Phonak Insight

Phonak Spice Generation Processing

A new generation of sound classification and directionality

Introduction

Is bigger better or is smaller superior? There is no single correct answer of course as it depends on the dimension to which you are referring. One dimension where bigger is clearly better is the processing power of a Phonak platform - the technology foundation underpinning a generation of hearing instruments spanning chip set, signal processing features, mechanical design and fitting software.

The new Phonak Spice Generation platform delivers twice the processing power of the previous generation CORE platform. This extra power has already been tapped by the first wave of Spice hearing instruments and provides a launching pad for advanced sound processing and innovative hearing instruments.

Is there such a thing as too much processing power?

Have you ever heard anyone say, thanks but my computer processor is actually fast enough, please keep those additional Gigahertz for yourself, oh and I also have plenty of memory as well so you can leave that spare memory stick in the cupboard. While you're at it, you can return that extra 100 gigabyte hard drive to the shop. These comments are never spoken. When the rest of the Spice development team started formulating ways to enhance the performance for wearers and fitters alike, the Phonak hardware engineers quickly responded with the blueprint for a new platform with twice the processing power of CORE. From these solid foundations and sharing a common vision, ongoing collaboration by the entire Phonak global research and development team led to the groundbreaking new Spice platform.

Often the best way to appreciate something new is to compare it with an existing point of reference. Figure 1 shows the evolution of key physical dimensions over the last three Phonak platforms. The number of transistors trends upward with each platform generation and the structure trends down. The more transistors available, the more processing can be done. The thinner the structure, the more components can be fit on the microchip and the less power the microchip consumes for the same processing task.

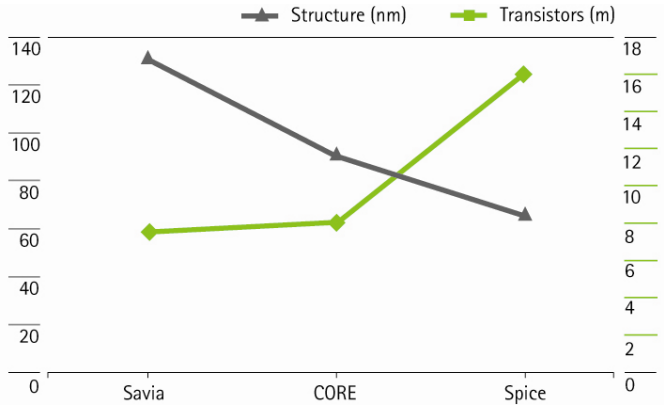

Figure 1 - Evolution of key physical dimensions

Figure 2 shows a similar picture for some key processing dimensions. The almost doubling of MOPS (million operations per second) from CORE to Spice means the new generation chip does twice as much.

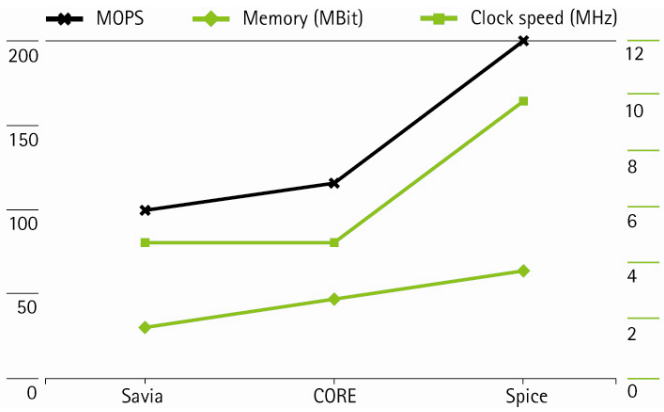

Figure 2 - Evolution of key processing dimensions

Phonak hearing instruments truly lead the way in taking full advantage of the underlying platform components on which they are built. This Phonak Insight explores some of the signal processing innovations now available on the Spice platform thanks to this leap in processing power.

PHONAK life is on

Pinpoint sound environment classification

Consider for a moment opening night of a new performance at the city concert hall and specifically the perspective of three different people in attendance. Firstly the usher showing people to their seats. He is busiest the ten minutes before curtain call, but there are always latecomers who need to be seated once the show has started. It is important for the usher to be able to understand a latecomer clearly so as to minimize any disruption for the already seated audience members. Now consider a second person, a music lover with season tickets for the city concert hall. She takes great delight in attending opening night and savoring the first polished performance following weeks of rehearsals. Finally consider a third person in attendance, the gaffer at the concert hall who must ensure the spotlight is always shining on the lead vocalist. He is situated directly above the loudspeakers and must contend with the booming sound whilst maintaining the precise direction of the spotlight. What may initially appear to be the same sound environment is very different for each person, and furthermore each person has a different listening intention. Spice processing provides sophisticated sound classification and intuitive learning capabilities to accurately match a wearer's listening intention to their immediate sound environment.

Is accuracy the same as precision?

Phonak Spice Generation hearing instruments enjoy the privilege of previously unimaginable processing capability. One of the many features of Spice sound processing that leverages this capability is the sound environment classification of SoundFlow, the automatic system available with every Phonak hearing instrument (Nyffeler, 2009)[1]. Most modern hearing instruments do a good job at classifying basic sound environments accurately. However the level of detail, or precision, of this classification is a finer art.

SoundFlow classification by the Spice chipset is accomplished by calculating 46 different parameters of the incoming sound such as signal-to-noise ratios, low frequency levels, onsets and spectral roll-offs. These parameters are then analyzed, further combined and projected onto a point within a 3D sound model containing four sound environment spheres - Calm, Speech in Noise, Noise and Music as shown in Figure 3.

If a point lies within one of the sound environment spheres it is considered to be 100% associated to that sound environment and the unblended base program for that environment is used. If the point does not lie within any of the spheres, the sound environment association is calculated using a law of attraction. This method provides a natural mapping of a sound environment onto the 3D sound model providing a more accurate, reliable and faster classification of incoming sounds.

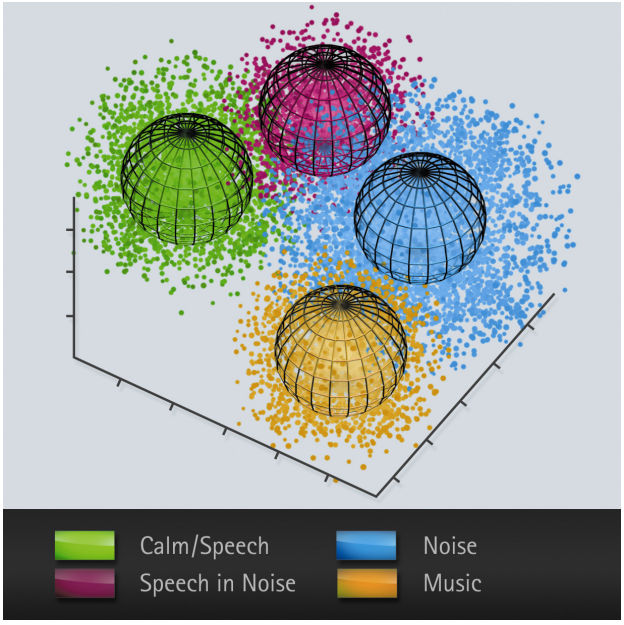

Figure 3 - High-definition, multi-dimensional sound classification system used by SoundFlow for precise, seamless automatic operation

If these calculations don't sound complex enough, the SoundFlow environment classifier now takes into account spatial sound differences. This means that the classifier takes into account which way the wearer is facing. So in the concert hall, speech from inconsiderate audience members sitting behind the music lover is rightly treated as background noise and does not result in any transition to Speech in Noise classification.

This precision classification is continuously recalculated in real time enabling SoundFlow to assemble an optimal blended program drawing from the multiple base programs for that instant. Furthermore the transitions between these blended programs are so smooth they are not even noticeable to the wearer.

A coming of age in hearing instrument understanding

Precise sound environment classification in real time appears very impressive, but to realize a tangible benefit for the wearer their listening intention must also be considered. Spice processing represents a coming of age in the level of understanding a hearing instrument develops with its wearer.

FlexControl, a Spice processing breakthrough innovation in intelligent user interaction, allows adjustment along the dimensions of greater clarity or increased comfort as per the wearer's listening intention. Back at the city concert hall - the usher's listening intention is to understand speech in a significant amount of background noise, the music lover's intention is the most pleasurable music experience possible while the gaffer is seeking comfort in what could be an overwhelming noisy situation to allow him to concentrate

on the job at hand. Simple volume up/down adjustments are only so useful for the wearer to express their hearing intention. FlexControl performs intelligent adjustments to both gain (hearing loss configuration, desired frequency response and volume levels) and sound cleaning (directional settings, wind noise management, background noise reduction and echo cancellation). Validation results show that FlexControl comprehensively performs better in all sound conditions compared to a conventional volume control (Phonak AG, 2010)[2].

User Preference Learning brings together the precision sound classification of SoundFlow and the multi dimensional parameter adjustments made through FlexControl. This convergence of interactive control and automatic adaptation provides an unparalleled new level of hearing instrument control for the wearer.

Dual pathways of compression performing in harmony

Modern digital signal processors in hearing instruments manage and control hundreds of parameters. In many cases these affect each other, sometimes with negative results. What distinguishes an effective signal processor is the art of harmonizing hundreds of different parameters to avoid artifacts and internal interference signals. Even in such a well developed area of signal processing as compression, attention to detail is paramount in providing the wearer with the best clarity and comfort. The need to react quickly and accurately to different situations means that compression systems often employ a dual-path compression strategy, with one path providing slow-acting, the other path providing fast-acting gain control. However, the fast-acting path with its short time constants can blur the amplitude fluctuations of the original signal and the slow-acting path can impede responsiveness in managing sudden uncomfortably loud sounds.

Some competitive systems use a process whereby both compression paths are directly controlled by averaging the input signal over time. Since an average is used to determine compression settings, neither may be ideal. Returning once more to opening night at the city concert hall, consider the moment that the performance actually begins. The lights dim and the audience chit chat fades to silence. The gaffer's spotlight pierces the darkness to reveal the orchestra poised for the conductor to bring them to life. With one fell swoop of the baton, the orchestra explodes in perfect harmony flooding the concert hall with the opening chord. At this moment, the gaffer is vulnerable to this sudden acoustic onslaught. In this scenario, a time-input average control system would first increase the gain, causing a substantial overshoot, before finally applying the appropriate compression as shown by the grey line in Figure 4.

Phonak Spice Generation processing avoids such pitfalls that can affect other systems by separating input level detection from the calculation of spectral amplification. By calculating these parameters many hundreds of times per second independently in both paths, the spectral cues are more accurately reproduced to keep pace with the ever-changing sound environment. So the appropriate level of compression is instantly applied resulting in no gain overshoot as shown by the green line in Figure 4. On opening night, this means the gaffer comfortably experiences the booming opening notes of the performance but can still concentrate on his job.

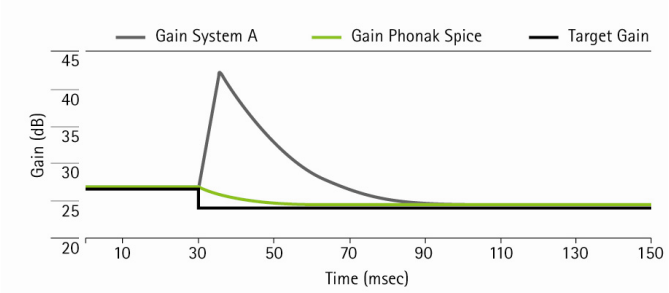

Figure 4 - Adjustments to gain over time in response to an abrupt increase in signal intensity

Furthermore this unique adaptive dual-path compression system is integrated into the SoundFlow automatic system, so amplification control is both time and situation-sensitive. As appropriate for the situation, the time constants which provide best signal transmission with the least distortion are automatically selected. This achieves instantaneous and smooth automatic adjustments, so even the most abrupt changes to the sound environment are efficiently managed without distortion or artifacts.

Directionality is a Phonak passion

Phonak has always led the way in directional microphone technology. The Spice platform once again takes the industry benchmark one giant leap forward with two pioneering innovations in directionality.

Directional noise cancelling goes spatial

Traditionally, regardless of microphone mode, the noise cancellation algorithm is always applied in the same manner based on temporal cues. However when in directional mode, the source of interest is actually known, so a new approach can be applied – UltraZoom with SNR-Boost is the next revolution in adaptive multi-channel beamforming technology.

SNR-boost is a spatial noise canceller used in conjunction with UltraZoom, the Phonak beamformer. In contrast to the temporal-based noise canceller, NoiseBlock, it places focus on the direction of the incoming sound as shown in Figure 5.

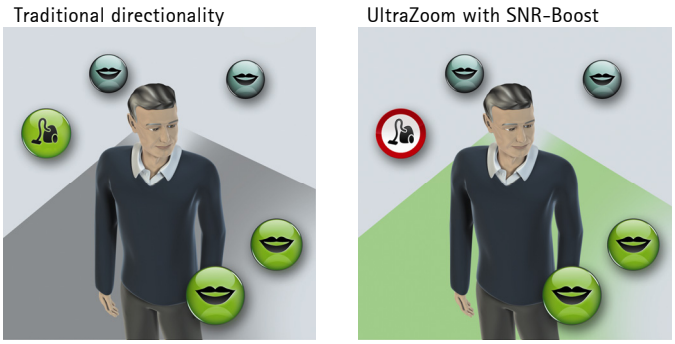

Figure 5 - Traditional directional microphones amplify everything within in the beam including unwanted noises. UltraZoom with SNR-Boost effectively cancels noise, enhancing SNR for speech coming from the front

NoiseBlock works by analysing variations of sound over time across multiple frequency bands, reducing gain for different frequency bands whenever it detects noise. In contrast, SNR-Boost analyses the direction-of-arrival of the sounds and if a target sound from the front is detected, reduces gain for sounds coming from the back hemisphere. In contrast to most noise cancellers it keeps target sounds from the front more accurately and reduces noise from behind much more selectively. Even when the noise contains speech. Of course, SNR-boost also acts individually in different frequency bands and applies gain reduction tailored to the conditions of the current sound. In combination with NoiseBlock, and dynamically activated from Soundflow, both algorithms act in unison and are fine tuned to their individual strengths.

Does a hearing system beat a pair of hearing instruments?

The answer with the Phonak Spice Generation is a clear yes. By cleverly combining a binaural directional advantage with sophisticated wireless and real broadband audio exchange capabilities, a hearing industry first has been created.

A single omni-directional microphone captures sound from all around, adding a second microphone creates some directionality. Acoustic theory says that the more microphones that are available, the greater the level of directionality (Brandstein and Ward, 2001)[3]. However there is a problem in adding more microphones to a hearing instrument as this would make it bigger. So there was a dilemma for the Phonak engineers, how to add another microphone without making the instrument bigger.

Phonak engineers are highly adept at thinking outside the box. This led them to the realization that another microphone was already available for a binaural wearer - the instrument on their other ear. Not only were there 2 extra microphones but the relatively large distance between the instruments contributed significantly to the low-frequency directionality as shown in Figure 6.

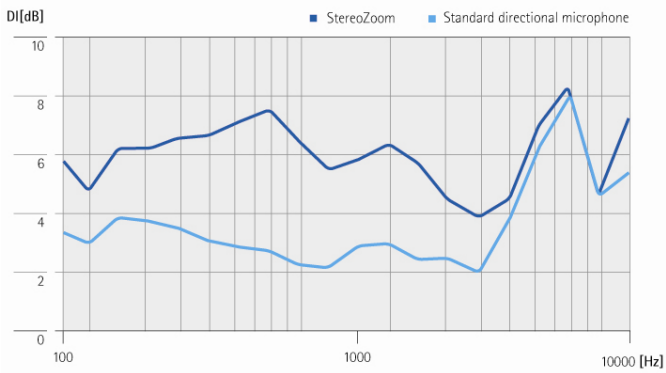

Figure 6 – Directivity Index improvement with StereoZoom

This multi-microphone configuration by itself was only half the story. In order for the contralateral microphones to contribute to directionality, the full audio signal from both devices must be available for integrated processing. Thankfully Phonak had the foresight to introduce this capability on its previous generation platform - CORE. This capability allowed binaural features such as ZoomControl and DuoPhone in CORE products. With Spice processing power, StereoZoom has become possible providing improved speech intelligibility and reduced listening effort as evidenced in clinical trials (Phonak AG, 2010)[4]. StereoZoom is a classic example of the whole being greater than the sum of the parts.

Summary

The Phonak Spice generation is testament to what is possible with a holistic approach to innovation. With one part of this platform, the Spice chipset, multitudes of signal processing features are orchestrated in harmony, realizing an unparalleled hearing experience for wearers. This Phonak Insight has presented just a taste of what Spice makes possible.

References

[1] Nyffeler M: Software seeks to provide seamless adaptation to changing soundscapes. *Hear J 2009:62(10):43-45*

[2] Phonak AG: FlexControl – Individualizing automatic performance. *Field Study News Sept 2010*

[3] Brandstein M, and Ward D. 2001. Microphone Arrays – Signal Processing Techniques. *Berlin: Springer-Verlag*

[4] Phonak AG: StereoZoom – Improvements with directional microphones. *Field Study News Sept 2010*