



PROGRAMMATIC SIMULATION OF DIGITAL FILTERS FOR AUDIO APPLICATIONS

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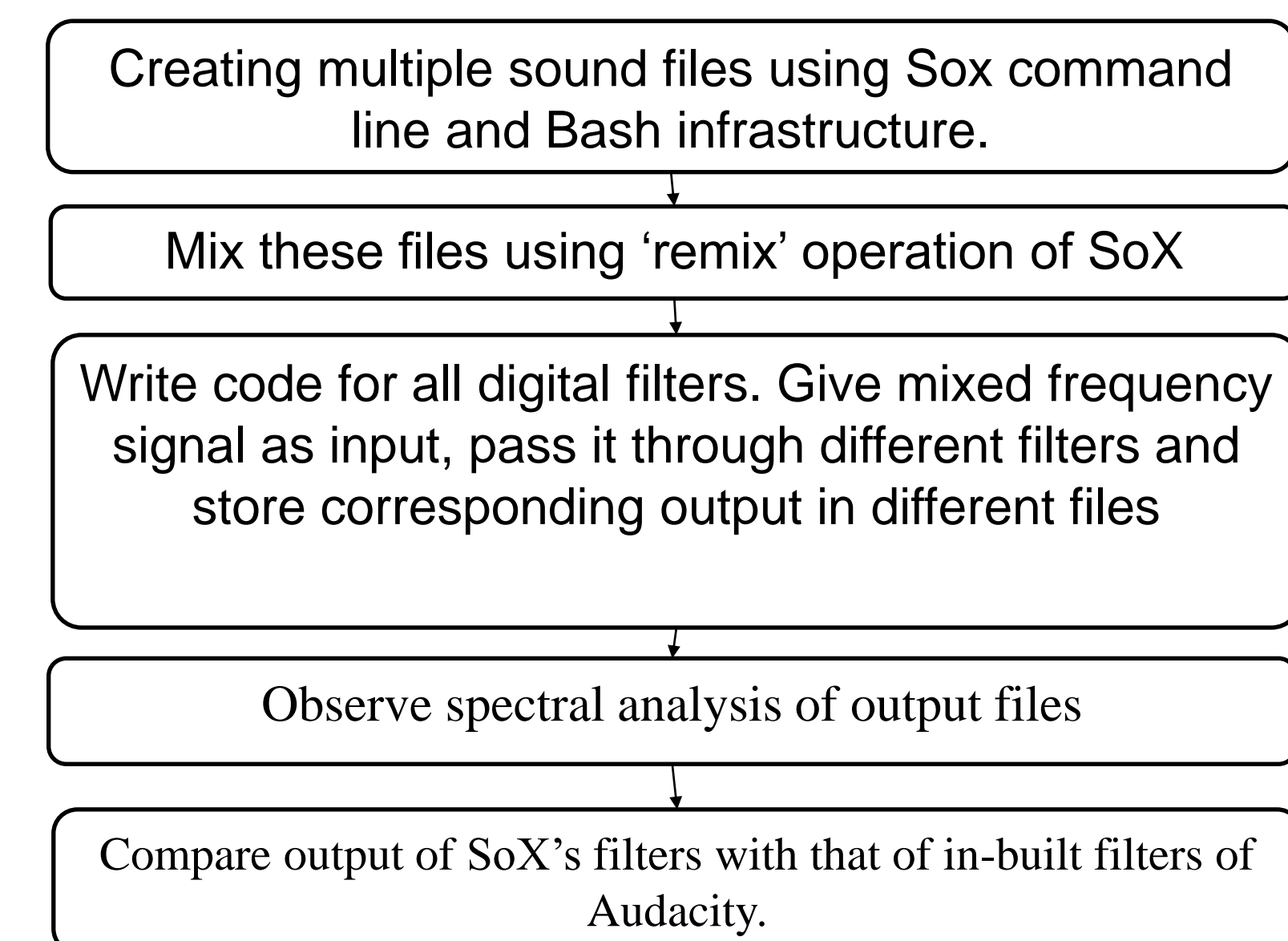
OBJECTIVE

To design and program digital filters (lowpass, high pass, bandpass, and band-reject) using an open-source library: SoX Library, and observing their responses using spectral analysis on Audacity.

PROJECT METHODOLOGY

Creating multiple sound files (.wav format) using SoX command line and. Mix the sound files using SoX library's 'remix' command to create a multiple-frequency wave. Write code for all the digital filters. Test the filters' response on Audacity. Compare the output of SoX's filters with that of in-built Audacity filters.

Assumption: Audacity will have better responses for all the filters.



Design flow

DESIGN

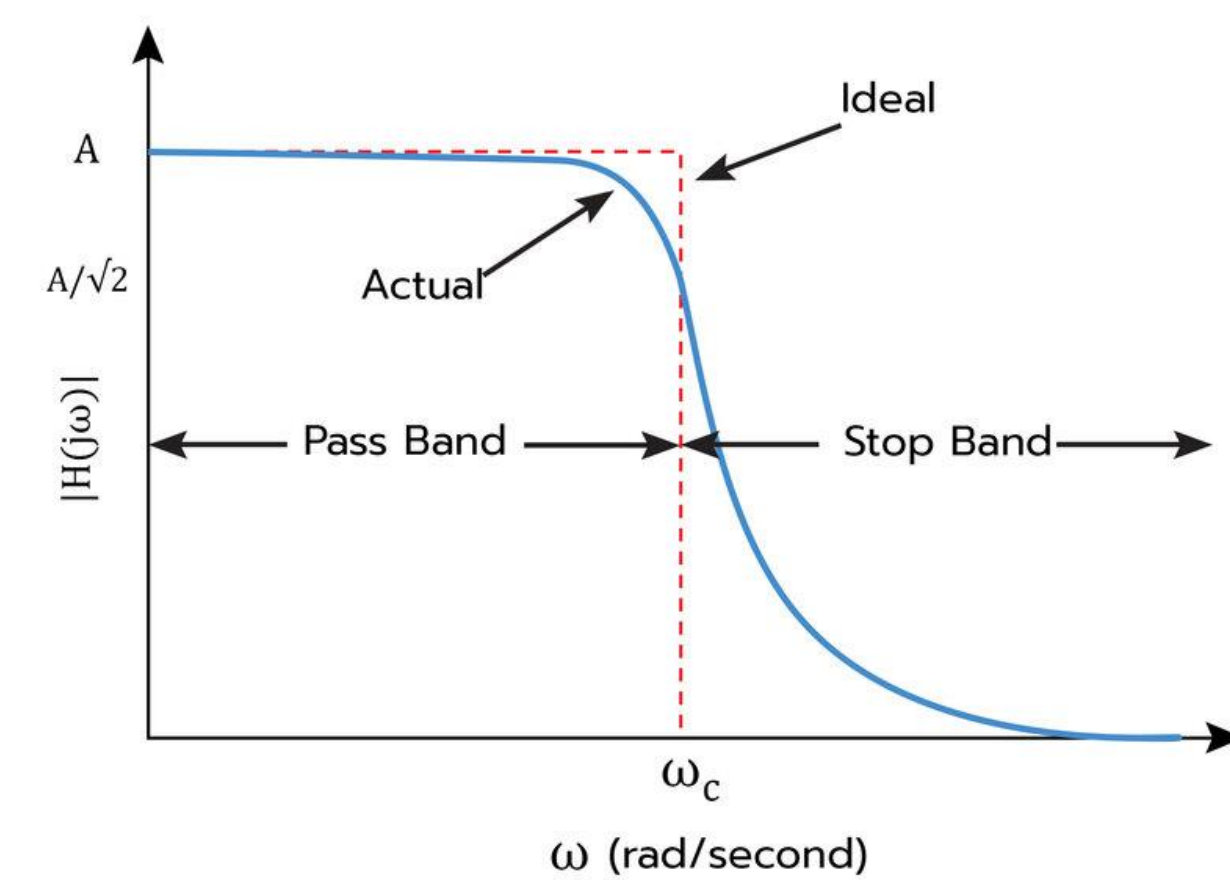
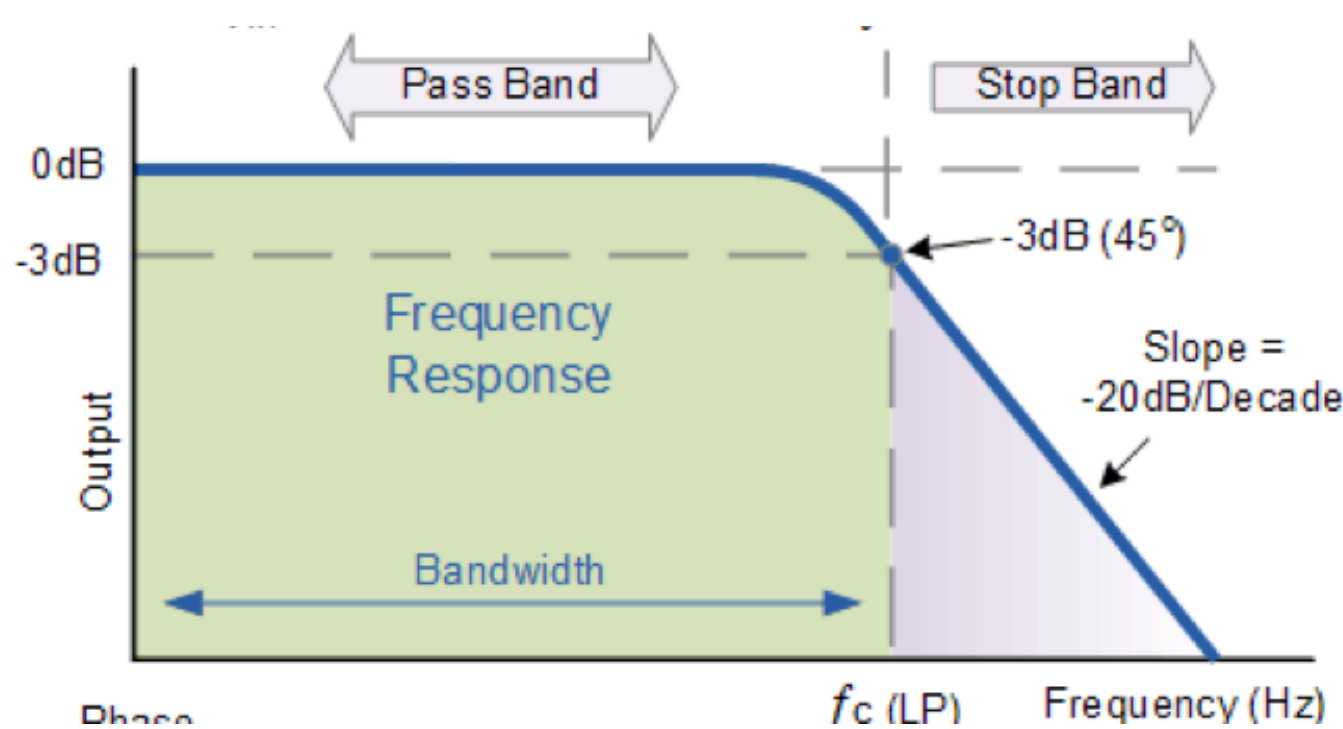
For input wave frequencies of 1kHz, 4kHz, 8kHz, 15kHz and 20kHz are to be remixed and stored in a file.

Lowpass filter: Higher cutoff frequency will be 6kHz. For all the filters, the quality factor is 0.707.

Highpass filter: Lower cutoff frequency of 10kHz.

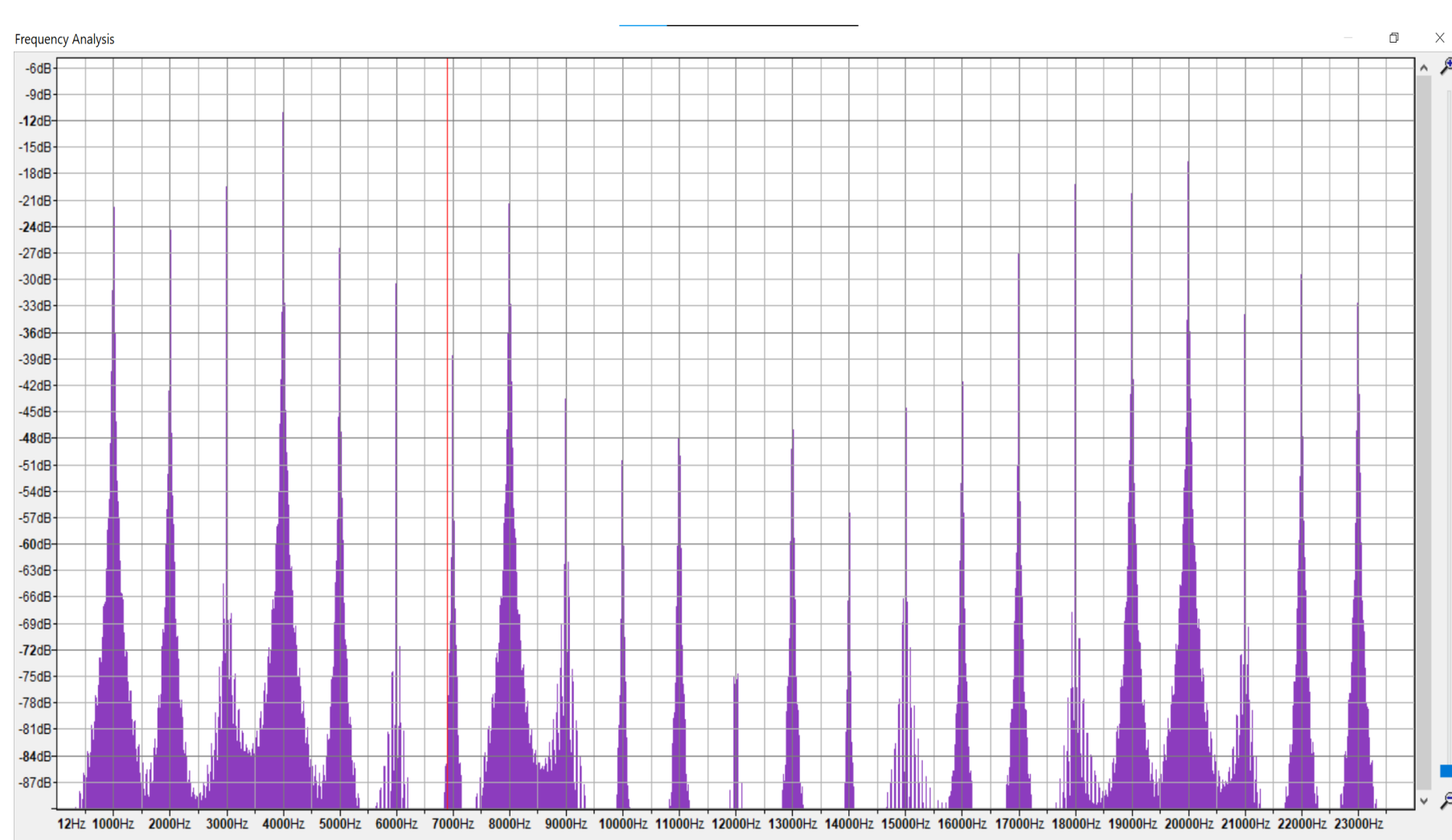
Bandpass filter: Lower cutoff frequency is 2kHz and upper cut-off frequency is 10kHz.

Band reject filter: Lower cut-off frequency is 6kHz and upper cut-off frequency is 17kHz

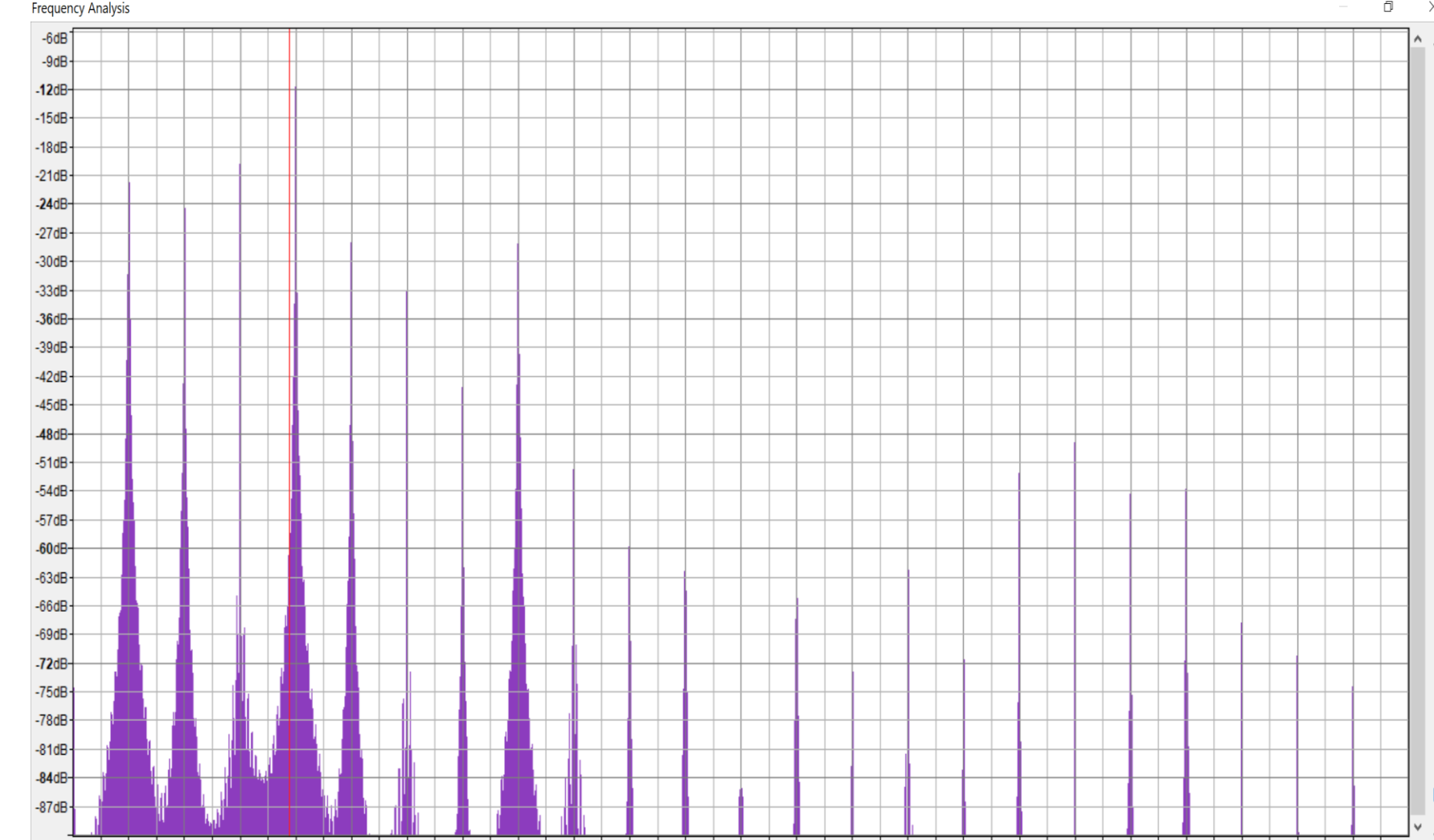


RESULTS

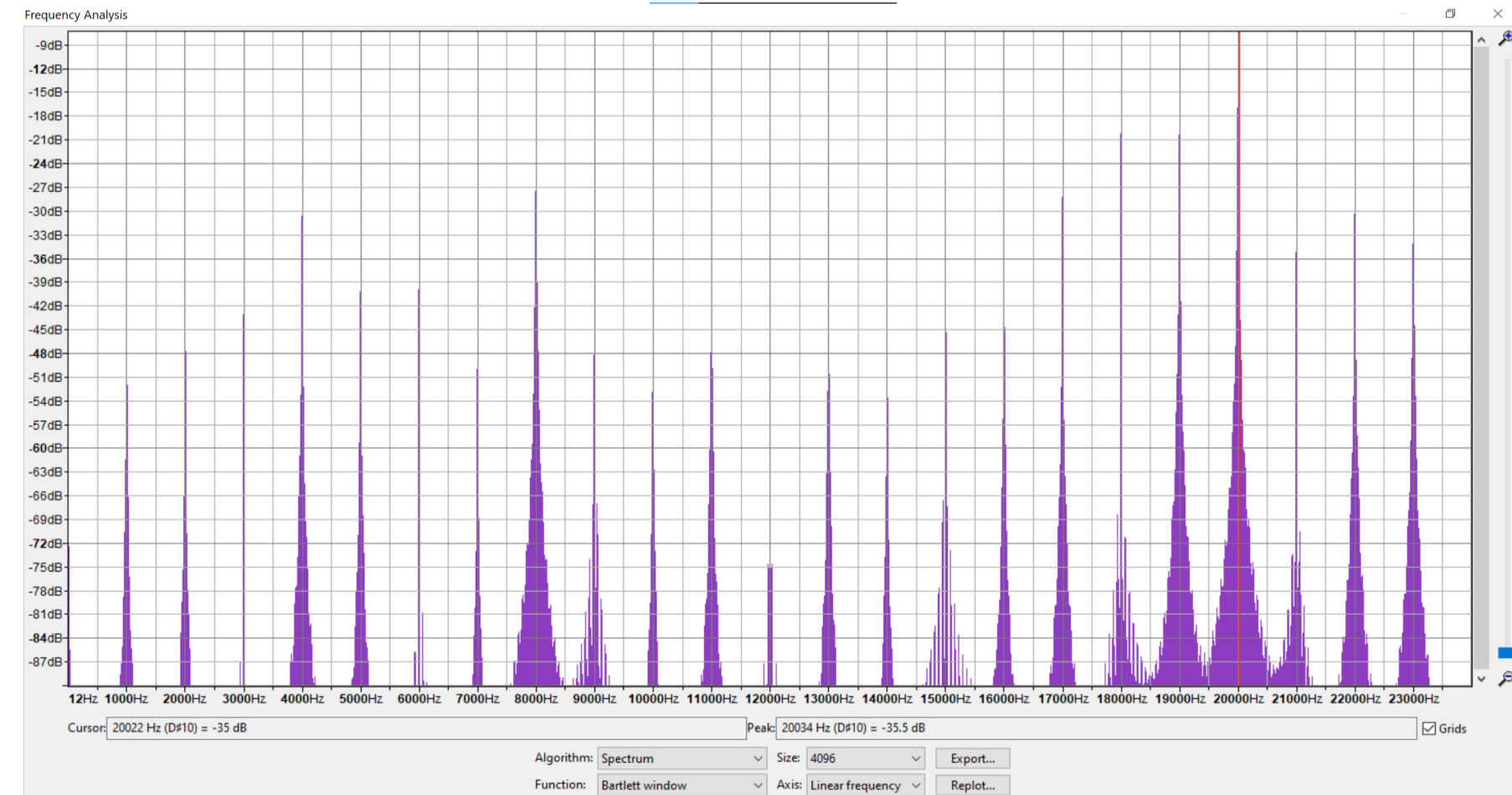
Spectrum Plot of mixed Frequency Wave



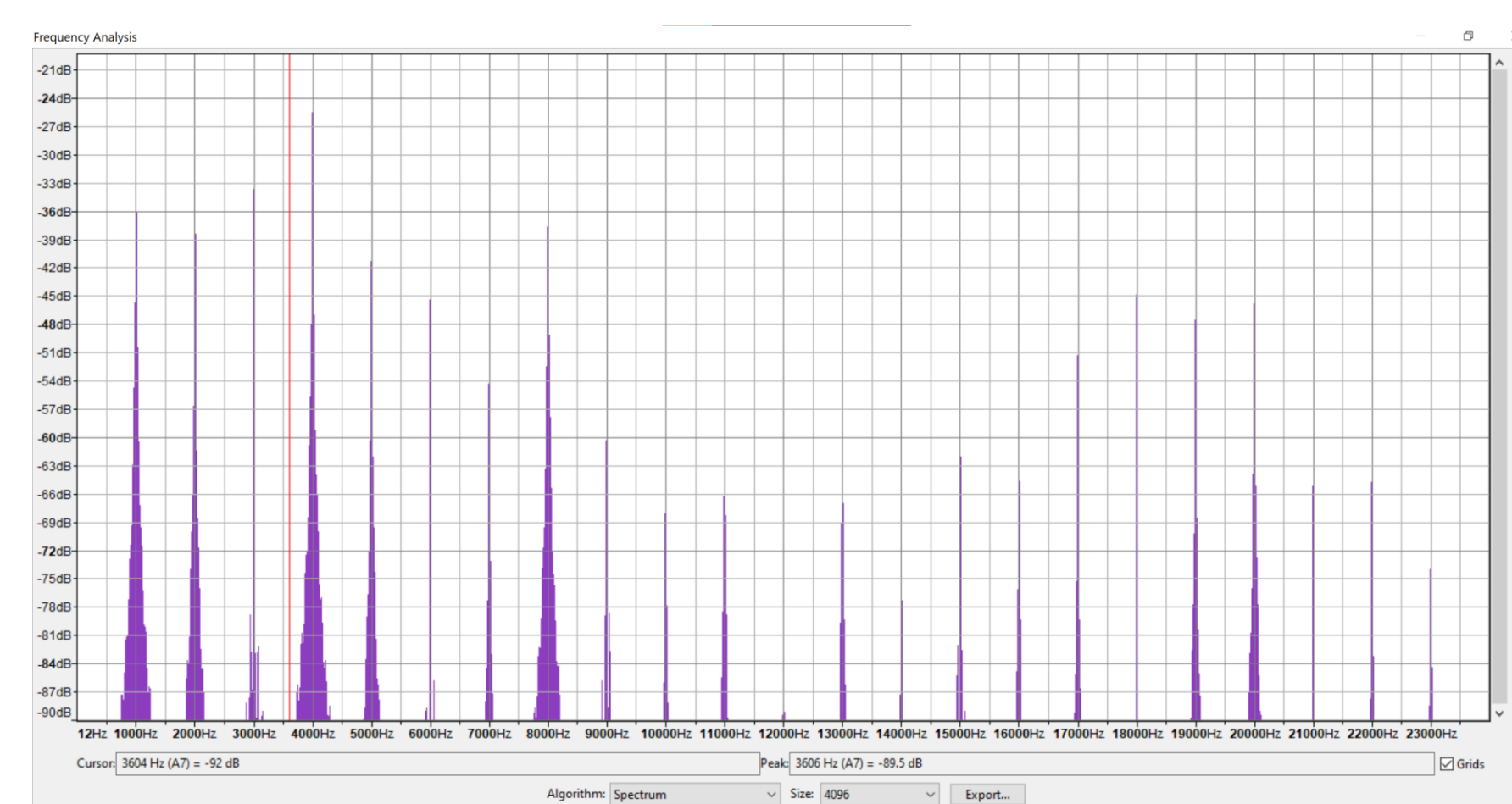
Low-pass Filter Response



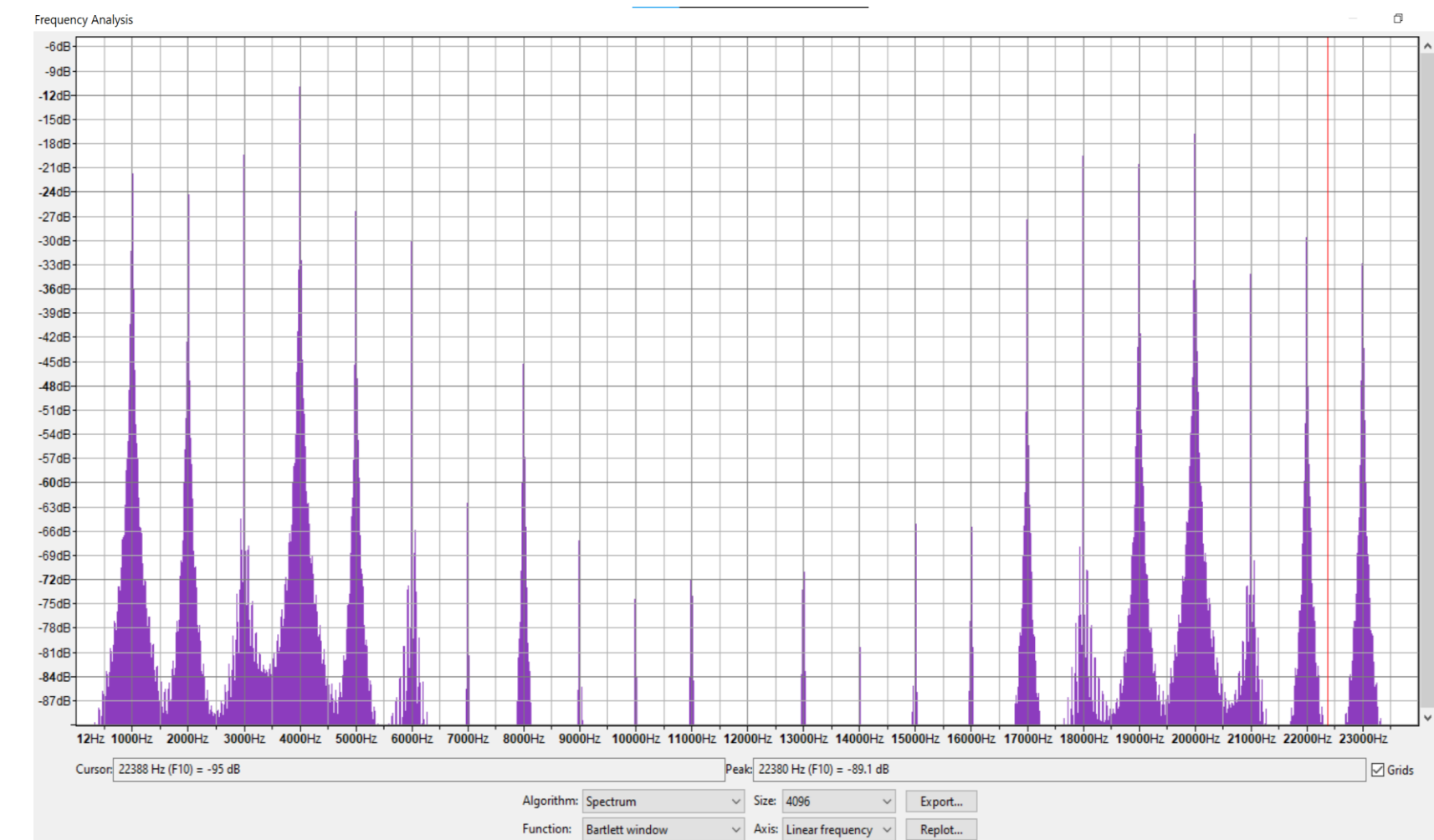
High-pass Filter Response



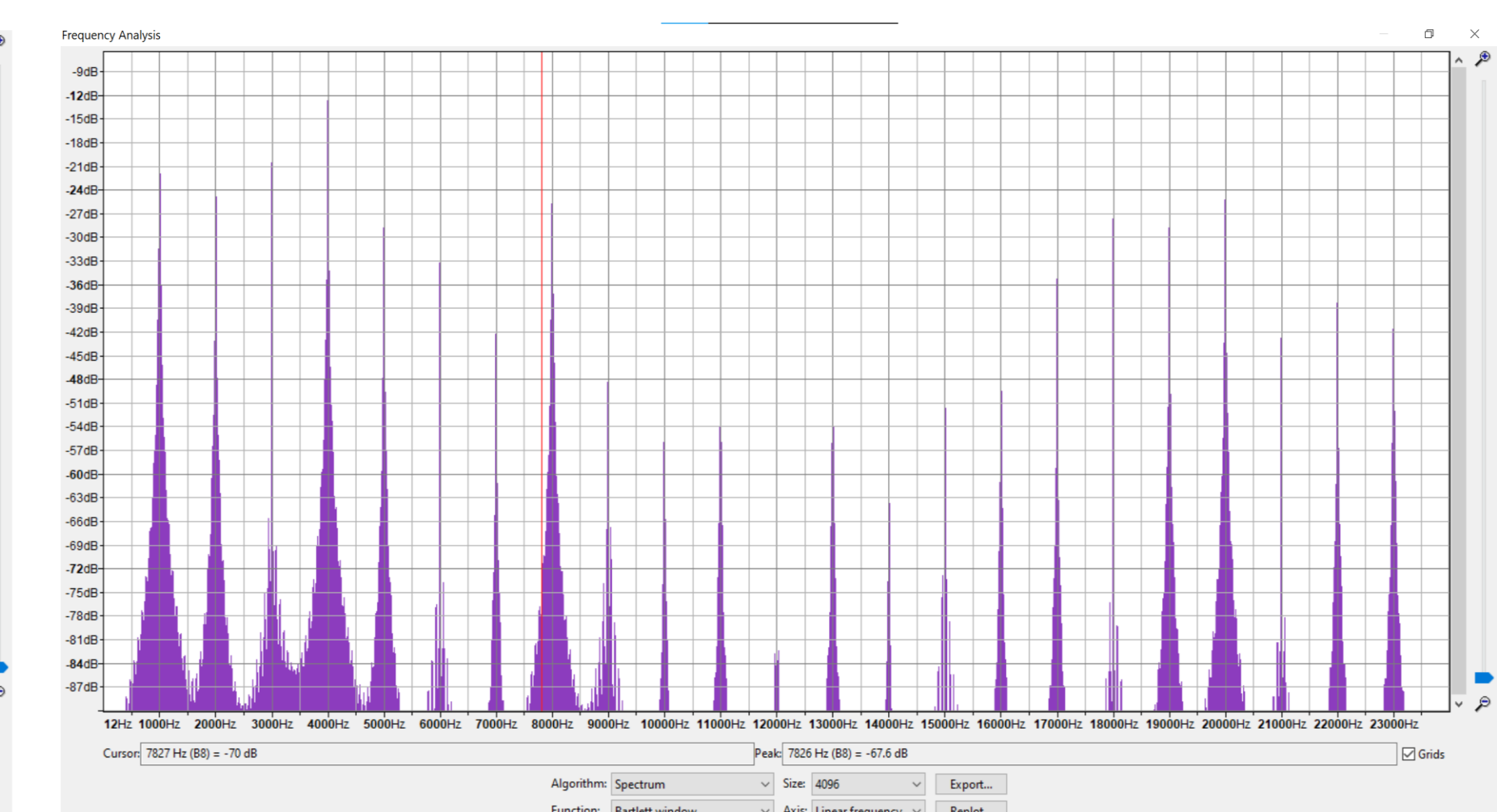
Band-pass Filter Response



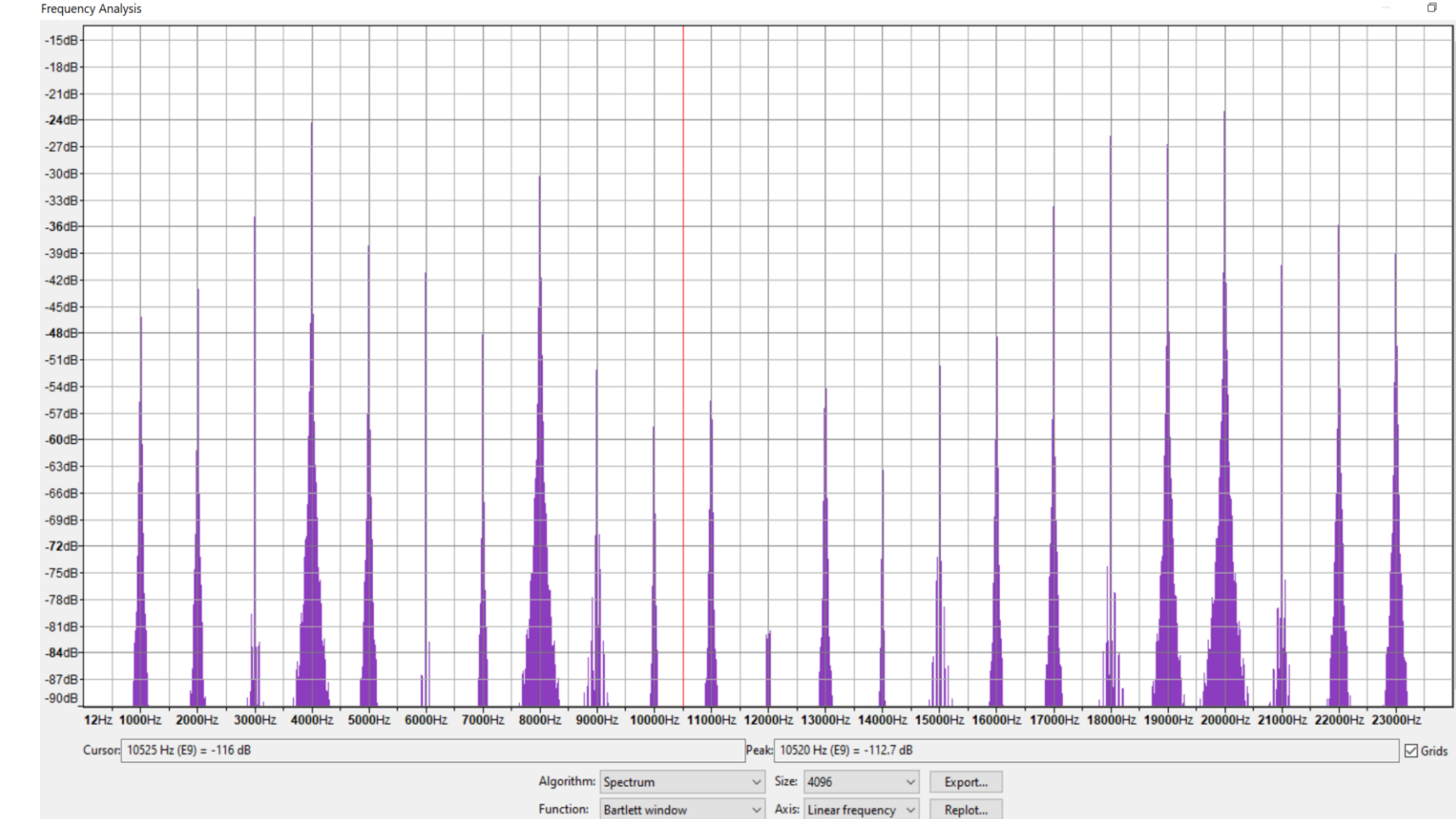
Band-reject Filter Response



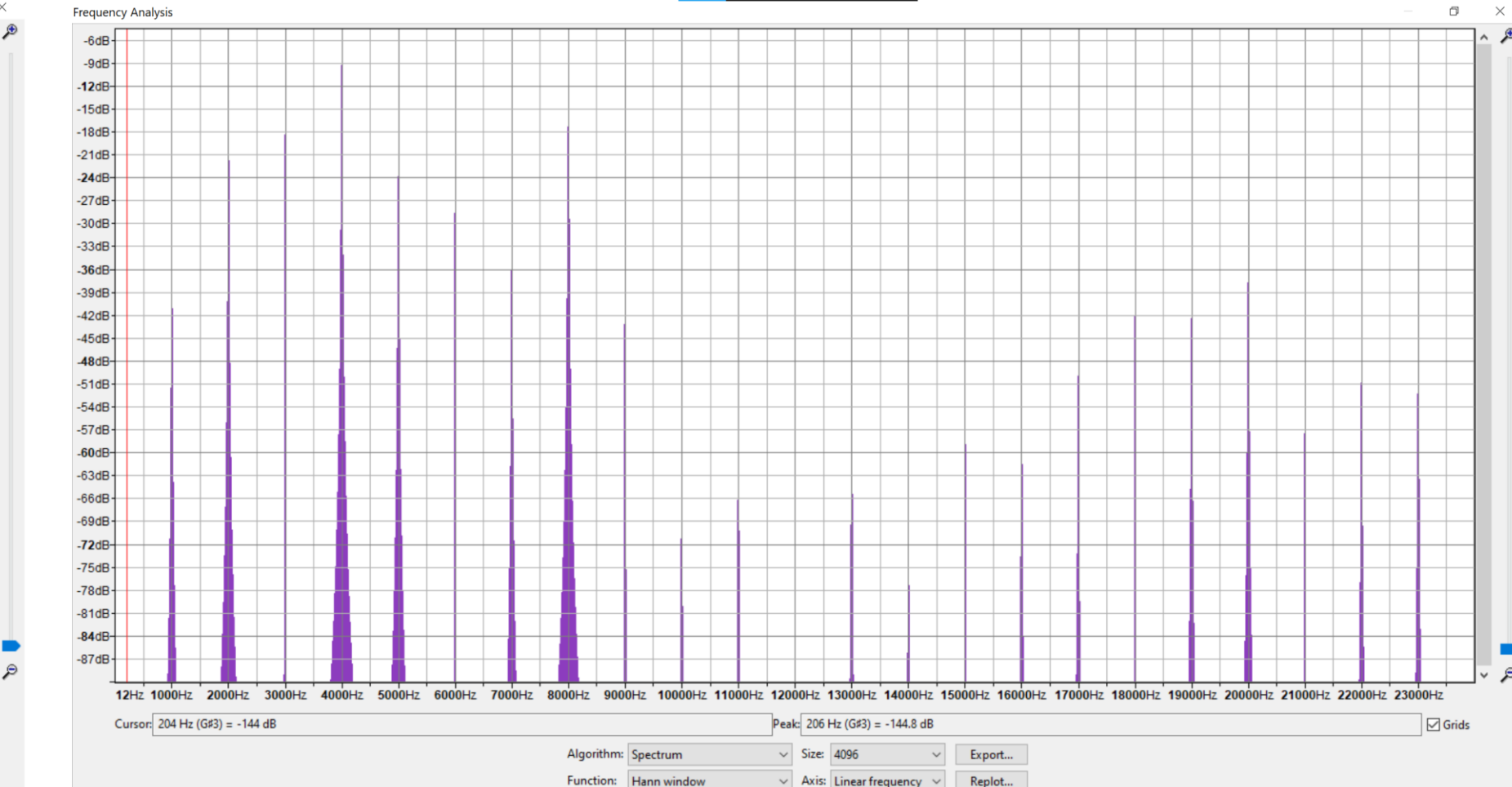
Low-pass Filter Response on Audacity



High-pass Filter Response on Audacity



Band-pass Filter Response on Audacity



Hardware /Software Used

- **SoX Library:** Is an open-source cross-platform audio editing software. It has a command line interface and is written in C. Some features of SoX include recording and writing into various audio file formats, recording, and playing audio, and multi-track mixing. The source code is available on GitHub.
- **Bash:** Powerful tool to automate system administration tasks and perform other routine tasks in Unix/Linux.
- **Audacity:** Audacity is a free and open-source digital audio editor and recording application software, available for Windows, macOS, and Linux.

Conclusions and Future Scope

- SoX library's Low-pass and high-pass filter responses were visualized using a spectral plot and the results were compared to the in-built filters of Audacity.
- SoX library seemed to have very similar response to audacity's high-pass, band-pass and band reject filters. Low-pass response was better on SoX's library.
- The results prove that SoX's filters and Audacity's filters have similar responses. This a contradiction to our previous assumption.
- Future Scope: To achieve better filter responses using SoX library. To remove unwanted noise from audio samples.

References

- Libsox Source Code: <https://github.com/dmkrepo/libsox>
- Documentation: https://fossies.org/dox/sox-14.4.2/libsox_8c.html
- Libsox Tutorial: <https://www.audiosciencereview.com/forum/index.php?threads/howto-sox-audio-tool-as-a-signal-generator.4242/>
- Man Pages of Linux: <https://linux.die.net/man/3/libsox>

COMPLETE RESULTS

- https://drive.google.com/drive/folders/1MHQFunauM_eFCpdSo0AAAdNpiz2lWuY8I?usp=drive_link

Acknowledgements

The authors thank Dr. Shanthi.P, HOD and Principal, Department of electronics and Telecommunication Engineering, RVCE for the kind support received for completion of the project.

This work is carried out as a part Experiential Learning component of the course Linear Integrated circuit and Applications (22EI233)