DreamScape: A Multi-Effect Guitar Sequencer

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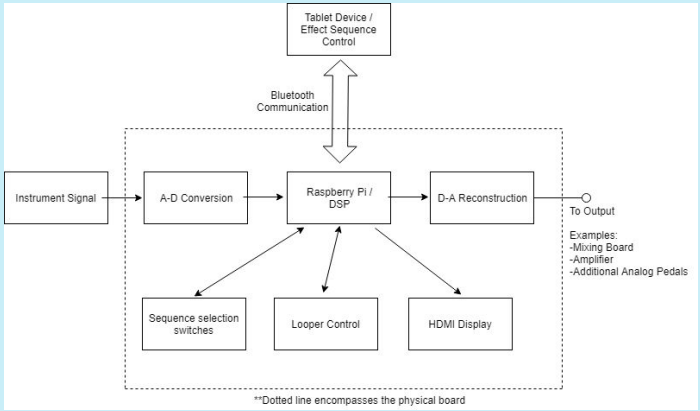
Problem Statement

- Effect Pedals play an important role in live performances.
  - Multiple effects require stringing multiple pedals with each other and become complex and messy
  - Effects in parallel not easily possible with standard effect pedals
- Configuration of configurable boards on market unintuitive
  - Many still only accept one effect at a time or only effects in series
  - Configuration of presets only allow one on the board at a time
- Our plan is to design a pedal-board that allows free configuration of effects
  - Intuitive UI
  - Multiple presets loaded to free-switch in the middle of a set
  - Efficient signal processing
  - Modular preset design to allow for additional effects to be added in the future

Our Solution

- Raspberry Pi microcontroller used to process signals
  - ADC/DAC circuit used to send signals to/from the Pi
- Android Application used to configure presets with the board
- Display on board used to show current selected preset
- Board takes input from a guitar, output to an amplifier
  - Input stage can accept a signal from any source with an amplitude between 50 mVpp and 4.5 Vpp



Project Design-Software

- Signal Processing code written in C
- Bluetooth Socket methods written in Python
- Reads preset files to set proper effect configuration
- Takes in an input signal from ADC input
- Outputs the processed signal to DAC output
- Individual effects are separate methods that modify the signal
- Some effects were referenced from PedalPi, an Open Source lo-fi single-effect pedalboard.
    - Most effects were edited for our purposes
    - Some effects (such as loopers) are 100% original.
- Early testing of effects used with wavefiles outputted through auxillary output using PortAudio Open Source Library.
- X11 Libarary used to display simplistic UI on the board.

Project Design-Software

Preset Format:

- Verification string (447448)
- Preset name prefixed with NAME
- START starts input, END signals end of preset
- STEP signals moving to the next layer
- Effect:
  - Name
  - Effect-specific Vals (optional)
  - Options bit (optional, usage varies)
  - Effect Weight (not on NOSOUND)
  - Which layer to get sound from (0=default)

```
447448
NAME SubtleTremolo
START

TREMOLO 10 1 0
CLEAN 1 0
NOSOUND
STEP
CLEAN 1 0
NOSOUND
NOSOUND
STEP
CLEAN 1 0
NOSOUND
NOSOUND
STEP
END
```

Project Design-Software

List of Effects:

- Clean:Output unaltered sound
- Bitcrush: Shift sound left by n bits
- Booster: Boost audio by a fractional value
- Delay: Adds a delay to outputted sound
- Distortion: Cap highest and lowest possible sound
- Echo: Plays a delayed sound that tapers off
- Fuzz: Sets signal above/below a threshold to max/0
- Tremolo: Compares amplitude with a waveform to change audio volume in a sine wave
- NoSound: Output nothing.
- Octaver: Shifts pitch of audio by changing the speed at which the sound outputs, can also be a looper
- Loopers: See Next Slide

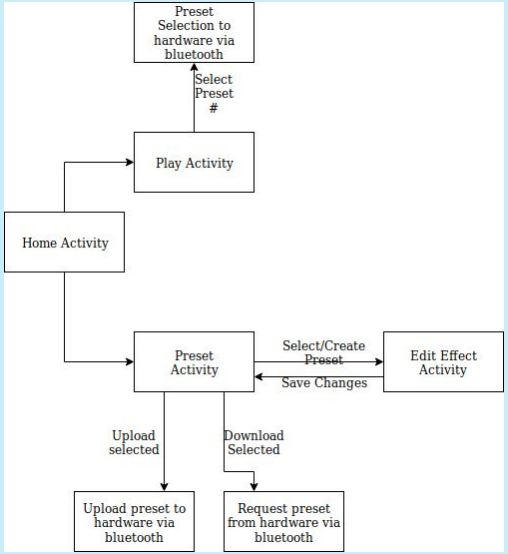
Project Design-Software

Looper Effects

- Accidental novel discovery
- Records an audio signal, and repeats the signal on an infinite loop
- Options to wipe audio or record over recorded audio
- Recorded audio can be outputted many ways:
  - Standard (Looper)
  - Reverse (InvertLooper)
  - Forward/Backward (or vice-versa)
  - At a different pitch/speed (Octaver)
- Looper buffer can be statically set, or dynamically set when recorded (to a certain limit)

Project Design-Application

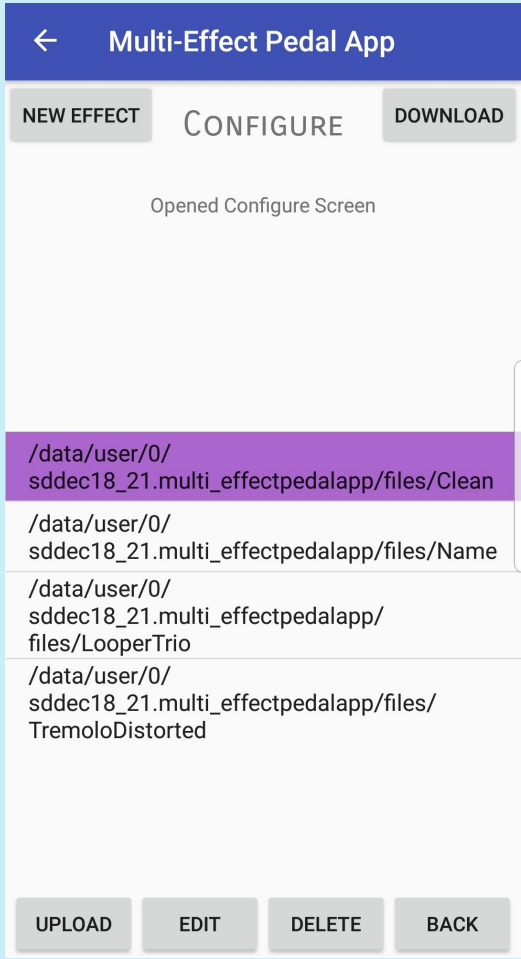
- Application developed in Android
- Communicates with Software via Bluetooth socket
- Sends/receives commands and preset files
  - Can send commands to change presets in software
  - Deprecated by footpedals but still implemented
- Configures and saves presets internally



Project Design-Application

Preset Configuration Activity:

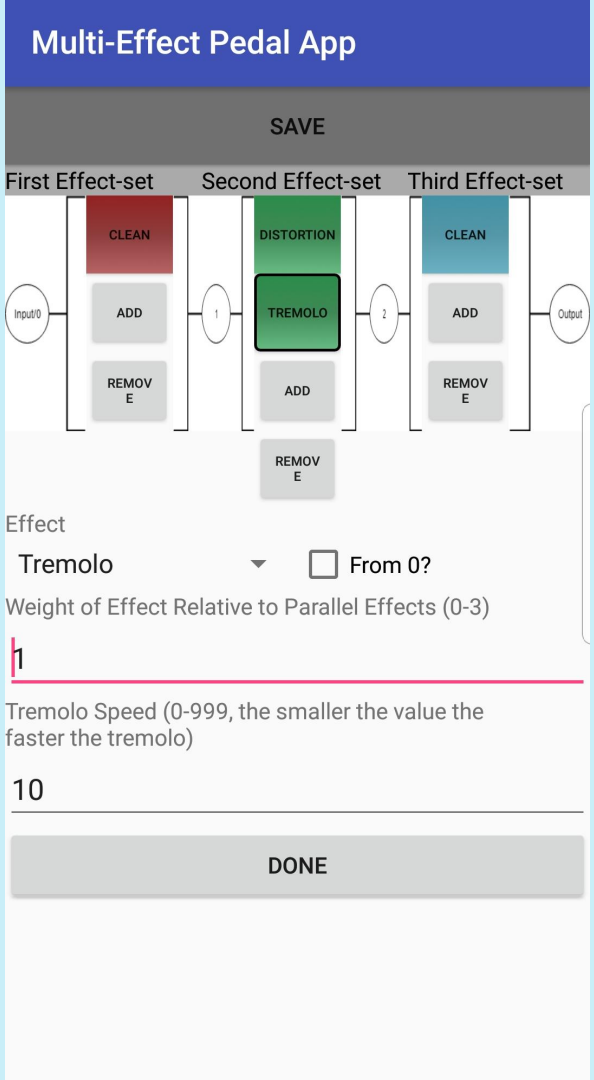
- Shows a list of presets stored on the device
- Can download presets from the board and add to the list
- Can upload presets onto the board
- Can create new(blank) presets
- Can edit presets



Project Design-Application

Preset edit activity:

- Shows a simplistic diagram of the effect mux
- More/Less effects can be added in parallel
  - Preset file stores unused spots as NOSOUND effects
- Tapping a preset opens a configuration box
  - Fields are unique to each effect



Project Design-Hardware

IC overview:

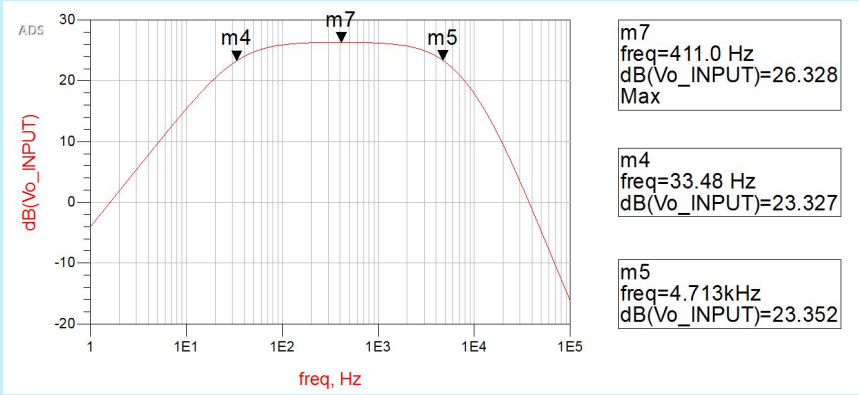
- ADC used to convert guitar signal to binary data for DSP stage
- DAC advantageous over PWM for D-to-A reconstruction
- Dual package Op-Amp used for input and output stage
- Chips used were specced with a Vdd supplied by Pi3 +5V rail

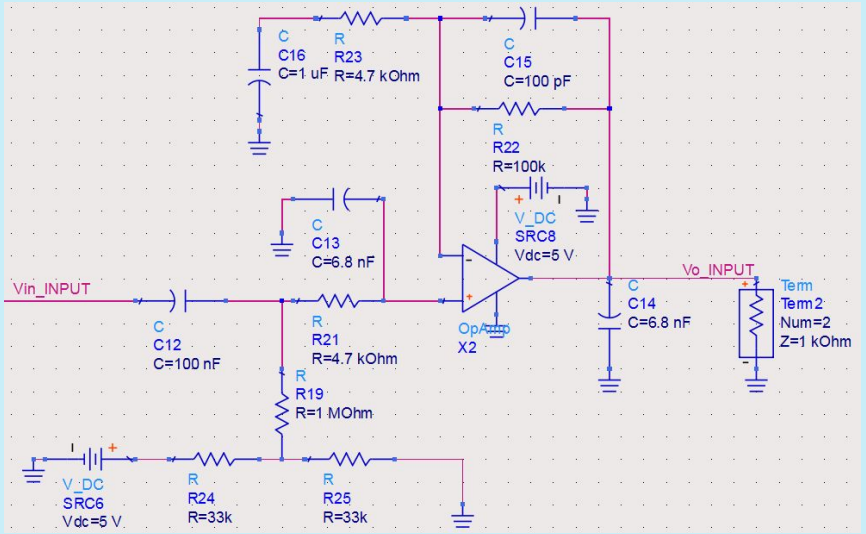
Project Design-Hardware

Input Stage:

- 4th order band-pass filter to remove noise and high order harmonics
- Bias network to prevent negative voltage input to ADC
- Op-Amp provides low impedance source per ADC datasheet

- Active pickups require removal of top panel

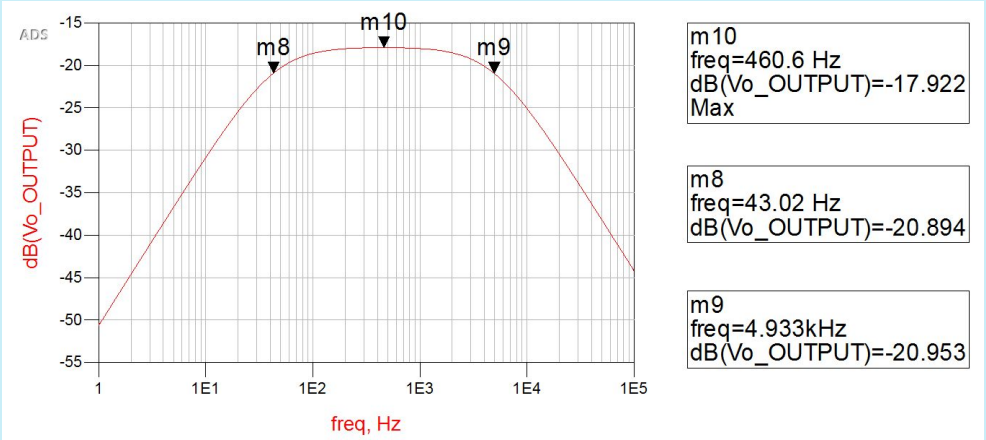


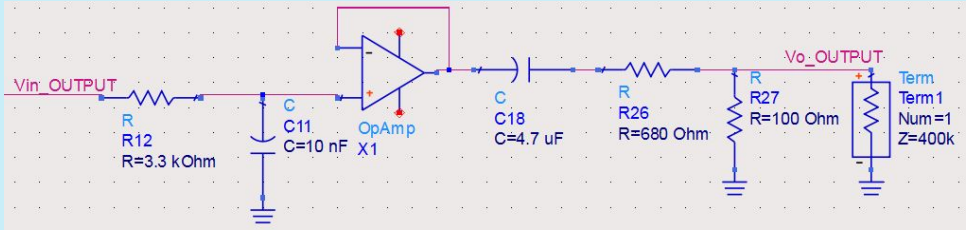


Project Design-Hardware

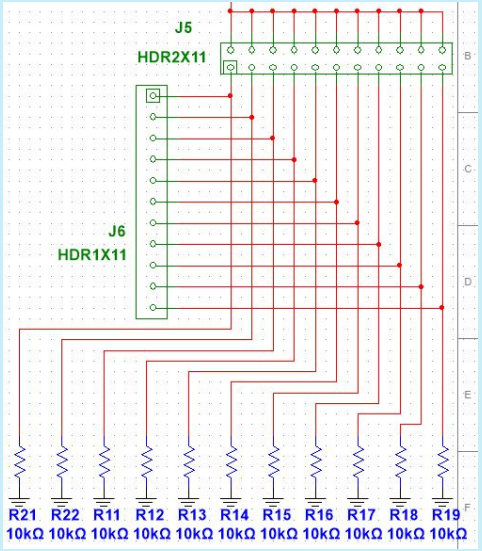
Output stage:

- 2nd order band-pass filter
- Unity buffer to provide low output impedance
- DC blocking capacitor to remove the bias of the DAC output.



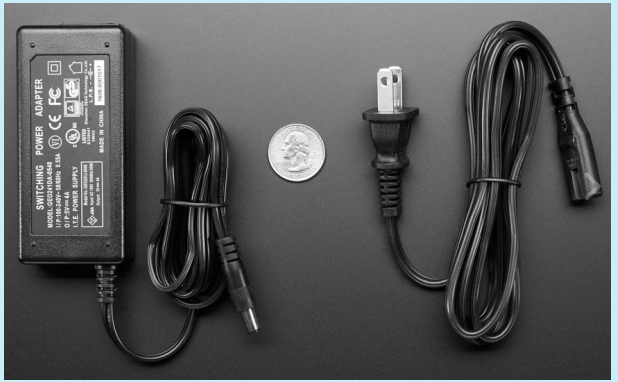


Project Design-Hardware



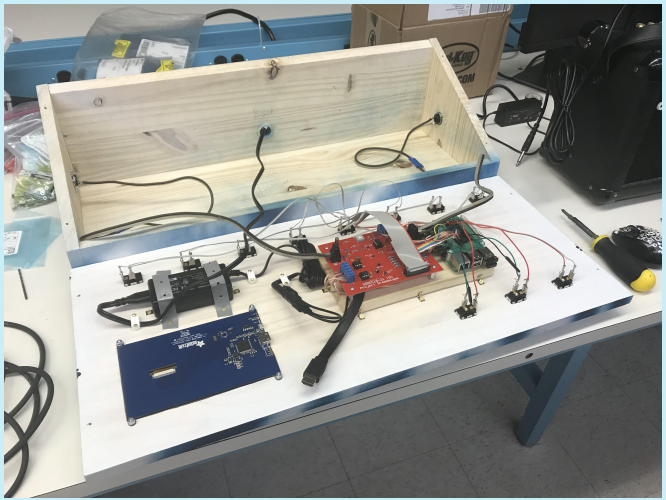
Switching and Display:

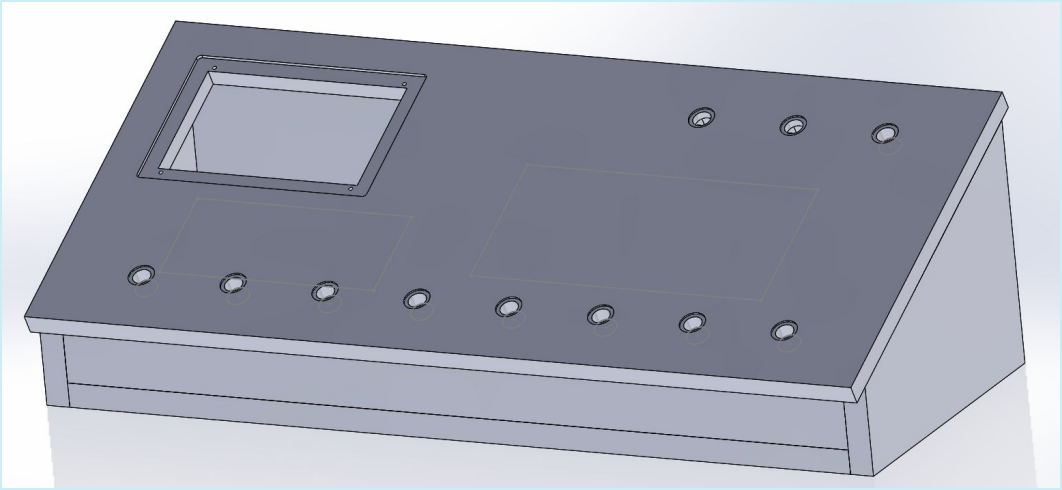
- Rugged, momentary contact push-button switches used for switching
- +3.3V Pi3 rail, along with 10k series resistor keep current draw low
- +5V, 4A power supply with Micro-usb splitter to power Pi and HDMI display
    - Pi3 suggested current rating of 2.5A max and display requires 600mA
- Display panel large enough to see across stage by performer



Project Design-Enclosure

- Solidworks used to model the enclosure and DXF export for CNC milling
- Made of wood with plexi-glass display cover
  - Cheap, durable, and easily workable - weather resistant with attentive care
- Hardware mounted to underside of top panel for easy removal





Project Cost Analysis

- Tablet - $60
- Raspberry Pi3 - $35
- Terminal Block Pi Shield - $20
- HDMI Display - $80
- Foot Switches - $60
- Power Supply - $20
- Interconnects - $30
- IC Chips - $10
- Passive Components - $20
- Prototyping + Leftover - $150

Enclosure:

- Wood - $20
- Screws - $10
- Brackets & Standoffs - $10
- Plexiglass - $5
- Paint - $15
- Other - $10

Total Project Cost = $555

Demo

Questions?