

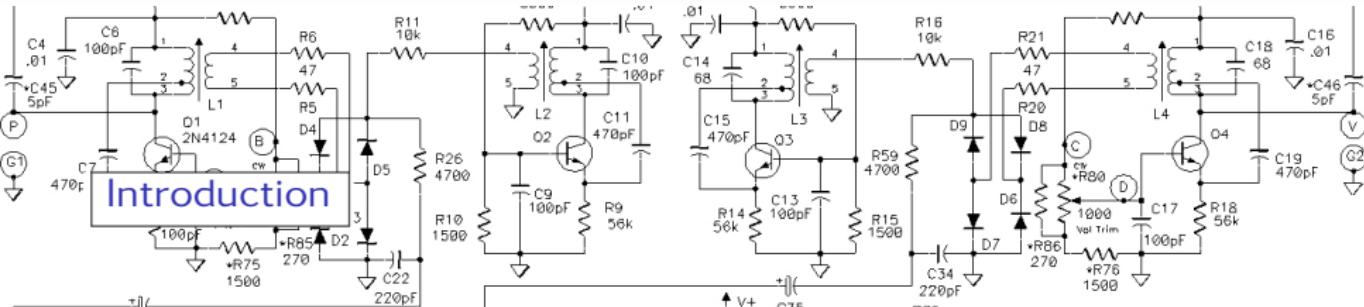
Building a Theremin

J. Wainwright

Department of Physics and Astronomy
University of Birmingham

24th Feb 2012

Outline



Basic Concept

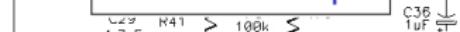
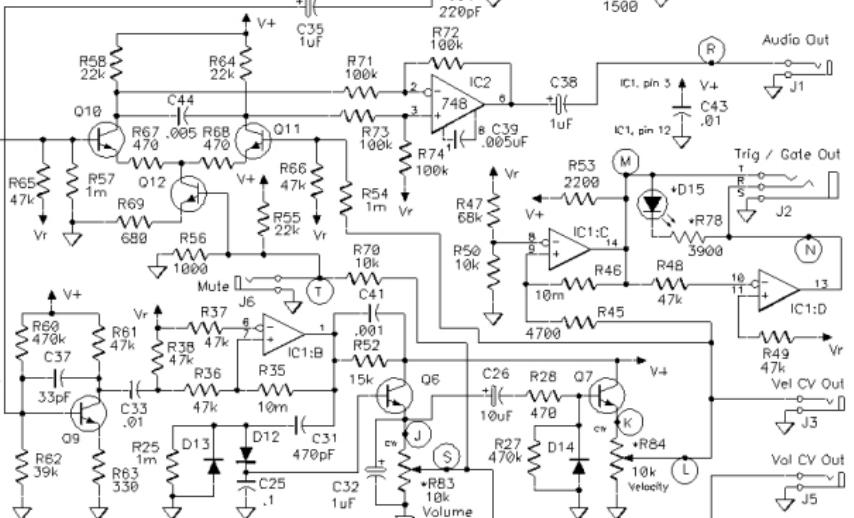
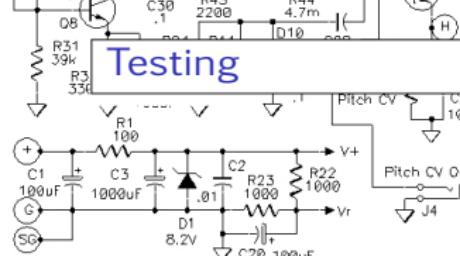


Fig. 5



Task

- As part of 2nd year Physics labs we had to choose a project to implement over a period of 11 weeks.
- Working in teams of 2 students
- The project that I chose was to "Build a Theremin"

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Implementation

First steps included;

- Research
 - Complex circuits in commercial theremin
- First ideas
- Concept designs
 - Started from scratch
 - Modular design to allow testing separately
- Ordering parts

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History

- Developed by Leon Theremin, known in Europe as Leon Theremin.
- Invented in October 1920.
- By product of proximity sensor development.
- Shown to Lenin who dismissed its usefulness but enjoyed the sound.
- Toured Europe to showcase the height of Russian technology.

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Basic Concept

- * One of the only instruments you don't touch to play.
- * Use two hands to interact with the instrument;
- * One hand moves the antenna, the other hand moves the loop antenna.
- * The signals are produced by voltage control oscillators (VCOs).



Basic Concept

- One of the only instruments you don't touch to play.
- Use two hands to interact with the instrument;
 - One hand to control pitch.
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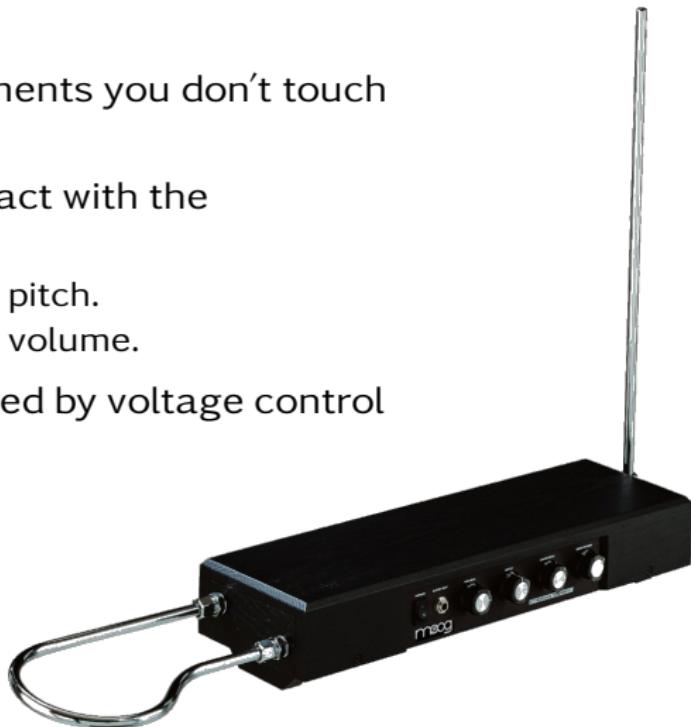
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Basic Theory

The electronics for each hand;

- Involves 2 VCOs
 - 1 as a control, remains fixed.
 - 1 is varied by the user
- 2 signals added and subtracted by a mixer circuit to produce final signal.

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Signal Generator

- As proof of concept, use a signal generator to output sinusoidal waveform.
- Send this wave through control method then to speaker to test.
- Can vary between sinusoidal, triangle and square waves.
- Test mixer when using two signals from the generator.

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- User acts as a grounded plate of parallel plate capacitor.
- Moving closer decreases the capacitance.
- When further away, the capacitance increases.
- Can make rough estimate of capacitance from the following capacitor equation;

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Capacitor Equation

$$C = \frac{k\epsilon_0 A}{d}$$

where

- k = relative permeability of the dielectric material between the plates, in this case air =1,
- ϵ_0 = permittivity of free space = $8.854 \times 10^{-12} Fm^{-1}$,
- A = area of the plates,
- d = separation of the plates, in this case the distance from the plate to the user's hand.

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Value estimated at $1.33 \times 10^{-12} F$.

555 Timer Chip

- The 555 timer IC outputs a square wave with frequency depending on the input voltage.
- Can be used as a VCO, changing the resistances changes the input voltage - voltage divider theorem.
- Characteristics of produced wave controlled by the equations;

$$\text{Frequency, } f = \frac{1}{\ln(2)C(R_1 + R_2)}$$

$$\text{Low time, } \tau_l = \ln(2)R_2C$$

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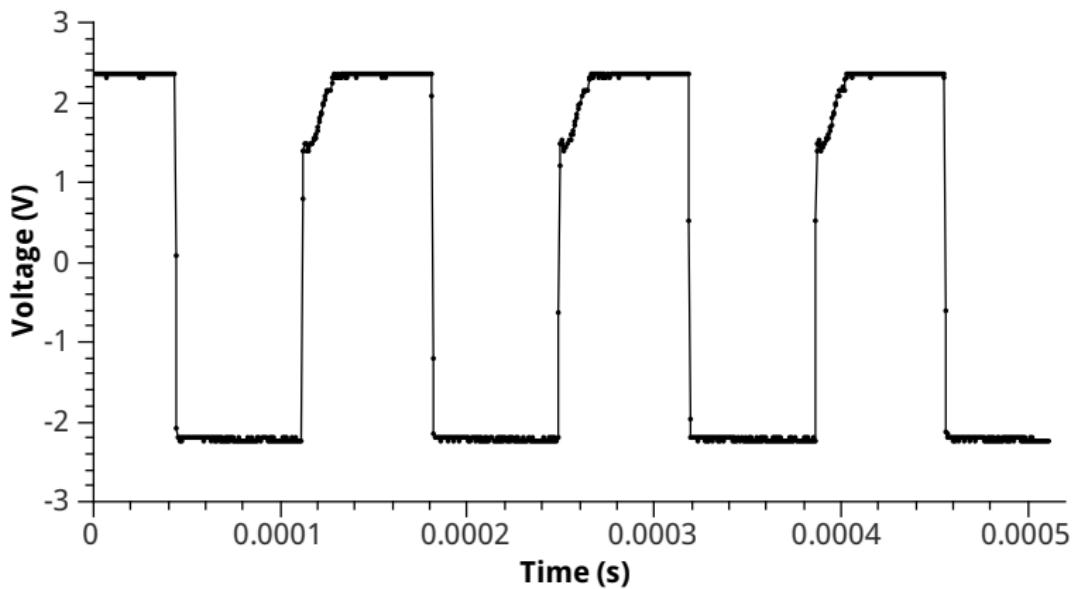
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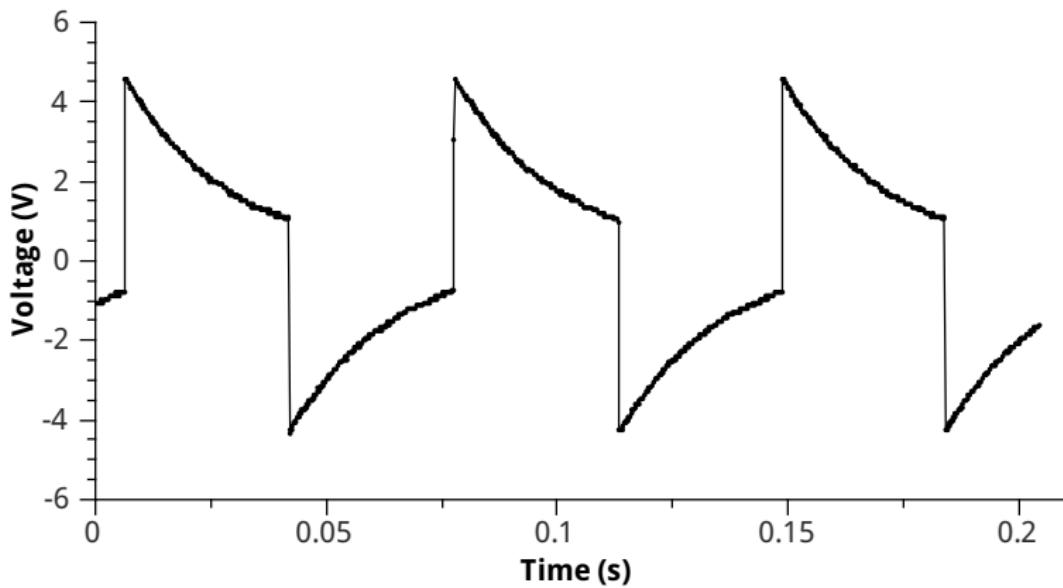
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High Frequency



Low Frequency



Mixer Circuit

The SA612A mixer chip is used for the mixer circuit.

- Takes 2 input signals and outputs both the addition and subtraction of them.
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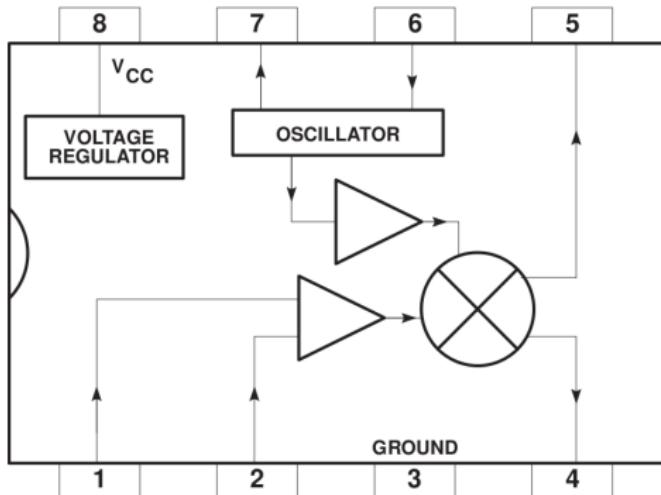
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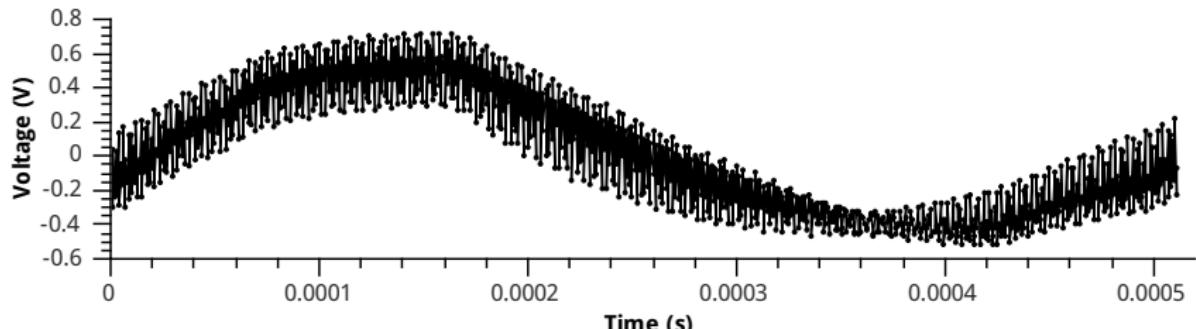
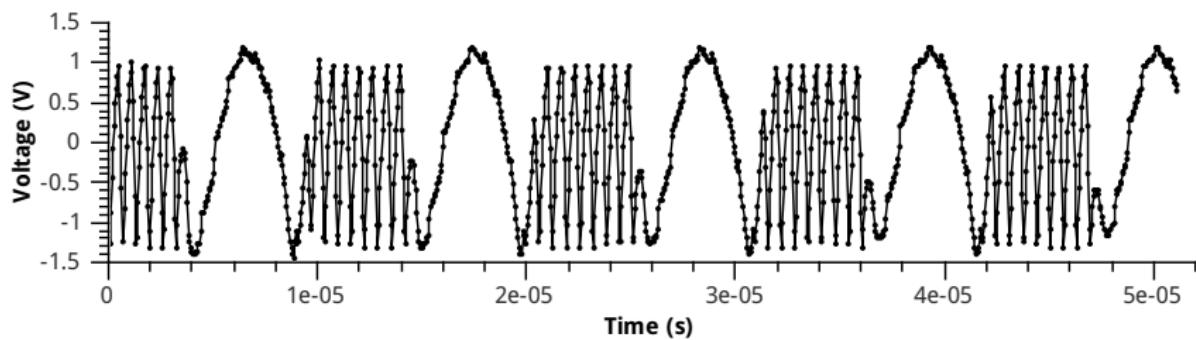
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Mixer Signal



Low Pass Filter

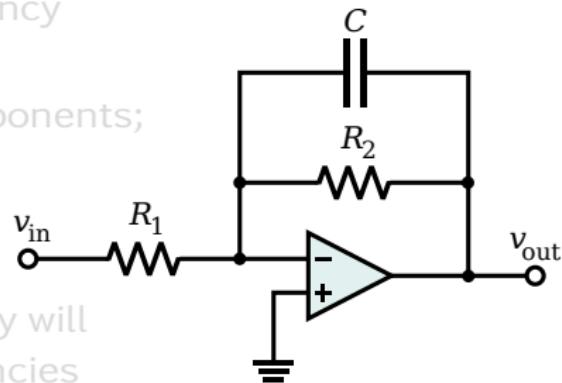
Low pass filter - electronic filter that passes low-frequency signals but reduces the amplitude of signals with frequencies higher than the cutoff frequency.

- * Use to remove the high frequency oscillations in waveform
- * Consists of simple cheap components;
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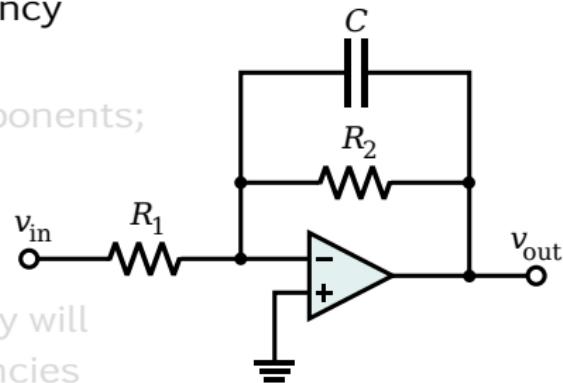
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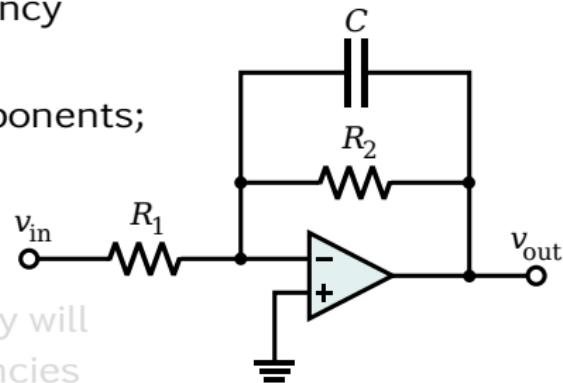
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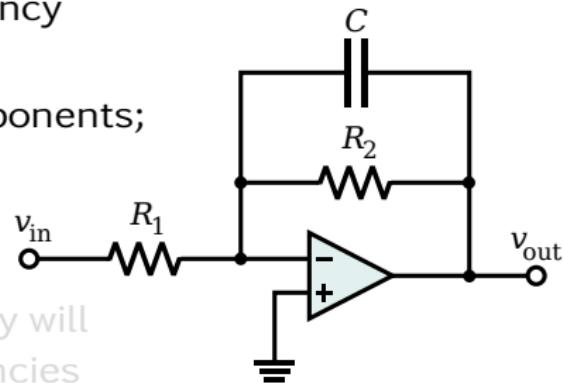
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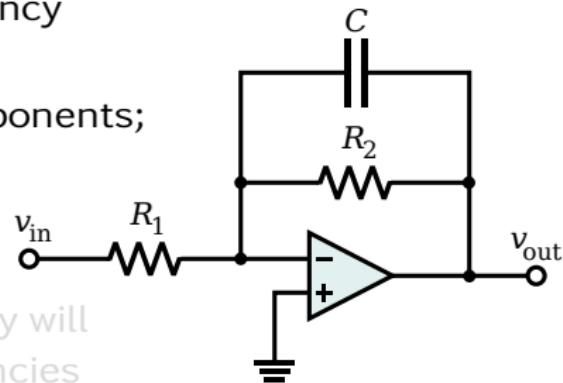
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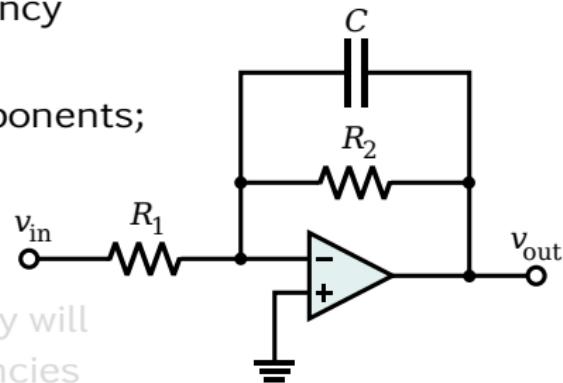
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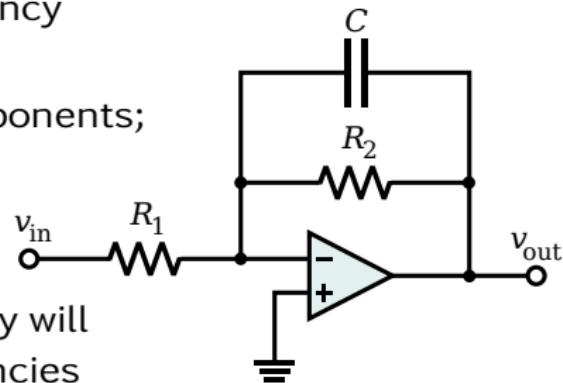
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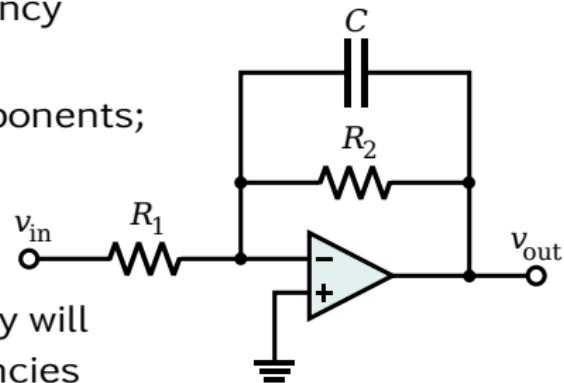
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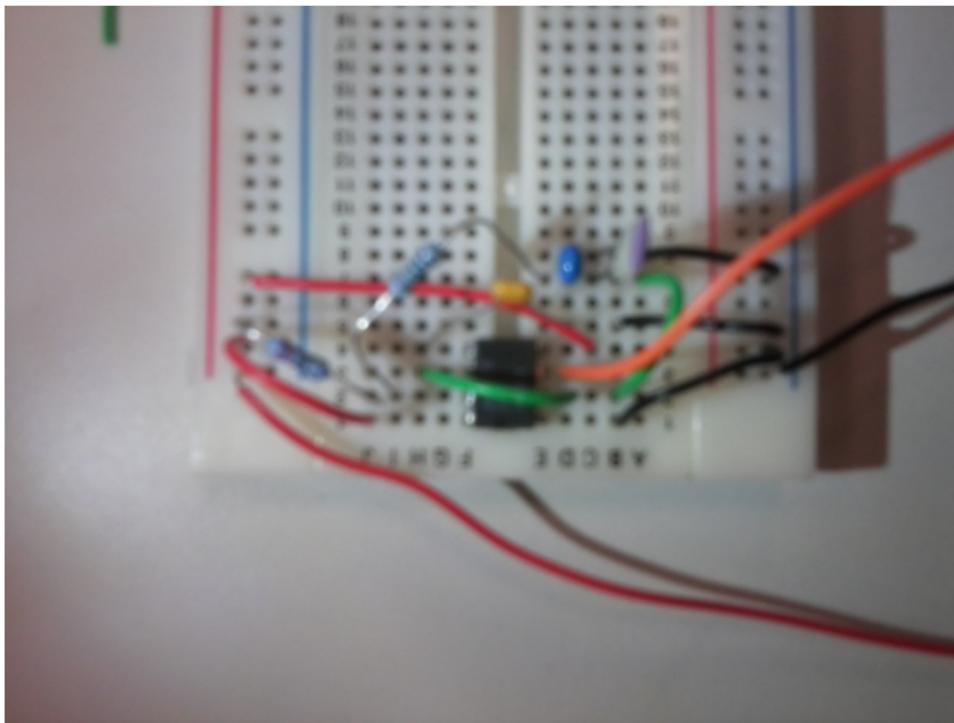
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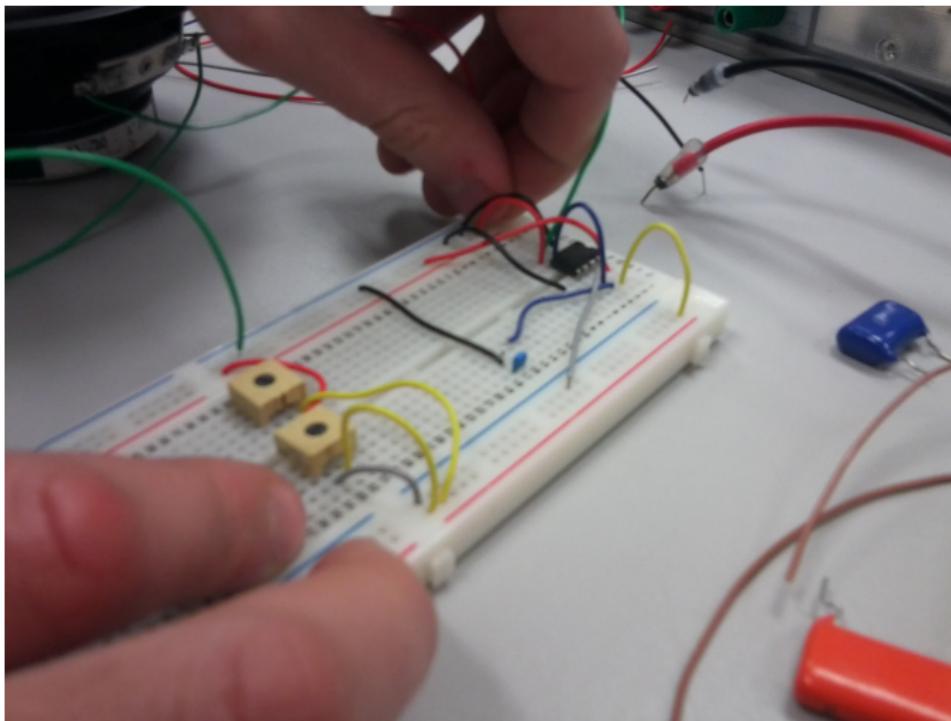
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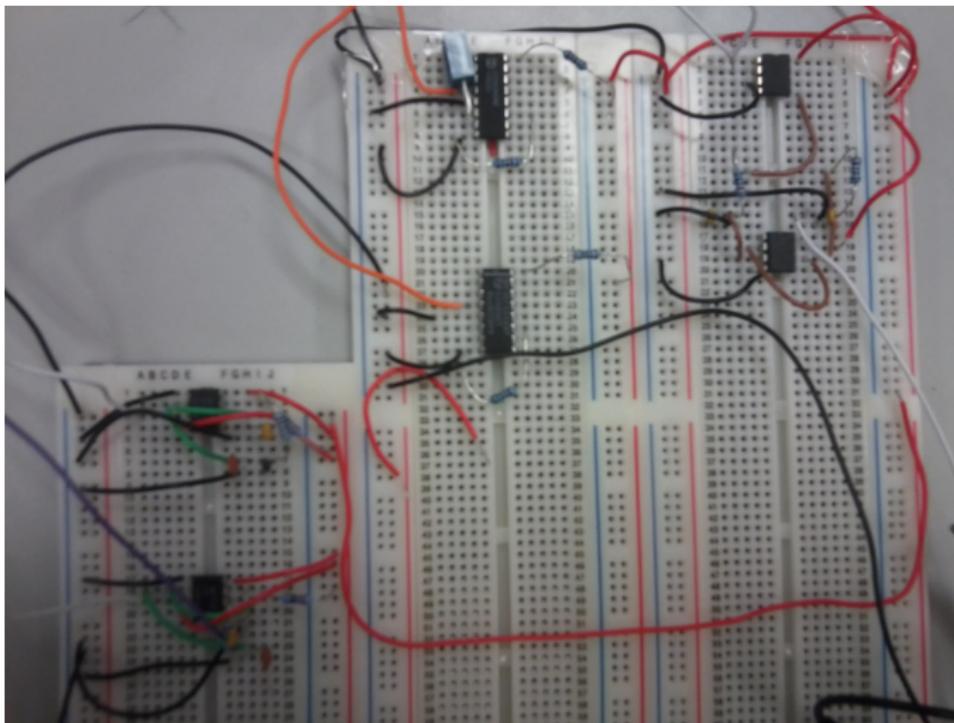
Progress



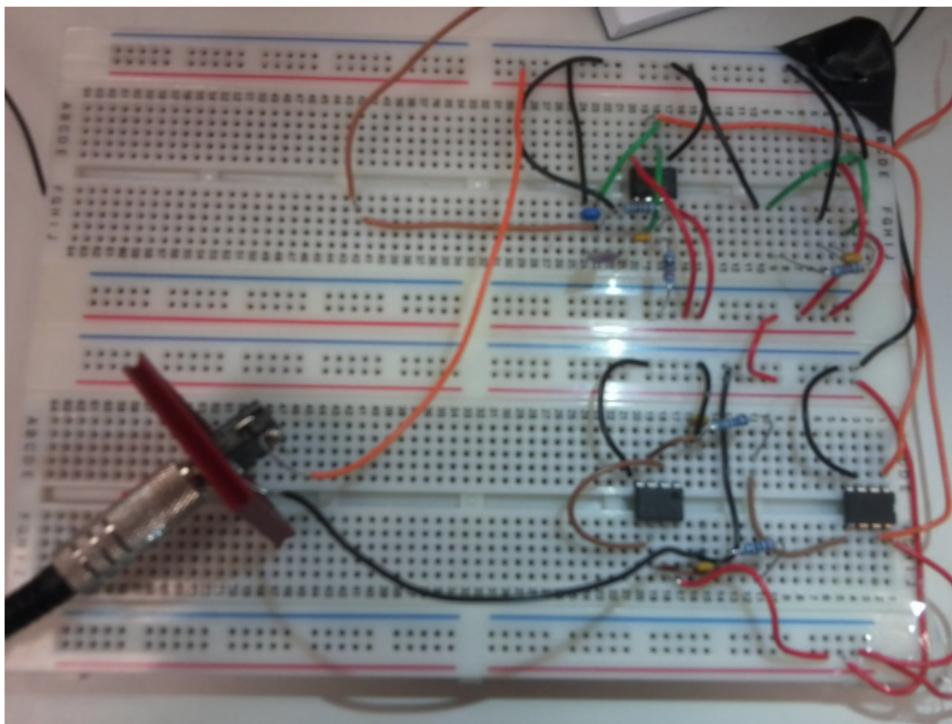
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 - Testing to improve quality and performance.
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