Lab Report 3

The purpose of this lab was to analyze the effect of manipulating the Q factor for an RLC low pass filter with a buffer op-amp. Our first step was to ensure we properly implemented the op-amp to our myDAQ, therefore we created the simple buffer circuits in Figure 1. If correctly connected, Vout is expected to have a gain of 1. After performing a sweep from -5V to 5V, Figure 2 verifies we have the expected gain of 1, verifying the op-amp is functioning as expected.

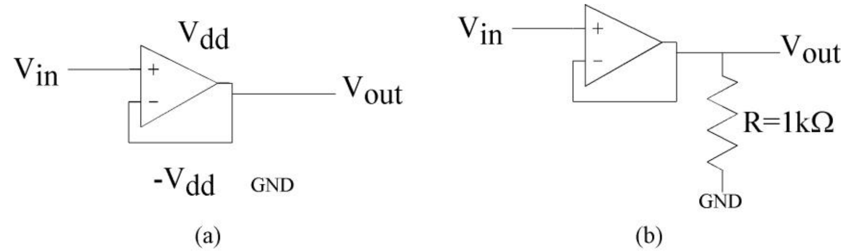

Figure 1: The schematic of the first two circuits used in this lab. Both are op-amp buffer circuits in which Vout is approximately equal to Vin.

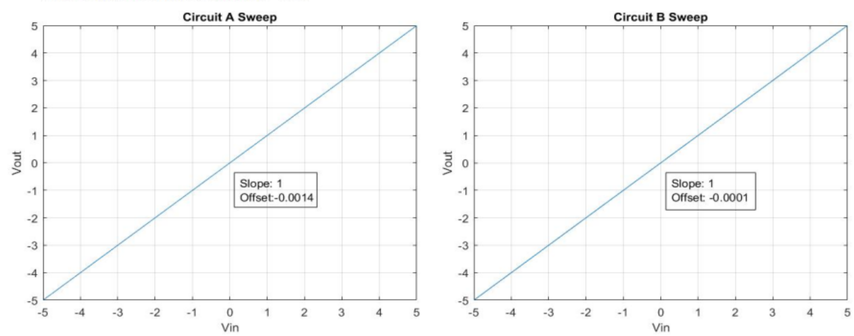

Figure 2. The plots show the curve fit of the output voltage as a function of the input voltage for circuits A and B

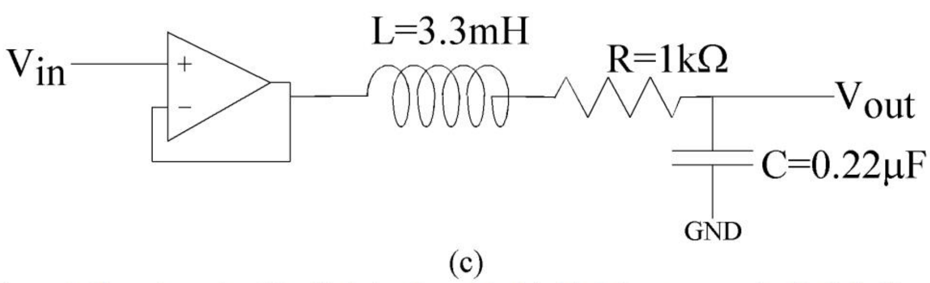

Figure 3: The schematic of the third circuit used in this lab. It is an op-amp buffer linked into a second order low pass filter LRC circuit.

Next we created the RLC low pass filter shown in Figure 3, which yields the following τ, Q-factor, transfer function, and center frequency:

$$\tau = \sqrt{LC} \quad Q = \frac{1}{R}\sqrt{\frac{L}{C}} \quad H(j\omega) = \frac{1}{1 + j\omega\frac{\tau}{Q} + (j\omega\tau)^2} \quad f_c = \frac{1}{2\pi\tau}$$

This yields a time constant of 2.694E-5, a Q-factor of 0.1225, and a center frequency of 5908 Hz for the circuit in Figure 3. Figure 4 shows a sinusoidal response where Vin is close to the center frequency. Vout is drastically minimized to roughly two orders of magnitude less than Vin, and this can be verified with the magnitude of the frequency in Figure 6.

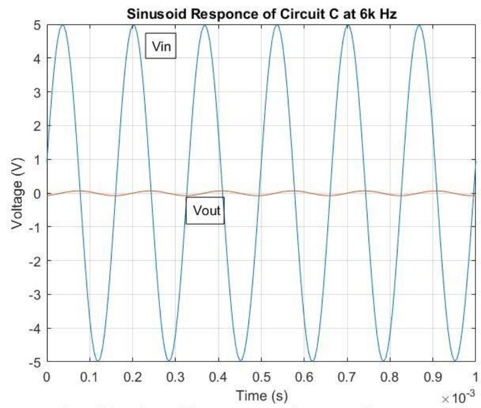

Figure 4: Plot of the sinusoid response at the center frequecy of circuit C (about 6k Hz).

By changing the resistance we could manipulate the Q-factor without changing the time constant. A resistance less than 61 ohms would yield a Q-factor of less than ½ and give us complex roots. We replaced the 1k ohm resistor in circuit C (Figure 3) with a trimpot so we can adjust the resistance in the circuit and see changing responses.

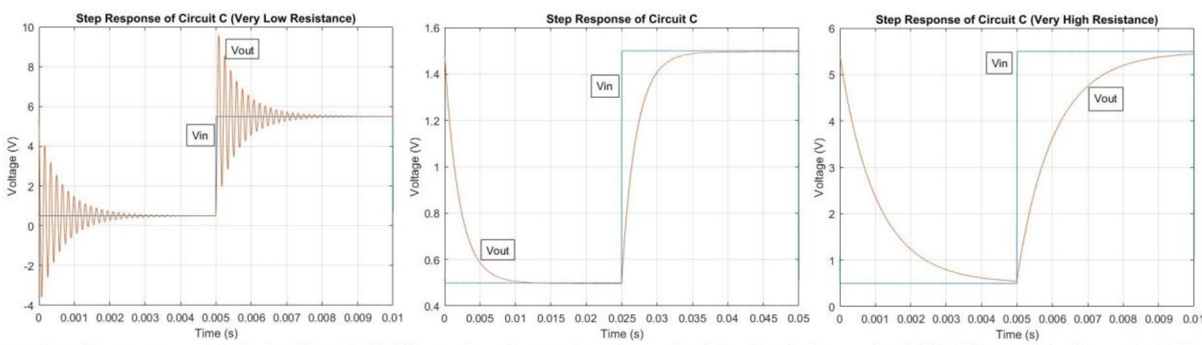

Figure 5: Plots of the step response of the Circuit C (Figure 3) with different resistor values. Very low resistance value (left), origional resistance value of 1kΩ(middle), very high resistance value (right)

Figure 5 shows the step responses of circuit C with three different resistances. The center plot is the original circuit, with a resistance of 1k ohm and a Q-factor greater than ½. The left plot has a resistance much smaller than 61 ohms, so the Q-factor is less than ½ and yields complex solutions. The output voltage of this step response oscillates around the input voltage directly after each step, eventually converging towards the input voltage. The right plot has a resistance and Q-factor higher than the original circuit and thus has a slower step response, similar to an RC circuit.

Figure 6 shows the frequency response of the same three versions of circuit C as used in Figure 5. The left plot shows the frequency response of the circuit with complex roots (Q-factor < ½), where there is a positive gain directly neighboring the center frequency of 5908 Hz. The other two plots represent a standard second order low pass filter, where as the Q-factor grows, the filter becomes less effective at minimizing high frequencies.

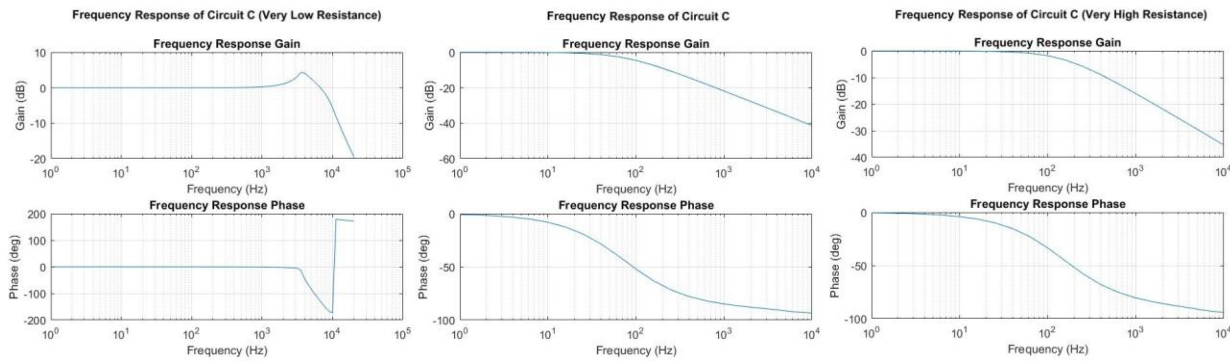

Figure 6: Plots of the frequecy response of the Circuit C (Figure 3) with different resistor values. Very low resistance value (left), origional resistance value of 1kΩ(middle), very high resistance value (right)