# Phonak Insight

## Roger™ MultiBeam Technology – Enhancing the group listening experience

**Listening in a group can be challenging for those with hearing loss, especially in a complex listening environment such as a busy restaurant or a reverberant conference room (Picou et al 2016, Thibodeau, 2014). Phonak MultiBeam Technology is a new generation of wireless microphone technology. It combines an array of microphones with advanced automatic functionality to focus exclusively on one speaker in the group and will seamlessly change focus as the speaker changes. By utilizing multiple microphones in six directions, speech from 360 degrees is calculated and compared. The direction with the best signal-to-noise ratio is automatically selected. MultiBeam Technology is now available in the new Roger Select and Roger Table Mic II. It represents a new paradigm in group listening environments.**

February 2018

### MultiBeam Technology

Typical directional microphones consist of two omnidirectional microphones separated by a distance specific to the application, such as BTE, ITE or hand held microphone. Sound coming from the front hits the front-facing microphone earlier than the rear microphone (Dillon 2012 p. 25). The time delay can be used to identify sound which is coming from the front. The sound from the rear can then be attenuated relative to the front. The output of the two microphones can be used in many different combinations such as activating only the front or the rear

microphone or delaying and subtracting the output of the rear microphone. It can be adaptively combined to produce beams of sensitivity in a specific direction and across a specific radius. (For more information on beamforming directional microphones please see Dillon 2012 chapter 7).

MultiBeam Technology utilizes three omnidirectional microphones arranged in an equilateral triangle. Each microphone in the array can act as either a front or rear microphone for either of the other two microphones. This elegant design creates a number of possible configurations. The first is the possibility of combining two of the omnidirectional microphones to create a pattern of directionality in two opposite directions. This would result in two beams which are separated by 180° as shown in Fig. 1.

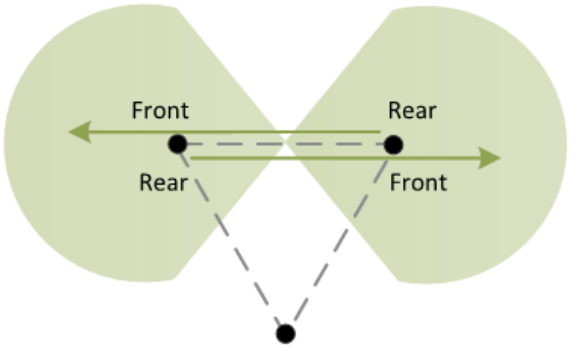


**Figure 1: Diagram showing the microphone array with 3 omnidirectional microphones in a triangle, indicated by 3 black dots. The microphone pairs result in directional beams shown in green shading.**

The second possibility is the interpolation of data from two of the omnidirectional microphones to create a "virtual" microphone between the pair. The triangular arrangement of the microphones means that this can be repeated for each pair, creating an array of 6 microphones, as shown in Fig. 2.

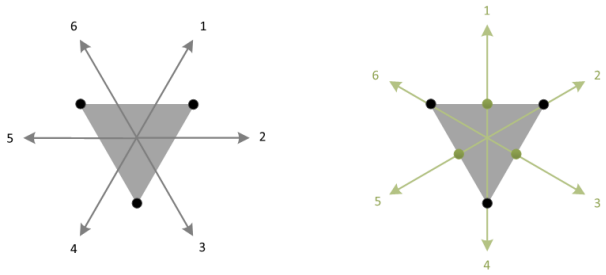


**Figure 2: Diagram illustrating the microphone array with 3 omnidirectional microphones in a triangle, 3 black dots and the 3 virtual microphones indicated by three green dots. This illustrates how the microphone pairs can be used to produce 12 directional beams.**

The full capacity of this design is understood when these two possibilities are combined. The directional behavior is then equivalent to the superposition/overlapping of six beams and adding the 6 "virtual" microphone beams means that Multibeam Technology can also be configured to create 12 directional beams or any combination of beams. Whether 6 or 12 beams, these can be configured as single beams or multiple beams combined to form continuous or spatially separated arcs of sensitivity.

Exploiting this potential to create multiple beams, the final design for the implementation in the Multibeam Technology is shown in Figure 3a and 3b. These are the 6 beams overlapping and spaced 60° apart applied when the device is lying on a table and12 beams, spaced by 30°, applied when the device is worn on a lanyard or lapel. (For a more detailed description of lapel and table modes please see below.)

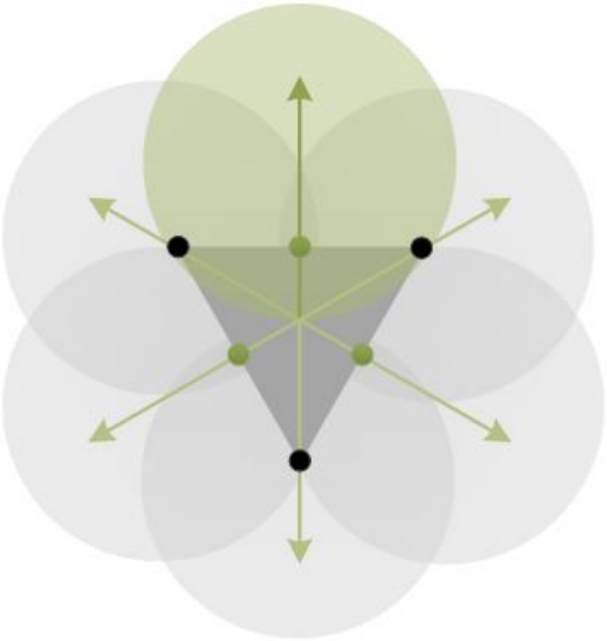

**Figure 3a: Diagram illustrating the resulting microphone beams spaced 60° apart in MultiBeam Technology with 3 omnidirectional microphones in a triangle 3 black dots and the 3 virtual microphones, green dots.**

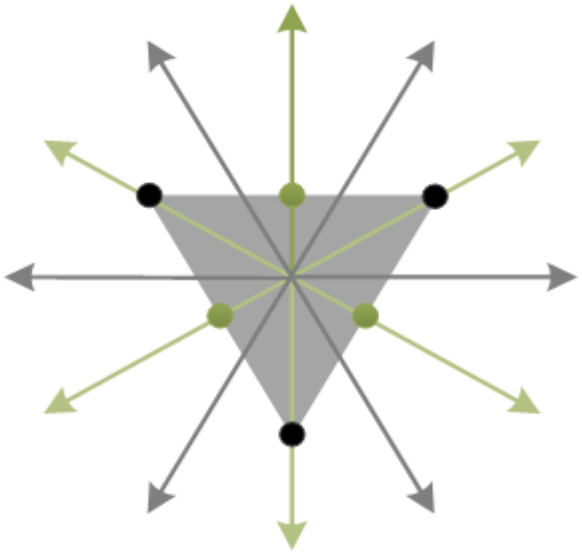

**Figure 3b: The illustration shows the possible configuration resulting in 12 directional beams.**

## Pick-up range for the microphone

MultiBeam Technology incorporates an adjustable pick-up range. This refers to the distance over which the microphone is sensitive or the range between the speaker and the microphone. By adjusting the knee points of the gain model in the Roger microphone it is possible to affect the lowest level of speech audible by the listener. As the sound pressure level (SPL) normally decreases in proportion to the inverse square of the distance to the sound source, it can be assumed that the perceived pick-up range of the microphone is also affected. In MultiBeam Technology two different compression knee points are implemented with a difference of 6 dB SPL, which corresponds to a theoretical doubling of the distance. So the pick-up range can be said to have doubled.

In quiet and non-reverberant conditions, the higher compression knee point typically results in the sound level at a single beam being maintained without strong attenuation over of a distance of more than 1.5 meters. This is the shorter or more focused pick-up range. When the lower knee point is used, the pick-up range is doubled. This broad pick-up range can extend the distance up to 3 meters before strong fading occurs, as shown in figure 4.

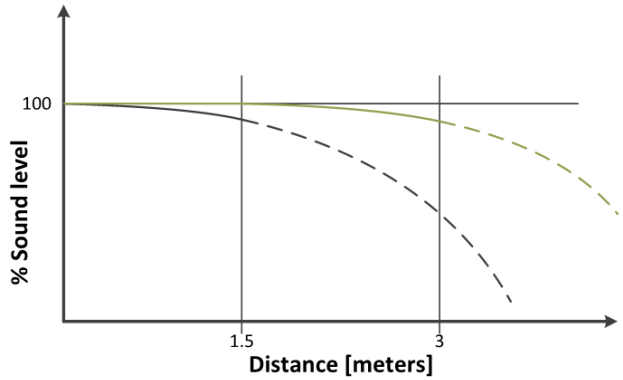


**Figure 4: Diagram illustrating the distance across which the microphone pick-up level is maintained (solid line) before stronger attenuation (dotted line). The green line indicates the broad pick-up setting which results in up to 3 meters distance and the grey line indicates the focused pick-up setting of 1.5 meters.**

The pick-range can be used to improve the listening experience. In an environment with high levels of background noise the high compression knee-point can be selected, resulting in a shorter pick-up range and a lower level of noise. This can improve the listener's comfort. In lower background noise a lowered compression knee point would allow the listener to perceive fainter sounds, and hear talkers from a longer distance.

As implemented, the pick-up range is automatically adjusted according to the level of background noise in the Roger Table Mic II when a single device is used, but provides the listener the freedom to manually select their preferred mode when several Roger Table Mic IIs are simultaneously operated.

## Selecting and activating beams

MultiBeam Technology automatically selects the optimal beam to activate. It analyzes the signal-to-noise ratio (SNR) of each directional beam hundreds of times per second. On the basis of this analysis the beam containing the highest SNR is accentuated, assuming that the voice with the highest level over the background noise is the speaker of interest in the group.

The decision to switch from one beam to another is based on an averaged SNR over time. This results in less frequent switching and better continuity than if the instantaneous SNR were used. The beam switching is also prevented during transient impulsive sounds to ensure that the directional microphone stays focused on the speaker of interest even when a brief loud sound occurs. This characteristic of Multibeam Technology is especially important in a restaurant or similar listening situation to ensure that the beam does not switch toward tableware and cutlery clatter while someone is speaking.

Thanks to an intelligent handling of the switching between beams, the transitions from one speaker to another are smooth and comfortable: the end of a sentence will still be audible if a new speaker starts, even before the previous speaker has finished. The continuity of the conversation flow in a group conversation is maintained by the MultiBeam Technology.

## Configured for different listening situations

MultiBeam Technology is implemented in the Roger Select and the Table Mic II for different listening situations. When placed horizontally at the center of a seated group MultiBeam Technology is configured with 6 beams spaced 60° apart, as shown in Fig 5a.

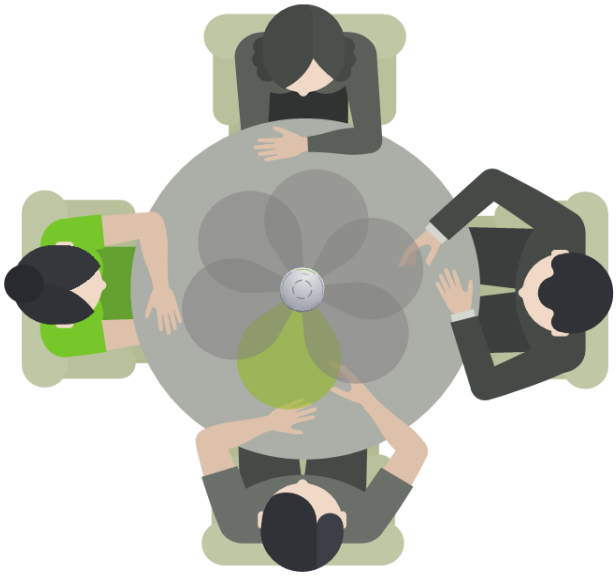

**Figure 5a: Diagram illustrating horizontal placement of Roger Select at the center of a table. Multibeam Technology selects and activates a single beam with the best SNR or selected beams, shown in green. The listener is shown in green.**

The combined polar plot of this MultiBeam configuration is sensitive in 360 degrees as seen in Figure 6. So much so, that if the active speaker walks around the table, there will be less than 1 dB of variance in the loudness of their voice as they move from one directional beam to the next. At the same time this configuration provides the high signal-to-noise-ratio of a directional microphone. The key advantage of MultiBeam Technology compared to a single directional microphone is that it is no longer necessary to manually orient the microphone toward the speaker of choice.

The Table Mic II may be used in pairs or with multiple microphones in a MultiTalker Network. In a network, switching between a number of Roger Table Mics II occurs quickly and automatically on a first-come, first-serve basis. In other words, voice activity steers this switching. When one voice finishes the next Table Mic II where a voice is detected will automatically activate. In this application of Multibeam Technology it is also assumed that multiple microphones may be in use for large groups which will sometimes result in greater distance between the Table Mic II and the speaker. The broad pick-up range or longer distance will be activated by default. In this case the shorter distance or more focused range can be manually activated.

**Figure 5b: Diagram illustrating a large meeting with a Table Mic II placed at each end of the conference table. Multibeam Technology selects and activates a single beam with the best SNR, shown in blue. The listener is shown in green.**

Sometimes in situations like a group conversation at a restaurant, the speaker with the best SNR (loudest voice over the background noise) may not be the speaker of interest. This can occur, for example, if a side conversation starts at the table. In this case MultiBeam Technology in the Roger Select allows the listener to manually override the SNR based automatic beam to focus on the speakers of choice.

An example is shown in Figure 6 where a side conversation has started within a group conversation. In this example the listener selects two separate beams oriented to side. The voices of those people on the other side of the table will be attenuated. In restaurants, it is assumed that one[1] Roger Select is in use and that the resulting group size is therefore more intimate. The Roger Select operates over the shorter or more focused pick-up range of around 1.5 meters (see Figure 4) by default.

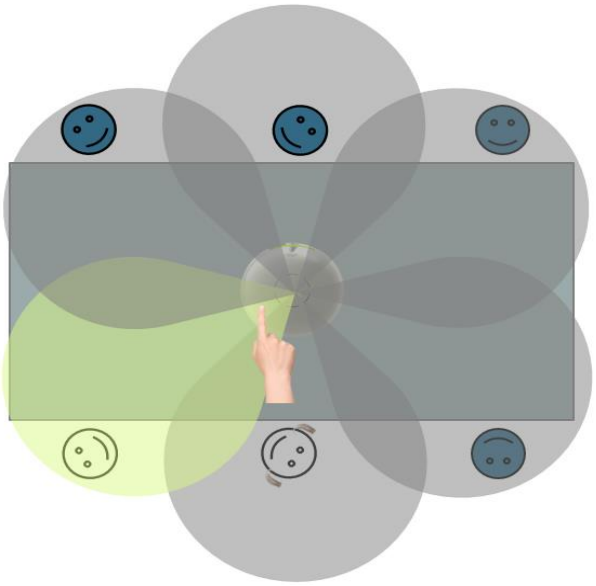

**Figure 6: Diagram illustrating Roger Select in the center of a small group in a noisy setting. The listener indicated by hearing aids, manually selects and activates one beam to improve the SNR during a side conversation.**

[1]When combined with other wireless devices in a MultiTalker Network, the Roger Select will automatically switch to lapel mode if vertical and be muted when horizontal.

The Roger Select MultiBeam Technology is also used in listening situations when the microphone is clipped to clothing or worn around the neck with a lanyard. The built-in accelerometer will automatically identify the vertical orientation and trigger MultiBeam Technology to apply a suitable configuration. For this application 12 beams spaced 30° apart are created. This increases the precision of the directionality to ensure that the wearer's mouth can be accurately pinpointed. The accelerometer determines which of the beams are oriented most vertically and selects two beams to be activated. Between these two beams the one with the best SNR will be accentuated, assuming that this beam has the best orientation toward the speaker's mouth. The advantage of this precision is that careful orientation of the directional microphone toward the speaker's mouth is no longer required. When worn in lapel mode, MultiBeam Technology continuously responds to the movement of the wearer or their clothing. The accelerometer will trigger the configuration to revert to table mode when the device is horizontal.

## Conclusion

The new Multibeam Technology automatically selects the direction with the best signal-to-noise ratio. It is implemented to provide optimal listening in the most challenging of group situations both in the workplace and during social interactions.

MultiBeam Technology in Table Mic II is designed to give optimal performance at work or other meetings. With multiple microphones networked, the speaker of interest can be automatically detected. Adjustment of the pick-up range allows the listener to adapt his individual listening comfort in various environments.

MultiBeam Technology in Roger Select is tailored to the needs of a listener in a social situation, a smaller group where the talker of interest can be manually selected and where more than one directional beam can be activated as needed. In Roger Select, MultiBeam Technology adapts to make listening to a microphone clipped on clothing or worn on a lanyard easier and better. It precisely locates the source of speech from a clipped on or lanyard location.

MultiBeam Technology is the latest breakthrough in adaptive digital wireless microphone systems from Phonak. It is designed for use in group settings, where following a conversation can be difficult given the dynamic nature of group dialogue. MultiBeam Technology focuses a directional microphone beam directly at the dominant speaker. It is no longer necessary to manually orient the microphone toward the speaker of choice. The MultiBeam Technology in Roger Select and Roger Table Mic II represents a new paradigm in group listening, allowing users to remain active and engaged in even the most challenging of environments.

## References


- Dillon, H. (2012). Hearing Aids (Second Ed.). Thieme USA.
- Picou, E.M., Gordon, J., & Ricketts, T.A. (2016). The effects of noise and reverberation on listening effort for adults with normal hearing. Ear and Hearing, 37(1), 1-13.
- Thibodeau, L. (2014). Comparison of speech recognition with adaptive digital and FM wireless technology by listeners who use hearing aids. American Journal of Audiology, 23(2), 201 – 210.


## Authors


**Xavier Gigandet**

Xavier Gigandet obtained a Master in Electrical and Electronical Engineering from the Swiss Federal Institute of Technology (EPFL, Lausanne) in 2005 and completed a PhD in Signal Processing at the Center for Biomedical Imaging (CIBM) in Switzerland in 2009. In 2010 he joined the Digital Signal Processing team at Phonak Headquarters and is now Senior Digital Signal Processing Engineer at Phonak Communications.

**Bernadette Fulton**

Bernadette Fulton completed her training in Clinical Audiology at Melbourne University (Australia) after undertaking a BA in Linguistics at Monash University (Australia). She has extensive clinical experience in audiology, including aural rehabilitation, hearing aids and diagnostic audiology in private and government clinics. In 2015, she joined the team dedicated to adults with severe to profound hearing loss at Phonak Communications in Murten as Audiology Manager.

**Chase Smith**

Chase Smith received his Doctor of Audiology from Northwestern University in 2016. He joined Sonova in 2016 for a one-year formal development program and has worked at Advanced Bionics, Connect Hearing, and Phonak.