

No Infidelity: Audio Test Platforms Benefit from New 24-Bit, Sigma-Delta ADC's Superior SINAD

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Overview

Audio has been integrated into almost every personal electronic device. You cannot walk down any busy city street or suburban area without seeing people of all ages listening as they go about their daily routine. The sheer number of audio devices available has jumped astronomically in the last five years. The typical consumer has access to a much wider variety of media sources, coupled with an even wider array of devices from which to view and playback content. This digital media explosion has seen the use of mobile phones, tablets, laptops, and Bluetooth speakers increase across the globe. Many people have a subset, if not all of these devices available to them in their home. High fidelity audio delivery is a given and is expected by modern users. Gone are the days of static and unwanted distortion in our audio systems. We also see the move to the cloud in terms of audio playback. There are many streaming services now competing for listeners that all offer high fidelity music at a fraction of the price of a compact disc collection. What does all this mean? Each of us will utilize multiple playback mediums to access the multitude of music, audiobooks, and podcasts now available online. The sheer number of audio modules also leads to an increased need for audio test platforms, which require both multifunction flexibility and high fidelity performance.

If we are to look toward the future, the general trend seen in technology is that the base technology doesn't change vastly, while the finished product is incrementally improved over time to achieve greater performance. This trend also applies to the audio space. We want more memory, more processing power, more accuracy, and increased definition. And of course—we want it all smaller than before. This same trend is seen as higher quality audio is demanded by everyday listeners. Voice recognition and voice commands are an example of an application space that has the potential to drive increased demand for high quality audio systems. Anything from a voice search on a smart device to a home automation system will employ this kind of technology. The ability to pick out the user's command from a noisy environment will require high quality hardware to be deployed in all of our smart devices. Key to this system will be the dynamic range achievable and the ability to filter out any noise and interference. Applications such as video conferencing, virtual presence, and virtual reality will all require background noise to be kept to a minimum to enhance the user's experience.

Design Challenge

The sheer number of audio modules that are being produced leads to a potential pain point; how can we test each of these devices quickly and efficiently, without compromising on performance? From an equipment manufacturer's point of view, it is clear that increasing the speed at which testing can be performed will lead to a cost reduction. Yet the end product's quality cannot be compromised. Keeping these motivations in mind, the key to designing an audio test platform for modern day audio nodes is this; we want increased performance, and we want to test faster than ever before. Audio test platforms need to achieve lower than ever levels of noise and distortion, to quickly and accurately measure the device under test.

The gap between the typical consumer's needs and the needs of professional studio equipment is closing. Consumers are opting for higher quality, more sophisticated headphones for example. Having an audio test platform that encompasses this entire spectrum would be invaluable. Typical CD quality music requires 92 dB to 96 dB of dynamic range, while an analog microphone and professional quality audio would require upward of 120 dB of dynamic range.¹ An audio test platform that can cover a greater proportion of this range, combined with a faster test time and better test throughput would suit the future needs. This audio test platform would be ideally positioned to cope with both current consumer level requirements and have the capability of meeting future trends toward higher fidelity systems.

The Search for a Solution

The search for a one size fits all solution may involve many design headaches. Incorporating these requirements into a modern audio test platform may cause the test system designer to come up against limiting factors. Some of these limiting factors may include system cost, design size, and power dissipation. In many cases, component performance limitations associated with the monetary or thermal budget are what will define the system performance. A product that helps to ease these common constraints is the [AD7768](#)—Analog Devices' multichannel, 24-bit, Σ - Δ ADC. This device is available in either 4- or 8-channel versions and is a proven fit in the audio test space, due to its SINAD performance, among many other features.

AD7768/AD7768-4 24-Bit ADC Suitability

In general, ADCs with 24 bits (and above) are used for high fidelity audio in the audio test space for the increased dynamic range, achievable with 24-bit accuracy. For signal integrity, we require low distortion and excellent noise immunity. Analog Devices' new 24-bit, Σ - Δ ADC, the AD7768, has unrivaled noise and THD performance across eight channels, and allows the output data rate to be tuned to the audio bandwidth. This makes it a logical fit for the audio space. THD performance is typically -120 dB.

The AD7768/AD7768-4's wideband, low ripple digital filter also suits audio applications. This can operate allowing six different decimation rates, so users can frame their bandwidth of interest. Providing a stop band attenuation of 105 dB, the AD7768 can provide a sharp brick wall frequency response maintaining an unaltered signal of interest, while noise is kept to a minimum.

What makes the AD7768/AD7768-4 the standout audio test platform anchor is its ability to fit the modern test platform. We see a trend toward modular instrumentation in small form factors. The AD7768/AD7768-4 with its integration of multiple channels, allows a smaller system with increased channel density. The ability of the AD7768/AD7768-4 to keep channel-to-channel crosstalk to a minimum, while allowing simultaneous testing of devices, is a key differentiator. Placed as the cornerstone of the configurable test platform, it solves many of the key design headaches. It is particularly applicable to modular systems where power consumption is also a key consideration.

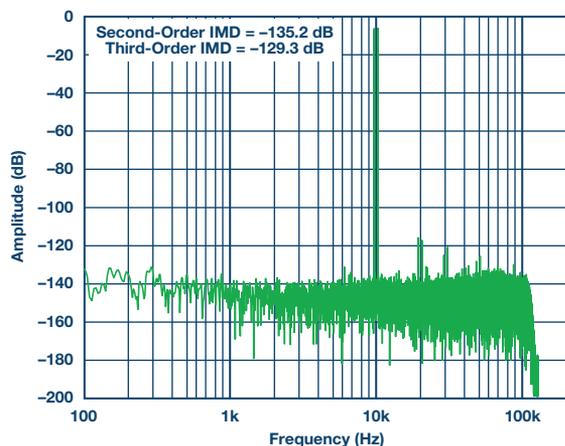


Figure 1. AD7768/AD7768-4 IMD with input signals at 9.7 kHz and 10.3 kHz.

An example of this performance is shown in the AD7768/AD7768-4 IMD results in Figure 1. This plot shows an outstanding second-order IMD result of -135.2 dB and a third-order IMD of -129.3 dB. The AD7768/AD7768-4 IMD test conforms to the CCIF standard, where two input frequencies of equal magnitude are applied to the device. The resulting FFT shows the presence (or lack) of an intermodulation of these two frequencies, appearing in the resulting sum and difference frequency bins. In this case, the center frequency is 10 kHz and the frequency offset is 600 Hz. IMD tests are commonly used to test audio devices for unwanted beat signals, caused by mixing of two or more tones.² If these tones were to be present while playing back a music stream, they would cause unwanted distortion. This distortion creates a noisy, unpleasant sound when compared to the original high fidelity audio file.

Test Case

In order to explore how the AD7768/AD7768-4 can fit into the audio testing space, typical audio testing experiments have been carried out to showcase the performance of differing consumer audio devices and how the AD7768/AD7768-4 can be utilized to test each of them. This test uses the AD7768 evaluation board, the EVAL-AD7768FMCZ, in conjunction with the SDP-H1 platform.

This test case involves testing multiple audio sources of varying quality and comparing the performance of each. Many possible test tones were considered such as IMD tones, logarithmic chirps, and level tests.

The two test tones chosen were:

- 1 kHz sine wave at -60 dBFS. This test is useful for dynamic range tests, as it keeps the device from muting, which artificially quiets the output.³
- IMD SMPTE test, 60 Hz/7 kHz, 4:1 (12 dB ratio), -20 dBFS. The IMD test shows nonlinear distortion products, produced as a result of multiple tones mixing. In this case, the 7 kHz signal is modulated by the 60 Hz tone at 7 kHz, ± 60 Hz.

Configuration

In order to tune the AD7768 to the required bandwidth, we must first make a few calculations to work out the required master clock (MCLK). This MCLK combined with a particular decimation rate will allow us to tune the output data rate of the AD7768/AD7768-4. In this case, the MCLK used is 12.288 MHz and the decimation rate is $\times 64$ to give an ODR of 48 kSPS. Other combinations could be used for a power vs. bandwidth trade-off. See the [Clocking, Sampling Tree, and Power Scaling](#) section on Page 41 of the data sheet for more information.

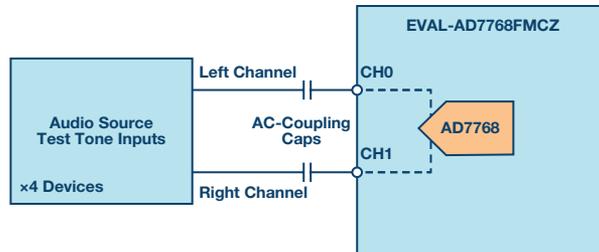


Figure 2. Connection diagram.

A typical setup is shown in Figure 2. This setup uses an EVAL-AD7768FMCZ board which has been ac-coupled from the on-board SMB connectors to the audio device. Up to four stereo outputs can be tested at once on the eight channels, with each stereo device having a left and right channel. Further optimization of this circuit could be carried out to increase the system performance. For example, the addition of a high-pass filter to remove noise below 20 Hz.

Results

Table 1. Test Tone Results

Device	Frequency (Hz)	Dynamic Range (dB)	IMD Second-Order (dB)	IMD Third-Order (dB)
Known good source	1000.5	101.2	-143.4	-139.2
Mobile phone	1000.5	101.2	-121.3	-125.8
Laptop	1000.5	89.6	-119.4	-119.5
Mobile phone over Bluetooth link	1000.5	93.7	-110.6	-118.3
MP3 player	997.6	99	-94.9	-104.7

From Table 1, we can see the range of results for both the low amplitude input signal and the IMD test vary quite a bit from device to device. Of particular interest was that the inexpensive MP3 player showed good dynamic range but under the IMD test, it was clear that there was significant distortion being introduced. The frequency output of this device demonstrated its lack of quality and the maximum IMD level that it was possible to test at was limited by the output drive capability of this device. As a result, the test tone was limited to -20 dBFS for all devices, in order to carry out an equal comparison.

The audio output of the laptop has many different driver and processing options. These have been developed to match the response of the human ear for a more pleasant sound, but result in some frequencies being altered. As a result, when these effects are turned off the laptop actually shows the worst dynamic range performance, while actually sounding just as good as the other sources.

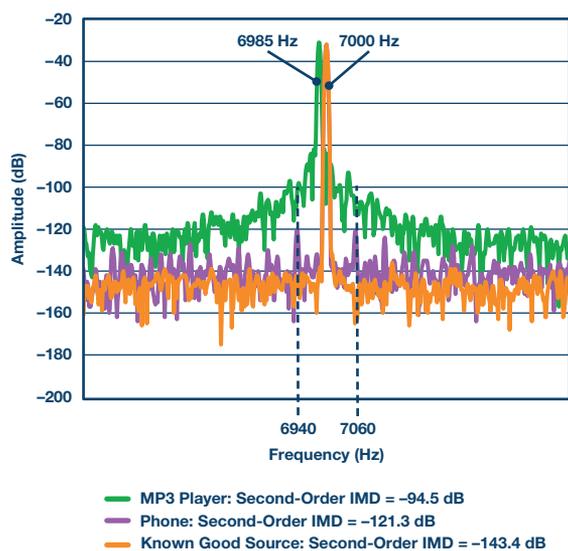


Figure 3. IMD SMPTE test samples, 7 kHz input.

Figure 3 shows the range of IMD that was seen across the devices from the known good source (orange) to the poor quality MP3 player (green). The IMD products are clearly visible at 7 kHz and ± 60 Hz for both the MP3 player and phone.

AD7768/AD7768-4 Solutions Differentiating Factors

The maximum output data rate (ODR) of the AD7768/AD7768-4 is 256 kSPS. This ODR can be tuned to typical audio bandwidths of 48 kSPS, 96 kSPS, or 192 kSPS, by adjusting the master clock (MCLK) and/or decimation rate, depending on the application need. This is particularly useful in power sensitive applications, especially as the power consumption of the AD7768/AD7768-4 on a per channel basis is relatively low when compared with other audio ADCs. It is also invaluable for other applications that require high dynamic range at larger bandwidths, such as sonar.

Many modern test platforms are moving towards modular systems where thermal requirements become an issue. The AD7768/AD7768-4 allows the user to trade signal bandwidth or dynamic range for power consumption, thereby providing for a wider range of uses. This flexibility is shown in Figure 4 which plots dynamic range vs. ODR. In addition to this flexibility, there are several methods of saving power available for the AD7768/AD7768-4 at both device and system level. See the data sheet for more details.

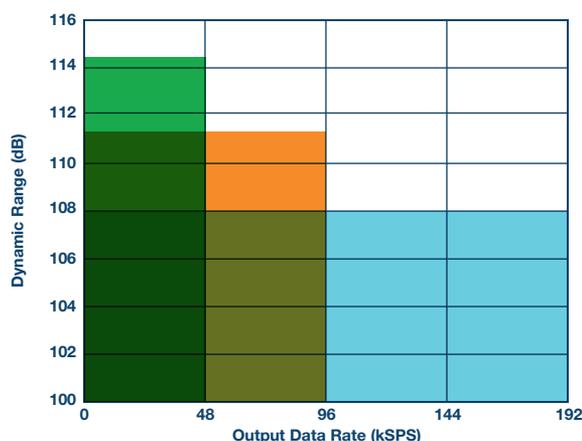


Figure 4. Dynamic range vs. ODR (per channel).

The number of channels is also an advantage of the AD7768 for the following reasons:

Speed of Test

Eight channels or four stereo devices can be tested simultaneously in parallel. This means the speed of test or cost of test is now divided by four—a key factor for the test system. With increasing numbers of audio modules in our environment, future audio test platforms will be increasingly mindful of the cost of test. An application where channel density is important is a home cinema system employing 7.1 surround sound.

Premium Performance

The performance achievable in the end system can be further boosted by combining multiple channels. Combining four channels into one will allow for up to a 6 dB improvement in dynamic range on the figures shown in Figure 4.

Smaller Form Factor

A multichannel audio platform may have restrictions on size. This could be because of increased channel density, limited system, factory floor space, or a move toward modular benchtop instrumentation. Combining eight ADCs into one package allows the system to follow the trend toward smaller instrumentation.

Summary

The number of audio modules is increasing and the quality required from these devices is also on the rise. This will result in increased demand for modern audio test platforms. The modern audio test platform will need to have high performance, be adaptable, reconfigurable, and rapid in operation, in order to exceed these needs and cater to a future with many more smart devices. Home automation, voice recognition, and speech to text applications are not future concepts but a reality. As voice control and similar technologies develop further and expand, the burden on the test platform increases. The AD7768/AD7768-4 can help in this regard. The test results show how the AD7768 can be used to test the wide range of audio devices currently on the market, from the lower range devices to higher fidelity systems.

For further information, please visit:

- ▶ analog.com
- ▶ AD7768 [Product Page](#)
- ▶ EVAL-AD7768FMCZ [Evaluation Board page](#)

References

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