GROUP 14: ESSENCE OF MUSIC

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Motivation

- Gain experience working with Audio Signals
- Implementing multiple systems to operate simultaneously (Audio and L.E.D)
- Work with Wireless Communications in a system

Project Goals

- Create a light and portable device capable of taking in audio signals and producing a visual output.
- Learn the process of designing and ordering a PCB.
- Learn how to use company libraries in order to program various functions on a microcontroller.

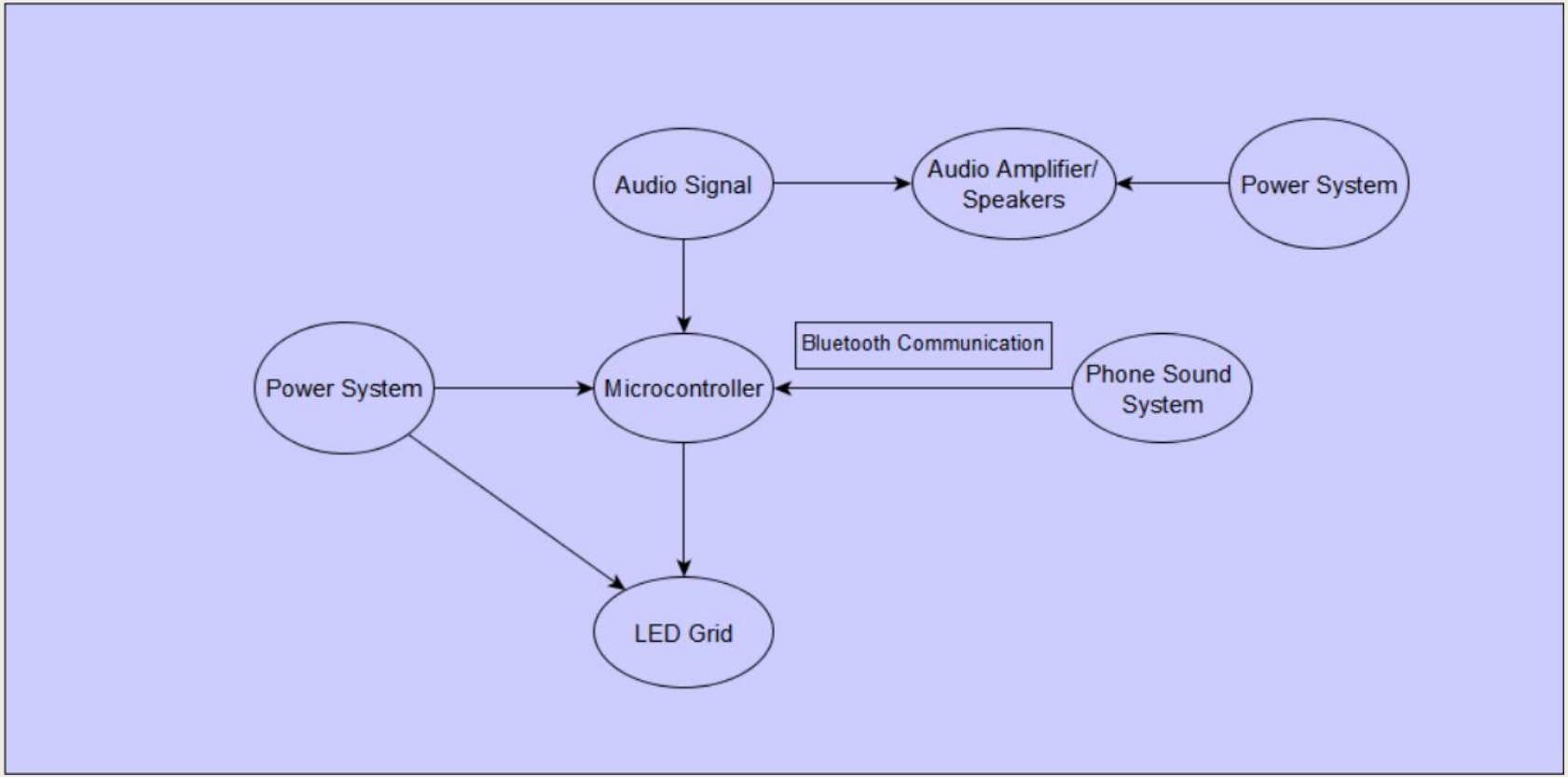
Specifications and Requirements

Description	Numerical Value or Representation
Able to produce audible sounds from a reasonable distance.	Can produce a clear sound of 80 dB from a distance of 8 meters.
Can be controlled wirelessly from a distance.	Wireless signal capable of reaching 10 meters.
Lightweight and compact for portability.	Overall weight < 2.5 kg Dimensions: 30 cm X 30 cm X 30 cm
Have a long lasting and quick charging power supply.	Battery life from max charge: ~4-5 hours Recharge time: 2 – 3 hours

Essence of Music: Front and Top Profiles

Essence of Music: Left and Right Profiles

Project Block Diagram



Hardware Components

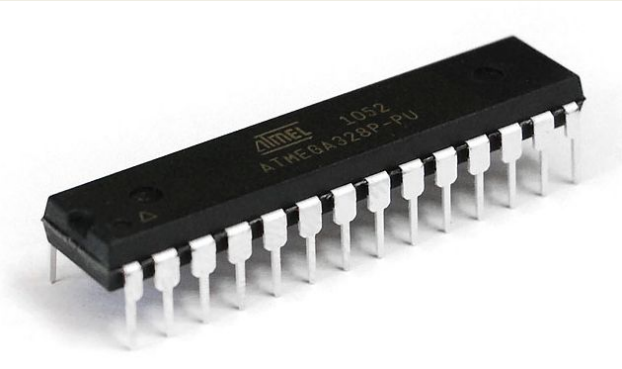
- A large amount of the total project relies on the hardware performing in certain ways.
- There are 4 main component sets: PCB, Audio System, L.E.D system, and Power Systems.
- Of the systems, the power systems are the most spread out and are not necessarily all connected.

Microcontroller Choices and Selection

Microcontroller	Pros	Cons
Atmega328p	Large community base for assistance, larger power supply, 28 pins, 2kB of RAM	More expensive peripherals,
MSP430G2553	Cheap peripherals, 16 MHz internal clock,	Lower Ram, smaller memory

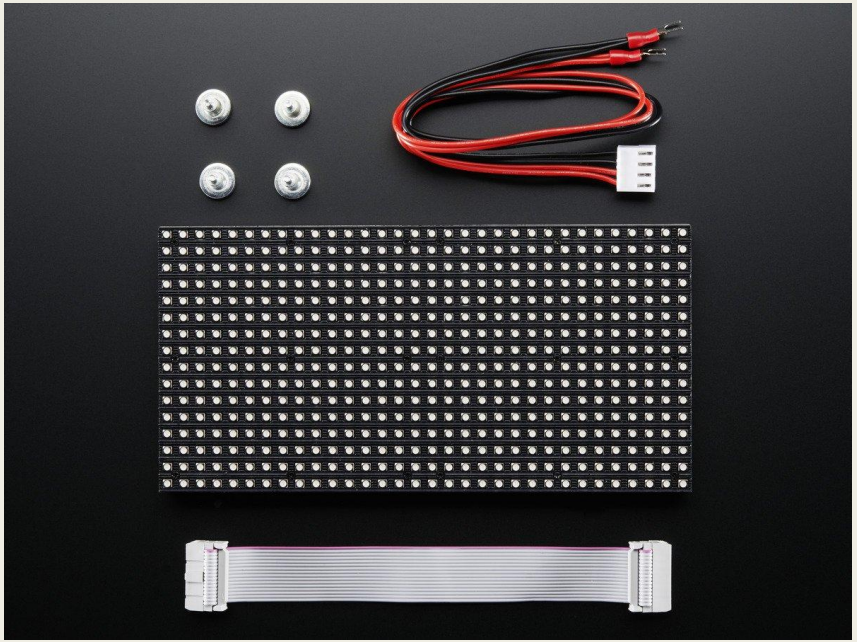
Selected Microcontroller: Atmega328p

- Meets the specification requirements.
- Able to be programmed using the Arduino for testing and easy to incorporate for the PCB.
- Large amount of community support.



Visual Display: LEDs

- LEDs in a grid of size 16 X 32.
- Ability to hold a large variety of colors that can be customized through the code.
- Lights blink and flash in various patterns based on the user's preference.
- Overall cheaper and provides an easy way to control the LEDs using output from the PCB.



Power Source

Power Source	Pros	Cons
Lithium Ion Batteries	Portable, Easy to incorporate into device, cheap.	Suffers from aging.
Lithium Polymer	Portable, smaller, safer.	Slightly more expensive, lower energy density
Wall Mount	Unlimited source of energy while connected. Provides a constant source of energy.	Little to no mobility away from wall outlets, requires wall adapter.
9-Volt Batteries	Easy to acquire, peripherals to allow for simple connection to the system.	Battery can drain quickly, low capacity.

Batteries

Selected Batteries: Lithium Ion 18650 Batteries.

- Lightweight batteries for added portability.
- Long lasting battery life.
- Quick to charge.
- Can support relatively high current for mobile device.
- One of the highest Energy/Volume ratios for batteries - very efficient

Power Sources and Systems

- The overall system is powered by Lithium Ion Batteries, 9-Volt Batteries, and Wall mounts.
- The Wall Mounts belong to the L.E.D Matrix and the Speaker Systems.
- The Lithium Ion Batteries are used to power the Microcontroller and the 7805 Voltage regulator. This provides power to the majority of the MCU.
- The 9-Volt batteries are used in order to power the TL082 Op-Amp which helps to manipulate the incoming audio signals for use by the MCU.

Power Sources and Systems Changes

- On the system, there is a port for a USB device.
- This port was used in order to connect a Bluetooth Audio receiver that we had planned to use earlier in the design.
- However, a slight in the circuit design seemed to have overheated the USB and caused a short circuit rendering the receiver useless.
- This caused us to replace the component with a rechargeable device for presentation purposes.

Bluetooth Receiver - Aluratek iStream

- Receives audio from up to ten meters distance
- Remembers up to six paired devices
- Works with any phone or device capable of transmitting Bluetooth audio - including smartphones, laptops, iPads etc.
- This device is being used to receive audio from output sources, which then leads to two parts of the project - the speaker system and the MCU

Audio Splitter

- Pre-fabricated device taken from a retail store.
- Takes a single audio signal and divides it in such a way that two devices can make use of the signal.
- Necessary to send the signal to both the PCB and the Speaker System.
- Helps to reduce the complexity of the PCB and the system in general.

Speaker System

- Utilizes the audio splitter and its own amplifier and PCB in order to produce sound.
- Consists of 2 speakers which are powered by a single power source.
- Speakers are placed on the sides of the case to allow the sound to permeate the area that it is placed in.
- Sound can be heard throughout a small building or house when at maximum volume

Speaker System

- The speakers being utilized in our system came with an amplifier circuit that includes volume control and a power switch that is also being used in our final design.
- The speakers are mounted in 2.25” diameter holes and are secured through the use of velcro. The velcro was chosen due to its ease in placing and removing components without permanent fixtures.

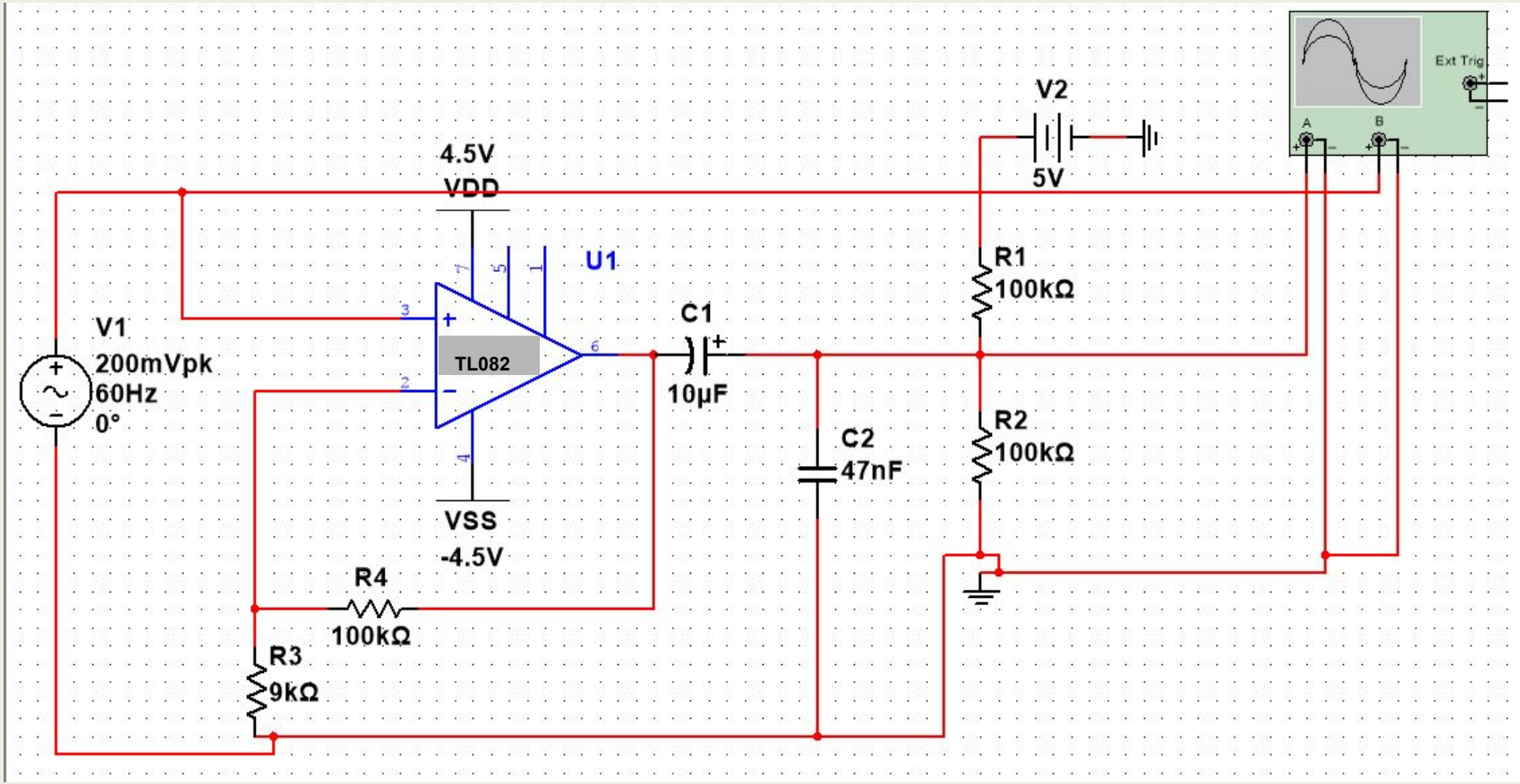
Amplifiers

- There are two amplifier circuits in the system:
  - TL082 amplifier that is used on the PCB board design.
  - Amplifying circuit that is use by the speaker system.
- As mentioned earlier, the speakers use their amplification system in order to produce enough of a gain in order to produce a sound in the speakers.
- The TL082 is used to increase the voltage levels of the audio signal from +-200mV to 2.5V+-2.5V (voltage range of 0V-5V)

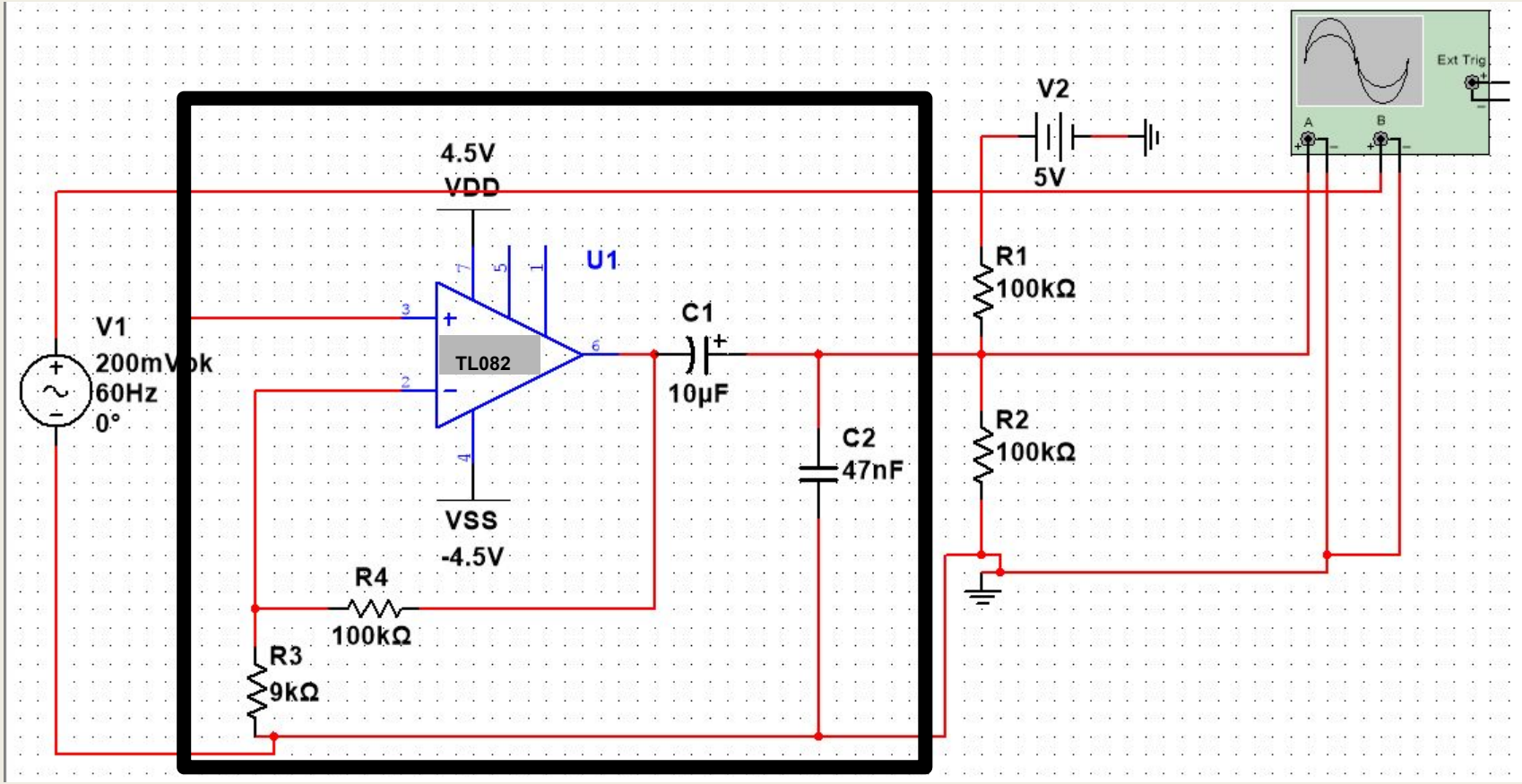
Amplifiers

- The TL082 in the PCB is used in order to generate a voltage that can be manipulated by the ATmega328p.
- The signal from the audio receiver has too low of nominal voltage values, and the TL082 is capable of fixing that issue.
- Furthermore, we implemented a voltage divider on the PCB in order to create a reference voltage of 2.5 Volts for our audio signal.
- A gain of 3 is implemented in the circuit in order to produce voltage values that are varied and distinguishable when read in by the microcontroller.

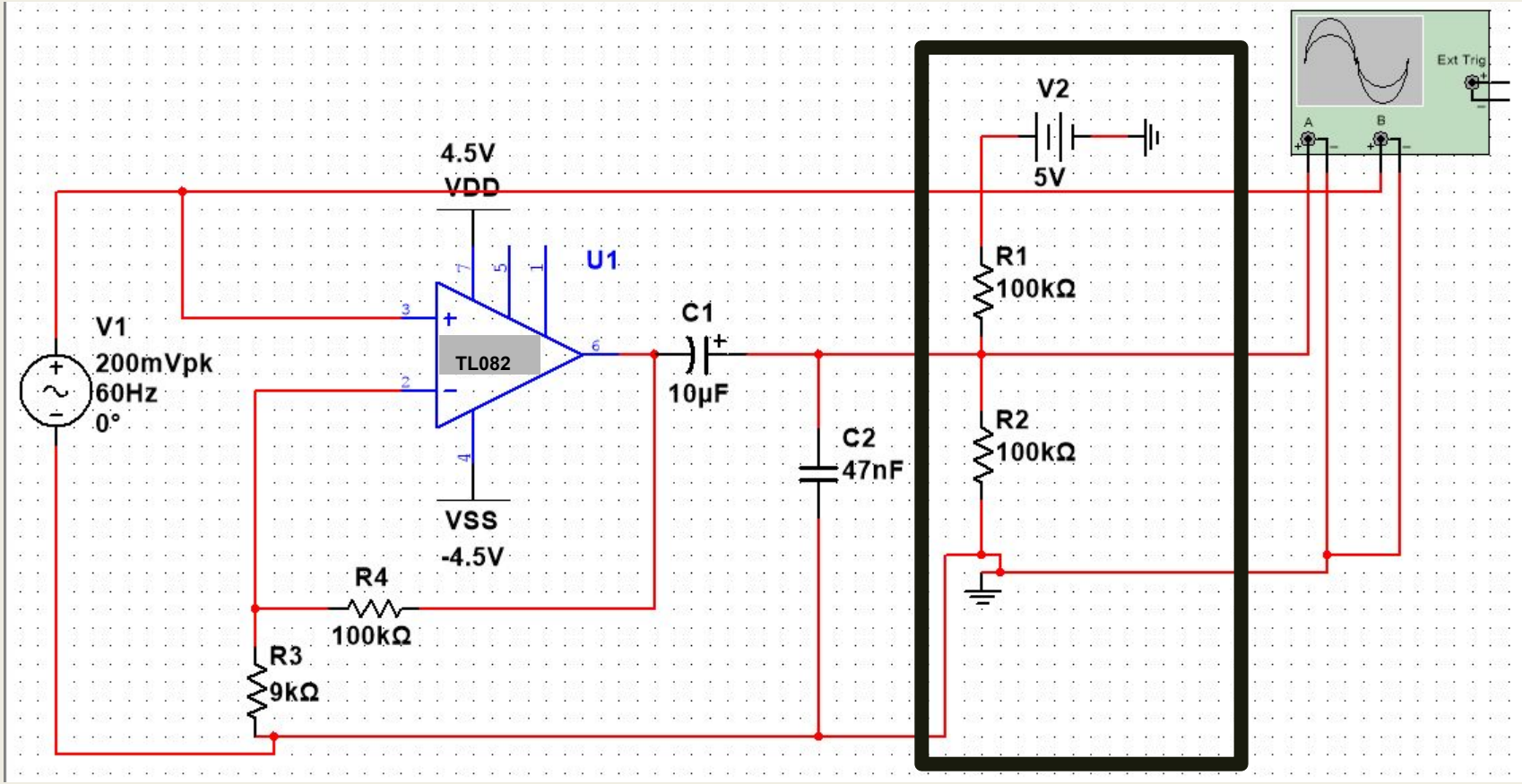
Audio Converter to MCU



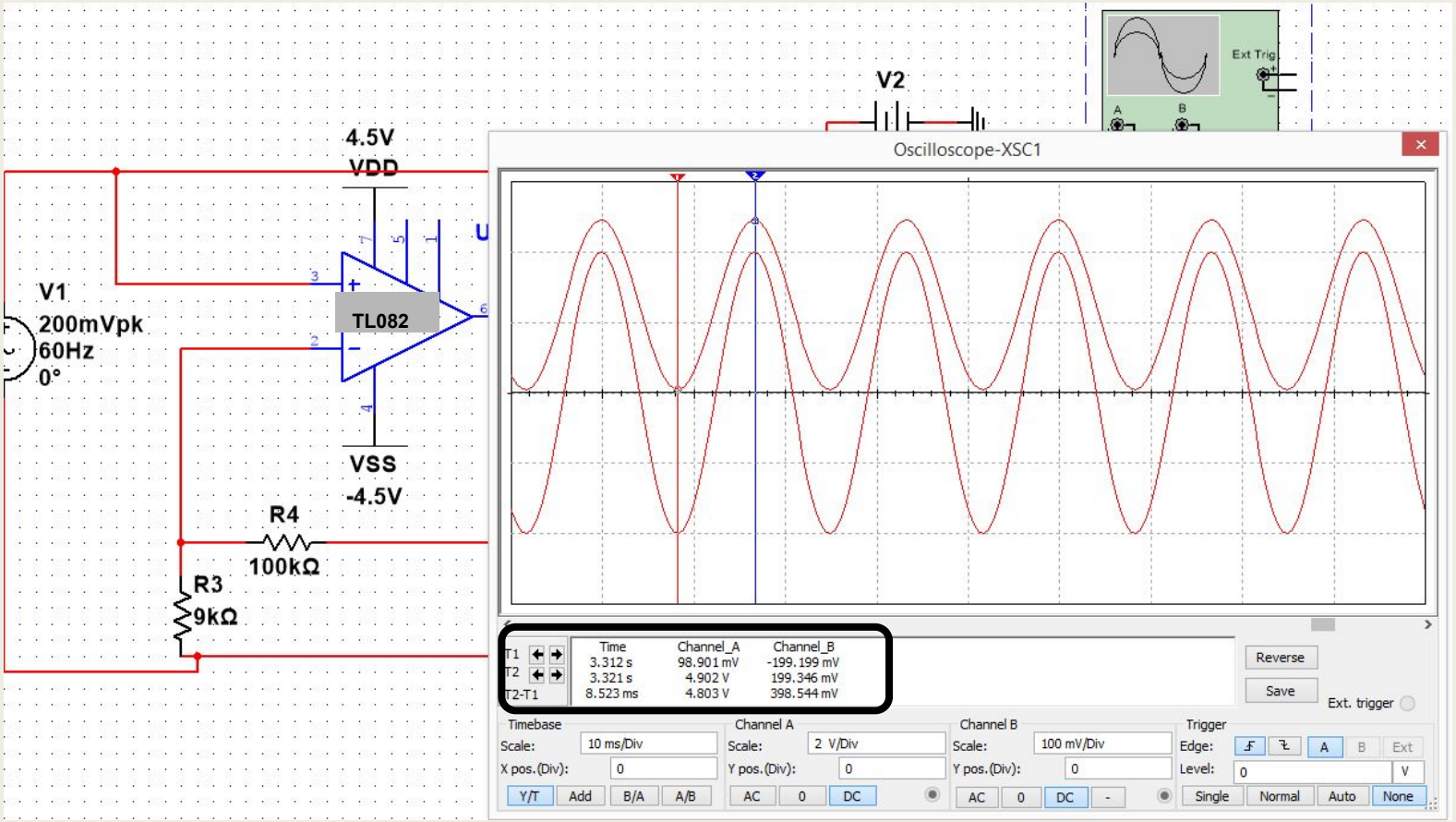
Audio Converter to MCU



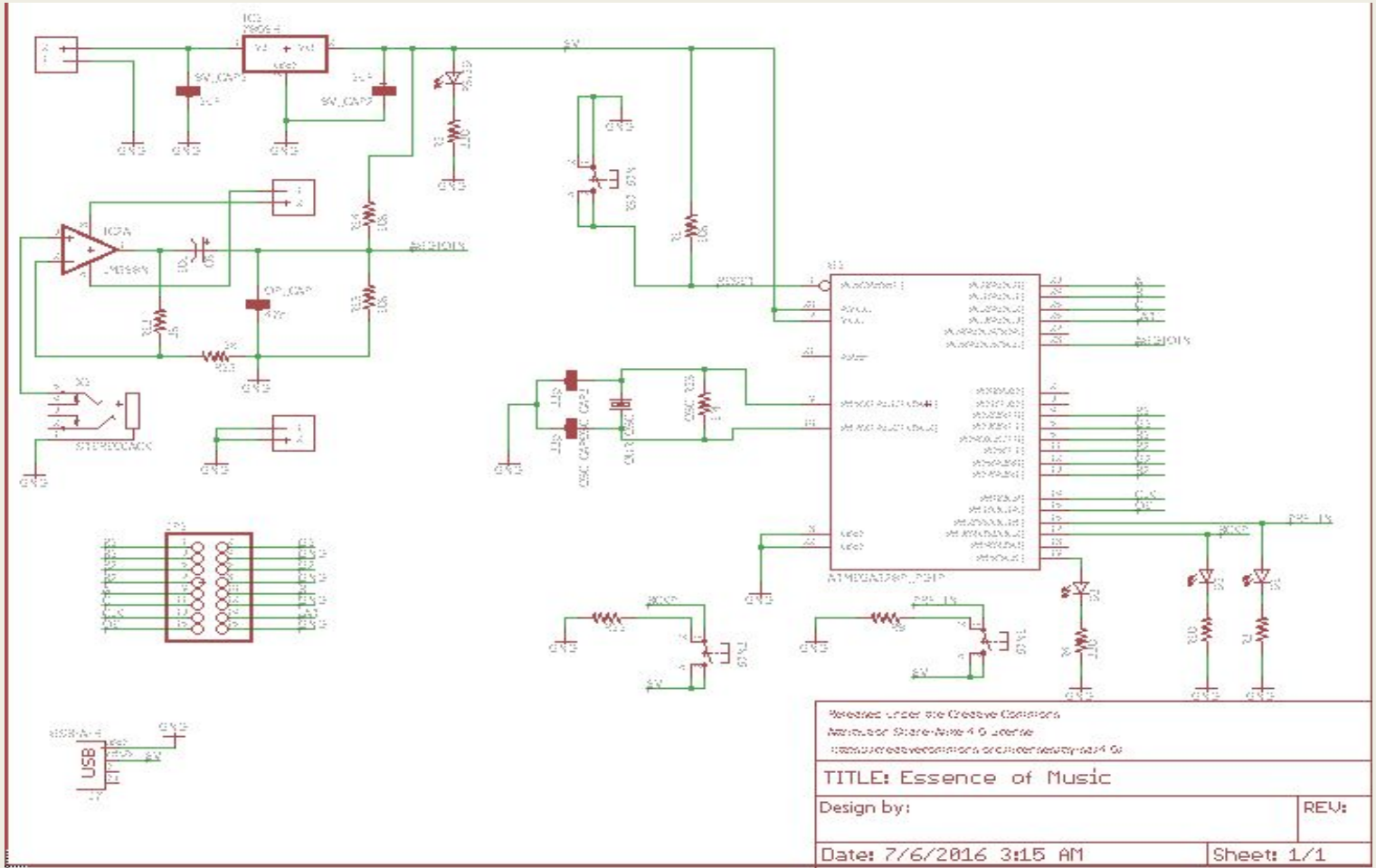
Audio Converter to MCU



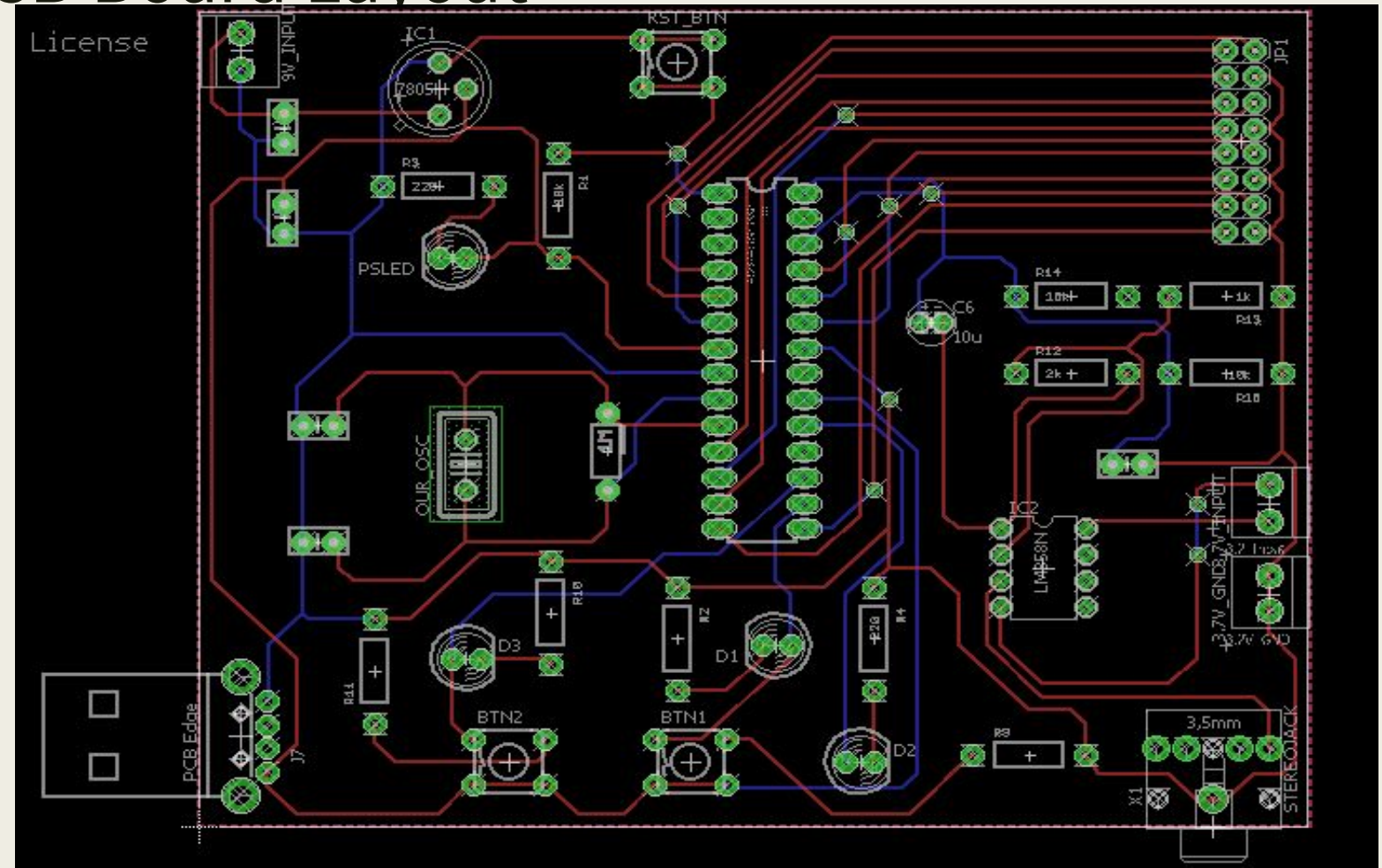
Audio input and output towards MCU



PCB Schematic



PCB Board Layout



MCU Connections

- Attached to the MCUs are 5 key peripherals.
  - 2 buttons on the left side of the box. These buttons are connected to pins 10 and 11 on the ATmega328p and are used to control the displayed pattern and the observed color on the L.E.D matrix
  - On the same side of the box, there is a power switch which is connected to the Lithium Ion 18650 batteries which supply power to the microcontroller. This switch helps to prevent the system from draining the batteries unnecessarily and extend the battery life.

MCU Connections

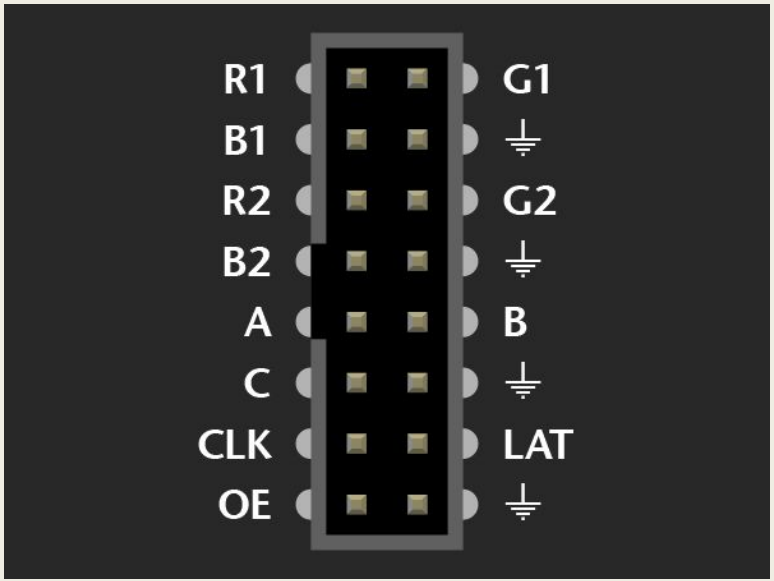
- There are also 2 peripherals attached to the audio PCB which the user will have access to.
  - The first peripheral is the speaker power button. This will allow the user to prevent the speakers from generating sound even when the rest of the system is powered up and performing.
  - The second peripheral is the volume control knob which is also located next to the speaker power button. This allows the user to control the volume at a close range and is necessary for the system to be able to produce a sizeable pattern on the L.E.D grid.

MCU Connections

- The peripherals on the system are attached to the outside of the box through the use of wires coming off of the PCB. This is done in order to allow the PCB to rest at the bottom of the box while the user has access to the buttons on the outside of the case. The case has a lid which allows the user to access the inner workings of the device, but this should only be used when pairing with the Bluetooth device for the first time.
- The power button and the volume control button of the audio PCB are connected to the outside of the box through the use of heatshrink. This is due to a time constraint and a lack of immediate materials. Future iterations of this device would definitely use an external button and power knob in order to connect the user to the device.

MCU Connections

- The main funcitonality of the MCU is to control the L.E.D. array so it is natural that there are many connections connecting the Atmega chip to the L.E.D.s.



Programming

- The code on the ATmega328p is loaded on using the Arduino IDE and is coded in C++.
- There are several libraries used in order to fulfill all of the tasks on the system.
  - Library for using the L.E.D matrix
  - Library with FHT information
  - Library for input and output from Atmel

Basic Patterns

- The coding system contains 3 different patterns that are affected by the values that are read in from the analog input pin.
- Two of the patterns are basic patterns that use the raw information from the input in order to produce different combinations of L.E.D lights.

Basic Patterns

- The first of the patterns reads in 32 signals and stores them in an array for use.
- The data is then taken and integer division is used in order to determine the height of the lights that are to shine.
- Ideally, there should only be two lights per column.
- The L.E.Ds are then lit up in one direction and then the same pattern is repeated in the opposite direction.
- This produces a fluctuating pattern that uses two colors in a symmetrical light show.

Basic Patterns

- The second pattern is a primitive beat detection pattern that fills the L.E.D matrix with color when it detects a “beat.”
- The “beat” is detected when a read in value from the analog signal has a value of 750 or more.
- A true beat detection algorithm could not be designed as the pattern was included later in the process and the design of a low-pass filter feeding information to the system could not be designed.

Fast Fourier Transform

- The most complex of the patterns that are included in the program.
- This pattern makes use of a faster version of the Fourier Transform in order to convert incoming voltages into frequencies
- These frequencies are then used in order to light up the L.E.D matrix in a specific way reminiscent of a spectrum analyzer.

Profile Swapping

- Of the peripherals that are located on the case, one of them is designed to alter the profiles when the button is pressed. This is done by taking advantage of the fast speed at which the code is processed and performing a Hi-Lo check on the button state.
- The button state is checked at the end of each loop and when detected, changes the profile.
- A delay is also placed in the code in order to prevent the system from rapidly switching between profiles.

Color Swapping

- The second of the button peripherals on the system is used in order to change the colors that are used in the pattern displays.
- The user presses the blue button on the side of the device which causes the MCU to scroll through the pre-set color profiles.
- Like the profile swapping, there is a delay to prevent the user from skipping over profiles.

Issues and Problems

- Throughout the process of completing the project, there were several problems that we encountered.
- Issues surrounding the hardware include: L.E.D powering, Initial Bluetooth receiver, and Speaker Systems.
- Issues Surrounding the software include: Fast Fourier Transform with L.E.D Matrix.
- Also, during the testing and altering of code, an extraneous wire also caused the system to damage the programming Laptop.
- Following the laptop incident, a short occurred and destroyed the pin headers used to connect the L.E.D matrix to the system.

Changes and Compromises

- Changes had to made throughout the process of creating the device in order to meet certain criteria.
- There were changes made in the hardware as well as the software.
  - *Hardware:* changed from fully battery powered to wall mount and battery hybrid.
  - *Software:* removal of the Android Application due to lack of time for programming, removal of FFT pattern from L.E.D display pattern.

Fast Fourier Transform Issues

- While the idea of the Fourier Transform is rather simple, the actual coding is more complex.
- This was simplified through our discovery of a library that included functions that showed how to perform the Fourier Transform.
- However, all of the methods that use the Fourier Transform used certain start-up functions which interfered with the L.E.D matrix system.

L.E.D Matrix Issues with Power

- The L.E.D. matrix can be powered by the PCB, but power distribution leaves much to be desired.
- Occasionally, the L.E.D matrix will appear to be getting less power than expected causing the wrong colors to appear.
- It is for this reason that we utilize a third party wall outlet source.
- Power supply seems to be inconsistent when powering all of the systems.

Administrative Content: Bill of Materials

Item Name	Supplier	Total Cost (USD)
17 Pcs x 28 Pin DIP IC Sockets Adaptor Solder Type Socket	Saim's Store	$4.47
uxcell® 10 Pcs Faux Leather Housing T Type Clip Connector for 9V Battery	VNDEFUL	$4.78
Aluratek iStream audio receiver	Aluratek	$29.99
AmazonBasics 9 Volt Everyday Alkaline Batteries (8-Pack)	Amazon.com LLC	$9.99
Battery Holders, Clips & Contacts PCB PLSTIC BATT HLDR SMT 2 CELLS	Lonesome Vapors	$7.24
50 Pcs 16.000MHz AT49S 20PF DIP Quartz Crystal Oscillator	Find4Fix (CN Direct Shipping)	$3.00
Addicore 5V 1.5A Positive Voltage Regulator L7805CV in Antistatic Foam (5pcs)	Addicore	$5.95
2 of LG 18650HE2 2500mAh Rechargeable Batteries, 2-Peices	unicshop	$12.85
4-pack NEW Atmega328p-pu Chip w/ Arduino UNO Bootloader	12V application	$17.49
Arduino Uno	Adafruit Industries	$25.00
Audio Splitter	Radio Shack	$14.99
3.5mm Stereo Coupler	Radio Shack	$5.49
Push Buttons	Skycraft	$3.00
On/Off switch	Amico	$4.52
Broder Birchwood	IKEA	$10.00
Various Resistors/ Capacitors	UCF Senior Design Lab	$0.00
TL082	Radio Shack	$2.50
PCB Production (5x) - Expedited shipping	PCBWay	$84.00
Velcro	Skycraft	$5.36
Zipties	Self ownted	$0.00
	Complete Total:	**$250.62**

Administrative Content: Division of Work

Work/ Person	Joshua	Baron	Nelson
Hardware: Battery	Primary	S	S
Hardware: Casing	S	S	S
Hardware: PCB design	S	Primary	S
Hardware: Electronics	Primary	S	S
Software: Programming	S	S	Primary
LED Programming	S	Primary	S
Materials Management	S	S	Primary

Questions?