

Elevating the Performance of Lossless Audio in the Home Theater: Dolby® TrueHD with Advanced 96k Upsampling

Blu-ray Disc™ lossless audio performance is exceptional, delivering every audible bit of the art of movies to the home theater. Lossless audio has extended our appreciation of sonic quality in concert videos and blockbuster movies. We can truly say we've reached the pinnacle in soundtrack delivery perfection. Or can we?

Lossless audio is but one link in the chain between the studio and your home theater's speakers (see Figure 1). If the audio processing that happens before or after the Blu-ray Disc is somehow less than perfect, lossless delivery can do nothing to help it. Until now.

The Content-Delivery Chain

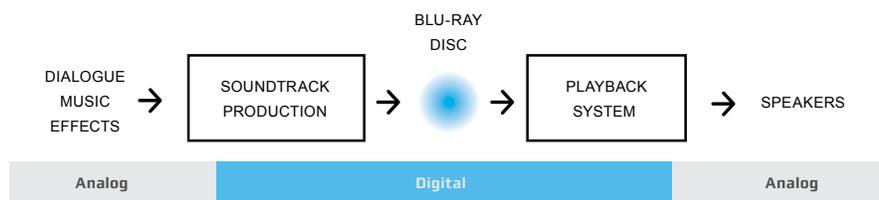


Figure 1

What Can Possibly Happen?

Whenever sound is converted from analog to digital (A-to-D), or from digital back to analog (D-to-A), steep filters are employed to avoid creating certain audible distortions. These filters, however, can introduce their own unwanted side effects because they alter the audio in subtle ways as it passes through. One of the best techniques to minimize these unwanted effects is to employ higher sample rates and gentler filters. Doubling the sample rate makes a dramatic difference in the performance of these filters, and as a result, the audiophile music industry has embraced higher sample rates as the preferred solution to delivering more natural sound.

The movie industry, for a variety of good reasons, has adopted 48 kHz as the standard sample rate for soundtrack capture and delivery for theaters, home video, and even digital TV. While doubling the original 48 kHz sample rate to 96 kHz might appear to be a simple way to upgrade movie sound, it also doubles the bit rates needed for LPCM audio, potentially impacting bit budget allocation and associated high-definition picture quality for Blu-ray Disc. As a result, home video companies have traditionally avoided this approach when releasing content on Blu-ray™.

Can Anything Be Done for Movies?

Since huge libraries of music, movie, and television content are already recorded at 48 kHz, and more are being released every day, consumer electronics makers have begun adding upsamplers in disc players and A/V processors to achieve improved performance from the D-to-A converters in these products.

One manufacturer in particular, Meridian Audio, elevated this concept to unprecedented extremes in its 808.2 Signature Reference CD Player, which retailed for a “mere” \$16,000.

Meridian—the developer of MLP Lossless™ compression adopted for the DVD-Audio format and the foundation for Dolby® TrueHD in Blu-ray Disc—possesses a rare level of digital audio expertise. Meridian’s upsampling technology is unlike any other in that it was designed not only to improve the sound of downstream D-to-A converters, but to identify and mask upstream artifacts introduced by anti-aliasing filters. These artifacts, referred to as preringing, are new sounds generated or produced by the filter in response to audio transients—generally louder, independent signals that occur within an audio waveform. A sonic event (or sound) that actually precedes the transient that induced it, preringing is an artificial phenomenon that can negatively affect the ultimate smoothness and detail of the sound. Movie soundtracks are constructed from a wide variety of audio elements—dialogue, music, special effects—that are mixed together in the final production. Preringing from A-to-D conversion of these sources can be introduced any time in the content-creation process.

Solutions: Obvious and Not

If upsampling to 96k is so effective, then every A/V playback device should have it. Unfortunately, that’s not as easy as it sounds. Upsampling itself is not a trivial task, and doing it to Meridian’s perfectionist standards is computationally intensive. In today’s 7.1-, 9.1-, or even 11.1-channel A/V processors, that’s a lot of extra processing, which is out of reach of most practical digital signal processors (DSPs). As a result, even the few products that offer basic upsampling may restrict it to certain channels or processing modes.

A Fresh Approach

Dolby’s approach to solving this problem is to fully implement Meridian’s proven upsampling process and to shift the computational burden of this processing to Dolby Media Producer, the professional product that encodes Dolby TrueHD bitstreams for Blu-ray Disc. This highly sophisticated solution is the foundation of Dolby TrueHD advanced 96k upsampling technology, a feature now incorporated in Dolby Media Producer.

Better Performance from Your Home Theater System

Dolby TrueHD with advanced 96k upsampling is an uncompromised, studio-grade algorithm, and is thus likely to perform even better than the more practical DSP upsamplers found in consumer products.

Once lossless audio is decoded in an A/V receiver, it is subjected to a variety of postprocessing steps in consumer playback systems, such as surround decoding, room equalization, and bass management. Makers of high-end A/V processors have confirmed that there are sonic advantages to performing these DSP steps at high sample rates. Any 48k content encoded with the Dolby TrueHD advanced 96k upsampling feature automatically takes full advantage of these benefits by clocking the digital bitstream at 96 kHz during the encoding process. As a result, the entire digital signal path in the A/V processor, not just the last stage prior to D-to-A conversion, is clocked at 96 kHz.

Blu-ray content encoded with Dolby TrueHD advanced 96k upsampling behaves just like any other 96 kHz Dolby TrueHD soundtracks that are currently being enjoyed on Blu-ray Disc players and A/V processors. The sonic benefits of Dolby TrueHD with advanced 96k upsampling automatically apply to every postprocessing algorithm and output channel in the playback device.

Dolby TrueHD with advanced 96k upsampling acts as a gatekeeper to prevent undesirable artifacts introduced upstream from A-to-D conversion from intruding on the sonic perfection of lossless audio delivery, and is an assurance that consumers are getting the very best audio performance possible from their playback systems. Movies, television programming, and concert videos encoded at 48 kHz will all benefit from this unique technology for Blu-ray Disc.

Dolby TrueHD with advanced 96k upsampling underscores Dolby's passion for audio and its meticulous attention to advancing the state of the art in audio playback. To take advantage of this next step in audio coding technology, look for the advanced 96k upsampling designation on specially encoded Dolby TrueHD Blu-ray content.

Benefits of Dolby TrueHD with Advanced 96k Upsampling

- Enables the highest-quality lossless Blu-ray audio experience by:
 - Minimizing the sonic impact of potential digital artifacts introduced in the production chain, preventing them from passing through to the playback system
 - Enabling an A/V receiver and Blu-ray Disc player to perform postprocessing (such as equalization or bass management) at higher sampling frequencies. The entire signal path in the A/V receiver prior to D-to-A conversion remains at 96 kHz.
- Provides listeners world-class 96 kHz upsampling performance from their playback systems
- Ensures that consumers are getting the very best playback performance possible from their Blu-ray content

Full Compatibility

Content encoded with Dolby TrueHD with advanced 96k upsampling is fully playback compatible with all Blu-ray disc players and A/V receiver products. No new hardware or upgrades are needed to experience the benefits of this technology. Blu-ray movies and television programming authored with Dolby TrueHD with advanced 96k upsampling enhance the performance of every postprocessing (DSP) algorithm and output channel in the playback product.

Technical Background

A Bit About Bits

When analog audio is converted to digital, a fundamental decision is made about what sample rate to use. Higher sample rates support higher audio frequencies, but consume higher bit rates. The compact disc format chose 44.1 kHz as the sample rate, which was the lowest that could support an audio bandwidth of 20 kHz. Any A-to-D converter requires a lowpass filter to prevent sonic artifacts called aliases from being generated. In the case of the compact disc, the required anti-aliasing filter must pass all the audio up to 20 kHz, then attenuate everything above 22.5 kHz. The resulting filter shape looks a lot like a brick wall, so that became its nickname (see Figure 2).

The Traditional Brick-Wall Filter Effect

- This type of filter can have a detrimental effect on the audio but is necessary to keep the audio from going above a certain (Nyquist) frequency.
- Dolby TrueHD with advanced 96k upsampling masks this pre-ringing artifact.

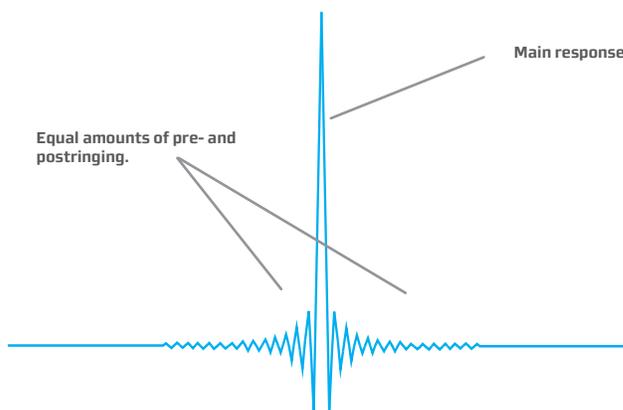


Figure 2

The audio described for this figure consists of an impulse similar to a rim shot on a snare drum. This type of sample or sound is the best manner to vividly exhibit the detrimental effect of pre-ringing.

Acoustically, this pre-ringing has a detrimental effect on high-frequency sounds such as cymbals and ambiences.

There are various ways to design anti-aliasing filters that can trade off the frequency response and rolloff characteristics for the amount of attenuation, thus minimizing the negative side effects these filters impose into the audio passband—including ripple, phase shift, and ringing. Decades of study and development have been devoted to the topic, and the CD format today sounds vastly better than that of those early days.

Even so, no single analog-to-digital filter solution is as effective as simply elevating the sample rate. The primary benefit of higher sample rates is not to extend the audio response beyond 20 kHz, but to allow a gentler lowpass filter to be employed so that the critical audio up to 20 kHz remains pure. The music industry came to this conclusion long ago, but for several well-founded reasons, the movie industry has not felt the need to follow suit.

Soundtrack Production

Movie soundtracks comprise dozens or even hundreds of sound elements captured on set, in the field, or in studios at various sample rates, and either mixed directly or converted to the 48 kHz sample rate used by digital audio workstations on dubbing stages. Each A-to-D converter and sample-rate converter includes its own anti-aliasing filter—designed with the intent to minimize distortion artifacts, but with the result that it may leave fingerprints on the audio.

Removing Fingerprints

Upsampling audio allows DSPs and D-to-A converters to perform with reduced side effects on the audio—delivering better fidelity in the process. As a result, some higher-end A/V products have begun adopting such processing. As with any algorithm, there are design trade-offs to be made that can affect DSP MIPS requirements and sound quality. Meridian Audio took an uncompromising approach to the problem, devoting all the DSP resources necessary to achieve world-class upsampling for its flagship CD player, the model 808.2. Besides performing upsampling, the process incorporates the remarkable ability to mask the side effects of any upstream anti-aliasing filters in the chain, replacing them with a filter designed to high-sample-rate, audiophile standards. Meridian calls this an apodizing filter.

It is usually the case that once audio is damaged or modified, these changes cannot be undone. But by using apodizing filters, the preringing that can be caused by certain brick-wall filters can be totally masked. Figure 3 illustrates the effect.

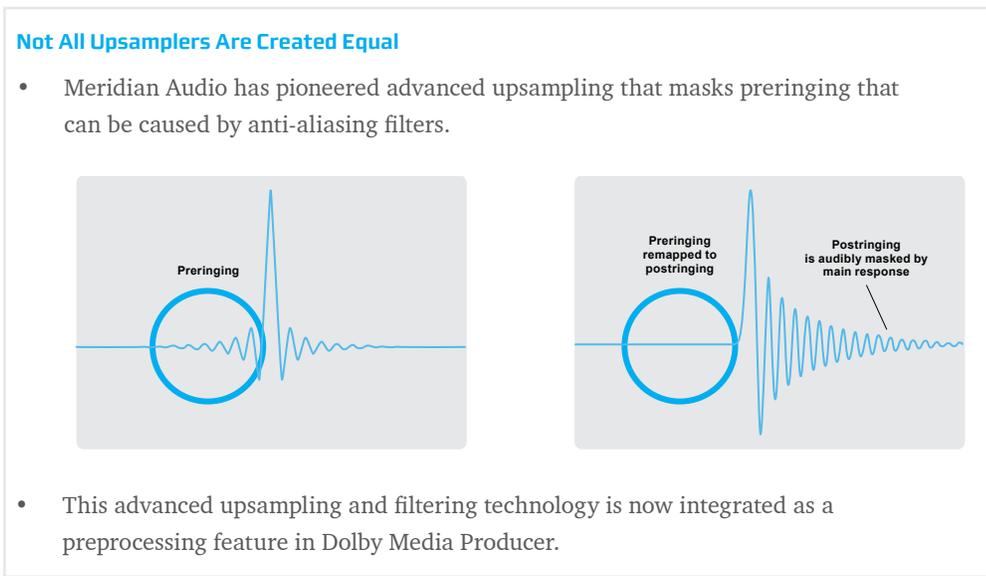


Figure 3

The apodizing filter included in Dolby TrueHD with advanced 96k upsampling technology acts as a gatekeeper to prevent undesirable artifacts introduced upstream from A-to-D conversion from intruding on the sonic perfection of lossless audio playback. Movies, television programming, and concert videos encoded at 48 kHz will all benefit from this unique technology for Blu-ray Disc.



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