# Multi-Effect Sound Pedal Sequencer for Performing Musicians

PROJECT PLAN

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ADC : Analog-to-Digital Converter

DAC: Digital-to-Analog Converter

# 1 Introductory Material

## 1.1 Acknowledgement

Considerable contribution to this project was made by our client, Randall Geiger, through technical advice and consultation. Iowa State University contributed equipment that proved vital to our project as well.

## 1.2 Problem Statement

Effect pedals for musicians exist, but adding effects in series or parallel requires stringing multiple pedals up to each other. While some high-end multi-effect pedals do exist, those pedals only allow for one effect to be used at a time, which limits the variety of sounds a musician can make live. Additionally, while attaching individual pedals together would allow for a similar effect, the tradeoff becomes losing dynamic switching, as it would

either require stopping the show for a time to switch pedals or would require a large mess of pedals to pull off a show with many diverse effects.

Our solution is to take the general idea of a digital multi-effect pedal and improve upon the design to allow for effects to be added and changed around in series or parallel, which would allow for many different distinct sound types to be possible. Our pedal would take in a sound, apply the effects as configured, and output the new sound through an amplifier. The configurations of effects or order of effects used will be set up through an app developed with the device, which would communicate with the pedal to set up configurations of pedal effects, add/remove effects, and configure the individual effects. This app could configure with the pedal either before a show or be done live.

### 1.3 Operating Environment

The end product will consist twofold of the pedal itself, and the display of which the pedal will be configured. The main operation of the pedal will be done via foot operation by the user, and thus will be on the ground in a variety of different stages. The pedal therefore must be durable enough to withstand long-term hard use (potentially heavy stomping on the pedal switch itself and to the case), as well as withstand dusty, wet, and hot conditions, depending on where a set might be played using the pedal. The re-configuration will be done using a user interface found on a tablet or smartphone device. This UI application would ideally run on a device with above average quality hardware. The primary environmental factor to consider in regards to the UI would be potential rainfall during outside shows.

### 1.4 Intended Users and Intended Uses

The intended users of our project primarily include performers and hobbyists. Keeping this in mind, we aim to design a product that satisfies both these audiences by including various features in our pedal board. Our design will reduce clutter onstage for performers while also possessing enough memory banks in the pedal board for all used effects. We also want to design a simple, but not limiting, UI for our intended users, whether it be for professional or at-home use.

### 1.5 Assumptions and Limitations

Given the scope of the project, there would be a limitation as to the maximum quality of sound that would come from the pedal. The quality would be sufficient for most small-scale performances and for hobbyists, but may require a higher-quality chipset for use with very high-end concerts. Additionally, the pedal will have a certain number of effects available by default, but it is assumed that if a user has another pedal effect, they would be able to upload it to the pedal and use it similarly to any other effect.

### 1.6 Expected End Product and Other Deliverables

We will have two deliverables. Our first deliverable will be a pedalboard with 8-10 switches, most likely arranged in two rows on the board. There will be an LED display on the board to notify the user as to which effects are "on." Our second deliverable will be a user interface in the form of an app that can communicate with our pedal board with Bluetooth or Wi-Fi. The app will be where a user can configure the effects they want to use in series or parallel. They will also be able to adjust the parameters of a few select effects.

## 2 Proposed Approach and Statement of Work

### 2.1 Objective of the Task

We will strive to create a user interface that allows in-depth customization, while being simple enough for any musician (hobbyist or professional) to operate. The board will be durable, portable and reliable. We wish to create a seamless blend between effect creation and live performance.

### 2.2 Functional Requirements

- Must be able to modify a sound as desired:

As with any pedal currently on the market, our pedal must as well be able to provide the desired digital pedal effects. This will be done by taking an analog input, converting it to digital when reaching the microcontroller, then modifying the sound as desired through an algorithm before sending the sound back out to an amplifier.

- Pedal effects must be modular:

The pedal effects within the pedal board must be configurable (depending on the desired effect), as well as interchangeable. The user must be able to add their own effects in place of any default effects.

- Pedal effects should be able to be utilized in series and/or in parallel:

This requirement is the core of the difference between our product and others on the market. Our pedalboard, when configured, must be able to run a sound through multiple effects, both in series (one effect after another) and in parallel (sound being split and modified two different ways before being recombined), before being outputted.

- The pedal must be able to be configured via an app:

This is the heart of the second main deliverable of our product. The board must be able to be configured via a mobile app (likely optimized for tablets), which will allow the user to change effects, configure effects, configure orders of effects, and add new effects.

### 2.3 Constraints and Considerations

Non-functional requirements include:

- There must be no significant delay during reconfiguration of the board.
- There must be seamless switching between effects without unwanted “pops”

### 2.4 Previous Work And Literature

Pedals are a very common tool to use for sound manipulation in the musical performance domain. While there are existing pedals out there that enable guitarists to implement effects such as distortion, fuzz, wah, delay, etc., these are usually one effect per pedal. Although there are also pedal boards out there where you can set up multiple pedals for the sake of organization, we intend to take this one step further by being able to program multiple interchangeable effects into one pedal board. We also aim to implement these effects digitally for a more refined design without the mess of many wires. The users of this product should be able to easily program the pedal board of their desired effects using the app we create that connects to the pedal board. This makes for a simple user interface that is intuitive to beginners and professionals.

### 2.5 Proposed Design

There are three main parts for the pedal board: The application, the microcontroller and the board.

1. Application
    a. Effects list
    b. Layout Design
    c. Configuration Storage
    d. Button Mapping
    e. Effect Manipulation
2. Microcontroller
    a. ADC and DAC
    b. Manipulate input signal
    c. Sampling and Signal processing
    d. Output new signal
3. Pedal Board

a. Change between saved effect configurations with the buttons
b. Toggle the enable for the effect with the foot pedal
c. 2-by-4 button array
d. LCD for displaying effects list
e. 2.5-by-1.5 feet

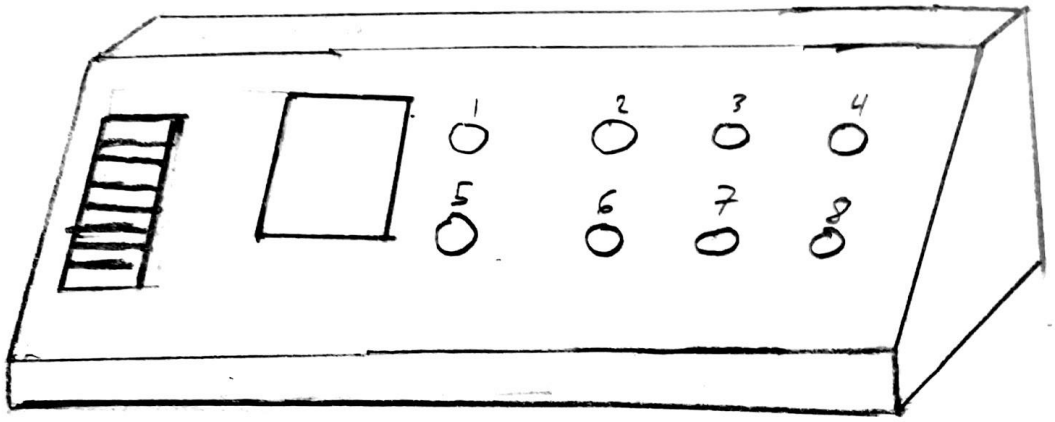


*Figure 1: A visual mockup of what the final pedalboard may look like*

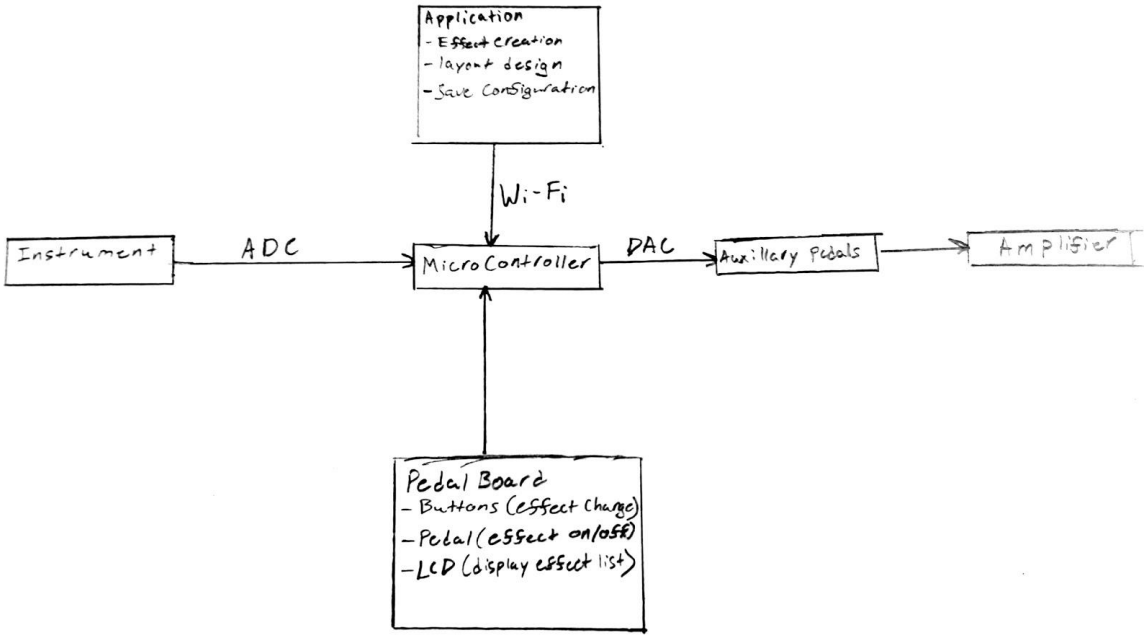


*Figure 2: A block diagram of our pedalboard system.*

The goal of this project is to create a multi-effect pedal board that allows the user a higher degree of control over their effects. Typically, artists collect an assortment of effect pedals and they wire them together in sequences of their choosing. The limitations of effect pedals stem from their size and wiring requirements. To create a custom effect from a variety of pedals requires a lot of time to connect the pedals and space to keep them.

With the board we are designing, we will be able to incorporate a multitude of effects housed in a digital library on a microcontroller. Using a GUI, the user will be able to configure their effect sequence and parameters easily and quickly. Once the user has created their custom setup, they are able to save that configuration and assign it to a button on the board. When playing live, the artist is able to change between their custom effects with the press of a button.

The board will utilize digital waveform processing to apply the effects the user has created. The use of a digital device instead of an analog one allows the reduction of space while improving the reliability of the board. Once complete our board will be responsive, easy to use and durable.

### 2.6 Technology Considerations

Our pedalboard needs a way to get data from the app and change the effects produced by the pedalboard. It also needs some storage to save these settings. Our solution for this is to use a microcontroller that handles all these responsibilities. We investigated using either the MSP430 or the Raspberry Pi 3 as our two primary options for microcontrollers. We chose to use the Raspberry Pi 3 since the community for it is much bigger than that of the MSP430. We also found effect libraries that our pedalboard can implement. This will save us time in development by not having to create each effect ourselves.

### 2.7 Safety Considerations

There aren't many safety concerns we need to worry about with this project besides making sure all the wiring and circuitry is done properly in the pedalboard.

### 2.8 Task Approach

We plan on developing the pedalboard and app concurrently. This will make integration between the two easier since we won't be stuck trying to force the app to work with the pedalboard and vice versa. This also provides more time to focus on making the UI for the app clean and intuitive. See 4.3 Appendices for reference to task plan.

### 2.9 Possible Risks And Risk Management

Acquiring materials is a small concern. We are most concerned with the knowledge and execution required to properly create the pedalboard. We plan on addressing these issues by collecting materials to reinforce our knowledge. We will properly execute the design implementation by using careful planning and measurements for the physical board and

using thorough examination of our implementation of the wave manipulation on the Raspberry PI. We plan to extensively test the final prototype to ensure it meets the standards of our client.

### 2.10 Project Proposed Milestones and Evaluation Criteria

The first key milestone would be to get a prototype of the pedalboard put together. This requires having the wiring properly done in a way that would allow us to switch the order of effects that it is using at one time. Testing this could be done by manually manipulating the effects that the board is set to create. The second key milestone would be to develop an app that which is capable of changing effects with an intuitive UI to encourage the user to want to use this system. The third and last key milestone will be to plug in a guitar to the pedal board and use the app to change the current effects on the pedalboard and hear the change in sound produced from the guitar.

### 2.11 Project Tracking Procedures

We are using Trello to keep a list of what tasks need to be done next and who is working on them. We will keep it up to date to ensure we know when things like deliverables and weekly status reports are to be finished.

### 2.12 Expected Results and Validation

We want to have a working pedalboard prototype that is controlled with an app designed specifically for it. We want to have a system that has multiple effects that can be switched between at any time by a guitarist using it. To confirm that our product works, we will plug in a guitar to the pedalboard with the effects preset by the app and go into an amplifier. Then we'll play the guitar and switch between effects and see how it sounds/works.

### 2.13 Test Plan

At this stage of our project, our test plan, after creating an early prototype of the pedalboard, is to ensure that the effects are working properly, and that the audio is being inputted and outputted properly. This would be done by testing a standard input against each effect we plan on using, as well as a no-effect pedal, ensuring that the output is as expected for each case. In the event of any undesirable outcome, the wiring setup will be first checked, followed by the code itself, making any necessary changes and retesting all cases to ensure that the effect pedal works for all individual effects.

## 3 Project Timeline, Estimated Resources, and Challenges

### 3.1 Project Timeline

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

SEMESTER 1:

The first semester will focus heavily on research, design, and initial prototype building. As we begin to meet with our client, we will begin to set roles and expectations in our group. We will conduct market research to be aware of similar products to ours and brainstorm what we can improve with our design. We will obtain our necessary starting materials, such as the raspberry pi 3 model. We will first learn how to effectively implement algorithms for signal manipulation using this microprocessor. We will be using recordings as signals for the initial testing. Once we can create effects with our initial prototype, we will begin work on our UI. We are planning to make an app that can successfully configure the pedal board with the desired effects.

SEMESTER 2:

The second semester will be dedicated to improving the prototypes for both the board and the UI with cycles of testing and re-design. We will be focusing on the app to make it as refined and intuitive for users as we can. We will also be moving into testing with actual musicians to gain feedback on both the functionality and usability of our final product. The final milestone of our project will be to plug in a guitar to our pedal board and successfully implement the correct effects in either series or parallel.

### 3.2 Feasibility Assessment

We will have a pedalboard that will have an app capable of manipulating the effects produced from the pedalboard. The app will have an intuitive design making it easy to use and understand. This design will produce a responsive system that will not have any lag to the sound produced. One challenge we will face is wiring the pedalboard in a way that simulates the changing of effect orders. Another challenge will be getting the pedalboard to work with the app we plan to develop with it. Sending data back and forth through WiFi won't be too difficult, but parsing the data one both ends to make it usable might be more difficult.

### 3.3 Personnel Effort Requirements

| Task | Description | Resources |
|---|---|---|
| Initial Meeting / Reflection | This covered the first meeting with the client to discuss what their vision and goals were for the project. The group then discussed how to realize those | This process took about 2 hours for each team member, as the meeting and reflection were both team actions. |

| | | |
|---|---|---|
| | visions. | |
| User/Market Feedback | This is similar to the empathy stage of the design process that was discussed in class. The goal with this action is to form an idea of what types of elements our design should and shouldn't include based on what users find useful in this type of product. | This process will be ongoing for most of the duration of the first semester. Measureable hours so far include an hour for creating a survey to hand to members of the Genre club and talking with them while they filled it out. The team spent another hour discussing the feedback received. |
| Analog / Digital Implementation Decision | There were two main methods to use to achieve the desired results for this project. We could make use of analog or digital effects. This required a little bit of research and discussion into which would best suit our needs. | This task was completed rather quickly, as one of the main criteria is re-configuring the board. Digital is the most convenient way for the user to do this. |
| Digital Effect Library | We need to create a large library of effects to be used by the Raspberry Pi. These will be done in C. These effects will be controlled by the UI. | This task was completed quickly, as well. We were able to find a host of effects already programmed and that are open-sourced for us to use. These are a great foundation to begin the prototype. |
| UI Creation | This will be the bulk of the work needed to complete this project. The interface controls most of the functionality that is unique to our product compared to other similar products already on the market. The UI will allow a musician to upload a new library of 8 effect sequences to the board. | This task is expected to take about four to five weeks between planning and creation. This will take effort from 2 or 3 members for most of the time spent working on it, as it will need to interface with the board. Testing will be done periodically as sections of this are completed. |

| | | |
|---|---|---|
| Prototype | This will be when all the working parts come together. The UI will be ready to manipulate the conversions taking place in the Pi. | This task is expected to take about a week to get everything to communicate effectively and produce the desired effects. |

### 3.4 Other Resource Requirements

We have planned to meet with the College of Design to get information regarding the influence that human factors have on UI design. Information regarding the effect algorithms is required. Information regarding the sampling and modification of digital waveforms.

### 3.5 Financial Requirements

For the pedalboard construction we require: 8 lockless pushbuttons, 1 foot pedal, 1 LCD, 1 Raspberry PI, 1 16gb micro SD, 1 micro USB cable, 1 HDMI cable, 1 ADC/DAC, Wood for the case and wire for the connections.

## 4 Closure Materials

### 4.1 Conclusion

Musicians need to be able to transition between effects, quickly and effortlessly, while playing a song in front of a live audience. The musician also requires a durable board that can withstand the pressure of a person depressing the buttons with their feet. The board should also be weather resistant to allow the musician to play at a variety of venues. We propose that we create a multi-effect pedalboard that can be preprogrammed with the artist's effects. This would allow the user the ability to create a board that is customized to their needs and allows for quick and easy transitions between the saved effects. An application will be created to allow the user to implement these effect configurations, while having a simple and intuitive layout for the user. When the board and the application work in tandem, the musician will have an effective tool for creating and transitioning between effects.

### 4.2 References

Raspberry Pi effect libraries:

Ray. “How to Start Programming Pedal-Pi.” ElectroSmash, 27 Apr. 2017, www.electrosmash.com/forum/pedal-pi/202-how-to-start-programming-pedal-pi?lang=en.

## 4.3 Appendices

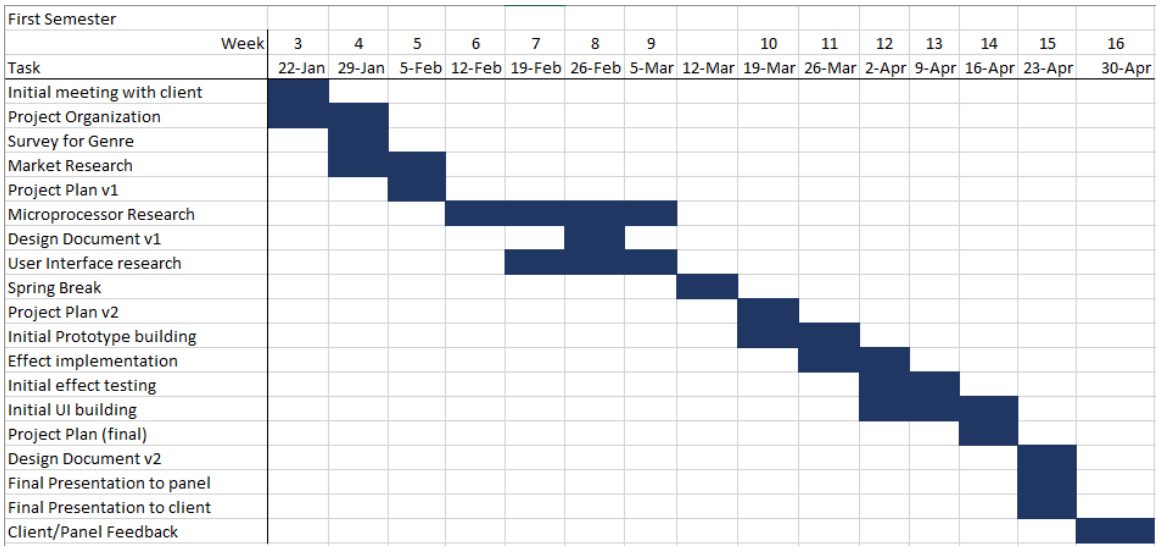


*Figure 3: A Gantt chart detailing our project schedule for the scope of 491 (first semester).*

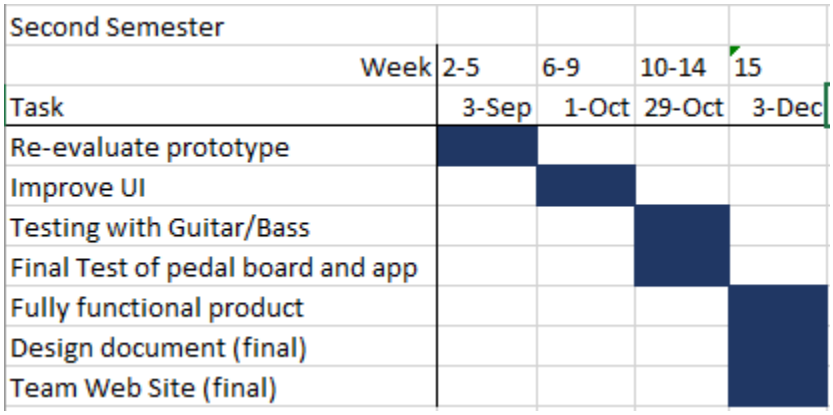


*Figure 4: A Gantt chart detailing our project schedule for the scope of 492 (second semester).*