FlexControl

Individualizing automatic performance

Introduction

Volume controls have been important to hearing instrument wearers for as long as hearing instruments have been available. Beginning as a wheel with a rotary potentiometer, volume controls can now be buttons or toggle switches with digital control function allowing hearing instruments to be adjusted to different volume settings in different listening environments. Sometimes the volume control is used to allow the enduser to have a more comfortable listening experience and sometimes it is used to create some peace and quiet, but the primary use of a volume control is an adjustment to hear better. This is where the challenges begin because as we know, "louder "does not necessarily always mean "clearer". With FlexControl, Phonak has developed a completely new combined method which not only uses a frequency selective volume control that is tuned to the level of hearing loss, but also incorporates other sophisticated sound cleaning functions to optimize hearing. FlexControl learns enduser preferences and can provide a more enjoyable hearing experience that ensures improved speech clarity in many different situations without the need to switch out of the automatic program. The original loud/soft function of a volume control has now evolved into a unique new opportunity to precision tune digital hearing instruments even better than before. This new type of finetuning, known as FlexControl, is available for the first time in the Phonak Spice Generation hearing systems.

Fitting a hearing system – an adaptive process

The fitting of a hearing system is an adaptive process which continues when an enduser leaves the hearing clinic and begins using his/her new hearing instruments. The hearing care professional recommends specific hearing instruments based on audiometric results, and adjusts the hearing instrument to meet the enduser's needs in what will undoubtedly be a wide range of listening environments. This initial tuning process may not be completely successful, as it may not necessarily be able to address individual listening environments. By using information obtained at subsequent follow up appointments, the hearing care professional (HCP) can fine tune the instruments to help improve the fitting. DataLogging functions, for example, allow the HCP to gain awareness of the enduser's various listening environments, allowing them to adjust the settings of the hearing instruments accordingly. When the system incorporates a learning function, the adjustment process can occur immediately during the enduser's operation of the hearing instruments.

Building on the basis of this current fitting practice, Phonak has developed a new type of interactive adjustment tool, FlexControl. This, together with the HCP's fine tuning capabilities will set the new standard in effective, user-specific fine tuning. In addition FlexControl can facilitate a precise fitting, enabling an enduser to benefit from the full potential of a new hearing system as soon as possible.

Getting the volume right – (not) an easy task?

The most common adjustment an enduser makes to a hearing instrument is to adjust the volume. This adjustment increases or decreases the volume by the same amount across all frequencies. While this may appear to be a straightforward process (Fig.1), this in fact is not the case. Human hearing does not operate this simply.

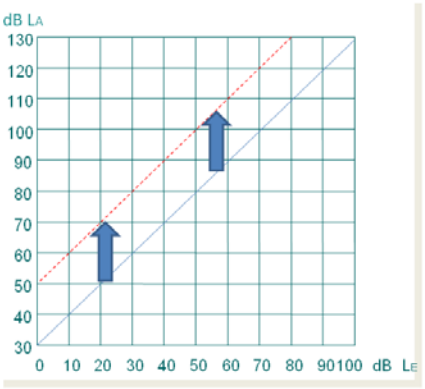

Fig. 1: Graph showing linear increase in volume

The perception of volume depends very much on frequency. Fletcher-Munson (1933) was the first to look closely at this link and produced the first graphs of equal volume levels, or "isophones" (Fig. 2). This shows very clearly that hearing operates in a highly nonlinear fashion across frequencies. For example, for the perception of equal volume for pure tones, the level must be markedly greater in the lower and higher frequencies than in the mid frequency range. Figure 2 shows how this nonlinearity is dependent on frequency.

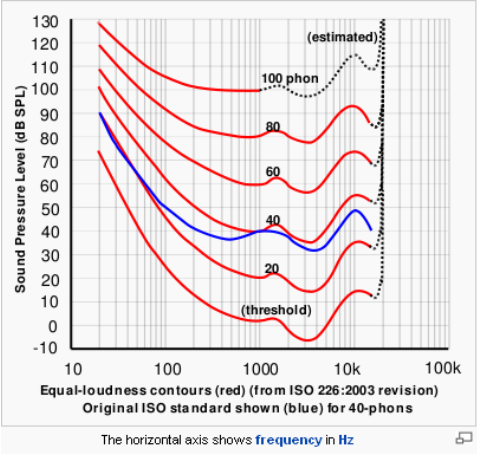

Fig. 2: Equal-loudness contours "isophones"

Since hearing, especially in the low frequency and low intensity range, is nonlinear, adjusting the volume uniformly can have a negative effect as it alters perception of loudness and sound. Even individuals with normal hearing may find that volume adjustments affect speech clarity and result in incoming signals being strange and unnatural.

The challenge is compounded when hearing loss is added to normal nonlinearity. The whole hearing range undergoes severe changes both in terms of frequency and dynamics. As such, it is a considerably more complex process to achieve accurate compensation for volume adjustment in both frequency and loudness perception for an individual with hearing loss. A volume control that adjusts all frequencies up or down equally is not the optimal solution.

Nonlinearity is only part of the problem

Unfortunately, the challenge as a whole is significantly greater than the difficulties described in the previous paragraph. As early as 1967, Zwicker, in his seminal tests on masked thresholds (Fig. 3), showed that sound signals in human hearing create an upward spread of masking that is dependent on sound level. In other words, background noise exerts more masking on higher frequencies as it gets louder. This is generally known as the "cocktail party" effect, which simply means that it can be very challenging to understand speech in loud listening environments.

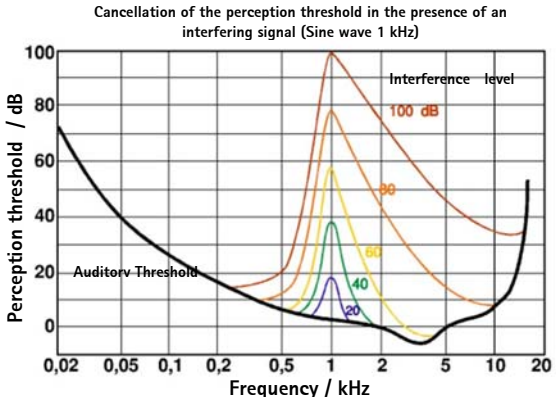

Fig. 3: Graph showing the upward spread of masking (Zwicker and Fastl 1990)

The cocktail party effect also impacts how endusers adjust the volume of their hearing instruments. When an individual with hearing loss turns up the volume of their hearing instrument to hear speech, the background noise is also automatically increased, resulting in poorer speech clarity. You might think that by reducing the low frequencies the effect would be lessened, however, the result is unacceptable changes in the sound pattern.

What do we actually mean by turning up and turning down?

When an enduser turns the volume of his hearing instruments up or down, is he really trying to achieve more or less volume? Probably not! The automatic systems that are now available in modern digital hearing instruments allow them to operate at the desired volume level in any situation. When an enduser makes his own adjustments, he is usually trying to hear more clearly by increasing the volume or to have less interference by turning the volume down. An individual with a hearing loss has his own preferences for sounds and volume level and these preferences will vary significantly between individuals. This is where the unique skills of the fitter are particularly important in fine-tuning to meet the enduser's specific needs and preferences. An enduser needs to be able to make adjustments to their hearing instruments because it is simply not possible inside a fitting room to tune the system to operate optimally in all situations. It is therefore best to regard the first fitting appointment as a basic fitting which compensates for hearing loss and which forms the basis for more personalized adjustments in the future. In the fitting room, it is not possible to cover all situation-related individual hearing preferences. It is inevitable that there will be listening environments where the enduser will want to adjust the volume of their hearing instruments. On subsequent fitting appointments, the fitter will have the opportunity to reconstruct the situation and optimize the hearing instruments as a whole, using tools such as DataLogging.

On-the-spot adjustments are normally carried out by using the volume control, however this may not be completely effective for situation-related optimization as it only changes volume in a uniform manner. Optimal hearing in specific situations is not usually achieved solely through volume adjustment, but by adjusting the settings of the situational

program. For this reason it is necessary to have a new operating element working in the background with an algorithm which allows the enduser to adjust his hearing preferences much more specifically to the listening situation. This algorithm must include a volume control system which is adapted to the individual's hearing loss configuration and can modify the situational programs (calm, speech in noise, comfort in noise and music). This allows the enduser to set their hearing preferences in individual listening environments. The algorithm must be adaptive so that consistent preferences in comparable listening environments can form a basis to reliably predict the settings of the hearing instruments in future similar situations. In this way, the tuning of the whole system becomes continuously more refined over time, making on-the-spot adjustments less necessary. With FlexControl, such an opportunity is now available.

A new chip platform lays the foundations

Phonak is the first company to develop an algorithm that meets the requirements mentioned above, using the technical capabilities of the new Spice platform. For the first time, FlexControl provides an integrated concept for adjusting not just volume but also hearing preferences in hearing instruments. In addition to changing the volume, FlexControl incorporates the enduser's preferences in different listening environments into the control. The FlexControl concept also offers completely new opportunities for fine-tuning digital hearing systems in conjunction with the new Phonak Target fitting software.

The objective of the development process was to produce a control function which can be operated by the enduser of the hearing instrument and also:

- Allows the enduser to adjust his hearing instrument to his unique hearing preferences in any situation.
- Allows the hearing system to learn from these adjustments so that it can better predict the enduser's wishes and make it easier for him to operate in the future.
- Improves the effectiveness and quality of the fitting process by logging data from the control instructions.

In technical terms, FlexControl comprises two basic functionalities. The first is an intelligent volume control that takes into account the hearing loss configuration, desired frequency response and gain levels. The second incorporates the SoundCleaning functions of the Spice platform into the control, including Wind Noise Management, NoiseBlock Processing, and EchoBlock.

While the intelligent volume control also operates as a function of the hearing loss configuration, the SoundCleaning functions are independent of it. Their strength is determined instead by the listening environment. FlexControl has an integral learning function which ensures that adjustments made by the enduser are recognized when a similar listening environment recurs. The system as a whole then adjusts itself gradually, to a new, optimized setting, seamlessly and automatically. These benefits can only be achieved when the enduser actively uses FlexControl. This means that the enduser should adjust his hearing instruments in the initial period to optimize hearing and understanding. The learning function then ensures that hearing preferences in comparable situations form the basis for reliably predicting the instrument settings in future listening environments. In this way, the settings become optimized over time and on-the-spot adjustments become less necessary. It is worth mentioning that the use of FlexControl does not necessarily require both ears to be fitted: FlexControl can also work with monaural fittings.

How does FlexControl work in practice?

FlexControl within the automatic program SoundFlow continuously analyzes the current listening environment. It recognizes the enduser's preferences from the adjustments he makes, and adjusts the hearing instrument parameters as desired by the enduser. The enduser can, in effect, override the automatic situation programming and adjust the hearing instruments in the direction he desires in order to achieve greater clarity or increased comfort. The system as a whole operates so that when the enduser selects "+" on the hearing instrument volume control toggle or the HI remote control, the system makes adjustments to optimize clarity. When the enduser selects "-", the system makes adjustments, to make the listening experience more comfortable.

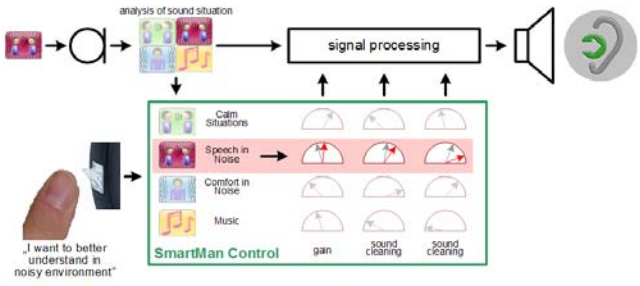

Fig. 4: An example of how FlexControl influences gain and sound cleaning features with one simple action

This is illustrated by an example (Fig. 4): the listening environment is "speech in background noise". The hearing instrument has classified this situation, and the various features have adjusted to the situation accordingly. Now, however, the enduser wants even better speech clarity. The previous solution has been to simply turn up the volume, bringing about the challenges and consequences discussed earlier. In comparison FlexControl will follow the amplification model, which is frequency-selective and is a function of the hearing loss configuration in addition to also incorporating the essential SoundCleaning functions. By moving the control towards "+", the effect of the directional beamformer is increased, noise cancellation is heightened,

and wind noise and reverberation suppression are greatly increased.

FlexControl is an auto-adaptive system. It is always active and runs permanently in the background. Thus, when the same listening environment arises again and the enduser makes the same adjustment, the learning mode of the FlexControl system recognizes this and re-adjusts itself. Eventually, the enduser will not have to make any manual adjustments when they are in similar situation. In this way, the enduser is an active contributor to the fine-tuning of his own hearing instruments.

And what about the Hearing Care Professional?

Does FlexControl mean that a significant part of the fitting process is now being taken away from the HCP? The answer is a resounding "no". FlexControl functionality is activated by the HCP who determines whether an enduser can benefit. It would be counterproductive to activate FlexControl if the enduser has no interest in playing an active part in the fitting process. When the enduser is a willing participant, the results of the fitting process can be markedly improved using FlexControl. All the settings, adjustments and self learning results are downloaded to the fitting software the next time the hearing instruments are connected. The HCP can monitor and track the adjustments the enduser makes to the settings of his hearing instruments.

FlexControl does not replace the fitting process carried out by an HCP nor does it increase follow up visits because:

- The integral learning function calculates a time-based average of the settings in order to reduce one-off situation settings and errors
- The logging function allows the HCP to analyze and fine-tune the data
- The FlexControl settings are graphically displayed in the fitting software, and can therefore be easily adjusted if necessary

If the enduser is unable to manage FlexControl, an alternative volume control can be selected in the fitting software.

What does FlexControl achieve overall?

In summary, it's clear that a standard volume control cannot always meet the different listening needs of individual endusers. The primary desire of an individual with hearing loss is not simply more or less volume. They may want greater clarity and speech understanding or perhaps increased comfort in background noise. Adjusting overall loudness is not always sufficient, and an integrated, intelligent system which takes into account the nonlinearities of the impaired ear and the effects of different environments is preferable. FlexControl meets all these requirements. It is far more than just an intelligent volume control, because it can:

- Continuously analyze the current listening environment
- Recognize the preferences of the enduser and respond to his adjustments
- Combine the fitting information contained in the hearing instrument with integral learning ability – a foundation on which the hearing instruments can continue to maximize enduser benefit.

It is a system under the intuitive control of the enduser, and its intent is to maximize benefit and comfort for the enduser in every listening environment.

FlexControl incorporates a large number of parameters, such as:

- Adjusting amplification characteristics as a function of frequency response, gain requirements and the individual hearing loss configuration
- Controlling the SoundCleaning functions e.g. wind, noise and reverberation cancellers.

FlexControl is not merely a tool that allows individuals with hearing loss to best meet their hearing needs in all listening environments. It is also a tool for the HCP to assist in making the fitting process more effective, more accurate, and substantially better.