

# Programming Cochlear Implants

*Second Edition*



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# Contents

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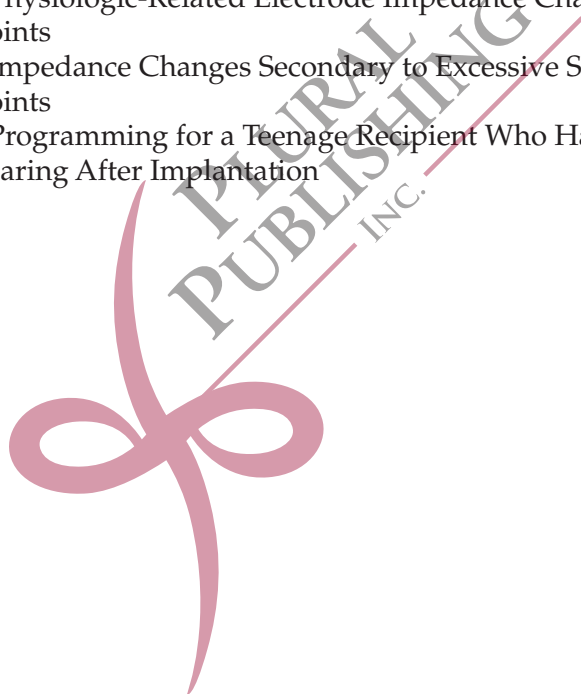
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# Foreword

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*Programming Cochlear Implants* (2nd edition) by Jace Wolfe and Erin Schafer is the latest addition to the Cochlear Implant Component of the Core Clinical Concepts in Audiology series of books. Similar to the first edition, this book provides detailed and comprehensive information about programming cochlear implants that cannot be found in other books. They begin by providing an overview of basic cochlear implant components, including updated information regarding newly introduced electrode arrays and speech processor components. A separate chapter is devoted to each of the three currently available cochlear implant systems (Chapters 4, 5, 6), where they review programming equipment (i.e., programming interface tools), programming software, sound processing features, and more. They provide the reader with step-by-step overviews of various programming appointments, describe uses for various objective

measures, and discuss rehabilitative activities that can be used with patients to enhance their performance.

In the final chapters, the authors provide an excellent update regarding hearing assistive technology and cochlear implants (Chapter 9). They describe various types of assistive technologies that can be utilized with the speech processor to enhance performance in difficult listening situations, including a comprehensive description of FM devices, speech processor telecoils, and recently introduced wireless accessories.

Both new and experienced clinicians will treasure this book and will refer to it regularly. We are both pleased and proud that Drs. Wolfe and Schafer took time out of their busy schedules to provide us with this valuable update to their original work.

—Teresa A. Zwolan, PhD  
Series Editor  
Cochlear Implant Series



# 5

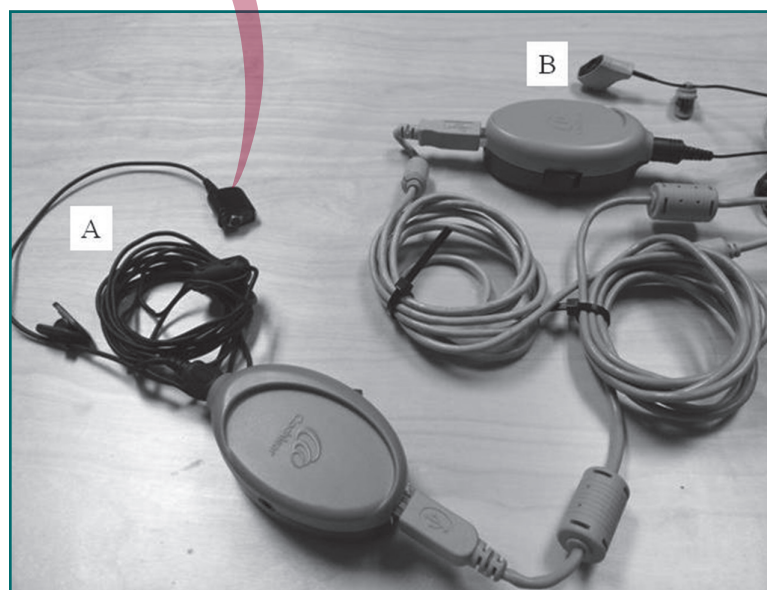
## Programming Cochlear Devices

### PROGRAMMING THE NUCLEUS 6 SYSTEM

The Nucleus 6 sound processor, the most recent release from Cochlear, possesses several new features relative to its immediate predecessor, the Nucleus 5 sound processor. Features include an option to provide electroacoustic stimulation, scene analysis with automatic adaptive direction-

ality (SCAN), digital noise reduction (SNR-NR), wind noise reduction, datalogging, and compatibility with a portfolio of proprietary wireless hearing assistance technologies (HAT). The various components of the Nucleus 6 cochlear implant system are described in Chapter 1.

The hardware used to connect the processor to the computer (i.e., the programming pod and cable) is shown in Figure 5–1. Briefly, a programming interface, known as a pod, is connected to the

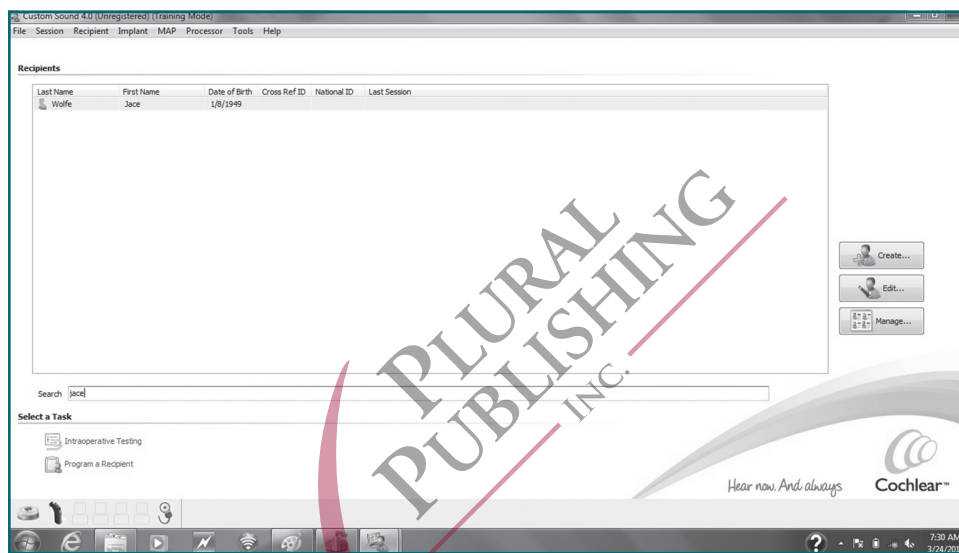


**FIGURE 5–1.** Cochlear programming Pod with cables for the Nucleus 5 and 6 (A) and Freedom sound processors (B).

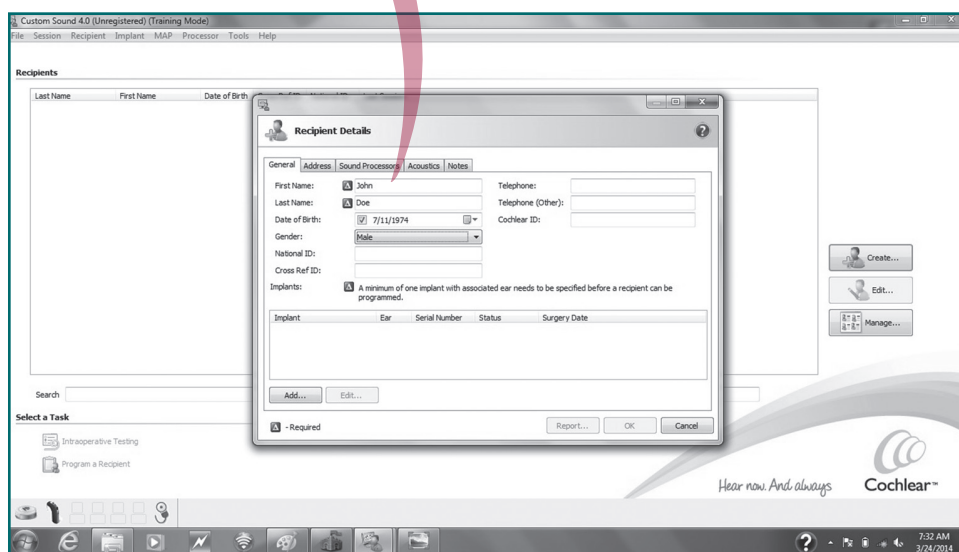


sound processor with a specialized programming cable, and the pod is connected to the programming computer with a USB cable. The same pod and programming cable (Figure 5–1A) are used to connect the Nucleus 6 and Nucleus 5 sound processors to the programming computer, whereas the same pod but a different programming cable (Figure 5–1B) is used to connect the Freedom sound processor to the programming computer.

Prior to creating a program, the clinician must create a file for the recipient and identify the implant(s) the recipient has received. In the Custom Sound 4.1 software, this is accomplished by selecting the “Create” function on the right-hand side of the patient selection “start-up” page (Figure 5–2). The recipient’s first and last names (Figure 5–3), the type of implant the recipient has received, and the ear that has been implanted must



**FIGURE 5–2.** Create a file for the recipient by selecting the “Create” function. *Note.* Provided courtesy of Cochlear™ Ltd.



**FIGURE 5–3.** In the “Recipient Details” menu, enter the recipient’s first and last names as well as other demographic information; select the “Add” button when complete. *Note.* Provided courtesy of Cochlear™ Ltd.



following description of programming Cochlear devices will be organized to correspond with the aforementioned categories.

## Measure Impedances

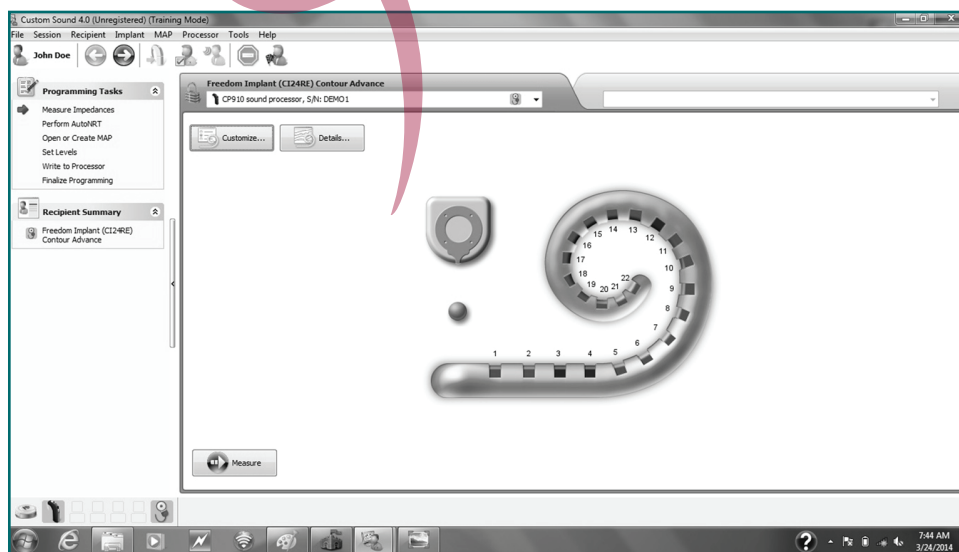
The first step involved in programming in Custom Sound 4.1 is to measure electrode impedance in four different electrode coupling modes. Electrode impedances are measured by simply selecting the “Measure” button within the “Measure Impedance” platform (Figure 5–6). The results of the measurement are promptly displayed in the illustration of the electrode array and reference electrodes by depicting impedances falling within the normal range in a green color and any abnormal findings in a red color (see Figure 5–6). The clinician should select the “Details” button to review to electrode impedances in graphical and tabular form (Figure 5–7).

In each electrode coupling mode, a low-level electrical current (100 CL with a pulse width of 25 usec), which is inaudible for most but not all recipients, is delivered sequentially to each intracochlear electrode contact. The impedance (in kOhms) is measured across the entire circuit as

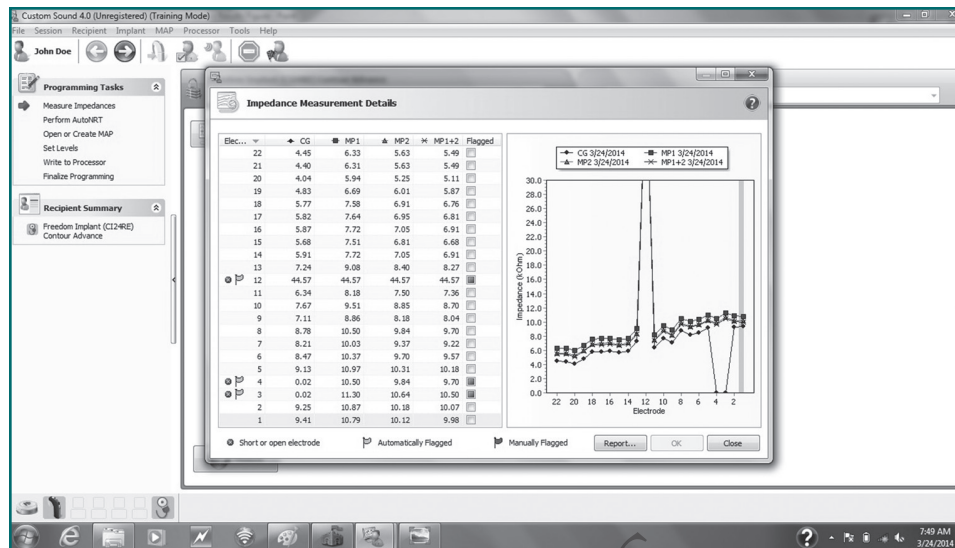
the current travels from the current source to the intracochlear electrode contact and finally to one or more reference electrodes.

Impedance is first measured in the common ground mode where the low-level current is delivered sequentially to each intracochlear electrode contact. Each of the remaining intracochlear contacts simultaneously serves as the return path. Because the common ground mode electrically couples each intracochlear electrode contact to the remaining intracochlear electrode contacts within the array, it is the most sensitive mode for detecting shorted electrode contacts. As a result, common ground is the preferred electrode coupling mode to detect anomalous intracochlear electrodes.

The Monopolar 1 and Monopolar 2 coupling modes measure electrode impedance by sequentially delivering the low-level current to each intracochlear electrode contact and by evaluating the impedance in the circuit from the current source to each intracochlear electrode and extracochlear reference electrode. Measuring electrode impedance in the Monopolar 1 and Monopolar 2 modes allows the clinician to identify the status of the extracochlear reference electrodes (located on the end of the nonstimulating electrode lead and the implant case, respectively).



**FIGURE 5–6.** Measuring impedances. *Note.* Electrodes 3, 4, and 12 are darkly shaded in this figure (abnormal impedance), whereas remaining electrodes are lightly shaded in this figure (normal impedance). Provided courtesy of Cochlear™ Ltd.



**FIGURE 5–7.** After measuring impedances, select the “Details” button to review to electrode impedances in graphical and tabular form. *Note.* Provided courtesy of Cochlear™ Ltd.

In the fourth mode, Monopolar 1+2, each intracochlear electrode is referenced to both the remote and case reference electrodes. In other words, the measure is completed by evaluating the impedance that exists in the circuit from the current source to each intracochlear electrode contact and finally to the reference, which is comprised of MP1 and MP2 which are electrically coupled to one another. The Monopolar 1+2 (MP1+2) mode is the default mode used for stimulation in the primary signal coding strategy used with Cochlear devices, the Advanced Combination Encoder (ACE) signal coding strategy (also in the Continuous Interleaved Sampling [CIS] and Spectral-Peak [SPEAK] strategies). As a result, impedance measured in the MP1+2 mode closely reflects the typical impedance present during stimulation when the implant is used on a daily basis.

According to the manufacturer, electrode impedances below 565 ohms are abnormally low and are designated as “short” circuits, whereas electrode impedances greater than 30 kohms for half-band electrode contacts (e.g., Nucleus Freedom, CI422, CI512, Hybrid) are abnormally high and are referred to as “open” circuits. It should be noted that the open circuit limit for the electrode array with full-band electrode contacts (e.g., Nucleus Straight Array and the Nucleus Double

Array) is 20 kOhms. Electrodes with abnormal impedances are typically “flagged” and deactivated for programming and subsequent impedance assessments. In the “Measure Impedance” module, “flagged” electrodes are depicted in yellow for all subsequent impedance measurements. Flagged electrodes are also “grayed out” (disabled) in the programming/“Set Levels” module of Custom Sound.

At initial activation, impedance is frequently high but will generally decrease with routine implant use. Therefore, the clinician should reassess the impedance of electrodes with abnormally high electrode impedance to determine whether impedance decreases to normal levels after stimulation of the electrodes. However, shorted electrodes will typically always remain as shorted electrodes and should be permanently disabled once they are identified. It should be reiterated that shorted electrodes are identified not only by their abnormally low impedance (i.e., less than 565 ohms) but also because the common ground mode allows for detection of two or more intracochlear electrodes that are electrically connected to one another.

For situations in which an electrode initially had abnormal impedance prior to stimulation and was subsequently flagged, the clinician may