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Real Time Audio Spectrum Analyser

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Abstract

In this report there is a detailed description of how to build an analog audio spectrum analyser which can visualize the frequency components of an input audio signal . Leveraging analog electronics, signal processing, and visualization techniques, the spectrum analyzer provides a graphical representation of the audio spectrum. The report contains all the implementation details including functional block diagrams, PCB design, enclosure design and discusses the results obtained through the final product.

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1 Introduction and Functionality

The analog audio spectrum analyzer functions as a crucial tool for real-time analysis of audio signals, offering a comprehensive understanding of their frequency distribution. The system first captures the input audio signal and then utilizes a series of bandpass filters to isolate specific frequency bands. These filtered signals are subsequently rectified to obtain their amplitudes, which are then graphically displayed on the output spectrum. The resulting visual representation provides an intuitive depiction of the varying intensities of different frequency components within the audio signal. Users can readily identify and analyze the dominant frequencies, harmonics, and overall spectral characteristics. This functionality proves invaluable in tasks such as identifying unwanted noise, equalizing audio signals, and gaining insights into the frequency composition of musical or voice recordings. The analog nature of the spectrum analyzer emphasizes its practical application in scenarios where real-time, hands-on frequency analysis is essential for audio engineering, music production, and related fields.

1.1 Basic Block Diagram

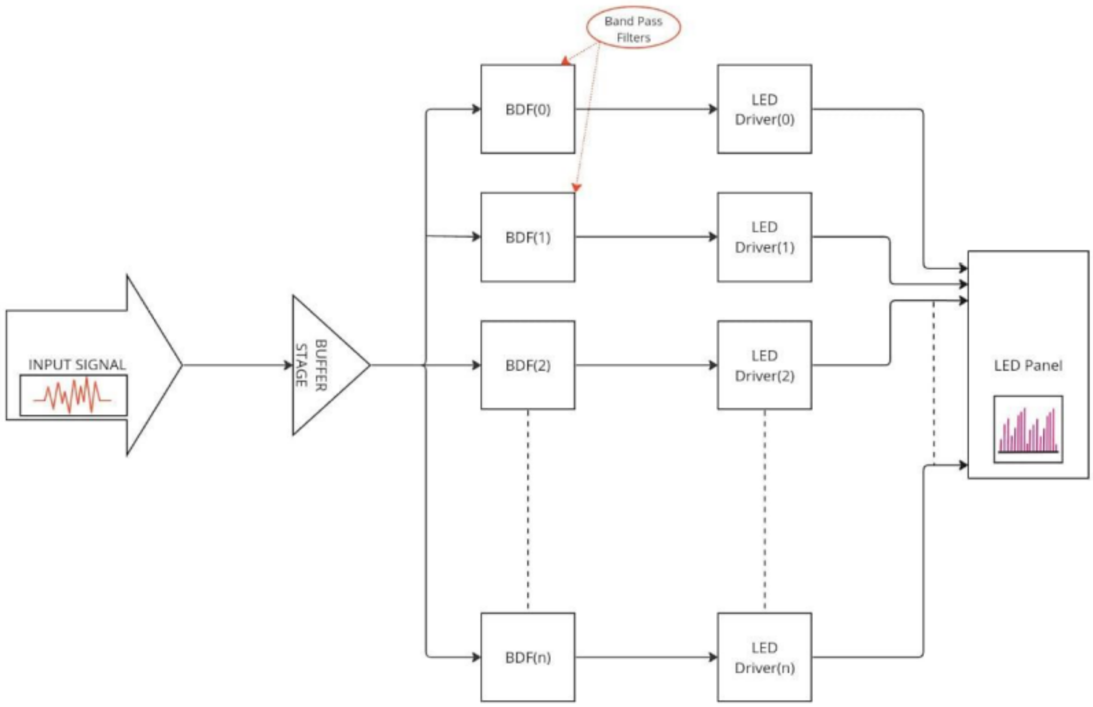


Figure 1: Block Diagram

1.2 Functionality

The functionality of the spectrum analyzer revolves around the analysis of the amplitude distribution across different frequency bands within the audio spectrum.

1.2.1 Signal Input

The spectrum analyzer begins by taking an input audio signal, typically from a microphone, audio source, or other input devices. In our design we are using a 3.5mm AUX port where we can get the input signal through an AUX cable.

1.2.2 Signal Conditioning

The incoming audio signal may be conditioned and pre-processed to ensure it meets the requirements of the spectrum analyzer circuit. This could involve amplification, filtering, or other adjustments depending on the specific design.

1.2.3 Frequency Analysis

The core functionality involves breaking down the audio signal into its frequency components. This is achieved through a series of filters or a Fast Fourier Transform (FFT) algorithm. Each frequency band is analyzed independently to determine its amplitude.

1.2.4 Amplitude Display

The amplitudes of different frequency bands are then displayed on a visual output, often in the form of a bar graph or a series of dots on an LED display. Each bar or dot represents the amplitude of a specific frequency band.

1.2.5 Spectrum Visualization

The displayed spectrum provides a visual representation of how the input audio signal is distributed across the frequency range. Higher bars or brighter dots indicate higher amplitudes, giving the user a quick overview of the dominant frequencies in the audio signal.

1.2.6 Real-Time Monitoring

The spectrum analyzer operates in real-time, continuously updating the display as the input audio signal changes. This real-time monitoring is crucial for observing dynamic changes in the audio spectrum, such as during music playback or live performances.

1.2.7 Applications

Analog audio spectrum analyzers find applications in various fields, including audio engineering, music production, and sound system optimization. Engineers and musicians use them to identify frequency imbalances, detect unwanted noise, and fine-tune audio systems for optimal performance.

1.2.8 User Interface

Many spectrum analyzers feature user-adjustable settings, such as the scale of the frequency axis, sensitivity, or the type of display (e.g., logarithmic or linear). These settings allow users to tailor the display to their specific needs.

2 Component Selection

2.1 Main Components Used

- NE5532p(Opamp) - Buffer
- TL072cp(Opamp) - Filters
- LM3914N - Dot Bar LED Display Driver IC
- Transformer(230V to 30V)
- LM7812ct Voltage Regulator
- 2W10 Bridge Rectifier

2.2 TL072 Opamp

The selection of the TL072 operational amplifier for the buffer circuit in your analog audio spectrum analyzer project is justified for several reasons. The TL072 is known for its low noise, making it suitable for preserving the quality of audio signals crucial in spectrum analysis. With a wide bandwidth and low distortion characteristics, the TL072 can effectively handle a broad range of frequencies, ensuring accurate analysis and visualization of the audio spectrum. Its high input impedance helps prevent loading effects on the preceding stages, maintaining signal integrity. Being a dual op-amp in a single package, the TL072 offers versatility and efficiency, especially if multiple buffer stages or additional signal processing functions are required. Lastly, the TL072 is widely available, making it a convenient choice for sourcing components.

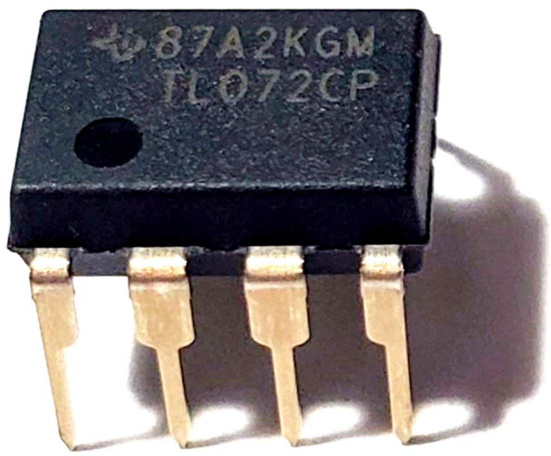


Figure 2: TL072 Opamp

2.3 NE5532 Opamp

The NE5532 is a dual op-amp known for its excellent audio performance, making it a popular choice in audio applications. It offers low noise, which is crucial for maintaining signal clarity in audio circuits, especially in the context of a spectrum analyzer where accurate analysis of frequency components is essential. The NE5532 also provides a wide bandwidth, ensuring effective handling of the audio frequency range. With low distortion characteristics, this op-amp contributes to preserving the fidelity of the filtered signals. Additionally, the NE5532 has a high input impedance, minimizing loading effects on the preceding stages and supporting efficient signal processing.Also the current gain of the opamp is high.

2.4 LM3914N - Dot Bar LED Display Driver IC

Renowned for its ease of use, the LM3914N simplifies the implementation of dot/bar LED displays without the need for complex multiplexing circuits. Its versatility in supporting both dot and bar modes provides flexibility in visualizing audio signal intensity. The linear scaling capability of the LM3914N is crucial for accurately representing signal strength or levels, a vital requirement in spectrum analysis. With a proven track record in audio applications and a minimal external component count, the LM3914N offers a reliable and cost-effective solution. Furthermore, the widespread availability and extensive documentation of the LM3914N facilitate integration into our circuit. Overall, the LM3914N emerges as a fitting choice, meeting the specific needs of our project while providing simplicity, versatility, and performance in visualizing audio signals.

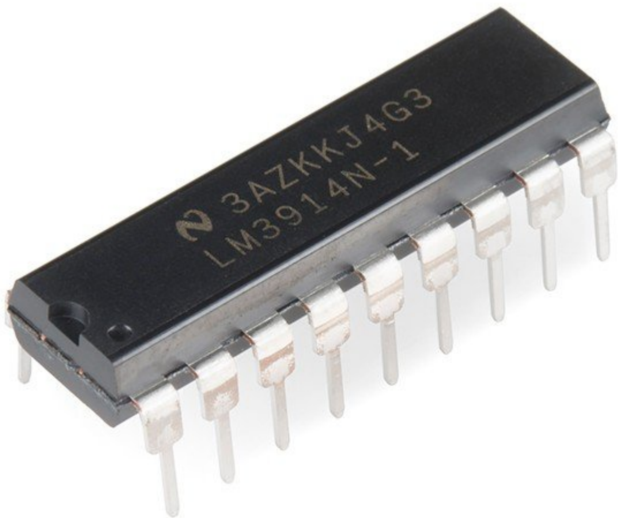


Figure 3: LM3914N

3 PCB Design

In our endeavor to design a robust and cost-effective Printed Circuit Board (PCB) for our project, we have successfully created two distinct PCBs. The first PCB is a dedicated power supply unit, designed to provide stable and reliable power to our system. The second PCB is a multifunctional board that incorporates two filters along with two LED drivers, serving as the backbone of our spectrum analyser.

During the design phase, we encountered a limitation in the availability of low noise Integrated Circuits (ICs). The ICs we sourced were equipped with only two operational amplifiers (op-amps) each. This constraint led us to the innovative solution of integrating only two filters per PCB. While our project required a total of ten filters, manufacturing a single PCB with all ten would have resulted in prohibitive costs. Therefore, we opted for a modular approach, distributing the filters across multiple PCBs to balance functionality with financial viability.

Each PCB is constructed with two layers, a decision driven by the necessity to accommodate several components that could not be efficiently arranged on a single layer. This dual-layer design not only allowed for a more complex circuitry but also enhanced the overall durability of the PCBs.

To further elevate the quality of our PCBs, we made several strategic choices. We replaced standard wire connections with JST connectors, ensuring a more secure and reliable electrical connection. Additionally, we meticulously optimized the PCB layout to minimize its size without compromising on performance or safety standards. This miniaturization effort not only reduced material costs but also paved the way for a more compact and elegant final product.

Our commitment to excellence is reflected in every aspect of the PCB design, from the careful selection of components to the precision of the layout. The result is a pair of high-quality PCBs that promise to be the cornerstone of our project's success.

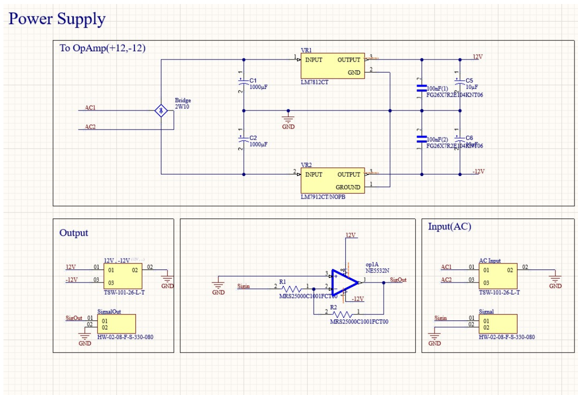


Figure 4:

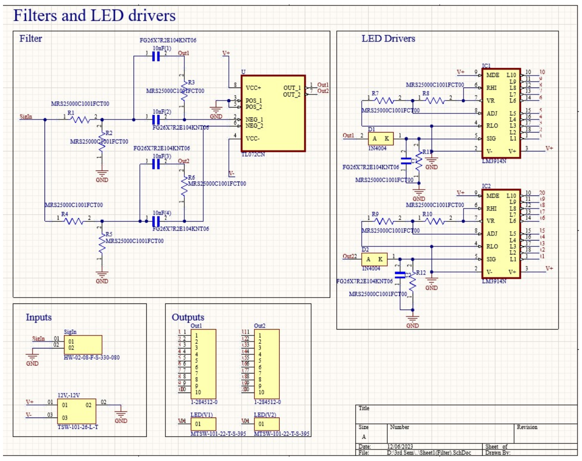
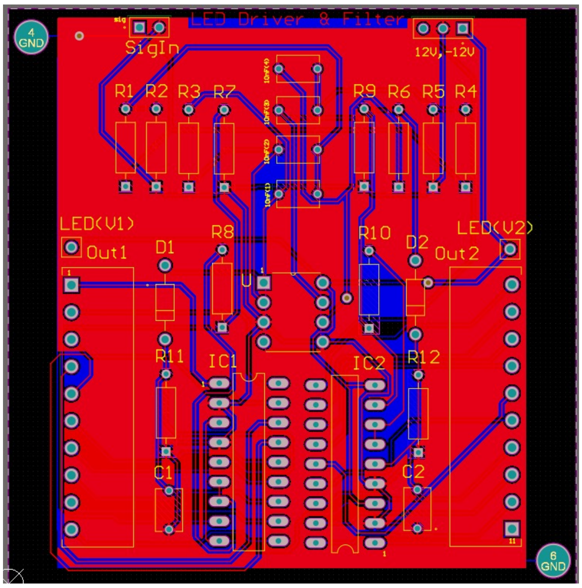


Figure 5:



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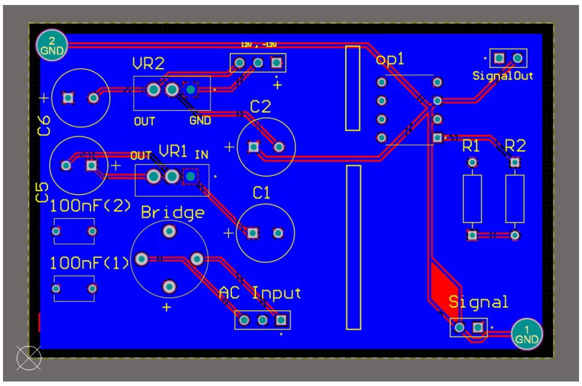

Figure 7:

4 Enclosure Design

The enclosure is basically made up from Acrylic and Wood.

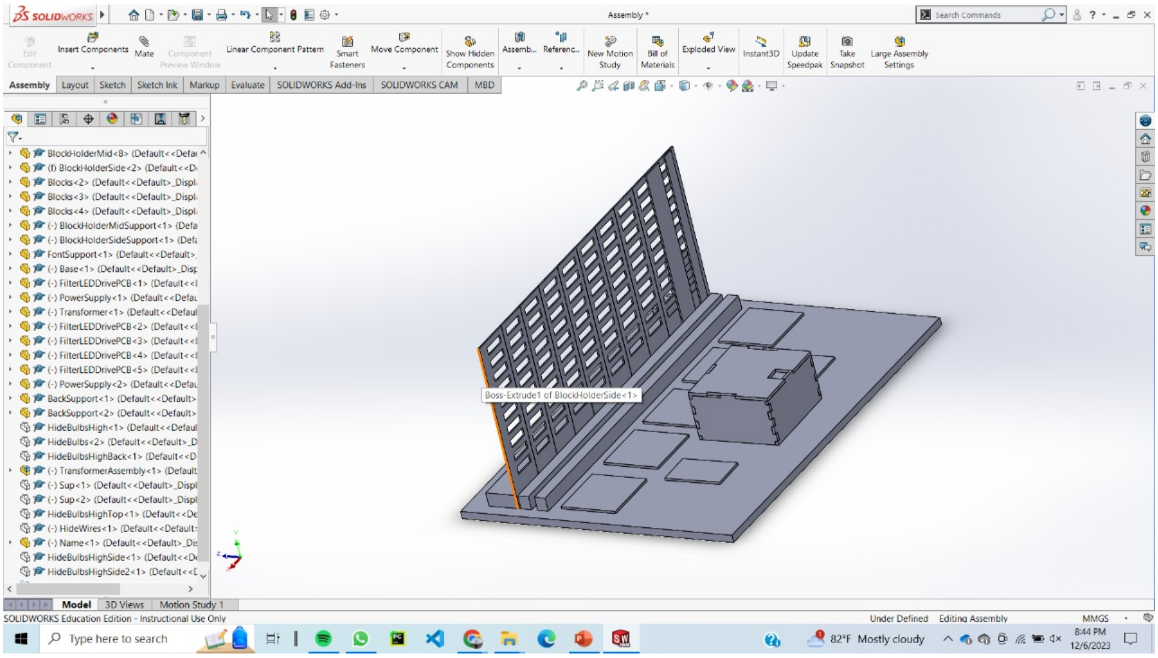

Figure 8:

Black Acrylic sheets were laser cut and mounted vertically on a wood base as in the above figure. Transparent acrylic cubes were glued onto the sheet. LEDs were grilled into each cube. All the electronic circuitry was mounted to the back of the panel. The wooden box in the above figure was made to mount the transformer.

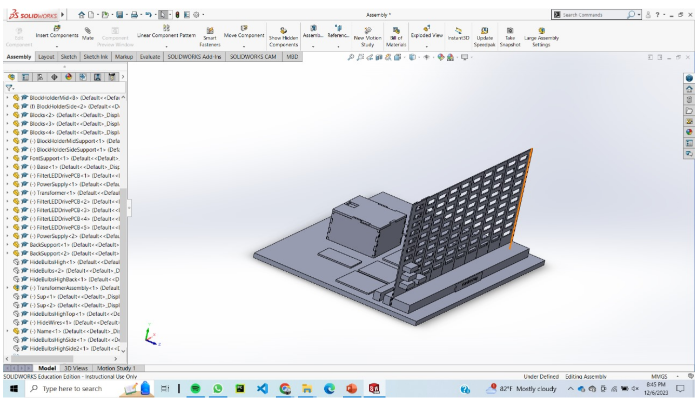

Figure 9: