Roger Pen

Bridging the understanding gap

This universal, cutting-edge wireless microphone helps people with a hearing loss to understand more speech in noise and over distance. Designed with discretion in mind, the Roger Pen features adaptive wireless transmission, fully automated settings, wideband audio Bluetooth for cell phone use, TV connectivity and an audio input for listening to multimedia. The Roger Pen works with either design-integrated Roger receivers for Phonak hearing instruments and select cochlear implant processors, or universal Roger receivers that can be attached via an audio shoe to the hearing aid or body-worn neck-loop receivers.

Roger – digital adaptive wireless at 2.4 GHz

Roger is a technology standard developed by Phonak, which features adaptive, wireless transmission and runs on the 2.4 GHz band. Roger audio signals are digitized and packaged into very short (160 µs) digital bursts of codes (packets) and broadcast several times, each time using different channels between 2.4000 and 2.4835 GHz. Frequency-hopping between channels, in combination with these repeated broadcasts, avoids interference issues. The audio delay from a Roger microphone to the output of a Roger receiver is just 17 ms, which is equal to the delay of sound traveling through the air over 5.8 m/19 ft. This therefore avoids any issues with either lip synchronicity or echoing. Roger systems are also tap-proof, ensuring the privacy of a user's signal is not compromized, even by accident.

The frequency-hopping which Roger employs is adaptive, meaning only free channels are used. Roger receivers regularly 'talk back' to the Roger Pen, informing the system of which channels are steadily occupied (by other nearby systems operating at 2.4 GHz, such as WiFi networks) and which channels are free. The Roger Pen then automatically 'hops' around the occupied channels (see Figure 1). This means that even if there is a lot of traffic at 2.4 GHz, the interruption or loss of a Roger connection is highly unlikely.

In comparison, Bluetooth wireless technology only repeats its packet broadcasts at the demand of the receiver, or employs repetition if using the SCO protocol. If acknowledgement of a packet's reception does not arrive at the Bluetooth transmitter, the packet is broadcast again. As a result, Bluetooth receivers are almost continuously transmitting back to the transmitter, which significantly increases a receiver's power consumption.

With Bluetooth, the maximum number of receivers is limited to three. Therefore, even two listeners with binaural ear-level Bluetooth receivers cannot listen to the same Bluetooth stream, let alone larger groups. In the Bluetooth headset protocol the audio delay is acceptable (10 to 15 ms), however, the audio bandwidth is often limited (up to 4 kHz), unless the 'wideband audio' feature of the hands-free profile version 1.6 is used, which can go up to 7 kHz. In the Bluetooth audio streaming protocol, A2DP, the bandwidth increases to 20 kHz, but the audio delay of well over 100 ms prevents this from being suitable for live face-to-face communication. Only with special Bluetooth chips on both ends can this delay be reduced, to around 40 ms.

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Roger offers a full audio frequency bandwidth – from 200 Hz to 7,300 Hz. The system's internal signal-to-noise ratio is around 55 dB, making background noise very quiet. With Roger, it is not only possible to transmit an audio signal, but also to transmit and receive control data – when setting up and/or maintaining a MultiTalker Network for example.
Electromagnetic waves at 2.4 GHz have a wavelength of about 12.5 cm/5". This enables the design of new, small wireless microphones such as the Roger Pen, containing short built-in antennas. At 800 MHz the wavelength is 37.5 cm/15" and at 200 MHz (in the traditional FM frequency range) the wavelength is 1.5 m/4.9 ft, which requires the external microphone cable to also act as the radio's antenna.
As 2.4 GHz is a freely accessible band worldwide (a so-called ISM band: Industry, Science and Medical), no license is necessary to use it. This gives Roger Pen users the freedom to use their systems anywhere in the world. Servicing Roger systems while traveling is also simplified, as this standard is the same in each country.

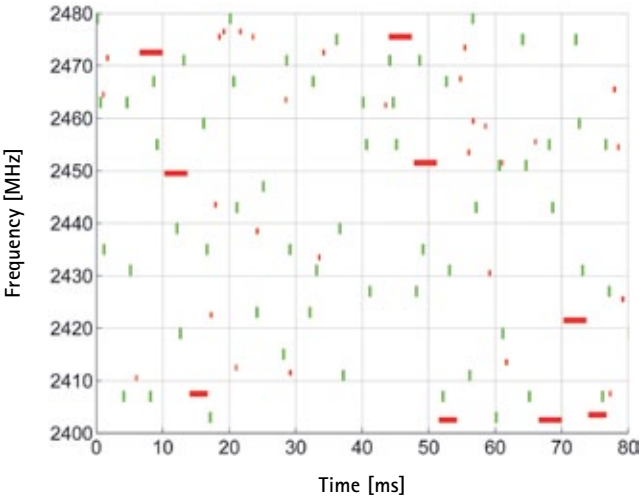

Figure 1
Time and frequency diversity of Roger codes (packets). On the vertical axis the frequency within the 2.4 GHz band is shown, while the horizontal axis shows time. By hopping frequencies and repeatedly broadcasting audio packages, collisions causing mutual interference are minimized.

The Roger chip

Phonak has developed the proprietary Roger microchip for dedicated use with miniaturized ear-level receivers (see Figure 2). This chip contains 6.8 million transistors, while a Pentium Pro processor by comparison contains 5.5 million.
On the chip, analog and digital blocks are situated next to RAM, ROM, EEPROM and Flash memory blocks.

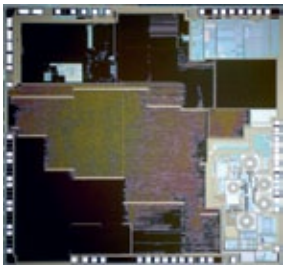

Figure 2
The Roger microchip.

Maximum performance in noise

The Roger Pen continually analyzes the surrounding ambient noise level. In parallel with the broadband audio signal, control bits are sent to Roger receivers, which adaptively adjust their gain to suit this acoustical environment. The adaptation range is even larger than that of Phonak Dynamic FM technology.
This advanced dynamic behavior leads to significant improvements in speech recognition in noise, especially at higher noise levels of up to 80 dB(A) – noise levels that are quite common in daily life, in public places such as restaurants, bars, parties, receptions, and some workplaces. Related study results – by Professor Linda Thibodeau, PhD, and Dr. Jace Wolfe, PhD – can be found in two Phonak Field Study News editions: 'Roger and Hearing Instruments' and 'Roger and Cochlear Implants'.

More recent measurements by the same investigators have shown that users of hearing instruments and CI (cochlear implant) recipients can actually achieve better speech recognition than people with normal hearing at noise levels of 65 dB(A) and above in the same test set-up (see Figure 3). It is important to note that during these measurements, the ear-level microphones of the hearing instruments and CI processors were not switched off and the Roger microphone was tested for transparency with the ear-level microphone at 65 dB(A), as recommended by the American Academy of Audiology. The Roger microphone was placed 20 cm/7.87" in front of the loudspeaker playing the HINT sentences, which represented a Roger Pen hanging around the talker's neck. The Roger Pen owes this performance to the sophisticated proprietary algorithms rather than the transmission frequency.

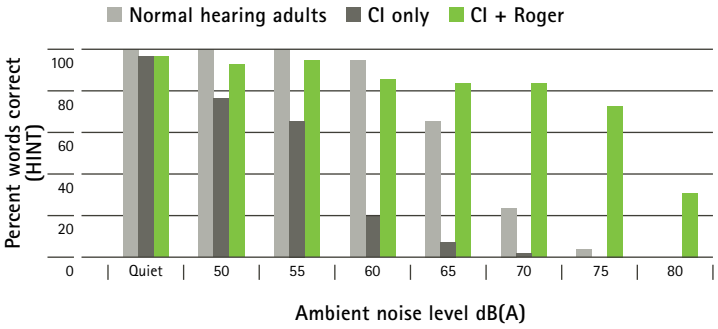

Figure 3
The listening distance was 17 feet/5,5 m. Data are shown for 13 recipients of Advanced Bionics Harmony (without [dark gray bars] and with [green bars] Roger) and for 20 normal hearing adults (light gray bars). At noise levels of 65 dB(A) and above, the CI recipients using a Roger system could understand speech better than their normal-hearing peers. (Dr. Jace Wolfe, 2013)

Context-dependent signal processing

One of the barriers to the uptake of wireless hearing technology to date has been its complexity or perceived complexity. Wireless microphones with multiple settings required hearing care professionals not only to understand these settings, but also to be able to explain these options to their clients.
The possibility, for example, of switching between microphone modes such as omnidirectional, fixed beamformers and adaptive beamformers added an extra potential benefit, but also another layer of complexity. As a result, the counseling of patients and their acceptance of such technologies, could be challenging.
Roger Pen is different, due to its settings being fully automated. To enable this automation, the device employs two different types of input: sound and acceleration. The presence of an acoustical speech signal, the level of that speech signal, and the level of the ambient noise, help to steer gain, various noise cancellation algorithms and beamforming.

The Roger Pen also features an accelerometer, which informs the device of its orientation with respect to gravity. An accelerometer is a miniature mechanical and electronic component that measures accelerations in three dimensions (X, Y and Z) at high speed and with high precision (see Figure 4). Smartphones, for instance, use accelerometers to ensure an on-screen image is rotated at the same time as the phone itself.

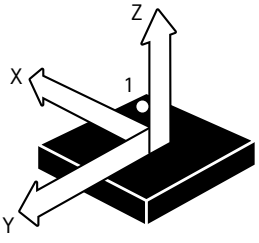

Figure 4
Top view of an accelerometer and directions of detectable accelerations. Accelerometers can measure just a few millimeters in size.

The Roger Pen is capable of detecting whether it is lying horizontally (i.e., on a table during dinner or a business meeting), held in the hand reporter-style, or hanging around the neck of the talker. This information – along with the previously mentioned acoustical classification – is taken into account when optimizing the Roger Pen's settings. And all of this occurs automatically.
Additionally, when the Roger Pen is lying on a flat surface such as a table, a carefully positioned extra weight inside the device positions it in a way that ensures its microphones always face upwards – allowing optimal access to sound and avoiding covering the microphone openings.

Hearing soft voices and hearing over distance
For adults and teenagers it is not always possible to hand a wireless microphone to the person speaking, for example if the talker is standing or sitting a few feet away.
The Roger Pen addresses this distance challenge with a new algorithm that can reduce 'perceived distance' by up to 75% in quiet situations.
This 'close-up' feature uses an innovative new way of combining an adaptive gain model with an advanced beamformer. It is activated automatically when the user points the Roger Pen towards the person they want to hear.

Conference mode
Listening to a group of people sitting around a table, which often happens at work or at dinner, can be challenging for those with a hearing loss.
The Roger Pen addresses this crucial use case with its automatic conference mode. This mode is activated by placing the microphone on a flat surface such as a table – choice of microphone mode, noise cancellation, gain and the pick-up of voices are controlled automatically. Placing the Roger Pen on the table in the middle of the group and switching it on is all that is required.

Silent Landing
If the Roger Pen is accidentally dropped, its accelerometer immediately detects this. Within just a few centimeters/inches of free fall, the device will automatically mute its microphones before it has hit the floor. As a result, connected Roger Pen listeners will not hear an uncomfortable banging sound when the device lands. Immediately following this 'silent landing', the Roger Pen will continue to operate normally.

Listening to the TV and music
The Roger Pen (and Roger Clip-On Mic) are both supplied with a docking station. This not only serves as a battery charger, but when connected to a TV (or any multimedia device) also functions as an audio streamer – sending the sound of the TV into the listener's hearing instruments or CI processors via their Roger receivers.
Another new feature in the Roger Pen is the automatic adaptation of the system's gain model when an audio signal is fed into the audio input of the Roger Pen (or Roger Clip-On Mic).

By shifting the knee-point for compression of the wireless microphone to higher sound pressure levels, and adjusting the gain in the receiver, the dynamic range is enlarged, while the average loudness remains unchanged. This expansion of the dynamic range has a highly positive effect on the richness and depth of the music the listener hears, due to the difference in loudness between soft and loud passages being increased.

Multiple microphones in a wireless network

One of, if not the most difficult situations for listeners with hearing loss is a conversation with multiple partners in high levels of noise, such as in noisy restaurants and parties. In these demanding situations the Roger Pen and the Roger Clip-On Mic can be combined to form a wireless network of multiple microphones – providing the Roger listener with improved access to the speech of the friends or family around them.
In this case each conversation partner wears their own wireless microphone, with one 'master' microphone in the network controlling which microphone is open at any one time. (Only one microphone can be active at any one time, all other microphones are muted.) Switching between microphones occurs quickly and automatically on a first-come, first-served basis. In other words, voice activity steers this switching.
Why only enable one microphone at a time? Typically a person cannot listen to two audio streams at the same time. And on average the signal-to-noise ratio (SNR) is at best 0 dB if multiple audio (voice) streams are audible, which is not a high enough SNR for listeners with hearing loss. Therefore it does not make sense to have more than one microphone active at the same time.
Additional Roger Pens or Clip-On Mics can be added at any time. It is also possible to build mixed networks with one or more Roger Pens and one or more Roger Clip-On Mics within the network.

Wideband audio Bluetooth

The Roger Pen features wideband audio (also known as HD voice) Bluetooth. This enables it to be paired with any Bluetooth-enabled device such as cell phones, smartphones, tablets and more.
If the Bluetooth device and the provider offer wideband audio, the listener can enjoy a cell phone call, in both ears, over an audio bandwidth of about 7 kHz (see Figure 5). The effect is like standing next to someone in a fairly quiet room.
The adoption of wideband audio is spreading quickly and is expected to offer a large improvement in phone calling for listeners with hearing loss. The Roger Pen is therefore fully prepared for this major evolution in digital telephone technology.

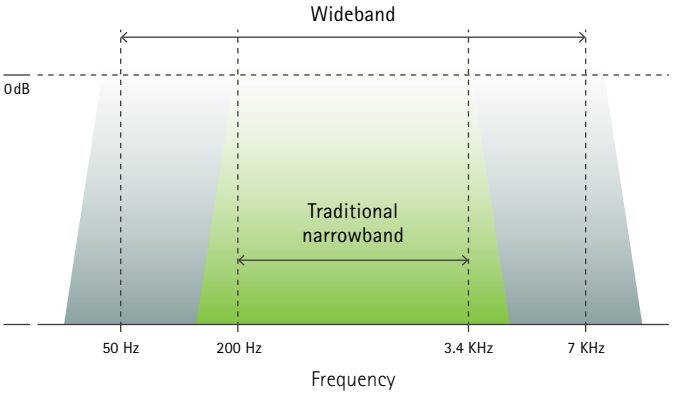

Figure 5
Bandwidth comparison of standard traditional narrowband phone and wideband audio Bluetooth or HD voice. The gray band contains clearly much more speech information than the green band, significantly enhancing speech clarity on the phone.

Inconspicuous design

The discreet design of the Roger Pen is expected to increase its acceptance by users (see Figure 6).
The design of a pen has not changed in decades. It is an everyday object that raises no eyebrows, whereas a hearing-impaired person placing an old-fashioned or medical-looking device in the middle of a group on a table might raise questions that some users prefer to avoid. A highly believable, everyday design helps overcome such barriers to acceptance.
The mechanical design of the Roger Pen is not only about mimicry however. It is also designed with performance, reliability and an intuitive user experience in mind. A special surface treatment reduces the noise caused by rubbing against other surfaces, such as clothing, to an absolute minimum.

Figure 6
The Roger Pen is available in three colors. Petrol, Silver and Ruby.

Summary

The Roger Pen is a cutting-edge wireless microphone, which enables clients to hear and understand more speech in loud noise and over distance. Its settings automatically adjust to suit its environment based on acoustic scene analysis and its orientation. Wideband audio Bluetooth for cell phone calling rounds up the long list of features, all packed into an inconspicuous design.

References

See www.phonakpro.com/evidence

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Phonak Field Study News: Roger and cochlear implants
Wolfe, J. et al. (2013) Better speech recognition with digital RF system in study of cochlear implants. The Hearing Journal, vol 66, No. 7, pp. 24-26.
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