



The Emergence of New Audio Formats for High-Definition DVD Standards: Design Challenges and Solutions

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The advent of next-generation high-definition DVD players, based on the Blu-ray Disc[®] and HD DVD[™] formats, presents significant design complexities for original equipment manufacturers (OEMs). While most of the attention has been placed on high-definition video, the emergence of new audio formats utilized in high-definition DVD standards poses even greater challenges for OEMs seeking to penetrate this quickly evolving consumer market.

Current system-on-a-chip (SOC) processors do not adequately address the new set of lossy (Dolby[®] Digital Plus and DTS[®]-HD High Resolution) and lossless (Dolby TrueHD and DTS-HD Master Audio) audio codec formats, which all require a higher bit rate, more memory, increased sampling frequency and better connectivity.

In order to keep pace and meet the formats' requirements for decoding the myriad audio algorithms, OEMs need a single integrated circuit (IC) solution that reduces design complexities while balancing cost, quality and time-to-market.

This paper offers an industry perspective to help OEMs understand these new standards, their audio-specific processing complexities and the impact on product designs. It also discusses current and future IC solutions that will enable OEMs to effectively address the challenges associated with high-definition DVD audio standards.

An Overview of High-Definition DVD

Upon typing the words "high-definition DVD" into any Internet search engine, you'll find a slew of reviews, blogs and other discussion on the format war between Blu-ray Disc and High-Definition DVD (HD DVD). But let's be clear: this paper is not about that ongoing battle. Rather, it's about the implications of the next-generation audio algorithms that these new high-definition DVD formats will have on OEMs designing next-generation consumer home theater products.

High-definition DVD is an evolution of standard DVD, becoming what DVD was to VHS videotapes in terms of video and audio clarity. Many television sets today are capable of displaying high-definition pictures, and the move to a high-definition DVD format is the next logical step in home theater. In fact, this year we're seeing strong growth in available movie

titles in both Blu-ray Disc and HD DVD formats already incorporating the next-generation audio algorithms.

For consumers, both new high-definition DVD formats offer exponentially better resolution and more audio capacity (7.1 or better surround sound) than standard DVDs, as well as Web connectivity for games, merchandise and content updates such as multi-language director cuts. In addition, high-definition DVD allows for extra features such as interactive content and bonus material to fit on a single disc. (See **Figure 1: Characteristics of High Definition DVD Video**).

Characteristics of High-Definition DVD Video

- **Better Picture**
 - True high-definition resolution support up to 1080p
 - Video compression standards: H.264, VC-1, MPEG-2 HL
- **Increased Capacity**
 - Up to 30 GB per single side (6x more than standard DVD)
 - More content (e.g. extra features) on a single disc
- **Web Connectivity**
 - Instant firmware updates
 - Better interactivity (e.g. games, merchandise, etc.)

Figure 1: Characteristics of High-Definition DVD Video

But for consumer home theater manufacturers, the multitude of audio decode formats can pose a challenge. The high-definition DVD formats have spawned a whole new set of lossless (the compression of audio files without losing *any* sound quality) audio codec formats that must be considered when designing new high-definition DVD players, high-definition receivers and standard audio/video receivers (AVRs).

Up until now, product designers have primarily focused on the system challenges associated with high-definition video. With a growing understanding that high-definition audio actually creates more complexity than video, however, OEMs are now realizing the challenges of supporting the six “standard” audio decode formats along with all of the legacy video and audio formats associated with today’s standard DVDs—a must, given the need for backwards compatibility to support legacy audio decoder equipment.







For the high-definition DVD market to really take off, OEMs are aware they need two things: availability of compelling content and acceptable equipment retail price points (generally less than U.S. \$250). With early high-definition DVD players requiring as many as four digital signal processors (DSPs) just for audio processing, it’s clear that in order to help OEMs achieve lower price points system costs must come down. While SOC solutions struggle in the near-term to

perform both audio and video decode tasks, separate ICs will be needed for dedicated audio decode tasks, and single-chip audio decode solution providers stand to benefit as a result.

Sound to Match the Picture

In this new high-definition DVD world, the number of audio standards has increased from two to six. Beyond the existing Dolby Digital and DTS Digital Surround, new audio codec formats include Dolby Digital Plus, Dolby TrueHD, DTS High Resolution and DTS Master Audio.

Below is a brief primer on each of the audio formats supported by the high-definition DVD formats (Blu-ray and HD DVD):

 <p>Introduced in 1992</p>	<p>Dolby Digital delivers up to 5.1 channels of surround sound audio. Dolby Digital is the multichannel audio standard for DVD-Video, HDTV, digital cable and direct broadcast satellite (DBS) systems.</p>
 <p>NEW</p>	<p>Dolby Digital Plus is the next-generation audio format that delivers "better-than-DVD" sound in high-definition packaged media because it requires less compression and provides more channels (up to 7.1). Dolby Digital Plus also provides new coding efficiencies for future broadcasting and streaming of multi-channel audio.</p>
 <p>NEW</p>	<p>Dolby TrueHD is the new audio format that delivers true high-definition sound, providing up to 7.1 channels of pristine, lossless audio 100 percent of the time. Dolby TrueHD will be found on HD DVD and Blu-ray Disc players and software, as well as in future A/V receivers and downloadable media.</p>
 <p>Introduced in 1993</p>	<p>DTS Digital Surround is the original DTS decoding format that revolutionized home theater audio. Enhanced dynamic range and improved frequency response combine to create an enveloping surround sound experience for movies and music when compared to competing audio decoding technologies available at the time.</p>
 <p>NEW</p>	<p>DTS-HD Master Audio is capable of delivering audio that is a bit-for-bit identical to the studio master. DTS-HD Master Audio delivers audio at super high variable bit rates—24.5 mega-bits per second (Mbps) on Blu-ray Disc and 18.0 Mbps on HD-DVD—that are significantly higher than standard DVDs. This high transfer rate enables delivery of 7.1 audio channels at 96k sampling frequency/24-bit depth resolution.</p>
 <p>NEW</p>	<p>DTS-HD High Resolution Audio can deliver up to 7.1 channels of sound. DTS-HD High Resolution Audio delivers audio at high constant bit rates superior to standard DVDs—6.0 Mbps on Blu-ray Disc and 3.0 Mbps on HD-DVD to produce outstanding sound quality. It is capable of delivering up to 7.1 channels at 96k sampling frequency/24-bit depth resolution. It allows content creators to deliver rich, high definition audio on movies where</p>

disc space may not allow for DTS-HD Master Audio.

Just as high-definition video has resulted in much better picture quality, high-definition audio delivers unsurpassed levels of sound clarity and capabilities. (See **Figure 2: Characteristics of High-Definition DVD Audio**).

Characteristics of High-Definition DVD Audio

- **“Studio Master” Quality Sound**
 - 100 percent lossless coding (24-bit at 192 kHz)
 - Bit-for-bit identical to the actual studio master
 - Up to 24.5 megabit per second bit rate
 - Full 7.1 surround sound channel support
- **Support for HDMI 1.3**
 - Single cable for high-definition video and audio
 - 24-bit per second for lossless audio
- **Low Bit Rate Solutions for Connectivity**
 - Internet Streaming Up to 5.1 channel at 48 kHz
- **More Content and Features**
 - Multiple mixes in a single encoded bit-stream
 - Different languages
 - Unique 5.1 and stereo mixes by content producer
 - Dialogue normalization and dynamic range control

Figure 2: Characteristics of High-Definition DVD Audio

The Shift in Focus from Video to Audio--And Inherent Design Challenges

In today’s increasingly complex design environment, the requirement to support these expansive high-definition DVD audio standards presents even greater challenges for OEMs. As a result, we’re seeing a paradigm shift around system design, whereby OEMs are placing more emphasis on audio processing algorithms than on video.

The primary challenge is bit rate. Because of new lossless audio standards, high-definition DVD audio can require twice as much bandwidth in the same period as video.

In the new DVD era, the bit rate can range from as little as 1 Mbps on Dolby to a whopping 24.5 Mbps on DTS-HD Master Audio, while tremendous advances in video compression technology enabled HD video to be at 12-15 Mbps (and even lower depending on desired resolution).

Clearly 1080p video formats would require the highest bit rates.

Due to the sheer size of the audio payload, high-definition DVD players require an entirely new digital transport from the 1.5 Mbps Sony/Philips Digital Interface Format (S/PDIF) transport utilized on standard definition DVD. High-Definition Multimedia Interface (HDMI) is an all-digital audio/video interface that has emerged as the standard for transmitting high-definition media streams. The most current version, HDMI 1.3, increases single-link bandwidth to 340 MHz (10.3 Gbps) and can carry either Dolby True HD or DTS-HD Master Audio streams for external decoding.

As a result, system designers must adhere to the HDMI standard and build a completely new interface if their products are to effectively meet the requirements for high-definition audio. Furthermore, because of digital content protection, all streams will be High-Bandwidth Digital Content Protection (HDCP)-encrypted through an HDMI transmitter, requiring multi-format decryption.

The new high-definition audio algorithms also require greater memory to support the DSP decode tasks, as well as increased DSP processing power.

For the consumer, each of the new audio formats promises an increase in sound quality, up from the typical 48 kHz sampling rate to now include both 96 kHz and 192 kHz. But, with the variety—and increased processing loads—of clocking rates that must now be supported, system designs must account for this increased resource requirement to decode and mix many differing combinations of primary and secondary audio sample rates.

Furthermore, mandatory networking for high-definition DVD players requires dual-decoding capability to support interactivity between various devices. Ideally, when two or more devices are turned on, they recognize each other's capabilities and adjust processing accordingly.

In addition to ensuring a system has all the right converters and codecs to support the new high-definition audio formats, it must also ensure backwards-compatibility with existing standards. Without question, this all presents a very complex design environment for OEMs.

Today's IC Solutions—Balancing Cost, Quality and Time-To-Market

As with any complex system design, OEMs must pay close attention to the impact on cost, quality and time-to-market, especially as they strive to hit the less than \$250 price point to achieve mass-market applicability. A negative slip in any of these areas can dramatically affect the success of their products.

While IC solutions have played a major role in the DVD player market for years, the advent of next-generation high-definition DVD players has escalated the importance of choosing the right “chip.”

Many DVD players today deploy a SOC solution, whereby various audio and video processing components are packaged into a single IC. These SOCs typically include more than one microcontroller, microprocessor or DSP core, multiple memory blocks, timing sources, power management components and other various interfaces.

While SOCs serve their purpose for several consumer electronic applications, they can be more complex, costly and time-consuming to implement. Moreover, they do not always meet intensive video and audio processing requirements because it becomes too much for the SOC to handle simultaneously.

Such is the case with next-generation high-definition DVD players, which must support three different video compression formats: H.264, VC-1 and MPEG-2. Being able to decode these complex video codecs places a heavy burden on the SOC's ability to adequately process the six new high-definition DVD audio formats.

As a result, in early generation of players, OEMs have incorporated multiple DSP chips in their design just for audio processing. And though alternative dual DSP chip solutions have emerged to partially help OEMs address these issues, they still lack the simplicity, affordability and functionality required to effectively support high-definition DVD audio in next-generation players.

Single-Chip Solution Now Available

The introduction of a single-chip solution brings relief and excitement to OEMs in the high-definition DVD player and AVR markets, enabling much easier design and support for implementing the comprehensive audio standards.

While SOCs typically focus on video, utilization of a single-chip IC solution provides additional dedicated resources to focus support on the intensive processing requirements associated with high-definition DVD audio. In addition to supporting the higher bit rate and increased memory required for lossless audio standards, a single-chip solution can streamline control logic for rapid auto detection and error concealment.

By enabling centralized digital-to-analog converter (DAC) clocking, a single-chip solution also effectively handles multiple interfaces, providing better overall management and distribution of audio. In contrast, if multiple DSPs have to interconnect with more than one clock, sequencing and audio distribution becomes much more complex.

What's more, a single-chip solution incorporates all of the necessary system components, so the vendor does not have to subcontract or "add on" various sub-components. Not only does this ensure systems have all the converters and codecs necessary for superior processing, it also translates into a lower system cost, which ultimately benefits both OEMs and consumers.

An Example

Single-chip solutions are just now appearing in the market. Cirrus Logic has applied its core audio expertise to provide OEMs a total market-ready solution for AVRs and high-definition DVD players, with all product price points in a single chip (See **Figure 3: Today's IC Solutions for High-Definition Audio**).

With its 32-bit, dual-core structure, the CS49700 generates true parallel processing power of 1.8 giga operations per second (300 million instructions per second) and supports all six Dolby and DTS surround-sound audio algorithms,

The CS49700's hardware design and software features, including firmware, are optimized for audio processing, which offers a more efficient chip solution that requires less memory and reduced overall processing power compared to many general purpose DSPs. As a result, manufacturers gain a full-featured but cost-effective IC solution that will speed the introduction of new products and give consumers an amazing audio experience.

Cirrus credits the audio-focused business structure and in-house DSP firmware team for its ability to lead the market with new algorithms, developing feature enhancements and providing real-time customer support—all of which help OEMs balance cost, quality and time-to-market.

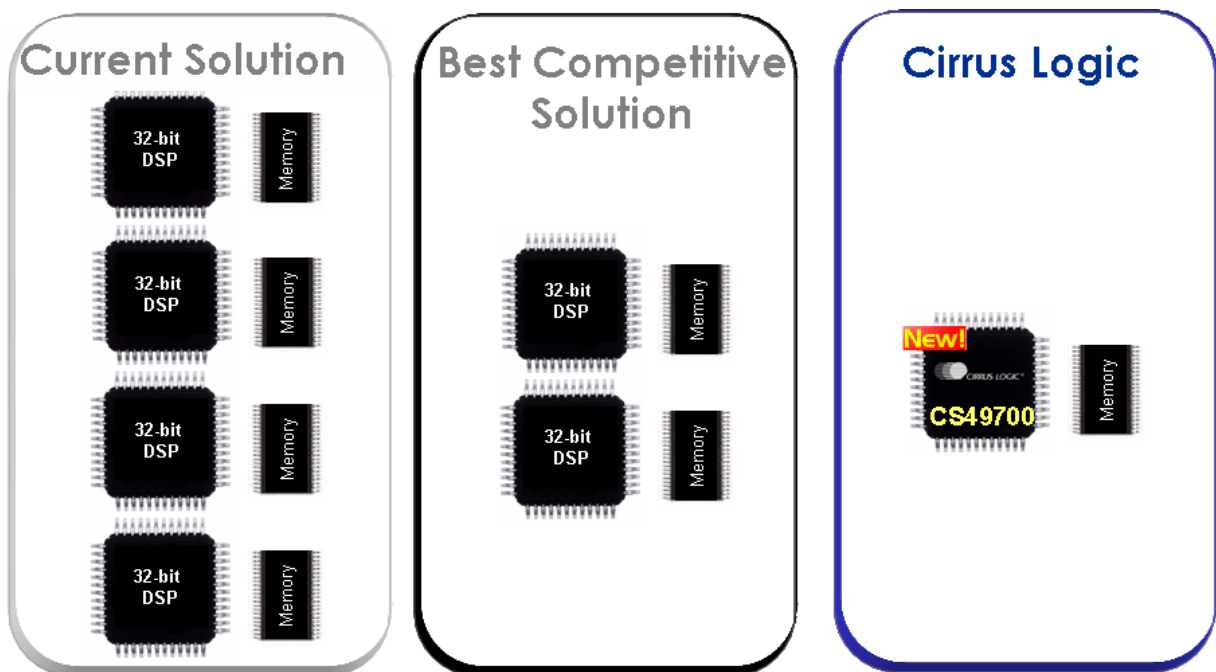


Figure 3: Today's IC Solutions for High-Definition DVD Audio.

Summary

With the emergence of next-generation high-definition DVD players based on the Blu-Ray Disc and HD DVD formats, OEMs are now required to support a more complex set of audio standards. For the player market, current SOC solutions focus more on video and do not

adequately address high-definition DVD audio processing, which requires a higher bit rate, more memory, increased sampling frequency and better connectivity.

Manufacturers of home theater receivers must be ready now to incorporate audio processing support for each of the six new high-definition audio formats associated with Blu-ray Disc and HD-DVD. Despite the uncertainty regarding which format will ultimately win out, it appears that 2007-2008 will be pivotal years for high-definition DVD. Availability of content from Hollywood is on the rise, and availability of IC solutions like the CS49700 will help the industry develop more fully capable and cost-reduced products this year, thereby spurring consumer interest.

About the Authors

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About Cirrus Logic

Cirrus Logic develops high-precision, analog and mixed-signal integrated circuits for a broad range of consumer and industrial markets. Building on its diverse analog mixed-signal patent portfolio, Cirrus Logic delivers highly optimized products for consumer and commercial audio, automotive entertainment and industrial applications. The company operates from headquarters in Austin, Texas, with offices in Europe, Japan and Asia.

For more information, please visit www.cirrus.com.