Lose the Feeback

Improving Gain-Before-Feedback in Worship

Sennheiser HOW Applications Tip #9
Kent Margraves, June 2008

This discussion focuses on the processing and optimization of miked sources on the worship stage, using the equalization available in the PA console channels strips or outboard equalization inserted into these channels. It does not discuss overall system processing or "tuning" and assumes appropriate system installation and optimization.

Have you ever experienced a case of microphones squealing feedback before they are loud enough in your PA mix? Even with great mics and a wise layout, sometimes you could still use more **GBF** (gain-before-feedback). We'll take choir miking as our example for discussion. We usually mic choirs with several cardioid condenser microphones, right?

The feedback that occurs here is caused by the microphone(s) hearing itself being amplified in the PA system. The microphone picks up the source in front of it (good) and also picks up itself coming out of the PA (bad). So, since we wish to have the mics "hear" less of themselves from the loudspeakers, several ideas seem fairly straightforward for increasing GBF:

1. Turn it down
2. Use fewer microphones
3. Use directional mics aimed at the choir (and away from the loudspeakers)
4. Move the mics closer to the choir (and further from the loudspeakers)
5. Use directional loudspeakers, placed and aimed away from the mics
6. Use parametric equalization

1. Turn it down:

The simplest way to stop a mic from ringing feedback. Not real practical if the intent is to hear *more* of the choir in our PA.

2. Use fewer microphones:

The **NOM** (Number of Open Microphones) should be as low as practical. In our application of choir miking, use the minimum number of cardioid condensers needed to cover the choir. This sounds better anyway and it improves GBF. (See Sennheiser's Choir Miking note #3).

3. Use directional microphones aimed at the choir:

Omnidirectional mics can sound great, but in many sound reinforcement applications they may not be practical, as they hear themselves in the PA more easily. Using directional microphones pointed at the choir with their **nulls** (least sensitive side) facing the PA effectively increases GBF.

4. Move the microphones closer to the sources (and further from the loudspeakers):

Less gain is now needed on these microphones. And the less gain that is applied to them, the more GBF margin is left.

5. Use directional loudspeakers, placed and aimed away from the mics:

This system design function is not the job of the system operator. A qualified, independent consultant or design-build contractor should be contracted.

6. Parametric EQ:

OK, so your choir and mics are behind the loudspeakers, you're using a few good quality, directional condensers, and you understand how to place and aim them - but you still need to turn the choir mics louder in the PA without ringing. Equalization is often used to carefully cut the feedback frequencies and maximize GBF. Let's step through a common method of "ringing out" these choir mics:

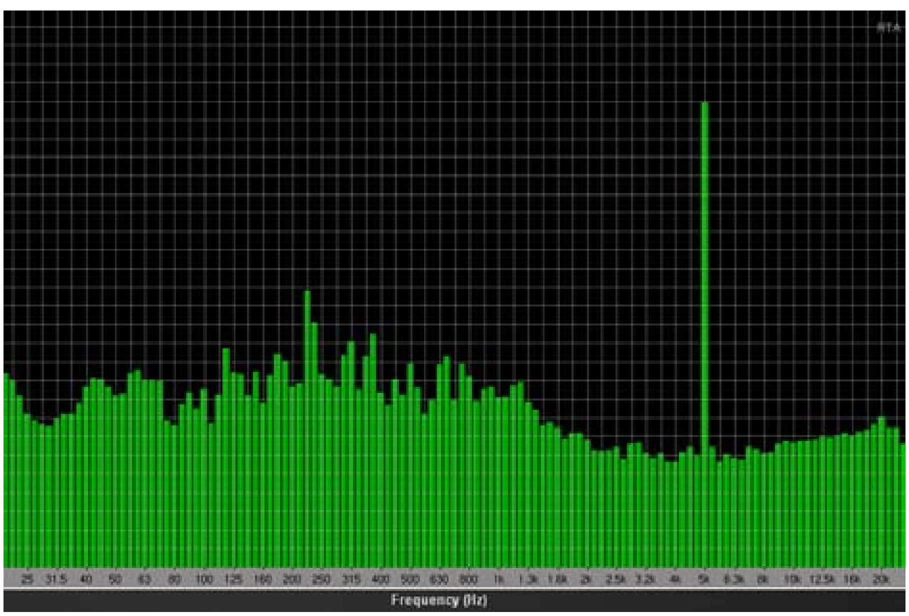
Turn off your choir microphone channels in your front-of-house console and flatten the EQ section of each. Go ahead and turn on whatever hi-pass filter is available on these channels. If it is just a switch, engage it. If it has a variable frequency control, set it to some reasonable starting place, such as 100 Hz.

Now, with the fader down, turn on ONE choir mic. Carefully and slowly raise the fader (your EQ is flattened now, feedback may come earlier than expected) until just the first ring occurs at a modest level. Hold onto the fader and pull back before the ring "takes off". It sounds like a pure tone. Determine by listening whether it is a low, mid, or high frequency ring (an RTA or FFT analyzer can be a wonderful visual aid by helping "see" exactly what frequency is ringing). Let's say it's a hi-mid frequency ring. So we turn down the hi-mid EQ control maybe 6 dB or more to stop the ringing.

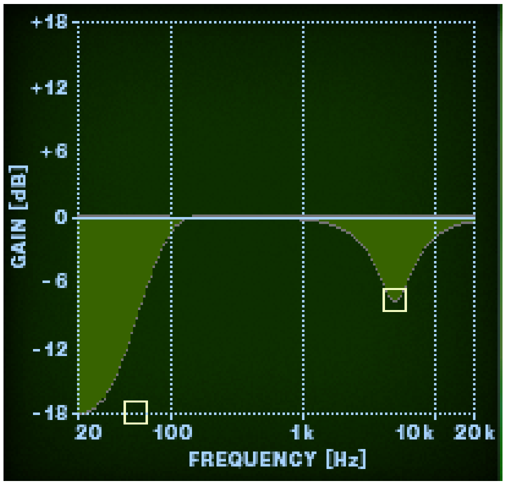
Then we push the fader a few dB higher until the next ring occurs. Let's say this is now a low mid frequency ring. We turn the low mid frequency control down several dB to stop the feedback. Now we push the fader further a 3rd time until it begins to ring once again, and this is maybe a midrange ring. So, you guessed it - we turn down the mid frequency control until the ringing stops. (By the way, continuing to do this "ring, cut, push higher" will eventually find a point where the ringing is no longer a single tone, but several tones together – a chord of sorts).

Awesome, we just increased the GBF on the choir microphone by doing three rounds of ring-and-cut, right? Maybe awesome, maybe not... This method can certainly work and sound good, but only with the right type of EQ filter, applied correctly. Let's look at why.

That first single ring looked something like this:

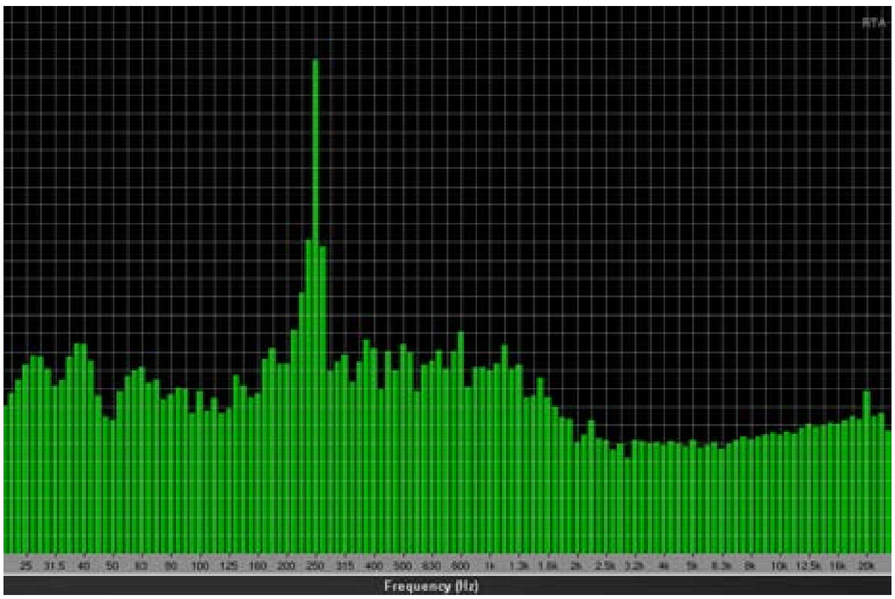


Note the ring is extremely narrow in frequency – centered right at about 5 kHz, in the high mid frequency range. And when we turned down the high mid frequency control on the mixer channel, we achieved something like this in the equalizer response:



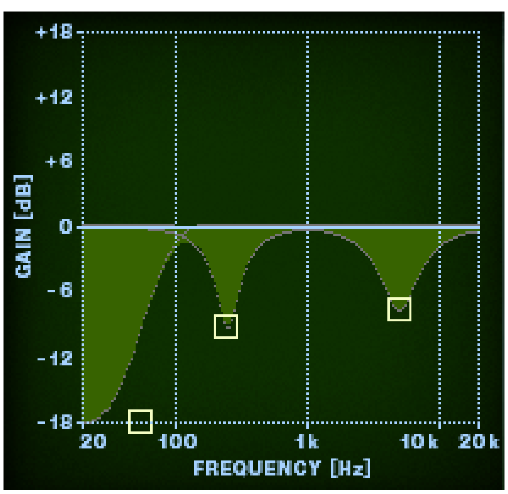
Hmmm. So we just cut the feedback and stopped it from ringing. Cool, but we also carved out an octave or more of this mic's hi midrange because the filter we cut has a fairly wide "bandwidth" (called Q). But we did meet our goal of stopping the feedback.

That next ring (low mid frequency) looks like this:



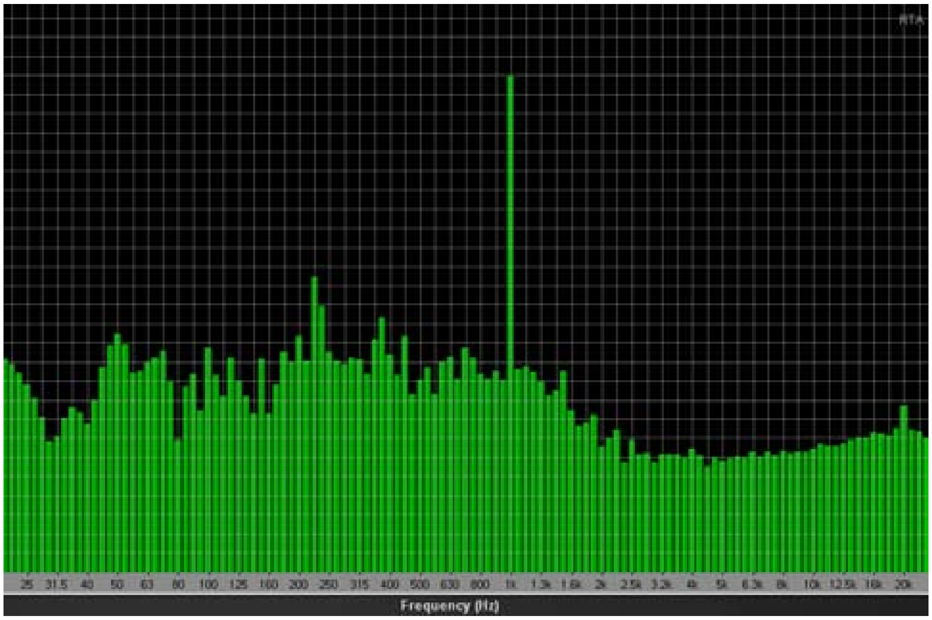
Again, the ring is very narrow, right at 250 Hz. That's in the low mid frequency range, and we turn down the correct low mid frequency control on the channel EQ.

Here's what we've done to the mic signal at this point:

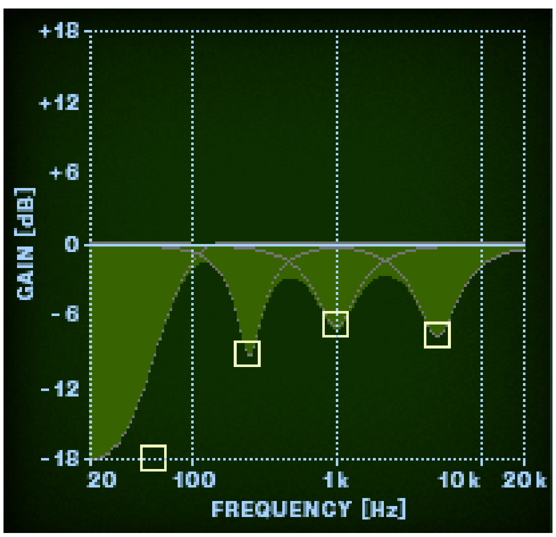


So, we just reduced that low mid frequency feedback maybe 7 or 8 dB, and we see the results of our EQ efforts thus far – a significant dip around 5kHz and another at 250 Hz. But what else happened, again? We also reduced the gain of a much wider low mid frequency range than the actual feedback spike at 250 Hz, because the filter we used is wider than the narrow feedback tone.

That third, midrange feedback ring was at, say, 1 kHz:



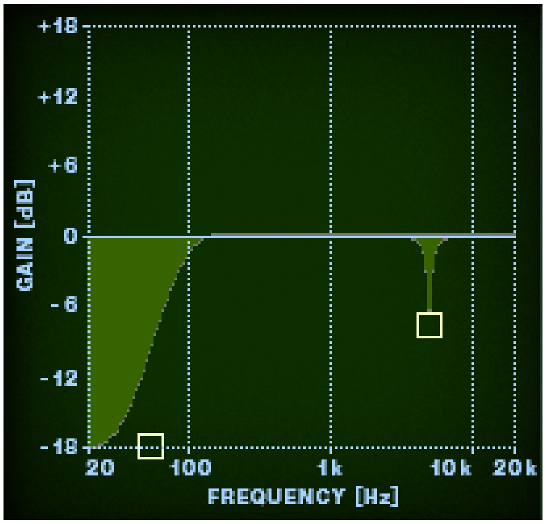
So we turn down the midrange control on our channel EQ and now this is the result of what we've done with our EQ at this point:



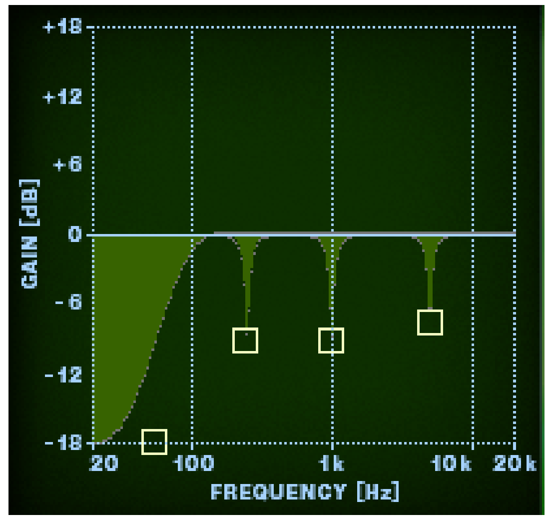
Note the 3 dips, centered at 250 Hz, 1 kHz, and 5 kHz. Our mic can be turned up louder now without feedback. Great, but how does it sound? By "carving up" this choir microphone with medium bandwidth EQ filters, we have DRASTICALLY changed to the tonal characteristic of the choir sound in the process of increasing GBF. We've taken away big chunks of the sound we would probably like to hear! Yes, it is louder (without feedback), but it may sound really rough. Wouldn't it be nice if we could reduce the gain on only the narrow feedback frequencies without affecting much of the ranges just above and below them? It is clear that we would benefit from cutting with EQ filters that are much narrower, and placed exactly on the feedback frequencies. So...

What is needed here is simply good parametric EQ. Some fine mixing consoles have fully parametric equalizers on each channel strip, but many do not. Some simply have fixed-frequency EQ, while others feature "semi-parametric" or "quasi-parametric" EQ. There is a big difference. Fully parametric EQ allows us to adjust three parameters: 1)the filter's gain (cut or boost), 2)the center frequency, and 3)the Q (bandwidth). Fixed frequency EQs have a pre-selected and permanent center frequency and Q. They are somewhat useful for tonal shaping, but don't allow the operator to adjust the frequency or bandwidth of the filter – they are far less than ideal for feedback filtering. Still, a number of consoles employ fixed frequency EQs for the Low and High filters, and then feature a semi-parametric Midrange control. But again, for notching feedback, we require control of all three filter parameters described above.

So in that first example where we cut the high mid frequency down, a parametric EQ would have allowed us to do this:

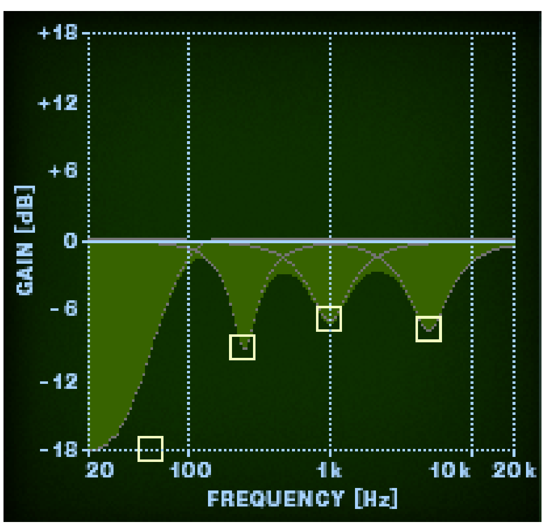


Note that the range of frequencies affected by this filter is considerably smaller than the original, broad cut we made at the same frequency of 5 kHz. If we use similarly narrow filters for those next ring tones (250 Hz and 1 kHz) the final result of our effort looks like this:

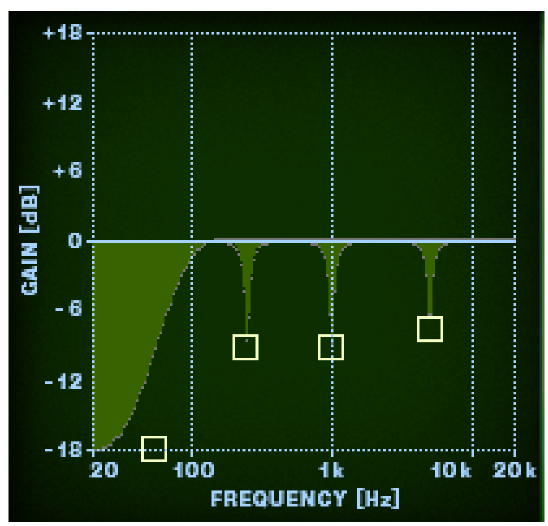


Big difference as compared to the original result with broader filters! So our filters are centered at exactly the same frequencies as before, but because we have set their bandwidths to be extremely narrow, we're now only cutting the feedback points, and cutting very little of the sounds above and below. Here are the results again, side by side, for comparison:

BEFORE (broad filters):



AFTER (narrow filters):



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This improves GBF nicely and has little effect on the sound quality. This is a dramatic improvement over using medium or broad filters.

This technique requires practice. Cutting feedback frequencies with very exacting, narrow filters is a bit tedious at first, but is well worth the effort and gets easier with experience. This practice of using parametric EQ to increase GBF is not specific to the choir example – it applies to most sound reinforcement miking applications. If there is also a need for artistic, shaping EQ adjustments, the EQ setting then becomes a careful and complex compromise – a balance of taste and required GBF.

In summary:

Any microphone in a sound reinforcement application will feedback if its gain is raised high enough. We can use proper microphone selection, directivity, and placement to maximize gain-before-feedback. In some cases, we still desire more.

Once the physical arrangement is optimized, narrow EQ filters (essentially ''notch filters''), achievable with parametric equalizers, can be very effective in further increasing gain-before-feedback without significantly degrading the sound quality. If the mixing console has fully parametric EQ on its channel strips, great! - Just practice. If it does not, external parametric equalization may be inserted.

Very narrow cut filters must be centered exactly on the feedback frequency, which requires care to find. A broader EQ filter is not as challenging to center, and as long as it is ''close'' it will help reduce feedback. But it cuts a wider range of frequencies than is actually needed for feedback control, at the cost of reduced sound quality. Ear training, practice, and the use of live visual tools such as an RTA or FFT display can improve one's ability to quickly identify and cut a specific feedback frequency with an appropriately narrow EQ filter.