PRELIMINARY INFORMATION

DOLBY DIGITAL PLUS PULSE

Audio for Next-Generation Broadcast Services: The Dolby MS10 Multistream Decoder Solution

Summary

- Two multichannel audio formats—Dolby® Digital Plus and Dolby Pulse—are attractive for next-generation broadcasts for different reasons, and it is likely that both will be used for new European services.
- Key new European HDTV receiver specifications include both Dolby Digital Plus and Dolby Pulse.
- Dolby is developing a new multiformat audio decoder implementation that will ease the inclusion of dual decoders in new receivers.

Broadcaster and Operator Requirements

Over the last 18 months, various European industry groups such as DVB, EBU, EICTA, and a number of national HDTV specification forums have considered the selection of audio coding systems for next-generation broadcast applications, including HDTV broadcasts, using MPEG-4 video. In general, these considerations have highlighted two standardized audio coding systems as particularly suited to next-generation transmissions: Dolby Digital Plus (also known as E-AC-3) and Dolby Pulse (Dolby's implementation of aacPlus or HE AAC). The EBU Project Group D/MAE, for example, concluded that the two coding formats are the best candidates for broadcasting HDTV audio services via satellite, cable, terrestrial, and IPTV networks.

Due to the diverse market requirements of different broadcaster/operators and the differing feature sets of these technologies, it has not generally been possible for these groups to recommend a single audio system that suits all applications. For example, Dolby Digital Plus currently offers comprehensive support for 5.1-channel sound as well as advanced metadata support. Dolby Pulse will also offer this support in the near future, along with its already formidable coding efficiency, which today enables quality stereo services to be transmitted at extremely low data rates.

In addition, over 200 European TV services already broadcast with conventional Dolby Digital audio, so next-generation receivers typically need to be compatible with this format.

While Dolby Laboratories intends to distribute a commercial release of Dolby MS10 Multistream Decoder, Dolby Laboratories reserves the right, at any time, not to release a commercial release of Dolby MS10 Multistream Decoder or, if it does so, to alter prices, features, specifications, capabilities, functions, licensing terms, release dates, general availability, or other characteristics of the commercial release.

	Dolby Digital Plus	HE AAC with Transcoder	Comments
EBU	✓	✓	See note 1.
EICTA	✓	✓	See note 2.
HD Forum (France)	✓	✓	Both Dolby Digital Plus and HE AAC required for terrestrial TV. See note 3.
NorDig (Sweden, Norway, Iceland, Finland, Denmark)	✓	✓	Both Dolby Digital Plus and HE AAC required. See note 4.
Spanish HD Forum	✓	✓	Both Dolby Digital Plus and HE AAC required in horizontal markets.

Table 1 Multichannel audio requirements in various European HDTV specifications.

Notes

1. The EBU Project Group D/MAE states that Dolby Digital Plus and Dolby Pulse are the best candidates for broadcasting HDTV. It states that both Dolby Digital Plus and HE AAC have advantages, and a single preference cannot currently be identified. Dolby Digital (Plus) offers consistently great performance at 448 kbps and above; HE AAC offers remarkable performance where data rate is limited.

2. The EICTA HDTV receiver specification requires Dolby Digital Plus or Dolby Pulse with transcoder output. A single universal audio solution has not been identified, so effectively both will be included unless manufacturers can be sure that a single format will be transmitted in all regions where the product is sold.

3. Whereas an HE AAC multichannel decoder (with downmix capacity) is required from the start of the service in October 2008, an HE AAC transcoder will be required after December 31, 2009.

4. NorDig requires dual decoders unless the operator can guarantee that a single audio format will be used within the entire market for the product.

European HDTV Receiver Specifications

As DVB does not specify which audio coder should be used for next-generation broadcasts, various broadcaster/manufacturer groups have recently worked collaboratively to gain consensus on the formats desired by broadcasters, which will then be included in European receivers. The key outcomes for multichannel format requirements so far are described in Table 1.

A New Multiformat Audio Decoding Solution

In November 2007, Dolby Laboratories acquired Coding Technologies, the leading contributor to the HE AAC standard. Dolby intends to bring to market a new licensable audio decoder implementation that offers support for Dolby Digital Plus (including Dolby Digital) and Dolby Pulse decoding in a single package. This implementation will reduce the complexity and cost of incorporating all audio technologies in new receivers as well as simplify product development and testing while meeting current requirements for next-generation HDTV services.

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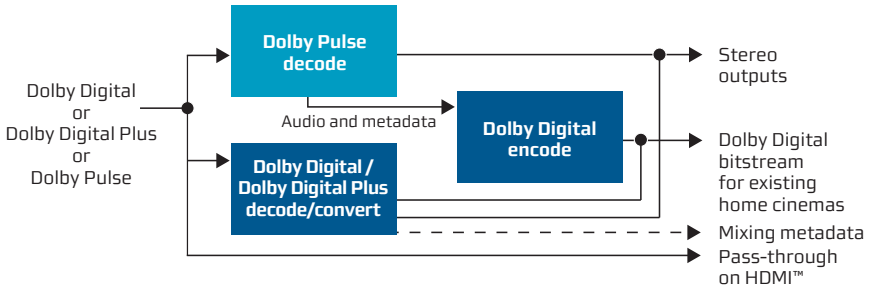

Figure 1 Block diagram of the multiformat Dolby MS10 Multistream Decoder for broadcast devices, TVs, and set-top boxes.

The Dolby MS10 Multistream Decoder will offer the following key benefits:

- A universal solution that maintains flexibility for broadcasters to choose the format that best suits their requirements: Dolby Digital Plus, Dolby Pulse, or Dolby Digital.
- Ease of implementation because deliverables, technical support, and testing are available from a single source: Dolby.
- Reduced licensing costs compared with the existing Dolby Digital Plus, Dolby Pulse, and transcoder option.
- Full compatibility with Dolby metadata and consumers' existing DVD home cinema systems with all transmission formats.
- Full multichannel support (transcoder) for Dolby Pulse in addition to Dolby Digital and Dolby Digital Plus decoding and conversion. One Dolby Digital output for all input formats.
- Support for audio description services delivered "receiver-mix" style using two simultaneous instances of Dolby Pulse, Dolby Digital, or Dolby Digital Plus decoders, respectively—all for the price of a single decoder instance.
- Support for multiprogram Dolby Digital Plus streams (main and associated audio delivered in the same audio stream).

The integrated decoder/transcoder and converter combines the ability to decode Dolby Digital, Dolby Digital Plus, and Dolby Pulse within one product. All of these input signals coming into the decoders for the main audio are passed through unaltered for output over HDMI™ and S/PDIF interfaces (Dolby Digital Plus is converted to Dolby Digital; Dolby Pulse will be passed once interface definitions are final).* The signals coming into the decoders for associated audio are not passed through the system but are decoded and sent to the mixing engine instead to support receiver-mix audio description.

At the same time, a two-channel downmix is always created from any of the input formats in order to support decoded output (for example, for analog outputs) of a broadcast device. For maximum compatibility, a multichannel decoder for Dolby Pulse is integrated to feed an embedded Dolby Digital encoder with a multichannel signal (up to 5.1 channels), which then outputs a standard Dolby Digital bitstream (up to 5.1 channels) at a fixed bit rate of 640 kbps for maximum compatibility and connectivity over S/PDIF and HDMI interfaces.

Dolby Digital and Dolby Digital Plus inputs are handled by the integrated Dolby Digital Plus decoder/converter, which provides a two-channel downmix for decoded outputs while converting Dolby Digital Plus streams to Dolby Digital in order to provide maximum compatibility on the S/PDIF output.

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The Dolby MS10 Multistream Decoder supports simultaneous decoding of main and associated audio for Dolby Pulse and Dolby Digital/Dolby Digital Plus, respectively, to support basic two-channel mixing (Dual-Decode mode) in order to meet European broadcast specifications for next-generation audio. Audio will be mixed in an external mixing module outside of the decoder. However, the system will provide the mixing metadata potentially carried within Dolby Digital Plus as a serial bitstream on one of its outputs. This mixing metadata shall be used to control the mix in the external/system-level mixing module. The implementation of dual decoding (Dual-Decode mode) is optional but strongly recommended.

** Transmission of Dolby Pulse streams via HDMI or S/PDIF connections will be enabled in the future as the specifications necessary to transmit the technology across these interfaces are completed.*

Comparing AAC Varieties and Dolby Pulse

Dolby Pulse is an optimized implementation of the MPEG-4 AAC family of audio codecs. It is designed by Dolby to bring additional functionality, flexibility, and reliability to the format while remaining fully backward- and forward-compatible with MPEG-4 AAC, MPEG-4 HE AAC v.1, and MPEG-4 HE AAC v.2 as defined in ISO/IEC 14496-3:2005.

Advanced Audio Coding (AAC) is a perceptual coding method used to compress digital audio for efficient storage and transmission. Upon playback, the expanded files can provide sound quality nearly indistinguishable from the original sources. In principle, AAC is similar to MP3, but it offers a number of advantages:

- More efficient compression
- Higher sampling frequencies
- Better frequency response
- More channels

Dolby Pulse is based on AAC. Versions 1 and 2 of aacPlus add spectral band replication (SBR) to improve efficiency and lower bit rates. In addition to SBR, aacPlus v.2 uses Parametric Stereo (PS) to further improve efficiency and lower bit rates by transmitting a mono channel with parametric information to extract stereo from it.

Both SBR and PS are backward- and forward-compatible. As a result, Dolby Pulse offers 5.1 audio at 160 kbps, nearly CD-quality stereo at 32 kbps, excellent-quality stereo at 24 kbps, and good quality for mixed content even below 16 kbps mono. A Dolby Pulse v.2 decoder can also decode aacPlus v.1 and AAC bitstreams.

The main difference between Dolby Pulse and standard MPEG-4 HE AAC is the support for audio metadata. The specification for MPEG-4 HE AAC describes a number of optional metadata parameters to control the reproduction of the audio signal in a consumer device such as a set-top box or a television set. Dolby Pulse implements some of these parameters.

Dolby Pulse integrates all metadata parameters required to allow the system to function as a broadcast audio system such as Dolby Digital and Dolby Digital Plus. It also offers significant improvements in the following areas:

- **Decoder stability:** Compared to generic HE AAC implementations, Dolby Pulse offers highly optimized switching times between channel configurations and improved reliability when used in a system with Dolby Pulse encoders.
- **Error concealment:** Sophisticated error concealment mechanisms have been added to Dolby Pulse to ensure reliable broadcast audio performance.

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- **Decoder requirements in terms of memory and computational complexity:** Dolby Pulse decoding within the Dolby MS10 Multistream Decoder platform is integrated into a combined code base that is optimized for H.264 system-on-chip architectures.
- **Encoder audio quality:** Dolby Pulse offers superior audio quality compared to other parametric audio codecs.

Since the inclusion of audio metadata in MPEG-4 AAC–based bitstreams is optional, the Dolby MS10 Multistream Decoder features mechanisms within its transcoder that optimize audio quality in cases where an incoming standard MPEG-4 HE AAC bitstream that contains no metadata is being decoded. Best possible performance of the entire broadcast system can only be achieved when the Dolby MS10 Multistream Decoder processes a Dolby Pulse stream generated by an appropriate Dolby Pulse encoder.

The Dolby MS10 Multistream decoder/transcoder and converter decodes various types of AAC content to PCM, and simultaneously transcodes this content to Dolby Digital for multichannel bitstream output. AAC formats supported include:

- Dolby Pulse
- aacPlus
- MPEG-2/4 AAC
- MPEG-4 HE AAC v.1
- MPEG-4 HE AAC v.2

The Dolby MS10 Multistream Decoder platform is designed to initially support DVB devices only (LATM/LAOS formatting). However, the source code deliverables already contain support for the use of Dolby MS10 Multistream Decoder in broadcast devices designed for ARIB (ISDB-T) systems. Full support of ARIB will require modifications to the implementation development kits (IDKs) and system development kits (SDKs).

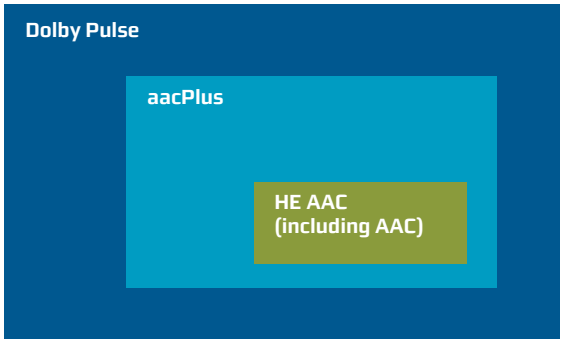

Figure 2 Dolby Pulse's feature set exceeds that of any existing AAC solution while remaining fully backward-compatible and in line with MPEG-4 specifications.

The support for the extended features of Dolby Pulse is implemented in a dedicated code base that is part of the Dolby MS10 Multistream Decoder. This extended code base refines the capabilities and reliability of existing HE AAC or aacPlus decoders and is therefore an essential and unique ingredient to the Dolby MS10 Multistream Decoder implementation. However, the Dolby MS10 Multistream Decoder provides full backward- and forward-compatibility to all AAC implementations and bitstreams; Dolby MS10 Multistream decoders will always be able to decode any form of AAC audio, while Dolby Pulse streams can be decoded on any HE AAC decoder platform (although with reduced functionality and performance).

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Broadcast Mix Versus Receiver Mix

Audio description has long been provided by broadcast services. The PAL system, for example, makes it possible for the second FM sound subcarrier, otherwise used for the Right channel in stereo transmissions, to carry an alternative version of the main soundtrack carried on the first FM subcarrier. While this "broadcast-mix" approach limits the transmission to mono main and associated audio soundtracks, it is an efficient way to provide a basic service for the visually impaired. Figure 3 shows the symbol used by European broadcasters to mark transmissions offering audio description.

Figure 3 Symbol used by European broadcasters for transmissions offering audio description.

This broadcast-mix approach, whereby the main and commentary tracks are mixed in postproduction prior to transmission, was carried over into digital television (DTV) systems because early receivers offered only basic functionality and the sources for digital transmissions were often still stored on analog media. This approach is also similar to that taken by the NTSC system where a secondary audio program (SAP) carries a premixed version of main and audio description tracks as a mono signal. However, due to the affiliate broadcast structure in the US, technical impediments can interfere with passing through a SAP signal on cable and satellite systems, making the service less accessible to viewers.

Many European public broadcasters offering a large portion of their programming with audio description services are facing the challenge of continuing to distribute their audio description service "analog style"—that is, leaving main audio on the Left channel and audio description on the Right channel of what is basically the main broadcast audio track carried as a stereo signal but signaled as dual mono. This requires broadcast receivers to pass only the Left channel or Right channel to their audio outputs. However, since this is not a requirement within DVB, which mandates that different audio services be transmitted and signaled using different audio PIDs, receiving and recording these services becomes a major challenge.

To date, transmitting audio description services in the form of a broadcast mix is standard practice in many parts of the world. Efforts to offer a more efficient way to provide services for the visually impaired in the form of a receiver-mix approach have culminated in the creation of a specification that is now part of DVB.

Annex E of ETSI TS 101 154 describes a basic approach to transmitting an isolated mono signal containing the description track alongside the main soundtrack as a separate bitstream. A suitable broadcast receiver can then perform the mixing of the main soundtrack with the commentary track in the device itself, hence the term "receiver mix."

Figure 4 shows the receiver-mix architecture designed to support mixing for audio codecs supported by the Dolby MS10 Multistream Decoder as well as from other sources such as MPEG-1 Layer II.

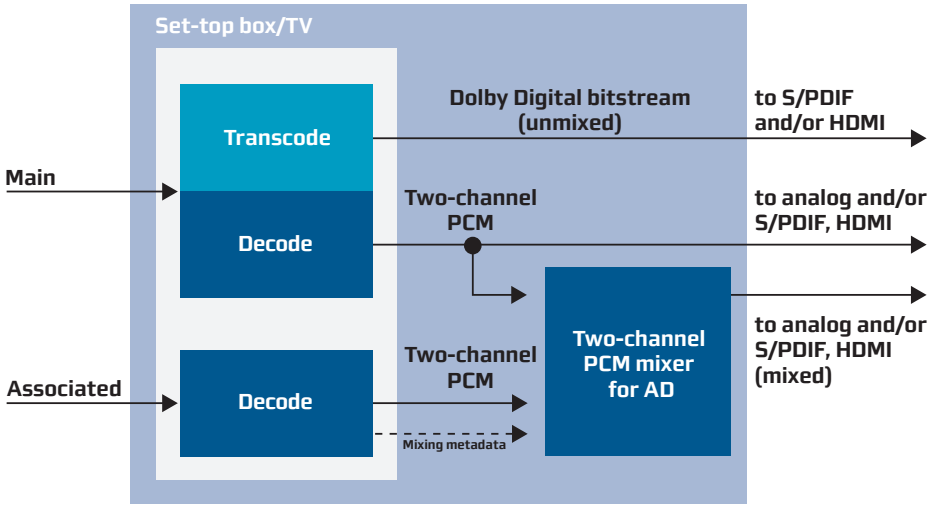

Figure 4 Mixing support as part of Dolby MS10 Multistream Decoder for audio description.

Mixing Architecture

The mixing of associated audio streams delivered as substreams with the main broadcast audio or as separate low-bit-rate audio streams enables services such as audio descriptions for the visually impaired or director commentaries, while at the same time maintaining the highest possible bandwidth efficiency.

This receiver-mix approach negates the need for broadcasters to transmit several final mixes to support multiple audience preferences. It is necessary only to add low-bandwidth substreams containing the additional information along with mixing metadata that determines how the associated audio stream is combined with the main broadcast audio track in the receiving device. There is strong demand for this feature from public broadcasters in Europe for future applications, and it can add another differentiating feature to broadcast devices that will help to drive the success of next-generation digital television services around the world.

Audio Service	Codec	Substream Usage	Channel Configuration
Main	Dolby Digital (AC-3)	N/A	Up to 5.1 channels
	Dolby Digital Plus (E-AC-3)	Independent substream 0	Up to 7.1 channels
	Dolby Pulse (aacPlus)	N/A	Up to 7.1 channels
Associated: Delivered in same bitstream as main audio service (as described in ETSI TSI 102 366)	Enhanced AC-3 (main audio must be AC-3 or Enhanced AC-3)	Independent substream 1 Independent substream 2 Independent substream 3	Up to 7.1 channels
Associated: Delivered in separate MPEG PES	E-AC-3 (main audio must be AC-3 or Enhanced AC-3)	Independent substream 0	Up to 7.1 channels
	aacPlus (main audio must be aacPlus)	N/A	

Table 2 Input formats for main and associated audio supported by the Dolby MS10 Multistream Decoder.

This design supports mixing one main audio service with one associated audio service. The associated service can be delivered in the same E-AC-3 bitstream as the main service through the use of an additional independent substream, or as an E-AC-3 bitstream carried in a separate MPEG PES. In the case of Dolby Pulse, the associated audio service is delivered as a Dolby Pulse bitstream carried in a separate MPEG PES.

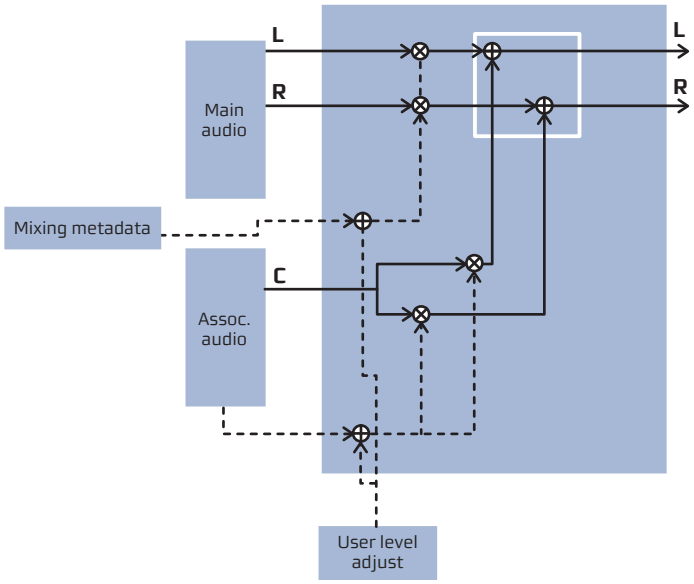

Figure 5 Mixer: 2/0 main audio, 1/0 associated audio (panning metadata enabled).

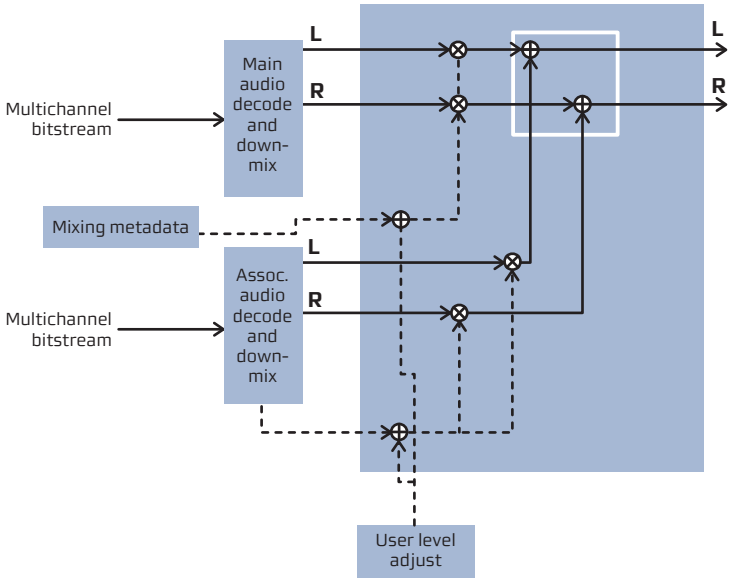

Figure 6 Mixer: 2/0 main audio, 2/0 associated audio (panning metadata disabled).

Information on the type of associated audio service is carried in the Dolby Digital Plus or Dolby Pulse descriptor that is found in the program map table (PMT) of the incoming MPEG-2 transport stream.

Each Dolby Digital Plus or Dolby Pulse bitstream used for the broadcast service has an identifying descriptor that the broadcast receiver device uses to inform the user which associated audio services are available. When the user selects a desired service, the broadcast receiver device demultiplexes it from the MPEG transport stream and delivers it to the Dolby MS10 Multistream Decoder. The following examples illustrate how this approach works in practice.

Example 1

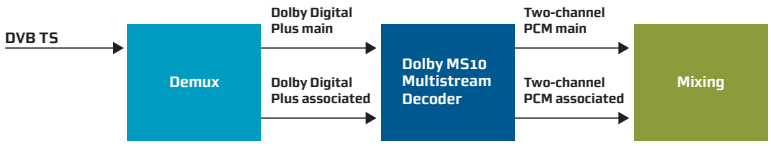

Figure 7 Main and associated audio delivered as Dolby Digital Plus in separate elementary streams.

The user selects an associated audio service being carried in a separate MPEG PES associated with the main audio service through its Dolby Digital Plus descriptor (see Figure 7). The broadcast receiver demultiplexes both Dolby Digital Plus streams from the broadcast transport stream, and passes them to both inputs of the Dolby MS10 Multistream Decoder. The decoder receives information on the user's stream selection from the system layer of the broadcast receiver device and activates both inputs, then decodes and mixes the two streams. The mixing metadata is carried in the Dolby Digital Plus bitstreams containing the associated audio track.

Example 2

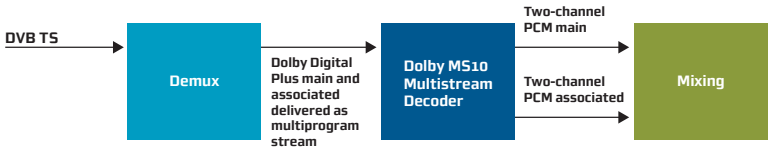

Figure 8 Main and associated audio delivered as Dolby Digital Plus in one multiprogram elementary stream.

The user selects an associated audio service that is being carried in an additional independent substream within the Dolby Digital Plus main audio bitstream (see Figure 8). The broadcast receiver demultiplexes only the main audio bitstream, while the Dolby MS10 Multistream Decoder receives information on the user's associated service selection from the system layer of the broadcast receiver device and activates its main audio input only. The decoder then uses the substream parser in the main audio chain to separate independent substream 0 (main audio) from the independent substream carrying the associated audio. The associated audio service is then routed inside the decoder to the associated audio input of the mixer, and both independent substreams are decoded and mixed. The mixing metadata is carried in the Dolby Digital Plus bitstreams containing the associated audio soundtrack.

Example 3

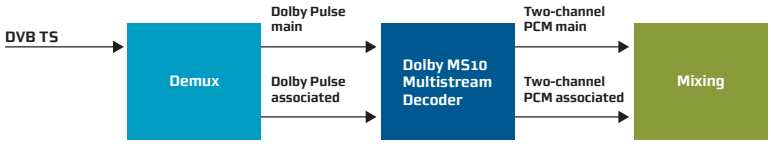

Figure 9 Main and associated audio delivered as Dolby Pulse in separate elementary streams.

The user selects an associated audio service that is being carried in a separate MPEG PES associated with the main audio service through its Dolby Pulse descriptor (see Figure 9). The broadcast receiver demultiplexes both Dolby Pulse streams from the broadcast transport stream, and passes these streams to both inputs of the Dolby MS10 Multistream Decoder. The decoder receives information on the user's associated service selection from the system layer of the broadcast receiver device, activates both inputs, then decodes and mixes the two Dolby Pulse bitstreams. The mixing metadata is carried in the PES header information of the Dolby Pulse bitstreams and has to be passed to the decoder from the system-level parser of the broadcast receiver device.

The Complete System Architecture

Dolby is also developing professional multichannel encoding solutions intended to further simplify the use of Dolby Pulse for broadcasts, including full support for Dolby metadata and compatibility with existing Dolby E infrastructure.

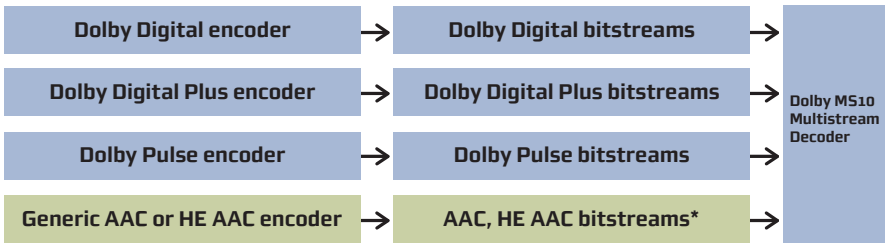

Figure 10 Dolby MS10 Multistream Decoder supports the Dolby family of broadcast bitstreams with maximum features and functionality within Dolby Digital Plus and Dolby Pulse systems.

*Generic AAC and HE AAC streams are supported but limited to basic functionality as specified in ISO/IEC 14496-3:2005.

Conclusion

Due to differing requirements among broadcasters, Dolby recommends that next-generation receiver specifications generally include both Dolby Digital Plus and Dolby Pulse decoding. This is in line with recent specifications published by EICTA and the French, Spanish, and Nordic groups, which do not identify a single preferred audio option. The Dolby MS10 Multistream Decoder implementation will significantly ease the design and manufacturing of receivers including dual audio decoders.

Resources

Standards document ETSI TS 102 366, V1.2.1, "Digital Audio Compression (AC-3, Enhanced AC-3) Standard," August 2008.

Standards document ETSI TS 101 154, V1.8.1, "Digital Video Broadcasting (DVB): Specification for the Use of Video and Audio Coding in Broadcasting Applications Based on the MPEG-2 Transport Stream," January 2007.

Louis D. Fielder et al., "Introduction to Dolby Digital Plus, an Enhancement to the Dolby Digital Coding System," 117th AES Convention, October 2004.

Advanced Television Systems Committee, "Digital Audio Compression Standard (AC-3, E-AC-3) Revision B, Document A/52B," June 2005.

Standards document ISO/IEC 14496-3:2005, "Information Technology—Coding of Audio-Visual Objects—Part 3: Audio," January 2005.

DOLBY

Dolby Laboratories, Inc.

100 Potrero Avenue, San Francisco, CA 94103-4813 USA T 415-558-0200 F 415-863-1373

dolby.com