TECHNICAL PAPER - 2015

Inium Sense feedback shield

ABSTRACT

In the Oticon Alta2, Nera2, and Ria2 hearing instrument families, Oticon has improved upon our existing anti-feedback system and it has now become the Inium Sense feedback shield. The purpose of this brief Tech Paper is to explain the updates that have been made to the Inium feedback shield in order to bring Hearing Care Professionals an anti-feedback system they can always rely on.

Phase inversion   **Frequency shift**   **Gain control**

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OTICON'S THREE FEEDBACK STRATEGIES

The anti-feedback system in any hearing instrument has the very important and formal function of enabling the Hearing Care Professional (HCP) to provide their patient with the most accurate and most appropriate target-matched fitting possible. It is not simply a matter of reducing feedback. If that were indeed the case, a simple reduction in gain would remove the feedback and the problem would be solved. In reality, if gain is drastically reduced to eliminate feedback, then the patient sacrifices audibility. Three separate factors need to be taken into account: elimination of feedback, safeguarding of audibility, and preservation of sound quality. Oticon's Inium Sense feedback Shield has been updated to provide even better feedback protection than before. This document will explain the main updates.

Generally, Oticon utilises three techniques to manage feedback: gain control, frequency shift, and phase inversion. The update on the anti-feedback system pertains to frequency shift and gain control.

WHAT IS A FEEDBACK PROBLEM?

A hearing instrument can have a serious feedback problem without the hearing instrument wearer ever hearing audible feedback. How is this possible? Sound will always leak out around a dome, even an ear mould. When the sound re-enters the microphone, it mixes with the "desired" sounds from the environment. In this way, the desired sound is polluted by the feedback, however, the instrument might never actually squeal or whistle. If the feedback limit is reached, feedback now becomes audible and the wearer complains, but already as we approach the feedback limit, feedback can cause serious degradation of sound quality. This is called inaudible feedback.

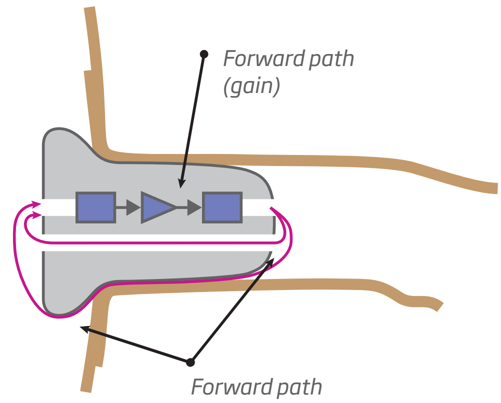


Figure 1. Courtesy of Dillon, 2012.
Feedback loop of a hearing instrument.

In Oticon's products, the anti-feedback system works continuously to keep the hearing instrument away from both audible as well as inaudible feedback.

If the HCP puts pressure on the anti-feedback system because the hearing instrument is fitted with a small gain margin and a large vent size, then compromises may become necessary relative to target gain and sound quality. An example might be a patient with a significant hearing loss requesting a small instrument and an open fitting. The more measures we have in place to prevent feedback, the higher the likelihood of audible artefacts for the patient.

An anti-feedback system is necessary, useful, and wonderful to have, however, using it conservatively has positive outcomes in terms of audibility and sound quality. Choosing an appropriate fitting algorithm, an appropriate hearing instrument style, and appropriate acoustic parameters to ensure a larger gain margin is therefore always encouraged.

GAIN CONTROL

There are two important and distinct ways that Oticon hearing instruments control gain in relation to feedback management. The first is related to the fitting in the office and it is referred to simply as the Feedback Manager. The second is related to the patient's everyday use of the hearing instruments and how feedback is handled in real-time once the patient leaves the office and goes about living their life. We start here.

Daily feedback challenges faced by the hearing instruments vary greatly and it is necessary to have a system in place which is completely adaptable to the ongoing environmental changes. Oticon's answer to this is gain control, which is an integrated part of the overall anti-feedback system engine.

Let's tackle head-on the taboo in feedback management: reducing gain. As mentioned earlier, solving the feedback problem by reducing gain too much is not desirable. However, realistically, solving the feedback problem by using only advanced mechanisms such as phase inversion coupled with frequency shift is not always possible if one wants to ensure good sound quality. All hearing instrument manufacturers must make difficult decisions on this trade-off:

Adequate gain and good sound quality versus no feedback.

Manufacturers that "never have feedback problems" sacrifice gain and/or introduce distortion and artefacts through aggressive frequency shift. Trying to find the balance is key.

In our improved anti-feedback system, the working range of the gain control system has been increased to allow for more efficient reduction of audible and inaudible feedback. This means that the system now allows up to 40 dB temporary reduction in gain, up from 10 dB gain reduction previously at the affected frequencies. This larger decrease in gain is coupled with a substantially faster gain restoration rate. The gain restoration rate is raised from 6dB/second to 40dB/second. Furthermore, this gain reduction is narrowly targeted to include only the specific frequency where the risk of feedback is temporarily heightened. The gain control system is responsible for reducing and restoring the prescribed gain and makes this change as needed in each band, independent of settings in adjacent bands. The reductions in gain are always limited in time and scope to preserve speech cues at all times.

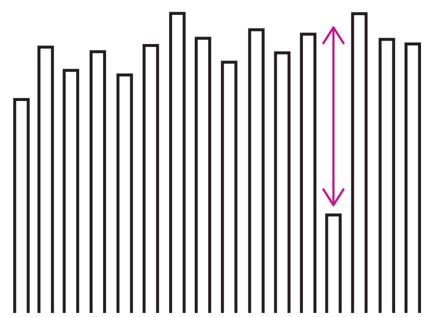


Figure 2. Gain is rapidly decreased at a targeted problem frequency. Gain is swiftly restored to prescribed level once feedback risk source is gone.

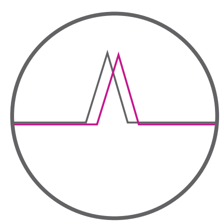
A real-life example to illustrate how a change in the feedback path makes an Alta2, Nera2, or Ria2 hearing instrument react: A father with a sloping high frequency hearing loss and an open fitting is wearing Alta2 hearing instruments. The feedback manager has been run to allow for more targeted feedback management. The father wants to hug his daughter and his ear is in close proximity of her head. The feedback system now finds itself at a higher risk of audible feedback, temporarily. It responds by swiftly decreasing gain substantially in the affected feedback region. No audible feedback is heard. As soon as the father moves away from his daughter's head, gain is immediately restored and he has only missed speech cues very briefly and in a very limited frequency region. Since audibility of speech (low frequencies) was not reduced, he most likely did not notice any change in incoming sound. He avoids poor sound quality completely because the instrument protects him from audible feedback.

FEEDBACK MANAGER

Oticon hearing instruments utilise a more aggressive strategy than previously to control gain. Therefore, a strategic and targeted approach is necessary so that audibility is not sacrificed. Minimum and targeted use of gain control, can be achieved in part by running the Feedback Manager (FBM) in the Genie fitting software for every patient.

Oticon recommends routine use of the Feedback Manager going forward. Running the FBM as a standard procedure in the fitting process gives the HCP an honest and realistic overview of the feedback limits at different frequencies and where the gain margin is small. If the fitting puts the hearing instruments at higher risk of feedback, the HCP may choose to do one of two things: 1) Change the acoustic parameters they have chosen for their patient (for example, less venting or use of ear mould). 2) Manually adjust down the gain only at the specific frequencies at risk of feedback. Running the FBM should be considered a beneficial tool because the clinician can now precisely see where a potential feedback issue may occur, so they can make targeted adjustments, rather than reducing gain at a broader range of frequencies and thus sacrifice more audibility.

The Feedback Limit curve tells the HCP the absolute amount of gain that can be provided given the audiogram, the fitting algorithm, and the current acoustic parameters. This curve will always be lower than the FOIG curve shown before the measurement. To the HCP, it may look as if a huge chunk of gain was just snatched away incurring limitations that were not seen prior to the measurement. In reality, the pre-measurement curve is merely a factory-set estimation of the Full-On Insertion Gain under an optimally specified and rigid test condition.



20 Hz FREQUENCY SHIFT

An important change has been implemented to the frequency shift functionality in order to optimise the day-to-day operation of the anti-feedback system in the Alta2, Nera2 and Ria2 families. In the Alta, Nera and Ria families, a 10 Hz frequency shift was implemented as part of the feedback strategy. This shift has been increased to 20 Hz. Frequency shift works in conjunction with phase inversion to ensure a precise estimation of the feedback path and, in turn, ensure a very effective anti-feedback system. However, as a frequency shift increases, so does the risk that audible artefacts such as clicks or distortion are created and sometimes detected by certain hearing instrument wearers. To ensure that this is a rare occurrence, if at all, the frequency shift is deployed in an intelligent and targeted manner. Frequency shift is only active when it is estimated that sound quality is not at risk or when the alter-

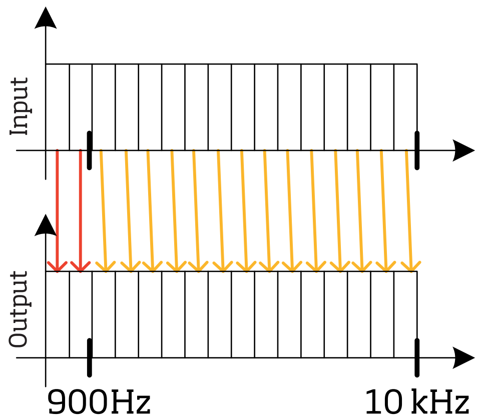


Figure 3. from 900Hz to 10000Hz, a 20 Hz frequency shift is temporarily implemented when needed.

native is audible feedback and therefore very poor sound quality.

Tonal sounds occur every day all around us. Prime examples of tonal sounds are speech, some musical instruments (flutes, piano, various string instruments), and environmental sounds such as car horns, telephone ringtones and a doorbell. A hearing instrument can mistake tonal sounds for internal feedback and try to eliminate it and this can cause distortion known as entrainment. Access to important speech cues is the number one priority for hearing instrument wearers and so, preserving the speech signal accurately is the main reason that frequency shift is not applied when external tonal sounds are detected. This ensures the consistent prioritization of the high sound quality that Oticon is known for. If audible feedback does occur in a highly tonal environment, a feedback detector will ensure immediate deployment of the frequency shift. The reader interested in learning more about the three feedback modes (stable, fast, dynamic) is referred to the "Inium feedback shield White Paper" for more detail (Neel Weile & Munk, 2013).

An added benefit to the increased frequency shift is that it allows the anti-feedback system a high level of stability because the system is less likely to mistake external sounds for feedback, due to the slight difference between the input and output of the hearing instrument. This stability leads to a decreased need for targeted gain control.

In an internal test with 34 test subjects comparing Alta and Alta2 feedback performance, Alta2 was rated as having significantly fewer feedback occurrences compared to Alta ($p<0{,}05$). In a test of Alta2 feedback performance in Oldenburg, Germany, test subject reports of feedback occurrences for Alta2 hearing instruments were down 20% when compared to Alta reports of feedback.

CONCLUSION

Oticon's Inium Sense feedback shield uses a fast and targeted gain control when necessary to improve performance when feedback issues arise. Oticon controls gain in two ways: the in-office Feedback Manager, and the ongoing adaptive anti-feedback system built into each hearing instrument. Due to this faster, more targeted, and more aggressive on-the-go gain control in the anti-feedback system, Oticon now recommends running the Feedback Manager for every patient. A 20 Hz frequency shift has been implemented for use in a targeted, limited, and intelligent manner that ensures the highest level of sound quality possible throughout the day. The combination of these updates will result in optimal elimination of audible feedback, safeguarding of audibility, and maximum preservation of sound quality.

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