Filter + Amp

toDos :

1. V_out change to 5V
2. Check what V_in actually is
3. Test with noises added (drift and powerline)
4. Determine which R to be adjustable (R1) and how

Current Design (May 6th)

- Two bp amplifiers

Single amp gain G = 37.8 = 31.55dB
Total gain G = 1428 = 63.10dB
$R_{IN} = 1k\Omega$
$C_{IN} = 1600uF$
$R_F = 38k\Omega$
$C_F = 168nF$
BP : 0.1 - 24.93Hz

- Actions

Verify whether I have the capacitors
Build and validate the circuit in real life

Detail

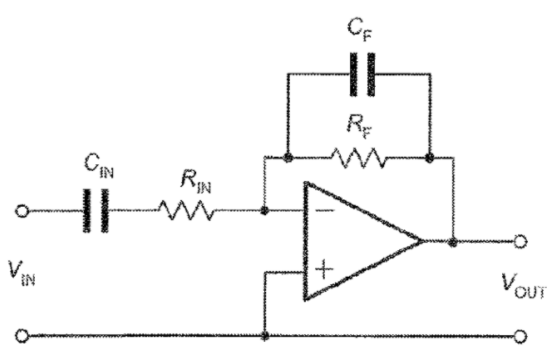


Figure 8.8 Adding capacitors to modify the frequency response of an inverting operational amplifier

(from perusal week 6 op amp)

Since only the frequency between 0.1 and 20Hz is related to eye movement, we will choose a bandpass between 0.1 to 25 Hz.

From ref[2], the typical signal is 50 to 3500 uV, and we want to amplify it to 0~1.5 V
So we need a gain of 428.6. If we choose $R_{IN} = 100\Omega$, $R_F = 42k\Omega$

Higher cutoff frequency :

$$R_F = 42k\Omega$$

$$F_H = \frac{1}{2\pi R_F C_F} = 25Hz,$$

$$C_F = \frac{1}{2\pi R_F F_H} = 152nF$$

For simpler circuit, we choose

$$C_F = \frac{1}{2\pi R_F F_H} = 150nF$$

$$F_H = \frac{1}{2\pi R_F C_F} = 25.26Hz$$

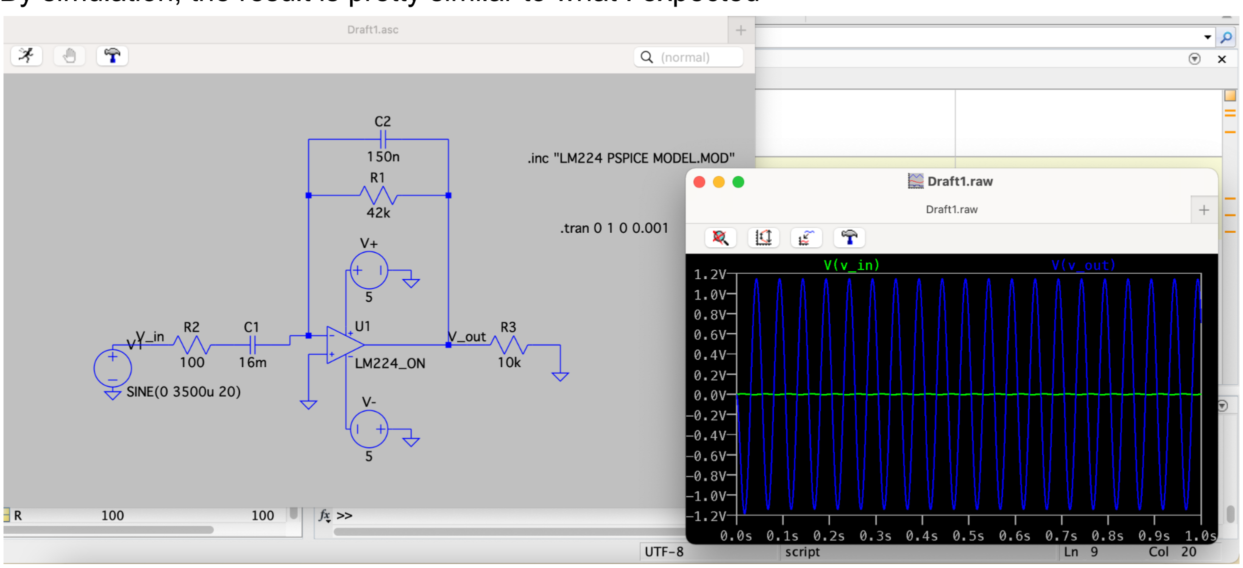
Lower cutoff frequency :

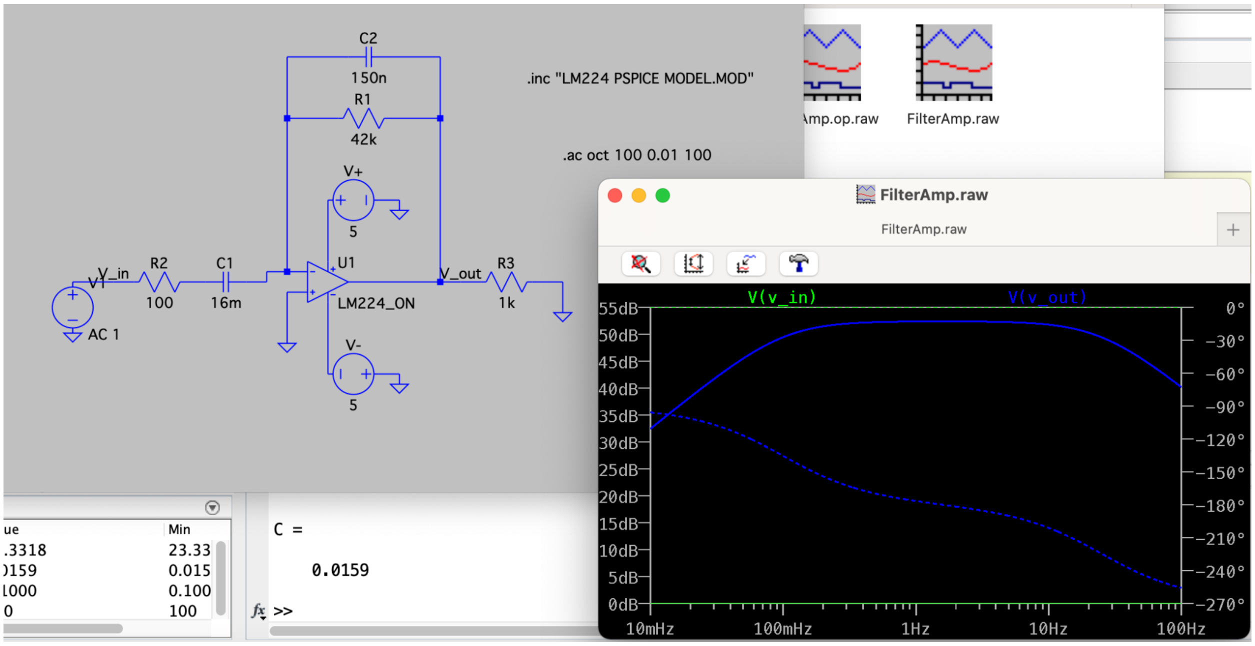
$$R_{IN} = 100\Omega$$

$$F_L = \frac{1}{2\pi R_{IN} C_{IN}} = 0.1Hz$$

$$C_{IN} = \frac{1}{2\pi R_{IN} F_L} = 16mF$$

By simulation, the result is pretty similar to what I expected





Ref

[2] - Deng, L. Y., Hsu, C.-L., Lin, T.-C., Tuan, J.-S., Chang, S.-M. (2010). EOG-based Human–Computer Interface system development. Expert Systems with Applications, 37(4), 3337–3343. doi:10.1016/j.eswa.2009.10.017

May 6, 2022

Issue 1 : The capacitance come in 1mF maximum

> R_in must be increased

Issue 2 : We need the output signal to be 5V instead of 1.5V

> Either change Rf or add another amplifier

New Gain : 5V/3500uV = 1428

If we use $R_{in} = 1k\Omega$

$$F_L = \frac{1}{2\pi R_{IN} C_{IN}} = 0.1Hz$$

$$C_{IN} = \frac{1}{2\pi R_{IN} F_L} = 1600uF$$

$$R_f = 1428k\Omega$$

$$C_F = \frac{1}{2\pi R_F F_H} = 4.581nF$$ This is a bit too small for our components, and 1.4MOhm may also induce large currents.

New Strategy: use two amplifiers with a same cutoff frequency

New Gain : $\sqrt{1428} = 37.78$ = 31.54dB

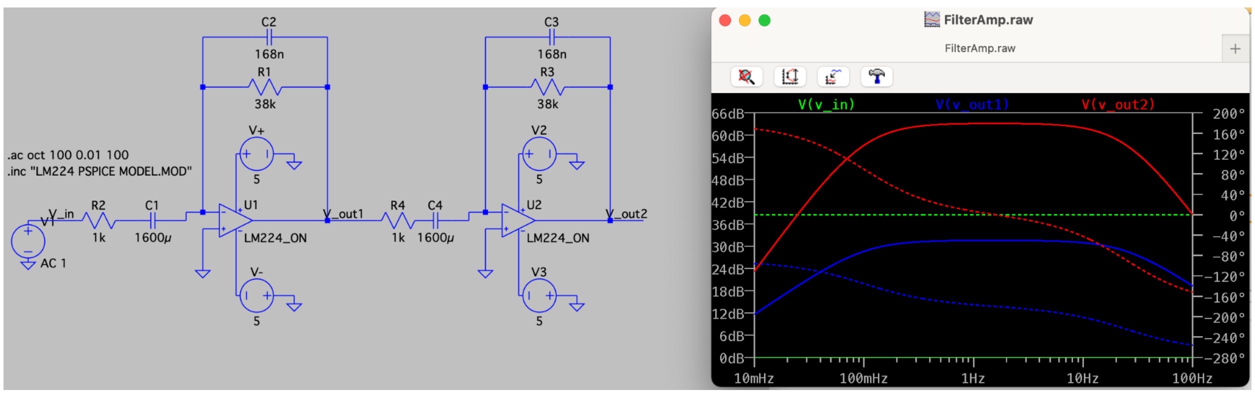
$R_f = 37.78k\Omega$

$$C_F = \frac{1}{2\pi R_F F_H} = 168.5nF$$

For simplicity,

Choose $R_f = 38k\Omega$, $C_F = 168nF$

New cut-off $F_H = 24.93Hz$



May 9, 2022

The full circuits were showing that the filt&amp are amplifying it to 3.5V instead of 5V. I noticed that I haven't truly validated the circuit yet.

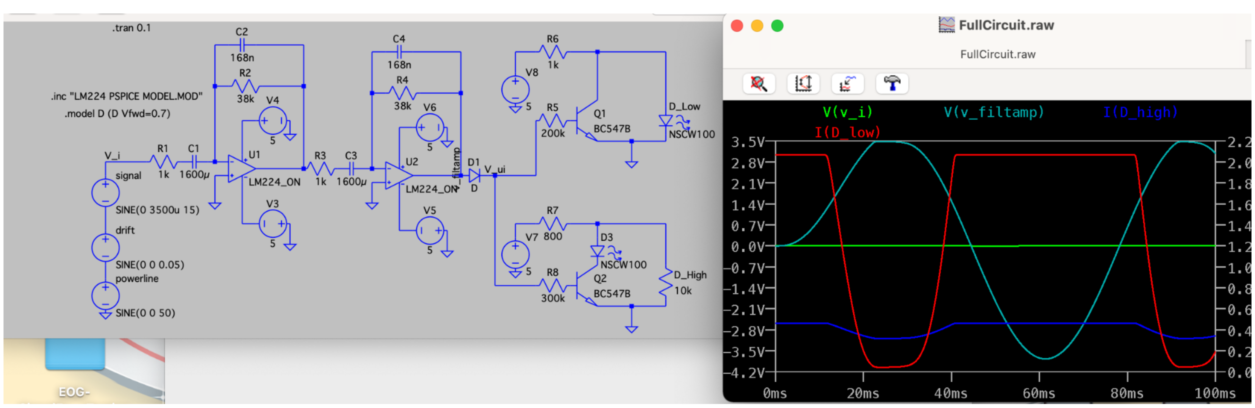
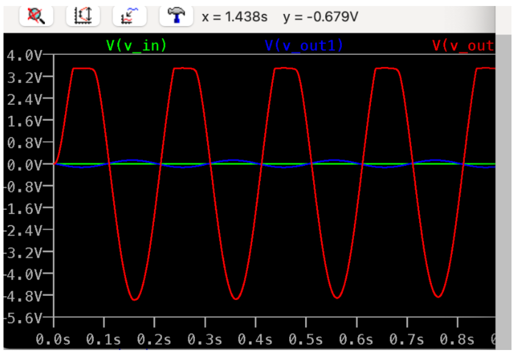
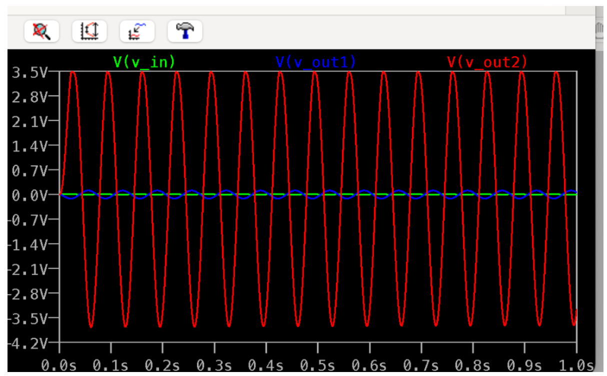
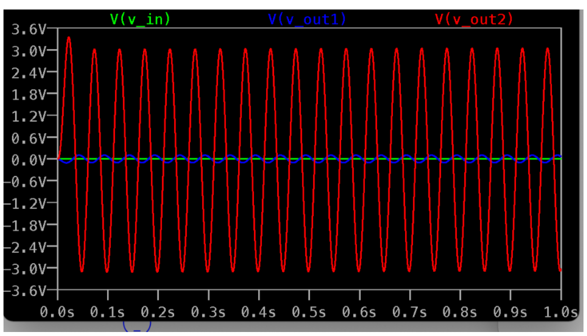
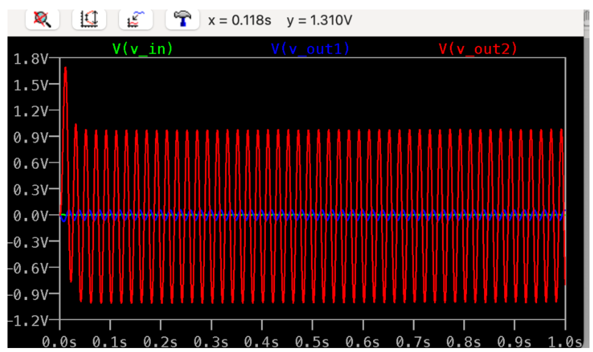


Figure : Result of the full circuit. The magnitude of the incoming signal to the ui was off, hence the threshold was not catered to that.

Testing the filt&amp circuit with sin wave of 3500uV magnitude, at 5 to 15 Hz, the output is consistent at around 3.5V. At 20 Hz, the output is starting to attenuate.
At a powerline frequency of 50 Hz, we can see that the output is lower than 1V, which I think is satisfactory for. If the actual magnitude is larger than the signal, we may need to redesign the filter again. Clearly, the calculations did not end up as I have anticipated, we will need a better understanding of the issue, probably bringing it up for consultation.

5Hz	15Hz
	
20Hz	**50Hz**
	

Future actions:

1. Reset the thresholds of the ui to suit this new gain.
2. May need a peak detector to capture the average signal value.