Atmosphere Based Color Changing Lamp
Group-17 Final Report

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Table Of Contents

1. Introduction

1.1 Objective:

The Importance of lighting often goes unnoticed. Light, like sound, has a heavy influence on the vibe of a room and can affect the mood of the people in it. People often take notice of this and attempt to control the vibe of their living space by adding various types of lighting fixtures. However, the mood of a room changes constantly, unlike a fixed light source. Constantly adjusting the lighting to adapt to the sudden changes of the environment is too cumbersome and unreasonable for any sane person.

The primary goal of our project was to create a Lamp that reacts to the change in atmosphere in the room where in our case we define the atmosphere to be the sound level in the room.

The Lamp reacts differently to different situation by emitting out different colors or no color at all based on the sound intensity and the sound frequency in the room. Our main implementation and use of this lamp is to detect the sound frequency at a really fast rate thereby reacting to music and it's different types by distinguishing the frequency of the different notes being played and how loud they are being played.

1.2 Background:

Being college students we entertain a lot of guests at home and it's mostly the lights and the music that sets the tone of night. Rather than only music we want our lamp to generally detect the mood in the room with the general noise level. Therefore at times when someone forgets to shut the lamp it will itself dim or luminate based on the noise level in the room currently. It concept of the lamp is to basically adapt to its surroundings based on the number of people and current mood of the room. With the mood we mean the color changing ability based on different environments and situations, here we do not mean to apply a particular algorithm but rather configure the lamp to illuminate/dim/change the color based on the inputs that we detect from the microphone and send to the microcontroller. So the 'mood' essentially is deciphered by how we configure the microcontroller for the different types of inputs and that would be done by setting up thresholds for a particular range of frequency which would be different of different types of things, like for example, frequency of conversation vs frequency of music.

We were specifically enamored by this project because this is something that we see ourselves using and bragging to our friends and family about. We want this to be that ‘one cool thing’ that we did in college. We understand that there are already products that change light based on some input but no product really that detects noise and changes light based on that input . For that reason we realize that this is more of a luxury project rather than a useful one but it helps us implement everything that we have learnt in college into use and put use of two of the most overlooked but important phenomenon of noise and light into good use.

 [1]

Image 1: Picture of what we want our final product to output

1.2.1 Application:

The target audience for our particular product would most likely be college environments. This would be a sort of product that would mostly dazzle people from the ages of 15-30 as the way we see it, it basically comes into use during a gathering when you have music playing where this device adds the ‘wow’ factor to the room.

1.3 High-Level Requirements

- Lamp responds to changes in the amount of sound in the room,Typically the range of the sound of the room would vary from 10dB to 100dB, Where 45dB is the minimum intensity required to awaken a sleeping person. Hence we set our microcontroller to react only to anything above 45dB. Where (45-55)dBs serve as quiet environments where we would just want our lamp to be dim , (55-70)dB's will serve as conversation where we want our lamp to be bright and (70-90)dB's to be loud music where the lamp would change its colors based on the changing frequencies. Anything above the 90dB mark the lamp would not change from it's previous behavior(we don't expect it should go there)
- Lamp reacts differently to loud music (70-90 dB) than to regular conversation (45-70 dB)
- Lamp reduces brightness during a prolonged quiet situation (<45dB on average for 10 seconds straight)

2. Design

The lamp could be divided into four sections: sound detection, microcontroller, LED array, and power supply. The sound detection includes a microphone component to capture noise of environment, and inputs the signal to ADC to feed to the Microcontroller. Microcontroller receives data and conduct mathematical analysis to manipulate LEDs. LED array is the output of the whole system to provide luminance. Power supply is a AC-DC circuit generating steady 5V and 12V voltage to support microcontroller and LED.

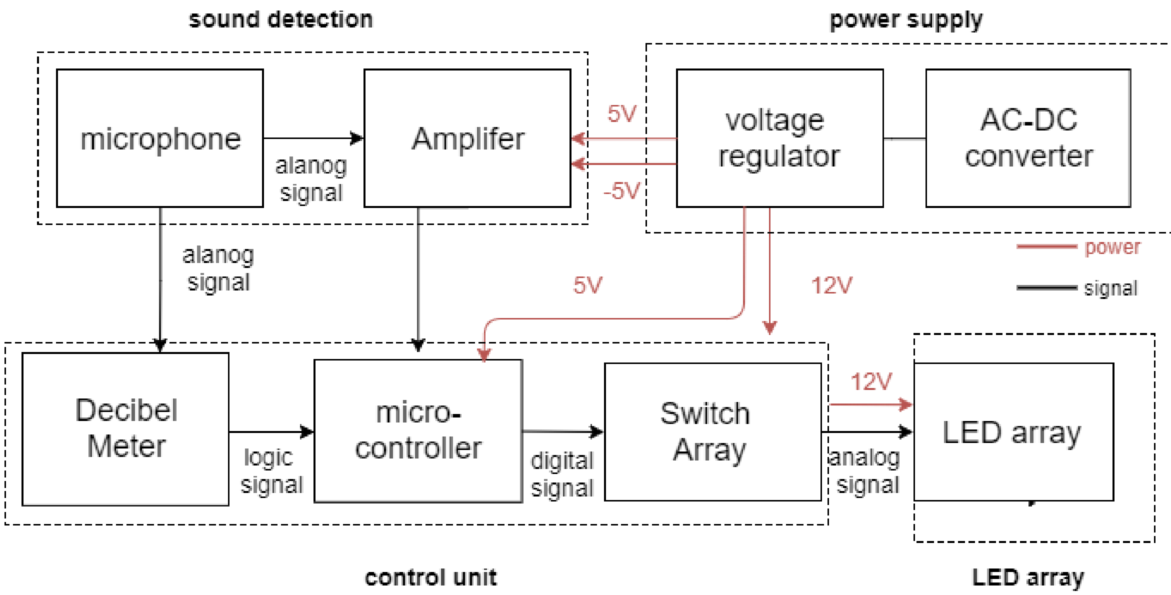

Figure 1: Design Block Diagram

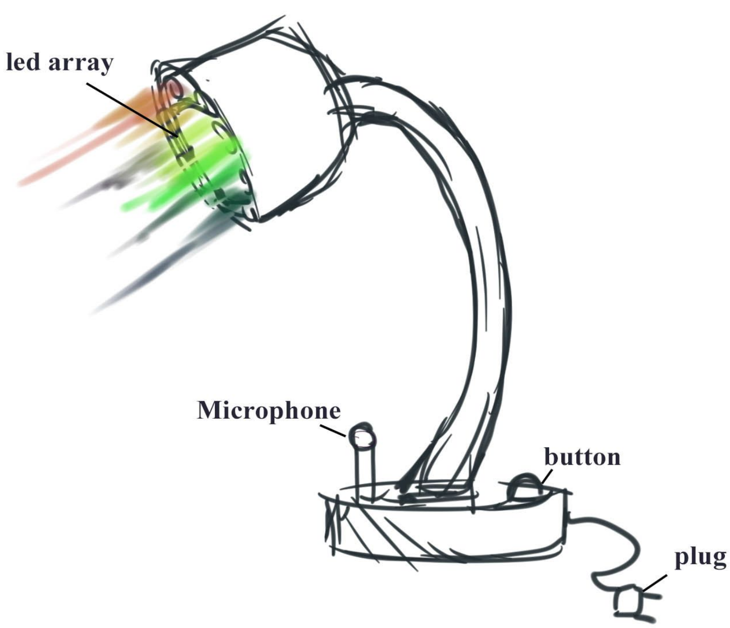

Figure 2: Physical Design Sketch

2.1 Sound Detection

The main feature of the lamp is its ability to respond to sound. This is accomplished using a microphone that detects the sound in the room, and then a filtering circuit to get rid of unnecessary data. Loudness thresholds will be determined by feeding the output of the microphone into a simple decibel measuring circuit.

2.1.1 Microphone

Microphone serves as the main input to our project where it detects and send the sound waveform to the microcontroller to do further processing of the sound wave.As the soundwave that initially comes in the microphone is distorted and not very clear we added a operational amplifier to give us a better waveform so as to yield better results.The challenges to this module though is to find the right kind of microphone as the the output completely are dependent on the inputs and if the input waveform has problems like delays, noise etc.. then it severely affects the outputs of the entire project.

Requirement	**Verification**
Frequency range: 20Hz to 4 kHz	Use App called Sonic in smartphone to generate sine waves with different frequency(20Hz to 4 kHz) and make the microphone receive the signals .
Microphone produces a positive signal	Use oscilloscope to measure the outputs and observe if the outputs meet the expectation(sine wave with certain frequency without distortion)

2.1.3 Decibel Meter Circuit

In order to determine whether the loudness has passed certain thresholds, we designed a simple noise measuring circuit that only distinguishes between quiet, noisy, and loud music volumes. The circuit will looked like the figure below, but with transistors that will turn on at each of the important sound thresholds.

Requirement	**Verification**
Analog signal from microphone is received by digital circuit and reacts differently to varying intensity levels	Use oscilloscope to measure the outputs and check for the varying voltage. The voltage goes high with loud sound (above 400mV) and low when quiet (below 100 mV)

2.2 Power Supply

The power supply convert the 120V AC electricity from socket to steady DC voltage to the other parts of the device, and some of them have different voltage requirement. It means that power supply should provide different voltage values including 5V,-5V, 12V.

2.2.1 AC-DC Converter

Since we want the lamp to be powered through a wall outlet, we will need a 120V/12V voltage regulator. However, we will be buying one off the shelf instead of designing our own in the interest of safety**.** It can not only convert AC to DC but bear maximum power of the whole device to avoid heat up and explosion. In concern of safety we may apply a ready component in our device.

Requirement	Verification
120V (AC) (wall outlet) converted to 24 V (DC)	Using a multimeter where we attach one end to the ground and the other to the VCC and check if the value meets the expectation.

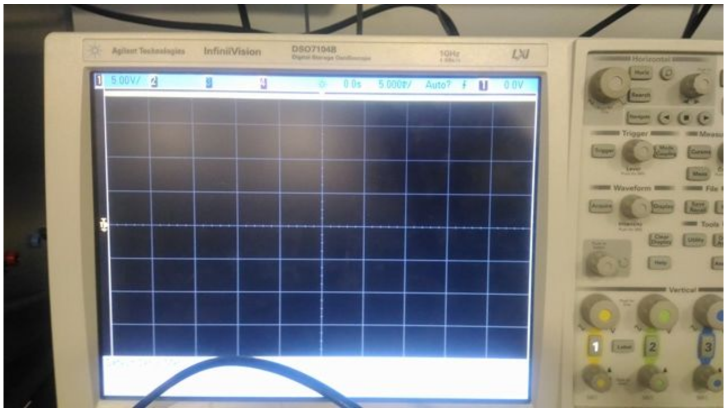

Figure 3-1: AC-DC on oscillator

2.2.2 DC-DC Converter

Since the microcontroller required 2.7-5.5V to operate, we need to convert the 12V from voltage converter to steady 5V for proper operation of microcontroller. A simpler method to achieve it is voltage divider circuit, which has low efficiency. To reach max efficiency we would apply a DC-DC converter to get 5V.

Requirement	Verification
1. Convert 24V to steady 12V 2. Convert 24V to steady 5V 3. Convert -24V to steady -5V	1, 2, 3. Use voltage meter to measure the voltage value.

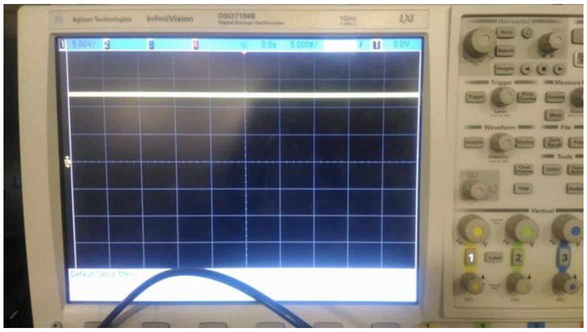

Figure 3-2: Output 12V

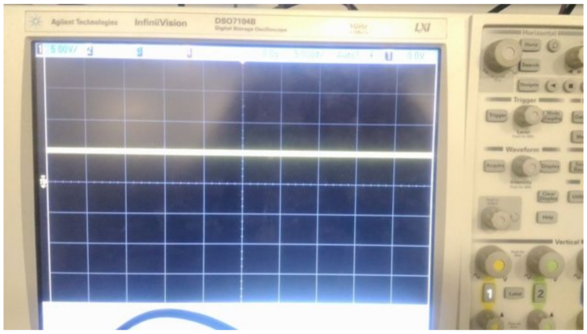

Figure 3-3: Output 5V

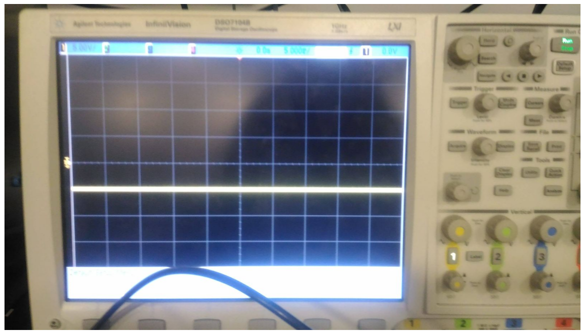

Figure 3-4: Output 5V

2.3 Control Unit

The control unit consists of the microprocessor on which all logical operations including FFT will be performed. The microcontroller outputs its signal to a voltage control circuit that delivers different voltage to control LED array.

2.3.1 Microcontroller

The microcontroller in a way serves as the 'Brain' of our project where it identifies the soundwave and runs Fast Fourier Transforms on the soundwave which will accurately tell at what frequency the sound wave is operating and change the colors of the LED's based on the intensity of the soundwave at that frequency level.

Each LED corresponds to a different frequency level and changes it's colors based on the intensity of sound at that particular frequency level. This makes the LED's react differently to different notes and thereby allowing the LED's to dance according to the music being played. The LED's also respond to conversation by just lighting based on the loudness of the conversation and completely turning off when there is a moment of silence or sound waveform has low frequency.

Requirement	**Verification**
Could conduct FFT with delay time between input and output signal < 0.1s	Write testing code to record the real time of FFT which MCU computing.
We expect our code for the microcontroller to be under 20 kbytes	Connecting MCU to computer and check the size of program.

which can be directly accessed from the Teensy 3.1/3.2 RAM which is 64 kbytes.	
Operate voltage is between 3.3v to 5v	Input voltage between 3.3v to 5v to MCU and check if the MCU operate successfully.

2.3.2 LED Control Circuit

This part includes MOSFET as bridge connecting the analog output of microcontroller and LED array with current limit awareness, and a decoder with MOSFET as switch to make LED light up turn by turn.

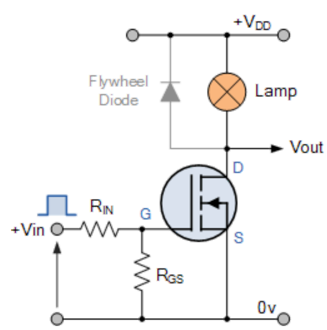

Figure 4: Mosfet as switch

Requirement	Verification
1.Total current tolerance > 0.6 A 2. Input 3-bit digital signal to control on/off 3. Input 3 analog signal to control color	1. Use current measurer to measure the value of current 2. Use decoder and mosfet as switch and verify they can work properly. 3. Use mosfet as bridge between MCU and led to bear large current flow. *

2.4 LED Array

The LED array consist of eight individual parts to perform different color and luminance. Generally the LED light consists of R,G,B input to determine the color performance.

Since R, G, B inputs require analog signal and limit number of analog output of microcontroller, all the separate LED parts will have common R, G, B inputs, and then every LED take turn to light up in very short time as if they shined simultaneously.

2.4.1 LED Light

The main advantage of led light is low power consumption for safety and energy saving purpose. It's also easy to control by simple circuit. We consider to apply led strip in our device for providing sufficient luminance.

Requirement	Verification
1. Current draw < 250mA per 200cm 2. Luminance > 100 lux in room	1. Use current measurer to measure the value of current 2. Use luminance detect APP to measure the values with different distance and record the values.

3. Cost

$$3 * \frac{\$40}{hour} * \frac{10hour}{week} * 10week * 2.5 = \$30000$$

Our labor cost are estimated to be $0.88/hour and 10 hour/week with 10 week to finish our project.

Part	Cost
Microphone	**$0.95**
AC-DC converter (120V-12V**)**	**$8.95**
RGB Led *30	**$45**
Microcontroller (Teensy USB Development Board**)**	**$19**
N-channel MOSFET(IRLB8721 **)**	**$4.04**
Resistors, capacitors, ICs, crystals, sockets, etc.	**$20**
PCBs (PCBway)	**$0**
Total	**$97.94**

The grand total of the cost is $97.94

5. Conclusion

This project taught us how to apply the fundamental concepts of electrical and computer engineering to implement a working device yielding desirable results. It helped us consolidate all the knowledge that we have acquired in our years as engineers where we used concepts of analog and digital waveforms, control circuits, Fast Fourier Transforms,etc. It also helped us learn the importance of teamwork and taught us valuable lessons in how to assess an individual's strengths and weaknesses and get the most out of them so as to maximize their contribution.

6. References

[1] Google Images: https://www.google.com/search?q=color+changing+lights+room&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiantGOlNjWAhWJrVQKHTuZAOEQ_AUICygC&biw=1366&bih=662#imgrc=wwwwkD7PeVW1BM:

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