ECE 321 - Homework #5

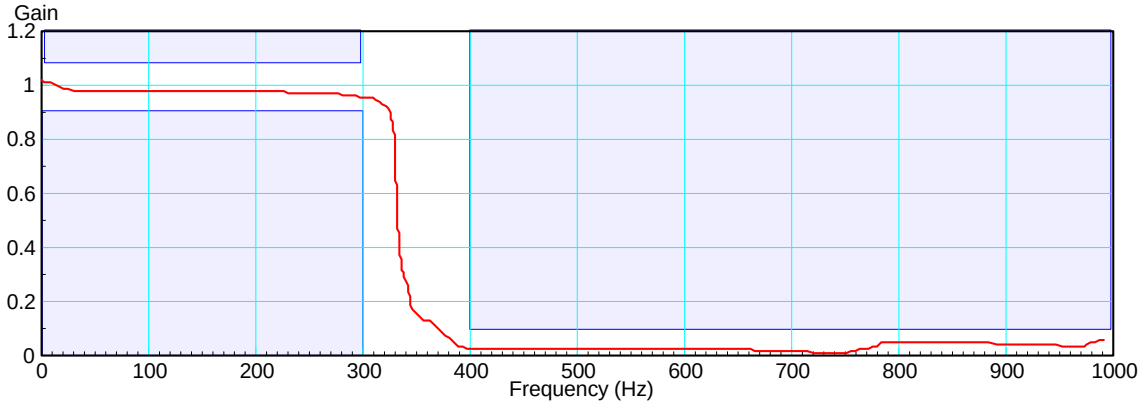
Project part (c). Due Monday, December 3rd, 2018

Project (part c):

Problem 1: Requirements Specify the requirements for the filter. You can use the following or change them if you like.

Bass Boost:

- Input: +/- 5V AC signal from 0 to 1000Hz capable of driving 10mA
- Output: +/- 5V AC signal capable of driving 10mA
- Relationship:
  - Pass-band (ex: 0.9 < gain < 1.1 for frequencies from 0 to 300Hz)
  - Reject band (ex: gain < 0.2 for frequencies above 400Hz)



Problem 2: Analysis: Design filter to meet these requirements.

First, find the order of the filter:

$$\left(\frac{300Hz}{400Hz}\right)^{N} < 0.2 \qquad \textit{changed from 0.1}$$

$$N > 5.59$$

Let N = 6.

Assume a Chebychev filter with a corner at 300Hz (1884 rad/sec). For a corner at 1 rad/sec

$$G(s) = \left(\frac{\alpha}{\left(s+0.47\angle\pm 36.1^{0}\right)\left(s+0.81\angle\pm 69.8^{0}\right)\left(s+1.04\angle 84.4^{0}\right)} \right)$$

For a corner at 300Hz, scale by 3770

$$G(s) = \left(\frac{\alpha}{\left(s+886\angle\pm 36.1^{0}\right)\left(s+1527\angle\pm 69.8^{0}\right)\left(s+1960\angle 84.4^{0}\right)} \right)$$

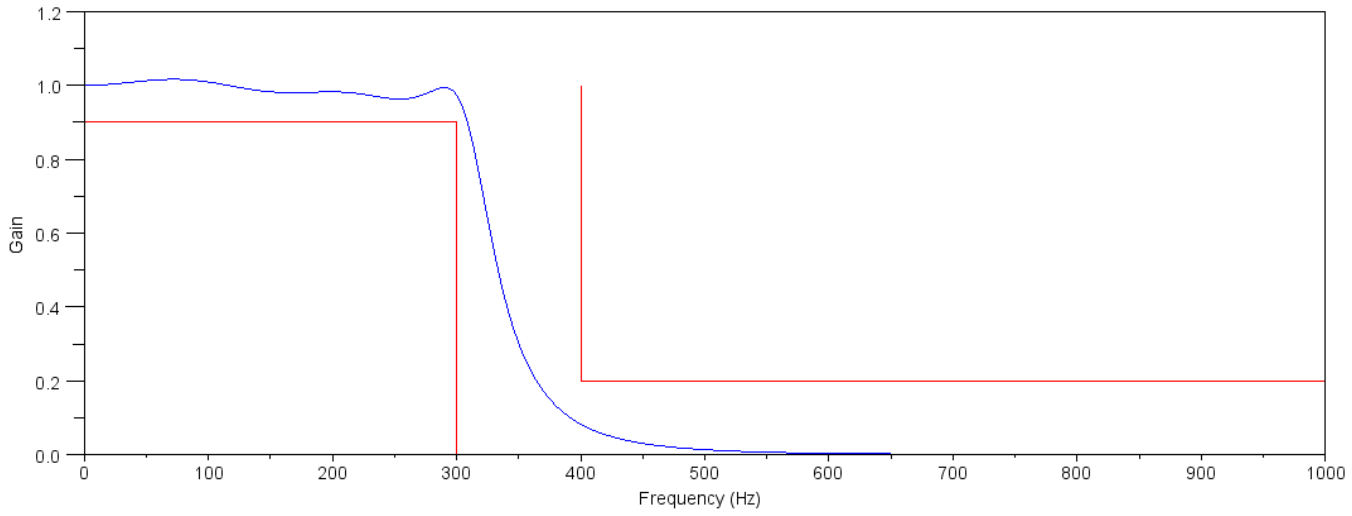
Putting this into Matlab:

```
f = [0:0.01:1000]';
w = 2*pi*f;
s = j*w;

s1 = 886*exp(j*36.1*pi/180);
s2 = conj(s1);
s3 = 1527*exp(j*68.9*pi/180);
s4 = conj(s3);
s5 = 1960*exp(j*84.4*pi/180);
s6 = conj(s5);
num = abs(s1)*abs(s2)*abs(s3)*abs(s4)*abs(s5)*abs(s6)

    7.032D+18

G = num ./ ( (s+s1).*(s+s2).*(s+s3).*(s+s4).*(s+s5).*(s+s6) );
plot(f,abs(G))
xlabel('Frequency (Hz)');
ylabel('Gain');
```



This meets the requirements. The gain at 300 and 400Hz are:

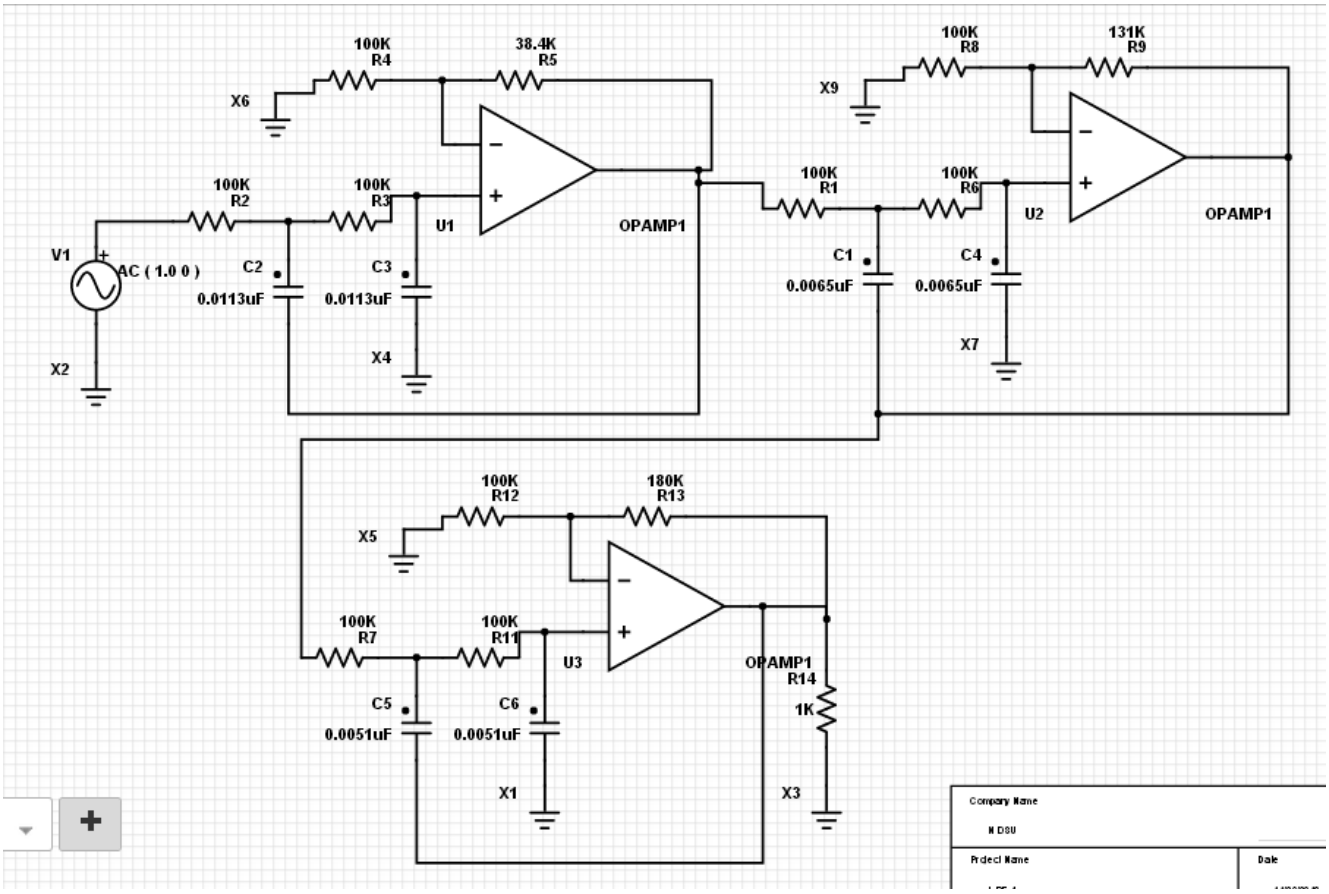
```
f(30000)
    399.99

abs(G(30000))
    0.9736473

f(40000)
    399.99

abs(G(40000))
    0.0827813
```

Resulting Circuit



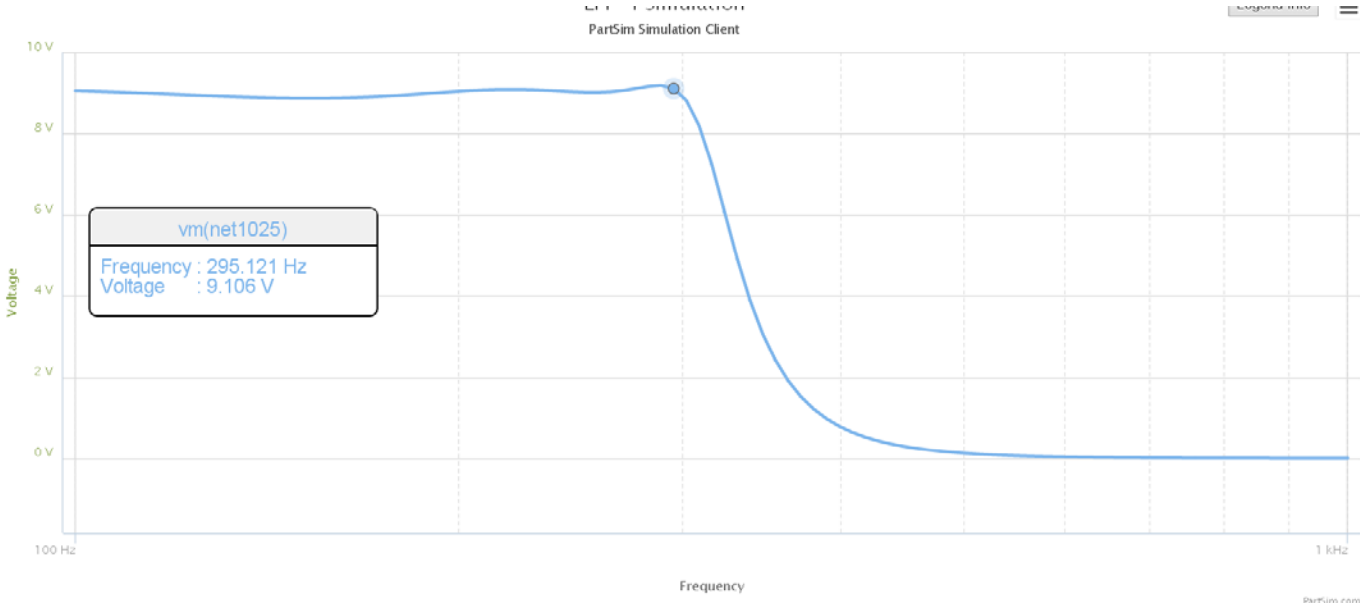
Note: The DC gain of this circuit is

$$G(0) = 1.384 \cdot 2.31 \cdot 2.80 = 8.95$$

The output is likewise 8.95Y

Problem 3: Simulation Check your circuit design by simulating your circuit. Include

- The gain at the edge of the pass-band (500Hz?)
- The gain at the edge of the reject band (500Hz?)
- Compare the simulated results vs. theoretical results from problem 2



Hz	Calculated Gain *problem 2 (x8.95)*	Simulated Gain *problem 3*	Measured Gain *problem 4*
100	9.0325035	9.05	
300	8.713706	8.81	
400	0.7407275	0.79	
1000	0.0011739	0	

Problem 4: Hardware Build your circuit in lab and verify it operates correctly. Check

- The gain at the edge of the pass-band (500Hz?)
- The gain at the edge of the reject band (500Hz?)
- Compare the simulated results vs. theoretical and simulation results from problem 2 and 3

Problem 5) Demo. Demonstrate your filter works with part (a) and part (b) (video or in person).