Electronics Section , IIT Roorkee

Music Spectrometer

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Content List--

1. Acknowledgement-

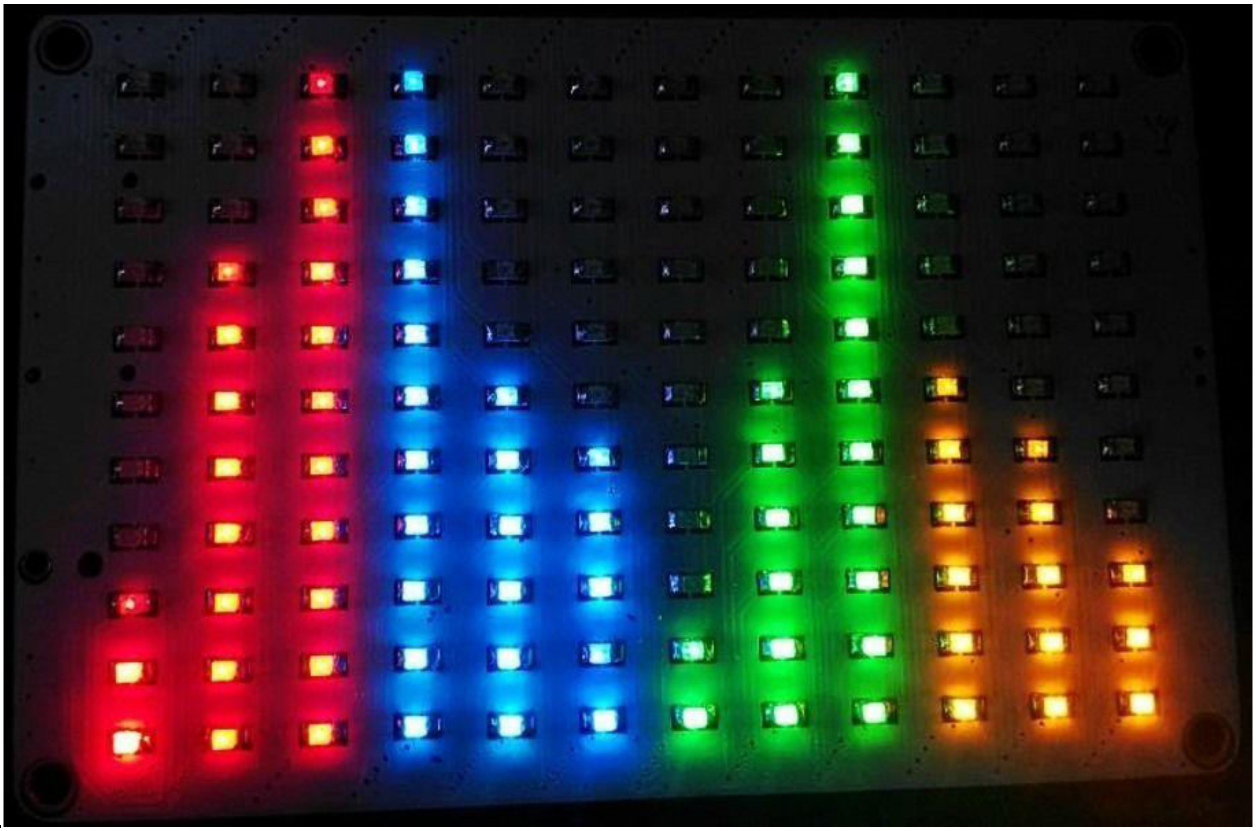
This proposal describes the research and development that was done to accomplish the project. The project was carried out under Electronics Section, Indian Institute of Technology, Roorkee.

First of all, we would like to thank our staff advisor, Mr. Kamal Singh Gotyan for his guidance and support. His knowledge and ideas have given us a lot of inspiration. Secondly, we would like to thank our mentors, Padmanabh Pande for his ideas and suggestions and Gaurav Waghmare for guiding us with concepts of VHDL and PCM and also motivating us at each step.

Big thanks to all of our friends and family who helped and supported us directly or indirectly with the project. Their help and support motivated us to finalize this project.

2. Introduction-

Our electronics project is an audio spectrum analyser that would display the frequency at which magnitude of Fast Fourier Transform of sampled audio signal is maximum. We will be able to successfully compute the frequency spectrum content of an audio signal in real-time using FFT v7.1 of digital signal.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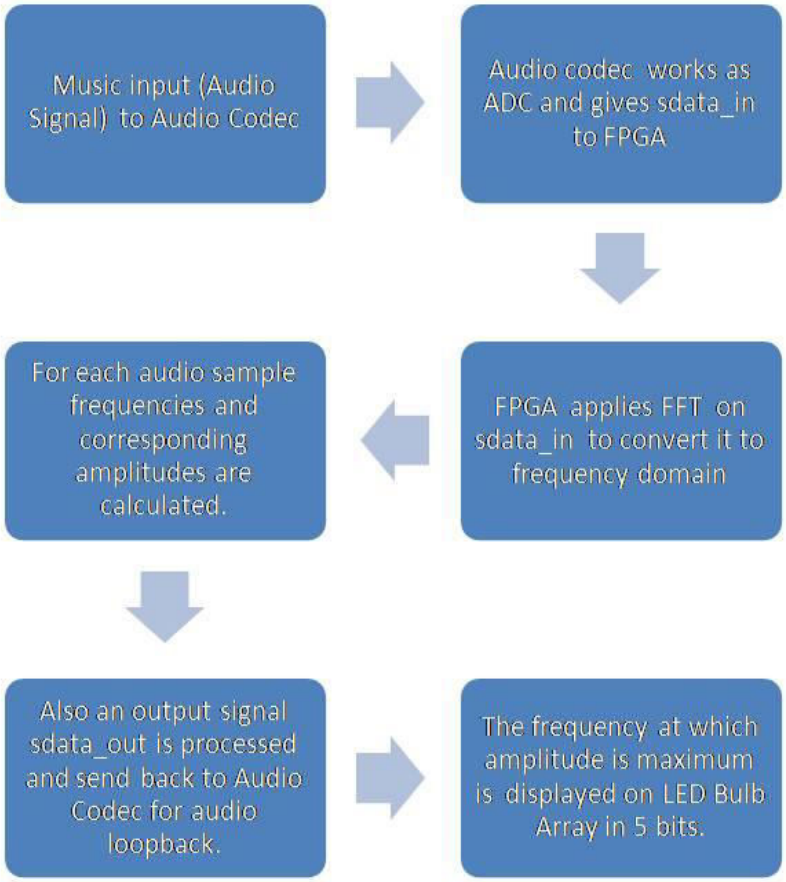
3. Objective-

Our project idea is inspired by popular toys and built in music visualizers in many software audio players such as Windows Media Player. We want to create a similar effect using LED bulbs that could be built cheaply and interface with standard audio inputs and visual outputs. Being able to view a visualization of the frequency spectrum of audio is both interesting as a visual entertainment source to pair with music as well as a way to view the different frequency components associated with certain sounds or instruments.

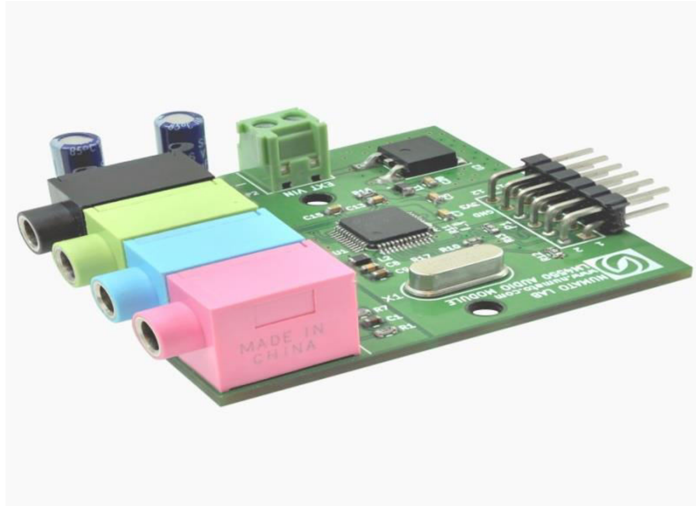
4. Block Diagram-



5. Components description:

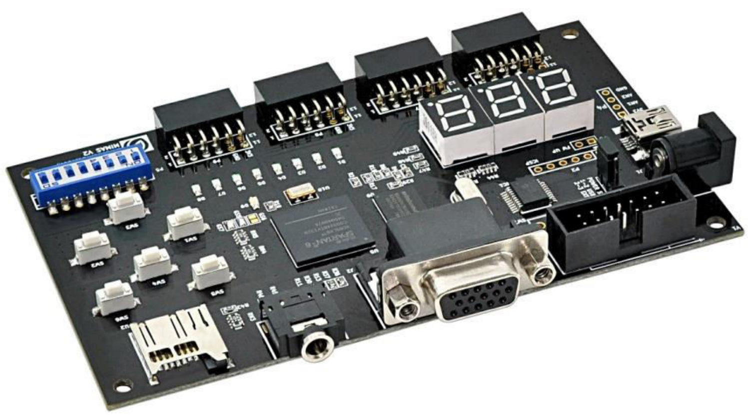
- Stereo Audio Codec Expansion Module:

This module features LM4550, an AC'97 Rev 2.1 compliant audio codec which enables producing and recording high quality stereo audio. This module is designed to be used with Numato Lab's FPGA/Microcontroller boards featuring a 2x6 pin Expansion connector. It can also be used with other boards and connector types by using manual wiring.



- Spartan 6:

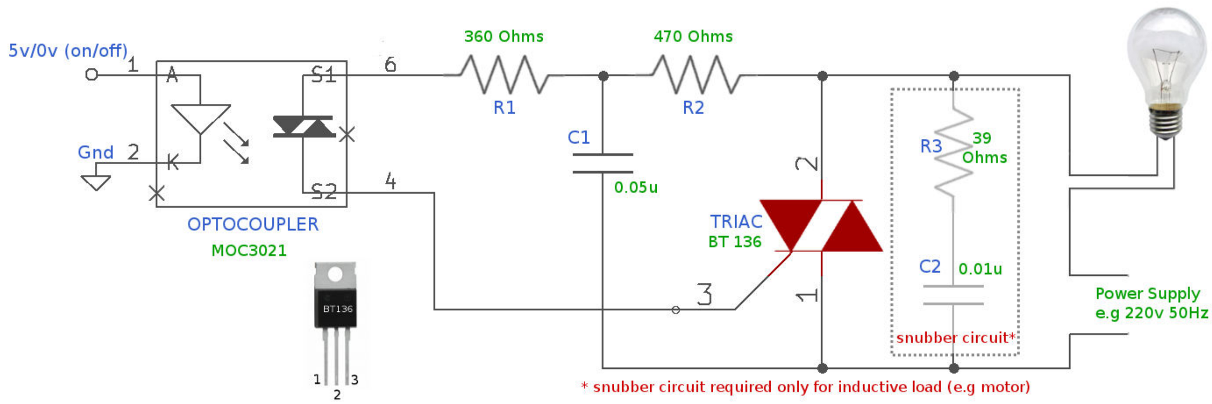
Mimas is an easy to use FPGA Development board featuring Xilinx Spartan-6 FPGA. Mimas is specially designed for



experimenting and learning system design with FPGAs. This development board features Xilinx XC6SLX9 TQG144 FPGA with maximum 70 user IOs. The USB 2.0 interface provides fast and easy configuration download to the on-board SPI flash.

- On / Off Switch:

The switch is realized using triac and optocoupler (MOC 3021) .T1 conducts when the OC sends a pulse to its base. C discharges through the collector-emitter line. The trigger current is limited by R2 to around 40 mA. The discharge current time of C1 is less than 1 ms .The RC circuit R4 and C3 protects the triac from voltage spikes.
This is very important in all inductive loads.



6. Theory

The audio signal is sampled and processed into the frequency domain. We used an audio codec AC97 LM4550 to convert mono or stereo audio input to PCM format using built in ADCs. We also used built in DACs of audio codec to loopback the audio input signal by controlling the sdata_out signal from FPGA. The sdata_in provided by the codec to FPGA in sent to FFT core to convert it into frequency domain. The magnitude of complex amplitudes corresponding to different frequencies of each sample is calculated and compared. The frequency at which the modulus of amplitude is maximum, is displayed in 5 bits using LED bulbs via On/Off circuit. The Fourier transform is a mathematical algorithm that converts a time domain signal into its frequency representation. Since we are working with finite digital systems, we chose to use the Discrete Fourier Transform (DFT) which converts a discrete time audio signal of a finite number of points N into a discrete frequency signal of N points, referred to as frequency bins throughout this report because each point represents a “bin” or range of frequency content. With a purely real-valued signal such as our audio signal, the frequency representation of the signal is mirrored perfectly across the (N/2)th point in the DFT. The highest bin represents the frequencies up to the sampling frequency, and the lowest bin represents the frequencies just above 0.

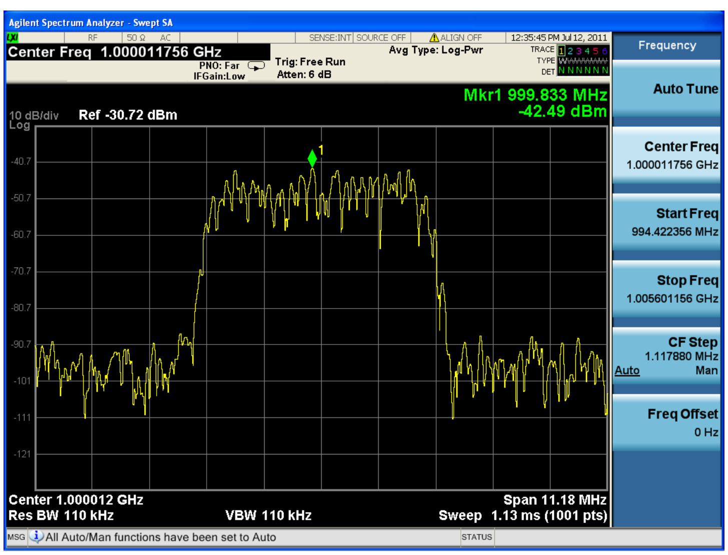
Each bin has the same frequency width, called the frequency resolution, which is the sampling frequency divided by the amount of bins N.

The Fast Fourier Transform algorithms exist, like recursive divide-and-conquer techniques, Cooley – Tukey's algorithm that reduce the O(N2) computation time of the DFT to O(Nlog2(N)). With large numbers of points N, this increase in speed is very significant in reducing computation time especially in software applications. We used in-built module of FFT core using Core Generator from Xilinx ISE Webpack 14.7 in our VHDL code.

7. Applications:

1. Spectrum Analyzer-

A **spectrum analyzer** measures the magnitude of an input signal versus frequency within the full frequency range of the instrument. By analyzing the spectra of electrical signals, dominant frequency, harmonics, bandwidth, and other spectral components of a signal can be observed that are not easily detectable in time domain waveforms. These parameters are useful in the characterization of electronic devices, such as wireless transmitters. Thus, our music spectrometer can be effectively used a spectrum analyser.



2. Voice stress analysis-

Voice Stress Analysis (VSA) technology is said to record psychophysiological stress responses that are present in the human voice when a person suffers psychological stress in response to a stimulus (e.g., a question), and the consequences of the person's answer may be dire. VSA is based on the analyzed frequencies ranges (8-14 Hz) The recorded "micro tremors" in a person's voice are converted via the algorithm into a scorable voice gram.

3. Home Theatres-

This spectrometer can be fitted along with the theatre system to create more visual effects by changing the amount of light with the sound from movie.

8. References:

1. National Semiconductor, LM4550 AC ’97 Rev 2.1 Multi-Channel Audio Codec with Stereo Headphone Amplifier, Sample Rate Conversion and National 3D Sound datasheet.

2. Xilinx, LogiCORE IP Fast Fourier Transform v8.0 datasheet.

3. http://www.mtl.mit.edu/Courses/6.111/labkit/audio.shtml

4. Pong P. CHU, FPGA prototyping with VHDL Examples