Modular Synthesizer

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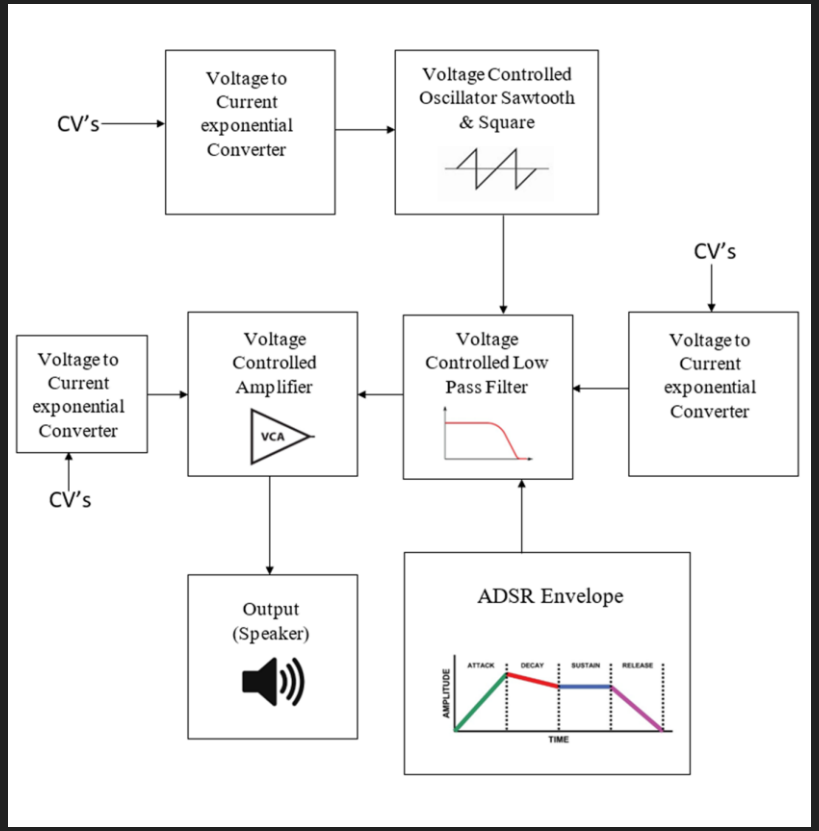
What is a Synthesizer?

- A Synthesizer is an electronic instrument
- They come in many forms
- They can come in one piece (Top Image) or modular (Bottom Image)
- They can be analog, digital, or a mix between both
- Can create extremely unique sounds that cannot be obtained otherwise (e.g. Blade Runner soundtrack)

Our Synthesizer

- We wanted a Modular Synthesizer
  - Modular means each of the components are divided up - oscillators, filters, amplifiers, etc
  - Benefits?
    - Gives the user more freedom as things can be patched together by the user and there is not a set structure
  - Components?
    - VCO (Voltage Controlled Oscillator)
    - VCA (Voltage Controlled Amplifier)
    - VCF (Voltage Controlled Filter)
    - ADSR Envelope Generator
    - MIDI instrument
    - Power Supply

Block Diagram



The system is modular, meaning the user can patch things together the way they want. The block diagram on the left is an example of how different modules can be connected

Standards/Constraints

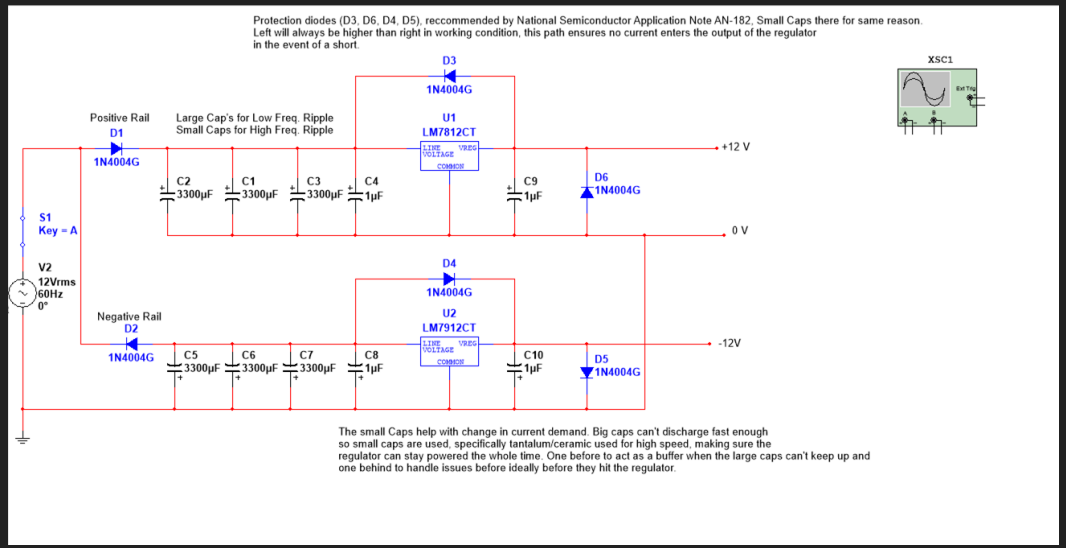
Standards

- 1 volt per Octave standard (This is a common tuning standard so that voltages correspond with musical pitches but we may choose to use another similar standard for the similar purpose of tuning)

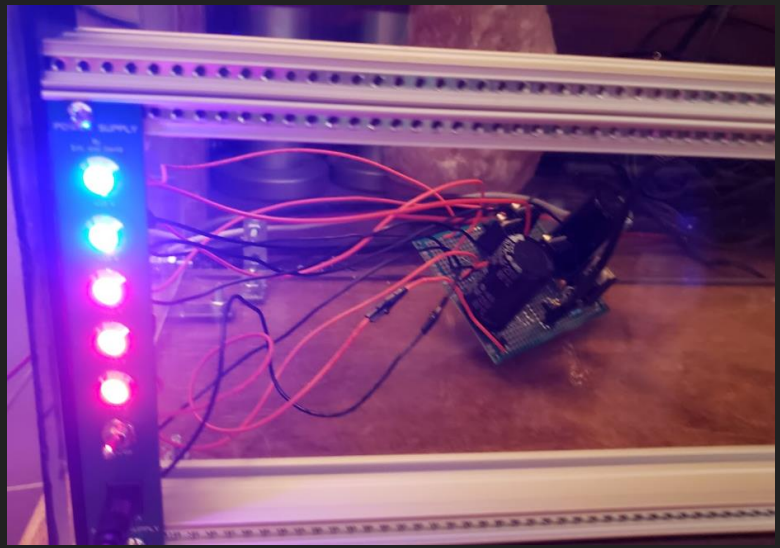
Constraints

- Dual rail power supply. A positive and negative voltage will be available to run the system via a single wall wart. (+12V, -12V, GND)
- Patches to modules on the user side will be done with standard 3.5mm ⅛ inch mono jacks. Stereo jacks will be used where appropriate if needed.

Power Supply Design

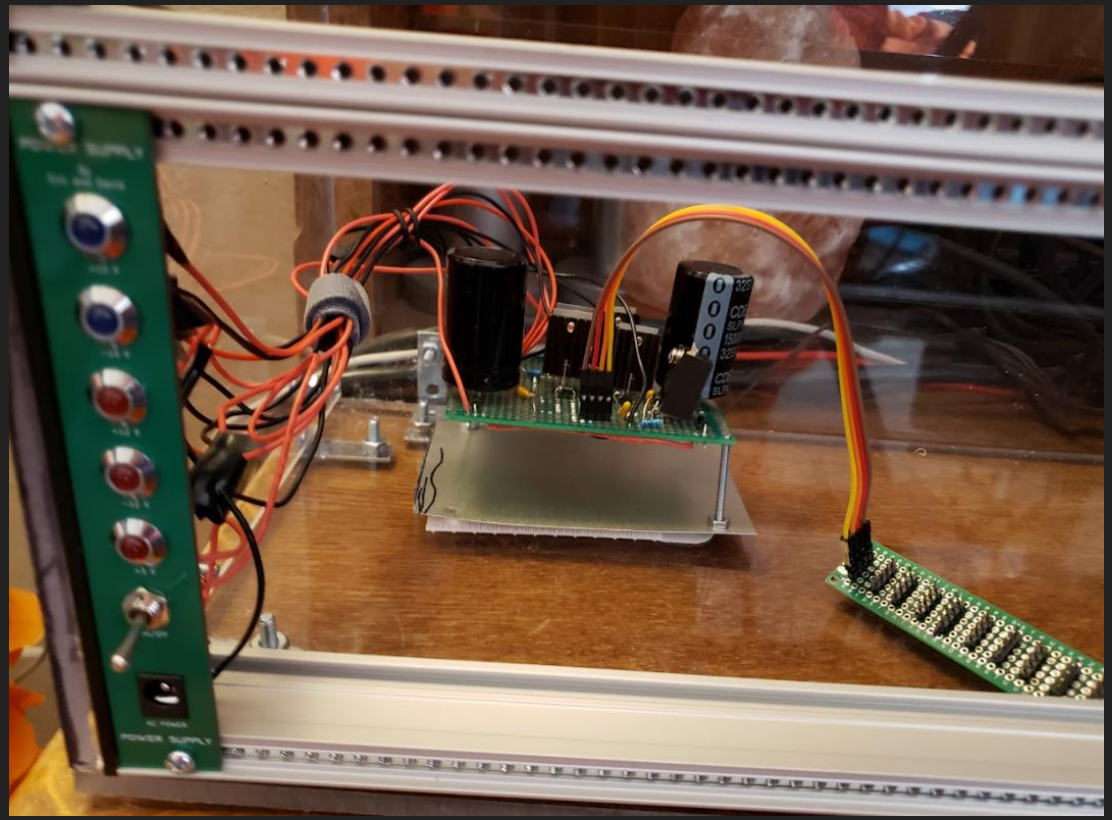


Standard Power Supply Design

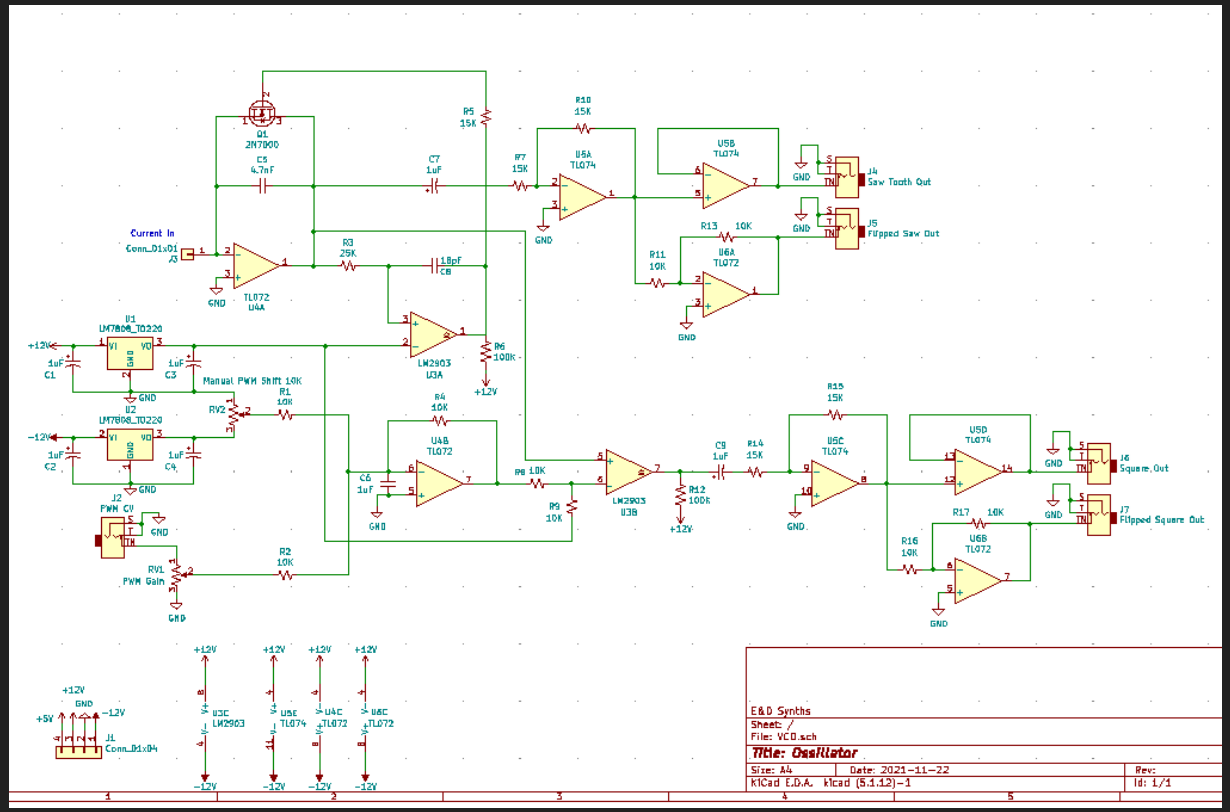


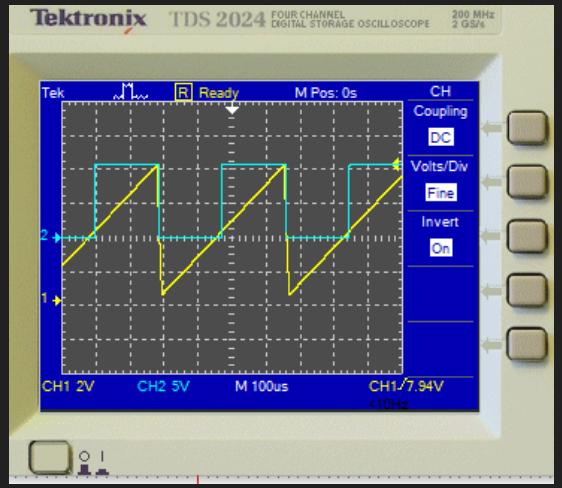
Soldered Power Supply on Perfboard. LEDs for visual confirmation of power.

Another Picture of Power Supply



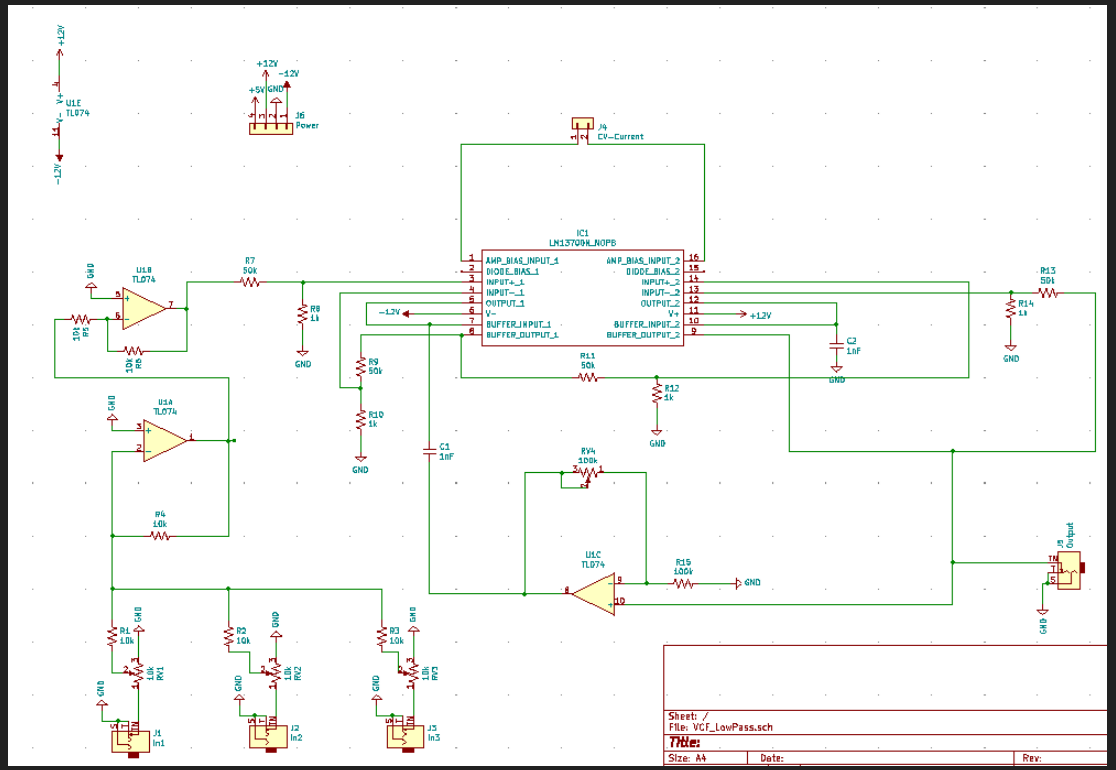
VCO



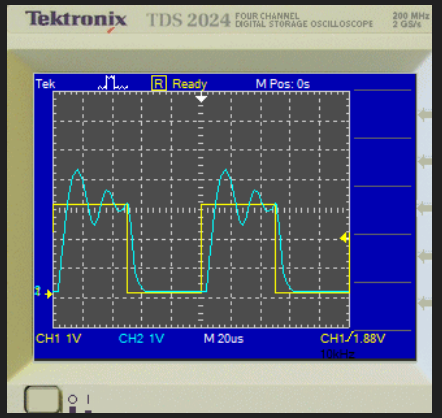


Sawtooth and Square wave oscillator. PWM control for Square wave.

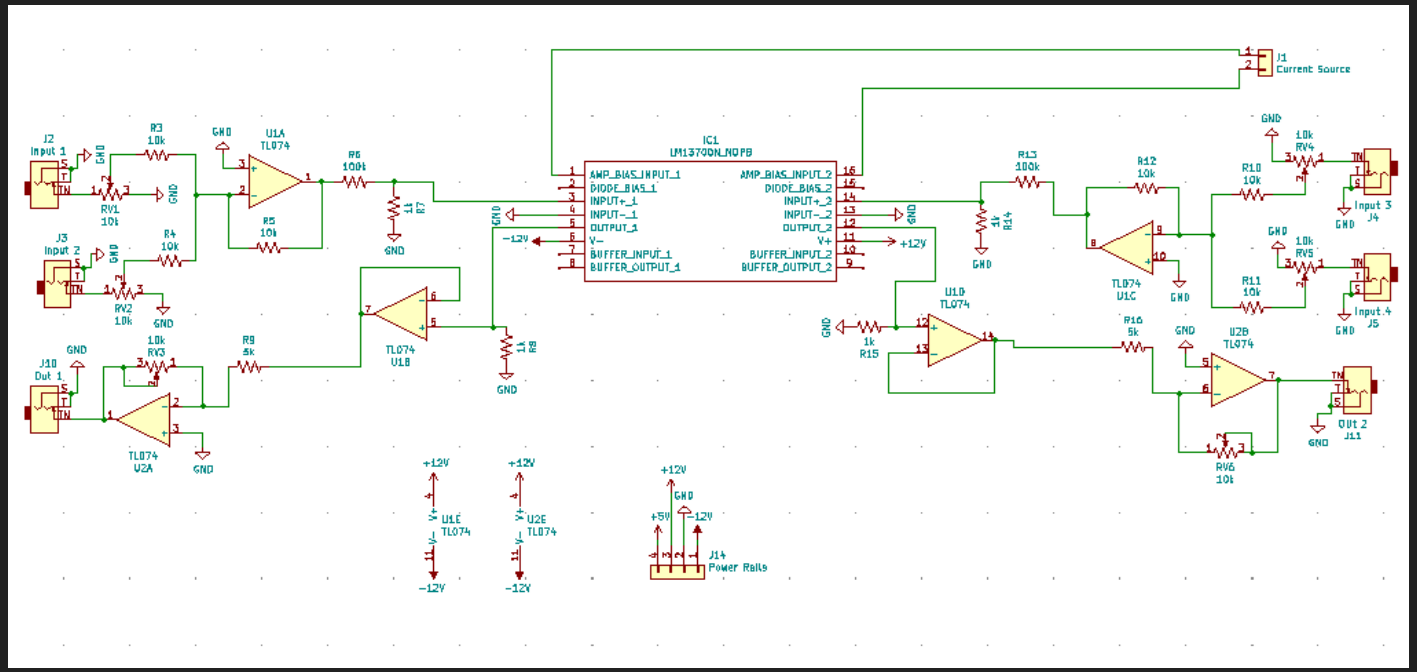
VCF (Low-Pass)



Low Pass filter (Sallen Key Topology). Uses OTA's for frequency cutoff control and a potentiometer for resonance control

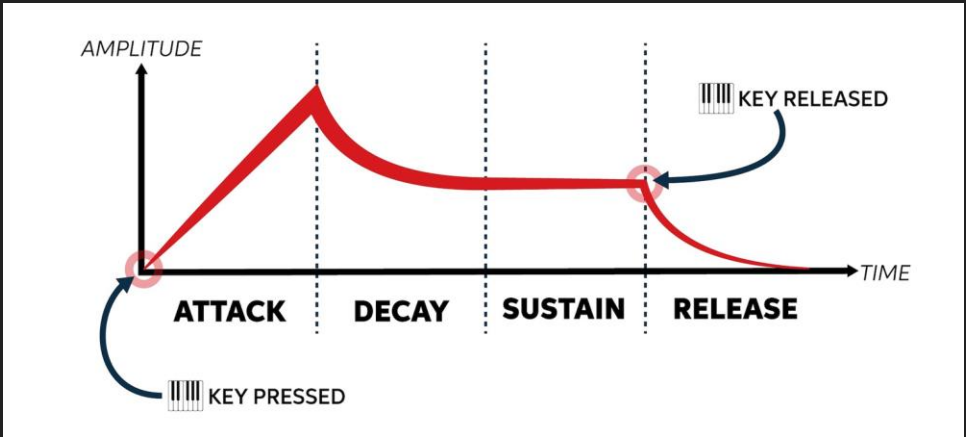


VCA



Uses OTA's for amplification. The design has two amplifiers on one board.

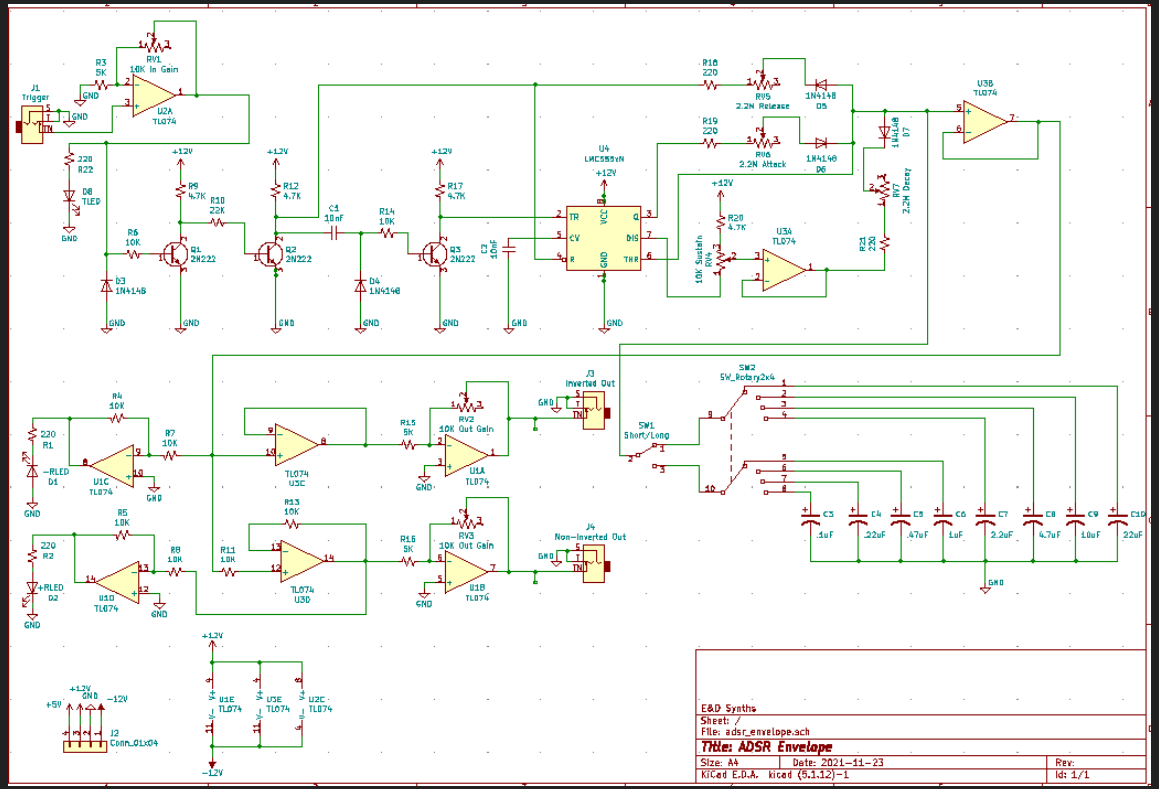
ADSR Envelope Generator



A - Attack
D - Decay
S - Sustain
R - Release

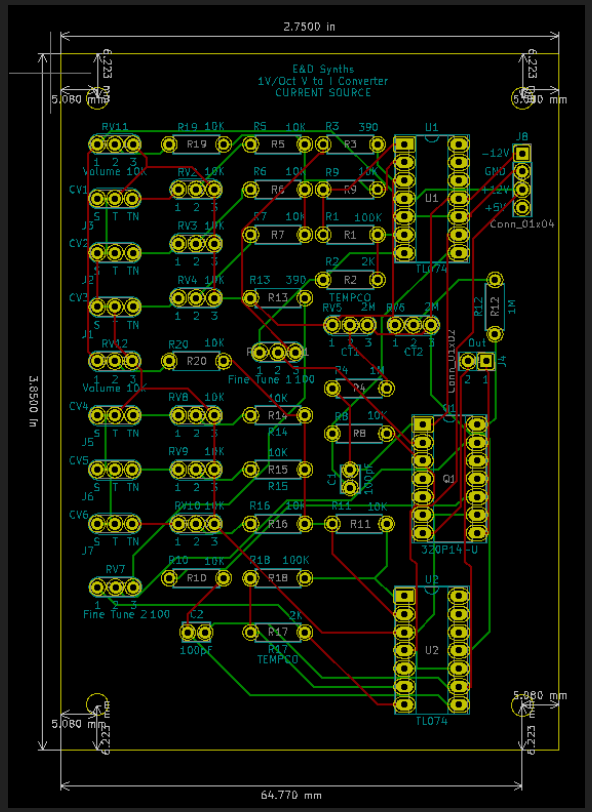
Important because its a voltage signal that can be adjusted. Our modules are voltage controlled so this can control the oscillator, filter, amplifier, etc

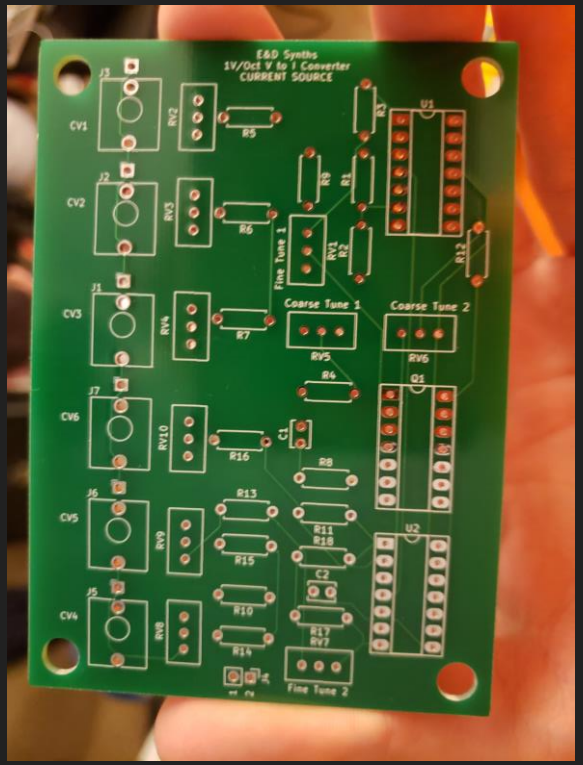
ADSR Circuit



Capacitors control the time constant (charge and discharge rate). This design allows the user to switch between capacitors for different speeds in the ADSR

Used KiCad for PCB Design

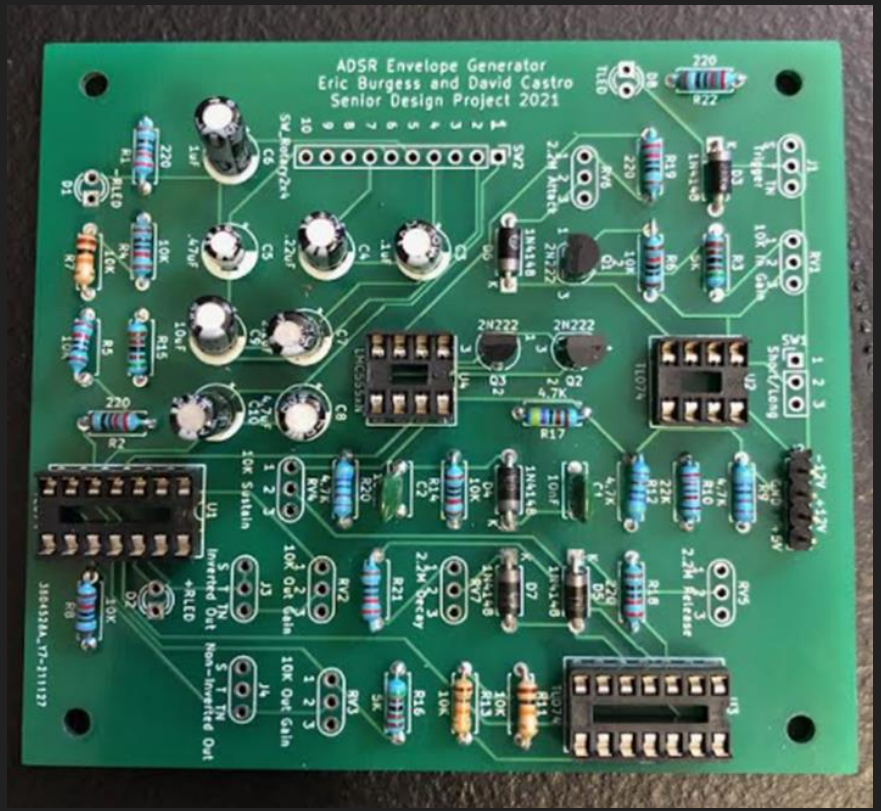


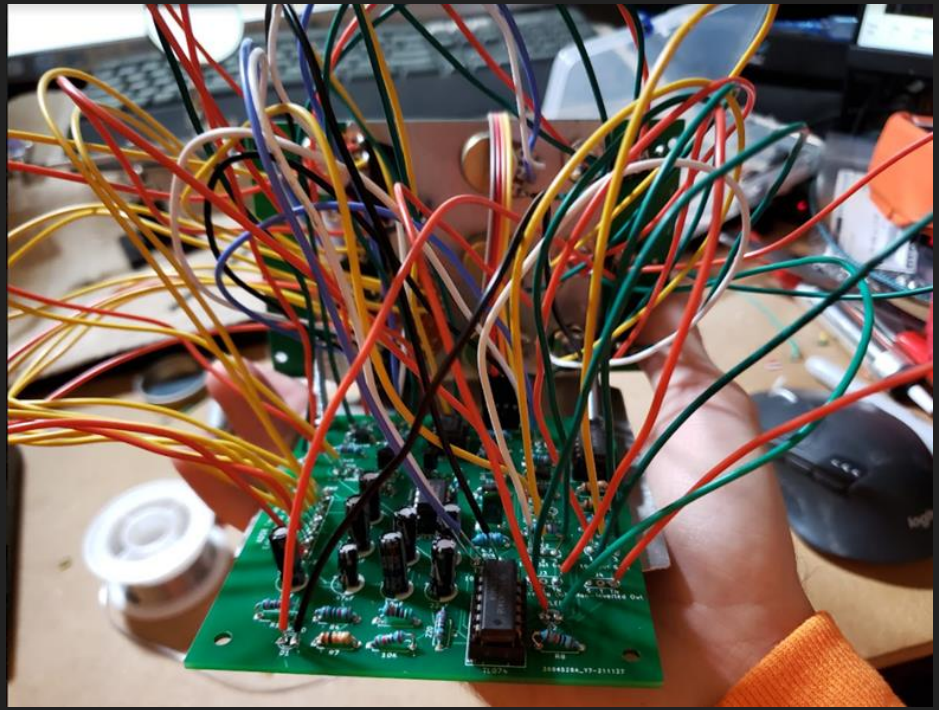


Design the board in KiCad and then order it online for it to be printed with the traces. Still have to solder parts onto it.

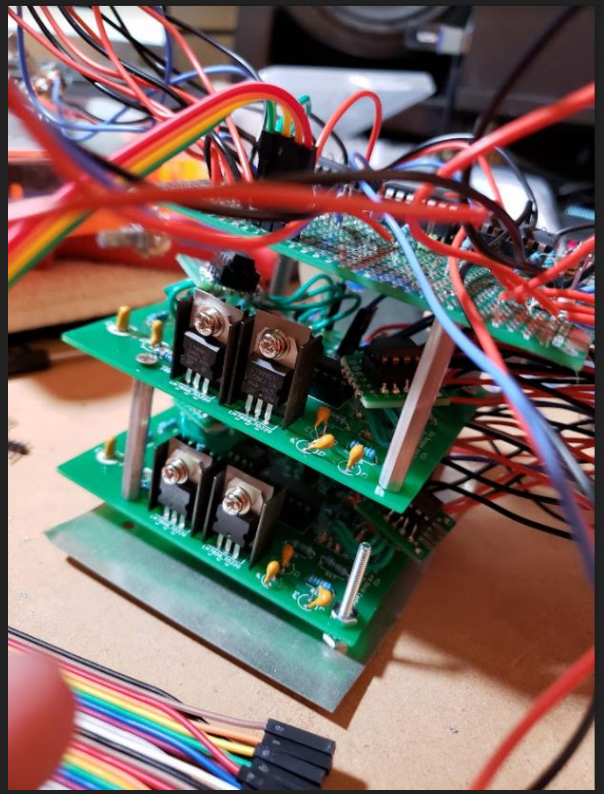
The two images are a bit different because some updates were made to the KiCad design (right picture was first time doing PCB design)

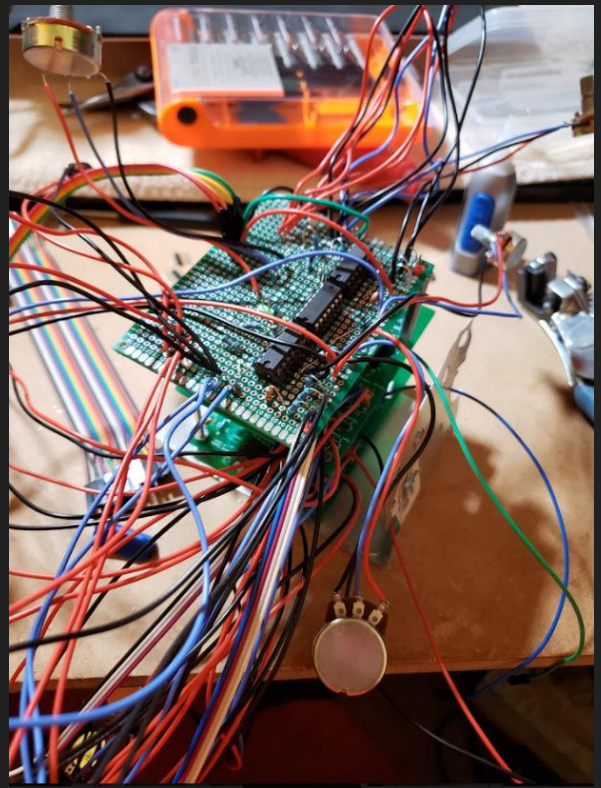
Completed ADSR





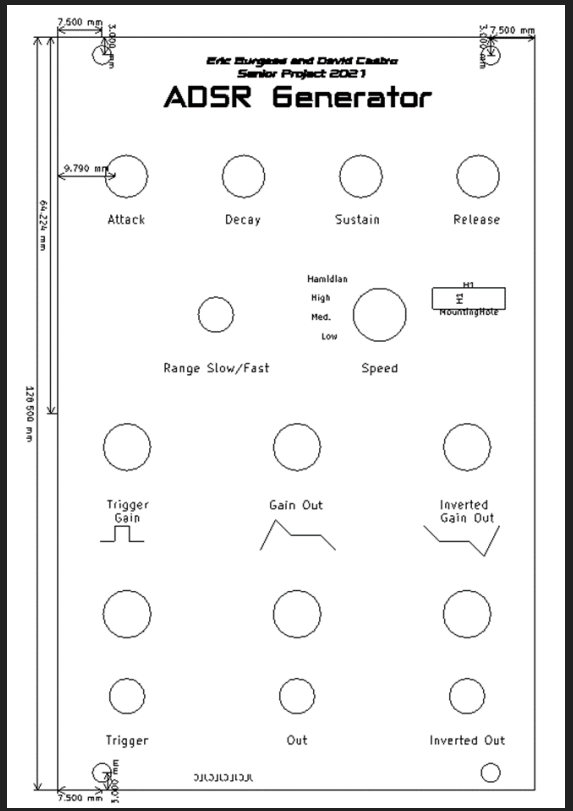
Putting Multiple Boards together



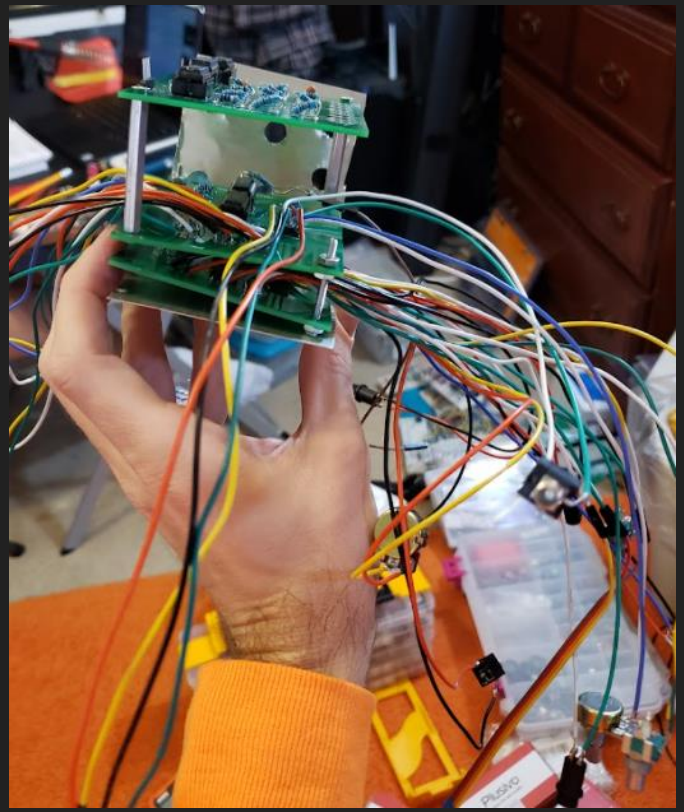


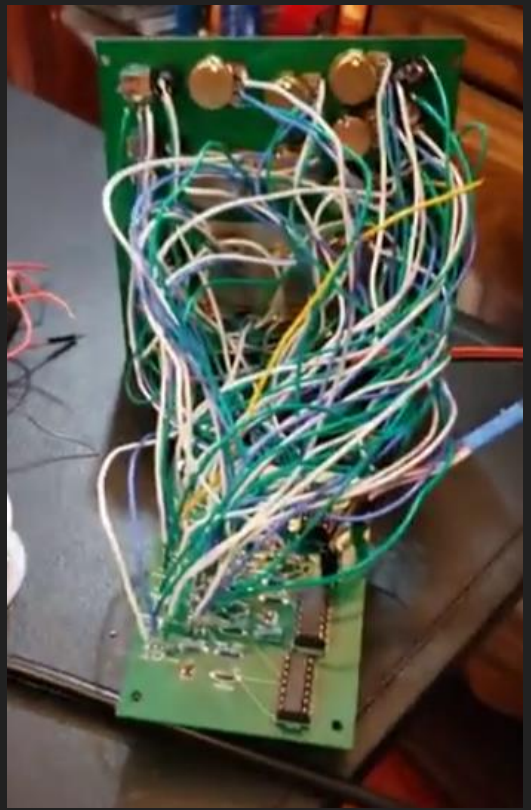
This is the Oscillator mounted with a voltage to current converter

Panel Design (Done in KiCad)



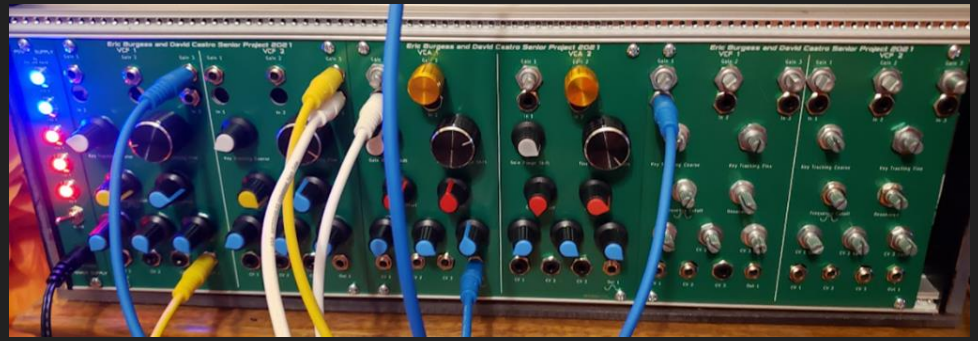
Mounting the Panel and PCB Board Together

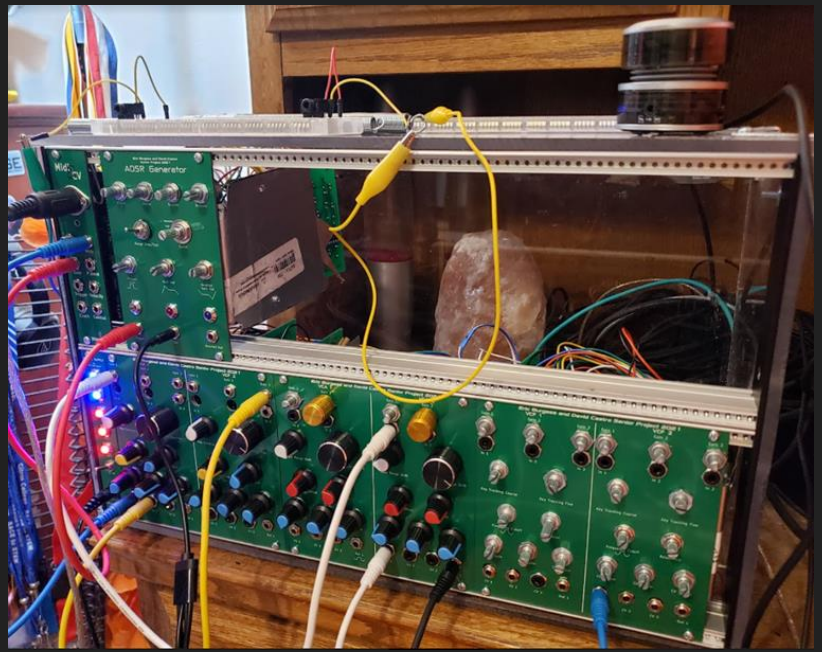




Case Design (EuroRack Standard)

Final Product





Does it work?

- It works. Although there was a lot of debugging/testing because the schematics/layouts had some slight errors
- The VCF is the only really buggy module. The potentiometers/knobs affect things inconsistently. We believe this occurs because the wiring in the back is touching each other causing connections that shouldn’t be occurring
- One of the sawtooths of the VCO’s also gets affected by the PWM. We know this is a cable management problem because this problem only started occurring when we put it in the case
- Besides these two problems, things are good

Last Topic - MIDI Instrument

- Musical Instrument Digital Interface (MIDI)
- Outputs pulses (1’s and 0’s (Digital Signals)) as CV’s that end up getting converted to analog voltage signals through a Digital to Analog Converter and can then be fed into any of the modules
- Important because it allows easy interface for the modules

Some Video Links (Not the Final Product)

https://drive.google.com/file/d/1J7yfCgqspWNE97duwDbHwXujPmt6Wm02/view?usp=sharing - This showcases us debugging/testing the modules a bit

https://drive.google.com/file/d/1u8E_wDMR5lwQMjyUZ2qSCMlq0Rg5-qJn/view?usp=sharing - This one shows us testing the filter a bit

https://drive.google.com/file/d/1MLvvsz7yZ2b3NFyEDO3lgpPcuzt6oSCv/view?usp=sharing - Shows the frequency modulation that can be outputted from the Oscillator by inputting a control voltage from another oscillator

https://drive.google.com/file/d/1TYD_inGY7WyK13ahnys_tnFNM8BbnNII/view?usp=sharing - This one shows the VCO, VCA, and VCF working together (No ADSR or MIDI)