PoV Music Visualizer

ECE 445: Mock Design Review

Team 8: Adam Belkhadir, Alex Dutrow, John Tran

TA: Dongwei Shi

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1. Introduction

1.1 Objective

Circular music visualizers, as shown in Figure (1) below, have recently become popular in the entertainment and music scene for their unique take on music visualization. Creating one is easy on a computer or an HD TV due to the high pixel count and large computation power. However, many light fixtures used by hobbyists / artists / entertainment companies use low resolution square dot pixel displays to visualize their music. This causes jagged edges on the frequency bins of a circular music display. Anti-aliasing filters can fix this issue but the end result looks messy and unprofessional.

We hope to create a Persistence of Vision display that can run a circular music visualizer. The idea for this is that spinning an LED bar at a high enough rate will display the visualizer cleanly and fluidly without the need of a pixelated display.

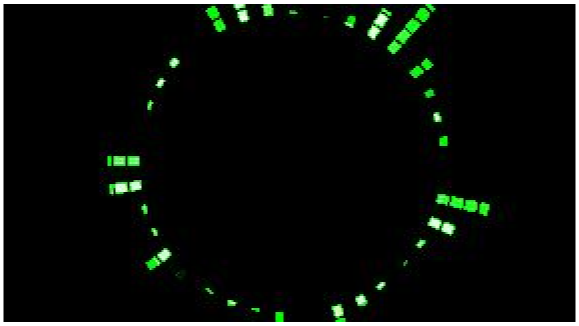

Figure 1: An example of a circular music visualizer

1.2 Background

PoV displays have been done many times before and they cover a wide range of functionalities. They have been used to generate 3D images, clocks or even display messages. Aliasing is a direct artifact of the resolution of a display and creates the commonly referred “jaggies” that appear on an image at a certain resolution. According to NVIDIA the only way to remedy aliasing is “is to create the effect of having more pixels on the screen” [1]. With a static dot matrix you can’t do this unless you create a blending effect between the edges of the image by utilizing more pixels. Utilizing our PoV display allows us to remedy this aliasing effect without the need or utilizing more processing power for our display. Our product is interesting to consumers as it allows the creation of any sort of image to render while captivating audiences with the fact that the image is created with a minimal amount of display elements on a rotating PCB.

1.3 High Level Requirements

- Motor must work and spin at a constant speed of 900 RPM with a -/+ 1% delta to ensure stable framerates.

- LEDs must change colors within 1/16th of a half-cycle or roughly 1.3ms with respect to themselves in order to keep up with the spin of the system to generate a working display.
- Microcontroller must have a clock speed of at least 3 MHz to be capable of performing DSP and updating LEDs within a reasonable time frame.

2. Design

Our block diagram consists of 5 modules: power supply, motor system, control unit, audio interface, and the LED display. The whole design will be powered by a plug-in wall outlet 12V DC power supply that will also be regulated in order to create a 5V and a 3.3V DC railing. The 12V rail will provide power to the motor system exclusively while the 5V rail will supply the LED array and the 3.3V rail will supply the controller unit and the audio interface. The motor system will be controlled to maintain a constant speed and to provide a timing for the microcontroller and LEDs to go off of. We will use a microcontroller to interface with the motor controller, LEDs, and to process the audio signal. The LEDs will be controlled according to the audio and the motor speed while the motor will be controlled purely by the tachometer.

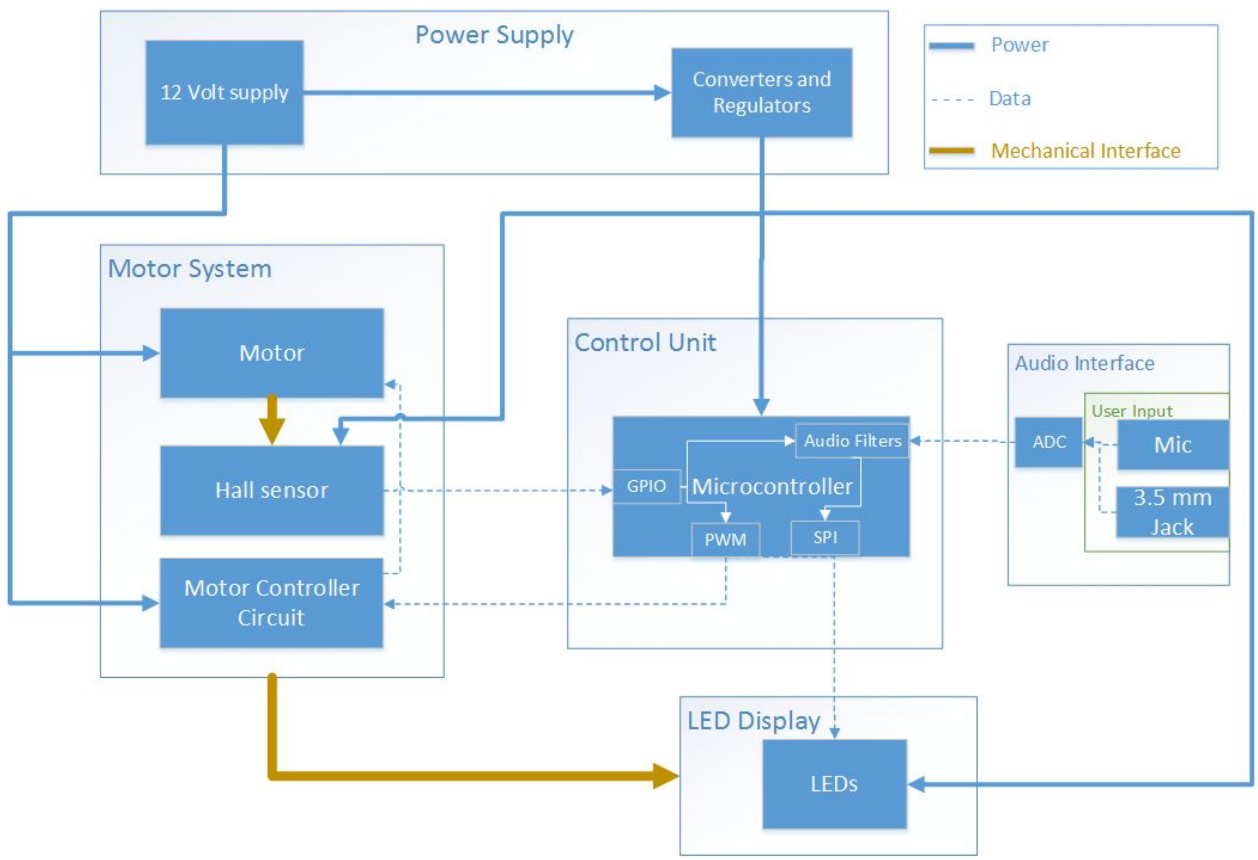

Figure 2: Block Diagram of the system

2.1 Power Supply

Power Supply: The power supply is a necessary and important component in most projects. Our project will need a 12V DC supply in order to properly power the entire system. We choose a

12V DC supply because our motor is going to consume a majority of the power in our project and the motor that we choose is a 12V DC motor. The power supply will be connected to all of the subsystems in our project. The power supply is the most crucial component in our system as without it, we can't satisfy any of our requirements as they would not be able to operate.

Requirement	Verification
1. Minimum power rating of at least 80 Watts and capable of outputting at least 5A. 2. Must provide 12V DC value and have less than +/- 1% ripple such that components are not damaged and can receive sufficient power.	1. a. Use power resistors to create max load situation and hook up supply to load. b. Measure resulting voltage and amperage with power meter and record values measured and load situation used. 2. a. Create load situation that is low amperage and measure load voltage with oscilloscope and measure voltage ripple. b. Save image of resulting voltage ripple waveform and record load situation used.

Converter Chips: The converters are important as they are needed to convert the 12V DC value into a 5V and 3.3V DC value in order to power the other portions of the system. The LEDs will need the 5V railing and the audio interface and the controller will need the 3.3V railing. We choose to regulate our 12V supply as opposed to getting individual supplies in order to cut back on cost and form factor while also being capable of supplying large amounts of power to the LED array. The converter circuit will be hooked up to the output of the power supply and produce the 2 separate voltage rails. The converter circuit is crucial to the system as without it, we would not be able to give power to our controller, audio interface, or controller and thus, would not be able to meet any of our requirements.

Requirement	Verification
1. Must be able to handle at least 3A. 2. Can convert 12V to 5V and 3.3V effectively while keeping resulting voltage ripple below +/- 1%	1. a. Use power resistors to create a 3A load situation and see if chip operates correctly / doesn't break. b. Measure resulting voltage and amperage with power meter and record values measured and load situation used. 2. a. Create 2 converter circuits that are low amperage and measure load voltages with oscilloscope and measure voltage ripple for each situation. b. Save image of resulting voltage ripple waveforms.

2.2 Motor System

Motor: A brushless DC motor to act as the main driving element to spin the LED bar. It will be mechanically coupled to the PCB, slip ring, and tachometer. If the motor does not operate properly then we would not be able to fulfill our first high-level requirement.

Requirement	Verification
1. Must be able to spin consistently at the target of 720 RPM in order to achieve 24FPS using two blades.	1. a. Create a test environment with the motor and working hall effect sensor mounted onto a test PCB. b. Measure the RPM from the data of the hall sensor

Hall Sensor: The external hall sensor will be used to gauge the speed of the motor. This signal will be fed to the microcontroller for calculating the current speed. If this does not operate correctly we will not be able to accurately measure the speed of our motor and move on to controlling it and therefor we would not be able to meet our first requirement.

Requirement	Verification
1. Must produce a 2 volt differential passing over a magnet at 27 m/s	1. a. Create a test armature on the motor with a magnet. positioned 7.5 inches away b. Put the output voltage pin onto a oscilloscope and measure the voltage drop.

Motor controller: The motor controller will adjust the speed of the motor according to a PWM pulse generated by the microcontroller. This will ensure that the motor will be given a constant voltage to produce a stable RPM for our display. If the motor controller is not able to provide enough power to the motor, then the motor w

Requirement	Verification
1. The motor controller should be able to consistently output the target RPM of 720 from a consistent PWM signal.	1. a. Connect motor controller to the power supply and the motor b. Connect the PWM cable of the motor controller to a signal generator. c. Generate a consistent square wave and test with the hall sensor if the output of the motor is stable.

2.3 Control Unit

Microcontroller: The microcontroller is the central hub of the project. The controller will generate the control pulses for the motor control circuit as well as generate the spectrogram of the music. If the microcontroller does not operate fast enough then we will not be able to successfully control our motor or process our input signal fast enough to alter our LED display. So if this doesn't operate properly, we will not be able to satisfy any of our requirements.

Requirement	Verification

1. The microcontroller must be able to communicate via SPI at a data rate of at least 500 KHz	1.

2.4 LED Display

LEDs: Individually addressable RGB LEDs will be used as they are easy to feed data into, can be cascaded, and offer a wide spectrum of colors. The LEDs will be connected in cascade with one another and will then be controlled by the controller unit. These LEDs need to be able to update within 1.3ms and if they are not able to, we will not be able to satisfy our second requirement.

Relevant equation(s):

$$\frac{1}{48} \text{ (Half revolutions per second)} \cdot \frac{1}{16} \text{ (Bins per half revolution)} = \frac{1}{768} \text{ (Seconds)} = 1.3 \text{ ms}$$

Requirement	**Verification**
1. Must be able to update within 1.3ms with respect to themselves.	1. a. Create a simple load resistor, LED, voltage source circuit and probe the input and output data lines of the LED with oscilloscope probes. b. Compare the waveform for the input and output and measure the time difference and record the measured results and save the resulting waveforms.

2.5 Audio Interface

ADC: The ADC will be used to sample the audio signal from the user input. The audio spectrum ranges from 20Hz to 20KHz. However, a majority of people can only hear from 20Hz to 16-17KHz. For this reason we will sample at a rate greater than 32 KHz in order to satisfy nyquist criterion. However to get an accurate representation of the audio we propose to sample at 44.1 KHz; a common audio standard. If the ADC is not able to sample the signal at a fast enough rate then we may run into microcontroller processing speed issues and therefore would not be able to fulfil our second or third requirements.

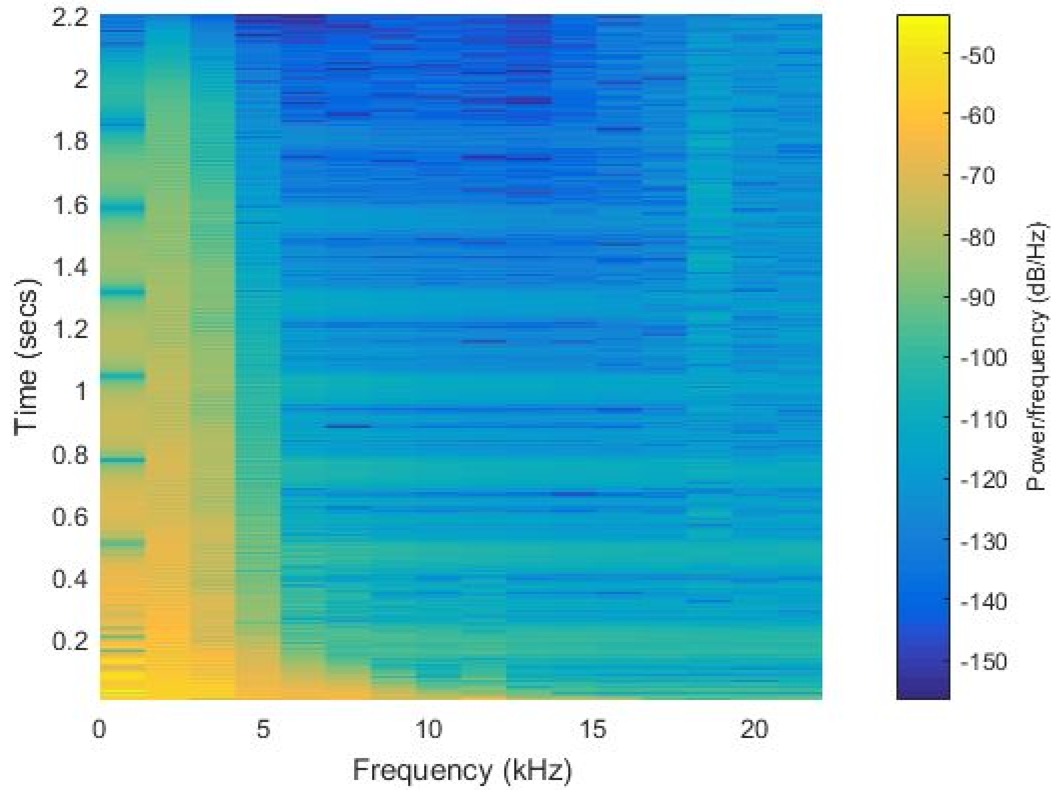

Figure 1. 16 bin FFT spectrogram

Requirement	Verification
1. The ADC must be able to communicate with the microcontroller 2. The ADC must sample an arbitrary analog signal of 20 KHz without aliasing	1. a. Create a serial monitor to print out ADC data b. Create print statements with the data as an input to see if connection was established 2. a. Produce a 20 KHz sine wave using a function generator as an input to the ADC b. Use frequency detection software on the MCU to make sure the frequency is correct

2.6 Schematics

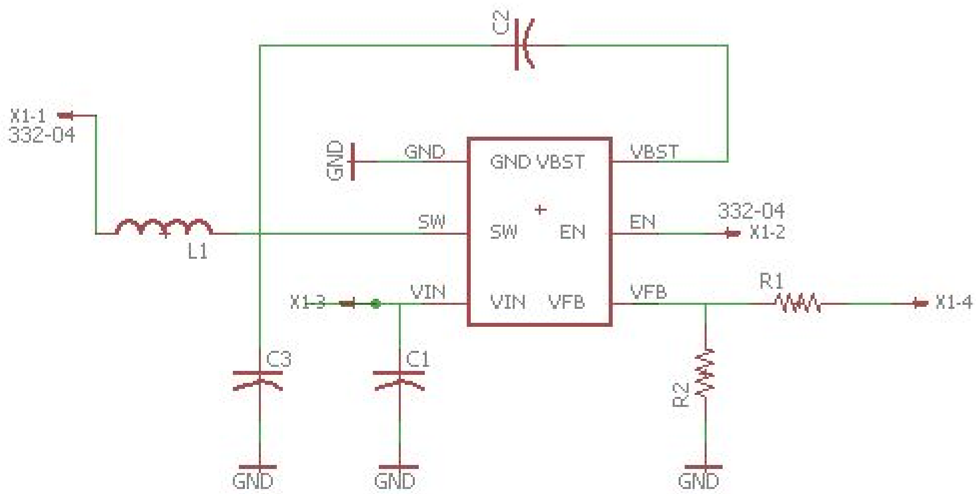

Figure 3. Power converter circuit

2.7 Tolerance Analysis

3. Cost and Schedule

3.1 Cost Analysis

Labor:

$$3 \cdot \$40\ per\ hour \cdot 10\ hours\ a\ week \cdot 16\ weeks \cdot 2.5 = \$48,000$$

Parts:

Parts	Quantity	Total Price
Total Price:		

Grand Total:

3.1 Schedule

Week	Adam	Alex	John
2/27			Purchase motor components
3/6			Program motor controller and experiment on PWM signal generation
3/13			Work with hall sensor timing. Work on motor speeds and timing with LED.
3/20			Add input into PCB design. Work on delegated micro controller code.
3/27			Work on physical installment of the project
4/3			Work on physical installment of project. Debug subsystems.
4/10			Mock demo work. Debug system communications issues from the motors. Help is LED and microcontroller debugging.
4/17			Debug system communications issues from the motors. Help is LED and microcontroller debugging.

4/24			Work on powerpoint and final papers
5/1			Finish up final papers

4. Ethics and Safety

Having considered the scope of our project and having read the IEEE Code of Ethics we can say for sure that there are a few ethical codes that should be addressed.

#1 of the IEEE Code of Ethics states: “To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment” [2]. Our product is going to be using strobing lights, though they may not be too intense, it is important to consider any audience members that are prone to epilepsy and seizures and warn them promptly. Also, our final product will likely be rotating at a significant speed and thus could cause harm to anyone who comes into contact with the rotating member and so a warning should be administered. Finally, our product’s power supply will be plugged into a wall outlet and is in contact with a large source of power and could cause harm to anyone who operates the device improperly and so a warning should be administered.

#7 of the IEEE Code of Ethics states: “To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others” [2]. The important portion to take from this is that we should properly credit the contributions of others. Persistence of Vision screens have been done many times in the past be it in this class or online. It is important to consider that our system should stay unique and if outside documentation is utilized that we credit the source appropriately.

#9 of the IEEE Code of Ethics states: “To avoid injuring others, their property, reputation, or employment by false or malicious action” [2]. This is a crucial point of consideration in our final product. As discussed previously, our product has the potential to cause physical harm to others. It is important that during the implementation of our project that we incorporate appropriate safety standards. In order to prevent the occurrence of someone coming in contact with the spinning member of our project we are likely to implement a safeguard in a similar sense to how the department of labor requires safeguarding for rotating parts [3]. Another thing to take into consideration is proper housing of the power supply as it is plugged into a wall outlet and therefore could cause significant harm to others if improper contact is made. One final important factor when considering safety is to ensure that the power supply that we choose meets the appropriate safety standards and has the necessary safety marks [4].

References

[1]Nvidia (2017). High-Resolution Antialiasing (HRAA). [Online].Available:http://www.nvidia.com/object/feature_hraa.html [Accessed: 7- Feb- 2017]

[2]IEEE (2017). IEEE Code of Ethics.
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[3]OSHA (2017).General requirements for all machines.
[Online].Available:https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9836 [Accessed: 1- Feb- 2016].

[4]CUI(2017).Power Supply Safety Standards, Agencies and Marks.
[Online].Available:http://www.cui.com/catalog/resource/power-supply-safety-standards-agencies-and-marks.pdf [Accessed: 1- Feb- 2016].