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APPLICATION NOTE

Videotek® Test and Measurement

Verifying Dolby® E Timing

Introduction

The engrossing quality of surround sound has become an essential component of the viewing experience. The combined impact of high-resolution pictures and high-quality sound from all around convinces viewers that they are really at the center of the action. With prices of large, flat-screen displays falling, and the enhanced experience of viewing content directly from DVD players and digital transmission, consumer expectations are becoming ever greater. As a result, most receivers now come with surround sound options and add-ons at affordable prices.

High-definition (HD) television creates its own expectations, and surround sound is an essential part of the viewing experience. HD programming with surround sound is already being broadcast in many parts of the world — and spreading fast!

What are the implications of these new audio technologies for the engineering community within the production broadcast environment?

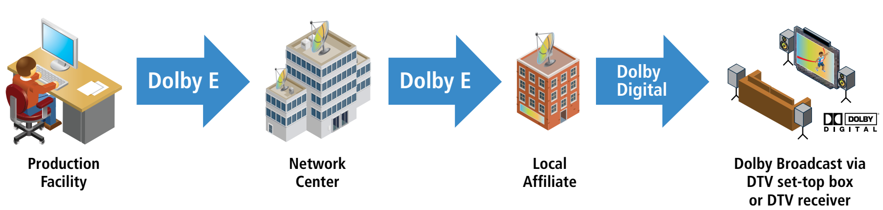
Dolby® E in Production and Post

As more and more broadcasters convert to multichannel audio transmission, production and post facilities serving the broadcast industry are being required to produce and deliver increasing volumes of programming with multichannel audio. However, the majority of production infrastructures were installed before the transition to multichannel audio was foreseeable, and these were designed almost exclusively for a two-channel audio infrastructure. The Dolby E encoding scheme was designed to overcome this limitation and allows the routing and manipulation of multichannel digital audio within these existing two-channel installations.

Using Dolby E, up to eight channels of broadcast-quality audio, plus related metadata, can be distributed via any stereo (AES/EBU) path with the capability of being recorded on two audio tracks of conventional digital VTRs or video servers and routed via communication links and switchers.

Dolby E is also specifically designed to allow numerous generations of encode/decode cycles that are incurred in the production and distribution of audio in a professional environment. The frame rate of Dolby E matches that of the video it accompanies, enabling programs to be switched, edited and successfully encoded and decoded multiple times throughout the various stages of the production workflow. Audio-to-video synchronization is also simplified, since no matter which video standard is in use, exactly one frame of delay is added at each Dolby E encode or decode stage and corrections can therefore be applied in advance. However, there are installation and device-specific issues related to the implementation of Dolby E that need to be addressed and will be covered later in this paper.

Dolby E never reaches home viewers; it is decoded back to baseband audio once post production is complete and is then re-encoded into the final audio format specified by the various DTV emission systems.



Dolby E and Metadata

Metadata provides content producers with control over how a program will be reproduced in the home. Dolby E is designed to transport both consumer and professional metadata created during program production. Consumer parameters are carried in both the Dolby E and the Dolby Digital bitstreams, and all metadata parameters can pass unchanged through the various broadcast distribution stages to the listening environment.

Metadata from a single program through eight individual programs on a single Dolby E stream can be handled. Each program is discrete and has its own associated metadata in the Dolby E stream. Metadata is first inserted during program creation or mastering, and is carried through transmission in a broadcast application or directly onto a DVD.

Here's a practical example. In a broadcast truck, the program mixer chooses the appropriate metadata for the audio program being created. The resulting audio program, together with metadata, is encoded as Dolby E and sent to the television station via fiber, microwave, or other transmission link. At the receiving end of this transmission, the Dolby E stream is decoded back to baseband audio and metadata. The audio program and the metadata are monitored, altered or re-created as other elements of the program are added in preparation for broadcast. This new audio program/metadata pair, re-encoded as Dolby E, leaves the studio and passes through the television station to Master Control, where many incoming Dolby E streams are once again decoded back to their individual baseband digital audio/metadata components. The audio program/metadata pair that is selected to air is sent to the transmission Dolby Digital encoder, which encodes the incoming audio program according to the metadata stream associated with it, thereby simplifying the transmission process.

This is an area where attention to timing is essential. Delays in devices such as embedders, de-embedders, and up/down/cross-converters in the signal path can cause audio data mis-timing. Many of these devices have adjustable audio and video delays that need to be matched. If this timing issue is not handled correctly, the Dolby data is interrupted whenever a switch or edit is made, and the header information may be missing for a frame or so. Due to the default operation of a Dolby decoder, PCM audio is assumed until a Dolby header is detected. This causes the Dolby data to be presented as AES audio — sounding like a full-scale noise burst — and potentially causing costly damage to monitoring speakers.

Technical Parameters

This section outlines how Dolby E is structured within the AES3-2003 carrier, and the subsequent section describes how to check timing in real installations.

Dolby E frames are embedded into the AES3-2003 interface by mapping the Dolby E data into the audio sample word bits of the AES frames. Both channels within the signal are utilized. The data can be packed to use 16, 20 or 24 bits in each AES3-2003 subframe.

Dolby E data is designed to be synchronous with its accompanying video signal, and encoders are designed to produce Dolby E bitstreams that are synchronous in this way. Each Dolby E frame includes the audio that accompanies one video frame, i.e., 40 ms of audio in 25 Hz territories and approximately 33 ms of audio in 29.97 Hz territories. Every time Dolby E is encoded or decoded, there is a latency equivalent to one video frame, making system design and correction conveniently predictable.

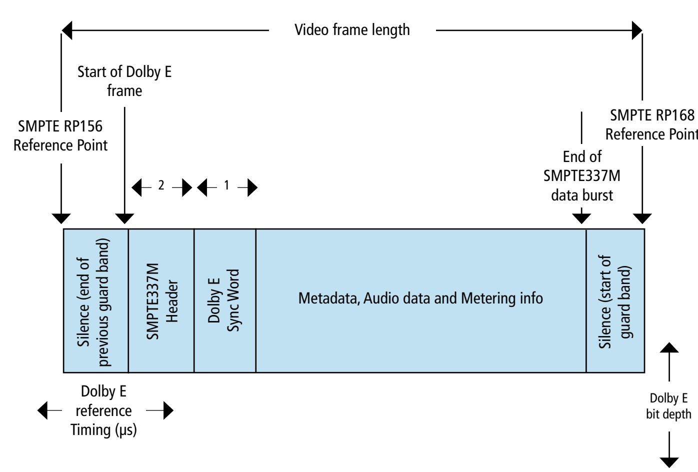
This diagram below shows how Dolby E metadata, audio and metering information are structured in relation to one video frame.

Dolby E has a feature known as the "guard band." This is an area of approximately 5 percent of the frame duration where no data is actually stored. This is around the video switching line and is designed to allow Dolby E to be switched and routed without any corruption to the data. To ensure that this corruption does not occur, this guard band must remain around the video switching line.

Dolby E is a frame-based system; it is not affected by the line rate of the video to which it is associated. Therefore, a Dolby E signal encoded with a 625i50 signal is the same structure as one encoded for a 1125i50 signal.

However, it is quite common to refer to the position of a Dolby E signal in terms of the number of the line with the packet containing the Dolby E sync words. The line position can be set for Dolby E with reference to an analog 625i50 or 525i59.94 video signal applied to the Dolby E encoder.

Video Frame and Dolby E



Recommended Dolby E Line Position

The preferred Dolby E reference position is ~700 µs from the SMPTE RP 168 Reference Point, with a tolerance of ±80 µs. The allowable range is where the Dolby E guard band encompasses the SMPTE RP 168 switching region for the video format being used while keeping the entire data burst within the video frame.

Dolby E (DE) Recommended Line Position

	625 25 PAL SD	1080i 50 PAL HD	720p 50** PAL HD	525 29.97 NTSC SD	1080i 59.94 NTSC HD	720p 59.94** NTSC HD
Potentially earliest valid DE position						
TV line	8	13	17	12	18	23
µs*	450	450	450	510	510	510
48 kHz AES sample***	22	22	22	25	25	25
Ideal DE line position — 80uS						
TV line	11	19	25	13	21	28
µs*	650	650	650	610	610	610
48 kHz AES sample***	32	32	32	30	30	30
Ideal DE line position ± 80 µs						
TV line ± 80 µs	12	21	28	14	24	32
µs ± 80 µs*	730	730	730	690	690	690
48 kHz AES sample***	36	36	36	34	34	34
Ideal DE line position + 80 µs						
TV line	13	23	31	16	26	35
µs*	810	810	810	770	770	770
48 kHz AES sample***	39	39	39	37	37	37
Potentially latest valid DE position						
TV line	30	53	70	26	48	63
µs*	1860	1860	1860	1400	1400	1400
48 kHz AES sample***	90	90	90	68	68	68

POTENTIAL RANGE OF VALID DOLBY E START POSITIONS

* In relation to SMPTE RP168 reference point and approximate values
** In relation to the 1st (odd) frame
*** Where the start of AES sample number 1 is approximately aligned to SMPTE RP168 reference point

Image provided courtesy of Dolby Laboratories.

Dolby E is carried within AES audio as an SMPTE 337M-2000 data burst. When looking for Dolby E within AES or HD-SDI, the first audio data words at the start of the frame are the SMPTE 337M-2000 header/preamble.

The burst preamble occupies 16, 20, or 24 bits in each of four consecutive subframes.

The preamble consists of four words designated as Pa, Pb, Pc, Pd. It is worth noting that this information only appears once per frame.

The frame beginning the data burst contains preamble word Pa in the Ch1 subframe, and Pb in the Ch2 subframe. The next frame contains Pc in Ch1 and Pd in Ch2.

The content of these four words is specified in the table below.

Preamble word	Contents	
Pa	Sync word 1	= 0xF872 (16-bit mode) = 0x6F872 (20-bit mode) = 0x96F872 (24-bit mode)
Pb	Sync word 2	= 0x4E1F (16-bit mode) = 0x54E1F (20-bit mode) = 0xA54E1F (24-bit mode)
Pc	burst_info value	
Pd	length_code (unsigned integer), equal to the number of data bits in the burst_payload	

How Videotek® Products Help You

Videotek VTM Series™ and TVM Series Monitoring Systems

Videotek multiformat VTM and TVM units are the most advanced, versatile and intuitive HD/SD-SDI monitoring solutions available today. Incorporating 100 percent digital signal processing technology, they provide an accurate and stable user-customizable display of multiple Waveform, Vector, Gamut, Audio, Picture, Relative Timing, Dual Link, Alarm Status and Data Analyzer functions in quadrant or full-screen views.

Various levels of audio capability can be incorporated into these products as options or upgrades by means of cards as shown below.

For full decoding and monitoring of the Dolby stream and metadata display, audio options A3-OPT 5 or A3-OPT 5TL are required. TVM-A3-OPT 5 is an advanced audio analysis option that allows the user to view up to eight audio channels. It includes four analog stereo inputs, eight AES/EBU inputs with four shared outputs, and 16 channels of embedded audio. Analog monitoring outputs of up to eight channels, channel-mapping, meter labels and peak value reporting are included, as is full Dolby® decoding with up to eight analog outputs. A3-OPT 5TL provides even further capability, adding 5x oversampling for enhanced True Peak detection and loudness monitoring to the ITU-R BS.1770 standard. All AES inputs are sample rate converted to 48 kHz. The AUX meter pair is selectable from the Dolby downmix, or any one of the eight pairs of the assigned input type (AES or embedded) to allow display of both the Dolby surround mix and the uncompressed PCM stereo mix.

Advanced Audio Options	Loudness Monitoring	SNR	Channels Displayed	Embedded Audio	Analog Inputs	Analog Outputs	AES/EBU Inputs	AES Input Expansion Channels	AES/EBU Outputs (shared with inputs)	Video to Audio Timing	Custom Meter Labels	Channel Map	Dolby Digital Outputs	Dolby 8-Channel Decode	Alarms	Dolby Metadata Display
VTM (or TVM) A3 OPT-2		100dB	8	●	●	8	4	OP	4			●			●	
VTM (or TVM) A3 OPT-3		100dB	8	●	●	8	8		4		●	●			●	
VTM (or TVM) A3 OPT-3TL	●	100dB	8	●	●	8	8		4	OP	●	●			●	
VTM (or TVM) A3 OPT-5		100dB	8	●	●	8	8		4	OP	●	●	●	●	●	●
VTM (or TVM) A3 OPT-5TL	●	100dB	8	●	●	8	8		4	OP	●	●	●	●	●	●

● Supported Feature
OP Product Option

Identifying the Start of Dolby E Data within the Frame

For instruments such as the Videotek VTM Series with the OPT 5 or OPT 5TL audio option, the Dolby E position is automatically indicated on the Dolby Metadata Option screen. See below:

An alternate location for the Dolby metadata, when carried separately, is the VANC data packet as illustrated in a Videotek TVM monitor below:

Pressing the OPT function button on a TVM or VTM system accesses the Option display for the selected pane. To select the type of optional display for that pane, press and hold the OPT button to access the OPTION pane menu. The choices are shown in the table below.

Selection	Selection Option
DISPLAY	DOLBY METADATA (only if the Dolby option is installed)
	VIDEO METADATA
	XDS
	TELETEXT
	CRC
	ASI
	EMBEDDED AUDIO DATA
SETUP	Press ENT

Dolby E Metadata Display

When the metadata information appears on the display, use the UP and DOWN navigation buttons to page through the metadata list. Press the RIGHT navigation button to move to the next program list. Press the LEFT navigation button to move to the previous program list. The metadata is read from the Dolby stream as listed below and cannot be changed.

1. Time Stamp	18. Lo/Ro Surround Downmix
2. Program Config	19. Lo/Ro Center Downmix
3. Program	20. Pref. Stereo Downmix
4. Data Rate	21. Dolby Surr (Surround) Ex. Mode
5. Bitstream Mode	22. A/D Converter Type
6. Channel Mode	23. Original Bitstream
7. LFE Channel (Enabled/Disabled)	24. Copyright Bit
8. Dolby Surr (Surround) Mode	25. DC Filter
9. Dialogue Level	26. Lowpass Filter
10. Center Downmix Level	27. LFE Lowpass Filter
11. Surround Downmix Level	28. Surround Attenuation
12. Audio Prod (Production) Information	29. Surround Phase Shift
13. Room Type	30. Line Mode Comp Gain
14. Mix Level	31. Dynamic Range Gain
15. RF Overmod Protection	32. RF Mode Comp Gain
16. Lt/Rt Surround Downmix	33. Compression Gain
17. Lt/Rt Center Downmix	

For Videotek instruments that do not have the Dolby option installed, it is still possible to use the Data Analyzers' search function using the ancillary DID (Data IDentification). The engineer specifies the DID as described in steps listed below. If the DID is present in the video, the line number where it was found is displayed. If this line number corresponds within the range of the Dolby specification (table x), the location is correct. If not, timing adjustments elsewhere within the system will be necessary to bring the timing into range.

A step-by-step example follows, using a Videotek VTM Series monitor and a 1080i 50 HD signal with embedded 20-bit audio:

1. Select Data Search Navigation Mode

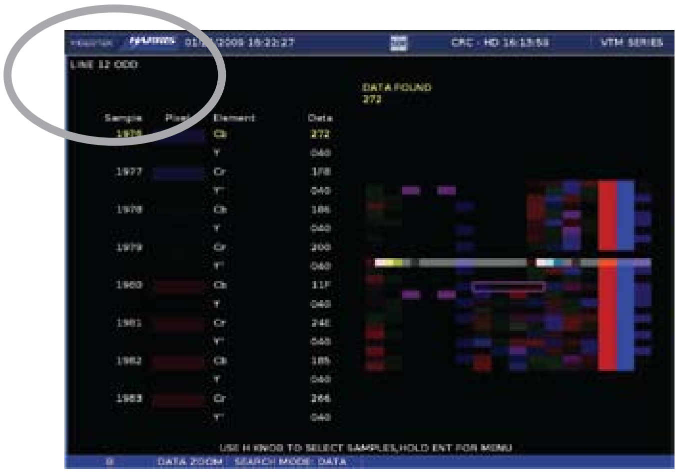
The Data Search menu is used to select the data ID of the ancillary data that will be highlighted when Data Search mode is enabled. Pressing and holding the MLT button accesses the MLT DISPLAY menu. From the MLT DISPLAY menu, select DATA ANALYZER to display the data word analyzer. The data display contains the data itself and the picture zoom box. A picture zoom box also appears in the picture display. To navigate through the Data Display, select the Data pane. Once selected, press the UP navigation button to page up the Data Display. Press the DOWN navigation button to page down the Data Display.

2. Select Custom for the Data search type.

Custom Data search is used to select a specific Data ID of the ancillary data that is not preset in the data search menu, and the resulting value is presented in hexadecimal form.

3. Set data value to 272 as shown below. This value enables the preamble sequence detailed in step 4 to be easily located.

4. Search for Preamble sequence 200 272 1F8 186 200 11F 24E 185 (20-bit example). The line number on which this sequence is found (line 12 in this example) is where the Dolby E data commences. This needs to be checked against the recommended position for the appropriate signal standard and re-timed if necessary, repeating the above sequence.



Conclusion

With any new technology, it is essential to become familiar with real-life implementation issues in order to minimize potential problems in operation. As increasing amounts of information are packed into signals as they are routed and manipulated in the production environment, it is vital to have access to quality assessment tools that have the depth of functionality and ease of use to produce fast, reliable results. The Videotek product range is constantly being enhanced to provide such capabilities.

For more information, please visit www.broadcast.harris.com.

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