AUTOMOTIVE

# Measuring Automotive Max SPL

By Steve Temme Listen, Inc.

I am currently a participant in an Audio Engineering Society (AES) technical committee working group on automotive audio. This diverse group of about a dozen worldwide experts has focused on trying to standardize the way essential attributes of complex automotive audio systems are measured across the industry. Three specific measurements have been our initial focus: Frequency Response, Max SPL, and Impulsive Distortion. The committee's proposals for measurements were presented for feedback at the AES Fall Online 2021 conference in a session titled "In-Car Acoustic Measurements." I presented our work on Max SPL Measurements, Hans Lahti (Harman) presented Frequency Response, and Stefan Irrgan (Klippel) presented Impulsive Distortion; the session was chaired by Jayant Datta. Here, I will describe our proposed method for Max SPL measurements.

Let's start with why this is important. People need to be able to compare how loud an infotainment system can play in a car—manufacturers like to quote this in specifications, and consumers enjoy bragging rights about the sound level of their car stereo.

Max SPL is defined as the maximum sound pressure level (SPL) that a car's infotainment system can reproduce inside the cabin with the windows, sunroof, and convertible top closed. There are many ways this can be measured, but to keep it simple, two different measurements are recommended—overall Max SPL and Max SPL Spectrum regardless of distortion level. The reason we don't take into account distortion when we measure the Max SPL is because it is difficult to characterize distortion in a modern-day infotainment system—these devices frequently contain much signal processing, and this makes them unsuitable for playing back the sine wave stimuli that are typically used for harmonic distortion measurements.

First, let's examine the physical test setup. Our proposed test configuration replicates the position of an average person's head in the driver's seat using a precisely and specifically positioned six-microphone array in the driver's seat. The height and the angle of the seat, the positioning of the microphones with respect to the seat, and the height and the angle of the microphones are clearly defined to ensure standardized measurements across all vehicles.

The sound system settings on the head unit—the tone control and fader—are set to the factory default setting; in most cases this is neutral or flat with no equalization. The head unit's volume control is set to its maximum level using the volume control knob or digital user interface equivalent (e.g., volume level slider).

Overall Max SPL can be measured using a microphone array with the six microphone signals power averaged by analog or digital means and connected to either a conventional or software-based sound level meter that can measure true RMS and be C-weighted, as described in the IEC-61672 standard. However, if a software-based system is used for measuring the Max SPL Spectrum, it is simpler to also measure the overall Max SPL through the software. **Figure 1** shows a test configuration that makes both measurements simultaneously using SoundCheck software, and an AmpConnect 621 audio interface.

For both the overall Max SPL and Max SPL Spectrum measurements, a broadband (20Hz to 20kHz) monophonic pink noise stimulus is used. It has a crest factor of 15dB and is played for 30 seconds to make sure the system can sustain that level continuously. This is played at maximum volume to ensure the system is tested at the loudest signal the car will play. The sound source may come from any source—a memory stick, a CD, or Bluetooth from a smartphone or auxiliary line in. The average SPL in dB(C) is measured for 30 seconds. This is called a Leq measurement, and it takes the spatial average of the six-microphone array, power averaged, to get the overall Max SPL level (**Figure 2**).

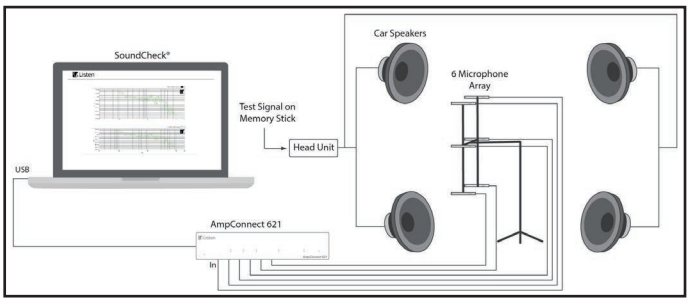


Figure 1: Test configuration for measurement of Max SPL and Max SPL Spectrum

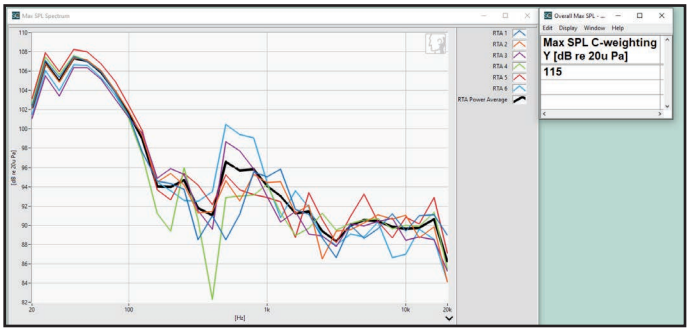


Figure 2: Max SPL Spectrum and Max SPL results

The Max SPL Spectrum is measured using a real-time analyzer set to 1/12 octave resolution, 30 second linear averaging time and no waiting. This enables us to measure the level versus frequency irrespective of the human ear's perception. The Max SPL is recorded at each microphone simultaneously from 20Hz to 20kHz and the power average calculated (Figure 2).

Listen offers a pre-written SoundCheck test sequence that measures both the Max SPL Spectrum and a single, power averaged value for Max SPL in line with the working group's proposed guidelines. This enables consumers and manufacturers to measure the maximum overall SPL and maximum SPL versus frequency that a car's infotainment system can reproduce inside its cabin. The sequence uses the method and test configuration with a six-microphone array in either the driver or passenger seats. It takes advantage of Listen's 6-in, 2-out AmpConnect 621 audio interface, which seamlessly integrates with the software-based multichannel analyzer to measure, display, and average the results from the six microphones in real time, and power average them to calculate Max SPL. This sequence may be downloaded free of charge from Listen's website. More details about these measurements, and the other measurement proposals developed by the technical committee, will be presented at the 2022 AES International Conference on Automotive Audio, June 8-10, in Dearborn, MI.

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