

# ELECTROACOUSTIC EVALUATION OF THE RESOUND MULTI MIC WITH OTOMETRICS AURICAL HIT

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## Abstract

With ReSound's 2.4 GHz wireless technology and the ReSound Wireless Multi Mic wireless accessory, clinicians are presented with a great option to meet patients' assistive listening needs. The ReSound Multi Mic provides the signal-to-noise ratio (SNR) advantages of traditional FM systems without the need for additional hardware worn at ear level, as the receiver is integrated in the hearing instrument. The integrated receiver also negates the need for separate programming outside of the hearing instrument fitting software. Verification of the assistive technology is possible through Otometrics AURICAL HIT (hearing instrument test chamber), which includes a special test designed for this purpose. This paper describes the protocol for measuring transparency, SNR advantage and maximum output of the ReSound Multi Mic using AURICAL HIT.

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Improving the signal-to-noise ratio (SNR) of a speaker's voice is the primary goal for hearing assistive technology (HAT) using a remote microphone (American Academy of Audiology (AAA), 2011). This technology, which includes FM systems, is widely used by the adult and pediatric populations, to overcome obstacles to speech audibility and intelligibility, including background noise, distance and reverberation. With any of these systems, the signal is transmitted by a device positioned close to the speaker's mouth to the hearing aids, via a dedicated receiver or through a receiver integrated in the hearing instrument. In typical use, the wireless (remote) and local (hearing instrument) microphones are active simultaneously. This allows for increased SNR benefits as well as audibility for the hearing instrument user's own speech and other environmental sounds.

To ensure proper functional status of this assistive technology, verification guidelines have been published (American Speech-Language and Hearing Association (ASHA), 2002; AAA, 2011). The verification process is especially important when fitting hearing assistive technology for pediatric patients, as children may not be able to give any subjective feedback regarding the performance and SNR benefits provided by the wireless system.

These verification procedures were initially developed for FM systems. However, they can also be applied for hearing instruments with integrated wireless 2.4 GHz technology

(Mulla & Archbold, 2012). With this technology, the hearing instruments themselves act as the FM receivers. Adjustments made within the fitting software and using the volume control on the ReSound Multi Mic itself allows for fine tuning of the response for optimal benefit.

The ASHA guidelines recommend monitoring performance through a variety of measures at least once a year for adults and children older than 5 years of age, and every 3-6 months for children younger than 5 years (2002). To realistically verify the benefit of this assistive wireless technology, responses from the hearing instrument (HI) are compared with responses from the hearing instrument and hearing assistive technology together (HI+HAT).

Two aspects of performance are important to verify electroacoustically: transparency and SNR advantage. The transparency measurement evaluates if the local and wireless microphones provide equal outputs from the hearing instrument when presented with the same 65 dB SPL input stimulus. A calibrated speech signal such as the International Speech Test Signal (ISTS) is recommended. The AAA guidelines state that the transparency must be within an average of +/- 2 dB for .75, 1 and 2 kHz (2011).

Once transparency has been verified, SNR advantage can be measured. The SNR advantage is the increase in the signal level by the wireless technology, as compared to the level provided by the hearing instrument alone. It is calcu-

lated by subtracting the output of the HI from output of the HI+HAT. SNR advantage is used to fine tune the wireless system so that an input of 80 dB SPL to the wireless microphone at a distance of 15-20 cm provides a 10 dB higher output than a 65 dB SPL input at a distance of 1 to 2 m to the hearing instrument microphone (AAA, 2011).

Furthermore, Schafer et al. (2007) recommend an additional measurement to confirm similar maximum output (OSPL 90) between the HI and the HI+HAT. This measure ensures the hearing instrument user's uncomfortable loudness levels are not exceeded and that the dynamic range is not adversely affected by the compression characteristics of the HI and wireless accessory.

Although FM systems provide increased SNR benefit to the patient, they have drawbacks outside of their financial cost. With FM systems, an ear-level or body-worn receiver is necessary for routing the signal to the patient's hearing instruments. For children especially, this can create problems due to increased size of the hearing aid with the ear-level receiver. In addition, FM system transmissions are susceptible to privacy concerns.

#### RESOUND MULTI MIC

The Multi Mic is a small personal portable streaming device for transmitting sound sources directly to the users hearing instruments (Figure 1). It can be affixed to the speaker's clothing in the same manner as an FM transmitter, to pick up the signal where it is strongest and clearest. The signal is then transmitted directly to the hearing instruments via ReSound's proprietary 2.4 GHz digital wireless technology, without the need for an ear-level receiver.

The ReSound Wireless Multi Mic offer microphone pick up both when worn vertically on the body as well as when placed horizontally on e.g. a table.



Figure 1. The ReSound Multi Mic wireless accessory.

It also offers extended audio source connectivity options by being able to receive telecoil signals, FM signals (optional FM receiver needed) and connecting to auxiliary audio sources through the built-in mini-jack line input and transmitting the sound from received sound directly to the hearing instruments Wright N. (2016).

The Multi Mic features an on/off switch, a volume control and a mute button for the microphone input. It is easily paired to the hearing instruments via the ReSound Aventa 3 fitting software, or manually outside the fitting software. The status of the device, including if the battery is running low, is indicated by the multi color LED on top of the device, making monitoring of its functionality easier for parents, teachers and caregivers. In addition, an unlimited number of hearing aid users can be connected to one Multi Mic, making it especially applicable for classroom setting.

The ReSound Wireless Multi Mic can be used in any situation where a SNR improvement is desired, and provides 25 meter of wireless connection in clear line of sight between the speaker and the hearing instrument user. The hearing instrument user can receive the streamed sound alone or in combination with the hearing instrument microphone input.

As with FM systems, electroacoustic verification of the ReSound Multi Mic is optimal to ensure proper functionality and SNR benefit. This can be accomplished through test box equipment such as the Otometrics AURICAL HIT.

#### AURICAL HIT

AURICAL HIT is a test chamber that facilitates measurement of hearing instruments and wireless accessories. The OnePosition Method alleviates positioning issues and improves accuracy and quality of results. The integrated coupler and microphone are connected in a designated slot that ensures a correct height of the hearing instrument for any style of instrument and for any measurement. A gooseneck reference microphone allows for easy, secure positioning.

AURICAL HIT's external accessory module acts as an extension of the test chamber, allowing for external coupler measurements. The position of the coupler with the hear-

ing instrument and Multi Mic can be easily exchanged to accommodate all steps of the verification process.

## A STEP-BY-STEP GUIDE TO OBTAINING RESOUND MULTI MIC MEASUREMENTS WITH AURICAL HIT

The following is a detailed guide to measuring transparency, SNR advantage and max output of the Multi Mic. To begin, assemble the following:

- AURICAL HIT
- ReSound Multi Mic
- ReSound wireless hearing instrument paired with the Multi Mic
- Coupler assembly (adapter, coupler cavity and coupler microphone), placed in external accessory module
- Coupler cable between the external accessory module and AURICAL HIT
- Insulating pad under external accessory module (optional)

### Step 1: Reference measurements

- Measure the hearing instrument output in omnidirectional mode with a 65 dB SPL ISTS input.
- Attach the hearing instrument to the coupler in AURICAL HIT.
- Position the reference microphone as close to the hearing instrument microphone as possible, without touching the front microphone of the hearing instrument (Figure 2).
- In the OTOSuite software Test Selector menu, choose the special test “FM Reference Sequence - HI in AURICAL HIT” on the PMM tab. This launches the Free-Style test screen.



Figure 2. Positioning of the hearing instrument and reference microphone in AURICAL HIT.

- Close the cover of AURICAL HIT and click the “Sequence” button in the Control Panel to measure curves 1 and 3. These curves will be identical because measurement settings are unchanged within the sequence (Figure 3).

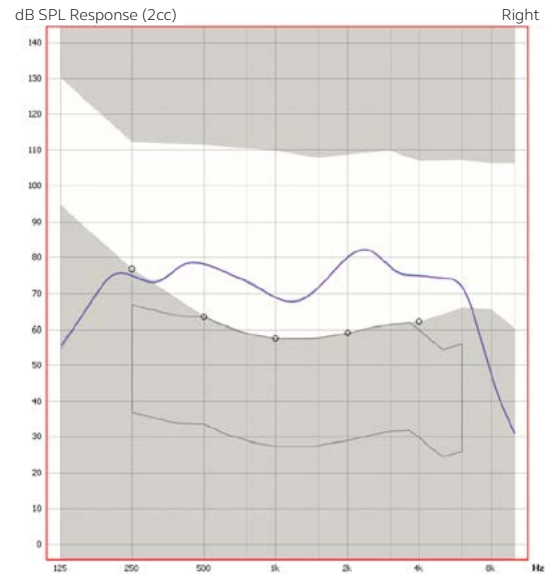


Figure 3. Output of the hearing instrument for a 65 dB SPL ISTS signal reference curves). The two identical curves appear as a single purple curve.

### Step 2: Transparency and SNR advantage measurements

- Before placing the Multi Mic in AURICAL HIT make sure that the Multi Mic is put in test mode.
- To enter test mode:
  - Make sure the Multi Mic is turned OFF
  - Press and hold the Mute button and the Power button for 1.5 sec until the status LED turns green and then release the Power button.
  - Keep pressing Mute until the green-orange-red sequence is shown on status LED after 10 seconds.
  - When in Test mode the Status LED will be solid orange.
  - When entering Test mode the default volume is applied. If needed volume can be adjusted on the Multi Mic until transparency has been verified.
- Raise the elevation plate in AURICAL HIT and position the ReSound Multi Mic on the elevation plate.
- Place the reference microphone over the microphone inlet of the Multi Mic (Figure 4).
- Connect the coupler cable from the external accessory module to AURICAL HIT.



Figure 4. Positioning of the Multi Mic in AURICAL HIT.

- Place the hearing instrument and coupler setup in the first coupler hole of the external accessory module (Figure 5). The external accessory module may be placed on an insulating pad to prevent any deleterious effects of noise and vibration.
- In the OTOSuite Test Selector menu, select the special test “FM Transparency & Advantage Sequence - HI outside AURICAL HIT” on the PMM tab.
- Close the cover of HIT and click the “Sequence” button in the Control Panel to measure curves 2 and 4. An ISTS input is presented to the Multi Mic at 65 dB SPL for the transparency measurement, and the result is shown by the orange curve. For the SNR Advantage measurement, an 80 dB SPL ISTS input is presented, and the result is displayed in HIT by the green curve (Figure 6).



Figure 5. Positioning of the hearing instrument outside AURICAL HIT in the external accessory module. The Multi Mic is positioned on the elevation plate in AURICAL HIT.

By viewing the FreeStyle tabular data (Table 1, curves 1 and 2), transparency results can be verified for acceptability. In this example, the results show differences between the Multi Mic and the HI output of 2 dB for .75 KHz, 1 dB for 1 KHz and 0 dB for 2 KHz, with a resulting average difference (for all input frequencies) of 0 dB. In this example, the Multi Mic performance falls within the AAA tolerances (+/-2 dB) for acceptable transparency.

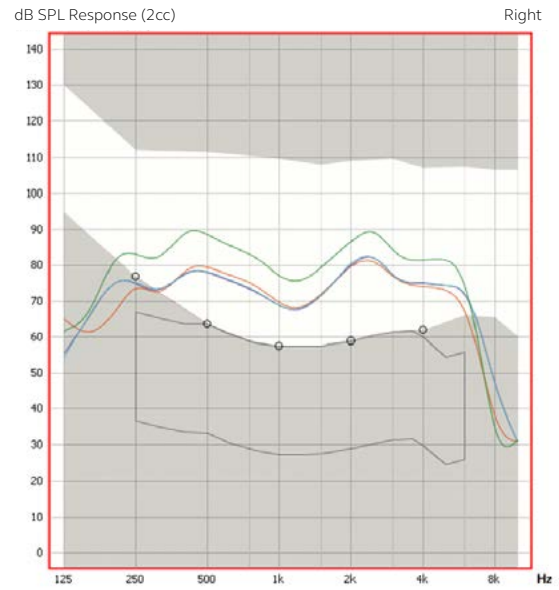


Figure 6. Output of the hearing instrument in streaming mode. The hearing instrument is placed outside AURICAL HIT. The orange curve represents the transparency measure and the green curve indicates the SNR advantage. The purple curve is the output of the hearing instrument for a 65 dB ISTS signal (the reference curves).

The tabular data for the SNR advantage sequence (Table 1, curves 3 and 4) shows differences of 9 dB at .75 KHz, 8 dB at 1 KHz and 7 dB at 2 KHz. According to Shafer et al (2007), a 3 dB tolerance of the 10 dB target result is acceptable for FM advantage measures in most cases; in this example, the SNR advantage is verified.

#### MODIFICATIONS:

##### MAXIMUM POWER OUTPUT MEASUREMENTS

AURICAL HIT can also be used to measure maximum output levels between the HI alone and the HI + Multi Mic system.

FreeStyle Table Right (* 2cc Measurement)										
Right	250	500	750	1k	1.5k	2k	3k	4k	6k	RMS
Curve 1*	75	78	73	69	72	80	78	75	71	88
Curve 2*	74	79	75	70	73	80	77	74	66	88
F2B 1	2	-1	-1	-1	0	0	0	1	5	
Curve 3*	75	78	74	69	72	80	78	75	71	88
Curve 4*	83	89	83	77	80	87	84	81	72	96
F2B 2	9	5	4	5	4	6	6	7	12	
Curve 5*	96	97	94	89	92	99	96	89	84	
Curve 6*	95	97	94	90	92	99	96	89	85	
F2B 3										
HTL (SPL)	77	64		58		59		62		
UCL (SPL)										

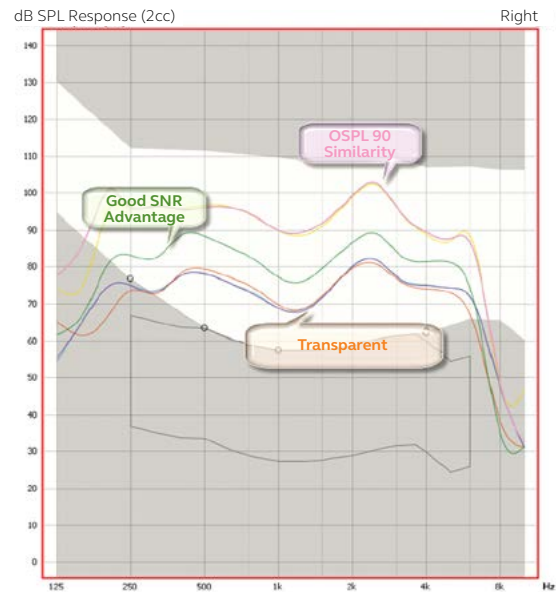
**Table 1.** Tabular data for all measurements. Differences between values for curves 1 and 2 illustrate transparency. Differences between curves 3 and 4 demonstrate SNR advantage. Differences between curves 5 and 6 indicate similarity of maximum output for the HI alone and the HI + Multi Mic.

- Modify the “FM Reference Sequence” to include measurement curve 5, and the “Transparency & Advantage Sequence” to include measurement curve 6.
- Set the stimulus to a 90 dB Maximum Power Output (MPO).
- Results of this max output (OSPL 90) test are shown in Figure 7 as the pink and yellow curves.

The tabular data (Table 1, curves 5 and 6) shows differences of 0 dB at .75 KHz, 1 dB at 1 KHz and 0 dB at 2 KHz. This confirms the maximum output is similar for the HI alone and the HI with the Multi Mic. In addition, this measurement helps to ensure the listener’s uncomfortable loudness levels (designated as the upper gray area of Figure 7) are not exceeded with high input levels. Furthermore, this indicates that the presence of the Multi Mic is unlikely to adversely affect the dynamic range of speech cues.

After completion of all tests exit test mode on the Multi Mic. To exit test mode turn off the Multi Mic and lock the volume control.

The volume level can be locked for Microphone and FM mode only. When the volume control is locked, it will be fixed to the level it had when the Multi Mic was powered OFF.



**Figure 7.** Output of the hearing instrument, showing the transparency, SNR advantage, and OSPL 90 curves

To lock the volume control on the Multi Mic:  
Make sure the Multi Mic is turned OFF

- Press and hold the volume ‘-’ and the Power ON button for 1.5 seconds until the status LED turns green (Multi Mic powering up) and release the Power button
- Keep pressing the volume ‘-’ button until a green-orange-red LED sequence is shown on the status LED after 10 sec

The status LED will now blink twice every 2 seconds to indicate that the volume control is locked.

## CONCLUSIONS AND DISCUSSION

As demonstrated with AURICAL HIT, it is possible to utilize existing verification procedures for FM systems to quickly verify performance of hearing instruments with integrated wireless 2.4GHz technology such as the ReSound Wireless Multi Mic. In the above examples, acceptable transparency, SNR advantage and max output measures were achieved without the need for further adjustments.

In the case that the desired transparency is not initially acceptable, adjustment of the microphone volume on the Multi Mic will serve as an easy way of fine tuning to achieve

transparency. The Multi Mic volume control also provides the ability to accomplish a favorable SNR advantage. If an acceptable SNR advantage is not achieved by simply adjusting the volume control on the Multi Mic, adjustments can be made to the gain or MPO settings of the Multi Mic and/or the hearing instrument within the Aventa 3 fitting software. If similarity is not observed for the OSPL 90 measurements, adjustments can also be made to MPO settings and compression characteristics in the fitting software.

Locking the volume control on the Multi Mic after any adjustments to achieve transparency or SNR advantage is easily done to ensure that the parent, caregiver, teacher nor the child accidentally adjust the output level of the Multi Mic.

The electroacoustic verification of transparency, SNR advantage, and maximum output similarity is important, but does not fully verify nor validate the fitting (ASHA, 2002; AAA, 2011). Behavioral procedures including sound field aided speech recognition should be done to further verify the wireless accessory fitting. Validation tools such as self-assessment questionnaires, observation surveys and evaluations such as the Ling Six Sound Test can assess the additional benefit the patient receives from wireless hearing assistive technology such as the ReSound Multi Mic.

## REFERENCES

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### Manufacturer according to FDA:

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