Phonak Insight

New dual-path processing of vent loss compensation by Phonak enables a clear and rich sound quality when streaming

In today's technological world, clients may wish to enjoy streamed signals such as music, TV, radio and the telephone whilst at the same time interacting with friends, family and colleagues via the microphone of the hearing aid. However, these streamed and environmental signal components require different amplified frequency responses to ensure a clear and rich sound quality in the streaming part whilst maintaining optimal own voice perception and sound quality in the microphone part. This is especially important for open fittings, where sound leaks out of the ear canal (vent loss) for both signals but only enters the vent (direct sound) for environmental signals and not streamed inputs. The new dual-path processing of vent loss compensation in Phonak Marvel hearing aids applied in the pre-calculation, solves the inherent challenge of different gain requirements for streamed and environmental signals, ensuring optimal sound quality for both inputs.

Jane Woodward, October 2018

Introduction

Modern hearing aids process sound from multiple audio input sources: environmental sounds via the microphones and streaming via Bluetooth®, Roger™, AirStream™ technology and the T-coil. In addition, clients can listen to: (1) only environmental sounds (such as the calm situations program); (2) only streamed signals with no input from the microphone (e.g. Roger and T-coil); or (3) a mixture of environmental and streamed inputs (such as Roger+mic, Media music+mic and Phone via T-coil+mic). For ease of understanding, the term 'streaming' will be used to also include any alternative input to the hearing aid other than via the microphone on the hearing aid, such as Bluetooth, Roger, AirStream and T-coil. These diverse streamed and environmental signals each have their own unique gain requirements and sound cleaning features to ensure excellent sound quality in the multi-faceted listening environments of everyday life.

The importance of vent loss and direct sound for open fittings

Receiver in the Canal (RIC) hearing aids are more likely to be fit with an open coupling such as a dome or earmold with a large vent due to the degree of hearing loss or the need for comfort. Figure 1 illustrates how open couplings and vents allow low frequency sounds generated by the hearing aid to escape out of the ear canal (vent loss) and allow low frequency sounds in to reach the ear drum directly without passing through the hearing aid microphone (direct sound). The overall sound pressure level (SPL) at the eardrum is the sum of the amplified sound attenuated by the vent loss, direct sound and in addition, bone conduction sounds generated from the client's voice (Kuk & Keenan, 2006). The processing in modern hearing aids can account for the impact of open fittings on the low frequency gain in order to accurately manage the trade-off between compensation of the hearing loss and optimal sound quality.

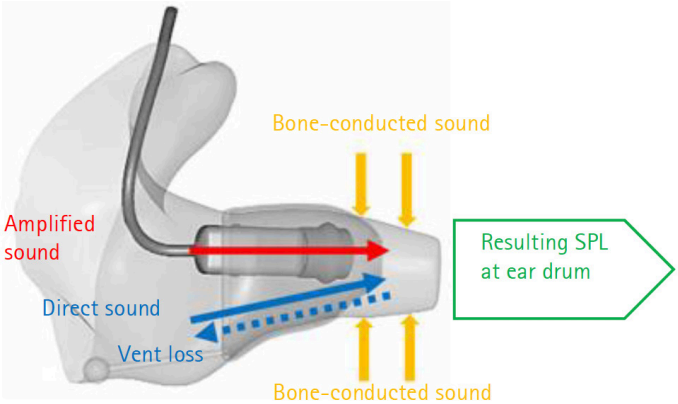

Figure 1: Contribution of amplified sound, direct sound and vent loss to the overall sound signal entering the ear.

As can be seen from Figure 2, the direct sound, also known as Real Ear Occluded Gain (REOG), or Vent-In, that enters the ear canal is greater for open fittings. Figure 3 indicates the amount of low frequency sound escaping out of the vent depending on the vent size, known as vent loss or vent-out.

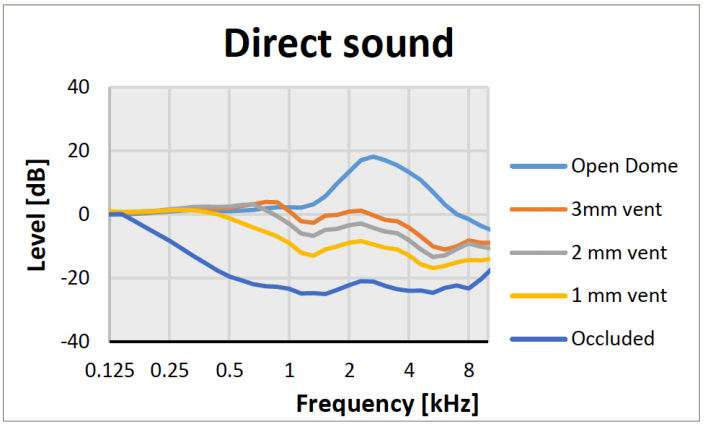

Figure 2: Direct sound entering the ear with occluded, open and vented fittings

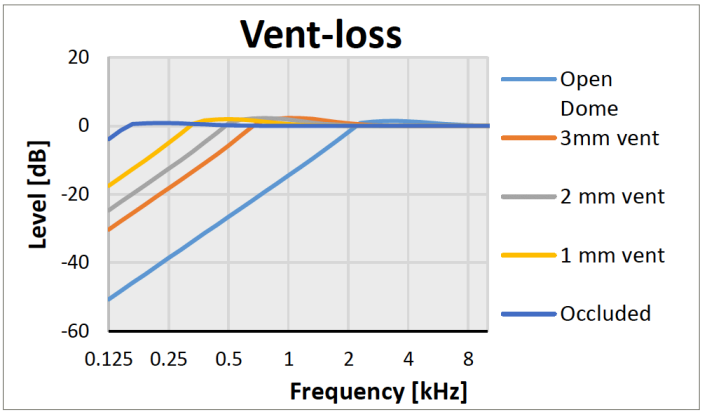

Figure 3: Sound escaping out of the ear (vent loss) with occluded, open and vented fittings.

Vent loss compensation

In a **microphone-only program** such as calm situations, listeners hear a combination of the amplified sound, and direct sound entering the ear through the ear mold vent or open dome. Clients with an open coupling often have normal or near normal hearing in the low frequencies. In this case the direct (unamplified) low frequency sound reaching the eardrum is sufficient and there is no need to compensate the low frequencies leaking out of the vent. By not compensating the vent loss, it is possible to optimize the sound quality and to avoid the client's own voice sounding 'hollow' or 'echoey'.

In a **streaming-only program** the listener hears only the streamed signal processed by the hearing aid as the microphone is switched off. In this situation, low frequency sounds from the streamed signal will escape from the open fitting/vent but there is typically no direct sound contribution. This vent loss is compensated by applying additional low frequency amplification to provide a rich sound, otherwise sounds may be perceived as too 'tinny'. The vent loss compensation is applied to inputs that bypass the microphone; these include (1) Remote signals streamed to the hearing aid such as telephone, Roger, T-coil; (2) Signals from multimedia sources such as TV, music, and radio streams; and (3) Signals generated in the hearing aid such as notification or voice messages. One disadvantage of a streaming-only program with no active microphone, is that the client may feel isolated as they are unable to hear the environment around them. Therefore, clients often chose a mixed program whilst streaming in order to include environmental signals

In **mixed programs with streaming and an active microphone** such as Media music+mic, Media speech+mic, Roger+mic and Phone via T-coil+mic, the vent loss compensation must be applied differently for the acoustic and streaming part of the signal. In many situations, it is important for clients to hear not only the streamed signal, but also to have the microphone active in order to stay engaged with their environment. This can be due to safety reasons like hearing traffic, or for information reasons such as doorbells or alarms. In addition it can also be related to the need to maintain a connection with those around them, for example whilst watching TV. This is a notable advantage over a streaming-only program or listening with headphones, where only the streamed signal is heard. For this reason the default in Phonak Target fitting software is to have the microphone active during streaming.

The challenge: combined microphone and streaming inputs require different vent loss compensation

For combined streaming and microphone inputs, each has different gain requirements. The hearing aids need to apply a vent loss compensation for the streamed inputs to provide the appropriate amplification for a rich sound quality, whilst simultaneously avoiding too much low frequency gain for the environmental input for good speech clarity and own voice quality. This was a challenge for hearing aids in the past.

Previously, it was only possible to offer one vent loss compensation for combined streamed and environmental signals in mixed programs in Phonak hearing aids. This led to a compromise in the low frequency gain of around 20dB for both the streamed and environmental signals, resulting in potentially too much low frequency gain for the microphone, and too little for the streamed part of the signal. Consuming entertainment with hearing aids is a great example where clients need to balance a connection with their environment while listening to a streamed signal. For example listening to music or watching TV while with friends or family.

The TV is a particularly important streamed signal, given that the average American spends over 5 hours a day watching media, either through live TV or streamed content, with people over 50 years of age consuming the most (Koblin, 2016). Watching TV can be a social experience and it is important that the streamed signal from the TV is clear, as well as the voices of the fellow TV viewers coming through the microphone of the hearing aid.

For these mixed inputs, the vent loss compensation must be applied differently for the acoustic and streamed part of the signal.

The solution: the new dual-path processing of vent loss compensation in Marvel hearing aids

Now it is possible to offer dual-path processing of vent loss compensation and the optimal gain setting for both environmental and streamed signals. For mixed programs with a streaming component and an acoustic microphone component, Phonak Marvel hearing aids are capable of processing the microphone signal and the streamed input signal separately and simultaneously. This means that for streamed signals, the vent loss is compensated as much as possible (up to 35 dB), while sounds entering the microphone of the hearing aid maintain the settings of calm situations. This helps to improve the sound quality of streamed signals and provides the appropriate gain for the microphone in mixed programs.

How is the new dual-path processing of vent loss compensation implemented?

The vent loss compensation applied in the pre-calculation depends on whether the signal is environmental-only, streaming-only or a mixed signal.

For environmental (microphone) only inputs, the gain settings of the hearing instruments are based on calm situations which has an amplified and direct sound component, therefore limited vent loss compensation is applied. For such inputs, the vent loss compensation depends on the hearing loss and acoustic parameters entered into the Phonak Target fitting software, taking into account potential leakage around the

dome or earmold. Thus, the effective vent size (vent size plus leakage) in combination with the hearing loss define the vent loss compensation for environmental inputs. As a rule, more vent loss compensation (larger frequency range and more gain) will be applied for larger vents and higher levels of hearing loss.

For streamed inputs, the vent loss is fully compensated as much as the hearing aid and digital signal processing allows, independent of hearing loss. Thus, the low frequency gain is increased by up to 35 dB, compared with the gain for environmental inputs, depending on the vent size. The Maximum Power Output (MPO) for the streamed signal is also boosted but this is limited in order to avoid distortion.

The benefits: a clear and rich sound quality when streaming

The separation of the input sources in the new vent loss compensation helps to enable a rich sound quality when streaming while signals received directly to the hearing aid microphone remain uncompromised, maintaining the response of calm situations. This enables listeners to stay connected to their environment at all times, even when streaming and results in no compromise between the streamed and environmental signal. Music can be heard as the musician intended it, and the listener can simultaneously engage in conversations at the same time.

Figure 4 illustrates how Phonak Marvel hearing aids allow direct connectivity with not only the telephone and the TV but also to many other devices and services, all of which allow the listener to stay connected with their environment at all times.

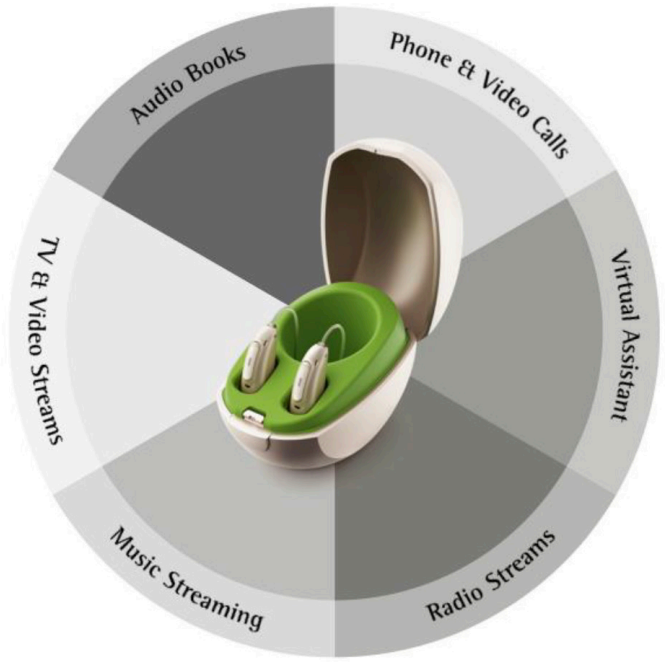

Figure 4: Phonak Marvel hearing aids allow direct connectivity whilst enabling connection with the environment via the microphone.

In addition to the new dual-path processing of vent loss compensation, there are two other beneficial factors that help to enhance sound quality whilst streaming:

(1) the new **AutoSense OS™ 3.0** is now able to classify streamed audio signals automatically and can detect whether the signal is music or speech (Rodrigues & Liebe, 2018). Depending on the streamed signal, AutoSense OS™ 3.0 fades into speech clarity or sound quality automatically and applies calculated gain depending on the signal.

(2) The **environmental balance** feature allows the client to adjust the volume level of the streamed signal in comparison to environmental sounds to achieve optimal balance of speech whilst streaming, depending on their listening needs (Jansen, 2017).

For which prescription formulae is the new dual-path processing of vent loss compensation implemented?

The new dual-path processing of vent loss compensation is applied in the pre-calculation for Adaptive Phonak Digital, Adaptive Phonak Digital Contrast and NAL for adults (age > 12 years) based on the hearing loss and vent size entered in Target. For DSL prescription formulae (DSL v5a Pediatric, DSL v5a Adult, DSL [i/o]) and for NAL for children (<= 12 years) vent loss compensation is not applied as these formulae have their own prescription targets, vent loss measurements and metadata which are used to calculate the hearing aid settings. Here the main goal is to meet the targets displayed in the verification test box.

The evidence

The purpose of the new dual-path processing of vent loss compensation is to ensure appropriate low frequency amplification for both streamed and environmental signals. During the feature development, several internal investigations were completed to confirm its efficacy. First, preference for more low frequency gain whilst streaming for normal hearing subjects was established. Next, this preference was confirmed with subjects presenting with mild-moderate hearing loss fit with open couplings.

A study conducted at DELTA SenseLab in Denmark revealed that the latest solution for television listening from Phonak, the Audéo Marvel hearing aids in combination with the TV Connector, is regarded among the best for streamed sound quality (Legarth, Latzel and Rodrigues, 2018). The TV Connector connects to the TV as well as all devices that have an audio jack such as radios and stereo systems.

Verification of fittings with the new vent loss compensation

For adult open fittings, the Phonak philosophy is to optimize the hearing instruments for real world performance rather than for the 2cc coupler. In doing so, the sound entering the ear through the vent (direct sound) and the sound leaking out of the vent (vent loss) is taken into account. As discussed, it is important to differentiate between environmental programs where the direct sound signal component is contributing to the overall sound level at the ear drum and streamed signals where this direct sound signal is missing or reduced. If open fittings are verified in an external test box using a 2cc coupler, acoustic inputs may be below the 2cc prescription targets in the low frequencies. This gap will be 'filled' in the real ear with direct sound.

For tips on verifying open fittings in the real ear see: Smriga, D. (2017).

The Verification Assistant in Phonak Target allows ease of verification with Phonak features that may affect meeting target gain in a verification test box. It is important to be aware that vent loss compensation is enabled for both insitu and 2cc measurements. As a consequence, there may also not be a target match in the low frequencies for acoustic inputs in the 2cc coupler in verification mode. However, in the real ear, the sound will be optimal.

Summary

For open fittings, the new dual-path processing of vent loss compensation offers the right amount of low frequency gain for both the streamed audio signal and signals entering the ear via the hearing aid microphone. The increased low frequency boost of up to 35dB for streamed signals offers a clear and rich sound quality when listening to sounds such as TV, music, audio books, Roger and T-coil, while the sounds entering the hearing aid microphone remain uncompromised, providing optimal own voice quality and speech clarity. The enhanced dual-path processing of vent loss compensation in Phonak Marvel hearing aids, in addition to classification of streamed signals in the new AutoSense OS™ 3.0 and the environmental balance feature, enable the ideal hearing performance for both streamed and environmental sounds.

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Experts

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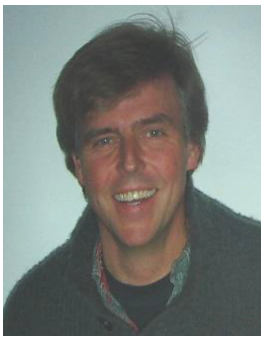

Stefan Pislak is an expert in Audiological Performance at Sonova R&D. His main area of work is the acoustics of hearing systems. Before joining Phonak in 2000, he studied physics at ETH Zurich, completed his PhD in the field of high energy physics at the University of Zurich and held a postdoc position at Yale University.

Volker Kühnel, Principle Expert Hearing Performance, Phonak HQ

Volker Kühnel, PhD, received his degree in Physics in 1995. From 1995 to 1997 he worked in Oldenburg as a post-doc in the group of Medical Physics of Prof. Dr. B. Kollmeier, Oldenburg, Germany. Since 1998, at Phonak/Sonova he has worked in product development at the interface between hearing aid algorithms, fitting software and audiological design. His work focuses on the audiological quality of hearing instruments in order to achieve the highest benefit for clients.

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Jane Woodward holds a BSc in Psychology and an MSc in Audiological Sciences from the University of Southampton, UK. She has many years of experience in audiology, working clinically in University hospitals in the UK and Switzerland, in hearing aid and software development and in training.

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