



Monitoring & Measurement Challenges in The Digital Television Transition

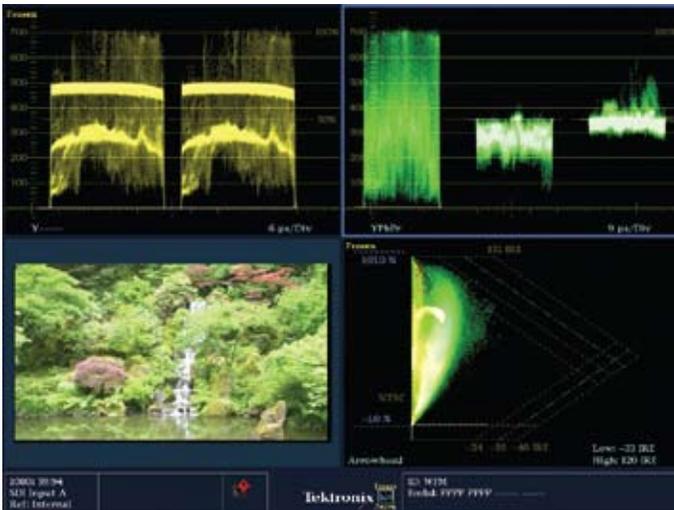
Technical Brief

With the transition from analog to digital and from standard definition (SD) to high definition (HD), there are a variety of technical challenges which need to be addressed within a facility in order to ensure correct processing of the signal from ingest to broadcast output. Some of these challenges are the direct result of new technology deployments. Other challenges are the result of the need to manage vast amounts of data and support new workflows which have been enabled as a result of technological transitions.

The highest priority for any operations or engineering group is to ensure continuous audio and video feeds that meet or exceed quality expectations. This technical brief discusses a variety of measurement and monitoring challenges and the Tektronix solutions that assist in the successful transition, while enabling increased operational efficiency for both engineering and operations teams.

At-a-glance benefits provided by Tektronix solutions

See & Solve™



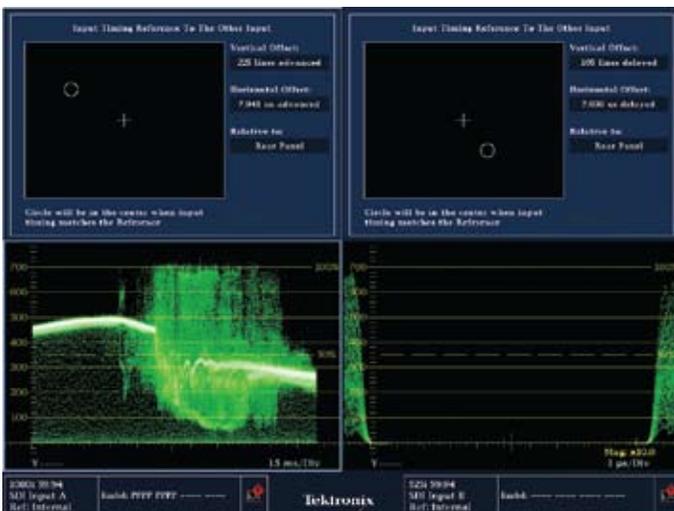
CaptureVu™

Do more than just “freeze” the display. CaptureVu stores a complete video frame of data. This data can be viewed with another waveform display and can easily be stored on a USB memory stick.



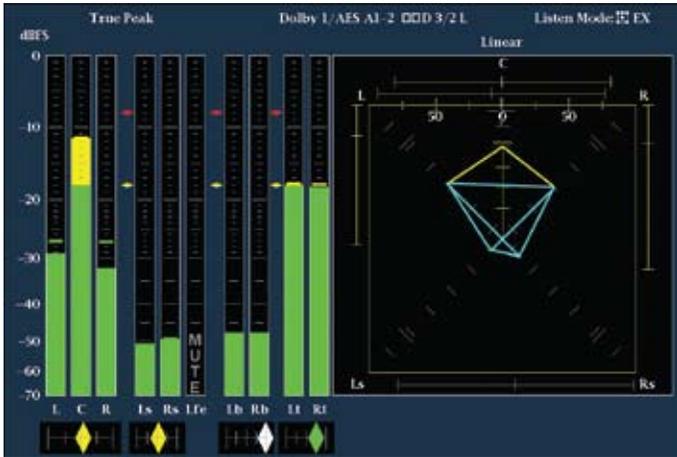
Physical Layer Measurements

The SDI Status Display provides a summary of jitter and cable length measurements which clearly indicate the characteristics of the signal.



Timing Display

The Tektronix patented Timing Display provides a clear indication of the timing relationship between the input signal and the external reference, or between simultaneous SDI input signals (SDI to SDI).



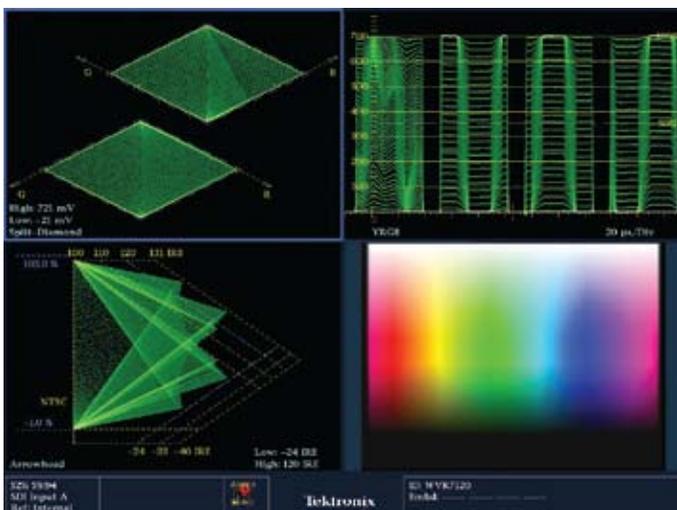
Surround Sound Display

An intuitive representation of total volume, dominant sound, phantom source and phase indicators, enabling you to visualize the interaction of the audio channels and efficiently make adjustments.



Audio Video Delay Measurement

Solve your audio and video delay problems and ensure complete system integrity throughout your facility by using the Tektronix out of service AV Delay measurement.



Diamond, Arrowhead and Lightning Displays

Tektronix patented Diamond and Arrowhead displays provide an easy way to keep the signal within the Gamut limits, allowing operators to make signal adjustments as needed.

Video & Audio Content Quality Assurance

The highest priority for any operations or engineering group is to ensure continuous audio and video feeds, while meeting or exceeding quality threshold expectations.

With today's increasingly complex standards, this task has grown significantly more complex. In the past, content sources for any given facility were relatively few: local studios, live feeds from events or partner network sources, and a few tape or archive formats. Today, source formats and feeds have increased dramatically in quantity and type. Content from local SAN archives, mobile videophones, studios, computers, ENG trucks and tape ingest must flow together in a way that appears nearly seamless to the viewer. Furthermore, the final content may need to be simultaneously formatted to transmit to a variety of different paths—SD, HD and even streamed file for IP or mobile phone distribution.

Tektronix has a host of new tools in the latest generation of waveform monitors and rasterizers to help manage this complexity. By using the built-in error log, the user can complete a thorough check of ingest material without having to manually QC the entire piece. Audio and video characteristics can be set to match the quality limits, and the instrument will automatically provide a complete list of possible problems, referenced to time or timecode (see Figure 1).

Error Status	Timecode	Date	Time
Black Detect Events	000000000.00	05-Mar-09	132538
Frozen Frame Events	000000000.00	05-Mar-09	132538
Audio Silence (1 - 30)	000000000.00	05-Mar-09	132539
Video Format Error (1)	000000000.00	05-Mar-09	132539
Audio Mute (1 - 30)	000000000.00	05-Mar-09	132539
Video Format Error	000000000.00	05-Mar-09	132539
Video Format Error (1)	000000000.00	05-Mar-09	132539
Video Format Error	000000000.00	05-Mar-09	132539
Video Format Error (1)	000000000.00	05-Mar-09	132539
Video Format Error	000000000.00	05-Mar-09	132539
Audio Silence (2 - 30)	000000000.00	05-Mar-09	132539
Audio Mute	000000000.00	05-Mar-09	132539
Video Format Error (1)	000000000.00	05-Mar-09	132539
Video Format Error	000000000.00	05-Mar-09	132539
Audio Mute (1 - 30)	000000000.00	05-Mar-09	132539
Audio Mute (2 - 30)	000000000.00	05-Mar-09	132539
Audio Mute (3 - 30)	000000000.00	05-Mar-09	132539
Audio Mute (4 - 30)	000000000.00	05-Mar-09	132539
Audio Mute (5 - 30)	000000000.00	05-Mar-09	132539
Audio Mute (6 - 30)	000000000.00	05-Mar-09	132539
Audio Mute (7 - 30)	000000000.00	05-Mar-09	132539
Audio Mute (8 - 30)	000000000.00	05-Mar-09	132539
Audio Mute (9 - 30)	000000000.00	05-Mar-09	132539
Audio Mute (10 - 30)	000000000.00	05-Mar-09	132539
Audio Mute (11 - 30)	000000000.00	05-Mar-09	132539
Audio Mute (12 - 30)	000000000.00	05-Mar-09	132539

Figure 1. Error Status Log showing errors related to timecode.

Tektronix waveform monitors help operations staff more thoroughly and efficiently verify video and audio quality through industry-leading content monitoring capabilities. This level of monitoring lowers the chance of undetected problems and reduces time spent checking content at ingest or play out. Features include extensive fault detection and alarm generation, in-depth status reporting, video and audio quality statistics, and sophisticated event logging such as that shown in Figure 1.

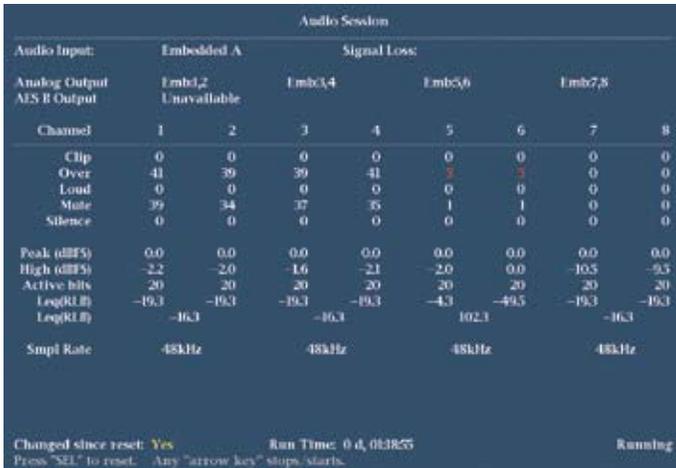


Figure 2. Audio Session Display.

Audio and video session displays provide detailed, real-time statistics on the audio and video content in your monitoring system. These tools help a user quickly isolate and solve any issue that will impact perceived quality. Comprehensive audio information including clips, mutes, over and silence conditions are summarized by individual audio channel (see Figure 2). Likewise, the video session display helps the user isolate where in the system the problem is located by tracking video presence and format, luma and gamut errors, and CRC statistics (see Figure 3).



Figure 3. Video Session Display.

The variety of formats and sources in a facility lead to increasing numbers of issues where equipment may receive a type of content not expected. This type of format incompatibility can lead to frozen or black frame conditions clearly not suitable for “air time.” These conditions or quality issues need to be resolved immediately. Unfortunately, some monitoring systems may miss these types of problems because the underlying signal is legal and passes other manufacturers’ monitoring tools. The latest Tektronix waveform monitors include built-in alarming for these common conditions, helping to quickly identify when a signal must be switched to back-up or a piece of equipment reset.

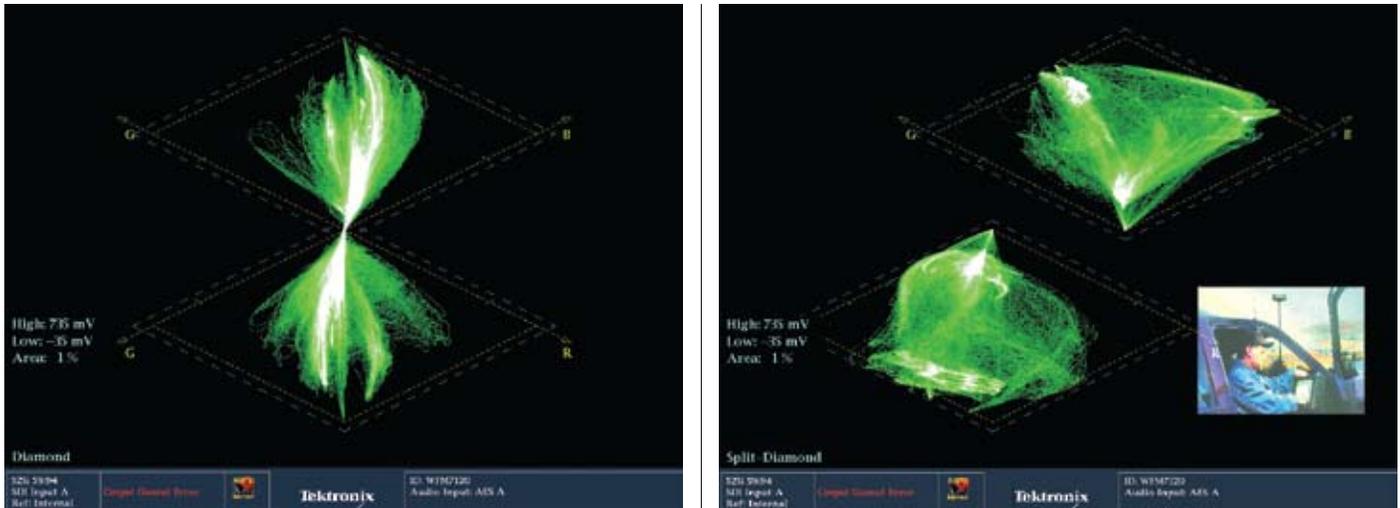


Figure 4. Diamond and Split Diamond Displays.

Gamut Monitoring

Whether the content starts out as film or video the intent is to create an artistic impression using both the visual and audio medium. Color plays a significant role in this artistic process. Color helps to create mood, focus attention, and as every colorist knows, create a sense of continuity from one scene to another. Control over the color content begins at the camera, and extends right through the post production phase. Once the delivery medium is received, whether for a television transmission or a movie theater, it is assumed the color is correct. At this point in the process, any gamut errors that exceed the maximum allowable limits will most likely be clipped, negatively impacting all the artistic effort that went into the content. Most colorist and post production people would agree they would rather spend their time maximizing the artistic content than correcting out-of-gamut problems. With so much original content being re-purposed today, it is critical to take this into account during the content creation and post-production phases.

The goal is to keep the signal Legal and Valid:

- The colors used in a video signal fall within the acceptable legal range of colors allowed
- A Signal legally stays within gamut compliance for the format in use
- A Valid signal meets two constraints: It is legal in the current format, and will remain legal when properly translated to any other color format

Tektronix waveform monitors help customers detect and prevent errors in content production and post-production through specialized displays and features. These features help to consistently “get the content right the first time.” This helps avoid costly rework or customer complaints that impact future projects. These capabilities include our Picture displays with bright-up, waveform and vector displays, video session displays, 10,000-event error logging, plus our proprietary Diamond, Split Diamond (see Figure 4) and Arrowhead displays for verifying gamut compliance.

The organization of the Diamond display shown in Figure 4 allows for easy and visual isolation of the component (or components) that is causing the gamut error, as well as which characteristic of the component is at fault.

Take a look at the screen shot in Figure 5 on the following page. Even though the YPbPr input signal shown in the upper left tile is legal it will produce an out-of-gamut condition when converted to composite analog. The bright-up display in the bottom left tile makes it easy to see which portions of the picture are out of Gamut. The Arrowhead display shows the extent to which the signals exceed the current thresholds set by the user. Notice however, that if this signal were converted to RGB as shown in the upper right tile, it would still be perfectly legal. FlexVu™ lets you customize your display to see a variety of these effects simultaneously. The ability to work in one format, but see the results that would take place if the format were converted, can help prevent otherwise unanticipated problems and rework costs.

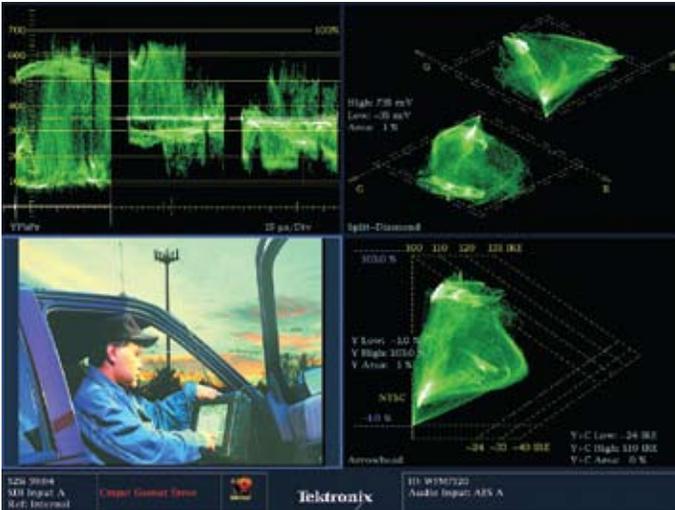


Figure 5. FlexVu™ showing YPbPr waveform, Split-Diamond, Picture & Arrowhead displays.

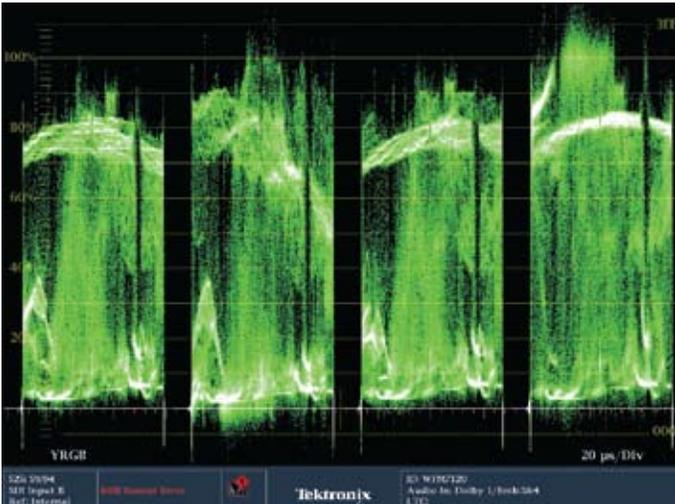
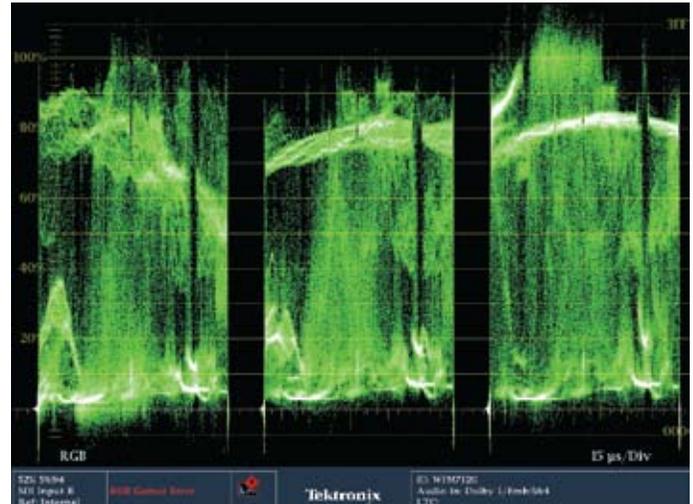


Figure 6. YRGB and RGB waveform displays.

If you're working in Post Production you may prefer the YRGB or the RGB displays shown in Figure 6 simply due to the familiar nature of working with this mode in non-linear editing systems.

With the capability of logging up to 10,000 error events, the error log can dramatically speed up the process of analyzing content for gamut errors and make it easier to locate and correct those errors. Customizable thresholds let the user



apply subjective analysis for how bad the errors have to be before triggering an error logging event. The capability to customize settings prevents wasted time by only logging pre-determined critical errors.

The ability to capture and off load error logs is ideal for record keeping and also provides a concise before and after view, enabling a quick view of the results for any error corrections performed.

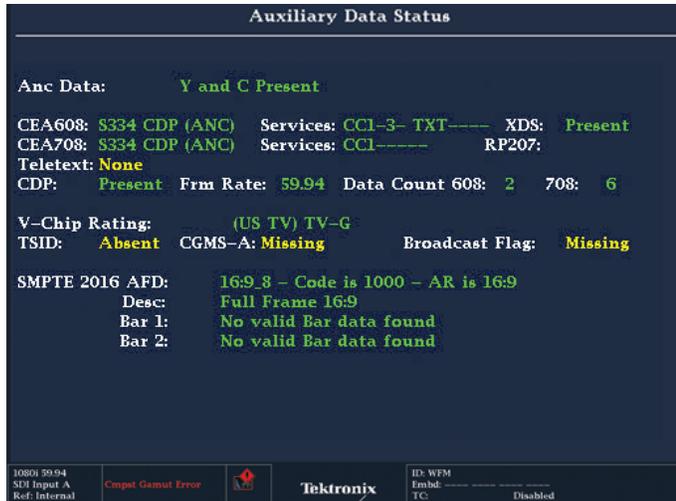


Figure 7. Auxiliary Data Status showing AFD information.



Figure 8. Picture display showing Active Format Descriptor information.

Ancillary Data & Metadata

SDI signals can accommodate a wide variety of customer and industry standard metadata. This metadata can carry information about the audio and video signal parameters, as well as content-specific items such as closed-captioning or teletext. Different kinds of operational equipment use this data to configure how the audio and video is processed. The rapid growth in the number of valid formats (worldwide)—spanning SD and HD video, AES embedded or Dolby audio—means there can be a large number of combinations of data. As a result, validating that the data is present in a signal can be an important but time-consuming challenge.

Tektronix waveform monitors provide a number of unique tools to help the user understand the data within a signal, and to quickly troubleshoot when a data problem is impacting service. Specifically, the auxiliary data status display provides a summary of the key data information within a signal. This allows the user to very easily check for information on broadcast flag, timecode, Teletext, closed-captioning, WSS, video index and aspect ratio AFD (Active Format Description) per SMPTE 2016 (see Figure 7).

The user often finds it much easier to “see” the results of some of these data settings instead of viewing status information. Therefore, a variety of data services are implemented in the picture monitoring screen of the rasterizer or waveform monitor. For example, Teletext or closed-captioning can be viewed within the video picture, making presence and verification of the subtitling information easier. Additionally, both 608 and 708 closed captions can be viewed at the same time within different picture displays, helping to quickly ensure compliance on transmitted content. AFD results from the embedded data can also be viewed directly on the picture display of the waveform monitor or rasterizer (see Figure 8).

The screenshot shows the ANC Data Inspector interface. At the top, there is a table with the following columns: Name, DID/SDID, Presence, Status, and Location. The table lists several data services, all with a 'Present' status and 'OK' error.

Name	DID/SDID	Presence	Status	Location
S299M Cbl Grp 2	E2--	Present	OK	Field 2 / Line 8
S299M Cbl Grp 1	E3--	Present	OK	Field 2 / Line 8
S299M Aud Grp 2	E6--	Present	OK	Field 2 / Line 61
S299M Aud Grp 1	E7--	Present	OK	Field 2 / Line 61
S12142 ATC	6960	Present	OK	Field 1 / Line 10

Below the table, there is a 'Detail' section for the selected 'S299M Cbl Grp 2' packet. It shows the following information:

- Format: SMPTE 299M Audio Cbl Group 2
- DID: 62 (2a2) Type: 1 Field: 1 Line: 3 Presence: Present
- DSN: 0 (200) DC: 11 (10b) Link: - Stream: Y
- Exp/Act Chksum: 201 / 201 Error: OK

At the bottom of the detail section, there is a hex dump of the packet data:

```

000 | 205 200 201 200 200 200 200 200 200 200
016 |
032 |

```

The interface also includes a 'View Mode: Watch List' and 'Time Elapsed Since Last Reset: 0 d, 06:03:01'.

Figure 9. ANC Data Inspector showing present ancillary data packets within the signal.

Often, the data services present in a facility are standardized. Tektronix's Ancillary Data Inspector makes verification a simple process. The ANC Data Inspector automatically scans the data locations within the SDI signal and provides a tabular summary of the present data services, the identifier codes and the locations within the signal (see Figure 9). The full list of data services is an ideal troubleshooting tool to help identify any data values that may be changing the behavior of equipment in the signal path. For operational monitoring, a watch list of expected data services can be customized which the waveform monitor will automatically provide a summary of the status for the custom list of signals.

Given the complexity of the variety of data services, a user may occasionally need to examine raw data values to isolate problems with equipment settings. The datalist display allows the user to look at specific words and verify values. The CaptureVu™ abilities of the WFM6120 and WFM7120 waveform monitors enable any engineer or operator to save a complete frame of video (active video and data values). This allows for review of the content later on another instrument, or even download to a PC to search the data for suspected problems.

Audio Monitoring Analog, Digital & Dolby

To enhance the viewing experience of digital television, more and more broadcasters are distributing and broadcasting multi-channel audio to provide home theater experience to viewers. 5.1 multi-channel audio has thus replaced stereo as the audio format of choice for digital television. The left (L), right (R), center (C), left surround (Ls) and right surround (Rs) channels form the “5” part of the 5.1 multi-channel audio. They create the overall surround sound experience and handle both the dialog, as well as many special effects. The Low Frequency Effects (Lfe) channel provides additional bass sounds especially for surround sound systems with small satellite speakers. This Lfe channel is the “.1” channel of the 5.1 multi-channel audio.

To monitor the 5.1 multi-channel audio, the Surround Sound Display (a visual representation of the sound stage) helps operators identify problems more quickly and helps engineers isolate problems effectively. This display associates an audio level with each of the five primary channels in the 5.1 audio system by determining the channel’s RMS signal level. It can compute an un-weighted RMS value or can apply a filter such as the A-weighting filter or the RLB-weighting filter (as defined in ITU-R BS.1770) that produces a frequency-weighted RMS value. These filters adjust for the frequency response of the human auditory system and yield an audio value that better approximates the perceived loudness of the audio signal. Continuous monitoring of audio loudness is important since sound level variations between programs and/or commercials can lead to viewer frustration caused by having to continuously adjust the volume to maintain a suitable loudness level.

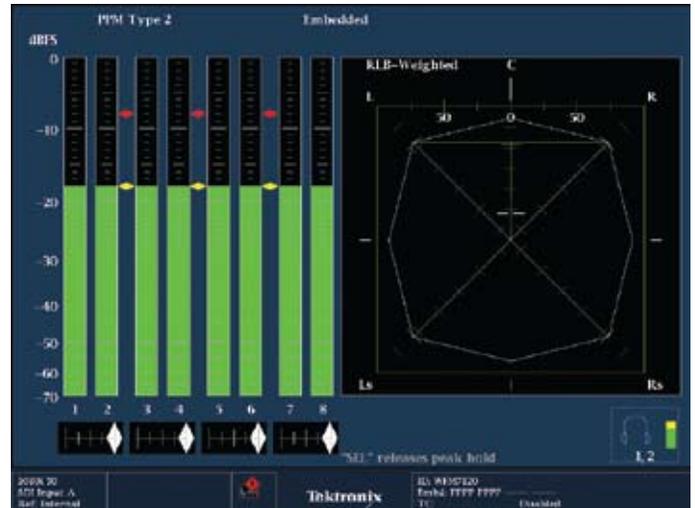


Figure 10. Audio Display with Surround Sound monitoring. Audio Surround Sound Display licensed from RadioTechnische Werksstätten GmbH and Co. KG (RTW).

In the Surround Sound Display, the ends of the audio level indicators are connected to form a polygon called the Total Volume Indicator (TVI). The TVI indicates the level balance among the main and surround channels and gives an indication of the total surround sound balance. As the size of the polygon gets larger, the audio volume gets higher. The TVI also indicates the amount of correlation between signals in adjacent channels. A positive correlation between adjacent channels increases the overall audio volume while a negative correlation between adjacent channels decreases the overall audio volume (see Figure 10).

Audio Session								
Audio Input:	Embedded A		Signal Loss					
Analog Output	Embe1,2		Embe3,4		Embe5,6		Embe7,8	
AES II Output	Unavailable							
Channel	1	2	3	4	5	6	7	8
Clip	0	0	0	0	0	0	0	0
Over	41	39	39	41	5	5	0	0
Loud	0	0	0	0	0	0	0	0
Mute	39	34	37	35	1	1	0	0
Silence	0	0	0	0	0	0	0	0
Peak (dBFS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
High (dBFS)	-2.2	-2.0	-1.6	-2.1	-2.0	0.0	-10.5	-9.5
Active bits	20	20	20	20	20	20	20	20
Leq(RL)	19.3	-19.3	19.3	-19.3	-4.3	-49.5	-19.3	-19.3
Leq(RL)	-16.3		-16.3		102.3		-16.3	
Smpl Rate	48kHz		48kHz		48kHz		48kHz	

Changed since reset: Yes Run Time: 0 d, 01:38:55 Running
Press "SEL" to reset. Any "arrow key" stops, starts.

Figure 2. Audio Session Display.

Besides monitoring audio loudness, it is also important to monitor audio clips, over, mute and silence, as well as maximum peak and high audio levels for each of the 5.1 audio channels. This ensures audio content integrity of the broadcast signal (see previous Figure 2 shown above).

In order to distribute and broadcast multi-channel audio within the defined bandwidth, compression of these audio channels is needed. Dolby E is the multi-channel audio compression format for production, post production and distribution, while Dolby D (commonly known as AC-3) is the multi-channel audio compression format for broadcast delivery to household viewers.

Both Dolby D and Dolby E use audio metadata to deliver audio stream information together with the audio signals to the decoders. For Dolby E, audio metadata can also be delivered as a VANC (vertical ancillary data) packet as per SMPTE 2020. There are a number of key Dolby metadata parameters (see Figure 11) that need to be monitored. The three most important parameters are Dialog Normalization (Dialnorm), Dynamic Range and Downmix.

Dolby Audio Status		Program: 1
Program Desc Text:	Prog 1	
Dolby Format:	Dolby E 20-bit	Dolby Surround Mode: N/A
Channel Mode:	2/1 1/2 L	Copyright Bit: Yes
Program Config:	31	Original Bitstream: Yes
Metadata Source:	Embedded 3-4	DC Filter: Yes
Dolby Data Rate:	Not Specified	Lowpass Filter: Yes
Bitstream Mode:	Complete Main	LFE Lowpass Filter: Yes
Dolby E Frame Rate:	25 fps	Surround J48 Attenu: Yes
Dolby E Frame Loc:	Line 22 (L 4072)	Surround Phase Shift: Yes
Dynamic Range Parameters		
Dialog Level:	-27 dB	Extended BS: N/A
Program Loudness:	-14.70 dBFS	Preferred Stereo Downmix: L/R
Average Loudness:	-12.88 dBFS	L/R Center Mix Lvl: -3 dB
Line Mode Compr:	Film STD	L/R Surround Mix Lvl: -3 dB
RE Mode Compr:	Film STD	Lc/Rc Center Mix Lvl: -3 dB
		Lc/Rc Surround Mix Lvl: -3 dB
RE Overmod Prot:	Disabled	Surround EX Mode: N/A
Center Mix Lvl:	-3 dB	Headphone Mode: N/A
Surround Mix Lvl:	-3 dB	A/D Converter Type: STD
Mixing Level:	N/A	SMPTE Timescode: 03:35:00.00
Room Type:	N/A	

2020.30 5.1 Input: A Ref: Internal Tektronix 03:35:00 Audio In: Dolby 1, 2, 3, 4, 5, 6, 7, 8 Disabled

Figure 11. Dolby E Metadata display.

Dialnorm provides Dolby audio decoders with information that allows uniform reproduction of dialog level. Dynamic Range provides information that allows decoders to limit the level of loud sounds and bring up the level of quiet sounds under different listening environment of the viewers. An example of this would be where there is higher background noise in the environment during day time and lower background noise in the environment during night time. Downmix provides decoders with information necessary to combine 5.1 Dolby surround sound audio into a stereo audio pair called Dolby Surround Downmix.

For production and post production applications, it is important to make sure that Dolby E audio data packets are appropriately aligned with the video frames. If any part of the Dolby E audio data packet is within the switching point interval of the video signal (known as Dolby guard band), the associated Dolby E audio signal may be corrupted during editing or during the video source switching process.

The Dolby guard band measurement provides the line position of the Dolby E frame so operators and engineers can easily identify whether there are any Dolby E frames situated within the switching point interval (see Figure 11).



Figure 12. Simultaneous SD/HD Inputs using FlexVu™ display.

Multicast Transmission SD & HD

Having only one waveform monitor in your monitoring facility doesn't mean you are limited to viewing only one signal at a time. The Tektronix Simultaneous Input Option (SIM) lets you look at two different inputs or the same content in two different formats at the same time, as shown in Figure 12. For example the ability to look at both the input and output of a format encoder will quickly let you know if the encoder is doing anything to the signal other than changing the format. Concerns over whether logos are being cut off, or if the safe title and safe action areas are being preserved are answered quickly. Now you can see these things simultaneously and document the results which make communicating with content providers or device manufacturers easier than ever.

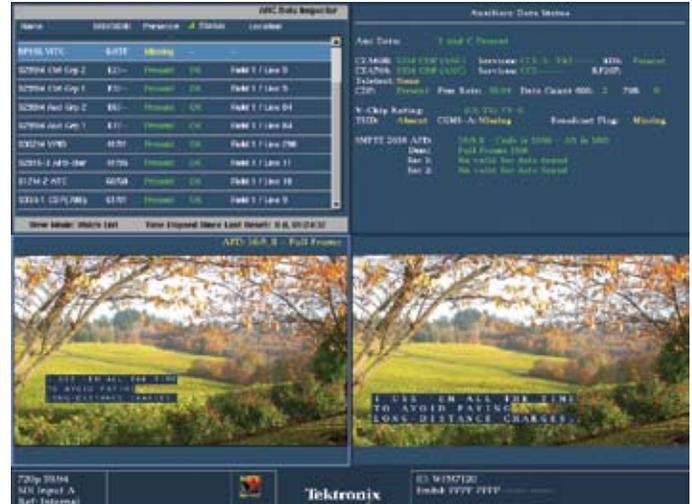


Figure 13. Simultaneous decode of 608 and 708 captions.

Option SIM provides the ability to simultaneously view:

- Pictures
- Trace Displays such as waveform, vector and gamut
- Status and Alarm Displays
- Error Logging each with its own time stamp
- Timing Displays
- Audio
- ANC Data Using Tektronix's proprietary ANC Data Inspector

In Figure 13 we can see both the CEA708 in the tile (bottom left) and the CEA608 closed captioning in the tile (bottom right). This could easily be the same content with the closed caption in one display being the primary language, while the second display shows the closed captioning in the secondary language.

Physical Layer

Today's broadcast facility is a hybrid of analog, SD digital and HD digital distribution. This poses a variety of challenges to the engineer on how to prevent contamination between these various formats and ensure patch panels, cable types and termination are appropriate for each type of format. The frequency response of an analog 75 ohm termination is not suitable for use with a 1.5 Gb/s high definition data signal and an engineer may mistakenly grab this analog termination and use it for an HD signal. This can lead to degradation of the signal's performance and cause contamination of the signal path. While a single analog termination may not cause a problem in the system, multiple instances of these types of contaminations can cause the integrity of the physical layer to degrade, resulting in degradation in the health of the system. This can lead to the signal falling off the "digital cliff" and producing signal loss or a frozen image depending on the processing device.

To prevent problems affecting the physical layer a variety of tools can be used to monitor the health of the serial digital interface (SDI). In HD a simple CRC (Cyclic Redundancy Code) is added to each line for the luma and chroma signal. CRC values are used to detect errors in the digital active line with a calculation that sums the active data word from the start of the first active line word to the end of the active line. This value is embedded at the end of the EAV (End of Active Video) and is carried throughout the transmission path of the signal. At the receiver end, the CRC value is extracted from the data and compared to a newly computed CRC value. If the values are identical then it is assumed there were no errors during transmission of the signal. If the two CRC values are different, it is likely an error occurred during the transmission and must be addressed.



Figure 17. FlexVu™ Physical Layer measurements.

The waveform monitor can show the number of CRC errors which occur during the session on the Video Session display (see Figure 3). An error that occurs infrequently (once or twice a day) will not be identified as a significant error to the system. If the frequency of these errors increases to one a minute or one a second, then this is an indication of a potential problem with the health of the physical layer and further investigation of the transmission path is required.

The EYE and jitter display of the WFM7120 are ideal tools to help visualize the health of the physical layer. The eye display can be used to determine how open the SDI signal is and can use the findings to recognize typical phenomenon that could be impairing the receiver's inability to recover the clock and data from the signal. The waveform monitor allows the engineer to enable infinite persistence to assist in visualizing the EYE opening. A jitter thermometer can gauge the amount of variation in the transition of data from the ideal position. If there is significant jitter present in the signal, the PHY option of the WFM7120 and WVR series allows the engineer to view the jitter waveform of the physical layer related to video line and field rates. A variety of bandpass filters are available to help isolate the various frequencies of jitter present, typically related to the line and field rate of the video signal. The standard specification refers to two specific jitter filters, Timing Jitter (bandpass starting at 10Hz) and Alignment jitter (bandpass starting at 1kHz for SD and 100kHz for HD).

Within the waveform monitor it is possible to measure both Timing and Alignment jitter simultaneously to help better characterize the jitter present within the signal (see Figure 17). Normally jitter between 10Hz to the start of the alignment bandpass frequency would be tracked by the phase lock loop of the receiver. If high jitter values are present within the alignment jitter measurement then the phase lock loop may have more problems in tracking the signal, resulting in clock or data errors. These errors mean the receiver will be unable to recover the signal and the signal will fall over the "digital cliff." The PHY option also includes the ability to make automatic, repeatable eye amplitude, overshoot/undershoot, rise/fall time, jitter, estimated cable length and source amplitude. These are summarized in the SDI Status display as shown in Figure 17. With these tools the engineer can help diagnose potential physical layer problems before the signal falls off the "digital cliff" and causes the loss of the signal and failure in the system.

To learn more about other Tektronix products referenced in this document, please visit:

WFM6000/7000 Series

www.tektronix.com/wfm7000

TG700

www.tektronix.com/tg700

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- Norway** 800 16098
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- Portugal** 80 08 12370
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For Further Information

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