Compact LED Audio Signal FFT Spectrometer

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Abstract

Radio astronomy is a field that came about in a unique way: Karl Jansky of Bell Labs detected Milky Way radiation while conducting a radio frequency interference experiment for AT&T. The evolution of technology has allowed for bigger and better instruments to observe radio sources throughout the universe. I am proposing to build an audio signal spectrometer that will produce an LED matrix spectrum of a sound input. This project mimics current hardware in radio astronomy and requires an understanding of techniques used by radio astronomers to analyze spectral data. The ultimate goal of this project is to create a device that inputs an audio signal, takes a Fast Fourier transform (FFT) of the input, and prints the resultant FFT spectrum (in a frequency range from 1 Hz to 512 Hz) on an LED Matrix.

Functionality of Spectrometer

This function of this device is to detect an audio signal and display a Fast Fourier Transform (FFT) spectrum of the sound on a 8x32 LED matrix.

The Arduino Mega microcontroller computes the FFT and actuates the LED display in about a second.

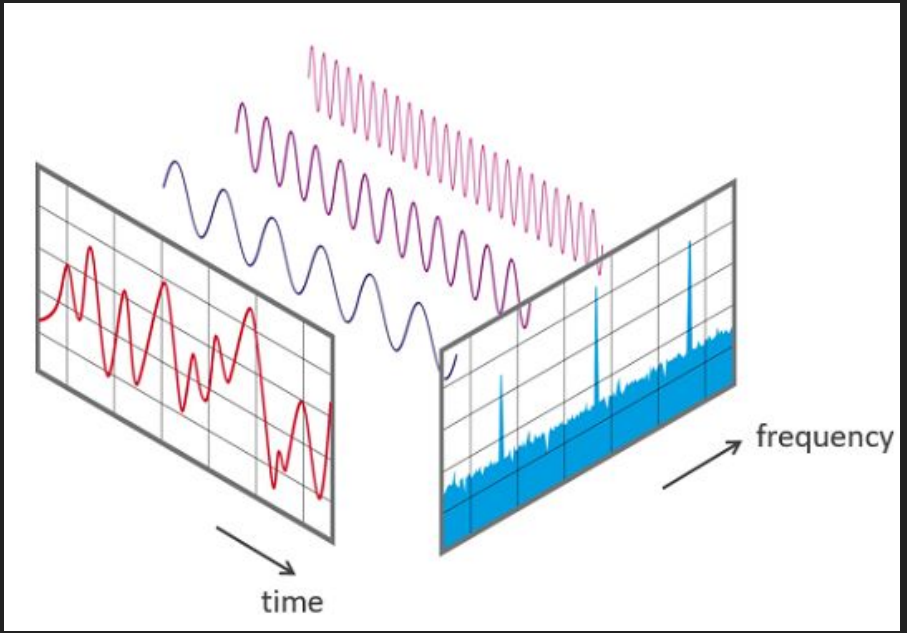


Figure of Fast Fourier Transform

https://www.nti-audio.com/en/support/know-how/fast-fourier-transform-fft

Parts List

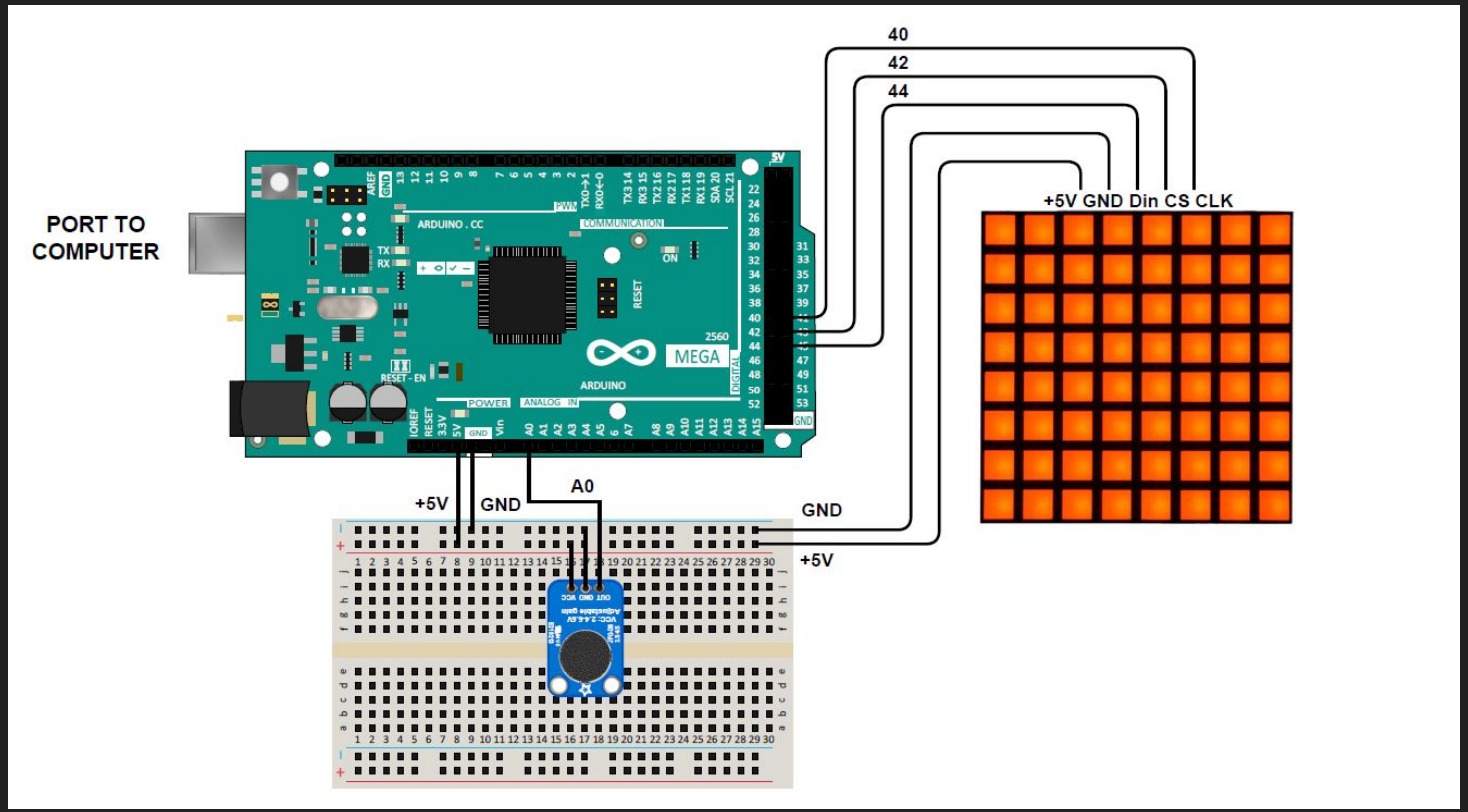
Arduino Mega 2560 Microcontroller - Arduino Store w/ Specs

Microphone Pre-Amplifier MAX4466 - Spec Sheet

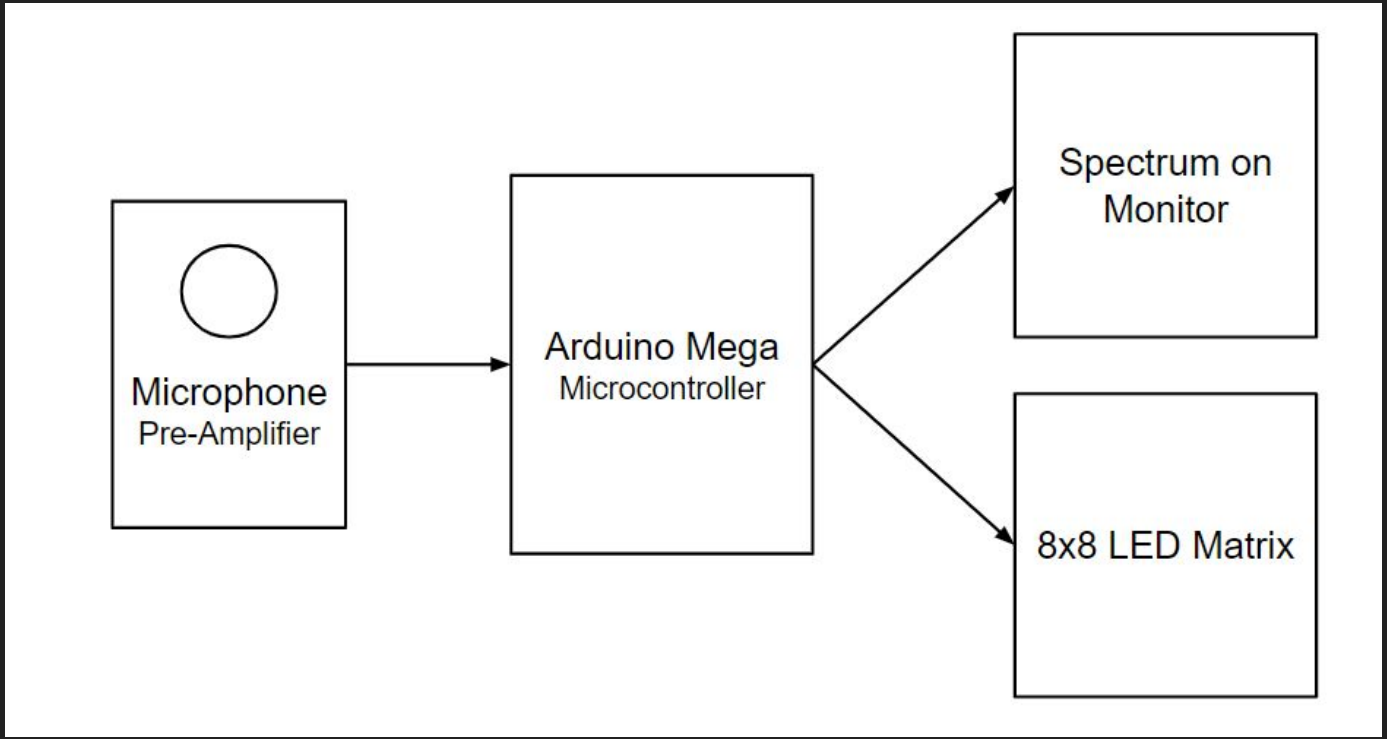
8x8 LED Dot Matrix MAX7219 - Spec Sheet

Breadboard and jumper wires

Spectrometer Schematic



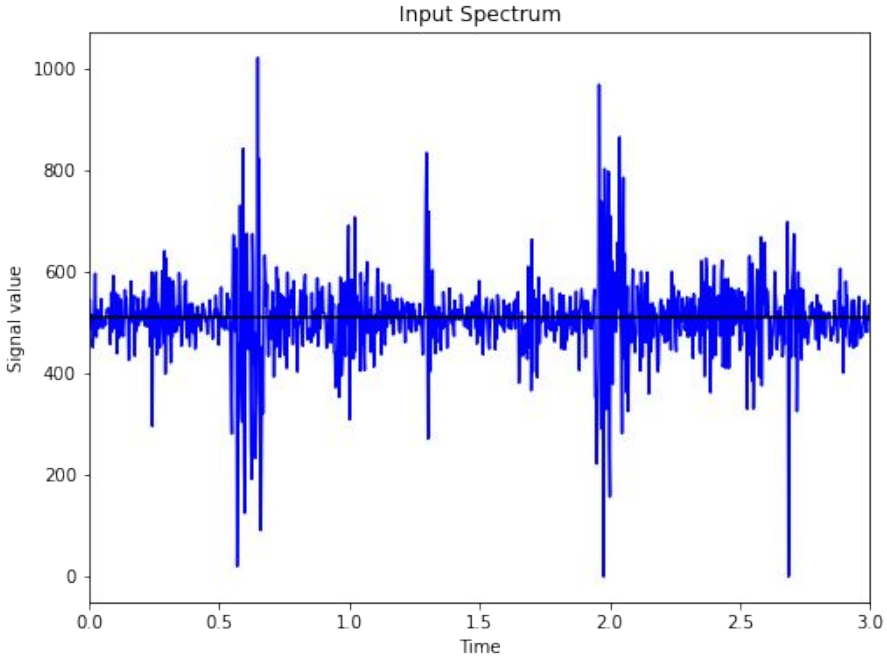
Block Diagram / Flow Chart

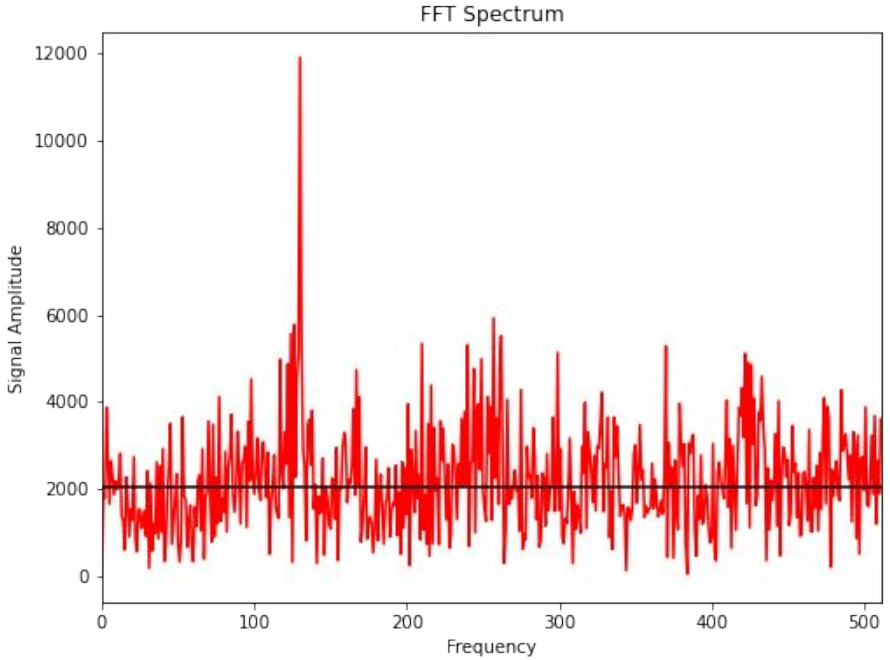


Sound detected by Microphone → Microcontroller performs FFT → LED Matrix prints spectrum

Input / Output Spectra

3 second audio sample of Give Life Back to Music - Daft Punk





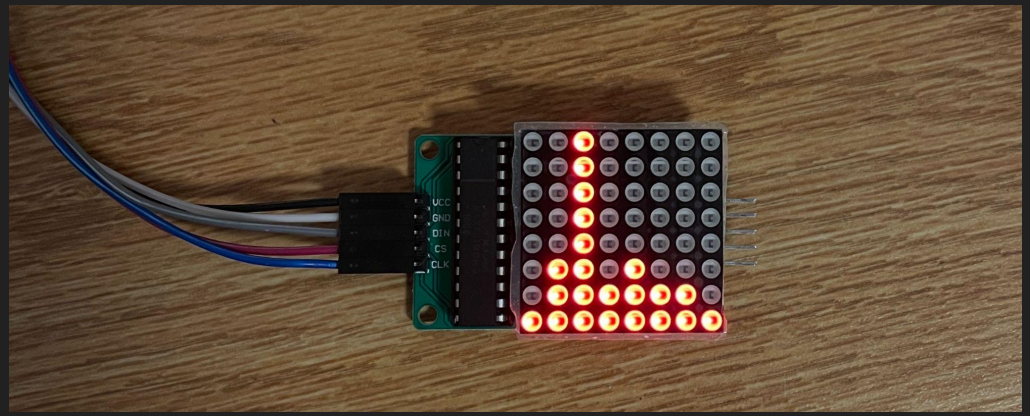
Raw Input Data (time domain) compared to **Output FFT Data (freq domain)**

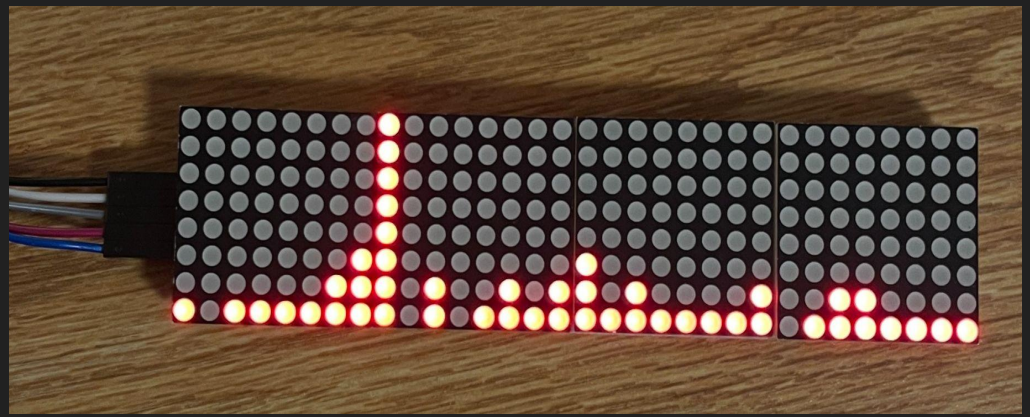
LED Matrices

(8x8 and 8x32 of “binned” frequency ranges)

The 8x8 LED Matrix has binned columns that represent a 64 Hz range, whereas the 8x32 LED Matrix provides better resolution with a 16 Hz range.

A successful aspect of this project was upgrading to the 8x32 LED Matrix, giving a higher resolution FFT spectrum.





Results

- Prints out an FFT spectrum of a 3 second audio signal, in approximately one second.
- The LED Matrix bins columns based on the maximum amplitude of the entire FFT spectrum, so the scale of the intensity axis is base 2 (since the Matrix operates on a binary scale).
- Can run continuously, but the Microcontroller begins to heat up (not too significantly) after about 30 minutes of consecutive use.

Coding Reference

ApproxFFT: Fastest FFT Function for Arduino by abhilashpatel121 on projecthub.arduino.cc.

Uses four functions that are NOT mine: ApproxFFT, FastSine, FastCosine, FastRRS.

https://youtu.be/lWr6ZUK_aps.

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