The Challenges of Testing Hearables

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Challenges

- Smart hearables respond to voice commands
- Wireless interfaces e.g. Bluetooth & Wifi
- Multiple microphones & speaker
- Asynchronous input and output requires open loop testing
- Complex signal processing (e.g. voice activity detectors, mic array beamforming, automatic ear detection, loudness control, equalization, active noise control, compressors, etc.)
- Smartphone app required to control and test settings

Standards

- IEC 60268-7: Sound system equipment – Part 7: Headphones and earphones
- EN 50332-1 Max SPL (European standard for max loudness)
- ANSI S3.22 Specification of hearing aid characteristics
- TIA 920.130: Telecommunications Communications Products Transmission
- ITU-T P.56 05/93 Method B: Active Speech Level

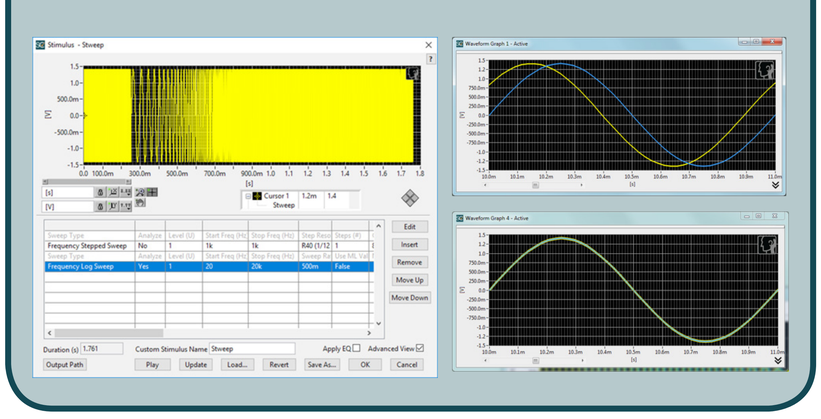
None of these standards address how to connect to the devices and how to measure them under real world conditions with real world signals!

Open Loop Testing

Most hearables require open loop testing as the input and output are connected via the cloud or with voice interaction and smartphone app, rather than directly. Open Loop testing overcomes input and output:

- in different domains
- asynchronous (different sample rates)
- with variable delay

Open Loop Testing uses frequency shift and triggering to ensure accurate measurement and analysis of data.

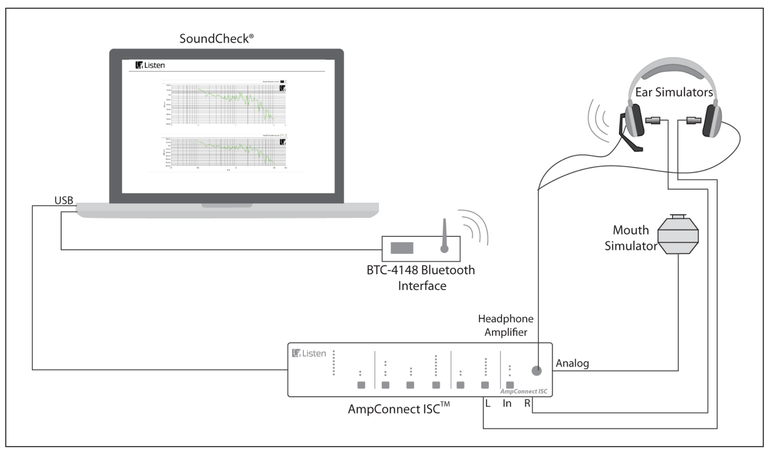


See Demos at our booth

Apple AirPods measurements compared to Harman Target Response including Predicted Preference Report	
Measurements of Hearables through smartphone app including adjustable ANC, equalization and hearing assistance	

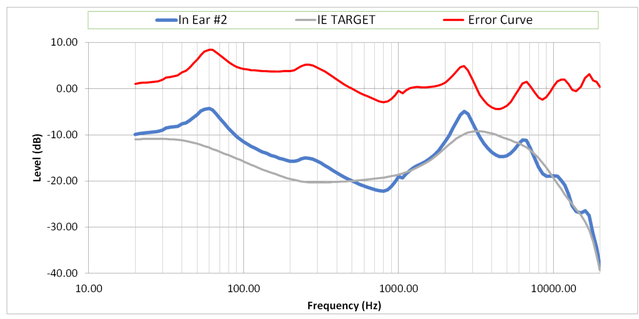
Basic Measurements

Frequency response, distortion left right tracking, Harman target response



Predicted Preference Report In Ear #2

STDEV OF ERROR	SLOPE OF ERROR	AVERAGE ERROR	Predicted Preference
3.09	-1.07	3.05	55.92



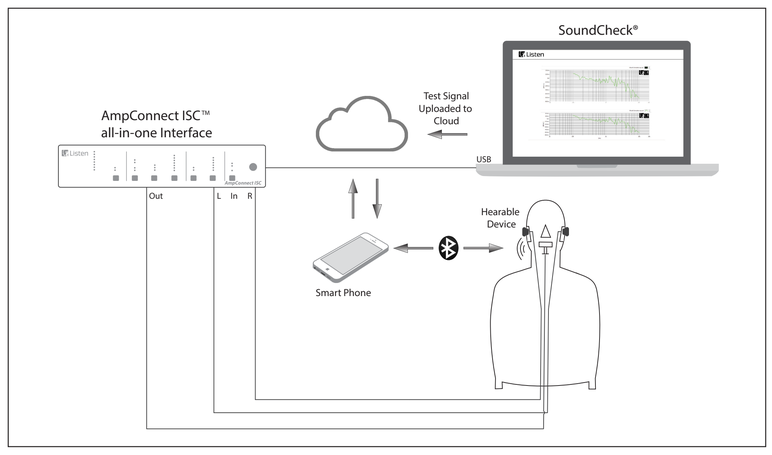
Voice Interaction Hearable Measurement Steps

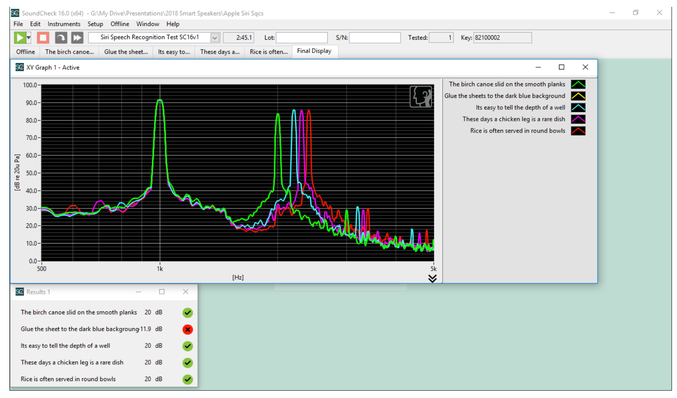
- Create activation phrase
- Upload test stimulus to cloud service
- Convert linear .wav file to highest quality format that the streaming music service supports
- Play activation word via mouth simulator and capture response with hearable's microphone(s)
- Analyze captured response signal

Voice Interaction Microphone Measurement Steps

- Combine recorded activation word with test signal eg. frequency sweep equalized at the MRP of the mouth simulator
- Play stimulus from mouth simulator then download from the cloud service
- Virtual Audio Cable can be used to capture the playback stream, or recall step can be used to load captured recording
- Analyze captured response recording

Voice Activation and Speech Recognition

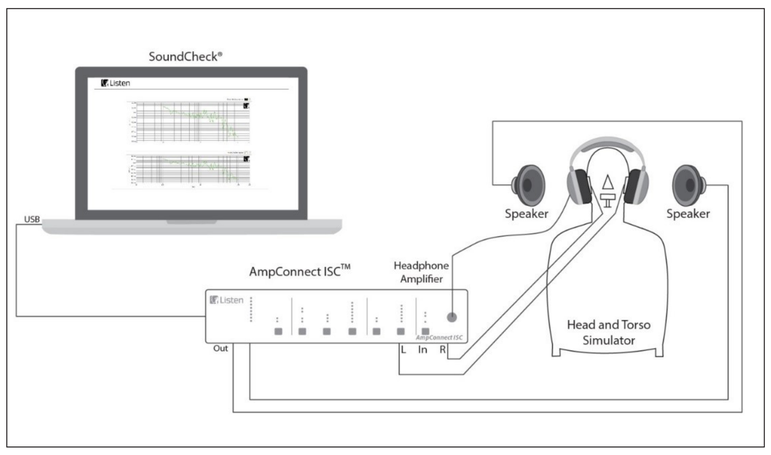


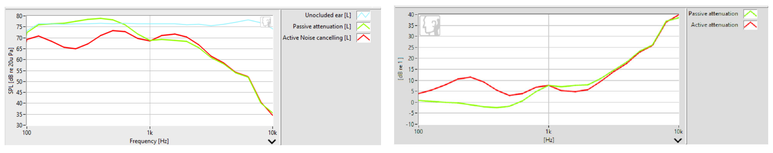


Automated Speech Recognition Test

- Upload a collection of special musical tracks
- The track titles are the words or phrases you want to test
- The actual content of the tracks is a single, dual, or multitone that allows the track to be identified by it's audio content.
- Record people speaking the test phrases as requests to play back the specific tracks.
- Harvard Sentences - a collection of phonetically balanced sentences that use specific phonemes at the same frequency they appear in English – are used for the track titles.
- Capture the response of the device and use a limit to detect whether the correct, or any signal, was played back.

Active Noise Cancellation

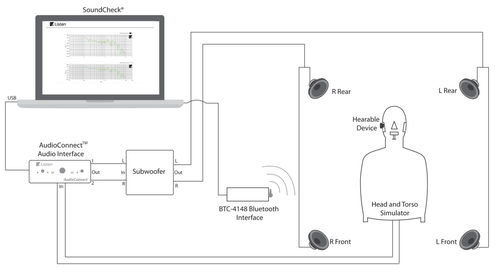




Three separate measurements are made:

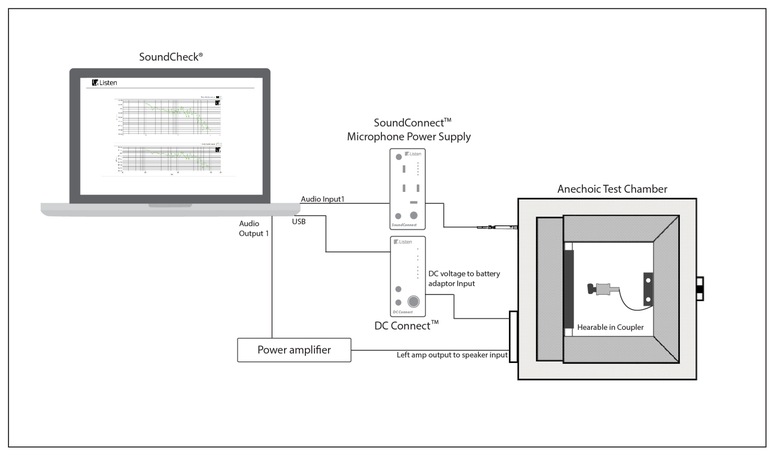
- Un-occluded ear (baseline of noise at open ear)
- Passive attenuation (measured with headphones in place but active cancellation off)
- Active cancellation switched on

Smartphone apps enable control of how much background noise cancellation is desired based on the user's environment.



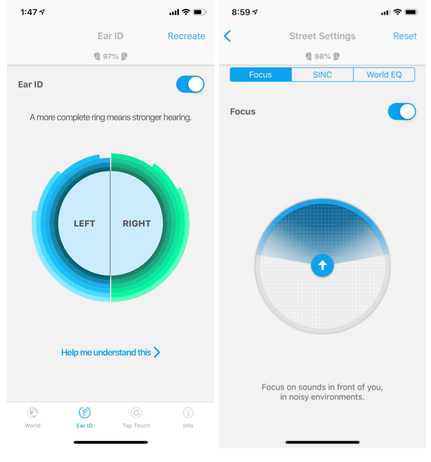
A background noise system is often used for ANC tests. This automatically calibrates a standardized 4.1 speaker / subwoofer, providing an equalized, calibrated playback solution to stress your device in a standardized and repeatable way.

Hearing Assistance



Measuring Hearing Assistance Devices

- Hearables that function as PSAPs need to be tested like hearing aids (ANSI/IEC).
- The device is placed in an anechoic box and the output of the hearing aid is plotted vs. the input on the graph to quantify the gain added for low level signals and compression at high levels for hearing loss compensation.
- Corresponding attack and release times can also be measured



Some headphones/hearables act like a hearing aid to compensate for hearing loss. This is customized via a phone app. For example, Nuheara EAR ID measures and analyzes your hearing thresholds to determine the relative strength or weakness of your hearing at various frequencies and uses this to offer a customized hearing enhancement experience.

In some cases, the smartphone app can also control the directionality of its microphone array to make it easier to hear someone talking in a noisy environment.

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