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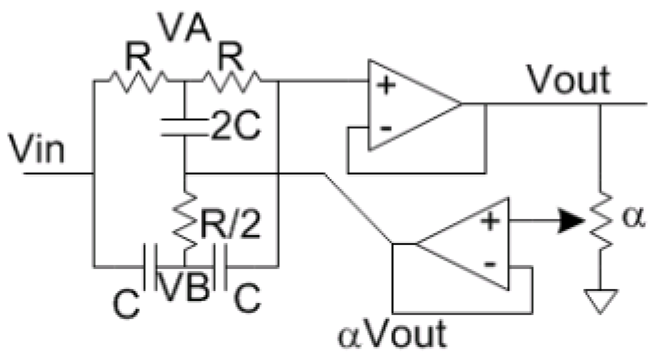
E84
Lab 10
4/28/2015

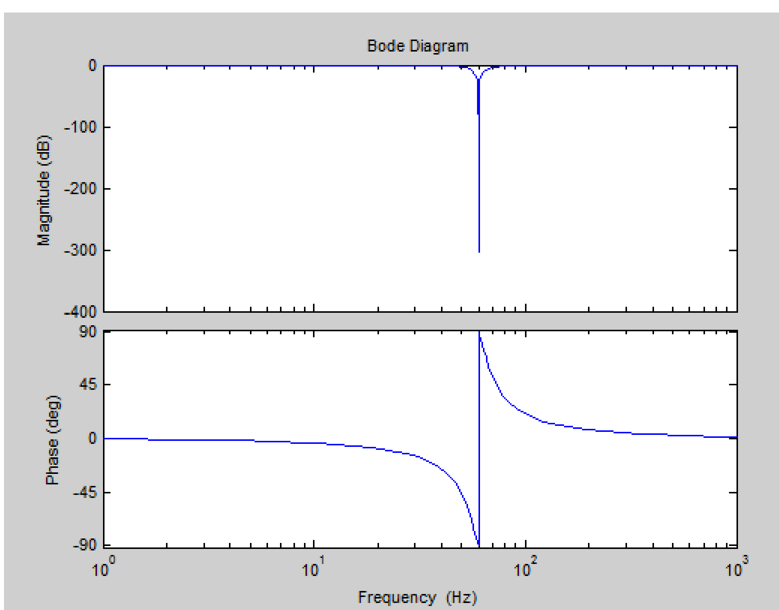
Lab 10: Active Filters

Time Spent: 5 Hours

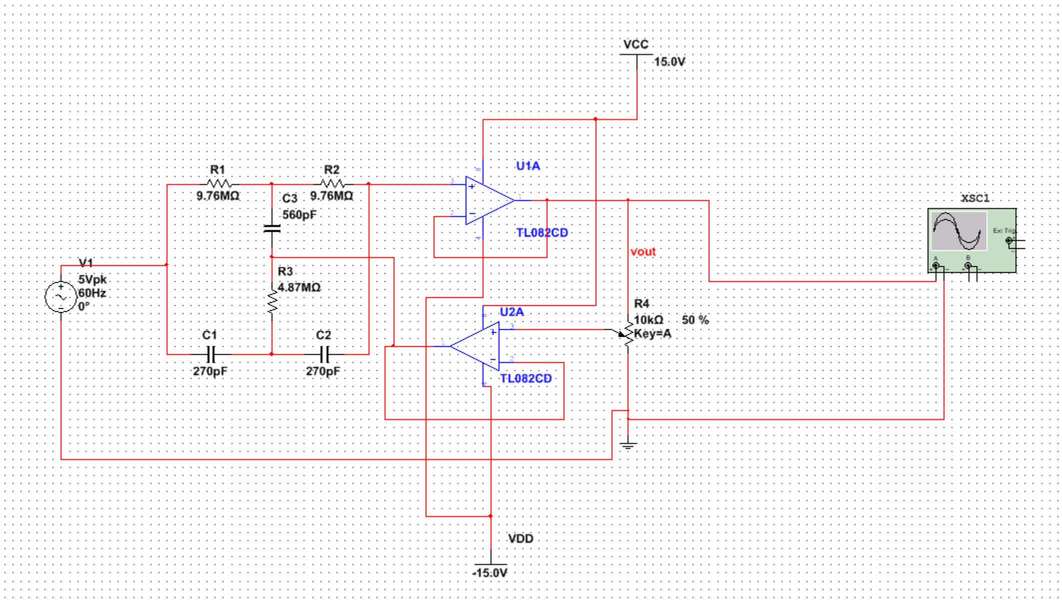
Notch Design To design the Notch Portion of the filter I used the same design as the warmup so that I would not have to rederive the transfer function. The design is shown below:



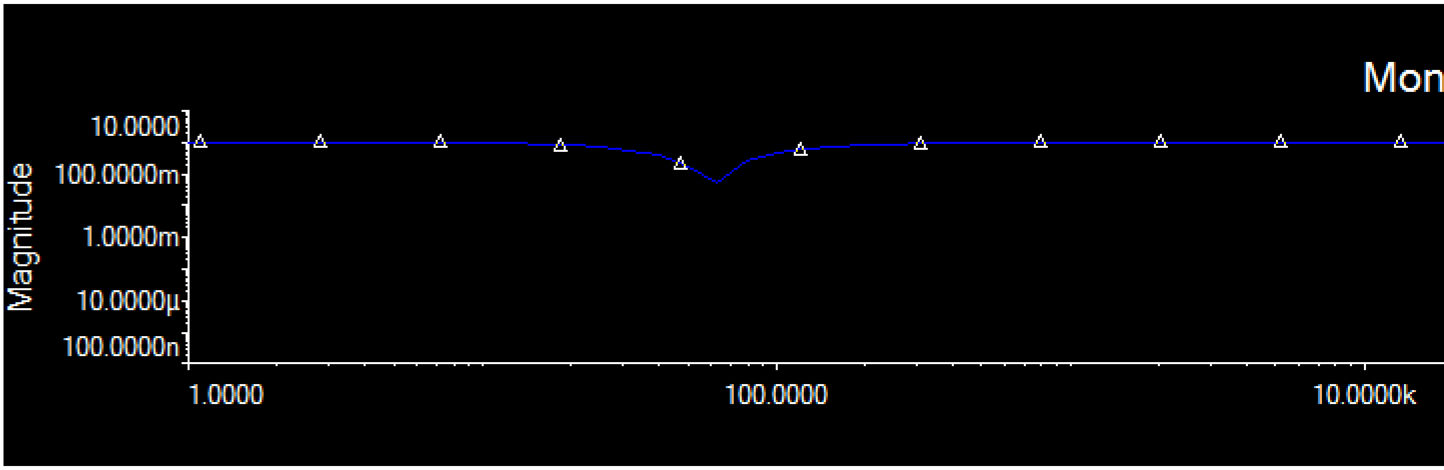
After analysis in the warmup my transfer function was: $\frac{s^2+\frac{1}{R^2C^2}}{s^2+\frac{4(1-\alpha)}{RC}+\frac{1}{R^2C^2}}$. With this transfer function $f0 = \frac{1}{2\pi RC}$ With this information we want to eliminate the 60Hz noise so we set $f0 = 60$ and we are given that $C = 270pF$. We solve 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.

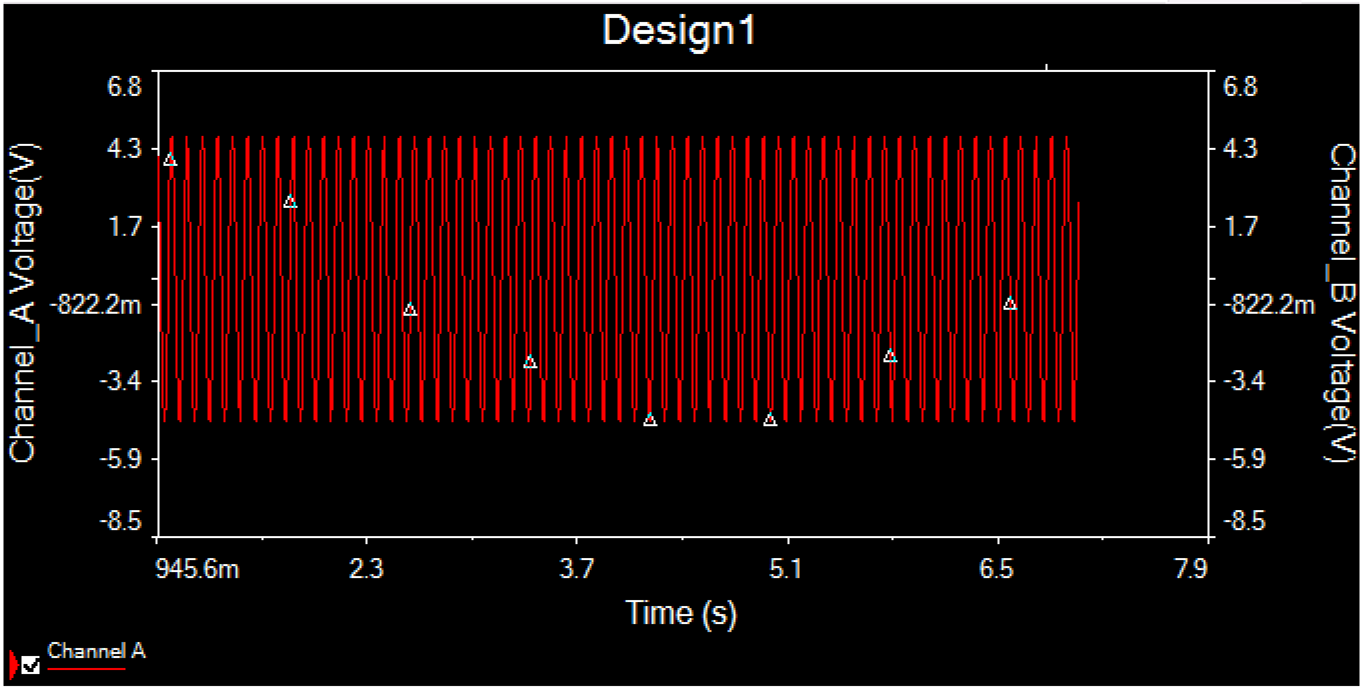


First I ran a montecarlo simulation:

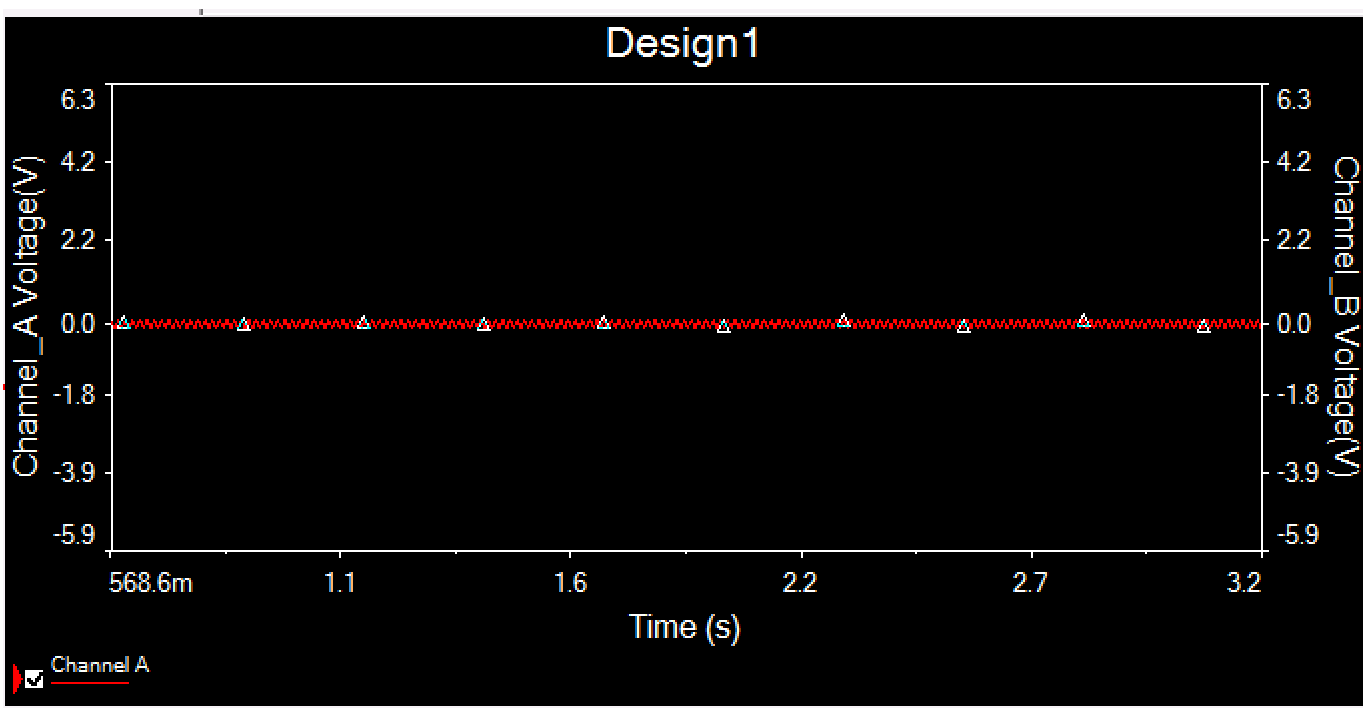


The filter has a dip around 60 Hz which is what we want.

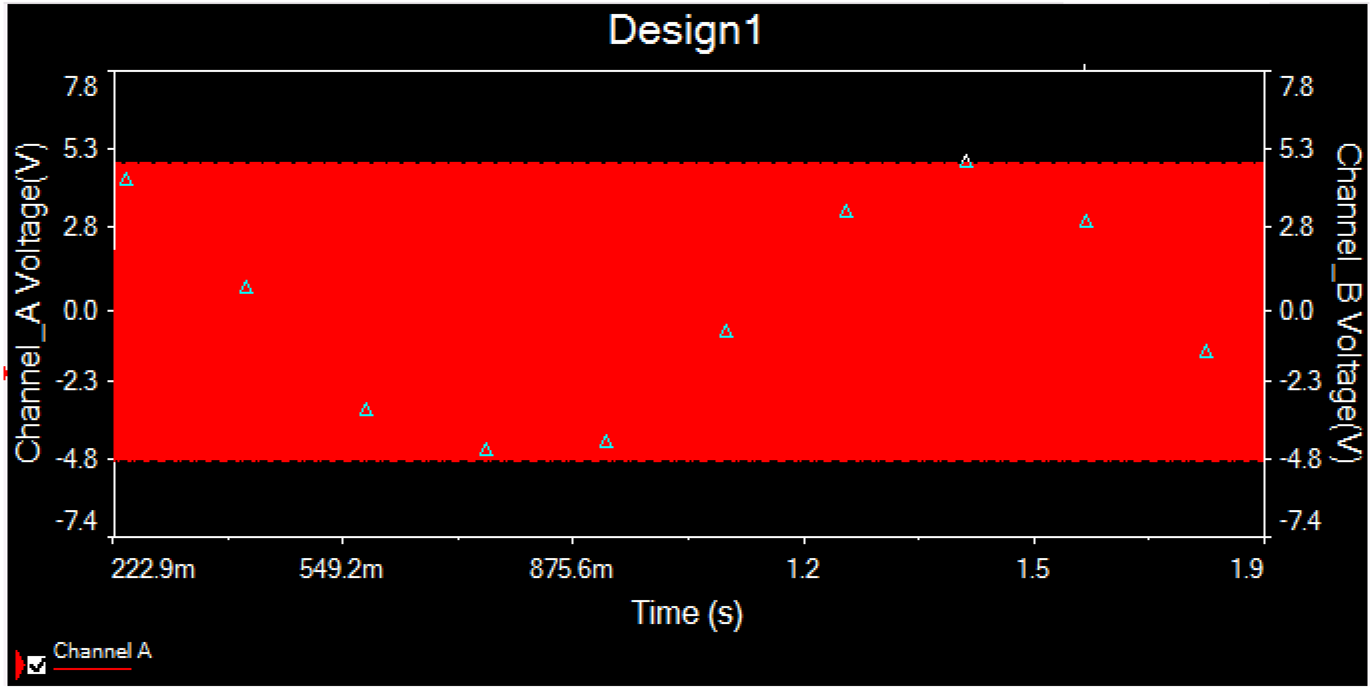
I then fed 3 different AC signals into the filter 10Hz,60Hz, and 500Hz.
10Hz:


Design1
Channel_A Voltage(V)
Channel_B Voltage(V)
6.8
4.3
1.7
-822.2m
-3.4
-5.9
-8.5
945.6m
2.3
3.7
5.1
6.5
7.9
Time (s)
Channel A

60Hz:

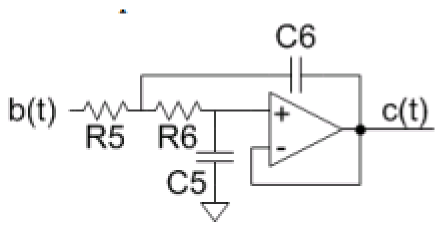

Design1
Channel_A Voltage(V)
Channel_B Voltage(V)
6.3
4.2
2.2
0.0
-1.8
-3.9
-5.9
568.6m
1.1
1.6
2.2
2.7
3.2
Time (s)
Channel A

500Hz:

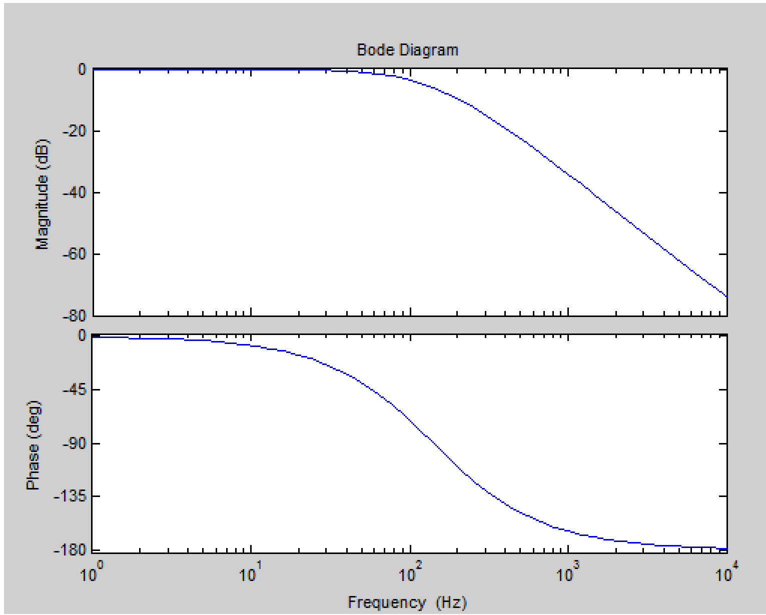


As we can see 10Hz and 500Hz retain their amplitude while 60Hz gets cutoff.

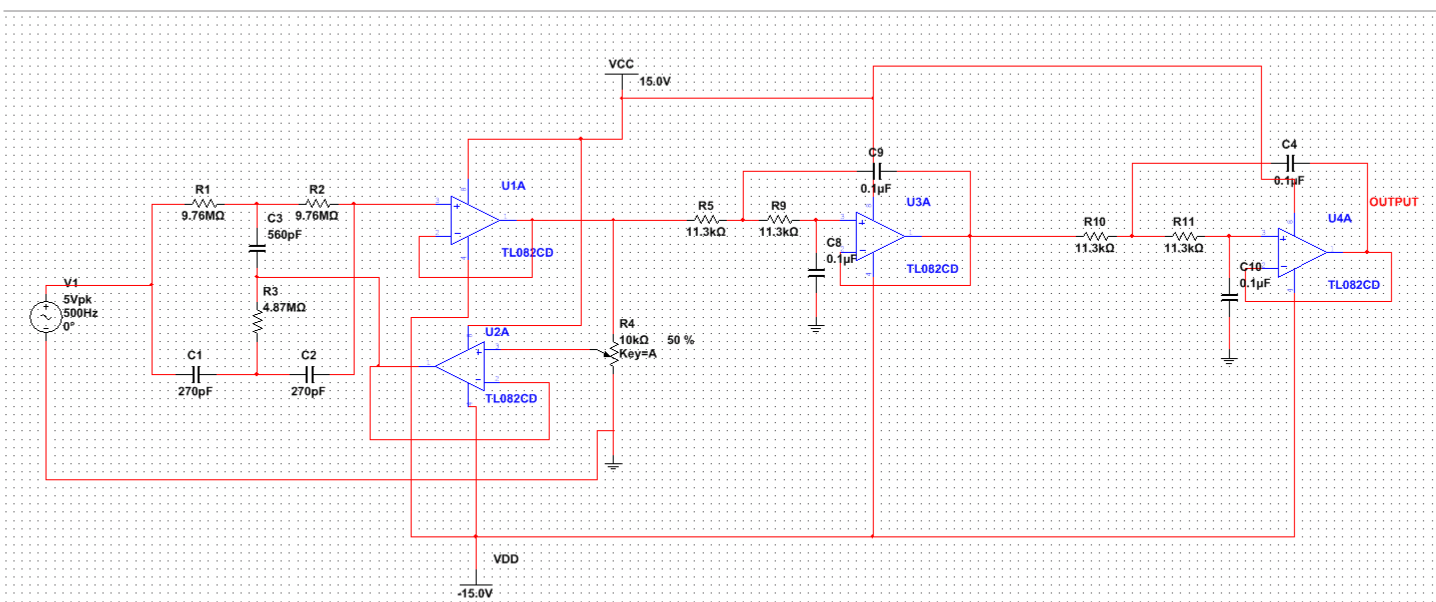
Sallen Keys For the Sallen Keys Portion I again used my transfer function from the warmup questions and got: $\frac{\frac{1}{R6*C6*C5*R5}}{s^2+s*\frac{R6+R5}{R6*C6*R5}+\frac{1}{R6*C6*C5*R5}}$ From this we get $wn = \sqrt{\frac{1}{R6*C6*C5*R5}}$ and $\zeta = \frac{R6+R5}{2*(R6*C6*R5)} * \sqrt{R6*C6*C5*R5}$ 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:

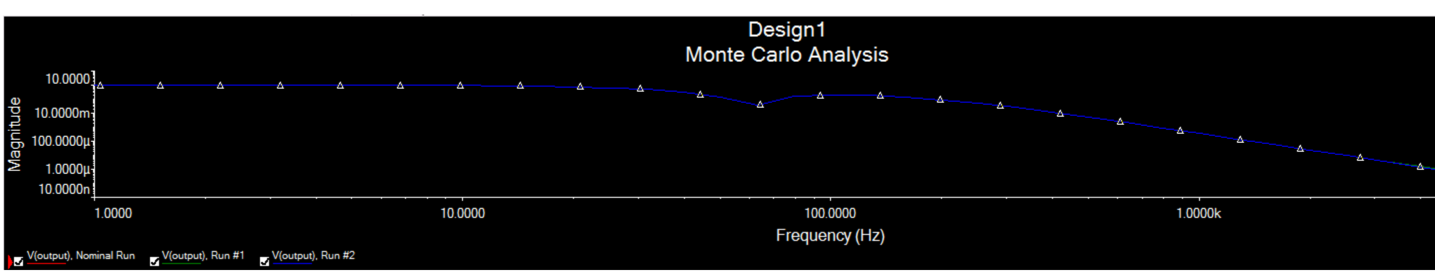


I used matlab to generate the Bode Plot:



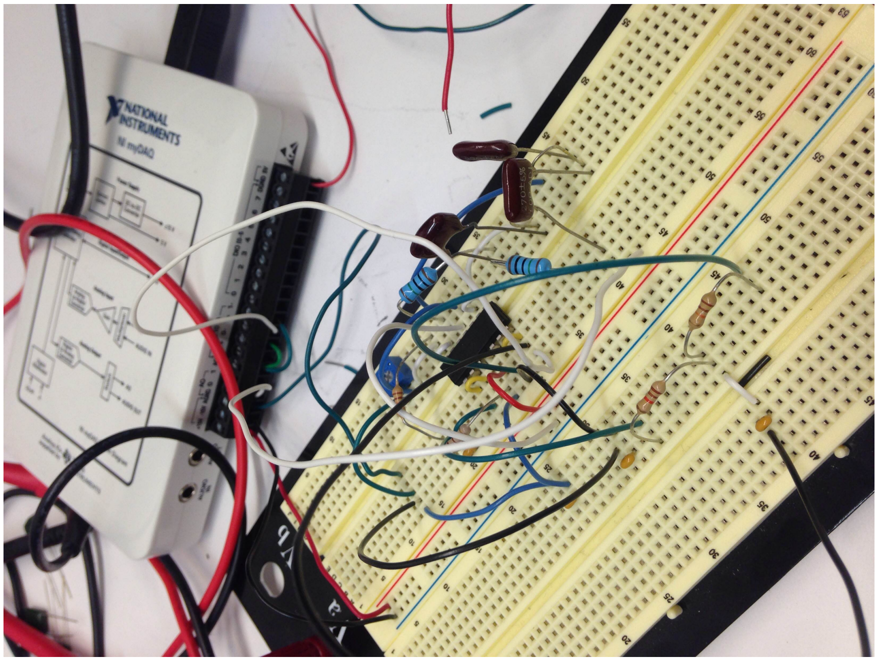
I then ran a montecarlo simulation on the full circuit:





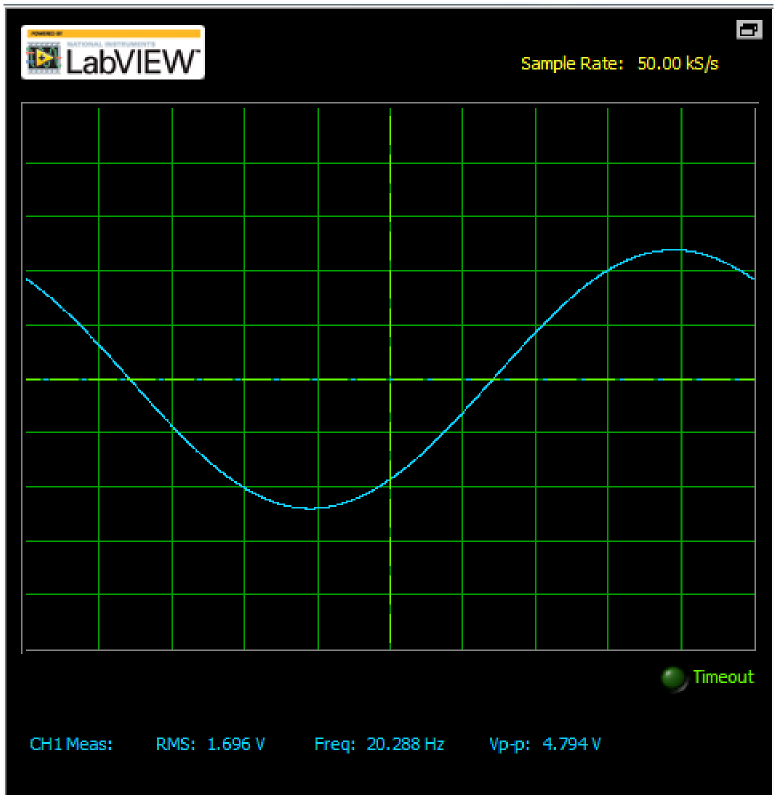
We have the cutoff at 60Hz as well as the dive downward at around 140 Hz from the simulation.

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

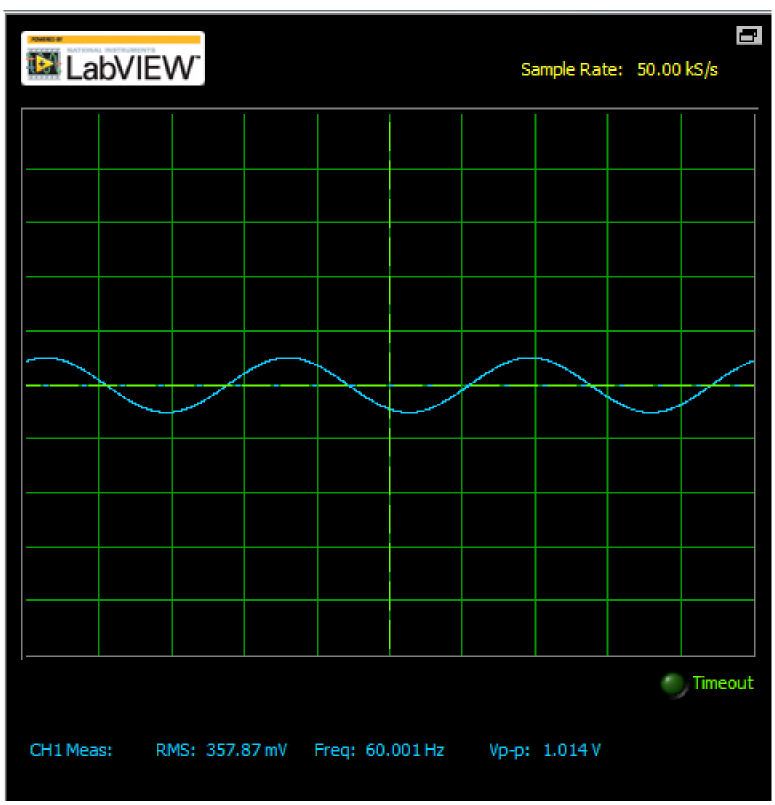


I tested the circuit on a number of frequencies from 20Hz to 200Hz with 20Hz intervals. Here are a few of the outputs:

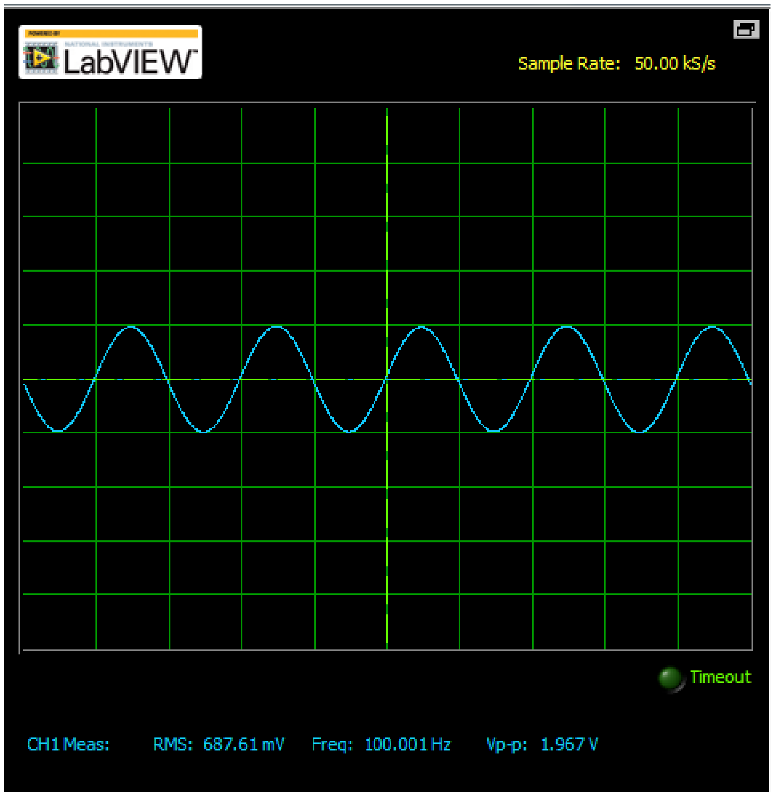
20Hz:


LabVIEW
Sample Rate: 50.00 kS/s
Timeout
CH1 Meas:
RMS: 1.696 V
Freq: 20.288 Hz
Vp-p: 4.794 V

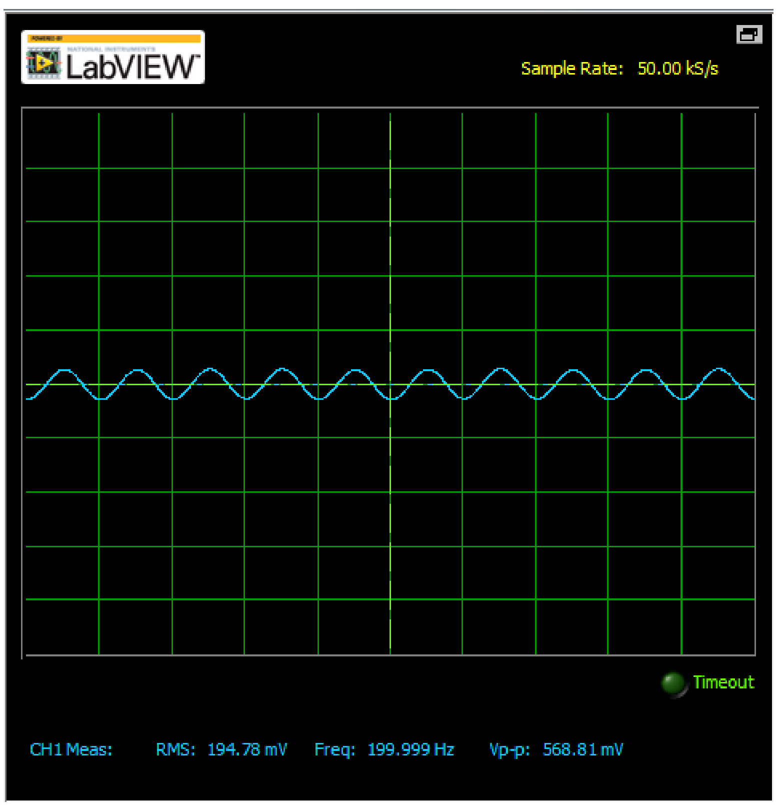
60Hz:


LabVIEW
Sample Rate: 50.00 kS/s
Timeout
CH1 Meas:
RMS: 357.87 mV
Freq: 60.001 Hz
Vp-p: 1.014 V

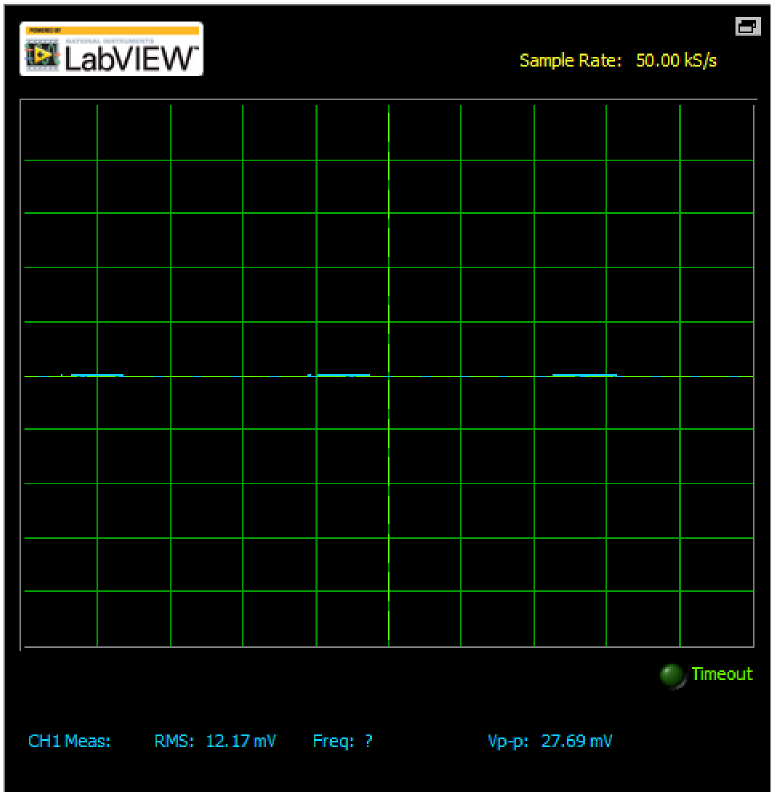
100Hz:


LabVIEW
Sample Rate: 50.00 kS/s
Timeout
CH1 Meas: RMS: 687.61 mV Freq: 100.001 Hz Vp-p: 1.967 V

200Hz:


LabVIEW
Sample Rate: 50.00 kS/s
Timeout
CH1 Meas: RMS: 194.78 mV Freq: 199.999 Hz Vp-p: 568.81 mV

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.