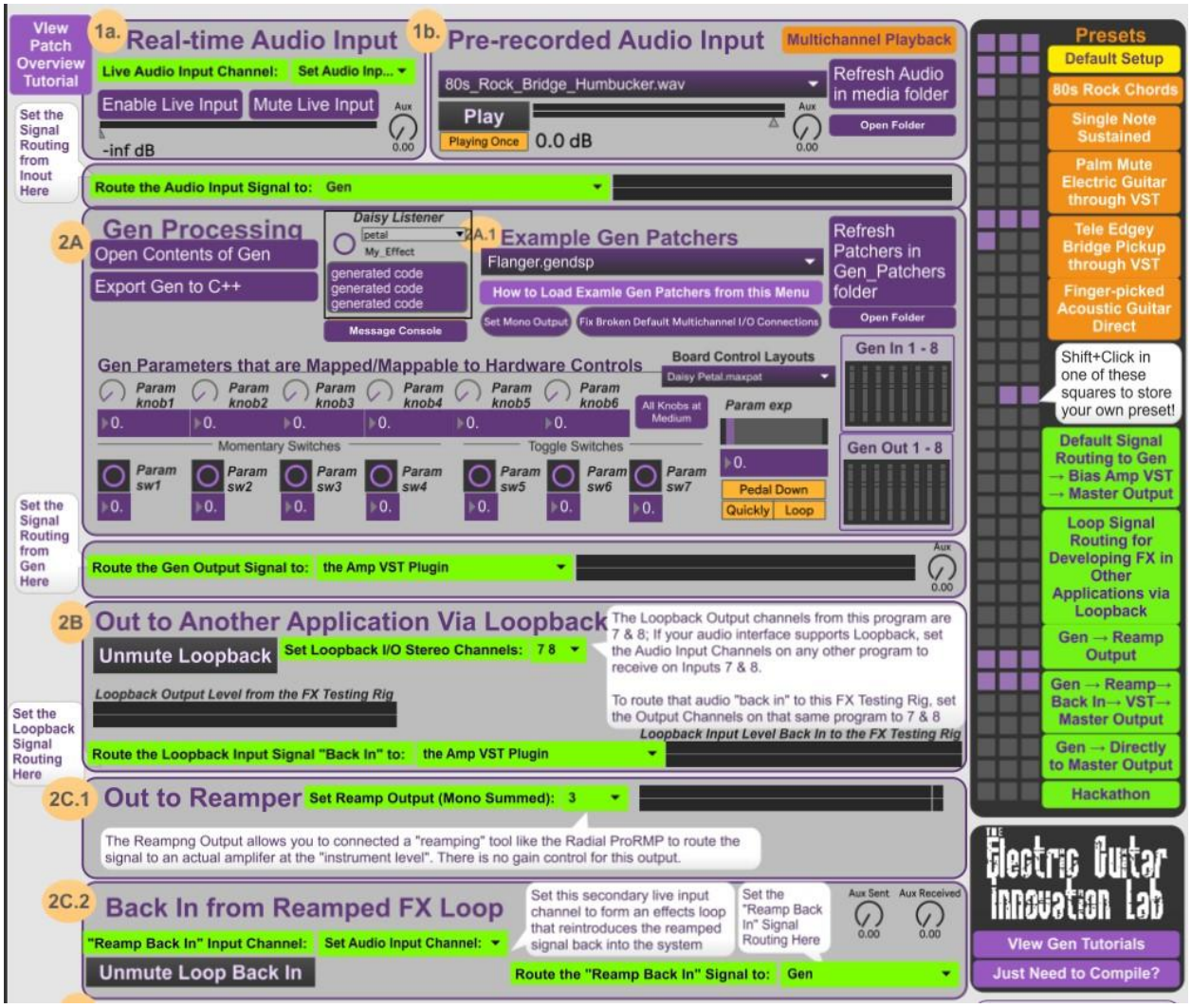
Les Paul Pedal Team: Paul Mara, James McAleese, & Tyler Reiser

Our team was inspired by Les Pauls' reimagining of a Rogers and Hart song named *Lover* which he released in 1948. His innovative track featured eight electric guitar tracks, all played by himself. The composition had an almost futuristic element that captivated fans that was achieved by tape recording some of the guitar sections at half speed, and then playing them back at normal speed. This effect allowed the guitar sections to be played back at effectively double speed and gives the song its iconic sound.

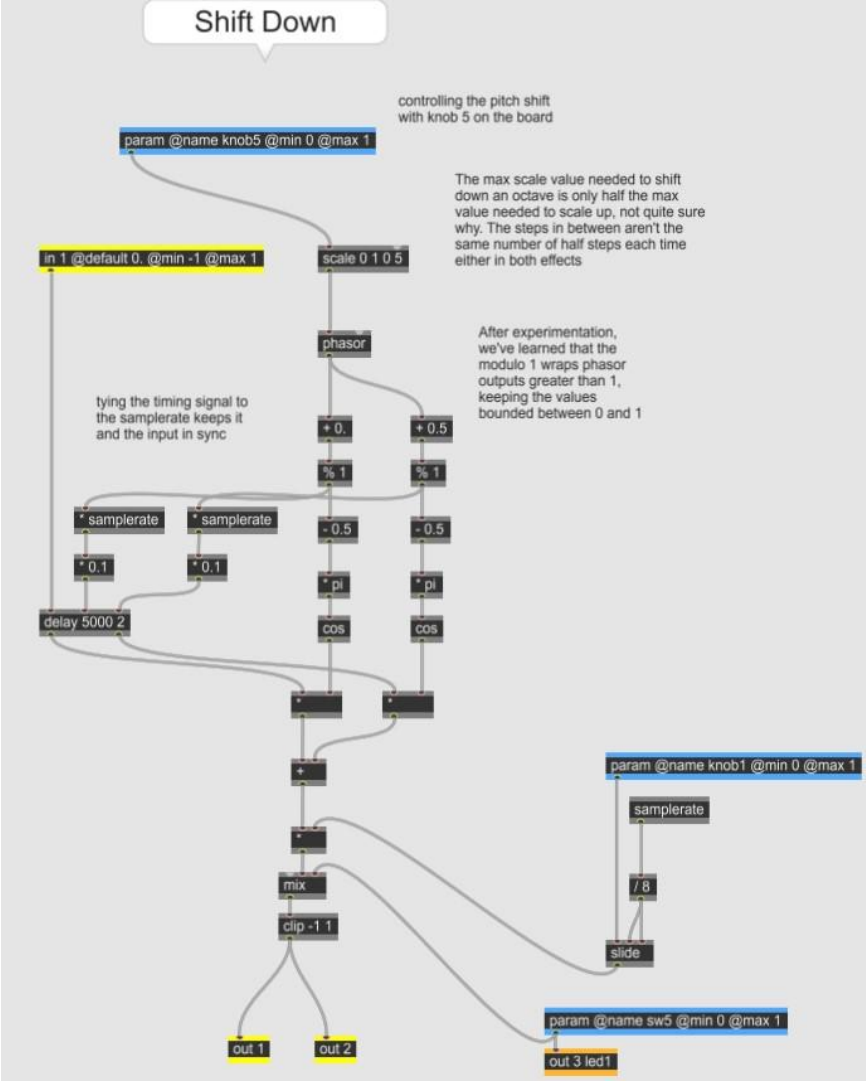
Our goal was research digital signal processing techniques and then use that knowledge to create a standalone guitar pedal that would be able to recreate the futuristic effects showcased in Les Paul's *Lover*. Our initial research and consultations allowed our team to attempt two different methods for pitch-shifting. The first method is a more traditional shifting that requires directly multiplying the frequency of the input by an external value to increase or decrease the frequency of the output.

However, after experimenting with this method, we learned that because Gen processes audio in discrete samples rather than continuous audio we could not achieve this method directly. The second method, which our project focuses on, is actually a method of Pitch control, which is a process which affects pitch and speed simultaneously by slowing down or speeding up a recording. This implementation incorporates frequency multiplication and takes advantage of the discrete sampling to produce the desired effects. Our team uses a prebuilt gen-patching tool called the FX-Testing-Rig to apply our custom Gen code to the pedal shown below.



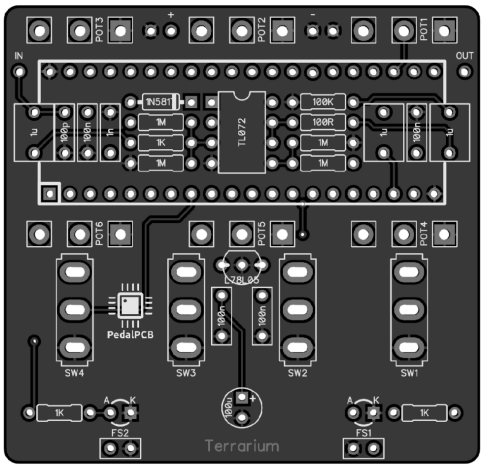
In order to achieve our pitch control effect, a series of steps are applied to the dry signal. Both the Shift Down and Shift up work the same way, but with different bounding parameters. A knob on the pedal controls the frequency of a phasor object within the gen patch. It creates a sawtooth waveform whose output is then split into two separate waveforms that are rotated out of phase by 50% with one another. Those phasor waveforms are then multiplied by the sample rate of the input audio and fed into a delay object. The delay object takes the input audio and outputs it in two channels, one sample at a time at the rate set by the (phasor * samplerate) value from earlier. Those individual delayed output samples are then multiplied by initial phasor values measured in radians. The result is that the input has been sliced into samples, had it's samples spaced out by a delay factor, then stretched or compressed to fit that new delay factor.

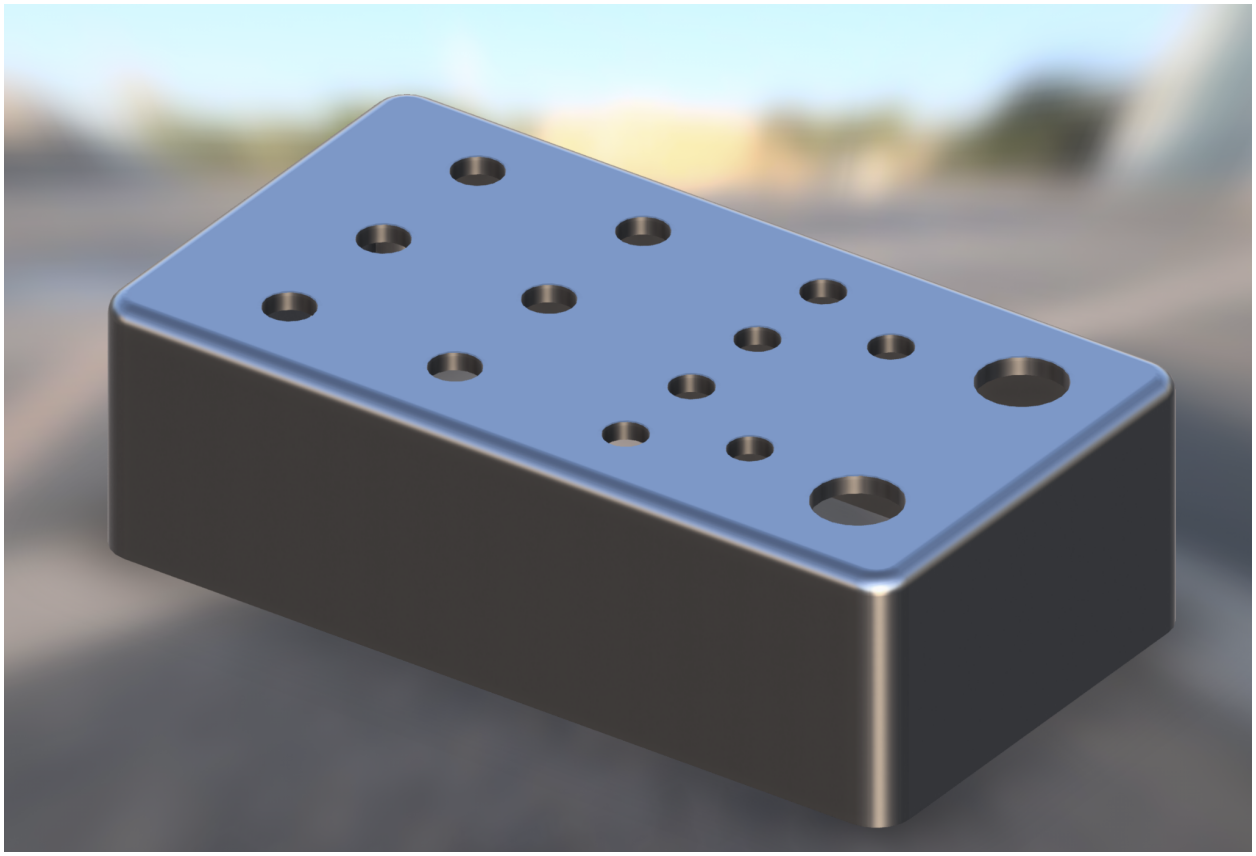
Once both output streams have been modified, they are added together to create a whole, single output. Lastly, the output is fed through a final multiplier object connected to a knob scaled from 0 to 1 for gain control of the effect, and through a mix object connected to a switch to toggle the effect on and off. To learn more, please download the most up to date version through the github page and associated wiki.

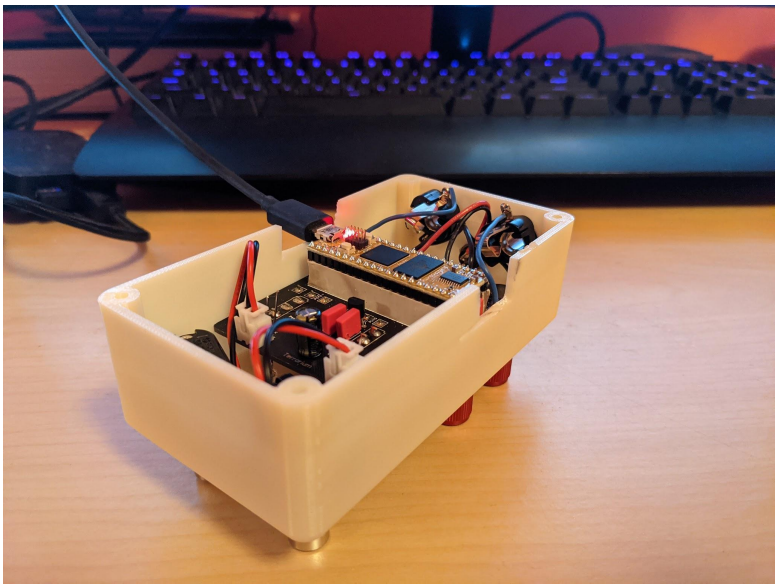


In addition to our pitch-controller, during the final stages of our signal-generator design, we realised we had some additional knobs on our pedal that were not being used. Inspired by Les Pauls' work with Flangers, we used this last space to add a controllable Flanging effect to the pedal as well that showcases the range of effect Les Paul worked with.

Once our signal-processing generator was working, we began working on the physical pedal. Our team was given the components and a guide to assemble a custom pedal in a Terrarium 125B Enclosure. Soldering all of the components onto the board was relatively easy, the complications came more from the close proximity of all the components and small work space. Once the components were added to the board, we were ready to slot the decorative cover over all of the components. We originally used an aluminum casing and a template to align the hole placement, however we encountered some tolerance issues that prevented us from using that original covering. Instead, our team designed and manufactured a 3D printed casing that is shown below. This new casing was more precise than our original case, and allowed the components to slot into place with only minor alignments. The link to our 3D printed casing can be found here.



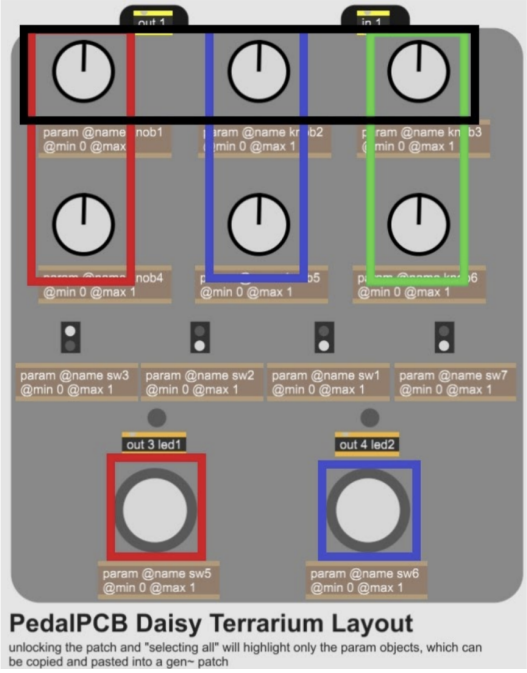




Our completed pedal works by first connecting the two 14mm audio jacks into the board. The jack to the left of the power jack is the signal output that gets connected to a standard amp. The jack to the right of the power plug is the signal input that is connected to a standard electric guitar. Once the jacks are inserted you can attach the 9V DC power plug and begin using the pedal. In the diagram below, you can see which knobs enhance or reduce which effects. The user interface was designed to be as intuitive as possible, while preserving as much functionality as possible as well.

Pedal Effects Breakdown

- The finalized pedal contains 3 effects:
- Shift Down (Red)
  - 1 Knob for the effect gain (Black)
  - 1 Knob for the shift amount, maxing at 1 octave down
  - 1 foot switch to toggle
- Shift Up (Blue)
  - 1 Knob for the effect gain (Black)
  - 1 Knob for the shift amount, maxing at 1 octave up
  - 1 foot switch to toggle
- Flanger effect on the Dry Audio (Green)
  - 1 Knob for the dry gain (Black)
  - 1 Knob for the flanger intensity on the unshifted output



PedalPCB Daisy Terrarium Layout

unlocking the patch and "selecting all" will highlight only the param objects, which can be copied and pasted into a gen~ patch

As of writing this document however, the knob outputs are not actually able to be processed on-board the daisy seed. The knobs work on the Daisy Petal, but we were not able to kludge support for the seed during our project in time.

As of writing this document, the code that supports this functionality is held in the “dev” branch of the oopsy library. The functionality is in pre-alpha, as defined by oopsy, which they say means it will change drastically over the coming months. There is a JSON file that you can find that describes what you need to change in the WIKI section of the oopsy library, “custom seed targets”. Also linked here:

https://github.com/electro-smith/oopsy/wiki/Custom-Seed-Targets

We believe that this pedal serves as a great prototype and inspiration for future custom effect pedals. Any future team that builds upon this project could continue

improving the pitch-shifting effects, and work on implementing a true discrete signal based shifter to showcase the differences in sound quality. Additionally, the team could expand on the types of effects by adding togglable effects onto the remaining switches on the terrarium pedal.