

Introducing **accessEQ**

FOR ENHANCED AUDIO
ON THE MAC



accessEQ Background

80% of hearing aid demos are returned by dissatisfied users, why?

Speech intelligibility is not improved

accessEQ Background

SNR determines speech intelligibility,
generic gain does not improve SNR

The hearing aids DSP is computationally weak
compared to the Mac's processor

Can the Mac processor be used to improve
speech intelligibility of Mac audio in real-time?

A: accessEQ

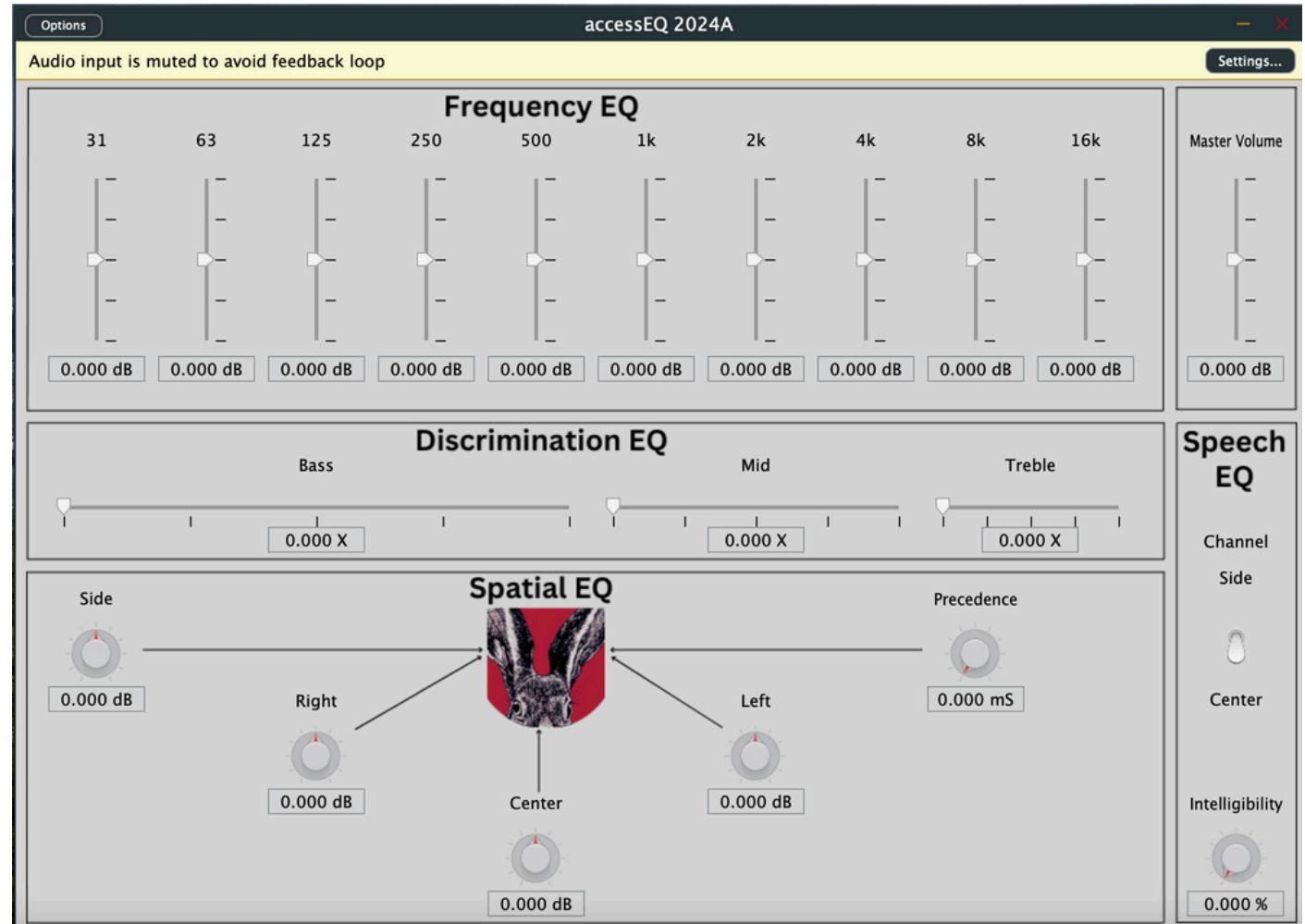
Downloading & Installing **accessEQ**

- Download the free **accessEQ** 2024A release (1.0.0.0) from Github @
 - <https://github.com/TCupolo/accessEQ/releases/download/1.0.0.0/accessEQ.app.zip>
- Unzip **accessEQ.app.zip** to **accessEQ.app**
- Move **accessEQ.app** over to the standard Mac Applications folder
- Double click **accessEQ.app** to run it

accessEQ App

accessEQ is like a software hearing aid when run as an app. It uses the Mac's built-in microphone.

Also, the very 1st time its run, it registers as an AUv3 plugin with macOS.



NOTE: to confirm registration was successful, run **auval -a** in the terminal, a complete list of installed plugins is returned.

accessEQ Plugin

Even when **accessEQ** is not being run as an app, it can still function as a plugin with 3rd party hosting apps. There are 2 types of hosting apps.

- **SWAC**: System Wide Audio Capture
 - Enables **accessEQ** to process all Mac audio real-time
 - The *primary* use case
- **DAW**: Digital Audio Workstation
 - Enables **accessEQ** to process recorded audio
 - A *secondary* use case

SWAC Hosting App Options

- **SoundSource** by Rogue Amoeba

- Has been around for over 10 years
- Has worked with **accessEQ** for 3+ years
 - Regular updates for bug fixes/new features
- Free 14 day trial then paid
- <https://rogueamoeba.com/soundsource/>



- **eqMAC** by Roman Kisil

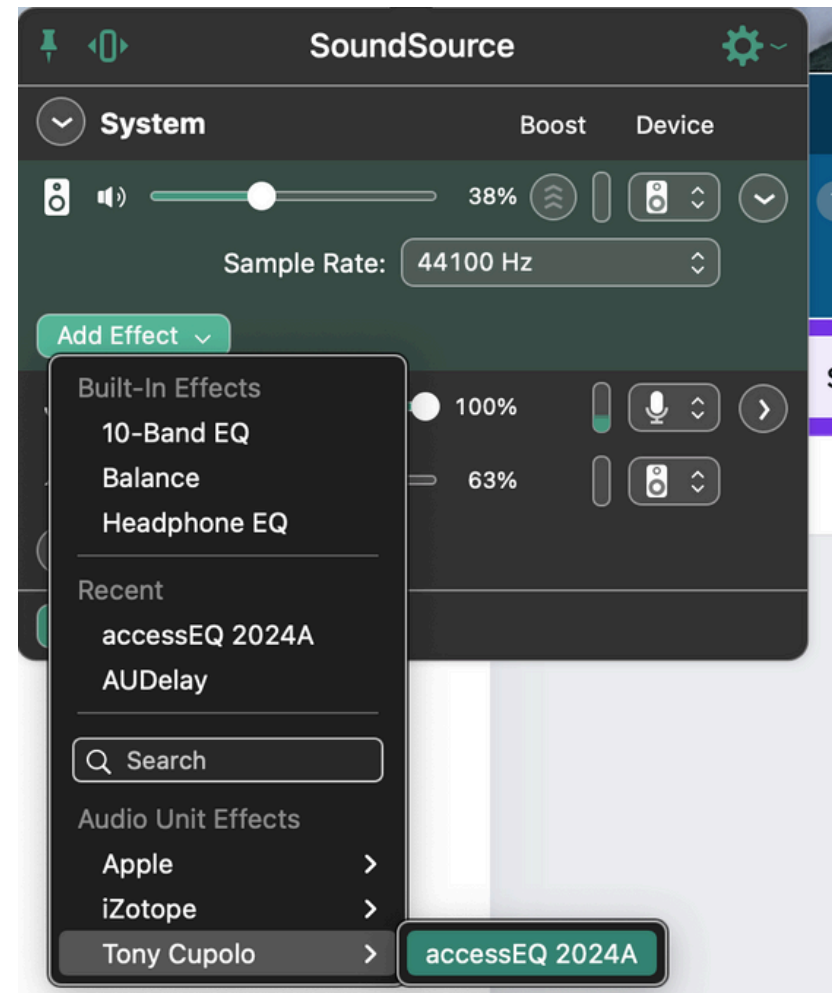
- Has been around for about 2 years
- Has worked with **accessEQ** for 1+ year
- Free Basic version, paid Pro version
- <https://eqMAC.app>



NOTE: Both of these apps must be downloaded from the above sites. Around 2022, as an enhanced security measure, Apple decided to make installing any app downloaded outside the Mac App Store intentionally difficult. As a result, the installation process for both of these apps now requires some manual intervention. This consists of changing security settings (which you will be prompted for) and rebooting the Mac before the installation can complete.

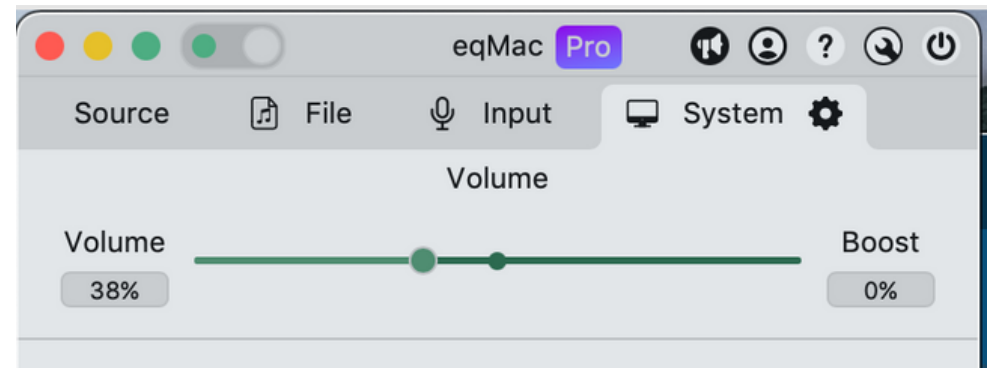
Using **accessEQ** with SoundSource

- Run SoundSource
- Click Add Effect
- Select Tony Cupolo
- Select **accessEQ** 2024A
- Enable **accessEQ** 2024A

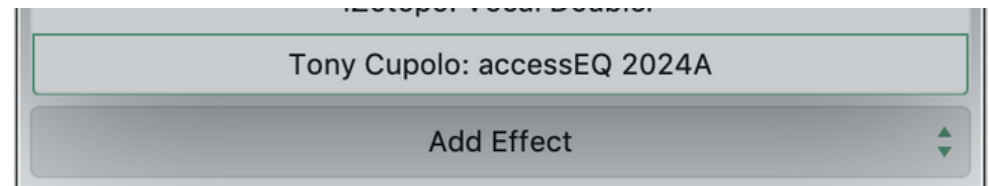


Using **accessEQ** with eqMAC

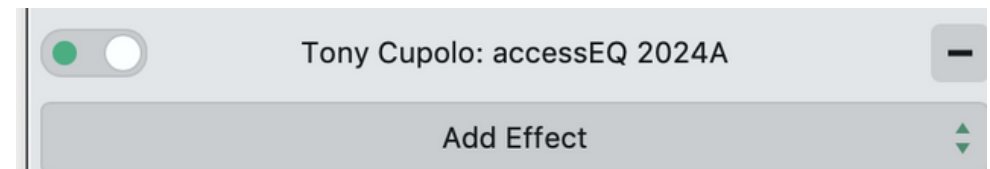
- Run eqMAC



- Click Add Effect
- Select Tony Cupolo: **accessEQ** 2024A



- Enable Tony Cupolo **accessEQ** 2024A



DAW Hosting App Options

- **Audacity** by The Audacity Team
 - Has worked with **accessEQ** for 3+ years
 - Free
 - <https://www.audacityteam.org/>
- **GarageBand** by Apple
 - Has worked with **accessEQ** for 3+ years
 - Free
 - Download from the Mac App Store



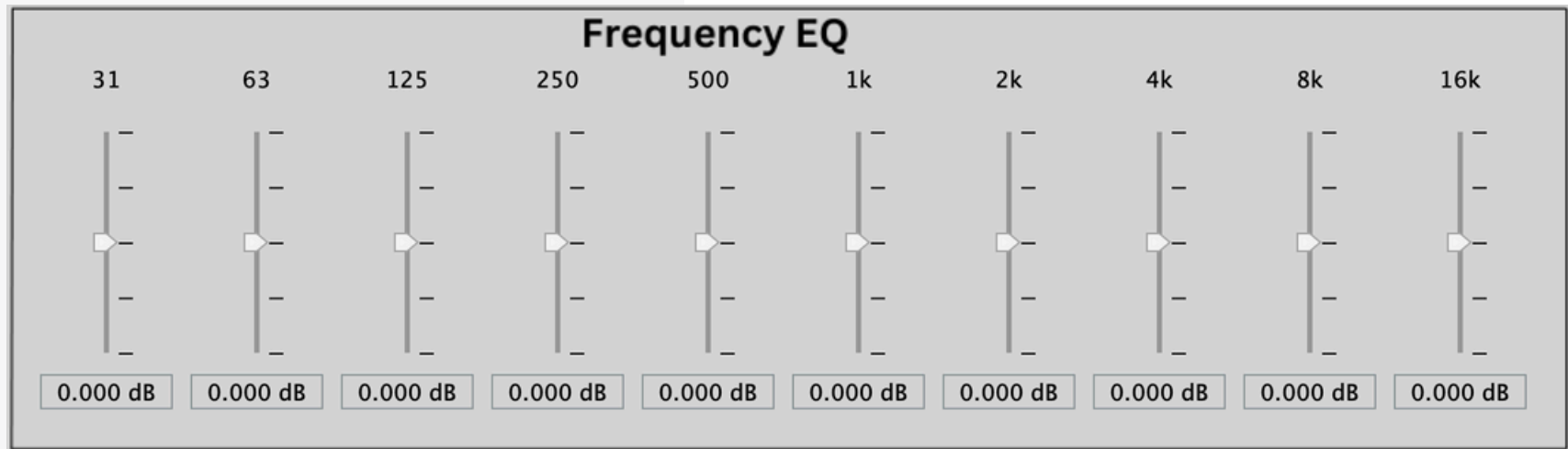
NOTE: AUv2 plugins were known to occasionally cause DAWs to “hang” and there was no easy way to exit this condition other than to reboot. So, Apple came out with the AUv3 format mostly to improve DAW users experience with plugins. AUv3 plugins (like **accessEQ**) can now be killed independently of the DAW process. This is simply accomplished by running “Force Quit” (under the Apple icon on the menu bar at the top) on the plugin.

EFFECTS

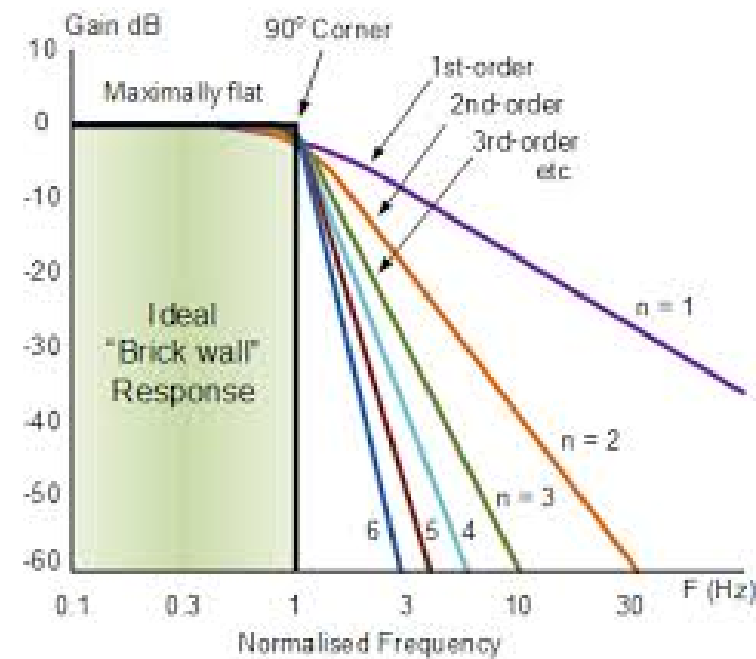
accessEQ provides 5 different types of EQ, all for the purpose of enhancing audio, and specifically to improve speech intelligibility.

Frequency EQ

The human hearing spectrum spans from 20hz to 20Khz, which **accessEQ** divides into 10 octaves, with center frequencies:

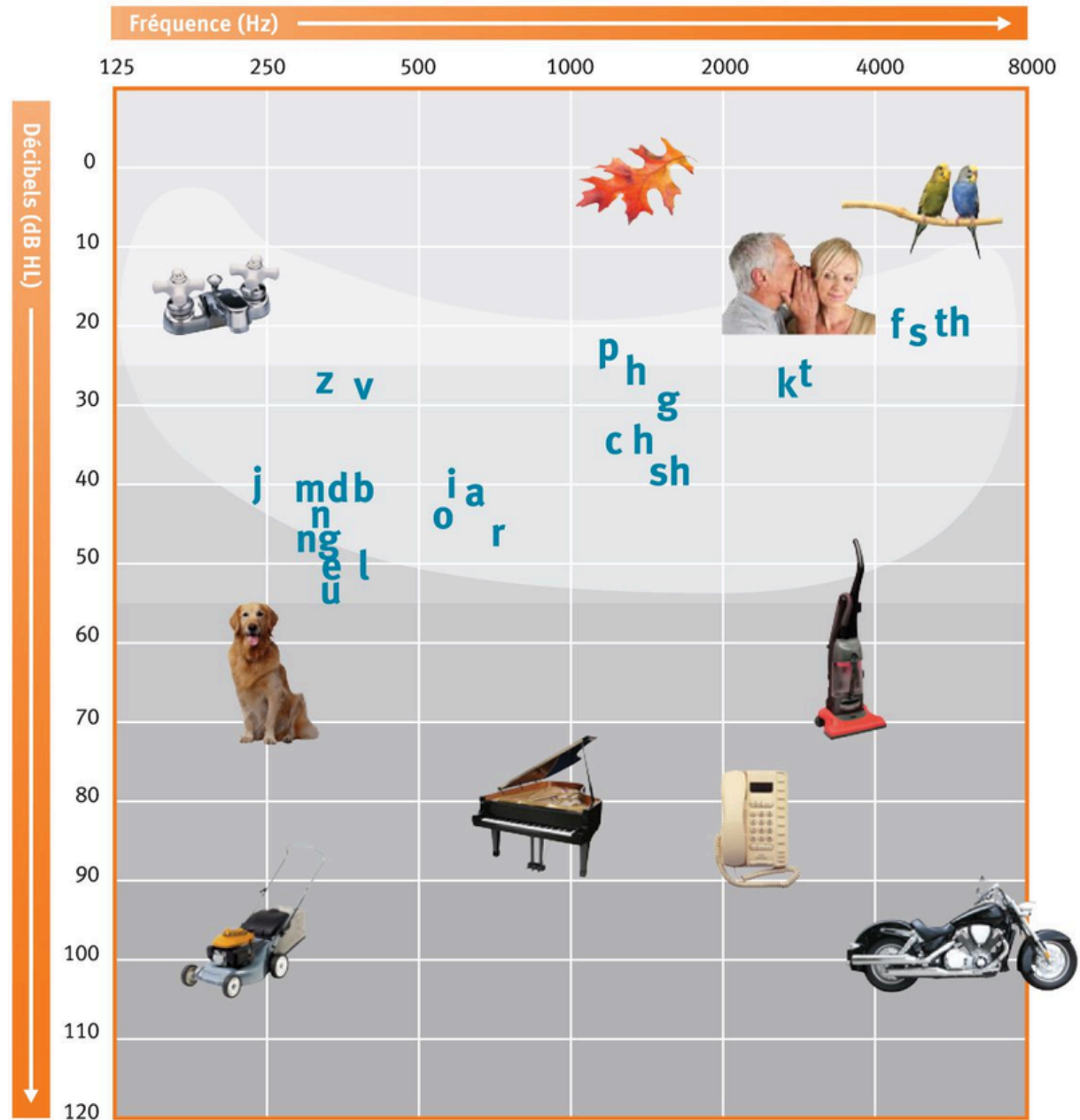


accessEQ uses 6th order filters to ensure the spectral purity of each octave. The graph to the right shows how they compare to other filter orders, which in turn reveals their practical equivalence to brick wall performance.



Frequency EQ

As a reference, the graph to the right shows how the so-called “speech banana” and other common sounds span the human hearing spectrum as a function of signal amplitude.



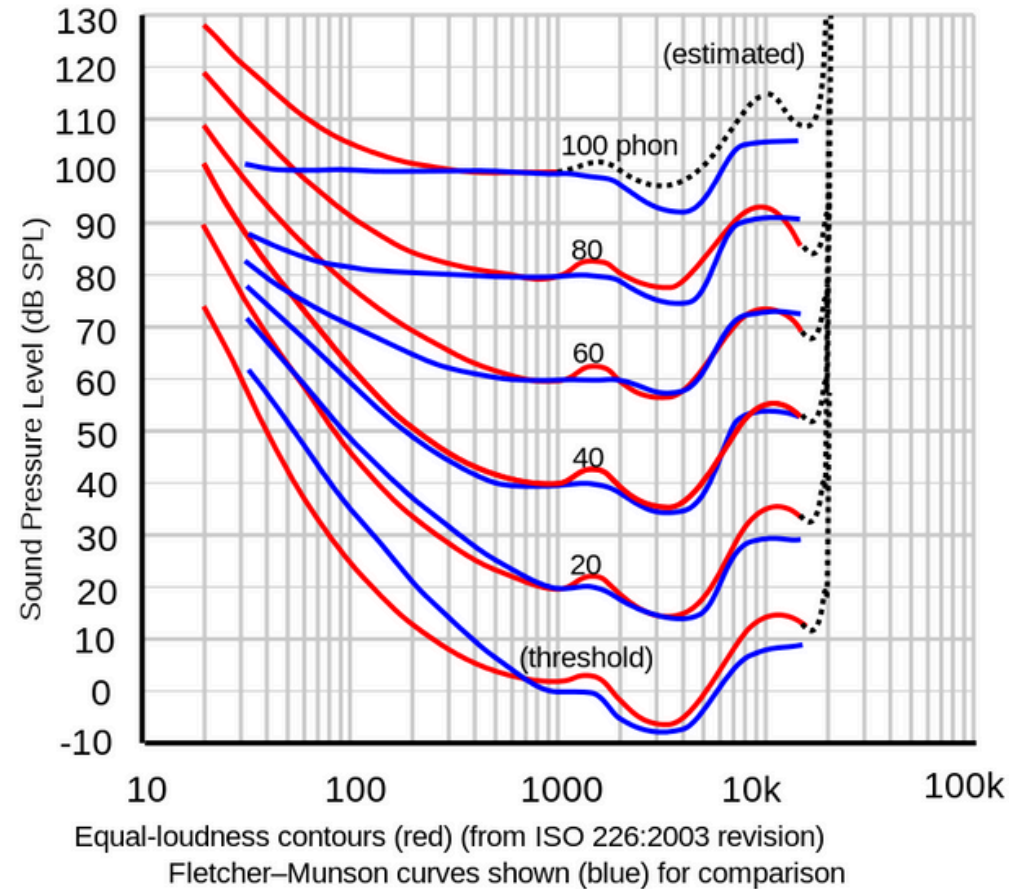
Discrimination EQ

One of the advantages of using **accessEQ** is it's inclusion of new effects related to frequency resolution metrics. They determine the SNR required for speech intelligibility. There are 3 key frequency resolution metrics:

- Frequency Discrimination:
 - Determines how far apart *in frequency* 2 different *sinusoids*, **separated in time**, must be to be perceived (as melodies).
- Frequency Selectivity:
 - Determines how far apart *in frequency* 2 different *sinusoids*, **present simultaneously**, must be to be perceived (as chords).
- Frequency Tuning:
 - Determines how far apart *in amplitude* 2 different *sinusoids*, **present simultaneously**, must be to be perceived (as a properly tuned instrument).

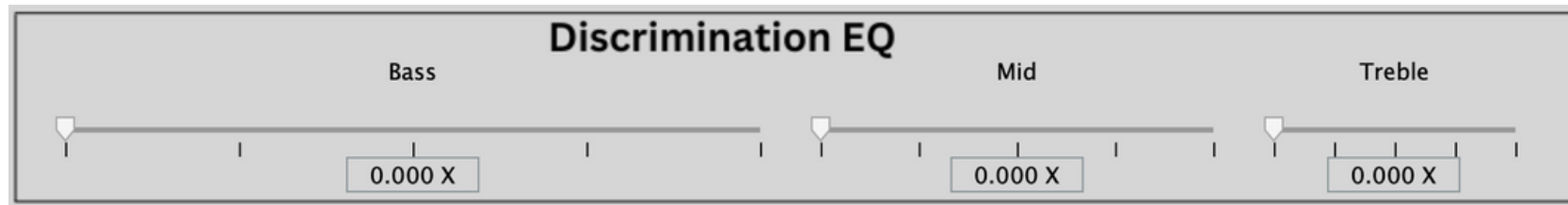
Discrimination EQ

Fletcher and Munson were the first auditory researchers to investigate how loud the human ear perceives different frequencies at the same amplitude. They published their results as a set of equal loudness contours. Later researchers published a more accurate set of measurements as the ISO 226-2003 standard, shown to the right.



Discrimination EQ

accessEQ converts these equal loudness contours into an equivalent single filter specification. The filter is partitioned into 3 bands as follows:



Each discrimination filters covers the following frequency band:

- Bass: 20Hz - 750Hz
- Mid: 750Hz - 6000Hz
- Treble: 6000Hz - 20000Hz

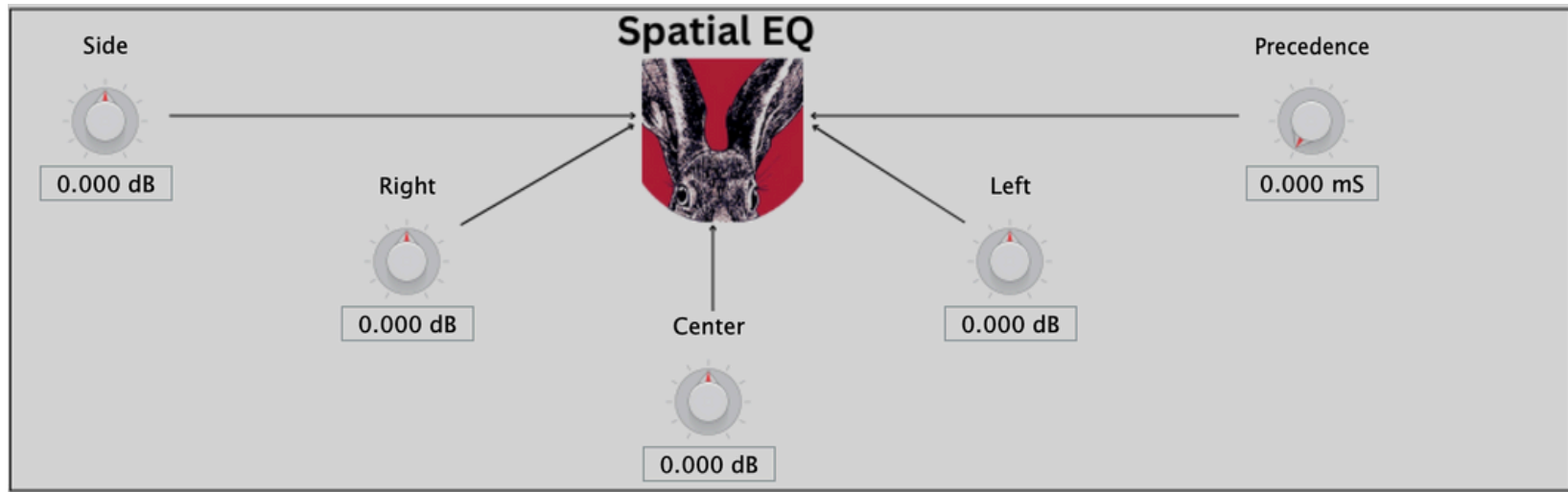
Testing has determined discrimination is typically most improved with the following settings:

- Bass: 0.15 - 0.25
- Mid: 0.50 - 0.65
- Treble: 0.20 - 0.50

Spatial EQ

Sound can also be viewed as a field, something that arrives from various directions. Most commonly, audio is delivered as a stereo signal which consists of a **left** and a **right** channel. Simple math allows these to be converted into **center** and **side** channels.

accessEQ provides independent gain controls for all 4 channels, which are displayed intuitively as follows:



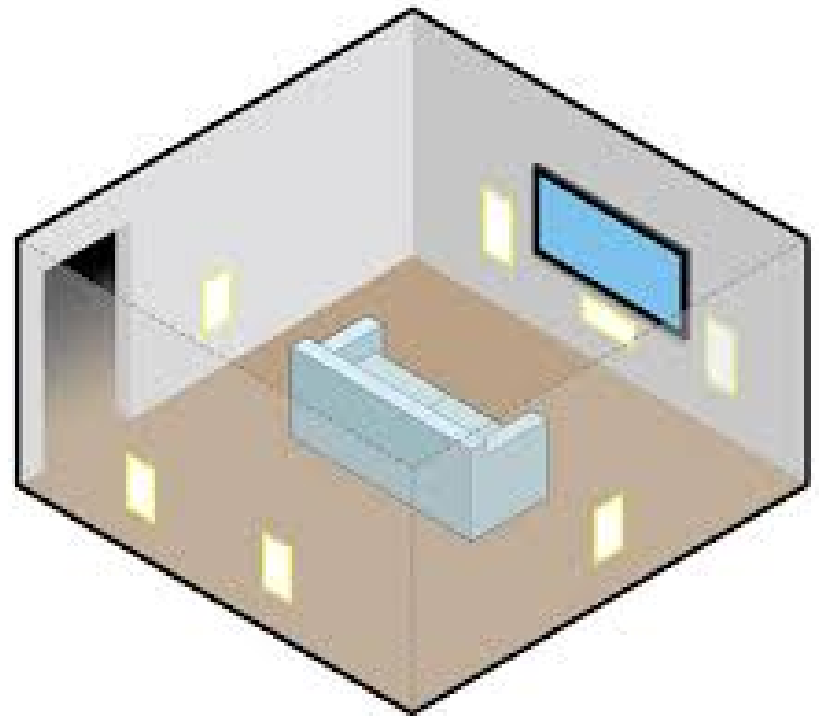
NOTE: The Precedence effect allows some delay to be introduced between the **center** and **side** channels. This can be used to add more of a “live” feel to both recorded audio and video soundtracks.

Spatial EQ

Older music was recorded with vocals in the **center** and instruments on the **side**. This was intended to replicate live performance setups as shown below. However, this tended to “mask” the instrument tracks, which can now be brought back out by applying **side** gain.



In home theater and vehicle settings, spatial EQ likewise allows for compensating out changes in the spatial signal balance due to distributed speaker placements:



Speech EQ

SNR is a function of:

- Signal amplitude
- Noise from frequency components
- Noise from spatial components
- Reduced frequency resolution due to mixing multiple audio sources at different loudness levels

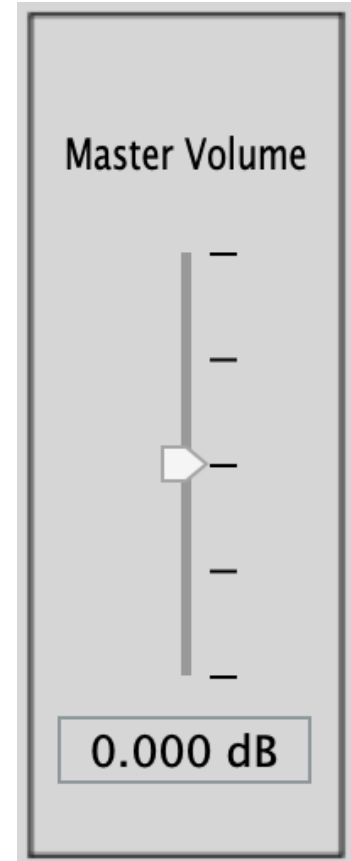
For these reasons, **accessEQ** provides a single control, shown to the right, that “overrides” all effects settings to simplify improving speech intelligibility real-time. The user only needs to select the desired speech channel (**center** or **side**).

Works great on web calls!



Loudness EQ

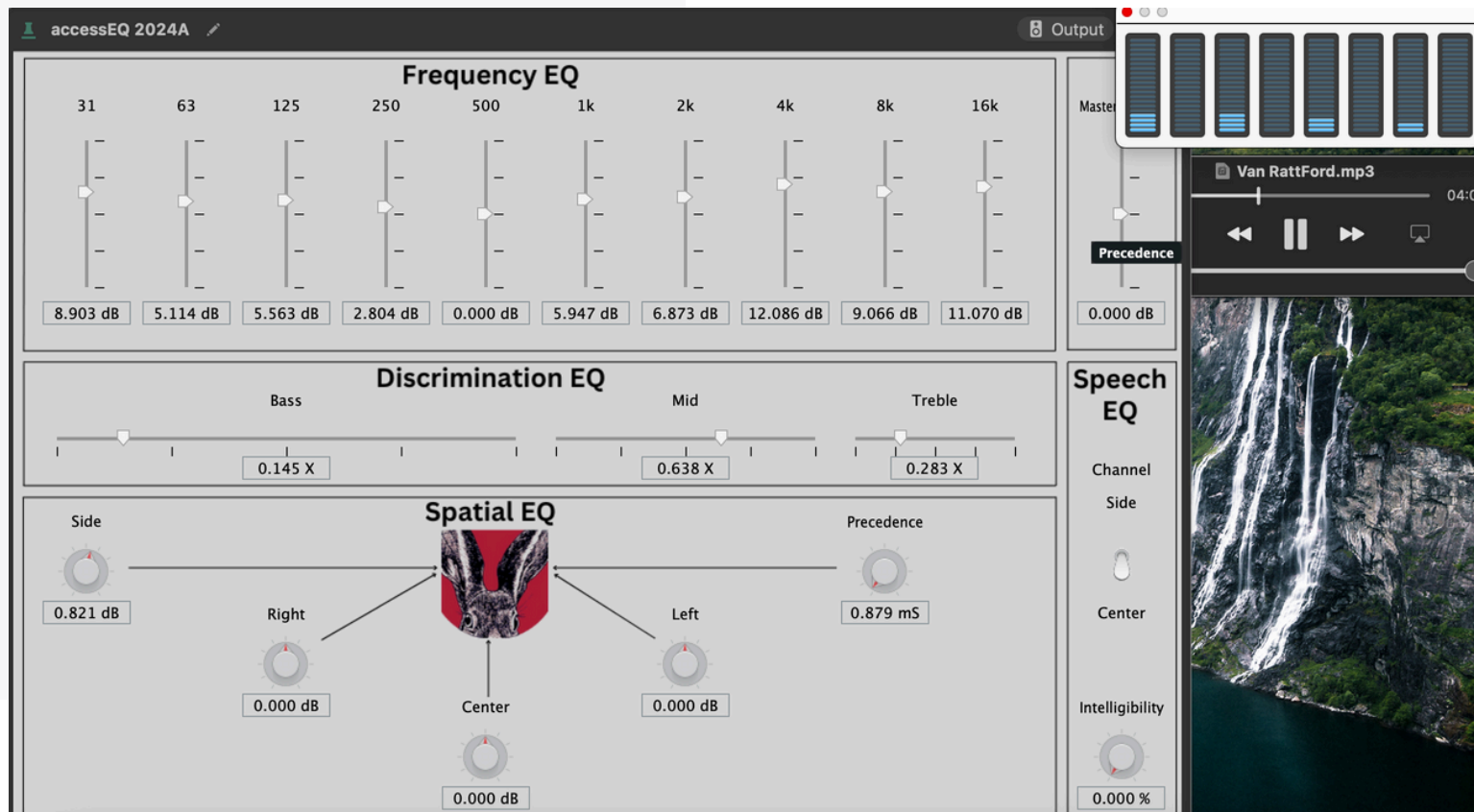
accessEQ was built for the purpose of enhancing audio quality at the SAME volume. After all the previous effects are applied, the new “wet” signal volume changes. Therefore, a Master Volume control is provided to allow users to adjust the wet volume back to the dry volume level. In this way, the master volume really should be considered a Loudness EQ effect.



NOTE: All the hosting apps provide a master “enable/disable” control for plugins. Toggling it, while adjusting the Master Volume, is a simple way to match the wet & dry volume *after* all other effects have been set.

Mac Processor Loading

Despite all the audio signal processing **accessEQ** performs real-time, when run from a SWAC hosting app there is minimal impact on the Mac's processor loading. The screen capture below shows the Mac's real-time Activity Monitor CPU (Quad-Core) Usage bar graph display. SoundSource is hosting **accessEQ** which is processing the audio QuickTime is playing.



accessEQ Open Source Motivation

- 50% for better user support
 - As the user base grows, it will quickly become too much for one person (me) to support
 - Finding the right effect settings can be challenging
 - Particularly for non-technical users
- 50% for broader platform deployment
 - iOS/Android/Windows
 - See the Fork Wishlist for details

Support Plan

End Users

- I'll create Youtube videos and share them on my YouTube channel:
 - <https://www.youtube.com/@RaidioTony>
- I'll create an AI chatbot assistant trained on **accessEQ**, it could be integrated with an **accessEQ** host app (see the Fork Wishlist).

Developers

- My LinkedIn account is publicly open to developers to connect with me for technical Q&A:
 - <https://www.linkedin.com/in/tonycupolo/>
- I'll add technical content to the **accessEQ** Github Wiki
 - <https://github.com/TCupolo/accessEQ/wiki>

Branch Roadmap

Branch here means features I plan on implementing in future Github releases. Matlab releases come out bi-annually, most contain new audio features.

accessEQ releases will follow the same schedule.

Branch Release	Feature	Description
2024B	Compression	A tri-band compressor that will raise accessEQ status to a full software hearing aid. Matlab already has support for compresion but the UI is too complicated given accessEQ's other features. So, this release is pending the release of an enhanced plugin UI feature from Matlab. I have submitted a request for such an improvement to Matlab.
2025A	Selectivity EQ	The second frequency resolution feature that will further improve speech intelligibility.
2025B	Tuning EQ	The third frequency resolution feature that will further improve speech intelligibility.
2026A	Speech Extraction	AI can already extract speech from any background but not yet in real-time.

Fork Wishlist

Fork here means features I hope others will implement in future Github releases.

Fork	Feature	Description
macOS	Audio Server Driver Based SWAC Host	Apple only allows SWAC hosting apps into the Mac App store if they use this method. (SoundSource and eqMAC do not.) Getting an integrated accessEQ SWAC host/plugin app into the Mac App store would be a big adoption driver, particularly if it's free. An integrated AI chatbot assistant would be a great additional feature.
iOS	AudioBus Host / iOS App Extensions	Apple doesn't offer any SWAC type framework on iOS due to their app sandbox policy. However, Audiobus is a highly adopted 3rd party API that allows apps to voluntarily exchange audio data real-time. This opens the door to the possibility of an Audiobus based integrated accessEQ host/plugin app. However, App Extensions for the core Apple iOS apps would also have to be developed to support sharing their audio data with accessEQ over Audiobus.
Windows	SWAC Host	Converting accessEQ to the PC compatible VST plugin format is trivial. However, I don't know of any SWAC hosting apps for the PC. Further, the Windows audio engine is well known to suffer from large audio latency.