whirlwind

Whirlwind Perfect Ten and Bass Ten
What is Constant Q and Why should I care?

19 January 2011 – Tony Gambacurta

Equalizer History
The earliest Graphic equalizers used Inductor-capacitor-resistor (LCR) tank circuits to select bands of frequencies for boost or cut. Inductors can be a problem in these types of circuits because inductors are expensive and perform poorly. With the introduction of low cost Integrated Circuit amplifiers in the 70's the inductors were replaced what is known as a gyrator, which is a form of and active or simulated inductor. Without going in to a lot of circuit theory, these designs were simple to do and easy to understand. The key aspect of the design is that it simulates an LCR tank circuit, or resonator, that in conjunction with the boost/cut potentiometer (pot) selectively alters the frequency response. The basic problem is that the pot is part of the tank circuit, and the position of the pot determines how much resistance is part of the tank. This means that the pot position affects the filter Q which represents the filter bandwidth.

During the 80's, engineers explored different circuit topologies in an effort to allow EQ bands to maintain the same Q independent of the amount of boost or cut. Technically this results in a filter that maintains its shape over a wide range of boost and cuts, and became known as "constant Q". Constant Q designs basically took over in most pro audio applications, and, the older "gyrator" designs continued to be used in many Music Industry and Consumer audio applications.

The following should make it clear as to why Constant Q equalizers became the choice of audio professionals.

The frequency plot thickens…

The following frequency response plots will illustrate the differences between gyrator and constant Q designs. All plots were done with a –20 dBV signal source level. For this paper, we only look at boost curves, the cut curves are assumed to be a mirror image of the boost curves.

This first graph is a gyrator style EQ with all bands boosted full and each individual band boosted full.

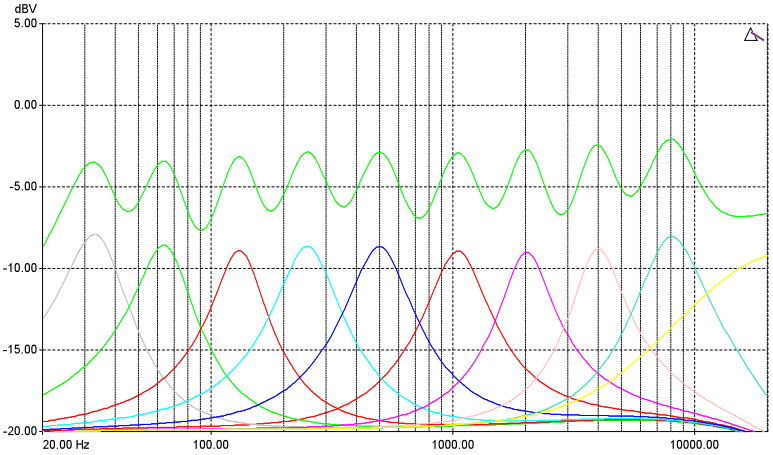

Figure 1 Gyrator - Full Boost

The next graph is a constant Q EQ with all bands boosted full and each individual band boosted full.

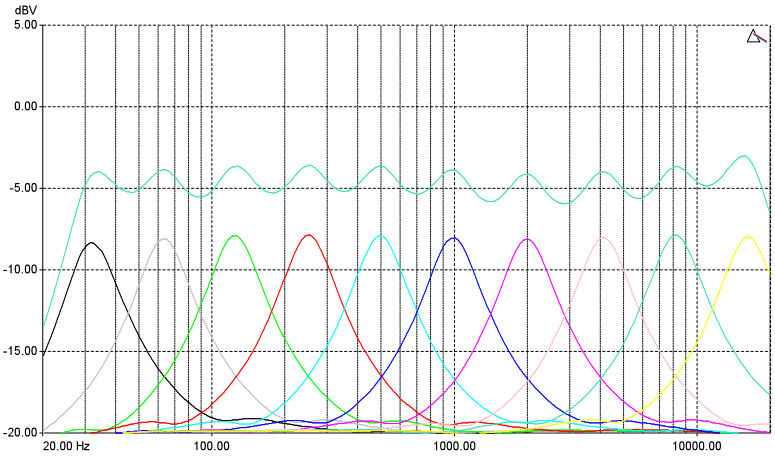

Figure 2Constant Q - Full Boost

These two sets of curves are very similar. One point of interest is that although the individual filters are very similar, when combined, the constant Q has less ripple than the gyrator EQ. This is not necessarily good or bad, just different.

The next plot is a gyrator EQ with bands boosted half way, individually as well as all bands boosted half.

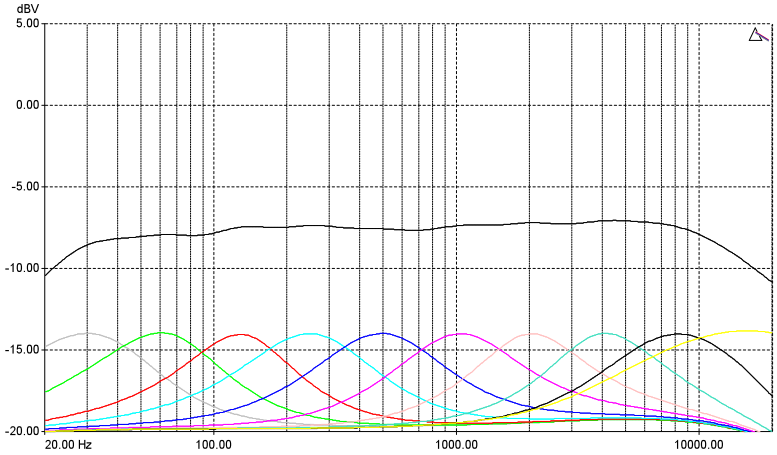

Figure 3 Gyrator EQ - Half Boost.

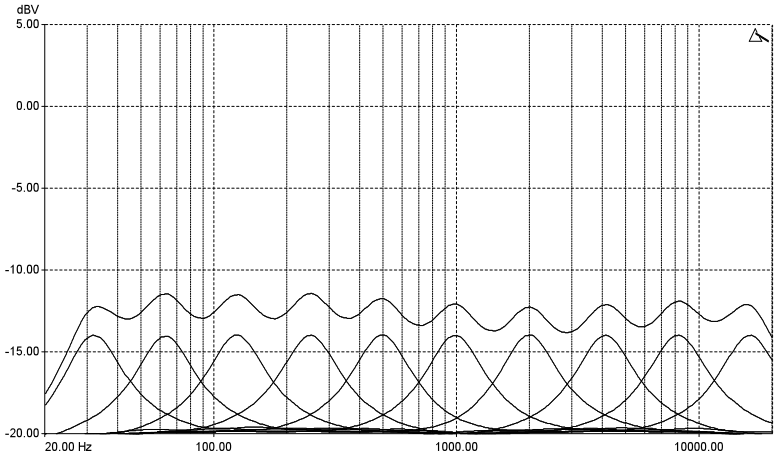

Figure 4 Constant Q - Half Boost.

The differences at half boost are quite clear. The relative filter width is quite a bit larger for the gyrator design. Notice that the composite curve has quite a bit more boost than the individual bands. The bandwidth of the filters mean that there is no ripple in the composite curve. The individual filters are very broad and don't allow selecting one band without affecting adjacent bands almost as much as the band one might be attempting to adjust.

Also notice that when we look at the curves for full boost and half boost for each of the two designs, the constant Q design's half boost and full boost look very similar. In contrast the gyrator design, the full boost and half boost curves look like they could be from two different products.

The following 2 curves illustrate the difference even more dramatically. The gyrator EQ used doesn't quite boost to its advertised 12 dB, it only did 11 dB of boost. As you can see, although we are trying to boost the 1 KHz band, at 3 dB of boost, we are boosting all the frequencies from 300 Hz to 3 KHz almost the same amount. This octave EQ boosts a band that is over 3 octaves wide. Any selectivity is gone at smaller boosts such as this.

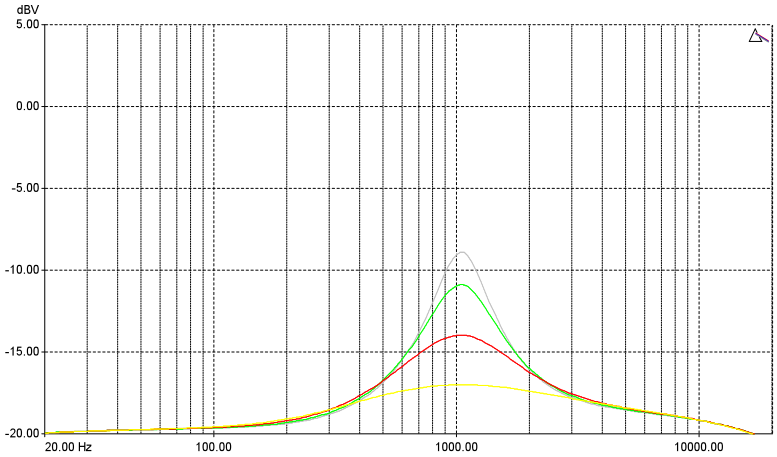

Figure 5 Gyrator EQ, 1K, 3, 6, 9, 11 dB of boost.

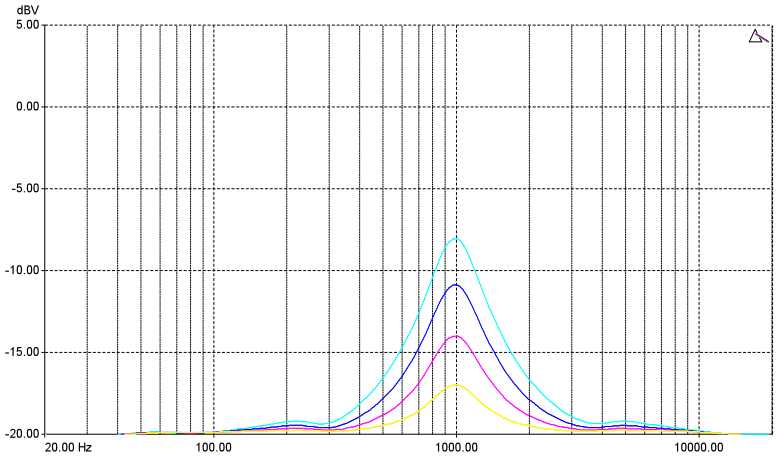

Figure 6 Whirlwind Perfect 10 EQ, 1 KHz, 3, 6, 9, 12 dB of Boost.

As shown here, the constant Q design keeps the bandwidth of the filter the same for any amount of boost. This allows surgical precision. Boosting 1K doesn't boost the adjacent band frequencies nearly as much, and, will result in a more predictable response. In order to achieve similar results with a gyrator design, adjacent bands would need to be attenuated in order to try to sharpen the filter. Good luck trying to do that.

Conclusion

A graphic equalizer is an audio tool that allows a great deal of freedom to alter the tone and character of a music signal. One method of adjusting EQs by ear is to boost each band full, one band at a time, to hear what portion of the frequency spectrum that band affects, then adjust the band to have as much or as little of that band we want in the final sound. If the characteristic sound of that band is not the same for small and large boosts, then it makes it very difficult to get the tone we are looking for because the characteristic sound at a bands full boost differs so greatly from the characteristic sound as small boosts. Constant Q designs fix this problem and allow the user to get to the tone they want quicker and easier.