DSP Implementation of Parametric Filters

David Gunness
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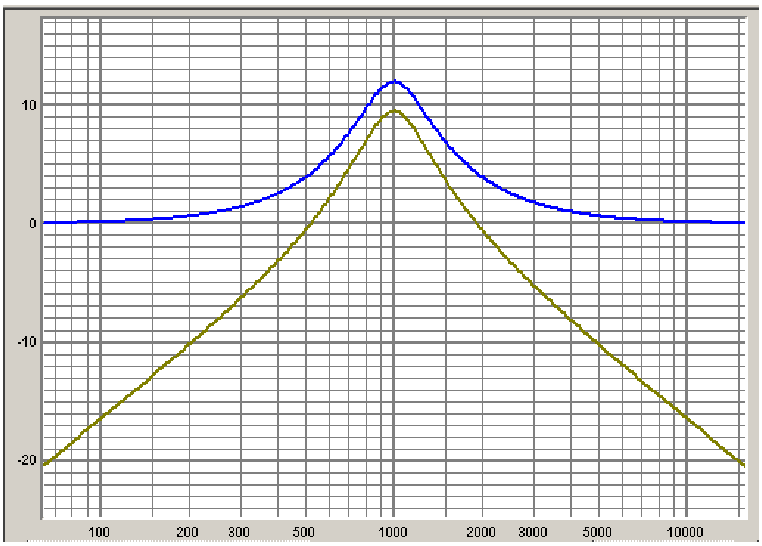
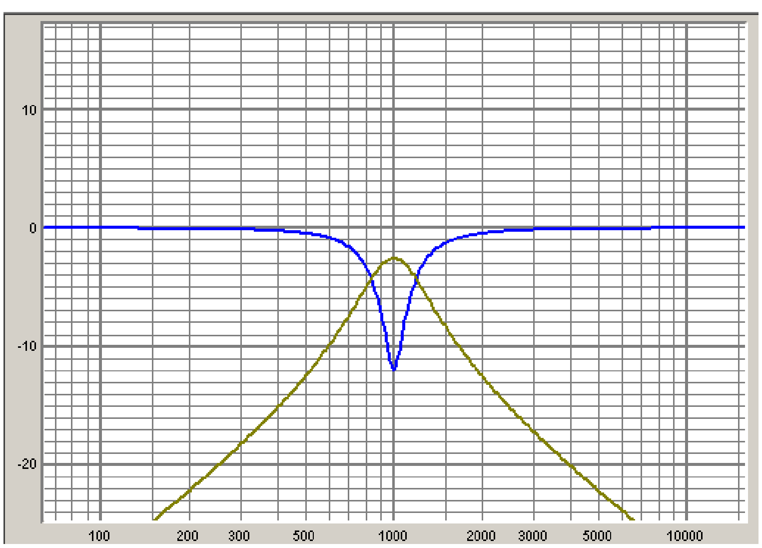
A parametric filter can be implemented as a 2nd order bandpass filter summed with a unity gain channel. For a cut filter the bandpass filter is inverted in polarity. The general expression for the gain applied to the bandpass filter is "boost – 1", where "boost" is the desired linear (as opposed to dB) gain of the parametric filter at its center frequency. Note that this expression is negative if "boost" is less than 1.

The response of a 2nd order bandpass filter is standardized, with its width specified by the term "Q". The following illustrations show a boost filter and a cut filter, constructed with the same Q=2 bandpass filter.



+12 dB Parametric filter, with bandpass filter used to create it.



-12 dB Parametric Filter, with bandpass filter used to create it.

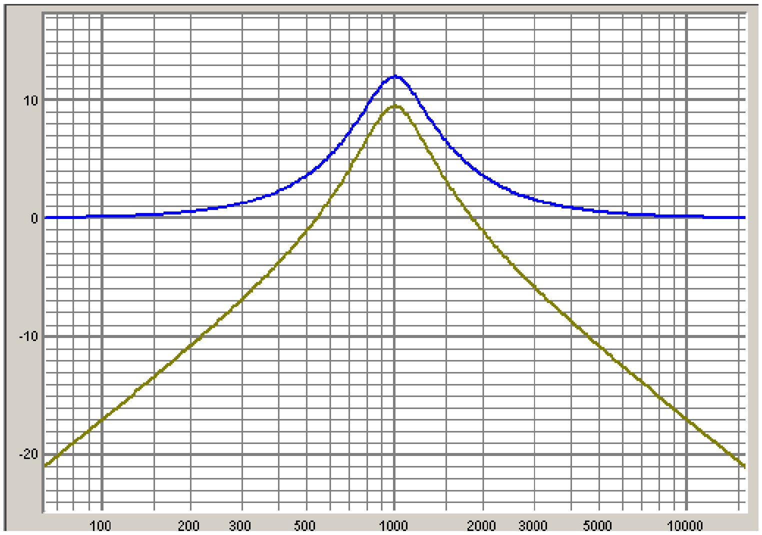
Notice that the boost filter is much wider than the cut filter. It is desireable for parametric filters to be complementary, so that a –12 dB filter applied after a +12 dB filter with the same width specification (Q) produces a flat magnitude and phase response.

A better way to define a parametric filter is to vary the Q of the bandpass filter in order to achieve a net parametric filter response with the same shape at its peak as a bandpass filter of the specified Q. With this approach, a cut filter will use a bandpass with a lower than specified Q, and a boost filter will use a bandpass filter with a higher than specified Q. XTA, TOA, Ashley, Rane, EAW, and several other companies have adopted this approach.

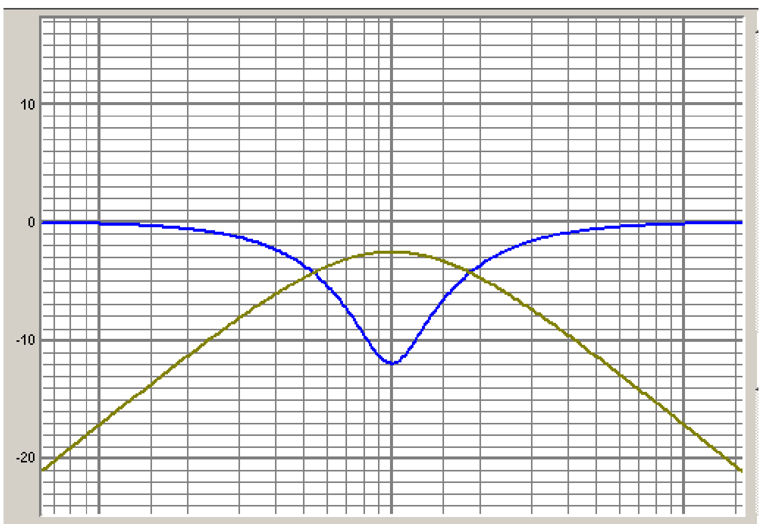
The expression for adjusted Q that achieves this has three parts:

Boost > 2 :	$Q = Q_{nom}$ * boost / sqrt(boost^2 – 2)
.5 < Boost < 2 :	$Q = Q_{nom}$ * sqrt(boost)
Boost < .5 :	$Q = Q_{nom}$ * boost / sqrt(1 – (2 * boost^2))

Here are the same two filter settings, with Q adjusted according to the above set of expressions:



+12 dB Parametric Filter, with adjusted-Q bandpass filter



-12 dB Parametric Filter, with adjusted-Q bandpass filter

Notice that the two filters are perfectly complementary, and have the same shape near their peaks as the Q=2 bandpass filter in the first examples

Another solution is to use the term "bandwidth" to specify the width of the filter. To obtain a consistent width at the "3 dB from peak" frequencies, and boost/cut symmetry over the full range of boosts; the Q must be varied with the amount of boost or cut. BSS (Omnidrive, Soundweb), and Media Matrix have taken this approach. To convert a "Q-based" filter to BSS & Media Matrix's "BW" (bandwidth) specifiation, use the following expressions:

boost = $10^{(\text{center frquency gain in dB / 20})}$

boost > 2, boost < .5 :	BW = sqrt(boost/2) / Q;
.5 < boost < 2 :	BW = 1 / Q

For converting “BW” to “Q”:

boost > 2, boost < .5 :	Q = sqrt(boost/2) / BW
.5 < boost < 2 :	Q = 1 / BW