

A GUIDE TO 4K/UHD MONITORING AND MEASUREMENT

6 Key Challenges of 4K/UHD Content Creation

eBook

Introduction

The transition to 4K/UHD offers high resolution either (4096x2160) for cinematic distribution or (3840x2160) for distribution to the home. Enhanced viewing experience is possible with High Dynamic Range (HDR) and wider extended color gamut using ITU-R BT.2020 color space. This enhanced viewing experience offers viewers imagery that envelopes them within the scene.



Producing 4K/UHD images start with acquisition from a high resolution camera that offers extended color gamut and high dynamic range to capture the image. On location larger high resolution images are saved to multiple disks for processing later. While in a studio or outside broadcast truck the signals are distributed as four links using 3G-SDI (Serial Digital Interface) for fast progressive formats such as 50p, 59.94p and 60p or HD-SDI for progressive signals from 23.98p to 30p. Inter-channel timing is critical to ensure that the quad links signals arrive at the end device and can be stitched back together correctly.

To monitor the 4K/UHD signals the Tektronix 8000 series waveform monitor or rasterizer can be easily upgraded to support a wide variety of 4K/UHD formats in square division or two sample interleaved. Traditional tools like waveform, vector and gamut displays can be used in 4K/UHD for different color spaces such as ITU-R BT.2020 that provides extended color range for 4K content.



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CHALLENGE 1

INTER-CHANNEL TIMING FOR QUAD LINK 4K/UHD SIGNAL

A Quad Link 4K/UHD signal comprises of four SDI physical links. As these four signals are distributed along different transmission paths the delay along each path can be different. It is therefore important that when these signals are combined back together that they are correctly timed together.





When distributing Quad Link signals it is important to ensure that the transmission of each link is the same. Different cable lengths and propagation delays through equipment can cause timing shifts as each link is sent along a separate path, Figure 1-1.

The SMPTE ST 425-5 standard requires that the inter-channel delay at the output of a device shall not exceed 400ns which is approximately 29 clocks. However no specification is standardized for the maximum signal delay at the receiving device. Therefore care has to be taken in ensuring that timing along each signal path is the same and the user should determine how much delay difference equipment can tolerate.

In the case of the Tektronix WFM/WVR 8000 series the instrument can tolerate up to 1024 clocks difference between the input signals. After which the signals will no longer be able to be combined together correctly.

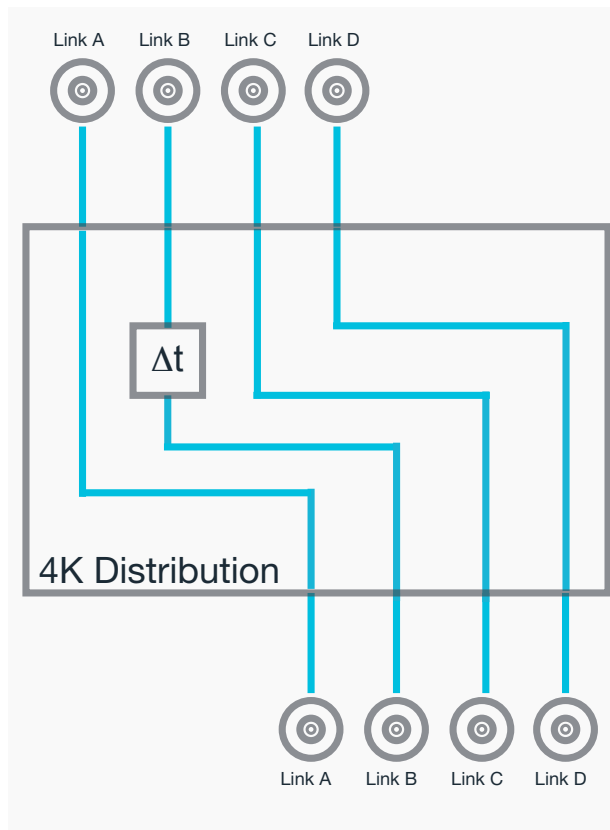


FIGURE 1-1. Quad Link Distribution between devices.

Tektronix Timing Display

When using the Tektronix patented timing display (Figure 1-2) in 4K/UHD formats additional information is added to the display to show the inter-channel timing between the links. Link A is assumed to be the reference signal to which the other links are compared. A black burst or tri-level reference signal can also be applied to the external reference signal and can compare the timing between the reference and Link A timing.

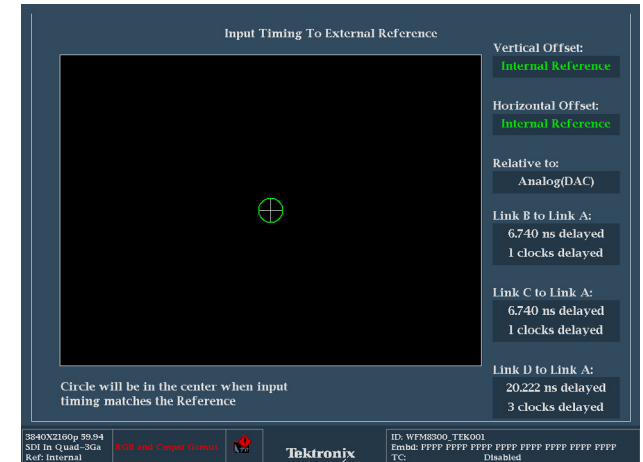


FIGURE 1-2. Tektronix Timing Display.



Troubleshooting Timing Issues

Initially when connecting the quad link signals to the instrument it is important to check that the video format of each link is identical. Otherwise the status bar may indicate a Video Format Mismatch in 4K/UHD mode. If this happens switch to Single Link mode and viewing the Video Session display of each Link A, B, C, D to confirm the video format and frame rate are the same for each signal or identify a format mismatch issue for one of the links.

To check the inter-channel timing of the links use the Timing Display under the MEAS application.

[Click to view the video.](#)

Learn how to adjust and troubleshoot quad link timing in [this video](#).

CHALLENGE 2

VIDEO PAYLOAD IDENTIFIER (VPID) MONITORING IS MORE IMPORTANT THAN EVER

With a wide variety of formats it is essential to use the SMPTE ST 352 Video Payload Identifier (VPID) that is carried within the ancillary data space to assist a device in quickly decoding the correct video format.



Table 2-1. Video Payload Identifier Ancillary Data Packet

Note Please refer to latest standard for complete details of VPID information.

	HEX	B9	B8	B7	B6	B5	B4	B3	B3	B2	B1	B0
ADF	000	0	0	0	0	0	0	0	0	0	0	0
	3FF	1	1	1	1	1	1	1	1	1	1	1
	3FF	1	1	1	1	1	1	1	1	1	1	1
DID	241	not b8	EP	0	1	0	0	0	0	0	0	1
SDID	101	not b8	EP	0	0	0	0	0	0	0	0	1
DC	104	not b8	EP	0	0	0	0	0	0	1	0	0
UDW1	XXX	not b8	EP	Version ID	Payload Identifier (see Table 2-2)							
UDW2	XXX	not b8	EP	Transport Interlace 0 Progressive 1	Picture Interlace 0 Progressive 1	Reserved 0	Reserved 0	Picture Rate (See Table 2-3)				
UDW3	XXX	not b8	EP	Reserved 0 ¹ Aspect Ratio 4:3 (0) 16:9 (1)	Reserved 0 ² Horz. Sampling 1920 (0) 2048 (1)	Reserved 0 ³ Aspect Ratio 4:3 (0) 16:9 (1)	Reserved 0 (See Table 2-6)	Sampling (See Table 2-4)				
UDW4	XXX	not b8	EP	Channel B7-B6 -B5 Single Link or Multi-Channel (See Table 2-5)			Reserved 0	Reserved 0	Reserved 0 Audio 3G SDI (See Table 2-7)	Bit Depth 8-bit (0h) 10-bit (1h) 12-bit (2h) Reserved (3h)		
CS	XXX	not b8	EP	Sum of B0-B8 of DID to Payload Byte 4 (UDW4)								

1 B7 used for Aspect Ratio in ST 425-1, 425-3 3G level A, 425-5 Quad Link 3G level A, 2081-10, 2082-10

2 B5 used for Aspect Ratio in ST 292, 372, 435-1. 425-5 3G level B, 3 Byte B7, B4 or B5-B4 Colorimetry Rec 709*1 (0h) Color VANC

Table 2-2. SMPTE 352 Video Payload Identifier UDW 1

For a complete list of Byte 1 registry <http://smpte-ra.org/mdd/ST352-2011.html>

Byte 1 Bit 0-7		Standard	Description
Decimal	Hex		
129	81h	SMPTE ST 259	Standard Definition (525i/625i) Signal/Data — 270Mb/s SDI
132	84h	SMPTE ST 292-1	720-line video payloads for High Definition TV 1.5 Gb/s SDI
133	85h	SMPTE ST 292-1	1080-line video payload High Definition TV 1.5 Gb/s SDI
135	87h	SMPTE ST 372	Dual Link 1.5 Gb/s SDI for 1920 × 1080 Picture Formats
137	89h	SMPTE ST 425-1	1080-line video payloads for 3 Gb/s Level A SDI
138	8Ah	SMPTE ST 425-1	Dual-link (ST372) 1080-line for the 3 Gb/s Level B SDI
140	8Ch	SMPTE ST 425-1	2 x 1080-line video payloads on a Level B 3 Gb/s
144	90h	SMPTE ST 435-1	Quad-link 1080-line video payloads on a 10 Gb/s (nominal) serial digital (optical) interface
148	94h	SMPTE ST 425-3	1080-line video payloads on a dual 3 Gb/s Level A SDI
149	95h	SMPTE ST 425-3	1080-line video payloads on a dual 3 Gb/s Level B-DL SDI
150	96h	SMPTE ST 425-3	2160-line video payloads on a dual 3 Gb/s Level B-DS SDI
151	97h	SMPTE ST 425-5	2160-line video payloads on a quad 3 Gb/s Level A SDI
152	98h	SMPTE ST 425-5	2160-line video payloads on a quad 3 Gb/s Level B-DL SDI
160	A0h	SMPTE ST 435-1	Octa-link 2160-line video payloads on a 10 Gb/s (nominal) serial digital (optical) interface
161	A1h	SMPTE ST 2036-3	UHDTV1 (4K image) — Mapping into Single-link or Multi-link 10 Gb/s SDI
162	A2h	SMPTE ST 2036-3	UHDTV2 (8K image) — Mapping into Single-link or Multi-link 10 Gb/s SDI
165	A5h	SMPTE ST 2036-4	UHDTV1 (4K image) video payloads on a multi-link 10 Gb/s SDI using multi-mode fiber
166	A6h	SMPTE ST 2036-4	UHDTV2 (8K image) video payloads on a multi-link 10 Gb/s SDI using multi-mode fiber
179	B3h	SMPTE ST 2048-3	4096×2160 Digital Cinematography Production Image Formats FS/709 on Multi-link 10 Gb/s SDI
192	C0h	SMPTE ST 2081-10 Mode 1	2160-Line Source Image and Ancillary Data Mapping for Single-Link 6G-SDI
193	C1h	SMPTE ST 2081-10 Mode 2	Carriage of 1080-line Source image formats and ancillary data in a single link 6G-SDI interface
194	C2h	SMPTE ST 2081-11 Mode 1	Carriage of 1080-line Additional Frame Rates (AFR) in a single link 6G-SDI interface
196	C4h	SMPTE ST 2081-12 Mode 1	Carriage of 4320-line Source image formats and ancillary data in a quad-link 6G-SDI
206	CEh	SMPTE ST 2082-10 Mode 1	2160-line Source Image and Ancillary Data Mapping for 12G-SDI
207	CFh	SMPTE ST 2082-10 Mode 2	Carriage of 1080-line Y'C'BC'R or R'G'B' 4:4:4 10-bit or 4:4:4 10-bit or 12-bit Additional Frame Rate (AFR) for 12G-SDI

Table 2-3.

SMPTE 352 Picture Rate UDW2 B3-B0

Value	Picture Rate
0h	No defined value
1h	Reserved
2h	24/1.001
3h	24
4h	48/1.001
5h	25
6h	30/1.001
7h	30
8h	48
9h	50
Ah	60/1.001
Bh	60
Ch	Reserved
Dh	Reserved
Eh	Reserved
Fh	Reserved

Table 2-4.

SMPTE 352 Sampling Rate UDW3 B3-B0

Value	Sampling Rate
0h	4:2:2 (YCbCr)
1h	4:4:4 (YCbCr)
2h	4:4:4 (G/B/R)
3h	4:2:0
4h	4:2:2:4 (YCbCrA)
5h	4:4:4:4 (YCbCrA)
6h	4:4:4:4 (G/B/R/A)
7h	SMPTE ST 2048-2 F-S
8h	4:2:2:4 (YCbCrD)
9h	4:4:4:4 (YCbCrD)
Ah	4:4:4:4 (G/B/R/D)
Bh	Reserved
Ch	Reserved
Dh	Reserved
Eh	Reserved
Fh	Reserved

Table 2-5.

SMPTE 352 Single or Multi-Link UDW4 B7-B5

Value	Single or Multi-Link
0h	ch 1 multi-link (0h)
1h	ch 2 multi-link (1h)
2h	ch 3 multi-link (2h)
3h	ch 4 multi-link (3h)
4h	ch 5 multi-link (4h)
5h	ch 6 multi-link (5h)
6h	ch 7 multi-link (6h)
7h	ch 8 multi-link (7h)

UDW4 B7-B6

Value	Single or Multi-Link
0h	ch 1 multi-link (0h)
1h	ch 2 multi-link (1h)
2h	ch 3 multi-link (2h)
3h	ch 4 multi-link (3h)

UDW4 B6

Value	Dual Link
0h	Dual-link A (0h)
1h	Dual-link B (1h)

Table 2-6.

SMPTE 352 Colorimetry UDW3 B4 or B5-B4

Value	Picture Rate
0h	Colorimetry Rec 709
1h	Color VANC Packet
2h	UHDTV
3h	Unknown

Table 2-7.

SMPTE 352 Audio 3G SDI UDW4 B2

Value	Audio 3G SDI
0h	Link 2 or 2 to 4 carries additional channels or audio not present
1h	Carries a copy of 3G-SDI Link 1 audio

The [Tables 2-1](#) show the possible values for the payload Bytes 1-4 (UDW 0-3) of the SMPTE 352 payload ID. The user can use this information to help troubleshoot issues with the VPID. Note that different formats may use some of the bit values differently depending on the format. For instance B7 of Byte 3 is used for Aspect Ratio in ST 425-1, 425-3 3G level A, 425-5 Quad Link 3G level A, 2081-10, 2082-10 standards. Whereas in the following standards ST 292, 372, 435-1, 425-5 3G level B, B5 of Byte 3 is used for Aspect Ratio. Additionally colorimetry information may be present using B7, B4 or B5-B4 of Byte 3 depending on the standard used.

Troubleshooting VPID Issues

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Quad Link can carry a wide variety of video formats and equipment can use the VPID to assist in determining the video format from the Ancillary data packet. This allows instruments like the Tektronix 8000 series waveform monitors and rasterizer to automatically determine the format of the video signal.

When the VPID is incorrect or multiple VPIDs are present in the same signal this can cause issues in processing equipment to correctly determine which ancillary packet to use.

By using the Video Session display the user can quickly check if the VPID is present and use the ANC Data Display and Datalist display to further investigate issues.

Troubleshooting VPID Issues

When in 4K/UHD mode, the status bar of the 8000 series instrument may show a Link Format Mismatch. For more information view the Video Session display to determine the problem Figure 2-5.

If the problem appears to be an issue of locking to the signal, it maybe necessary to switch the instrument to single mode and check the format of each link using the video session display to determine if one of the signals is not identical to the others. Once it has been determined that all signals are identical switch back to 4K mode and verify the VPID of each signal using the video session display.

Check the UDW words for each link. The first three bytes should be identical for each of the links. Byte 4 may also be identical if compliant to the single link format. However in 4K/UHD format the fourth byte should indicate the multi-link information to help the user identify if the links are swapped. Figure 2-5 shows in the Status bar that there is a Link Format Mismatch by checking the Video Session display. This display shows that the Links are swapped. In this case Byte 4 should have a sequence 01h, 41h, 81h and C1h indicating the multi-link information. Therefore link B and C are swapped and the signal path should be verified and the connections should be changed to correct the issue.

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Video Session				
Input:	SDI Input 1A	Signal:	Links swapped	Colorimetry: BT709
Effective:	Auto 3840X2160p 59.94	YCbCr	422 10b	425.5A 4x2.970/M Gbps Sq
Selected:	Auto Format – Auto Structure – Auto Transport			
Links	352M Payload	Y Stuck Bits	C Stuck Bits	AP CRC
A	89h CAh 00h 01h	-----	-----	DA36h 9753h
B	89h CAh 00h 81h	-----	-----	FD17h 84A8h
C	89h CAh 00h 41h	-----	-----	91B0h D7F9h
D	89h CAh 00h C1h	-----	-----	0C18h F371h
Ancillary Data: Y Present		CRC Changed since reset: Yes		
SAV Place Err: OK		Line Length Err: OK		
Field Length Err: OK		Line Number Error: OK		
Press SEL – reset. L/R arrow key stop/start. Up/Down change page				
Link Fmt Mismatch SDI In Quad-3Ga Ref: Internal		Alarms No Alarms	Tektronix	ID: WFM8300_TEK Embd: ----- TC: Disabled

FIGURE 2-5. Video Session display showing Links swapped.

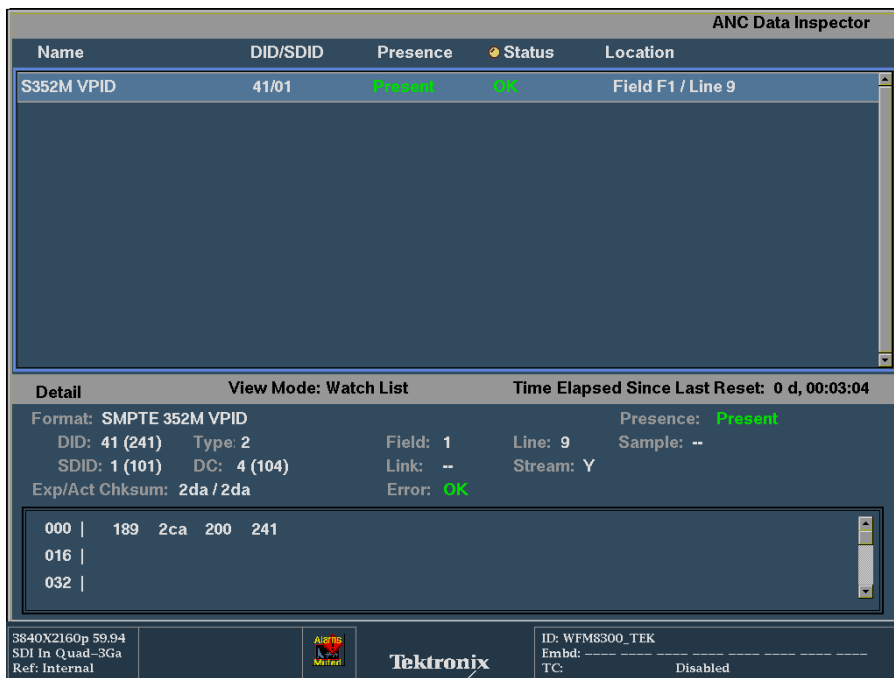


FIGURE 2-6. ANC Data Inspector showing SMPTE 352 payload.

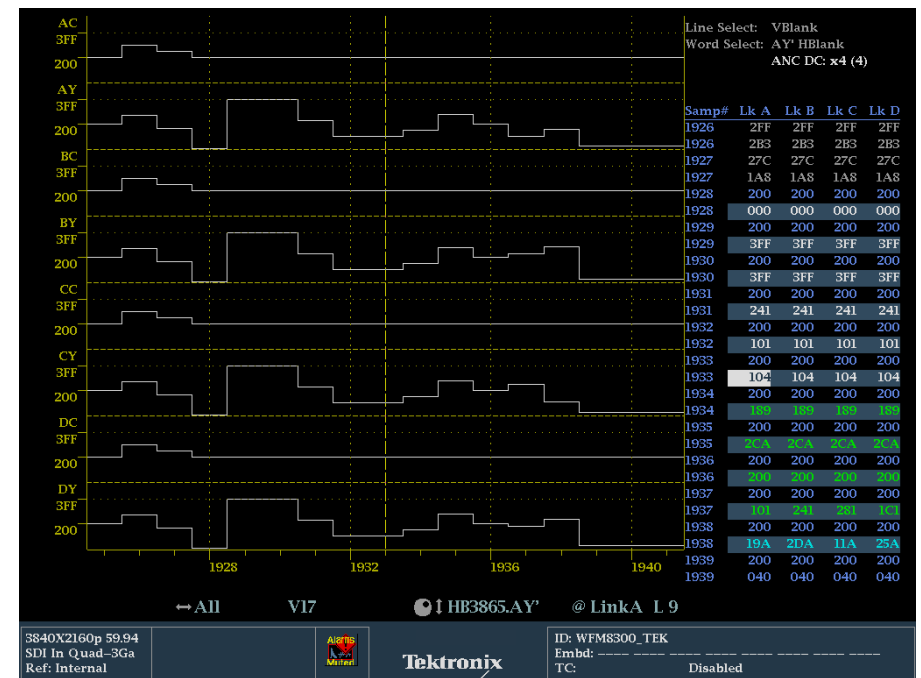


FIGURE 2-7. Datalist display showing line and sample location of SMPTE 352 VPID.

In some cases, to further investigate a VPID issue, the ANC Data Inspector or Datalist displays can be used. Figure 2-6 shows the ANC Data Inspector display that shows the ANC data present and provides information on the field and line locations of the ancillary data packets. This field and line location can be used in the Datalist display (Figure 2-7) to help select the line and sample value to find the SMPTE ST 352 information. In the Datalist display both the line and sample location of the complete 4K/UHD signal are shown along with the specific link / line location. The user can switch between all links for easy comparison of the links or an individual link (A,B,C,D) to help isolate a particular issue on a specific link. Note: capture cannot be performed in 4K/UHD mode and therefore the user should switch to single link mode and use buffer capture to see all ANC data present within a link and to assist in determining sample location information.

CHALLENGE 3

SELECT THE CORRECT COLORIMETRY

4K/UHD can support either traditional HD colorimetry ITU-R BT.709 or the extended colorspace available in ITU-R BT.2020 to get higher color fidelity.



Understanding Colorimetry

The television color specification is based on standards defined by the CIE (Commission Internationale de L'Éclairage) in 1931. The CIE specified an idealized set of primary XYZ tristimulus values. This set is a group of all-positive values converted from R'G'B' where Y is proportional to the luminance of the additive mix. This specification is used as the basis for color within 4K/UHDTV1 that supports both ITU-R BT.709 and BT.2020 (Figure 3-8).

In order to view this extended color gamut a display capable of displaying the BT.2020 color space is required.

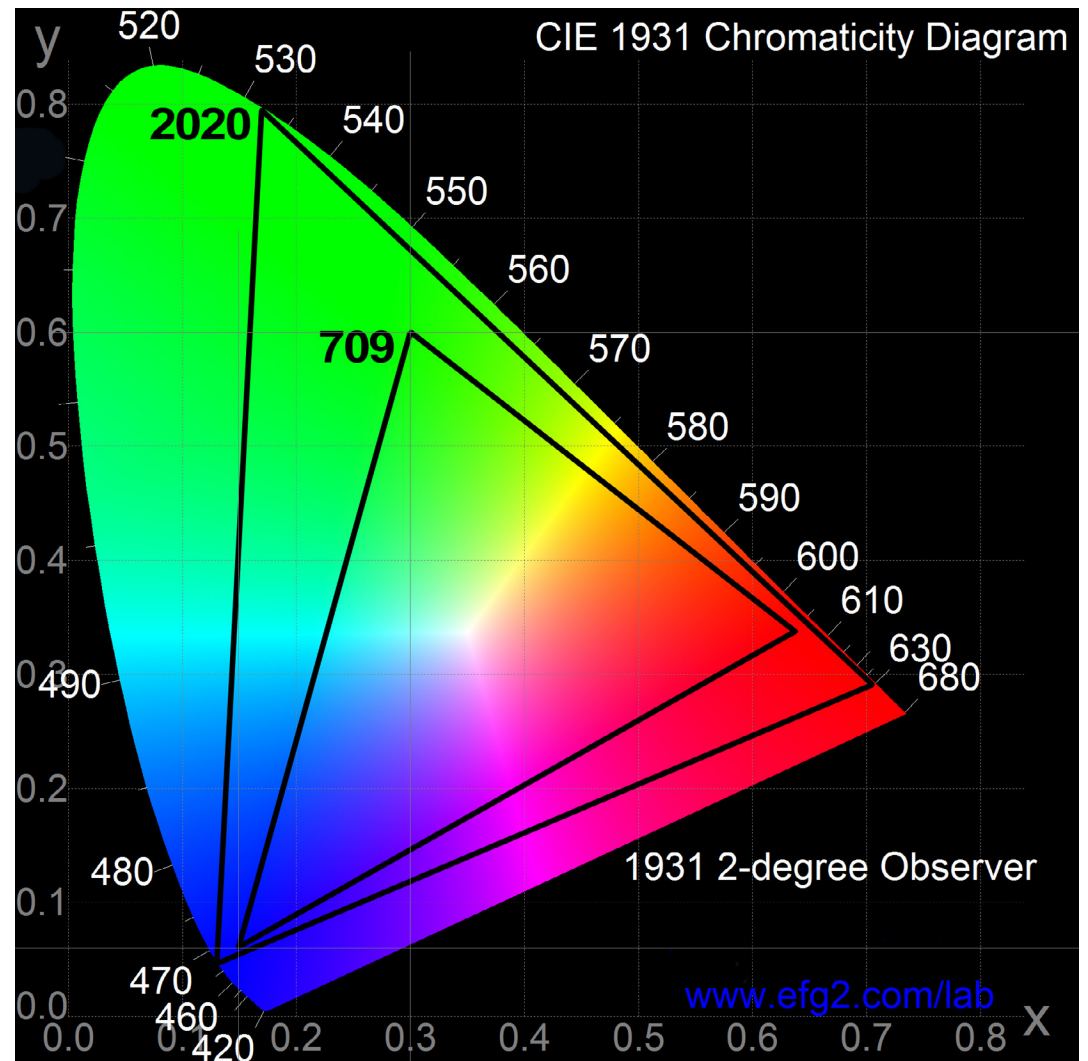


FIGURE 3-8. CIE xy diagram with color coordinates used by ITU-R BT 709 and 2020 color spaces.

Color Gamut

A color gamut is the complete range of colors allowed for a specific color space. This range is bounded by the xy coordinates of the primary red, green, and blue colors within the color space. The xy coordinates for these primary colors is given in table 3-8 for several different gamuts.required.

Table 3-8. CIE XY Coordinates for Various Color Gamuts

Gamut	Illuminant	Red	Green	Blue
ITU-R BT. 2020	D ₆₅	x=0.708 y= 0.292	0.170 y= 0.797	x = 0.131 y = 0.046
ITU-R BT. 709	D ₆₅	x = 0.640 y = 0.330	x = 0.300 y = 0.600	x = 0.150 y = 0.060
SMPTE 431-2 (DCI-P3) XYZ		x = 0.680 y= 0.320	x = 0.265 y= 0.690	x = 0.150 y = 0.060
SMPTE	D ₆₅	x = 0.630 y = 0.340	x = 0.310 y = 0.595	x = 0.155 y = 0.070
PAL/SECAM	D ₆₅	x = 0.640 y = 0.330	x = 0.290 y = 0.600	x = 0.150 y = 0.060
NTSC	C	x = 0.670 y = 0.330	x = 0.210 y = 0.710	x = 0.140 y = 0.080

Definition of Luma and Color Difference Values

The Table 3-9 show the equations used to convert R'G'B' voltage levels into Luma and Color Difference signals Y'P'bP'r. In the next section we will take a look at these voltages levels on a waveform monitor.

Table 3-9. Definition of Luma and Color Difference Values

	Rec. 601	Rec. 709	Rec. 2020
Y	$0.299R' + 0.587G' + 0.114B'$	$0.2126R' + 0.7152G' + 0.0722B'$	$0.2627R' + 0.6780G' + 0.0593B'$
Pb	$(B' - Y') / 1.772$	$(B' - Y') / 1.8556$	$(B' - Y') / 1.8814$
Pr	$(R' - Y') / 1.402$	$(R' - Y') / 1.5748$	$(R' - Y') / 1.4746$

Troubleshooting Colorimetry Issues

To understand color let's look at a 100% color bar signal that has two states for the video levels 100% (700mv) and 0% (0mv) for each color component RGB (Red, Green and Blue). The waveform monitor shows (Figure 3-9) the video level transitions that make up all the combination of colors for the color bar signal Figure 3-11 (White, Yellow, Cyan, Green, Magenta, Red, Blue and Black).

The different equations used for the various color standards (Rec. 601, Rec. 709 and Rec.2020) produce different levels for each of the component signals in Y'P'bP'r as shown in the series of YPbPr waveform monitor displays.

Firstly notice the small spikes in the RGB waveform parade (Figure 3-9). This is due to the unequal rise time between Luma and Color Difference bandwidths and the conversion of SDI Y'P'bP'r back to R'G'B' in the waveform display.

Secondly in the Green/Magenta transition between SD (Standard Definition Figure 3-10) and HD (High Definition Figure 3-12), there is a much larger transition in HD compared to SD. This is due to the difference in equations described in Definition of Luma and Chroma Difference Values previously.

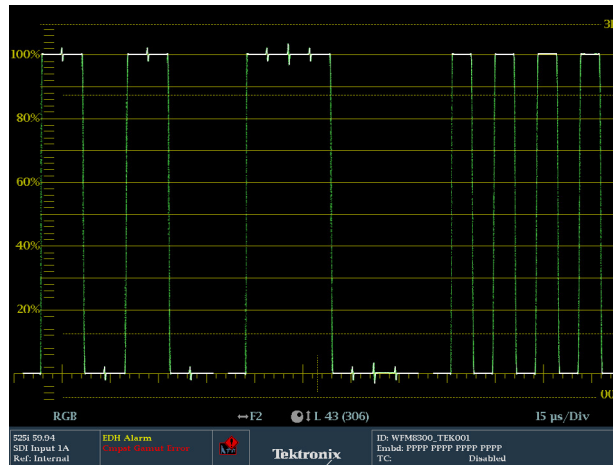


FIGURE 3-9. Standard Definition 100% color bar RGB parade.

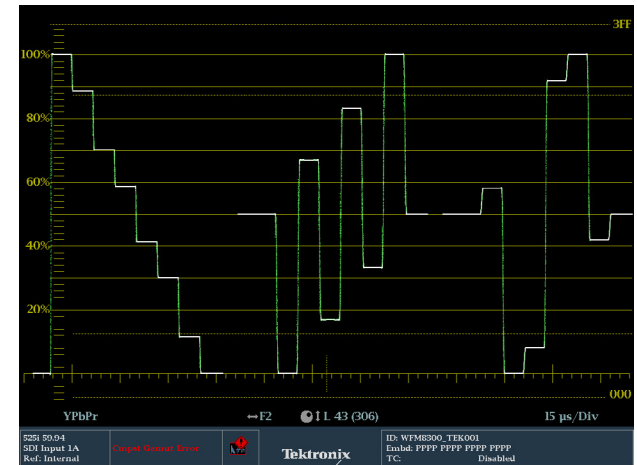


FIGURE 3-10. Standard Definition 100% color bar YPbPr parade.

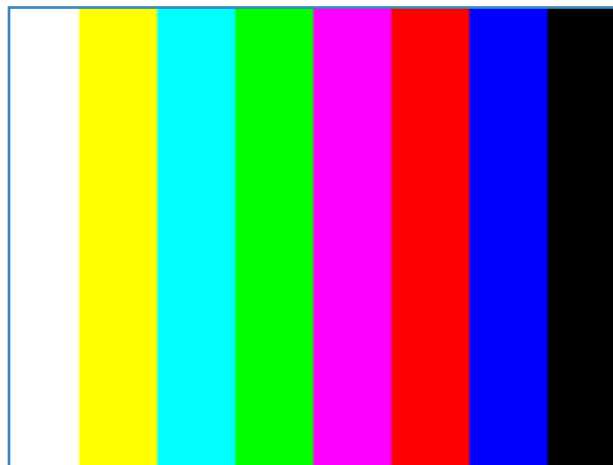


FIGURE 3-11. Standard Definition 100% color bar test pattern.

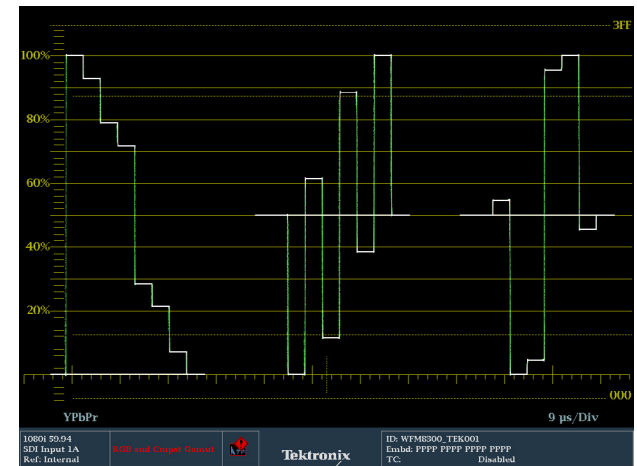


FIGURE 3-12. High Definition 100% color bar YPbPr parade.

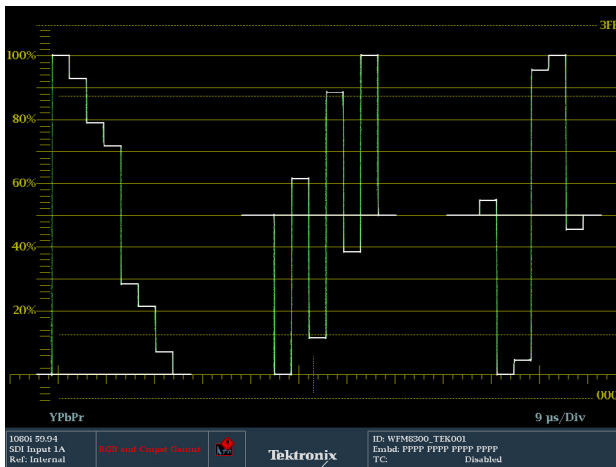


FIGURE 3-13. HD 100% color bars YPbPr parade, Rec. 709.

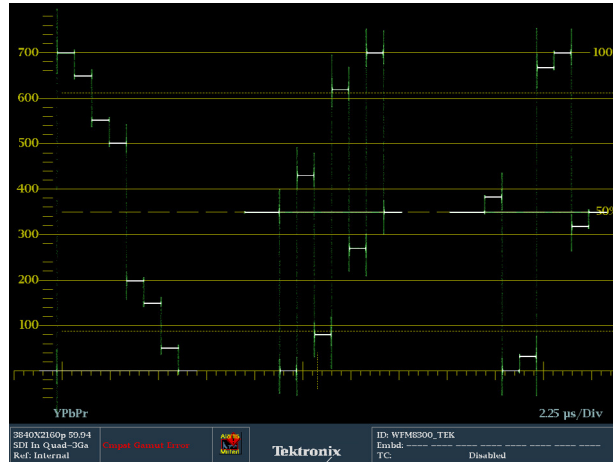


FIGURE 3-14. UHD 100% color bars YPbPr parade, Rec. 709.

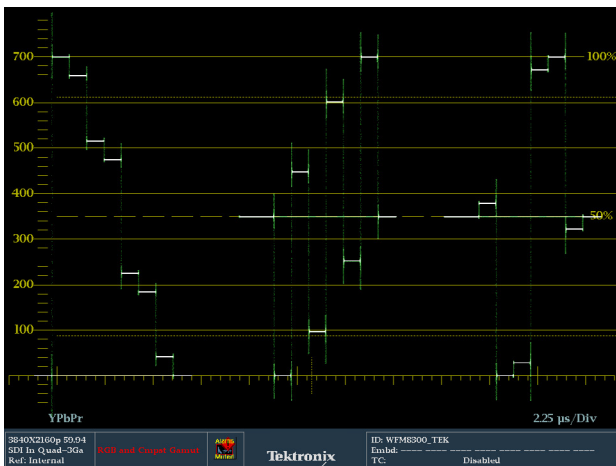


FIGURE 3-15. UHD 100% Color Bars YPbPr parade, Rec. 2020.

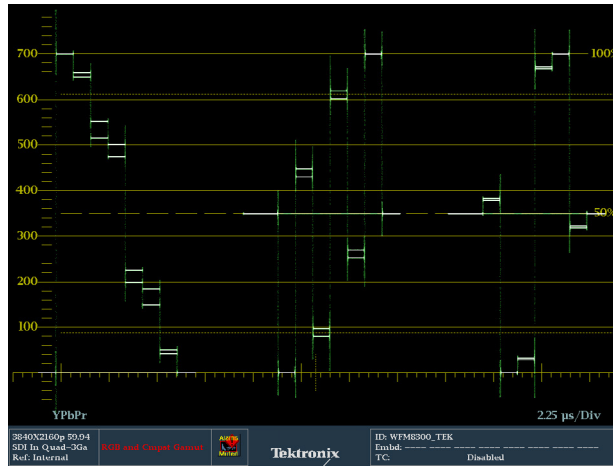


FIGURE 3-16. UHD 100% Split Field Color Bars with both 709 and 2020 colorspaces in YPbPr Parade display.

Troubleshooting Colorimetry Issues

Now let's take a look at the difference between HD using Rec. 709 and 4K/UHD which can use both Rec. 709 and Rec. 2020.

Firstly compare the HD signal in Figure 3-13 to the UHD signal in Figure 3-14. Notice the spike transitions in the UHD 100% color bar waveform display. This is normal and due to the fact that no video filtering is applied to each link. This allows the quad links to be seamlessly stitched together to form the 4K/UHD image otherwise a thin black line would be seen between the links.

You can compare the difference in levels between Rec. 709 (Figure 3-13 (HD), Figure 3-14 (UHD)) and Rec. 2020 (Figure 3-15 (UHD)). There are slight difference in the video levels as shown in Figure 3-16 which is a split field 100% color bar signal with both 709 and 2020 color spaces. Care has to be taken to chose the correct colorspace.

Determining the correct color space

In some cases the SMPTE 352 VPID may contain information on the colorimetry data that is used. Then this information can be used by the Tektronix 8000 series waveform monitor or rasterizer to automatically use the appropriate colorspace. Often however, this may not be the case and a known test signal such as color bars will be necessary to assist the user in determining the correct color space.

In Figure 3-17 a 100% split field color bar signal containing both Rec. 709 and Rec. 2020 color spaces is used to show the difference in levels on the RGB paraded waveform display. The user must manually select from the configuration menu between the 709 and 2020 colorspace. When the correct colorspace is selected then the traces will be at 0% and 100% (700mv) levels. If the incorrect colorspace is chosen then there will be variations in level of the signal and not all the color bars will lie at the 0% and 100% levels.

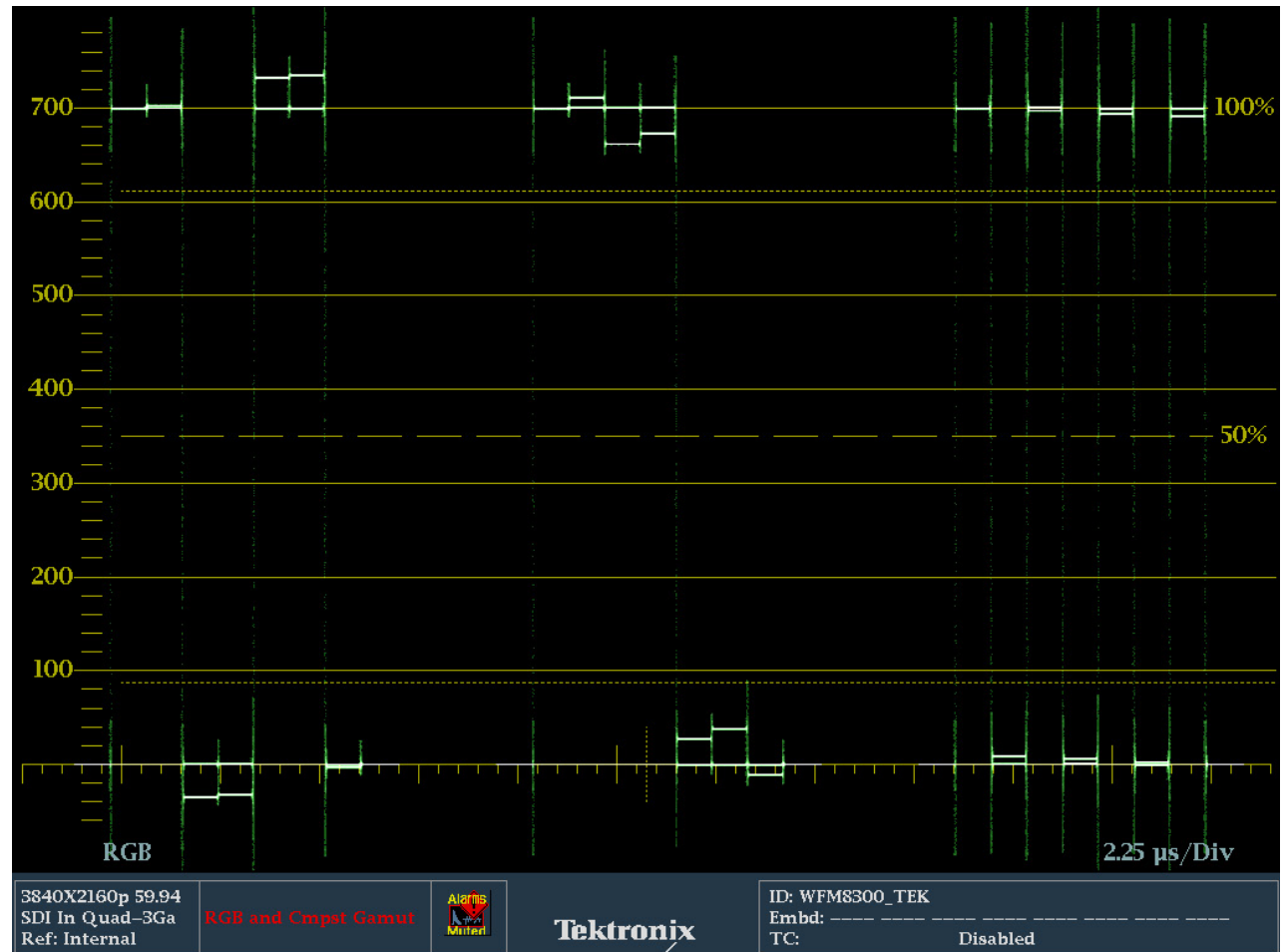


FIGURE 3-17. RGB Paraded waveform display of 100% Color Bar split field test signal with Rec. 709 and Rec. 2020 colorspace.

CHALLENGE 4

TRYING TO FIGURE OUT THE ASPECT RATIO OF INCOMING 4K/UHD CONTENT

To check whether the 4K/UHD content was scanned and matted correctly for the proper aspect ratio could be a daunting task.





Aspect Ratio

The ratio of the horizontal size to the vertical size of the image.

For instance HD can have an image size of 1920 pixels horizontally by 1080 lines vertically.

This produce an aspect ratio of:

$$\frac{1920}{1080} = 1.778 = 16:9$$

The aspect ratio for film and digital cinema are different typically having aspect ratios of 1.85:1 or 2:39:1 which are then fitted into images sizes of 4096x2160, 3840x2160, 2048x1080 or 1920x1080 depending on the application (Table 4-10).

Table 4-10. Aspect Ratio for various image sizes

Note: Standard Definition (SD) uses non square pixels.

Aspect Ratio	Image Size	Active Pixels	Active Lines
1.33:1 (4:3)	720x480 (SD NTSC)	720	486
1.33:1 (4:3)	720x576 (SD PAL)	720	576
1.778:1 (16:9)	HD (720)	1280	720
1.778:1 (16:9)	HD (1080)	1920	1080
1.33:1 (4:3)	HD(1080)	1440	1080
1.896:1	HD (2K)	2048	1080
1.85:1	HD (2K)	1998	1080
2.39:1	HD(2K)	2048	858
1.778:1 (16:9)	UHD	3840	2160
1.896:1	4K	4096	2160
1.85:1	4K	3996	2160
2.39:1	4K	4096	1716

Determining Correct Aspect Ratio

During the film scanning or other image conversion processes the image may become distorted or cropped. Therefore it is important to ensure the correct aspect ratio of the image.

To perform this task it is necessary to check the start and end of the active picture both horizontally and vertically. This can be done either in the waveform displays using line select and magnification or by using datalist with line select and sample cursor.

For instance if the user wishes to check the aspect ratio of 1.85:1 of 4K content. Then the image size will be 3996x2160. The first active line will be at line number 83 (A0) Figure 4-18 and the end of the active image will be at line number 2242 (A2158) Figure 4-19. If the pictured is centered then the first active pixel Y sample should be at sample 50.AY Figure 4-20 and the last active pixel should be at sample 4045DY Figure 4-21. In this case Y waveform and line select were used to check the start and end of active picture and Datalist was used to check the start and end of active pixels in the image as shown in the pictures from the WFM8300. To simplify this process presets can be used to set up default positions for verifying the aspect ratio of the image.

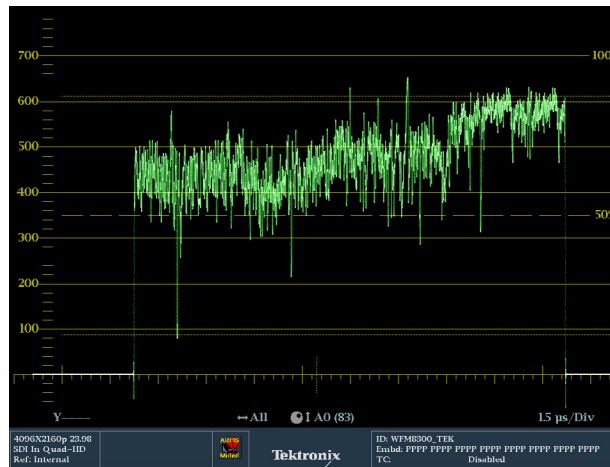


FIGURE 4-18. Line Select mode showing first active line



FIGURE 4-19. Tile 1 show line select mode of last active line.

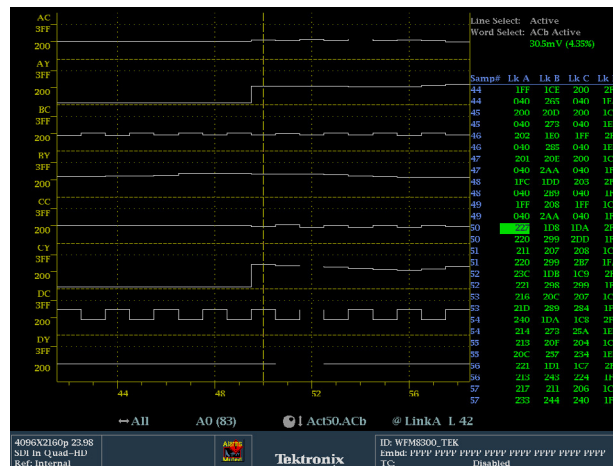


FIGURE 4-20. Datalist display of first active sample

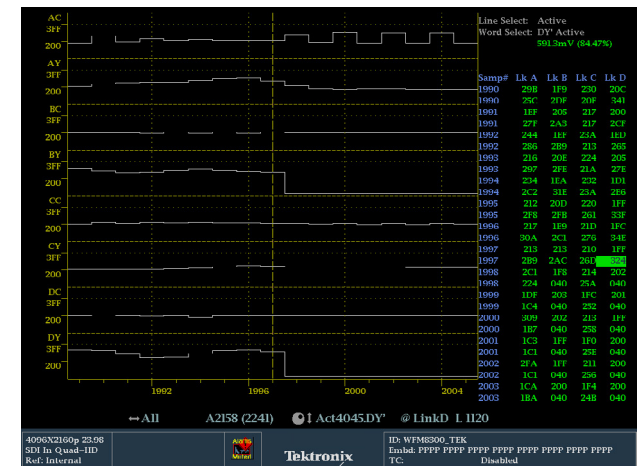


FIGURE 4-21. Datalist display of last active sample.

Image Size

The following Table 4-11 shows the various formats in use today from SD to 4K and is illustrated in Figure 4-22.

Table 4-11. Aspect Ratios

Format	Aspect Ratio	H Pixels	V Lines
SD	4:3	720	486
SD	4:3	720	576
HD	16:9	1280	720
HD	16:9	1920	1080
2K	1.896:1	2048	1080
UHDTV 1	16:9	3840	2160
4K	1.896:1	4096	2160

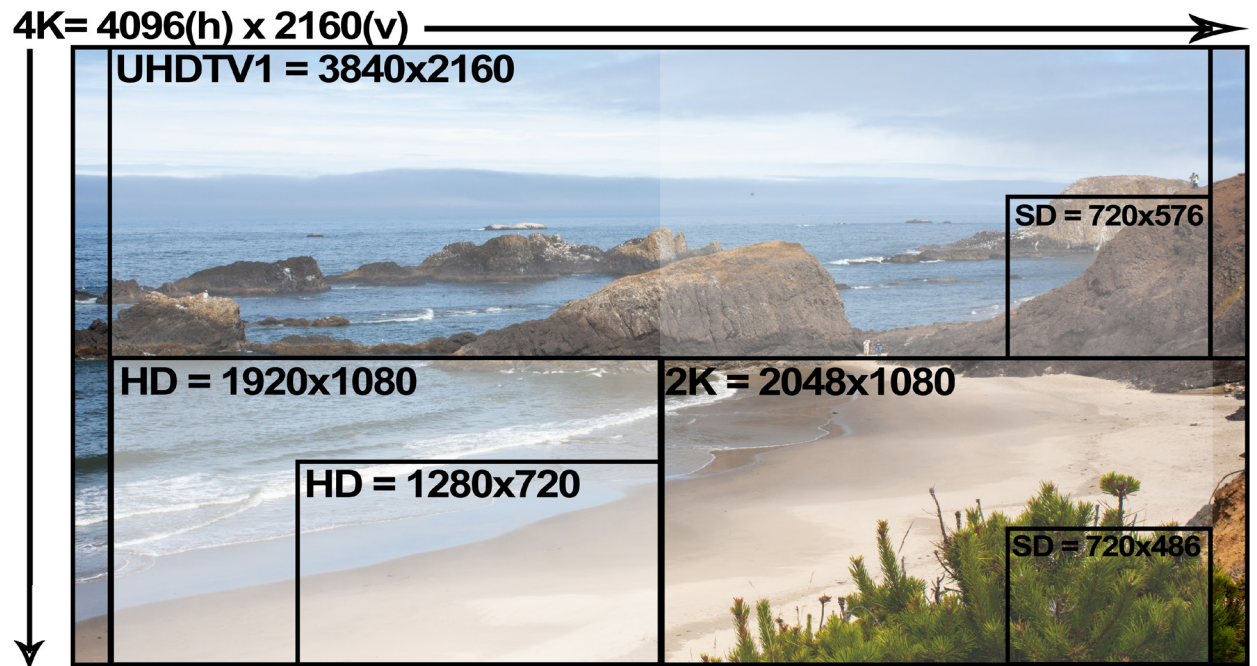


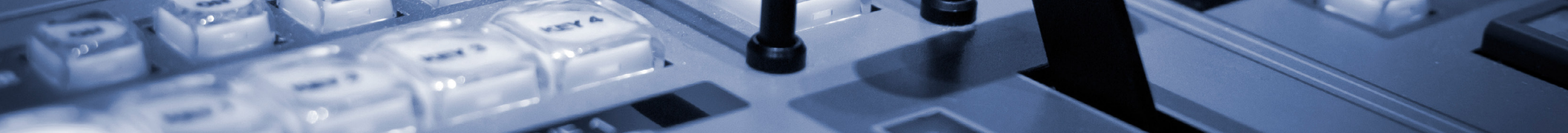
FIGURE 4-22. Image sizes for different resolutions.

CHALLENGE 5

HIGHER EXPECTATIONS FOR 4K/UHD CONTENT QUALITY

Tight Quality Control (QC) of Luma and Chroma gamut is needed for 4K/UHD content QC as expectations are higher than ever to maintain compliance without sacrificing the artistic intent of the image.



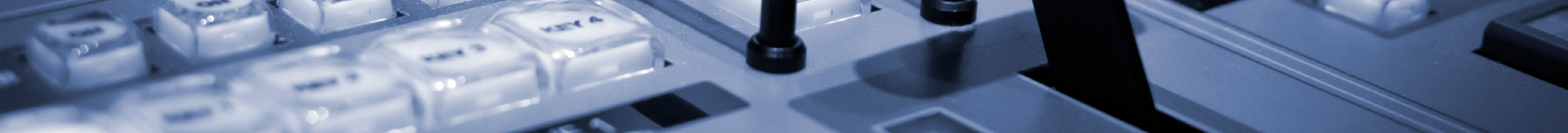


Quality Control

When the program is finally assembled the operator needs to ensure that the video and audio meet the specified delivery specifications. This will involve setting up the specified thresholds within the waveform monitor or rasterizer to trigger an alarm if these values are exceeded. These errors can then be logged within the Error Log of the instrument and related to timecode to allow the user to easily locate the error. An error log can also be downloaded from the instruments and sent along with the content, allowing the editor to quickly resolve any issues found in the material.



FIGURE 5-23. Four tile display showing quality assurance monitoring of video and audio with waveform, error log loudness session and audio displays.



Setting up Quality Control Thresholds

The user needs to read the delivery specifications to determine the audio and video threshold and levels required to meet the specification. Within the configuration of the waveform monitor these levels need to be set for each of the required specifications.

For example Gamut Thresholds can be set within the configuration menu for RGB Diamond upper and lower limits. Composite limits are setting within the Arrowhead limits for the specific format and minimum and maximum luma limits can also be set. There is an EBU-R103 preset which defaults the gamut limits to the required thresholds.

If the user requires specific limits for Loudness this can be performed in the Loudness Settings configuration menu. To simplify configuration a set of Loudness preset is available to conform to the various country standards.

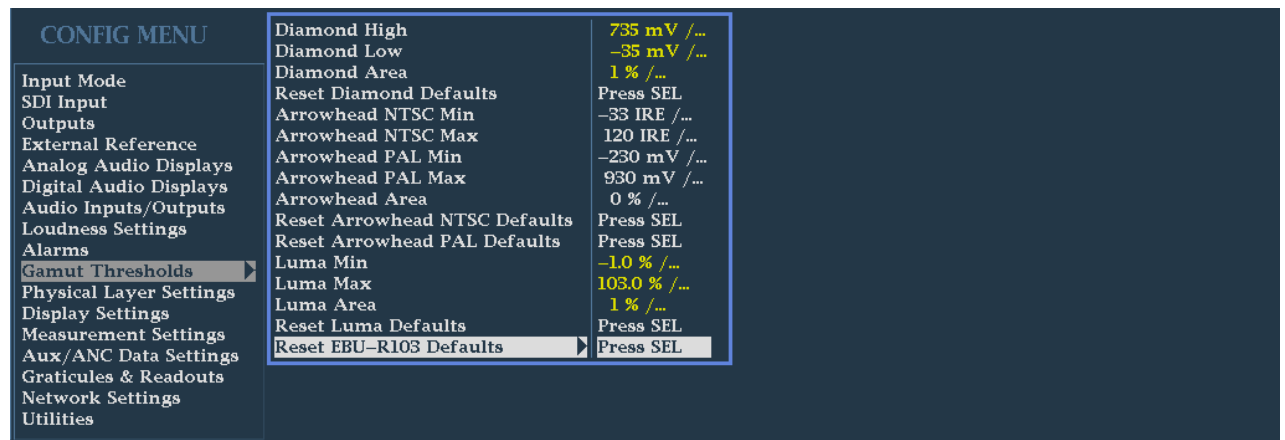


FIGURE 5-24. Configuration menu for Gamut Threshold limits

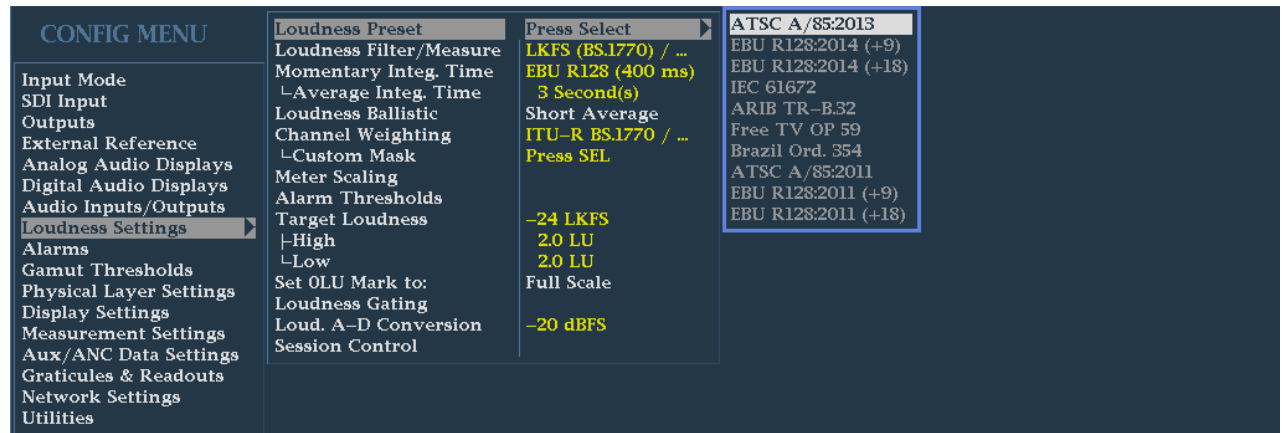


FIGURE 5-25. Configuration menu for Loudness Settings

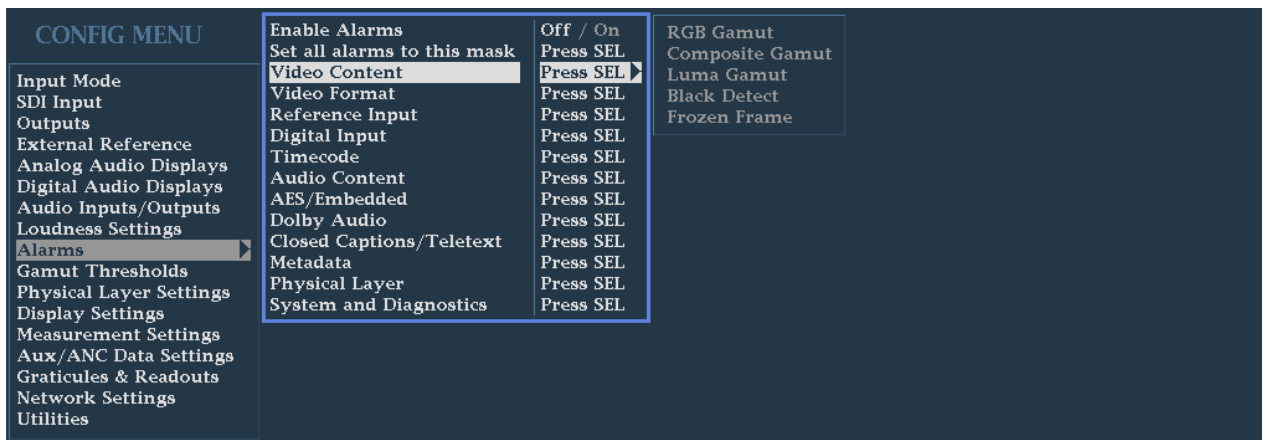
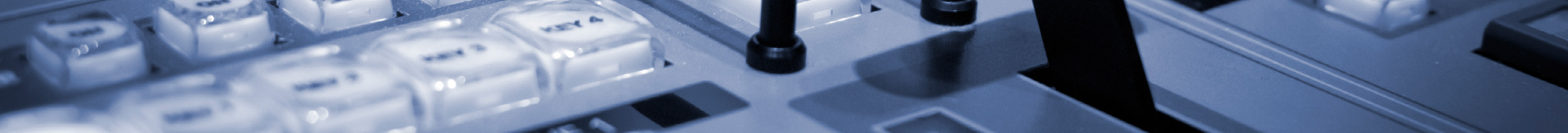


FIGURE 5-26. Configuration menu for Alarm settings

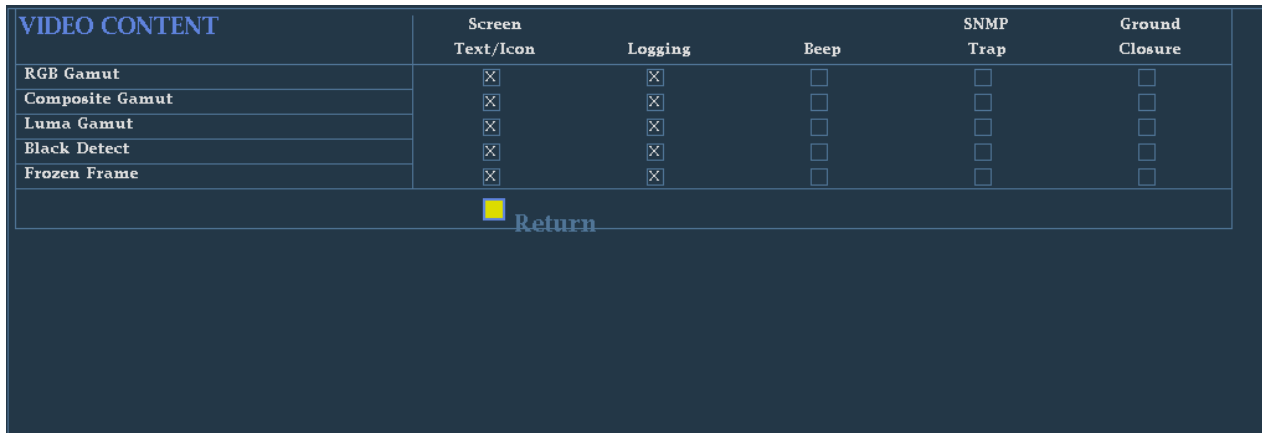


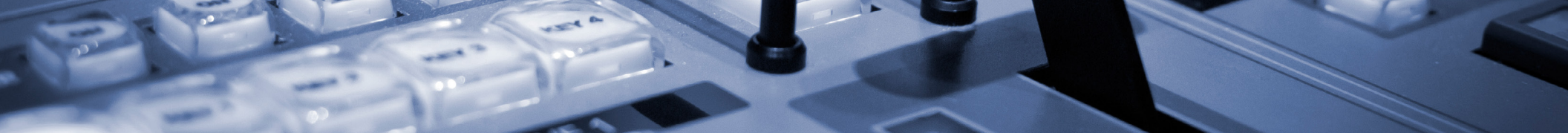
FIGURE 5-27. Configuration menu for Video Content alarms.

Setting up Alarm Configuration

After the user has set up the individual threshold limits for the required delivery specification, then each alarm should be set within the alarm configuration menu.

For example the Video Content alarms allows monitoring of the RGB Gamut, Composite Gamut and Luma Gamut. The user can set monitor of alarms to be On Screen Text, Logging to the error log, Beep, SNMP Trap or Ground Closure for each type of alarm.

The tick boxes show alarms currently being monitored. There are a wide variety of alarms and the user should configure those which are required to be monitored for the delivery specification. Once configured the user should save this configuration as a preset for easy recall of the settings and configuration.



Quality Control Monitoring

Once the threshold levels and alarms are configured within the instrument the user can begin quality control monitoring of the content.

If the material has timecode present then the user should select to enable timecode monitoring within the configuration menu. This will then be shown in the status bar and the Error Log display.

Then the content can be monitored by the waveform monitor and errors found in the content will be logged via the instrument. When the content has finished the operator can review the Error Log to determine any errors within the content. By using timecode the operator or editor can quickly go to specific content to review the material in question.

The error log can also be downloaded from the instrument or saved to USB device and sent to the production company or editor to assist in determining the errors within the content.

Active Log(Full) Filter: All 12/18/2015 Page 853 of 854

	Source	Error Status	Timecode	Time
✓	SDI 1A	Luma Gamut Error	00:09:17:15	20:04:07
✓	SDI 1A	RGB Gamut Error	00:09:17:25	20:04:07
✓	SDI 1A	RGB Gamut Error (- r-----)	00:09:18:26	20:04:08
✓	SDI 1A	Composite Gamut Error (C-)	00:09:19:13	20:04:08
✓		Audio Session Loud (l-----)		20:04:08
✓	SDI 1A	Luma Gamut Error (-l)	00:09:19:17	20:04:09
✓	SDI 1A	RGB Gamut Error (- r--B-)	00:09:19:20	20:04:09
✓	SDI 1A	RGB Gamut Error (- r--Bb)	00:09:20:02	20:04:09
✓	SDI 1A	Luma Gamut Error	00:09:20:10	20:04:09
✓	SDI 1A	RGB Gamut Error	00:09:20:13	20:04:09
✓	SDI 1A	Composite Gamut Error	00:09:22:19	20:04:12
✓	SDI 1A	RGB Gamut Error (- r-----)	00:09:24:18	20:04:14
✓		Audio Session Loud		20:04:15
✓		Audio Session Loud (l-----)		20:04:17
✓		Audio Session Loud		20:04:17
✓	SDI 1A	RGB Gamut Error	00:09:28:07	20:04:17
✓		Audio Session Loud (l-----)		20:04:19
✓		Audio Session Loud		20:04:20
✓		Audio Session Loud (l-----)		20:04:21
✓	SDI 1A	RGB Gamut Error (- r-----)	00:09:31:28	20:04:21
✓		Audio Session Loud		20:04:21
✓	SDI 1A	RGB Gamut Error	00:09:32:22	20:04:22
✓	SDI 1A	RGB Gamut Error (- r-----)	00:09:32:29	20:04:22
✓		Audio Session Loud (l-----)		20:04:22

Arrow Left – Previous, Right – Next, Up – First, Down – Last.

4096X2160p 29.97
SDI In Quad-HD
Ref: Internal

RGB Gamut Error

ID: WFM8300_TEK
Embd: PPPP PPPP ----- PPPP PPPP -----
LTC: 00:09:44:20 30 fps DF

FIGURE 5-28. Error Log displays show alarm values related to timecode and internal time.

CHALLENGE 6

TRANSMISSION OF 4K/UHD CONTENT

The quad link signals data can be transmitted as Square Division or Two-Sample Interleaved depending on the application.



Transmission & Distribution

The way in which the 4K/UHD image is split apart into the quad links can be achieved by Square Division (Figure 6-29) where the image is divided into four quadrants. Each quadrant of the image is then encapsulated into an individual SDI signal. This is the simplest way to segment the image but requires more memory to store each of the quadrants before assembling the complete image. This method is commonly used by a variety of post-production equipment.

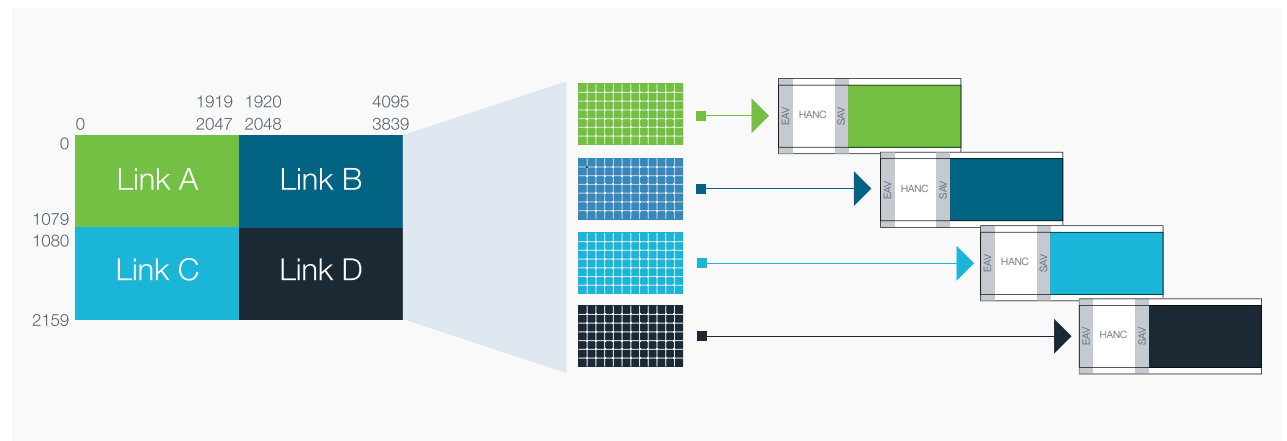


FIGURE 6-29. Square Division process of separating the 4K/UHD image into quad link signals.

Transmission & Distribution

Another way in which the 4K/UHD image is split apart into the quad links is to use Two Sample Interleave. In this process groups of two pixels are separated from the image and sent on four different links as shown in Figure 6-30. This method requires less memory to be used and allows groups of pixels to be processed more quickly. However this process requires multiplexing of the data into four separate SDI streams. Two-Sample Interleaving is typically used within the transmission process.

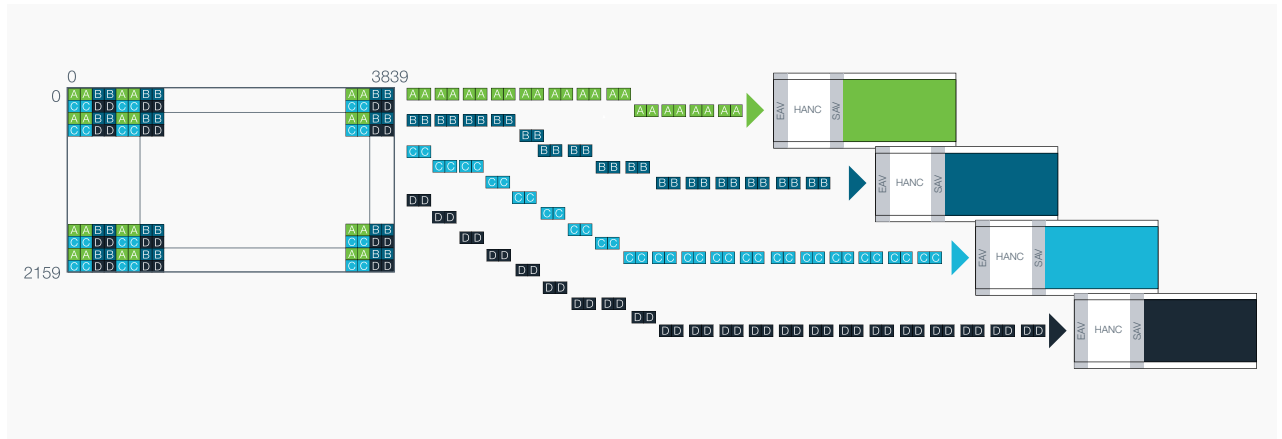


FIGURE 6-30. Two-Sample Interleave process of separating the 4K/UHD image into quad link signals.

Transport Configuration

There are no bytes used in SMPTE ST352 to indicate the transport mode of Square Division or Two Sample Interleave. Therefore in the 8000 series waveform monitors to determine the transport mode the instrument uses the VPID information and the standard used to automatically select Tile or Two Sample Interleave mode. Alternatively the user can force the Quad SDI mode within the configuration menu. The user can use the picture display to verify the correct mode has been selected and the image is assembled correctly.

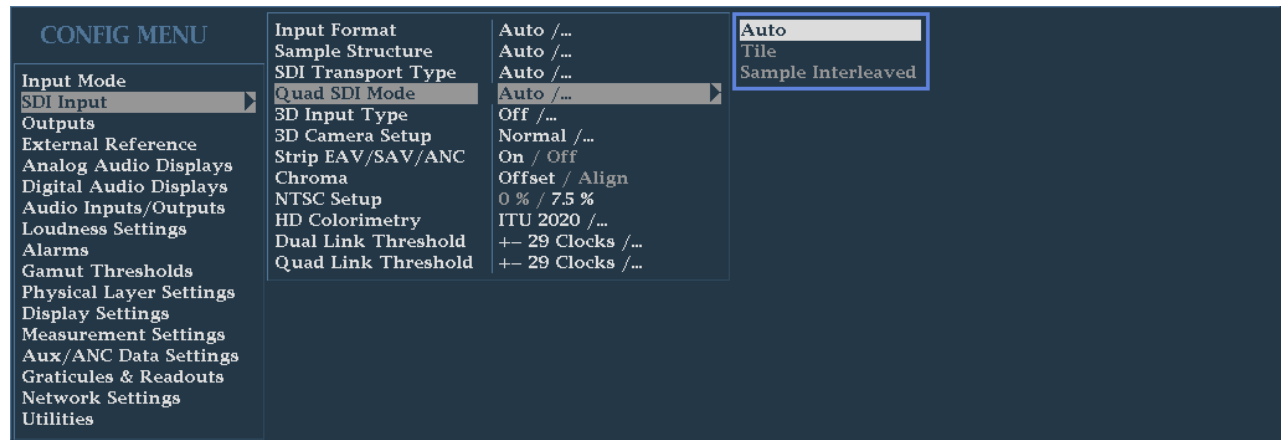


FIGURE 6-31. Configuration menu Quad SDI Mode.

CONCLUSION

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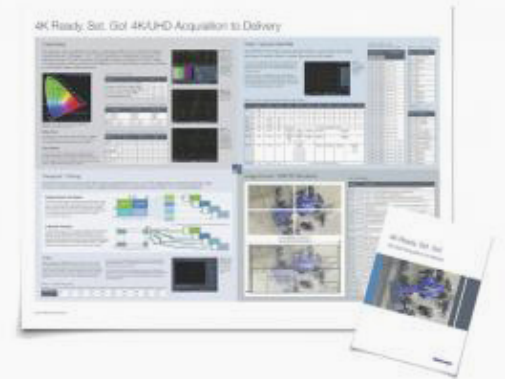
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References

4K/UHD Content Creation Poster

tek.com/4k



Delivering 4K/UHD Television using HEVC/H.265 Poster

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