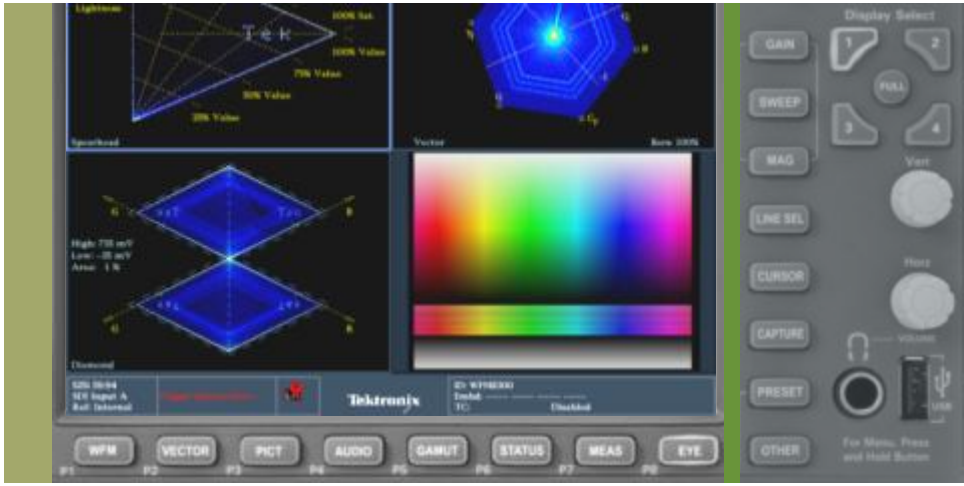
STE February
HDMI Overview and Picture testing

Presented by Steve Holmes



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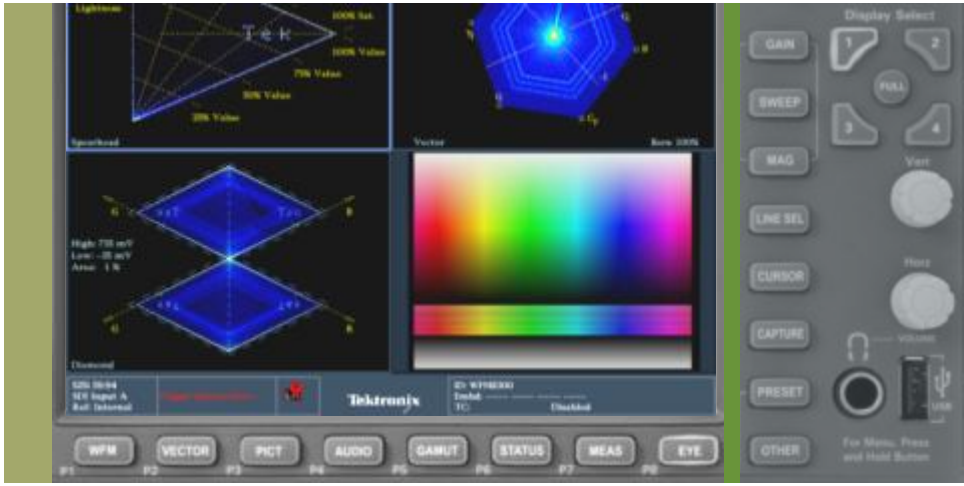
Agenda

- Overview, HDMI 1.3, 1.4, 1.4A & 3D
- Deconstructing HDMI how is it related to SDI
- Where did my Anc data go
- Challenges in Monitoring Video over HDMI, HDCP, STB, OTT, CALM act, Tablet, Phone, ??

HDMI Overview



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HDMI what is it

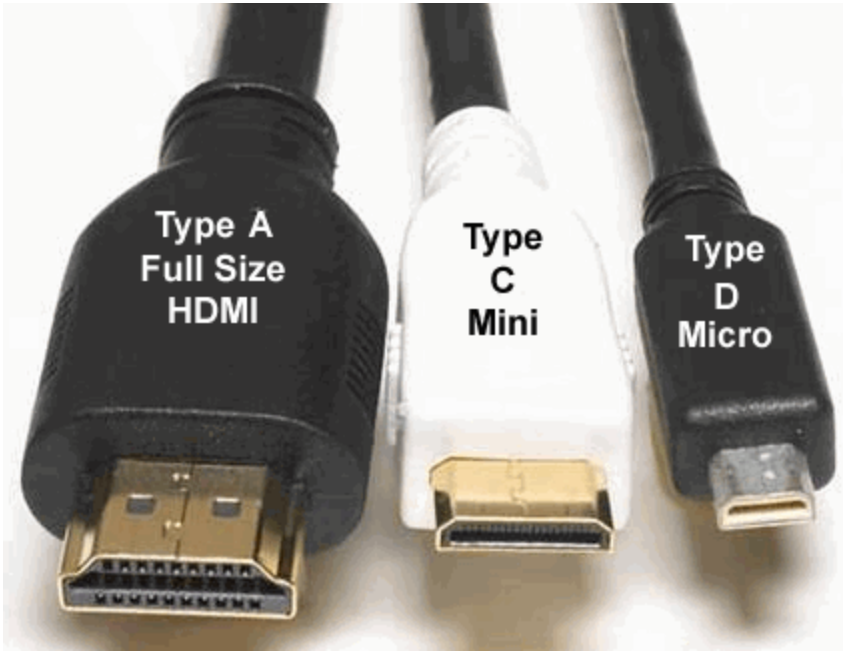
- **HDMI** (**High-Definition Multimedia Interface**)
  - is a compact audio/video interface for transferring uncompressed digital audio/video data from an HDMI-compliant device ("the source device") to a compatible digital audio device, computer monitor, video projector, or digital television. HDMI is a digital replacement for existing analog video standards.
  - can be used for any uncompressed video format, including standard, enhanced, high definition, and 3D video signals; with up to 8 channels of compressed or uncompressed digital audio
  - HDMI can use **HDCP** (High-bandwidth Digital Content Protection) to encrypt the signal if required by the source device. CSS, CPRM and AACS require the use of HDCP on HDMI when playing back encrypted DVD Video, DVD Audio, HD DVD and Blu-ray Disc

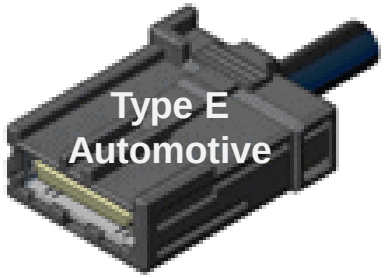
HDCP what is it?

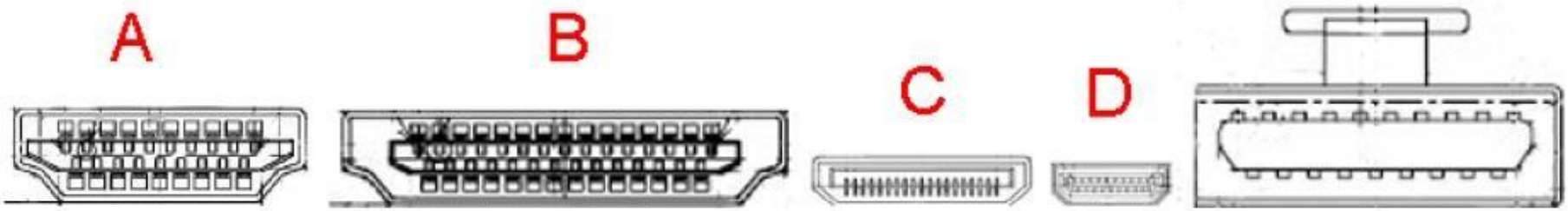
- HDCP (High-bandwidth Digital Content Protection)
  - HDMI can use HDCP to encrypt the signal, if it is required by the source device.
- Content Scramble System, (CSS), is a Digital Rights Management, (DRM), and encryption system employed on commercially produced DVD-Video discs. Utilizes a proprietary 40-bit stream cipher. Introduced around 1996.
- Content Protection for Recordable Media and Pre-Recorded Media, (CPRM/CPPM), mechanism for controlling the copying, moving and deletion of digital media on a personal computer or other digital player. A form of Digital Restrictions Management, (DRM), developed by the 4C Entity, LLC (consisting of IBM, Intel, Matsushita and Toshiba).
- The Advanced Access Content System, (AACS), intended to restrict access to and copying of the post DVD generation of optical discs. Released April 2005 and adopted as the access restriction scheme for HD DVD and Blu-ray Disc . Developed by a consortium that includes Disney, Intel, Microsoft, Panasonic, Warner Bros., IBM, Toshiba and Sony.

HDMI Connectors

- There are 5 types of HDMI Connectors.
- Type A, B, C, D, E
- Type A Standard HDMI Connector
- Type B has a 2 TMDS links. (Dual Link HDMI) for Supper High Resolutions >4K
- Type C is a smaller Version of Type A
- Type D is a Micro Version of Type A
- Type E is for Automotive applications



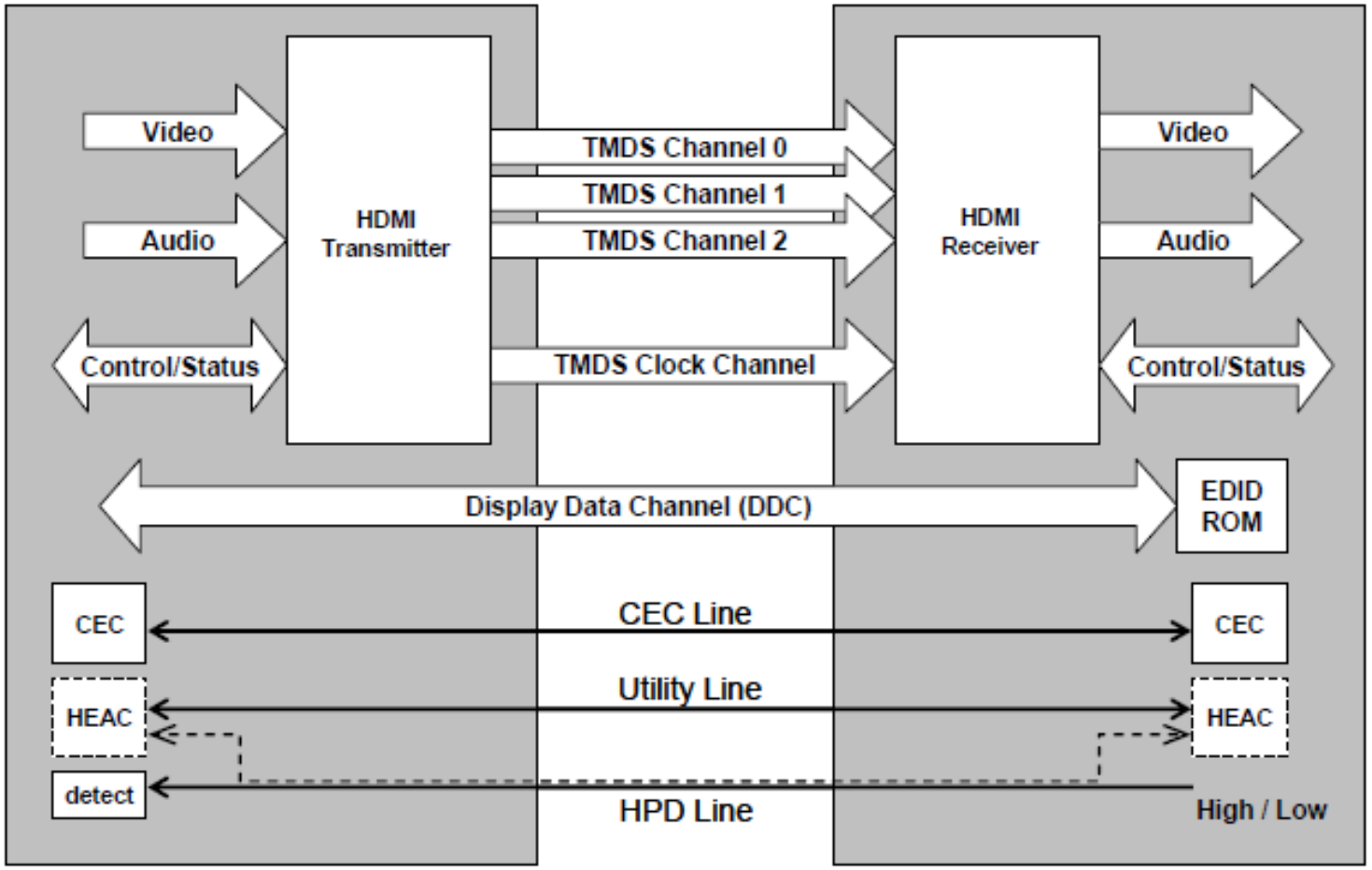




HDMI Video Channels and Signals

- TMDS - Transition Minimized Differential Signaling
  - During the Video Data Period, the pixels of an active video line are transmitted during the horizontal and vertical blanking intervals, audio and auxiliary data are transmitted within a series of packets. The Control Period occurs between Video and Data Island periods.[
- DDC - The Display Data Channel
  - a communication channel used by the HDMI source device to read the E-EDID data from the HDMI sync device to learn what audio/video formats it supports. The standard mode speed (100 kbit/s) and allows optional support for fast mode speed (400 kbit/s) used for HD Content Protection.
- Utility Line
  - Is used for Ethernet and return Audio
- HPD - Hot Plug Detect
- CEC - Consumer Electronics Control
  - command and control up-to ten CEC-enabled devices

HDMI Channels



HDMI Block Diagram

High-Definition Multimedia Interface

Specification Version 1.4

HDMI Licensing, LLC

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HDMI Versions 1.0 – 1.2a

- HDMI 1.0 was released on December 9, 2002
  - A single cable digital Audio/Video interface with a TMDS bandwidth of 4.95 Gbit/S allowing 3.96 Gbit/S of video bandwidth, (1080p/60 UXGA) and 8 channel s of LPCM/ 192 kHz/24 bit Audio.
- HDMI 1.1 was released on May 20, 2004
  - Added support for DVD Audio.
- HDMI 1.2 was released on August 8, 2005
  - Added up to 8 channels of one bit audio and the Type A connector for computer sources.
- HDMI 1.2a was released on December 14, 2005
  - Fully specifies Consumer Electronics Control.

HDMI Versions 1.3 – 1.3C

- HDMI 1.3 was released June 22, 2006
  - Increased the single-link bandwidth to 340 MHz, (10.2 Gbit/S), increased deep color from 24 bit to 30 bit, 36 bit, 48 bit. Added Dolby TrueHD & DTS-HD audio and Audio/Video Sync. Defined category 1 & 2 cables and test procedures. Added type C connector.
- HDMI 1.3a was released on November 10, 2006
- HDMI 1.3b was released on March 26, 2007
- HDMI 1.3b1 was released on November 9, 2007
- HDMI 1.3c was released on August 25, 2008
- Each adding or changing specific items and some housekeeping.

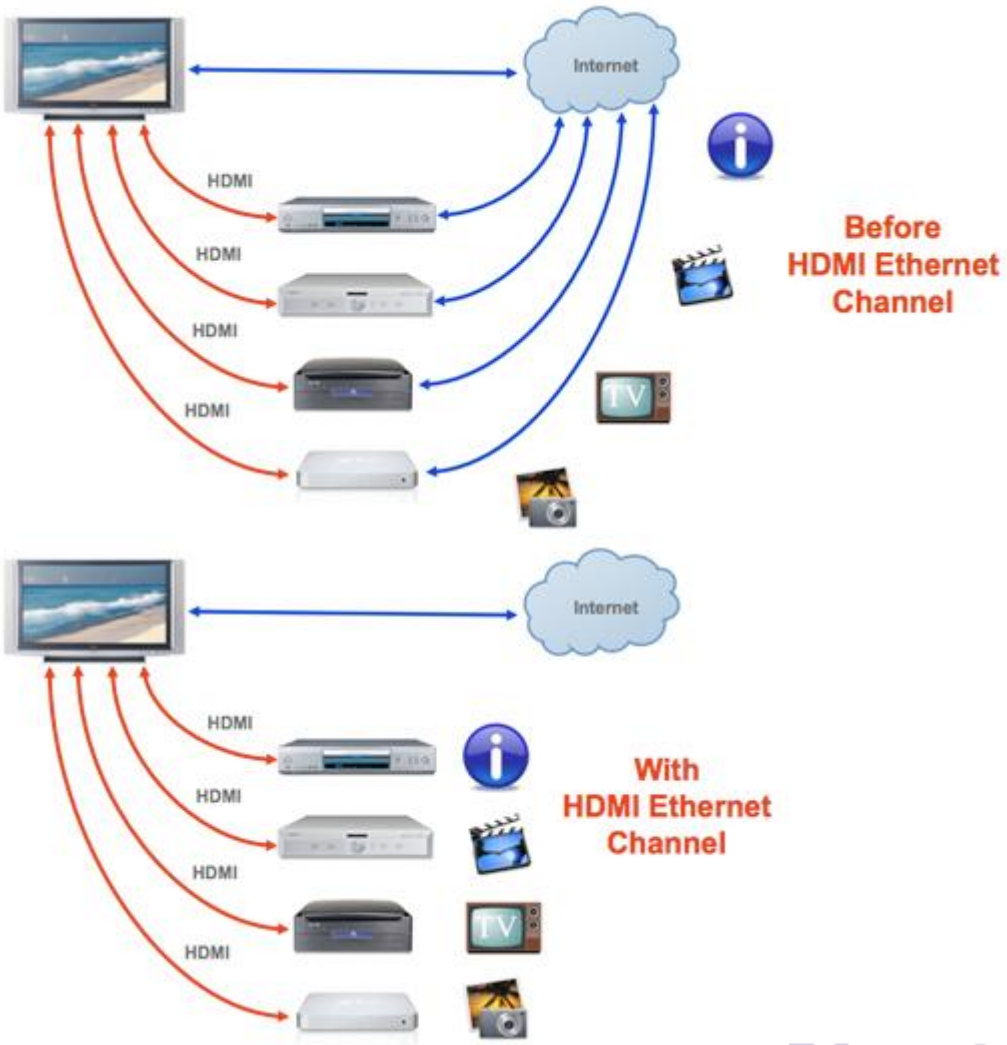
HDMI 1.4 – 1.4a

- HDMI 1.4
  - HDMI 1.4 cable has a new data channel that 1.3 and earlier did not have, for a Reverse Ethernet Channel and return audio.
  - HDMI 1.4 required that 3D displays support the frame packing 3D format at either 720p50 and 1080p24 or 720p60 and 1080p24
  - Increase in the maximum resolution to 4K × 2K
- HDMI 1.4a
  - The big change from 1.4 was that 1.4a added side-by-side 3D horizontal at either 1080i50 or 1080i60 and top-and-bottom 3D at either 720p50 and 1080p24 or 720p60 and 1080p24.
- Change in the cable from 1.3 to 1.4, No change in the cable between 1.4 and 1.4a

HDMI 1.4 Ethernet Channel

- Change from 1.3 to 1.4

- Some STB may check to see if Pin 14 is used, to know that the TV supports Side-by-Side 3D
  - Needs 1.4 HDMI cable
  - (HEC –data)



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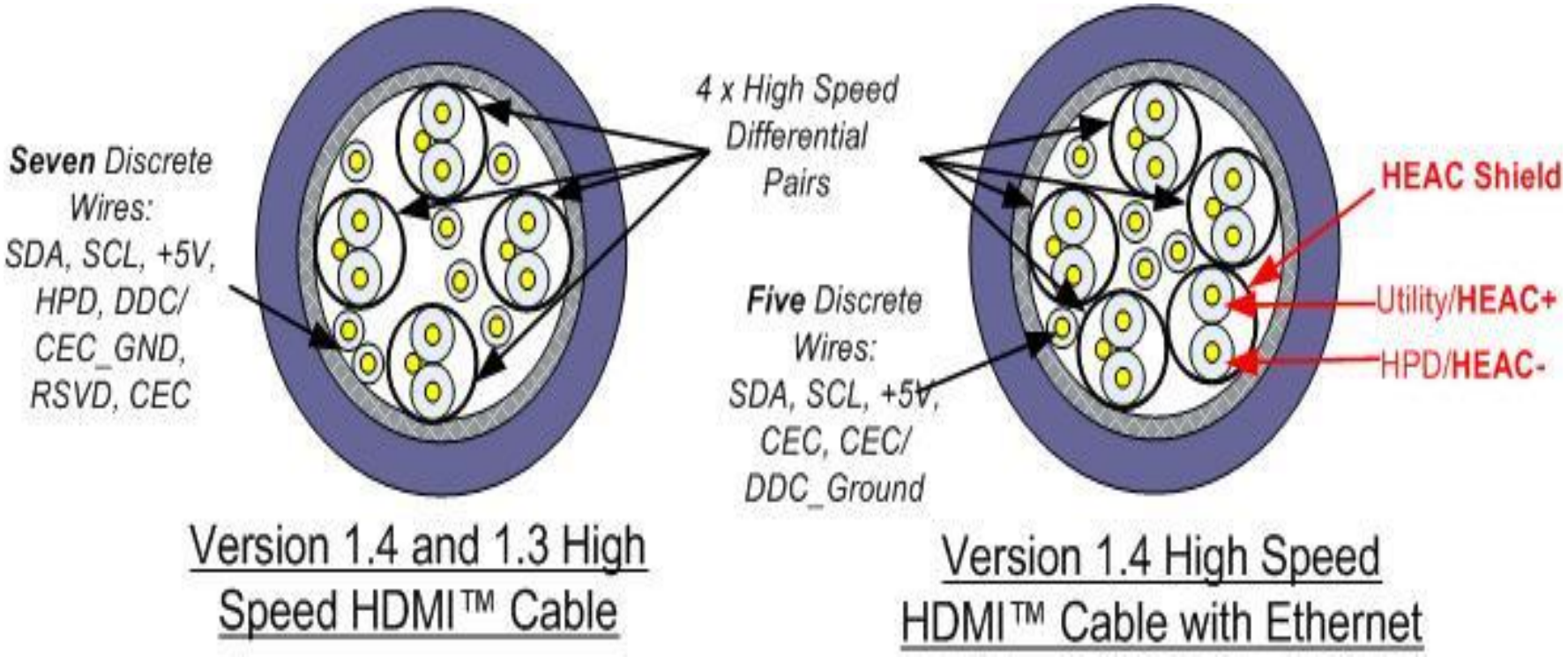
HDMI 1.4 **4K x 2K Support**

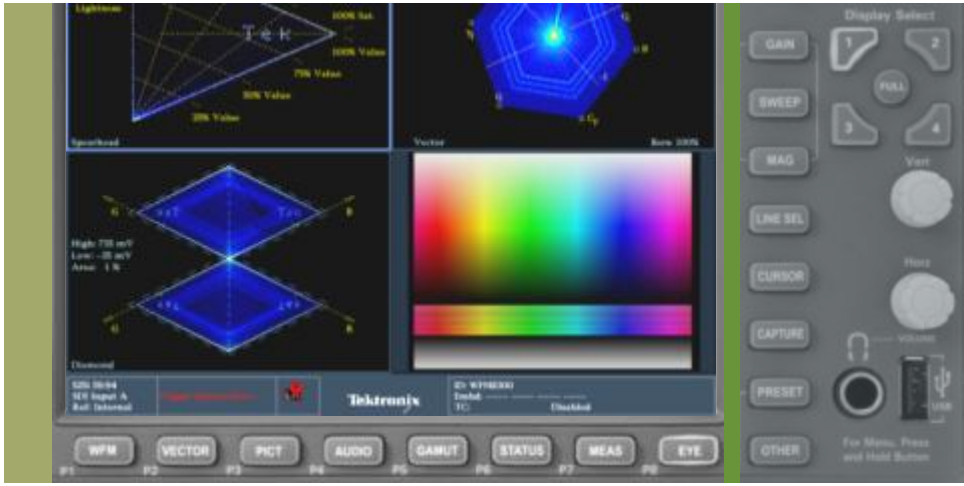
- Resolution on par with state-of-the-art Digital Cinema projectors used in the local multiplexes will be coming to your living rooms. 4K x 2K which represents resolutions of 3840x2160 and 4096x2160 will both be supported by HDMI 1.4

High Speed HDMI Cables w Ethernet



The specification for this channel is not as challenging as for the higher speed 3.4Gbps TMDS pair and performance can be achieved by managing the physical cable design with particular consideration to the attenuation, common mode impedance and differential impedance. For more details on the HEAC channel performance targets, refer to the HEAC1 Supplement to the HDMI Specification.

HDMI vs SDI



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HDMI signals

- **Transition-minimized differential signaling** (**TMDS**) is a technology for transmitting high-speed serial data and is used by the DVI and HDMI video interfaces, as well as other digital communication interfaces.
- The transmitter incorporates an advanced coding algorithm which reduces electromagnetic interference over copper cables and enables robust clock recovery at the receiver to achieve high skew tolerance for driving longer cables as well as shorter low cost cables.
- HDMI carries video, audio and auxiliary data via one of three modes, called the Video Data Period, the Data Island Period and the Control Period
- During the Video Data Period, the pixels of an active video line are transmitted. During the Data Island period (which occurs during the horizontal and vertical blanking intervals), audio and auxiliary data are transmitted within a series of packets. The Control Period occurs between Video and Data Island periods.

- This format is very Similar to SDI SAV-Video-EAV-Anc data

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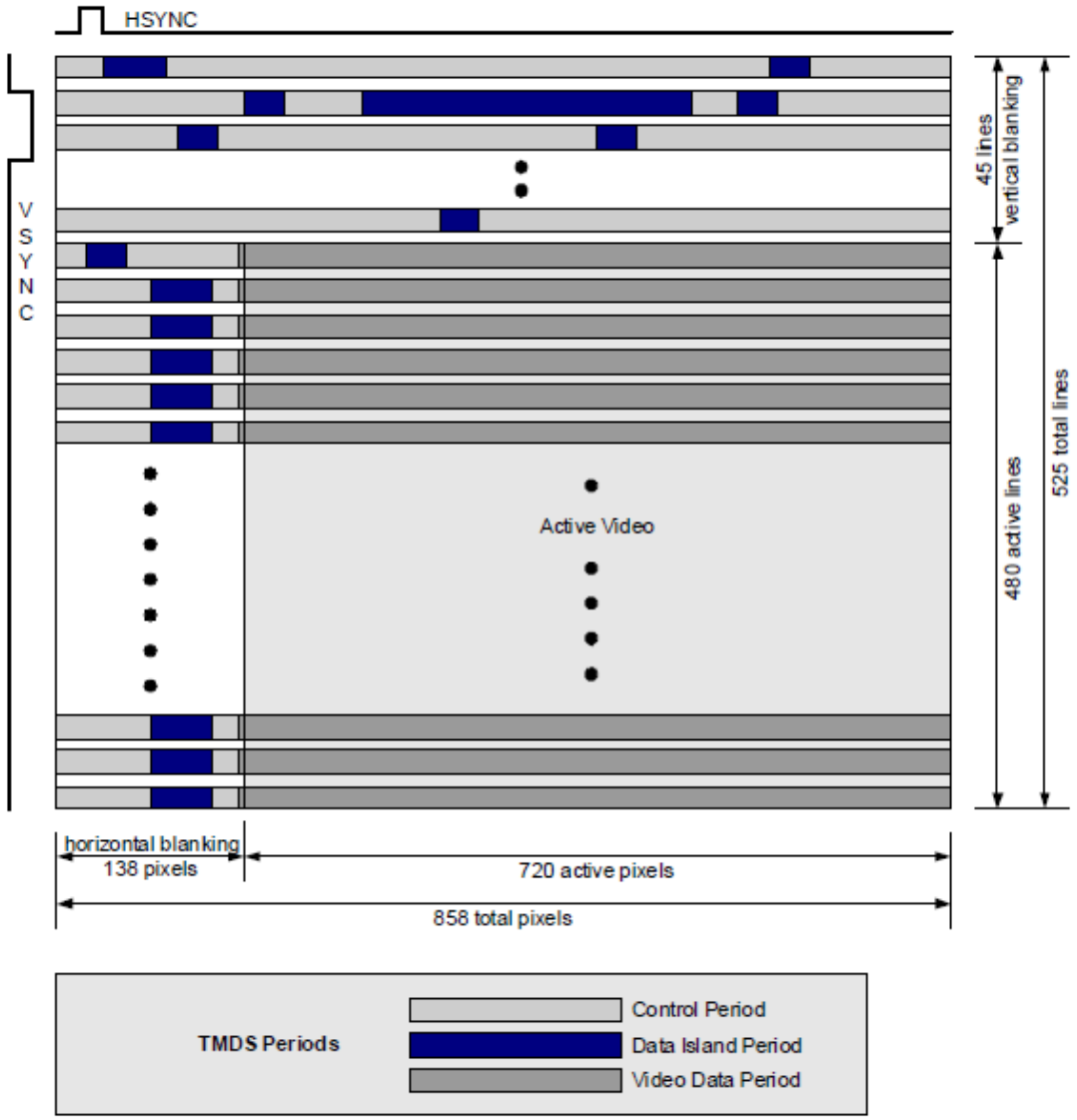
Sample Frame of HDMI data



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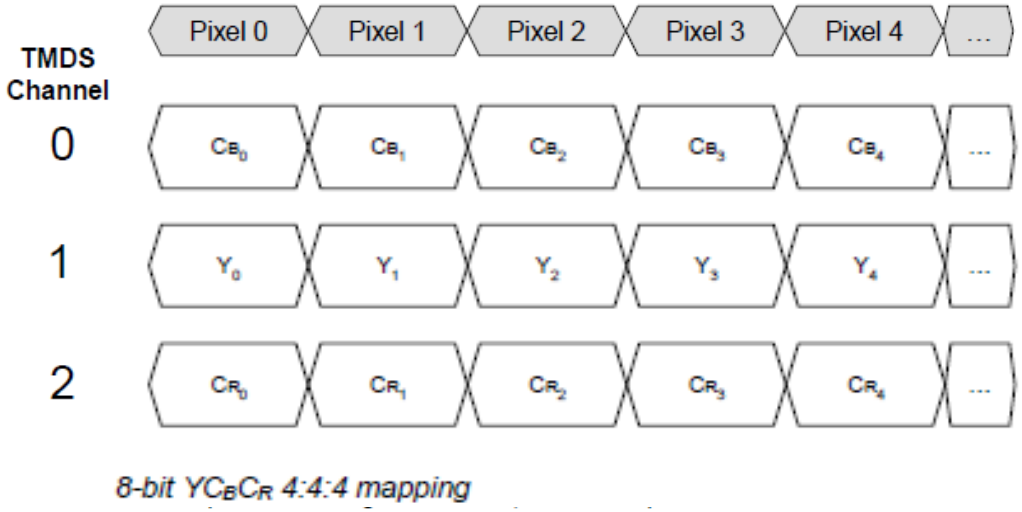
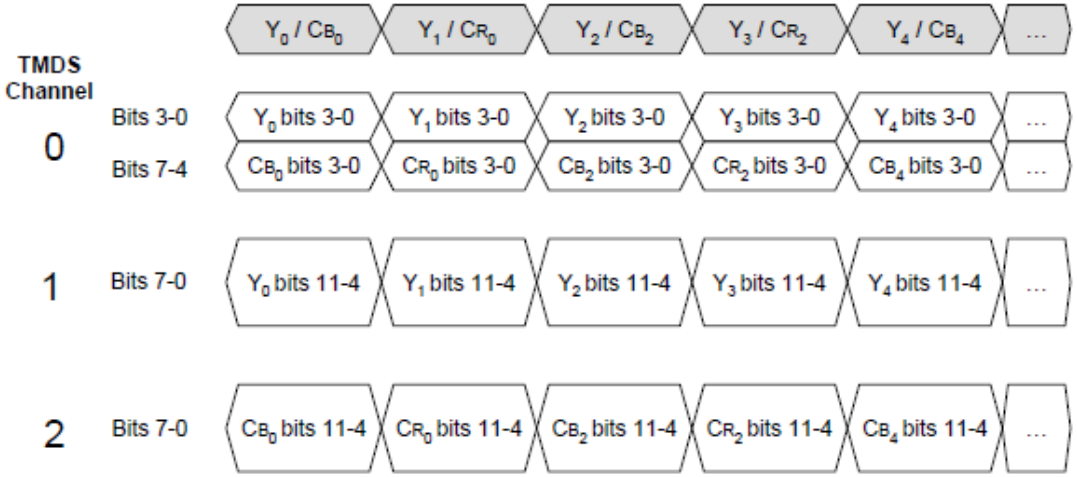
TMDS channels

- The Video carried across the link will be in one of 3 formats.
- RGB 4:4:4
- YCBCR 4:4:4
- YCBCR 4:2:2
- 8 Bit color is mandatory
- 10, 12, or 16 Bit color is optional. (Deep Color) if Deep Color is supported 12 Bit is minatory. (1.3)



8-bit YC_BC_R 4:4:4 mapping



YC_BC_R 4:2:2 component

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Video Levels Full Range, Limited Range

- SDI normal range 10 bit video is 64 to 940
- SDI extended range 10 bit is 4 to 1019
- HDMI see below

Color Component	Component Bit Depth	for Full range		for Limited range		
		Black level	Nominal Peak (White level)	Black level	Nominal Peak (White level)	Valid Range
R / G / B	8	0	255	16	235	1 to 254
R / G / B	10	0	1023	64	940	4 to 1019
R / G / B	12	0	4095	256	3760	16 to 4079
R / G / B	16	0	65535	4096	60160	256 to 65279

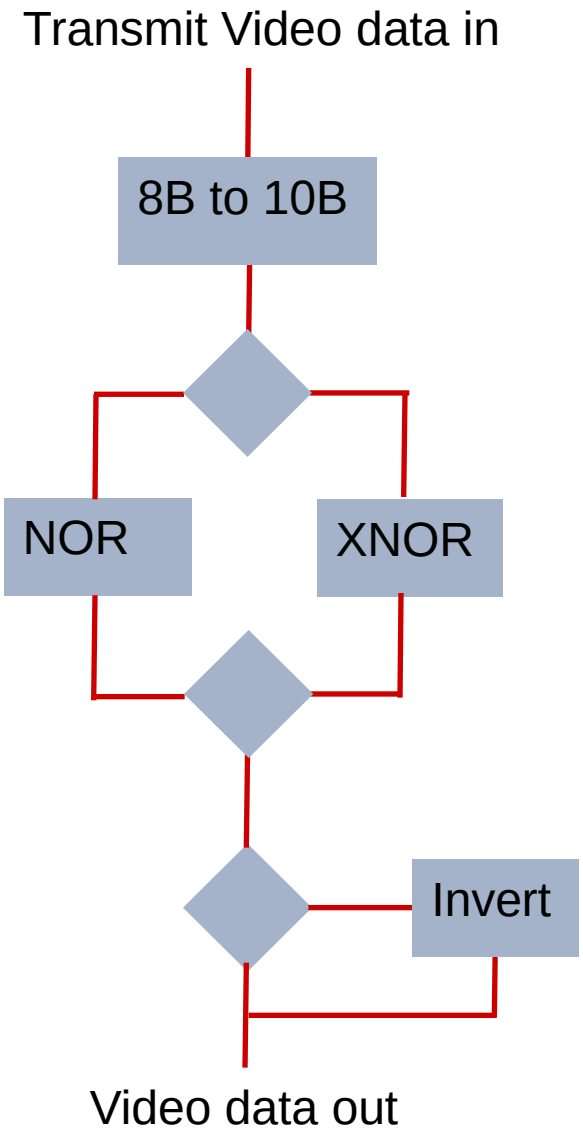
Color Component	Component Bit Depth	for Full range		for Limited range		
		Black level	Nominal Peak (White level)	Black level	Nominal Peak (White level)	Valid Range
Y	8	0	255	16	235	1 to 254
C_B / C_R		128	0 and 255	128	16 and 240	
Y	10	0	1023	64	940	4 to 1019
C_B / C_R		512	0 and 1023	512	64 and 960	
Y	12	0	4095	256	3760	16 to 4079
C_B / C_R		2048	0 and 4095	2048	256 and 3840	
Y	16	0	65535	4096	60160	256 to 65279
C_B / C_R		32768	0 and 65535	32768	4096 and 61440	

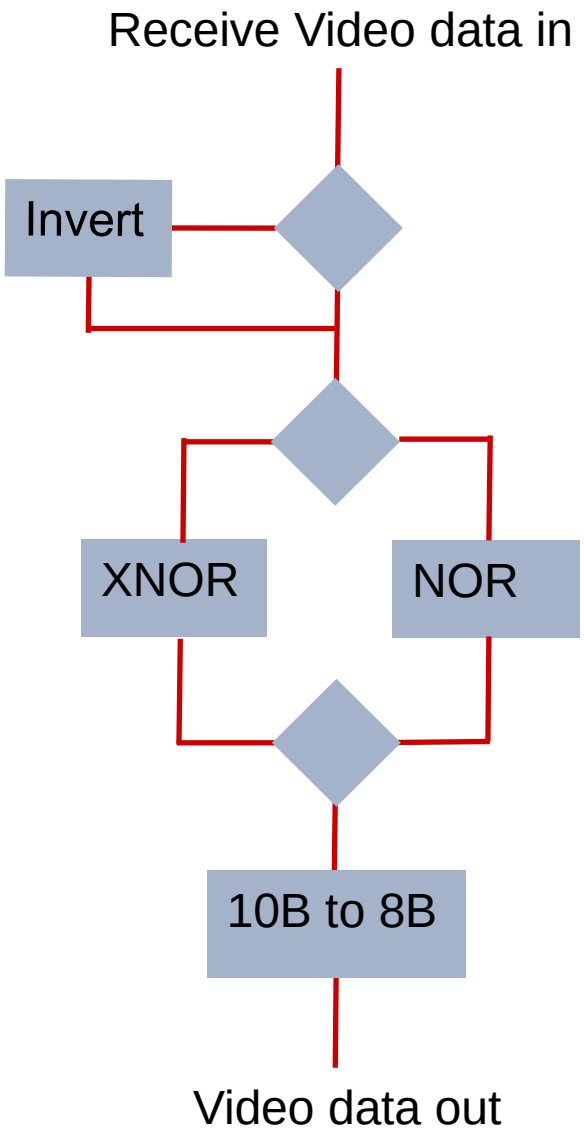
Extended Range Y Cb Cr added in 1.4

Video Data Encoding

- Each 8 bits of video data is coded to 10 bits, using a type of 8b 10b coding.
- Each 10 Bit output is either XOR or XNOR to produce the fewest transitions. With LSb of output matching LSb of input.
- This output then may be inverted to produce the best DC balance of the transmitted stream.
- On Sources and Sinks any analog format that is supported will be supported in HDMI, frame rate and color space.
- All HDMI Sources and Sinks shall support RGB 4:4:4
- All Sources shall support either YC_BC_R 4:4:4 or YC_BC_R 4:2:2.
- All Sinks shall support both YC_BC_R 4:4:4 and YC_BC_R 4:2:2

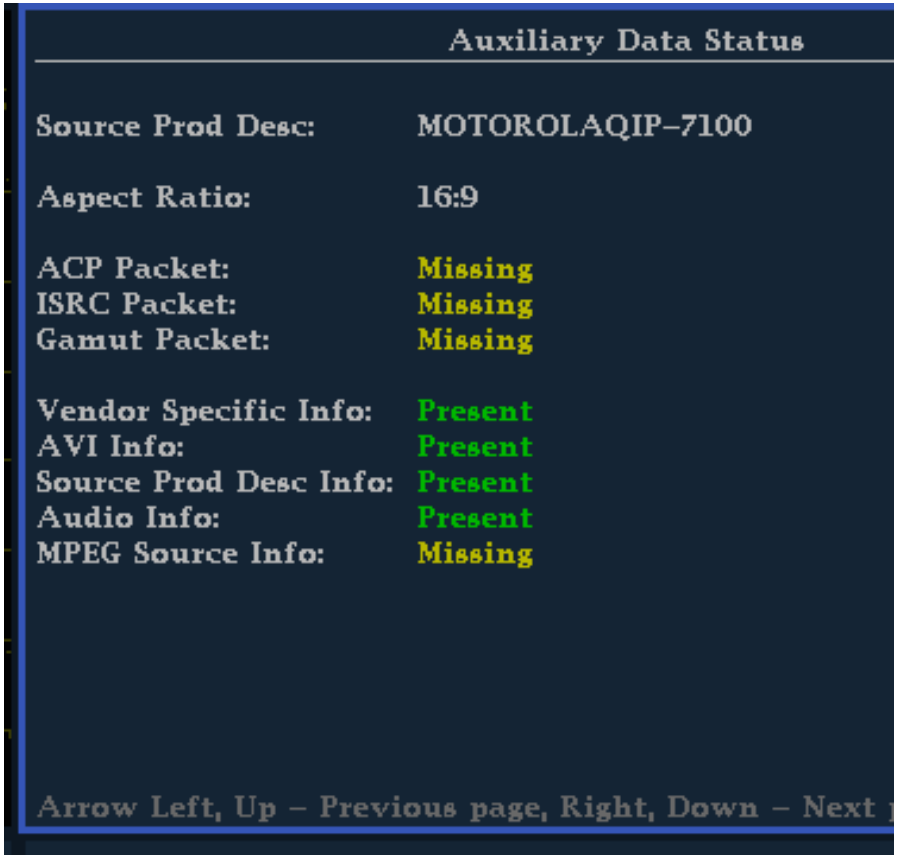
Video Data Encoding





Aux Data Information

- **Source Prod Desc:** - indicates the Source Product Description that is the name of the manufacturer of the device, if present.
- **Aspect Ratio:** - indicates the aspect ratio of the image.
- **ACP Packet:** - indicates presence of Audio Content Protection Packet .
- **ISRC Packet:** - indicates presence of International Standard Recording Codes
- **Gamut Packet:** - indicates presence of .
- **Vendor Specific Info:** - indicates the presence of Vendor Specific Information.
- **AVI Info:** - indicates presence of AVI Info frame.
- **Source Prod Desc Info:** - indicates the presence of Source Product Description Information .
- **Audio Info:** - indicates presence of Audio Information.
- **MPEG Source Info:** - indicates presence of MPEG Source Information.



Sent during Data Island periods

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Closed Captions

- In NTSC 608 captions are carried on Line 21 of the actual Video
- In HD SDI 708 captions are carried as a Data packet in the Vertical Ancillary space (608 are carried inside of the 708 packet)
- In MPEG 608 are on a Visible Picture line so it is coded with the Video
- In MPEG 708 Captions are carried as user data in the header of each Picture start code
- HDMI knows nothing about Captions!! It is STB or DVD/BluRay player that will overlay the captions on the video

Content protection (HDCP)

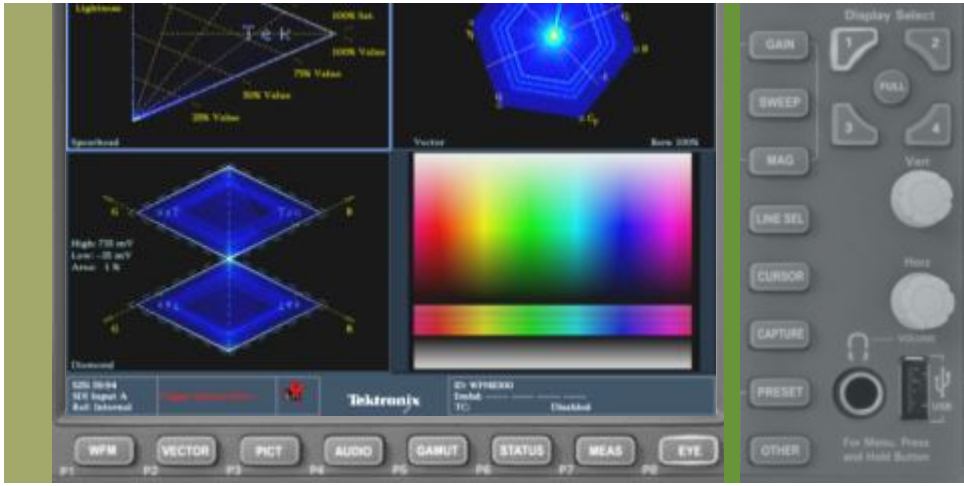
- There are three main parts to HDCP's security system.
- AKE
  - First, there is the cryptographic Authentication and Key Exchange (AKE). When a company wishes to produce an HDCP-compliant device, that company requests a set of keys from the HDCP licensing body.
  - After the licensing body has determined that the company's product has been designed in a manner robust enough to withstand attacks and that the keys will be protected, the company will be given a series of unique secret keys.
- Hand Shake
  - Once both the playback device and the display device have settled on a value with which to encrypt the content, all the video content will be encrypted using this mutual value (this is the second part). Additionally, the system will check every couple of seconds to ensure the integrity of both the keys and the link.
- Key-revocation list
  - The third aspect of HDCP security is device renewability. This is the ability for media, streaming content, or even other devices to invalidate keys known to be a problem.

Non HDCP receivers

- What happens when a Non HDCP receiver is hooked to a HDCP transmitter.
  - The transmitter tries to handshake the receiver does not respond and the transmitter shuts off in about 3 to 5 seconds.
    - We have not even started the content yet to see if it is protected or not.

- HDCP does not turn on and off. If a device is HDCP compliant the HDCP signaling is always on, even for not protected content.

HDMI Monitoring



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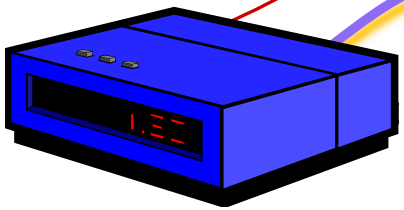
How to see the Output of a HDMI device

- You need an HDCP compliant device..



Set Top Box

HDCP compliant Waveform Monitor

Cell Phone or Tablet

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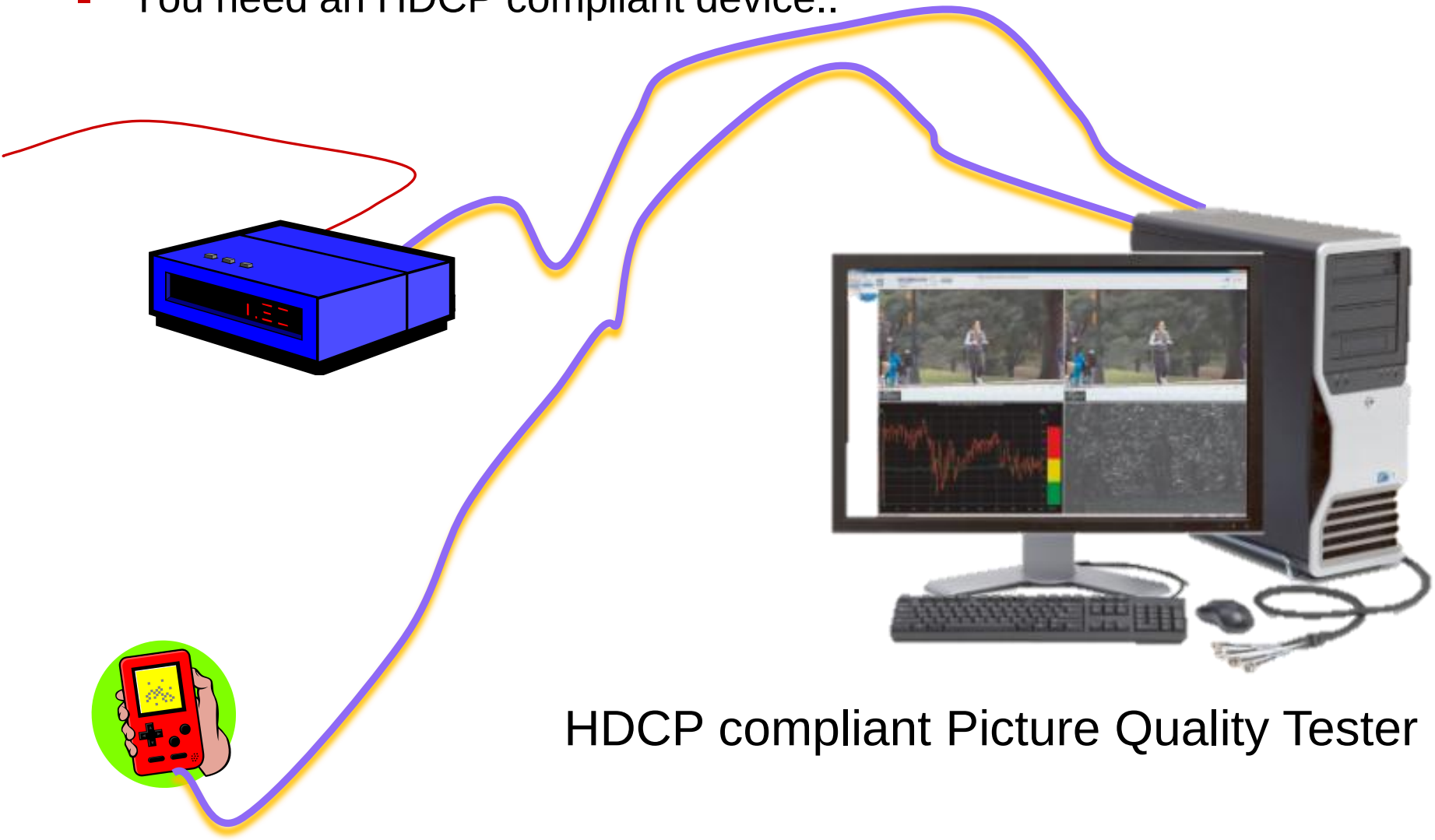
How to see the Output of a HDMI device

- You need an HDCP compliant device..



HDCP compliant Picture Quality Tester

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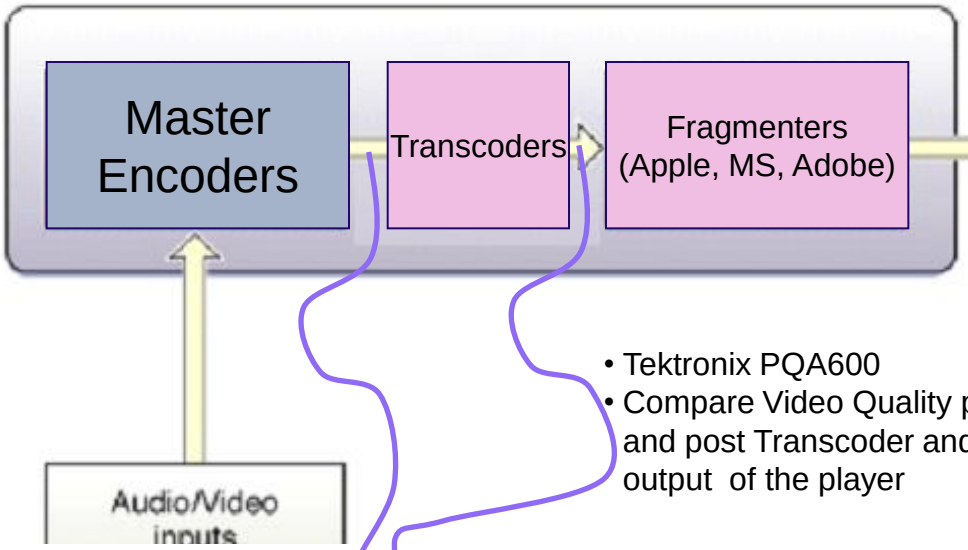
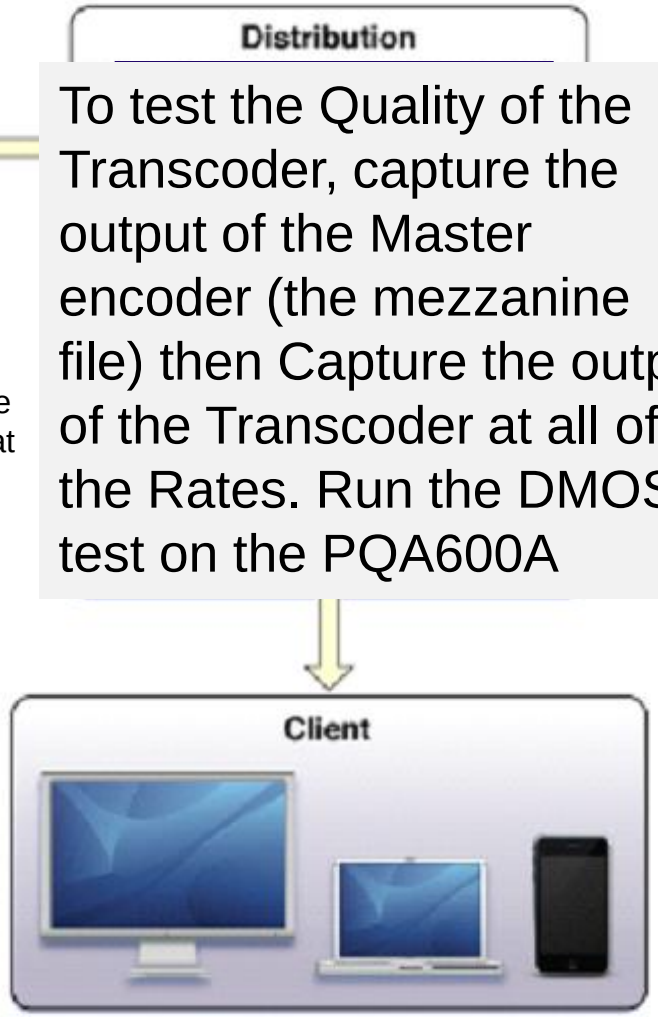
Tektronix Transcoder Performance Verification Application



- Tektronix PQA600
- Compare Video Quality pre and post Transcoder and at output of the player



To test the Quality of the Transcoder, capture the output of the Master encoder (the mezzanine file) then Capture the output of the Transcoder at all of the Rates. Run the DMOS test on the PQA600A

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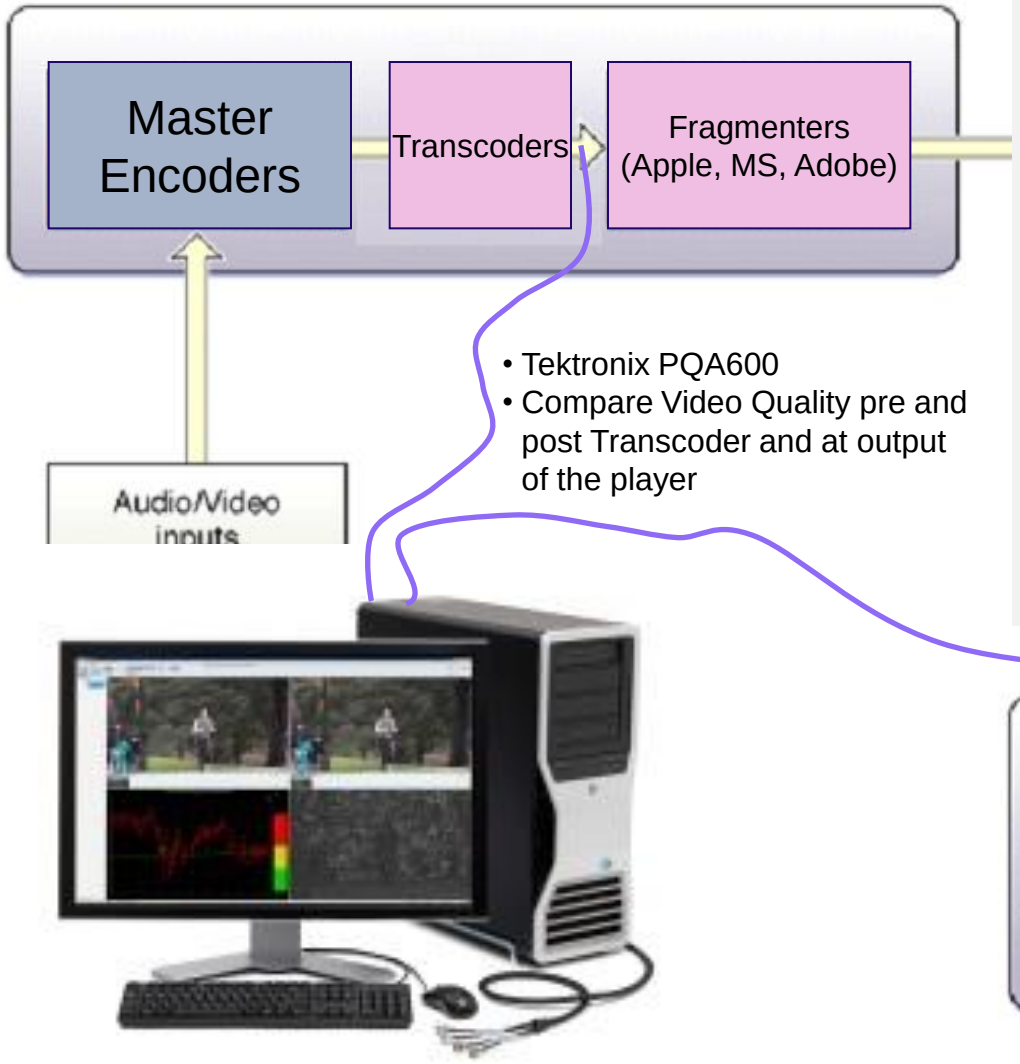
Tektronix Transcoder Performance Verification Application



To test the Quality of the System End to End, capture the output of the Transcoder (use the captured file from the previous test) then Capture the output of Playout device if you have the Test Client you can request the different rates. Run the DMOS test on the PQA600A

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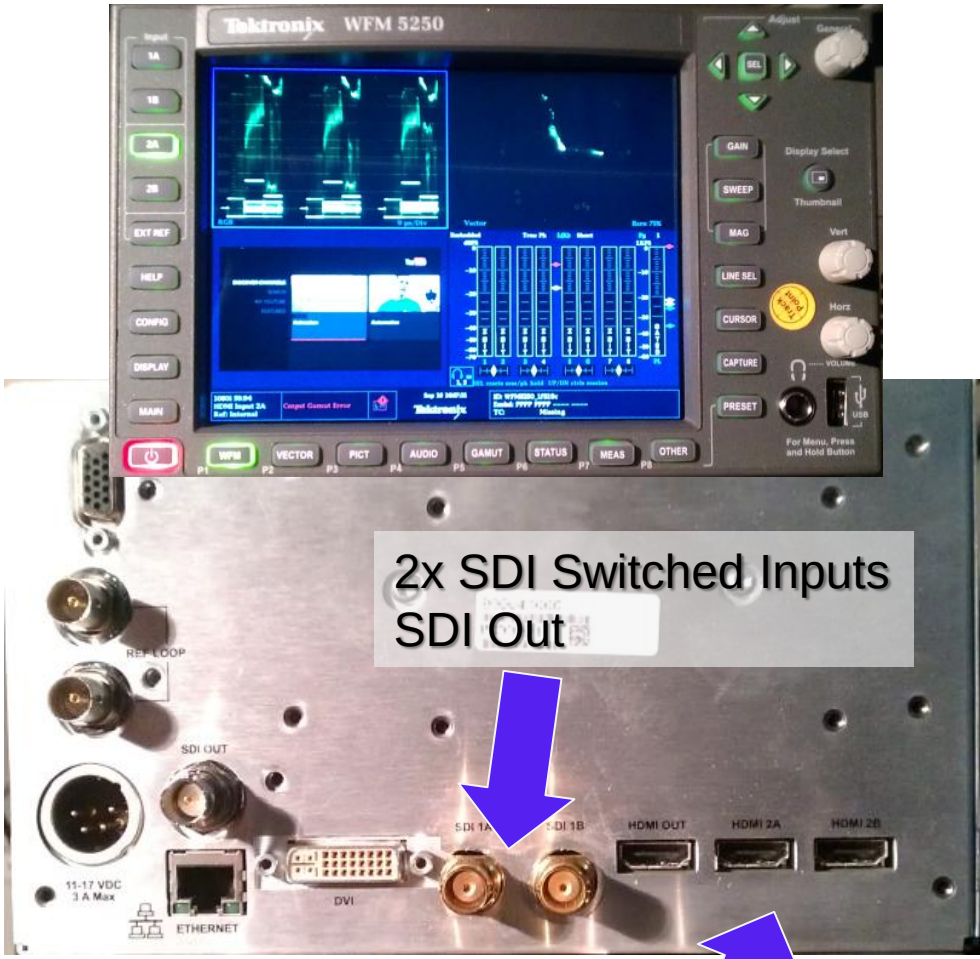
New Set Top Box Monitoring – WFM/WVR5250

- HDMI (with HDCP) Content Monitor
  - Audio Loudness Monitoring for the CALM "Quick Check"
  - Black / Frozen Video Detection and valid color gamut
  - Advanced Error Logging with Web Server UI Full Control



- HDMI A/B Switched Input
- HDMI Out

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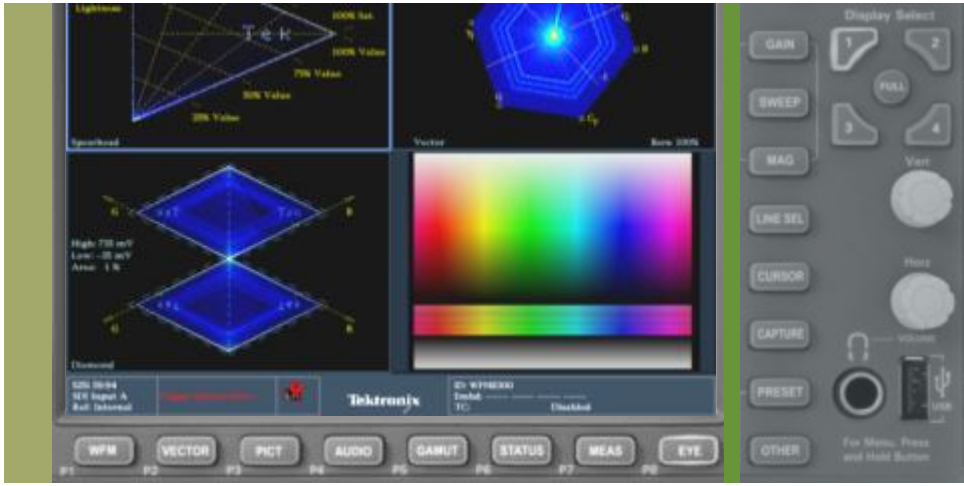
HDMI Data Screens



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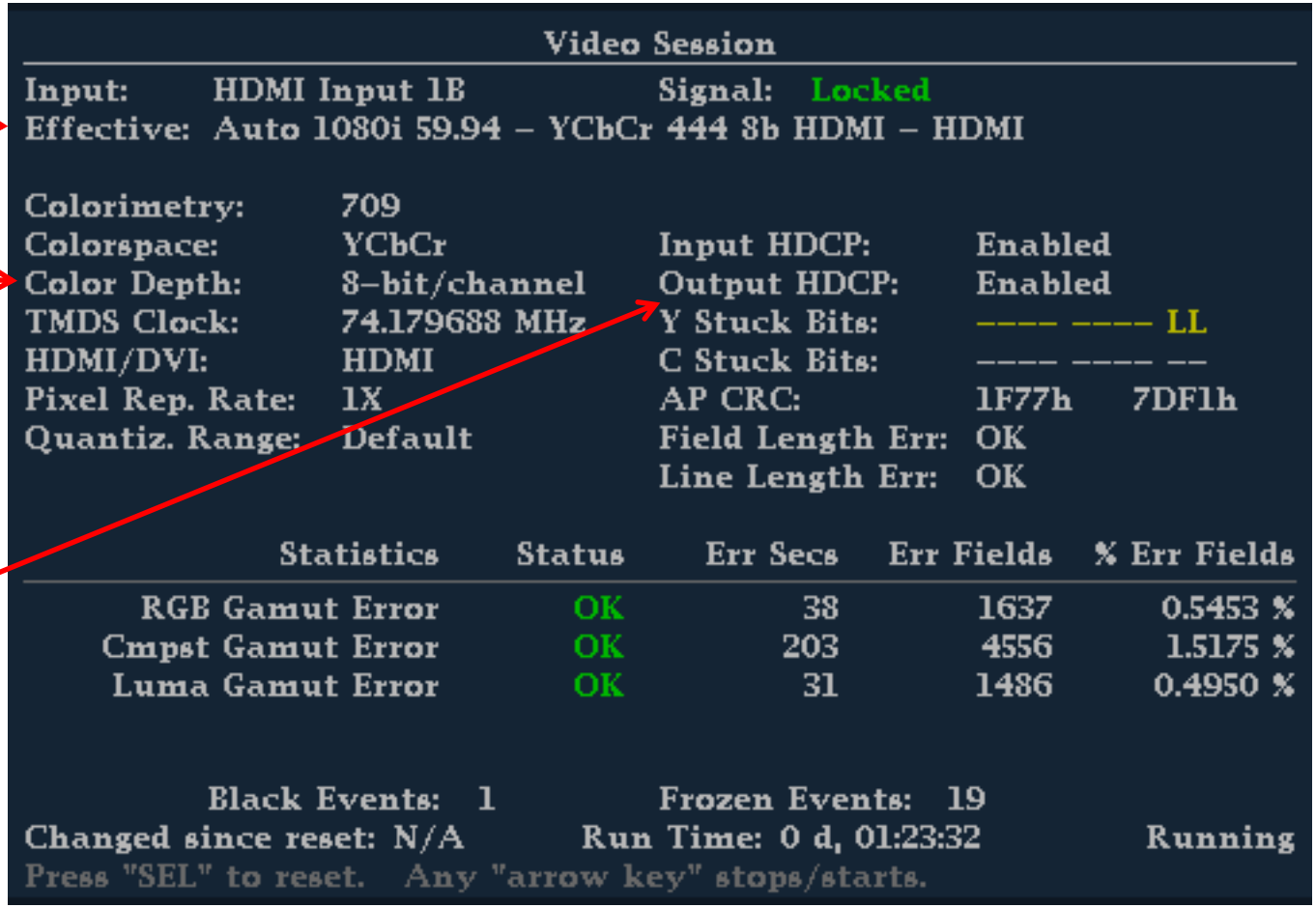
Video Session Screens

- Input Signaled format
- Measured Format
- Input & Output HDCP status



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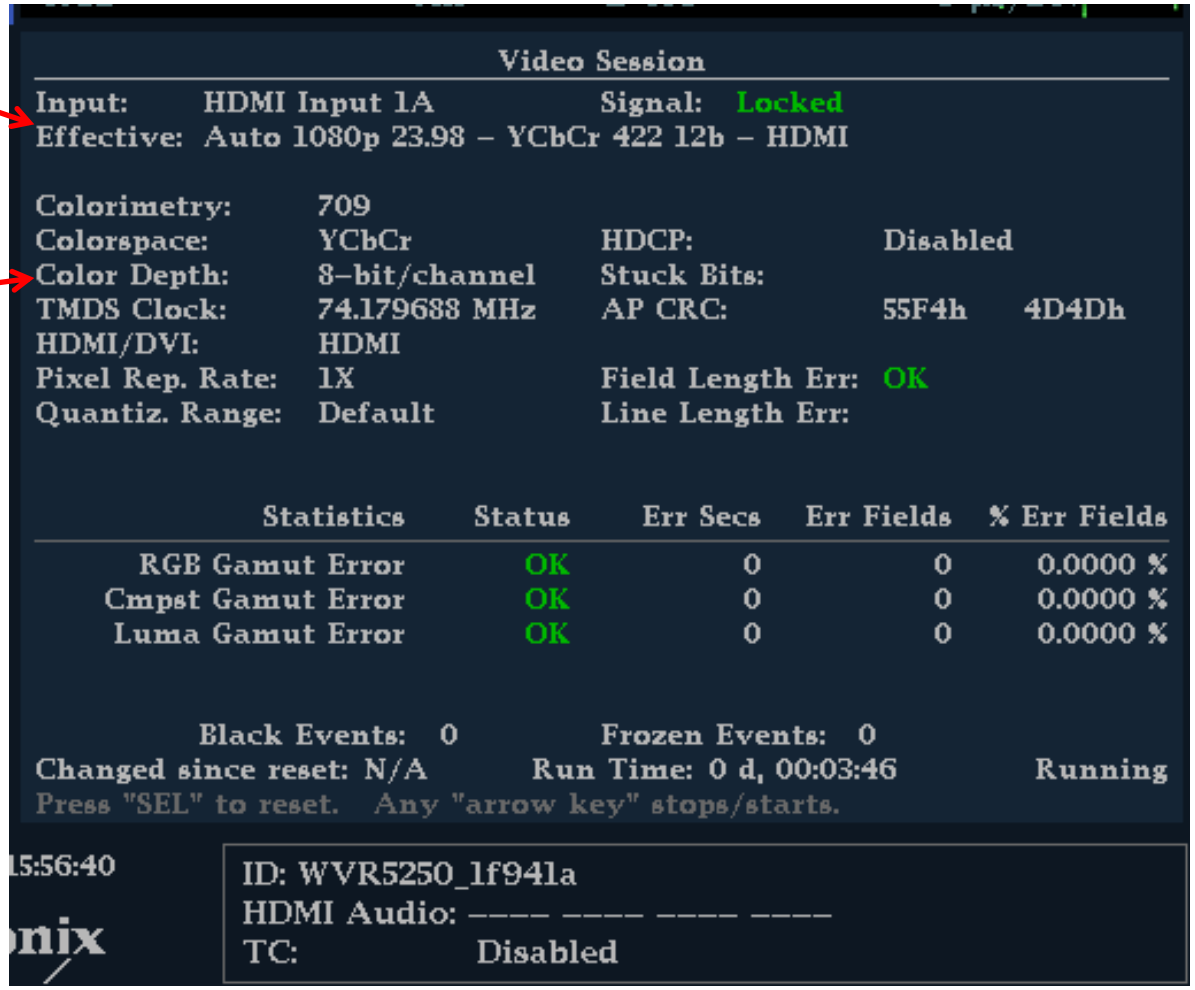
When things are not correct…

- Input format was signaled as 12b
- But received data was only 8b



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When things are not correct…

- Input format was signaled as 1080P
- But received data was 601 color space

Video Session

Input:	HDMI Input 1A	Signal:	Locked
Effective:	Auto 1080p 59.94 – RGB 444 8b HDMI – HDMI		
Colorimetry:	601		
Colorspace:	RGB	Input HDCP:	Disabled
Color Depth:	8-bit/channel	Output HDCP:	Not Connected
TMDS Clock:	148.359375 MHz	Y Stuck Bits:	---- ---- --
HDMI/DVI:	HDMI	C Stuck Bits:	---- ---- --
Pixel Rep. Rate:	1X	AP CRC:	760Eh A9E5h
Quantiz. Range:	Default	Field Length Err:	OK
		Line Length Err:	OK

Statistics	Status	Err Secs	Err Fields	% Err Fields
RGB Gamut Error	OK	1	11	0.0575 %
Cmpst Gamut Error	OK	1	1	0.0052 %
Luma Gamut Error	OK	1	11	0.0575 %

Black Events: 0 Frozen Events: 0
Changed since reset: Yes Run Time: 0 d, 00:09:12 Running
Press "SEL" to reset. Any "arrow key" stops/starts.

Color is washed out

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When things are not correct…

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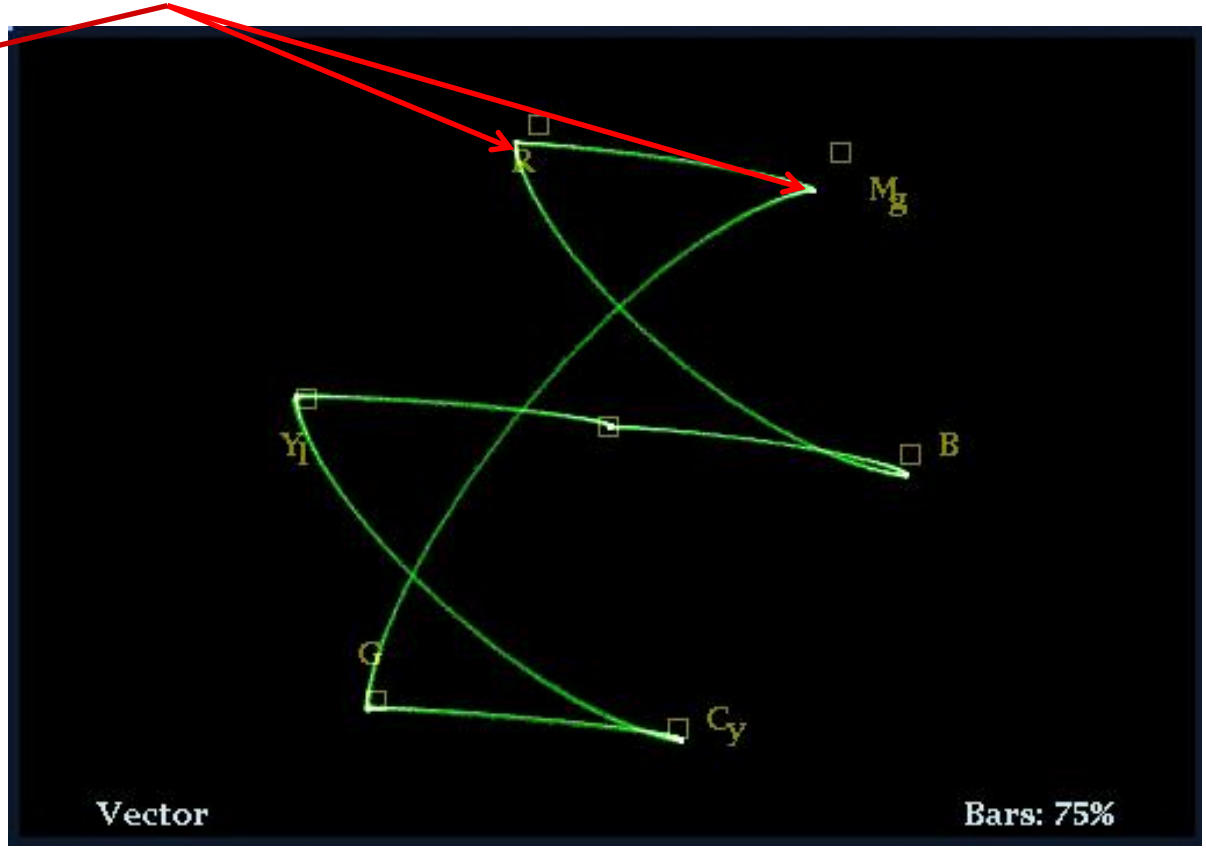
When things are not correct…

- Color Bars not quite correct look at Red and Magenta
- Other colors are off also



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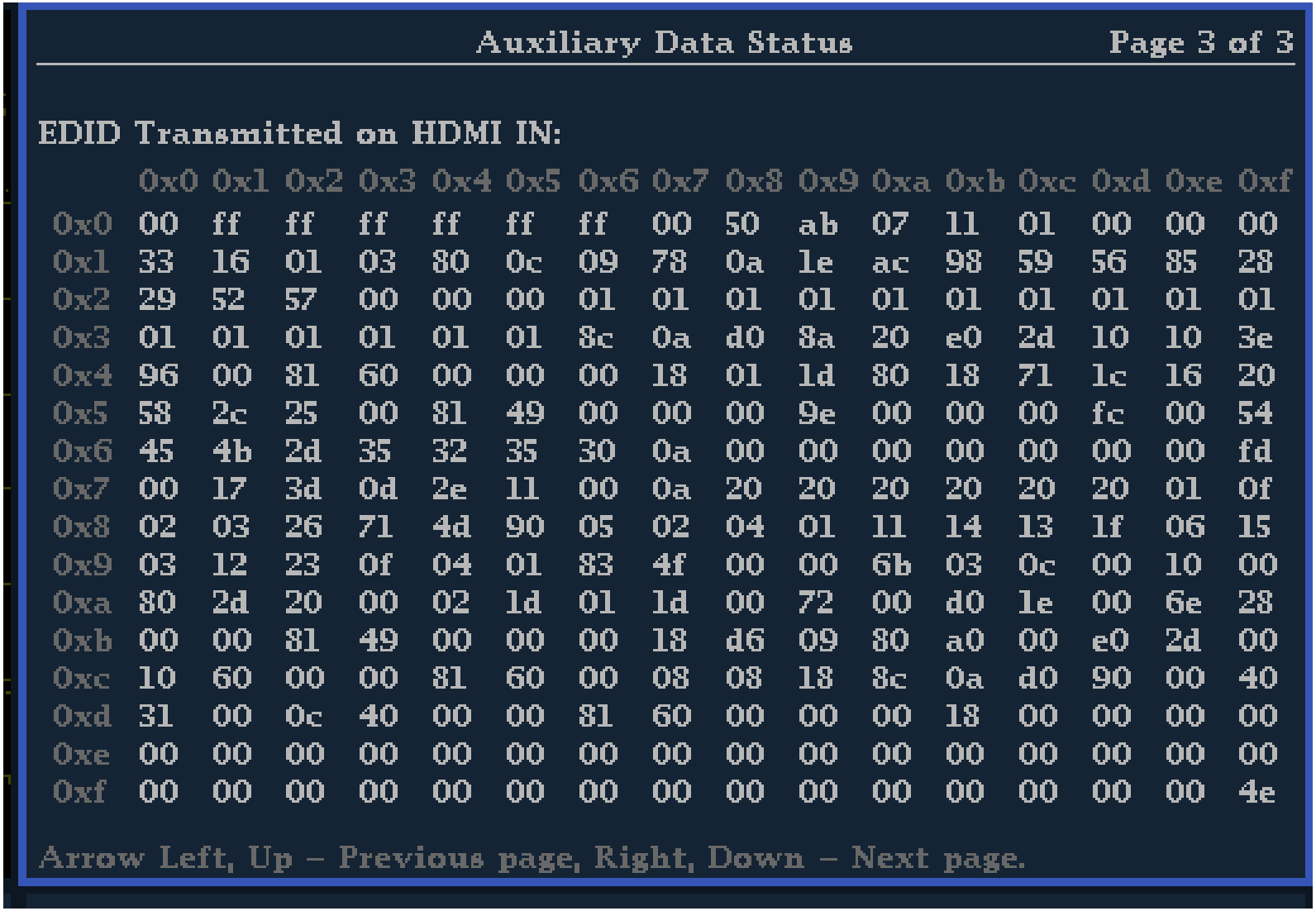
EDID data dump



Auxiliary Data Status — Page 3 of 3

EDID Transmitted on HDMI IN:

	0x0	0x1	0x2	0x3	0x4	0x5	0x6	0x7	0x8	0x9	0xa	0xb	0xc	0xd	0xe	0xf
0x0	00	ff	ff	ff	ff	ff	ff	00	50	ab	07	11	01	00	00	00
0x1	33	16	01	03	80	0c	09	78	0a	1e	ac	98	59	56	85	28
0x2	29	52	57	00	00	00	01	01	01	01	01	01	01	01	01	01
0x3	01	01	01	01	01	01	8c	0a	d0	8a	20	e0	2d	10	10	3e
0x4	96	00	81	60	00	00	00	18	01	1d	80	18	71	1c	16	20
0x5	58	2c	25	00	81	49	00	00	00	9e	00	00	00	fc	00	54
0x6	45	4b	2d	35	32	35	30	0a	00	00	00	00	00	00	00	fd
0x7	00	17	3d	0d	2e	11	00	0a	20	20	20	20	20	20	01	0f
0x8	02	03	26	71	4d	90	05	02	04	01	11	14	13	1f	06	15
0x9	03	12	23	0f	04	01	83	4f	00	00	6b	03	0c	00	10	00
0xa	80	2d	20	00	02	1d	01	1d	00	72	00	d0	1e	00	6e	28
0xb	00	00	81	49	00	00	00	18	d6	09	80	a0	00	e0	2d	00
0xc	10	60	00	00	81	60	00	08	08	18	8c	0a	d0	90	00	40
0xd	31	00	0c	40	00	00	81	60	00	00	00	18	00	00	00	00
0xe	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
0xf	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	4e

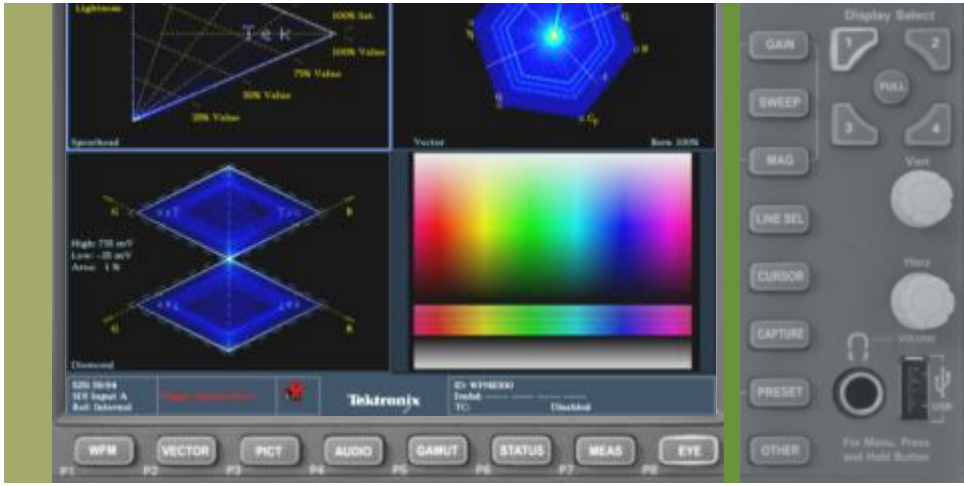
Arrow Left, Up – Previous page, Right, Down – Next page.

EDID Data fields

EDID			
Row	Column	Value	Description
0x0	0x0 - 0x7	00 FF FF FF FF FF FF 00	Fixed Header
0x0	0x8 - 0x9	XX XX	Manufacturer ID
0x0	0xa - 0xb	XX XX	Manufacturer Product Code
0x0	0xc - 0xf	XX XX XX XX	Serial Number
0x1	0x0	XX	Week of Manufacture
0x1	0x1	XX	Year of Manufacture
0x1	0x2	01	EDID Version
0x1	0x3	03	EDID Version
0x1	0x4 - 0x8	XX XX XX XX XX	Display Parameters
0x1	0x9 - 0xf	XX XX XX XX XX XX XX	Chromaticity Coordinates
0x2	0x0 - 0x2	XX XX XX	Chromaticity Coordinates
0x2	0x3 - 0x5	XX XX XX	Established timing bitmap
0x2	0x6 - 0xf	XX.....XX	Standard timing information
0x3	0x0 - 0x5	XX.....XX	Standard timing information
0x3	0x6 - 0xf	XX.....XX	Descriptor 1
0x4	0x0 - 0x7	XX.....XX	Descriptor 1
0x4	0x8 - 0xf	XX.....XX	Descriptor 2
0x5	0x0 - 0x9	XX.....XX	Descriptor 2
0x5	0xa - 0xf	XX.....XX	Descriptor 3
0x6	0x0 - 0xb	XX.....XX	Descriptor 3
0x6	0xc - 0xf	XX.....XX	Descriptor 4
0x7	0x0 - 0xd	XX.....XX	Descriptor 4
0x7	0xe	XX	Number of Extensions
0x7	0xf	XX	Checksum

Additional rows 0x8 to 0xf can contain CEA-861 extension block information that contains further audio and video descriptors.

Notes On CALM Act



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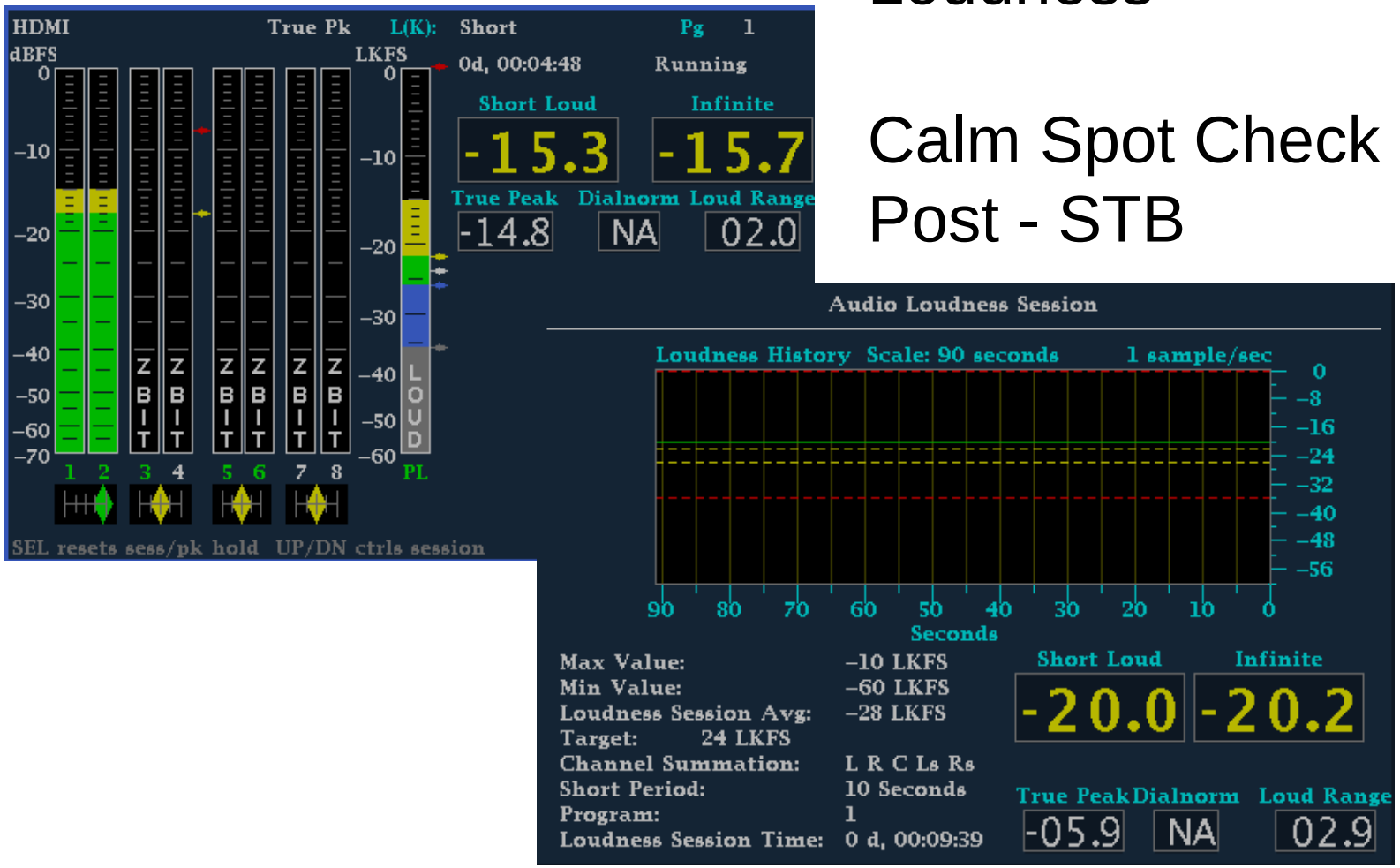
Audio Monitoring

Loudness

Calm Spot Check Post - STB



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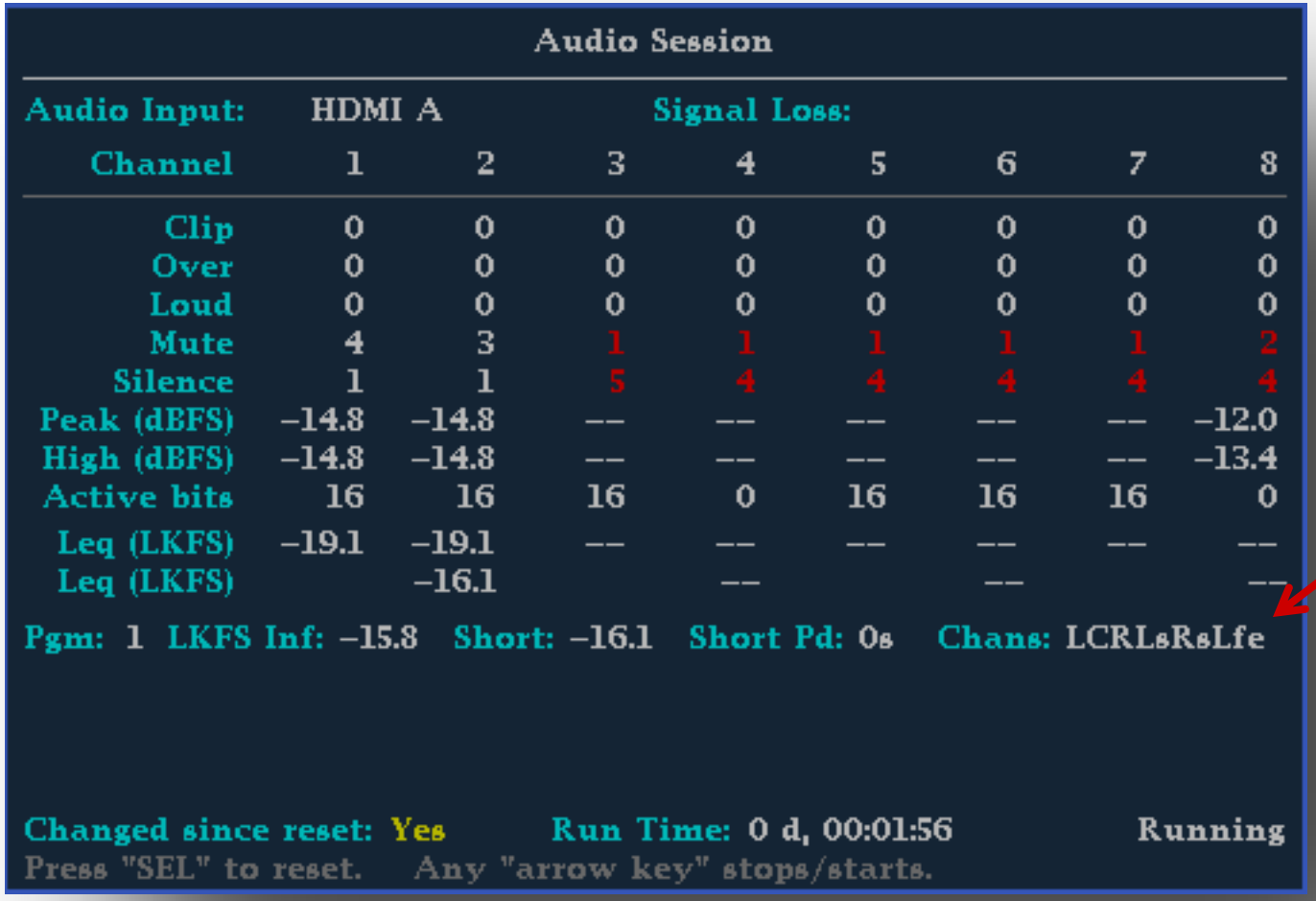
Audio Monitoring



Channel Mapping

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CALM Act Spot Check

- *A "spot check" requires monitoring 24 uninterrupted hours of programming with an audio loudness meter employing the measurement technique specified in the RP, and reviewing the records from that monitoring to detect any commercials transmitted in violation of the RP.*
- *To promote the reliability of the spot check, the station or MVPD must not provide prior notice to the programmer of the timing of the spot check. This requirement applies with respect to all spot checks (annual or in response to a Commission inquiry) on all programming, and for all stations and MVPDs – large and small. Stations (and occasionally MVPDs) may have multiple program suppliers for a single channel/stream of programming.*
- *In these cases, there may be no single 24-hour period in which all program suppliers are represented. In such cases, an annual spot check could consist of a series of loudness measurements over the course of a 7-day period, totaling no fewer than 24 hours that measure at least one program, in its entirety, provided by each non-certified programmer that supplies programming for that channel or stream of programming.*

CALM Act Spot Check

- *To verify that the operator's system is properly passing through loudness metadata, spot checking must be conducted after the signal has passed through the operator's processing equipment (e.g., at the output of a set-top box or television receiver). If a problem is found, a station or MVPD may check multiple points in its reception and transmission process to determine the source of the noncompliance.*
- *For a spot check to be considered valid, a station or MVPD must be able to demonstrate appropriate maintenance records for the audio loudness meter, and to demonstrate, at the time of any enforcement inquiry, that appropriate spot checks had been ongoing.* ***(FCC 11-182 Paragraph 38 Pg. 25)***

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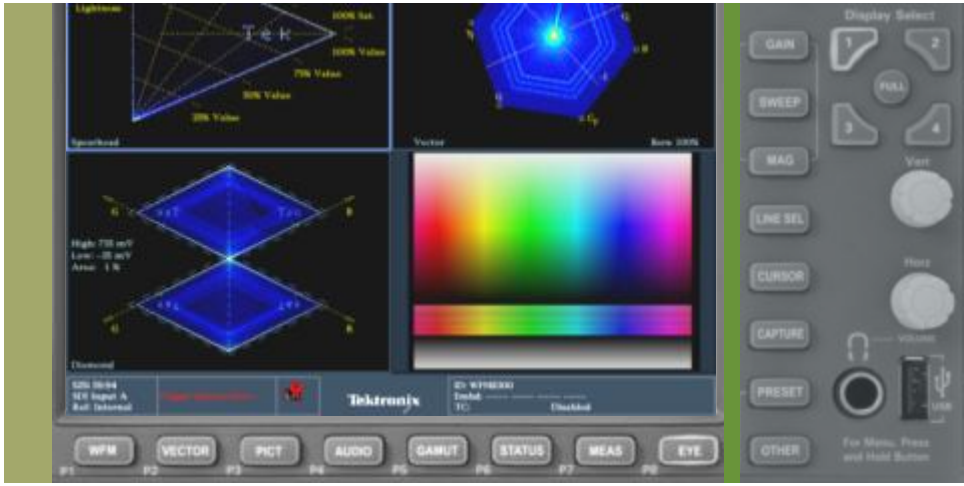
CALM Act 24 hour run

Date & Time	LKFS
Tue, 16 Oct 2012 10:00:08	-26
Tue, 16 Oct 2012 11:00:15	-26
Tue, 16 Oct 2012 12:00:45	-24
Tue, 16 Oct 2012 13:00:45	-26
Tue, 16 Oct 2012 14:01:44	-26
Tue, 16 Oct 2012 15:04:46	-27
Tue, 16 Oct 2012 16:04:46	-27
Tue, 16 Oct 2012 17:04:46	-27
Tue, 16 Oct 2012 18:04:46	-27
Tue, 16 Oct 2012 19:04:46	-27
Tue, 16 Oct 2012 20:00:08	-26
Tue, 16 Oct 2012 21:00:15	-26
Tue, 16 Oct 2012 22:00:45	-22
Tue, 16 Oct 2012 23:00:45	21
Tue, 16 Oct 2012 00:01:44	-25
Wed, 17 Oct 2012 01:04:46	-27
Wed, 17 Oct 2012 02:04:46	-27
Wed, 17 Oct 2012 03:04:46	-27
Wed, 17 Oct 2012 04:04:46	-27
Wed, 17 Oct 2012 05:04:46	-27
Wed, 17 Oct 2012 06:00:08	-26
Wed, 17 Oct 2012 07:00:15	-26
Wed, 17 Oct 2012 08:00:45	-24
Wed, 17 Oct 2012 09:00:45	-26

HDMI 3D formats



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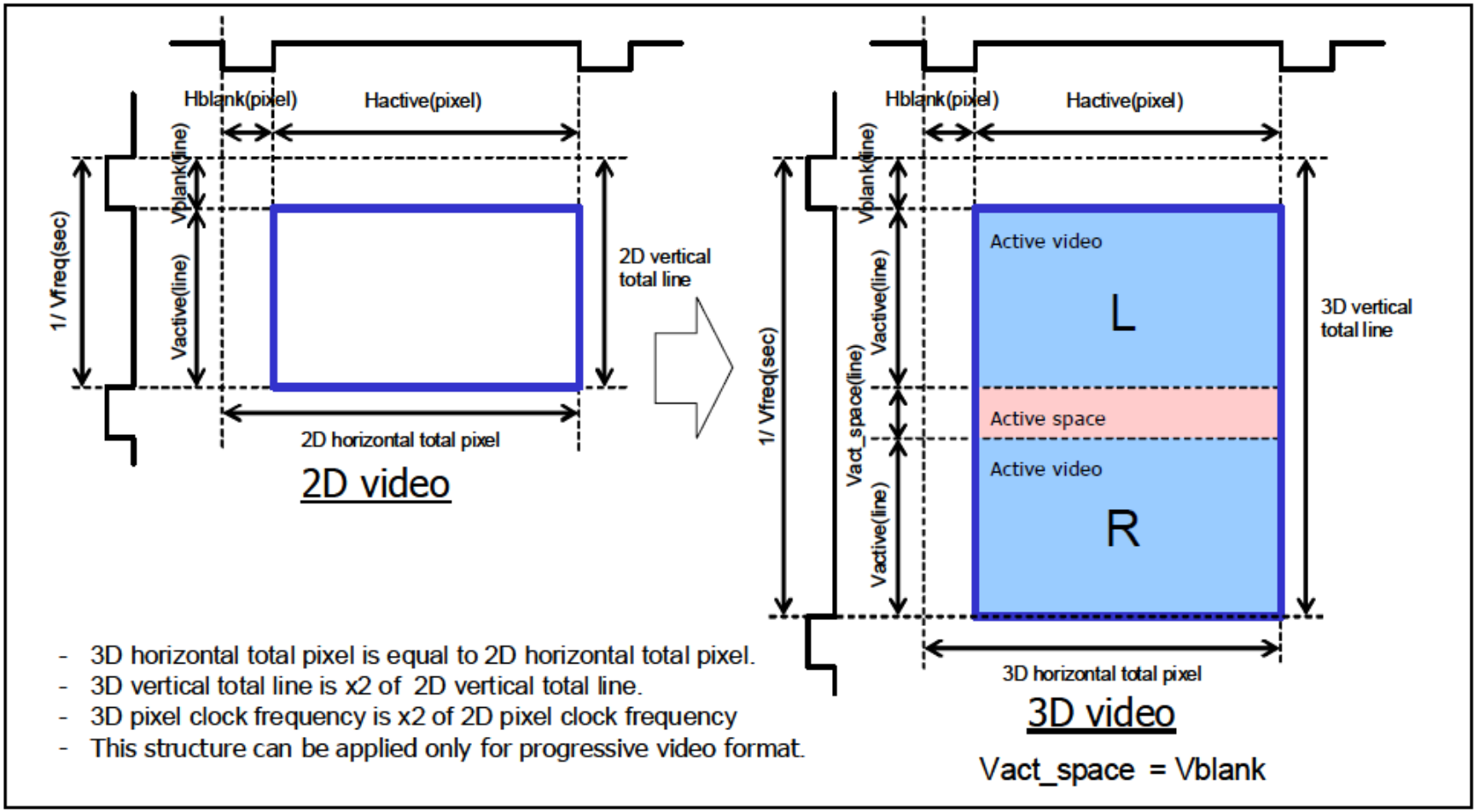
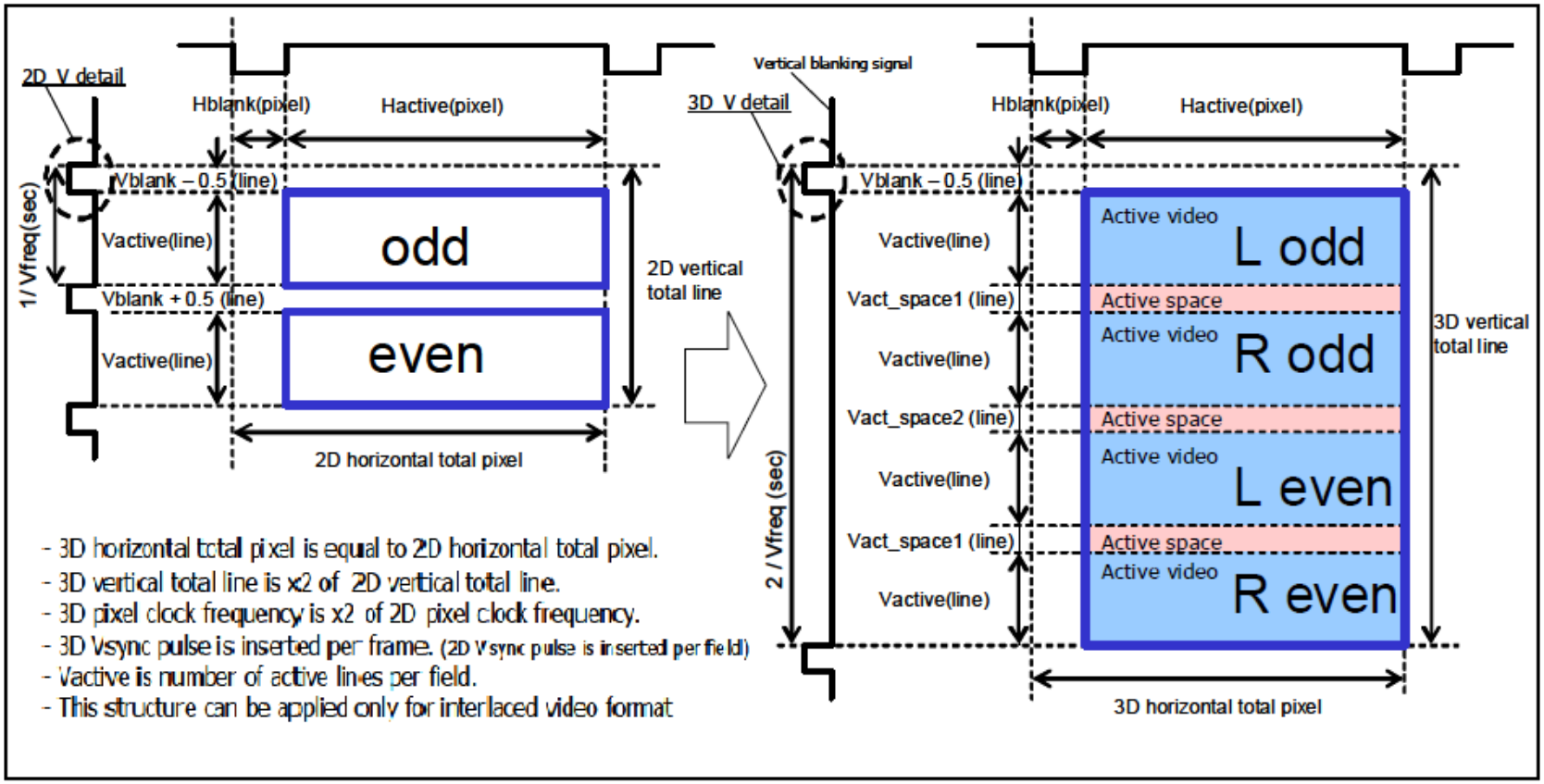
3D Formats

- Frame Pack



3D Formats

- Frame Pack Interlace



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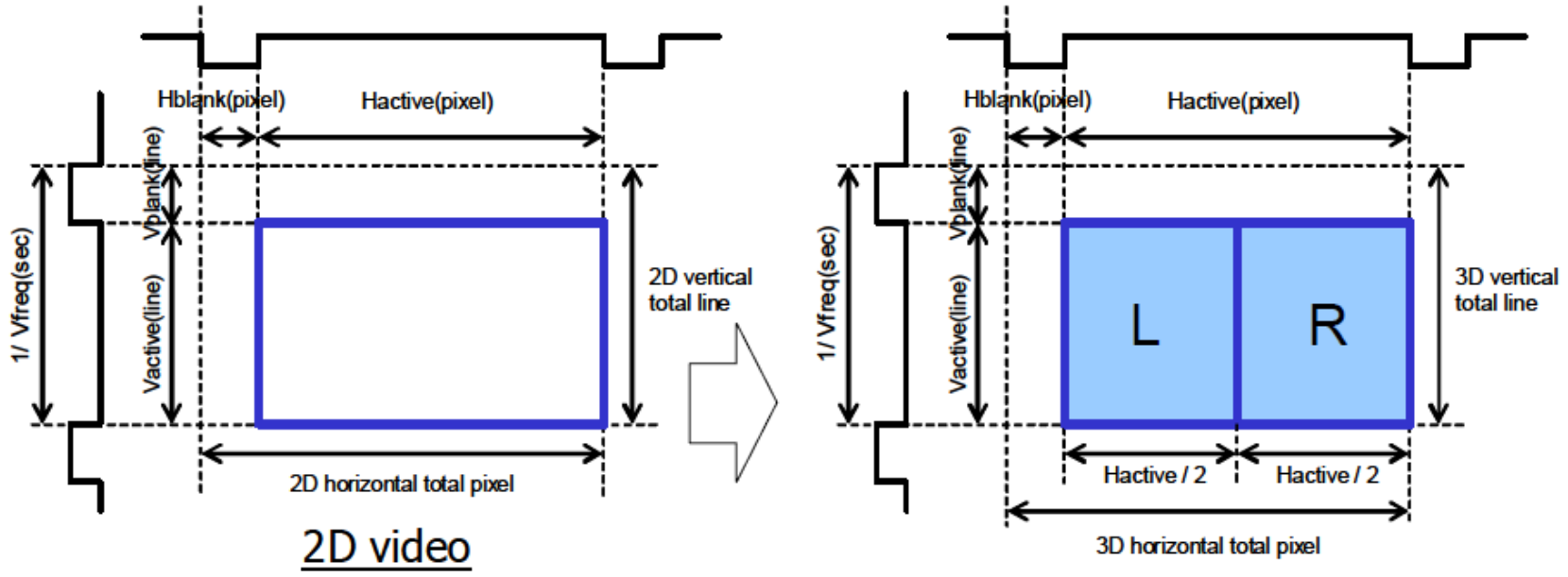
3D Formats

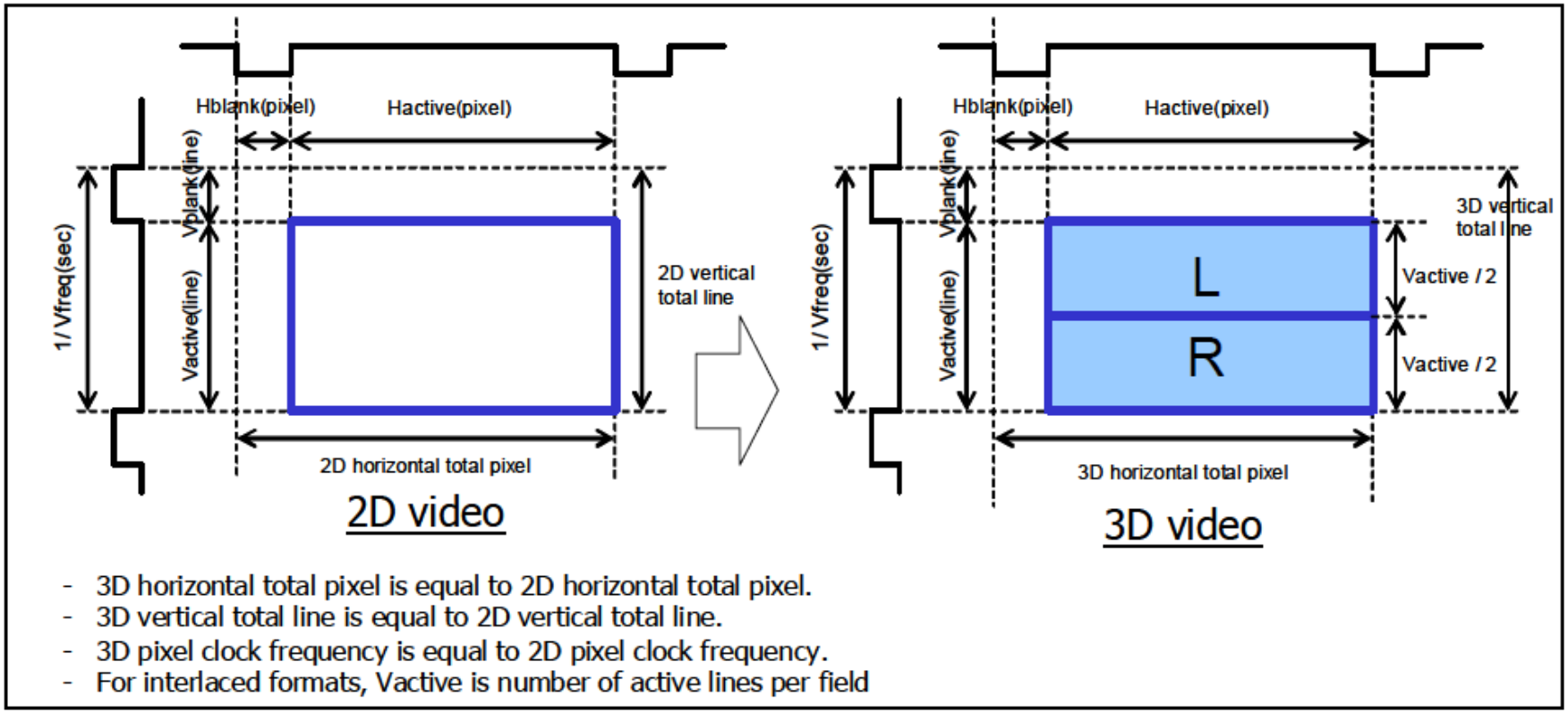
- Side by Side (Half)



- 3D horizontal total pixel is equal to 2D horizontal total pixel.
- 3D vertical total line is equal to 2D vertical total line.
- 3D pixel clock frequency is equal to 2D pixel clock frequency.
- For interlaced formats, Vactive is number of active lines per field

3D Formats

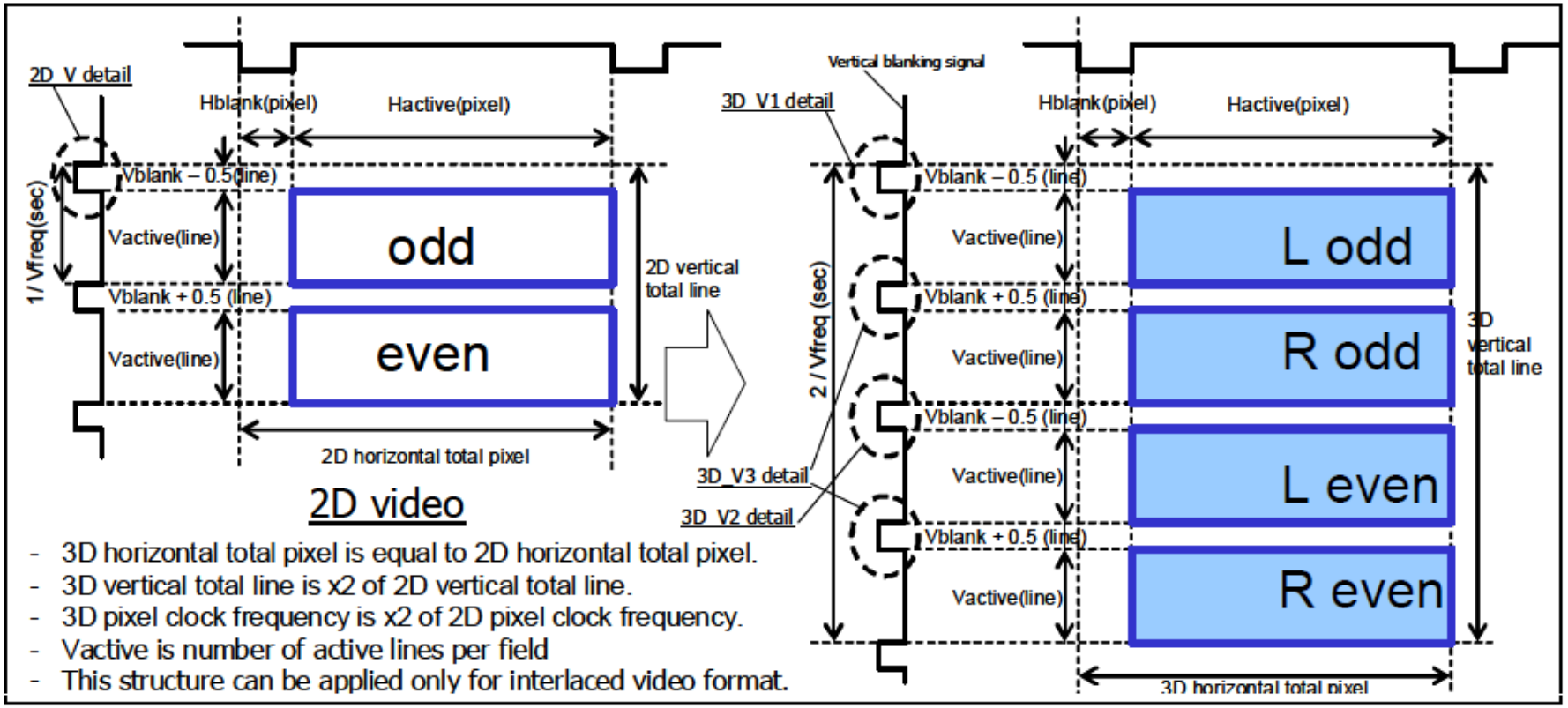
- Top Bottom (Half)



- 3D horizontal total pixel is equal to 2D horizontal total pixel.
- 3D vertical total line is equal to 2D vertical total line.
- 3D pixel clock frequency is equal to 2D pixel clock frequency.
- For interlaced formats, Vactive is number of active lines per field

3D Formats

- Field alternative



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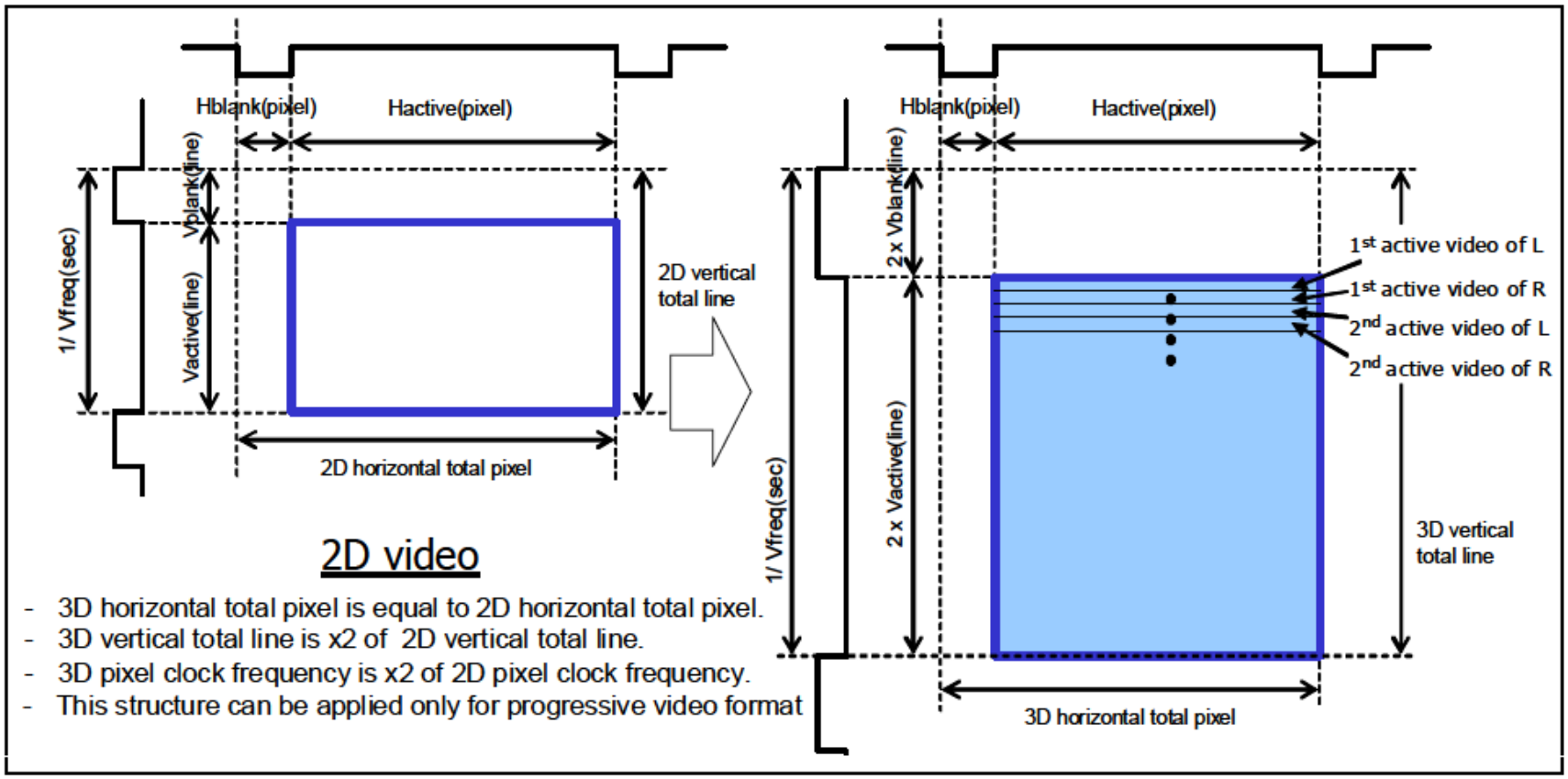
3D Formats

- Line alternative



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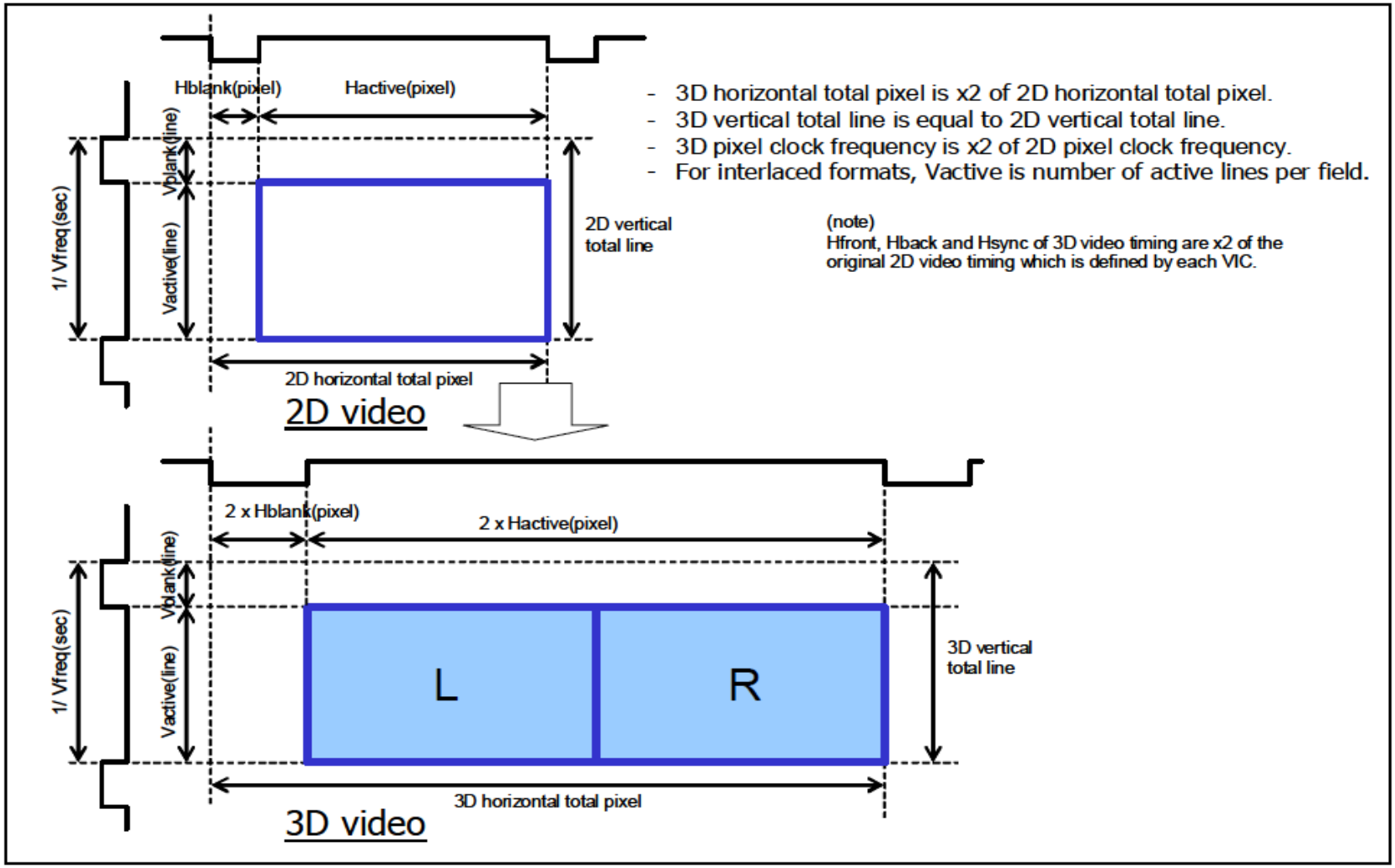
3D Formats

- Side by Side (Full)



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