Lab 4: Filters

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Abstract

In this lab we built a hysteretic oscillator followed by a string of two low pass filters and two high pass filters in order to observe the effects of filters on the waveforms of a hysteretic osscilator.

1 The Circuit

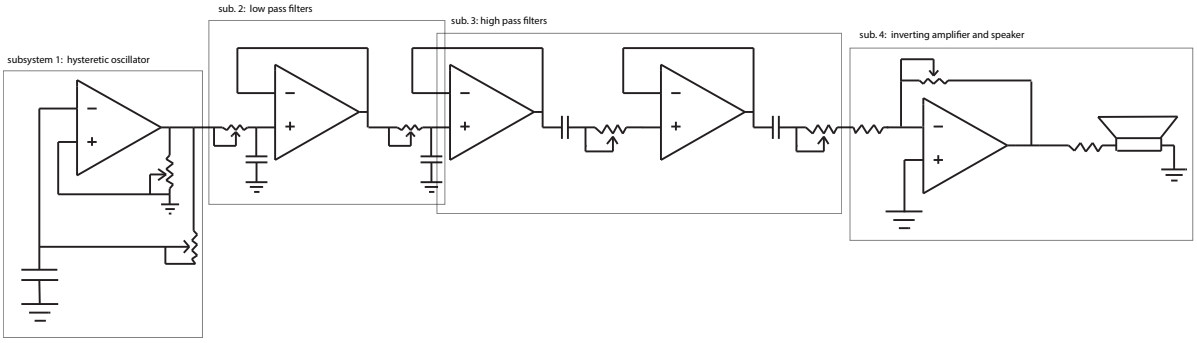

Figure 1: Circuit Diagram

1.1 Qualitative Analysis of Filters

A square wave is composed of lots of frequencies of sine waves squished together. Filters filter out some of those frequencies and allow others to pass through. Low pass filters allow lower frequencies to pass through while high pass filters allow higher frequencies to pass through. Having two low pass filters followed by two high pass filters in series, such as in fig. 1, has the effect of allowing more mid-frequencies to pass through.

1.2 determining the frequency of the oscillator

Below is the math for determining the frequency of the oscillator when the potentiometers are centered and for a capacitor with a capacitance of 1μF. Keep in mind that t is only half a period, so when we want period we will mutiply t by 2.

$$V_c = V_{target} - (V_{target} - V_{co})\, \mathrm{e}^{\frac{-t}{RC}} \tag{1}$$

$$6V = 12V - (12V + 6V)\, \mathrm{e}^{\frac{-t}{.005}} \tag{2}$$

$$6V = (18V)\, \mathrm{e}^{\frac{-t}{.005}} \tag{3}$$

$$\frac{1}{3} = \mathrm{e}^{\frac{-t}{.005}} \tag{4}$$

$$\ln \frac{1}{3} = \frac{-t}{.005} \tag{5}$$

$$t = -.005 \ln \frac{1}{3} \tag{6}$$

But we want frequency. To get frequency we simply take the inverse of one period:

$$f = \frac{1}{2\pi\,(2t)} \tag{7}$$

inserting t from line 6 above we get:

$$f = \frac{1}{4\pi\left(-.005 \ln \frac{1}{3}\right)} \tag{8}$$

$$f \approx 14.4869 \tag{9}$$

1.3 Buiding the Circuit

Debugging the circuit was frustrating and difficult, especially because I still don't entirely understand how potentiometers work and how to align the pins for various desires effects. But my circuit hygiene is awesome, so it was very easy for the ninjas in the room to help me figure out my potentiometer problems. The following images show the process of the circuit being built.

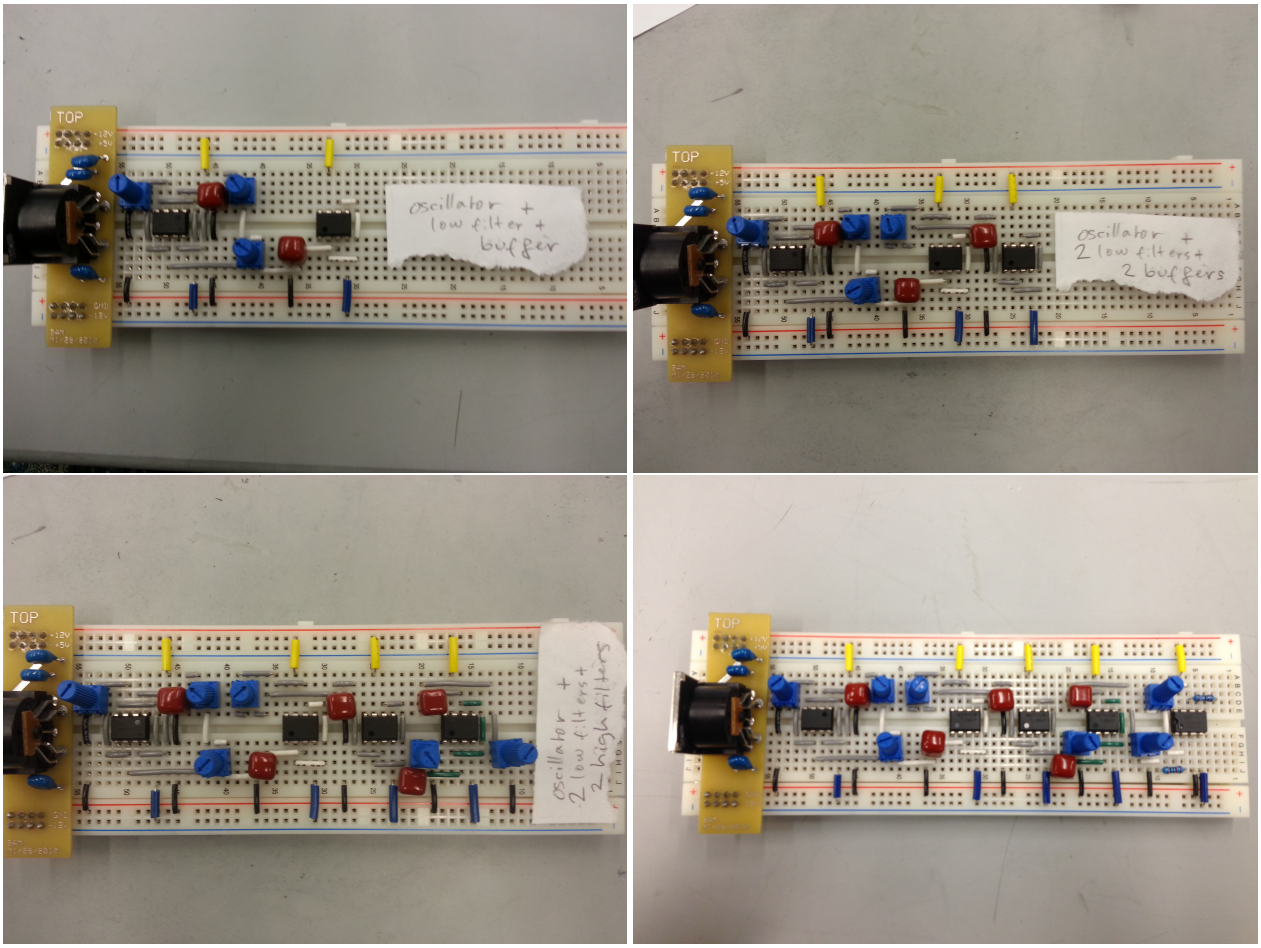

Figure 2: Awesome Circuits!

2 Waveforms of Filters

Below you can see a somewhat lovely graph of overlapping waveforms for the oscillator output and each successive filter output. I did a not so lovely job lining up the waveforms, but Forrest has taught me how to fix this problem so hopefully future graphs will be better.

Anyways, each filter's potentiometer was centered, and the resulting waveform after the final filter shows only the frequencies that were not filtered out. Aka, the whole point of the filters and the potentiometers is to control what frequencies continue to flow through the circuit. When the potentiometer of a filter is set to 0 (zero resistance), no current is drawn and therefore the voltage across the capacitor is zero and the filter has no effect on the system.

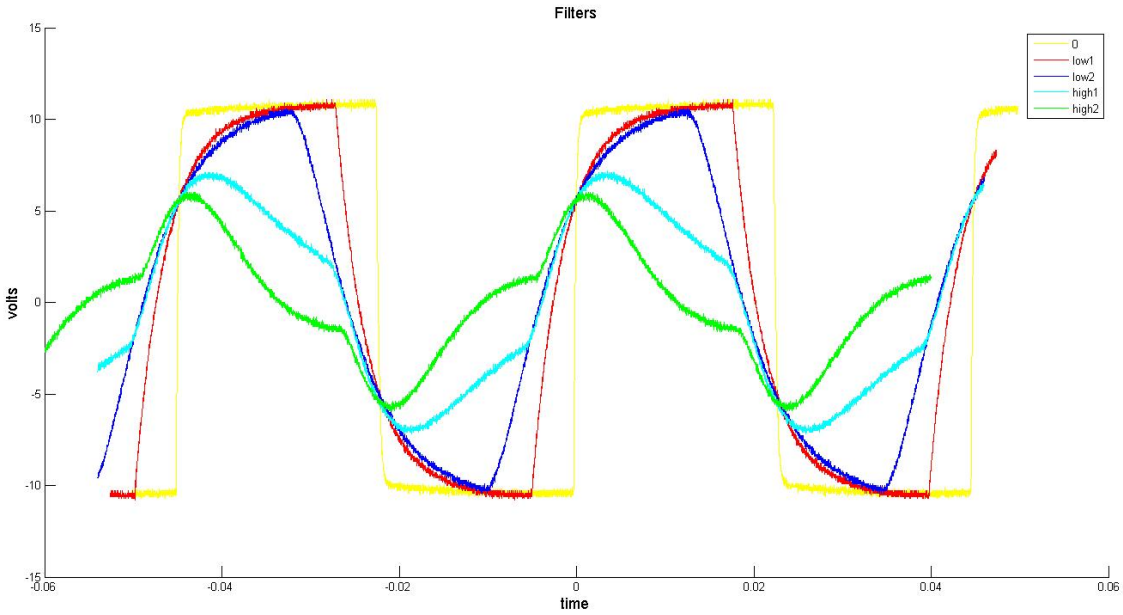

Figure 3: Filter Waveforms