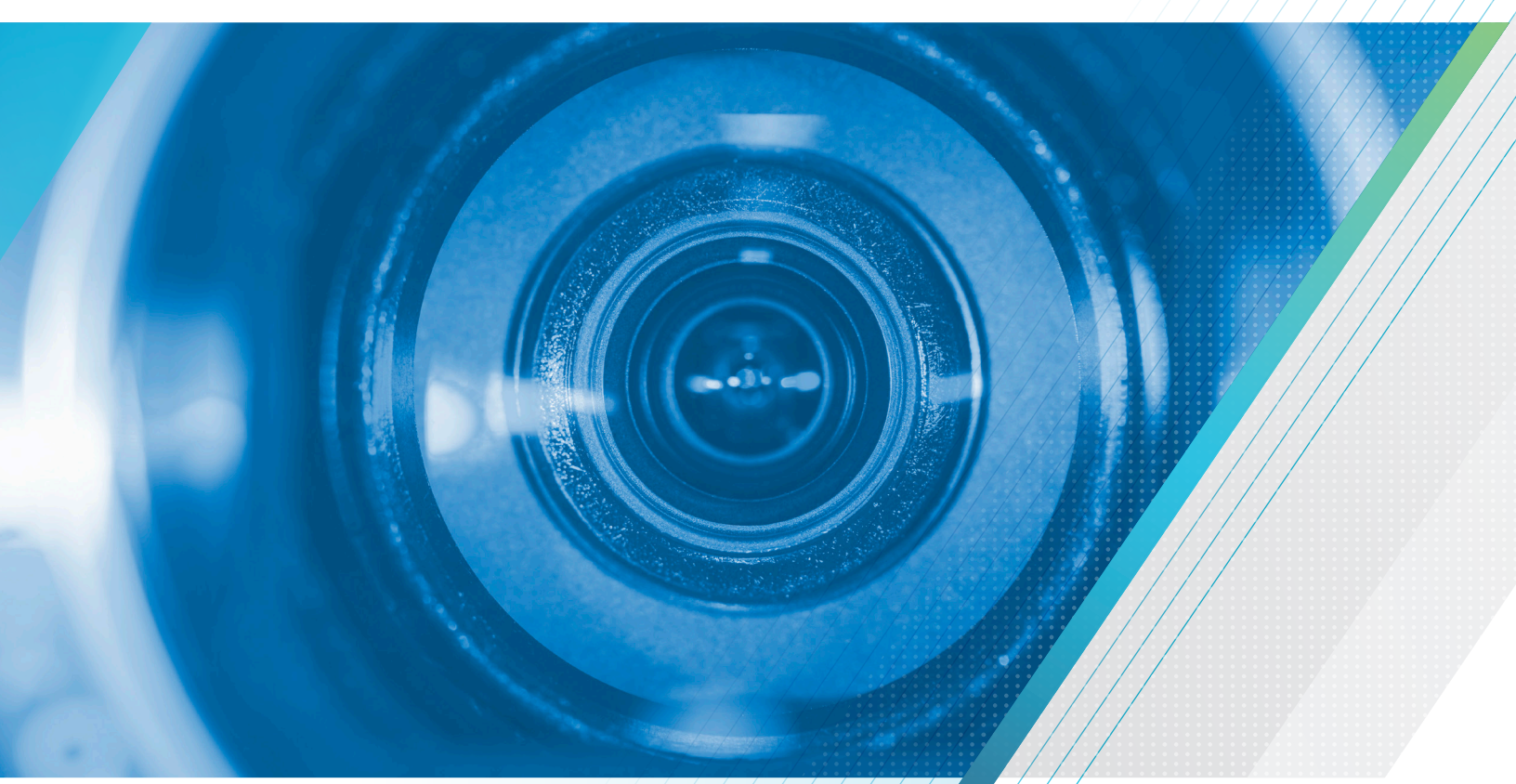
High Dynamic Range (HDR)

WFM/WVR8000 Series

HOW TO GUIDE



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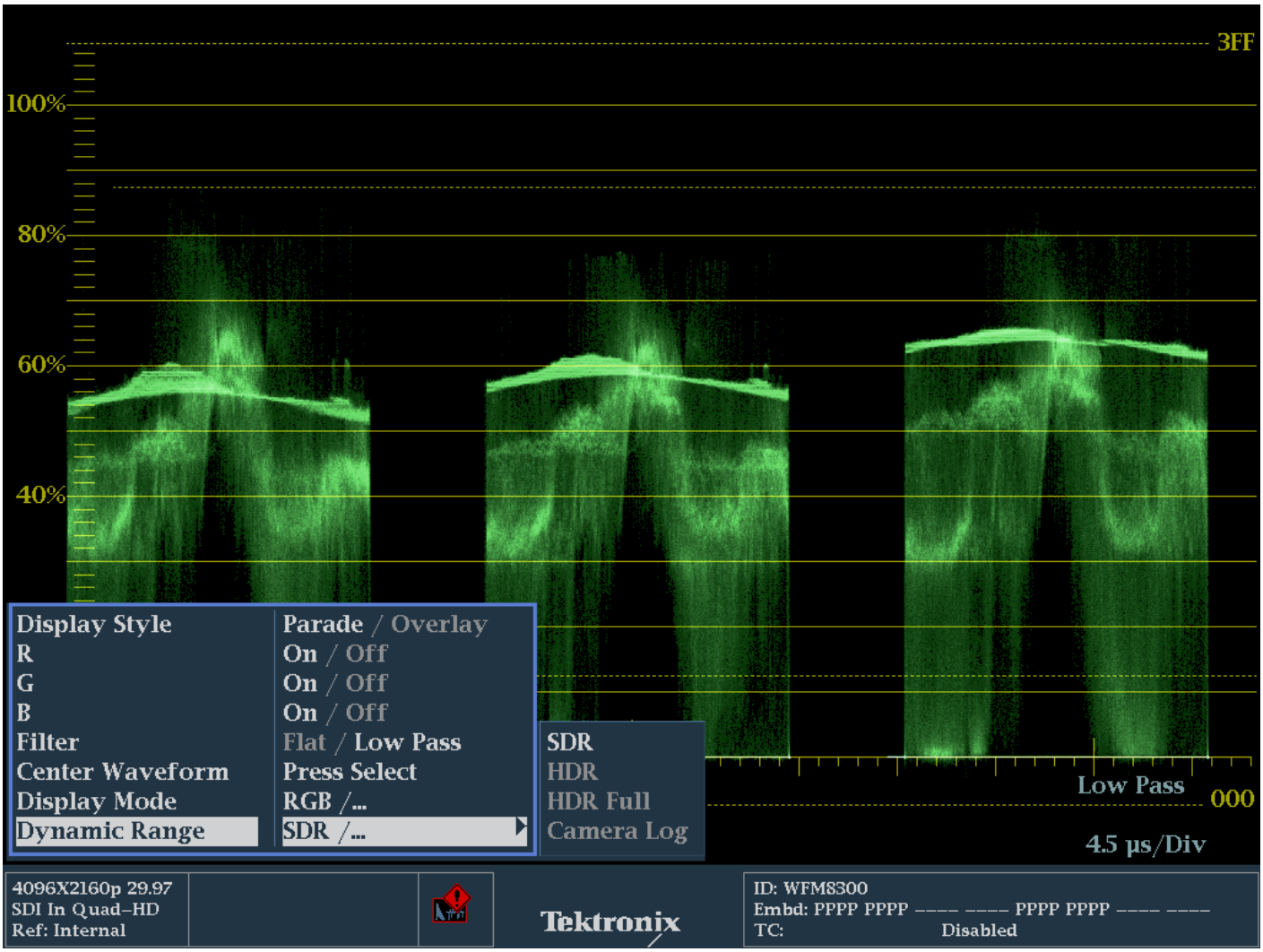

FIGURE 1. HDR Waveform Menu.

HOW TO CONFIGURE HDR WAVEFORM DISPLAY

1. Select one of the tiles (1, 2, 3 or 4) using the **Display Select** and press the **WFM** button.
2. Select **FULL** using **Display Select** to bring the waveform display to full screen mode
3. Push and Hold the **WFM** button to display the Waveform menu.
4. Using the general knob or up/down arrow keys navigate to and select Dynamic Range as shown in Figure 1.
5. Press **SEL** to enter the sub menu and then navigate using the arrow keys or general knob to select between **SDR, HDR, HDR Full** or **Camera Log**.
6. Select HDR mode and notice the change in the graticule.
7. Press WFM button to dismiss the menu.
8. Use the Left or Right arrow keys to change the units of the vertical scale in terms of **NITS, STOPS** or **REFLECTANCE** see Appendix A

Note:

Standard Dynamic Range (SDR) for conventional HD and 3G signals uses ITU-R BT.709/2022 with an OETF (Optical to Electrical Transfer Function) gamma of 0.45 and with a display gamma (Electrical to Optical Transfer Function) of 2.4 as defined in ITU-R BT 1886.

High Dynamic Range (HDR) uses the bit depth more efficiently producing smoother blacks and brighter specular highlights following the HDR standards such as Hybrid Log Gamma (HLG) defined by ARIB ST B-67 Essential Parameter values for the Extended Image Dynamic Range Television System for Programme Production or SMPTE ST.2084 High Dynamic Range Electro-Optical Transfer Function of Mastering Reference Displays.

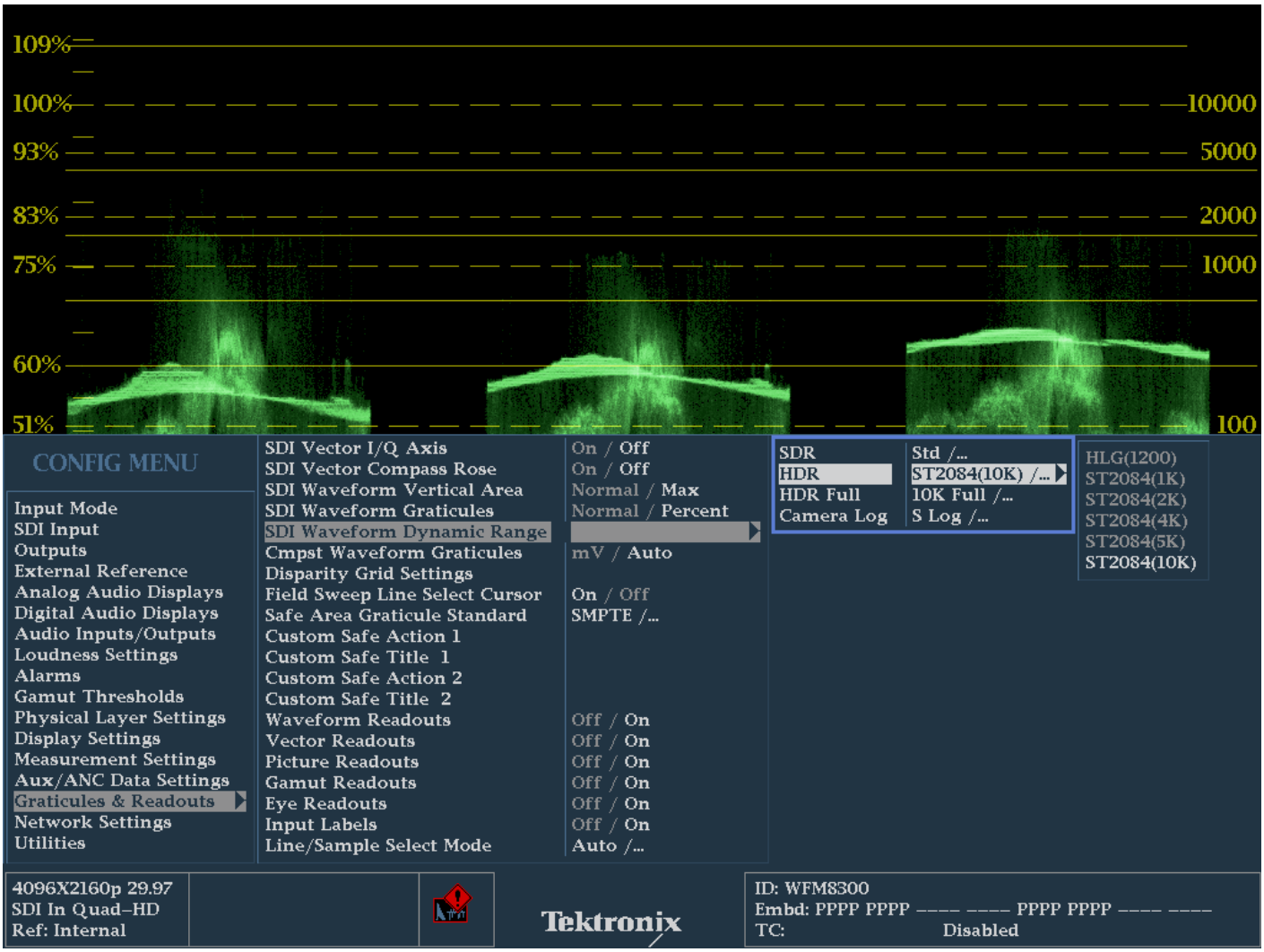

FIGURE 2. SDI Waveform Dynamic Range Configuration Menu.

9. The HDR scale can be changed in the configuration menu by pressing the **CONFIG** button.
10. Using the general knob or up/down arrow keys navigate to **Graticules and Readouts**
11. Press **SEL** to enter the sub menu and using the general knob or up and down arrow keys navigate to **SDI Waveform Dynamic Range**
12. Then press **SEL** to enter the sub menu and select between **SDR, HDR, HDR Full** or **Camera Log** using the up/down arrow keys or general knob.
13. Each sub menu has a range of graticules that are available for that mode, for instance HDR can select between **HLG(1200), ST2084 (1K), ST2084 (2K), ST2084 (5K), ST2084 (10K)** as shown in Figure 2.

Note: For HDR / HDR Full and Camera Log monitoring the waveform Graticules and Readouts for SDI Vertical Area and with the SDI Waveform Graticule have no effect on the graticule as shown in Figure 2.

MODE	SELECTIONS	EXPLANATION
SDR	STD	Standard graticule that can either be configured with **SDI Waveform Vertical Area** of **Normal** or **Max** and **SDI Waveform Graticule** of **Normal** or **Percent**.
	Narrow	Uses a Nits scale and code values that are used for the traditional signal representation with code value 64 decimal (10-bit) equal to 0mv or 0% and code value 940 decimal (10-bit) equal to 700mv or 100%.
	Full	Uses a Nits scale that uses the full range of values to represent the signal with code value 4 decimal (10-bit) equal to 0% and code value 1019 decimal (10-bit) equal to 100%. Note in SDI the code words 0-3d and 1020-1023 are excluded and clipped from the file that uses 0-1203 as the full range as defined in ITU-R BT 2100.
HDR	HLG (1200)	Hybrid Log Gamma is defined in standard ARIB ST B-67 Essential Parameter values for the Extended Image Dynamic Range Television System for Programme Production and graticule is configured for a maximum of 1200 Nits.
	ST2084 (1K)	Uses the SMPTE ST.2084 standard curve with a maximum value of 1000Nits using a narrow range.
	ST2084 (2K)	Uses the SMPTE ST.2084 standard curve with a maximum value of 2000Nits using a narrow range.
	ST2084 (4K)	Uses the SMPTE ST.2084 standard curve with a maximum value of 4000Nits using a narrow range.
	ST2084 (5K)	Uses the SMPTE ST.2084 standard curve with a maximum value of 5000Nits using a narrow range.
	ST2084 (10K)	Uses the SMPTE ST.2084 standard curve with a maximum value of 10000Nits using a narrow range.
HDR Full	ST2084 (1K)	Uses the SMPTE ST.2084 standard curve with a maximum value of 1000Nits using a Full range. Please see appendix B.
	ST2084 (10K)	Uses the SMPTE ST.2084 standard curve with a maximum value of 10000Nits using a Full range. Please see appendix B
Camera Log	S Log	Provides graticule with Sony S Log curve
	S Log2	Provides graticule with Sony S Log2 curve
	S Log3	Provides graticule with Sony S Log3 curve
	C Log	Provides graticule with Canon C Log curve
	Log C	Provides graticule with Arri Log C curve at (ISO) EI 800
	BT709	Provide graticule with ITU-R BT.709 gamma curve

TABLE 1. Dynamic Range Modes.

CAMERA ACQUISITION USING CAMERA LOG GRATICULE

GAMMA	0% BLACK 10-BIT CODE-VALUE	%	18% GREY (20 NITS ILLUMINATION) 10-BIT CODE-VALUE	%	90% REFLECTANCE 10-BIT CODE-VALUE	%
S Log 1	90	3	394	37.7	636	65
S Log 2	**90**	**3**	**347**	**32.3**	**582**	**59**
S Log 3	95	3.5	420	40.6	598	61
Log C Arri	134	3.5	400	38.4	569	58
C-Log Canon	128	7.3	351	32.8	614	63
BT.709	64	0	423	41.0	940	100

TABLE 2. Camera log curve reference levels.

Today's video cameras are able to capture a wide dynamic range of 14-16 Stops depending on the camera in order to record this information a log curve is used by each camera manufacturer to be able to store this wide dynamic range effectively with 12- 16 bits or resolution as a Camera RAW file. Each camera manufacture has develop a range of Log Curves for instance Sony has developed S-Log, S-Log2 and S-Log 3, whereas Canon had C Log curves and ARRI has Log C curves.

Within the configuration menu as show in Table 1 the appropriate camera log curve can be selected. Each curve has defined 18% Grey and 90% reflectance white levels as shown in Table 2.

Use a suitable grey scale camera chart or Spyder Cube as used in this example and shown in Figure 3.

This cube has a hole that produce super black, a reflective black base, and segments for 18% grey and 90% reflective white. The ball bearing on the top produces reflective specular highlights.

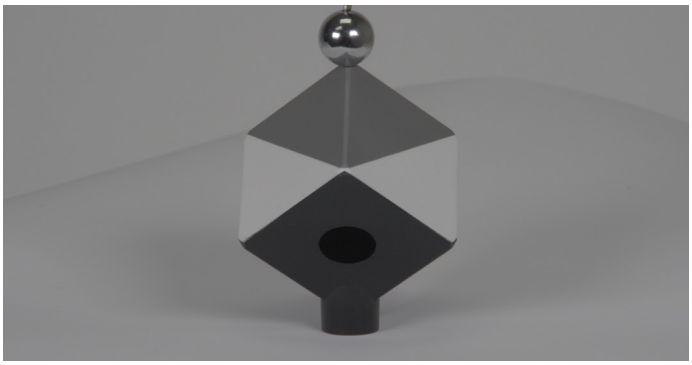

FIGURE 3. Datacolor Spyder Cube.

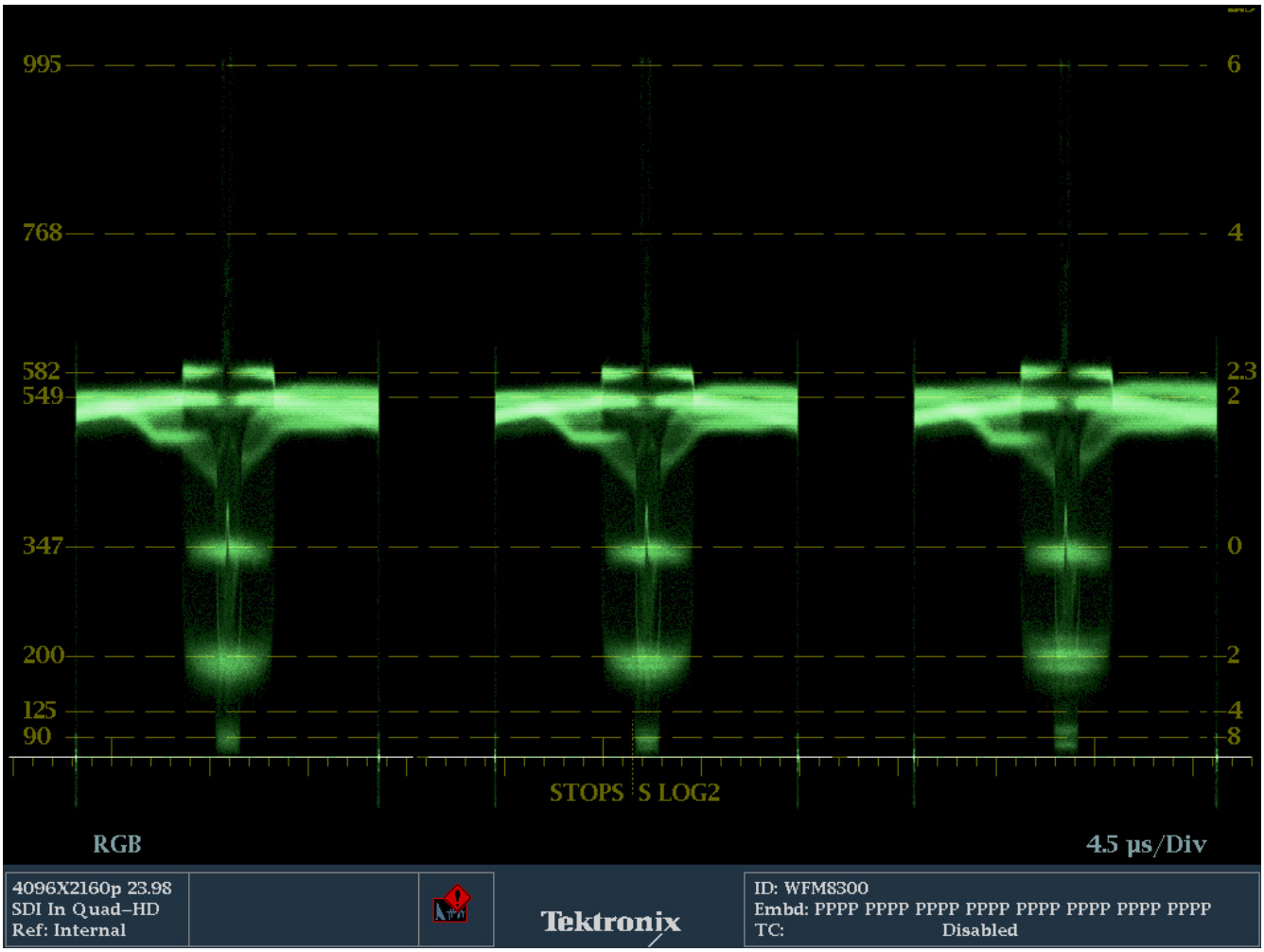

FIGURE 4. Camera Log graticule using S Log2 curve.

In this example we capture an image in S-Log 2 using the Spyder cube and adjust the camera and lighting until the 90% reflective white was at about 582d (59%) equivalent to 2.,3 Stops and the 347d (18%) grey was at about 32% equivalent to 0 Stops as shown in Figure 4.

1. Select one of the tiles (1, 2, 3 or 4) using the **Display Select** and press the **WFM** button.
2. Select **FULL** using **Display Select** to bring the waveform display to full screen mode
3. Push and Hold the **WFM** button to display the Waveform menu.
4. Using the general knob or up/down arrow keys navigate to and select **Dynamic Range**.
5. Press **SEL** to enter the sub menu and then navigate using the arrow keys or general knob to select Camera Log.
6. Notice the change in the graticule and 0 Stops is equivalent to 18% grey level.
7. Press **WFM** button to dismiss the menu.
8. The **Camera Log** scale can be changed in the configuration menu by pressing the **CONFIG** button
9. Using the general knob or up/down arrow keys navigate to **Graticules and Readouts**
10. Press **SEL** to enter the sub menu and using the general knob or up and down arrow keys navigate to **SDI Waveform Dynamic Range**
11. Then press **SEL** to enter the sub menu and select **Camera Log** using the up/down arrow keys or general knob.
12. Each sub menu has a range of graticules that are available for that mode, for instance **Camera Log** can select between **S Log, S Log2, S Log3, C Log, Log C** and **BT709**. In this case **S Log2** was selected.

    Note: If your specific camera is not one of the preset camera log graticule then you can use the percent graticule and percentage cursors to configure the 90%reflectance white and 18% grey points on the waveform monitor. For instance if you have a Panasonic Varicam camera using the V Log curve then this defines 18% grey at a level of 42%(433d 10-bit) and 90% reflectance white at 62% (602d 10-bit)

FIGURE 5. Camera Log using cursors.

1. Select one of the tiles (1, 2, 3 or 4) using the **Display Select** and press the **WFM** button.
2. Select **FULL** using **Display Select** to bring the waveform display to full screen mode
3. Push and Hold the **WFM** button to display the Waveform menu.
4. Using the general knob or up/down arrow keys navigate to and select **Dynamic Range**.
5. Press **SEL** to enter the sub menu and then navigate using the arrow keys or general knob to select **SDR**.
6. Notice the change in the graticule and 0 Stops is equivalent to 18% grey level.
7. Press **WFM** button to dismiss the menu.
8. The **SDR** scale can be changed in the configuration menu by pressing the **CONFIG** button
9. Using the general knob or up/down arrow keys navigate to **Graticules and Readouts**
10. Press **SEL** to enter the sub menu and using the general knob or up and down arrow keys navigate to **SDI Waveform Dynamic Range**
11. Then press **SEL** to enter the sub menu and select SDR using the up/down arrow keys or general knob.
12. Each sub menu has a range of graticules that are available for that mode, for instance **SDR** can select between **Std, Narrow** and **Full**, in this case **Std** was selected.
13. While in **Graticules & Readouts** make sure **SDI Waveform Vertical Area** is set to **Max** and **SDI Waveform Graticule** is set to **Percent**.
14. Press **CONFIG** to dismiss the menu
15. Press and hold the **Cursor** button to bring up the cursor menu and then using the general knob or arrow keys navigate to **Voltage Cursor Units** and press **SEL** to use % cursors.
16. Note: The user, using Set 100% can define the voltage range to be used for the percentage cursors. The normal default for 0-100% to be 0-700mv and should be verified before setting the 90% and 18% grey levels.
17. Press the **Cursor** button to dismiss the menu.
18. Using the general knob to move the cursors to the 61% and 42% levels as shown in Figure 5.

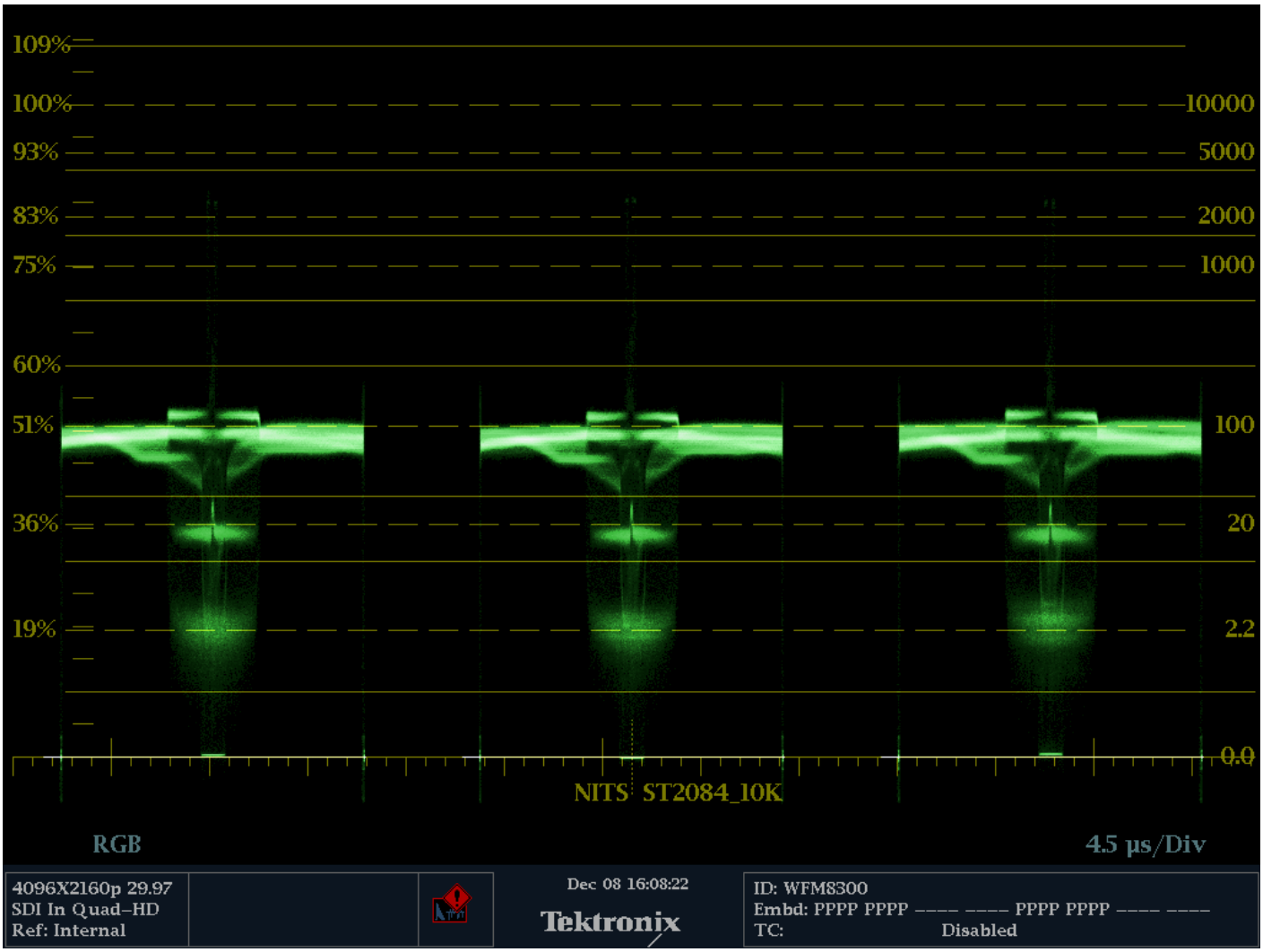

FIGURE 6.CHDR graticule using ST2084 10K.

USING LOOK UP TABLES (LUTS) IN POST PRODUCTION

The Camera Raw files are typically low contrast desaturated images due to the curve and additional processing is required to produce suitable images. In live production a LUT box can be used to convert the camera raw output to a 709 image or an HDR image depending on the curve applied. In editing or color correction a similar look up table can be applied or adjustment of the lift, gamma and gain can be applied to produce a suitable image.

In this example we took the S Log camera raw image and converted it to SMPTE ST.2084 partially using a look up table to make the basic curve adjustment between S Log2 and ST.2084 PQ (Perceptual Quantizer). Then making fine adjustment within the color correction tools to produce the final image.

1. Select one of the tiles (1, 2, 3 or 4) using the **Display Select** and press the **WFM** button.
2. Select **FULL** using **Display Select** to bring the waveform display to full screen mode
3. Push and Hold the **WFM** button to display the Waveform menu.
4. Using the general knob or up/down arrow keys navigate to and select **Dynamic Range**.
5. Press **SEL** to enter the sub menu and then navigate using the arrow keys or general knob to select **HDR**.
6. Notice the change in the graticule and 0 Stops is equivalent to 18% grey level.
7. Press **WFM** button to dismiss the menu.

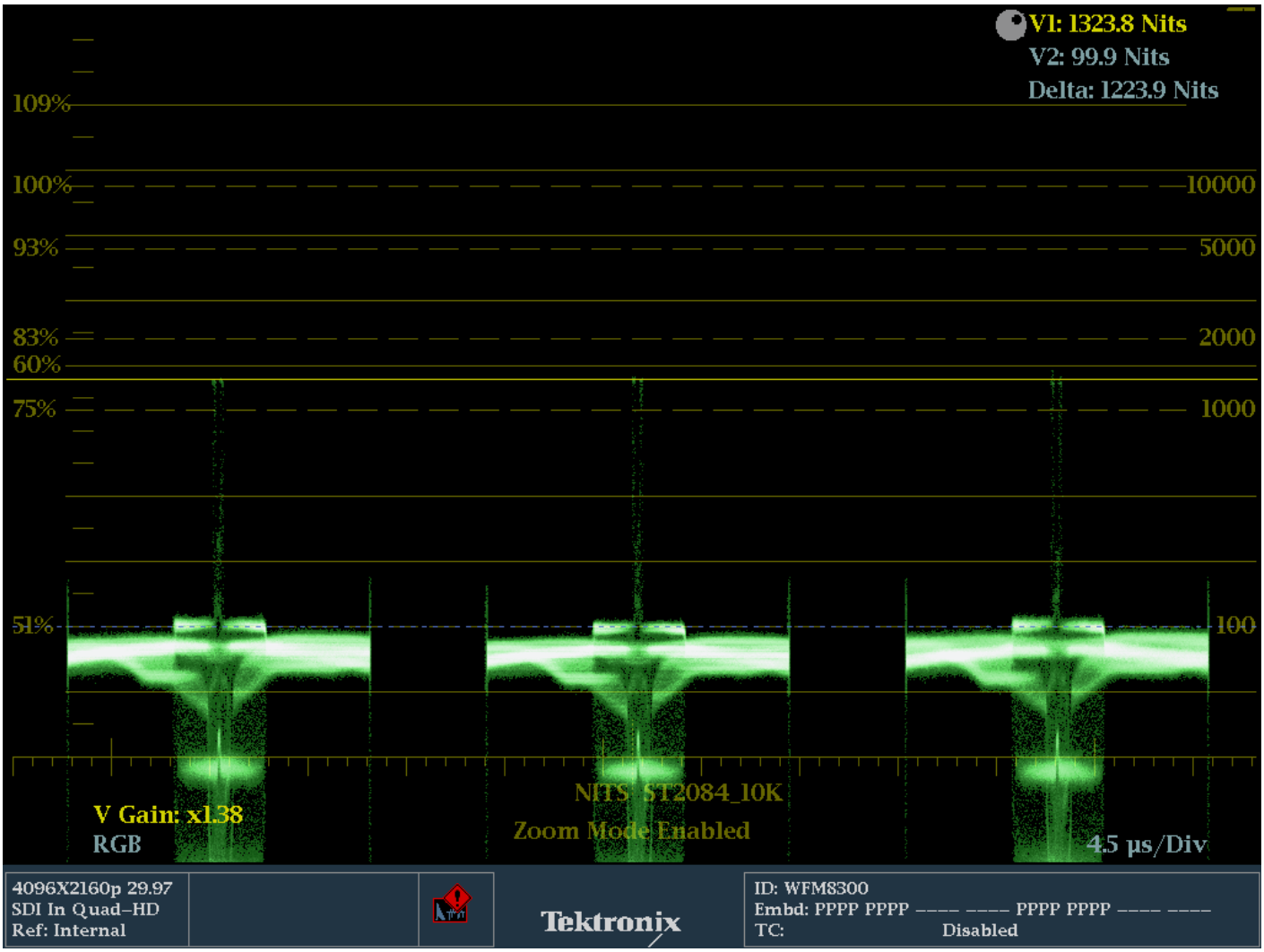

FIGURE 7. Zoom Mode Enabled in ST2084 10K HDR graticule.

8. The **SDR** scale can be changed in the configuration menu by pressing the **CONFIG** button
9. Using the general knob or up/down arrow keys navigate to **Graticules and Readouts**
10. Press **SEL** to enter the sub menu and using the general knob or up and down arrow keys navigate to **SDI Waveform Dynamic Range**
11. Then press **SEL** to enter the sub menu and select **HDR** using the up/down arrow keys or general knob.
12. Each sub menu has a range of graticules that are available for that mode, for instance HDR can select between **HLG(1200), ST2084(1K) and ST2084(2K), ST2084(4K), ST2084(5K) and ST2084(10K)**, in this case **ST2084(10K)** was selected as shown in Figure 6.

In some cases you may wish to look at the specular highlights above 100Nits and in 1K and 10K HDR modes there is a zoom function that can be enabled by pressing the **UP** arrow to select zoom mode (Figure 7) and the **DOWN** arrow to deselect zoom mode. Note: Gain, Line select and Cursors also use the arrow keys and you will need to deselect these functions if enabled in order to select the zoom mode. The vertical position and gain functions are locked in the zoom mode.

Note: In HDR modes the Variable Gain function is always enabled to allow selection between Zoom mode and other custom Gain selections the user may want to configure.

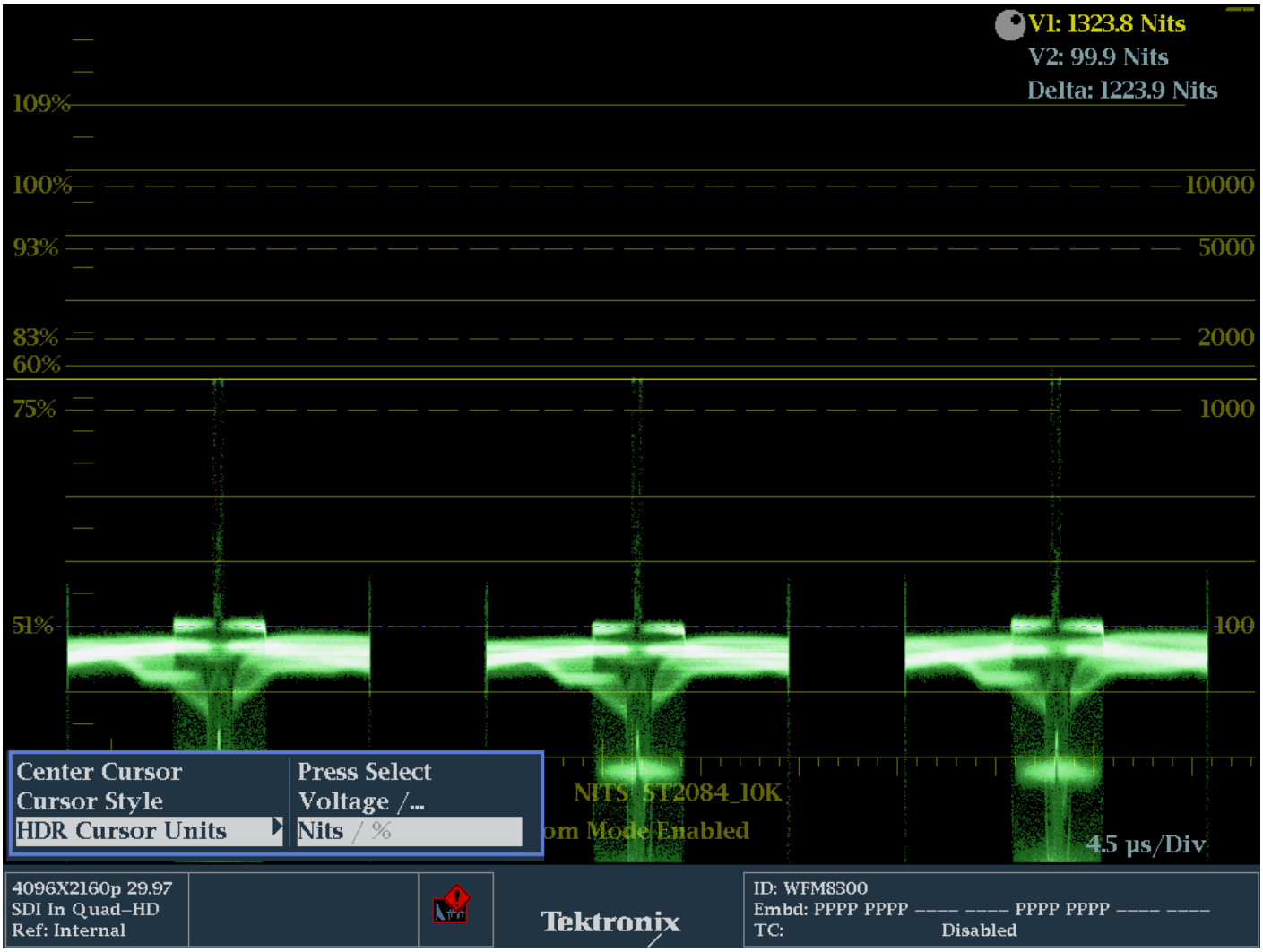

FIGURE 8. Nits cursors used in ST2084 10K HDR graticule.

When in HDR/HDR Full mode the user can choose between Nits and Percentage cursors. Using the Nits cursor can be useful to determine the maximum signal level for the specular highlights as shown in this example in Figure 8.

1. When a **WFM** display is selected and the **Dynamic Range** is in **HDR** or **HDR Full** mode.
2. Press and hold the **Cursor** button to bring up the menu as shown in Figure 8.
3. Navigate using the arrow keys or general knob to **HDR Cursor Units** and press **SEL** to select between **Nits** and % cursors.

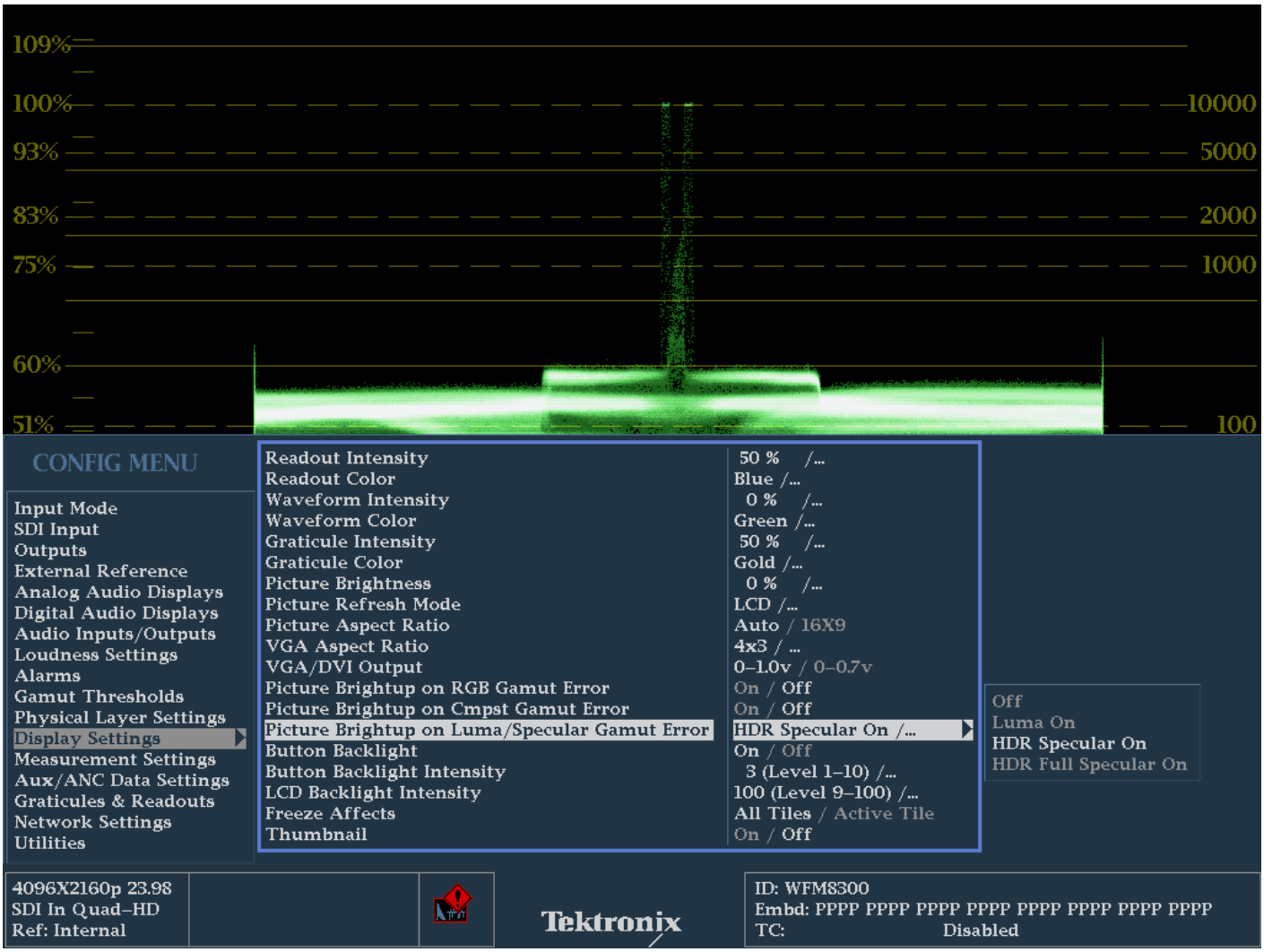

FIGURE 9. Configuration menu for enabling specular highlight Zebra pattern within picture display.

In some cases it may be useful for the editor or colorist to know what parts of the image are above the 100Nit level.

A specular highlight zebra pattern can be enabled within the configuration menu for HDR or HDR Full and then applies a zebra highlight to parts of the image that are above 100 Nits of the specific HDR OETF. To enable the specular highlight mode perform the following operation.

1. Press **CONFIG** button to enter the configuration and use the arrow keys or general knob to navigate to **Displays Settings**
2. Press SEL to enter the sub menu and navigate to **Picture Brightup on Luma/Specular Gamut Error** using the up/down arrow keys or general knob.
3. Press **SEL** to enter the sub menu and select either **HDR Specular On** or H**DR Full Specular On** depending on the HDR format you are currently using. In this case I selected **HDR Specular On** as shown in Figure 9.
4. Press **CONFIG** to dismiss the menu
5. Select one of the tiles (1, 2, 3 or 4) using the **Display Select** and press the **PICT** button, if any of the signal goes above 100Nits then a zebra pattern will be observed in the picture display.

Note: Specular Highlight zebra pattern can be primarily used for large areas of specular highlights that go above 100Nits on the specific OETF curve. Fine specular highlights may not be observed due to the high frequency filtering performed by the luma gamut engine. Luma gamut alarms are disable in the HDR specular highlight modes.

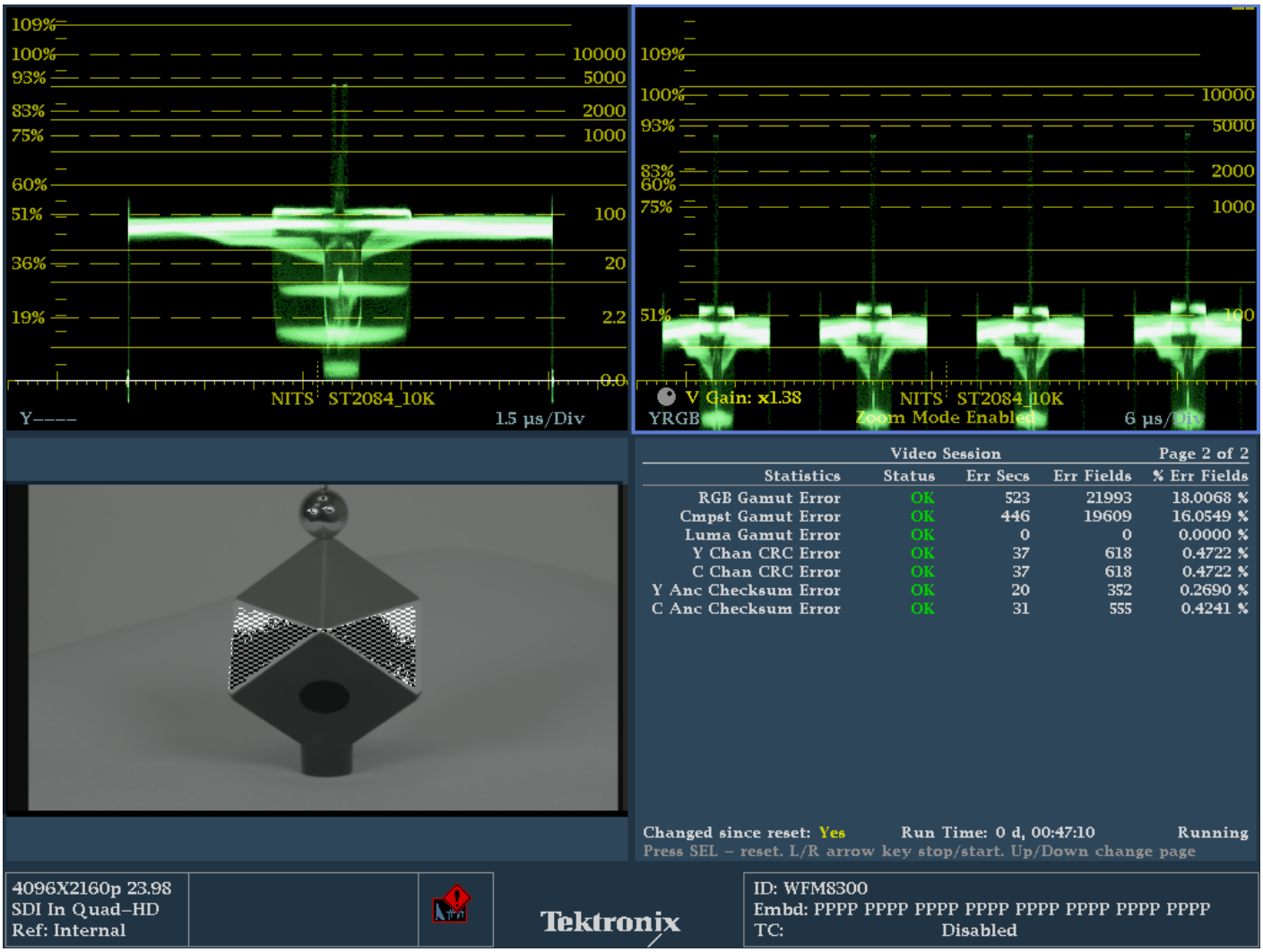

FIGURE 10. Four tile display on WFM8300 showing specular Highlight zebra pattern in picture display.

Figure 10 shows a SMPTE ST2084(10K) HDR image that needs to be adjusted for white to be at 100Nits. With the Specular Highlights on the picture displays in tile 3 showing that the white part of the Spydercube is currently above 100 Nits since the zebra pattern is visible.

Tile 1 shows a standard Luma Y trace of the waveform displays and Tile 2 shows an YRGB waveform display in Zoom mode to more easily see the levels from 100 Nits to the maximum scale and that the white part of the trace is above 100Nits and needs to be slightly adjusted to correctly balance the image.

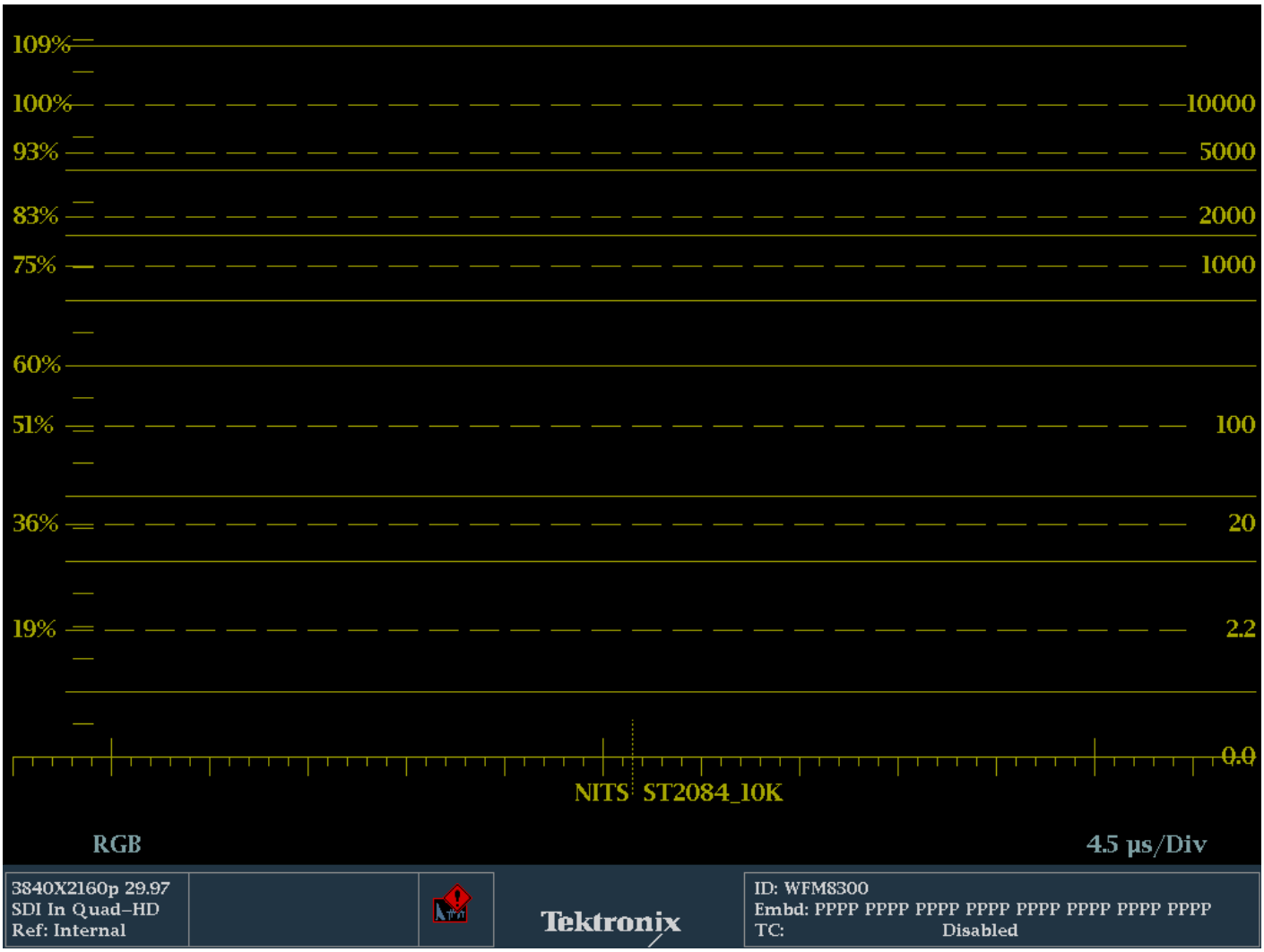

FIGURE A1. SMPTE 2084 PQ 10000NIT scale with 100% reflectance white.

APPENDIX A: HDR WAVEFORM GRATICULES

The scale in Figure A1 was set to **HDR** using the **ST2084(10K)** Nits graticule scale within the configuration menu. The percentage scale is shown on the left hand side and the Nits scale is show on the right hand side. When using this graticule with SMPTE ST.2084 encoded content the 90% reflectance white level of the signal should be at about 51% that is equivalent to 100 Nits and the 18% grey level will be at 36% that is equivalent to 20 Nits. The 100% level is equivalent to 10,000Nits when using this scale.

Pressing the left or right arrow keys when in HDR or HDR FULL graticules will toggle the vertical graticule values between **NITS, STOPS, REFLECTANCE** and **Code Value**.

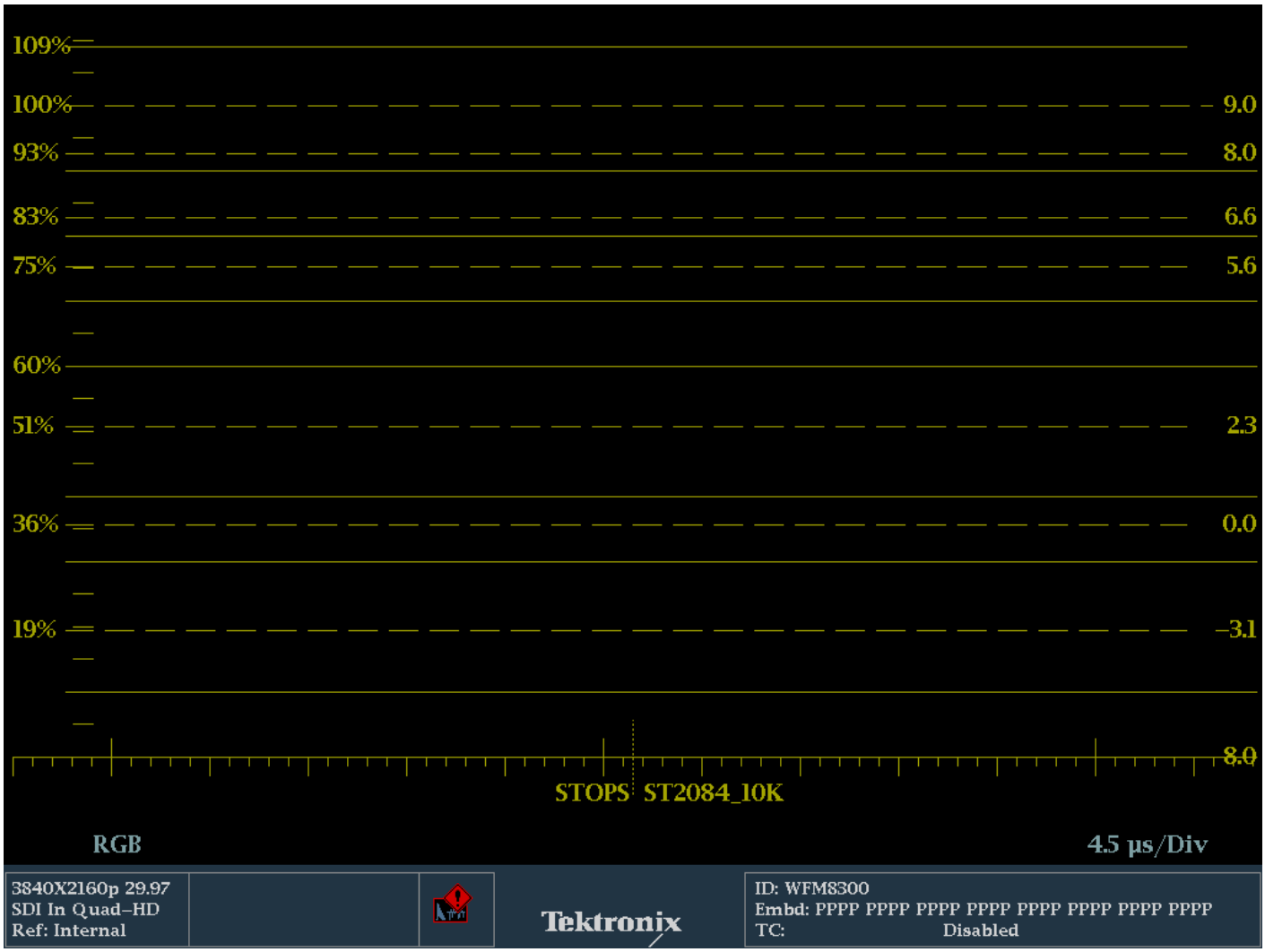

FIGURE A2. SMPTE 2084(10K) with 90% reflectance white with graticule scale in terms of STOPS

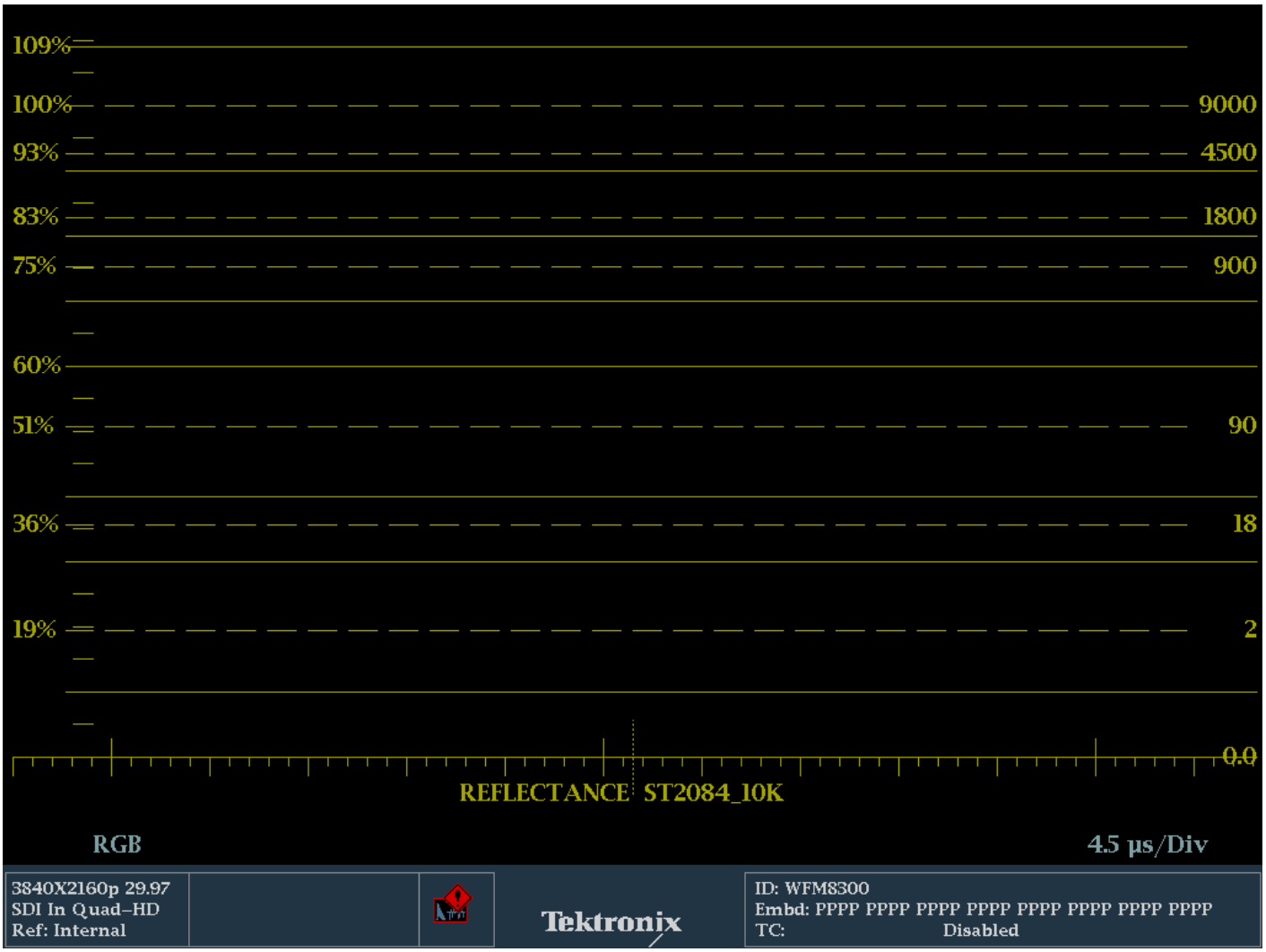

FIGURE A3. SMPTE 2084(10K) with 90% reflectance white with graticule scale in terms of REFLECTANCE.

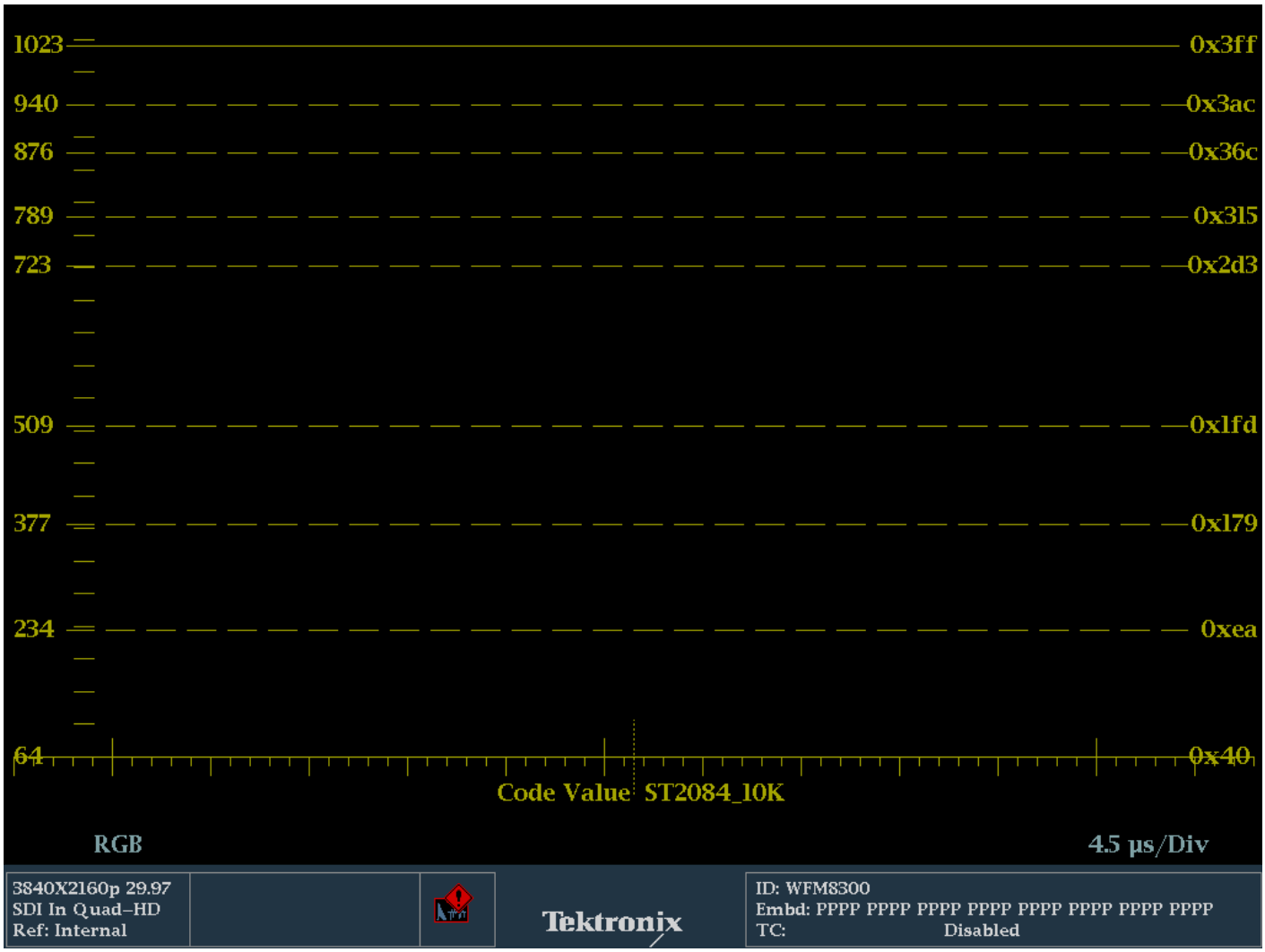

FIGURE A4. SMPTE 2084(10K) with 90% reflectance white with graticule scale in terms of Code Values.

APPENDIX B: NARROW AND FULL RANGE

Traditional SDI has used 0-700mv to represent levels from black to white which is typically referred to as 0%-100% or 0IRE to 100IRE. Within a 10-bit system this range has been represented by black at 64 decimal and white at 940 decimal that allows for overshoot and undershoot within the video signal and has been termed Narrow range as defined in ITU-R BT.2100.

In file based workflows however the full range of video levels can be used to improve accuracy in color conversion in a 10-bit or 12-bit system. Therefore in 10-bits 0 is represented as black and white is represented by 1023 decimal, however in SDI codewords are used for bits 0-3d and 1020d-1023d and are excluded from the active video signal. Hence when a file is converted to SDI the data maybe scaled or clipped depending on the device to the allowed range of SDI levels from black at 4d to white at 1019d. Similarly in a 12-bit workflow the range of allowed values is from 16d represented as black to 4092d represented white as shown in Figure B1.

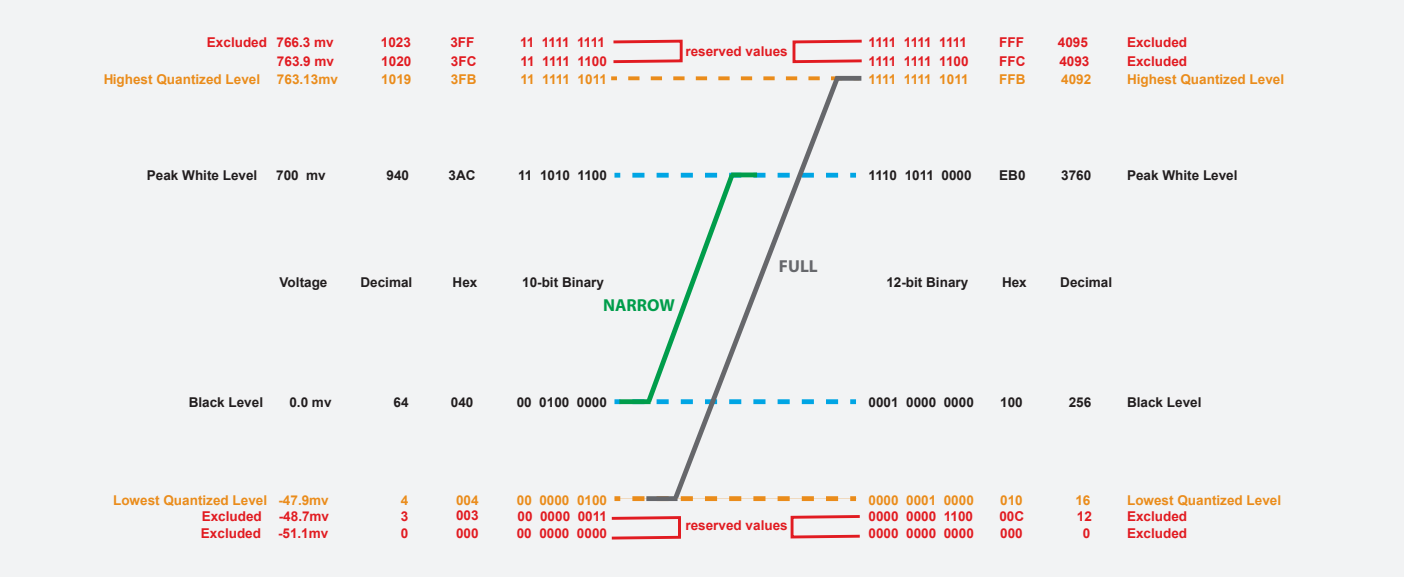

FIGURE B1. Code Values for 10-bit and 12-bit Y or RGB.

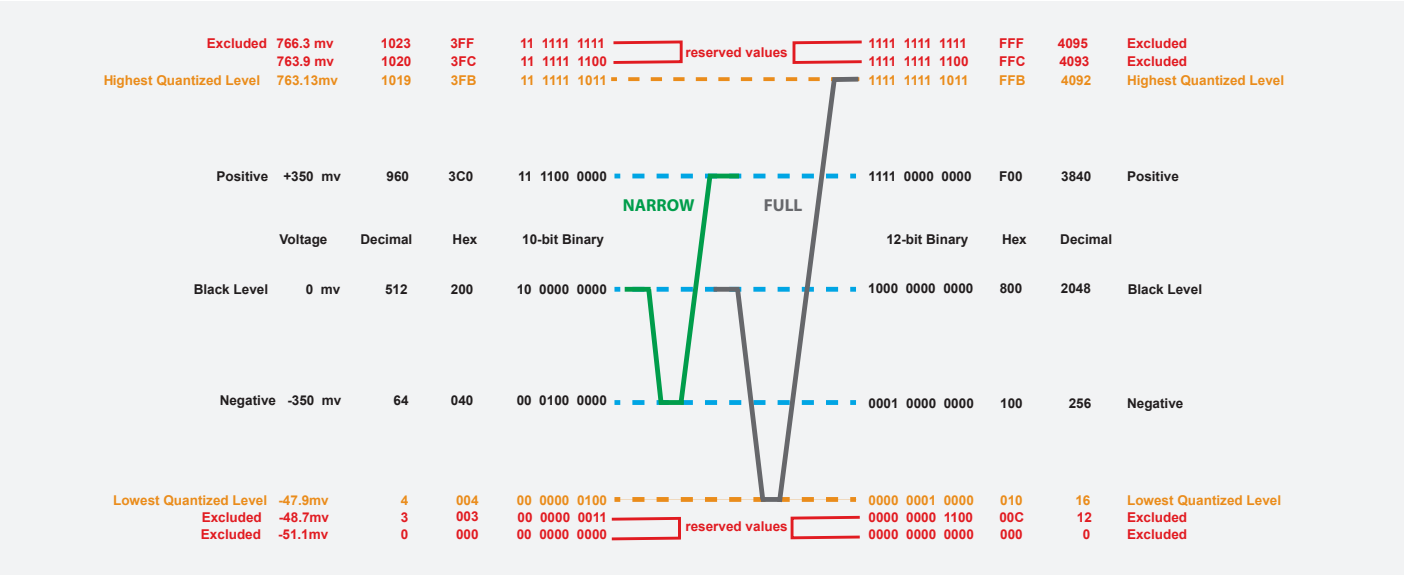

FIGURE B2. Code Values for 10-bit and 12-bit Cb and Cr.

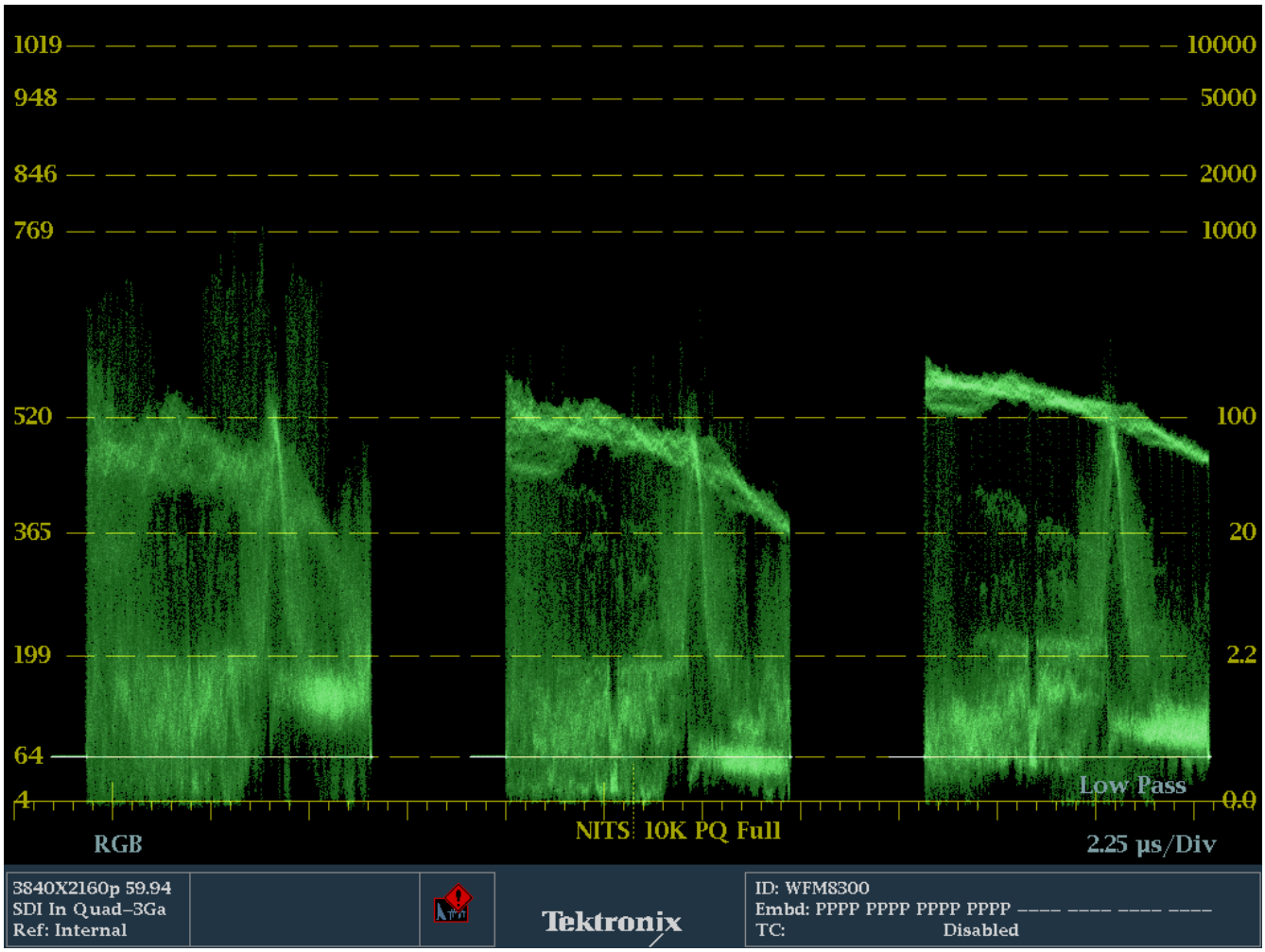

FIGURE B3. RGB waveform display in HDR ST2084 10K PQ Full range.

Note: Code Values will changed based on 10-bit or 12-bit video, automatically based on the video transport or forcing the format within the configuration menu.

In HDR full range video the maximum quantization levels are used and this changes the representation of the video levels in these formats that is reflected within the changes to the ST2084 1K and 10K graticules.

You can change the percentage cursor to represent the full range values by performing the following procedure.

1. Select one of the tiles (1, 2, 3 or 4) using the **Display Select** and press the **WFM** button.
2. Select **FULL** using **Display Select** to bring the waveform display to full screen mode
3. Push and Hold the **WFM** button to display the Waveform menu.
4. Using the general knob or up/down arrow keys navigate to and select **Dynamic Range**.
5. Press **SEL** to enter the sub menu and then navigate using the arrow keys or general knob to select **HDR Full**.
6. Press **WFM** button to dismiss the menu.
7. Press and hold the Cursor button to display the menu. Ensure that **Nits** cursors are selected.
8. Using the General knob rotate one of the cursor to the top of the scale.
9. Press the up or down arrow key to toggle to the other cursor and position it at the bottom of the scale.
10. Press and hold the **Cursor** button to display the menu. Navigate using the arrow keys or general knob to **HDR Cursor Units** and press **SEL** to toggle from **Nits** to **%**
11. Then navigate to **Set 100%** and press **SEL** to set this range to 100% scale.

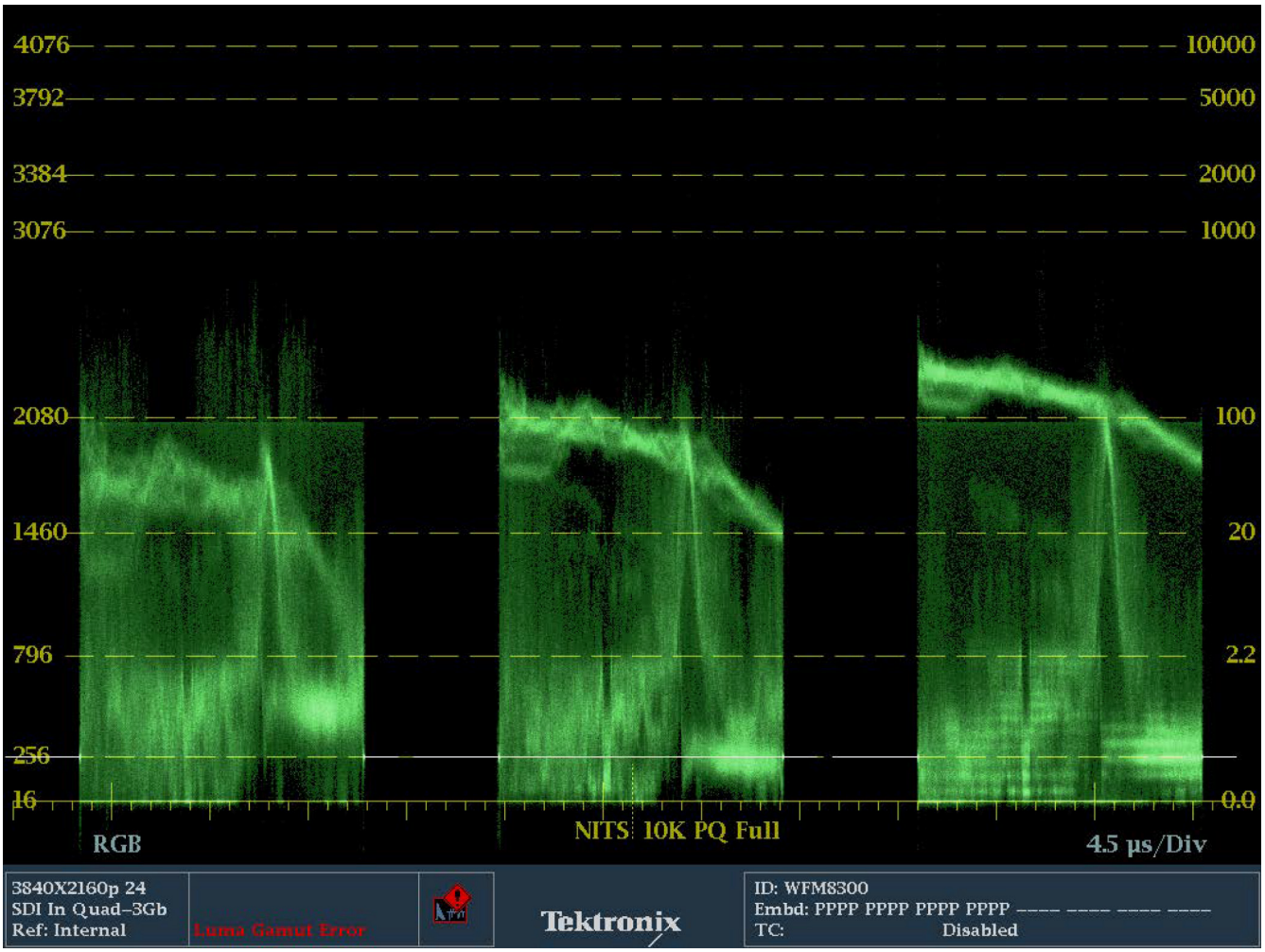

FIGURE B4. SMPTE ST2084(10K) with graticule scale in terms of 12-bit values.

In Figure B4 an HDR waveform display is shown using 12-bit full range video with video levels starting at 4 decimal rather than the traditional 64d. Using a HDR Full Dynamic Range mode with ST2084 10K PQ means that 100 Nits is equivalent to 2080d on the scale on the left hand side of the graticule.

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