



System Solutions Using Dolby-E Technology

Introduction

For several years, the home viewer's listening experience was restricted to either mono or stereo audio generated by stereo analog production facilities. These facilities could also produce a surround sound product using Dolby Surround Pro Logic encoding which is compatible with stereo analog paths and storage devices used in audio production.

The introduction of DTV required a new digital audio technology. Dolby Digital (AC-3) and Dolby E formats both provide compressed multi-channel (surround capable) solutions that are compatible with 2-channel systems using AES3.

In this document, we

- Describe Dolby Digital and the need for Dolby E.
- Show how Miranda applies Dolby technology to solutions supporting contribution-quality audio within a typical broadcast facility.

Dolby Digital (AC-3)

Starting back in the late 1980s, the Advisory Committee on Advanced Television Service in the United States determined that a surround sound standard should be developed for HDTV. Originally, the existing Pro Logic Matrix system was proposed but was not considered robust enough. A 4-channel system was examined but was dropped because it would require twice the bit rate to achieve a nominal improvement in surround quality. Finally Dolby Digital (AC-3) was conceived as a high-quality multi-channel audio codec format that outperformed Pro Logic but still fell within the bit rate of a 2-channel system.

The first application of Dolby Digital was not in television but in cinema. A 5.1 split surround system already existed in 70mm theaters and it was determined that AC-3 would be compatible with both 35mm and 70mm film. As a result, a data rate of 320kb/s was required so that it could fit between the sprocket holes on 35mm film.

Today, AC-3 has been adopted as the audio standard by most DTV systems worldwide. The standard supports up to six channels of audio within an AES3 frame. Typical deployment is at 384kb/s for 5.1 surround (3/2) and 192kb/s for stereo (2/0). The standard can support up to 640kb/s which is typically used for DVDs. One U.S. network uses 640kb/s as a mezzanine distribution format to their affiliates. ATSC limits AC-3 to 448kb/s for terrestrial transmission.

When compared to the 3.072Mb/s required for two channels of linear PCM data sampled at 48kHz in an AES transport, a rate of 384kb/s represents a substantial amount of compression. This amount of compression is necessary so that multi-channel audio can fit along with HD video in a 19.4Mb/s signal for ATSC.

Dolby can attain such a high level of compression by fine-tuning bit allocation in their algorithms to match the frequency sensitivity of the human ear. Not only are bits dynamically concentrated on these chosen frequencies but also on the noise associated with those frequencies as well. All of this adds up to a high quality distribution audio format at a very low data rate.

AC-3 also has *metadata* that is attached to the audio payload. Settings such as dynamic range control (DRC) and dialog level ("dialnorm") can be set with this metadata.

However, just as in ATSC video (1.485Gb/s through 19.4Mb/s), a highly compressed distribution format such as AC-3 is not recommended for contribution-quality audio processing. For example, each time AC-3

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Dolby Digital (AC-3)

is decoded and encoded (cascaded), distortion (particularly noise) is introduced by the audio encoding technique using the very low number of bits available.

Dolby Digital Plus (E-AC-3)

Both ATSC and DVB¹ have approved a new audio standard known as Dolby Digital Plus or Enhanced AC-3. This format offers higher compression making it compatible with MPEG 4 and H.264 encoding with increased audio channel capacity. E-AC-3 is being introduced with a 7.1 capacity that will result in a 13.1 channel capability when it is fully released. One of many advantages to this format is the ability to distribute SAP in surround along with the main program audio.

AXON is currently introducing the first Dolby Digital Plus encoders available on the market as a new entry in the Synapse modular product line.

Dolby-E

AC-3 audio works very well as a distribution format because it has a very low bit rate and can allow multi-channel audio to pass through dual-channel signal paths and storage devices. However, when it comes to contribution-quality audio production, AC-3 has two significant weaknesses:

- AC-3 was designed to provide the highest quality at the lowest bit rate. Cascading (more than one encode/decode cycle) can result in loss of quality.
- When AC-3 is decoded, the metadata is no longer available.
- There are no splice points with video, resulting in disruption of audio during transitions.

In 1999, Dolby introduced Dolby E, which allows up to 8 channels of audio to be carried within an AES3 transport in accordance with SMPTE 337M. The most common channel configuration is 5.1 surround with Lt/Rt stereo. It supports options such as 8 mono channels or 4 stereo channels as well.

Like AC-3, Dolby E is compatible with dual-channel signal paths and storage devices. Unlike AC-3, Dolby E has a much higher bit rate (1.92Mb/s with 20-bit data) that allows several encode/decode cascades with minimum distortion (approximately 10 cascades for 5.1 plus Lt/Rt). Dolby E can be used as a mezzanine format for network distribution and in-house production of contribution audio content in the same way that using a mezzanine level (usually around 45Mb/s) is used for HD-SDI video.

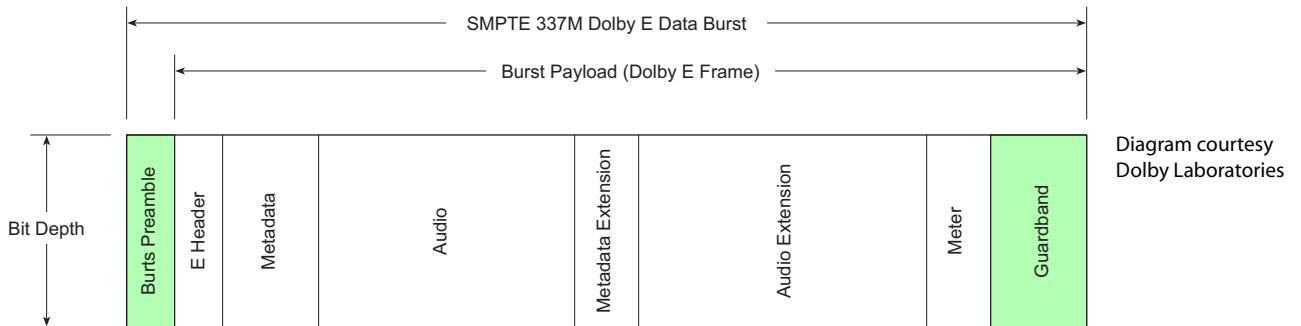
A major feature of Dolby E is that its metadata can be extracted from a Dolby E decoder onto an RS-485 bus. The metadata can either be modified or sent directly to a Dolby E (or AC-3) encoder where it is encoded with discrete audio channels processed within the facility.

It is Miranda's philosophy to pass through Dolby E metadata as the original author intended. Miranda equipment does not alter Dolby E metadata.

Figure 1, next page, shows a Dolby E frame with its associated burst preamble and guard band.

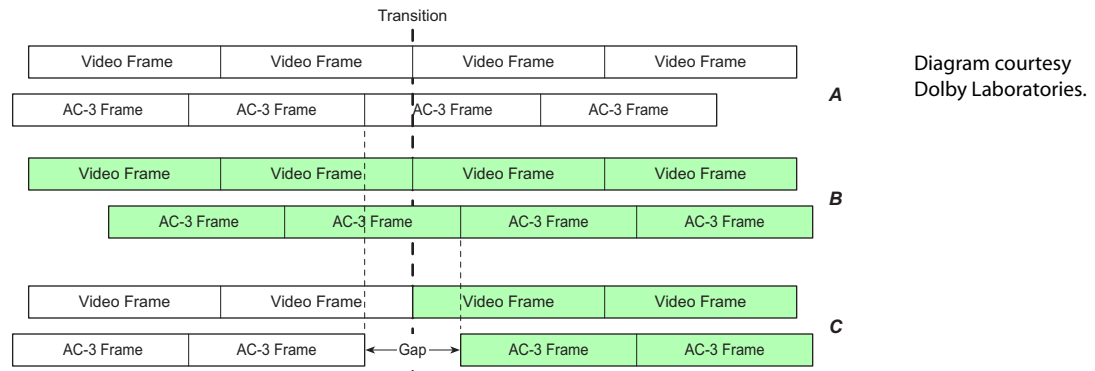
1. Digital Video Broadcasting. A European and far Eastern counterpart to ATSC.

Figure 1. Dolby E Format



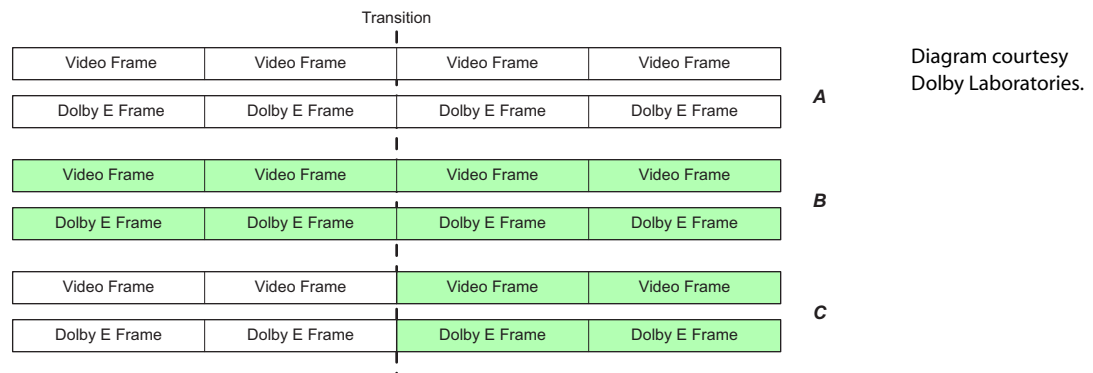
Because AC-3 has no timing relationship with video, audio disruptions can occur during video transitions. Figure 2 shows a cut between two video sources and their respective AC-3 audio frames. Notice the audio gap that occurs as a result of the transition.

Figure 2. AC-3 Audio Gap



Dolby E solves the problem illustrated in Figure 2 (AC-3 audio gap) by creating a direct timing relationship between Dolby E frames and interlaced video frame boundaries. It introduces exactly one video frame of delay to the audio every time a Dolby E decode or encode occurs. When processing Dolby E, Miranda products introduce the necessary video delays to maintain the proper synchronization between video and audio at all times. Figure 3 shows a cut between two interlaced video sources and their respective Dolby E audio frames. There is no disruption in the audio because of the timing relationship between the interlaced video and Dolby E frame boundaries.

Figure 3. No Audio Gap



Because progressive video formats, such as 720p, have a frame rate that is equivalent to interlaced field rate, progressive video references should not be used with Dolby E. Dolby E requires an interlaced reference. Dolby E and 720p video will work fine when a system is locked to an interlaced reference and the Dolby E is properly synchronized with this reference.

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NVISION System Applications using Dolby Technology

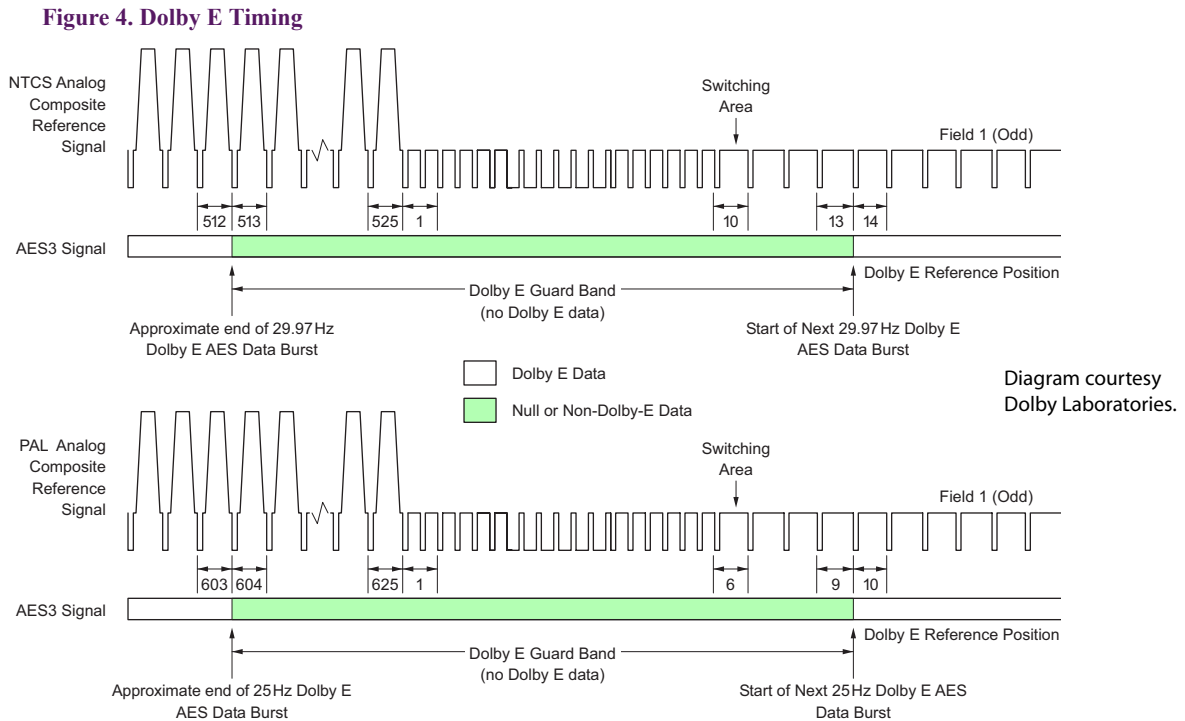


Figure 4 illustrates the timing relationship between composite references (PAL or NTSC) and the Dolby-E guard bands (which do not have Dolby E content). With properly timed Dolby E content, all switch transitions occur within the guard band and outside of the Dolby E data, ensuring glitch-free switching.

Sometimes, even with embedded Dolby E, the guard band can be out of proper alignment. This can be corrected by the use of a Dolby E synchronizer such as the Synapse HES20 module.

Miranda System Applications using Dolby Technology

Miranda's routing products, modular products, and master control products either implement or are compliant with Dolby technology:

Routing Products

Miranda's 5000, 7000 and 8000 series routers have undergone rigorous certification by Dolby Laboratories. Miranda routers ensure glitch-free routing of properly synchronized Dolby E signals whether they are discrete AES or embedded in video.

Miranda routers switch discrete AES, Dolby E, and AC-3 on a pass-through basis. Glitch-free switching of AC-3 cannot be ensured because of problems like the one illustrated in Figure 2.

Modular Products

Synapse products provide the most comprehensive selection of Dolby modules including the new Dolby Digital Plus encoder. All Synapse modules allow hot swapping, making troubleshooting much easier. The Synapse tray system is very space efficient and offers redundant power supplies, remote network control and optional SNMP. See of these modules can be found in Appendix A of this document.

Master Control

Miranda was the first vendor to offer internal Dolby E decoding in a master control processor with the introduction of the NV5128-MC Master Control System in 2003. This system offers the unique capability of per-

forming transparent transitions between multi-format audio signals including analog, PCM, or Dolby E sources. The NV5128-MC ensures proper lip sync relationships with associated video for all transitions.

Figure 5. Miranda Products

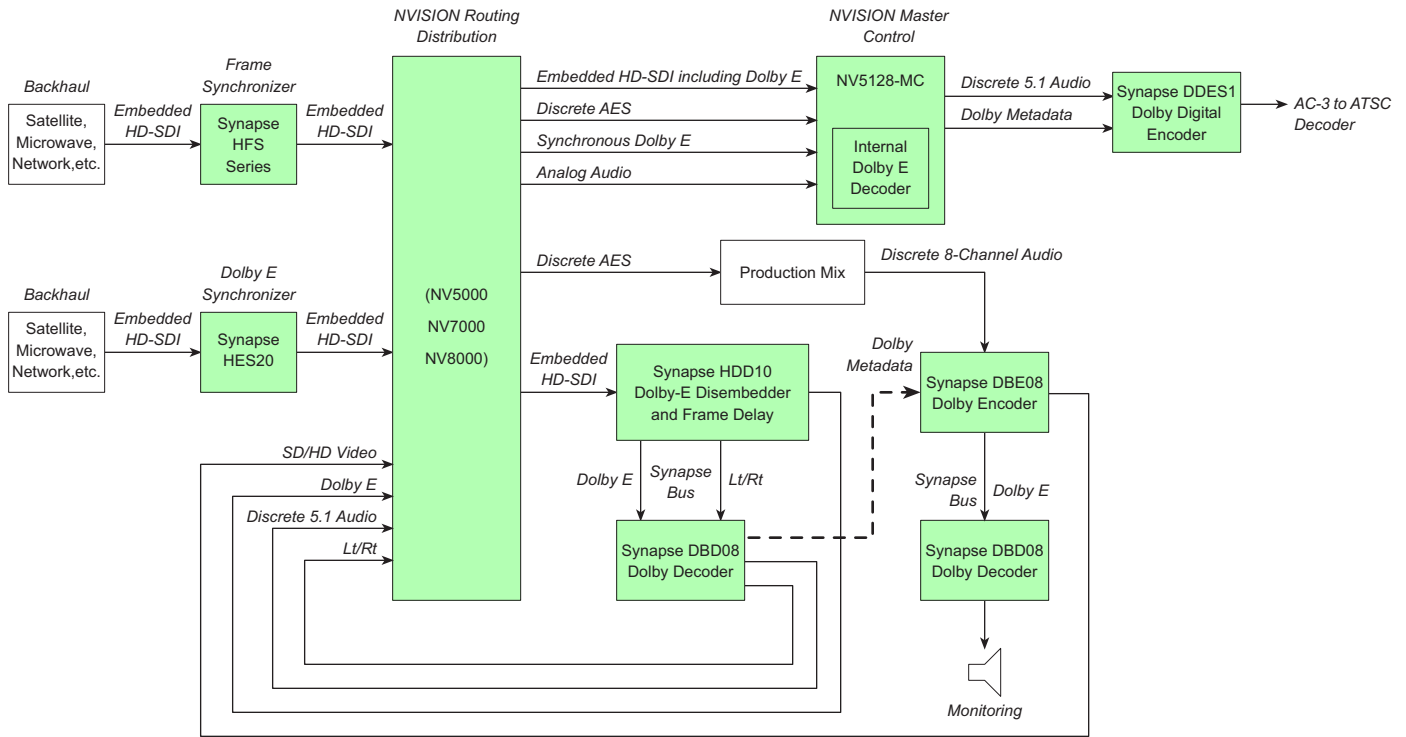


Figure 5 illustrates Miranda products positioned in the production/post-production and master control workflows within a typical broadcast facility.

Starting on the left, backhaul sources are synchronized by the Synapse HFS series frame synchronizers that pass embedded Dolby E transparently. The new Synapse HES20 corrects synchronization errors in embedded Dolby E coming from an IRD. The embedded outputs of these modules feed to Dolby-compatible Miranda SD- or HD-SDI 5000 and 8000 series routers.

At the bottom center, an embedded audio source (in this case, Dolby E + Lt/Rt) feeds a Synapse HDD10 Dolby E disembedder that includes a video frame delay to preserve the correct video/audio timing relationship for Dolby E. The disembedded and delayed video is sent back to the 5000 or 8000 series router for facility use. The HDD10 outputs are sent to the Synapse DBD08 Dolby E decoder via the unique internal Synapse bus in the Synapse frame. The discrete 5.1 and Lt/Rt decoded outputs of the DBD08 feed an Miranda 5000 or 7000 series AES router that supports both the production and master control areas in the facility.

Discrete AES audio (in lip sync with its original video) feeds from the AES router for production and post-production processing. Up to 8 channels of audio can then feed a Synapse DBE08 Dolby E encoder coupled with Dolby metadata output from the Dolby decoder. The Dolby E output feeds back to the AES router where it can be accessed anywhere in the facility. Another Dolby E output is sent to a Synapse DBD08 Dolby E decoder over the Synapse bus where it is used in a monitoring application.

At the top center, embedded, discrete AES, Dolby E, and analog audio feed the NV5128-MC Master Control System. Here, with the use of an internal Dolby E decoder, Miranda has the unique capability of performing transparent transitions between multi-format audio signals including analog, PCM, or other Dolby E sources while maintaining proper lip sync with video.

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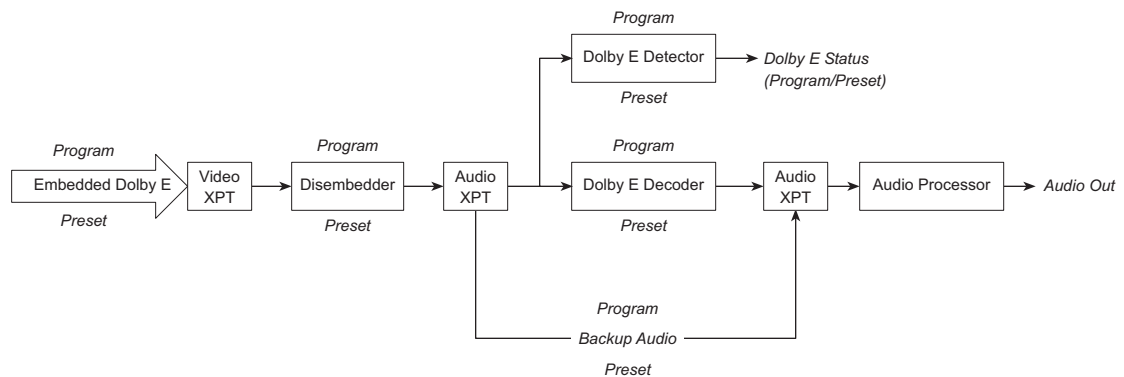
Dolby E within the NVISION Master Control Processor

In this example, discrete 5.1 surround channels derived from internally processed decoded Dolby E audio are sent to a Synapse DDE51 Dolby Digital encoder with the Dolby metadata associated with the 5.1 audio. The AC-3 output of the DDE51 is then sent to the facility transmission encoder.

Dolby E within the Miranda Master Control Processor

Figure 6 shows the functions of the Miranda Master Control processor as they pertain to Dolby E processing. As shown, this functionality is mirrored between “Program” and “Preset” on the processing module. Not shown in Figure 6 is the video bus architecture that allows another unique master control audio feature: breakaway audio using any format, whether embedded or discrete.

Figure 6. Master Control Processor Functions



In this example, SD or HD video with embedded Dolby E enters the local video crosspoint matrix where it reaches a disembedder. It sends the disembedded Dolby E to the local audio crosspoint matrix where it is switched to a Dolby E decoder and a Dolby E detector.

The Dolby E detector is a critical element of the processor. When combined with proprietary Miranda algorithms, the detector’s status output allows the processor to perform transparent Dolby E transitions, trigger backup audio, and control Dolby metadata output.

In the main audio path, the Dolby E is decoded into discrete components (typically 5.1 + Lt/Rt) that are sent to the local audio crosspoint matrix.

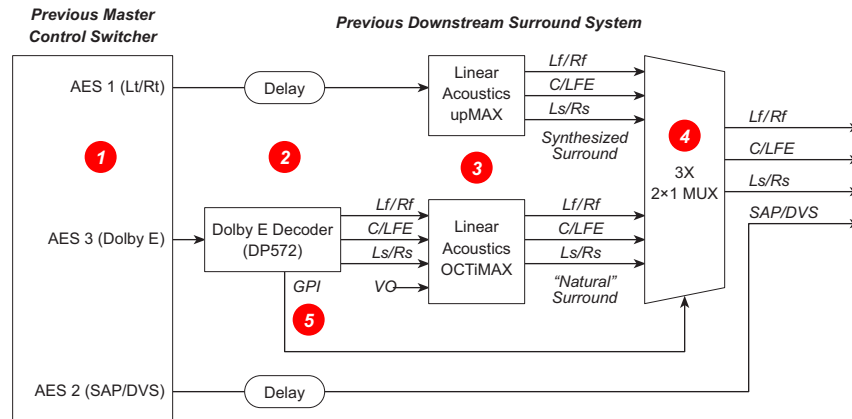
Miranda also provides a very powerful backup audio feature. Any Dolby E source can be configured with an associated backup audio path that engages automatically when Dolby E is not present. The following case study describes the use of this feature in more detail.

Finally, up to 8 channels of audio are switched from the local audio crosspoint matrix to the audio processor where the final mixing is done.

Audio Case Study

The following case study is based on a Miranda solution implemented for a major content provider’s Dolby E master control workflow. The system requirement is eight channels of processed audio as well as a SAP/DVS path. Originally, the customer was externally switching between Dolby E and a synthesized surround output from a Linear Acoustics UpMax box in the event of a loss of Dolby E (i.e. switching to a PCM source). Miranda’s local router capability in the NV5128-MC coupled with its Dolby E backup audio feature removes the external switch requirement and moves this functionality inside the 5128-MC.

Figure 7. Original System



These points apply:

- 1 AES 1 (Lt/Rt), AES 2 (SAP/DVS,) and AES 3 (Dolby E) appear as outputs on the original Master Control Switcher.
- 2 AES 3 feeds a Dolby Decoder. AES 1 and AES 2 go to compensation delays.
- 3 The decoded AES 3 output goes to a Linear Acoustics OCTiMAX for additional processing including voice-over (VO) insertion. AES 1 Lt/Rt goes to the input of a Linear Acoustic UpMAX where it is synthesized into 3 surround component signals.
- 4 The Lf/Rf, C/LFE and Ls/Rs outputs of the OCTiMAX and UpMAX go to an array of three 2:1 multiplexers controlled by the Dolby E decoder.
- 5 The Dolby E decoder provides a GPI trigger that is connected to the 2:1 multiplexer array. When a Dolby E source is present at the decoder, the multiplexers pass the outputs of the OCTiMAX. When there is no Dolby E input, the multiplexers pass the synthesized output from the UpMAX.

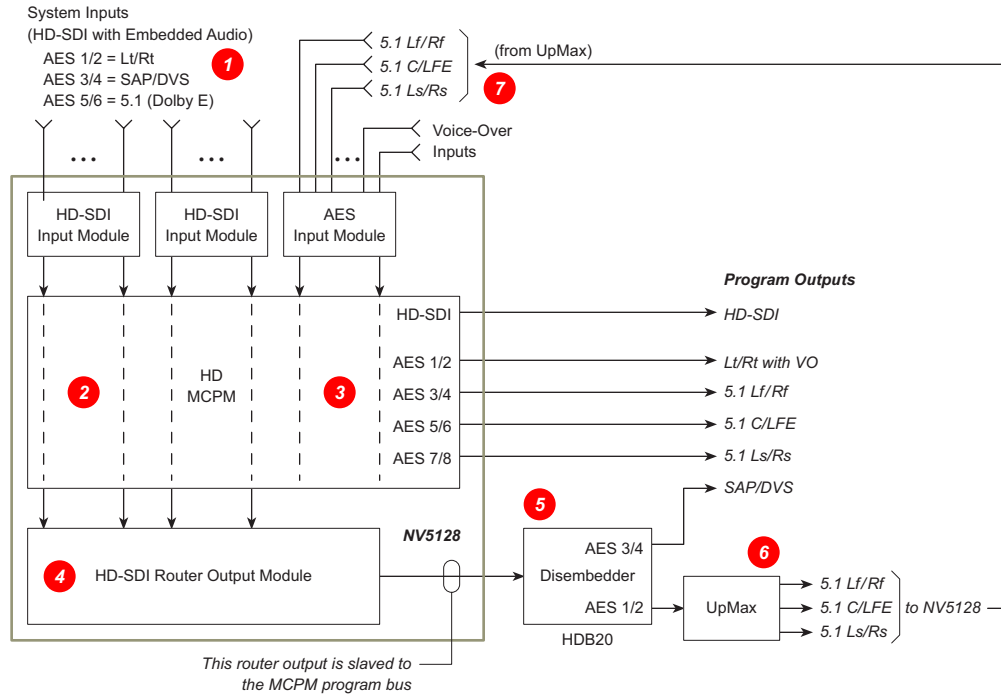
The Miranda Solution

The Miranda system, with internal Dolby E decoding, and backup audio and routing, eliminates the need for most of the discrete components in the original design (shown in Figure 7). It also provides 2 additional audio channels (SAP/DVS).

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Audio Case Study

Figure 8. Miranda Solution



These points apply:

- 1 The facility uses embedded audio where AES 1/2 = Lt/Rt, AES 3/4 = SAP/DVS, and AES 5/6 = Dolby E.
- 2 The embedded inputs are disembedded and processed (Dolby E decoding, mixes, transitions, VOs etc.) by the HD MCPM.
- 3 The HD MCPM produces 4 AES outputs, consisting of Lt/Rt with VOs, Lf/Rf, C/LFE and Ls/Rs.
- 4 The embedded inputs are also sent to an HD output module that has one of its outputs slaved to the MCPM's program bus.
- 5 The slaved output feeds an external disembedder (in this case, a Synapse HDB20) with a "pass through" SAP/DVS output and an Lt/Rt, without VO, that goes to a Linear Acoustics UpMax.
- 6 The UpMax synthesizes the Lt/Rt pair to 3 AES outputs (Lf/Rf, C/LFE and Ls/Rs).
- 7 The UpMax outputs go to an AES input module where they are configured as backup audio inputs for Dolby E sources. Therefore, a switch to backup audio keeps the listener in surround mode (albeit synthesized).

Conclusion

As a long-time Dolby partner, Miranda has always been an industry leader in implementing Dolby technology. Miranda is continuing this role with its current offering of routing, modular and master control technology that leverages Dolby technology to address the needs of today's DTV market.

SD-SDI Dolby E Disembedder (Master Card)

Figure 9. DDB10

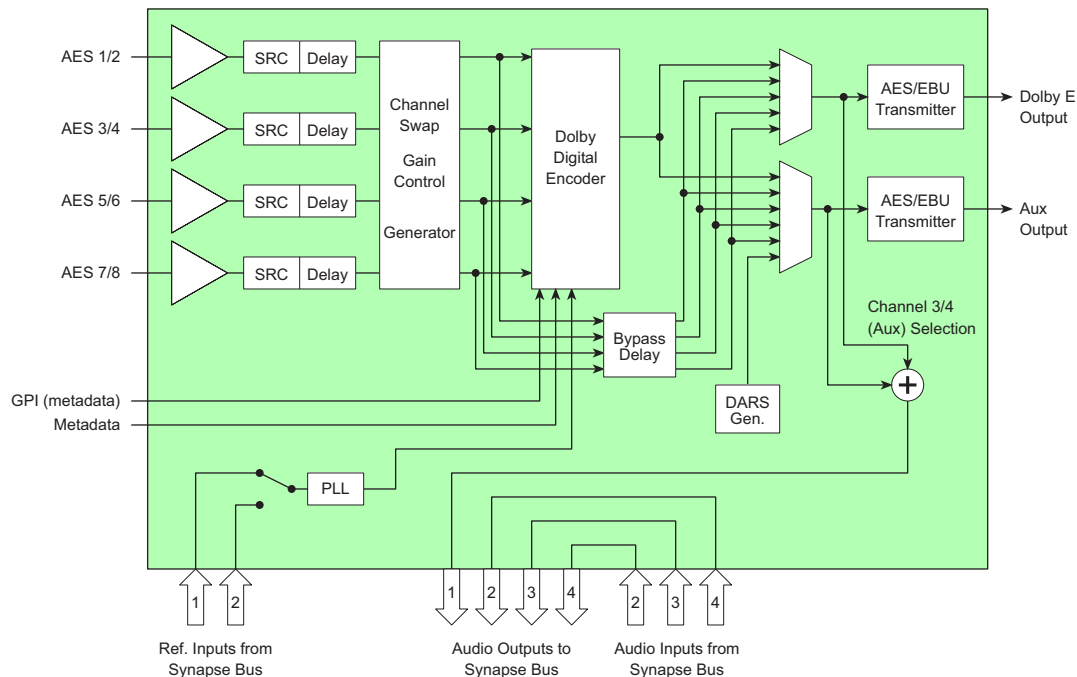


The DDE51 was the first modular Dolby Digital Pro encoder in the world. Targeted at transmission environments, the DDE51 has all the advantages of the Synapse system, such as hot swapping, redundant power supplies, SNMP compatibility, and a host of other modular solutions that fit the same chassis.

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Synapse Dolby Modules

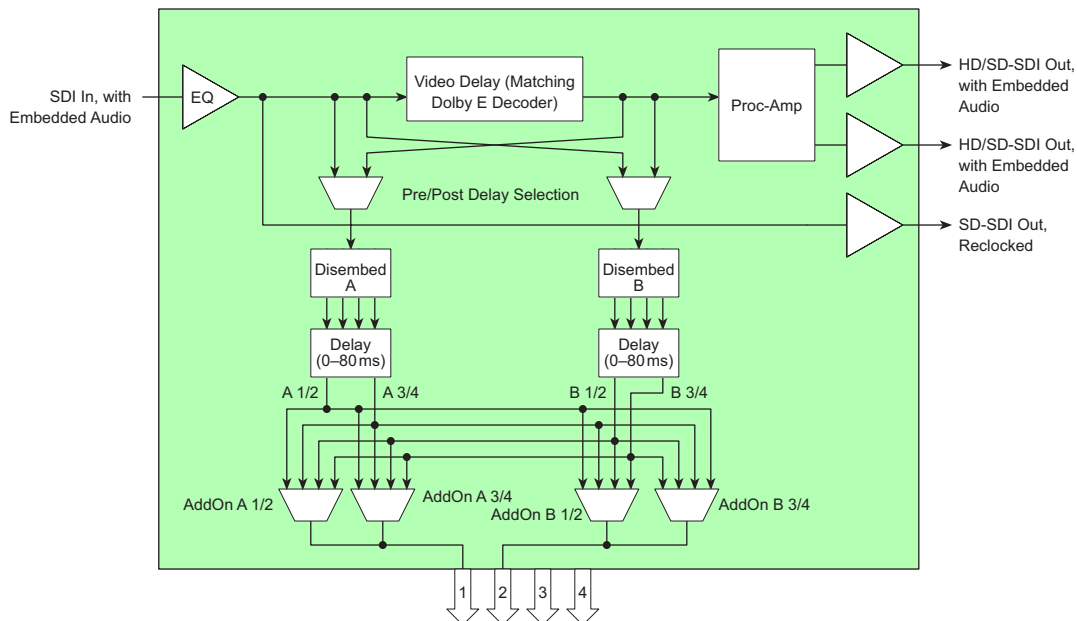
Figure 10. DDE51



HD/SD-SDI Dolby E Disembedder (Master Card)

The HDD10 is an HD master card especially designed to be used in combination with the Synapse DBD08 Dolby E decoder. The propagation delay of the HD/SD-SDI is matched to the Dolby E decoder card (1 frame). The benefit of this card is that there are two full disembedder blocks, one before and one after the delay. This ensures a matched audio delay for Dolby E and PCM. Both can be sent to the “Add-On” bus. The unit has fixed dual-channel selection criteria so that the Dolby E stream cannot be separated and corrupted.

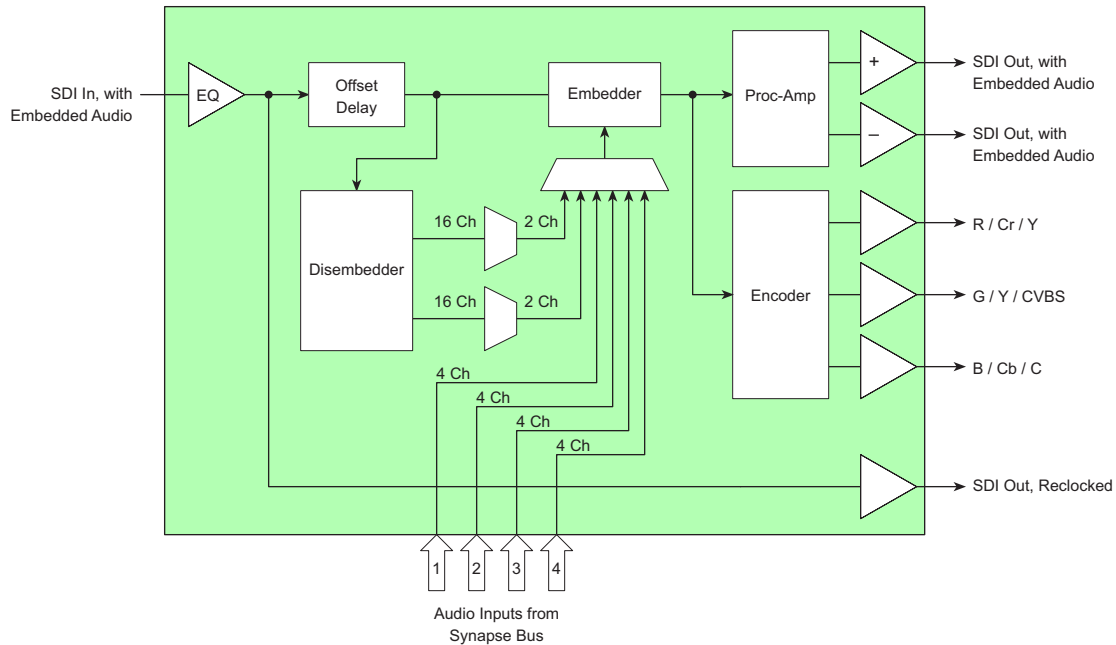
Figure 11. HDD10



SD-SDI Dolby E Embedder (Master Card)

The SDE10 is a master card especially designed to be used in combination with the Synapse DBE08 Dolby E encoder. The propagation delay is adjustable from 0 to 24 frames making this module compatible with the Dolby D encoding process (187ms).

Figure 12. SDE10



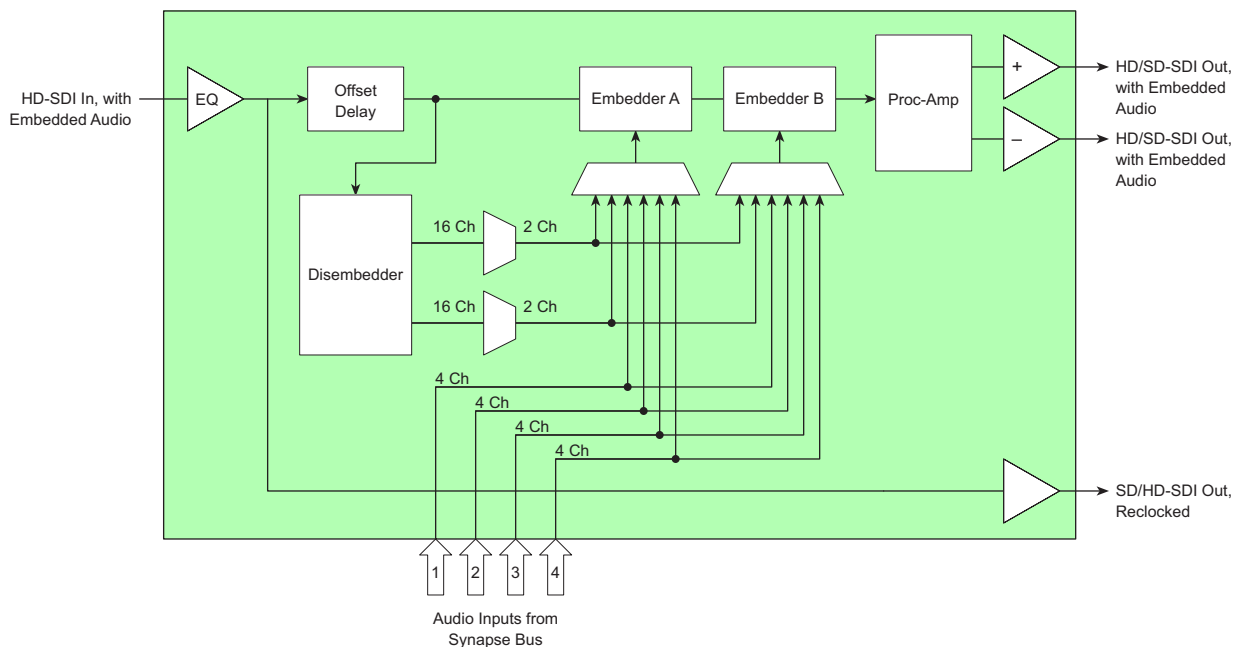
HD/SD-SDI Dolby E Embedder (Master Card)

The HDE10 is a master card especially designed to be used in combination with the Synapse DBE08 Dolby E encoder. The propagation delay of the HD/SD-SDI is adjustable to either Dolby E or Dolby Digital encoders. The HDE10 has a dual-channel disembedder that can re-insert program channels 1 and 2. On channels 3 and 4, the unit can embed Dolby E or Dolby Digital. A second embedder block can embed a full extra group.

System Solutions Using Dolby-E Technology

Synapse Dolby Modules

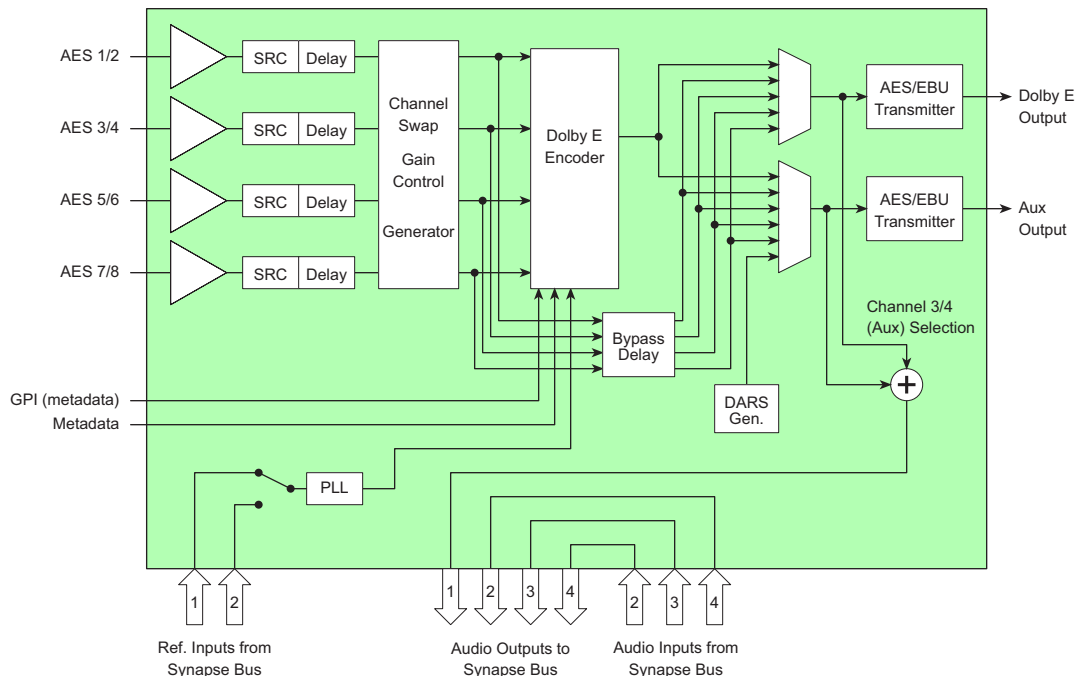
Figure 13. HDE10



Dolby E Encoder

The DBE08 is a fully compliant Dolby E encoder. Dolby E is designed to transport multi-channel audio (discrete 5.1 surround Dolby Digital) in a broadcast environment. The DBE08 encodes up to 8 channels of high quality audio plus Dolby digital metadata to a single AES pair. All Dolby E encoders and decoders must have either a direct reference video signal, or the information derived from a video reference signal. Dolby E is a perfect method of recording up to 16 channels (languages, for example) on a 4-channel recorder such as a Sony Digi-Beta.

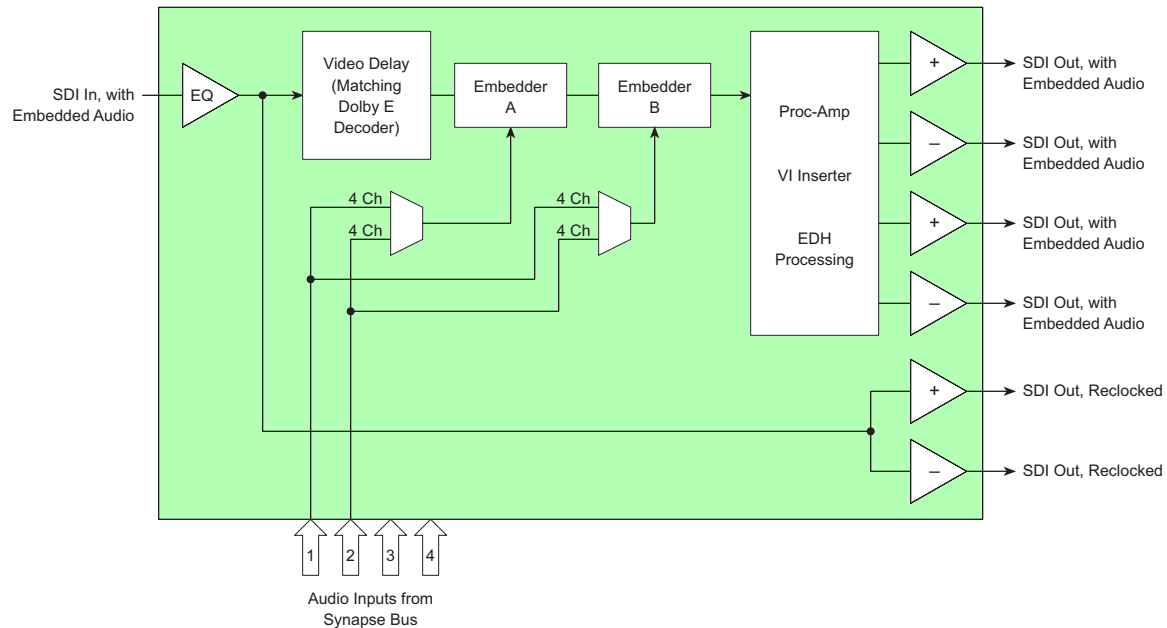
Figure 14. DBE08



SD-SDI Dolby E Embedder (Master Card)

The DEB10 is a master card especially designed to be used in combination with the Synapse DBE08 Dolby E encoder. The propagation delay of this embedder is matched to the Dolby E decoder card (1 frame).

Figure 15. DEB10



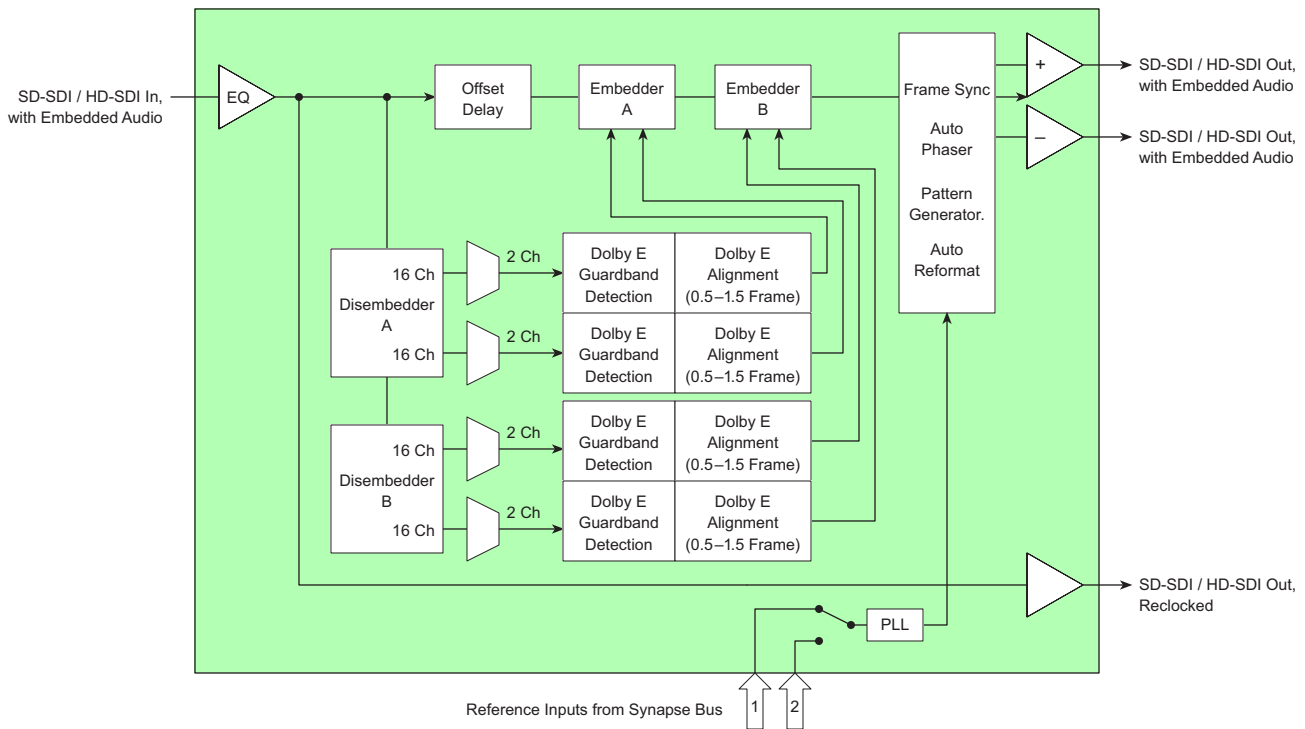
Dolby-E Aligner and Synchronizer

The HES20 is a Dolby E aligner and synchronizer. Individual audio and video propagation delay problems can cause a time shift of the Dolby E stream with respect to the SDI carrier even when embedded. The HES20 detects and corrects these errors as well as frame synchronizes the embedded output.

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Synapse Dolby Modules

Figure 16. HES20



Dolby E Decoder

The DBD08 is a fully compliant Dolby E decoder. Dolby E is designed to transport multi-channel audio (discrete 5.1 surround Dolby Digital) in a broadcast environment. The DBD08 decodes up to 8 channels of high-quality audio plus Dolby digital metadata from a single AES pair. Fundamental to the operation of Dolby E is the synchronization with video frames. To provide an exact match between encoded Dolby E audio frames and video frames, Dolby E requires synchronization to a video signal. All Dolby E encoders and decoders must either have a direct reference video signal or derive the information from a video reference signal.

Figure 17. DBD08

