Lab 2: Analog Circuits

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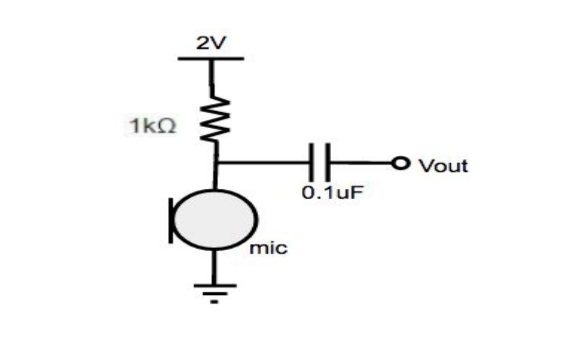
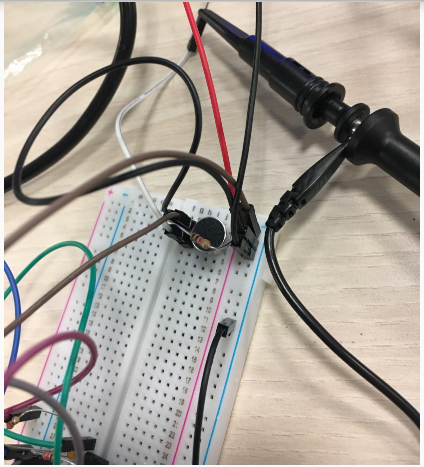
Objective

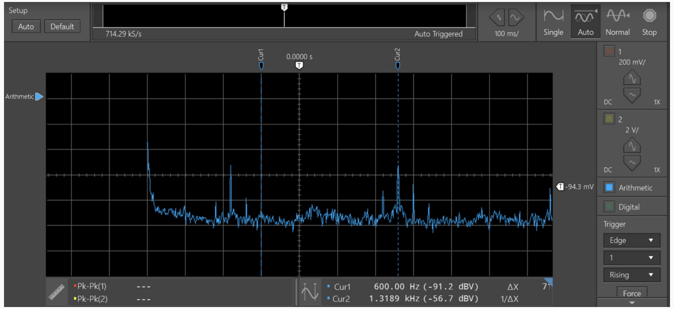
The objective of this laboratory is to understand (and/or review) some basic concepts about analog circuits. The concepts include voltage-to-voltage gain, lower cutoff frequency, upper cutoff frequency, frequency-domain representation, and time-domain representation. Also, the idea that signals can be filtered by a low-pass filter, high-pass filter, and a band-pass filter is depicted.

Challenge #1 - Microphone Circuit



Schematic of Microphone Circuit

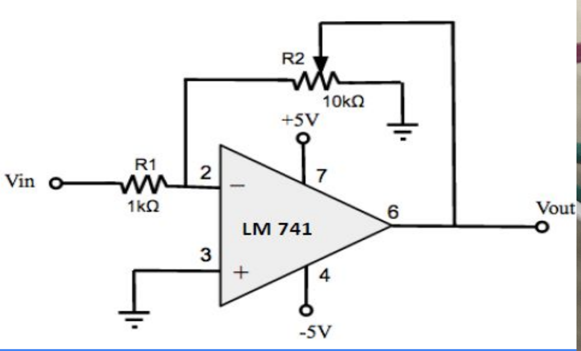




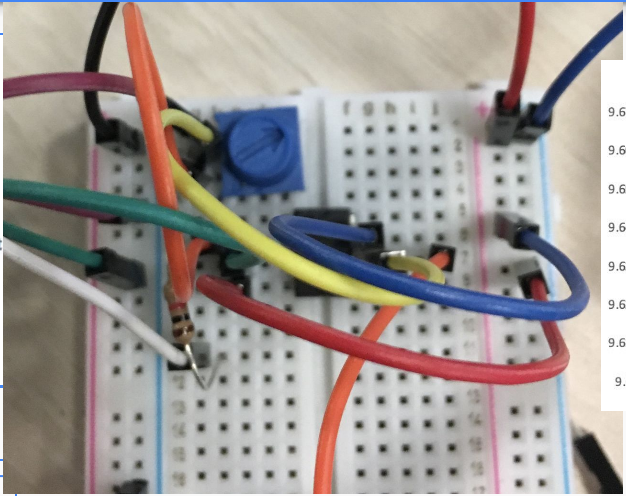
Our circuit has a resistor going from the positive pin of the microphone to power, and the negative pin is grounded. There is also a capacitor from the positive pin and we measure the signal on the other side of it.

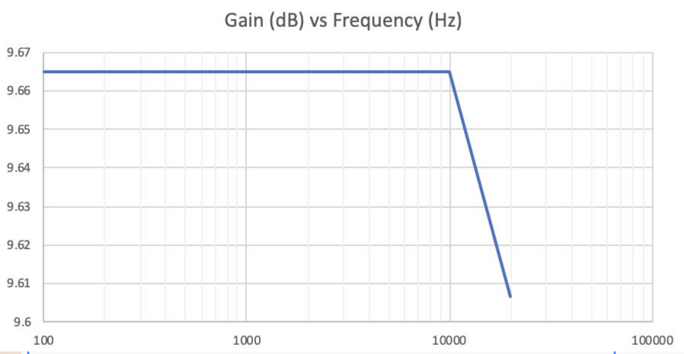
- The plot in this slide shows a fundamental frequency at 450Hz and a harmonic at 3 times that value at 1350Hz.
- The frequency domain is a representation in which an engineer is interested in the amplitude of a signal at each frequency.
- The fundamental frequency of note 1 is 450Hz, the fundamental frequency of note 2 is 1050Hz.

Challenge #2 - Amplifier



Schematic of Amplifying Circuit

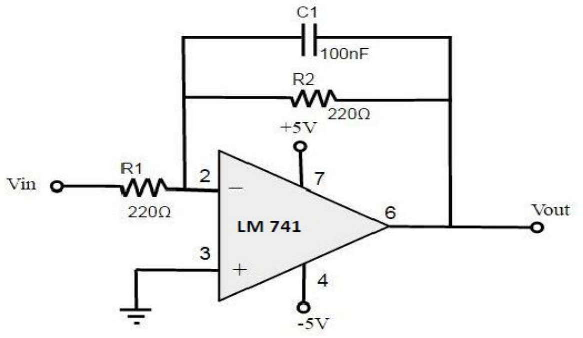




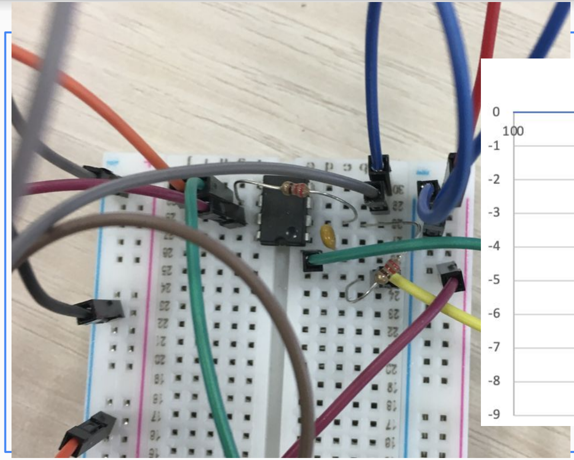
Our circuit has an LM741 IC with a resistor at the input and a potentiometer to ground with the middle pin connected to the output.

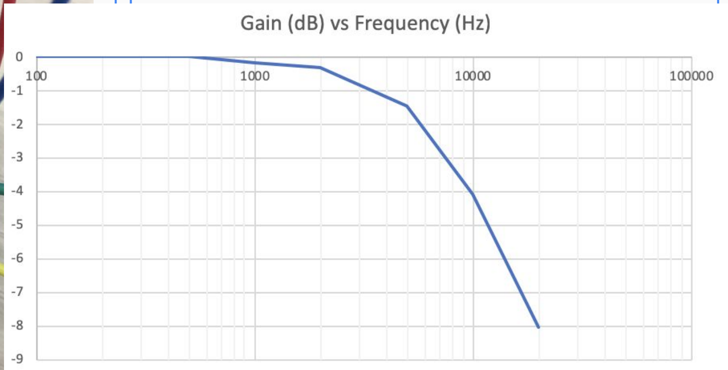
Our plot shows a basically constant gain vs frequency, meaning that the cutoff frequency of this amplifier is higher than 20kHz.
An amplifier is a circuit in which the output is an amplified version of the input. The output divided by the input is a transfer function. The transfer function of the amplifier is an equation that represents the frequency response of the amplifier. For the given circuit on this slide, at the frequencies of interest, the gain is approximately R_2/R_1. This gain is actually the midband gain, and the actual gain of the circuit depends on the frequency of the input signal. An amplifier does have a cutoff frequency because an amplifier like the amplifier that we used for Challenge #2 for Lab 2 has poles because the operational amplifier, resistors, and other elements that we used are not ideal elements.

Challenge #3 - Low Pass Filter



Schematic of Low-Pass Filter

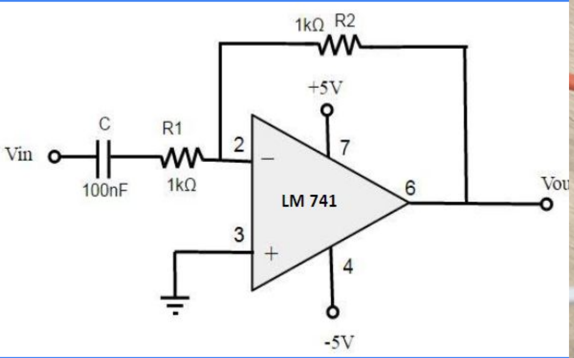




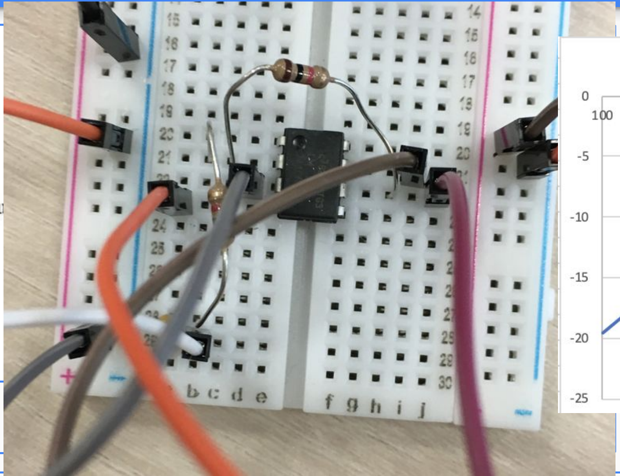
Our circuit has an LM741 IC with a resistor at the input and a resistor and cap in parallel connecting the negative input and output, while the positive input is grounded.

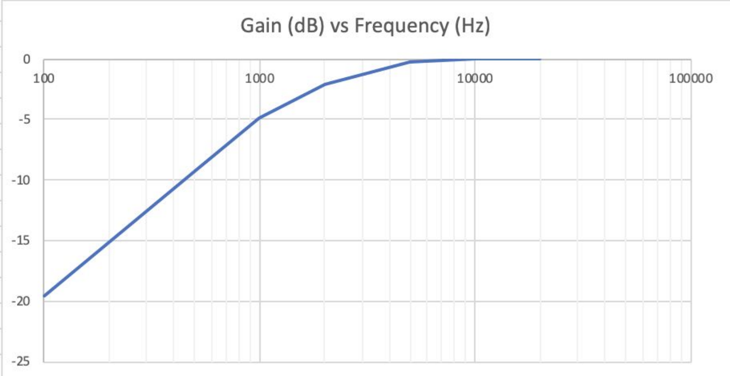
Our plot shows a curve of constant gain until ~1kHz where it starts to drop off. The cutoff frequency seem to be about 7.5kHz which is where the gain reaches -3dB. This is called a lowpass filter because it attenuates signals that are at frequencies that are above the cutoff frequency.

Challenge #4 - High Pass Filter



Schematic of High-Pass Filter

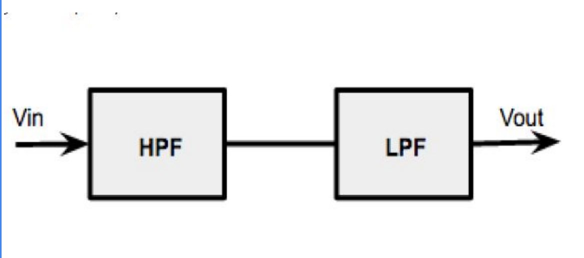




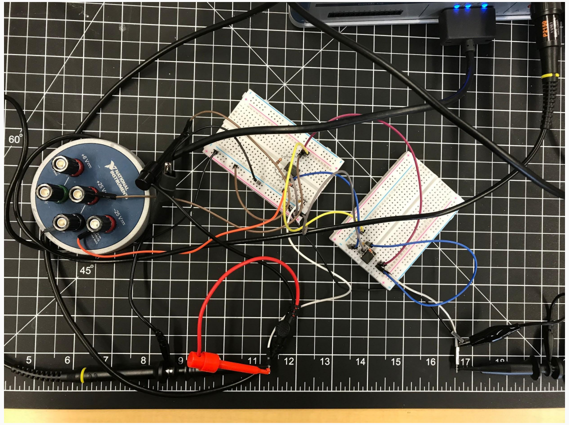
Our circuit has a capacitor in series with a resistor as input to the negative terminal, and a resistor connecting the negative terminal and output, while the positive terminal is grounded.

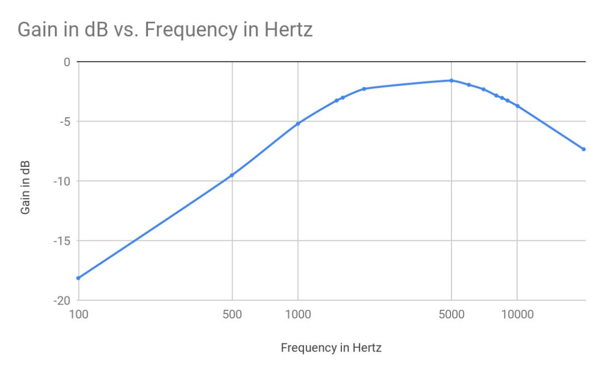
Our plot shows the gain being very small so if you sweep from DC to 20 kHz, lower frequency signals are attenuated until somewhere between 1 kHz and 10 kHz. If we look for where the curve hits -3dB we can estimate the cutoff frequency which looks to be about 1100 Hz. This circuit is called a high-pass filter because low-frequency inputs are attenuated while frequencies that are at least as high as the cutoff frequency are passed.

Challenge #5 - Band Pass Filter



Block diagram of Band Pass Filter





Our circuit is a bandpass filter that is constructed by putting the output of our previous high pass filter as the input of our previous low pass filter. The input to this overall filter goes to the input of the high pass filter and the output is the output of the low pass filter.

The plot shows that the circuit attenuates lower frequencies and higher frequencies, with a range of frequencies in the middle that are not attenuated. A band pass filter is a filter that passes intermediate frequencies of a certain range and does not pass other ranges of frequencies that are either lower than the lower cutoff frequency or higher than the upper cutoff frequency. The band pass filter that is built for Challenge #5 is shown. There are two cutoff frequencies for this band pass filter: the lower cutoff frequency is approximately 1.6 kHz and the upper cutoff frequency is approximately 8.5 kHz. The bandwidth is the difference of the two, which is 6.9kHz.

When the input is a square wave that has a frequency of 1 kHz, the output looks like a rounded off square wave, like it has less coefficients of the Fourier series. The output is not affected by the 100mV offset. A square wave at 100 Hz gives an output that resembles a sine wave but it still has remnants of a square wave. For an input of 10 kHz the output does not at all look like a square wave.