3Gb/s SDI for Transport of 1080p50/60, 3D, UHDTV1 / 4k and Beyond
Part 1 - Standards

Today’s Speaker

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3G SDI Historical Context

SD-SDI Evolution Timeline

1985
SD SDI
ST 292-1
128x720 line
Interspersed 2:3
Interlace

1993
SD SDI
RP 174
625 line
1500 MHz
HD progressive

2000
SD SDI
ST 347
12Gbps line
12Gbps and RGB + Y UV/CR Component

HD-SDI Evolution Timeline

1998
HD SDI
ST 292-1
128x720 line
Progressive 4:2:2
and RGB 4:4:4 Component

2002
HD SDI
ST 372
Progressive 4:2:2
and RGB 4:4:4 Component

2006
3G SDI
ST 425-1
Single Link @ 5.4Gbps

3G SDI Standards – Overview

3G SDI first standardized in 2005...

ITU-R BT.1120
Restricted to 1920 x 1080p50 Y'CbCr 4:4:4 10-bit

SMPTE 3G SDI standards first published in 2006
SMPTE ST 425:2006
Video, audio and ancillary data mapping for the 3G interface
SMPTE ST 424:2006
Physical layer – 3G equivalent of ST 292-1 (1.5Gb/s SDI)
SMPTE ST 297:2006
Optical interface standard covering all SDI rates from 143Mb/s through to 3Gb/s

ST 425 - 3G SDI Mapping Standards

SMPTE ST 425 – the 3 mapping modes
Three different mapping modes are defined as:

Level A Direct Image Mapping
Level B-DL Dual Link mapping
Level B-DS Dual Stream mapping

Level A is the direct mapping of an uncompressed image into a serial digital interface operating at a nominal rate of 3Gb/s

Level B-DL is the mapping of ST 372 dual-link data streams into a serial digital interface operating at a nominal rate of 3Gb/s

Level B-DS is the dual-stream mapping of two independent 1.5Gb/s video streams into a single serial digital interface operating at a nominal rate of 3Gb/s
3G SDI physical Interface

ST 424 3Gb/s SDI Signal/Data Serial Interface
This standard defines the 3Gb/s SDI physical interface
10-bit multiplex
Serialization
Scrambling
Coding
Electrical specifications (eye shape, jitter, return loss,....)

ST 297:2006 Serial Digital Fiber Transmission System
This standard defines an optical fiber system for transmitting bit-serial digital signals

It is intended for transmitting SMPTE ST 259 signals (143 through 360 Mb/s), SMPTE ST 344 signals (540 Mb/s), SMPTE ST 292-1/2 signals (1.485 Gb/s and 1.485/1.001 Gb/s) and SMPTE ST 424 signals (2.970 Gb/s and 2.970/1.001 Gb/s)

In addition to optical specification, ST 297 also mandates laser safety testing and that all optical interfaces are labelled to indicate safety compliance, application and interoperability.

Part 2 and 3 of this PDA provides a detailed review of the 3G SDI physical interface.

Formats, Payloads, Interfaces

The Bandwidth Disparity
3Gb/s SDI Standards – Continuing Evolution

**SMPTE ST 424:2012**
Updates to add provisions for use of other connector types
Typical cable loss recommendation changed from -20dB to < -30dB

**SMPTE ST 425:2011**
Revised to include Digital Cinema production formats and add 32 channel audio support

Split into multiple parts to accommodate future revisions for stereo and high resolution images:

- 425-0 – Index
- 425-1 – Replaces current 425
- 425-2 – A Stereo Pair of 1.5Gb/s images – tie up with ST292-2
- 425-3 – Single Images with payload up to 6 Gb/s, carried on 2 links
- 425-4 – A Stereo pair of 3 Gb/s signals on 2 links
- 425-5 – Single image with payload up to 12 Gb/s, carried on 4 links
- 425-6 – A Stereo Pair of 6 Gb/s signals, transported via 4 links

The 3Gb/s SDI Standards suite

**CURRENT STANDARDIZATION ACTIVITIES**

- **ST 274, 396, 428-9, 428-19 & 2048-2**
  - 1920x1080, 1280x720 & 2048x1080

- **ST 273, 428-9, 428-19, 2048-1, 2048-2 & 3036-1**
  - 1024x1080, 1920x1080, 2048x1920, 3408x2160 & 5408x3120

- **ST 2048-1, 428-19 & 2036-1**
  - 4096x2160 & 3408x2160

- **ST 425-1**
  - Source Image Format and Auxiliary Data Mapping for 3Gb/s SDI

- **ST 425-3**
  - Source Image Format and Auxiliary Data Mapping for Dual 3Gb/s SDI

- **ST 425-5**
  - Source Image Format and Auxiliary Data Mapping for Quad 3Gb/s SDI

- **ST 425-6**
  - Stereoscopic Image Formats on a Single 3Gb/s SDI

- **ST 425-8**
  - Stereoscopic SDI for Stereoscopic Image Transport

- **ST 425-9**
  - Stereoscopic Image Formats on a Single 3Gb/s SDI

- **ST 427**
  - Stereoscopic Image Formats on a Single 3Gb/s SDI

- **ST 428-19**
  - 3Gb/s SDI for Stereoscopic Image Transport

- **ST 429**
  - Stereoscopic Image Formats on a Single 3Gb/s SDI

- **ST 437**
  - Stereoscopic Image Formats on a Single 3Gb/s SDI

- **ST 447**
  - Stereoscopic Image Formats on a Single 3Gb/s SDI

- **ST 428-19 & 2048-2**
  - 1920x1080, 1280x720 & 2048x1080 Image Formats

- **ST 428-19 & 2036-1**
  - 4096x2160 & 3408x2160 Image Formats

- **ST 428-19 & 2048-2 & 3036-1**
  - 4096x2160 & 3408x2160 Image Formats

- **ST 428-19 & 2048-1 & 3036-1**
  - 4096x2160 & 3408x2160 Image Formats

- **ST 428-19 & 2048-1 & 3036-1**
  - 4096x2160 & 3408x2160 Image Formats
The 3G SDI Document suite

Extending the ST 425 document suite in support of HDTV and 2K D-Cinema production with higher resolution (bit depth and sampling)
The 3G SDI Document suite

Extending the ST 425 document suite in support of HFR 2K D-Cinema production

<table>
<thead>
<tr>
<th>System</th>
<th>Horizontal Data Rate (GB/s)</th>
<th>Vertical Samples</th>
<th>Frequency (MHz)</th>
<th>samples per second (Frames)</th>
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<tbody>
<tr>
<td>1080p 24</td>
<td>276</td>
<td>1120</td>
<td>120</td>
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<tr>
<td>1080p 30</td>
<td>414</td>
<td>1680</td>
<td>165</td>
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<td>1080p 50</td>
<td>828</td>
<td>3360</td>
<td>330</td>
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<td>1080p 60</td>
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<td>4080</td>
<td>405</td>
<td>240</td>
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ST 424: 3Gb/s Signal/Data serial Interface
ST 297: Optical Interface

The 3G SDI Document suite

Extending the ST 425 document suite in support of Stereoscopic 3D HDTV and 2K D-Cinema production

<table>
<thead>
<tr>
<th>3D HDTV and 2K D-Cinema Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Resolution</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>1080p 24</td>
</tr>
<tr>
<td>1080p 30</td>
</tr>
<tr>
<td>1080p 50</td>
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<tr>
<td>1080p 60</td>
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</table>

ST 424: 3Gb/s Signal/Data serial Interface
ST 297: Optical Interface
The 3G SDI Document suite

Extending the ST 425 document suite in support of Stereoscopic 3D HDTV and 3D HFR 2K D Cinema production

ST 424 3Gb/s Signal/Data serial Interface
ST 297 Optical Interface

Under Consideration linear frame rates (1/2 quoted fps per eye)

The 3G SDI Document suite

Extending the ST 425 document suite in support of 4K D-Cinema and UHDTV-1 production

ST 424 3Gb/s Signal/Data serial Interface
ST 297 Optical Interface

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3G SDI – Some things to Consider

General Issues for 1080p50/60

Both Level A and Level B-DL mapping modes have similar capabilities BUT they are not compatible

For 1080p50/60, conversion between Level A and Level B-DL introduces a delay of at least one video line on each conversion

Conversion of signals with embedded audio or other ancillary data may increase the delay and introduce additional complexity to correct the positioning or timing of some ancillary data packets

Some devices process signals internally using a different standard to their own input/output standard. It is always advisable to confirm these devices compensate for any conversion delay internally before installation

Users should establish capabilities of proposed purchases before designing new installations

Facility designers may wish to select one mapping format (Level A or Level B-DL) for each facilities routing / vision mixer signal “cloud”

Switching Regions

For Level A and Level B-DS, the serial stream switch point is defined in SMPTE RP 168:2009

For Level B-DS (carriage of two 1.5Gb/s streams on a single 3Gb/s link), there is no requirement for frame alignment of each image. If the two images are not frame aligned, video switching could be adversely effected

Users and facility designers should always ensure that Level B-DS equipment guarantees frame alignment.

ST 352 Payload ID

The use of the SMPTE ST 352 Payload ID is mandatory due to the large number of different video formats that can be carried in the 3 Gb/s interface

Without the payload ID, it is not possible to correctly identify all of the supported formats or mapping modes purely from inspection of the payload data

Users should ensure that any proposed new purchases support ST 352 payload ID before designing new installations
**3G SDI – Some things to Consider**

**Embedded audio**

Level A, Level B-DL, and Level B-DS can all carry up to 32 audio channels but channel assignments and identification are different:

- Level A uses 8 separate audio groups (of 4 channels each) - in accordance with ST 299-1 and ST 299-2 - all 32 channels are uniquely identified.
- Level B-DL uses two streams of 4 audio groups (of 4 channels each) - in accordance with ST 299-1 - identical channel numbers are used but channels 1–16 can only be differentiated from channels 17–32 at the ST 372 Dual-Link (Link A / Link B) level.
- Level B-DS is similar to Level B-DL carrying two links of 16 channels but there is no defined channel assignment for this mapping.

*End-users and facility designers should ensure that audio embedders / de-embedders correctly identify audio channel mapping in mixed Level A / Level B systems.*

*Extra care should be taken in 3G system upgrades to ensure that these new audio embedding capabilities are handled transparently throughout the plant.*

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**Summary**

In summary, the 3G SDI Document suite is continuing SMPTE’s evolutionary approach to the development of the SDI interface.

This approach allows broadcasters to extend their ROI (return On Investment), for capital purchases recently made as part of their 3G-SDI core infrastructure upgrade, while they transition to supporting emerging production image formats.

Dual-link 3G-SDI and quad-link 3G-SDI provide a very pragmatic solution to solving the bandwidth disparity problem for (arguably), the most common 2D and 3D HDTV, 2K, 4K D-Cinema and UHDTV-1 production requirements.
Beyond 3G SDI

Eventually, as stereoscopic 3D, 4K D-Cinema and UHDTV1 / UDHTV2 production moves from “application and infrastructure islands” to mainstream production requirements, a new core-infrastructure and real-time media streaming interface data rate and build out will be required.

The evolution of the SDI interface continues in SMPTE with the formation of the 32NF70 Working Group on UHD-SDI....

But that's a topic for another time

Q & A

• John Hudson
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