Electronics

**External Audience Protocol (EAP) – Smart Speakers**

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Introduction

The following document presents the protocol for testing and evaluating Smart Speaker audio systems at Consumers Reports. (For the purposes of brevity, we will use the term "system" to refer to Smart Speakers in general. The purpose of this test process is to expose the performance strengths and weaknesses for each system under test and to make a final assessment of each system’s overall performance. The following steps can summarize a high-level description of our test process:

1. System audio set-up and adjustment
2. Sound quality test
3. Ease of use test
4. Versatility assessment

Audio Quality Expectations

A system may have user-adjustable or non-adjustable audio controls. Some of these controls, such as bass and treble controls, tone presets, multi-band graphic equalizer setting, can be used to adapt the system to the listening environment to achieve the flattest frequency response or theoretically provide clearest sound possible for that system; they can also be used to adjust the system frequency response to user taste. Other controls, such as DSP reverberant field effects, stereo to multi-channel matrixing, simulated surround sound, and 3-D sound, can be used to add enhancement to the original audio program which users may, or may not desire.

At CR, the audio test process is designed to determine the baseline fidelity of audio reproduction to the original source for a given audio system. This means turning off, if possible, all audio enhancement modes, and, if needed, using any provided frequency response adjustment controls (which includes any "direct" setting switch) to achieve the best combination of clearest sound and flattest frequency response for the system under test in our test environment. The systems under test are sequentially compared to reference audio systems that represent various standards of quality. The characteristics that we look for when assessing audio quality are as follows:

- **Clarity and detail** - Ideally notes should be distinct and clean, there should be a sense of space between instruments and voices, complex musical lines and vocal harmonies shall maintain their richness and detail and should not sound homogenized, and the recording site ambience should be clearly evident and unique - different recordings should have distinctly different ambient sounds.

- **Frequency response** - Ideally the reproduced frequency response should be flat throughout the entire audible frequency range. Bass should be extended (no low bass roll-off), and should have a solid quality that is not thumpy, boomy, thuddy, etc. The midrange should be full and smooth, and should not sound nasal, thin, gritty, etc. Treble should be extended (no high frequency roll-off) and smooth, and shall not sound peaky, sizzly, etc.

- **Spatial image placement (vertically, laterally, and depth)** - Ideally the system should provide a stereo sound stage that has a reasonable sense of height, width, and depth; The placement of instruments and voices in the sound stage shall be realistic and consistent with the placement found with the better reference systems.

- **Dynamics** - The dynamics of the audio program shall not be noticeably compressed or exaggerated.
- **Freedom from obvious distortion at reasonable volume levels** - This includes electrically based distortions (such as clipping, intermodulation, etc.) and mechanically based distortions (such as voice coil rubbing, speaker cabinet buzzing, etc.).

- **Seamless sound field integration for stereo paired systems and speaker/sub** - The left and right channels shall have a similar sound characteristic and for stand-alone speaker/sub, channels shall blend seamlessly.

The efficacy of any simulated surround sound and/or 3D sound feature is also commented on.

**Test Infrastructure**

The audio system test environment at CR consists of a dedicated testing room (lab) patterned after the applicable specifications of IEC Publication 268-13: Sound System Equipment, part 13, Listening Tests on Loudspeakers. The lab has a switching system that is used to switch analog audio input signals between a high reference system, and any combination of up to five other systems. In addition to the high reference system, four additional reference systems that represent four different performance benchmarks are used for audio quality judgments. Audio analysis software, a computer, a microphone, and other assorted support hardware are used when setting up the systems to verify proper operation and frequency response adjustment of the reference systems and to optimize and record the frequency response of the systems under test.

**Description of Test Process**

1.0  **Audio Set-up**

- **Reference system set-ups:**
  All reference systems are set up in a stereo configuration with any audio enhancement features turned off. The following parameters are optimized first though positioning of the speakers and subwoofers, if any, and then though use of their auto or manual calibration function if any, tone controls, tone presets, and/or built-in equalizers (an outboard equalizer is used with the high reference system):
    - Spatial imaging
    - Frequency response

  All measurements and judgments are made from a fixed listening position located midway between the speakers of the reference system being set up and at a fixed distance from the front listening room wall. Spatial imaging is optimized via subjective judgment. Frequency response is optimized via pink noise reproduction measurements using a microphone and audio analysis software, and further adjusted by subjective judgment if the frequency response is not flat to a fixed dB tolerance. All reference systems are set to the same moderate volume level as determined first by pink noise measurement and then subjective judgment of a vocal passage. Once a reference system has been optimized, its pink noise frequency response curve and all pertinent mode, tone, and volume settings are documented for future reference and verification.

- **Test system set-up:**
  A multi-channel surround sound system is initially set up in a multi-channel configuration with any audio enhancement features turned off, and any automatic or manual calibration function is run. It is then switched to stereo mode. Two channel systems are set up in a stereo configuration with any audio enhancement features turned off. If they have an auto or manual calibration function then that is
run. Monophonic or multi-channel speaker array systems (two or more channels with all channels in the same enclosure) are set up with any audio enhancement features turned off. If they have an auto or manual calibration function then that is run. The following parameters are optimized first through positioning of the speakers and subwoofers, if any, and then through use of their tone controls, tone presets, and/or built-in equalizers, if any:

- Spatial imaging
- Frequency response

All measurements and judgments are made from a fixed listening position located midway between the speakers (or in the case of monophonic or multi-channel speaker array systems directly in front) of the test system being set up and at a fixed distance from the front listening room wall. Spatial imaging is optimized via subjective judgment. Frequency response is optimized via pink noise reproduction measurements using a microphone and audio analysis software, and further adjusted by subjective judgment if the frequency response is not flat to a fixed dB tolerance. All test systems are set to the same moderate volume level as the reference systems as determined first by pink noise measurement and then subjective judgment of a vocal passage. Once a test system has been optimized its monophonic, multi-channel speaker array, or two speaker stereo pink noise frequency response curve and all pertinent mode, tone, and volume settings are documented for future reference and verification. In case of multi-channel surround sound systems; without changing adjustments the right front speaker is disconnected and pink noise frequency response curves are recorded, if possible and applicable, for the left front channel running the left front speaker, center channel speaker, left surround speaker, and left rear surround speaker. At the time of the recording, each speaker is placed in the position that was originally occupied by the left front speaker.

2.0 Audio Tests

- Subjective Audio Tests:
  Select tracks from commercially available audio CDs are used in testing. Each “test track” has particular audio content (i.e. deep bass with a resonate quality, detailed delicate treble, midrange with complex instrumental and vocal layering, natural recording site ambience, artificially added echo, dry multi-tracked recording space, etc) that is used to characterize the test system’s performance and rank it in comparison to the reference systems. A group of trained listeners assesses the audio performance of the systems for the test tracks based on the characteristics listed under the Audio Quality Expectations section above.

3.0 Ease of Use

Ease of use evaluations are conducted by panelists that fill out a questionnaire that assess the following attributes:

- Setup – covers the steps that a user will have to take to get the system up and running such as physical set-up (making wiring connections) and, if applicable, using the system set-up menu and/or voice control. Considerations include Wi-Fi and Bluetooth connection/pairing, are console and speaker connections identified in a way that will facilitate correct connection, and are set-up menus intuitive to use.

- Console ease of use - covers day-to-day operation using the system console. Considerations include how well can the system be operated from the console if the remote control is
unavailable, how intuitive are the controls to use, control ergonomics, and what information is provided by the console display about the system’s status.

- **Remote control ease of use** – covers day-to-day operation using the system’s remote control/App remote/voice control. Considerations include how well can the system be operated from the remote control without having to use the console controls, how intuitive is the remote control to use, and remote control ergonomics.

### 4.0 Versatility

Tabulation of value-added features such as the number of supported voice assistants, the number of supported OS for remote control app, the number of supported common streaming services by voice control, supports voice identity, the number and types of audio inputs and outputs, the presence of device charging ports, docks, voice control calling functions, speakerphone functionality, provisions for smart speaker system capability (Wi-Fi, Bluetooth or both), if applicable number of Bluetooth pairing memories, Stereo/Mono audio, optional multi-room support, tone adjustability, etc.