MAAT

# Understanding EQ Architectures

## thEQblue
## SantaCruzEQ

MAAT Inc.

MAAT Incorporated

101 Cooper St

Santa Cruz CA 95060 USA

*More unique and essential tools and tips at:*

*www.maat.digital*

## Introduction

Since the advent of parametric equalization in the early ’70s, a wide variety of EQ architectures have been created. As an experienced audio engineer, we have our own personal library of properties and applications in our head, like “…SuperProExtreme is good for vocals or MonsterEQPink works great on the kick and is particular silky in the highs.” One may be more surgical while another is more musical. However, the majority of us has never fully explored the differences between proportional, constant, symmetrical, asymmetrical and all their variations, whether advantageous or not. thEQblue is not only a pure, excellent sounding “swiss army knife” equalizer, it’s also the tool that will help you understand the subtleties between EQ architectures and their aural differences.

## Quality Factor

Q or Quality Factor can be thought of as the rate at which the filter transitions between the reference value, unity gain, and the maximum filter gain. Before we look at the different Gain/Q relationships, we need to fully understand how Q is formally calculated.

For Bell filters, Q is calculated at 3dB below the peak or highest gain. In other words: If gain set to +12dB, the Q is going to be calculated at +9dB. The formula: Q = $f$ (resonant or center frequency, $f0$)/bandwidth at 3dB below maximum gain. Here is an example: $f$ is at 1000Hz (f0). The left side of the bell crosses 891Hz (f1) at 3dB below maximum gain and the right side at 1123Hz (f2). Bandwidth is equal to f2 minus f1, or 1123 - 891 = 232Hz. The Q is 1000/232 = 4.31.

In Figure 1 below, a bell is set to +3dB and another bell is set to +9dB. Both filters have the same Q due to the fact that the Q is calculated not at unity gain but at the point 3dB below max gain. We know, those two heavy gold horizontal lines don’t look the same length, but they are! This concept of how Q is calculated is crucial to understand thEQblue, as a filter could be falsely interpreted as having a smaller or broader Q value than it does.

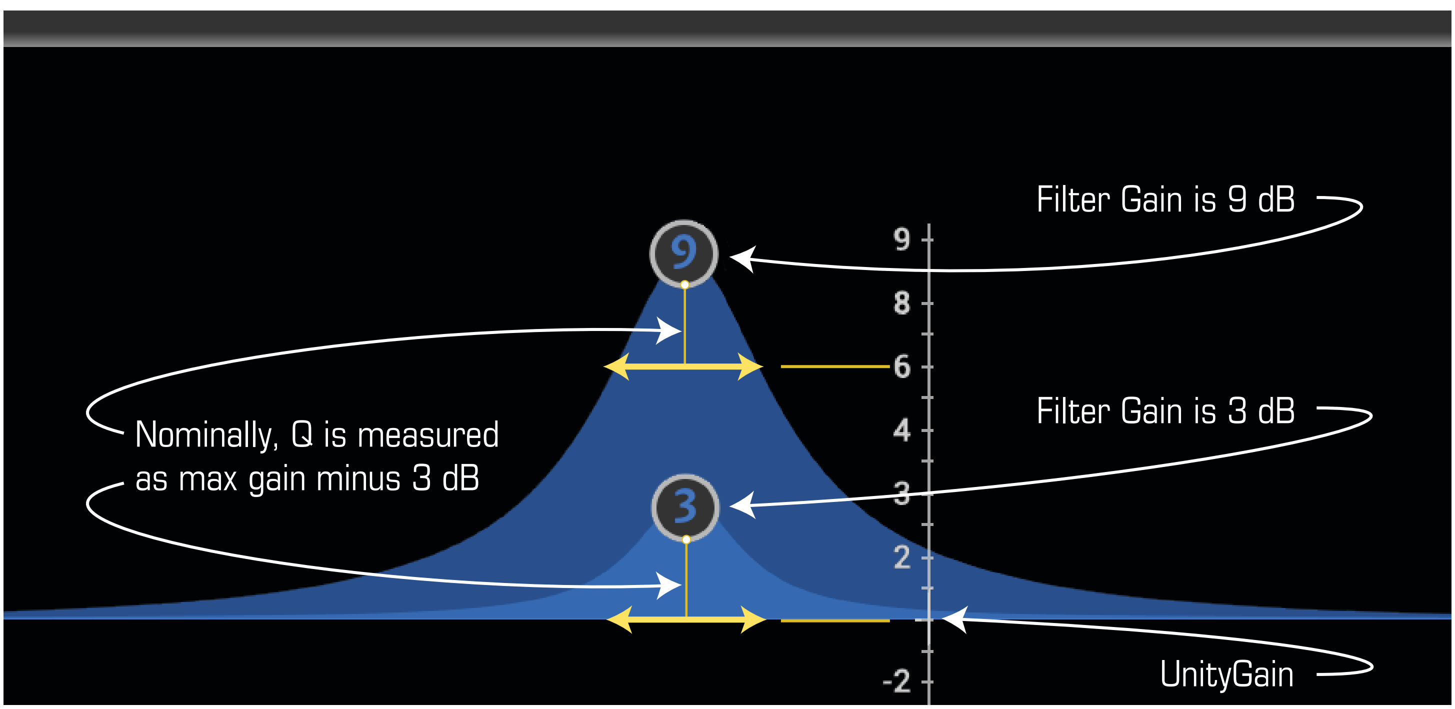


*Figure 1 – Constant Q means just that*

### Q/Gain Interaction

The purpose of Q/Gain dependency is to offer you a faster way to good results for different situations. Over time, hardware manufacturers have developed a range of different solutions. In order to make this comprehensive for your daily work, it's helpful to understand the different approaches. There are two main EQ groups describing Q/Gain interaction:

a) Constant Q — a constant Q at different gain settings

b) Proportional Q — Q values which change proportionally with gain

From there, we can break those two down further with Symmetrical or Asymmetrical classes, which tells us whether the EQ behaves equally or symmetrically with positive and negative gain or not (Asymmetrical).

## Understanding Ripple

All filters have small amplitude variation in both the passband and the stopband. Passband ripple is much lower in amplitude than stopband ripple.

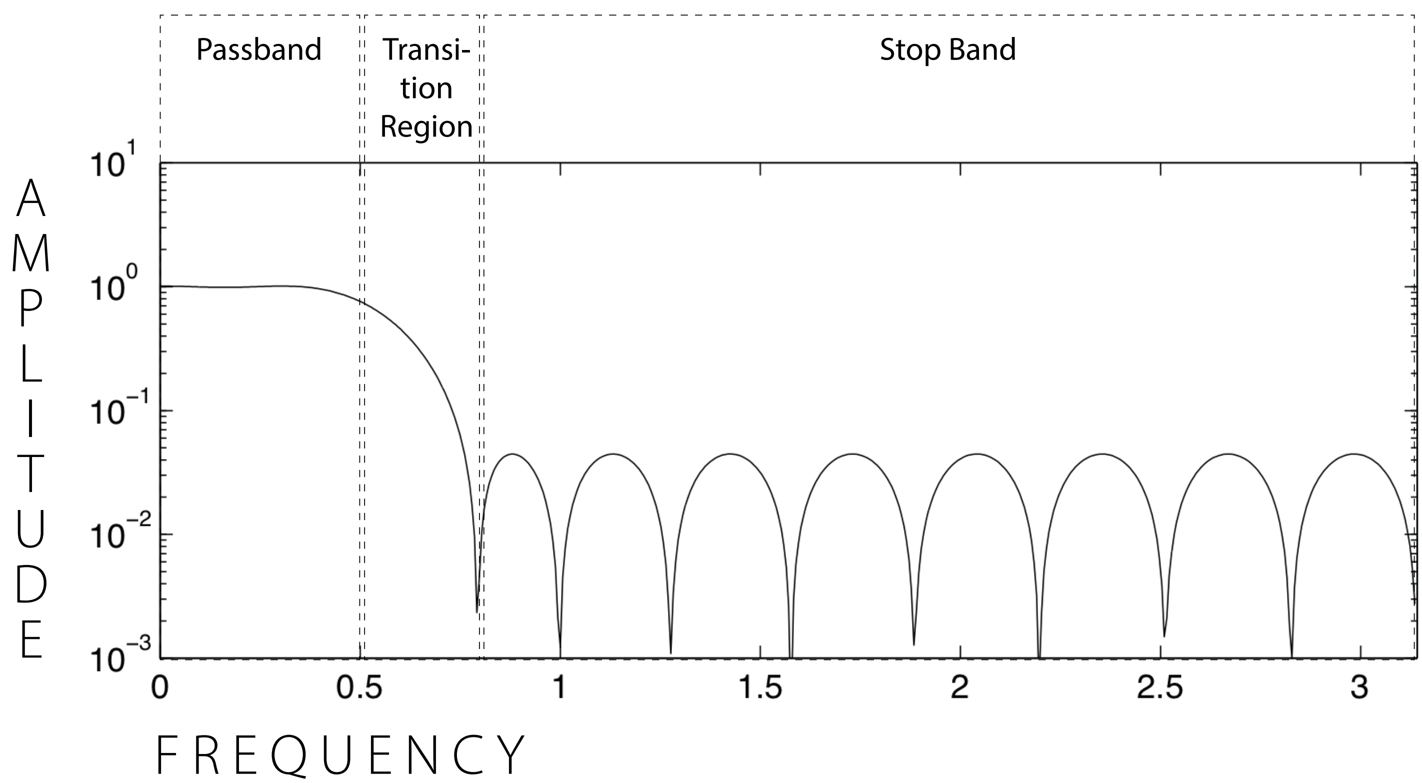


*Figure 2 – Ripple: non–ideal amplitude variations*

The stopband is the region not affected by the filter, if it's a bell or shelf, or the region cut by the filter if it's a high or low cut. The passband is the opposite: it's the region of frequencies passed or affected by the filter, if it's a bell or shelf, or the region no cut or passed unscathed by the filter if it's a high or low cut.

Ripple is usually specified as some number of decibels “down” from unity gain. In other words, how many dB quieter are the peak amplitude variations relative to unity. Generally speaking, the higher the slope, the more pronounced the ripple. Ripple in the stopband can also be thought of as minimum stopband attenuation, since the ripple amplitude maxima represents the worst case attenuation in the stopband.

# The Architectures

## Constant Q Symmetrical [No. 1 Classic Sym]

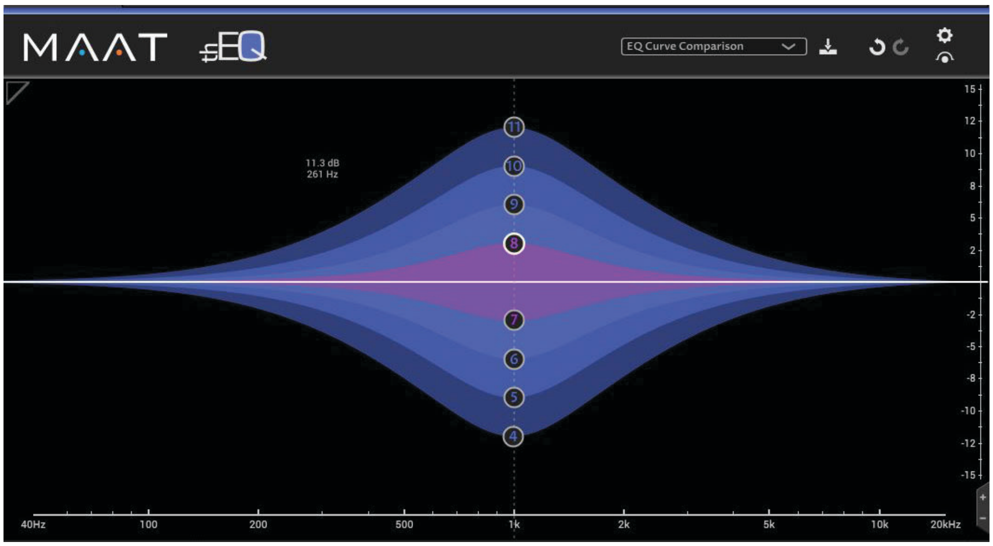


*Figure 2 – Constant Q Symmetrical*

Visually, you can spot a Constant Q equalizer by its Matryoshka-style, nested curve–within–a–curve response. A Constant Q equalizer has the same Q at all cut and boost settings. In other words, the bandwidth between the 3dB points does not change at all as the gain is adjusted. With this architecture, small amounts of gain still have relatively high Q, making it easy to understand aurally. The flip side is that sometimes it isn’t so easy to find a setting, especially with complex sources or for when more subtle effects on vocals are needed, as you have to adjust Q to maintain the aural result when the gain is changed.

The No. 1 architecture is “symmetrical” or “complementary” because the response is symmetrical for boost and cut. Also, because the parameters of a Constant Q EQ are truly independent; they don’t interact, you may initially think that the results are “harsh.” However, spend some time getting to know the sound and you’ll be rewarded with flexibility in a wide range of use cases. By the way, some manufacturers refer to this architecture as a “Symmetrical Q” rather than Constant Q, which is a bit of a misnomer given that symmetrical behavior is a subset.

Analog antecedents: SSL 4000E, MDWEQ (UAD), “clinical” EQ from the ’80s

### Constant Q Asymmetrical [No. 2 Classic Asym]

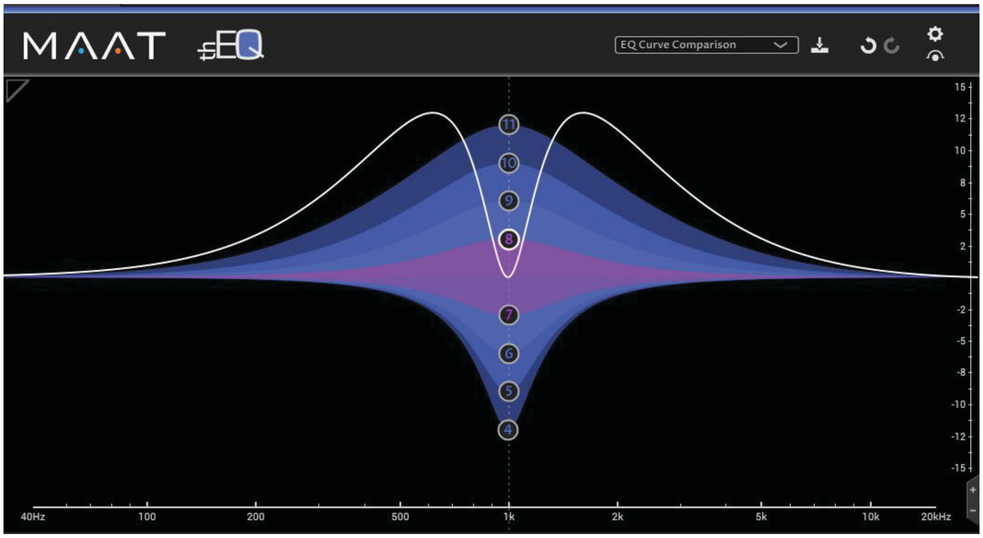


*Figure 3 – Constant Q Asymmetrical*

The important aspect about No. 2 is that the frequency response is not symmetrical for boost and cut. For negative gain, the bandwidth is determined by the -3dB point relative to 0dB, not relative to the minimum gain at the center frequency. This makes a lot of sense musically too…if you listen to music and apply a notch filter, then change the shape of the curve around the minimum gain or center point, it will make little difference to the sound since that region is already attenuated. If, however, you change the curve around the 3dB points, it will affect the sound much more as more or less of the audio "falls into" the notch. Note that many equalizers that are described as "Constant Q" by their manufacturers are not called "asymmetrical," and are instead described as "Constant Q Symmetrical" designs due to different interpretations of how Q is calculated.

Analog antecedents: This EQ resembles some specialty legacy units, and works well for resonance control of percussion, since relatively high Q (which is what resonance is all about) is available at low gain settings, while quite subtle "fill" or timbral compensation can be achieved by simultaneously using No. 2 for boost.

### Proportional Q (Symmetrical) [No.s 3 to 5]

As the amount of boost or cut of a Proportional Q equalizer is increased, the Q also increases. This has the effect of making the equalizer "focus" more tightly on that passband as the amount of positive or negative gain is increased. This mean you can use a fairly low Q filter, at small boost or cut settings, to provide gentle control of tonal balance with low ripple. At high gain settings, a Proportional Q equalizer "automatically" increases its Q for more dramatic problem solving such as feedback or resonance suppression.

This provides the EQ with a "softer" subjective character as EQ is progressively applied. Since the effective bandwidth is increased at low gain, it subjective sounds more effective at moderate settings. Its gentle Q curve also lends itself to overall EQ fills and more subtle corrections of vocals and instruments. Cranking the gain subjectively produces the effect you're expecting, without needing to fiddle or compensate with Q. Because of this, Proportional Q Symmetrical EQs are often thought of as more "musical."

thEQblue offers 3 variations of Proportional EQ types with different shades of proportionality.

Analog antecedents: These architectures most resemble the older, beloved Neves, plus their modern derivatives and the EQ from the SSL G Series. Also, many popular EQs from API, Harrison and UREI were proportional Q.

## № 3 - Proportional 1

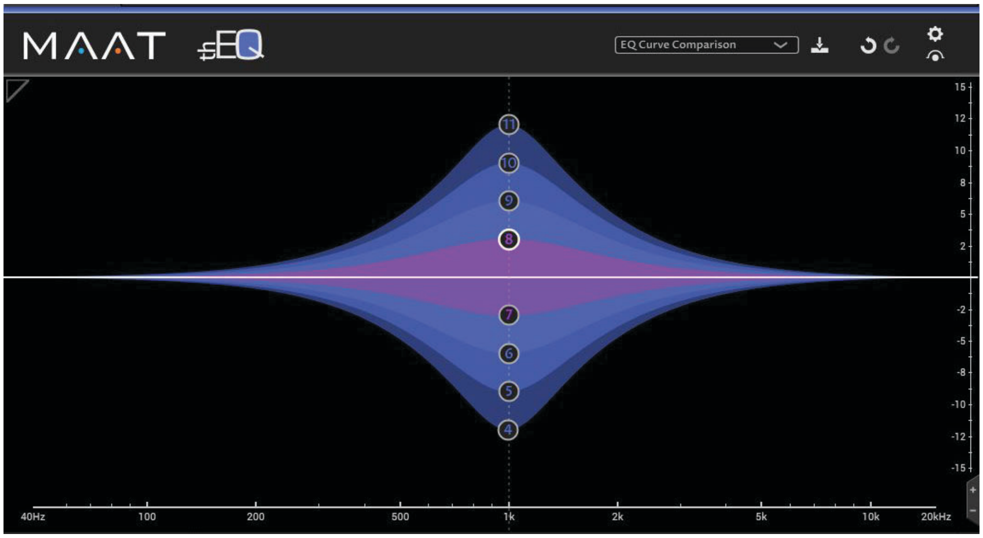


*Figure 4 – Proportional 1*

Proportional 1's bells are wider at 0 to +6dB, and narrower at greater than +6dB of gain. Behavior is symmetrical for negative gain changes.

Analog antecedents: Neve 1081

## № 4 - Proportional 2

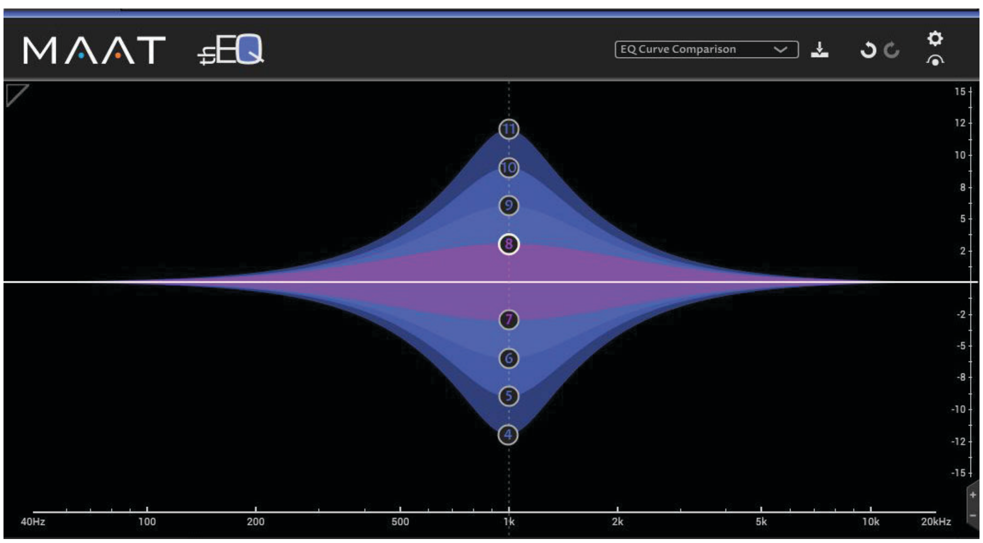


*Figure 5 – Proportional 2*

Like Proportional 1 above, but with bigger changes in that ±6 dB of gain region of action.

Analog antecedents: Neve 88

№ 5 - Proportional 3

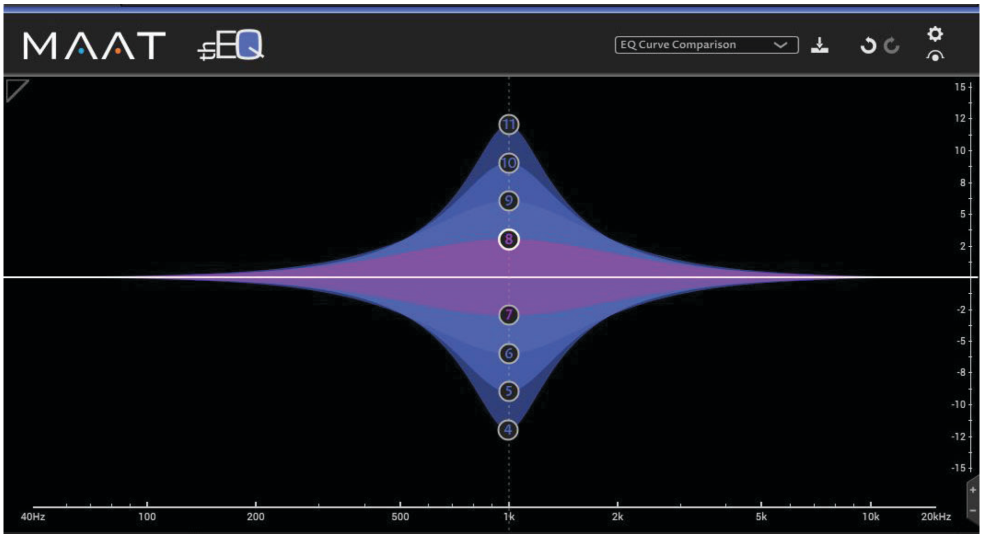


*Figure 6 – Proportional 3*

Like Proportional 1 above, but with extra wide bells between 0 and ±3dB of gain. The bell becomes more "focused" at higher gains.

ANALOG ANTECEDENTS: MILLENNIA

## Constant Q Asymmetrical [No.s 6 to 10]

No.s 6 through 10 are all different shades of Constant Q.

№ 6 - Constant Q Asymmetrical

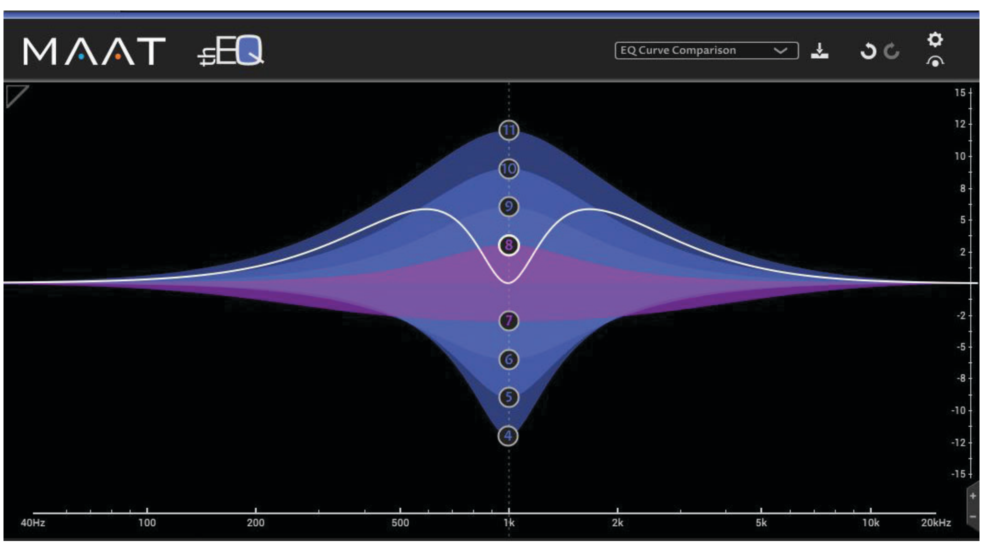


*Figure 7 – Constant Q Asymmetrical*

No. 6 boosts like No.s 1 & 2, but cuts extra wide between 0dB and -3dB. This architecture is good for gentle overall cut corrections with dips up to -3dB. As negative gain increases past 3dB, it transitions into a more surgical cut mode.

## № 7 - Constant Q Asymmetrical Reversed

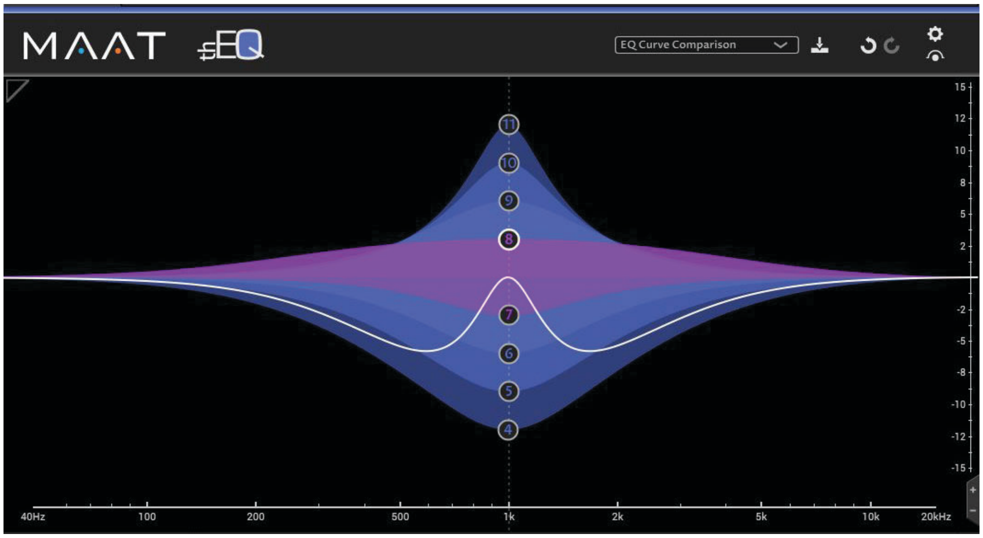


*Figure 8 – Constant Q Asymmetrical Reversed*

Exactly like No. 6, but No. 7 exhibits mirrored boost and cut characteristics.

## № 8 - Constant Q Inverse

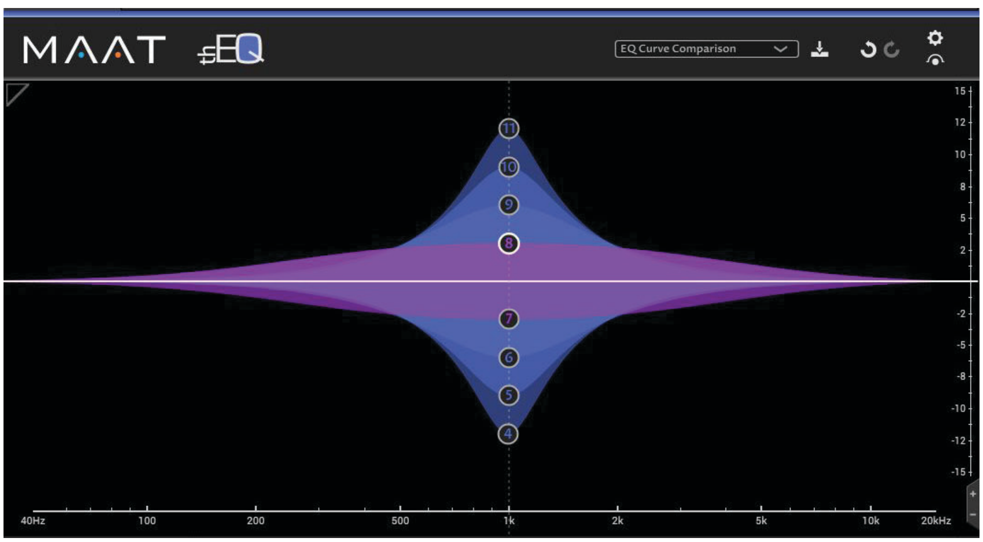


*Figure 9 – Constant Q Inverse*

The definition for Q used in No. 6 for cut is symmetrically applied to boost.

№ 9 - Constant Q New

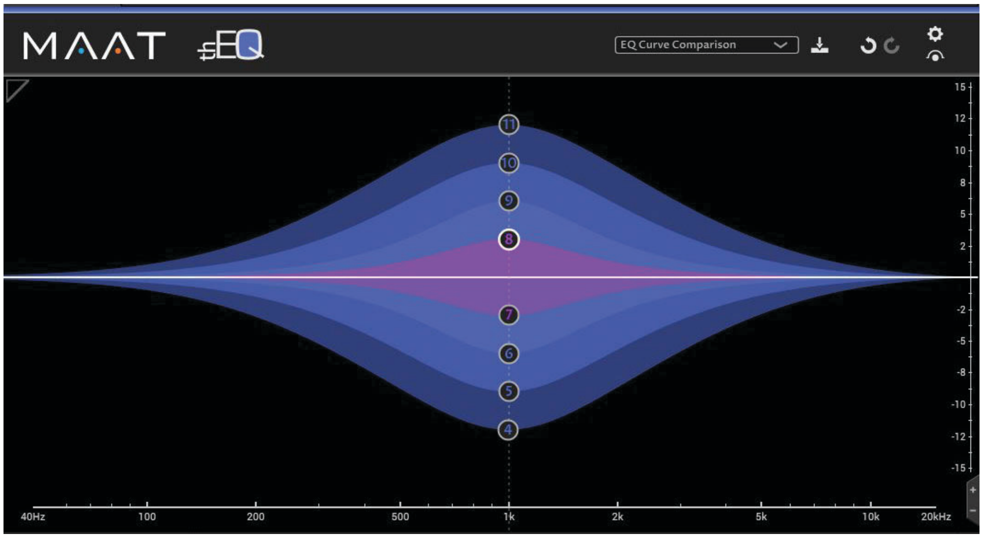


*Figure 10 – Constant Q Ideal*

A unique definition for Q: midway between peak and 0dB. The result is that Q is always maintained independent of bell gain, even below 6dB.

№ 10 - Constant Q Ideal

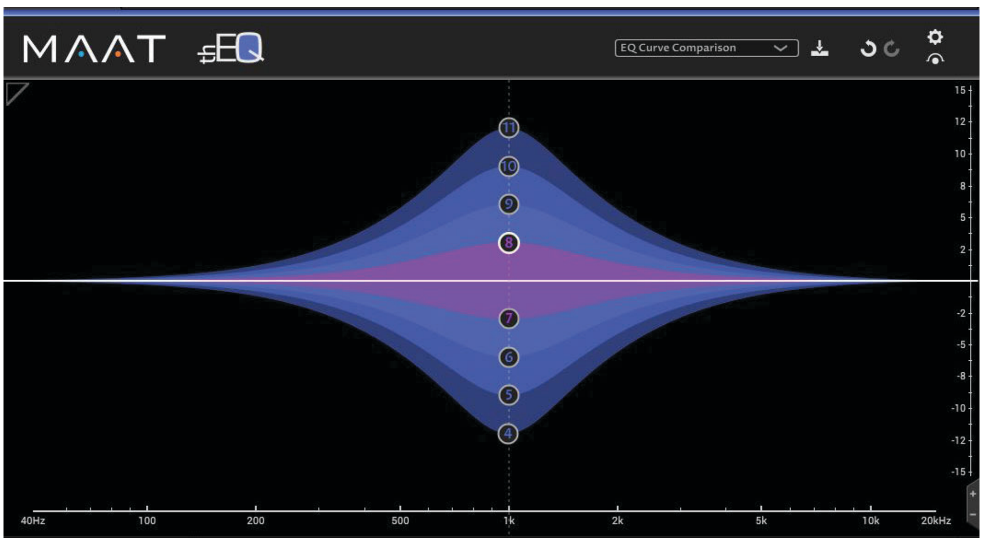


*Figure 11 – Constant Q New*

Like No. 1, but with perfectly maintained Q for any gain value above or below ±6dB of gain.

## Serial vs. Parallel

Let's have a quick look at Serial versus Parallel EQ architecture…The majority of equalizers with more than one section are "Serial," meaning each section's output is connected to the input of the following section.

In "Parallel" equalizers, the input is multed or split so it runs through all sections in parallel. Parallel architectures exhibit band interaction. That is, every parameter influences all other settings. This makes parallel EQs more fiddly, requiring careful, iterative tuning of parameters.

## № 11 - Parallel FF-FB

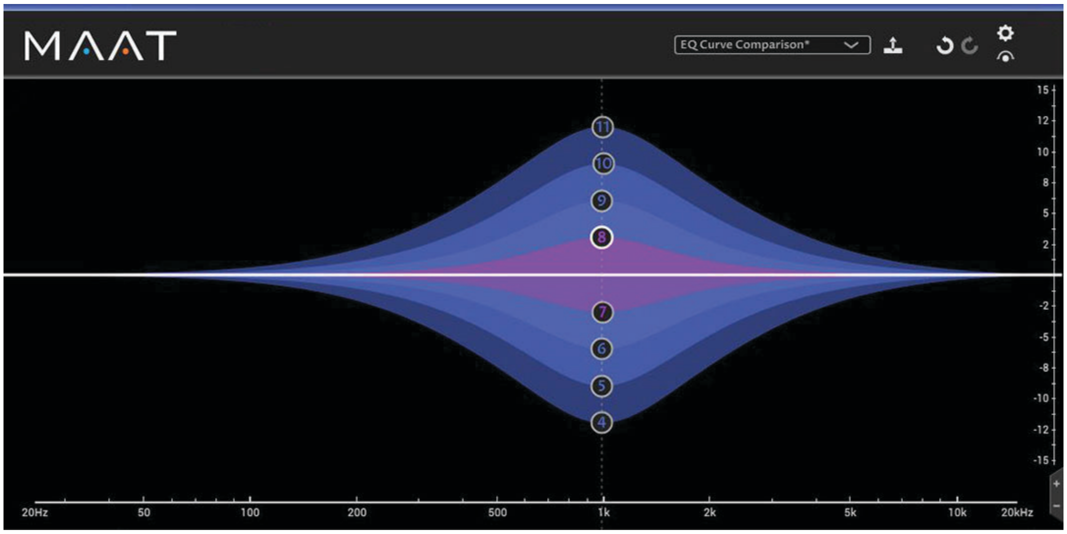


*Figure 12 – Parallel Feed Forward–Feedback*

As seen in Figure 12, architecture No. 11 is a symmetrical design, with the same shape for both boost and cut. Also, No. 11 has less interaction between bands compared to No. 12, as well as less noise. This technology is also used in high end graphic equalizers. This MAAT architecture is a very transparent, esthetic EQ most often used in mastering.

Analog antecedents: Sontec, GML 9500

No. 11 analog architectures produce higher THD+N (Total Harmonic Distortion plus Noise), often at -80dB or higher due to the architecture. This is particularly true of Sontec. The name refers to the application of both feedforward and feedback paths in the design.

## № 12 - Parallel LC

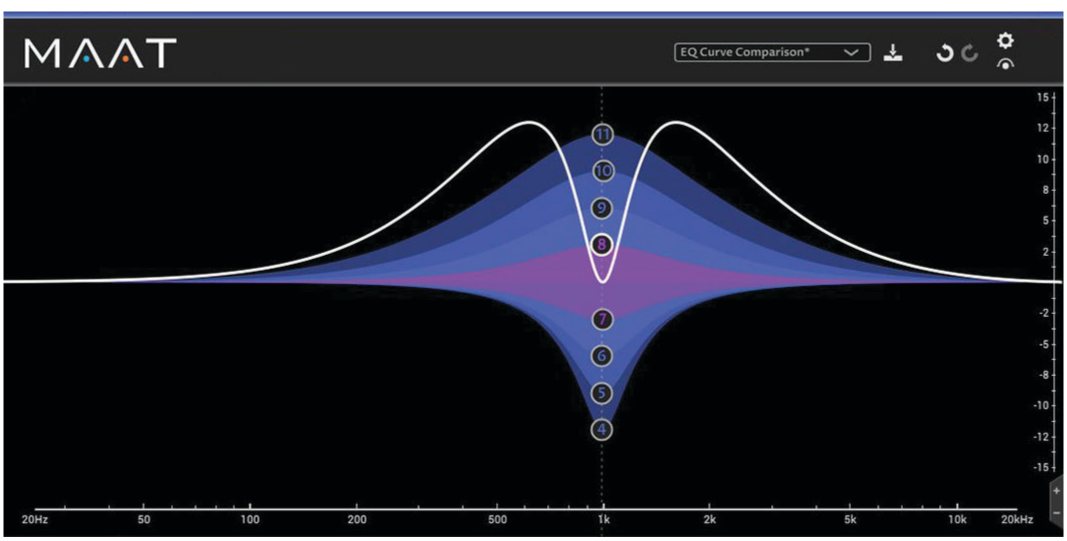


*Figure 13 – Parallel LC*

The twelfth thEQblue style is highly asymmetrical, and can be subjectively "creamy" in that it smears or blurs transients. It exhibits greater band interaction compared to series architectures, and that band interaction may require careful tuning. No. 12 is an “organic,” analog–sounding EQ popular in mastering suites the world over. Practically, it’s more useful for aesthetic corrections rather than surgical applications.

### Analog antecedent: Massive Passive

No. 12 analog architectures use buffered “LC” reactive components. The L stands for inductance, produced by coils, while the C stands for capacitance. Together, they make a frequency–responsive electrical circuit.

## About This Document

This manual was written by O.A. Masciarotte in Adobe InDesign CC 14.0.2, and is set in Minion Pro and Myriad Pro. The cover page is set in the classic Eurostile. Dr. Christoph Musialik supplied the original Classic PEQ Blue user manual from which some material was adapted for this architecture discussion.



### Notice of Liability



190911-2.5