

molecule synth 1.1

owners' manual

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1. Introduction

Molecule Synth began as my DIY-inspired approach to experimental modular synthesizers. I had been building synth modules and trying my hand at various electronic creations, and as things went along I found I was having great fun using different sensors and unusual controllers to make physical interfaces for electronic musical instruments. Even the simplest single-chip synth designs were a ton of fun to play with, given the right combination of sensors and blinky LED responses.

With physical electronics I had found a new world opening up, and in terms of music creation I discovered, too, that a simple flex sensor could be used for all kinds of tonal and pitch variations that were new to my ears. Physical sensors were more interesting and more fun to manipulate than anything I was getting from piano keys and patch cords!!

Thus, I began to build a bunch of little experimental devices that shared two basic traits: (1) they were hardware-based, simple circuit synths; and (2) they were controlled by physical sensors and tactile interfaces that made operating them more “playful” in the sense of playing a game.

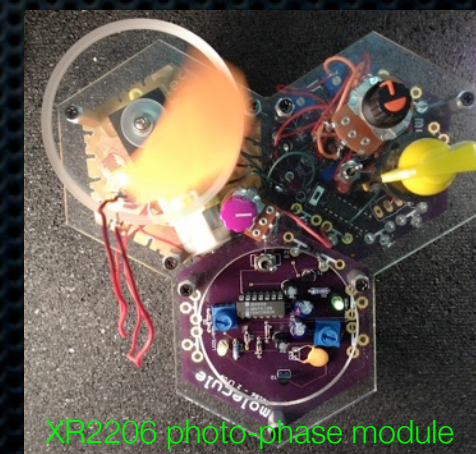
I was hooked and rapidly built dozens of noisy little synths. I tinkered with accelerometers, IR sensors, piezos, and vibro motors pulled from old PS2 controllers (see photos below, one is a joystick-controlled tripodic synth that shimmies across the tabletop as it sings its wildly pulsing electric ecstasies; the other is a XR2206 function generator used as a VCO with a tremolo-like effect created by the photosensors and a servo-powered “shadow wheel”)...there was no turning back. I had tasted the fun of physical electronics, and I realized I was manipulating the very ELEMENTS of sound design in ways I never could before with a “normal” keyboard-based synth. The pitch controls weren’t always precise, true, but the results were wild, sometimes ghostly, spacey, almost always utterly gratifying and especially fun at loud volumes!

This sort of DIY-ELEMENTAL approach was my guide, and by early 2012 my explorations and discoveries had led me to map the basic features of what became the Molecule Synth and its still-growing universe of interconnecting hexagon modules. By the time I had made the engineering leap of repurposing 9V connectors for my own uses, the entire Table of Elements for “Molecular Synthesis” was well underway, and as I write this today, I am at Molecule Synth 1.1, having made about three significant design revisions, first with homemade copper PCBs and later with factory-made PCBs...

This Owners’ Manual is meant to be a start-up guide, I hope that it helps you and explains just about everything you need to know at first, but really it’s only just to get you started. My intention is that **Molecule Synth 1.0** should lead everyone who gets ahold of it to experiment fearlessly, to enjoy creating their own modifications, and to have fun inventing and learning to Design Your Own Instrument!

Cheers,
-Travis

Travis Feldman
<http://www.moleculesynth.com>
moleculesynth@gmail.com



2. Quick Start

- **4X9V Batteries:** Molecule Synth needs four 9Volt batteries -- one for the Amp/ Speaker, and one in each of the three Sound Generators. A small screwdriver (Phillips#1) will also be needed for the machine screws on the bottom acrylic panel.
- **Arduino, MIDI-Controller, MIDI cable:** If you have the 9-Piece POLYMER MOLECULE SYNTH SET, then you've got some MIDI connections to make! You will also need the following:
 - (1) a programmed Arduino Uno R3 with power (all things Arduino-related are addressed in section 6 below),
 - (2) a MIDI-controller (keyboard, keytar, iDevice, or just about any other thing you like that's capable of sending MIDI signals should work),
 - (3) a cable that connects your MIDI device to your Molecule Synth.

Optional: you might opt to use an external amplifier and speaker with a 1/4" STEREO patch cord connecting to Molecule Synth's "Audio Out" jack. The speaker/amp of Molecule Synth was deliberately kept on the quiet side (see more about that below in section 5) -- but, yes, loud can be good!!! :)

3. Connecting Hexagons

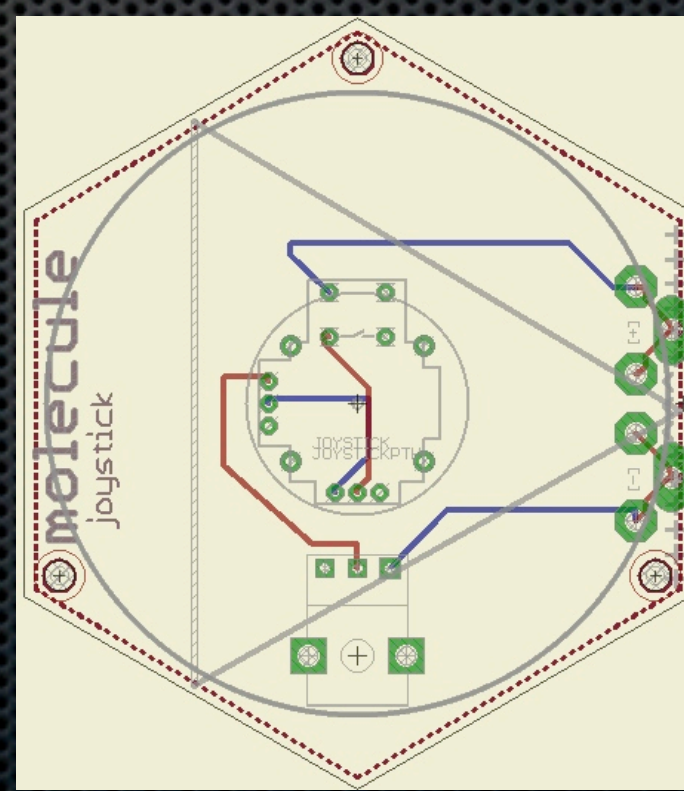
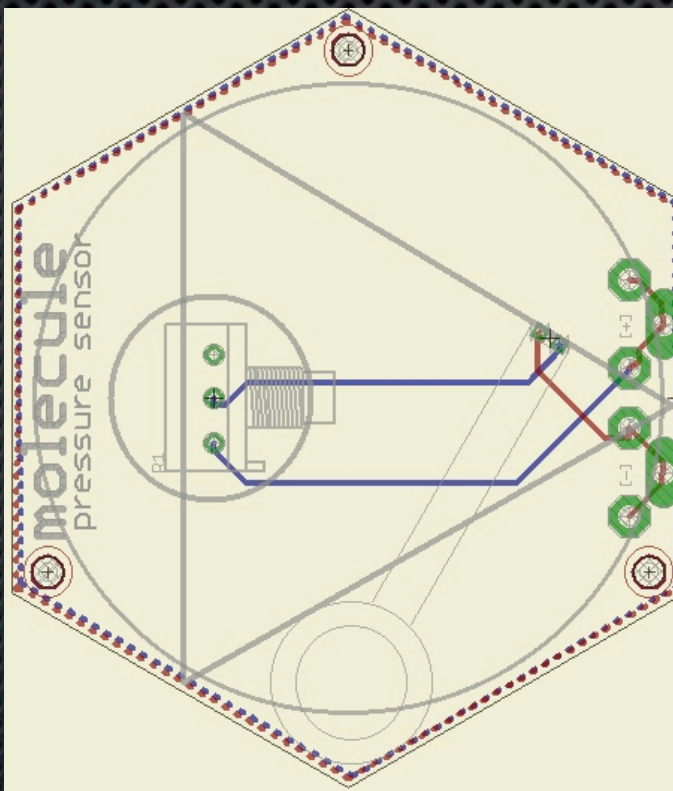
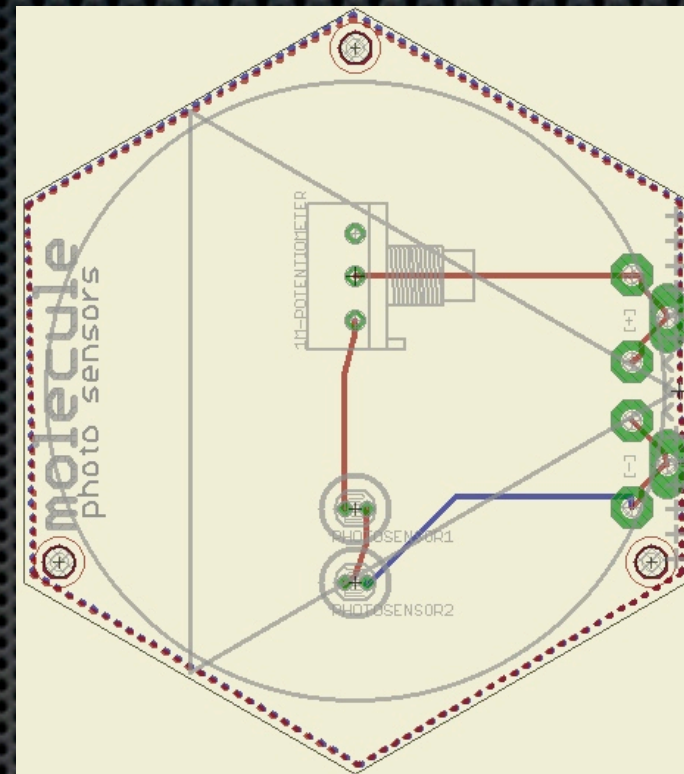
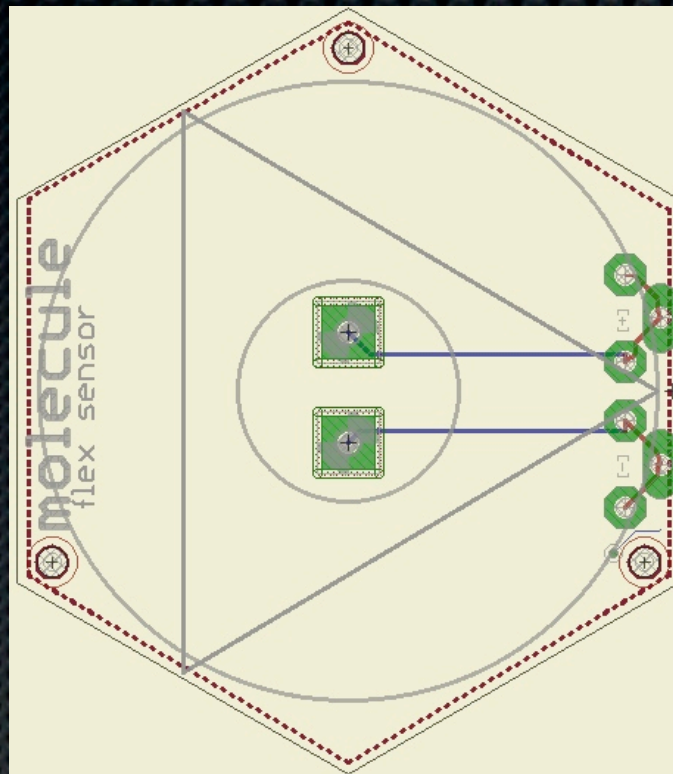
The hexagons of MOLECULE SYNTH all connect to one another by “snapping” 9V battery-type terminals together. There are two varieties of connections, and these connections are constructed to be 2 different sizes, which means that one size **WILL NOT CONNECT** to terminals spaced according to the other size. For instance, a PITCH CONTROL hexagon will not connect to AUDIO/CV terminals. See Sections 4 and 5 below for pictures and details for each hexagon.

- (1) **PITCH CONTROL**; the connections between these are non-directional loops.
- (2) **AUDIO / CV SIGNAL**; the connections between Audio or Control Voltage [CV] hexes are directional: some are input, some are output, as will be explained below.

Note: you may want to create a system of your own for marking the connections, at least until you get the hang of it. Maybe something like small arrows for the audio/CV connections (indicating direction, input or output), and a dot or circle over pitch control connections.

4. Pitch & Tone Controllers

- (1) **Flex Sensor** - in many ways, this is the simplest of the pitch controllers. It's intuitive to use, and easy to manipulate. See data sheet for "Medium" FLX-01-M here: <http://www.jameco.com/Jameco/Products/ProdDS/2124867.pdf>
- (2) **Photo Sensor** - two photo resistors are wired in series with a turn knob (1M ohm potentiometer). The knob can be used for establishing the range, while the light sensors create intricate variations, from warbles, whale swoons and tremolos, to chirps, taps, and scratches. As the photosensor face is exposed to more light, resistance goes down. The resistance ranges from about 5-10K Ω when light, up to about 200K Ω when dark.
- (3) **Pressure Sensor** - the pressure sensor can be secured onto the acrylic hexagon with a spot of glue or Sugru, or you might want to leave it loose and flappy. Again, a turn knob (1M potentiometer) controls the overall range. [These are from Sparkfun.com, where you'll find a nice Guide to Pressure/Force Sensors: http://www.sparkfun.com/datasheets/Sensors/Pressure/fsrguide.pdf](http://www.sparkfun.com/datasheets/Sensors/Pressure/fsrguide.pdf)
- (4) **Joystick** - this controller has an On / Off button built into it, so be warned that it is wired to be "normally Off" and must be (gently) pressed to turn On. Once turned On, the joystick controls pitch through both the X- and Y-axes. [I got these from Sparkfun -- for more information see https://www.sparkfun.com/products/9032](https://www.sparkfun.com/products/9032)

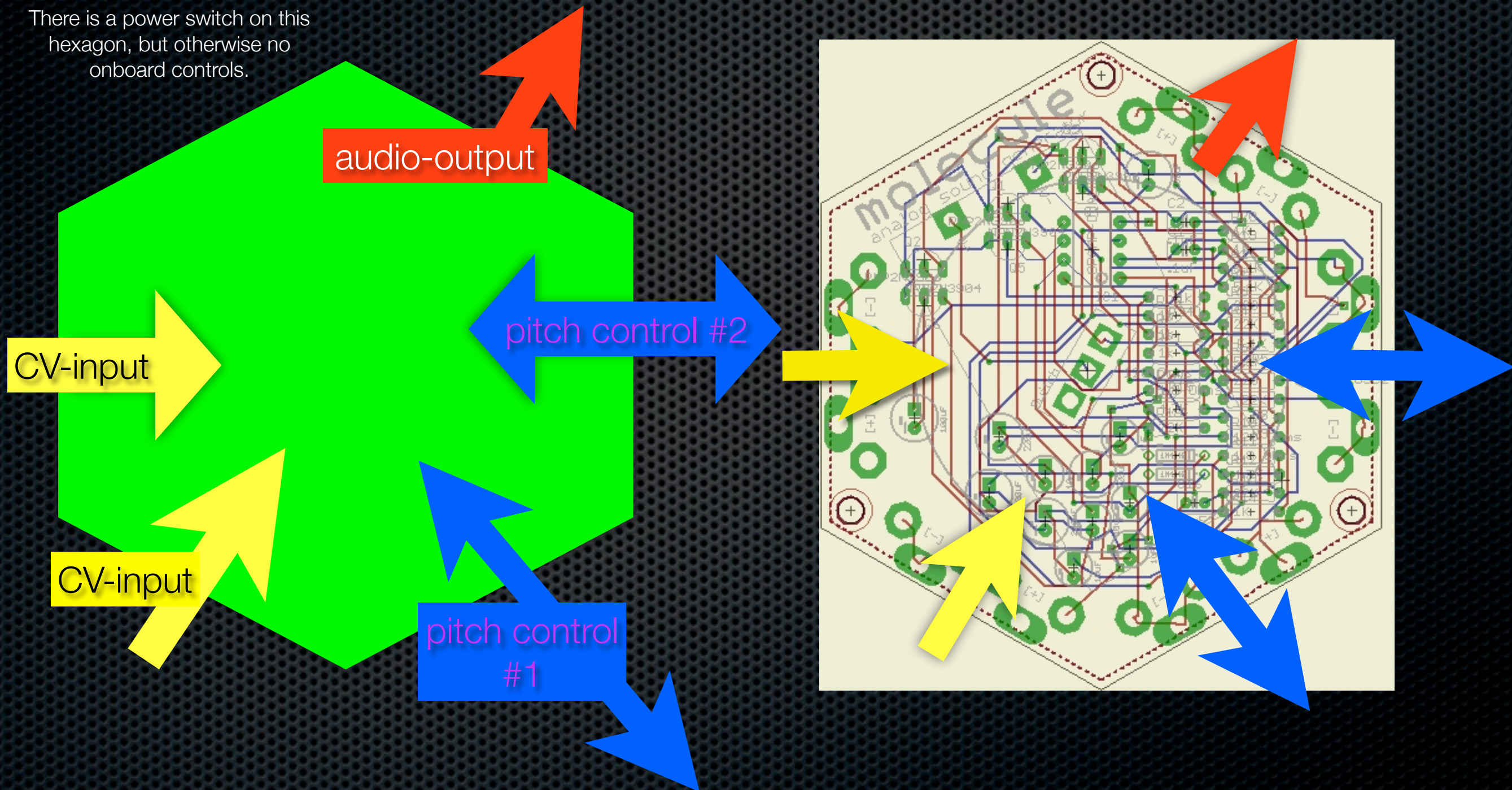


5. Audio / CV Generators

- (A) **Analog Sound Generator** - 1458 Op Amp Dual Oscillators each with a VCA (Voltage Controlled Amplifier)
- (B) **Digital Sound Generator** - 556 Timer “Stepped-Tone Generator” with two CV-input terminals
- (C) **2LFOs (Low Frequency Oscillators)** - 40106 Hex Schmitt Trigger with two CV-output terminals
- (D) **Speaker/Amplifier** - 386 Power Amp with Overdrive

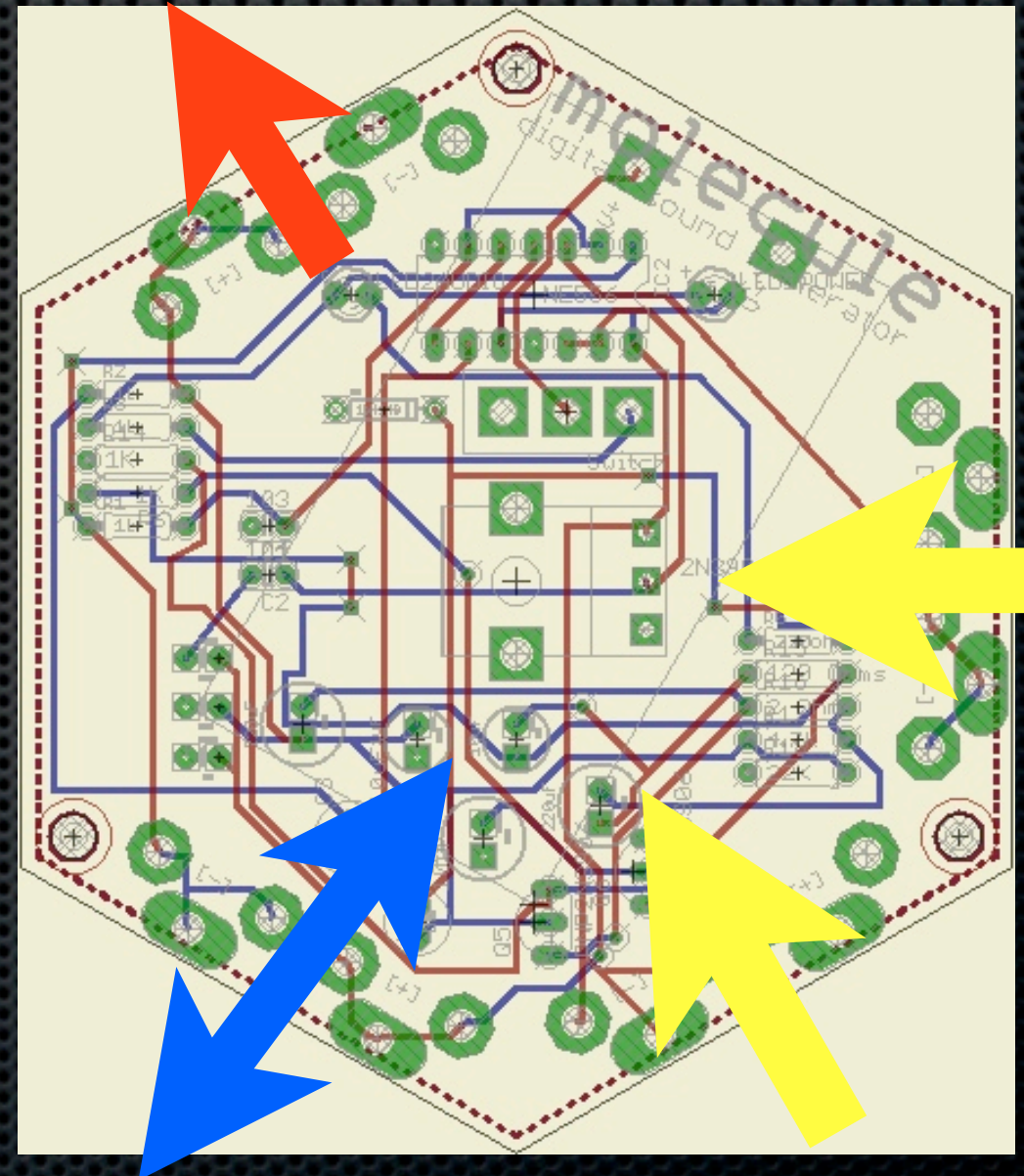
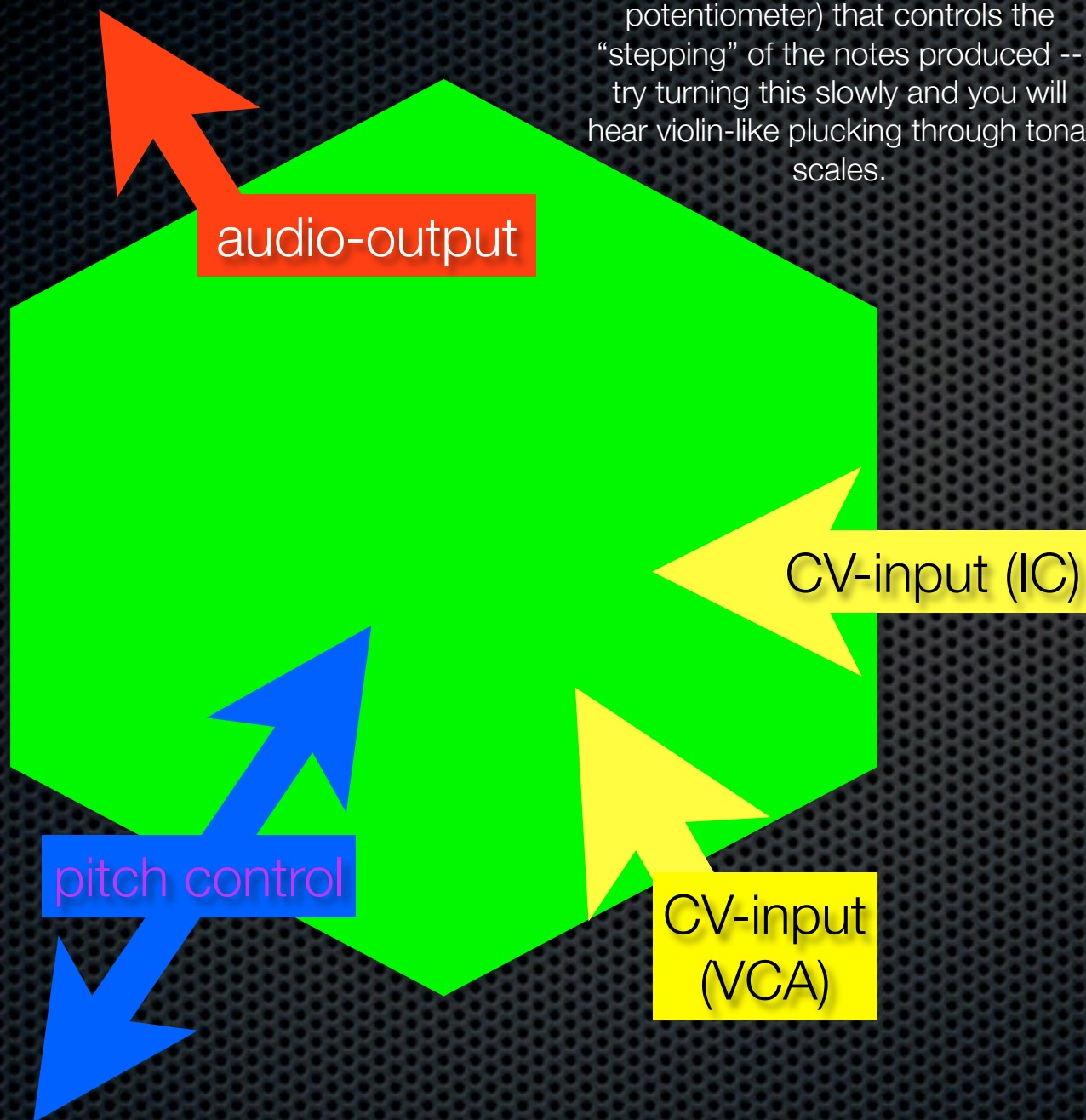
(A) Analog Sound Generator

There is a power switch on this hexagon, but otherwise no onboard controls.



(B) Digital Sound Generator

This hexagon has a power switch and an onboard turn-knob (500K potentiometer) that controls the "stepping" of the notes produced -- try turning this slowly and you will hear violin-like plucking through tonal scales.

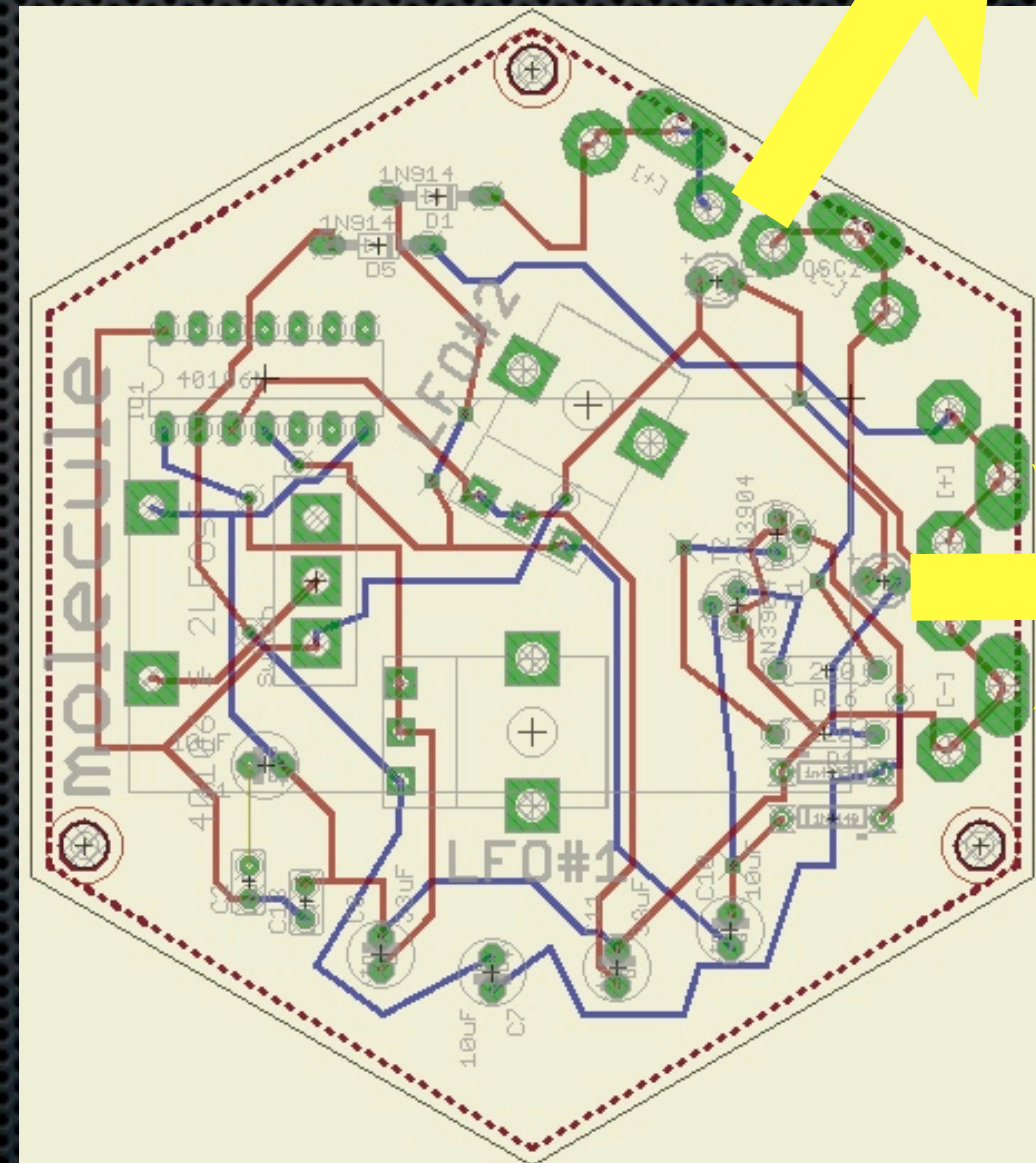


(C) 2LFOs

CV-output#2

This hexagon has two onboard turn knob controllers (each is a 25K potentiometer) that adjusts the oscillation rate of its respective LFO. These LFOs produce square wave pulses that are rhythmic, but at their highest speeds they become tonal, and if plugged into the Speaker/ Amp, they emit a small range of low pitch tones.

CV-output#1



(D) Speaker/Amplifier

please note: the audio-out is a 1/4" STEREO jack -- if you have a mono plug, only plug it in to the second

This super-sized hexagonal form contains 4-inputs, each with its own volume control, and a master volume control (differentiated with a "chicken head" knob near the center). There is also an Overdrive control, with a black and white knob just to the right-hand side of the power switch.

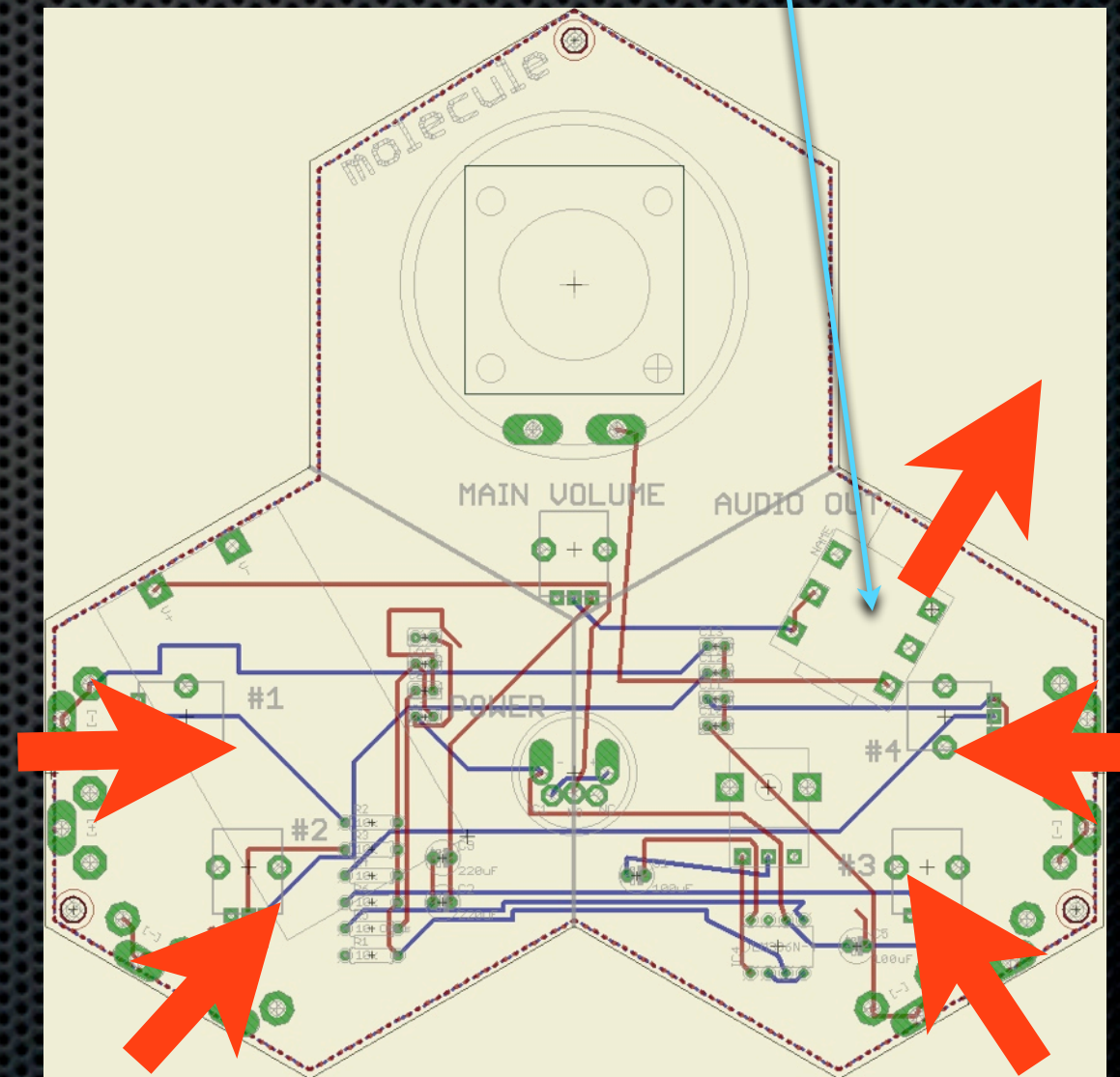
audio-output

audio-input

audio-input

audio-input

audio-input



6. MIDI-Input & Arduino Set-Up

The MIDI-Input requires an Arduino UNO, preferably R3. This should be about \$20-\$25.

Once you have that, then you need to download Processing, the programming language for Arduino: it's free and here's where you can get that:

<http://arduino.cc/en/Main/Software>

Next, it's time to connect your Arduino to your computer -- do that with a USB cable -- you can follow instructions on the arduino.cc link above.

Once your computer and Arduino have made friends, now it's time to upload a killer synth program! There are a few around the internet that will work, so with this hexagon you head off into the land of software experimentation --woohoo!

The hardware of this hexagon is a slightly modified version of Collin Cunningham's famous "MidiVox," and Collin's fun and variable synth sketches are the best I know of. You can find them on his site, along with excellent information about the circuit, schematics, etc. -- check it out: <http://narbotic.com/projects/midivox/>

Also, don't miss Marc Nostromo's "Piano Squealer" -- http://www.marc-nostromo.com/?page_id=14

The Soundcloud samples ("Etudes") of Marc's synth are very nice: <http://soundcloud.com/marc-nostromo-etudes/arduino-pocket-piano-eery/>

Finally, you will want to find a good MIDI controller. Anything could work -- keytar, old timey MIDI keyboards in your garage, you name it! I think the iPad or an iPhone are worth checking out because of the many apps available that allow for some really terrific sounding manipulation of the synths (several of which I've found are free, and I like running a sequencer along with something like Touch OSX that allows me to tweak parameters as I'm playing... once you start and throw in some Digital Sound Generator SQUEEKS you'll have everyone's attention for sure :), though with an iDevice you also need a \$50-\$80 MIDI-out. There are several good ones out there, and here is the one I've been using, though I'm not suggesting this is the best one, just one I've had fun with -- <http://www.sweetwater.com/store/detail/MidiMobil2>

[N.B., I'll have more info about Molecule MIDI-Input "sketches" in the coming months, and I plan to have a MIDI-output developed soon.]

Tips, Mods, Hacks

- Sugru!! -- this stuff is awesome, and I included it to be used in any way you see fit or dream up! I started off using it to fix the flex sensor in place, and to attach the pressure sensor (I like the “organic” feel of the silicon in Sugru, though my creations tend to look a little blobby!) -- on the more creative side of things, see the photos at right for an example of an Audio-Out attachment created by Bob G. in Portland -- radness!!
- All of the IC chips used on Molecule Synth designs were placed into IC-sockets. This means you can pop them out and replace them very easily. One possible quick upgrade to your SPEAKER/AMP might be to replace the LM386L chip that is in there with an LM386N4. The -N4 is about 1/2 a Watt more powerful and is a bit louder. Rock on, Molecule, Rock on!!
- Of course the acrylic casings are relatively easy to alter with a Dremel tool or other small saw (1/8” is a LITTLE bit tough for the scoring method, but you might be able to do it for some cuts).
- I tried to include a useful selection of replacement hardware with every Molecule Synth set, for fixing or further mods. If you need specs for any of the Molecule Synth or its hardware, just send email and I'll get whatever data I've got to you soon :)

