

CROS L Verification Guide.

Introduction

Most clients present with bilateral, aidable hearing loss. However, some people have hearing loss in only one ear, known as unilateral hearing loss (UHL). People with UHL may experience challenges communicating in noise, at a distance, in quiet and when localizing sounds (Lieu et al., 2013; Snapp et al., 2017; McKay et al., 2008). Contralateral routing of signal (CROS) supports clients with unaidable UHL, where one ear has normal hearing, and the other has an unaidable hearing loss. A CROS transmitter is worn on the unaidable ear to pick up signals and wirelessly transmits them to a hearing aid (HA), which is worn on the ear with normal hearing.

Alongside UHL where the affected ear is unaidable, some people may also develop hearing loss in the other ear, resulting in an asymmetric hearing loss. Bilateral microphones for Contralateral Routing of Signal (BiCROS) is ideal for clients with unaidable UHL who also have a hearing loss in their better hearing ear. A microphone is worn behind both ears. Again, the signal from the unaidable ear is transferred from one ear to the other. However, this signal, as well as sound originating from the aidable side, is then amplified according to the gain requirement for the hearing loss in the better ear.

Benefits of CROS and BiCROS

A comprehensive literature review of the benefits and limitations of CROS and BiCROS systems completed in March 2021 (Stewart & Woodward, 2021), examined published literature from the last 10 years and found:

1. improved speech intelligibility in noise when speech is presented to the unaidable ear.
2. improved speech intelligibility in diffuse noise.
3. improved subjective quality of hearing, such as ease of communication and sound quality.

The role of verifying CROS fittings using probe microphone measures

While the benefits of binaural amplification for clients with aidable hearing loss in both ears are often immediately evident, they may initially be more subtle for those with unaidable UHL. Mueller & Hawkins (1992) reported that such clients sometimes find it challenging to reliably report whether their CROS system is operational.

Thus, probe microphone measures present an ideal, objective way for verifying that a CROS/BiCROS system is functioning well and overcoming the head shadow effect (Pumford, 2005). Further support for utilizing probe microphone measures comes from MarkeTrak findings for conventional hearing aid fittings, showing those clients receiving best fitting practice experience greater reduction in hearing handicap compared to those that don't (Kochkin, 2011a), and that clients receiving both verification and validation measures required on average 1.2 less visits compared to those that did not (Kochkin, 2011b).

Accordingly, the goal of this paper is to provide an easy, step-by-step guide for performing probe microphone measures to verify CROS/BiCROS fittings in clinic.

Verification of CROS fittings

To illustrate the method for verifying CROS fittings using probe microphone measures, consider this case of John, a 16-year-old young man who has an unaidable sensorineural hearing loss with poor speech discrimination in his right ear that occurred several years ago. The left ear has normal hearing (Fig 1).

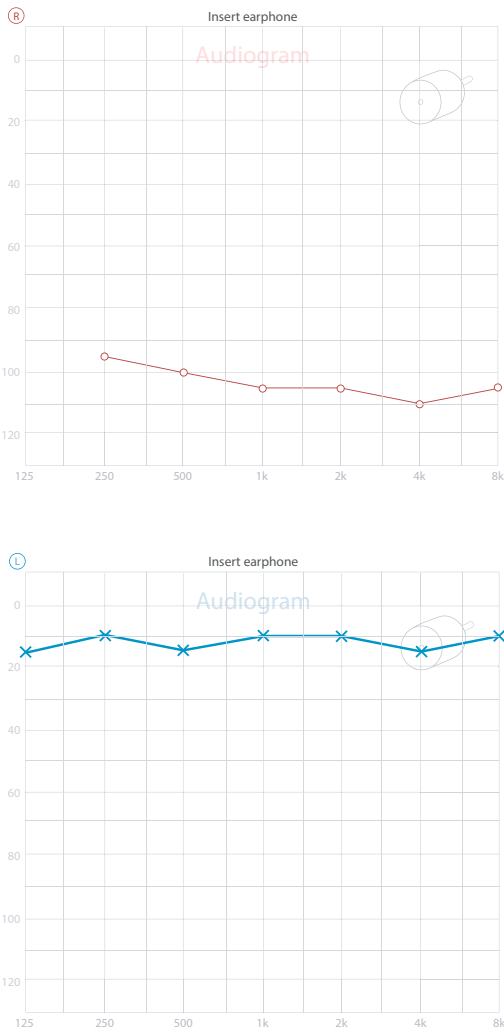


Fig 1: Pure tone audiogram showing profound hearing loss on the right and normal hearing on the left.

He persevered with this UHL during his final years at school, however since starting university, has found it very difficult to hear fellow students on his right side during lectures/ tutorials. He also drives an Uber part time for income and has difficulty hearing passengers in the front seat (left-hand drive country). His clinician decided to fit him with a Phonak Audéo™ L90-R and open dome on the left and a CROS L-R on the right. In order to get the best out of the CROS system and to obtain some objective measures to support John's subjective feedback, John's clinician carried out verification for the CROS fitting. Below are the steps used to set up and verify the fitting using a speech mapping method.

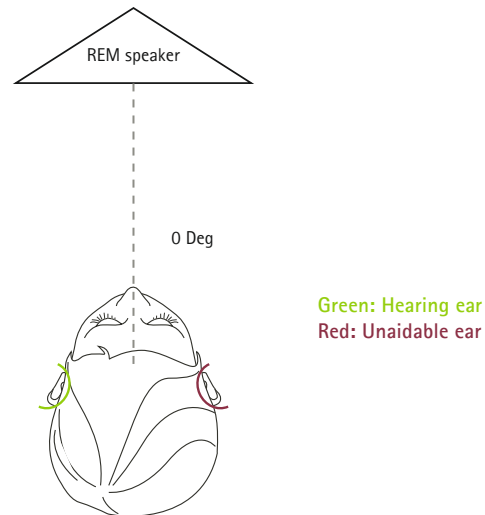
CROS system setup within Phonak Target

1. Connect Audéo L and CROS L to Phonak Target 9.0 or later
2. Audéo L and CROS L should remain in the startup program (Calm Situation)
3. Don't use Verification Assistant as this disables the CROS stream

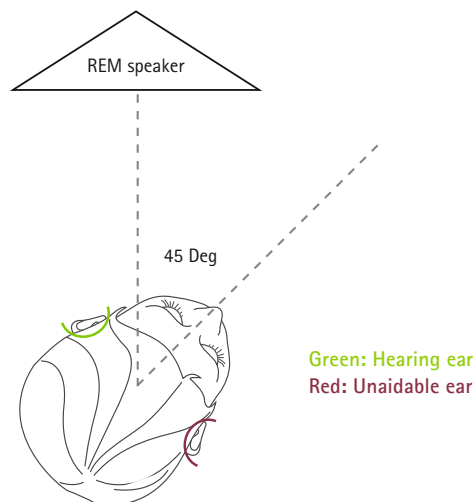
Step 1: Probe microphone setup. This guide assumes the REM system does not enable switching reference microphones between ears while measuring the output in one ear. Please place the real ear reference and probe tube microphone complex behind the better ear (this is the only ear the hearing aid output will be measured from).

Step 2: Select <RIC> in the REM system instrument menu. Note, there is no need to enter pure tone thresholds as hearing aid gain/output is not being matched to prescription targets as the hearing sensitivity is normal.

Step 3: Place the Audéo L and CROS L on the normal and unaidable ear, respectively. Leave the devices muted. Perform the open REM calibration once with the client facing the REM speaker (at 0 degrees azimuth).



Step 4: Orient the hearing ear between a 45 and 90 degree angle facing the REM speaker.



Unmute the hearing aid and keep the CROS muted. Measure REAR 1 with an ISTS (speech) signal at 65 dB (Fig 2).

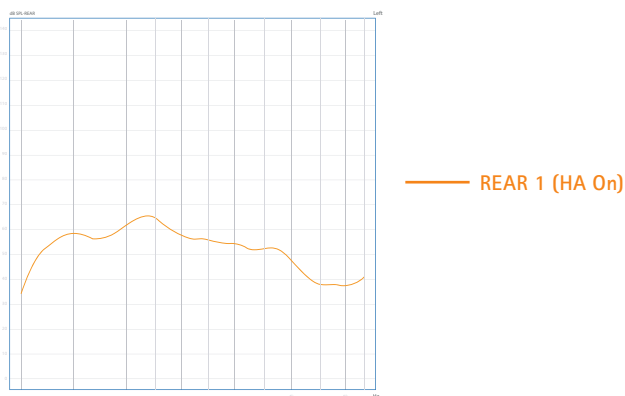
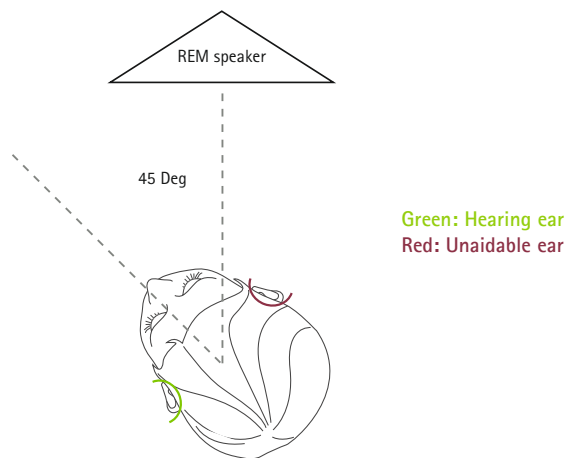


Fig 2: REAR 1 curve with hearing aid on and the CROS muted (ISTS 65 dB).

Step 5: Unmute the CROS and change the orientation of the client such that the unaidable ear is now oriented between a 45 and 90 degree angle facing the REM speaker. The head orientation for each side should be approximately equal to ensure there is no significant difference in stimulus levels reaching the hearing aid and CROS microphones during measurement.



Measure REAR 2 with an ISTS (speech) signal at 65 dB. The curve should be similar to REAR 1 (Fig 3).

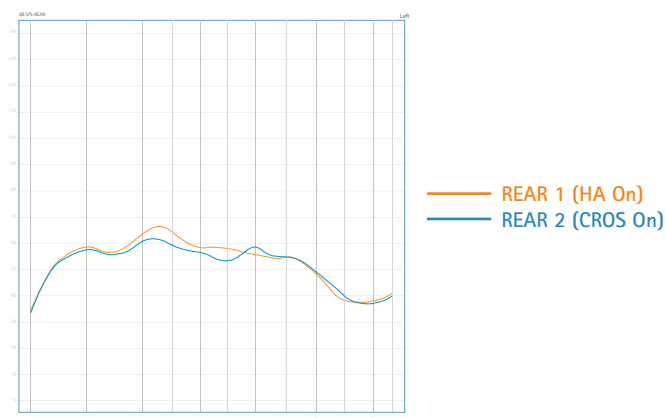


Fig 3: REAR 2 verification measurement curve with client's unaidable ear between 45 and 90 degrees facing the stimulus with both the hearing aid and CROS on (ISTS 65 dB).

Step 6: To demonstrate the head shadow effect, keep the unaidable ear facing towards the REM speaker and mute the CROS microphone. Run REAR 3 at the same stimulus level

(65 dB). The difference between the orange and green curves demonstrate the head shadow effect (Fig 4).

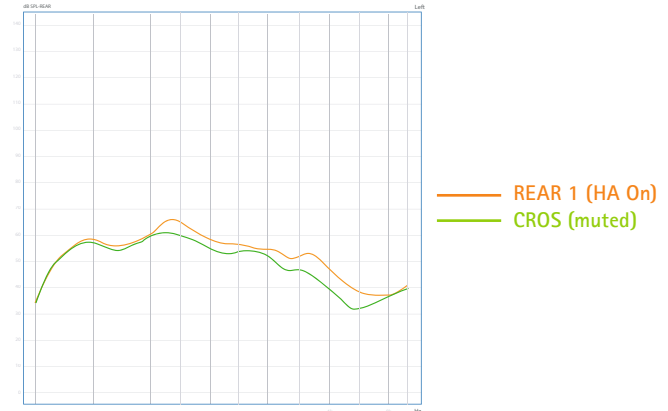


Fig 4: REAR 3 curve (ISTS 65 dB) with the hearing aid on and CROS muted, demonstrating the head shadow effect.

Additional fine tuning tips

If the output, when the stimulus is presented to the CROS transmitter, is substantially lower than the REAR 1, try adjusting CROS Balance (Fig 5) or increasing the gain at relevant frequencies (Fig 6). It's important to note that it is the gain settings that dictate the absolute output level in the better hearing ear, whereas the CROS Balance adjusts the relative contribution of the CROS and hearing aid microphones to that output. Large adjustments should not be required.

It is also recommended to carry out a subjective check on loudness balance across ears using a soft, high frequency sound (e.g. live voiced /s/). The reason to use a soft, high frequency stimulus is because the head shadow effect predominantly affects frequencies >1500 Hz (Pickles, 1988).

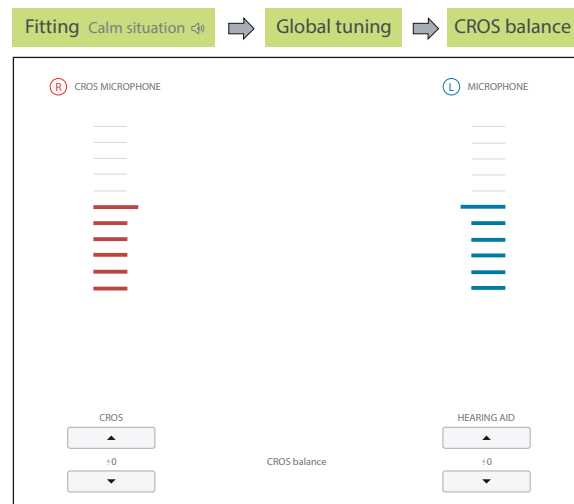


Fig 5: CROS Balance

Fine tuning Gain & MPO

MPO	75	90	98	101	102	106	108	105	99	89
ALL	250	500	750	1k	1,5k	2k	3k	4k	6k	8k
G80	1	1	3	8	13	18	22	20	14	5
G65	1	3	8	13	17	24	29	27	22	13
G50	1	2	11	16	21	29	35	33	28	20
CR	1	1	1,3	1	1,4	1,5	1,7	1,8	1,9	2,1

Fig 6: Gain adjustment

Verification of BiCROS fittings

To illustrate the method for verifying BiCROS fittings, consider this case of a 52-year-old woman, Maria, who had longstanding mild-moderate hearing loss bilaterally. Unfortunately, she sustained a sudden drop in hearing on the right to an unaidable level during a viral infection (Fig. 7). Therefore, a BiCROS fitting was recommended using an Audéo L90-R on the left with a vented dome and a CROS L-R on the right.

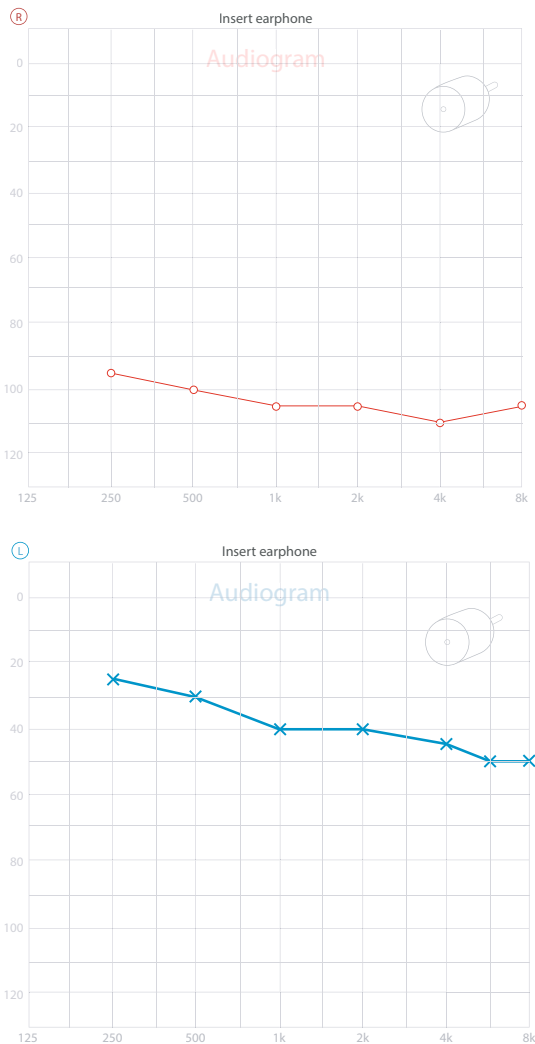


Fig 7: Pure tone audiogram showing an unaidable profound hearing loss on the right and mild-moderate hearing loss on the left.

For BiCROS fittings, the only difference compared to the approach for verifying a CROS fitting is to firstly fine-tune the hearing aid output according to the prescription targets and sound preference to account for the hearing loss in the better hearing ear (Figure 8).

Following this, the procedure is identical to verifying the CROS system. If the output is lower when the stimulus is presented to the CROS transmitter, try adjusting the CROS Balance tool to balance and match the curves (Fig 5). Avoid adjusting the hearing aid gain (Fig 6) for balancing as this will take the output in the aidable ear away from target/preferred settings.

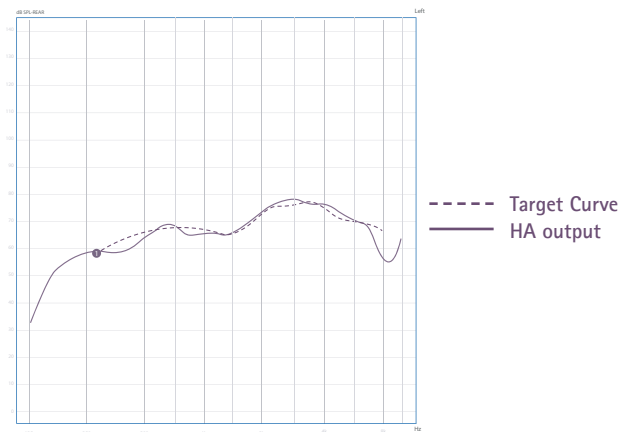


Fig 8: Program and verify the monaural hearing aid fitting on the aidable ear as per standard practice. CROS L should be muted.

Summary and Conclusions

Recent studies with the latest wireless CROS/BiCROS technologies have shown significant benefits for people with unaidable UHL and asymmetric hearing loss, where one ear has an aidable hearing loss and the other is unaidable. Probe microphone measures provide an easy, objective and reliable way to verify CROS and BiCROS fittings and help clients get the most out of their CROS L system.

References

- Kochkin, S. (2011a). MarkeTrak VIII: Patients report improved quality of life with hearing aid usage. *Hearing Journal*, Vol. 64 (6): p. 25-32.
- Kochkin, S. (2011b) MarkeTrak VIII: Reducing patient visits through verification and validation. *Hearing Review*, Vol. 18 (6):10-12.
- Lieu, J.E., Karzon, R. K., Ead, B., & Tye-Murray, N. (2013). Do audiologic characteristics predict outcomes in children with unilateral hearing loss? *Otol neuotol*, 34 (9), 1703-1710.
- McKay, S., Gravel, J. S., & Tharpe, A. M. (2008). Amplification considerations for children with minimal or mild bilateral hearing loss and unilateral hearing loss. *Trends in Amplification*, 12 (1), 43-54.
- Mueller, H.G. & Hawkins, D. B. (1992). Assessment of fitting arrangements, special circuitry, and features. In Mueller H.G., Hawkins D.B., & Northern J.L. *Probe Microphone Measurements: Hearing Aid Selection and Assessment*. San Diego: Singular, p: 201-225.
- Pickles, J. O. (1988). *Introduction to the physiology of hearing* (2nd edition). Academic Press.
- Pumford, J. (2005). Benefits of probe-mic measures with CROS/Bi-CROS fittings. *The Hearing Journal*. 58 (10): p.34-40.
- Snapp, H. A., Holt, F. D., Liu, X., & Rajguru, S. M. (2017). Comparison of Speech-in-Noise and Localization Benefits in Unilateral Hearing Loss Subjects Using Contralateral Routing of Signal Hearing Aids or Bone-Anchored Implants. *Oto Neurotol*, 38 (1), 11-18.
- Stewart, E. & Woodward, J. (2021). Out of the (Head) Shadow: A Systematic Review of CROS/BiCROS Literature. *Hearing Review*; 28 (8): 22-25.

A special thanks to David Crowhen, Director Phonak & Operations, New Zealand for his expertise in writing this CROS L Verification Guide.