VLA-252A: Passive Graphic Equalizer prototype that replicates the iconic Langevin EQ252A

Andrea Sofia Vallejo Budziszewski, Chris Morse, Tommaso Settimi,
Du Huang, Pablo Rodríguez, Polina Zvoda

Third trimester 2023

Abstract

The objective of this project is to develop an innovative Passive Graphic Equalizer (GEQ) prototype that emulates the renowned Langevin EQ252A, a highly sought-after analog graphic EQ from the early days. However, instead of relying on expensive physical analog components with a price tag of approximately 1400 GBP (equivalent to around 1600 EUR or 1750 USD), the project team adopts a contemporary approach by employing Wave Digital Filters to create an affordable and efficient digital model. Wave Digital Filters represent a modern digital signal processing technique capable of simulating analog circuits in a cost-effective and efficient manner. The primary goal is to make the timeless audio characteristics of the Langevin EQ252A accessible to a broader audience while simultaneously revolutionizing digital equalization methods. The EQ spectrum coverage has been thoughtfully designed, featuring a set of precisely positioned bands at fixed frequencies. This design not only simplifies workflow but also ensures accuracy in the equalization process. By strategically selecting fixed frequencies for each band, the project team aims to achieve a seamless and effective EQ curve tailored to their specific requirements.

Keywords: Passive Graphic Equalizer, Langevin EQ252A, Wave Digital Filters, Digital audio processing

1 Introduction

Equalizers. Equalizers are indispensable tools in audio processing that provide the ability to adjust the balance among various frequency components within an audio signal. They allow customization of sound according to personal preferences by manipulating bass, midrange, and treble frequencies. The two primary categories of equalizers are parametric and graphic.

Parametric equalizers offer precise control over the frequency response of a sound system through targeted amplification or attenuation of specific frequencies. Termed ”parametric” due to their capacity for parameter adjustment, such as center frequency, bandwidth, and gain, these equalizers enable fine-tuning of sound to individual preferences or adaptation to the acoustic characteristics of the listening environment.

In contrast, graphic equalizers permit simultaneous adjustment of multiple frequency ranges using sliders or knobs arranged in a graphical pattern, where each control corresponds to a specific frequency band. This type of equalizer proves ideal for tailoring sound to personal preferences or compensating for deficiencies in the original audio signal.

The project at hand focuses on the development of passive graphic equalizers, termed ”passive” because they operate without external power. These equalizers rely on passive components like resistors, capacitors, and inductors to perform the equalization process. By incorporating a combination of filters including high-pass, low-pass, and bandpass, the incoming audio signal is divided into multiple frequency bands, each directed to its corresponding slider. Passive potentiometers enable adjustment of the level for each band. The modified signals are then recombined and delivered as output, resulting in a customized frequency response.

Filters. A filter refers to a device or process designed to selectively transmit certain frequencies while blocking or attenuating others. A low-pass filter permits the passage of low frequencies while hindering higher frequencies. Conversely, a high-pass filter allows high frequencies to pass through while obstructing lower frequencies. A band-pass filter exclusively permits a specific range of frequencies to pass while preventing frequencies outside that range from passing through.

Figure 1: Langevin EQ252A graphic equalizer

The Langevin EQ252A is a vintage analog equalizer that gained popularity in the mid-20th century. It is a "white box" model, meaning its internal workings are well-documented and understood. The EQ252A consists of two separate stereo equalizers that can be used together or independently. Each equalizer features five bands of EQ with adjustable frequency and gain controls. The EQ bands are centered at 50Hz, 150Hz, 500Hz, 1.5kHz, and 5kHz, offering a boost or cut range of +/- 8dB. The EQ252A utilizes passive LC filtering, employing inductors and capacitors to create a frequency-dependent resistance for boosting or cutting specific frequencies. Its EQ circuits are designed to provide a smooth and musical sound, characterized by a gentle roll-off and a low noise floor.

In terms of parameters, here are some commonly found in both graphic and parametric EQs:

Center Frequency: This parameter allows you to select the specific frequency band you want to modify, typically measured in Hertz (Hz) and ranging from low to high frequencies (e.g., 20 Hz to 20 kHz).

Gain/Level: This parameter controls the amount of boost or cut applied to the selected frequency band. It determines the volume increase or decrease within that frequency range, usually expressed in decibels (dB), with positive values indicating a boost and negative values indicating a cut.

Q Factor/Bandwidth: This parameter determines the width of the frequency band affected by the EQ. It controls the range of frequencies around the selected frequency that will be modified. A narrower bandwidth (higher Q factor) affects a smaller range of frequencies, while a wider bandwidth (lower Q factor) affects a broader range.

Filter Type: EQs often offer various filter types that alter how frequencies are modified, such as high-pass filters (HPF), band-pass filters (BPF), or notch filters, catering to specific needs.

On/Off/Bypass: This parameter enables or disables the EQ for a particular track or audio signal. When bypassed, the EQ settings have no effect, allowing a comparison between the original and modified sound.

Equalization is a fundamental tool in audio production that allows adjustment of the frequency response of a track or audio signal. By manipulating specific frequencies, you can emphasize or attenuate them to achieve the desired sound. During the mixing process, EQ plays a crucial role in ensuring seamless blending of different instruments in a song. For instance, when two instruments occupy the same frequency range, they can clash and create muddiness or clutter. EQ helps separate these instruments by emphasizing different frequencies, resulting in distinct and clear sounds. [1]

2 Results

The VLA-252A software is a digital audio processing tool designed to replicate the characteristics and behavior of the vintage Langevin 252A hardware unit through the use of wave digital filters. By employing advanced analog modeling techniques, specifically wave digital filters, the software strives to faithfully recreate the unique sound and response of the original hardware.

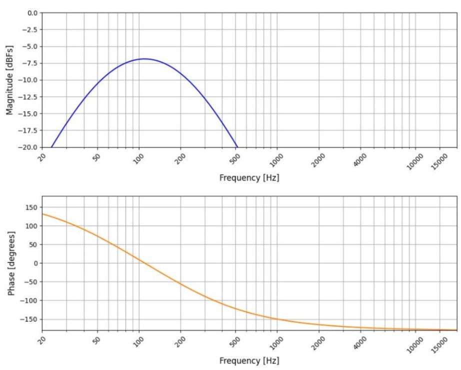

Figure 2: Example of the band-pass filter working at 230 hz

System overview: The system consists of a digital signal processing engine that simulates the analog circuitry of the Langevin 252A equalizer. The engine utilizes Wave Digital Filters to accurately reproduce the frequency response and phase shift characteristics of the original hardware. The software is compatible with Windows and Mac operating systems. The prototype was developed using Wave Digital Filters in Python and includes a graphical user interface for parameter adjustment and visualization.

To create the user interface for the Langevin 252A equalizer software, several requirements must be met. By this we mean that It should support at least seven equalization bands with fixed frequency and variable gain control. Furthermore, the front-end should include a display using PyQT. The back-end will require several libraries, including soundfile, essentia, matpltlib, sns, numpy, and sounddevice. The software accurately replicates the frequency response of the Langevin 252A equalizer. The interface allows for loading an audio file from the system and feature a play/stop button. Users are able to save and recall presets and manage them, including the ability to save, recall, and delete presets, which can be managed locally once the application is run. A bypass function allows for A/B comparison of processed and unprocessed audio signals. A graphical representation of the equalizer bands with adjustable parameters included.

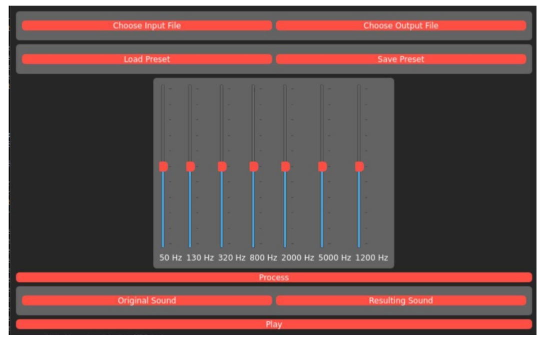

Figure 3: Graphical interface

Python Prototype: The evaluation results of the python prototype showcased exceptional accuracy and fidelity in terms of sonic reproduction. We were able to achieve a remarkably close sound to our desired outcome, highlighting the prototype's potential in delivering high-quality audio. However, one significant drawback surfaced during the evaluation process - the computational efficiency of the prototype was insufficient for real-time performance. This limitation impacted the overall feature set and functionality of the prototype, falling short of our initial expectations. While the prototype could potentially serve as a standalone version of the plugin, it remains less convenient due to its inability to operate in real time.

Real-time with Supercollider The evaluation results showed that it may not be able to perfectly reproduce the distinctive sound of the Langevin 252A due to the unavailability of its schematics. However, it does possess a commendable ability to accurately reproduce the sonic characteristics of a bandpass filter. While it may not replicate the exact sound signature of the Langevin 252A, it still offers a satisfying audio experience.

Moreover, this plugin has the potential to deliver high-quality audio output. It is designed to ensure that the audio signals passing through it are faithfully reproduced, maintaining their clarity, dynamics, and fidelity. In addition, it offers sufficient computational efficiency to enable real-time performance. It can handle audio processing tasks without significant latency or lag. This capability is especially important for applications where immediate audio feedback or live performances are involved.

3 Discussion

The VLA-252A software is a digital audio processing tool designed to replicate the characteristics and behavior of the vintage Langevin 252A hardware unit through the use of wave digital filters. By employing advanced analog modeling techniques, specifically wave digital filters, the software strives to faithfully recreate the unique sound and response of the original hardware.

The evaluation of the VLA-252A software follows a structured and systematic methodology to ensure a thorough and reliable assessment of its performance, features, and overall suitability for professional audio production. The following methodology outlines the approach taken to conduct the evaluation:

Testing and Analysis: Extensive testing was conducted to evaluate the software's accuracy, fidelity, sonic reproduction, and computational efficiency. This involved running the software in different scenarios, applying various audio sources, and assessing its performance based on predefined criteria and metrics. Real-time processing capabilities were measured, and the software's response to different parameter adjustments and signal routing options was analyzed.

Comparative Analysis: The VLA-252A software was compared with other similar analog modeling plugins or hardware alternatives available in the market. This involved benchmarking against established industry standards and conducting side-by-side comparisons to identify the unique strengths, advantages, and potential areas for improvement of the VLA-252A software.

Documentation Review: The software's technical specifications, user guides, and any relevant documentation were thoroughly reviewed to gain insights into its features, functionalities, and intended usage. This allowed for a comprehensive understanding of the software's capabilities and provided context for the evaluation.

Data collection methods: The data collection process included a combination of methods to gather comprehensive insights and feedback on the VLA-252A software. The following methods were employed:

Testing and Measurements: Quantitative data was collected through rigorous testing procedures. Measurements, such as computational efficiency, latency, and processing accuracy, were recorded to assess the software's performance objectively.

The evaluation of the VLA-252A software has identified several strengths and weaknesses that provide a comprehensive understanding of its capabilities and limitations.

One of the main weaknesses is that basic SuperCollider programming knowledge is required from the users. Moreover it is rare to find analogue models of classic audio processors in SC since the use of the program that users perform emphasizes the algorithmical aspect of control, rather than mixing methods where the 252A is mainly used.

Based on the evaluation of the VLA-252A software, several recommendations have been identified to enhance its performance, features, and overall suitability for professional audio production. This section provides an overview of the key recommendations derived from the evaluation process, aiming to guide users and decision-makers in maximizing the benefits of the software and addressing any areas for improvement.

First and foremost, it is advisable to conduct the prototyping phase using the C++ programming language. While the PyWDF library provides a convenient way to work with Python, it is important to consider the real-time processing requirements of the specific circuit being utilized. In this case, the circuit employs an R-Type adaptor which significantly hampers the processing speed when using Python. Processing just one second of audio can take up to 13 seconds, indicating a substantial performance bottleneck. Therefore, opting for C++ would be more suitable, as it offers better performance and real-time capabilities.

Furthermore, the team recommends exploring the use of a dedicated framework like JUCE for implementing the real-time version of the project. JUCE is specifically designed for audio and DSP applications, making it an excellent choice for this type of project. Leveraging JUCE's features and functionalities will likely result in more efficient and streamlined development, ultimately improving the real-time performance and overall user experience of the final product.

By following these recommendations, you can ensure that the prototyping is conducted in a language (C++) that is better suited for real-time processing, and that the implementation phase benefits from the capabilities of a specialized framework like JUCE, leading to improved performance and a more optimized end product.

4 Methods

Hardware: In the realm of equalization hardware similar to the Langevin 252A, three notable pieces stand out: Motown EQ, Cinema Engineering 7080, Altec 9062A.

Of these three, the Cinema Engineering 7080B was the first to be introduced, followed by the Altec/Langevin 252A and the Motown EQ. Interestingly, there is a shared lineage between these three pieces of equipment. The AM-5116 circuit, which is similar to the Langevin 252A, was produced by a number of different companies, including Collins and General Electric. These similarities can be attributed to Arthur "Art" Davis, who was involved with many of these companies and played a key role in the development and refinement of the circuit. [2]

The development of the Langevin 252A, Altec 9062A and Motown EQs can be traced back to the pioneering work of the Cinema Engineering. Art Davis, a highly respected audio engineer and designer, played a crucial role in the creation and refinement of these designs, and his contributions to the field of professional audio are still recognized and celebrated to this day. In the early 1950s, he designed the Model 7080B, which became the first-ever passive graphic equalizer. This design would go on to influence countless engineers and designers in the years to come. Later, Davis brought his design expertise to Langevin, where he continued to refine and improve upon his earlier work. It was at Langevin that the groundbreaking 252A equalizer circuit was born, which set the standard for equalizer design for decades to come.[2]

Afterwards, some reeditions of the EQs were made, for example the Cinema Engineering 7080B or the Heritage Audio´s Motorcity EQ, which is based on the Motown EQ. [1]

Software: As of the writing of this document, the only known plugin that emulates the Langevin 252A passive graphic equalizer is the True 252 from Krazrog. This plugin, which was released in late 2022, comes with a range of features, including: 7 band graphic equalizer, Continuous gain controls, Gain compensation, Cramping-free equalization.

It also comes with a preset manager with A/B compare, compensated internal bypass, and separate oversampling settings for both real-time and offline processing. Users can choose between two UI themes - black and gray - which are based on the original 252-A and its cosmetic variation, the 270. While there are no other known plugins that offer virtual analog modeling of the Langevin 252A, it is possible that new options may become available in the future as this technology continues to evolve. [3] [4]

Another similar plugin is the Unique Recording Software´s Motorcity EQ, which is an emulation from the Motown EQ from the 1960s.

While there are no other known plugins that offer virtual analog modeling of the Langevin 252A, it is possible that new options may emerge in the future as this technology continues to evolve. In the meantime, audio enthusiasts can also explore other virtual analog modeling plugins from top industry brands such as Universal Audio, Overloud, PluginAlliance, Waves, Chowdhury, Physical Audio and Softube. One notable example is the Unique Recording Software's Motorcity EQ, which emulates the iconic Motown EQ from the 1960s. With virtual analog modeling technology on the rise, we can expect to see even more exciting developments in the world of audio plugin emulation.

The system architecture of the software system includes: The digital signal processing engine, which will utilize Wave Digital Filters to simulate the analog circuitry of the Langevin 252A equalizer. And the graphical user interface, which will allow users to adjust parameters and visualize the frequency response.

The data model of the software system includes: The equalizer settings will be stored in preset files and recalled by the user; The audio input and output signals, which will be processed by the digital signal processing engine; The GUI parameters will be adjusted by the user through the graphical user interface in line with the abilities and behavior of the Langevin 252A equalizer.

This project's UX system is intuitive, efficient, and enjoyable for users to use. This means providing clear and concise instructions, easy-to-use controls, and a responsive design that adapts to different screen sizes and resolutions. Also, the team considers factors such as color contrast, font size, and keyboard accessibility to ensure that the system is usable by as many people as possible. This project's UI system is clear, simple, and intuitive, providing users with easy-to-use controls and a visually appealing design. The project team considers factors such as color scheme, typography, and layout to create a cohesive and aesthetically pleasing user interface.

The user interaction of the software system includes: Adjusting equalizer settings through the graphical user interface; Saving and recalling presets; Loading and saving audio files; Bypassing the equalizer; A/B comparison; Monitoring the frequency response of the equalizer; Choose between working on mono stereo.

5 References

[1] G. Louie and G. White, "The Audio Dictionary", University of Washington Press, 2005, p. 140. [Online].

[2] "In Memoriam," Audio Engineering Society Journal, [Online].

[3] "True 252A," Kazrog, [Online].

[4] "URS M Series Motor City Equalizer," Unique Recording Software, [Online].

6 Acknowledgements

We thank our teachers: Xavier Serra (coordinator), Xavier Lizarraga, who were in touch throughout the project and also gave us enough comments and help. Your support has been an important part of our success and we are delighted to have had the opportunity to work with such outstanding teachers.

7 Authors

Andrea Sofia Vallejo Budziszewski, REC Música, Mexico, Pompeu Fabra University, Spain, sofiavallejo98@hotmail.com

Chris Morse, University of Vermont - Burlington, USA, Pompeu Fabra University, Spain, cemorse100@gmail.com

Du Huang, Stony Brook University, USA, Pompeu Fabra University, Spain, du.huang01@estudiant.upf.edu

Pablo Rodríguez, Pompeu Fabra University, Spain, pablo.rodriguez04@estudiant.upf.edu

Polina Zvoda, ITMO University, Russian Federation, polina.zvoda@gmail.com

Tommaso Settimi, University of Music and Performing Arts Graz, Graz, Austria, Pompeu Fabra University, Spain, tommsett@gmail.com