Simple Signal Processing: Designing a User-Experience-Oriented Digital Equalizer

Andrew Bainton, Master of Fine Arts in Recording Arts and Technologies

Primary Advisor: John Merchant | Secondary Advisors: Michael Fleming and Misty Jones Simpson

MIDDLE TENNESSEE STATE UNIVERSITY

COLLEGE OF MEDIA AND ENTERTAINMENT

ABSTRACT

In the current era of digital software, audio processing plug-ins have become complex and feature-rich, offering more choice and flexibility with greater Central Processing Unit (CPU) efficiency. However, clarity, simplicity, and an open User Experience (UX) are often lost in the excess of features. This project aims to create a simple, easy-to-use, and non-intrusive digital equalizer for mixing and mastering, developed using JUCE, a C++ programming framework, and Pro Tools, the industry-standard digital audio workstation. This project's design component focuses on creating an equalizer plug-in that caters to my learning disability called dysgraphia, which makes it difficult for me to write by hand and operate machinery. The plug-in, for example, does not require fine mouse movements to operate its controls and allows one to focus on subjective spectral changes. One unique feature of the plug-in is the use of intuitive terms such as “presence” and “warmth” for the various controls, allowing for perceptive control of the equalizer. The project's creative component consists of utilizing the plug-in to mix “Left Feet,” by singer/songwriter Maggie Aldridge, which I produced at MTSU and is showcased on aptitudeaudio.com. While the project is not created for individuals with disabilities, the intent is to provide a sound engineer a UX like mine when applying the plug-in to their productions.

BACKGROUND

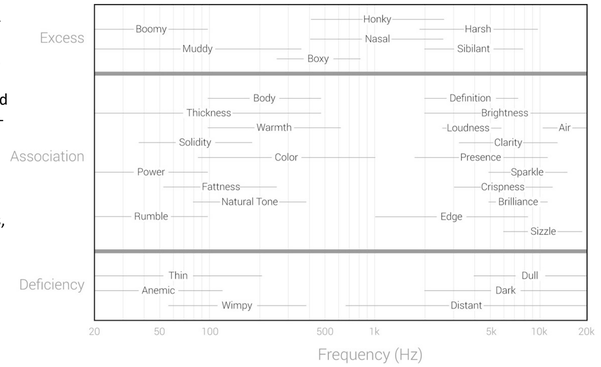
I decided to create an equalizer plug-in because of limitations I experienced with my learning disability Dysgraphia, which makes it difficult for me to write by hand and operate machinery. I am also fascinated with shaping the spectral balance of sound. Between these two factors, I created an equalizer that is simple and easy for me to use. To note, I am not claiming that this device will make mixing easier for other people with the same or different disabilities, as I am not a medical professional. I have simply designed it for myself in the context of my challenges, and hope that other people will enjoy using it as well.

I created this plugin with JUCE, a C++ programming framework, and AVID’s Pro Tools, the industry standard Digital Audio Workstation (DAW). JUCE has many pre-built functions such as filters, gain modifiers, and measurement tools that allow one to design and program a plug-in without having to worry about spending time to create one’s own functions. The convenience of this allows the programmer to focus on their design and implementing their vision. As such, they can spend time refining the behavior of their filters through manipulating their parameters, for example, rather than the Digital Signal Processing (DSP) components and coefficients. I found that Pro Tools is the ideal DAW for me to test my plug-in designs because it is the industry-standard DAW, and because of my familiarity with it as a graduate student in audio.

This project started from a simple design and has grown into a simple and versatile one. The first drawings I have of the GUI and first descriptions of what I wanted the core functions of the device to be featured a high-pass filter, input gain, and two peak filters with a wide range of flexibility in terms of center frequency selection and gain selection. The most recent design that one may see in the photograph above features subjective names for each of the peak filters, rather than names of frequencies explicitly. The purpose of this is to provide the user with a more subjective experience of spectral balance shaping.

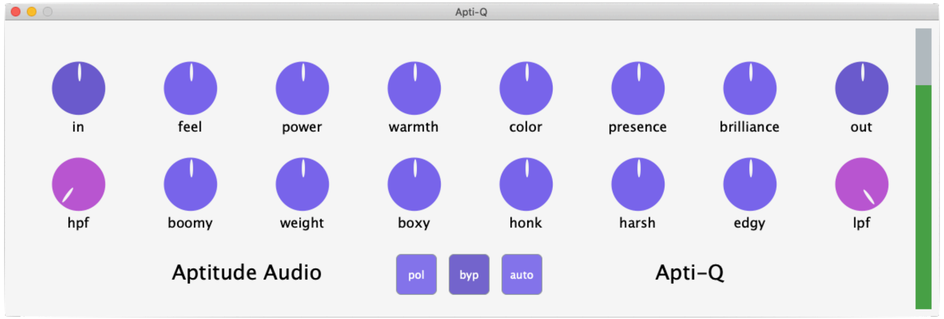
EQUALIZER DESIGN

The focus of this equalizer plug-in is to offer the user an opportunity to think subjectively while equalizing in a mix. Terms in the plug-in such as “Warmth” and “Presence” are based on frequency ranges offered in Roey Izhaki’s *Mixing Audio*, where he describes “[s]ubjective terms we associate various frequency ranges with, and excess or deficiencies in these ranges.” The chart below highlights these subjective terms for frequency ranges in the audio spectrum and inspired me to create an equalizer using several of them.



In terms of the Graphical User Interface (GUI), I decided to use softer yet vibrant colors reminiscent of the color schemes of Apple’s macOS. I grew up using the Macintosh, and its presence in my life significantly helped me to fight against my limitations regarding my learning disability. For this reason, I wanted the colors in my GUI to reflect the macOS aesthetic.

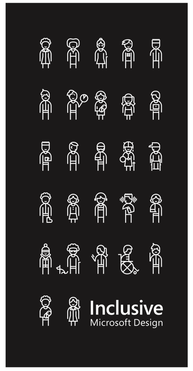
In terms of the technical parameters of the design, the plug-in (shown below) features twelve peak filters, a high-pass filter, a low pass filter, input and output gain, a polarity inverter, a master bypass, and auto make-up gain. In terms of the device’s intricacies, the twelve peak filters are all asymmetrical Proportional Q filters, meaning that Q, or quality factor, increases as gain deviates from 0 dB, and that the cuts or gain reduction half of the Q function is narrower than that of the boots or gain enhancement section. Further, Q is narrower at higher frequencies and broader at lower frequencies. The high- and low-pass filters have a slope of 18 dB/octave, meaning that they are made of a 6 dB/octave filter and a 12 dB/octave filter strung together in series. For the purpose of high- and low-pass filtering, I believe 18 dB/octave filters have the optimal slope in the way that they compromise between the sonic characteristics of 12 and 24 dB/octave filters. The auto make-up gain switch in this design is limited to a change of ±6 dB. This allows the user to still push the gain of the device while keeping the overall balance in a reasonable range. This allows the user to make drastic changes to their sound while not worrying about clipping the output of the device based on the timbral changes one makes internally to the plug-in.



ABOUT EQUALIZATION

The history of equalization spans from the telegraph through modern artificial intelligence, including analog and digital designs. While the purpose of equalization has evolved, the common element is a goal to communicate clearly. According to Alex Case, an equalizer could be defined as a “frequency-specific amplitude adjuster.” Equalizers have filters which one uses to adjust the spectral balance (evenness of frequency representation across the audio spectrum) of a sound. These filters have parameters including type (pass filter, peak, and shelf), slope, frequency, Q (or quality factor), and gain. These parameters are determined by the structure of the components in the electrical or software engineer’s designs. In an analog (electrical) equalizer design, resistors, capacitors, and inductors (among others) make-up analog circuits, which adjust the properties by which analog audio signals flow through a device. In a digital (software) equalizer design, mathematical coefficients and calculations manipulate digital audio signals. This digital style of processing is called Digital Signal Processing (DSP), and this project’s digital equalizer plug-in implements DSP to process audio signals.

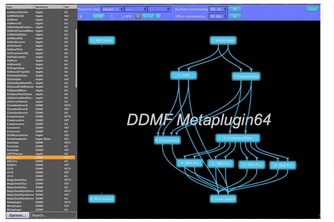
USER EXPERIENCE DESIGN



The most significant aspect of User Experience Design (UX/D) is the attention to detail for the care of the user. Rather than assume a user will like a product because it is well-engineered, UX designers focus on the whole picture of a person using a product or service and consider everything they will interact with and think about as part of their product experience. Ensuring this quality of a product or service requires knowledge and insight on the part of a designer to oversee a product’s creation and make the experience of using the product seamless. One aspect of UX is Inclusive Design (ID), which focuses on the full range of human diversity when designing a product. I created this project from my experience with my disability and use the ID concept “Solve for One, Extend to Many” as part of my design ethos.

APPLICATION

For the creative element for my project, I used my plug-in to mix a song “Left Feet” by Maggie Aldridge which I produced at MTSU in the summer of 2019. My classmate Dustin Painter recorded “Left Feet” to Pro Tools, and I mixed it in Pro Tools exclusively. Currently, my plug-in is not available in the AAX Native format, the plug-in format Pro Tools uses to host processors and virtual instruments. As such I used DDMF’s Metaplugin as a wrapper to host the VST3 build of my plug-in in the Pro Tools Session. I found that my plug-in allows me to shape the spectral balance more efficiently, due to the intentional limitations of the device. I found that in using the tool I am not so absorbed in trying to control the device properly and can instead redirect my energy to the music and the mix.



REFERENCES

Izhaki, Roey. *Mixing Audio: Concepts, Practices, and Tools*. 3rd edition. New York: Routledge, 2017.

Microsoft Design. “Inclusive,” 2016. https://download.microsoft.com/download/b/0/d/b0d4bf87-09ce-4417-8f28-d60703d672ed/inclusive_toolkit_manual_final.pdf.

ACKNOWLEDGMENTS

Acknowledgment and thanks to John Merchant, Michael Fleming, Misty Jones Simpson, Bill Crabtree, Dan Pfeifer, John Hill, Dr. Deborah Wagnon, Dustin Painter, Benjamin Warsaw, and Maggie Aldridge for their support.