

## Equalization Tips

Everybody knows you're supposed to EQ (otherwise why would we put all those knobs there), but where to start? And what do the knobs really do?

Simply, this is what an equalizer does – it takes our carefully designed ruler-flat frequency response and mucks it up, boosting a frequency range here, lowering one there, all in the interest of making what comes out sound more musical than what went in, if not technically more accurate.

Like many things audio, the concept of equalization came from The Telephone Company, who used equalizers to correct frequency response loss in hundreds of miles of telephone lines. Initially, equalization in the studio was used to correct deficiencies — a mic or loudspeaker weak in high or low frequency response could be made more “flat” by the use of an equalizer. It's only been in the last quarter century of multitrack recording that we've learned to use EQ as a creative tool, not just a corrective one.

### EQ Function Follows Form

Equalizers come in many forms and functions – the EQ built into your console, stand-alone equalizers that you can plug into INSERT jacks or between the console output and a monitor or front-of-house speaker system, the low-cut filter on your microphone, single-band, multi-band, graphic, parametric, active, passive, analog, and digital EQ. Even the bass and treble tone controls on the living room stereo or boombox are equalizers.

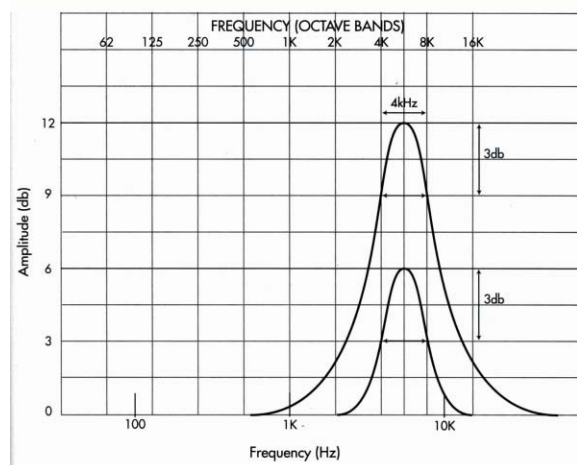
The operation of an equalizer is always described by its frequency response, sometimes in words, sometimes in numbers, but most often with a graph of amplitude versus frequency. The frequency response plot of an equalizer at work is anything but a straight line. Let's look at the fundamental building blocks that comprise an equalizer in terms of their frequency response curves.

### Logs and Octaves

Frequency response is normally plotted with frequency on the horizontal axis, using a logarithmic scale. Each decade (10 Hz, 100 Hz, 1 kHz, 10 kHz, etc.) is represented by a major division of the graph, with the intermediate frequency divisions scrunched closer together as they approach the next major division. This lets us represent a wide range of numbers while maintaining good resolution in areas that relate to how we hear.

The vertical axis of a frequency response curve is normally plotted on a linear scale of decibels (dB), which are in themselves logarithmic, relating to the way we hear loudness.

Interestingly, when plotted on a logarithmic scale, frequency intervals one octave apart are equally spaced. A book on the mathematics of music theory will tell you why. This is handy because we often describe the working range, or bandwidth, of an equalizer in terms of octaves.



Compare the logarithmic frequency divisions (100 Hz, 1 kHz, and 10 kHz) labeled at the bottom of the graph, with the linear frequency scale along the top that's divided into intervals of one octave.

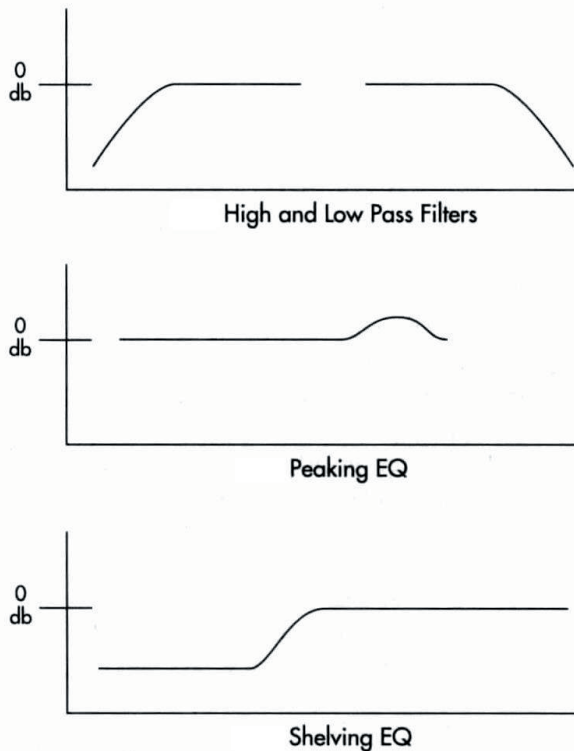
When looking at spec sheets, you'll usually see EQ curves plotted with the horizontal axis divided logarithmically, with 1 kHz in the middle of the axis. We'll use 1 kHz as our reference point for octaves, doubling the frequency at each division above 1 kHz and halving it at each octave division below, rounding off decimals for sanity's sake.

### Building Blocks and Dangerous Curves

The basic building block of an equalizer is a filter. A high-pass filter (also called a low-cut filter) passes frequencies above its design (or “corner”) frequency and attenuates frequencies below that frequency. Similarly, a low-pass (high-cut) filter allows frequencies below its design frequency to pass through, while cutting the amplitude of frequencies above its design frequency.

A resonant filter puts a bell-shaped hump in the frequency response, flattening out on either side of its resonant frequency.

A filter with a “shelving” characteristic only goes so far down along the attenuation slope and then the curve flattens out, allowing adjustment of a range of frequencies equally.



Because this is the real world, the frequency response of a filter doesn't just drop off like the face of a cliff. Its attenuation changes with frequency at a rate determined by the filter's design. A simple filter has a slope of 6 dB per octave, meaning that a signal one octave above a low-pass filter's design frequency will be attenuated by 6 dB (one-half), a frequency two octaves above will be attenuated by 12 dB, and so on, until the signal finally gets lost in the noise.

Filters, by nature, are lossy - they only reduce signal's amplitude. But by combining a filter with an amplifier, it's also possible to boost a range of frequencies. With the exception of a simple low- or high-cut filter (generally an in-or-out switch like those at the top of the channel strip on several Mackie mixers), an equalizer can be adjusted so that, relative to “flat,” the frequency response curve can be pulled either upward or downward. This is starting to look like a pretty useful gadget.

## Knobs, Dials, and Switches

The various flavors of equalizer differ in the degree of control they offer in shaping the frequency response. The most basic EQ consists of low and high frequency EQ knobs. Their operating frequencies are

usually fixed, typically around 120 Hz for the low EQ, around 8 kHz for the high. Those frequencies aren't magic, but tend to be useful when working with music - putting more “whomp” into a kick drum, removing rumble from a bass or guitar, or adding brightness to a guitar. Both bell-shaped (peaking) and shelving characteristics are found in this application.

Sometimes the operating frequencies of high and low EQ controls can be selected by a switch for more flexibility. Choosing whether the EQ is centered around 100 Hz or 250 Hz can be handy to bring a particular bass instrument out in a mix, while a choice between, say, 6 kHz or 12 kHz on the high end lets you add articulation to a vocal or shimmer to a cymbal.

As high and low EQ frequencies shift toward the center of the audible frequency range, the difference in sound between “peaking” and “shelving” shape becomes more apparent, and there are good applications for both curve shapes. Some equalizers allow you to choose a peaking and shelving characteristic for the low and high frequency bands for greater flexibility.

## Mid-Range EQ

Frequency response shaping is often needed in places other than at the ends of the spectrum, so it's common to include controls for tweaking mid-band frequencies. The fancier the EQ, the more controls you have. All Mackie mixers have at least one EQ control in the 2 - 4 kHz range.

## Sweepable EQ

While basic, fixed frequency EQ is useful for overall trimming, when using an equalizer as a sound shaping tool, you'll quickly discover that the fixed frequencies are never quite in the right place. The sweepable, or “semi-parametric” equalizer adds another dimension of control. Here, rather than a fixed (or switch-selectable) frequency, a knob lets us tune the equalizer's center frequency over a fairly wide range to put the action precisely where it's needed. The hip term for this is “dialing-in the EQ.”

## Graphic EQ

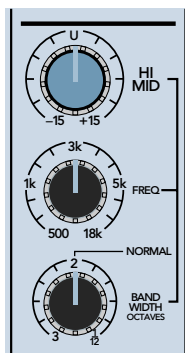
A specialized form of fixed frequency EQ is the graphic equalizer. It consists of a large number of peaking filters with their center frequencies spaced one (or 1/2 or 1/3) octave apart, with the frequencies spanning the full audio range of about ten octaves. The boost or cut in each band is adjusted using a vertical slider, giving a graph-like representation of

the frequency response. The PPM and CFX series mixers are equipped with graphic equalizers, and many of the mixer hookup diagrams show an external graphic equalizer following mixer outputs that feed the loudspeakers.

Graphic equalizers aren't terribly common in recording applications, but they're frequently the EQ of choice for overall system tuning in PA applications where they're used to compensate for boomy room acoustics or to eliminate feedback by cutting gain at the howling frequency. Skilled live-sound engineers have the uncanny ability to hear a squeak and immediately grab the right graphic EQ slider, even in the dark.

### Parametric EQ and Parameters

Frequency, bandwidth, and amplitude of the boost or cut are the three parameters that describe the curve of an equalizer. With a fully parametric equalizer such as found on the middle EQ section of the 8-Bus console, you can control all of them. We've been talking about these parameters in general terms, but let's take a close look at them.



Bandwidth is defined as the number of kilohertz between the points along the frequency response curve where the amplitude changes by 3dB from the value at the top of the peak or trough of the dip. Take a look back at the graph showing the two peaks at 6 kHz. Notice that for both the 6 and 12 dB boost curves, the amplitude is 3 dB down from the peak at 4 kHz and also at 8 kHz. Since those two frequencies are an octave apart, we say that this equalizer has a one-octave bandwidth, independent of the amount of boost.

Sometimes “Q” is used to specify an equalizer’s bandwidth. It’s a much hipper sounding term than octaves, though the term is actually more useful to a designer than a musician.

### Bandwidth or Q

Q is defined as the filter’s center frequency divided by its 3 dB bandwidth. It’s just a number, with no units. For the peak equalizer shown in the graph on page 193, we have:

$$Q = \frac{6\text{kHz}(\text{center})}{8\text{kHz} - 4\text{kHz}} = 1.5$$

Where 4 kHz and 8 kHz are -3 dB points.

The bandwidth control on a parametric equalizer is often marked in octaves (usually something less than 0.5 to 3 or more) as it is on the 8-Bus, or it may be marked in Q, with a typical range of 2 to 10.

Notice that Q is independent of the amount of boost or cut, so a large amounts of boost affects frequencies beyond the center frequency to a greater extent. This is apparent if you compare the 6 dB and 12 dB curve boosts shown in the graph on page 193.

Higher values of Q mean a narrow bandwidth (steep slope) while lower values of Q represent a curve with a gentler slope. If you want 12 dB of boost at 6 kHz but don’t want more than, say, 3 dB boost at 4 kHz, you must increase the Q of the equalizer.

A large amount of cut with a Q of 10 or more is useful for notching out a narrow band of frequencies like AC line frequency hum or air handler noise. A Q of 1.5 with a small amount of boost is a good for gentle correction of spectral balance.

While some equalizers boast of “Constant Q,” not many of them actually work that way. Equalizers generally sound more musical when the Q varies with the amount of boost or cut so that “out of band” frequencies are affected in proportion to the bandwidth.

## A Little EQ Philosophy

There are two principal uses for EQ – corrective and creative, and there’s no “right” EQ for any particular instrument or voice, so don’t ask.

### Creative EQ

When using EQ in a creative fashion, you intentionally want to change the sound, sometimes radically, creating a new sound – a rhythm guitar with practically no mid-range, a voice that sounds like it was recorded over the telephone – you get the idea.

When trying to create a new sound, there are no rules and no principles. Just turn all the knobs until you either get the sound you’re looking for, find something else that sounds really cool and you decide that’s just the sound you really wanted, or discover that there just isn’t enough to work with, either with the source or the controls provided by your equalizer.

The main thing to remember is that while you can take away or emphasize frequencies present in the original source, an equalizer can’t add frequencies that weren’t there in the first place. (Well, it will if it’s driven into distortion, and that’s indeed a

legitimate creative use.) If you want the bass track to sound like it was played on a flute, it ain't gonna happen.

## Corrective EQ

The proper starting point for a mix is with no EQ. Don't begin mixing by reaching for the EQ knobs, at least not until you've developed a lot of listening and mixing skills. Don't try to fix something until you know it's broken.

How do you know it's broken? When you can't get a good mix just by balancing levels and panning. Then, and only then, is the time to start twiddling the EQ knobs.

A frequent piece of advice when EQ-ing is to first try cutting rather than boosting. If the basic tracks are well recorded, most mix problems are the result of two or more sounds trying to occupy the same portion of the spectrum.

This is a common situation with modern multitrack recording techniques. Every instrument and voice is recorded up close and personal, using the full bandwidth of the mic and the recording system. In real life, high and low frequencies drop off at different rates depending on how the instrument's sound radiates, and we don't usually encounter a situation where we hear every instrument in the ensemble right in our face.

Low frequencies (in the 150-250 Hz range) tend to add up in the mix very quickly and it's tempting to boost another frequency range to balance them. Rather than pile more highs into the mix, it's better to cut some lows out of instruments that, even though they may sound great on their own, are muddying up the mix.

While it's rarely a good idea to start out mixing by setting EQ knobs to where you think they should be without listening first, if all of your instrumental tracks have been close-miked and are likely to have excess bass, you might start out a mix with a couple of dB scooped out of this range on everything but the bass and kick drum, then put some lows back in judiciously to add a little warmth.

Sometimes, corrective surgery is called for when an instrument booms at a certain note, or a particular note is weak. Tuning in on that note and adjusting it with a narrow band parametric equalizer maintains much more of the instrument's characteristics than

simply limiting or compressing the track to even it out.

It's very helpful to know the range of instruments in your mix (charts can be found in just about any recording reference book), but it's also important to understand that the overtone structure affects the timbre of an instrument.

By dropping the fundamental frequency range of a lead instrument by a few dB but leaving its most important overtones unchanged, it will still sound like the same instrument in a mix, but by cutting a little, you've made room for another instrument that was fighting for the same chunk of spectrum. Generally an equalizer with a bandwidth of around an octave is appropriate for this sort of work. It's fairly common to use a high-pass filter to clear away most of a guitar below 80 Hz or so to leave room for the bass and kick drum.

## Warming Up a Track

In addition to making a mix work, EQ is sometimes used to modify the tone of an instrument or voice to add one of those obtuse characteristics such as "warmth" (around 250 Hz) or "air" (around 15 kHz).

## Practice Safe EQ

Successful equalization is all about understanding what you're hearing. A skill that will make you a better engineer is the ability to recognize weakness or overemphasis in certain frequency ranges so you'll know which knobs to reach for, or if EQ is required at all. Sharpen your listening skills by running well mixed music through an equalizer and learn what happens when you boost or cut different frequency ranges. And keep your ears clean.

Here are a couple of charts to get you started:

## Key Frequencies for Instruments

Instrument	Principal Frequencies
Electric Bass	700 Hz - 1 kHz = attack or pluck 60 - 80 Hz = bottom 2.5 kHz = string noise and slap
Kick Drum	60 - 80 Hz = boom (be careful of conflict with bass) 1.5 - 2.5 kHz = beater smack
Snare Drum	80 - 100 Hz = fullness 200 - 300 Hz = fat 1 - 2.5 kHz = crispness
Cymbals, Hi-hat	200 - 400 Hz = gong sound 7.5 - 10 kHz = shimmer
Rack Toms	200 - 300 Hz = fullness 5 kHz = attack
Floor Tom	80 - 120 Hz = fullness 5 kHz = attack
Conga	200 - 400 Hz = resonant ring 5 kHz = presence, slap
Electric Guitar	250 Hz = body (too much is muddy) 2.5 kHz = clarity
Acoustic Guitar	Same as electric, but there's almost always too much 250 Hz
Piano	80 - 100 Hz = bass 2.5 - 5 kHz = presence 10 kHz = crispness narrow boost around 2.5 kHz = honky tonk
Brass, woodwinds	120 - 240 Hz = fullness 5 - 7.5 kHz = shrill
Voice	150 - 250 Hz = body 400 - 800 Hz = nasal 2 - 4 kHz = presence

## Characteristics of Frequency Ranges

Frequency Range	Produces This Desired Effect	When Overused
16 - 60 Hz	Sense of power, felt more than heard. Caution! not reproduced on most small monitors.	Makes music sound murky when boosted
60 - 250 Hz	Emphasizes fundamental tones of the rhythm section, changes musical balance making it fat or thin	Makes music boomy if boosted or thin if cut
250 Hz - 2 kHz	Low-order overtones of most instruments fall in this range. Changes an instrument's timbre, helps to separate instruments with similar fundamental ranges	500 Hz - 1 kHz creates telephone effect, 1 - 2 kHz sounds honky. Makes music tiring to listen to.
2 - 4 kHz	Vocal presence	Makes vocals lispy, loses intelligibility of consonants (merry, very, berry will sound similar)
4 - 6 kHz	Clarity and definition of instruments, up-front sound, small boost around 5 kHz makes a complete mix sound louder.	Vocal sibilance, listener fatigue
6 kHz and up	Brilliance	Sibilance, vocal harshness