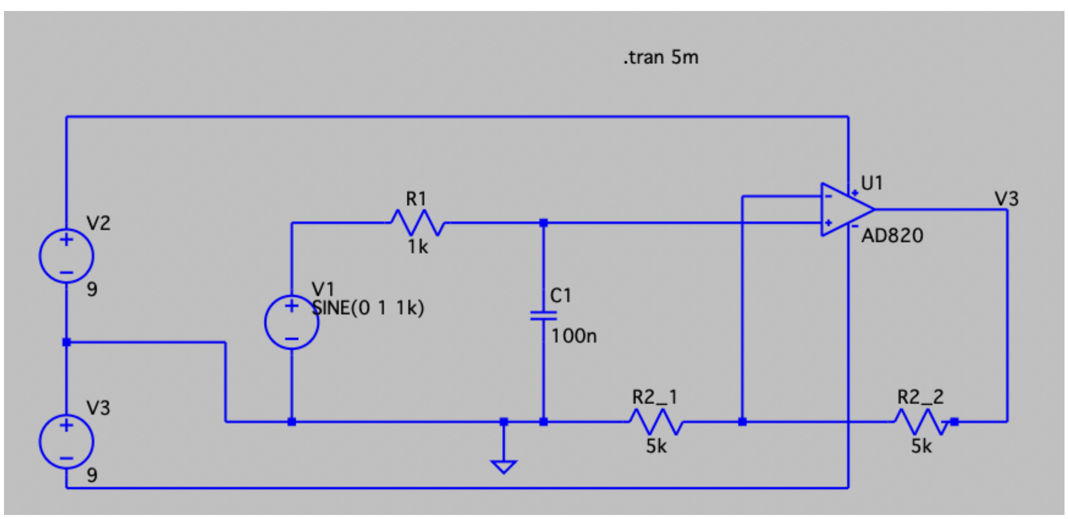

Figure 3: Schematic of challenge 2 circuit in LTspice

4 Observation and Data

For challenge 1, we output the voltage of the top-right node as a function of ac frequency. This is presented in Fig. 4.

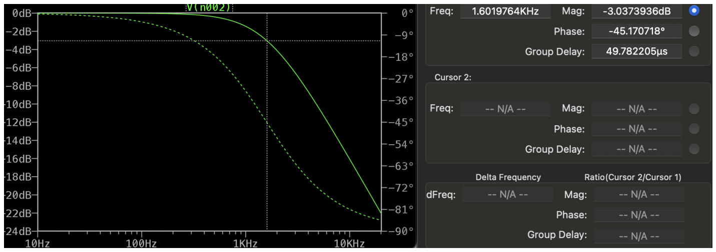

Figure 4: Output voltage of the filter section of the circuit

To continue we outputted the input and output voltage to the amplifier as a function of time, with $R_{2.1} = R_{2.2} = 5$ kΩ. This is presented in Fig. 5. Further, through trial and error, we found the cutoff amplitude to be achieved when $R_{2.1} = 0.93$ Ω and $R_{2.2} = 9.07$ Ω. This cutoff amplitude is presented in Fig. 6.

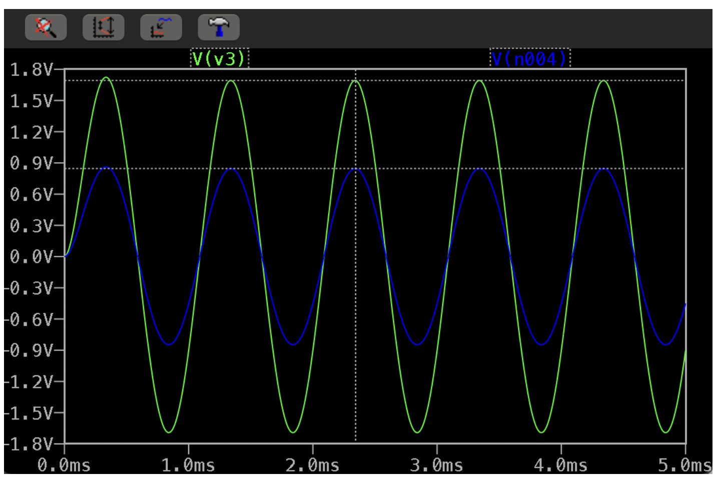

Figure 5: Amplitude of V_{in} and V_{out} for $R_{2.1} = R_{2.2}$

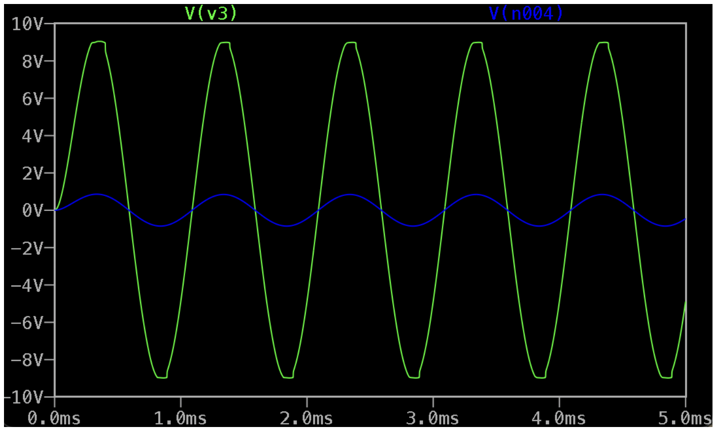

Figure 6: Amplitude of V_{in} and V_{out} for $R_{2.1} = 0.93\ \Omega$ and $R_{2.2} = 9.07\ \Omega$

5 Analysis

The observed gain in Fig. 5 is 2, which conveniently pops out of the equation for gain, Eq. 2, when inserting 5 kΩ for both resistance values. Further, when inserting the resistances from the second part of challenge 2, we obtain an output voltage of 9 V.

$$V_{out} = V_{in} \cdot \left(1 + \frac{R_2}{R_1}\right) \tag{2}$$