

# The REAL Story on Spectral Resolution

*How Does Spectral Resolution Impact Everyday Hearing?*



*Harmony® HiResolution® Bionic Ear System by Advanced Bionics®*

# Harmony's Spectral Resolution

## ...what it means and why it matters

Choosing a cochlear implant system is a big decision. As a cochlear implant candidate or the parent of one, you want to know how to select the best system for you or your child. To make the right choice, it's crucial that you compare the technology on the inside (the cochlear implant) as well as the technology on the outside (the sound processor). The sound processor is the part of the cochlear implant system that you wear on or off the ear, and it's important to keep in mind that you can replace it with a new model as the size and appearance change over time. Unlike the processor that can be easily exchanged for a new one, the cochlear implant that you choose today is designed to be with you for years to come and will determine how well you hear.

As you look into the internal implant technology to inform your decision, you may wonder what the comparative numbers mean and how they impact hearing performance. This brochure will give you the real story on the technology behind spectral resolution—a critical component of hearing your best with a cochlear implant system.

### *What is spectral resolution?*

Spectral resolution refers to how well the cochlear implant delivers frequency, or "pitch" information, to the inner ear. Pitch is the highness or lowness of a tone. In normal-hearing ears, pitch is encoded in two ways. The first way is called the "place" code because different pitches stimulate different places along the coiled inner ear. The second way is called the "temporal" code because the hearing nerve responds at different rates depending upon the pitch of the sound.

Like normal-hearing ears, cochlear implants take advantage of both of these codes to deliver sound to you. Cochlear implant electrodes stimulate different places in the inner ear. Part of how the hearing nerve responds depends on the stimulation rate of the pulses delivered to each electrode. Typically, cochlear implant recipients hear different pitches when different electrodes are stimulated and when the rate of the stimulation varies. The better the spectral resolution, the better you can hear these pitches. High spectral resolution is especially important for listening in noisy situations and for hearing and appreciating music.

### *How are spectral resolution and the number of electrodes related?*

Historically, spectral resolution has been limited by the number of electrodes that can fit into the tiny inner ear. Thus, the number of spectral bands that could be delivered was limited to the maximum number of electrodes. Limiting the spectral resolution to 22 or fewer spectral bands worked fairly well for hearing speech in quiet, most likely because hearing voices does not require high spectral resolution.<sup>1</sup> However, when the listening environment becomes more challenging, increased spectral resolution is required to separate speech from noise or to distinguish multiple voices. Even for normal-hearing listeners, as many as 100 spectral bands are required for music perception.

The challenge for cochlear implant manufacturers is to increase the number of spectral bands without adding more electrodes, so that you can hear more pitches. Early research suggested that "virtual" spectral bands could be created by stimulating two electrodes at the same time, a process called current steering.<sup>2,3</sup> With current steering, additional

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...delivers the pitch and timing of sound with the greatest accuracy

itches were heard compared to when either of the two electrodes were stimulated alone. However, in order to stimulate two different electrodes at the same time, multiple current sources are required.

## **HiRes Fidelity 120<sup>®\*</sup> (HiRes 120):**

### **Improving spectral resolution through current steering**

Advanced Bionics was the first manufacturer to offer a cochlear implant with multiple current sources to support current steering. Research has shown that AB recipients can perceive additional pitches when current steering is implemented.<sup>4-7</sup> In fact, some AB recipients have heard over 460 pitches!<sup>6</sup> Based on those results, AB introduced HiRes 120, a breakthrough in sound-processing technology that uses current steering to increase the spectral resolution delivered by the Harmony<sup>®</sup> cochlear implant. Studies have shown that compared to using other sound-processing strategies, AB recipients using HiRes 120 hear speech better in noise and experience improvements in music and sound quality.<sup>8-10</sup>

### **How does the internal technology differ among cochlear implant systems?**

It's the technology inside the cochlear implant, which includes spectral resolution capability, that truly impacts how well you or your child will hear. The table (shown right) compares the internal technology of today's cochlear implant systems. It's important to note that conventional systems with only one current source (like Cochlear's Nucleus 5 System) cannot stimulate electrodes simultaneously, which means that current can't be steered and spectral resolution is limited to the number of electrodes. For example, the Nucleus 5

System, Cochlear's newest cochlear implant system, still uses dated internal technology that does not have the capability to steer current or to deliver high spectral resolution. Cochlear claims they offer 161 pitches, but they currently have no sound-processing strategy to deliver that many pitches to recipients. With only one current source, the Nucleus 5 System provides 22 spectral bands, delivering far fewer pitches than AB's Harmony System.

### **Hear your best with the best technology: It's what's inside that counts**

Harmony's HiRes<sup>®</sup> 120 is designed to deliver the pitch and timing of sound with the greatest accuracy so that you can hear and enjoy music or hear well in noise like people with normal hearing do. Only HiRes<sup>®</sup> 120 from AB:

- Offers 120 spectral bands for unsurpassed spectral resolution so that you can hear all the colorful details of sound. Other implants limit stimulation to one electrode at a time, which limits the number of spectral bands to the number of electrodes (at most 22).
- Provides the ability to stimulate two or more electrodes at the same time. This simultaneous stimulation allows current to be "steered" between electrodes giving Harmony recipients 120 spectral bands for better hearing.
- Allows you to hear many more pitches than the number of electrodes implanted in the ear.
- Has been proven in studies to show better speech perception in noise, as well as improvements in music and sound quality compared to other sound-processing strategies.<sup>8-10</sup>

\*HiRes Fidelity 120 is not approved for pediatric patients in the United States.

*Hearing your best means choosing to hear with Harmony, only from AB.*

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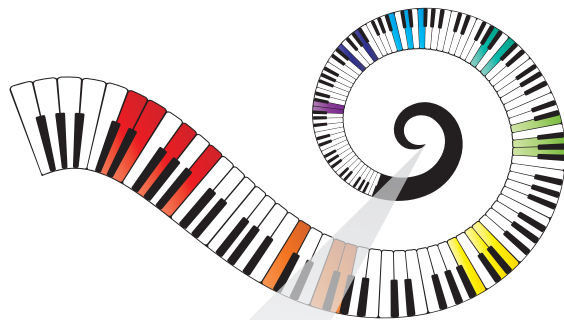
...gives you the best possible hearing experience

	AB's Harmony System	Cochlear's Nucleus Freedom System	Cochlear's Nucleus 5 System	Med-El's Maestro System	Why this Matters
Temporal Resolution (Stimulation Rate, pulses per second or pps)	Up to <b>83,000 pps</b>	Up to 32,000 pps	Up to 31,500 pps	Up to 50,000 pps	The faster the stimulation rate, the more accurate the timing of sound.
Spectral Resolution (Spectral Bands)	Up to <b>120</b>	Up to 22	Up to 22	Up to 12	The higher the resolution, the more detailed sound you hear.
Potential Pitch Percepts	<b>460*</b>	161*	161*	Data not available	The more pitch percepts, the better the opportunity you have to differentiate sounds.
Input Dynamic Range (IDR) (Decibels or dB)	Up to <b>80 dB</b>	45 dB	45 dB	55 dB	The wider the range, the more sounds you hear.
Current Sources	<b>Multiple</b>	Single	Single	Multiple	Multiple current sources allow unique sound processing strategies. AB has 16. Cochlear has 1.
Current Steering	<b>Yes</b>	No	No	No	Delivers a fuller musical experience

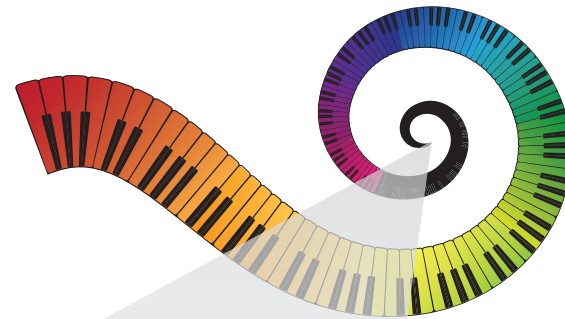
\*Capability representative of software that is not commercially available from any cochlear implant manufacturer

# Harmony's Spectral Resolution

...delivers 5 times more sound than any other cochlear implant system



**OTHER SYSTEMS**  
up to 22 bands



**HARMONY**  
up to 120 bands

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## References

1. Shannon RV, Fu QJ, Galvin J. 2004. The Number of Spectral Channels Required for Speech Recognition Depends on the Difficulty of the Listening Situation. *Acta Otolaryngol Suppl* 552:50–54.
2. Townshend B, Cotter N, Van Compernelle D, White RL. 1987. Pitch Perception by Cochlear Implant Subjects. *J Acoust Soc Am* 82:106–115.
3. Wilson BS, Lawson DT, Zerbi M, Finley CC. Recent Developments with the CIS Strategies. In I. Hochmair-Desoyer and E. Hochmair E (Eds), *Advances in Cochlear Implants*. Proceedings of the Third International Cochlear Implant Conference, Innsbruck, Austria, April 1993 (pp. 103–112). Vienna, Austria: Datenkonvertierung, Reproduktion and Druck.
4. Brendel M, Frohne-Büchner C, Stöver T, Lenarz T, Büchner A. Investigation of Pitch Discrimination and the Effect of Learning for Virtual Channels Realized by Current Steering. *Acta Otolaryngol*. Published online Feb. 27, 2009.
5. Donaldson GS, Kreft HA, Litvak L. 2005. Place-Pitch Discrimination of Single- Versus Dual-Electrode Stimuli by Cochlear Implant Users. *J Acoust Soc Am* 118:623–626.
6. Firszt JB, Koch DB, Downing M, Litvak L. 2007. Current Steering Creates Additional Pitch Percepts in Adult Cochlear Implant Recipients. *Otol Neurotol* 28:629–636.
7. Koch DB, Downing M, Osberger MJ, Litvak L. 2007. Using Current Steering to Increase Spectral Resolution in CII and HiRes 90K Users. *Ear Hear* 28(2):385–415.
8. Firszt JB, Holden L, Reeder R, Skinner MW. 2009. Spectral Channels and Speech Recognition in Cochlear Implant Recipients using HiRes 120 Sound Processing. *Otol Neurotol* 30:146–152.
9. Brendel M, Büchner A, Krüger B, Frohne-Büchner C, Lenarz T. 2008. Evaluation of the Harmony Sound Processor in Combination with the Speech Coding Strategy HiRes 120. *Otol Neurotol* 29:199–202.
10. Oleson J, Lesh S, Gfeller K, Knutson J. The Effect of Advanced Bionics' HiRes 120 on Self-Report of Music Enjoyment. Poster Presentation at the 10th International Conference on Cochlear Implants and Other Implantable Auditory Technologies, April 10–12, 2008, San Diego, California.

