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ATTRIBUTES AND TUNING OF A PARAMETRIC EQUALIZER

White Paper

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ATTRIBUTES AND TUNING OF A PARAMETRIC EQUALIZER

All heard sound is a subjective experience. Multiple factors contribute to our perception of sound quality. The equipment used to record a sound and the audio system used for its playback will both dramatically affect the observed quality of a finished recording. In an environment in which sound is played through a speaker, the physical space can deaden (absorb) some frequencies, while the natural resonance of the room can enhance others.

Sound systems can change the perceived quality of sound for the listener by enhancing or decreasing the output power at specific frequencies through the use of an equalizer. Voice and music playback can thus be tuned to the listener's preferences.

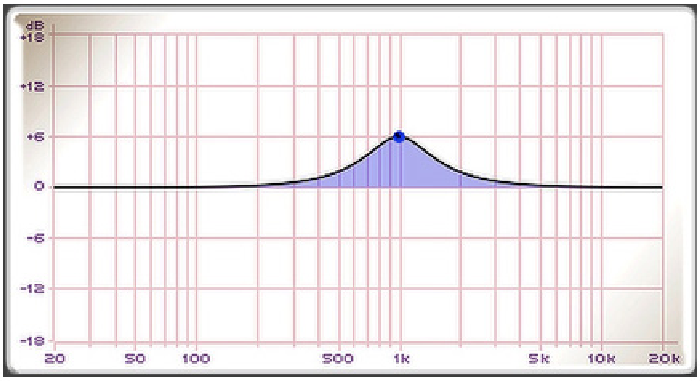
When it comes to equalizing your sound, a parametric equalizer (EQ) is one of the most versatile equalizers you can use. That's because it offers the flexibility to make vastly different types of alterations to the sound of an audio signal.

A parametric EQ allows you to make both very subtle and extreme changes to the frequency spectrum of your audio. Similarly, you can both pinpoint very specific frequencies to equalize, and make broad changes to large groups of frequencies.

A parametric EQ enables increases in gain (boosts) or reductions in gain (cuts) to relatively narrow bands of the frequency spectrum. The frequency response curve of a parametric EQ at a given frequency band resembles the shape of a bell. These bell-shaped regions of cut and boost can be made at a desired frequency and bandwidth as seen in the figures below.

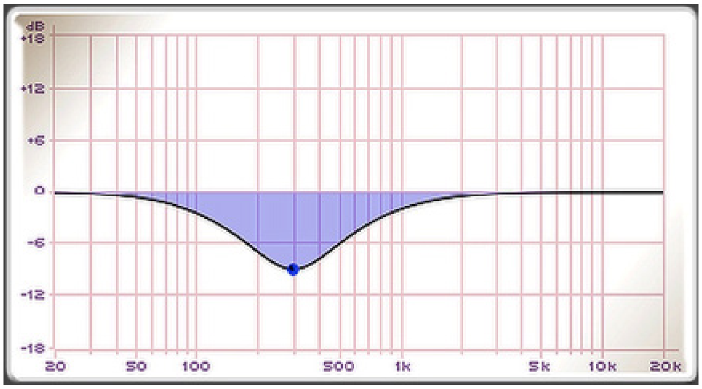
This adjustment versatility allows selection of the frequency and the bandwidth at which the boost or cut is made.

This graph shows a boost of 6dB* at 1kHz



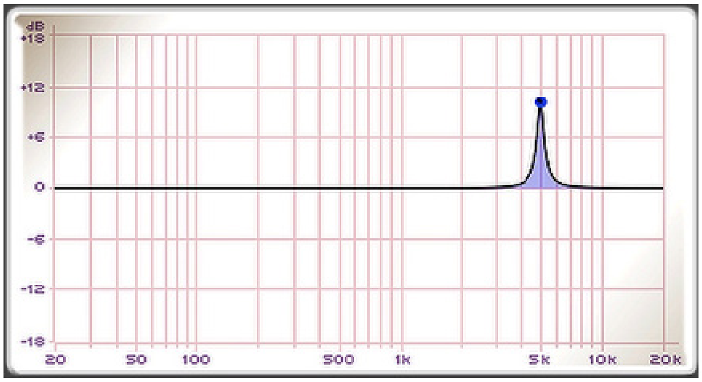
***decibel, a measure of sound power*

This graph shows a cut of -9dB at 300Hz:

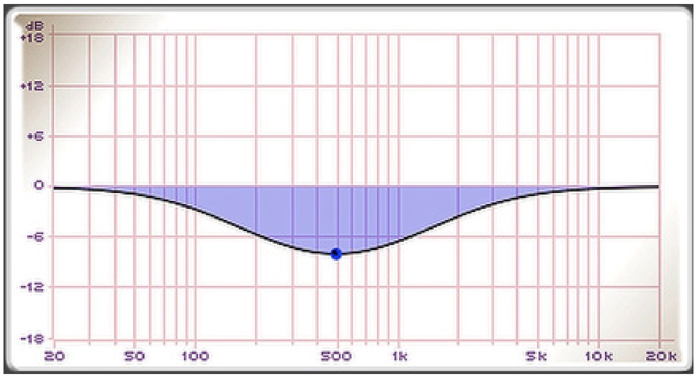


In addition to being able to specify your desired frequency and gain amount, a parametric EQ allows you to control the width of the bell curve (i.e., Q) of the cut or boost that you're making. In equalizers, Q is the ratio of center frequency to bandwidth, and if the center frequency is fixed, then bandwidth is inversely proportional to Q—meaning that as you raise the Q value, you narrow the bandwidth.

For example, here you can see a very narrow boost of 10dB at 5kHz using a relatively large Q value:



Whereas here, you can see a very wide cut of -8db at 500Hz using a relatively small Q value:



THE THREE CONTROLS OF A PARAMETRIC EQUALIZER

GAIN: The gain parameter adjusts the amount of boost or cut that you are applying. This is typically in the range of +15 dB to -15 dB.

CENTER FREQUENCY: The center frequency refers to the frequency that resides at the very center of the bell-shaped boost or cut that you are making to the audio signal. The range of the center frequency adjustment can be from 2 or 3 octaves to as fine as 1/3 octave, depending on how many frequency bands the EQ is equipped with.

Q or BANDWIDTH: Q refers to how narrow or wide your boost or cut is. Bandwidth is usually controlled by a ‘Q’ setting, which stands for ‘quality factor.’ The higher the value of the Q setting, the narrower the bandwidth will be. Similarly, the lower the Q value, the wider the bandwidth will be.

Mathematically, Q can be calculated simply by dividing the center on frequency of the filter by the difference of the two frequencies at the -3 dB points either side of the center frequency. For instance, if the filter center frequency is set to 980 Hz, and the two frequencies on either side of 980 Hz (where the amplitude is -3 dB down from the center frequency) happen to be 856 Hz and 1122 Hz, then this equates to a Q of 3.68. The equation looks like: **Q = 980/(1122-856) = 3.68**

WHY USE A PARAMETRIC EQUALIZER?

Parametric equalizers offer an unparalleled level of flexibility over the kind of equalization you create. By controlling the equalizer’s gain, center frequency, and bandwidth parameters, you can make precise EQ alterations to suit the needs of your sound application.

You can make changes to large portions of the frequency spectrum to change the overall sound. But you can also make very specific, surgical alterations to fine-tune the sound. The ability to make such varied alterations makes a parametric equalizer an extremely versatile equalizer to use.

Feedback Control

Feedback occurs when a device such as a microphone “hears” the speaker(s) to which it is supplying the source audio, creating an acoustically coupled loop (i.e., feedback).

The initial solution to remove this form of acoustic feedback is to physically break the path that allows the microphone to hear its own audio from the speaker(s) by repositioning one or both. If that is not possible, then EQ can be used to reduce the gain at a strategic frequency that breaks the audio feedback loop.

The offending feedback signal is primarily sinusoidal in form. This is good, because it makes it much easier to dial-in a narrow Q notch (cut) to eliminate it.

To the uninitiated, a total reduction in gain is usually attempted to stop the feedback. This has the unfortunate effect of reducing the amplitude of all the other frequencies in the audio spectrum that are not involved with the feedback.

Feedback elimination only requires a 3dB reduction in gain—that’s half the power at the offending frequency. Once that offending frequency is found, there is no need to compromise the adjacent audio spectrum by making the notch too deep.

The offending feedback frequency will often change in a given listening space due to the presence of people and/or the movement of reflective surfaces in that space. As such, widening the bandwidth (Q), and/or gently moving the notch frequency above or below its present setting, may need to be repeated in order to fine-tune the space.

For Public Address and General Paging

Use equalization to make voices sound more natural in an office or retail environment. Also, use equalization—with a modest boost, less than 6dB in the 1000 Hz to 6000 Hz range—to make speech more intelligible in high-noise environments. For vocals, roll off frequencies below 300 Hz and above 10 kHz. Doing so will conserve power in the paging system.

Music/Live Voice Control

In a recording studio, music mixes are tailored to please the widest possible audience, on the widest sampling of playback devices. This is done, of course, to sell the largest number of recordings, but does not necessarily produce the highest sound quality. So, in a given listening space outside of the recording studio, it may be necessary to add or subtract parts of the audio spectrum.

This applies equally to live vocal presentation. Not only is the parametric equalizer useful for feedback control, it can also shape the overall frequency content for the listening environment to compensate for how that environment affects a live vocal event.

Reducing Phase Distortion and Optimizing Headroom When Using EQ

Use both cut and boost for EQ adjustments—not just boost or cut exclusively. All EQ filters introduce phase-shift to the source signal, which is a form of distortion. It shifts the sound in time at the filter being used, relative to the adjacent filters.

For example, for a music situation, it would be a fair bet that the user/installer would want to increase the lower frequencies to accentuate the bass and the higher frequencies to bring out the vocals. This usually is done for no other reason than to compensate for deficiencies in the human ear, as characterized by Fletcher and Munson back in 1933. This is the basis behind the ISO 226:2003 "Normal equal-loudness-level contours" standard.

Now we have a situation where the EQ is boosted only. This has two negative effects on the system:

1. ***It reduces amplifier headroom. This means that there is less amplitude available to increase the total sound volume of the system should it become necessary.***
2. ***It introduces phase distortion.***

It is a far better practice to introduce a cut of the midrange frequencies (assuming they are set at 0) by half the amount of the current boost at low frequencies or high frequencies, whichever is greater, then decrease the boost of the low and high frequencies by half of their former values. This results in a much smoother sounding EQ because the phase-shift distortion has been reduced, while achieving the desired EQ effect.

For example, if initially some low frequencies were boosted +7 dB and a complimentary group of high frequencies were boosted +5 dB (with the midrange frequencies remaining at 0), then change those settings to: low frequencies +3.5 dB, midrange frequencies -3.5 dB, and high frequencies +2.5dB.

Now, it will be noted this results in a lower overall volume of the system, but the volume difference is compensated for by increasing the MASTER control. If this is implemented correctly, using the EQ BYPASS switch will not change the overall volume of the system when moved between BYPASS and EQ, but will simply present the overall EQ improvements that were made in the EQ switch position.

Sources and adaptations from:
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