# Multi-effect Pedal Project Document

By Sean-Michael Riesterer, Trenton Bastasch, Michael Guske

Table o	f contentsi
Section	11
1	1.1 Executive Summary
1	1.2 Team Communication Protocols
1	1.3 Gap Analysis
1	1.4 Timeline/Proposed Timeline
1	1.5 References and Files Links
1	1.6 Revisions Table

#### **1.1 Executive Summary:**

This document outlines the design and fabrication of a custom Multi-Effects Pedal to be used by musicians. This pedal will allow a user to modify the sound of their electric guitar or other instrument by applying different effect profiles to the sound like distortion and reverb. The signal will pass from the guitar, through the pedal, and finally be projected out by the normal guitar amplifier and speaker.

The purpose of pursuing this project is to create a more affordable and hackable multi-effect pedal solution than those currently available on the market. By making a modular system, users can easily transport the Multi-Effects Pedal from performance to performance. Our custom Multi-Effects Pedal also offers unparalleled audio performance, due to our premier analog-mixed signal design solutions.

In order to accomplish this task several developmental milestones have been set and will be reached. They are detailed in a visual representation in *Figure 1.3 Project Timeline*. These primarily include the creation of a block diagram that outlines key modules that will allow the effect pedal to operate, from there a PCB will be designed with a microcontroller in mind (for control purposes). These elements will be synthesized into a testable device that will undergo verification and system validation to allow for final additions or revisions to be made.

## **1.2 Team Communication Protocols:**

Name	Phone Number	Email	Role
Sean-Michael Riesterer	509-637-6566	riesters@oregonstate.edu	Software Development
Trenton Bastasch	503-559-4224	bastasct@oregonstate.edu	Analog Design
Michael Guske	650-240-6104	guskem@oregonstate.edu	Digital Design

Figure 1.0 Contact Information Table

Торіс	Protocol	Standard
Task Management	Utilize our Jira Board to assign tasks to stories, and track progress.	During each meeting we will review the board and discuss our tickets. We will review how tickets were completed over the course of the sprint.
On-Time Deliverables	When a task is assigned to an individual, an expected	We will discuss our ticket progress openly and honestly

	due date is presented and expectations are clear.	during meetings, asking for help early to ensure completion by the deadline we set.
Team Meetings	Utilize meeting minutes documents to track discussion topics. Be on time to meeting, prepared with any predetermined tasks or research beforehand. Team collaborative activities completed or started during this time.	We will discuss our tickets, tasks coming up ahead between now and the next time we meet. Set up goals for deadlines for individual work at this time and work on collaborative work now.
Discord Usage	Team discord is our primary communication method. Meeting scheduling, general discussion, and sharing of resources.	We will use the #scheduling channel to schedule meeting times. Use the voice channel to meet remotely to supplement in-person Team Meetings. We can use the #general channel to further discuss projects and upcoming assignments.

Figure 1.1 Communication Protocol Table

Project Partner Communications Analysis:

In communications with our project partner we will adhere by the following guidelines:

- Communicate primarily through Project Partner Update emails once every three weeks.
- These emails will detail the steps we have taken as of yet on the project, and the steps we plan to take in the future.
- Set up meetings on Zoom with our Project Partner to discuss our progress and to address any project bottlenecks.

# 1.3 Gap Analysis:

The current process that is required to apply an effect to an instrument can be an exhaustive and expensive process. As it currently stands, an individual effects pedal can cost anywhere from \$20 to \$80 [1], and currently available multi-effect pedals can cost over \$300 to buy. To close the gap that currently exists between customers and the effect pedal, we have engineered a novel multi-effects pedal that will be both modular and cost-effective. We are assuming that the dimensions of our multi-effects pedal should be under 3.6" x 17.62" (L x W). A popular design choice in most available multi-effects pedals is to offer customers a digital processing solution for audio effects. This can lead to distortion when an effect is applied to the input signal. In fact, some of the worst effect pedals use digital designs for signal processing [2].

It is safe to assume that our analog solution will have extremely low distortion from our analog mixed-signal designs. An analog design does not have a sampling time for the input signal, therefore the output signal will have extremely low distortion when used correctly [3]. Our multi-effects pedal will help generate revenue for the music industry by giving musicians a better pedal and stores a product that sells itself.

#### 1.4 Proposed Timeline:



Figure 1.3 Project Timeline

#### 1.5 References & Links:

[1] Amazon, "Overdrive Guitar Pedal, Blues Drive Vintage Overdrive," *Donner Overdrive Guitar Pedal*, 2021. [Online]. Available:

https://www.amazon.com/dp/B00GROJWAW/ref=sspa\_dk\_detail\_2?pd\_rd\_i=B00GROJWAW&p d\_rd\_w=wOR1o&pf\_rd\_p=54ed5474-54a8-4c7f-a88a-45f748d18166&pd\_rd\_wg=wFIUI&pf\_rd\_r =N6ASBZKJDAS5ZSQ424BA&pd\_rd\_r=50b27b5e-dd0d-49cc-bcf2-a42d2caf4654&smid=ABZJ C0ZX82FPL&spLa=ZW5jcnIwdGVkUXVhbGImaWVyPUEzR0JJTEFUTkNUR0FaJmVuY3J5cH RIZEIkPUEwOTUwMDk0MjQ3TVIzSU9USFRFVyZlbmNyeXB0ZWRBZEIkPUEwMzYyMzY2SD A0V1QxMEFVRUpDJndpZGdldE5hbWU9c3BfZGV0YWIsX3RoZW1hdGljJmFjdGlvbj1jbGlja1JIZ GlyZWN0JmRvTm90TG9nQ2xpY2s9dHJ1ZQ&th=1. [Accessed: 11-Nov-2021].

[2] D. Slavokic, "Top 10 most hated distortion pedals," *ULTIMATE GUITAR TABS - 1,100,000 songs catalog with free Chords, Guitar Tabs, Bass Tabs, Ukulele Chords and Guitar Pro Tabs!*, 17-Jul-2019. [Online]. Available:

https://www.ultimate-guitar.com/articles/features/top\_10\_most\_hated\_distortion\_pedals-93709. [Accessed: 13-Nov-2021].

[3] D. John, "Analog pedals vs. digital pedals, which is a better pick?," *BAJAAO.COM*, Jun-2020. [Online]. Available:

https://www.bajaao.com/blogs/the-bajaao-blog-knowledge-base/56269955-analog-pedals-vs-dig ital-pedals-which-is-a-better-pick. [Accessed: 13-Nov-2021].

## 1.6 Revision Table:

10/17/21	Trenton: Added Communication Protocols
10/21/21	Trenton: Added Gap Analysis
10/22/21	Sean-Michael: Added executive summary
10/22/21	Michael: Added reference links

#### 2.1 Requirements:

	Requirement 1
Partner Requirement	The multi-effects pedal will be compact.

Engineering Requirement	The system will have a compact enclosure that will be under 6" x 12" x 4" (L x W x H).
Verification	<ol> <li>Measure the length.</li> <li>Observe that it is less than 6".</li> <li>Measure the width.</li> <li>Observe that it is less than 12".</li> <li>Measure the height.</li> <li>Observe that it is less than 4".</li> </ol>

Requirement 2		
Partner Requirement	The multi-effects pedal will have a distortion effect.	
Engineering Requirement	The system will peak, clip, and compress an audio signal between 0-20kHz.	
Verification	<ol> <li>Start the system with no effects applied.</li> <li>Attach an oscilloscope to the audio output of the system.</li> <li>Play a note.</li> <li>Observe the shape of the wave as being sinusoidal. Ex. [insert picture of sine wave]</li> <li>Activate the overdrive effect.</li> <li>Play the same note.</li> <li>Observe the shape of the wave as being hard clipped at the peaks. Ex. [insert picture with clipping]</li> <li>Repeat steps 37. as desired.</li> </ol>	

Requirement 3		
Partner Requirement	The multi-effects pedal will have a reverb effect.	
Engineering Requirement	The system will delay audio output based on at least 3 user-configurable interval settings.	
Verification	<ol> <li>Power the system on.</li> <li>Activate the delay effect.</li> <li>Attach the audio input to an oscilloscope.</li> <li>Attach the audio output to an oscilloscope.</li> <li>Play a note.</li> <li>Observe a time delay between the input and output of the signal.</li> <li>Press the interval button on the system to change the preset interval.</li> <li>Repeat steps 57. as desired.</li> </ol>	

Requirement 4		
Partner Requirement	The multi-effects pedal will have an easy-to-use user interface.	
Engineering Requirement	The system will be usable by 90% of users with no instructions.	
Verification	<ol> <li>With the pedal powered on, plug the audio cables of the guitar and amplifier into the pedal.</li> <li>Gather participants, ask them to choose the audio effect they would like to enable.</li> <li>Time how long it takes for the participants to enable their chosen effect.</li> <li>If 90% of participants are able to do so and consider it easy when surveyed the requirement is passed.</li> </ol>	

Requirement 5		
Partner Requirement	The multi-effect pedal will behave in a way that allows pass-thru signal when switched off.	
Engineering Requirement	The system will support pass-through audio with minimal noise (+/- 5%).	
Verification	<ol> <li>With the pedal powered on, plug the audio cables of the guitar and amplifier into the pedal.</li> <li>Ensure that no effect is selected with the switch toggle, play an audio signal through via the guitar and observe the sound from the amplifier using a decibel meter.</li> <li>If sound comes through the amplifier with minimal noise (± 5%), the requirement is met.</li> </ol>	

Requirement 6		
Partner Requirement	The multi-effect pedal will include a chromatic tuner.	
Engineering Requirement	The system will identify a note that is within +/-5% of the reference frequency for that note.	

Verification	<ol> <li>Attach a signal generator to the audio input of the system.</li> <li>Plug the system into power.</li> <li>Tune the waveform to 110 Hz <i>A</i> with 2.5V peak-to-peak</li> <li>Verify that the display shows the note is <i>A</i>.</li> <li>Tune the waveform to 116 Hz.</li> <li>Verify that the display still shows <i>A</i>.</li> <li>Repeat steps 3-6 as desired with the following frequencies.</li> <li><i>E</i> 82 Hz (E) and 86 Hz (still E)</li> <li><i>D</i> 147 Hz (D) and 154 Hz (still D)</li> <li><i>G</i> 196 Hz (G) and 205 Hz (still G)</li> </ol>
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Requirement 7			
Partner Requirement	The multi-effect pedal will include a chromatic tuner.		
Engineering Requirement	The system will visualize where the input note lies between reference notes.		
Verification	<ol> <li>Attach a signal generator to the audio input of the system.</li> <li>Plug the system into power.</li> <li>Tune the waveform to 110 Hz <i>A</i> with 2.5V peak-to-peak.</li> <li>Verify the display shows the note between <i>E</i> and <i>D</i>.</li> <li>Repeat steps 3 and 4 as desired for the following frequencies.</li> <li><i>D</i> 147 Hz, between A and G</li> <li><i>G</i> 196 Hz, between D and B</li> <li><i>B</i> 247 Hz, between G and E</li> </ol>		

	Requirement 8		
Partner Requirement	The multi-effect pedal will behave in a way that allows pass-thru signal when switched off.		
Engineering Requirement	The system will allow users to quickly switch the active audio effect profile during use.		
Verification	<ol> <li>Power the system on.</li> <li>Activate an effect.</li> <li>Play audio and confirm that the audio was effected.</li> <li>Deactivate the effect.</li> <li>Repeat steps 24. as desired.</li> </ol>		

# 2.2 Design Impact Statement

This section intentionally left blank.

# 2.3 Risks:

ID	Risk Description	Category	Risk Prob	Risk Impact	Indicators	Liable Party	Action Plan
R 1	Parts may not arrive on time.	Schedule	30%	High	<ul> <li>Parts are ordered late.</li> <li>There is a chip shortage on our parts.</li> <li>Design or schematic not complete.</li> </ul>	ТВ	<ul> <li>Look into what is available locally.</li> <li>Look into alternate designs.</li> </ul>
R 2	The product creates electronic waste.	Environm ental	5%	Low	<ul> <li>The product is not durable.</li> <li>The product uses lithium or other hard-to-recycle materials.</li> </ul>	MG	• Retain
R 3	Team members did not complete assigned tasks.	Organizat ional	15%	Mediu m	<ul> <li>Lack of communication.</li> <li>Not following the schedule.</li> <li>Not using the JIRA board (workflow application).</li> </ul>	SMR	<ul> <li>Review communicati on protocol.</li> <li>Work on tasks together to make up time.</li> </ul>
R 4	Internal systems have low audio fidelity.	Design	20%	High	<ul> <li>Heavily distorted or noisy signal reproduction</li> <li>Audio artifacts, clipping, etc.</li> </ul>	SMR	• Retain components, review design and identify flaws.
R 5	Short circuit causes board failure.	Design	20%	High	<ul> <li>Instant failure upon the system turning on</li> <li>Instant failure when toggling the controls.</li> </ul>	ТВ	<ul> <li>Salvage components</li> <li>Replace ruined components</li> </ul>
R 6	Failure of electronic components.	Design	15%	High	<ul> <li>Component meltdown due to temperature.</li> <li>Capacitor</li> </ul>	MG	Replace

					failure due to high voltage.		
R 7	Scheduling Conflicts	Organizat ional	10%	Mediu m	Group members do not attend scheduled meetings.	ТВ	Review Communicat ion Protocols
R 8	Audio interface Incompatible	Design	5%	High	• The guitar & amp cannot interface with the pedal.	SMR	Replace interface components

# Figure 2.0 Risks Assessment Table

# 2.4 References and Files Links:

## 2.5 Revision Table:

12/03/21	Team: Updated risks table, added new risks, and action plan column.
12/03/21	Team: Created verification steps for requirements.
12/02/21	Trenton: Edited old requirements.
12/02/21	Trenton: Added new requirements.
11/12/21	Sean-Michael: Updated project timeline
11/12/21	Michael: Revised gap analysis. Added citation links for gap analysis.
11/12/21	Trenton: Added columns and edited risk descriptions on the Risk Register.
11/12/21	Trenton: Reformatted requirements section to use tables.
10/29/21	Sean-Michael: Added a new risk
10/29/21	Michael: Added verification to requirements
10/28/21	Sean-Michael: Revised executive summary, added figure labels.
10/28/21	Trenton: Added requirements and risks

## 3.1 Block Diagram:



Figure 1. High Level Block Diagram



Figure 2. Block Diagram

## 3.2 Block Descriptions:

Name	Description
Power Champion: Trenton Bastasch	This block is the power supply for the guitar pedal. It will take in a 120VAC wall outlet and give 9VDC to the pedal. This block exists to power all of the active components of the pedal, specifically the microcontroller. Our current plan for implementation is to use a typical 2.1mm jack and wall-wart to rectify the wall outlet power to 9VDC.
Code Champion: Sean-Michael Riesterer	This block exists in our design because it is necessary to control the microcontroller. The block will likely involve an embedded C programming implementation that instructs the microcontroller on how to switch between different effect blocks. The logic within the code block will determine smooth operation and switching between effects as well as user input and display driving.
Microcontroller Champion: guske michael	The microcontroller block is focused on the integration of a microcontroller into our system. The purpose of the microcontroller is to allow for the selection of an effect to be applied (delay, distoriation, etc.) . The microcontroller also serves to do some basic signal processing especially for the tuning of a musical instrument. We will purchase a small microcontroller (such as an Arduino Nano) and connect the microcontroller directly into the PCB through a designated pinout. The microcontroller's inputs will be used to analyze input signals and to detect the proper indication to switch effects.
Display Champion: guske michael	The display block will be used to notify the user of the current effect being applied to the input signal. The display will be a simple liquid crystal display (LCD) that will interface with the microcontroller. When an instrument is being tuned, the microcontroller should sample the input signal and determine the note being played. The current note should be shown on the LCD. The display should be one of the few visible parts outside of the enclosure.
User Interface Champion: Trenton Bastasch	This block is the knobs and buttons that are used to select effects and adjust the values used in the effects. The knobs will adjust the voltage of an analog signal and send that to the microcontroller. This signal will then be used to adjust the effects included on the pedal. The buttons will allow the user to select

	between various effects. The block will be implemented using potentiometers on the knob inside a voltage ladder to adjust the voltage going into the microcontroller, while the buttons will be simple on/off switches.
Delay Effect Champion: Sean-Michael Riesterer	The reason for having this block is because we want to implement a Delay Effect into the Multi-Effect pedal because Delay is a very unique and popular audio effect. The block will take in our audio signal and hold (delay) it for some time interval determined by the user input settings before playing through the audio output. At the moment we are considering digital or analog methods of achieving this effect.
Distortion Effect Champion: Sean-Michael Riesterer	The reason for this block is because we wanted a distortion effect to be a part of the Multi-Effect pedal because it is an iconic electric guitar sound. Achieving this effect will be done with analog circuitry designed to increase the gain and cause clipping with the audio signal that will then pass through the output as distorted, higher volume, and highly textured. It will be variable in it's intensity based upon user input.
Enclosure Champion: Trenton Bastasch	This block is the enclosure of the guitar pedal. The enclosure will need to be able to withstand the weight of someone stepping down onto it. It also will need to be designed in a way where it is easy and comfortable to step on the pedal. The current plan for implementation is to use treated wood because it would be sturdy, the main concern would be with heat and wood being a fire risk.
Tuner Champion: guske michael	The tuner block is a subsystem that is used to check the accuracy of the instrument. The function of the tuner block is dependent on a microcontroller, though the microcontroller being used may not be directly related to the microcontroller block, which is focused on the broader control of the system. The stand alone microcontroller in the tuner will use a Fast Fourier Transformation (FFT) to determine the type of note being played. The tuner block should interface with the display in some way to show the note.
Audio In Champion: Trenton Bastasch	This block is for the audio input received from the guitar. It will take it in through a standard ¼" audio jack and pass the signal through to the rest of the system, specifically to the effects. It will do this via a low impedance wire to maintain signal integrity.

Audio Out	This block is for the audio output to be connected to the amplifier
Champion: Trenton	or other musical equipment. It will be the inverse of the Audio In
Bastasch	block, where it will take in the processed signal through a low impedance line and output it to a standard 1⁄4" jack.

# 3.3 Interface Definitions:

Name	Properties
otsd_pwr_acpwr	<ul> <li>Inominal: 100mA</li> <li>Ipeak: 500mA</li> <li>Other: NEMA 5-15R</li> <li>Vnominal: 120VAC</li> </ul>
otsd_usr_ntrfc_usrin	<ul> <li>Type: Buttons</li> <li>Type: Knobs</li> <li>Usability: Must be usable by 90% of test users</li> </ul>
otsd_enclsr_envin	<ul> <li>Other: Size: 90% of users must approve of the height of the pedal</li> <li>Other: Weight: Must sustain 15lbs of weight on the pedal</li> </ul>
otsd_ad_n_asig	<ul> <li>Impedance: 10Ω</li> <li>Max Frequency: 40kHz</li> <li>Vmax: 500mV</li> </ul>
pwr_mcrcntrllr_dcpwr	<ul> <li>Inominal: 300mA</li> <li>Ipeak: 500mA</li> <li>Vmax: 9.5V</li> <li>Vmin: 8.5V</li> </ul>
cd_mcrcntrllr_code	<ul> <li>Other: Filesize: &lt;25KB</li> <li>Payload: Embedded C Compiled Instructions</li> </ul>
mcrcntrllr_dsply_data	<ul> <li>Datarate: Refresh rate of 60Hz</li> <li>Messages: Displays current effect and values used by effect</li> </ul>

mcrcntrllr_dly_dsig	<ul> <li>Fall Time: 1ms</li> <li>Logic-Level: Active High</li> <li>Rise Time: 1ms</li> </ul>
mcrcntrllr_dstrtn_dsig	<ul> <li>Fall Time: 1ms</li> <li>Logic-Level: Active High</li> <li>Rise Time: 1ms</li> </ul>
mcrcntrllr_tnr_dsig	<ul> <li>Fall Time: 1ms</li> <li>Logic-Level: Active High</li> <li>Rise Time: 1ms</li> </ul>
dsply_otsd_usrout	<ul> <li>Other: Characters displayed: 32</li> <li>Type: Current effect, values associated with said effect</li> </ul>
usr_ntrfc_mcrcntrllr_asig	<ul> <li>Max Frequency: 120Hz</li> <li>Vmax: 3.3V</li> <li>Impedance: 10Ω</li> </ul>
dly_ad_t_asig	<ul> <li>Impedance: 10Ω</li> <li>Max Frequency: 1MHz</li> <li>Vmax: 500mV</li> </ul>
dstrtn_ad_t_asig	<ul> <li>Impedance: 10Ω</li> <li>Max Frequency: 1MHz</li> <li>Vmax: 500mV</li> </ul>
tnr_ad_t_asig	<ul> <li>Impedance: 10Ω</li> <li>Max Frequency: 1MHz</li> <li>Vmax: 500mV</li> </ul>
ad_n_dly_ffct_asig	<ul> <li>Impedance: 10Ω</li> <li>Max Frequency: 40kHz</li> <li>Vmax: 500mV</li> </ul>

ad_n_dstrtn_ffct_asig	<ul> <li>Impedance: 10Ω</li> <li>Max Frequency: 40kHz</li> <li>Vmax: 500mV</li> </ul>
ad_n_tnr_asig	<ul> <li>Impedance: 10Ω</li> <li>Max Frequency: 40kHz</li> <li>Vmax: 500mV</li> </ul>
ad_t_otsd_asig	<ul> <li>Impedance: 10Ω</li> <li>Max Frequency: 40kHz</li> <li>Vmax: 500mV</li> </ul>

## 3.4 References and File Links:

#### 3.5 Revision Table:

11/18/21	Trenton: Created Section 3	
11/19/21	Michael: Added High Level Block	
	Added Microcontroller block description	
	Added Display block description	
	Added Tuner block description	
12/02/21	Trenton: Edited interface definitions	
12/03/21	Trenton: Updated interface definition properties	

## 5.1 Universal Constraints:

## 5.1.1 The system may not include a breadboard.

The system does not include a bread board in the final design. It has all components attached to a PCB and a set of protoboards. as shown in the below figures.



Figure 5.1: Partial system view



Figure 5.2: Partial system view.

# 5.1.2 The final system must contain both of the following: a student designed PCB and a custom Android/PC/Cloud application.

The microcontroller will be placed on a PCB with a set of surface mount components. The integrated circuits that do not fit on the PCB will be attached to protoboards and connected to the PCB via wires with connectors.

The system is not connected to a PC or to the Cloud so it will not have an app. The application will not apply to this project. This is because pedals currently on the market like the BOSS ME-50 and ours cater to musicians and performers who want stand-alone audio tools, making a software app unnecessary.[1]



Figure 5.3: Project PCB

# 5.1.3 If an enclosure is present, the contents must be ruggedly enclosed/mounted as evaluated by the course instructor.

The enclosure will be created to be durable. It will be made out of metal to fit the enclosed parts snuggly and securely with the only openings being for connectors such as connecting to a power outlet. The enclosure will be opened and closed using a set of screws to ensure it stays shut during use and is not accidentally opened.

## https://drive.google.com/file/d/1vm18ZBd60zgE7sJFj-BysuMeKLw9m7vS/view?usp=sharing

# 5.1.4 If present, all wire connections to PCBs and going through an enclosure (entering or leaving) must use connectors.

There will be a connector used to connect to a power outlet and for all of the components being connected to and from the microcontroller on the PCB (see Figure 5.3). The audio input and output of the system go through the enclosure using  $\frac{1}{4}$ " barrel jacks as is standard in most pedal systems.



Figure 5.4: Connectors on enclosure

## 5.1.5 All power supplies in the system must be at least 65% efficient.

The power supply purchased for this system is roughly 75% efficient. When attached to an electrical load of  $500\Omega$  it output 9.24VDC and 14mA. The ideal power usage over a  $500\Omega$  load is 0.170W, the actual power used was 0.129W. This gives us an efficiency of 76%.



Figure 5.5: Electronic load read-out

# 5.1.6 The system may be no more than 50% built from purchased modules.

The only purchased modules used in the final design are the power supply and the LCD screen. The rest of the system is the team's own design.



Figure 5.6: The Arduino Nano and the LCD back.

# 5.2 Compactness:

## 5.2.1 Requirement:

The system will have a compact enclosure that will be under 6" x 12" x 4" (L x W x H).

# 5.2.2 Testing Process:

- 1. Measure the length.
- 2. Observe that it is less than 6".
- 3. Measure the width.
- 4. Observe that it is less than 12".
- 5. Measure the height.
- 6. Observe that it is less than 4".

# 5.2.3 Testing Evidence:



Figure 5.7.1: Width Measurement



Figure 5.7.2: Length Measurement



Figure 5.7.3: Height Measurement

## 5.3 Distortion Effect:

**5.3.1 Requirement:** The system will peak, clip, and compress an audio signal between 20-20kHz.

## 5.3.2 Testing Process:

- 1. Start the system with no effects applied.
- 2. Attach an oscilloscope to the audio output of the system.
- 3. Attach the signal generator to the audio input of the system.
- 4. Tune the Signal to have a frequency of 123Hz with amplitude of 0.5V.
- 5. Observe the shape of the wave as being sinusoidal.
- 6. Activate the overdrive effect by pressing the Distortion Switch.
- 7. Observe the shape of the wave as being hard clipped at the peaks, making square waves thus meeting the requirement.(Rescale the channel to account for gain)
- 8. Repeat steps 3.-7. as desired.

## 5.3.3 Testing Evidence:

https://drive.google.com/file/d/1jdTwC3s31b8tELX0RbS31zOyCAz9m1-Z/view?usp=sharing

## 5.4 Reverb Effect:

**5.4.1 Requirement:** The system will delay audio output based on at least 3 user-configurable interval settings.

## 5.4.2 Testing Process:

- 1. Power the system on.
- 2. Activate the delay effect.
- 3. Attach Channel 1 of the Oscilloscope to Audio Output.
- 4. Attach Channel 2 of the Oscilloscope to Audio Input.
- 5. Attach the signal generator to the Audio Input.
- 6. Tune the Signal to be 85Hz, 0.5V
- 7. Observe that CH1 and CH2 are out of phase.
- 8. Observe how pressing the interval button allows for at least 3 different degrees of change.
- 9. Repeat steps 5.-7. as desired.

#### 5.4.3 Testing Evidence:

https://drive.google.com/file/d/1MNOId-BiW8xDbIIFSdWBIoUPfjqfgBnR/view?usp=sharing

#### 5.5 User Interface:

**5.5.1 Requirement:** The system will be usable by 90% of users with no instructions.

## 5.5.2 Testing Process:

- 1. With the pedal powered on, plug the audio cables of the guitar and amplifier into the pedal.
- 2. Gather participants, ask them to choose the audio effect they would like to enable.
- 3. Time how long it takes for the participants to enable their chosen effect.
- 4. If 90% of participants are able to do so and consider it easy when surveyed the requirement is passed.

## 5.5.3 Testing Evidence:

https://drive.google.com/file/d/13mwi80bZ4vR05tU4q\_gzTCecWUyDeLTa/view?usp=sharing\_

## 5.6 Pass Through:

#### 5.6.1 Requirement:

The system will support pass-through audio with minimal noise (+/- 5%) frequency.

#### 5.6.2 Testing Process:

- 1. Power the system on.
- 2. Attach signal generator to audio input.
- 3. Attach Channel 1 of the oscilloscope to audio out.
- 4. Attach Channel 2 of the oscilloscope to audio input.
- 5. Ensure that no effect is selected with the switch toggles. (no LCD, no noise)
- 6. Attach the function generator to the audio input, tune the signal to 85Hz 0.5V.
- 7. Observe that Channel 1 and 2 are identical therefore being within 5% of each other's frequency.

#### 5.6.3 Evidence:

https://drive.google.com/file/d/15cOZpZp8imBvFa727e8zd477hbqbZHdO/view?usp=sharing

I agree that the Multi-Effects Pedal is easy to use and understand without instruction.

Chindi Taishi Neilsen and

Figure 5.8: User Interface Signatures

#### 5.7 Chromatic Tuner:

#### 5.7.1 Requirement:

The system will identify a note that is within  $\pm$ -5% of the reference frequency for that note.

#### 5.7.2 Testing Process:

- 1. Attach a signal generator to the audio input of the system.
- 2. Plug the system into power.
- 3. Tune the waveform to 110 Hz A with 2.5V peak-to-peak..

- 4. Verify that the display shows the note is A.
- 5. Tune the waveform to 116 Hz.
- 6. Verify that the display still shows A.
- 7. Repeat steps 3-6 as desired with the following frequencies.
  - E 82 Hz (E) and 86 Hz (still E)
  - D 147 Hz (D) and 154 Hz (still D)
  - G 196 Hz (G) and 205 Hz (still G)

## 5.7.3 Testing Evidence:

https://drive.google.com/file/d/1d9OITVS2QvbvjegG4tOgepEM6ywBuJNK/view?usp=sha ring

#### 5.8 Tuner Display:

#### 5.8.1 Requirement:

The system will visualize where the input note lies between reference notes.

#### 5.8.2 Testing Process:

- 1. Attach a signal generator to the audio input of the system.
- 2. Plug the system into power.
- 3. Tune the waveform to 110 Hz A with 2.5V peak-to-peak.
- 4. Verify the display shows the note between *E* and *D*.
- 5. Repeat steps 3 and 4 as desired for the following frequencies.
  - **D** 147 Hz, between A and G
  - **G** 196 Hz, between D and B
  - **B** 247 Hz, between G and E

#### 5.8.3 Testing Evidence:

https://drive.google.com/file/d/1S\_qdprmsofpyULOku6NSYY1TyI9GCinB/view?us p=sharing

#### 5.9 Switch Effect:

**5.9.1 Requirement:** The system will allow users to quickly switch the active audio effect profile during use.

## 5.9.2 Testing Process:

- 1. Power the system on.
- 2. Activate an effect.
- 3. Play audio and confirm that the audio was affected.
- 4. Deactivate the effect.
- 5. Repeat steps 2.-4. as desired.

#### 5.9.3 Testing Evidence:

https://drive.google.com/file/d/10tpFEO90wEvLd0UVLB4sqHJiB4EME8YH/view?usp=sh aring

#### 5.10 References and File Links:

1. BOSS Corporation, "Me-50: Guitar multiple effects," *BOSS*. [Online]. Available: https://www.boss.info/global/products/me-50/. [Accessed: 06-Mar-2022].

#### 5.11 Revision Table:

03/06/22	Trenton: Created Section 5
03/06/22	Sean-Michael: Updated some Section 5.2 content
03/06/22	Michael: Adjusted Sections 5.7 and 5.8.
04/22/22	Trenton: Adjusted Sections 5.3, 5.4, 5.6, and 5.9.
05/04/22	Sean-Michael: Adjusted Sections 5.3, 5.4, and 5.6.

## 6. Project Closing

## 6.1 Future Recommendations

## 6.1.1 Technical Recommendations

While working on this project, the team discovered several things that could be further optimized.

The first of which is being able to "daisy-chain" effects. With the current design, when multiple effects are active they play their own outputs on top of each other, rather than applying effects on top of each other and putting out a single output. The solution to this would be an overhaul of the wiring between effects and a different setup for the bypass circuitry. If an effect's output is connected to the input and the bypass of the next effect it should allow for daisy-chaining in theory.

The second recommendation the team has is to implement a DAC (Digital to Audio Converter) on the delay effect. The team used the pulse width modulation function of the Arduino to create the output of the delay effect which made the effect sound a little off. Using a DAC would create a cleaner sound by actually outputting a voltage in between 0-5V as opposed to simulating it.

Another recommendation from the team is to step down the voltage at the output. The system does not currently step the voltage down at the output, creating its own amplification

before reaching a guitar amplifier. This makes it louder than most effects on the market. This could be done several ways, like with a voltage divider or an audio transformer.

Lastly, the team would suggest the ability to display which effects are active. The current system does not have an obvious display for which effect is active. Setting up the Arduino that controls the LCD display for the tuner to display the active effect and even some values associated with the effect if possible. This could be done by connecting the latching buttons to the arduino and coding it to change the display.

## 6.1.2 Global impact recommendations

- The Multi-Effect pedal could potentially become an issue if not used properly. By this we mean, a user of the pedal could abuse it and create an excessive amount of noise that could lead to hearing loss or noise complaints. We recommend that to mediate this problem we can include a user manual to allow the user of the pedal to understand the consequences of their actions and hopefully discourage any abuse of the pedal by citing possible legal action that may be taken against them.
- We know that the Multi-Effect pedal is a somewhat niche product, as it only caters to people to know how to use the instrument for which the pedal is catered to. The Multi-Effect pedal was designed to be used with a guitar, so for users who are unable to play a guitar, the pedal has no real use for them. We recommend that in order to combat this issue, we can use some of the "profits" of this pedal (if it were to be sold) to fund a training program for guitarists. Allowing more people to play guitar would definitely boost the use of the Multi-Effect pedal.

## 6.1.3 Teamwork Recommendations

Working in an engineering team can become challenging, but it doesn't have to be. While working on this project we learned a few things about teamwork and project management. Here are the key takeaways:

- 1. Adopt some form of project management strategy or framework to help guide the process. Our team elected to utilize a Software Development strategy known as Agile Development. This methodology involved the usage of two week long sprints in which we set out goals and defined tasks associated with them.
- Have clear communication guidelines. It is important that each team member understands the when and where of information flow. Having dedicated channels for scheduling, project discussion, and resources helps to facilitate faster responses and more efficient communication. Our team utilized Discord to instantly message and setup dedicated channels for categories of communication.
- 3. Maximize face to face and online meeting time. Planning meeting agendas beforehand and keeping a record of the meeting minutes is how we were able to maximize our time when we got together. Time wasted in meetings is detrimental to the completion of the project as that is time not spent working. By planning key talking points in an agenda and keeping track of them in the notes of minutes, the team can ensure that meetings are not seen as a waste of time, but rather a valuable space for collaboration.
- 4. Trust in the process and stick to the plan. Each project management framework will have its own version of meeting occurrence, for us the weekly sprint meeting was invaluable in

keeping the team on track. That being said towards the end of the cycle our team missed a few meetings and lost track of the Agile board usage. This was ultimately detrimental to our ability to maintain schedule, causing us to cram toward the end. Consistency is the key factor in maintaining strong team collaboration.

#### 6.2 Project Artifact Summary with Links

Relevant project artifacts are available within the following categories:

- Code:
  - Tuner & Display: <u>https://github.com/MGUSK3/Arduino-Tuner-LCD-Code</u>
- Hardware Schematics:



Figure 6.1 PCB preamp schematic







Figure 6.3 Delay Schematic

Audio In		GND SV		
L		AS		
	GND	14	GND	1 Talay Tes
		AO	SDA	ISC LCD
	Arduino /	Vano		

Figure 6.4 Tuner to Display Wiring Diagram

- Misc. Parts:
  - 3PDT Footswitches:

https://www.amazon.com/DaierTek-Guitar-Effect-Footswitch-Latching/dp/ B08TBT9S5J/ref=sr\_1\_3?crid=1V4CBKHQHWWDD&keywords=3pdt+foo tswitch&qid=1651881529&sprefix=3pdt+footswitc%2Caps%2C144&sr=8-3

- SPST Momentary Switches: <u>https://www.amazon.com/dp/B08TBTWDYV?psc=1&ref=ppx\_yo2ov\_dt\_b</u> <u>product\_details</u>
- Aluminum Enclosure: <u>https://www.amazon.com/dp/B08K7GHTVP?psc=1&ref=ppx\_yo2ov\_dt\_b</u>\_product\_details

#### **6.3 Presentation Materials**





#### 6.4 Revision Table

5/6/22	Sean-Michael: Created Section 6 headers, subheaders, etc. Completed 6.1.3 & 6.3
5/6/22	Trenton: Completed 6.1.1, uploaded schematics to 6.2
5/6/22	Michael: Completed 6.1.2