MMI401 Lab 6

Op-Amp Mic Preamps

In this lab you will design two balanced mic preamps. Both will use the NE5534 as a non-inverting amp. The TA will show you how to connect the extra 22pF cap across the HF Compensation pins of the device. The 5534 is a Single op-amp, so its pin connections are not the usual.

1. Transformer Coupled Balanced Mic Preamp

Design a mic preamp using a (new) 1:20 Transformer and an op amp. Place the 1:10 Transformer on your workspace in CM. Right click the transformer and choose Edit Device Data. Change the RATIO from 10 to 20 (CM uses the upside down equations, their ratio is ns/np though they name it np:ns) and also change the name to something else; we are trying to mimic the Jensen transformer in your book. You need to design this to be adjustable for various gains.

Specs:
Rails = +/- 15V
Max Gain = 60 dB, *adjustable*
Input: Balanced (use 2 signal generators, the TA can show you how)
Output: Unbalanced
DC Stabilized Design

You will need to do the proper calculations to account for all the gains - the transformer and op amp. Also remember to include the HF Compensation cap in the feedback path as well as the one you need for the 5534. The DC Stabilization cap is going to affect the low frequency rolloff. Adjust the cap to give you a LF cutoff of 20Hz. **Submit** your CM plots and your hand-calculations to prove your design works.
- What is the minimum gain in dB?
- Why does it have that value?
- What is the bandwidth of the amp?

Next, design this microphone preamp to have the maximum gain possible while keeping an upper cutoff of 20kHz.
- What is your maximum gain in dB?

2. Non-Transformer Coupled Balanced Mic Preamp

Design a mic preamp with op-amps alone, no transformer.

Specs:
Rails = +/- 15V
Max Gain = 60 dB

Input: Balanced (use 2 signal generators, the TA can show you how)
Output: Unbalanced
DC Stabilized Design in second gain stage

You will need two circuits (at least) one for the subtraction and the other for more gain. You can also distribute your gains across the two circuits if you want to try that. Also remember to include the HF Compensation cap in the feedback path as well as the one you need for the 5534. The DC Stabilization cap is going to affect the low frequency rolloff. Adjust the cap to give you a LF cutoff of 20Hz. **Submit** your CM plots and your hand-calculations to prove your design works.

- What is the minimum gain in dB?
- Why does it have that value?
- What is the bandwidth of the amp?

Next, design this microphone preamp to have the maximum gain possible while keeping an upper cutoff of 20kHz.

- What is your maximum gain in dB?

Circuit 1

Specs:
Rails = +/- 15V
Max Gain = 60 dB, adjustable
Input: Balanced (use 2 signal generators, the TA can show you how)
Output: Unbalanced DC Stabilized Design

Transformer:

$$a = \frac{n_p}{n_s} = \frac{V_p}{V_s}$$

$$V_s = \frac{V_p n_s}{n_p} = \frac{(1V)(20)}{(1)} = 20V * 2 = 40V$$

- Balanced to unbalanced doubles the signal

$$dB = 20\log\left(\frac{V_s}{V_p}\right) = 20\log\left(\frac{40V}{1V}\right) = +32dB\ gain$$

Op-Amp:

$$10^{\frac{dB}{20}} = \frac{V_{out}}{V_{in}}$$

$$V_{out} = V_{in}10^{\frac{dB}{20}} = (40V)10^{\frac{+28dB}{20}} = 1004V$$

- +28dB is the remaining amount of gain we need to get the +60dB total gain (+32dB comes from the transformer)

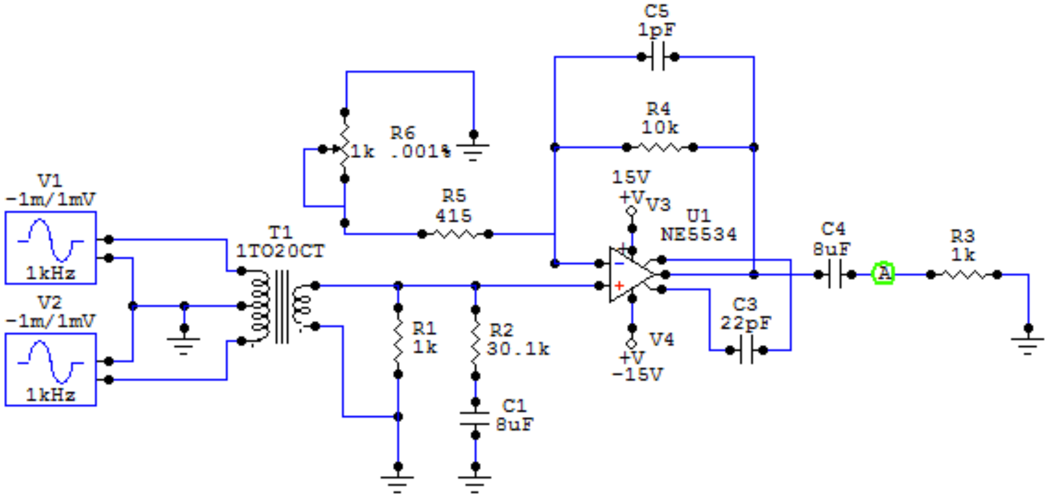
$$V_{out} = V_{in}(1 + \frac{R_f}{R_i})$$

$$\frac{R_f}{R_i} = \frac{V_{out}}{V_{in}} - 1 = \frac{1004V}{40V} - 1 = 24.12 = A_v$$

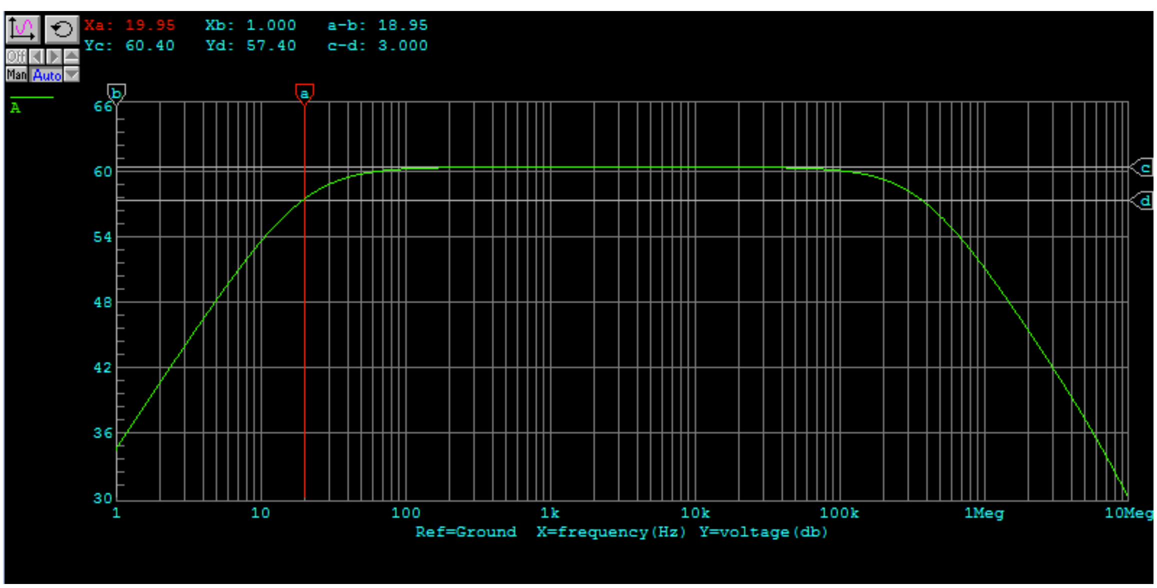
$$R_f = 10k\Omega$$

$$\frac{R_f}{R_i} = 24.12$$

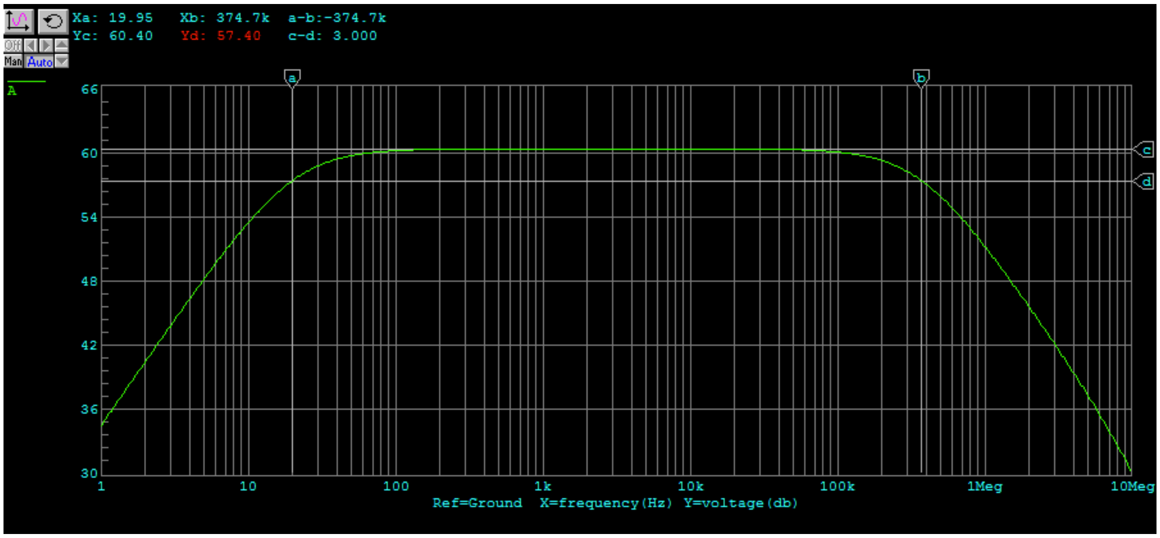
$$R_i = \frac{R_f}{24.12} = \frac{10k\Omega}{24.12} = 415\Omega$$



- The low cutoff frequency of 20Hz (marker 'a') was achieved with an 8uF DC stabilizing cap at the output. Also shown is the total amplification Av of the circuit as +60dB (marker 'c').



- Total bandwidth of the amp is 375kHz-20Hz approximately 375kHz.

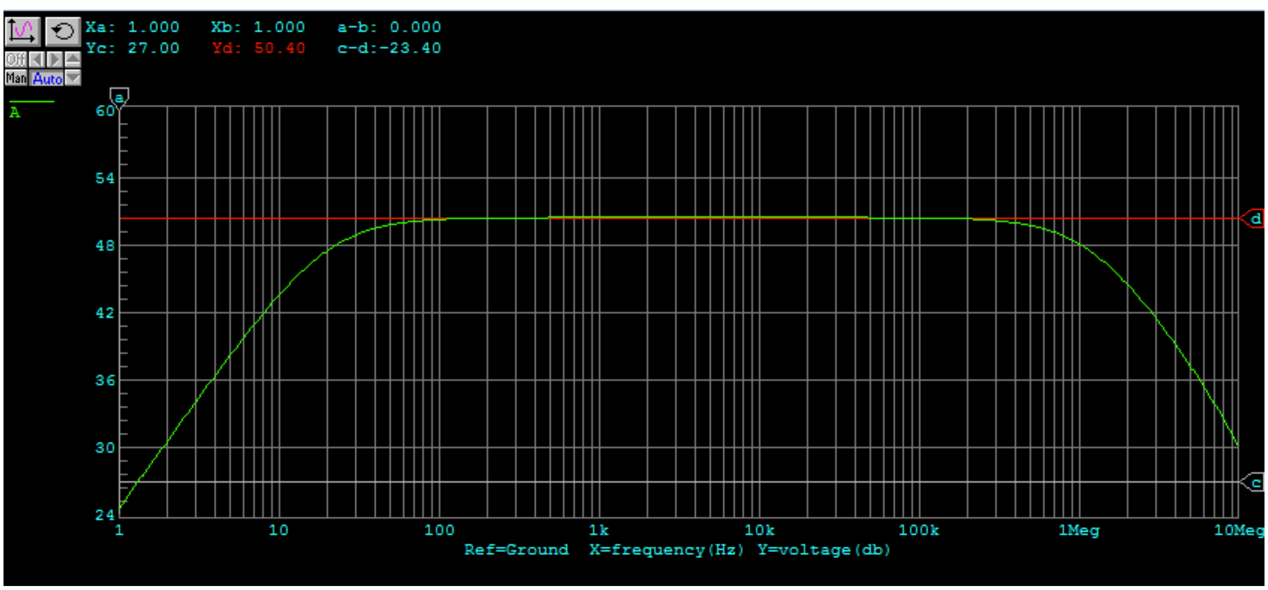


- The minimum gain Av in dB from this amp is +50dB because I set the variable resistor in the Ri path to be 1k ohms. When this is set at a maximum, Ri becomes 1415 ohms and the new Av is given by these equations:

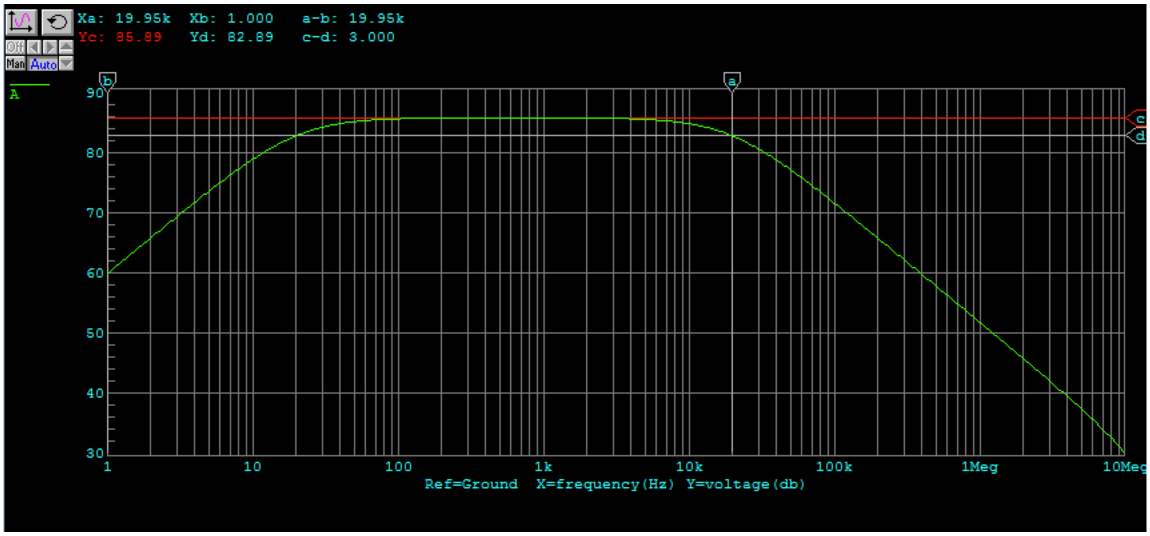
$$A_v = 1 + \frac{R_f}{R_i} = \frac{10k\Omega}{1415\Omega} = 8.07$$

$$dB = 20\log(A_v) = 20\log(8.07) = +18dB$$

$$+18dB + 32dB\ (transformer) = +50dB$$



- The maximum gain of the amp (+86dB shown by marker 'c') while maintaining an upper cutoff of 20kHz. This was achieved with an Ri value of 11 ohms.



Circuit 2:

Specs:
Rails = +/- 15V
Max Gain = 60 dB, adjustable
Input: Balanced (use 2 signal generators, the TA can show you how)
Output: Unbalanced

Subtracting Amp:

- Note: Rf and Ri were chosen arbitrarily

$$A_v = 1 + \frac{R_f}{R_i} = 1 + \frac{1k\Omega}{1k\Omega} = 2$$

$$dB = 20\log(A_v) = 20\log(2) = +6dB$$

Gain Amp:

- Must make up the other +54dB gain

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

$$A_v = 10^{\frac{dB}{20}} = 10^{\frac{+54dB}{20}} = 501$$

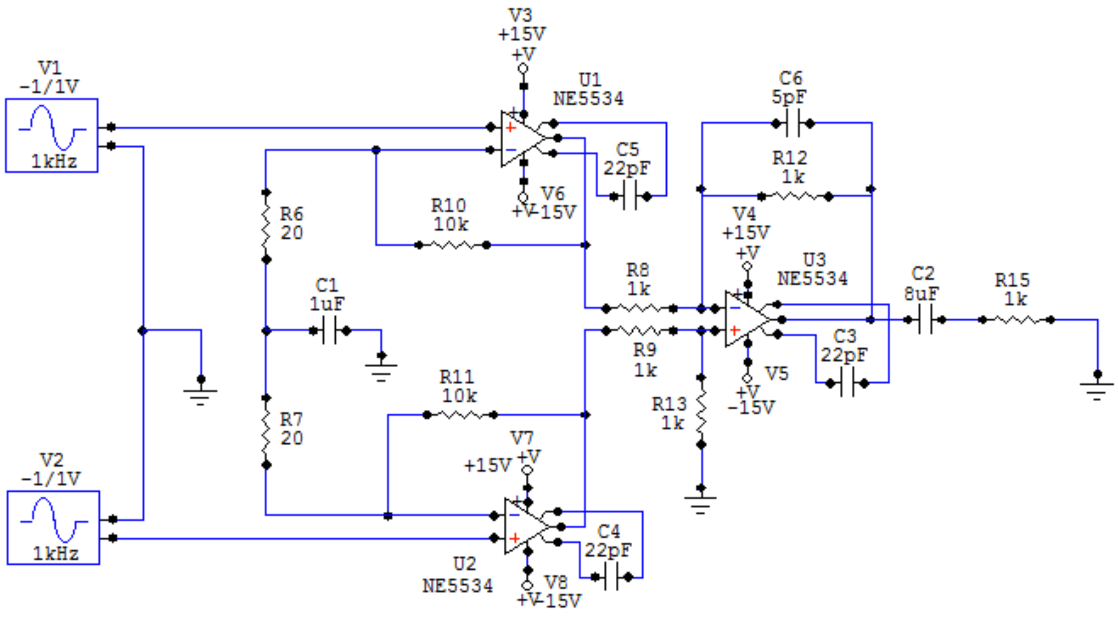
$$A_v = 1 + \frac{R_f}{R_i}$$

$$\frac{R_f}{R_i} = A_v - 1 = 501 - 1 = 500$$

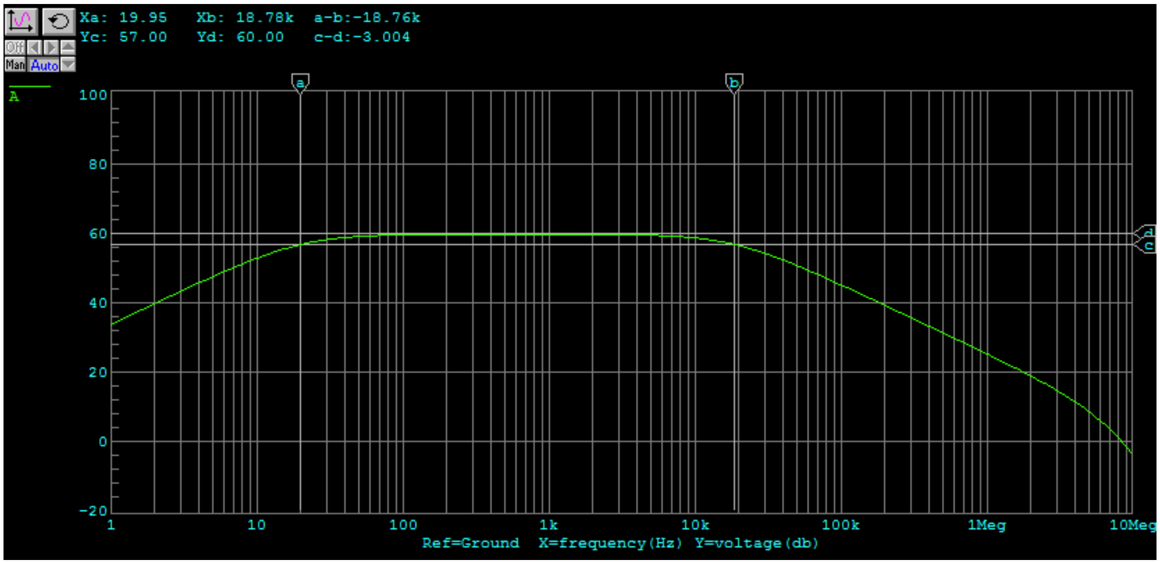
$$R_f = 10k\Omega$$

$$\frac{R_f}{R_i} = 500$$

$$R_i = \frac{R_f}{500} = \frac{10k\Omega}{500} = 20\Omega$$



- The low cutoff frequency of 20Hz (marker 'a') was achieved with an 8uF DC stabilizing cap at the output. Also shown is the total amplification Av of the circuit as +60dB (marker 'd'). The bandwidth is given by marker 'b' – 'a' and is approximately 18.8kHz-20Hz = 18.8kHz.



- My circuit did not have quite 20kHz (1.2kHz short) so the highest practical gain Av is the given +60dB.