



Improved Ear Simulators for Headphone Testing

IEC 60318-4 compliant/compatible ear simulators for testing of headphones, earphones and headsets up to 20/50 kHz

R&D / PL / QA / QC TESTING





High-Frequency Ear Simulators

RA0401 Externally Polarized

RA0402 Prepolarized



A Family of Future-Proof Ear Simulators

Two improved versions of the IEC 60318-4 ear simulator

Hi-Res audio has become a major market driver in wearable audio. Testing Hi-Res headphones and headsets confront the industry with new challenges: Test equipment must be able to handle high frequencies but at the same time present test objects with a realistic, human-like load – requirements that until now could not be met at the same time.

Our new improved 60318-4-based ear simulators change that. They combine realistic loading of the transducer up to 10 kHz with much improved high-frequency capabilities. The GRAS RA0401/02 uses a ½" microphone and can measure up to 20 kHz. The GRAS RA0403/04 uses a ¼" microphone and can measure up to 50 kHz and beyond.

Hi-Res Ear Simulators

RA0403 Externally Polarized

RA0404 Prepolarized



Evolution of the IEC 60318-4 Ear Simulator

For more than three decades, the IEC 60318-4 (formerly 711) ear simulator has been the recognized industry standard for testing audio transducers with a realistic simulation of the acoustical load presented by the human ear. However, its undamped resonance at 13.5 kHz makes it difficult to use for high-frequency testing. Therefore, GRAS has introduced two improved variants of the IEC 60318-4 ear simulator. They retain a firm footing in the standard but improve the ability to measure at high frequencies.

The Standard IEC 60318-4 Ear Simulator (GRAS RA0045)

The RA0045 has a steep half-wave resonance at 13.5 kHz which effectively limits its usefulness

to below at least 10 kHz. As the steep and undamped resonance is related to the length of the ear canal, any changes to this length will affect the resonance. The length can easily vary in practical measurements, and the resonance can, therefore, easily affect measurements. Also, the resonance will influence distortion measurements – even as low as at 3-5 kHz.

The High-Frequency Ear Simulator (GRAS RA0401/02)

The RA0401/02 has a damping system that attenuates the half-wave resonance at 13.5 kHz and thus extends the useful frequency range to 20 kHz. It uses the same ½” microphone as the original version and fully complies with

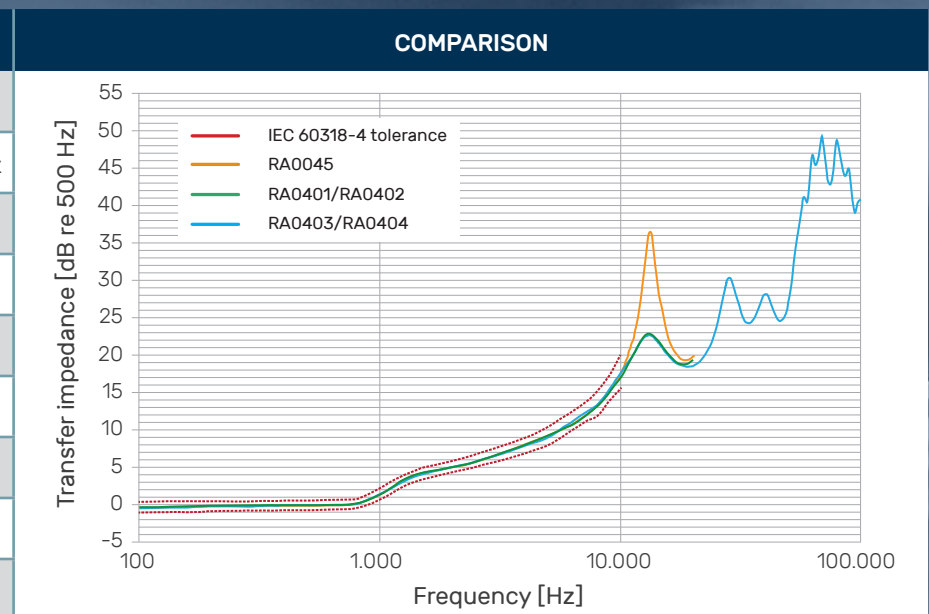
the standard. This is why we recommend it as the first choice when you are looking for a “standard” 60318-4 ear simulator – but without its shortcomings at high frequencies. We think of it as “**the new normal**”.

The Hi-Res Ear Simulator (GRAS RA0403/04)

The RA0403/04 also has a damping system that attenuates the length-related resonances above 10 kHz, but the use of a ¼” microphone extends the useful frequency range to 50 kHz and beyond. The 60318-4 standard calls for a ½” microphone – this is the only reason why the Hi-Res Ear Simulator is not standard compliant, but “only” standard compatible, as it fully complies with the standard in all other respects.

| | RA0045/-S1 | RA0401/02 | RA0403/04 |
|--------------------------------|-----------------|-----------------|-----------------|
| Microphone | 1/2" | 1/2" | 1/4" |
| Frequency range (Hz) | 100 Hz - 10 kHz | 100 Hz - 20 kHz | 100 Hz - 50 kHz |
| Sensitivity (mV/Pa) | 12.5 | 12.5 | 1.6 |
| Volume (mm³) | 1,260 | 1,260 | 1,260 |
| Dynamic range (dB)* | | | |
| Ext. polarized | 25 - 164 | 25 - 164 | 44 - 169 |
| Prepolarized | 25 - 153 | 25 - 153 | 44 - 166 |
| Resonance freq. (Hz) | 13.5 kHz | 13.5 kHz | 13.5 kHz |
| IEC 60318-4 | Yes | Yes | Compatible |

* Measured at Drum Reference Point



Explore the Benefits

Our new ear simulators build on industry standards - and improve upon them in important ways. They introduce major improvements: High-frequency capability and improved repeatability. When combined with our anthropometric pinna, improved collapsibility, fit and seal are added benefits.



The perfect companion...
... GRAS Anthropometric Pinna



- ✓ Drop-in replacement for 60318-4 ear simulator in any test setup
- ✓ Improved distortion measurements
- ✓ Improved repeatability
- ✓ Human-like load up to 10 kHz
- ✓ Extended and stable frequency response
- ✓ IEC 60318-4 compliant/compatible

High-Frequency Ear Simulator

- IEC 60318-4 compliant
- Built-in 1/2" microphone
- The 13.5 kHz resonance damped by approximately 14 dB
- From 100 Hz to 10 kHz: IEC 60318-4
From 10 kHz to 20 kHz within ± 2.2 dB
- Noise floor: 25 dB(A)



Hi-Res Ear Simulator

- IEC 60318-4 compatible
- Built-in 1/4" microphone
- The 13.5 kHz resonance damped by approximately 14 dB - resonance damping effective up to 50 kHz
- From 100 Hz to 10 kHz: IEC 60318-4
From 10 kHz to 20 kHz within ± 2.2 dB
From 20 kHz to 50 kHz within ± 3.2 dB
- Noise floor: 44 dB(A)



Choose the Right Test Solution

HIGH-FREQUENCY EAR SIMULATOR
RA0401/RA0402



HI-RES EAR SIMULATOR
RA0403/RA0404



HEAD AND TORSO SIMULATORS

45BB KEMAR Head and Torso



| | | |
|-----------------|----------------|---|
| 2-Ch. 🎧 👂 | 45BB-13 | KEMAR with High-Frequency Ear Simulator and Anthropometric Pinnae, 2-Ch. LEMO |
| | 45BB-14 | KEMAR with High-Frequency Ear Simulator and Anthropometric Pinnae, 2-Ch. CCP |

| | |
|----------------|---|
| 45BB-15 | KEMAR with Hi-Res Ear Simulator and Anthropometric Pinnae, 2-Ch. LEMO |
| 45BB-16 | KEMAR with Hi-Res Ear Simulator and Anthropometric Pinnae, 2-Ch. CCP |

45BC KEMAR Head and Torso with Mouth Simulator



| | | |
|----------------------|----------------|---|
| 2-Ch. 🎧 👂 👄 | 45BC-13 | KEMAR with High-Frequency Ear Simulator and Anthropometric Pinnae, 2-Ch. LEMO |
| | 45BC-14 | KEMAR with High-Frequency Ear Simulator and Anthropometric Pinnae, 2-Ch. CCP |

| | |
|----------------|---|
| 45BC-15 | KEMAR with Hi-Res Ear Simulator and Anthropometric Pinnae, 2-Ch. LEMO |
| 45BC-16 | KEMAR with Hi-Res Ear Simulator and Anthropometric Pinnae, 2-Ch. CCP |

R&D

- Multi-configurable
- Realistic simulation of head- and torso-related diffraction
- 3-D simulation model of HRTF
- Easily reconfigurable for other applications
- Ideal for R&D
- 45BC with mouth simulator for testing of headsets

VERSATILE TEST FIXTURE

45CA Headphone Test fixture



| | | |
|-----------------|----------------|---|
| 2-Ch. 🎧 👂 | 45CA-9 | With High-Frequency Ear Simulator and Anthropometric Pinnae, 2-Ch. LEMO |
| | 45CA-10 | With High-Frequency Simulator and Anthropometric Pinnae, 2-Ch. CCP |

| | |
|----------------|---|
| 45CA-11 | With Hi-Res Ear Simulator and Anthropometric Pinnae, 2-Ch. LEMO |
| 45CA-12 | With Hi-Res Ear Simulator and Anthropometric Pinnae, 2-Ch. CCP |

R&D / PL / QA / QC

- Very high self-insertion loss (>65 dB)
- Easy to use – precise, repeatable mounting of all types of headphones
- Equally suited for R&D, PL and QA testing

DESKTOP TEST SOLUTIONS

43AG Ear and Cheek Simulator



| | | |
|-----------------|---------------|--|
| 1-Ch. 🎧 👂 | 43AG-6 | With High-Frequency Ear Simulator and Anthropometric Pinna, 1-Ch. LEMO |
| | 43AG-7 | With High-Frequency Ear Simulator and Anthropometric Pinna, 1-Ch. CCP |

| | |
|---------------|--|
| 43AG-8 | With Hi-Res Ear Simulator and Anthropometric Pinna, 1-Ch. LEMO |
| 43AG-9 | With Hi-Res Ear Simulator and Anthropometric Pinna, 1-Ch. CCP |

R&D / QA / QC

- Easy-to-use 1-channel desktop test fixture
- Ear simulator integrated into test jig with mounting base and adjustable force clamp
- Ideal from R&D testing to final approval

43AC Ear Simulator Kit



| | | |
|------------|----------------|---|
| 1-Ch. 🎧 | 43AC-S4 | With High-Frequency Ear Simulator, 1-Ch. LEMO |
| | 43AC-S5 | With High-Frequency Ear Simulator, 1-Ch. CCP |

| | |
|----------------|---------------------------------------|
| 43AC-S6 | With Hi-Res Ear Simulator, 1-Ch. LEMO |
| 43AC-S7 | With Hi-Res Ear Simulator, 1-Ch. CCP |

R&D / PL / QA / QC

- Easy-to-use 1-channel desktop test fixture
- Ear simulator integrated into test jig with mounting base and adjustable force clamp

1-Ch. 2-Ch. Number of channels 🎧 Supra- and circumaural headphones 👂 Insert-type earphones 📞 Headsets

Specifications – The High-Frequency Ear Simulator

The GRAS RA0401/02 High-Frequency Ear Simulator is based on the standard IEC 60318-4 ear simulator, but extends the useful frequency range to 20 kHz. It is fully compliant with the specifications in IEC 60318-4.

The extended frequency range is obtained by using a resonance damping system, resulting in an extended frequency range and improved repeatability.

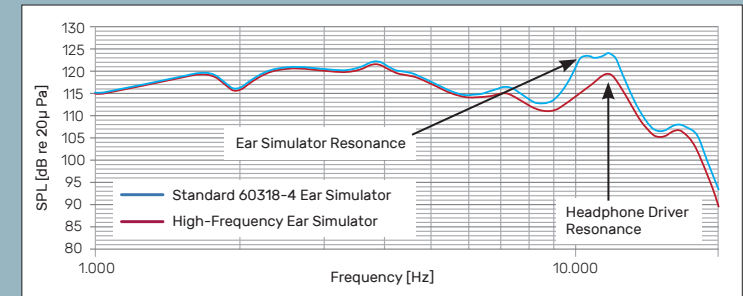
It is now possible to measure the performance of headphones up to 20 kHz. Total Harmonic Distortion (THD), frequency response and driver resonance-related phenomena can now be investigated, and an objective supplement to the "golden ear" approach is now available for concept validation, R&D and production testing – all based on a "human-like" test method.

In the standard ear simulator, the resonance of the headphone driver and the resonance of the ear simulator will often almost coincide (top right), and the driver resonance can easily be confused with the ear simulator resonance. This makes it difficult to interpret the measurement results.

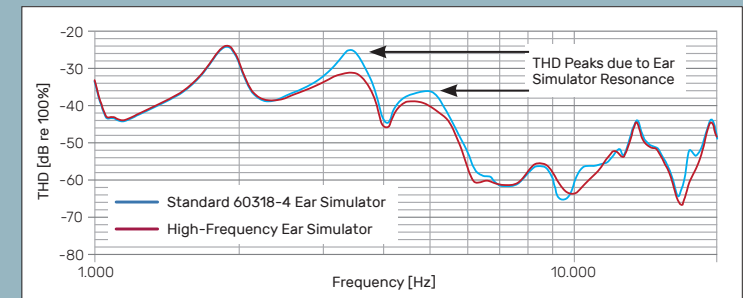
In the High-Frequency Ear Simulator, the length-related resonance is damped and the resulting frequency response is much clearer. It is now easier to distinguish the headphone driver resonance from the ear simulator resonance. As shown in the figure to the right, THD measurements are now less influenced by resonance-related peaks.

RA0401/02 is used in the preconfigured test solutions shown on page 5, but can also serve as a drop-in replacement for a standard IEC 60318-4 ear simulator.

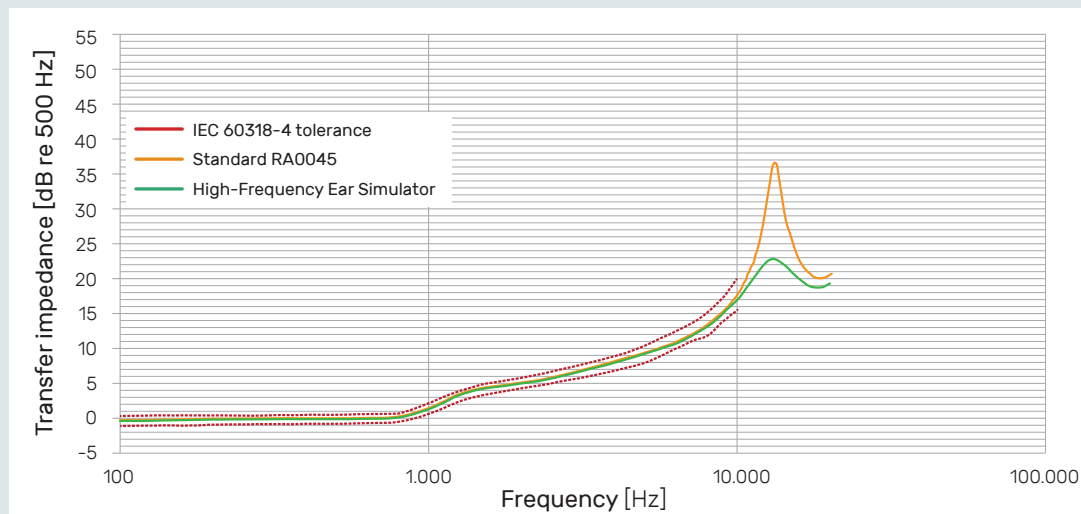
IEC 60318-4 ear simulator with and without damping



In-Ear headphone: Standard ear simulator vs High-Frequency Ear Simulator



THD measurements: Standard ear simulator vs High-Frequency Ear Simulator



The resonance is attenuated by 14 dB

RA0401 Externally Polarized and RA0402 Prepolarized

| | | |
|-----------------------------|-----------------|---|
| Dynamic range RA0401 (LEMO) | dB(A) - dB | 25 - 164* |
| Dynamic range RA0402 (CCP) | dB(A) - dB | 25 - 153* |
| Sensitivity | mV | 12.5 |
| Frequency range | Hz | 100 - 10 k (IEC 60318-4) 10 k - 20 k (± 2.2 dB) |
| Resonance frequency | kHz | 13,5 |
| Coupler volume | mm ³ | 1,260 @ 500 Hz |
| IEC 60318-4 | | Compliant |

* Measured at Drum Reference Point

Specifications – The Hi-Res Ear Simulator

The GRAS RA0403/04 Hi-Res Ear Simulator is based on the standard IEC 60318-4 ear simulator, but extends the useful frequency range to 50 kHz and beyond.

The extended frequency range is obtained by using a 1/4" microphone instead of a 1/2" microphone combined with a resonance damping system. This makes it possible to evaluate and compare headphones in a wide frequency range, and more realistic THD measurements are now possible.

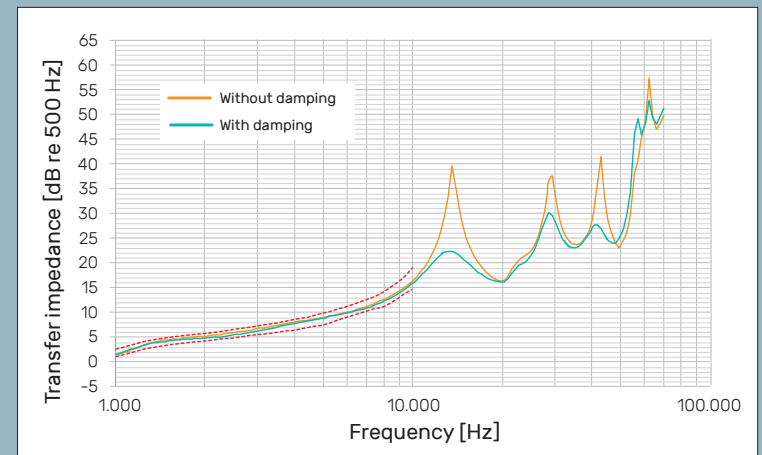
The resonance damping system is similar to that used in the RA0401/02, but the useful frequency range is extended to 50 kHz and beyond. Therefore, it meets the 40 kHz requirement of the JAS Hi-Res standard for high-performance headphones.

Up to 10 kHz the transfer impedance of the Hi-Res Ear Simulator complies with IEC 60318-4. Up to 20 kHz it is within ± 2.2 dB, and up to 50 kHz it is within ± 3.2 dB.

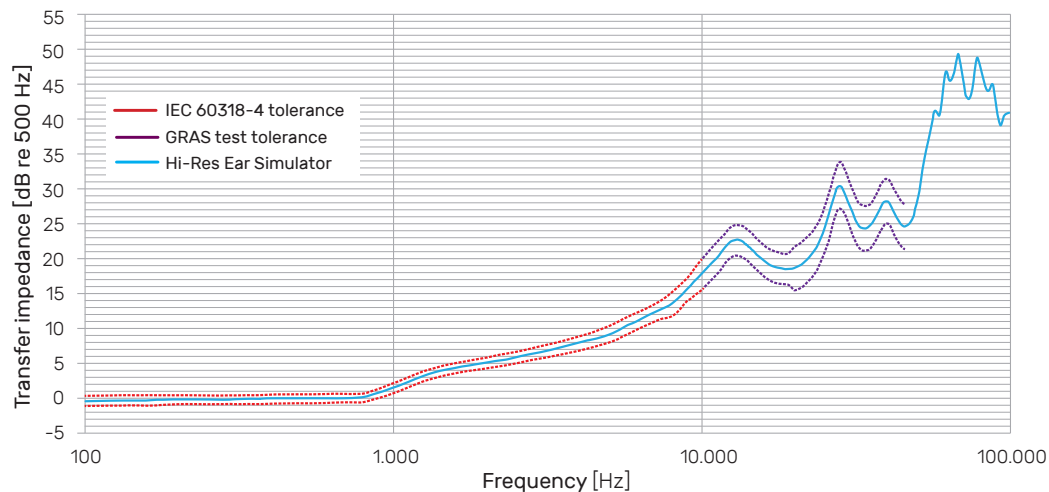
The advantages of the resonance damping are obvious when comparing the Hi-Res Ear Simulator with an identical ear simulator without damping, as shown to the right. The only real disadvantage is the lower sensitivity and higher noise floor of the 1/4" microphone.

RA0403/04 is mechanically backward compatible. It can be used as a drop-in replacement for standard 60318-4 ear simulators in existing systems or be used in the preconfigured test solutions shown on page 5.

1/4" microphone-based ear simulator with and without damping



The damping system attenuates the resonances up to 50 kHz.



The transfer impedance is within ± 2.2 dB up to 10 kHz, within ± 3.2 dB up to 50 kHz

RA0403 Externally Polarized and RA0404 Prepolarized

| | | |
|-----------------------------|-----------------|-----------------------------|
| Dynamic range RA0403 (LEMO) | dB(A) - dB | 44 - 169* |
| Dynamic range RA0404 (CCP) | dB(A) - dB | 44 - 166* |
| Sensitivity | mV | 1.6 |
| Frequency range | Hz | 100 - 10 k (IEC 60318-4) |
| | Hz | 10 k - 20 k (± 2.2 dB) |
| | Hz | 20 k - 50 k (± 3.2 dB) |
| Resonance frequency | kHz | 13,5 |
| Coupler volume | mm ³ | 1,260 @ 500 Hz |
| IEC 60318-4 | | Compatible |

* Measured at Drum Reference Point

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ABOUT GRAS SOUND & VIBRATION

GRAS is a worldwide leader in the sound and vibration industry. We develop and manufacture state-of-the-art measurement microphones to industries where acoustic measuring accuracy and repeatability is of utmost importance in R&D, QA and production. This includes applications and solutions for customers within the fields of aerospace, automotive, audiology, and consumer electronics. GRAS microphones are designed to live up to the high quality, durability and accuracy that our customers have come to expect and trust.

GRAS Sound
& Vibration