

Why acquire an eABR?

When fitting a patient with a new cochlear implant (CI) or Auditory Brainstem Implant (ABI), it is essential to obtain an objective measure of the auditory capabilities provided by the device. Electrically Evoked Auditory Brainstem Response (eABR) measurements help determine necessary adjustments to optimize the implant settings (e.g., balancing electrode levels), ensuring the patient's hearing reaches the expected functional level. This method is especially useful when traditional audiometric testing is not feasible, such as for individuals with pre-lingual deafness or newly implanted patients.

What is eABR?

eABRs are electrical potentials generated when the auditory brainstem is stimulated with an electrical pulse, bypassing the outer, middle, and inner ear. Electrical stimulation is delivered directly to the implant. The responses originate primarily from the eighth cranial nerve (VIII) and the auditory brainstem pathway. The signal is averaged across multiple sweeps to enhance the signal-to-noise ratio and yield a clearer recording.

eABR recordings display characteristic peaks and valleys. Among these, wave V is the most prominent, usually occurring at around 4 ms.

Patient Preparation

The patient should be in a quiet environment and resting comfortably on a bed or reclining chair. Instruct the patient to relax during testing. To ensure optimal results, it is recommended that the patient avoid stimulants, such as caffeine, before the procedure.

Proper Grounding

Before starting the acquisition, ensure that all devices in the setup are properly connected to an earth ground, including the Duet, the stimulator, and any connected computers. Any other electrically connected devices should either be grounded in the same way or disconnected, if not required, to prevent electrical interference.

Electrode Usage

Disposable surface electrodes are generally sufficient for eABR recordings. However, a gold cup electrode is often preferred for the Vertex (Cz) position to maintain low impedance. To ensure signal clarity, electrode sites must be thoroughly cleaned and prepared to minimize skin-to-electrode impedance.

Dual Channel Electrode Placement

This is the recommended setup for most patients. It allows for recording from two channels, by setting the **[Mode]** to Both. For bilateral (double implanted) patients, ensure the implant on the non-test side is turned off.

The following shows a setup for a right-side implant.

- **Midline Inverting (-):** Red inverting electrode position connected to the Hairline Nape.
- **Contralateral Inverting (-):** Blue inverting electrode position connected to the contralateral mastoid (M1) or Tragus.
- **Joint Non-Inverting (+) :** Join White and Grey non-inverting positions using a Y-Adapter, then connect to the Vertex (Cz).
- **Ground:** Black ground position connected to the left acromion (tip of the shoulder bone).

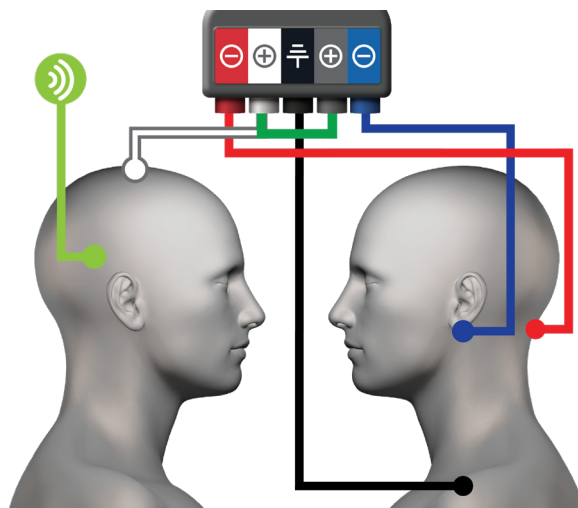


Fig.1 - eABR Contra + Midline dual channel setup, right-side implant, on Duet

To use this setup for the left side, simply mirror the setup shown in the figure above as follows:

- **Midline Inverting (-):** Blue inverting electrode position connected to the Hairline Nape.
- **Contralateral Inverting (-):** Red inverting electrode position connected to the Contralateral Mastoid (M2) or Tragus.
- **Joint Non-Inverting (+) :** Join White and Grey non-inverting positions using a Y-Adapter, then connect to the Vertex (Cz).
- **Ground:** Black ground position connected to the right acromion (tip of the shoulder bone).

Midline Electrode Placement

The midline setup is typically used for both CI and ABI patients.

- **Inverting (-) :** Hairline Nape.
- **Non-Inverting (+) :** Vertex (Cz).
- **Ground:** Forehead (Fz).
- **Second Channel:** Shorted. Joined to ground using two Y-adapters connected in series.

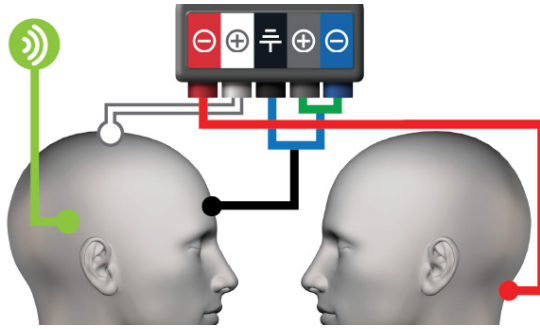


Fig.2 - eABR Midline setup, right implant, on Duet
For left implant testing, the electrodes would remain as shown above.

For additional electrode placement recommendations, refer to relevant literature, Cochlear Implant manufacturer documentation, or your institution's guidelines.

Contralateral Electrode Placement

This is an optional single-channel setup. Ensure to turn off the ipsilateral implant for double-implanted patients.

- **Inverting (-) :** Contralateral Mastoid (M1 when the implant is on the right, M2 when the implant is on the left)
- **Non-Inverting (+) :** High Forehead (Fz) if using snap electrodes, or Vertex (Cz) if using cup electrodes.
- **Ground:** Low Forehead (Fpz) or Nasion.
- **Second Channel:** Shorted. Joined to ground using two Y-adapters connected in series.

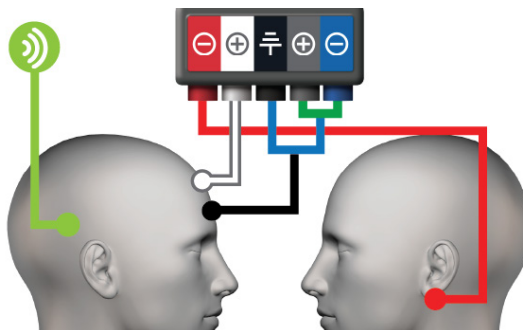


Fig.3 - eABR Contra setup, right implant, on Duet

Blanking in eABR

A blanking period is a period at the start of acquisition where the amplifier is momentarily disabled. This prevents the large electrical artifact from the CI stimulus from saturating the amplifier, which would otherwise render the data unusable.

While "No-Blanking" is the preferred method if the recording environment and stimulus artifact allow, it is not always possible. SmartEP enables blanking by default, but it can be toggled manually:

To Deactivate Blanking

1. Navigate to the DSPFiles folder in the software installation directory (typically C:\NHSPrgs).
2. Locate EABRDUET.OUT and rename it to EABRDUET_withBlanking.OUT. (Or delete if the file already exists).
3. Make a copy of EABRDUET_NoBlanking.OUT
4. Rename that copy to EABRDUET.OUT

To Restoring Blanking

1. Navigate to the DSPFiles folder in the software installation directory (typically C:\NHSPrgs).
2. Locate EABRDUET.OUT and rename it to EABRDUET_NoBlanking.OUT. (Or delete if the file already exists).
3. Make a copy of EABRDUET_withBlanking.OUT
4. Rename that copy to EABRDUET.OUT

Setting up the CIC

1. Configure Stimulation: Set up the CI computer stimulation options as required for the patient.
2. RF Blanking: If using the hardware blanking option, enable RF blanking in the CI software and set the value to 10,000.
3. Optimize Stimulus Parameters: For the best results, follow the CI manufacturer's recommendations. It is highly recommended to consult the literature (see Suggested Reading below) regarding the Interphase Gap (IPG).

Suggested Reading

Nada, N., Kolkaila, E., Schendzielorz, P. et al. Electrically evoked auditory brainstem response in cochlear implantation: what you need to know (short review). *Egypt J Otolaryngol* **38**, 67 (2022). <https://doi.org/10.1186/s43163-022-00259-1>

Setting up SmartEP

Follow these steps for setup:

1. Connect the trigger ports: Connect the trigger output port of the Cochlear Implant Computer (CIC) to the trigger input port of your hardware. Use the Digital port on the Duet or BNC Trigger-In for the USB Box.
2. Set up the electrode montage as previously specified or according to the CI manufacturer's recommendations. Then press **[CHECK IMPEDANCE]**. The CIC must not be presenting stimulation at this point or the impedance check may fail.
3. In the SmartEP main menu, go to **[PROTOCOL > MODALITY]**, then choose one of the Auditory eABR options (ECoch, ABR, MLR or LLR).
4. If using a blanking time, in the main menu, go to **[AMPLIFIER > AMPLIFIER BLANKING TIME]** and enter a time value that covers at least a little over the

- stimulus duration, in 25 μ s increments. It must be at least 25 μ s.
5. In the side panel, click **[AMPLIFIER]** to configure the channel settings.
 6. If using a dual-channel setup (Fig. 1): Set the gain, filters, notch filter, artifact rejection level and artifact rejection region for Channel A and Channel B. Turn Designation to ON for the Midline montage channel. If you would also like to record a contralateral recording, set the designation ON for the contralateral channel, otherwise set the contralateral channel to OFF and open the artifact rejection level to 100%.
 7. If using a single-channel setup (Fig. 2 or Fig. 3): Set Channel A designation as ON, then set the gain, filters, notch filter, artifact rejection level and artifact rejection region for channel A. Set channel B designation as OFF, and open the artifact rejection level to 100%.
 8. Click **[OK]** to close the Amplifier window
 9. Double click to enter the number of **[SWEEPS]** to be acquired in the SmartEP control panel.
 10. Ensure stimulus settings match the CIC:
Although this does not affect acquisition, it is recommended to set Intensity, Rate, Polarity, and Stimulus to match the values specified in the CIC. This will make it easier to identify recordings after acquisition. In addition, the selected stimulus will output through the selected stimulator for audible feedback.
 11. Press the **[ACQUIRE]** button to start. The SmartEP system will wait for the triggers from the CIC to start acquisition.

Note that IHS devices require 5-volt TTL signals with a pulse width between 100 microseconds and 2 milliseconds.

Recommended Test Settings

This table shows the recommended settings for eABR acquisition (ABR Mode). Some of the recommended settings may vary according to the specifications of the Implant manufacturer, please consult the appropriate literature. For best record keeping practices, some of the settings need to be copied from the Cochlear Implant Computer (CIC).

- **Stimulus Parameters (Type, rate, polarity, intensity):** Match those specified on the CIC.
- **Gain:** 100K. Reduce if the amplifier is saturating.
- **High Pass Filter:** 10 Hz. Note that when using the blanking option, the filter is forced to 0.1 Hz internally, regardless of what is chosen in the drop-down.
- **Low Pass Filter:** 5000 Hz. May need to adjust to 3000 Hz based on noise conditions.
- **Notch Filter:** OFF. When using the no-blanking option, the notch filter may be turned ON based on noise conditions. When using the blanking

option the line filter is forced to OFF, regardless of the status of the checkbox in the Amplifier window.

- **Rejection Region:** Must be adjusted to start after the stimulus artifact region.
- **Rejection %:** About 45%.
- **Sweeps:** 2048 (1024 for large responses).
- **Recommended Analysis Time Window:** 2 ms to 12.8 ms. Modify the start time using the options on the **[SET PAGE]** menu to just after the end of the stimulus artifact region.
- **Scale:** Normalized Page

Analysis

The following shows a section of a Cochlear Implant eABR recording set acquired using the described techniques. This was acquired using a blanking region of one millisecond.

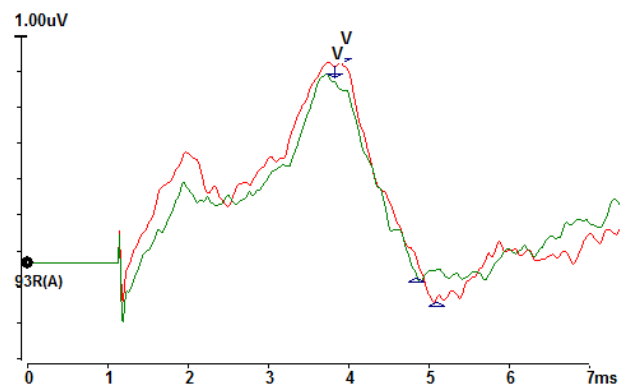


Fig.4 - Sample eABR recording

To accurately assess the results, you should first place the applicable labels on the acquired recording. Peaks I to VII may be marked when recognizable, for eABR usually peaks II, III and V are typically used. Follow these steps for each label:

1. Right click at the point of the recording where the label is to be placed.
2. Select the peak label to be marked.
3. Once placed, drag the top marker of the labels to the top of the peak. You may also use the Left/Right arrow keys on your keyboard to move the selected peak.
4. Drag the bottom marker to the valley following the peak. You may also hold down the **[ALT]** key and then use the Left/Right arrow keys on your keyboard to move the bottom marker.

Since label placement is subjective, all results must be evaluated by an audiologist or other medical professional trained in Cochlear Implant eABR techniques.

Select **[PRINT PAGES]** or **[PRINT PAGE]** from the SmartEP main Menu to print a report of the currently displayed signals. You may also save to report to an electronic file using the PDF report generation options in the Print menu. See the Duet Instructions for Use manual for other report generation options.