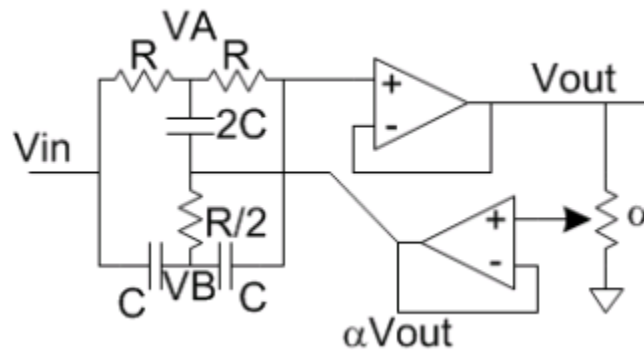


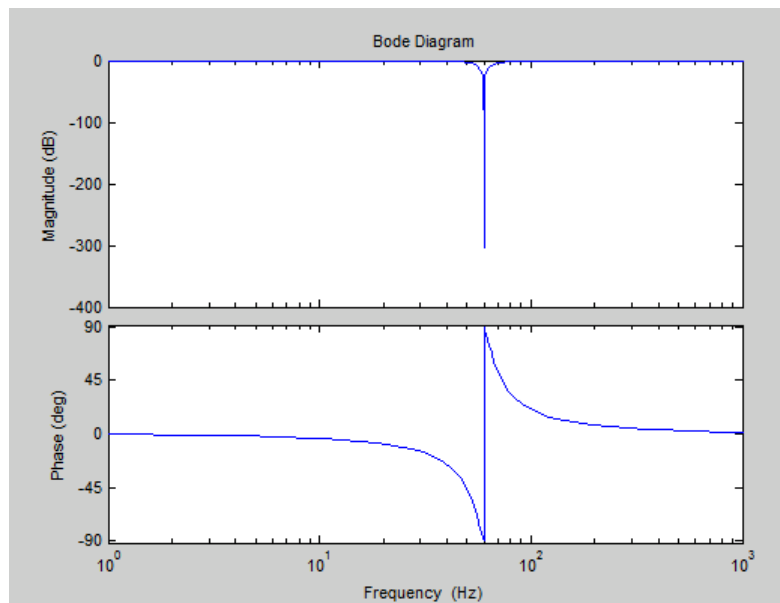
## Lab 10: Active Filters

**Time Spent: 5 Hours**

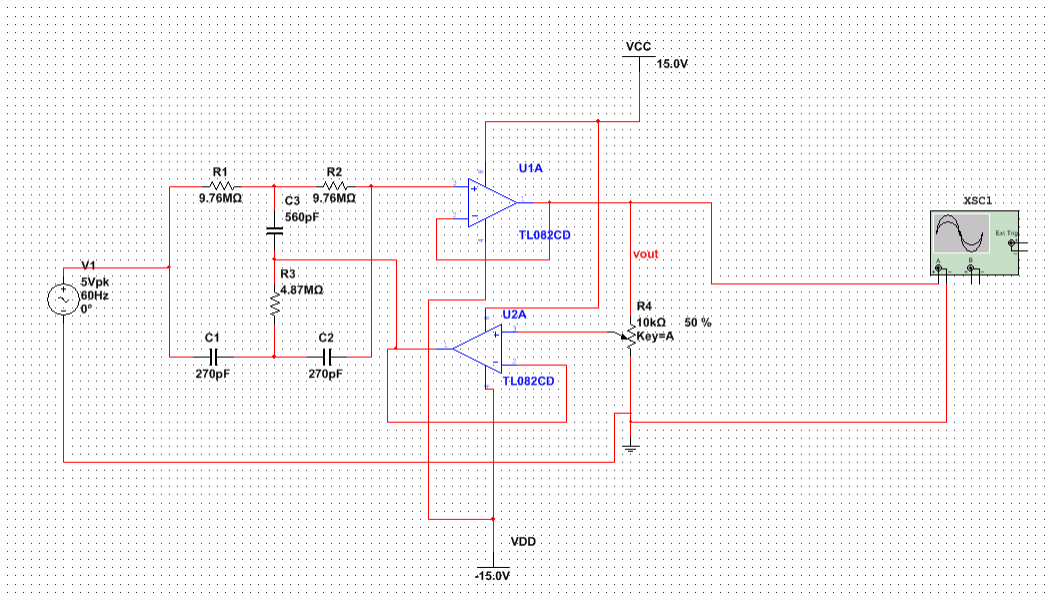
**Notch Design** To design the Notch Portion of the filter I used the same design as the warmup so that I would not have to rederive the transfer function. The design is shown below:



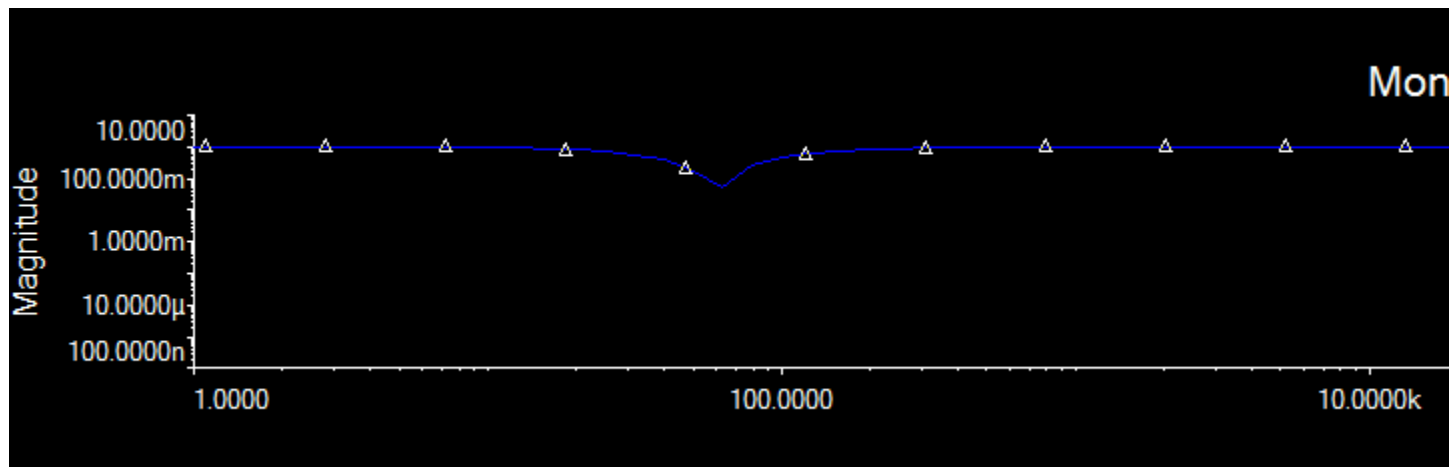
After analysis in the warmup my transfer function was:  $\frac{s^2 + \frac{1}{R^2 C^2}}{s^2 + \frac{4(1-\alpha)}{RC} + \frac{1}{R^2 C^2}}$ . With this transfer function  $f_0 = \frac{1}{2\pi RC}$  With this information we want to eliminate the 60Hz noise so we set  $f_0 = 60$  and we are given that  $C = 270pF$ . We solve for R and find R to be  $9.82M\Omega$ . Using matlab I generated the following Bode plot:



Note the phase looks interesting because the bodeplot function probably doesn't use atan2. As we can see the bode plot dips at approximately 60 Hz. I then simulated the circuit in Multisim.

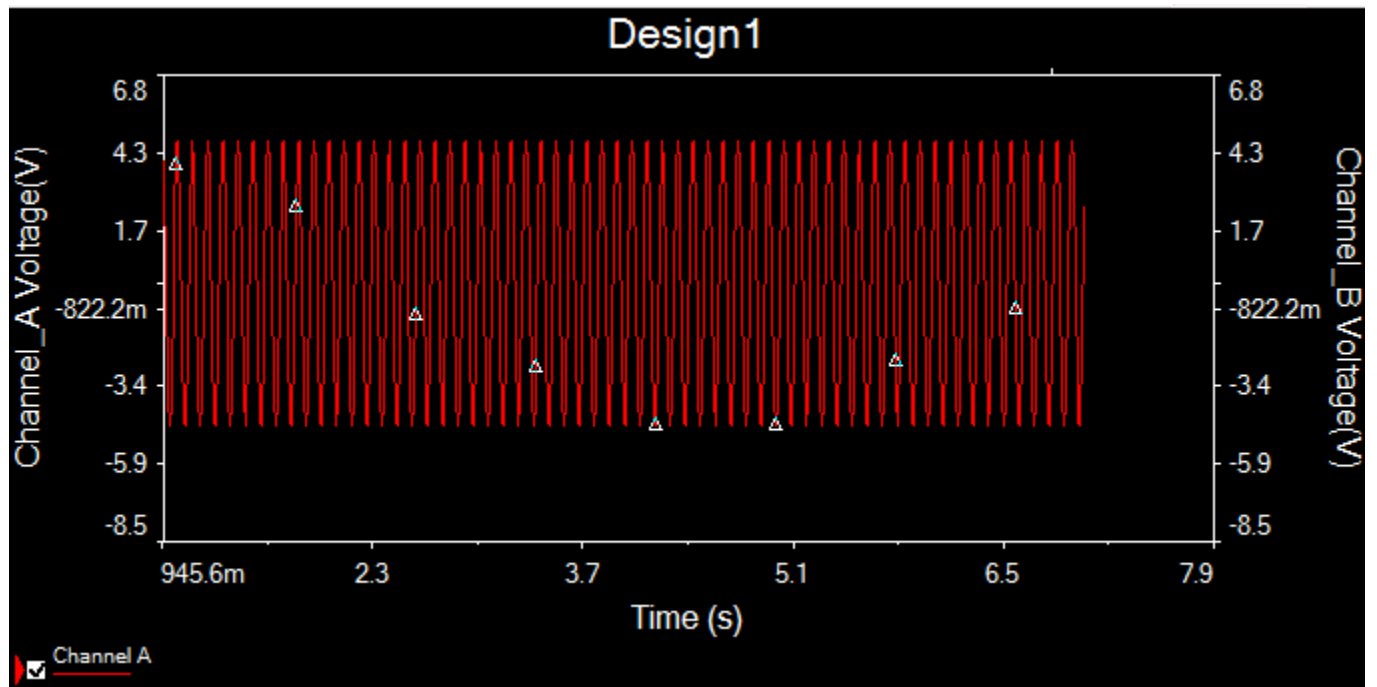


First I ran a montecarlo simulation:

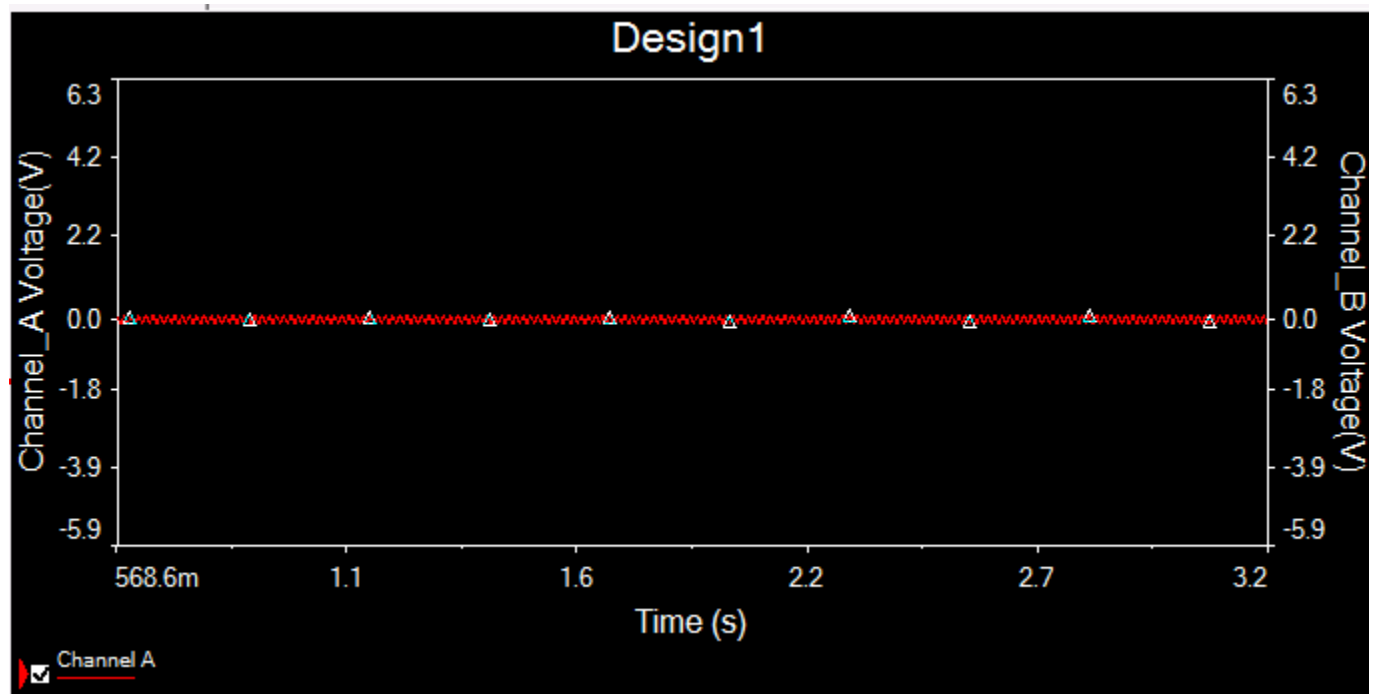


The filter has a dip around 60 Hz which is what we want.

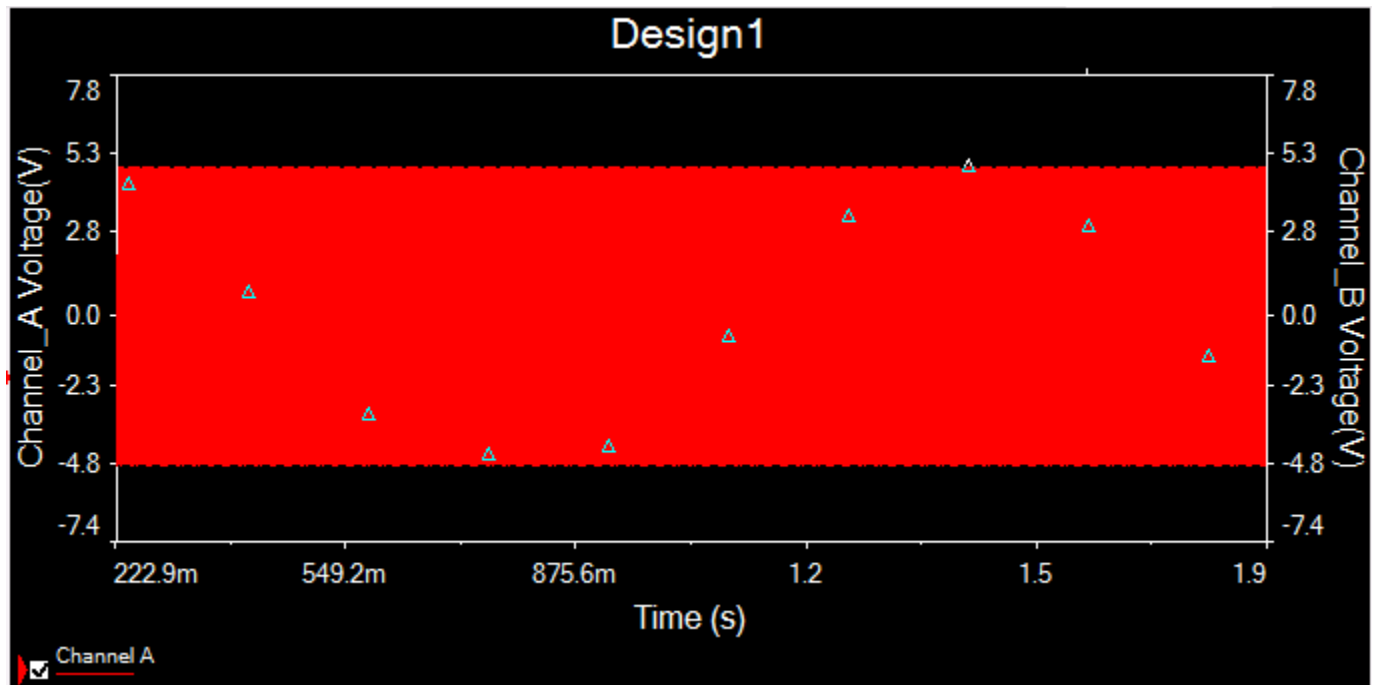
I then fed 3 different AC signals into the filter 10Hz, 60Hz, and 500Hz.  
10Hz:



60Hz:

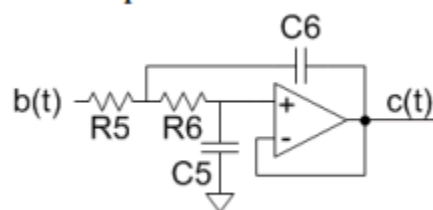


500Hz:

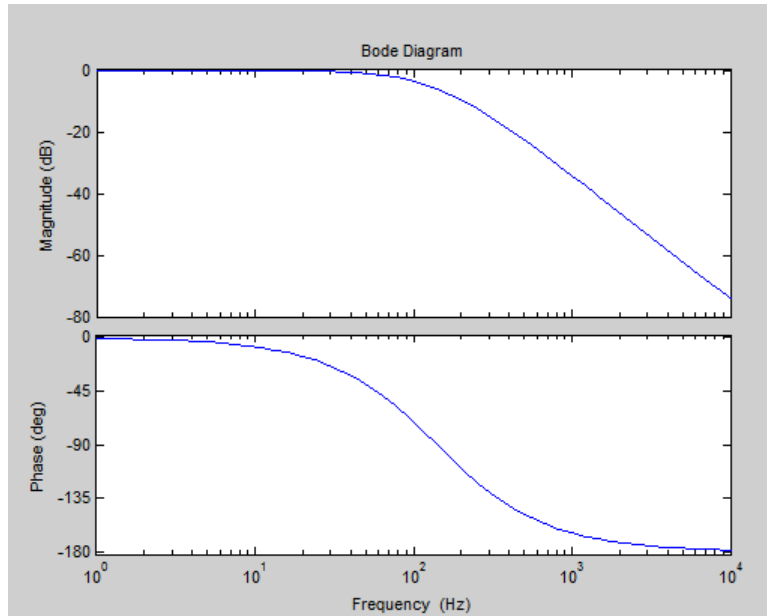


As we can see 10Hz and 500Hz retain their amplitude while 60Hz gets cutoff.

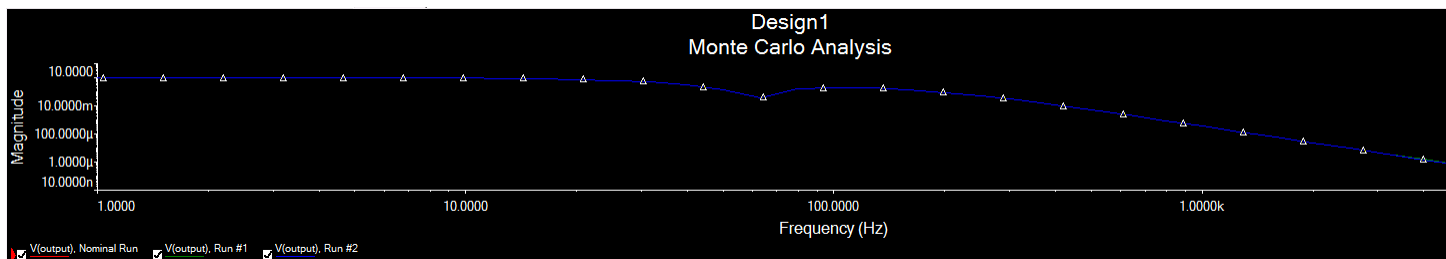
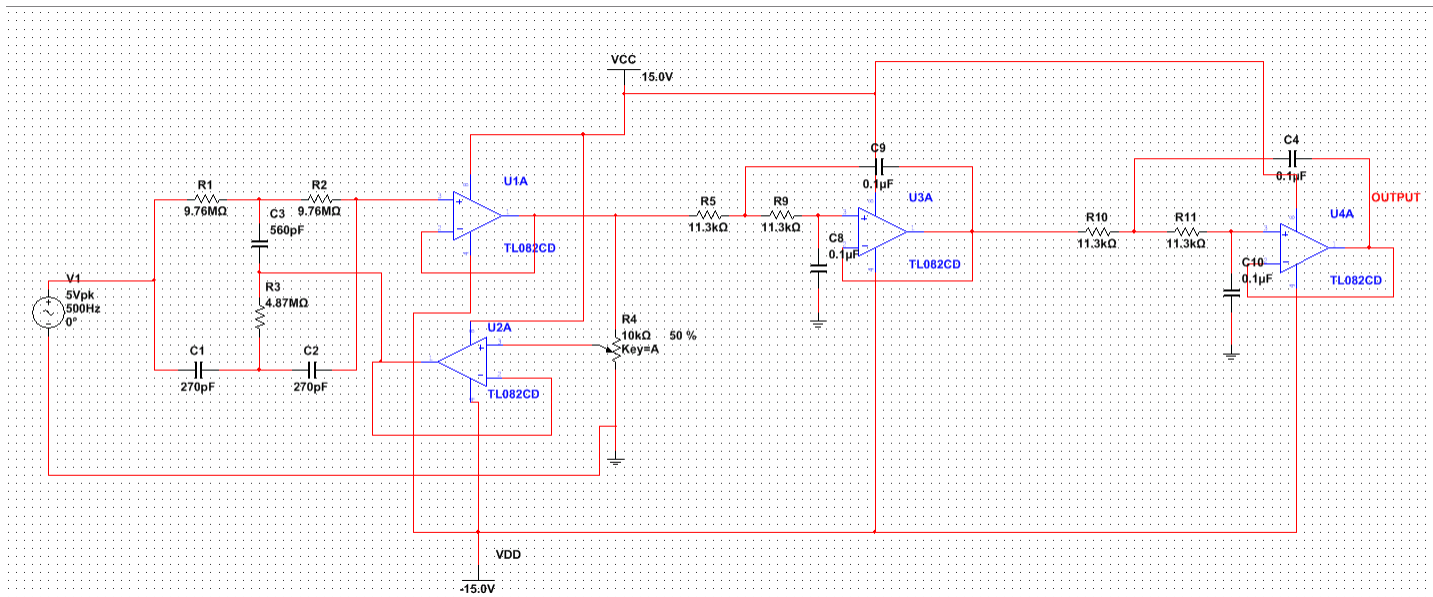
**Sallen Keys** For the Sallen Keys Portion I again used my transfer function from the warmup questions and got:  $\frac{1}{s^2 + s \frac{R_6 + R_5}{R_6 * C_6 * R_5} + \frac{1}{R_6 * C_6 * C_5 * R_5}}$  From this we get  $\omega_n = \sqrt{\frac{1}{R_6 * C_6 * C_5 * R_5}}$  and  $\zeta = \frac{R_6 + R_5}{2 * (R_6 * C_6 * R_5)} * \sqrt{R_6 * C_6 * C_5 * R_5}$  To come up with values for the Sallen Keys filter I knew I wanted the cutoff frequency to be 140Hz and that we want the filter to decay quickly so we need a critically damped system  $\zeta = 1$ . I set the capacitors to  $0.1\mu F$  and solved for the resistors and got both resistors should be  $R = 11,368\Omega$ . The filter looks like the following:



I used matlab to generate the Bode Plot:

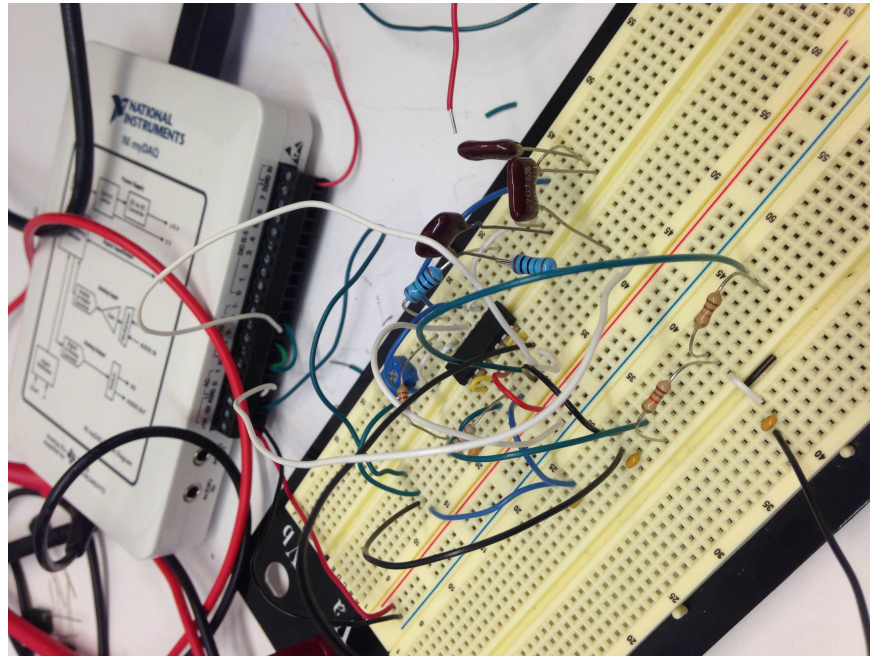


I then ran a montecarlo simulation on the full circuit:



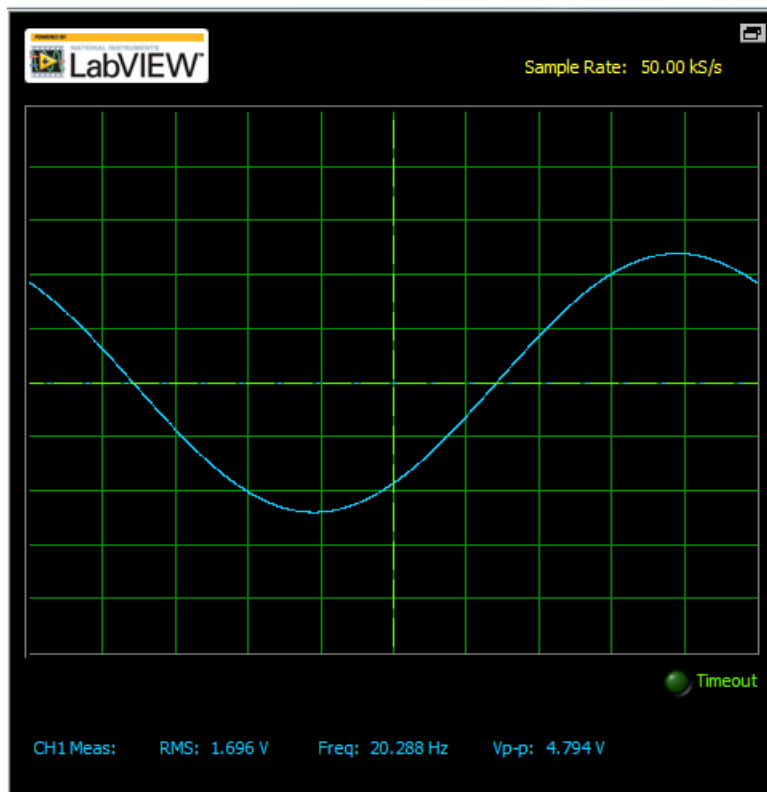
We have the cutoff at 60Hz as well as the dive downward at around 140 Hz from the simulation.

**Lab** For the lab I tested my circuit on a breadboard as shown below:

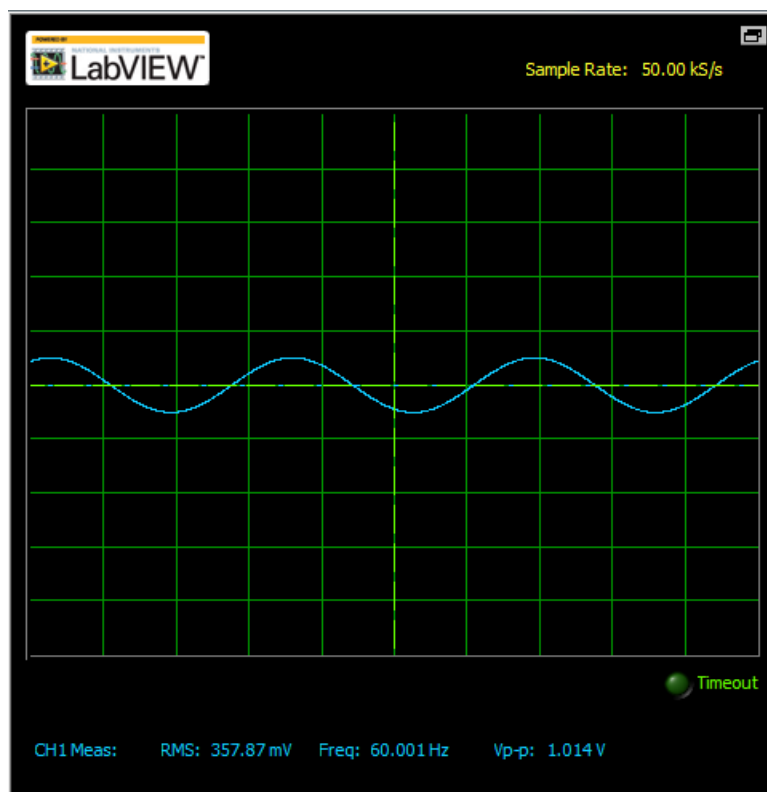


I tested the circuit on a number of frequencies from 20Hz to 200Hz with 20Hz intervals. Here are a few of the outputs:

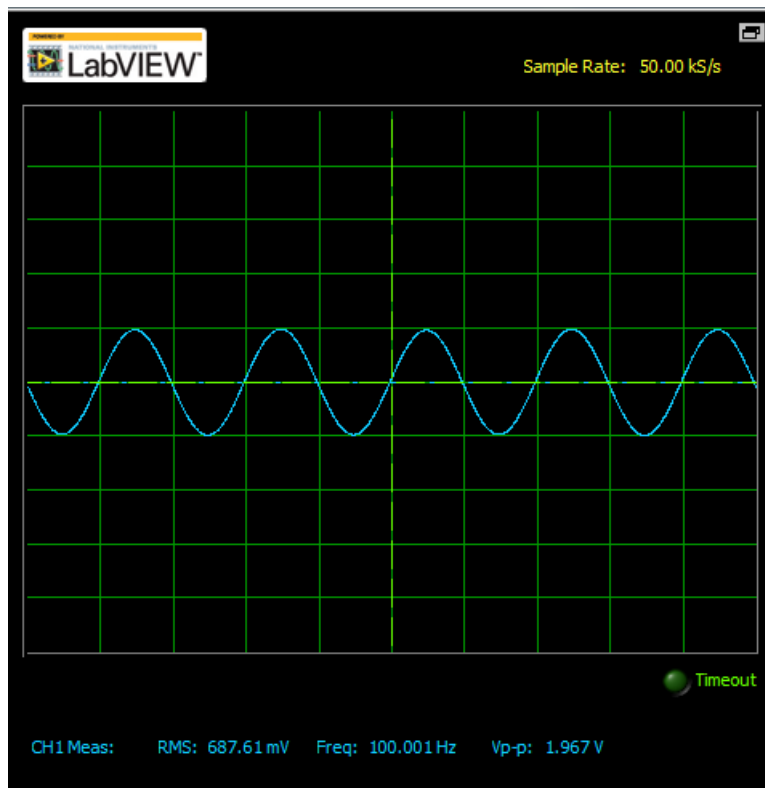
20Hz:



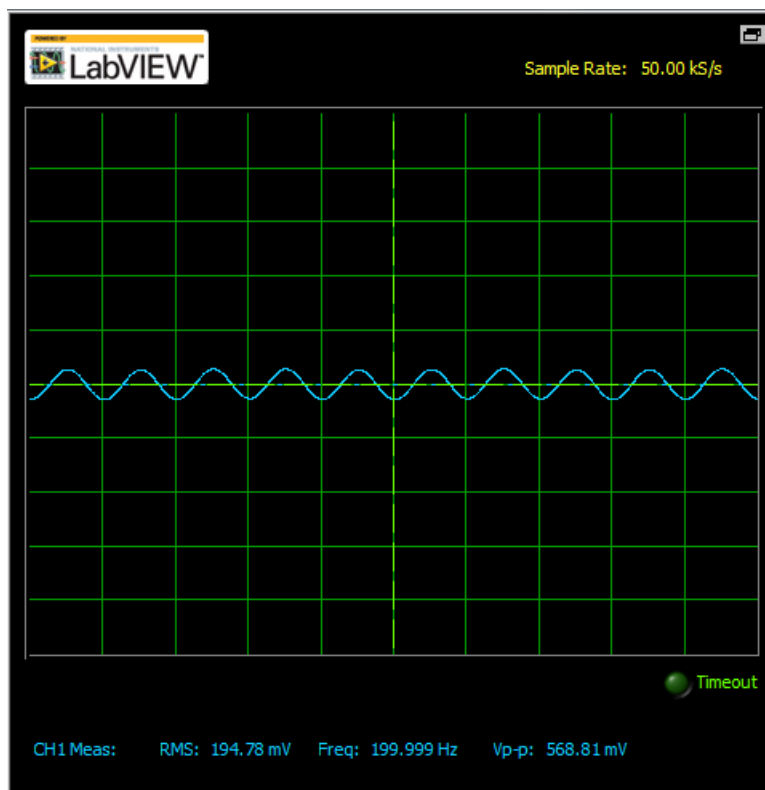
60Hz:



100Hz:

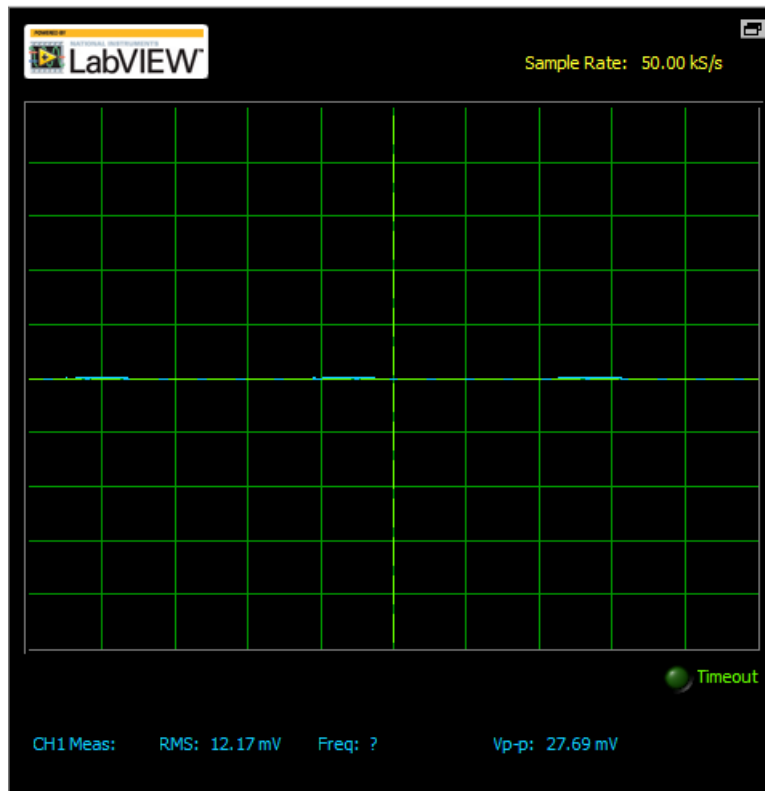


200Hz:





1000Hz:



From the graphs shown It appears that the filters are working the way they are supposed to. Prior to 60Hz we see little attenuation, at 60Hz we see a severe drop in magnitude. After 60Hz we see a rise in magnitude until 140Hz where we see a decline in magnitude. My plots don't show very steep cutoffs for 60Hz and 140Hz and I believe it is because I forgot to tune the potentiometer when testing my circuit, however my plots show that my circuit followed the expected behavior.