dbx Advanced Feedback Suppression™ (AFS™)

INTRODUCTION

Feedback is the bane of almost all PA systems. It can take a great performance and turn it into a painful and embarrassing experience for the performer, audience, and the sound operator. Up until a few years ago there was little that could be done electronically about feedback except rudimentary efforts using EQ. With the advent of Digital Signal Processing (DSP), automatic feedback elimination has been made possible. Unfortunately, many of these earlier products did not maintain the sonic integrity of the audio signal because they required wide notch filters to suppress feedback. The dbx® AFS™ algorithm solves this problem by using Precision Frequency Detection™ with adaptive filter bandwidth to place the minimum number of very narrow notch filters, which will stop the feedback without degrading the audio signal.

HOW ACOUSTIC FEEDBACK OCCURS

Acoustic feedback occurs in a sound re-enforcement system when the signal output from the speaker is picked up by the microphone and amplified, creating a feedback loop. What results is an audible "squealing" or "howling" of the system. Figure 1 illustrates a typical system setup with a microphone, mixer, amplifier, and speaker.

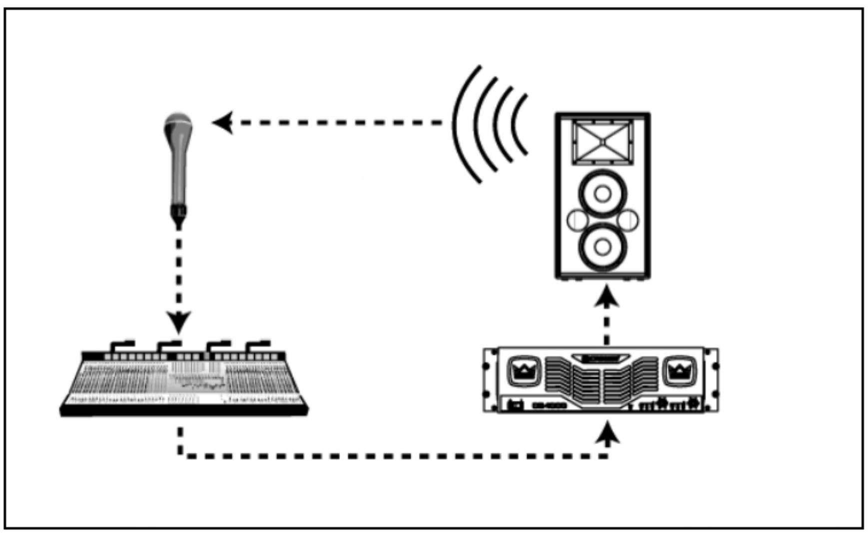

Figure 1

The loop gain consists of the gains in the mixer (*G_mix*) and amplifier (*G_amp*), as well as the losses in the system (*L_sys*), as illustrated in Figure 2.

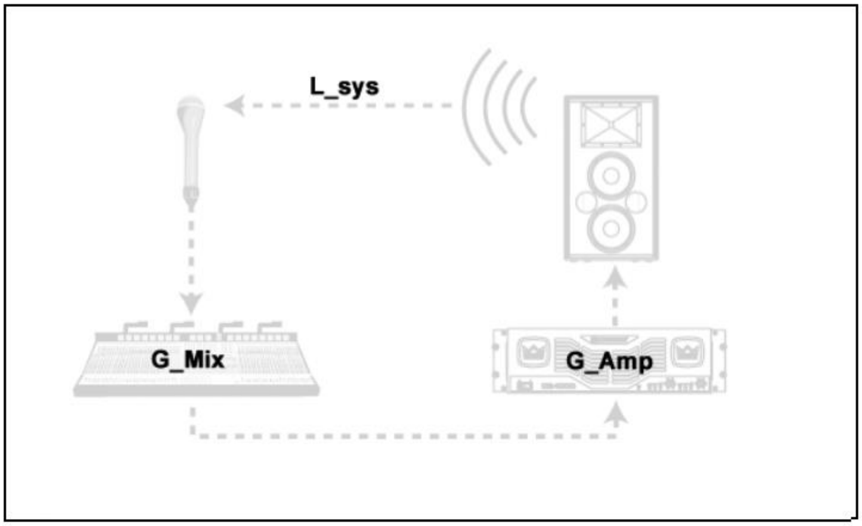

Figure 2

L_sys includes the losses from microphone to mixer, speaker to microphone, and any other losses in the loop. Therefore, the loop gain of the system can be represented mathematically as

$$LoopGain = G\_mix * G\_amp * L\_sys.$$

This equation can be represented in dB as

$$LoopGain_{dB} = G\_mix_{dB} + G\_amp_{dB} + L\_sys_{dB}.$$

For feedback to occur, the loop gain must be greater than unity (or greater than 0 dB) and in phase at a particular frequency. When this occurs, the loop gain at the feedback frequency must be reduced below unity to remove the feedback. This gives us

$$LoopGain_{dB} = G\_mix_{dB} + G\_amp_{dB} + L\_sys_{dB} + G_{atten} < 0_{dB},$$

where G atten represents the necessary amount of attenuation required to pull the loop gain at that frequency below 0 dB.

dbx ADVANCED FEEDBACK SUPPRESSION™ (AFS™)

The dbx Advanced Feedback Suppression™ (AFS™) algorithm eliminates feedback by placing a very narrow notch filter at the frequency feeding back. When the loop gain at that frequency is pushed below unity, the feedback disappears. Using our patent pending Precision Frequency Detection™ with adaptive filter bandwidth, we are able to place the minimum number of very narrow notch filters (Q = 116, bandwidth = 1/80 octave1). Utilizing very narrow notch filters preserves the sonic quality of the system.

Historically (before automatic feedback elimination), feedback was removed manually using a 1/3 octave graphic or parametric EQ. When feedback occurred, the sound engineer would guess where the feedback was located, and pull down a fader to decrease the gain at that frequency. This method unnecessarily cuts out large portions of the spectrum.

The dbx Advanced Feedback Suppression™ (AFS) algorithm uses a very narrow notch filter to reduce the gain at the feedback frequency. Figure 3 compares a 1/3 octave graphic EQ with the dbx AFS™ very narrow notch filter. Again, atten G represents the necessary cut required to guarantee that the feedback is removed. It is easy to see the limitations of the manual approach.

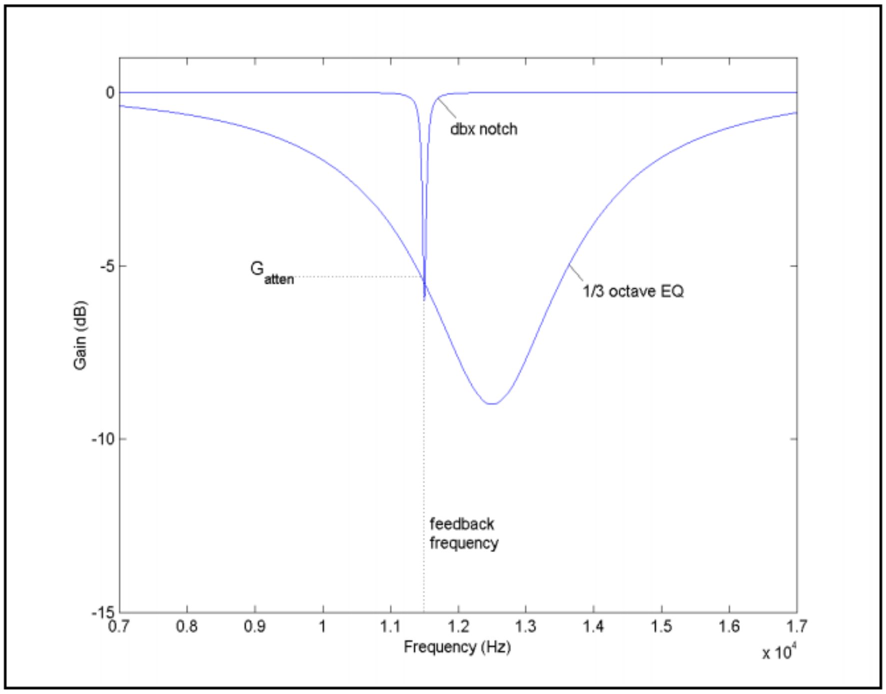

Figure 3

The bandwidth of a filter can be stated as Q or in octaves. The Q is computed by dividing the center frequency by the bandwidth of the filter. For dbx feedback notch filters, the bandwidth is measured at the -3dB point (from 0 dB). That means that no matter how deep the notch filter cuts, its bandwidth will be measured from –3 dB. This is important because many competitors will claim to have narrow notch filters, but they measure their bandwidth 3dB above the peak cut depth. In other words, for a cut depth of –18 dB, some of our competitors measure the bandwidth at –15 dB, which results in a significantly wider bandwidth filter (this will be explained graphically in the next section). The other way to measure filter width is in octaves. This means that the number stated (say 1/10 octave) is the bandwidth of the filter, which varies depending on the center frequency.

PRECISION FEEDBACK FREQUENCY DETECTION™

While the placement of notch filters to eliminate feedback is common among all automatic feedback eliminators, where to place them and how narrow to make the filters varies drastically.

A common complaint of traditional feedback eliminators is that the feedback filters cut out large portions of the spectrum, which ultimately degrades the audio quality of the system. While most competitors would like you to believe that they use narrow notch filters that don't alter the fidelity of the signal, in reality the limitations of their feedback elimination algorithm require them to use wider bandwidth notch filters. Some competitors claim to use as high as 1/60th octave (Q = 87) notch filters2, but what they don't tell you is that the deeper they cut, the wider the bandwidth gets. Figure 4 illustrates Behringer's "1/60th octave" notch filter compared to dbx's 1/80th octave notch filter at a cut of –18 dB.

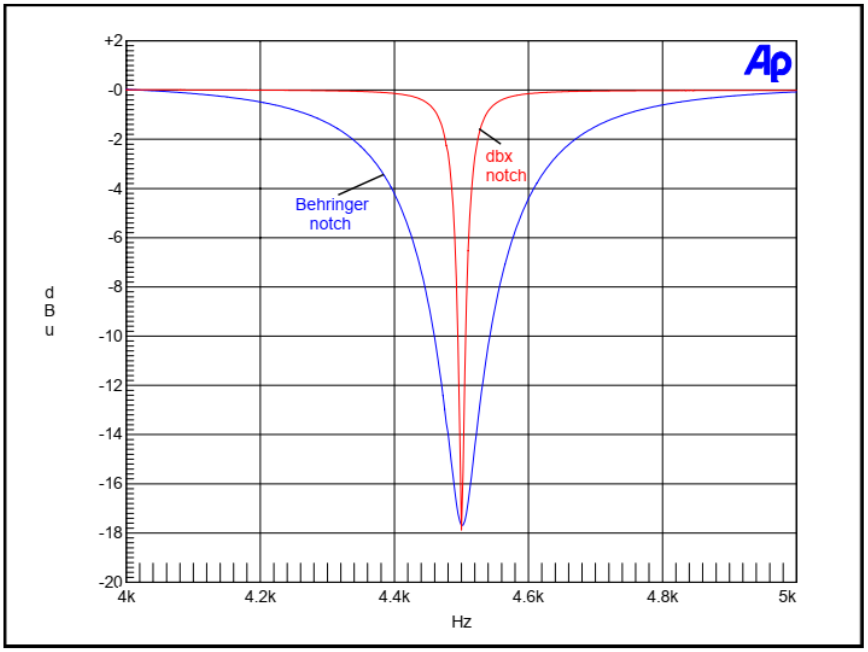

Figure 4

With our patent pending dbx Precision Feedback Frequency Detection™, we are able to pinpoint the feedback frequency and place an extremely narrow notch filter there. Having very narrow notch filters minimizes the unwanted effect of the filters to the sonic quality of the system. Figure 5 illustrates dbx's very narrow notch filter placed at the feedback frequency, 1 f . The value atten G represents the necessary filter depth required to remove the feedback. Most feedback eliminators can only detect feedback and place notch filters at discrete frequency positions. For example, in the case of Figure 5, the feedback frequency 1f - is at 3011 Hz. If you can only place a filter at 12 or 6 Hz increments, then you must have a notch filter wide enough (or deep enough) to cut out the feedback at 3011 Hz. The Sabine filter necessary to do this cuts out a much larger portion of the audio spectrum by using a wide bandwidth notch filter3. Using Precision Frequency Detection™, the dbx algorithm can place a filter virtually anywhere in the spectrum, not just at discrete frequency locations. By placing the filter at the feedback frequency we are able to cut out less of the spectrum.

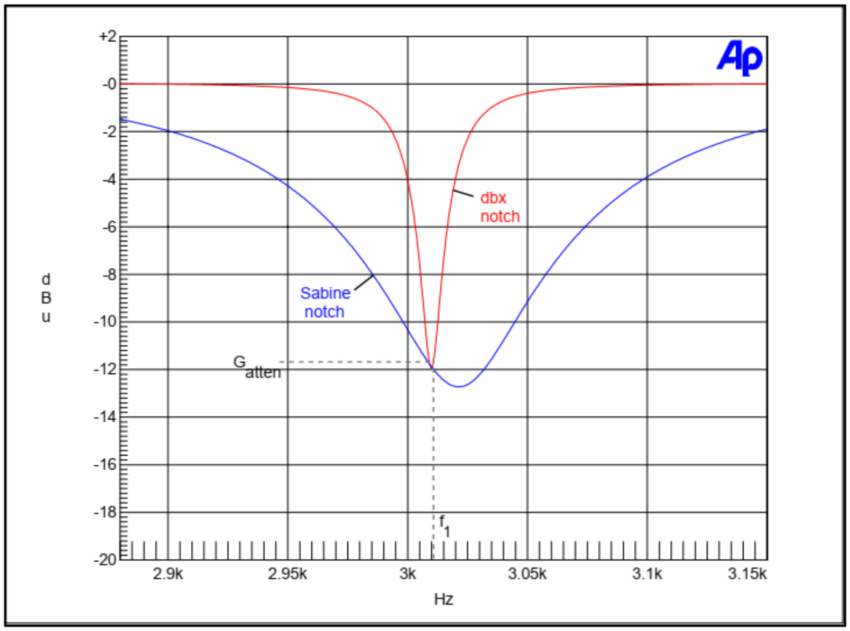

Figure 5

Similarly, some competitors increase the cut depth of the notch filter to compensate for the uncertainty of the feedback frequency. This effectively increases the width of the filter, and unnecessarily cuts out a large portion of the spectrum. Again, the dbx algorithm precisely locates the feedback and places a filter at the feedback frequency, resulting in less music spectrum being affected.

ADAPTIVE FILTER BANDWIDTH

As feedback is detected and notched out, it is possible (and even common) to have filters placed very close to each other. This phenomenon may occur because the system can feed back over a very close range of frequencies, or the feedback frequency may shift over time. Figure 6 illustrates the frequency response of two adjacent notch filters (Q = 116; cut = -6 dB) placed 6 Hz apart at 1003 Hz, and

3 The Sabine FBX1020 and the Shure DFR11EQ have a maximum Q of 14.4 (1/10 octave).

1009 Hz. In this case, feedback was detected separately at these frequencies, and two notch filters were set.

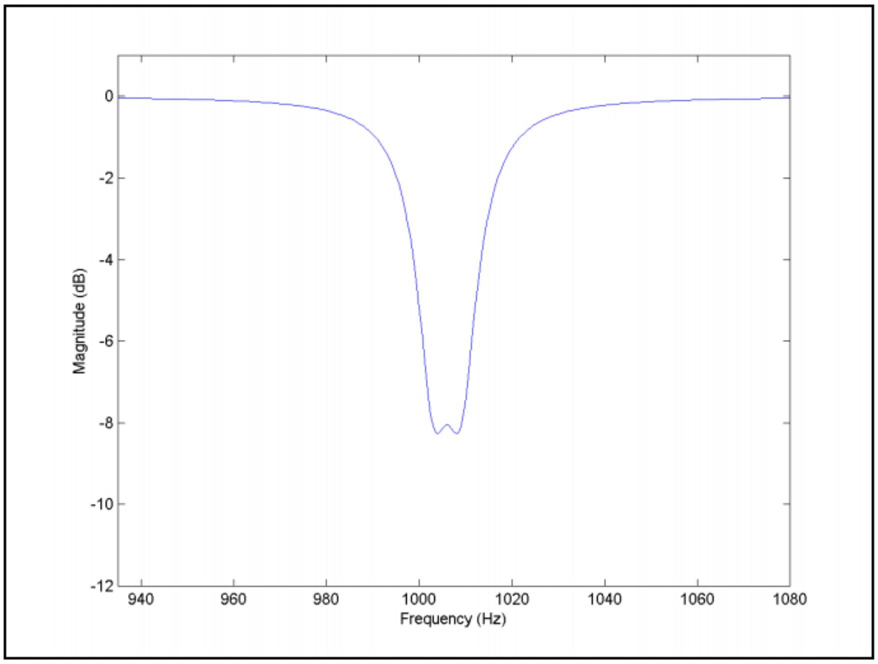

Figure 6

We can release one of the two filters and place a single notch filter with a wider bandwidth (lower Q) filter between these two frequencies (at 1006 Hz, Q = 50) as shown in Figure 7.

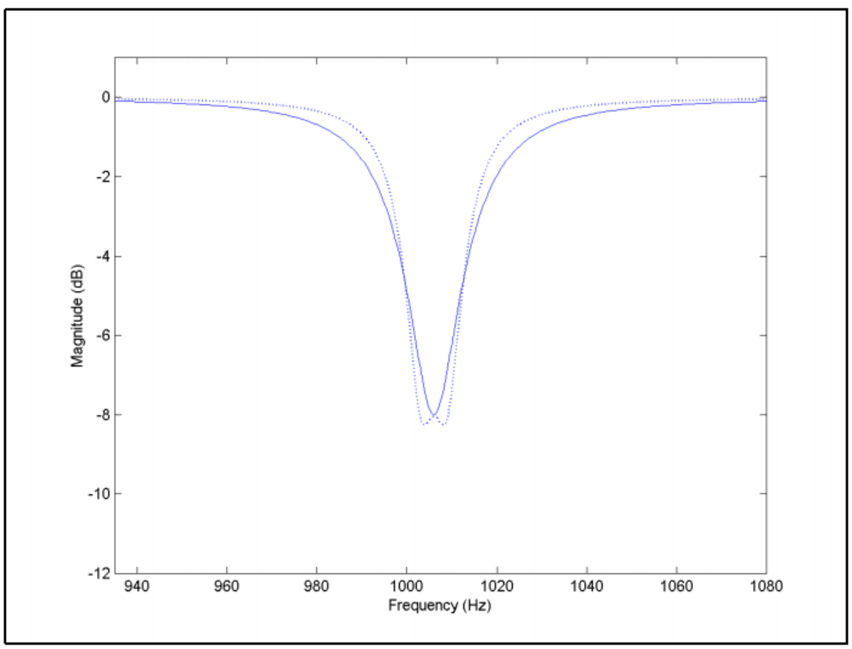

Figure 7

This one filter effectively approximates the frequency response of the two filters located very close in frequency. By adaptively changing the filter Q, dbx AFS™ uses as few filters as possible which makes more filters available to remove new feedback.

MULTIPLE FILTERS SET AT ONE TIME

Many feedback eliminators expect that a sound re-enforcement system will only have one feedback frequency at any moment in time. In practice however, it may be possible to have more than one frequency feeding back. In these cases, many of the competitor's feedback eliminators can only remove one at a time. dbx's Advanced Feedback Suppression™ (AFS™) can remove up to 6 feedback frequencies at any one time. This increases the perceived speed of the feedback eliminator, and prevents multiple cases of runaway feedback.

dbx ADVANCED FEEDBACK SUPPRESSION™ OPERATION

FIXED AND LIVE MODES

Typically, every venue is prone to feedback at certain "resonant" frequencies according to the characteristics of the room, as well as the setup and position of the microphones and speakers. The FIXED setup mode is designed to remove these occurrences before a performance. These filters remain set during the performance and they are not removed (unless manually reset).

The LIVE mode is designed to adaptively remove feedback as the characteristics of the system change. This may occur if a microphone is moved, if the signal content or gain changes, or when the room acoustics change. If all of the LIVE filters are used, then they begin to round robin at the instance of new feedback. The first filter that was placed is released and then set at the frequency of the new feedback occurrence. LIVE filters are designed to work during a performance.

LIVE FILTER LIFT

During a performance, the LIVE filters adapt to the changing environment, notching out feedback as it arises. This is useful because the frequency response of the venue may change over time. Because of the dynamically changing environment, a filter set 5 or 10 minutes ago may no longer be preventing feedback at that particular frequency. The "Live Filter Lift" parameter allows the user to set up a timer for the LIVE filters. After the timer for each filter has expired, that filter is slowly lifted. If the need for feedback suppression at that frequency still exists, then the filter is not removed and it continues to prevent feedback. However, if feedback suppression at that frequency is no longer needed, then the filter is removed, and is available to notch out another feedback.

This parameter is useful because it removes unnecessary filters, and it frees up more filters to catch future feedback. Also, it provides an automatic reset mechanism for the LIVE filters. It then becomes unnecessary to manually reset the LIVE filters after a performance.

CONCLUSION

dbx's patent pending Advanced Feedback Suppression™ (AFS™) provides the security and protection of feedback elimination using ultra-narrow notch filters (Q = 116) which maintains the integrity and sonic quality of the system. Using Precision Frequency Detection™, the location of the feedback frequency is pinpointed and a very narrow notch filter is set, which maintains the fidelity of the audio signal. The adaptive filter bandwidth algorithm frees up adjacent