Sound Effect Devices for Musicians

PROJECT PLAN

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1 Introduction

1.1 Project statement

Our project is to take multiple pedal interfaces and combine them into one functioning pedal, and to control our pedal with an easier interface with greater versatility for users.

1.2 purpose

Our main purpose for this project is to provide musicians with a new pedal that can accomplish many of the sounds achieved in various pedals, and to give them a better interface to control their pedals. Today's musicians collect several pedals and try to manipulate sound in their own unique way with the limitations of the pedals they buy, but we want to give them more freedom in their sound selection as well controlling them live.

Currently there is no user interface that allows a musician to adjust the individual settings of a pedal in a live setting. Normally a musician is focused on the music and does not have the time to adjust the settings manually, usually by hand, which is crazy!! Why would we make a musician use their hands as the only method to adjust the settings on a pedal? These sound effect devices are mostly used by musicians for changing the sound of their guitar, bass, or keyboard. All of these instruments require the use of almost both hands at all times to operate, so there is no way to adjust a setting on a pedal in a live performance. With our pedal mat interface, we could use foot switches to adjust each setting on a given pedal that's compatible with our design. This mat would free up musicians to adjust their pedals to their heart's content while playing their instruments uninhibited.

The pedal we are designing is unique itself by having the necessary interface that allows it to be controlled by the pedal mat. Using a microcontroller to communicate the adjustments to the rest of the pedal, making adjustments live seamlessly. Another feature unique to this pedal is the splitting of the input signal and manipulation to the split signal, giving the musician two outputs to utilize. One output could go straight to an amp, while sending the other signal through a series of other pedals to create a unique sound synchronized with the other signal.

We are going away with the days of old, where a musician would have to adjust their pedal before a performance and deal with the settings throughout the show. Sometimes a musician might kick a pedal's settings on accident or realize too late that his settings don't sound right, well not any more. With our pedal mat, the performer can quickly adjust any setting on the pedal hands-free!!!

1.3 Goals

The goals we would like to accomplish are having performers in a more relaxed setting with all their pedals at a single location, free state of mind from hazardous wires, and programmable interface for the user to control and customize. In the end, we would like to influence the pedal industry to convert to this standard such that the pedals may be controlled with the pedal itself or a universal interface.

2 Deliverables

Our deliverable will be a mat, something similar to the “Dance Revolution” video game mat, that has the functionality of all user pedals into a single, 2-by-6 button layout interface with the help on a microcontroller. To avoid stepping on two buttons, we will have a vertical rise on the back row and for the majority of the buttons, there will be an “on” or “off” state; To aid the user, we will have an LED display to notify the user what state they are in so they can prepare for the next sequence of buttons for another sound effect. Another thing we will consider are the wires on the stage that can be hazardous for the performer; However, our pedal will be able to function with Bluetooth, Wi-Fi, and wired. The pedal itself will be taking in one input from the user’s instrument and then splitting this signal, where one half will be manipulated and the other half will pass unaltered. This allows the user multiple combinations for a wide range of sound adjustments and phenomenon.

3 Design

There are two portions to this project: the pedal effect and mat interface. The pedal effect has a few possible methods. See Figure 1 on page 4 for a system diagram of our design.

Possible Octave Modifier Methods:

1. Analog Circuits
    a. Use all analog components to manipulate the signal to our desire output
    b. Build printed circuit boards to reduce the size of the pedal
    c. This will provide the purest sound and nothing will be lost
2. Digital Circuits
    a. Use digital circuits to manipulate the signal and analog components to deliver the sound
    b. Use a microcontroller to sample the input frequency, write a program that reads the data, and manipulates the output to our specifications.
    c. Frequencies may be lost due to sampling and limits of the microcontroller.
    d. Need microcontroller that meets the specifications.
    e. Use Matlab to simulate different sound effects
    f. Will make the communication between the mat and the pedal.
3. Teensy - Microcontroller
    a. Read in input signal and sample values
    b. Find frequency of wave
    c. Create new signal from samples that is raised by one octave by doubling the frequency
    d. Output new signal

Pedal Mat Design

1. Physical Layout
    a. 2-by-6 button layout
    b. Size: 0.75x0.35 (m)^2
    c. Back row raised to accommodate for the chance of accidently pressing two buttons
    d. Button Square
        i. Each will have a LED display

ii.Each will have a two digit seven-segment display

2. Circuitry
    a. Shift Registers
    b. Seven-Segment Display Decoders
    c. Pull-up and pull-down networks
3. Controller
    a. Teensy 3.6 microcontroller
    b. Teensy Audio Adapter

3.1 Previous work/literature

In the world of pedals, there are lots of sound effect devices that manipulate the signal for an effect; However, most of these pedals are only able to produce a single manipulation. Two pedals we would like to use are the octave up and octave down pedal built onto one device interfaced with our mat. Example of these devices are the pedals called "The Green Ringer" (1) and the Octave-down fuzz (2). These pedals have the ability to increase/decrease the octave and output to one or more amps. Our design will be very similar except there will be one pedal with a mat to select the sounds the user wants with a single interface, rather than several pedals. There's a group of musicians that use this setup with multiple pedals called Royal Blood (3). This is a two-man group that sounds like a full 4- man group; They accomplish this by having the guitar and bass being played by one person switching between the two sounds or playing their sounds simultaneously. We want to take the idea and build a better setup for the pedals and a more efficient way to interface with the pedals using wireless communication.

3.2 Proposed System Block diagram

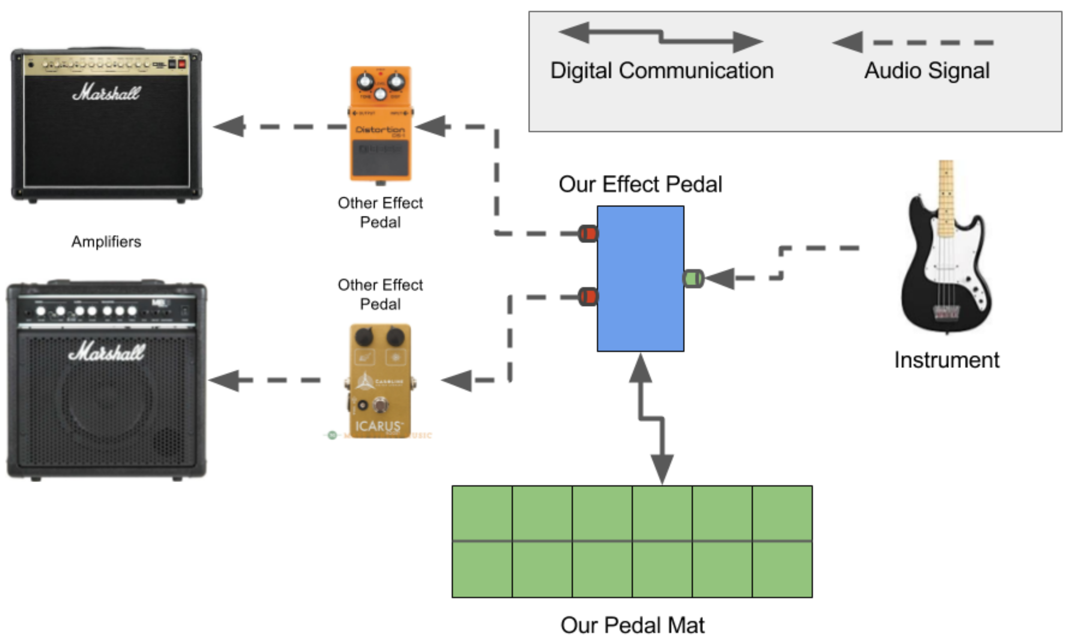
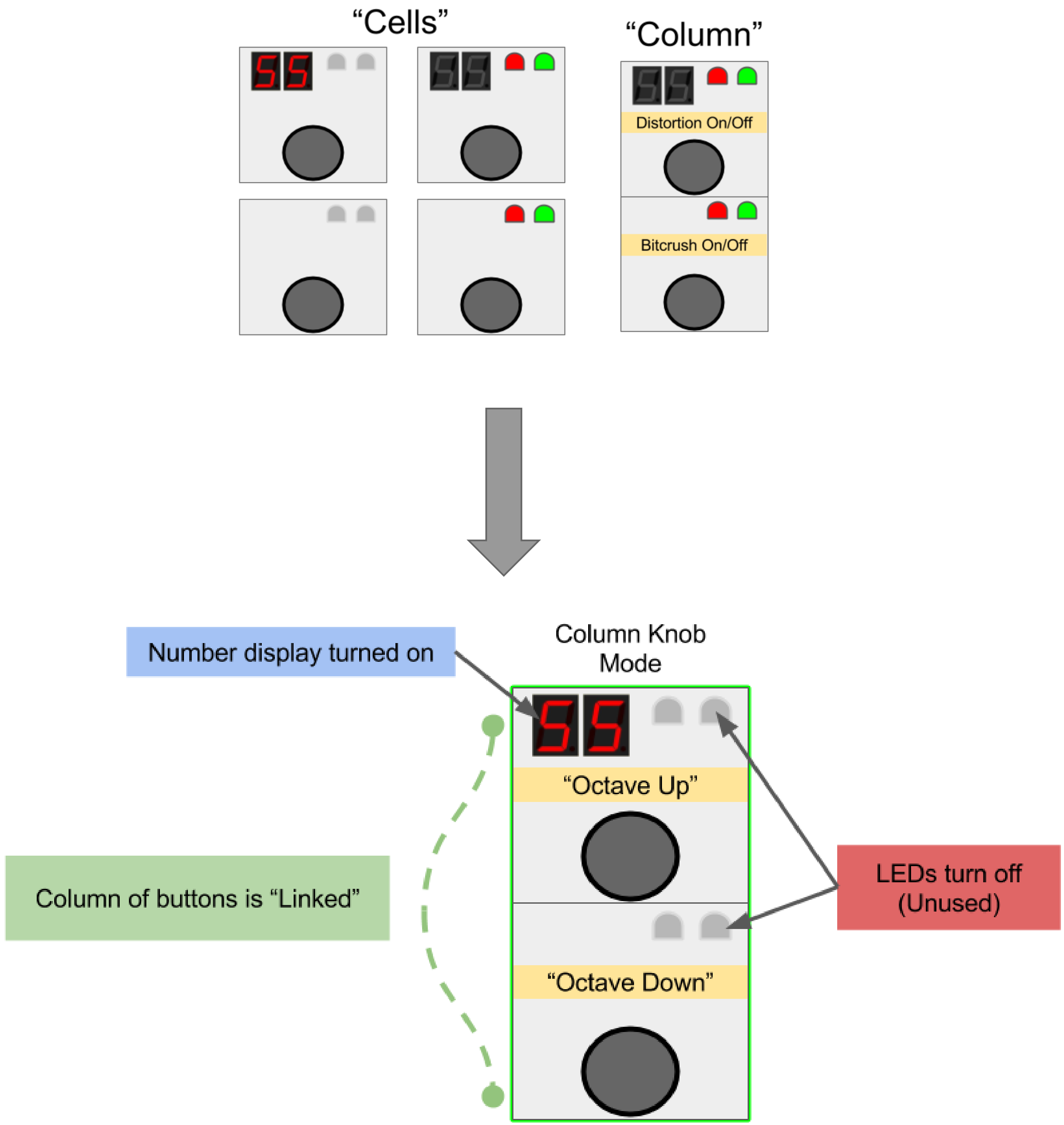


Figure 1: *System Block Diagram for the Pedal and Pedal Mat Layout/Flow of Information*



From the diagram above (Figure 1), you can see the general flow for our pedal and pedal mat designs. We want to take the input from the guitar/bass/keyboard/whatever instrument they're using and use that input to manipulate and split the signal. The pedal then has the option of sending the input signal and the manipulated signal to other pedals, or sending their signal straight to an amplifier. The main function for our pedal is to split the input signal to manipulate another signal and synchronize it with the original input signal. The pedal mat feature would interface to our pedal, and from there it will be able to control multiple features of a wide variety. Ultimately the goal of the pedal mat is to have a section to control every feature on a pedal that would normally be adjusted by hand. This allows the user to have the freedom with their hands, and the luxury of adjusting their sound live.

3.3 Assessment of Proposed methods

We have the potential to implement the octave up pedal with analog or digital. We have built the schematic of the analog circuit, see reference 1, have seen the output waveform that increases the frequency by a factor of two, upping the octave by one. However, we cannot do this for the octave down pedal with analog components. We found out that our microcontroller, the Teensy 3.6, had some extensive capabilities (2). The Teensy 3.6 could read sample audio input at sampling rate of 44.1kHz at 16 bits depth (3), then manipulate the digital samples with the Teensy's Audio Library effects (4). We can then start coding our own custom effect to output a value of either an octave up or an octave down. At the time we were contemplating our main problem, another arose. We wanted to know of an interface we could use with the device to allow adjustments to be made to our pedal during a live performance.

We could design the mat like a dance revolution mat, but would constrain the perform in one location unless they are very careful. We decided on building a mat that's a 2-by-6 button layout, see Figure 1, with some indicator to notify the user what the mats doing currently. We have decided upon using momentary push buttons for the pedal mat and pedal. This will allow the user to use the buttons in either the toggle state mode or the incremental mode. These momentary push buttons will have to be debounced in order to not count the press of a button more than once, but that can be fixed with a debounce library in the Teensy.

3.4 Validation

To test our design, we will test the individual parts by itself (separate testing for mat and pedal). Testing the pedals will involve a sinusoidal source such as a guitar input or function generator and measure the output with the oscilloscope. Once the pedal is functional, we can test the logic of the mat switch circuitry. We can build the schematic and have LED's at the load where the microcontroller will be referencing. Once the logic is correct, we replace the LED loads with the microcontroller and then run the program and see if the correct functions are called. We will have a "Serial.Print()" statement that tells us where we are at in the program for debugging purposes. Once the individual tests work, we will test everything together. We will setup everything and have a function generated sinusoid to validate the signal is correct. Once the logic matches the mat commands and the output is what's requested, we will use a guitar input and hook up the amp to listen.

4 Project Requirements/Specifications

4.1 FUNCTIONAL

The functional requirements for this pedal design are to output the octave up/down and original signal up to three loads to get multiple harmonics of the note/chord that's played. We want the pedal to easily be controlled by the user without touching the physical pedal but instead on a single interface, the mat. The mat will have a microcontroller that communicates with the pedal wirelessly on what effect the pedal should make with the given pedals connected/programmed. The mat will have a LED display to state the current effect for the user for easy accessibility to change the effect.

- Effect Pedal
    - Output an effect signal
    - Raise input/output volume up and down
    - Output an unmodified input signal
    - Will be able to function with Bluetooth, Wi-Fi, and wired

- Pedal Mat
    - Reprogrammable 2-by-6 button interface layout
    - LED display to notify the user what state the microcontroller is currently in.

4.2 NON-FUNCTIONAL

- Run off of a 9-volt power supply
- There must not a significant delay between the input signal going into the effect pedal and the signal being sent out of the effect pedal

4.3 STANDARDS

Since we will potentially be writing C code for the Arduino, we will be following the Google C++ style guide. Some goals of this style are to optimize for the reader, not the writer and to be consistent with existing code. There are not very many protocols for guitar/instrument pedals, since the industry is very vast and spread amongst a wide variety of professionalism. Some guitar pedal manufacturers are part of a global company and are of a higher level of professionalism, but some users seek out the pedals by hobbyists for their unique design and sound. One of the general standards for guitar pedals is that most use a 9V power supply.

5 Challenges

Like most project, challenges are unavoidable or the project it dull. Some difficulties that may arise include: wireless communication via Bluetooth/Wi-Fi and sampling accuracy. When it comes to analog and digital, frequencies will be lost and we want as much of the original signal as possible with little error. To achieve this, we need a high ADC/DAC resolution along with a fast microcontroller that will sample quickly, analyze the data, and modifies the single fast. Plus, we want to connect to Bluetooth/Wi-Fi with the microcontroller so there are no wires from the pedals to the mat with very small delay. These are some of the issues that are more than likely to arise plus anything else that comes to the project. Regardless the challenge, they will need to be resolved for the design to reach the final phase.

6 Timeline

The Gantt chart is in the appendices for semester one and two.

6.1 First Semester

To start the first semester, we are conceptualized some ideas for a pedal. After we brainstormed we then went out and researched some pedals similar to the functionality of our own. Upon finding the circuit diagram for the Green Ringer pedal (2) we built this circuit in PSPICE to test the functionality of the circuit. We found the pedal could achieve a frequency that was double of the input sine wave, but the amplitude could be inconsistent, depending mostly on the amplitude of the input signal. After some more thought we thought we could implement the frequency doubling/halving using digital logic. Once we were settled on the basic idea to make our pedal work, we discussed how we would want to interface with our pedal. Which made us think of the creative way of controlling every feature of the pedal using a pedal mat. We figured that the average musician could not afford to free their hands to make adjustments to the actual pedal while playing so we made every feature controllable with their free feet. Then we discussed how we would layout our pedal, and the general functionality of our pedal mat came into focus. The pedal mat should make small incremental changes depending on how many times someone taps a momentary switch, with higher on the mat increasing the level and lower on the mat lowering the level. The momentary switches would deliver a higher voltage to the microcontroller, which would then interpret the signal and communicate back to the pedal what would need to be adjusted. After the functionality of the mat was figured out, we moved back to making the pedal work. The microcontroller we decided on using was discovered to be powerful enough to measure frequency of input signals and then output an analog signal. We have made progress on testing our pedal mat as well, with the shift registers working exactly as we expected. The output shift registers are able to control 16 LEDs individually as well the input shift registers are able to read 8 push buttons. Also, the output shift registers are able to display correct numbers with the seven segment displays.

6.2 Second Semester

After summer 2017 break, we will meet up to finish the project. We will first start by reevaluate our prototype that we finished in the last semester. If we come up with a better design during the summer break or first two weeks of classes, we will build the second version and compare to the original and see which one is the better design and functionality. Once the design is complete, we will proceed to the testing phase with an input from a guitar to see how the pedal changes the sound. During this time, if we find flaws or areas of improvement, we will adjust the software/hardware and test again. Once we are clients and ourselves are satisfied with the performance of our design, we will print a circuit board for the hardware, build the pedal, and build the mat. Once the product is finished, we will have some guitar players/live musicians come and test our pedal and interface to hear their input. We will adjust accordingly the first batch of testers' input and test again with the original and other guitar players.

7 Conclusions

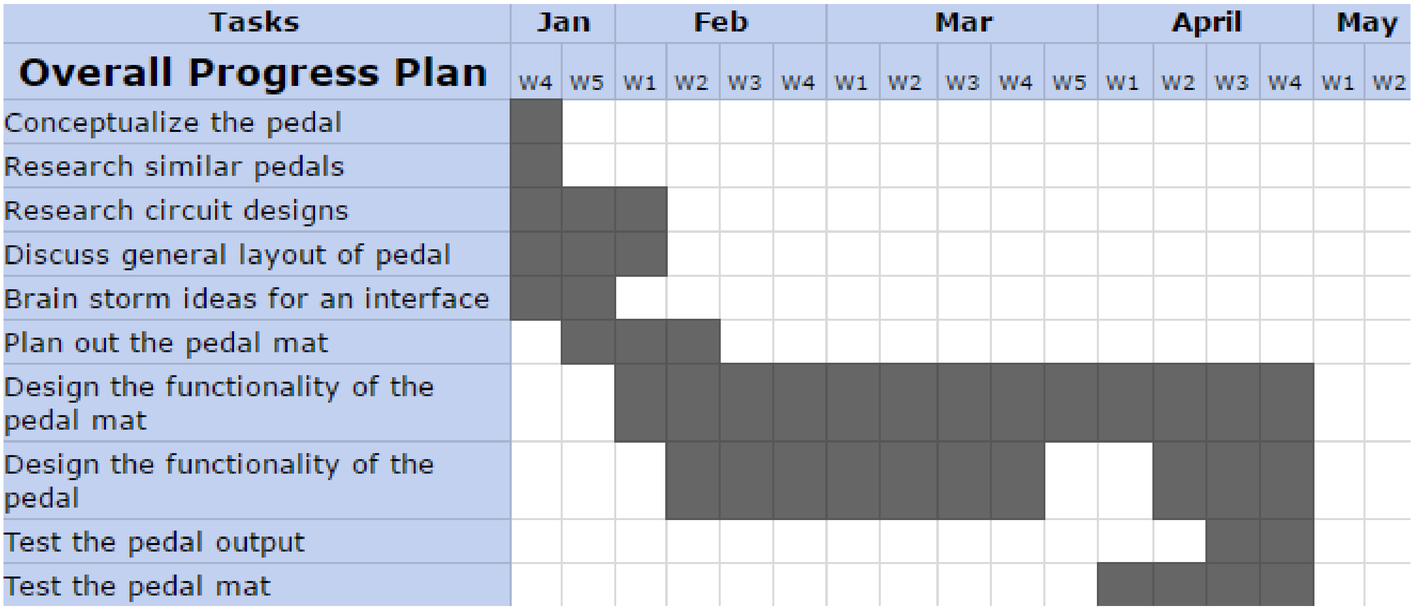
The objective of this project is to grasp the concept of taking multiple guitar pedals and make an interface that can control the pedals effects in once interface. We want the pedals, the devices that make the sound effects, to be off the stage and controlled by our mat and only our mat. Our mat will have the ability to toggle through multiple pedals and adjust the settings on each individual pedal. In the end, we will have a universal interface that can be controlled and customized by the user.

8 References

1. Octave-down fuzz
    a. http://pedalparts.co.uk/docs/BlueFool.pdf
2. Green Ringer Pedal
    a. http://www.generalguitargadgets.com/pdf/ggg_gro_sc.pdf
3. Royal Blood Band: YouTube video of the octave up/down in use.
    a. https://www.youtube.com/watch?v=ere2Mstl8ww&feature=youtu.be

9 Appendix

1st Semester



2nd Semester

Tasks	Aug		Sept				Oct					Nov				Dec	
Overall Progress Plan	W4	W5	W1	W2	W3	W4	W1	W2	W3	W4	W5	W1	W2	W3	W4	W1	W2
Reevaluate Prototype	■	■			■	■			■	■			■	■			
Work towards better functionality			■	■			■	■			■	■					
Testing with Guitar/Bass					■				■				■				
Readjust Circuit/Programming						■	■			■				■			
Final test of pedal and mat														■	■	■	
Fully functional pedal and mat																■	■