ECE 304 Final Project Report: VU Meter

Fall 2023

College of Engineering and Computing

Department of Electrical and Computer Engineering

ECE 304: Electronics

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Due - December 8, 2023

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Introduction

Our final project is the Volume Unit (VU) Meter. The VU Meter measures and displays the audio signal levels present in a system. For our version of the VU Meter specifically, we play audio from a laptop which is connected to the circuit via an auxiliary cable, and the circuit displays the audio signal levels using 10 LEDs. We decided to build this circuit because we thought that the VU Meter provides an interesting visual representation of audio levels, and also we thought having changing lights would be neat. We used [1] as inspiration and as the source for our initial schematic.

This report goes through the entire project process by starting with our circuit theory, describing our circuit simulations, exploring our experimental results, and ending with our overall project analysis. In the Circuit Theory section, we explain how our VU Meter circuit should work and we create a plan for our circuit build by designing the schematic and introducing relevant equations. Then, under Simulation Description and Results, we describe how we simulated our circuit by showing our LTspice schematic and simulation results. We use the simulation results to demonstrate the functionality of the circuit focusing on how the LM3915 executes turning on the 10 LEDs in a logarithmic 3 db/step pattern as well as how it has adjustable characteristics that enable more customization within the circuit. Next, in Experimental Results, we explore our experimental process by including our estimated results, labeled VU Meter circuit build, and experimental results. We had a lot of success creating the VU Meter, but from comparing our estimated results to our experimental results, we learned that we required some additional components that we did not anticipate when we first simulated the circuit such as the 1N4007 diode. Last, under the Analysis of Results section, we compared our circuit theory, simulation results, and experimental results to find similarities and differences between the three sections. Overall, we were successful in creating the VU Meter and we learned a lot throughout the process.

Background

The VU Meter first takes in audio signal voltage from an audio source via a spliced auxiliary cable. Then, the audio signal voltage is sent through a non-inverting operational amplifier (op amp) to amplify the audio signal voltage, and the amplified signal voltage goes into the LM3915 integrated circuit (IC) chip. The LM3915 uses its internal 10-step voltage divider to detect how much signal voltage is coming in and then it determines which LEDs to turn on based on that. We have the LM3915 in bar mode so the lights below, up to, and including the level of signal voltage detected turn on. If the LM3915 were in dot mode, then only the corresponding light to the signal voltage level would turn on.

High school or freshmen college students could learn a lot from the VU Meter. First, students would learn about a basic application of op amps through using the non-inverting op amp to amplify the input audio signal. Second, students would learn about the LM3915 IC chip, and even though it is not a basic element used in Electronics class, they would learn how to use their resources to figure out how to set up and adjust the chip. These students would enjoy doing this project because it is an engaging way to visualize how electronics and analog circuits can work together. Also, the LEDs provide a visual representation of the audio levels which is much easier to comprehend than simply looking at graphs of signals.

For us, Claire and Sam, we found the more interactive projects in ECE 304 further increased our interest in our respective majors, computer/electrical engineering and robotics engineering. Specifically, we enjoyed Lab 4 where we used the SN74HC191 IC chip to execute binary counting visualized with LEDs. The visualization of the binary counting process made the project more engaging and interesting, so we hope that our VU Meter project will provide another source of interest in electronics such as ECE 304 Lab 4 did for us.

Circuit Theory

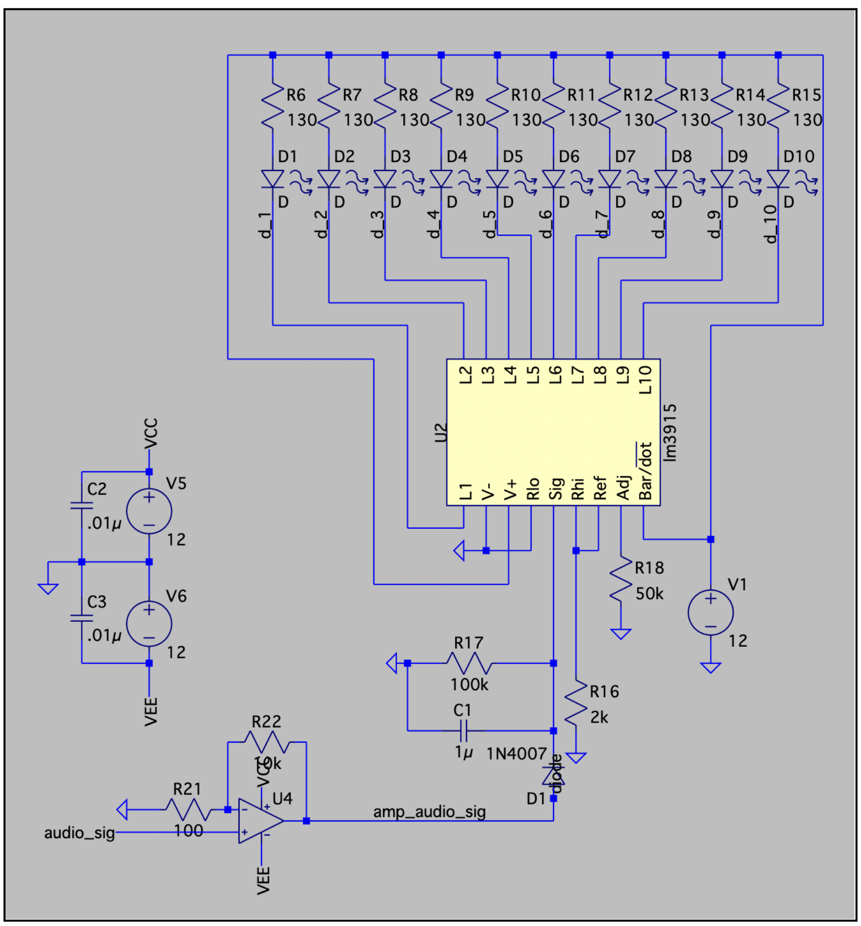

Fig. 1: VU Meter circuit schematic.

The basic functionality of our VU Meter circuit seen in Fig. 1 is to take in audio signal input and output a visual representation of the volume level via 10 LEDs. Our VU meter circuit first takes in audio signal voltage which we get from an audio source by using a spliced 3.5 mm auxiliary cable (Appendix A Item #17). Then, the audio signal voltage is sent through a non-inverting op amp to amplify the signal, and we use (1) to determine by how much we amplify the signal. For example, in (2), we use the values from Fig. 1 to determine the gain ratio used to amplify the input audio signal voltage. We use the µA741 op amp (Appendix A Item #2) in this circuit, and the pin layout of the op amp is shown in Fig. 2.

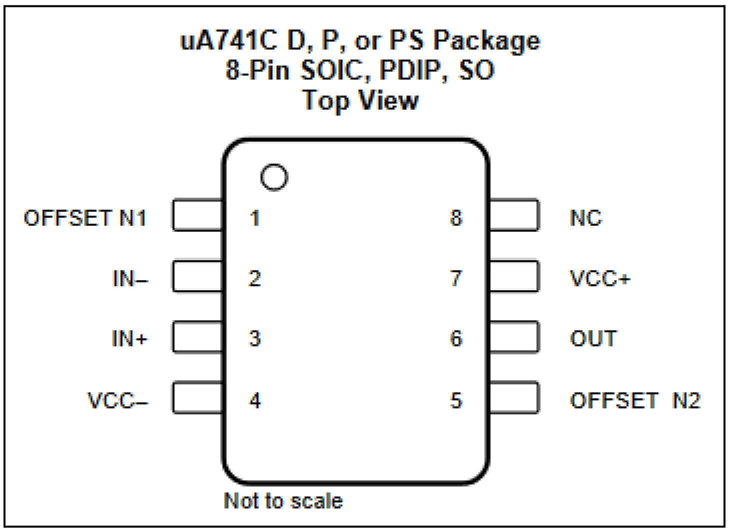

Fig. 2: µA741 op amp pin layout provided in [2].

$$VOUT = VIN \times \left(\frac{RF}{R1} + 1\right) \tag{1}$$

$$amp\_audio\_sig = audio\_sig \times \left(\frac{10\ K\Omega}{100\ \Omega} + 1\right) = audio\_sig \times 101 \tag{2}$$

After going through the non-inverting op amp, the amplified audio signal goes through a 1N4007 diode (Appendix A Item #3) partnered with a 1 µF electrolytic capacitor (Appendix A Item #11) and 100 kΩ resistor (Appendix A Item #8) in parallel with each other. All together, these three components act as a filter and the diode specifically helps convert the audio signal alternating current to direct current. The filtered audio signal voltage then goes into the LM3915 IC (Appendix A Item #1) which executes the majority of the work for this circuit. The LM3915 uses its internal voltage division to create a logarithmic 3 dB/step analog display with the 10 LEDs.

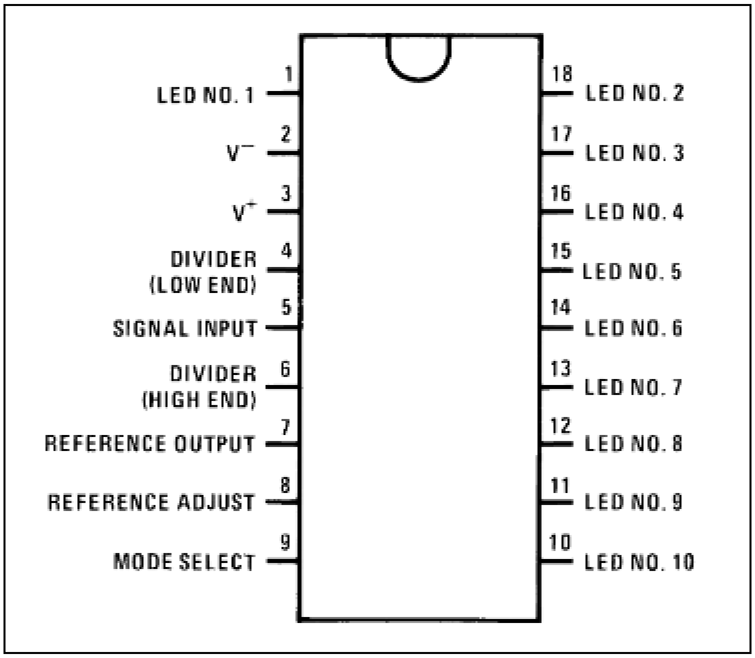

Fig. 3: LM3915 IC pin layout provided in [3].

The LM3915 has several adjustable characteristics such as bar/dot mode and an adjustable sensitivity. Bar/dot mode affects the LED display, where bar mode turns on all the lights below, up to, and including the light that the signal voltage corresponds to, while dot mode turns on only the light that the signal voltage corresponds to. In Fig. 1, we have the bar/dot pin, which is pin 9 shown in Fig. 3, of the LM3915 connected to power, which puts the chip in bar mode. If the bar/dot pin were connected to ground, the chip would be in dot mode.

The second LM3915 adjustable characteristic we are using is the adjustable sensitivity. By connecting pin 8, the reference adjust pin as shown in Fig. 3, to a resistor or potentiometer, we can adjust the sensitivity of the LM3915's internal voltage divider. In Fig. 1, we have only a single resistor connected to the "Adj" pin, but when we build the circuit, we use a 50 kΩ potentiometer (Appendix A Item #9) to enable more adjustability of the circuit when it is in use. Increasing the resistance connected to this pin increases the amount of voltage needed to turn on each LED, whereas decreasing the resistance decreases the amount of voltage needed to turn on each LED.

Simulation Description and Results

Simulation Schematic

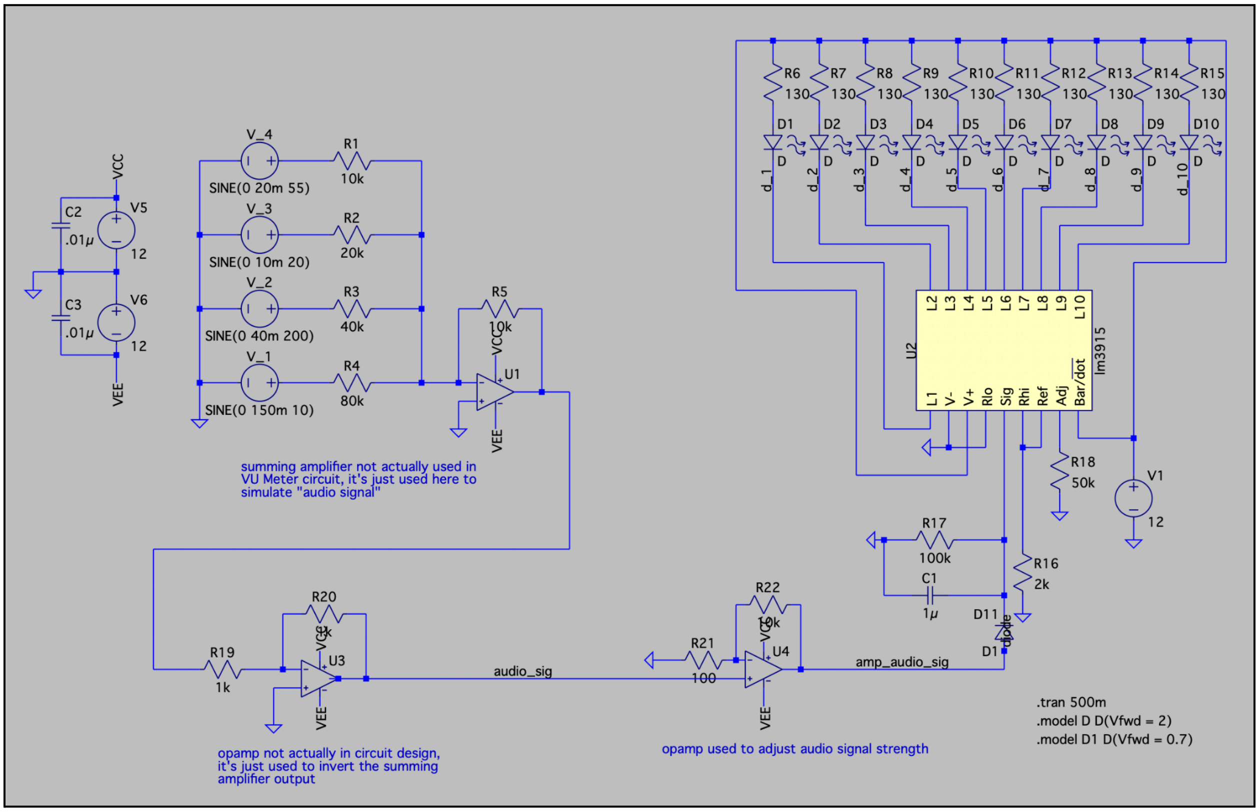

Fig. 4: LTspice schematic for our VU meter circuit design.

The schematic in Fig. 4 shows how our VU Meter circuit is built with some additions to help the simulation. The summing amplifier (Fig. 4 U1) and inverting amplifier (Fig. 4 U3) are not part of the physical circuit build, but they are included in the schematic to create a fake “audio signal” input. The summing amplifier allows us to add different voltage inputs to create an alternating voltage to simulate “audio input,” and then the inverting amplifier inverts the output of the summing amplifier so we have the intended magnitude of the voltage input.

The non-inverting op amp (Fig. 4 U4) is part of the circuit build and it is included to amplify the “audio signal” input voltage. The diode (Fig. 4 D1), capacitor (Fig. 4 C1), and resistor (Fig. 4 R17) act together as a filter to smooth out the “audio signal” going into the LM3915 (Fig. 5 U2).

The LM3915 is our IC chip and the most integral part of the circuit build. It executes most of the functionality of our VU Meter by using its internal 10-step voltage divider to detect how much signal voltage is coming in. Then, it provides a logarithmic 3 dB/step analog display with the 10 LEDs, turning the LEDs on in a logarithmic pattern in increasing order.

As mentioned in Circuit Theory, the LM3915 has two adjustable characteristics that we use. First, the LM3915 has bar/dot mode which we have set to bar mode in the simulation by connecting that pin to power so all of the lights below, up to, and including the level of signal voltage detected stay on. Second, the LM3915 has adjustable sensitivity to the input voltage which affects how many LEDs turn on with the same amount of input voltage. We explore how changing the resistance connected to the "Adj" pin of the LM3915 affects the LEDs later in this section under Simulation Results.

Simulation Results

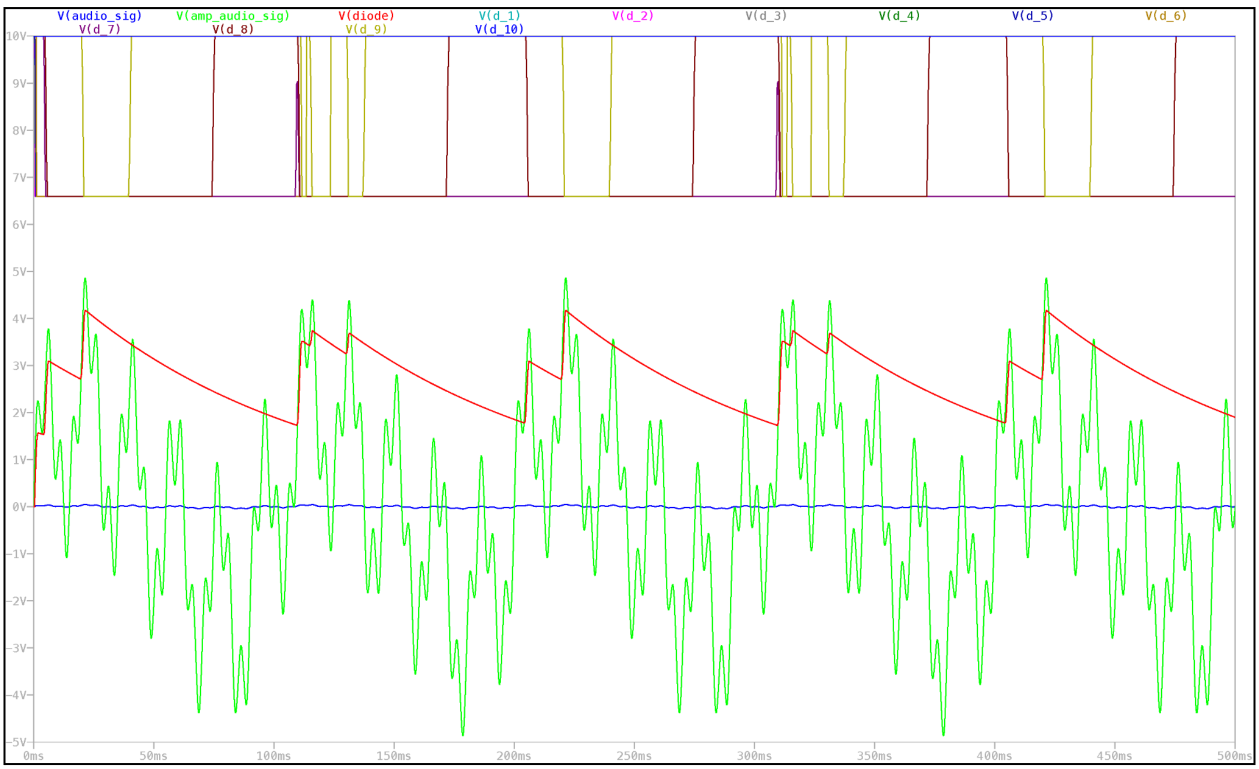

Fig. 5: LTspice simulation results showing the input "audio signal" voltage (V(audio_sig)), the amplified "audio signal" voltage (V(amp_audio_sig)), the filtered "audio signal" (V(diode)), and each of the 10 LEDs (V(d_1) - V(d_10)) being activated.

In Fig. 5, the blue line at the bottom, V(audio_sig), is the input "audio signal." The green line at the bottom, V(amp_audio_sig), is the amplified input "audio signal" after going through the non-inverting op amp. The red line in the middle, V(diode), is the filtered "audio signal.. The 10 lines at the top, V(d_1) through V(d_10), are the voltages that make it through the LEDs which drop when the LEDs turn on.

Fig. 6: LTspice simulation results showing each of the 10 LEDs (V(d_1) - V(d_10)) being activated the same way as in Fig. 5.

In Fig. 6, each of the 10 LEDs' voltages are shown in separate panes to better display the different activations of the increasing LEDs. LEDs d_1 through d_6 stay on for the length of the simulation, d_7 stays on for the majority of the simulation with short periods of being off, d_8 and d_9 turn on less frequently, and lastly d_10 does not turn on at any point during the simulation. The non-linear pattern to how much each of the increasing LEDs turns on is due to the LM3915's internal voltage divider which provides a logarithmic 3 dB/step analog display.

To demonstrate how adjusting the resistance at the "Adj" input of the LM3915 in Fig. 4 affects how many LEDs turn on for the same amount of input "audio signal" voltage, the following Fig. 7 is simulated with the "Adj" resistance set to 25 kΩ and Fig. 8 is simulated with the "Adj" resistance set to 75 kΩ as compared to the initial 50 kΩ in Fig. 5 and 6.

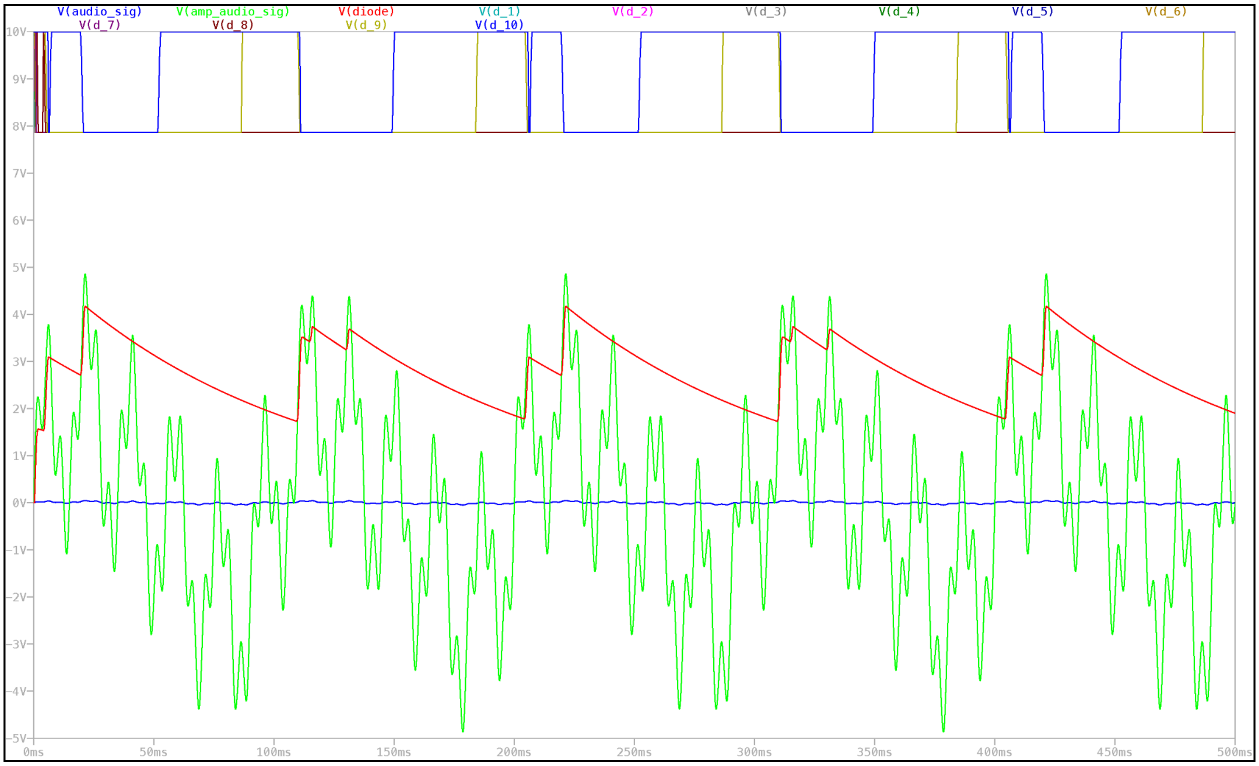

Fig. 7: LTspice simulation with “Adj” resistance of 25 kΩ.

As seen in Fig. 7, when the “Adj” resistance is decreased from 50 kΩ to 25 kΩ, more of the LEDs turn on with the same amount of input “audio signal” voltage as compared to the initial simulation in Fig. 5. In Fig. 7, all 10 LEDs turn on at some point, whereas in Fig. 5 and 6, LED d_10 never turns on. It is also notable that the drop in voltage when the LEDs are turned on is decreased.

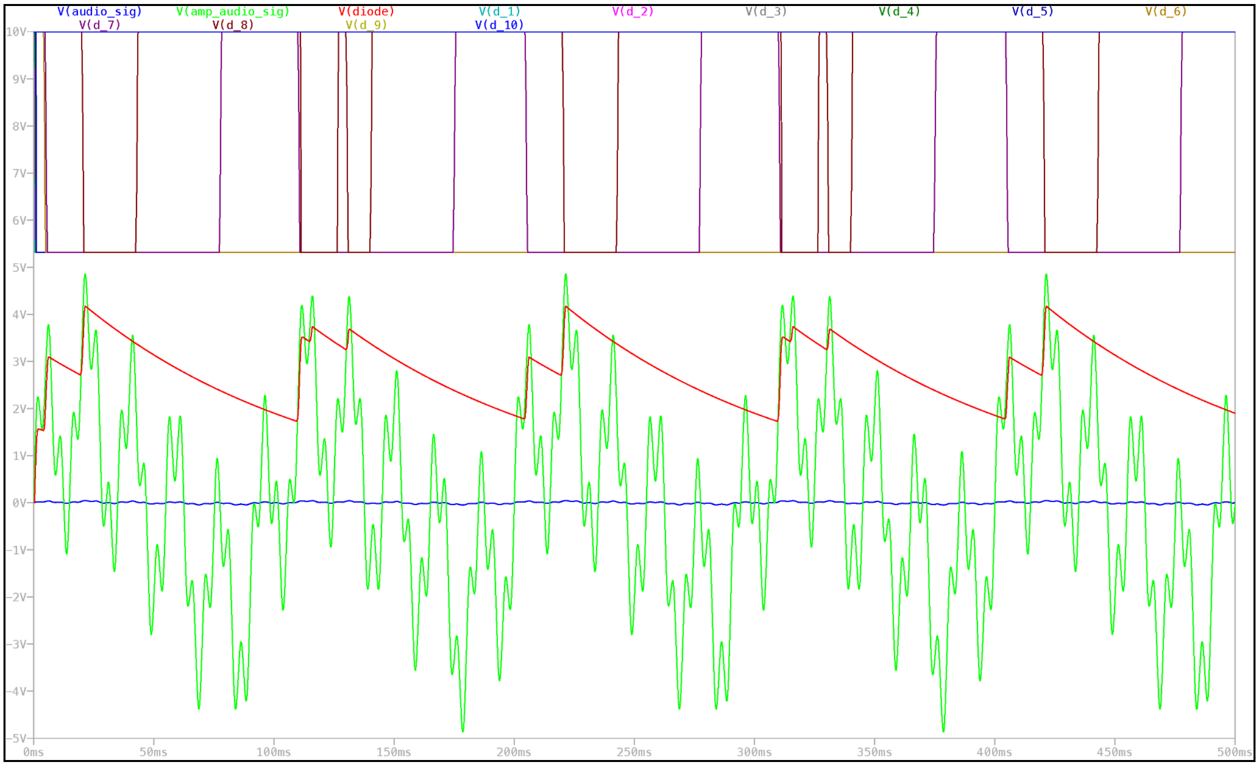

Fig. 8: LTspice simulation with “Adj” resistance of 75 kΩ.

As seen in Fig. 8, when the “Adj” resistance is increased from 50 kΩ to 75 kΩ, less of the LEDs turn on with the same amount of input “audio signal” voltage as compared to the initial simulation in Fig. 5. In Fig. 8, the first 8 LEDs turn on at some point, whereas in Fig. 5 and 6, the first 9 LEDs turn on. It is also notable that the drop in voltage when the LEDs are turned on is increased.

Circuit Theory and Simulation Alignment

Most of our circuit theory and simulation results align. We did not change much between the basic build and functionality of the circuit shown in each section, so for the most part, the two sections are similar. For example, the main thing that aligns between the circuit theory and the simulation results is showing how the non-inverting op amp amplifies the input audio signal. In Circuit Theory, (1) and (2) are the equations we used to calculate the amplified signal, and in Simulation Description and Results, the amplification can be seen in Fig. 5, 7, and 8 where the blue lines are the initial “audio signal” voltage, and the green lines are the amplified “audio signal.”

Another thing that aligns between the two sections is how the adjustable sensitivity affects the output of the LM3915. As seen in Fig. 5, 7, and 8, the number of LEDs turning on changes with the adjustable resistance being changed. As the adjustable resistance increases, the LM3915’s sensitivity to the signal decreases, causing the number of LEDs being turned on with the same amount of “audio signal” voltage to decrease. Then, as the adjustable resistance decreases, the LM3915’s sensitivity to the signal increases, causing the number of LEDs being turned on with the same amount of “audio signal” voltage to increase.

Simulation Challenges

One of the biggest challenges we encountered when creating our LTspice schematic was figuring out how to include the LM3915 IC chip since it was not in the basic library. We ended up finding an online forum [4] where people were talking about creating their own LTspice LM3915 component, and that website is where we got the files to import the chip component. We followed a YouTube video [5] on how to create elements from imported files to successfully add it to our schematic.

Another more minor challenge we faced when creating our project simulation was deciding how to simulate audio signal input. Instead of using a singular sinusoidal voltage input, we utilized a summing amplifier as seen in Fig. 4 so we could add multiple sinusoidal voltages together to create a signal that looked more similar to real audio signals with inconsistent jumps and dips.

Experimental Results

Estimated Results

Going into the process of building and testing our VU Meter, we assumed we would be able to easily produce similar results compared to [1] which inspired us to make this circuit in the first place. We thought we would get the audio signal from an audio source using an auxiliary cable, connect the cable to the LM3915 input pin, and the chip would do the hard work of making the LEDs light up for the different volume levels. Initially, we believed that we would not need the op amp but would include it anyways to satisfy all the requirements for this project. From having completed this project now, we know that we did indeed need the op amp to amplify our audio signal because the audio signal coming from the audio source is too low for the LM3915 to detect with the adjustments we have included in our circuit build.

Experiment Setup

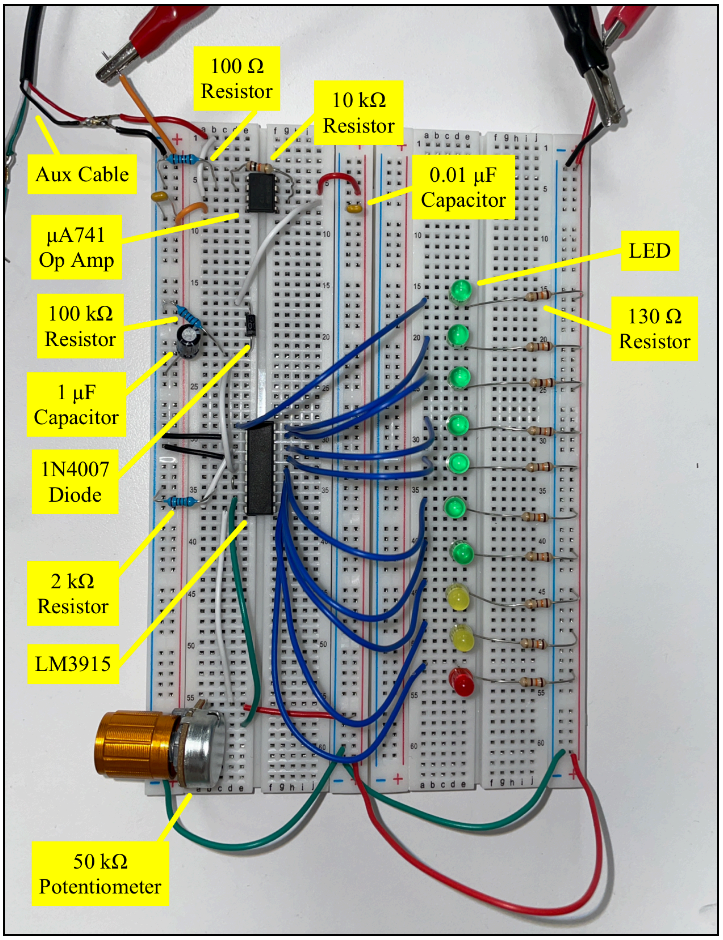

Fig. 9: Labeled VU Meter circuit build.

Fig. 9 shows our physical VU meter circuit build based on the circuit schematic in Fig. 1. The biggest difference between the schematic and our physical build is that the 50 kΩ resistor connected to pin 8 of the LM3915 shown in Fig. 1 is instead a 50 kΩ potentiometer shown in Fig. 9. Using the potentiometer instead of the resistor allows us to have more adjustability in our circuit execution and display.

The first left red rail is connected to -12 V from the power supply. The first right red rail is connected to +12 V from the same power supply, and this voltage is connected to the second left red rail as well. Our first left blue rail, second left blue rail, and first right blue rail are all connected to ground.

The audio input comes from the spliced auxiliary cable shown in the top left of Fig. 9, with the red wire going into the top left terminal strip and the black wire connecting to the left blue rail which is ground.

The µA741 op amp is used for a non-inverting op amp to amplify the audio signal, the 1N4007 diode is used to filter the amplified audio signal and turn the alternating current into direct current, the LM3915 IC chip is used to drive the 10 LEDs, and the 50 kΩ potentiometer is used to adjust the sensitivity of the LM3915. These significant components are more thoroughly described in the previous Circuit Theory section.

Experimental Results

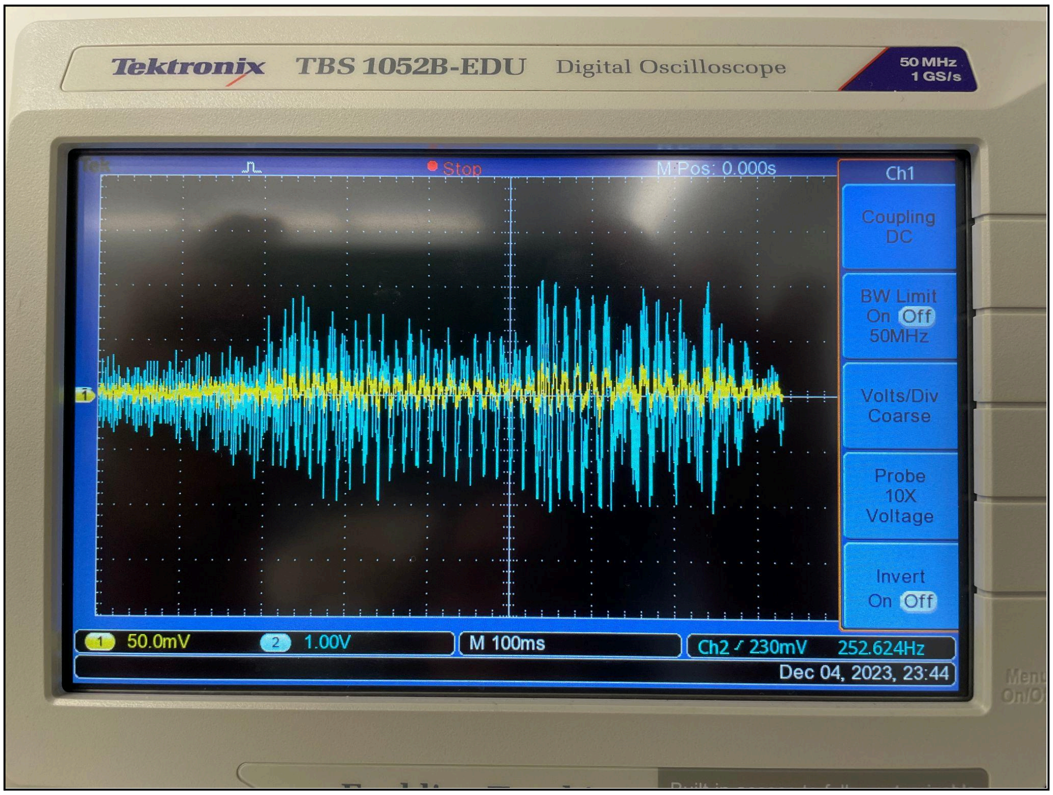

Fig. 10: Oscilloscope image of input audio signal voltage (channel 1, yellow) and amplified audio signal voltage from the non-inverting op amp output (channel 2, blue).

Fig. 10 shows the audio signal before and after going through the non-inverting op amp, visualizing how the audio signal is amplified. The yellow line, channel 1, is the input audio signal coming from the audio source, and the blue line, channel 2, is the amplified audio signal coming out of the non-inverting op amp. As shown in (2), the audio signal is amplified by 101 times. Throughout our experimental process, we spent a good bit of time attempting to find the best gain for our non-inverting op amp so that our audio signal would be large enough to be detected by the LM3915. It was strenuous, but after troubleshooting this part of the circuit several times, we found an ideal gain value which allowed for satisfactory display output.

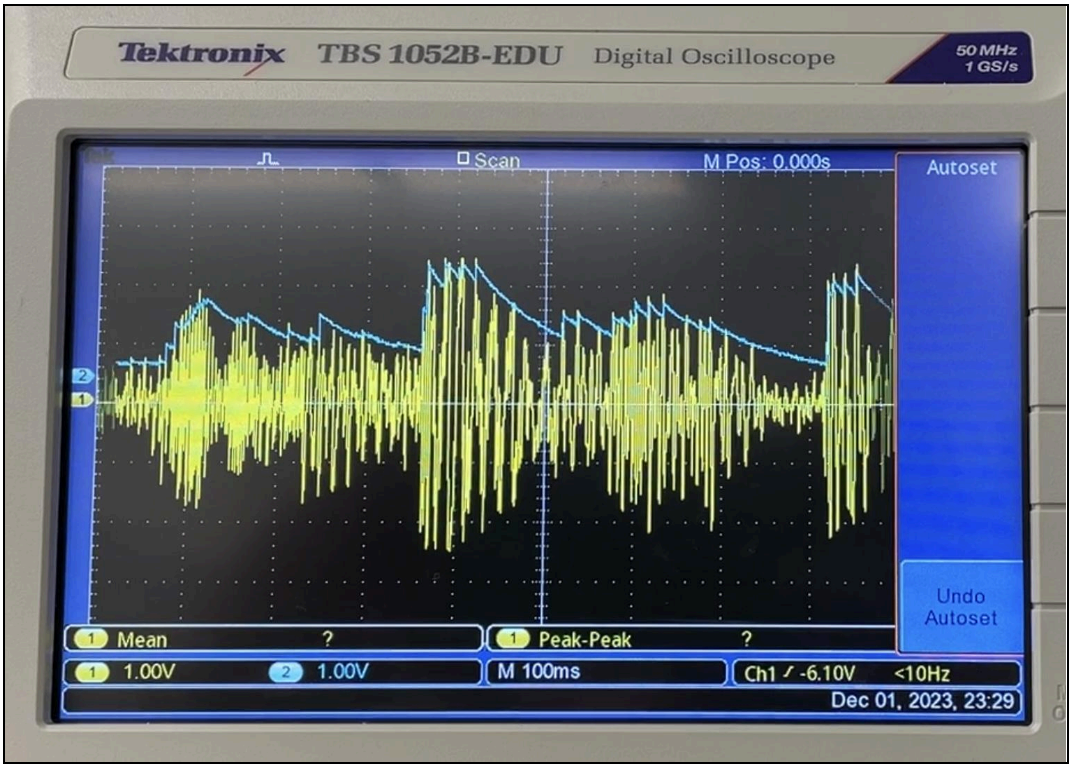

Fig. 11: Oscilloscope image of amplified audio signal voltage from the non-inverting op amp output (channel 1, yellow) and filtered audio signal voltage after the 1N4007 diode (channel 2, blue).

Fig. 11 shows the audio signal after being amplified by the non-inverting op amp and after being filtered by the 1N4007 diode. The yellow line, channel 1, is the amplified audio signal coming out of the non-inverting op amp, and the blue line, channel 2, is the filtered audio signal coming out of the 1N4007 diode. By filtering the audio signal, we get a cleaner overall pattern of the audio signal voltage which then goes into the LM3915.

We initially did not have the 1N4007 diode included in our build, so the amplified audio signal, the yellow line, was going into the LM3915. The high frequency spikes and dips in the signal resulted in the overall pattern change not being apparent with the LEDs. The LEDs displayed roughly the average audio signal level and barely flickered above or below that level. By adding the 1N4007 diode, we were able to convert the amplified audio signal alternating current into direct current which we then sent into the LM3915, allowing us to more accurately display the audio signal levels with the LEDs.

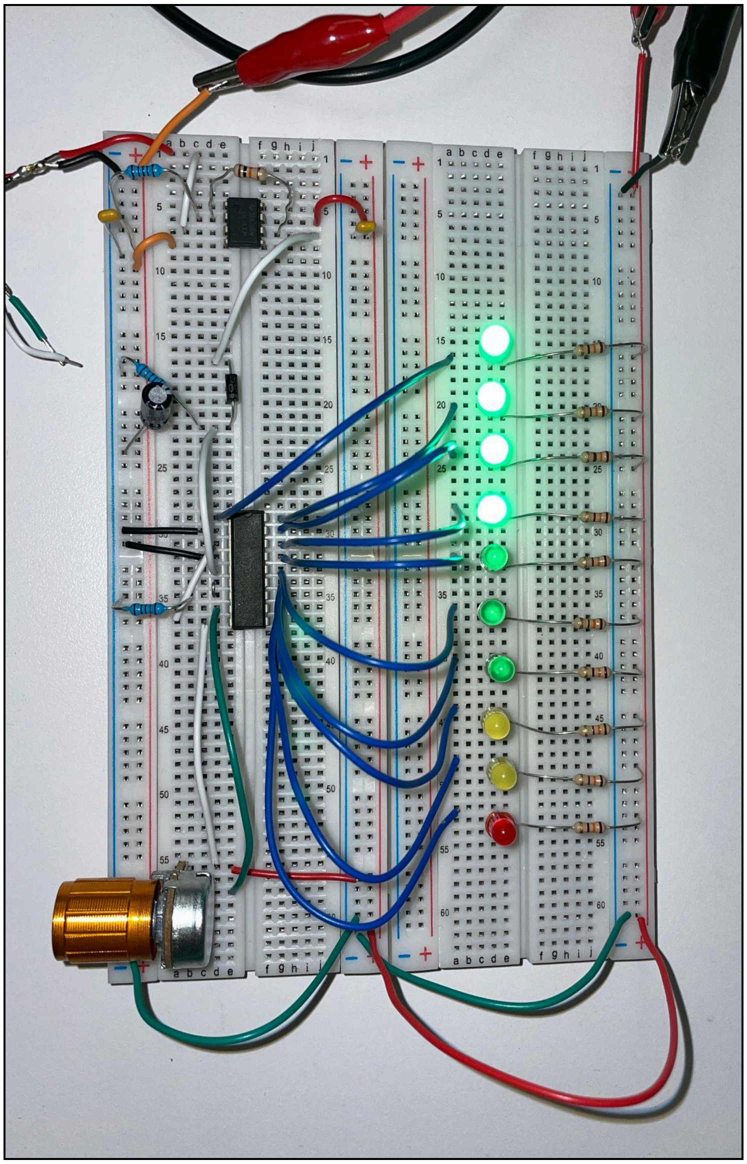

Fig. 12: VU Meter circuit with some LEDs on.

Fig. 12 shows the VU Meter with several of the LEDs turned on. The pattern of the lights turning on successfully reflected the volume of the audio input. Video demonstrations of the circuit's performance are included in Appendix B.

Analysis of Results

Similarities Between Results

Consistently between the circuit theory, simulation results, and experimental results, we used a non-inverting op amp to amplify our audio signal and we also provided our circuit with +/- 12 V from the power supply (Appendix A Item #18). First, using the non-inverting op amp was consistent because we anticipated that our input audio signal voltage would not be high enough to trigger the LM3915 with the settings and other components we were using, so we implemented the non-inverting op amp in our plans, simulations, and experiments. Second, using +/- 12 V was consistent because we planned to use that amount of voltage from the beginning due to needing that amount for the op amp and [3] specifying that the LM3915 functions well with 12 V, so all of our plans worked together perfectly.

Our VU Meter circuit execution and behavior was also consistent throughout the process of this project. The circuit experimentally functioned and simulated how we expected it to in the circuit theory which was based on our inspiration [1]. We would like to think that the consistency in our circuit theory, simulations, and experimental performance are due to us being capable engineers at following directions accurately, planning effectively, and testing our circuit adequately.

Differences Between Results

The biggest difference between our simulation and our circuit theory and experiment is that we included a summing amplifier and inverting op amp in our simulation. The circuit theory was created with the idea that we would input a real audio signal into our circuit, and we were able to do so in our experiment using an auxiliary cable. In order to simulate our circuit with an audio signal, we created a quasi-audio signal using the summing amplifier and inverting op amp. The summing amplifier was used to combine different sinusoidal voltage sources, and the inverting op amp was used to invert the input audio signal so it accurately reflected the magnitudes we desired.

Another difference we had was that we used the generic diode component in our simulation whereas we used the 1N4007 diode in our circuit theory and experiment. We chose to use the generic diode in the simulation because the 1N4007 diode was not included in the base LTspice library, and we figured that a slightly different diode would not affect our outcomes too significantly. This difference did not appear to affect our simulation and experimental results.

The last main difference we found between our simulation results and our experimental results was that in the simulation, as we increased the LM3915 pin 9 resistance, the LM3915's sensitivity to the audio signal decreased, turning on less LEDs with the same amount of input voltage, whereas in the experiment, when we turned the potentiometer knob clockwise, the sensitivity to the audio signal increased, turning on more LEDs with the same amount of input voltage. We believe this difference could be because we wired the potentiometer backwards from what we expected. Wiring it backwards technically does not affect the circuit, but doing so makes the adjustable aspect of the LM3915 function backwards from how we simulated it.

What We Learned

We learned a handful of skills while working on this project. First, we learned how to import and create a new component into LTspice when we had to do so to get the LM3915 into our schematic for simulation. Second, we learned how to connect the LM3915 and adjust it to fit our desired outcomes. We have not used this chip before in class, so it was interesting learning how to use it for our project. Third, we learned how to more specifically troubleshoot our circuit using the oscilloscope. We used the oscilloscope to test each part of our circuit to see if it worked independently before connecting it to the rest of the circuit. This technique was very helpful and helped us pinpoint where our issues were so we could tackle them more easily and quickly.

Last and potentially most important, we learned that something will always go wrong especially when you need everything to go right, so it pays off to have backup plans and components. On the day of our circuit demonstration, our VU Meter stopped working after functioning perfectly the day before. We put our new troubleshooting skills to work and determined that our auxiliary cable was not outputting the audio signal correctly from the audio source and that our op amp seemed to have broken. Luckily, there was a spare auxiliary cable in the lab and we had a backup opamp. After replacing both components, our VU Meter functioned great once again and we successfully demonstrated it.

Future Work

If we were to continue working with this project, we have two main tasks we would want to complete. First, we sometimes had this issue where initially our non-inverting op amp would not work until we changed it to an inverting op amp and then changed it back. We are not sure why this fix worked to make our op amp eventually function properly, but we would find it much more ideal if the non-inverting op amp worked as intended on the first try every time. The second task we would want to complete is figuring out how we could output the audio from the same audio source outloud and into the circuit simultaneously. We had attempted using a cheap auxiliary splitter, but the splitter created a ton of noise and made the audio signal indistinguishable. For demonstration, we played audio from two separate audio sources simultaneously with one source connecting to the circuit and the other source playing the audio out loud.

Conclusion

Our final project was the VU Meter. Throughout this report, we introduced the VU Meter, planned out the circuit design and explained how it worked in Circuit Theory, simulated the circuit and interpreted the simulation results in Simulation Description and Results, described the process of building and troubleshooting the circuit and explored the functionality of the circuit in

Experimental Results, and compared and contrasted the circuit theory, simulation results, and experimental results in Analysis of Results. We were successful in creating the VU Meter, and despite a couple of differences between theory, simulation, and experiment, our results of representing the input audio levels via 10 LEDs were as expected. We learned a lot throughout the process of completing this project with the biggest lesson being always have a backup plan because something will always go wrong especially when you need everything to go right. Alongside learning, we genuinely enjoyed creating the VU Meter, and we hope future students find this project interesting and inspiring to continue down the path of becoming an engineer.

References

[1] Electronics Projects Stefano91ste. *Vu-Meter 21 LED (Mirror Effect) with LM3915*. (Oct 20, 2018). Accessed: Dec. 4, 2023. [Online Video]. Available: https://www.youtube.com/watch?v=porxXiQf7wg&list=PLrB00mZhT3Nke4F9DWDZTUYDZOcf3rLqf&index=3&t=69s

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Appendix A

Bill of Materials

Item #	Part Name	Part Number	Description	Quantity
1	LM3915 Dot/Bar Display Driver	LM3915N-1	Texas Instruments monolithic integrated circuit that senses analog voltage levels and drives ten LEDs	1
2	µA741 Operational Amplifier	UA741CP	Texas Instruments general-purpose operational amplifier	1
3	1N4007 Diode	1N4007	Rectifier diode, used to convert alternating current to direct current	1
4	100 Ω Resistor	OX101KE	100 Ohm Resistor	1
5	130 Ω Resistor	CFM12JT130R	130 Ohm Resistor	10
6	2 kΩ Resistor	CF18JT2K00	2k Ohm Resistor	1
7	10 kΩ Resistor	CF14JT10K0	10k Ohm Resistor	1
8	100 kΩ Resistor	CF14JT100K	100k Ohm Resistor	1
9	50 kΩ Potentiometer	P160KN2-0EC 15B50K	50k Ohm Linear Rotary Potentiometer	1
10	0.01 µF Capacitor	VY2103M63Y 5US6UV7	0.01 µF Ceramic Capacitor	2
11	1 µF 50V Electrolytic Capacitor	ESS105M050A B2EA	1 µF 50 V Aluminum Electrolytic Capacitor	1
12	Green LED	XLUG12D	Green LED Indication - Discrete T/H	7
13	Yellow LED	XLUY12D	Yellow LED Indication - Discrete T/H	2
14	Red LED	XLUR12D	Red LED Indication - Discrete T/H	1
15	Breadboard	N/A	Construction base for circuit build	2
16	Wires	N/A	N/A	As Needed
17	3.5 mm Auxiliary Cable	N/A	Used to input audio signal from audio source to circuit	1
18	Power Supply	N/A	Provided +/- 12 V to circuit	1

Appendix B

Demo Videos

Link to folder with demo videos: Demo Videos

Appendix C

Quad Chart

ECE 304 – Fall 2023 : VU Meter
Sam Asebrook, Claire Hopfensperger

Circuit Selection

- Circuit Function: Our circuit is a Volume Unit (VU) Meter, and it measures and displays the audio signal level present in a system.
- Circuit Elements:
  - Op Amp (μA741)
  - Integrated Circuit Chip (LM3915)
  - Resistors (100 Ω, 120 Ω, 1 kΩ, 2.2 kΩ, 10 kΩ, 100 kΩ)
  - Potentiometer (47 kΩ)
  - Diodes (LEDs)
- Time to Build: We estimate the total build time will be roughly a half hour. Our goal is to be able to build the circuit in a timely manner in order to have adequate time for troubleshooting and possible improvements.
- Simulation: We will use LTspice for the schematic and simulation of our circuit.

Schematic

- Main Circuit Operation: The circuit takes in audio signal voltage and sends it through an op amp to adjust the max voltage which goes into the LM3915. The LM3915 uses its internal 10-step voltage divider to detect how much signal voltage is coming in and determines which LEDs to turn on based on that. We will have the LM3915 in bar mode so the lights below, up to, and including the level of signal voltage detected stay on. If the LM3915 were in dot mode, then only the corresponding light to the signal voltage level would be on.
- Main Elements and Functions:
  - Op amp adjusts max voltage going into LM3915
  - LM3915 senses analog voltage levels and drives ten LEDs, providing a logarithmic 3 dB/step analog display
  - LEDs provide visual output representing level of audio voltage
  - Potentiometer adjusts sensitivity of LM3915
- Schematic on Separate Page
  - NOTE: summing amp in schematic is only used to simulate “audio signal”, it will not be used in actual circuit

Motivation for selecting the circuit

- Why We Find the Circuit Interesting: The circuit provides a visual representation of audio levels, plus lights are neat!
- Targeted Age Group: People of all ages would find this circuit interesting because the lights are entertaining, and so is sound, and it is hard to visualize what sound really is. Circuits like the VU Meter provide an easy way to experience sound with more than just your ears.
- Why Future Students Would Find the Circuit Interesting: In ECE304, we discuss a lot about signals, and how there are many different ways to both analyze and utilize them. Audio is a very interesting signal that can be much more easily digested with a visual aid, and circuits like the VU Meter help create that connection. Also, creating a project such as the VU Meter shows

Course objectives / ABET outcomes

- ECE 304 Course Objectives Our Circuit Meets and How It Does So:
  - Have a good understanding of the basic electronic devices and circuits as well as the principles and methods used for electronic circuit analysis.
    - In order to build our circuit in the first place, we must understand how the different circuit components we are using operate. We learned about op amps and diodes in class, so we have the knowledge to properly understand and integrate them into our circuit. Then, to analyze how our circuit works, we will use skills learned in this class to do so, such as simulating our circuit using

other students that cool projects are achievable to make.	LTspice and using other skills we practiced in the lab. o Be able to analyze and solve practical problems about electronic circuits with a degree of difficulty comparable to the materials covered. ▪ Since our circuit uses an IC chip not covered in this class, we will use the knowledge we gained in this class to analyze our circuit and apply problem-solving skills if we run into issues. o Be able to design electronic circuits to amplify a current or a voltage with proper frequency response using op amps and transistors. ▪ We plan to amplify our input audio signal voltage using an opamp. ● <u>ABET Learning Outcomes Our Circuit Addresses and How It Does So:</u> o An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives. ▪ Sam and Claire are effectively working together as a team to work toward and achieve the goal of creating the VU Meter. Together, they are planning out the steps to achieve this goal and taking the actions to do so. o An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions. ▪ This entire project process includes all of the steps of creating and executing an experiment, analyzing the circuit, and interpreting the outcome to then adjust to make the circuit better or conclude on our experimentation. o An ability to acquire and apply new knowledge as needed, using appropriate learning strategies. ▪ Since we are using an IC chip (LM3915) we haven't used before, we've had to research and learn about the function and implementation of it in order to be prepared to use it in our circuit.

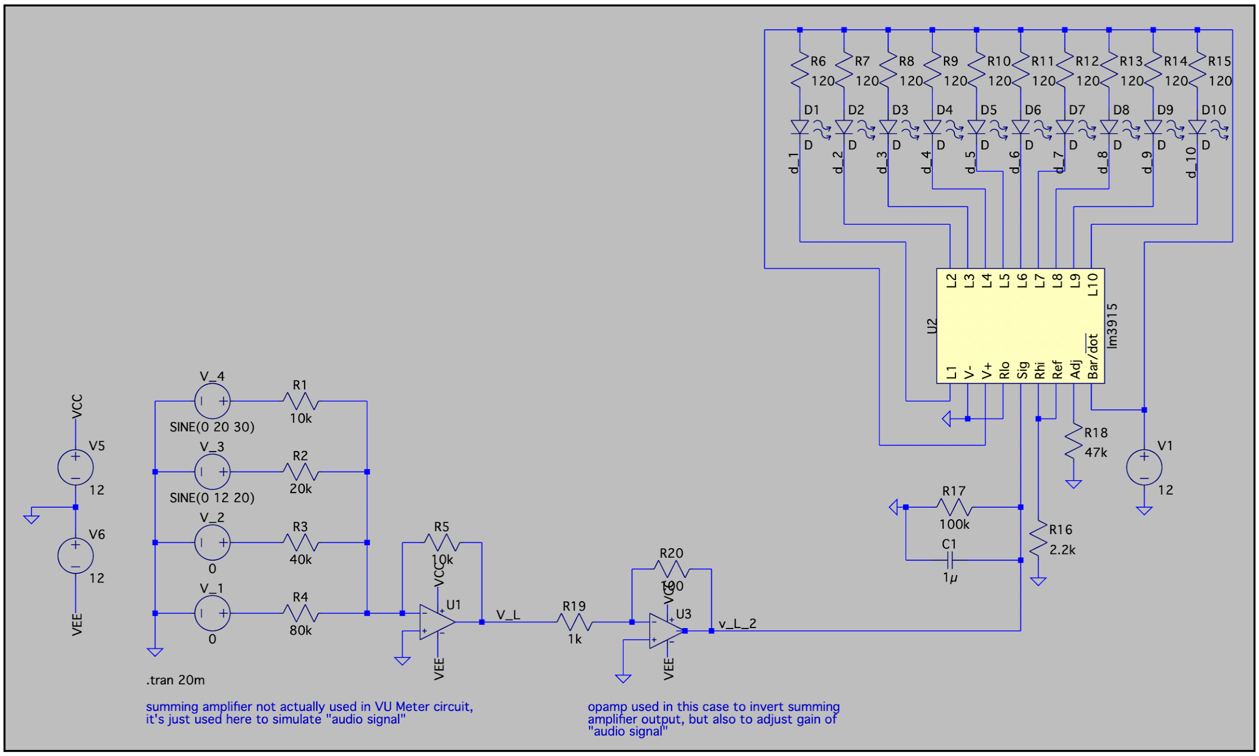

Fig. 1: LTspice schematic for our VU Meter circuit.

Appendix D

Simulation Model

Link to folder with simulation file and additional component files: LTspice Google Drive Folder