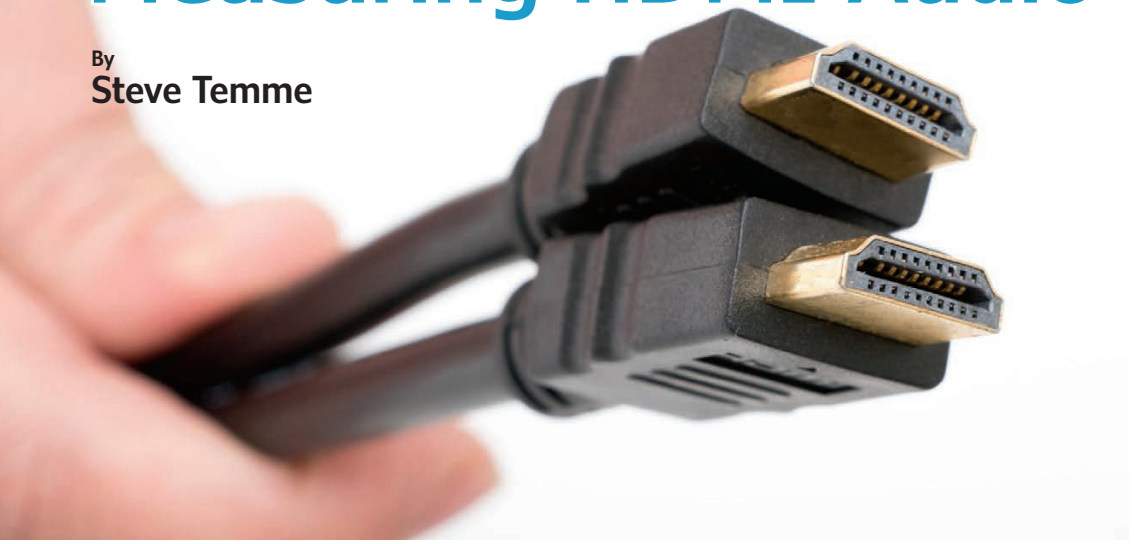
Measuring HDMI Audio

By
Steve Temme



From its origins in 2002 as a new, smaller connector for HDTV, High-Definition Multimedia Interface (HDMI) evolved continuously over the years to become one of the most widely adopted interfaces. This article provides practical answers on how to perform HDMI audio measurements, dealing with the interface's multiple options and configurations.

How do you measure HDMI audio? This is a question we often hear as HDMI soundbars become more commonplace and the rapid adoption of surround sound and spatial audio systems with televisions continues. While some manufacturers offer expensive custom interfaces to test HDMI devices, there is a much more cost-effective method. Some software-based audio measurement systems can be used with a $100 off-the-shelf interface that enables test signals to be sent via HDMI to a soundbar or surround sound system for measurement. In this article, we discuss how the HDMI protocol handles audio and demonstrate acoustic measurements on a soundbar using Listen SoundCheck software with a commercially available HDMI audio extractor. This method can be extended to a wide range of HDMI connected devices including multichannel surround sound systems.

HDMI Audio

Modern HDMI systems offer Audio Return Channel (ARC) functionality. This allows a single HDMI connection to be used as both an audio input and an output, providing a two-way flow of audio, in addition to video, between devices. This eliminates the need for a dedicated audio cable to connect a soundbar or AV receiver to the television, simplifying configuration and reducing cost and cabling. ARC supports up to six-channel compressed audio and has a maximum bandwidth of 1Mb/second. It supports various audio formats including PCM (2 channel), Dolby Digital (up to 5.1 channel), and DTS Digital Surround (up to 5.1 channel).

A newer version, Enhanced Audio Return Channel (eARC) improves upon ARC with a significant boost in bandwidth and speed, enabling transmission of higher quality audio from a TV to a soundbar or AV receiver. It carries up to 32-channel audio, including eight channels of 24-bit/192kHz uncompressed audio, and supports modern advanced audio formats such as DTS-HD Master Audio, DTS:X, Dolby TrueHD, and Dolby Atmos.

Many audio devices that are used with audiovisual systems, such as soundbars, speakers, gaming headsets, and so forth, are unable to accept an HDMI input with video directly. A small device called an HDMI extractor is commonly used to split the audio and visual HDMI signals so that the audio signal can be played directly on a soundbar or surround sound system. Audio extractors typically cost around $100 and can be purchased online or from electronics or AV stores.

These widely available devices also enable HDMI audio devices to be measured using a software-based audio analyzer. To measure audio, a test stimulus must be sent from the computer to the device under test (DUT). Although soundbars usually feature an HDMI port, as do most computers, typically the device's audio channels will not be accessible if they are directly connected via an HDMI cable.

If an HDMI extractor is used as a simple HDMI pass-through, the computer then recognizes the soundbar (or other device) as an audio output and is able to transmit a test signal to make audio measurements. Note that there is no visual signal being transmitted. It is simply an audio signal that is transmitted via the HDMI-in and HDMI-out ports of the audio extractor.

Measurement Configuration

To demonstrate basic audio measurements on a soundbar using this method, we can just make a simple audio measurement using a single microphone in one position, and analyze frequency response, total harmonic distortion (THD), and Rub & Buzz. The measurement method could easily be expanded with additional channels and microphones, which we will discuss later.

Figure 1 shows a schematic of the test configuration, and **Photo 1** shows the equipment we are using.

The computer is running SoundCheck, Listen's audio test and measurement software, in this case connected to AudioConnect 2, a portable two-channel audio interface also from Listen, which powers the SCM measurement microphone and transmits the measured signal to the laptop. The microphone is positioned about 50cm from the soundbar, centered between the speakers. The HDMI port of the computer is connected to the HDMI input of the soundbar via an Ezcoo HDMI 2.1 Audio Extractor that was purchased from Amazon.

Once the computer is connected to the soundbar via the HDMI extractor, the output channels are configured in SoundCheck's hardware setup, shown in **Figure 2**, to ensure that the software is sending test signals to the soundbar. The driver is set to WASAPI, the channel type is set to digital and the sample rate matched to the sample rate of the input channel hardware. It is critical that the WASAPI driver option is selected as only WASAPI drivers provide multichannel support for HDMI. They also allow multiple WASAPI drivers to be used simultaneously and provide better latency than WDM drivers. HDMI signal paths are then created. Although this demonstration uses just two channels, any number of channels can be similarly configured. For example, we could set up six or more channels to measure a multichannel surround sound system with an HDMI AVR receiver.

The SoundCheck measurement sequence is simple and takes only a couple of seconds to run. It plays a stepped sine stimulus, captures the response, and graphically presents frequency response, THD, Rub & Buzz, and Perceptual Rub & Buzz.

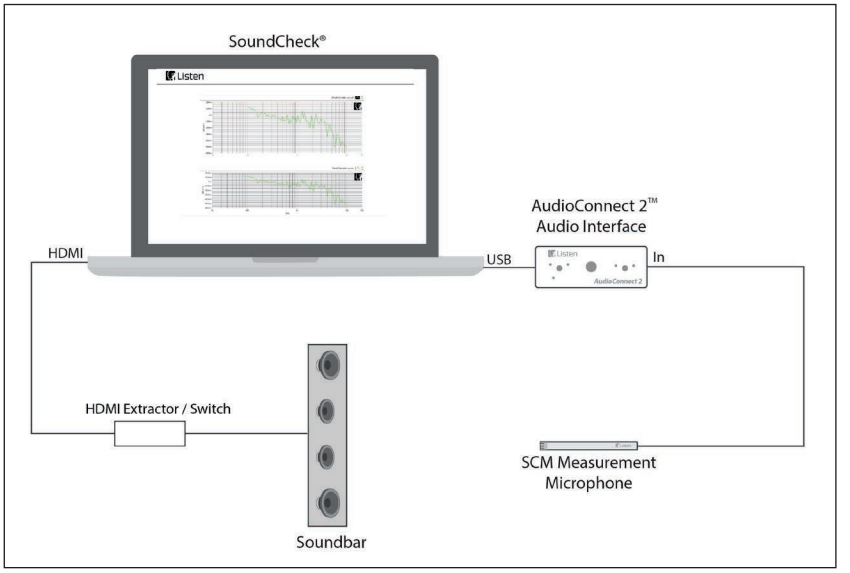


Figure 1: Test configuration for HDMI Soundbar Audio Test.

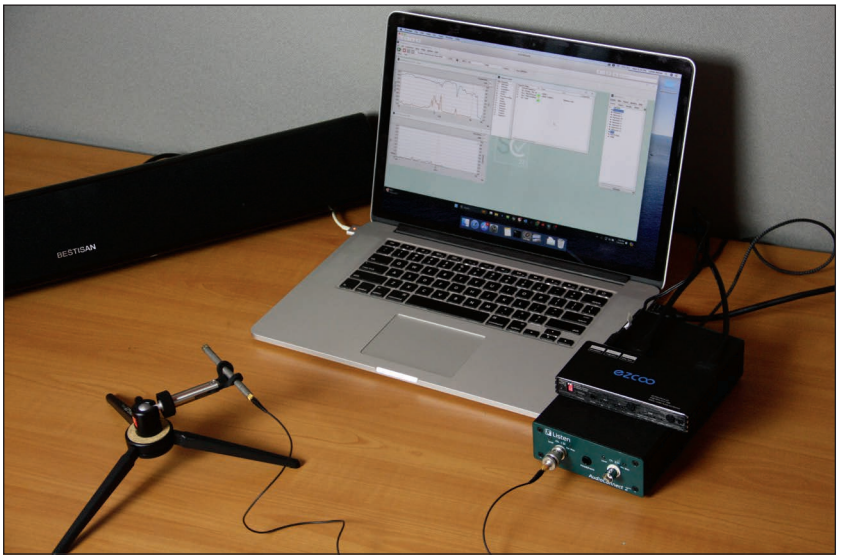


Photo 1: Equipment used for HDMI Soundbar Audio Test.

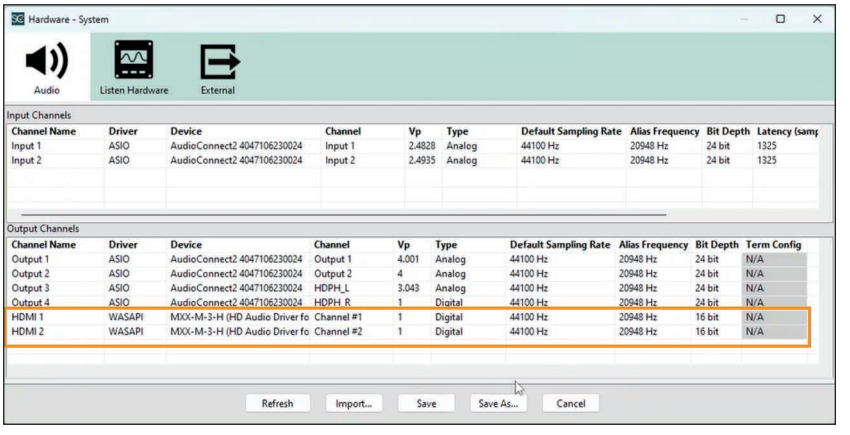


Figure 2: HDMI channel configuration in SoundCheck's hardware setup.

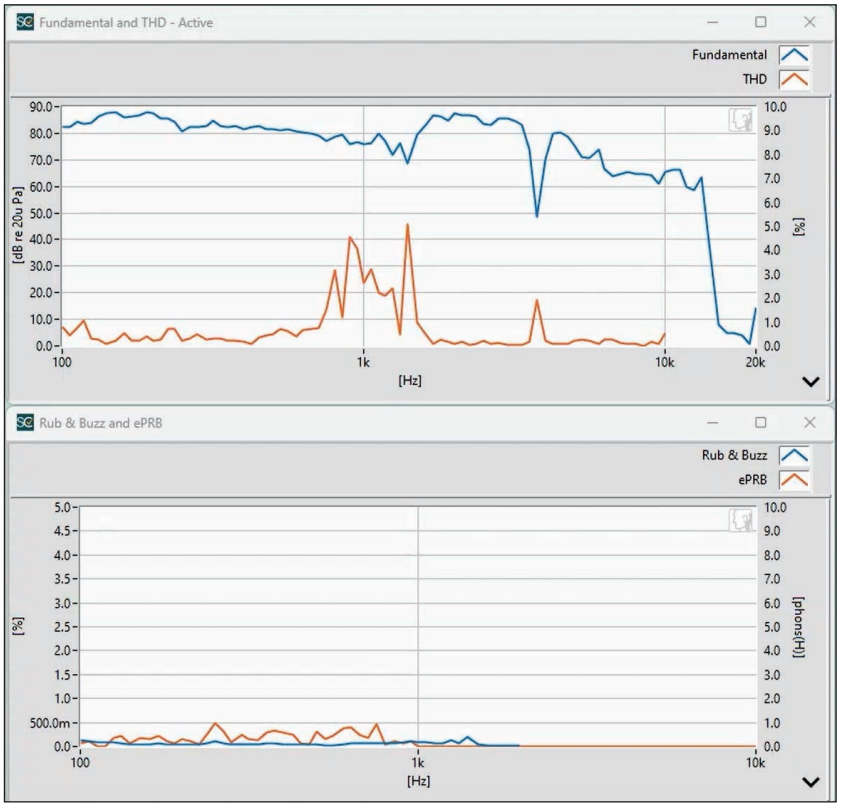


Figure 3: Frequency response, THD, Rub & Buzz, and Perceptual Rub & Buzz of a soundbar.

Photo 2: Example of a commercially available and affordable HDMI audio extractor.

About the Author

Steve Temme is founder and President of Listen, Inc., manufacturer of the SoundCheck audio test system. Steve founded the company in 1995, and over the past 30 years the company has remained on the cutting edge of research in audio measurement, introducing many new measurement algorithms and techniques. In recent years, Listen's product development focus has been on creating the algorithms, interfaces and test methods to measure today's newest devices including MEMS speakers and microphones, as well as automotive audio and various wireless and cloud-communicating devices. Prior to founding Listen, Steve worked for many years as an acoustic test and measurement applications engineer at Brüel & Kjær, and also as a loudspeaker design engineer at Apogee Acoustics. He holds a BSME from Tufts University, has authored numerous papers on acoustic testing, and has lectured extensively throughout the world.

Results

Figure 3 shows the results. The top graph shows frequency response (blue) and THD (orange). The lower graph shows Rub & Buzz, measured both using conventional higher-order harmonic distortion methods (blue) and using a perceptual algorithm (orange). As you can see, it measures and provides results much as you would expect from a conventionally wired speaker. It is simple to add additional measurements to this test sequence.

Further Measurements

As a simple example, the ability to control the destination of any computer audio output via HDMI using an HDMI extractor is a valuable technique for more complex applications (**Photo 2**). For example, the HDMI extractor could be connected to the eARC input on an audio video receiver (AVR) to route test signals to various specific speakers in a multichannel surround sound system. This would enable detailed R&D analysis or comprehensive production line testing of surround sound systems. With a multichannel audio interface, additional microphones could be added to capture sound from different speakers.

This solution also offers flexibility with the source signal. Although in this example the stimulus is a stepped sine wave generated by the audio analysis software, there are times when a real music test signal is required. Dolby Atmos source material can be played from a Blu-Ray disc or streamed from the cloud and output via the computer and extractor to various speakers. This would necessitate more complex analysis capturing an open-loop response, but it would allow the rendering of different virtual source locations. A head-and-torso (HAT) simulator could be substituted for the microphones to evaluate inter-aural time delays and level differences.

Summary

As spatial audio continues to grow in popularity and more products supporting multichannel audio come to market, measurement demands are also increasing. In addition to traditional measurements of frequency response and distortion, such measurements also include phase response, directivity, and spatial reproduction accuracy. This growth is not restricted to home theater. As computers, monitors, gaming consoles, and more adopt multichannel audio, audio over HDMI is becoming as ubiquitous as audio over USB. This means accurate, cost-effective measurement solutions are essential. Multichannel software-based audio test systems with WASAPI support, paired with HDMI extractors, provides a viable and cost-effective solution.