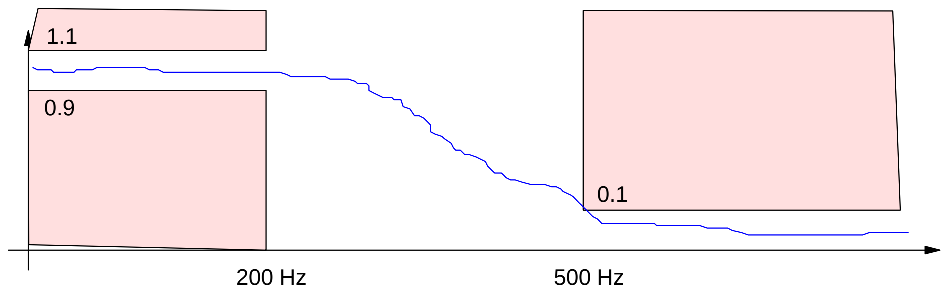
ECE 311 - Homework #25

Problem 1-3) Design a low-pass filter to meet the following requirements:

- Input: +/- 10V, capable of 20mA
- Output: +/- 10V capable of 20mA
- Relationship:
  - 1.1 < Gain < 0.9 f < 200 Hz
  - Gain < 0.1 f > 500 Hz



1) Give a filter, G(s), which meets these requirements. Plot the gain vs. frequency for your G(s) in Matlab.

First, determine the number of poles you need:

$$\left(\frac{200Hz}{500Hz}\right)^n = 0.1$$

$$n = \frac{\ln(0.1)}{\ln(0.4)} = 2.51$$

Let n = 3

Second, pick a type of filter. Let's use a Chebychev filter. From Bison Academy, a 3rd-order Chebychev filter with a corner at 1 rad/sec is

$$G(s) = \left(\frac{k}{(s+0.85)\left(s+1.21\angle\pm 69.5^0\right)}\right)$$

Scale this so the corner is at 200Hz (400 pi)

$$G(s) = \left(\frac{k}{(s+1068)\left(s+1520\angle\pm 69.5^0\right)}\right)$$

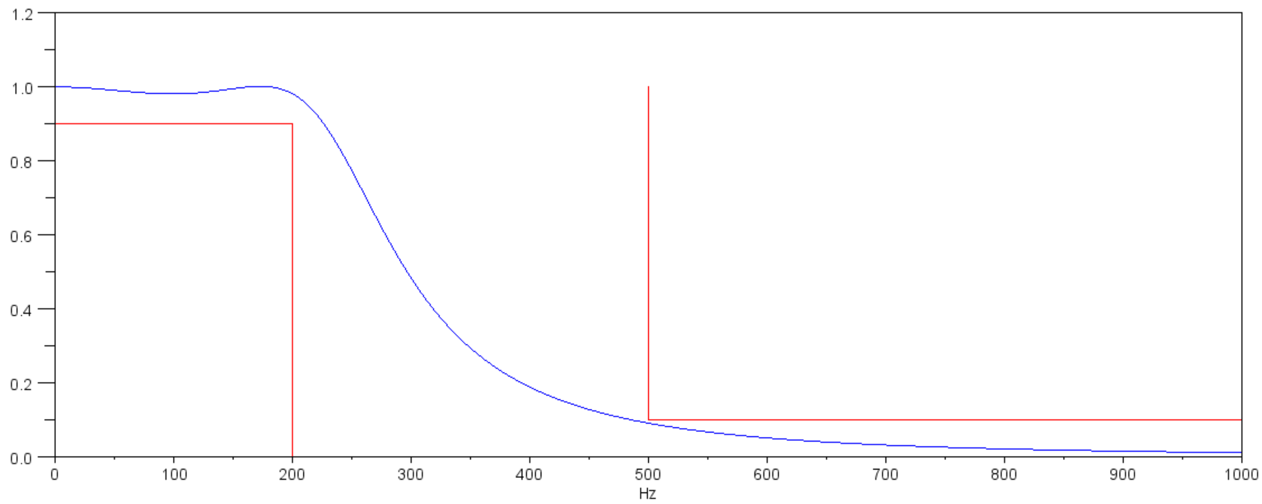
Plot the gain vs. frequency in Matlab

```
-->f = [0:1000]';
-->w = 2*pi*f;
-->s = j*w;
-->p1 = 1068;
-->p2 = 1520*exp(j*69.5*pi/180);
-->p3 = conj(p2);
-->G = 1 ./ ( (s+p1) .* (s+p2) .* (s+p3) );
-->k = 1/abs(G(1))

    2.468D+09

-->G = k ./ ( (s+p1) .* (s+p2) .* (s+p3) );
-->plot(f,abs(G))
```

```
-->plot([0,200,200],[0.9,0.9,0],'r')
-->plot([500,500,1000],[1,0.1,0.1],'r')
-->xlabel('Hz');
```



Pretty lucky: this meets the requirements.

answer:

$$G(s) = \left(\frac{2.468 \cdot 10^9}{(s+1068)\left(s+1520\angle \pm 69.5^0\right)} \right)$$

2) Design a circuit to implement this circuit

Let R1 = 10k

$$\frac{1}{R_1 C_1} = 1068$$

$$C_1 = 94nF$$

Let R2 = 100k

$$\frac{1}{R_2 C_2} = 1520$$

$$C_2 = 6.58nF$$

For the gain:

$$(3-k) = 2\cos(69.5^0)$$

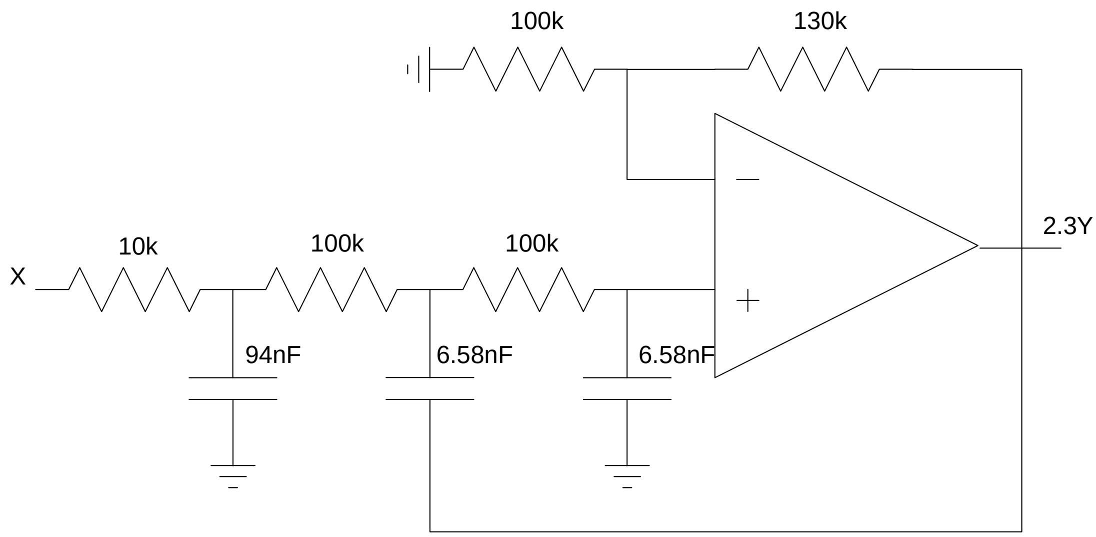
$$k = 2.3$$

Let R3 = 100k, R4 = 130k

This results in the circuit having a gain of 2.3. Either

- Live with it. Call the ouput 2.3Y and adjust later stages, or

- Drop the gain by a factor of 2.3

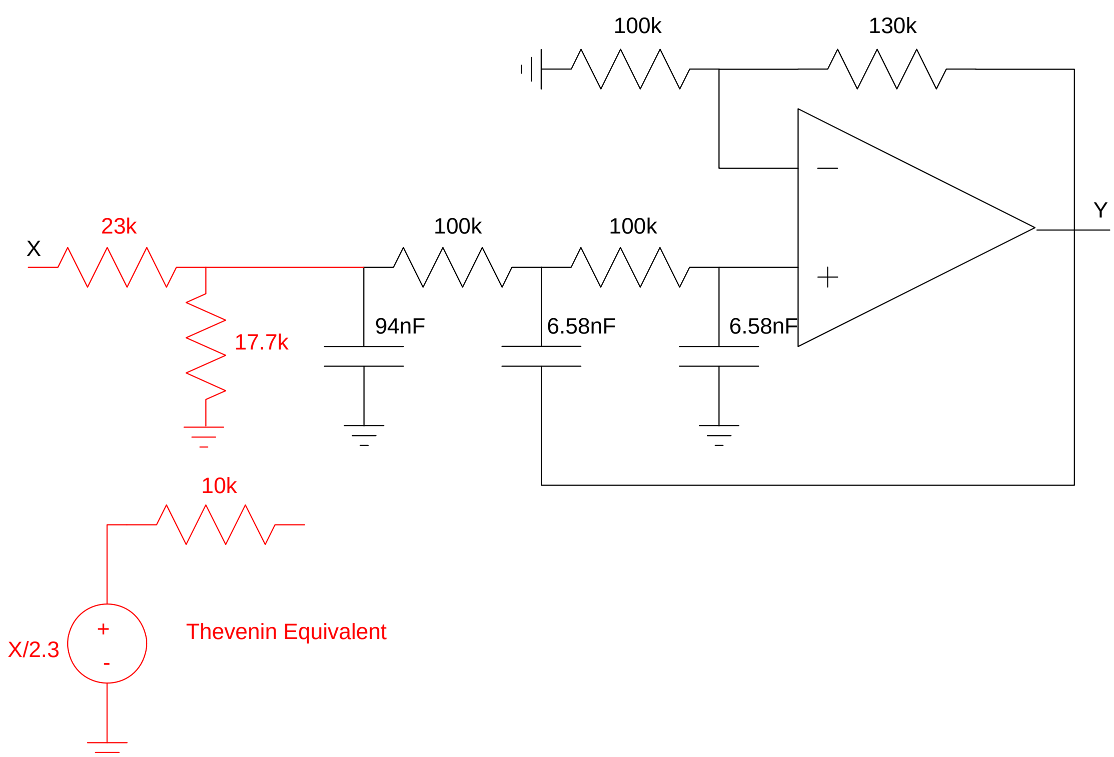


Using the latter and Thevenin equivalents.

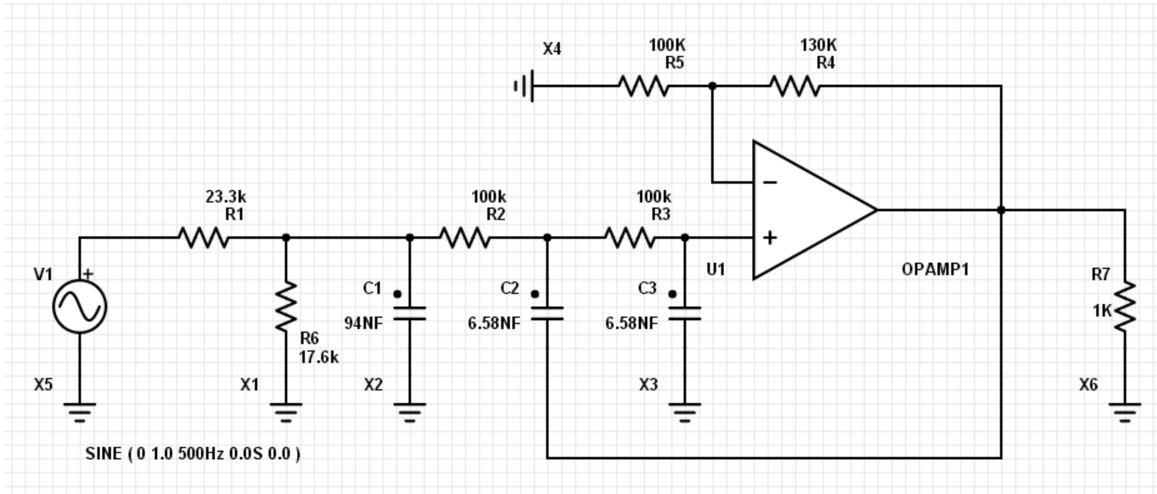
$$R_a||R_b = R_{th} = 10k$$

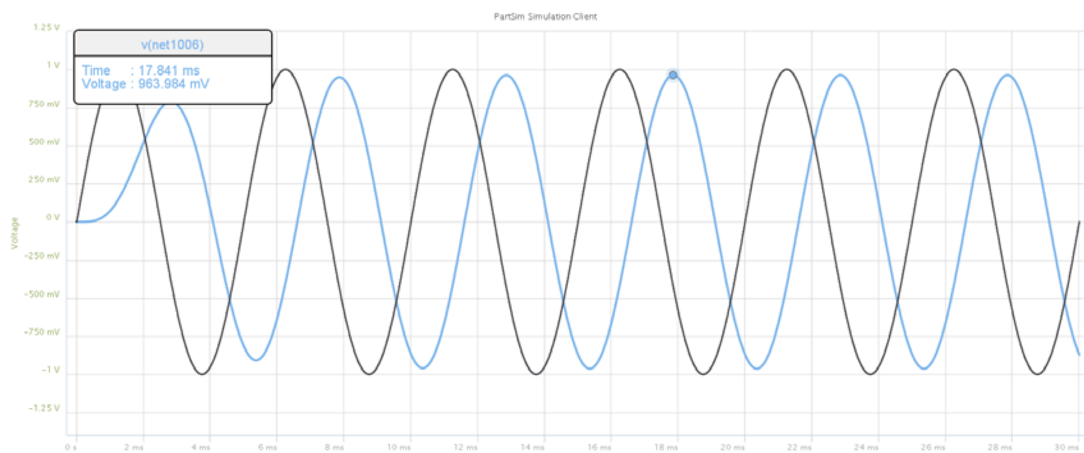
$$\left(\frac{R_b}{R_a+R_b}\right)X = \frac{X}{2.3}$$

which gives Ra = 23k, Rb = 17.7k

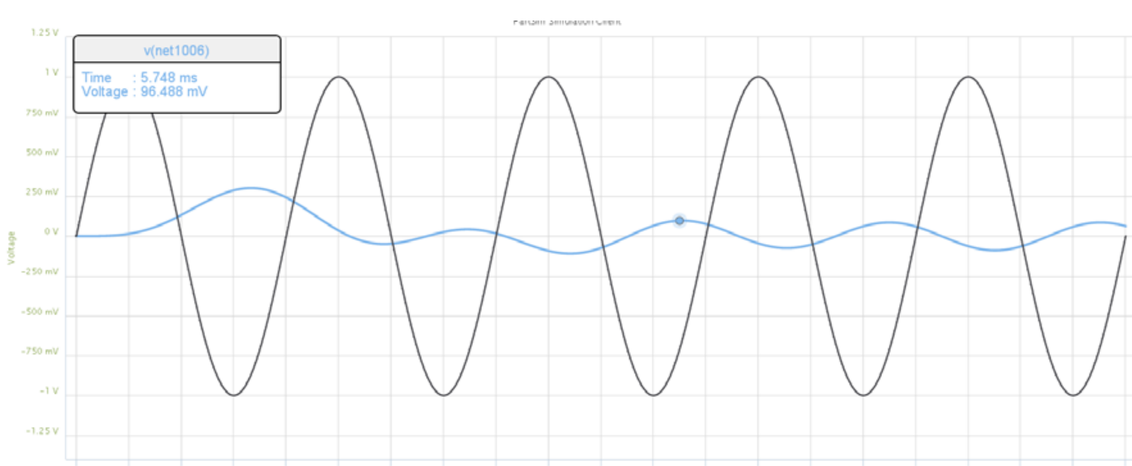


3) Test your design in PartSim: Assume a load of 1k Ohms is added (should be part of the requirements: capable of driving a 1k Ohm load)





200Hz: Gain = 0.963



500Hz: Gain = 0.09648

	200 Hz	500 Hz
Gain (calc)	0.9815	0.0899
Gain (sim)	0.963	0.09648
Spec	0.9 < G < 1.1	< 0.1
Meet Spec?	yes	yes