Pro Video Formats for IEEE 1722a

Rob Silfvast

Avid Technology, Inc.

17-April-2012

Today's Pro Video Infrastructure
(for Live Streams, not file-based workflows)

- SDI (Serial Digital Interface) carries video, audio, and meta data
  - SMPTE standards
  - 75-ohm coax links
  - Uncompressed frame encoding (4:4:4, 4:2:2, 4:2:0)
  - Audio may be embedded or carried separately

Standard	Name	Bitrates	Example Video Formats
SMPTE 259M	SD-SDI	270 Mbit/s, 360 Mbit/s, 143 Mbit/s, and 177 Mbit/s	480i, 576i
SMPTE 344M	ED-SDI	540 Mbit/s	480p, 576p
SMPTE 292M	HD-SDI	1.485 Gbit/s, and 1.485/1.001 Gbit/s	720p, 1080i
SMPTE 372M	Dual Link HD-SDI	2.970 Gbit/s, and 2.970/1.001 Gbit/s	1080p
SMPTE 424M	3G-SDI	2.970 Gbit/s, and 2.970/1.001 Gbit/s	1080p

From Wikipedia, the free encyclopedia

- House Sync carried on separate links
  - 75-ohm coax
  - Video frame rates
    - Film rates (24 fps, other?)
    - NTSC rates (29.97, 30, 59.94, 60 fps)
    - PAL rates (25, 50 fps)

Objective: Map SDI content and House Sync onto 1722a over Ethernet/AVB

- Standard Def fits on Gigabit Links (up to 360 Mbps)
- Hi-Def requires 10-gig links (or faster)

- Fit the entire SDI signal into a single AVB stream, including all types of ancillary data, audio, HANC, VANC, etc (not just active video).
- Important to preserve the ancillary data and preserve its location within the video raster.

SD-SDI (NTSC & PAL)

- Standard Definition video
- References various other SMPTE standards
- Audio content encoded per SMPTE 272

SMPTE 259M

From Wikipedia, the free encyclopedia

SMPTE 259M is a standard published by SMPTE which "... describes a 10-bit serial digital interface operating at 143/270/360 Mb/s." [1]

The goal of SMPTE 259M is to define a Serial Digital Interface (based on a coax cable), called SDI or SD-SDI.

There are 4 bitrates defined, which are normally used to transfer the following standard video formats:

Variant	Bitrate	Display Aspect Ratio	Total Lines (per Frame)	Active Pixels	Active Lines	Framerate
SMPTE 259M-A	143 Mbit/s	4:3	525	768	486	59.94i
SMPTE 259M-B	177 Mbit/s	4:3	625	948	576	50i
SMPTE 259M-C	270 Mbit/s	4:3 or 16:9	525	720	486	59.94i
SMPTE 259M-C	270 Mbit/s	4:3 or 16:9	625	720	576	50i
SMPTE 259M-D	360 Mbit/s	16:9	525	960	486	59.94i

HD-SDI 720p & 1080i

SMPTE 292M

SMPTE 292M is a standard published by SMPTE which expands upon SMPTE 259M and SMPTE 344M allowing for bit-rates of 1.485 Gbit/s, and 1.485/1.001 Gbit/s. These bit-rates are sufficient for and often used to transfer uncompressed High Definition video.[1]

This standard is usually referred to as **HD-SDI**; it is part of a family of standards that define a Serial Digital Interface based on a coaxial cable, intended to be used for transport of uncompressed digital video and audio in a television studio environment.

Technical details   [edit]

The SMPTE 292M standard is a nominally 1.5 Gbit/s interface. Two exact bitrates are defined; 1.485 Gbit/s, and 1.485/1.001 Gbit/s. The factor of 1/1.001 is provided to allow SMPTE 292M to support video formats with frame rates of 59.94 Hz, 29.97 Hz, and 23.98 Hz, in order to be upwards compatible with existing NTSC systems. The 1.485 Gbit/s version of the standard supports other frame rates in widespread use, including 60 Hz, 50 Hz, 30 Hz, 25 Hz, and 24 Hz.

The standard also defines nominal bitrates of 3 Gbit/s, for 1080P applications. This version of the interface is not used (and has not been commercially implemented); instead, a dual-link extension of SMPTE 292M known as SMPTE 372M is used for very-high-definition applications.

3G-SDI

- "3 gigabit" data rate
- 1080p, D-Cinema
- Up to 12-bit pixel depth
- Does not cover 4k frame sizes

(4K cinema = 9.2 Gbps)

Picture format	Signal format	Progressive frame rate	Interlaced field rate
1920 × 1080	10-bit 4:2:2 (Y'C'BC'R)	60, 59.94, 50	
	10-bit* 4:4:4 (R'G'B') 4:4:4:4 (R'G'B' + A) 4:4:4 (Y'C'BC'R) 4:4:4:4 (Y'C'BC'R + A)	30, 29.97, 25, 24, 23.98	60, 59.94, 50
	12-bit 4:4:4 (R'G'B') 4:4:4 (Y'C'BC'R) 4:2:2 (Y'C'BC'R)*		
1280 × 720	10-bit 4:4:4 (Y'C'BC'R) 4:4:4:4 (Y'C'BC'R + A) 4:4:4 (R'G'B') 4:4:4:4 (R'G'B' + A)	60, 59.94, 50, 30, 29.97, 25, 24, 23.98	
2048 × 1080 (D-Cinema)	12-bit 4:4:4 (X'Y'Z')*	24	
*Includes PsF (Progressive segmented Frame) format			

Table 1. 3Gig-SDI supported video formats, per SMPTE-425M
From Broadcast Engineering May 1, 2009

SMPTE 424M

From Wikipedia, the free encyclopedia

"SMPTE 424M" is a standard published by SMPTE which expands upon SMPTE 259M, SMPTE 344M, and SMPTE 292M allowing for bit-rates of 2.970 Gbit/s and 2.970/1.001 Gbit/s over a single-link coaxial cable. These bit-rates are sufficient for 1080p video at 50 or 60 frames per second[1]. The signal formats carried over SMPTE 424M are specified in SMPTE 425M.

This standard is part of a family of standards that define a Serial Digital Interface; it is commonly known as **3G-SDI**.

Ancillary Data in SDI

- Embedded Audio
- Error Detection and Handling

Ancillary data

From Wikipedia, the free encyclopedia

Ancillary data (commonly abbreviated as **ANC data**), in the context of television systems, refers to a means which by non-video information (such as audio, other forms of essence, and metadata) may be embedded within the serial digital interface. Ancillary data is standardized by SMPTE as SMPTE 291M: Ancillary Data Packet and Space Formatting.

Embedded Audio in SDI

Embedded audio   From Wikipedia, the free encyclopedia   [edit]

Embedded audio is audio payload which is (typically) the soundtrack (music, dialogue, and sound effects) for the video program. Two standards, SMPTE 272M (for SD) and SMPTE 299M (for HD and 3G) define how audio is embedded into the ancillary space. The SD and HD standards provide for up to 16 channels of PCM audio, while 3G allows up to 32 channels, typically encoded in the AES3 format. In either case the embedded audio data packets are carried in the HANC space of Cb/Cr (chroma) parallel data stream.

In addition, both standards define **audio control packets**. The audio control packets are carried in the HANC space of the Y (luminance) parallel data steam and are inserted once per field at the second video line past the switching point (see SMPTE RP168 for switching points of various video standards). The audio control packet contains audio-related metadata, such as its timing relative to video, which channels are present, etc.

Embedded audio packets are Type 1 packets.

Time Code

- ## SMPTE time code
  - Carried/encoded on various interfaces
    - Originally an audio signal (track 24 on 2-inch tape!)
    - SDI ancillary data
    - MIDI
    - AES/EBU audio ancillary data

  - Resolution ~120Hz (quarter frame at 30Hz/29.97 Hz)
  - Different streams reference different time code
  - Many (or all) streams share common house sync

- ## For AVB, embed into SDI video stream
  - Use Ancillary Data (more investigation needed)

House Sync

- aka Genlock
- A raw timing signal, carries no data
- One 'tick' per video frame (very low data rate!)
- Signaling formats in regular use
  - Black Burst
  - Tri-level Sync

Next steps: How to encode it?

Video Bit Rates -- Example Math			
Format	1080p 60Hz	4k full aperture (cinema)	
Y:Pb:Pr	4:2:2 (10 bit)	4:4:4 (12 bit)	
Width (pxls)	1920	4096	
Height (pxls)	1080	3112	
Bits/pxl	20	36	
Frame Rate (Hz)	60	24	
Video bits/sec	2.488E+09	1.101E+10	
Ancillary data budget	2.0%	2.0%	(place holder, this will change)
Total Bytes/sec	3.173E+08	1.404E+09	
Encoding for 1722a			
Max Frame size (bytes)	1542		q-tagging in use
Ethernet frame header	42		q-tagging in use
1722 common stream header	24		
Payload available	1476		bytes
Packets per second	214,946	951,343	(minimum, not considering how frames are broken up into packets)
Packets per video frame	3,582.44	39,639.29	