LEDzeppelin

SDP22 Team 25 | PDR

Michael Forbes, Gavin Baril, Stephen Thimothe, & Sebastian Harder

Senior Design 2022 – Team 25

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The idea

- To create a lighting system to be used as a live performance aid for solo guitarists.
- The lighting is on the guitar and responds to the live audio signal created by the guitarist.

Background – LEDshred and its Shortcomings

LEDzeppelin was initially inspired by last year's senior design project, “LEDshred”.

LEDshred’s goal was to create an LED-covered fretboard, and to use this, combined with a microphone signal of the guitar audio, as a tutorial device.

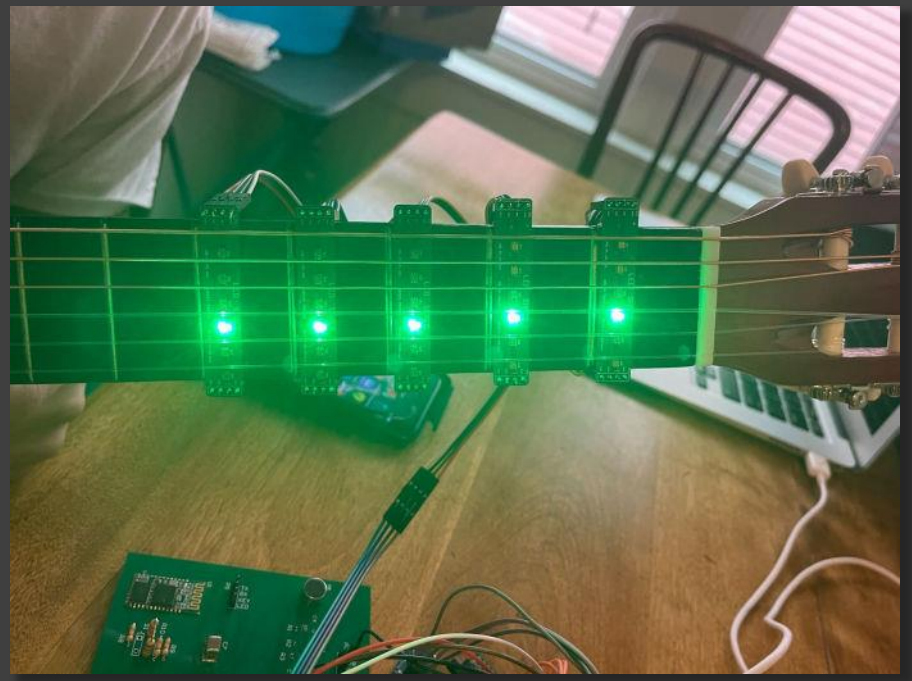


Figure #1.
“LEDshred” from SDP21

LEDzeppelin is fundamentally different.

1. The signal will be retrieved from the wired audio signal of the guitar.
2. LEDzeppelin will be primarily a performance element for solo guitarists and small bands.

Background – Guitars and Guitar Pickups

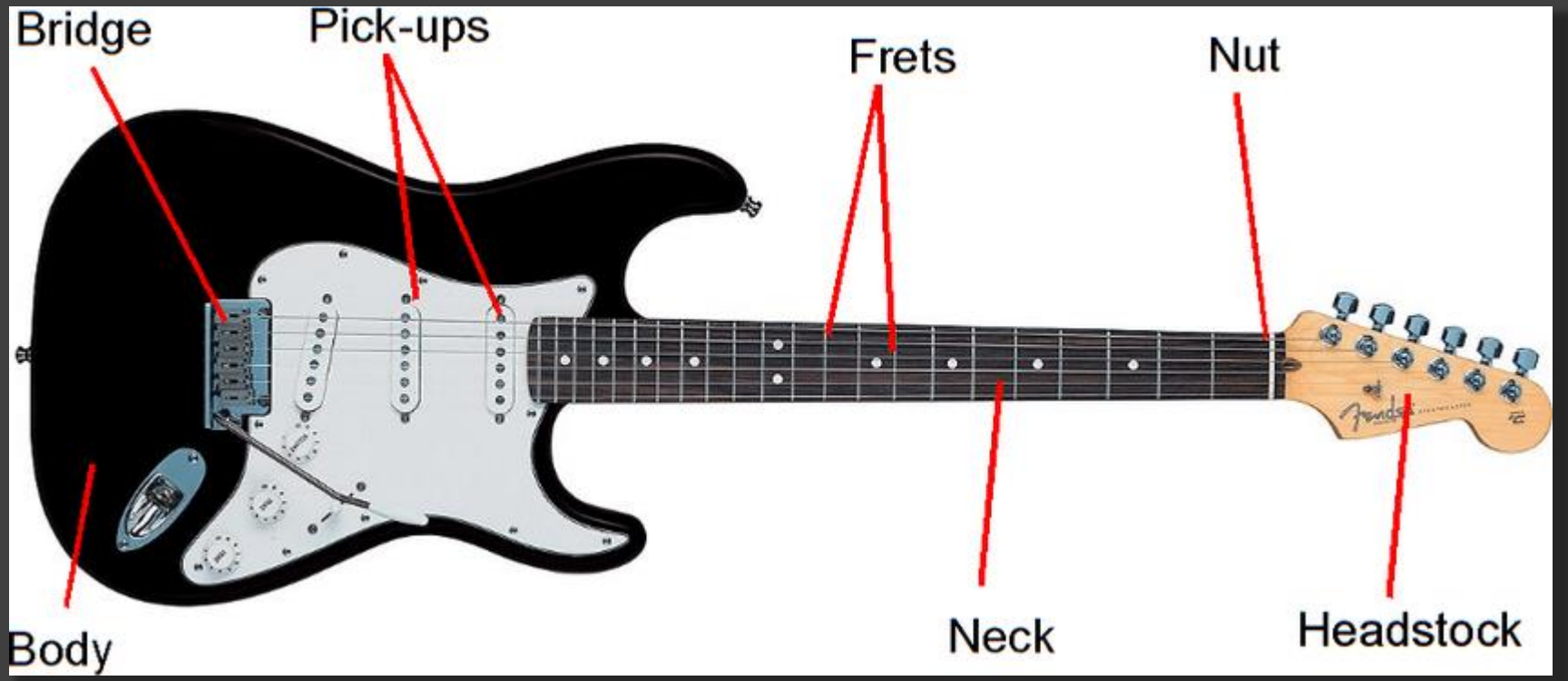


Figure #2
Guitar Diagram

Background – Guitars and Guitar Pickups

With each guitar string acting as a magnetic body, a magnet and coil is used to create an electronic signal, corresponding to the frequency of the string vibration.

While different electric guitars have different pickups, the basic output signal has roughly the same properties.

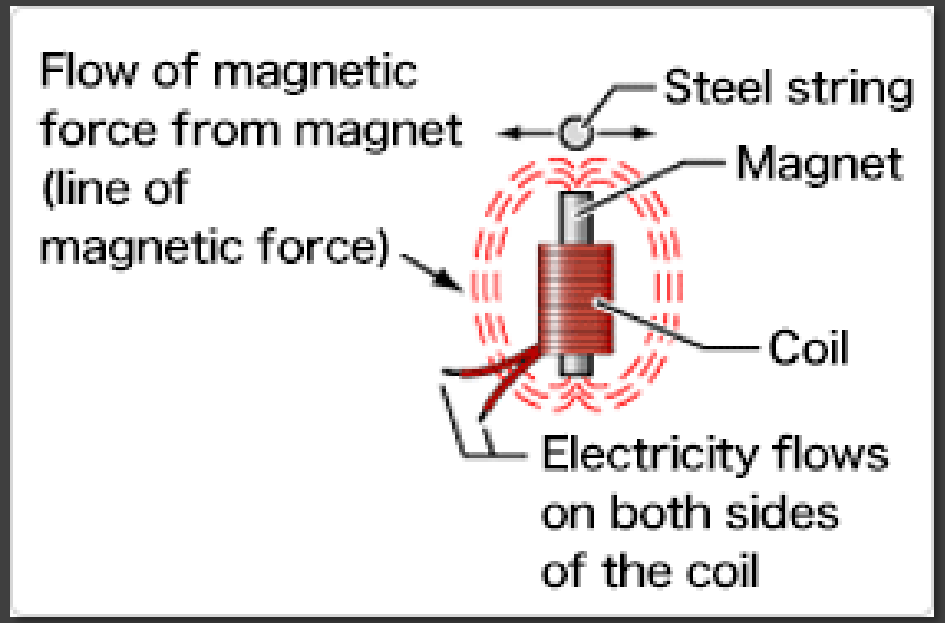


Figure #3.

A basic diagram of a 'pickup' on an electric guitar

We asked a small local band to name some priorities.

“Portability is a huge part of it; we already have to lug so much around.”

“Having something that is ‘set it and forget it’ is always ideal. It’s not like we have a dedicated lighting staff…”

Problem Statement

Independent guitarists are often looking for ways to make their sets more interactive and unique. However, as artists at small gigs, their options are limited by finances, space, and portability as well as limited in flexibility and customizability.

LEDzeppelin will be piece of equipment that solo artists or small bands can use to create a customizable lighting experience for live performances. The product will be portable, scalable, and unintrusive as to not interfere with the artists' playing style.

System Specifications

- The system has no more than 20ms latency.*
- An advanced knowledge of programming is not necessary to operate LEDzeppelin.
  - A DMX controller allows for easy adjustments mid-performance.
  - The system is compatible with any standard electric guitar.
  - Impermanent, and easy to install.
- The LEDs respond to a variety of signal parameters; Amplitude and frequency at least.

** Where for this project, latency is defined as the time between the creation of the signal (guitar is strummed), and the visual response of the LEDs*

System Specifications

- LEDs are assigned to each string and fret, at least down to the body of the guitar.
- The system is portable.
  - It does not require more than one person to setup.
  - The entire system (not including the guitar) is no more than 5 lbs.
- There are LED profiles that users can control / assign as functions.
  - Example: Preset #3 causes the LEDs to respond to low-frequency audio and change colors depending on the frequency.
  - One of the preset functions will be a built-in tuner.
- The tuner preset will be >90% accurate.

System Specifications

The latency specifications for the system are based on the distance of the audience and the musician from the sound source, and the average musician's threshold for such latency (about 12-20ms).

For example, a musician standing 1 meter from the amplifier experiences ~3ms of latency.

The audience, however, in a small venue is likely ~4-5 meters away.

Also, note that while individual note detection results in significant latency, a tuning function has room for this.

Existing Solutions: Fret Zealot

- LED-based learning tool for beginner guitarists
- Also has simple performance mode presets
- App for User Interface with preprogrammed tutorials
- No feedback for the user so all errors are managed by them
- Entire Product is $199

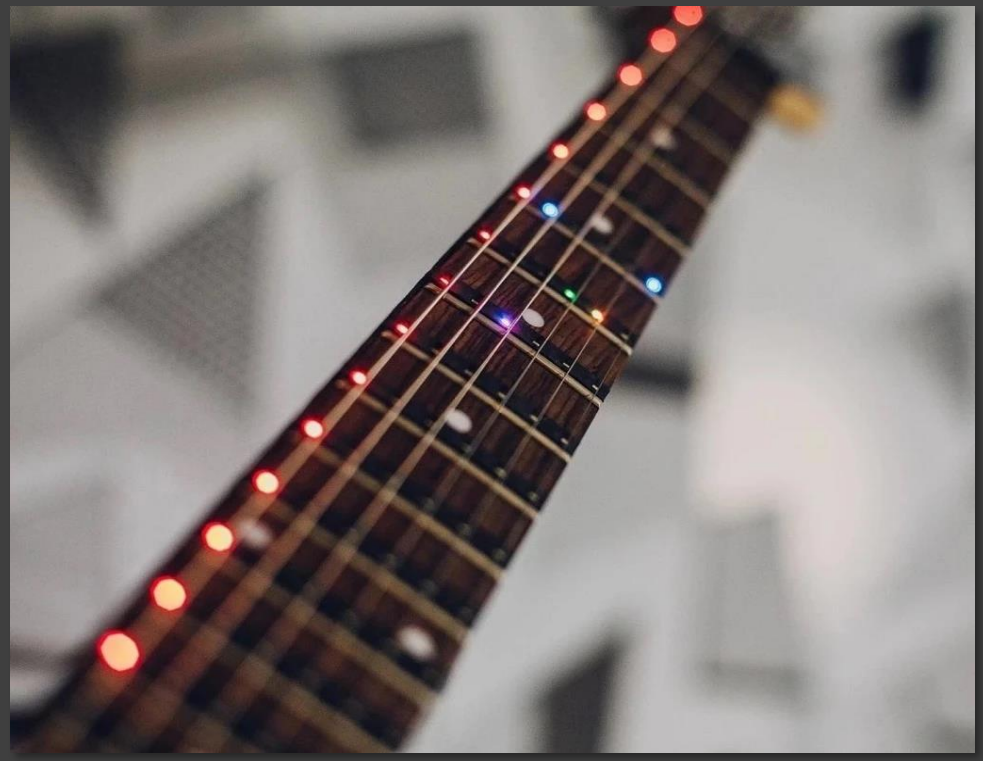


Figure #4.
Fret Zealot LEDs on a guitar

Existing Solutions: Jands Stage CL

- DMX LED light system controller
- Channel grouping allowing for changing multiple LEDs at once
- Able to pre-record light patterns for performances
- Setting presets before performance is necessary
- Product is $1345.50

Figure #5.
Jands Stage CL controller

A loose analogy: an RGB keyboard

- A user-friendly interface allows for a variety of lighting preset combinations.
- There is a level of compatibility with other programs, creating a more immersive user experience.

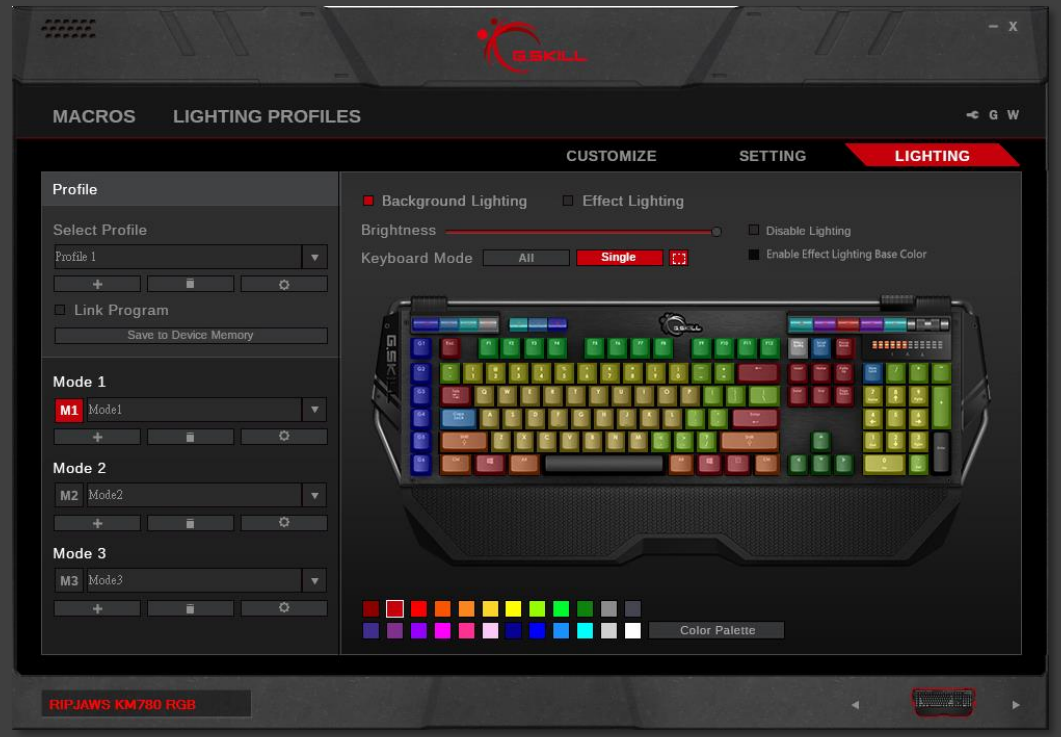
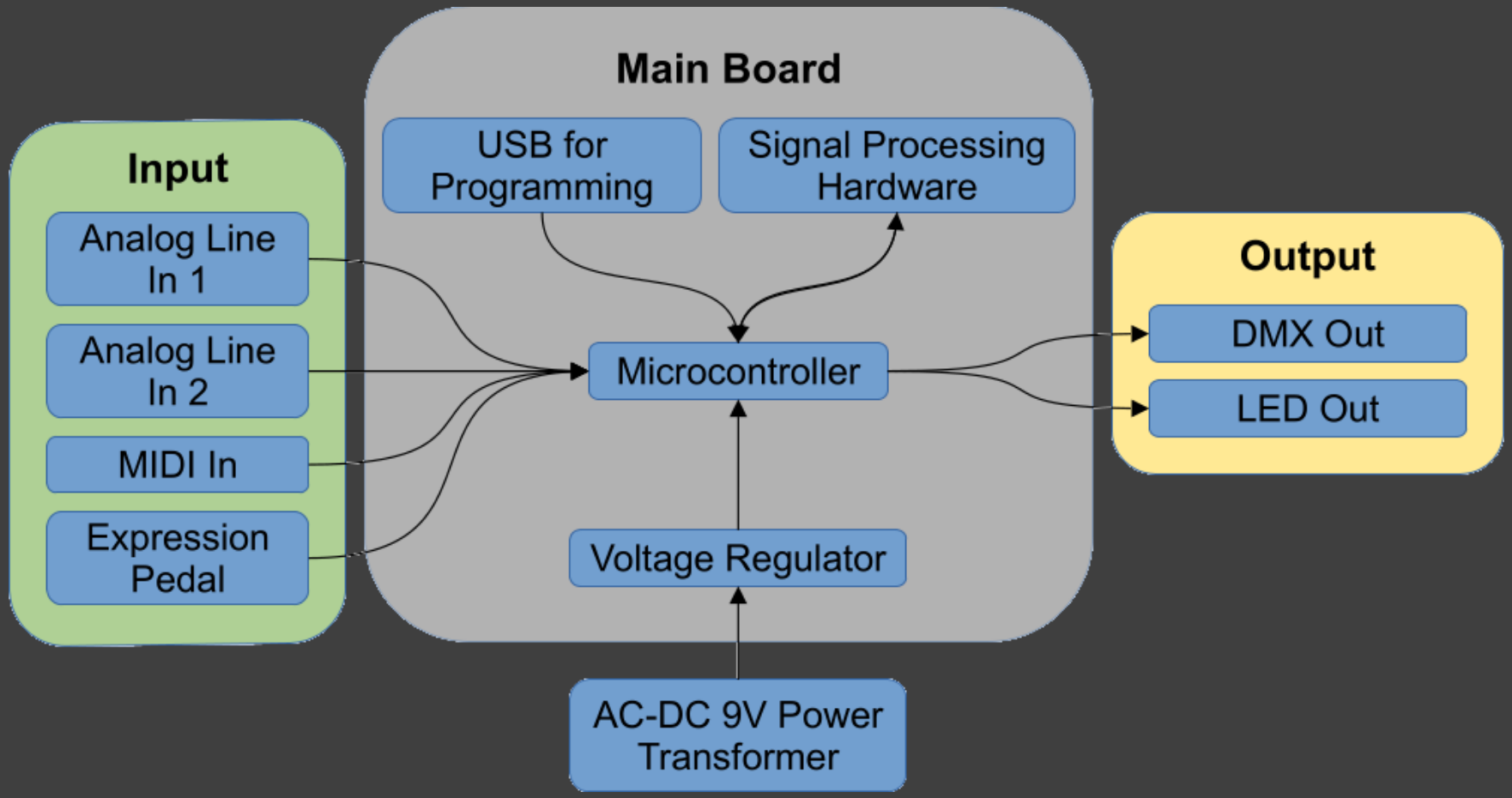


Figure #6.
Lighting control for RGB keyboard by *GSKILL*

Our Design

- Processes the wired audio signal, providing feedback to the user.
- Includes a user-friendly GUI for customization and system management.
- Allows for easy adjustments by the guitarist *while performing*.
- Is portable and easy to setup for performance.

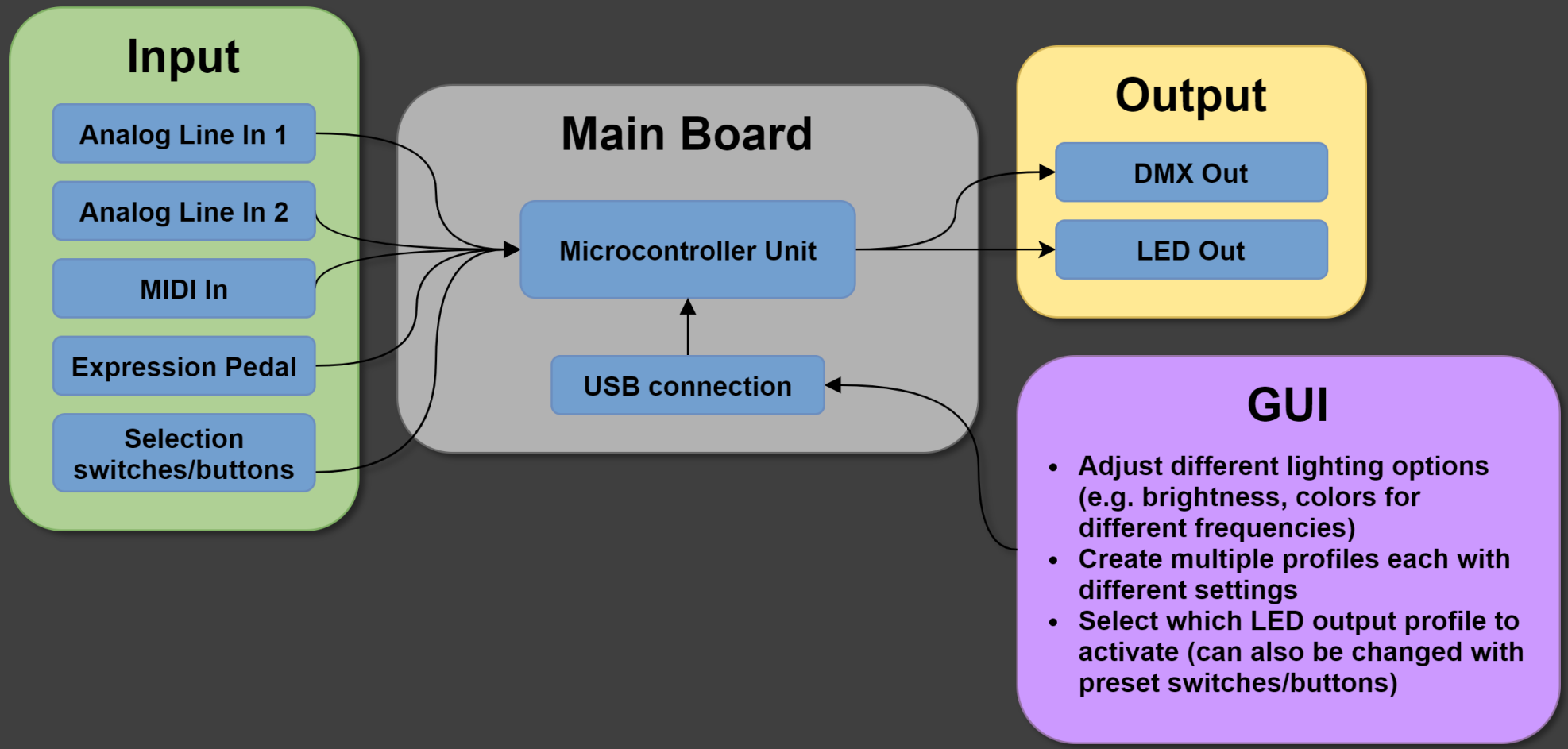
Hardware Block Diagram



The final design will require a custom PCB.

- Voltage regulators
- Signal processing hardware
- Microcontroller(s)
  - May require a smaller MCU for the LED control.
- Analog-digital converter

Software Block Diagram



Team Responsibilities

- Michael Forbes
  - Hardware / signal processing methods
- Gavin Baril
  - Hardware / embedded design
- Stephen Thimothe
  - Programming embedded components
- Sebastian Harder
  - Software / GUI program design

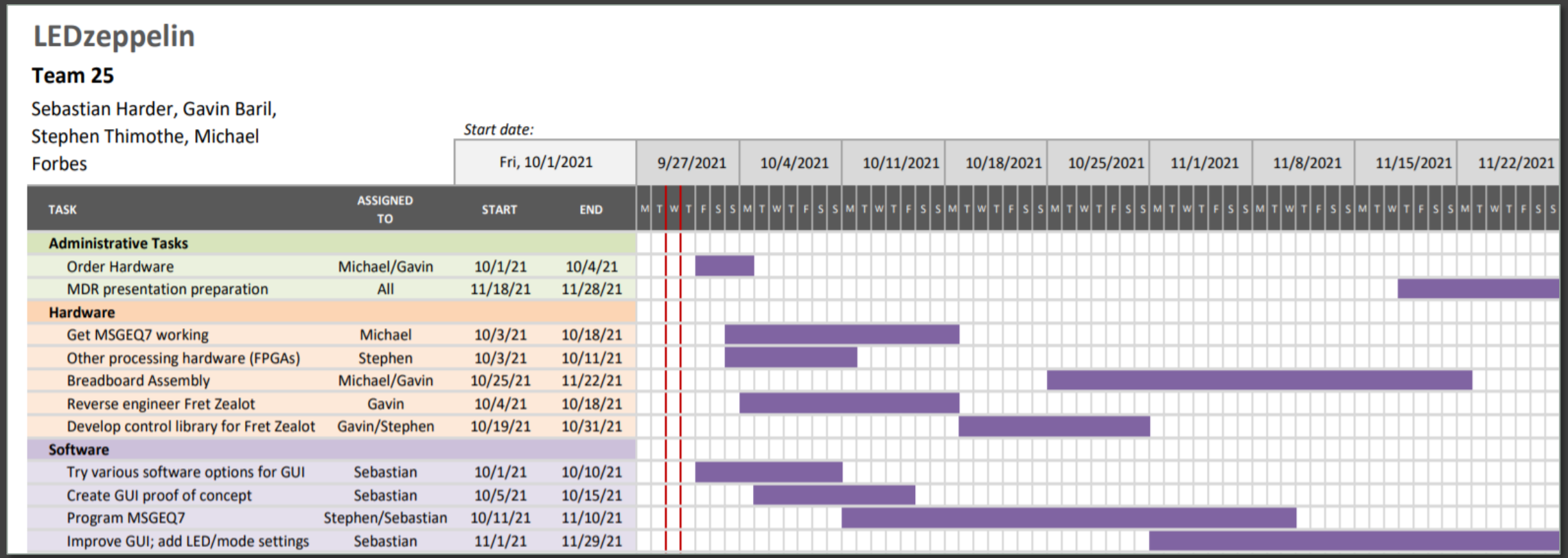
Budget

Item	Quantity	Price
Guitar	1	$0, Already owned
Fret Zealot Strip	1	$100
PCBs	5	$50
Hardware (MCUs, equalizer)	~	$60
9V Power Supply Unit	1	$0
Total	~	$210

The following are proposed deliverables for MDR:

- The ability to retrieve signal parameters
  - Demonstration of amplitude dependent mode.
- Full control of the fretboard LEDs
- Preliminary GUI adjusts aspects of the LED output
- The ability to switch between preset ‘modes’

The path to MDR: a Gantt chart



LEDzeppelin

Team 25

Sebastian Harder, Gavin Baril, Stephen Thimothe, Michael Forbes

Start date: Fri, 10/1/2021

TASK	ASSIGNED TO	START	END
Administrative Tasks			
Order Hardware	Michael/Gavin	10/1/21	10/4/21
MDR presentation preparation	All	11/18/21	11/28/21
Hardware			
Get MSGEQ7 working	Michael	10/3/21	10/18/21
Other processing hardware (FPGAs)	Stephen	10/3/21	10/11/21
Breadboard Assembly	Michael/Gavin	10/25/21	11/22/21
Reverse engineer Fret Zealot	Gavin	10/4/21	10/18/21
Develop control library for Fret Zealot	Gavin/Stephen	10/19/21	10/31/21
Software			
Try various software options for GUI	Sebastian	10/1/21	10/10/21
Create GUI proof of concept	Sebastian	10/5/21	10/15/21
Program MSGEQ7	Stephen/Sebastian	10/11/21	11/10/21
Improve GUI; add LED/mode settings	Sebastian	11/1/21	11/29/21

Questions?