Sonic Spotlight

Adaptive Feedback Canceller Pro combines two systems for advanced feedback control

Advanced feedback cancellation is now available for your most challenging-to-fit patients. The Adaptive Feedback Canceller Pro (AFC Pro) from Sonic is an innovative system that can improve hearing aid use in terms of decreasing feedback occurrence, allowing more open fit options, and providing a closer target match for a better hearing solution. Hearing care professionals will enjoy fitting a higher number of patients with a reduced risk of feedback. Read on to find out how this technology works for you – and your patients.

Physics of feedback

It's a fact – feedback happens. From electronic systems like hearing aids, feedback occurs when amplified sound gets re-amplified and causes an unpleasant high-pitch squeal or howl. Complaints about annoying feedback persist year after year and are a common reason for dissatisfaction and non-use of hearing aids (McCormack and Fortnum, 2013). As such, effective technology to address this issue remains an important research area to explore. Luckily there are some known variables that can help us understand its behavior, in order to better control it. To start, it's useful to know a definition of the feedback path. It is the acoustic path of amplified sound escaping from the ear back to the microphone. However, there are two noteworthy types of feedback paths when a hearing aid sits in the ear canal: 1) the static path is the leakage of sound when the hearing aid user remains still; and 2) the dynamic path occurs when the user moves or touches the aid (Schaub, 2008). How much sound escapes from the static or dynamic path depends on the venting of the earmold, dome, shell, or slit leaks and determines the loudness and duration of the acoustic feedback; it also provides key insights to engineers who develop anti-feedback technology to reduce it (Agnew, 1996).

Phase cancellation technology – for the static feedback path

Adaptive feedback cancellation is well-established in the hearing aid industry – it's been around for more than a decade (Chalupper et al., 2011). Sonic's existing Adaptive Feedback Canceller (AFC), for example, uses a feedback monitor and adaptive filter to estimate the static feedback path of the hearing aid sitting in the ear canal. The system detects signals coming from the output of the receiver and subtracts them from the microphone's input to cancel feedback before it starts. Via phase cancellation, the adaptive filter generates a new signal 180 degrees out of phase to cancel the feedback loop. This makes it capable of suppressing feedback without degrading the audibility of speech (Nordholm et al., 2018). The technology works well in stable or gradually changing conditions, where the actual feedback path matches the algorithm's estimated feedback path. However, in more challenging conditions with sudden, fast movements (e.g. inserting or removing the aid, putting a phone to the ear, putting on a hat), the estimation occurs too slowly and the filter can't react quickly enough, causing feedback to occur (Guo & Kuenzle, 2017). In these cases of fast movements when the actual feedback path doesn't match the estimated one, different technology should be considered, since the phase canceller needs more time to re-estimate the correct feedback path. Accordingly, a solution that employs a faster estimation of the feedback path would be ideal to reduce the risk of feedback in challenging conditions.

Spectro-temporal modulation – for the changing feedback path

Due to additional processing power in the latest Sonic SoundDNA platform chip, a fast-acting supplementary system to manage feedback associated with sudden, unpredictable changes to the feedback path is now available. This added algorithm in the digital signal processor's feedback-management block more quickly estimates the feedback path. It then uses spectro-temporal modulation, or STM processing, to proficiently eliminate feedback caused by quick movements that alter the anticipated, predictable pathway (Guo & Kuenzle, 2017). Essentially, brief spectral and temporal modulation cues are added to the signal to help break the feedback loop and suppress feedback; these STM-processed sounds are soft and less intrusive than the characteristic feedback squeal that is typically louder and longer in duration (Guo et al., 2018).

The new algorithm is faster than AFC alone and can detect the feedback signal within milliseconds. It therefore quickly identifies and then suppresses feedback that occurs when the feedback path abruptly changes. This offers robust feedback cancellation capabilities, even at higher output levels, compared to previous technology. While AFC continually operates in the background to quickly cancel feedback in static conditions, the new system quickly detects fast changes to the feedback path and applies STM processing whenever the adaptive filter is insufficient to cancel feedback. Its speed allows the system to add up to 6 decibels (dB) stable gain in feedback-susceptible situations. Called **AFC Pro**, these two systems work together as one to improve feedback cancellation performance in both stable and challenging situations. By reducing the occurrence of feedback, it provides the hearing aid with a higher threshold of feedback in the fitting software, offering a better target match for soft sounds and allowing for a more open fitting with less feedback risk. Examples to illustrate each of these points follow.

AFC Pro reduces occurrence of feedback

Test measures were made to compare feedback variations in the previous versus current technology. Two equivalent miniRITE hearing aids were programmed with a standard S2 audiogram (Bisgaard et al., 2010) (Fig. 1) and fitted with 85-Speaker units and open domes. The NAL-NL2 fitting rationale was selected and gain was matched to target for both devices. One device had AFC activated, while the other had AFC Pro activated.

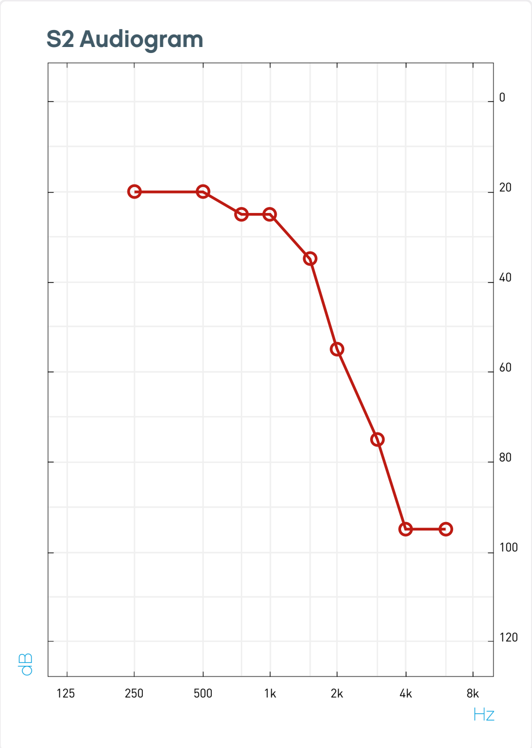

Figure 1: Hearing threshold levels programmed into devices activated with AFC and AFC Pro.

The technical evaluation consisted of four attempts to trigger and record feedback with fast-changing movement. The devices were individually placed on an artificial head. A loudspeaker was placed in front of the device and a 12-second extract from Bach Chaconne in D-minor for violin was played at an average level of 65 dB SPL. Two recordings were made: the first time without any changes in the feedback path, and a second time where each device was covered and uncovered four times with the hand of the tester. The recordings from the second time with movement are displayed in the form of a spectrogram (Fig. 2). The spectrogram differences between both device recordings are shown for frequencies between 1 and 6 kHz. The portions on the spectrogram representing the acoustical feedback are displayed in red.

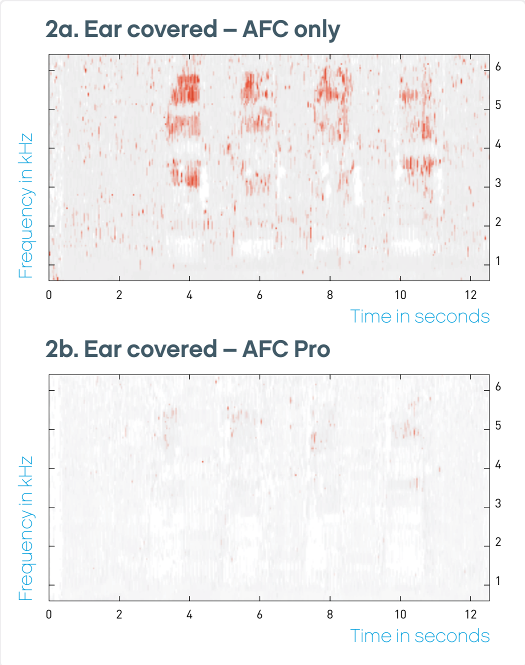

Figure 2: Spectrogram differences between hearing aid output with AFC (2a) and with AFC Pro (2b) as the device was covered and uncovered four times with a hand. The portions on the spectrogram representing acoustical feedback are shown in red. With AFC Pro, nearly all audible feedback has been eliminated from the output.

Results show more feedback for the device with AFC (Fig. 2a) than with AFC Pro (Fig. 2b). The rapid movements in this example resulted in negligible feedback with AFC Pro – nearly all audible feedback was eliminated from the output during the test. The faint, light red components indicate feedback that is barely perceptible, soft and brief in duration. AFC Pro's ability to quickly suppress feedback with STM doesn't permit the signal to reach higher levels. Comparatively, louder and longer audible feedback occurred in the device with AFC. This can be a distraction or perceived as annoying to hearing aid users.

From this test, we can conclude that feedback occurs less frequently with AFC Pro with common, expected hand movements. The loudness and duration of acoustical feedback is reduced in fast-changing conditions in the feedback-susceptible situation where a hand is rapidly brought up to the ear to cover the aid. There will be fewer interruptions from the annoyance of feedback, in both stable and changing conditions. This is the fundamental improvement of the new feedback cancellation system and leads to more advantages as a consequence, explained in the following section.

AFC Pro improves feedback margins in fitting software to offer more advantages

As described above, the new feedback canceller reduces acoustical feedback when the feedback path changes suddenly, while feedback performance in static situations remains the same between both technologies. Because of this enhanced performance, the feedback threshold margins in the EXPRESS*fit*® Pro fitting software can be increased. The feedback margin is the dark grey-colored area in the amplification screen that represents a risk of feedback for target gain. We can visualize the improved feedback margins with a side-by-side comparison of two products with both technologies. Figure 3 shows two identical fittings programmed with the same hearing loss (Fig. 1), fitting rationale (NAL-NL2), and speaker unit (85-Speaker). The software-recommended earpiece "Bass dome, double vent" which provides a more closed fitting was selected for each device.

Results show different feedback margins for the device with AFC (Fig. 3a) versus AFC Pro (Fig. 3b). The feedback margin with AFC Pro is about 4-6 dB higher compared to AFC. This means AFC Pro can allow more gain before the risk of feedback occurs. In this case, the margins do not affect the target match as there is ample headroom above the target gain for a 50 dB input signal (top curve).

Consider what would happen if a more open fitting is preferred for this loss with normal low-frequency hearing. Theoretically, the feedback margins in the software will change (lower) with a more open earpiece, which has the potential to affect the target match. The gain required for the loss may cause the prescribed target curves to approach or cross into the feedback margin. If this happens, the software initially restricts the gain below the feedback margin to ensure feedback does not occur. Therefore, the attempt to alleviate occlusion with a more open fitting must be carefully considered, since it may compromise audibility for important soft (50 dB) and medium (65 dB) input levels. (It is possible to manually increase the gain above the feedback threshold to match target, however this increases the risk of feedback.) Let's now examine how the selection of an open dome affects the target match with the previous vs. current feedback management technology for this particular fitting.

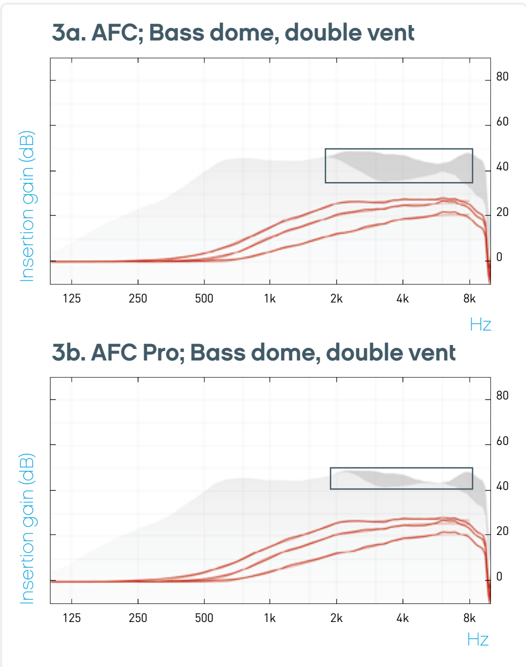

Figure 3: Feedback threshold margins for AFC (3a) and AFC Pro (3b) in EXPRESS*fit* Pro for bass dome fitting. The feedback margin is lower for AFC and higher for AFC Pro.

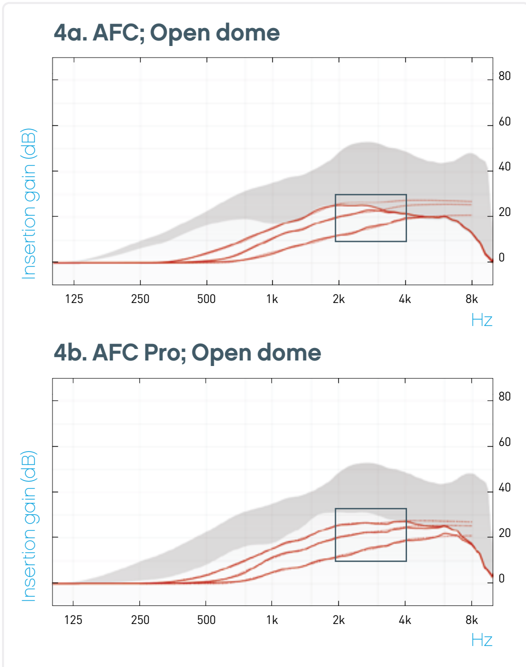

Figure 4: Feedback threshold margins for AFC (4a) and AFC Pro (4b) in EXPRESS*fit* Pro for open dome fitting. The feedback margin is lower for AFC and higher for AFC Pro.

With AFC (Fig. 4a), the feedback margin is lower, as expected, when using an open dome compared to the bass dome example (Fig. 3a). The gain for soft and medium input levels is restricted, or lowered, compromising amplification especially between 2-4 kHz with this dome type. Although this reduces feedback risk, it may ultimately lead to unsatisfactory benefit for the patient due to reduced audibility for these inputs. The trade-off to alleviate occlusion with an open-dome fitting has a negative impact on the required amplification to fit the loss appropriately.

With AFC Pro (Fig. 4b) however, the feedback margin with an open dome is higher compared to the open-dome fitting with AFC (Fig. 4a). The increased feedback threshold allows for a better target match between 2 and 4 kHz. The gain is not restricted, which provides the required audibility for soft speech inputs with negligible risk of feedback. A headroom buffer exists if more gain is desired, whereas it was not available without risk with AFC. As such, it is possible to fit the same hearing loss with a more open acoustic earpiece and without experiencing more acoustical feedback with AFC Pro.

In summary for this example, AFC Pro offers a better solution than AFC for an improved target match due to the increased feedback margins. The device with AFC Pro can offer an open fitting that not only provides improved audibility for soft speech sounds, but also less occlusion for a more natural own-voice sound, and with less feedback risk compared to previous technology for this high-frequency hearing loss. This benefit of AFC Pro is evident not only for this example, but also extends to others like it. Performing software simulations for other hearing loss degrees, configurations and earpieces will demonstrate this trend of benefit on a case-by-case basis when comparing previous to current anti-feedback technology, although exact performance per level and frequency of feedback margins differs per individual loss.

Using AFC Pro in EXPRESS*fit*® Pro fitting software

Using AFC Pro in EXPRESS*fit* Pro 2019.1 and later, is simple. Go to the feedback management screen (Fig. 5). Ensure the aid is seated properly in the patient's ear and background noise is not present. Click "Measure" to run the measurement and "Accept" to apply the measured feedback limits. It is recommended to run the feedback measurement for every fitting, even if no occurrence of feedback happens during the fitting. There is no graphical or functional change between former and current software versions.

Figure 5: Feedback Manager screen in EXPRESS*fit* Pro.

AFC Pro benefits

Feedback may be a fact of life with any system that uses a microphone, amplifier and receiver. However, when feedback occurs that is shorter and softer in duration, it will lead patients to experience fewer distractions and interruptions from its annoyance. With a faster system that offers additional stable gain compared to previous technology, the hearing aid will be able to deliver a better target match in the fitting software, providing patients with improved audibility of soft speech sounds in typical feedback-susceptible frequencies. At the same time, more open fittings become a possibility for the same degree of loss, which will lead to a more natural own-voice sound compared to more closed fittings.

The reduction in feedback occurrence and the improved feedback threshold margins offers listeners many benefits compared to previous technology, such as:

- *Fewer distractions and interruptions from the annoyance of feedback, in both stable and changing conditions*
- *A better target match, for improved audibility of soft speech sounds*
- *More open fittings for a natural, own-voice sound*

AFC Pro is an effective system that aims to alleviate many problems related to acoustic feedback, in order to maximize the full use of the fitting range provided by the instrument. It is available in new products starting in 2019 and is one more way that Sonic makes everyday sounds better.

To schedule a product demonstration, contact your Sonic representative.

References

Agnew, J. (1996). Acoustic Feedback and Other Audible Artifacts in Hearing Aids. Trends in Amplification, 1(2), 45–82.

Bisgaard, N., Vlaming, M. S. M. G., & Dahlquist, M. (2010). Standard Audiograms for the IEC 60118-15 Measurement Procedure. Trends in Amplification, 14(2), 113–120.

Chalupper, J., Powers, T.A., Steinbuss, A. (2011). Combining phase cancellation, frequency shifting, and acoustic fingerprint for improved feedback suppression. Hearing Review, 18(1):24-29.

Guo, M., Kuriger, M., Lesimple, C., & Kuenzle, B. (2018). Extension and Evaluation of a Spectro-Temporal Modulation Method to Improve Acoustic Feedback Performance in Hearing Aids. In 2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). IEEE.

Guo, M., & Kuenzle, B. (2017). On the use of spectro-temporal modulation in assisting adaptive feedback cancellation for hearing aid applications. In 2017 51st Asilomar Conference on Signals, Systems, and Computers. IEEE.

McCormack, A., & Fortnum, H. (2013). Why do people fitted with hearing aids not wear them? International Journal of Audiology, 52(5): 360–368.

Nordholm, S., Schepker, H., Tran, L. T. T., & Doclo, S. (2018). Stability-controlled hybrid adaptive feedback cancellation scheme for hearing aids. The Journal of the Acoustical Society of America, 143(1), 150–166.

Schaub, A. (2008). Digital Hearing Aids. Stuttgart, Germany: Thieme.

SoundDNA Platform

www.sonici.com

04.19 I UK

SONIC
Everyday Sounds Better