# Direct Music Synced LED Strips

**ECE 445 Project Proposal**

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# 1 Introduction

## 1.1 Objective

Modern-day LED strips that respond to audio are often driven by a microphone that detects sound and simply reflects the changes in sound level as changes in the colors of the LEDs. As such, there's often quite an extensive delay between when sound is picked up from the microphone and when it's accurately reflected by the LED lights that it's connected to. Such a system only allows for variation of lights based on the changes in sound level, or small levels of pitch differentiation (treble, bass, midrange). Our approach is innovative because it addresses the pitfalls of currently available market products by directly connecting to the music. We also will resolve the lack of pitch detection, while offering various application capabilities that aren't offered.

## 1.2 Background

To solve this problem, we plan to directly connect the LED strips with music and use FFT analysis to generate broader levels of pitch differentiation. This will allow us to have the LED lights display both corresponding to sound level and pitch. To address the customizability, we would like to either develop an application that allows for color-based pitch assignment, specific color outputs, and other light-frequency related options displayed with aural direction on two separate "left" and "right" LED strips

## 1.3 Physical Design

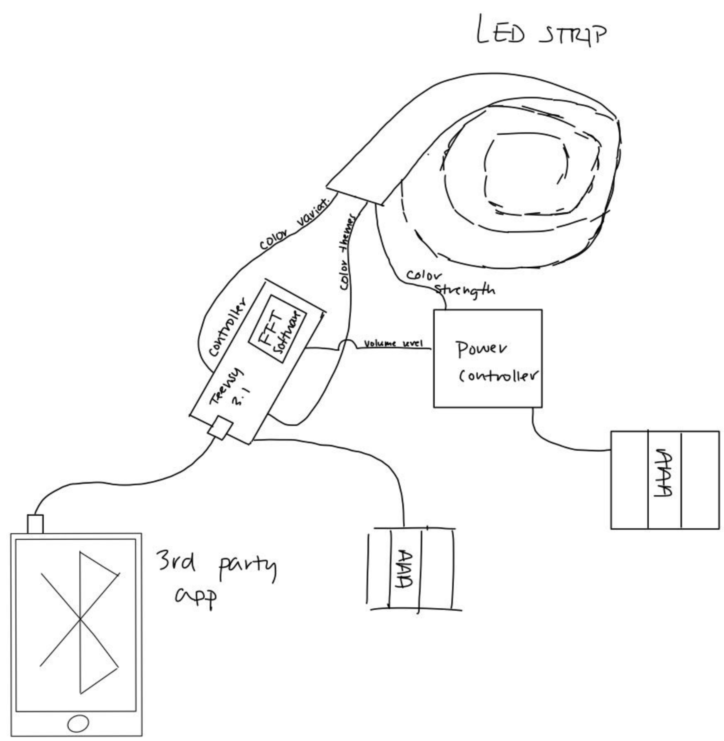


Figure 1: A simple depiction of the connected elements of our project

### 1.4 High Level Requirements

1.4.1. Our project must be able to reflect changes in frequency and intensity of sound by changing the LED color or change in color strength (power). These preferences should be user controlled.

1.4.2. Our light strip should be able to reflect custom color selections based on pitch and strobe patterns based on user input from an application.

1.4.3.The application should allow the user to select “color themes” to ensure that colors aren’t blended together.

# 2. Design

### 2.1 Block Diagram

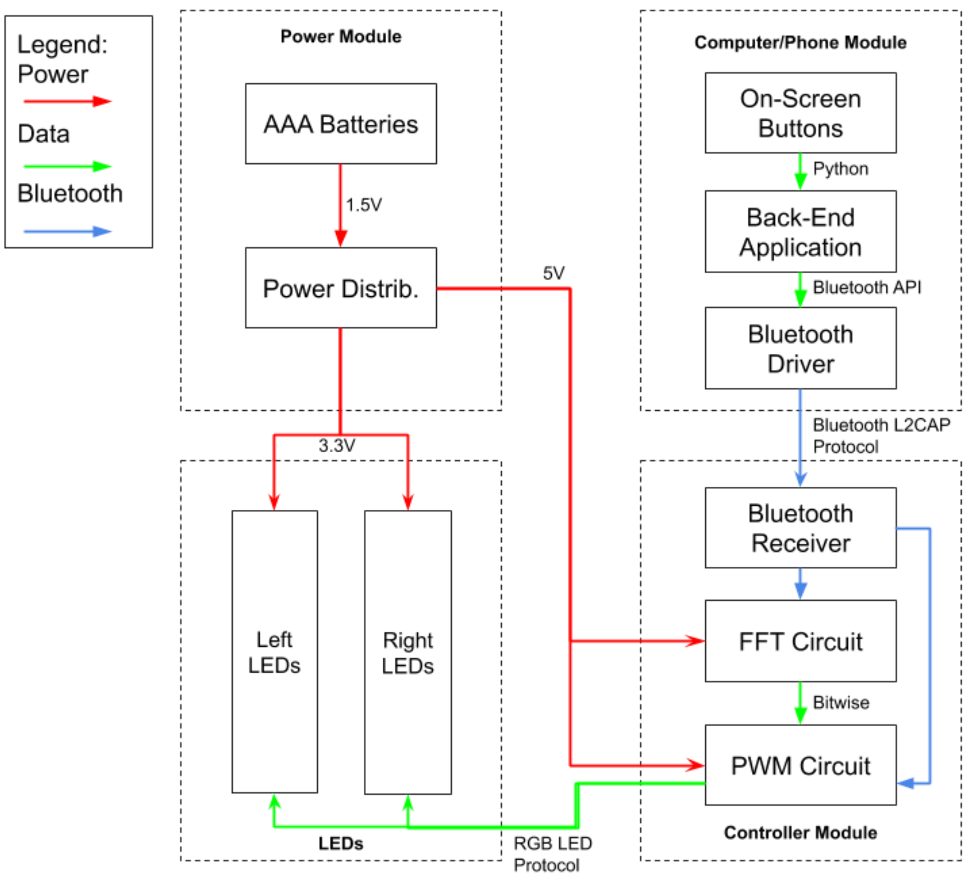


Figure 2: A block diagram of the components and modules of our project

2.1.1. Block Diagram Description

Both the LEDs and Controller Module are powered by AAA batteries regulated by a power distribution element. Data is generated from user input via the user interface that submits requests to the back-end application, which prepares and generates the necessary data to be sent over Bluetooth. The actual transmission is handled by the Bluetooth driver and is sent to the FFT and PWM Circuits, which in turn generate the necessary output to drive the color, intensity, and functional behavior of both the left and right LED strips

## 2.2 Functional Overview

### 2.2.1 Power Module

The power module is split into two blocks, the batteries and power distribution block. The batteries are there to supply power to the entire project, and feed its power directly to the power distribution circuit.
The power distribution circuit is there to change power needs and route power to different blocks of the project. LEDs will have different power needs than the controller and so must have that power compensation.

### 2.2.2. LEDs

The LED block is made up of two sections, the Left and Right LED blocks. They are identical in every way except in the data that they receive. These blocks will be made up of LEDs in parallel that will receive RGB data from the controller to change colors when the controller says to. This will be aligned with the analog music data and match the audio being played.

### 2.2.3. Controller Module

This is our most important module, as it controls the output to the LEDs. It consists of a FFT block, PWM block, and a Bluetooth receiver. The FFT and PWM blocks are on the same physical chip, however there is different logic for each. The FFT block will take in the analog data and perform real-time FFT analysis to determine frequencies being received. It will also be able to determine the strength of frequencies and so change its color logic to the PWM.

The Bluetooth receiver block will communicate with the external bluetooth device and communicate to the rest of the controller whatever settings have been determined by the user. This information will change what RGB colors are sent out.

The PWM block is where much of our logic is housed as it will control how much power goes to the LEDs to change brightness. It will also send the RGB data to the LEDs. This block will take into consideration the colors, theme, pitch or volume preference to change the LED outputs.

### 2.2.4. Computer/Phone Module

This module is how the user will be able to customize their lighting experience. It comprises the initial user interface, the backend application that packets the inputs, and a bluetooth transmitter that communicates with the lighting controller. The user interface will allow the user to select color themes, how they want the lighting to be displayed, or if they want to give a pitch range a certain color.

The backend application will take in that information and crunch it down to logical outputs for the controller as to reduce the  amount of the logic the controller holds to allow faster FFT computations.

The bluetooth driver will transmit the color logic data to the controller in a format where minimal logic is done on the controller itself. This driver allows for wireless communication and allows for many bluetooth devices to work as long as it has the application.

### 2.3 Block Requirements

2.3.1. Power Module

Must be able to deliver 5V +/- 0.1 to the controller. Must also be able to deliver 3V +/- 0.1 to the LED modules.

2.3.2  LEDs

Must display selected colors selected from the 3rd party app. Lighting will change in color/brightness coinciding with musical volume changes or pitch increases.

2.3.3 Controller Module

Real-time FFT analysis and be able to recognize 5 different pitch levels ranging from 20 Hz to 10kHz. Will also be able to take in inputs from the 3rd party application to control RGB colors sent to the LEDs. Must also connect to the bluetooth device and read data.

2.3.4 Computer/Phone Module

Have a UI capable of letting the user select color themes, select certain pitch colors, and lighting effects. Must be able to communicate with the controller module wirelessly.

### 2.4 Risk Analysis

The Controller Module block poses the biggest design and functionality challenge and is extremely important in properly interfacing between the user inputs (both color themes and input song) and translating this information into the proper current passed through both LED strips. We need to make sure the FFT analysis successfully creates separate frequency bands to allow us to assign colors and tones to each one, and simultaneously work with the PWM circuit to determine the intensity

## 3. Ethics and Safety

### 3.1 Ethics

When developing this product, it is crucial to keep in mind the end user, and how our design might have an overall impact on their safety when using the product. By incorporating electrical components into our overall design, it is imperative that we adhere to ethical standards and disclose any components that could potentially cause harm to the user [3].

### 3.2 Overheating Hazards

LEDs can reach junction temperatures up to 80°C when operating at manufacturer-recommended currents, where junction temperature is a function of ambient environment temperature, current through the LED, and amount of heat sinking material around the LED [2]. With this last parameter in mind, we aim to encase the LEDs in a translucent heat sinking material to prevent contact with skin or other sensitive objects while still providing desired exposure to light

### 3.3 Electric Shock Hazards

The maximum amount of current will be drawn when the three LED colors (RGB) are active, powered by a 12V supply. Each of these LEDs draws ~20mA of current, meaning that for the color white, our LED strip will be drawing 60mA of current per segment. For a proposed LED with 20 segments per meter, the maximum current draw is 1.2A/meter [4]. This amount of current is more than enough to end a human life, so it is imperative that we ground the LED strips at multiple points to ensure multiple layers of redundancy and therefore minimize risk of our end user.

### 3.4 Seizure Warning

Those with photosensitive epilepsy may have seizures triggered by flashing lights and bold and over intensive light patterns [5], both of which can be produced by the LED strips featured in our design. In particular, flashes between 3-60Hz are known to trigger seizures for this with underlying conditions [1]. In order to provide proper warning, we will include an epilepsy warning within our user interface to ensure users are aware of the potential light exposure

**References**

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[5] “Photosensitive Epilepsy: Causes, Symptoms, and Treatment,” *WebMD*, 11-Nov-2018. [Online]. Available: https://www.webmd.com/epilepsy/guide/photosensitive-epilepsy-symptoms-causes-treatment. [Accessed: 17-Sep-2020].