DTS-*HD*® and DTS-*HD* Master Audio™: Enabling HD Audio Across an Evolving Media Delivery Landscape

White Paper

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Executive Summary

Nine in 10 consumers rank "sound quality" and "compelling audio content" as the #1 and #2 elements of a quality listening experience (CEA). Unfortunately, most of today's popular CE products cannot deliver high definition (HD) surround sound. This is because they lack the decoding technology necessary to produce it from both low-bit-rate-streaming media and advanced, lossless audio content. By adopting next generation encoders and decoders designed for the rapidly evolving media delivery landscape, CE manufacturers and application developers can quickly tap into strong demand for HD audio and offer greater value to consumers.

DTS-*HD* and DTS-*HD* Master Audio are two versions of a new DTS decoder designed to process the high quality DTS audio streams that accompany a vast and growing library of movies and music. Using these decoders, consumers can enjoy immersive DTS surround sound (up to 7.1 channels) from physical discs (DVDs, BDs), digital delivery, video-on-demand (VOD), and file-based and broadcast media sources. When these decoders are implemented in automotive, computer, game, mobile, or connected home A/V products (offering stereo and/or multichannel playback), consumers gain access to more content sources and superior HD sound, including lossless audio.

Consumers can expect CE products with DTS decoders to feature one of the best surround sound experiences available from popular streaming and VOD content sources. And CE manufacturers and application developers can feel confident that the choice to use a DTS decoder today is a decision to give their customers the best surround sound decoding technology available now and for many years to come.

What CE Product & Application Developers Need to Succeed

Consumers are looking for out-of-the-box solutions from companies they trust for high quality sound. CE manufacturers and applications developers can shorten the path toward delivering greater audio value by choosing decoding technology that offers the following advantages:

- ✓ **Decoding of the highest quality audio streams available from digital delivery, VOD, and broadcast sources.**
- ✓ **Future-proof decoding technology that enables CE products to process more advanced audio, when available, like:**
  - Adaptive Streaming to overcome bandwidth, storage and network constraints.
  - Multi-Asset Mixing to support multi-language requirements and secondary audio features, like the Director's commentary and content for the hearing-impaired.
- ✓ **Decoding of lossless, Blu-ray™ quality HD audio from any source** (when lossless content is available).
- ✓ **Playback of legacy/current audio streams that accompany a vast library of CDs, DVDs and BDs.**

Table 1: DTS-*HD* and DTS-*HD* Master Audio Decoders

	DTS-*HD* Decoder	DTS-*HD* Master Audio Decoder	
Logo			
Channel Output[1]	2.0, 3.1 or 5.1	2.0, 3.1 or 5.1	7.1
Sampling Rate	Up to 96 kHz	Up to 192 kHz	Up to 192 kHz
[1] This row provides the required number of output channels on the product for the respective logo.			

The Power of the DTS Brand

DTS is one of the most well-known brands in audio decoding, recognized by consumers for delivering premium surround sound from Blu-ray Discs[TM] and DVDs. In fact, it is the #1 format chosen by leading entertainment studios for their movies on Blu-ray Disc[TM]. DTS is also a founding member of the Digital Entertainment Content Ecosystem and its digital locker system, UltraViolet, which includes all DTS formats.

To date, approximately 86 percent of the top 100 Blu-ray Disc[TM] titles in the market feature DTS-*HD* Master Audio, the highest quality lossless audio format.* CE manufacturers and application developers who implement DTS decoders enable their customers to tap into premium DTS audio streams that ensure the ultimate experience in entertainment. Audiophiles have consistently recognized the quality of DTS audio, giving glowing reviews of soundtracks encoded in DTS-*HD* Master Audio with DTS 7.1 and 5.1 surround sound.

Top 100 Blu-ray Disc™ Titles

Other
Dolby

Figure 1: DTS Leads the Way in High Definition Audio*

DTS also has strategic relationships with key players in the digital ecosystem, enabling its streams to be enjoyed from a wide variety of connected CE platforms and digital distribution sources. To provide universal encoding into DTS formats, DTS continues to partner with CE manufacturers, application developers, studios, professional tools providers, prosumer/consumer software developers, content aggregators, content delivery networks, and Over-the-Top (OTT) service providers.

DTS works with major content creators − including Hollywood studios and distributors − to ensure that consumers can access DTS audio from all digital delivery sources. DTS audio formats are widely supported, including in digital media standards, and DTS profiles exist in all major container formats. In addition, DTS diligently works with new standards like MPEG-DASH, assuring a presence in future containers and delivery formats.

DTS also works with Digital Rapids, which offers encoding and multiplexing of a wide range of profiles of the DTS-*HD* codec – from low bit rate to lossless DTS-*HD* Master Audio. Elemental Technologies has enabled encoding of several profiles of DTS Express[TM] audio in MPEG-4 and UV CFF containers. Rovi has also enabled encoding and multiplexing of DTS Express audio in its TotalCode and TotalCode Professional products, and the company supports DTS audio format encoding and multiplexing in SDKs for digital delivery and physical media.

Rovi's popular DivX Plus Streaming solution supports secure distribution of DTS surround sound streams to connected devices such as HDTVs, BD players, smartphones, game consoles, PCs, Macs, and cable set-top boxes. As a result, DTS audio can be delivered in Rovi offerings for the cable industry and seamlessly integrated with the Rovi Entertainment Store.

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* Note: Based on total movie units sold from 1/3/11 through 1/1/12. Data does not include Wal-Mart or Sam's Club. Most other major retailers are included. It is based on titles sold that may have multiple audio codecs. Source: © The Nielsen Company (US), LLC. Used with permission.

Big Changes in CE Markets and Media Delivery

Consumers want the best entertainment experience available, and they want it now. Judging by their most recent CE choices, it's clear that they highly favor the convenience of accessing music and movies from all their devices anytime and anywhere. In addition, they appreciate freedom from fixed broadcast schedules, the ability to catch up on missed programming, and the avoidance of commercials offered by VOD and streaming entertainment. As a result, streaming and file-based entertainment usage is exploding, even as CD and DVD sales decline and Blu-ray Disc^{TM} player sales are leveling.

In 2012, Americans are predicted to pay to consume 3.4 billion movies online – 1.04 billion more movies per year than seen on DVD and BD combined (See Figure 1). Some consumers are even opting to "cut the cord," leaving behind cable and satellite TV services in favor of on-demand streaming content from companies like Amazon, Netflix, Hulu, and VUDU.

SOURCE: IHS Screen Digest Research, March 2012

Figure 2: Online Movie Purchases Will Surpass Physical Video for the First Time in 2012

This popular shift toward more online and VOD entertainment sources has greatly changed the CE business landscape. Many CE products are now Internet-enabled. However, most of these products deliver audio that pales in comparison to high definition (HD) video. As devices have become smaller, sound quality has deteriorated and convenience has overshadowed audio quality.

Better Entertainment Access, Lower Audio Quality

Because of the technical challenges involved in delivering rich content, many TVs and portable CE products cannot deliver surround sound from streaming and file-based content. Consequently, many consumers cannot enjoy HD-quality audio as part of their entertainment experiences.

"We've tested hundreds of flat panel TVs since they first appeared," says Mike Briggs, a technology researcher reporting on flat screen TVs for the UK Website *Which? Conversation,* "but I can count on one hand the few that have delivered truly impressive sound quality. Too many are weedy, bass-free zones that give nothing but the odd spot of earache and a new level of meaning to the word 'tinny.'"

> **Mobile phones will soon be able to render multichannel lossless streams for audio playback in cars and home theater systems. They will process audio into intensely realistic surround sound through stereo headphones.**
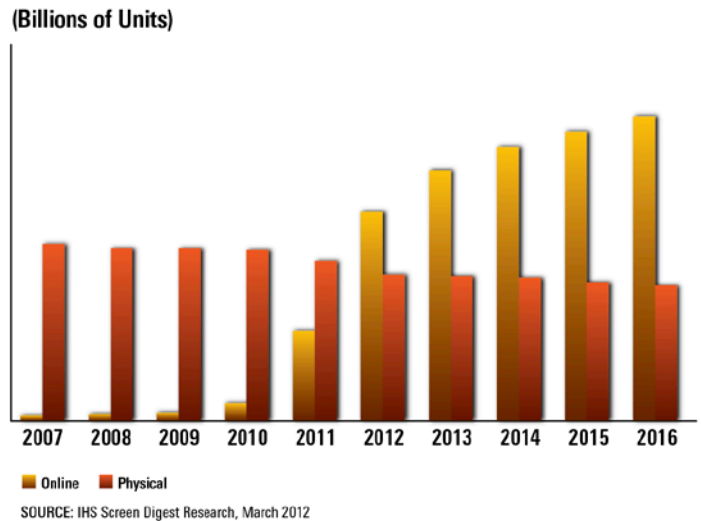
As technology has advanced, the streaming limitations holding back HD audio have been largely overcome. Processors are faster, batteries last longer, and bandwidth is growing worldwide. As a result, technology improvements have almost completely eliminated the need to sacrifice audio quality for convenient entertainment access. For instance, some broadcasters are targeting delivery of lossless audio streams for existing services. Mobile phones will soon be able to render multichannel lossless streams for audio playback in cars and
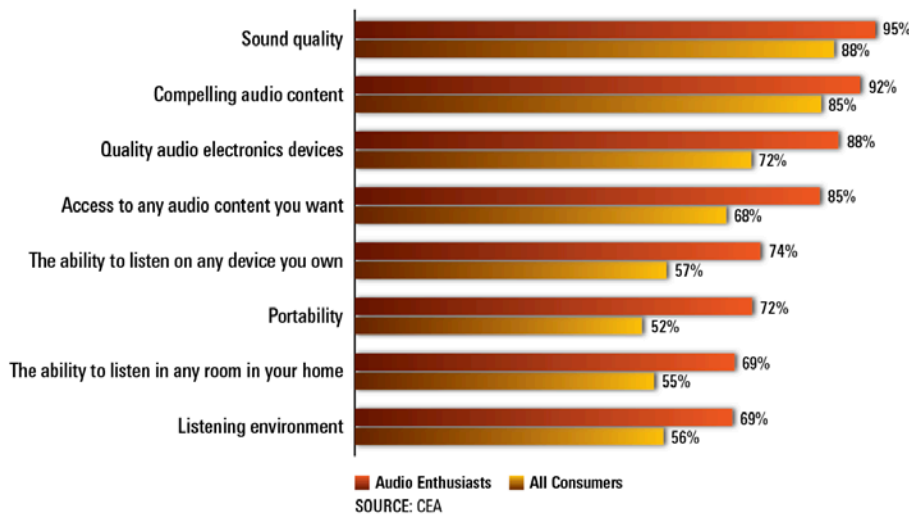
home theater systems. They will also have the ability to process audio into intensely realistic surround sound through stereo headphones.

For consumers to be able to enjoy the ultimate in-home and mobile entertainment experience, CE manufacturers must integrate more advanced audio decoders as soon as possible. This will enable their products to handle advanced streams (including lossless). As a result, consumers will see and *hear* dramatic improvements in the quality of their entertainment experiences.

Demand for Quality Audio Grows

Audio plays an extremely important role in entertainment quality – especially for movies and TV shows now being watched on TVs, phones, tablets, and PCs. The report, *Music As A Source of Emotion in Film*, demonstrated that quality audio in film soundtracks is vitally important because it "directs attention to important features on the screen (in movies)…induces mood… communicates meaning and furthers the narrative, especially in ambiguous situations [and] heightens the sense of reality of...film." (A.J. Cohen, *Music As A Source of Emotion in Film*. 2001). This also applies to non-film AV entertainment.

> **Since entertainment is significantly enhanced by high quality audio, devices with advanced audio decoders will have a competitive advantage in the marketplace.**

Figure 3: Consumers Rank "Sound Quality," "Compelling Audio Content" and "Quality Audio Electronics Devices" ahead of "Access to any audio content" and "Portability"

Consumer demand for better audio quality from *all* of CE products is on the rise. In a survey by the Consumer Electronics Association (CEA), nine in 10 consumers said sound quality is the most important component of a quality audio experience. "Sound quality, compelling audio content, and quality audio electronics" were ranked as the top "elements of quality listening," and "access to any content" and "portability" were viewed as less important, as shown in Figure 2.

This demand for higher quality audio is led by audio enthusiasts – people who tend to be early adopters of new sound technologies. Approximately 49 million US audio enthusiasts would be willing to pay extra for high quality audio content, according to the above-cited CEA study. And with sales of connected CE products on the rise, they have the technology they need to access it.

> **Approximately 49 million US Audio Enthusiasts would be willing to pay extra for high quality content.**

According to IHS, global shipments of Internet-enabled CE products will overtake PC shipments by 2013, for the first time. Based on the rapid shift toward online content sources and increasing sales of Internet-enabled devices, it is clear that *all* consumers (not just enthusiasts) strongly prefer the best entertainment experience they can get now. However, without the proper decoding to render surround sound from LBR to

lossless streams, consumers still will not enjoy the best audio experience available. Therefore, CE manufactures should move quickly to capitalize on pent up demand for high quality audio by building advanced decoding into their products.
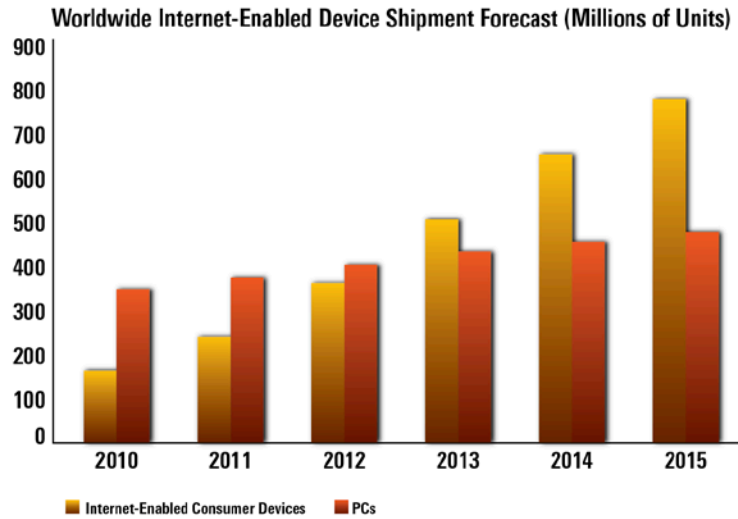
Source: IHS, *Shipments of Internet-Enabled Consumer Devices to Exceed PCs in 2013*. Press Release. 8/9/11

Figure 4: Shipments of Internet-Enabled CE Products Predicted to Overtake PCs for the First Time in 2013

Consumers are not the only ones clamoring for high quality audio. Audio professionals and recording artists also express a strong preference for higher quality audio from CE products. Artists want consumers to hear their music at the high bit rates of the original recordings, and some are pushing for stricter encoding standards to make that possible. Fortuitously, a new electronic entertainment sell-through process (see Figure 4) is taking shape that offers broader content choices to consumers. That content includes high quality audio as part of the entertainment package.

The New Media Delivery Landscape

While physical discs and "all you can eat" access to recently release movies via subscriptions (e.g., Netflix, Hulu, etc.) are still in demand, plans are in place to offer value-added purchases using the UltraViolet (UV) ecosystem. This will give consumers compelling access alternatives. UltraViolet, the leading digital rights and cloud-based licensing system, can

> **Sweden-based Spotify is making available higher bit rate music to its 10 million subscribers in Europe. To translate this into a higher quality audio experience for the consumer, advanced decoding is required.**

enable consumers to stream and download purchased content to multiple platforms and devices. They will be able to purchase movies, a la carte network shows, and cable programming from "the cloud."

UV is at the core of a new electronic entertainment sell-through sequence (Figure 4) that harnesses digital distribution and offers customers more flexibility. Top Hollywood studios, Over-the-Top (OTT) services, cable/satellite providers, and CE manufacturers are leveraging UV to provide an incentive for consumers to purchase more content and the Internet-enabled devices to play them. Higher quality audio with such content is sure to be greatly valued by consumers.

Figure 5: The New Electronic Entertainment Sell-Through Process

As the shift toward more electronic sell-through continues, deals are being made by companies like Netflix, Hulu, Pandora, and UV retailers that are beginning to clear the path toward delivery of quality audio via more CE devices. Pandora is being integrated into more and more CE products, expanding streaming playback to whole-house automation systems and automotive receivers. Sweden-based Spotify is making available higher bit rate music to its 10 million subscribers in Europe. VUDU is offering full HD video and 7.1 surround sound as a key differentiator, while Sony and Netflix are offering value-added features like full HD video and surround sound. However, consumers won't be able to enjoy the higher quality DTS audio made possible by these developments unless CE manufacturers use decoders that are capable of processing HD-quality, surround audio streams.

Table 2 describes the business models and content delivery options being used by the various OTT services.

Table 2: OTT Service Provider Business Models

OTT Service	Business Models				Viewing Options	
	EST*	Rental	Subscription	Advertising	Stream	Download
Amazon Instant Video	✓	✓			✓	✓
Amazon Prime Instant Video			✓		✓	
Disney Studio All-Access	✓				✓	✓
Flixster				✓	✓	✓
HBO GO			✓		✓	
Hulu / Hulu Plus			✓	✓	✓	
iTunes	✓	✓			✓	✓
Netflix			✓		✓	
ParamountMovies.com	✓	✓			✓	✓
Sony Crackle				✓	✓	
Sony Video Unlimited (Qriosity)		✓			✓	
Vudu	✓	✓			✓	✓
YouTube		✓		✓	✓	

* EST: Electronic sell-through. (Source: Javelin Ventures White Paper: Over-the-Top (OTT) Broadband Video Streaming: Opportunities & Challenges, 3/5/12.)

While better decoding technology is the key to processing high quality audio streams, it is important to note that the delivery of the ultimate audio experience (i.e., lossless streams) is dependent on bandwidth and encoding. To receive Blu-ray Disc^{TM} caliber, lossless surround sound, connectivity to the home must provide the greater bandwidth required to deliver high quality streams. With the deployment of fiber-to-the-home and Long Term Evolution (LTE) mobile network technology, many consumers will have access to lossless audio streams from digital delivery sources. Even small CE products, like mobile phones, will be able to receive lossless surround sound because of bandwidth improvements for mobile networks and Wi-Fi hotspots. Again, advanced decoding is the key to leveraging such advancements to deliver an immediate audio quality improvement from DTS streams.

The DTS-*HD* and DTS-*HD* Master Audio Decoding Solution

DTS believes that Internet-enabled CE products should be able to play compelling, HD-quality audio from all of a consumer's favorite content – including music, movies, and TV shows. The DTS-*HD* and DTS-*HD* Master Audio decoders were built to meet this need, guaranteeing playback of the broad array of critically-acclaimed DTS audio bitstreams. This includes the audio stream most acclaimed by Blu-ray^{TM} movie critics, artists, and engineers alike – lossless DTS-*HD* Master Audio. And, of course, both DTS decoders deliver outstanding surround sound from DVDs.

HD Audio from New Media Sources

As more consumers stream and download content, CE manufacturers must deal with a complex array of audio and video profiles in multiple container formats. Audio and video are now encoded using widely varying methods that can result in stammering, lower quality audio playback that disappoints listeners.

For the new generation of listeners who want access to the best audio available, anywhere and on any device, the new DTS-*HD* and DTS-*HD* Master Audio decoders offer access to digitally delivered, VOD, file-based content, and broadcast entertainment. And with Adaptive Streaming, content seamlessly switches – as available bandwidth changes – to provide the best bitrate possible.

Key DTS Decoder Features

DTS-HD and DTS-HD Master Audio are application-agnostic decoders designed for all CE product categories, offering simplified implementation, licensing, certification, and logos. They include future-proof technology capable of decoding high quality audio (including lossless surround) that will continue to improve as global bandwidth expands.

✓ **Guaranteed HD-Quality Audio:** Playback of critically-acclaimed DTS Audio Streams, automatically.

✓ **Lossless DTS-HD Master Audio**: Blu-ray^{TM} quality audio playback that is identical to the studio master (when lossless streams are supplied to the CE device).

✓ **Better Content Access:** Audio decoding for optical disc**,** digital delivery, VOD, file-based, and broadcast content.

✓ **Superior Handling of Low Bit Rate (LBR) Streams:** Delivers unparalleled surround sound from popular streaming and VOD content providers. DTS Express technology supports mono, stereo, 5.1, and 7.1, with superior quality and flexibility, at bit rates from 48 to 768 kbps.

✓ **Adaptive Streaming:** Seamless switching as bandwidth changes (without audio drop-outs) to a different bitrate.

✓ **Multi-Asset Mixing:** Meets multi-language requirements and supports secondary audio features, like Director's commentary and content for the hearing-impaired.

✓ **Transparent Transcoding:** If necessary, a device-compatible DTS bitstream is created in real time by the DTS Transcoder. This ensures backward compatibility and support of future DTS streams.

✓ **Coreless/Lossless Decoding:** A flexible, scalable format offering less MIPS and memory consumption.

✓ **MIPS Optimization:** To conserve power and processing resources, and reduce production costs. Enables more entry-level devices to offer superior DTS audio.

DTS-*HD* and DTS-*HD* Master Audio decoders both use highly acclaimed DTS Express low bit rate audio technology for better overall sound quality from streamed and downloaded content. In listening tests, DTS Express has received some of the best reviews when stacked up against competing technology. Listener after listener has reported that DTS Express renders a more immersive, high quality surround sound experience that is extremely life-like.

Future-Proof Decoding Technology: Adaptive Streaming & Multi-Asset Mixing

DTS understands that consumers want consistent and reliable playback performance from their CE products. Nothing is worse than having an entertainment experience interrupted by stuttering audio delivery.

With Adaptive Streaming, DTS decoders are able to seamlessly adapt to the changing input stream, thereby eliminating annoying drop-outs from streaming music.

Therefore, DTS rebuilt its decoder software development kits (SDKs) from the ground up with two key new features: Adaptive streaming and multi-asset mixing. These features combine to enable the best surround audio experience from streamed and downloaded content for years to come.

Adaptive Streaming helps smooth the content delivery process when using DTS-*HD* and DTS-*HD* Master Audio decoders. It accomplishes this by allowing streaming services to dynamically adapt the bit rate to the available bandwidth. DTS decoders are able to seamlessly adapt to the changing input stream, thereby eliminating annoying audio drop-outs, clicks or pops. As a result, consumers enjoy HD audio from streamed and downloaded content.

What's more, DTS-*HD* and DTS-*HD* Master Audio decoders are ready to process higher quality lossless streams, rendered exactly as they were captured, whenever they are available with content. A favorite of Hollywood studios and movie critics alike, lossless DTS-*HD* Master Audio offers the most impressive 7.1 surround sound audio stream experience available.

Even with CE products that have limited speaker technology, DTS-*HD* Master Audio can be put to work using sophisticated virtualization technology to place various sounds in their most lifelike and realistic surround sound positions. Furthermore, when broadcasters eventually stream lossless audio, DTS decoders will be ready to support mobile phones and other portable devices (with multichannel support and bitstream outputs) with lossless surround sound.

Multi-Asset Mixing is another feature that sets DTS decoders apart from other decoder technology. Multi-Asset Mixing meets the compliance requirements set by countries requiring the audio in their own language. It also enables secondary audio features, like the Director's commentary and content for the hearing-impaired – thereby serving the distinct needs of a much broader, global consumer audience.

Backward Compatibility with Legacy DTS Streams

DTS-*HD* and DTS-*HD* Master Audio decoders feature a built-in transcoder that guarantees playback of all DTS audio streams, with backward compatibility to legacy streams and forward compatibility to new streams. When necessary, the transcoder creates a new bitstream from the delivered DTS stream, assuring seamless playback on the CE product in use.

DTS-*HD* and DTS-*HD* Master Audio decoders are designed for ease-of-implementation across multiple product categories, with efficient bitstream processing. These two DTS decoders represent a universal standard for audio decoding that enables decoding of all current DTS content. As content providers deliver higher quality audio streams, CE products with DTS-*HD* and DTS-*HD* Master Audio decoders will be ready.

DTS-HD vs. DTS-HD Master Audio

The differences between the DTS-*HD* and DTS-*HD* Master Audio decoders are based on the distinct needs of different categories of CE products. Both decoders support all DTS audio streams and deliver impressive HD-quality sound. For CE products that require a more cost-efficient decoder package with a smaller footprint and lower MIPS (e.g., mobile, tablet, etc.), the DTS-*HD* decoder delivers all the basic DTS audio playback functionality, with up to 5.1-channels of playback. It offers an economical subset of DTS-*HD* Master Audio capabilities, plus stereo downmix of 5.1 and 7.1 sources for backward compatibility.

For CE products that can accommodate the complete DTS audio experience, such as automotive and connected home A/V equipment, DTS-*HD* Master Audio adds support for up to 7.1 channels of immersive surround audio. It supports all current DTS bitstream extensions and enables lossless DTS-*HD* Master Audio surround sound playback at sampling rates up to 192 kHz, creating a bit-exact audio experience that is exactly as the artist intended. DTS-*HD* Master Audio also features DTS Neo:6[®] technology to upmix content in CE products like AVRs, digital media players, and media PCs, delivering premium 5.1 and 7.1 channel surround sound.

Complementary DTS Technologies: DTS Neo:X and DTS Neural Surround Upmix with DICE

The DTS Neo:X[TM] and DTS Neural Surround[TM] upmixers offer advanced upmixing features that add even greater value to CE products. They can be licensed separately for use in conjunction with the DTS-*HD* and DTS-*HD* Master Audio decoders.

DTS Neo:X offers up to 11.1 channels of immersive surround sound through AV receivers, separate audio components (e.g., preamps), and automotive audio systems. It upmixes discrete audio content to new Front-Height and Wide channels, taking listeners beyond two-dimensional 5.1 and 7.1 surround sound and enveloping them overhead and side-to-side in an immersive, semi-spherical sound field with impressively realistic sound imaging.

DTS Neural Surround UpMix with Dynamic Image Control Enhancement (DICE) mode offers high performance upmixing technology for broadcasters, Internet streaming services and game developers to enhance surround sound playback of non-encoded stereo signals. It creates a clean surround sound experience with wider staging, even from compressed audio sources such as MP3s. This technology can be licensed separately for use in conjunction with DTS-*HD* and DTS-*HD* Master Audio decoders.

Additionally, DTS Neural Surround UpMix with DICE mode offers sophisticated compensation for perceptual encoding to prevent the unmasking of artifacts during the surround sound upmixing process. As a result, consumers can enjoy an immersive and natural surround sound experience from low bit rate content sources such as online streaming services, MP3s, and satellite radio.

Conclusion

Companies can quickly gain a competitive advantage in the CE product marketplace by using advanced audio decoders that enable high quality audio. Consumers no longer have to settle for stammering audio delivery and tinny low bit rate audio performance from digitally delivered media. Rather, they can use connected devices to enjoy the best surround sound experience available using the low bit rate streams offered by popular streaming and VOD content providers.

> **CE product manufacturers and application developers can feel confident that the choice to use a DTS decoder today is a decision to support the best audio technology available throughout the life of their products.**

Consumer demand is increasing for high quality audio. Consumers want the best entertainment experiences available, and they want them now. While technology to support immersive, surround audio via digital delivery has been limited in the past, it is rapidly improving. It is now possible to offer consumers HD audio from many more entertainment sources when playing music, movies, and TV shows, including physical discs (DVDs, BDs), digital delivery, download, file-based content, and broadcast entertainment sources.

From low bit rate delivery using DTS Express to bit-exact lossless streams, DTS-*HD* and DTS-*HD* Master Audio decoders are built from the ground up to deliver high quality surround sound from multiple sources. Both decoders offer future-proof DTS playback, with advanced capabilities like Adaptive Streaming and Multi-Asset Mixing. When implemented in automotive, computer, game, mobile, and home A/V products, advanced DTS-*HD* and DTS-*HD* Master Audio decoders can deliver HD audio that adds significant entertainment value and sets CE products apart from the competition. To help companies quickly benefit from these decoders, both are offered with simplified licensing, marketing and certification programs.

DTS is the #1 audio format chosen by studios for their Blu-ray^{TM} movies. As a founding member of the UltraViolet entertainment delivery system and other standards, DTS offers decoding technology that will continue to deliver the best audio quality available from the evolving media delivery landscape. CE product manufacturers and application developers can feel confident that the choice to use a DTS decoder today is a decision to support the best audio technology available throughout the life of their products. Consumers can expect CE products bearing the DTS-*HD* and DTS-*HD* Master Audio logos to support the best audio entertainment experience available, using DTS decoders.