DOLBY DIGITAL PLUS

Dolby® Digital Plus Audio Coding

Dolby® Digital Plus is an advanced, more capable digital audio codec based on the Dolby Digital (AC-3) system that was introduced first for use on 35 mm theatrical films and then chosen for consumer formats that include DVD, cable, satellite, and digital broadcast television. Today Dolby Digital Plus has been adopted for use on Blu-ray Disc™ optical media, advanced A/V receivers, and for the ATSC and DVB digital broadcast formats.

Among the factors leading to the development of Dolby Digital Plus was the need for a more efficient codec for emerging bandwidth-critical broadcast formats such as IPTV. Equally important was the need for a means to bring into the home the additional audio channels that are included in the SMPTE 428M specification for digital cinema. Digital cinema enables up to 20 channels—7 equivalent to the current 6.1 format, and 13 for additional speaker locations such as above the screen. A further factor was the necessity to provide full compatibility with the millions of existing Dolby Digital 5.1-channel home theater systems.

Dolby Digital Plus supports up to 7.1 discrete channels when implemented in Blu-ray Disc media. Designed to be expandable, Dolby Digital Plus can support up to 15.1 discrete channels in the future, while retaining compatibility with all Dolby Digital Plus players and decoders.

Dolby Digital Evolves into Dolby Digital Plus

Several approaches to extending the number of channels while maintaining compatibility with existing playback configurations have been tried. For 7.1-channel content, for example, MPEG-2 LII incorporates three preconfigured downmix subsets to enable two-, 5.1-, and 7.1-channel presentations.

For a stereo presentation, the decoder plays a two-channel downmix. For 5.1, the decoder rematrixes the two-channel downmix with a second 3.1-channel substream. For 7.1, the decoder rematrixes the reconstructed 5.1-channel program with the third two-channel substream.

However, as attractive as rematrixing seems on paper, in the real world of lossy digital audio codecs it has a significant drawback: it reveals coding

artifacts that were formerly inaudible. Upon decoding, the audio and the artifacts are routed to different speakers, thereby unmasking the artifacts. Of course, the coding bit rate could always be increased to reduce the artifacts, but that would reduce the codec's efficiency and practicality.

Dolby Digital Plus, by contrast, uses a "core plus extension" structure, a new and unique technique to address downmix compatibility. The core is a complete 5.1-channel mix, while an extension contains any additional channels.

With 7.1-channel content, for example, the Dolby Digital Plus bitstream contains a core audio packet with a 5.1 mix, plus an extension audio packet containing the original 7.1 mix's separate Left Surround, Right Surround, Left Back, and Right Back channels. To ensure that no surround information is lost in 5.1 playback, the surround channels of the 5.1 mix are downmixed from the separate surround and back channels of the original 7.1 mix. For 7.1 playback, the Left, Center, and Right channels of the core 5.1 packet are used, but its two downmixed surround channels are replaced by the four separate surround channels from the extension packet. There's no need to include a separate stereo (two-channel) mix because all Dolby Digital decoders can create a stereo mix from a 5.1 mix on the fly.

Thus Dolby Digital Plus supports both 5.1 and 7.1 presentations without the need for rematrixing and its potential for negative side effects. The high coding efficiency of Dolby Digital Plus—coupled with the large capacity of the Blu-ray Disc format—means there is no real penalty for the resulting 9.1-channel load: Dolby Digital Plus can deliver 7.1-channel soundtracks with superb quality at bit rates of 1 Mbps or less.

A Separate Approach to Lossy and Lossless Codecs

That Dolby Digital Plus enables compromise-free downmix strategies is made possible by limiting its function to lossy coding. Dolby offers a completely separate lossless codec, Dolby TrueHD (also adopted by the Blu-ray Disc format). Forcing lossy and lossless functions to be treated together—as with codecs that use a lossy core paired with a lossless extension—inevitably compromises one or the other. Either the lossy audio is degraded by rematrixing, or the lossless audio payload increases because of the extra channels it carries. The Dolby solution elegantly avoids these compromises by using the optimal method for each codec.

Dolby Digital Plus on Blu-ray Disc

Blu-ray Disc carries audio and video signals in the MPEG-2 transport stream format, the same manner in which ATSC DTV and DVB signals are broadcast. In addition to Dolby Digital Plus audio, Blu-ray Disc can also output for the first time a Dolby Digital bitstream at its maximum

of 640 kbps, which all existing Dolby Digital consumer decoders can handle. This means better performance on legacy playback systems compared to DVD, which is not able to carry Dolby Digital bitstreams of more than 448 kbps.

While Blu-ray Disc requires only Dolby Digital compatibility in all hardware players, virtually every Blu-ray Disc player features Dolby Digital Plus and Dolby TrueHD compatibility as well. When a Blu-ray™ disc carries Dolby Digital Plus (or Dolby TrueHD) bitstreams, there is also a companion Dolby Digital track to ensure playback compatibility with every player configuration. Rather than transporting separate 5.1-channel Dolby Digital and 7.1-channel Dolby Digital Plus bitstreams on the same disc, the Dolby Digital Plus bitstream is constructed as a hybrid of a 5.1 Dolby Digital core frame followed by a Dolby Digital Plus extension frame. A basic two- or 5.1-channel Blu-ray player needs only a conventional Dolby Digital decoder IC to play these bitstreams, while a more advanced player can include a Dolby Digital Plus decoder that will decode both frames for 7.1 playback.

Because the Blu-ray Disc format has no audio packet constraints, Dolby Digital Plus always operates with full six-block coding frames, just like Dolby Digital. This yields the maximum coding efficiency, and makes the process of decoding core and extension frames easier because they always have identical frame structures. It also means that in those cases where a disc and player permit direct bitstream output over S/PDIF, the core Dolby Digital bitstream can be routed directly to the S/PDIF output with no need for conversion.

The maximum bit rate for Dolby Digital Plus on Blu-ray Disc is 640 kbps for the core audio packet (carrying from one to 5.1 channels) and 1.024 Mbps for the extension packet (carrying up to 5.1 channels) for a total bit-rate maximum of 1.7 Mbps. In the future, the bit rate can rise to as high as 4.7 Mbps (a core packet plus up to four extension packets) should the format developers elect to support more than eight discrete channels.

Audio Mixing in Blu-ray Disc

Dolby Digital Plus also plays an important role in enabling the Blu-ray Disc format to provide new measures of audio sophistication that are dramatically greater than that of standard-definition DVD-Video. For example, rather than simply delivering a separate commentary track on the disc, Blu-ray Disc can mix the disc's commentary track (BonusView) or one downloaded from the Internet (BD-Live™) with the disc's main soundtrack. This means not only that new features can be delivered for a title long after the discs have shipped but also that more output options can be enabled. Players compatible with BonusView (Profile 1.1) and BD-Live (Profile 2.0) can decode all incoming streams and mix in standard PCM format, and output the PCM digital signal either directly via HDMI™

interface or through DACs as analog signals to the connected audio receiver. When equipped with Dolby Digital Compatible Output, they can also support the direct output of Dolby Digital audio bitstreams as with DVD-Video.

Low-Bit-Rate Mode

Thanks to its new high-efficiency coding tools, Dolby Digital Plus offers improved performance at low bit rates ideally suited for these new disc features. Files for BD-Live need to be as compact as possible so that they can be downloaded rapidly and take up minimum space in the player's internal memory. A commentary track can usually be mono and coded at a reduced audio bandwidth, enabling a dramatic reduction in download file size.

Connection Options for Blu-ray Disc Players

Because of the greater variety of output options, consumers need to shop carefully to select a Blu-ray Disc player with the right type of outputs for their existing equipment; they can no longer assume that every player will work with every A/V receiver. The accompanying table shows some examples of the types of connectors and output signals Blu-ray Disc players could deliver.

For some time, many A/V receivers and processors have been equipped with six- or even eight-channel analog audio inputs for high-resolution DVD-Audio or SACD playback. These inputs work equally well for Blu-ray Disc players equipped with internal decoding of Dolby Digital Plus and multichannel analog outputs. They provide consumers with full-bandwidth audio performance without having to upgrade their A/V systems.

A growing number of A/V receivers include HDMI inputs, providing a direct digital connection for the new optical disc players. A/V receivers equipped with HDMI 1.1, 1.2, or 1.3 inputs accept direct PCM (decoded from Dolby Digital Plus inside the player), while the latest generation of A/V receivers can accept and decode Dolby Digital, Dolby Digital Plus, and Dolby TrueHD bitstreams delivered by means of HDMI 1.3 inputs.

HDMI ensures not only that the full audio quality of the new HD formats is realized but also that the receiver's digital postprocessing (bass management, room compensation, speaker equalization, Dolby Pro Logic® IIx, and so on) can be performed directly on the source audio without any extra analog and digital conversion steps along the way.

Finally, for A/V receivers with neither analog nor HDMI multichannel inputs, there are Blu-ray Disc players with S/PDIF outputs for compatibility with existing home playback systems with S/PDIF inputs. Selected players employ built-in Dolby Digital encoding technology (known as Dolby Digital Compatible Output) to convert any output signal from their internal mixer

to a compatible 640 kbps Dolby Digital bitstream. Depending on the source material, 640 kbps Dolby Digital can deliver higher audio quality on existing systems than the 448 kbps Dolby Digital soundtracks on DVD-Video.

As a result of these options, Blu-ray Disc players can ensure complete compatibility with any existing A/V system and that every system attains the highest audio performance it was designed to achieve, without compromise.

Dolby Digital Plus in Broadcast Formats

Whereas the Blu-ray Disc format takes advantage of the higher bit-rate capabilities of Dolby Digital Plus, next-generation satellite, IPTV, and cable broadcast systems are considering adopting the technology because its new coding tools enable bitstreams that are roughly half the data rate of Dolby Digital. These tools include an improved filter bank, improved quantization, enhanced channel coupling, spectral extension, and a technique called transient prenoise processing.

Broadcast applications also benefit from a unique backward-compatibility feature. By means of an elegant conversion process, Dolby Digital Plus bitstreams, regardless of their source bit rate, are repackaged into a standard Dolby Digital format at 640 kbps. The conversion process does not decode the signal to PCM and reencode it, therefore avoiding the introduction of compounding coding artifacts. If the source is of sufficient quality, the repackaged 640 kbps Dolby Digital stream enables better sound with legacy A/V receivers than standard Dolby Digital broadcast audio, which is limited to 448 kbps. This benefit is unique to Dolby technology. Set-top boxes equipped with HDMI 1.1, 1.2, or 1.3 may output Dolby Digital Plus bitstreams to A/V receivers equipped with Dolby Digital Plus.

Blu-ray Disc Player Connector/Signal Types

Connector	Signal
Line output	Two-, six-, eight-channel analog
S/PDIF	Two-channel PCM, Dolby Digital
HDMI 1.1/HDMI 1.2	Two-, six-, eight-channel PCM, Dolby Digital
HDMI 1.3	Two-, six-, eight-channel PCM, Dolby Digital, Dolby Digital Plus, Dolby TrueHD bitstreams

Dual-Stream Mixing

Another new capability of particular benefit for broadcast applications is dual-stream mixing for applications such as adding an additional descriptive dialogue track for the visually impaired on top of the main soundtrack. Using the Dolby Digital Plus low-bit-rate encoding mode, main and descriptive soundtracks plus any mixing metadata can be delivered in a single Dolby Digital Plus bitstream that is easy both to produce and to distribute. Once received by the set-top box, a single Dolby Digital Plus decoder IC can handle the entire decoding and mixing process, and even convert the mixed signal to Dolby Digital for output via S/PDIF.

Providing all these capabilities with other codecs would require the set-top box to have two separate audio decoders, a mixer, metadata support, and an encoder to create a compatible 5.1 signal for S/PDIF output, resulting in significantly higher MIPS/DSP complexity and a potential for reduced quality. Improved efficiency and support for dual-stream mixing, plus the unique ability to provide a compatible Dolby Digital bitstream output via S/PDIF, make Dolby Digital Plus the ideal audio companion for advanced video codecs such as H.264 in broadcast applications.

Conclusion

Dolby Digital Plus delivers the flexibility and quality demanded by content providers, broadcasters, and home theater enthusiasts. It delivers superb multichannel audio without impacting the data needed for high-quality video or added-feature content, while also enabling multiple surround audio streams when required. And it enables advanced HD optical players both to extract the maximum capability from existing digital A/V surround systems and to deliver their expanded sonic benefits without compromise on newer systems.

Dolby Laboratories, Inc.
100 Potrero Avenue, San Francisco, CA 94103-4813 USA T 415-558-0200 F 415-863-1373
Wootton Bassett, Wiltshire SN4 8QJ England T 44-17093-842100 F 44-1793-842101

dolby.com

S08/19052/20073