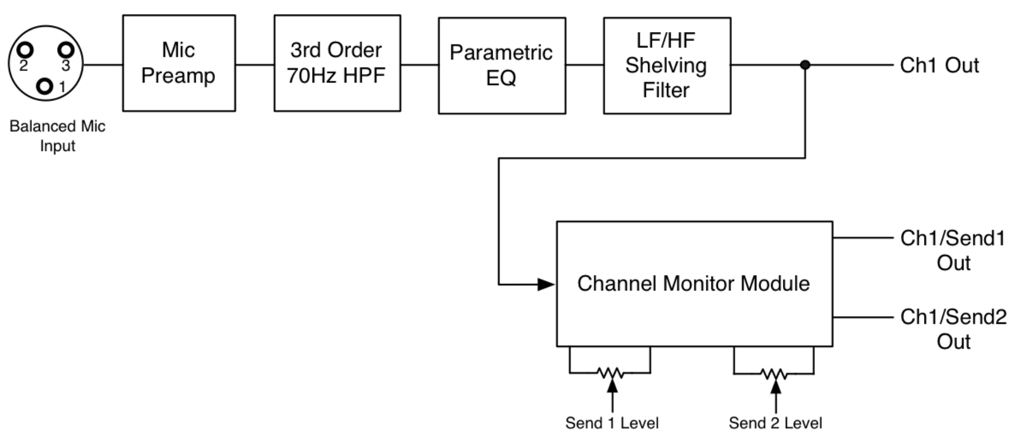
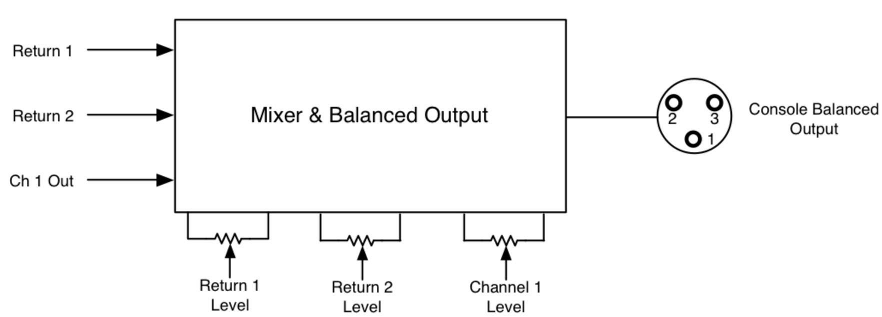
Nate Paternoster 12/5/12

MMI401 Final Project

Overview

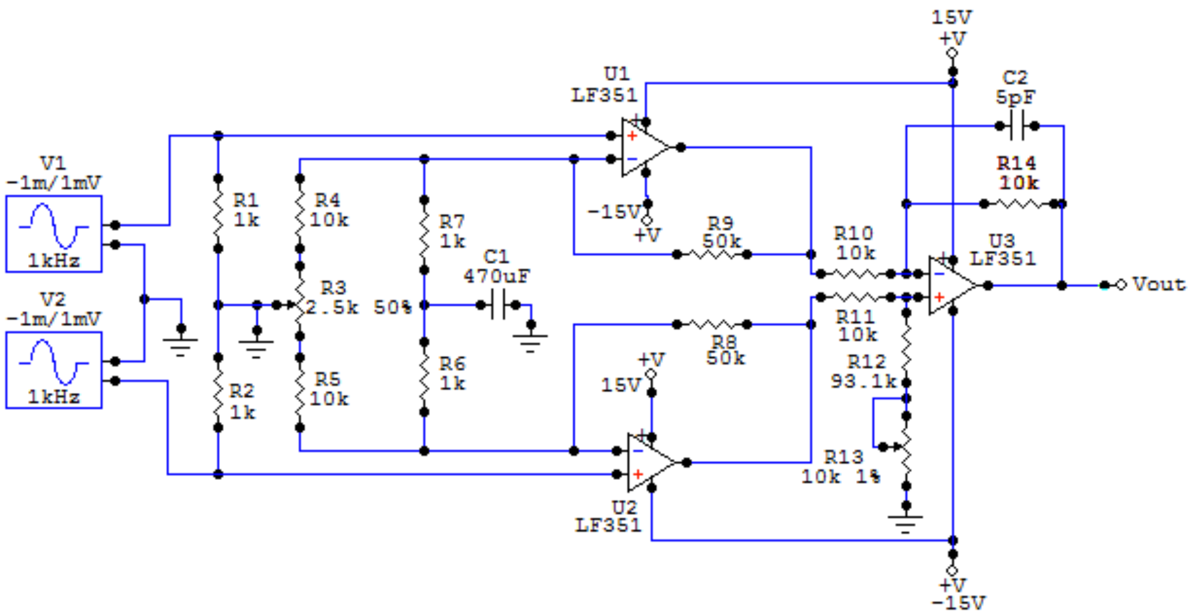
The following circuits detail important components of a mixing console. With this project I'll summarize basic signal flow directly from microphone to mixer. The first circuit is a high performance (I) balanced microphone preamp. It accepts balanced input from a microphone and gives the signal an initial boost in amplitude. This signal is fed into a (II) 3rd order high pass filter that acts as a rumble filter to clean the signal of any low frequencies. The third circuit will describe a (III) single band parametric EQ used to boost or attenuate specified frequency bands. The final circuit designed to manipulate the original signal is a (IV) 2-band shelving filter. This gives further control to adjust dB levels of low or high frequencies. From here some of the signal will be sent into a (V) channel monitor module that is responsible for routing the signal into two Sends, 1 and 2. The last circuit, an (VI) active combining network, acts as a mixer. It accepts the 2 returns that were introduced in the channel monitor module and the dry input channel (along with all the other returns and channels that are just duplicates of the first). It sums them all together and outputs the final product as a balanced signal.





I. Balanced Microphone Preamp

- The microphone preamp circuit accepts a balanced, differential input. There are two main parts to this circuit, the first being the two op-amps U1 and U2. They set most of the gain for each signal. The amount of gain is controlled by R1, R2, R8, and R9, the input resistances R_i and feedback resistances R_f. The second part of the circuit is to subtract the two differential signals into one. This is accomplished by a third op-amp, U3. This op-amp's primary function is to subtract the two signals so it only provides a slight amount of gain. R13's function is to adjust the common mode rejection. Since we are primarily interested in the differential gain and not the common mode signal gain we want to try to get as low a common mode gain as possible. R13 and R12 should be tweaked so that the input voltage to the non-inverting port of op-amp U3 is as close to the input voltage of the inverting port as possible.



- For my chosen R_i and R_f values the amplitude gain A_v of the first part of the circuit is given by:

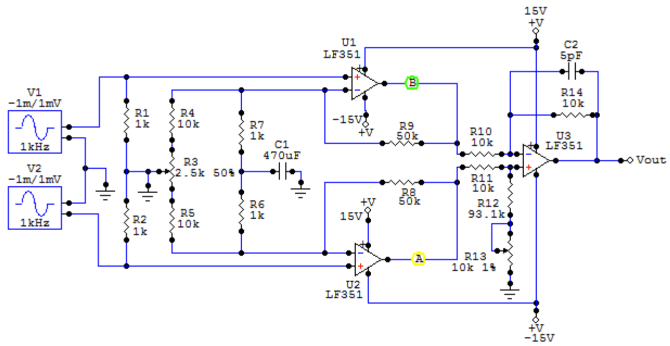
$$A_v = 1 + \frac{R_f}{R_i}$$

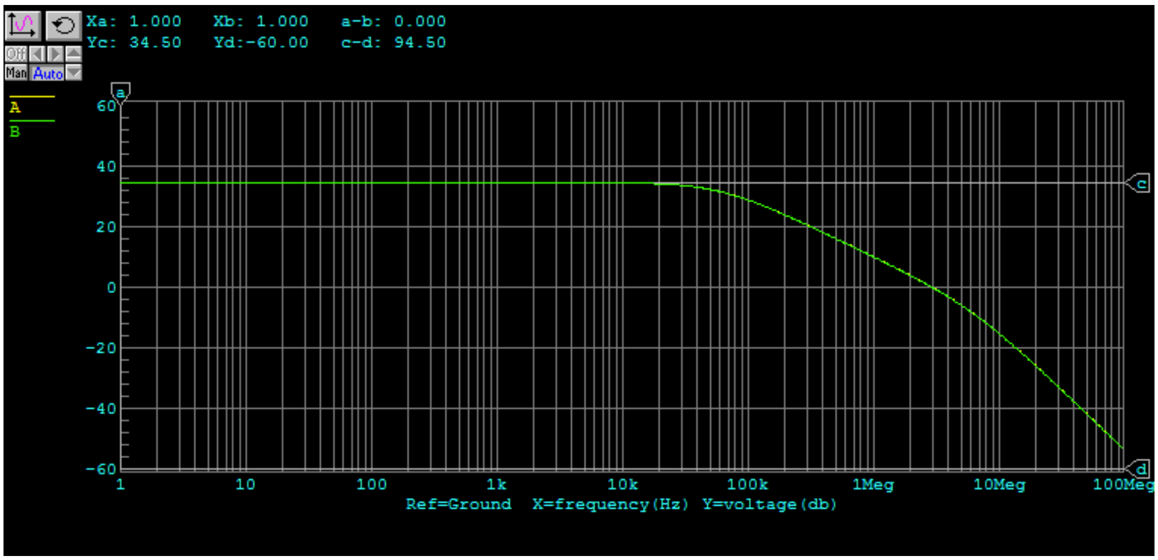
$$A_v = 1 + \frac{R_f}{R_i} = 1 + \frac{50k\Omega}{1k\Omega} = 51$$

$$dB = 20\log(A_v)$$

$$dB = 20\log(51) = +34dB$$

- Here’s the gain of the circuit when probed after U1 and U2 confirming the +34dB calculated. (Shown by marker ‘c’).



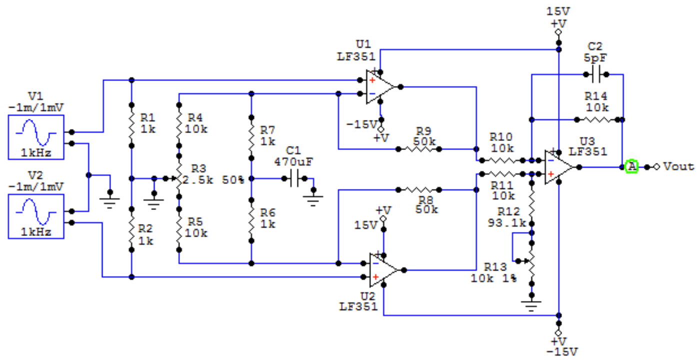


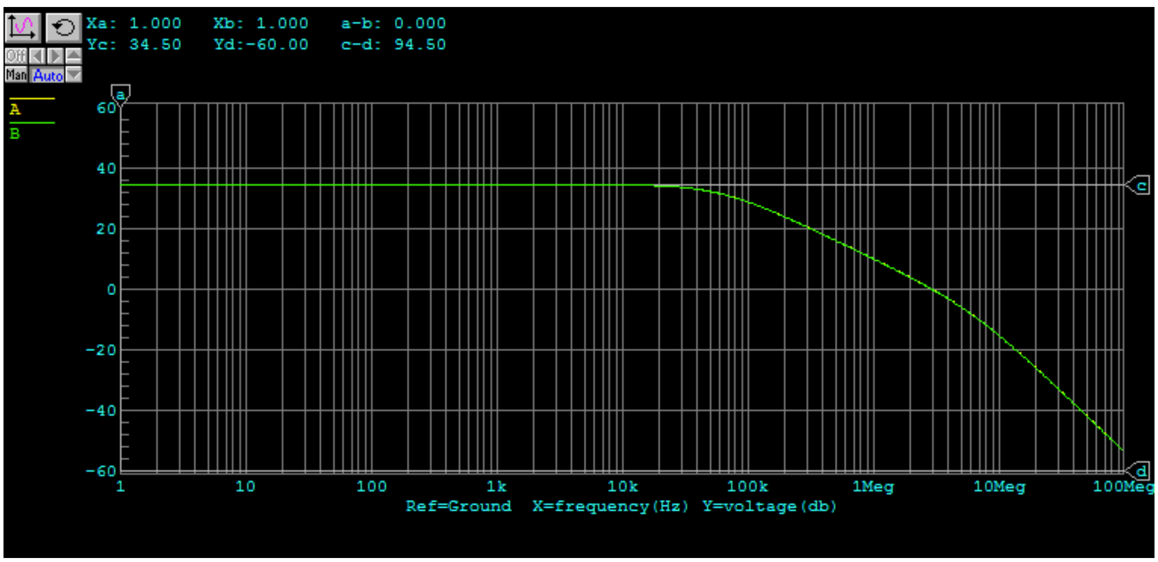
- For my chosen R_i and R_f values the amplitude gain A_v of the second part of the circuit is given by:

$$A_v = -\frac{R_f}{R_i}$$

$$|A_v| = -\frac{10k\Omega}{10k\Omega} = 1$$

- This is just unity gain, so the second part of the circuit ends up ideally providing no gain.

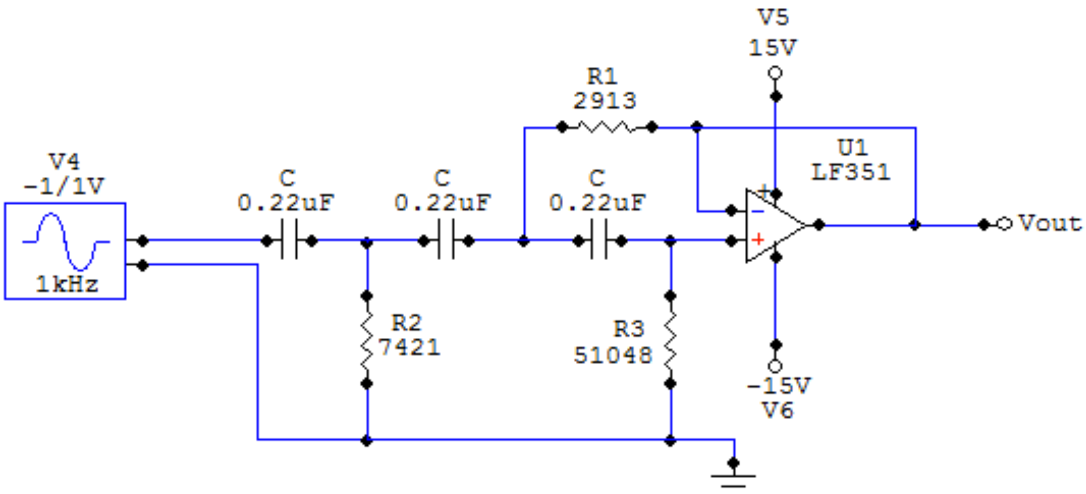




- Marker ‘d’ confirms that the gain is still +34dB.

II. 3rd Order High Pass Filter

- This active 3rd order HPF is specified to have a cutoff frequency f_c of 70Hz.



- Design Equations:

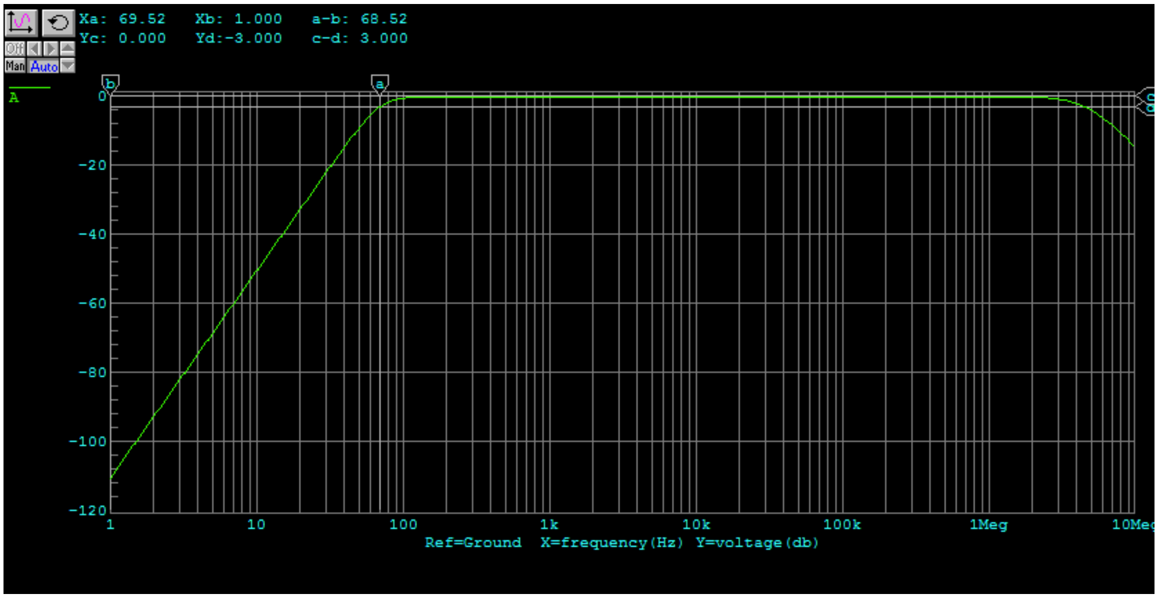
$$f_c = 70Hz$$

$$C = 0.22uF$$

$$R_1 = \frac{0.28194}{2\pi f_c C} = \frac{0.28194}{2\pi(70Hz)(0.22uF)} = 2913\Omega$$

$$R_2 = \frac{0.71808}{2\pi f_c C} = \frac{0.71808}{2\pi(70Hz)(0.22uF)} = 7421\Omega$$

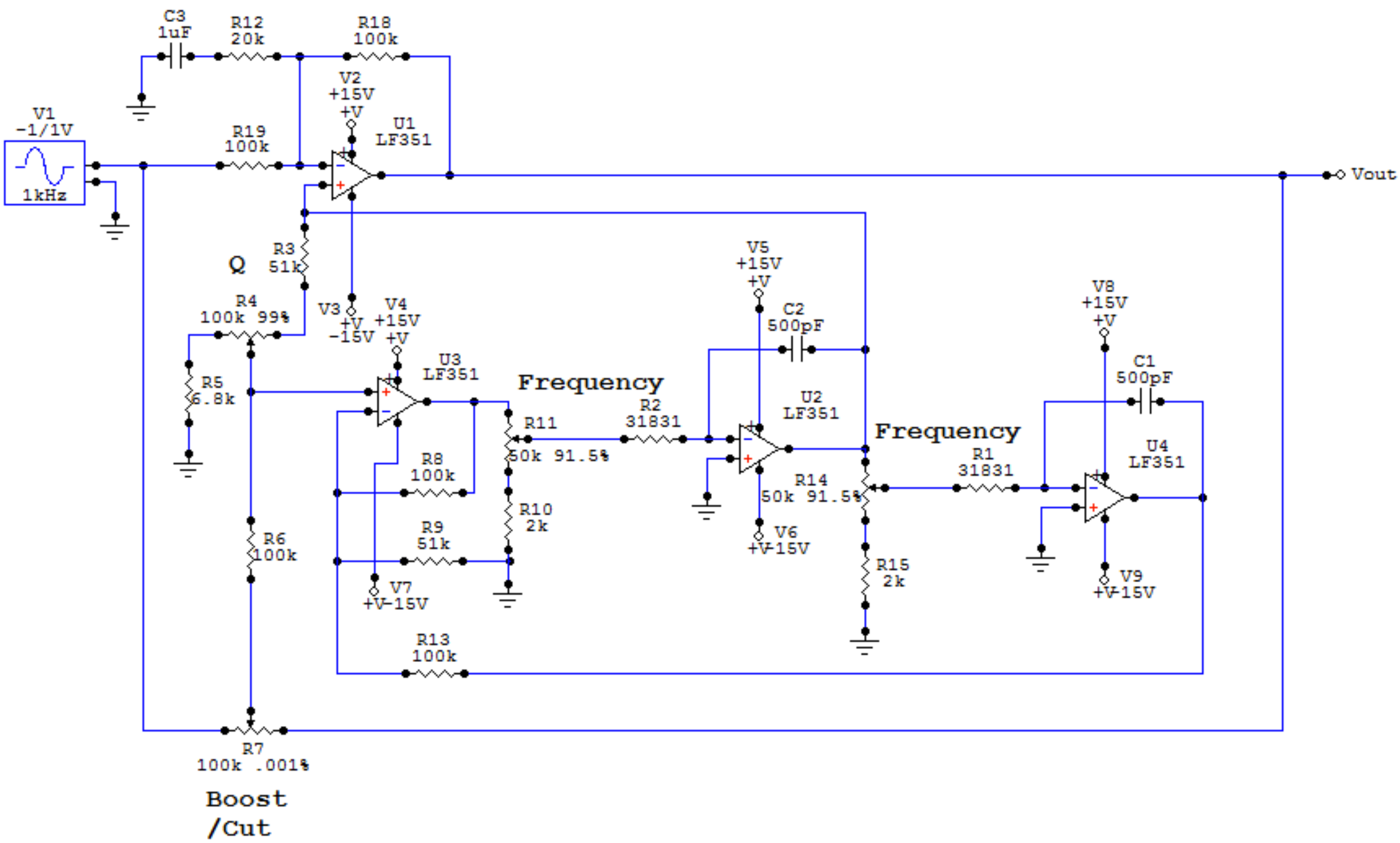
$$R_3 = \frac{4.93949}{2\pi f_c C} = \frac{4.93949}{2\pi(70Hz)(0.22uF)} = 51048\Omega$$



- Probing at the output confirms that the cutoff frequency of this HPF is 70Hz (notated by marker 'a').

III. Parametric EQ

- The parametric EQ circuit shows four variable resistors that can be used to alter the Q resonant hump, the center frequency, and boost/attenuation of the affected frequency bands. R11 and R14 are dual-ganged variable resistors that are both turned with one knob to control the center frequency. This circuit only has one band of control for EQ modifications.

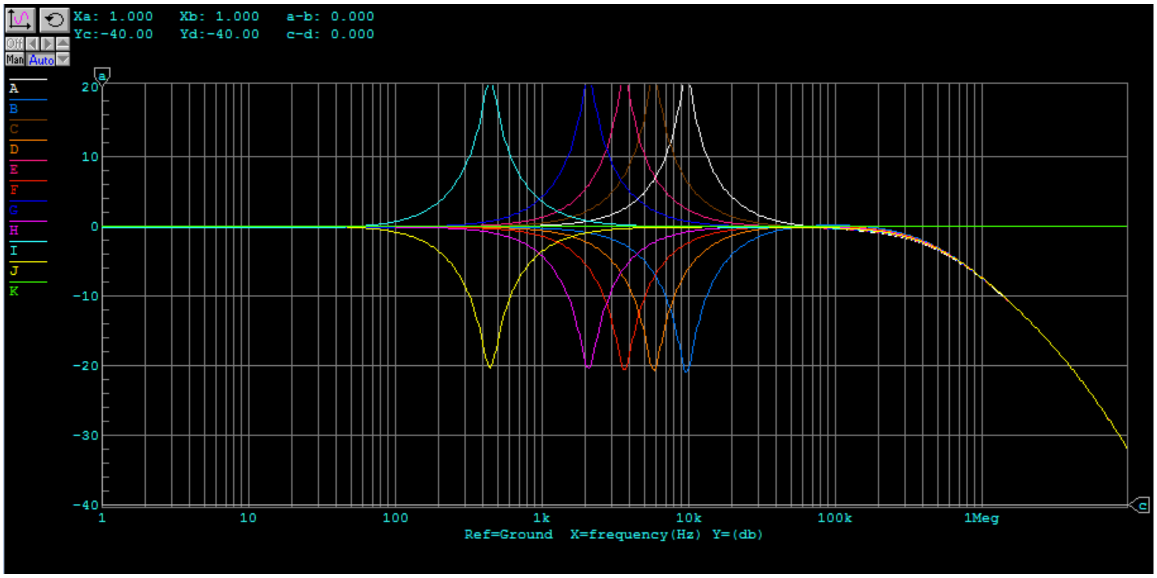


- Specs:

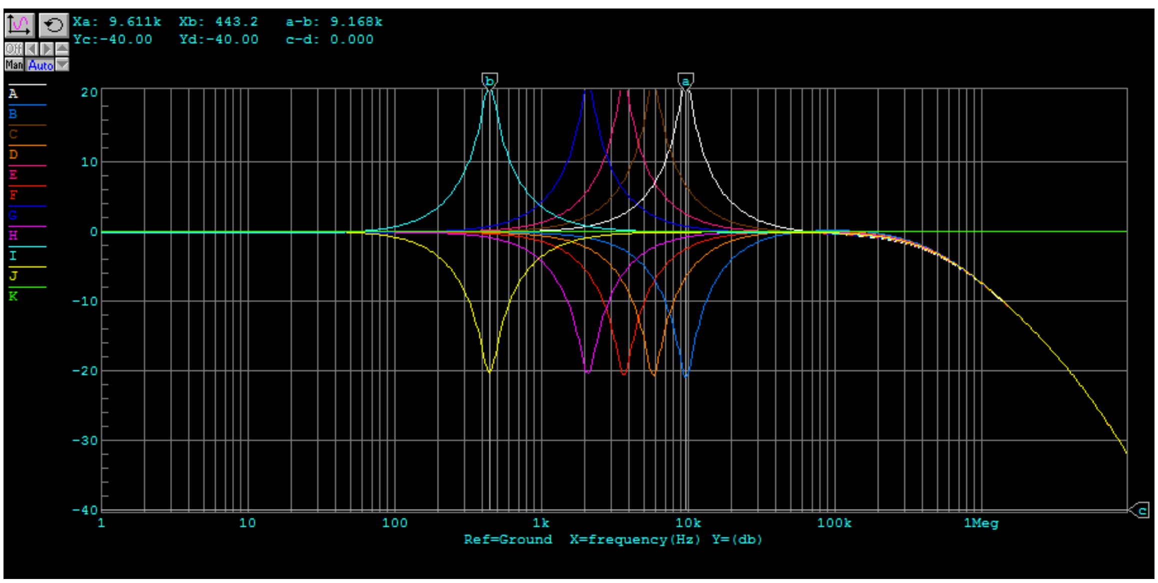
$f_h = 10kHz$
$C_1 = 500pF$
$C_2 = 500pF$

- Design Equations

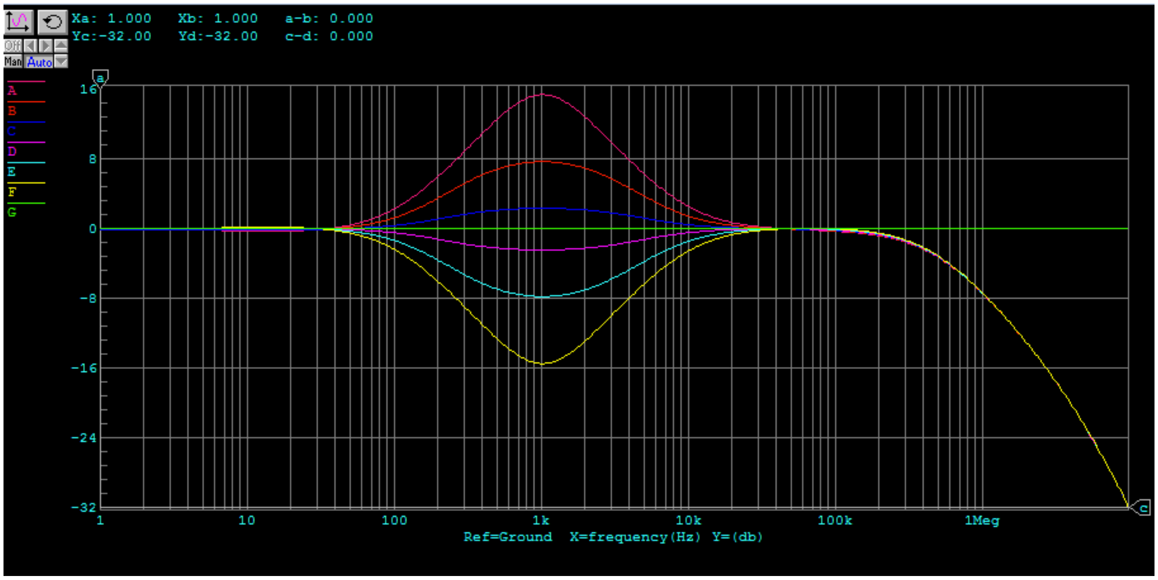
$$R_1 = R_2 = \frac{1}{2\pi f_h C_1} = \frac{1}{2\pi(10kHz)(500pF)} = 31831\Omega$$



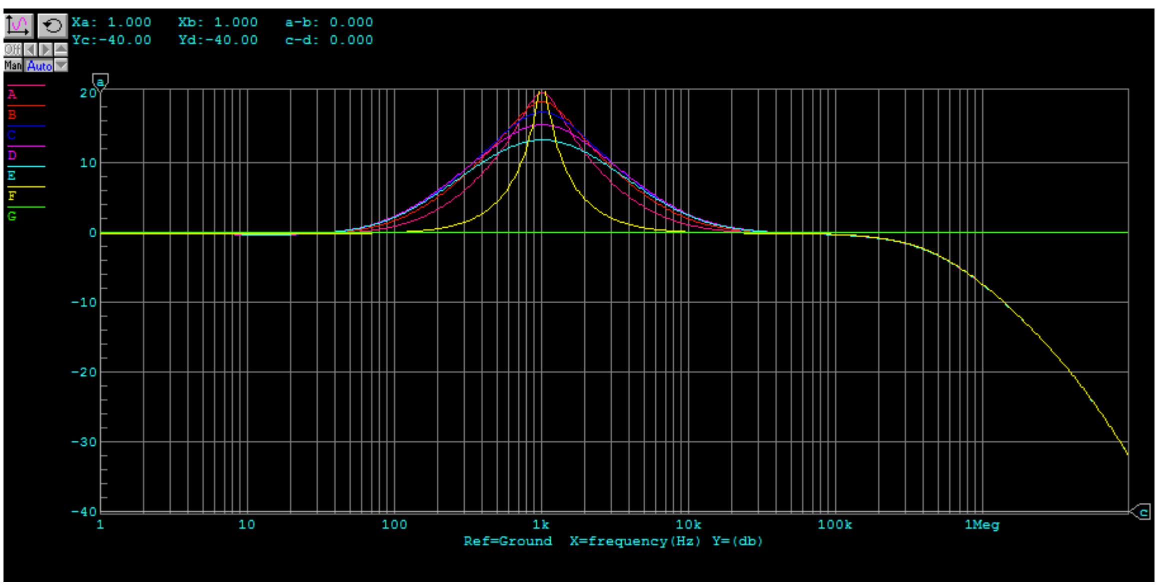
- With the Q, boost, and cut set at a maximum here we can see five plots of varying center frequencies.



- Marker 'a' shows the highest center frequency as about 9.6kHz and marker 'b' shows the lowest center frequency as about 440Hz (the A above middle C).
- 4.5 octaves above 440Hz is approximately 10kHz. The theoretical range of the parametric EQ is slightly higher than the practical range.



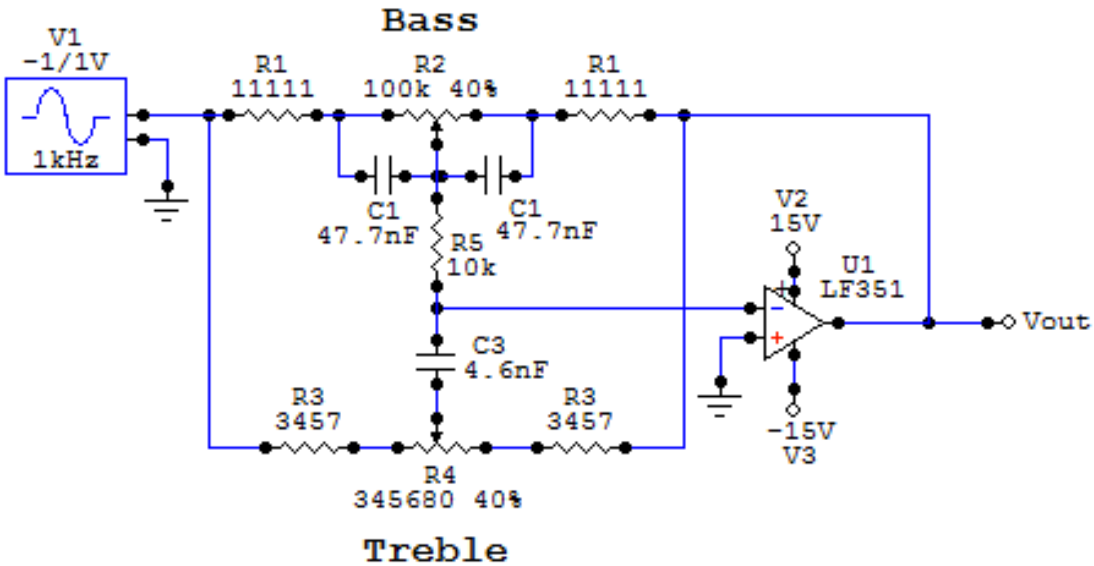
- With the Q and center frequency controls set at a medium value we can see the range of boosts and cuts this parametric EQ is capable of.



- Similarly, with the center frequency and boost controls set at a maximum value we can see the range of Q this parametric EQ is capable of.

IV. 2-Band Shelving Filter

- This 2-band shelving filter uses a Baxandall design. It is called an *active* Baxandall design because it utilizes an active component – the amplifier. It is designed to provide a maximum boost/cut of 20dB for two separate bands. The two variable resistors R2 and R4 control the bass (lower band) and treble (upper band) respectively.



- Specs:

$f_L = 30Hz$
$f_H = 10kHz$
A boost/cut of +/- 20dB

- Design Equations

$$A_{VB} = A_{VT} = 10^{\frac{dB}{20}} = 10^{\frac{20}{20}} = 10$$

$$R_2 = 100k\Omega$$

$$R_1 = \frac{R_2}{A_{VB} - 1} = \frac{100k\Omega}{10 - 1} = 11111\Omega$$

$$f_{LB} = 10f_L = 10(30Hz) = 300Hz$$

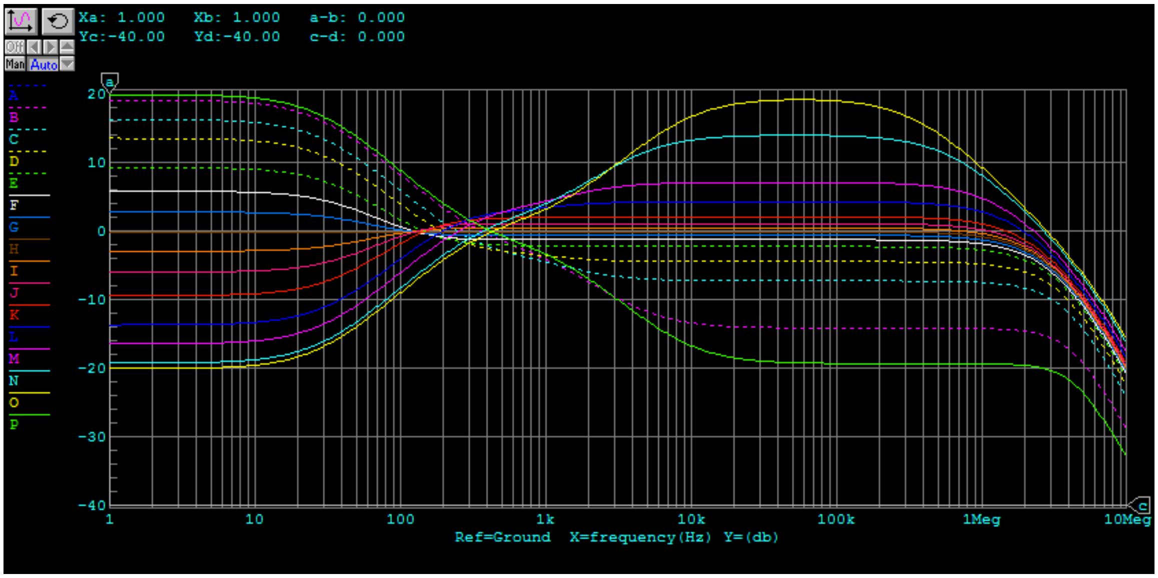
$$C_1 = \frac{1}{2\pi f_{LB} R_1} = \frac{1}{2\pi(300Hz)(11111\Omega)} = 47.7nF$$

$$R_5 = 10k\Omega$$

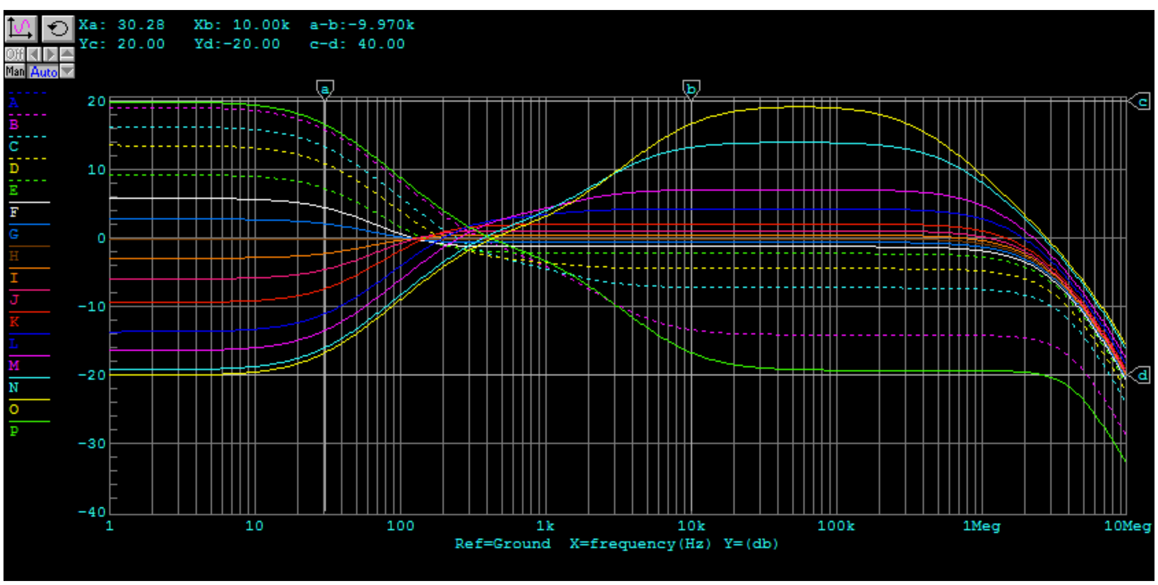
$$R_3 = \frac{R_1 + 2R_5}{A_{VT} - 1} = \frac{11111\Omega + 2(10k\Omega)}{10 - 1} = 3457\Omega$$

$$C_3 = \frac{1}{2\pi f_H R_3} = \frac{1}{2\pi(10kHz)(3457\Omega)} = 4.6nF$$

$$R_4 \geq 10(R_3 + R_1 + 2R_5) = 10\big(3457\Omega + 11111\Omega + 2(10k\Omega)\big) = 345680\Omega$$



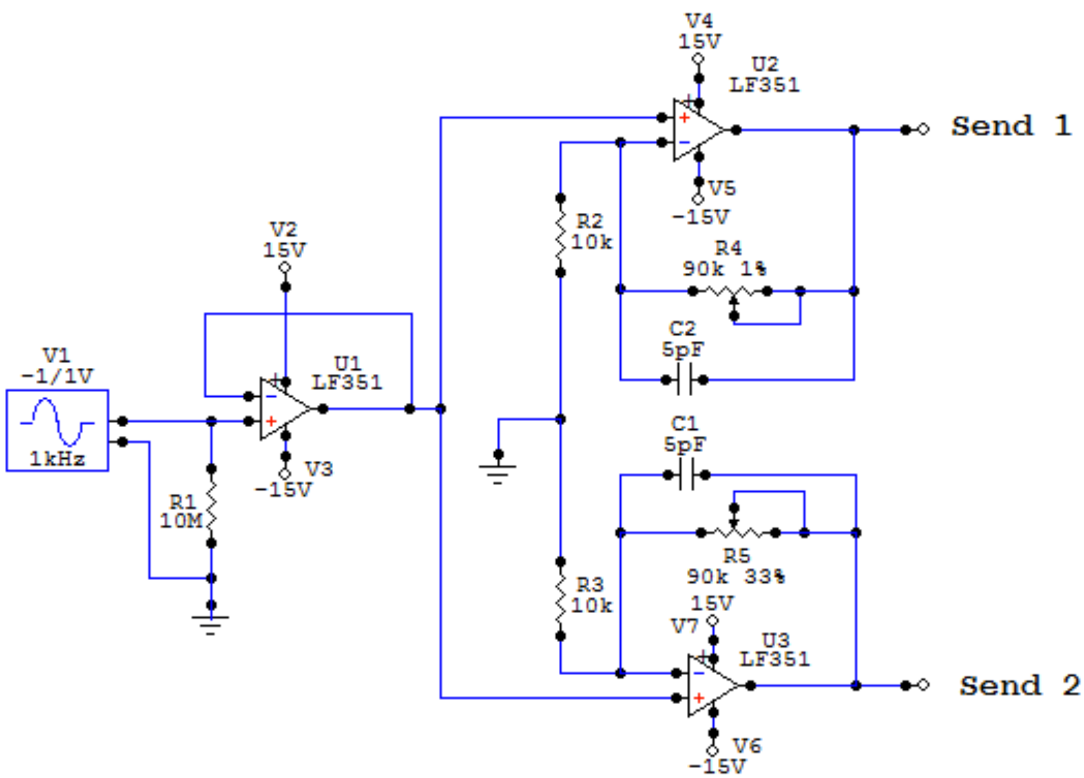
- A visual representation of various shelving settings available to this filter.



- A maximum gain of +20dB is confirmed by marker ‘c’. Likewise, marker ‘d’ shows a maximum cut of -20dB. The low break frequency of 30Hz and high break frequency of 10kHz are verified by markers ‘a’ and ‘b’ respectively.

V. Channel Monitor Module

- This circuit takes 1 input and splits the signal into two new inputs, each with gain control. R1 sets the initial input impedance to 10MΩ and U1 serves as a unity buffer to prevent loading on the outputs. R2 acts as R_i for Send 1 and R3 acts as R_i for Send 2. The two potentiometers R4 and R5 serve as R_f for Send 1 and Send 2 respectively. They also allow you to control the individual gain for each output with a max output of +20dB being achievable.



- Specs:

Input Impedance: 10MΩ
Min Send Gain: 0dB
Max Send Gain: +20dB

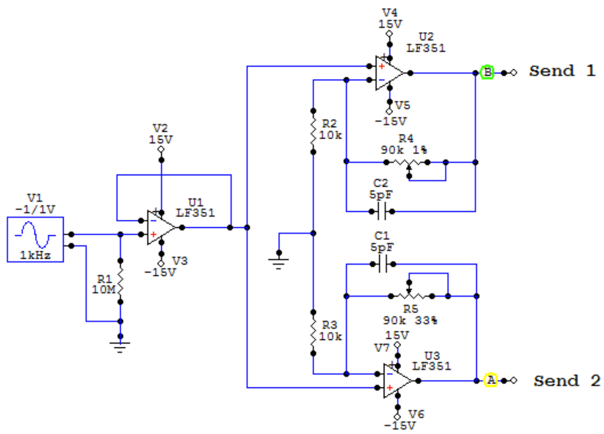
- Design Equations:

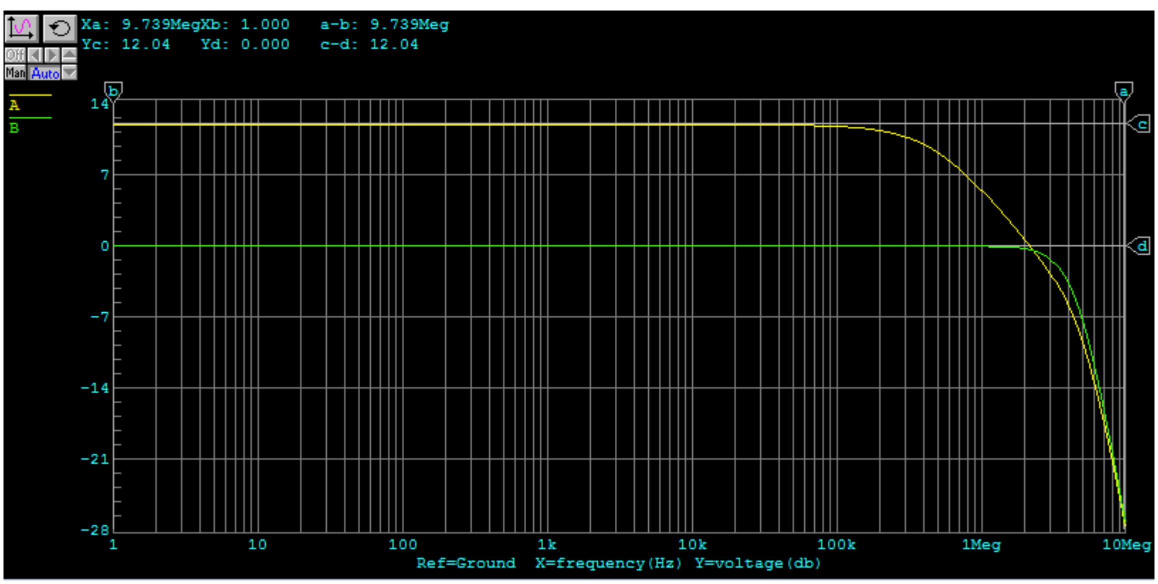
$$A_v = 10^{\frac{dB}{20}} = 10^{\frac{20}{20}} = 10$$

$$R_i = 10k\Omega$$

$$A_v = 1 + \frac{R_f}{R_i}$$

$$R_f = R_i(A_v - 1) = 10k\Omega(10 - 1) = 90k\Omega$$

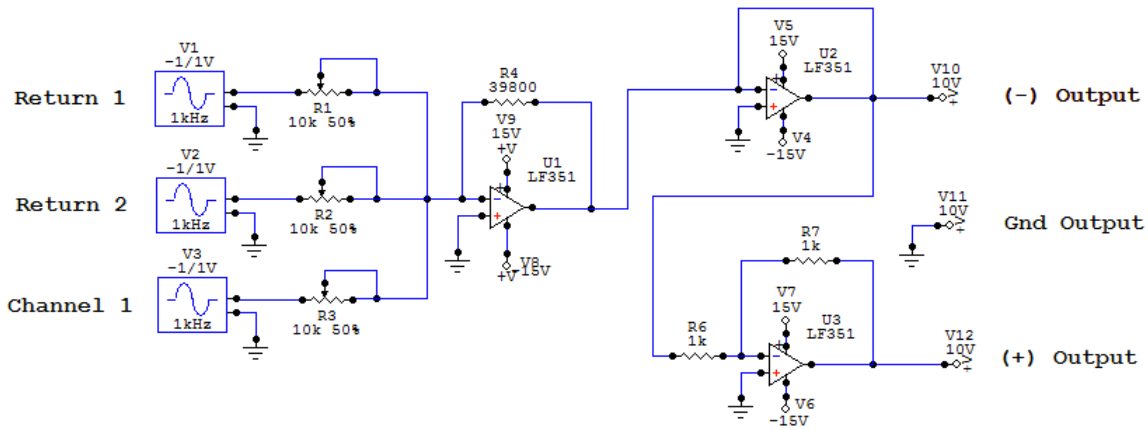




- As an example, Send 1 is set to unity gain and Send 2 is set to +12dB of gain. This is verified by probing both sends simultaneously and observing that marker ‘c’ confirms +12dB of gain for Send 2 and marker ‘d’ confirms a gain of 0dB for Send 1.

V. Mixer (Active Combining Network)

- The final circuit, an active combining network, accepts the two returns as well as the dry channel signal and mixes sums them together. It also outputs a balanced signal. The summing is done with op-amp U1. R1, R2, and R3 control the levels of the three inputs with a max gain of +12dB being realizable at this last stage. Balanced line drivers U2 and U3 are used to split the signal into an inverted and non-inverted output. R6 and R7 are matched to not allow for any gain from U3 and U2 is a unity gain buffer that does not alter the phase or gain.



- Specs:

Inputs: Return 1, Return 1, Channel 1
Max Channel Gain: +12dB
Output: Balanced

- Design Equations:

$$R_1 = R_2 = R_3 = 10k\Omega$$

$$A_v = 10^{\frac{dB}{20}} = 10^{\frac{12}{20}} = 3.98$$

$$A_v = -\left(\frac{R_4}{R_1} + \frac{R_4}{R_2} + \frac{R_4}{R_3}\right)$$

$$3.98 = \frac{R_4 + R_4 + R_4}{10k\Omega + 10k\Omega + 10k\Omega}$$

$$R_4 = 39800\Omega$$