WFM8200 and WFM8300
Waveform Monitors
Specifications and Performance Verification

Technical Reference

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Technical Reference

This document applies to firmware version 1.0.X.

Warning

The servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing unless you are qualified to do so. Refer to all safety summaries prior to performing service.

www.tektronix.com

077-0259-02

Tektronix

Contacting Tektronix

Tektronix, Inc.
14150 SW Karl Braun Drive
P.O. Box 500
Beaverton, OR 97077
USA

For product information, sales, service, and technical support:
- In North America, call 1-800-833-9200.
- Worldwide, visit www.tektronix.com to find contacts in your area.

Warranty

Tektronix warrants that this product will be free from defects in materials and workmanship for a period of one (1) year from the date of shipment. If any such product proves defective during this warranty period, Tektronix, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product. Parts, modules and replacement products used by Tektronix for warranty work may be new or reconditioned to like new performance. All replaced parts, modules and products become the property of Tektronix.

In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, with shipping charges prepaid. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Tektronix shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Tektronix representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; c) to repair any damage or malfunction caused by the use of non-Tektronix supplies; or d) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

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General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

To Avoid Fire or Personal Injury

Use proper power cord. Use only the power cord specified for this product and certified for the country of use.

Ground the product. This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

Observe all terminal ratings. To avoid fire or shock hazard, observe all ratings and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Power disconnect. The power cord disconnects the product from the power source. Do not block the power cord; it must remain accessible to the user at all times.

Do not operate without covers. Do not operate this product with covers or panels removed.

Do not operate with suspected failures. If you suspect that there is damage to this product, have it inspected by qualified service personnel.

Avoid exposed circuitry. Do not touch exposed connections and components when power is present.

Replace batteries properly. Replace batteries only with the specified type and rating.

Recharge batteries properly. Recharge batteries for the recommended charge cycle only.

Use proper AC adapter. Use only the AC adapter specified for this product.

Use proper fuse. Use only the fuse type and rating specified for this product.

Do not operate in wet/damp conditions.

Do not operate in an explosive atmosphere.

Keep product surfaces clean and dry.

Provide proper ventilation. Refer to the manual's installation instructions for details on installing the product so it has proper ventilation.

Terms in This Manual   These terms may appear in this manual:

⚠ *WARNING. Warning statements identify conditions or practices that could result in injury or loss of life.*

⚠ *CAUTION. Caution statements identify conditions or practices that could result in damage to this product or other property.*

Symbols and Terms on the Product   These terms may appear on the product:

■ DANGER indicates an injury hazard immediately accessible as you read the marking.

■ WARNING indicates an injury hazard not immediately accessible as you read the marking.

■ CAUTION indicates a hazard to property including the product.

The following symbol(s) may appear on the product:

⚠   ⏚
CAUTION   Protective Ground
Refer to Manual   (Earth) Terminal

Environmental Considerations

This section provides information about the environmental impact of the product.

Product End-of-Life Handling

Observe the following guidelines when recycling an instrument or component:

Equipment Recycling. Production of this equipment required the extraction and use of natural resources. The equipment may contain substances that could be harmful to the environment or human health if improperly handled at the product's end of life. In order to avoid release of such substances into the environment and to reduce the use of natural resources, we encourage you to recycle this product in an appropriate system that will ensure that most of the materials are reused or recycled appropriately.

This symbol indicates that this product complies with the European Union's requirements according to Directive 2002/96/EC on waste electrical and electronic equipment (WEEE). For information about recycling options, check the Support/Service section of the Tektronix Web site (www.tektronix.com).

Battery Recycling. This product may contain a Nickel Cadmium (NiCd) or lithium ion (Li-ion) rechargeable battery, which must be recycled or disposed of properly. Please properly dispose of or recycle the battery according to local government regulations.

Mercury Notification. This product uses an LCD backlight lamp that contains mercury. Disposal may be regulated due to environmental considerations. Please contact your local authorities or, within the United States, the Electronics Industries Alliance (www.eiae.org) for disposal or recycling information.

Restriction of Hazardous Substances

This product has been classified as Monitoring and Control equipment, and is outside the scope of the 2002/95/EC RoHS Directive. This product is known to contain lead, cadmium, mercury, and hexavalent chromium.

Preface

This reference document provides technical information about using the WFM8200 and WFM8300 Series multi-format waveform monitors.

Related User Documents

The following related user documents are available:

- *WFM8200 and WFM8300 Waveform Monitors Safety and Installation Instructions* (Tektronix part number 071-2639-XX). This multi-lingual document provides safety and compliance information along with hardware installation instructions to present the associated safety warnings.

- *WFM8200 and WFM8300 Waveform Monitors User Manual* (Tektronix part number: 077-0253-XX). This document provides detailed operating information for the instrument.

- *WFM8200 and WFM8300 Waveform Monitors Declassification and Security Instructions* (Tektronix part number 077-0262-XX). This document provides instructions clear or sanitize the memory devices and disable the data output devices.

- *WFM8200 and WFM8300 Waveform Monitors Release Notes* (Tektronix part number 077-0264-XX).

- *WFM8200 and WFM8300 Waveform Monitors Service Manual* (Tektronix part number 077-0393-XX). This document provides servicing information for the waveform monitor and is intended for qualified service personnel only.

- *WFM8200 and WFM8300 Waveform Monitors Rackmount Kit Instructions* (Tektronix part number 071-2773-XX).

- *WFM8200 and WFM8300 Waveform Monitors System Integration Instructions* (Tektronix part number 077-0391-XX). This document provides information about installing the instrument into a system.

- *WFM and WVR Series Management Information Database (MIB) Programmer Manual* (Tektronix part number 077-0261-XX). This document provides SNMP command reference for remotely controlling the instrument.

Related Reference Documents

The following related reference documents are available at the Tektronix, Inc. Web site (www.tektronix.com):

- *Preventing Illegal Colors*. This application note describes how the Diamond, Arrowhead, and Lightning displays can be used to help prevent the undesired impact of color gamut violations and to simplify the assessment of proper gamut compliance.

- *Understanding Colors and Gamut*. This poster provides a large visual display of how the Diamond, Arrowhead, and Lightning displays can be used to help prevent the undesired impact of color gamut violations.

- *A Guide to Standard and High Definition Digital Video Measurements*. This book is a primer for understanding the basics for making standard and high-definition, digital-video measurements.

- *Analog and Digital Audio Monitoring*. This application note describes how to monitor analog and digital audio signals. Also discussed are specific differences in the methods used to monitor analog audio versus digital audio, and how to plan the transition from monitoring analog audio to monitoring digital audio.

- *Audio Monitoring*. This application note describes balanced and unbalanced audio signals, and explains the physical and electrical characteristics and the specific strength and weaknesses of the different digital audio signal formats.

- *Monitoring Surround Sound Audio*. This application note describes the basics of 5.1-channel surround sound audio and how to use the Surround Sound display to visualize key audio-level and phase relationships in this audio format.

Specifications

The following tables list the specifications for the Tektronix WFM8200 and WFM8300 Waveform Monitors. Items listed in the Performance Requirement column are generally quantitative and can be tested by the *Performance Verification* procedure in Section 2 of this manual. Items listed in the Reference Information column are useful operating parameters that have typical values; information in this column is not guaranteed.

The specifications listed in the Electrical Specifications portion of these tables apply over an ambient temperature range of +0 °C to +40 °C. The rated accuracies are valid when the instrument is calibrated in an ambient temperature range of +20 °C to +30 °C.

Electrical Specifications

Table 1: SDI input waveform vertical characteristics

Characteristic		Performance requirement	Reference information
Vertical Measurement Accuracy			Using graticule or cursor. Measure in YPbPr mode.
	1X	± 0.5% of 700 mV full scale mode	
	5X	± 0.2% of 700 mV full scale mode	
Gain		X1, X2, X5, and X10	
Variable Gain Range, Typical			0.25X to 2X, typical (variable gain multiplied by fixed gain to get total gain).
Frequency Response - HD	Luminance Channel (Y)	50 kHz to 30 MHz, ± 0.5%	50 kHz to 60 MHz for 1080P 60/59.94/50 formats (148.5 MHz interface sampling frequency).
	Chrominance Channels (Pb, Pr)	50 kHz to 15 MHz, ± 0.5%	50 kHz to 30 MHz for 1080P 60/59.94/50 formats (148.5 MHz interface sampling frequency).
Frequency Response - SD	Luminance Channel (Y)	50 kHz to 5.75 MHz, ± 0.5%	
	Chrominance Channels (Pb, Pr)	50 kHz to 2.75 MHz, ± 0.5%	
YPbPr to RGB Conversion Accuracy			0.1%, nominal

Table 1: SDI input waveform vertical characteristics (cont.)

Characteristic		Performance requirement	Reference information
Step Response, Typical			Sine-squared bars
	Preshoot		
	SD		≤ 0.3% peak (2T5 bar)
	HD		≤ 0.5% peak (2T30 bar)
			(2T60 bar for 148.5 MHz 1080p formats.)
	Overshoot		
	SD		≤ 0.3% peak (2T5 bar)
	HD		≤ 0.5% peak (2T30 bar)
			(2T60 bar for 148.5 MHz 1080p formats.)
	Ringing		
	SD		≤ 0.8% peak-peak (2T5 bar)
	HD		≤ 0.8% peak-peak (2T30 bar)
			(2T60 pulse for 148.5 MHz 1080p formats.)
			Most of the error seen on the display comes from the inherent ringing in the digital data. The response of the monitor is close to the theoretical limit of a perfect sinx/x reconstruction filter.
Pulse Response, Typical			Blackman pulse
	Baseline Ringing		
	SD		≤ 0.6% peak-peak (2T5)
	HD		≤ 0.7% peak-peak (2T30)
			(2T60 pulse for 148.5 MHz 1080p formats.)
			Pulse-to-bar ratio 0.995:1 to 1.005:1 on appropriate Sine Squared or Blackman 2T pulse.
			A sine-squared pulse near Nyquist is not band-limited and so inherently has ringing much larger than the waveform monitor filter. A three term Blackman pulse with the same HAD has much less inherent ringing, so it is a better choice for most testing. See *Digital to Analog Conversion, Data and Filter Requirements*, SMPTE Journal Mar 1995, Vol. 104, Fibush, Baker, Penny.
Tilt	Field Rate	0.1%	
	Line Rate	0.1%	
Off Screen Recovery		0.1% variation in baseline of a 5 MHz modulated pulse when positioned anywhere on screen at any gain setting.	

Table 2: Composite analog input waveform vertical characteristics

Characteristic		Performance requirement	Reference information
Vertical Measurement Accuracy			Measured using cursors or graticules
	1X	± 1%	
	5X	± 1%	
Gain			X1, X2, X5, and X10
Variable Gain Range, Nominal			0.25X to 2.0X
Frequency Response		50 kHz to 5.75 MHz, ± 1%	
Delay Variation over Frequency		± 10 ns to 5.75 MHz	Typically ± 2.5 ns
Transient Response on Sine Squared 2T4/2T5 Pulse		Pulse to bar ratio 0.99:1 to 1.01:1	
	Preshoot		≤ 1%
	Overshoot		≤ 1%
	Ringing		≤ 1%
Field Rate Tilt		< 0.5%	With DC Restore Fast or Off
Line Rate Tilt		< 0.5%	With DC Restore Fast or Off
Off Screen Recovery			≤ 0.5% variation in baseline of a Chroma modulated pulse when positioned anywhere on screen. Signal must meet specification for Video Maximum Operating Amplitude. Any gain setting.
SNR, Typical			60 dB$_{RMS}$ minimum, relative to 700 mv for PAL or 714 mv for NTSC.

Table 3: Composite analog inputs A and B physical layer

Characteristic	Performance requirement	Reference information
Formats Supported		NTSC, NTSC no setup, and PAL systems, I, B, D, G, H. Complies with SMPTE 170M & ITU-R BT.471
		Manual or auto detect of input standard
Internal Reference		Proper horizontal and vertical synchronization with a composite signal of appropriate line and field rate
Input Dynamic Range, Typical		1 V ± 6 dB range
Video Maximum Operating Amplitude with Clamp Off (DC Coupled), Typical		–1.8 V to +2.2 V (DC +peak AC) all inputs
Maximum Absolute Video Input Voltage		–6.0 V to +6.0 V (DC + peak AC)
Input Type		Passive loop-through 75 Ω compensated
DC Input Impedance		20 kΩ

Table 3: Composite analog inputs A and B physical layer (cont.)

Characteristic	Performance requirement	Reference information
Return Loss		Typically > 46 dB to 6 MHz, > 40 dB to 10 MHz. Typically 35 dB with power off for standard amplitude video
Video Input Crosstalk Between Channels, Typical		≤ –60 dB to 6 MHz
Loop through Isolation, Typical		≥ 70 dB to 6 MHz
DC Offset with Restore Off, Typical		≤ 20 mV Measured in full screen mode at X5 Gain
DC Restore Modes		Fast, Slow, and Off modes Slow has a typical bandwidth of 10 Hz, Fast has a typical bandwidth of 500 Hz
DC Restore Offset Error, Typical		≤ 2 mV Registration between back porch and 0 V graticule
DC Offset Between Inputs With Restore Off, Typical		≤ 7 mV
DC Restore 50 Hz and 60 Hz Attenuation	Fast Mode: > 95% attenuation Slow Mode: < 10% attenuation, < 10% peaking	
Blanking Shift with 10% to 90% APL Change, Typical		≤ 1 IRE (7 mV PAL)
Blanking Shift with Presence and Absence of Burst, Typical		≤ 1 IRE (7 mV PAL)
Lock Range		± 50 ppm Vector typically OK to ± 80 ppm. waveform display typically locked to ± 200 ppm
Lock in Presence of Hum, Typical		Remains locked, 700 mV$_{p-p}$ hum on full amplitude 100% color bar signal
Lock in Presence of White Noise, Typical		Remains locked, Signal/Noise ratio of 32 dB, 5 MHz bandwidth on black burst
Color Framing		Correct color framing detected for signals having < 45 SCH phase error with burst present

Table 4: Waveform sweep (horizontal) deflection

Characteristic		Performance requirement	Reference information
Sweep	Accuracy	± 0.5%, all rates	Fully digital system
	Linearity	0.2% of time displayed on screen	Fully digital system
Timing Cursor Delta Readout Accuracy, Typical			± 0.5% of sweep time displayed on screen

Table 4: Waveform sweep (horizontal) deflection (cont.)

Characteristic	Performance requirement	Reference information
Rates		1, 2, 3, or 4 line, or field depending on mode
Line Select		In 2-line sweep, the selected line is the first displayed line.

Table 5: Eye pattern display

Characteristic		Performance requirement	Reference information
Type			Equivalent Time Sampler
Formats			SMPTE 424M/425M, SMPTE 292M/BTA-S0004A, and SMPTE 259-C
Signal Bandwidth, Typical			100 kHz to 7 GHz at –3 dB point. Derived from rise time measurement using BW = 0.247/tr (20–80)
20% to 80% Rise Time			< 35 ps
Time Base Jitter, Typical	270 Mb/s		60 ps$_{p-p}$ in 1 kHz high-pass filter mode
	1.5 Gb/s		20 ps$_{p-p}$ in 1 kHz high-pass filter mode
	3.0 Gb/s		13 ps$_{p-p}$ in 1 kHz high-pass filter mode
Eye Clock Bandwidth Settings			Clock bandwidth can be set to 10 Hz, 100 Hz, 1000 Hz, 10 kHz, or 100 kHz high pass filter
Eye Clock Bandwidth Accuracy			Actual –3 dB frequency within 10% of nominal
Jitter Attenuation Error	3 Gb/s and 1.5 Gb/s		
	10 Hz High Pass Filter		Within 0.3 UI + 10% for jitter frequencies above five times bandwidth selection
	100 Hz to 100 kHz High Pass Filter		Within 0.05 UI + 10% for jitter frequencies above five times bandwidth selection
	270 Mb/s		
	All High Pass Filter settings		Within 0.05 UI + 10% for jitter frequencies above five times bandwidth selection

Table 5: Eye pattern display (cont.)

Characteristic		Performance requirement	Reference information
Display Modes	270 Mb/s		
	Overlay		Overlays all bits to form each eye opening. Useful for observing peak jitter
	10 Eye		Displays eye relative to the parallel clock. Useful for observing jitter correlated to word clock
	3 Gb/s and 1.5 Gb/s		
	Overlay		Overlays all bits to form each eye opening. Useful for observing peak jitter
	20 Eye		Displays eye relative to the parallel clock. Useful for observing jitter correlated to word clock
Vertical Scale Accuracy		800 mV ±5% with an 800 mV$_{p-p}$ input signal	
Horizontal Scale Accuracy			Indicated time per division ±1%, fully digital system
Eye Derived Measurements	Rise Time / Fall Time, Typical		± 10 ps + 5% of measurement for signals with greater than 60 ps rise and fall times
			Measurements only valid on a clean signal. Excess jitter, overshoot, or other aberrations will reduce the accuracy. Limited by inherent rise time of eye display
	Amplitude, Typical		± 10 mV
			Measurements only valid on a clean signal. Excess jitter, overshoot, or other aberrations will reduce the accuracy. Limited by inherent rise time of eye display
Equalized Eye Display			Shows eye from input after it has gone through equalizer
			Allows limited use of eye at long cable length. Equalizer adds some jitter. Can bypass equalizer at short cable lengths to overcome this effect
Equalized Eye Amplitude, Typical			600 mv ±80 mv
			Amplitude of equalized eye is not related to input amplitude. This waveform is from the digital output of the equalizer. It is intentionally displayed at a smaller size to reduce the chance of it being confused with the input eye

Table 6: Jitter display (Option EYE and PHY)

Characteristic	Performance requirement	Reference information
Type		Displays numerical and graphical readouts of peak-to-peak jitter. Jitter derived from demodulated recovered clock as described in SMPTE RP192 2003. If Opt. PHY is installed, then Jitter Waveform can also be displayed
High-Pass Filter Settings		Can be set to 10 Hz, 100 Hz, 1 kHz, 10 kHz, or 100 kHz.
		High pass filter has type-3 response for low frequency rejection of 60 dB/decade below the filter setting. High pass filter also applies to digital readout, jitter waveform and Eye diagram display, but not the reference clock output. There are two independent Jitter demodulators which may be configured with different loop bandwidths. One is applied to the upper two tiles of the display, and the other applies to the lower two tiles
High-Pass Filter Attenuation Accuracy		Frequency at which response is –3 dB is within 10% of nominal
		High-Pass Frequency Response also applies to readout and jitter waveform
High-End Frequency Response, Typical		–3 dB at 5 MHz
		Applies to digital readout, jitter waveform, and reference clock output

Table 6: Jitter display (Option EYE and PHY) (cont.)

Characteristic	Performance requirement	Reference information
Maximum Jitter Amplitude Measurement, Typical		Applies to digital readout, jitter waveform, and Reference Clock output
	Maximum is a function of jitter frequency and standard:	Maximum jitter is limited by measurement range at low frequencies, and by jitter tolerance of serial receiver at high frequencies
	10 Hz to 30 kHz, 3 Gb/s and 1.5 Gb/s	20 UI$_{p-p}$
	10 Hz to 40 kHz, 270 Mb/s	10 UI$_{p-p}$
	30 kHz to 1 MHz, 3 Gb/s and 1.5 Gb/s	Declines to 0.35 UI at 1 MHz
	40 kHz to 1 MHz, 270 Mb/s	Declines to 0.35 UI at 1 MHz
	>1 MHz, 3 Gb/s and 1.5 Gb/s	0.35 UI
	1 MHz to 4 MHz, 270 Mb/s	0.35 UI
	>4 MHz, 270 Mb/s	0.25 UI

Table 6: Jitter display (Option EYE and PHY) (cont.)

Characteristic		Performance requirement	Reference information
Jitter Measurement Noise Floor	Minimum is a function of bandwidth selection:		Applies to jitter waveform
	10 Hz, 3 Gb/s and 1.5 Gb/s		200 ps typical
	100 Hz, 1 kHz, 10 kHz, 100 kHz, 3 Gb/s and 1.5 Gb/s		40 ps typical
	All HPF settings, 270 Mb/s		250 ps typical
Digital Readout Type			Displays peak to peak value of jitter detected over the measurement period, as defined by selected high-pass filter setting. Indicates timing jitter or alignment jitter if appropriate
Digital Readout	Accuracy, Typical		For jitter frequencies from 5 times bandwidth selection to 4 MHz
	10 Hz, 3 Gb/s and 1.5 Gb/s		<0.3 UI + 10% of reading
	100 Hz, 1 kHz, 10 kHz, 100 kHz, 3 Gb/s and 1.5 Gb/s		<0.05 UI + 10% of reading
	All HPF settings, 270 Mb/s		<0.05 UI + 10% of reading
	Resolution		0.01 UI

Table 6: Jitter display (Option EYE and PHY) (cont.)

Characteristic		Performance requirement	Reference information
Jitter Waveform	Gain Error, Typical		For jitter frequencies from 5 times bandwidth selection to 4 MHz
			Error for jitter frequencies between HPF setting and 5x HPF setting due to loop peaking: max of 1.5 dB
	10 Hz, 3 Gb/s, and 1.5 Gb/s		<0.4 UI + 10% of reading
	100 Hz, 1 kHz, 10 kHz, 100 kHz, 3 Gb/s, and 1.5 Gb/s		<0.1 UI + 10% of reading
	All HPF settings, 270 Mb/s		<0.1 UI + 10% of reading
	Scale		
	Horizontal Modes		1 Line, 2 Line, 1 Field, 2 Field
	Vertical Modes		1 UI / div, 0.2 UI / div, 0.1 UI / div
Recovered Clock Output, Typical			1 V p-p into 75 Ω load SD frequency = 27 MHz HD frequency = 74.25 or 74.17852 MHz
Jitter Measurement Time			0.5 Sec
			Approximately 5,000,000 independent samples

Table 7: Component vector mode

Characteristic		Performance requirement	Reference information
Vertical Bandwidth, Typical	SD		800 kHz
	HD		3.4 MHz (6.8 MHz for 1080P 148.5 MHz formats)
Vertical Gain Accuracy		± 0.5%	Fully digital system
Horizontal Gain Accuracy		± 0.5%	Fully digital system
Display to Graticule Registration		± 0.5%	Fully digital system limited by sample resolution

Table 7: Component vector mode (cont.)

Characteristic	Performance requirement	Reference information
Vector Display		P_B is displayed on horizontal axis and P_R is displayed on vertical axis
Luma Qualified Vector Threshold Accuracy	± 1%	Vectors between the high luma and low luma threshold are displayed

Table 8: Waveform mode filter characteristics

Characteristic		Performance requirement	Reference information
Low Pass Filter Gain	SD, component only		1 ± 0.1% relative to flat gain
	HD, component only		1 ± 0.1% relative to flat gain
Low Pass Filter Frequency Response	SD, component only	≤ 3 dB attenuation at 800 kHz ≥ 32 dB attenuation at 3 MHz Filter meets IEEE STD-205	
	HD, component only	≤ 3 dB attenuation at 4.5 MHz ≥ 25 dB attenuation above 15 MHz, Noise bandwidth is approximately 8 MHz Stopband null at 18 MHz	For 1080P 148.5 MHz formats: ≤3 dB attenuation at 9 MHz ≥25 dB attenuation above 30 MHz
Luma Filter Gain, composite only		1 ± 0.1% relative to flat gain at 50 kHz	
Luma Filter Frequency Response, composite only		≤ 3 dB attenuation at 800 kHz 32 dB attenuation at F_{SC} Same as SD serial component low pass filter	
Chroma Filter Gain, composite only		1 ± 1% relative to flat gain	
Chroma Filter Response, composite only		3 dB bandwidth 1 MHz ± 0.2 MHz F_{SC} autoselected based on input standard, implemented digitally, centered on F_{SC}	
Chroma Filter Attenuation at 2x F_{SC}, composite only		≥ 25 dB Implemented digitally. Typically 28 dB for NTSC, 53 dB for PAL	

Table 9: SDI Lightning and Diamond modes

Characteristic	Performance requirement	Reference information
Vertical Gain Accuracy	± 0.5%	Fully digital system

Table 9: SDI Lightning and Diamond modes (cont.)

Characteristic		Performance requirement	Reference information
Electronic Graticule Display	Diamond		RGB deflection axis indicated. Upper and lower halves are separated, to see negative signals
	Lightning		Displays signal components as follows: Y vertically Pb horizontally on top half of display P$_r$ horizontally on bottom half of display
Detection Level	High Limit	+630 mV to +756 mV in 1 mV steps	
	Low Limit	-50 mV to +35 mV in 1 mV steps	
Detection Level Accuracy		± 3.5 mV	
Diamond Area Threshold Range			0% to 10%

Table 10: Data mode

Characteristic	Performance requirement	Reference information
Digital Waveform		Non-interpolated waveform display. Cursor identifies selected sample value (hex, decimal, binary). Cursor inserted on picture monitor output shows selected line
Digital List		Sequential list of sample values in table format. Cursor identifies selected sample
Display Format		HEX, DEC, BIN

Table 11: Composite vector mode

Characteristic		Performance requirement	Reference information
Displayed Horizontal and Vertical Gain Accuracy	X1 Gain	±1%	
	X5 Gain	±1%	
Display to Graticule Registration		Centered in target, ±0.5 box diameter with the color bar black/white display dot centered in target. Boxes are 2% targets	
Vector Display			B-Y is displayed on horizontal axis and R-Y is displayed on vertical axis
Bandwidth, Typical			360 kHz
Horizontal to Vertical Bandwidth Matching		< 0.5° at 500 kHz and 2 MHz	
R-Y B-Y Axis Orthogonality, Typical			± 0.1°, implemented digitally
Luma Qualified Vector Threshold Accuracy		± 1%	Vectors between the high luma and low luma threshold are displayed

Table 12: Composite SCH mode

Characteristic	Performance requirement	Reference information
Type		Polar display of H Sync Phase
Displayed Angle Accuracy	± 5°	± 100° range

Table 13: Arrowhead mode (NTSC/PAL composite limit display for SDI inputs)

Characteristic	Performance requirement	Reference information
Signal to Graticule Accuracy	± 1%, 100 IRE (700 mV), and 131 IRE (900 mV)	(PAL values in parenthesis)
Composite Limit Cursor Accuracy	± 1.0% at 100 IRE, 110 IRE, 120 IRE, and 131IRE (700 and 950 mV)	(PAL values in parenthesis)
	± 1.0% at -24 IRE, –33 IRE, and –40 IRE (-230 and 300 mV)	(PAL values in parenthesis)
Detection Level, nominal		Adjustable thresholds, 1% steps
Composite Limit Detection Level Accuracy	Detection Level = ± 7 mV of cursor level	Upper detection level can be set to 100, 110, 120, or 131 IRE (700 mV or 950 mV PAL)
		Lower detection level can be set to –24, –33, and –40 IRE (–230 mV or –300 mV PAL)
Composite Limit Area Threshold Range		0% to 10%
Luma Limit Detection Range, Typical — High		90 to 108%, 0.5% steps
Luma Limit Detection Range, Typical — Low		+5 to –6%, 0.5% steps
Luma Limit Detection Level Accuracy, Typical		Detection level = ± 7 mV of cursor level, nominal
Luma Limit Area Threshold Range		0% to 10%

Table 14: Spearhead HVS color space display

Characteristic	Performance requirement	Reference information
Signal to Graticule Accuracy	± 1%	

Table 15: Bowtie mode

Characteristic	Performance requirement	Reference information
Common Mode Rejection Ratio — SD	≥ 34 dB at 2.5 MHz	
Common Mode Rejection Ratio — HD	≥ 34 dB at 5 MHz	
Interchannel Timing Match	± 0.5 ns	
Functional Description		Displays Y minus Pr and Y minus Pb signals. Requires bowtie signal to be useful. Null in center indicates the channels are time aligned.

Table 16: Timing display

Characteristic	Performance requirement	Reference information
Input Timing Relative to External Reference		Display of Vertical and Horizontal timing offset graphically and numerically. One clock cycle resolution.
		Patented proprietary display. Display Timing difference between input and Ref at rear panel or relative to an offset saved by the user.
Timing Display Zero Definition		For vertical timing, conforms to SMPTE RP168-2002.
		For horizontal timing, zero delay analog signals have coincident syncs. For digital signals, timing is such that if converted to analog by a WFM601A, then the resultant analog signal is conincident with the reference.
		Timing zero is equivalent to nominal zero delay on TG700. Also agrees with signal that shows minimal shift on the waveform display when going from internal to external.
		Vertical timing, according to SMPTE RP168, specifies that the lines with the start of the broad pulses are aligned.
Operation with input and reference being different formats		Compatible with any combination of frame abd field rates. (See Table 45.) (See Table 46.) (See Table 47.) In cases where there are multiple ways to interpret the phase relationship, multiple indicators of the phase will be shown. The numeric display will follow the smallest phase offset.
Link B to Link A		Display of dual link timing skew. Uncertainty of ± 1.5 clocks or 20 ns.
Input Timing Reference to Other Input		For Simultaneous inputs, allows selection of other channel as reference.

Table 17: Picture mode

Characteristic	Performance requirement	Reference information
Format (XGA)		Allows viewing picture in all formats.
		In SD formats, full screen picture occupies the central portion of the XGA raster area. For tile mode, the image is downsampled to fit the 512 x 350 size.
		In HD formats, picture is downsampled to fit in 1024 x 768 size (512 x 350 in 4-tile mode). In 1080P 60/59/50 dual link formats, picture is formed by averaging two lines, one from each link, then downsampling as required for display.
		In Low Frame Rate formats, frames are repeated as needed to achieve XGA frame rate; similar to 3:2 pulldown on some frame rates.
Pix Border On/Off		Allows user to mask or show the inactive portions of the raster such as ANC area for digital and sync for analog.
		When the border is on, the image is scaled to correct the aspect ratio. When the border is off, the image is either mapped pixel to pixel (full screen SD), or minimally decimated to reduce the artifacts.
Synchronization		Picture mode always uses internal timing; it is not affected by external sync.
Aspect Ratio		Allows choice of 16:9 or 4:3 for SD, to support widescreen.
Interlace to Progressive Options		Allows choices optimized for CRT, LCD, and interlaced displays.

Table 18: Signal level / cable length detector

Characteristic	Performance requirement	Reference information
Cable Length Measurement Error, Typical		15 m ± 10% for cable types listed at the end of this table.
		Requires clean SD signal with rise time <1 ns for full accuracy. Excessive ringing or slower rise time may appear as increased cable length.
Cable Length Measurement Resolution		3 meters, nominal

Table 18: Signal level / cable length detector (cont.)

Characteristic	Performance requirement	Reference information
Cable Length Measurement Range, Typical		Cable loss range of 0 to 30 dB at $^1/_2$ serial bit rate.
		Typically runs to 40 dB, but with reduced accuracy.
		Equivalent to 0 to 300 m Belden 8281 for SD, 0 to 120 m Belden 8281 for HD.
Launch Amplitude Measurement Accuracy, Typical		± 40 mV at 800 mV level, 0 to 100 m Belden 8281 cable
Launch Amplitude Measurement Resolution, Typical		10 mV
Launch Amplitude Measurement Dynamic Range, Typical		± 50% from 800 mV
Cable Types		Belden 1694A/1505A/8281/1855A Canare L-5CFB Image 1000
Cable loss measurement		Displays loss around 160 MHz minus loss around 18 MHz.

Table 19: Data error detection (Video Session under STATUS button)

Characteristic		Performance requirement	Reference information
Data Integrity	270 Mb/s	Active picture and full field. Field rate resolution Complies with SMPTE RP165	Uses CRC check-word system. System is known as EDH (Error Detection and Handling) in industry literature.
			Error icon asserted for 1 second after any error.
	1.5 Gb/s, 3 Gb/s	Detects line CRC errors. Field rate resolution, separate reporting for errors in Y or Color Difference data streams	Error icon asserted for 1 second after any error.

Table 20: ANC data and ARIB

Characteristic	Performance requirement	Reference information
Displays		Detects ANC data in SDI streams, displays data from user specified DID and SDID. Displays Audio Control Packet. Decodes data for ARIB types B39, B37, B35, TR-B22, and TR-B23.
Alarms		Allows Alarms to be set for: ANC Parity, ANC Checksum, B39 Absence, B37 Absence, B35 Absence, TR-B22 Absence, TR-B23 Absence, and Absence of user specified DID and SDID.

Table 21: Audio bar displays

Characteristic	Performance requirement	Reference information
Modes		The user may configure the response dynamics (ballistics), reference levels, peak hold, offset, and scale of the meters to suit the monitoring needs of the particular installation or situation.
	Channel Mode	Any 10 channels configured into 5 pairs with phase correlation meters between pairs; analog audio inputs have a 6 channel maximum.
	Surround Mode	Left, Right, Center Lfe, Left surround, Right surround meters, and an extra channel pair. Phase correlation meters between L-R, L-C, C-R, Ls-Rs, L-Ls, R-Rs and the extra pair.
		In Dolby mode, the bar configuration is automatically set by metadata.
	Dual Audio Display Mode	For Simultaneous inputs, Dual Audio Displays are available. A total of 8 bars may be allocated between the two displays. Dolby decoding may be enabled for either display, but not for both.
Audio Sources		Monitoring the signal levels and stereo phase of AES/EBU digital audio, digital audio embedded in serial digital video, and Analog Audio inputs.
		Digital Audio (direct and embedded) may be PCM, Dolby digital, or Dolby E.
Level Meter Resolution		0.056 dB steps at 30 dB scale, from full scale to –20 dB FS.
		XGA Full Screen mode = 510 steps XGA 4-tile mode = 255 steps.

Table 21: Audio bar displays (cont.)

Characteristic	Performance requirement	Reference information
Correlation Meter Speed		User selectable 1 to 20. Factory default is set to 8.
		Speed 1 averages over 0.04 sec.
		Speed 2 averages over 0.04 sec.
		Speed 3 averages over 0.08 sec.
		Speed 4 averages over 0.12 sec.
		Speed 5 averages over 0.28 sec.
		Speed 6 averages over 0.52 sec.
		Speed 7 averages over 1.0 sec.
		Speed 8 averages over 1.5 sec.
		Speed 9 averages over 2.0 sec.
		Speed 10 averages over 2.5 sec.
		Speed 11 averages over 3.0 sec.
		Speed 12 averages over 3.5 sec.
		Speed 13 averages over 4.0 sec.
		Speed 14 averages over 4.5 sec.
		Speed 15 averages over 5.0 sec.
		Speed 16 averages over 5.5 sec.
		Speed 17 averages over 6.0 sec.
		Speed 18 averages over 6.5 sec.
		Speed 19 averages over 7.0 sec.
		Speed 20 averages over 7.5 sec.
		The Phase Correlation Meter Speed setting determines how quickly the meter reacts to changes in phase relationship. The meter reading is actually an average of correlation over time, and this setting determines how many samples are used to calculate the average. The instrument uses the fewest samples when this setting is 1, and the meter reacts almost instantaneously. The instrument uses the most samples when the setting is 20, and the meter reacts much more slowly. Experiment to find the setting that best fits your application.
Metering Ballistic Types		Selectable from true peak, PPM Type 1, PPM Type 2, and Extended VU.
Peak Program Meter (PPM) Ballistic Response		PPM Type I (IEC Type I, essentially the same as DIN 45406 and Nordic N-9).
		PPM Type II (IEC Type II, the same as IEEE std. 152-1991).
		PPM Type I has a slightly faster attack time and a faster return time, 1.7 seconds to fall 20 dB as opposed to 2.8 seconds for Type II.
True Peak Ballistic Response		PPM Type II decay characteristics, no attack delay, factory default ballistic.

Table 21: Audio bar displays (cont.)

Characteristic		Performance requirement	Reference information
Extended VU Ballistic Response			VU meter as defined in IEEE 152-1991, but with an extended dB-linear scale. The meter bars also contain true peak indicators when VU is selected.
Peak Hold			True peak indicator remains at the most recent peak for a user selectable time of 1 to 10 seconds.
Clip Indication Delay Count			Consecutive FS samples for Clip Indication, user selectable Off or 1 to 100. Factory default is set to 1. A setting of 0 is equivalent to "Off".
Mute Indication Delay Count			Consecutive "0" samples for Mute Indication, user selectable Off or 1 to 100. Factory default is set to 10. A setting of 0 is equivalent to "Off".
Clip/Mute Error Readout Hold Time			1 to 30 seconds, user selectable. Factory Default set to 2.
Silence Indication Threshold			Audio level below which the signal will be considered "silent". Used to trigger on-screen indication and alarms.
Silence Indication Delay			Off or 1 to 60 seconds, user selectable. Indication and alarm will not be asserted until signal stays below the silence threshold for this number of consecutive seconds. Factory default is set to 10. A setting of 0 is equivalent to "Off".
Over Indication Threshold			Audio level above which the signal will be considered "over". Used to trigger on-screen indication and alarms.
Over Indication Delay			Off or 1 to 30 seconds, user selectable. Indication and alarm will not be asserted until signal stays above the Over Indication Threshold for this number of consecutive seconds. Factory default is set to 2. A setting of 0 is equivalent to "Off".
Adjustable Peak Program Level			Peak Program level is the level, relative to digital full scale, that the user chooses as the maximum desired level for monitored programs. The meter bars change to red above Peak Program level.
	Digital	Range 0 to –30 dBFS	
	Analog	Range 24 to –6 dBu	

Table 21: Audio bar displays (cont.)

Characteristic		Performance requirement	Reference information
Adjustable Test Level			Test level is the level, relative to digital full scale, that the user chooses as the test or "line up" level for monitored programs. The meter bars change to yellow between the Test and Peak Program levels.
	Digital	Range 0 to –30 dBFS	
	Analog	Range 24 to –6 dBu	
Set 0 dB Mark		Selections are 0 dBFS or 0 dBu, Peak Program Level (dB), or Test Level (dB)	Use this item to number the meter scale relative to Digital Full scale with digital sources, or relative to 0 dBu with analog sources, or to one of the two user-adjustable levels. When the zero mark is set to either Peak Program or Test level, the scale units are dBr, relative to the 0 dB level; units above the selected 0 dB mark are positive, while units below it are negative.
Analog Audio Scale Types			Selection of DIN, Nordic, or PPM preset the scale, test, and reference levels to match these defined meter types.

Table 22: Audio bar and Lissajous/Surround display

Characteristic	Performance requirement	Reference information
Description		In combination with Bar mode can have Lissajous or Surround Display in one tile. (See Table 21.)
Automatic Gain Control (AGC)	Lissajous gain control may be on or off	AGC time constant: 0.5 second to expand display after a 0 to –40 dB level transition, 0.05 second to reduce gain after a –40 to 0 dB level transition.
Manual Scaling		When AGC is off, level at perimeter of display follows Peak Program Level on Bar display.
Surround Display Frequency Weighting Filter		Frequency weighting can be A-weighting or Linear (Flat Response) as described in IEC 651. Dominant sound indicator can be turned on and off.

Table 23: AV Delay display (WFM8300 Option AD or DPE)

Characteristic	Performance requirement	Reference information
Audio Video Delay measurement		Displays the delay of embedded audio relative to SDI video. Shows delay in milliseconds and in fields. Requires SDI signal from TG700 in AV Timing mode.

Table 23: AV Delay display (WFM8300 Option AD or DPE) (cont.)

Characteristic	Performance requirement	Reference information
Measurement Range		At least –2 to +2 seconds: a negative reading indicates audio is advanced with respect to video; a positive reading indicates it is delayed. Range depends on the repetition rate of the test signal. Specification applies for TG700 AV Timing mode, which has a nominal 5 second repetition rate.
Measurement Accuracy	± $^1/_2$ video field.	

Table 24: AES audio inputs

Characteristic	Performance requirement	Reference information
Inputs		2 sets with 8 channels each, 32-192 kHz, 24 bit, meets requirements of AES-3ID and SMPTE 276M-1995.
Input Connector		BNC, terminated, unbalanced [1]
Input Impedance		75 Ω
Input Return Loss		Typically better than 30 dB to 24 MHz.
		Input A has passive terminations, so they are the same with power on or off. Input B has active terminations that go to a higher impedance with the power off.
Input Amplitude Range		0.2 V to 2 V peak-to-peak
Input Sample Rate	32 k to 192 k samples/sec	
Input Lock Frequency Range		>± 5%. If input sample rate changes more than 5%, then the instrument may search again for a new lock point. Typically stays locked to 12.5%.

Table 24: AES audio inputs (cont.)

Characteristic	Performance requirement	Reference information
Level Meter Accuracy Over Frequency	±0.1 dB from 20 Hz to 20 kHz with 0 to –40 dBFS sine wave input, Peak Ballistic mode. Within 5 Hz of some submultiples of the sampling frequency it may be additionally attenuated.	May not display full amplitude on fast transients due to sampled nature of digital signal.
	Sampling frequency refers to the 192 kHz upsampled data used for the bar ballistics. For example: 1/12th of rate –0.30 dB (16 kHz ± 5 Hz) 1/16th of rate –0.17 dB (12 kHz ± 5 Hz) 1/20th of rate –0.11 dB (9.6 kHz ± 5 Hz)	
Audio Levels		Bars display signals up to 0 dBFS.
		Must not exceed maximum power specification on analog outputs. Configure output attenuation if necessary.

1   The AES B connectors can be configured for input or output functionality.

Table 25: AES audio outputs (alternate function on second set of inputs)

Characteristic	Performance requirement	Reference information
Source		AES Line B outputs can be sourced from embedded, AES line A inputs (active loopthrough) or analog inputs.
		If either Dolby option is installed, then the source may also be a repeat of the encoded Dolby stream, or decoded AES from a Dolby input. See the Dolby spec section for limitations.
Number of Outputs		Up to 8 channels.
Output Format		AES 3-ID Output, 48 kHz, 20 bit for embedded; 48 kHz, 24 bit for analog to AES. For AES to AES loopthrough, output format equals input format. Meets requirements of SMPTE 276M-1995 (AES 3-ID).
		For decoded Dolby Digital, output is 24 bits at a rate of 32, 44.1, or 48 kHz. For decoded Dolby E the output is 24 bits at 48 kHz, or 47.952 kHz.
Output Connector		BNC, terminated, unbalanced [1]
Output Impedance		75 Ω
Output Return Loss		Typically better than 30 dB to 24 MHz.
		Tested in input mode.
Output Amplitude Range	0.9 V to 1.1 V peak-to-peak into 75 Ω	

Table 25: AES audio outputs (alternate function on second set of inputs) (cont.)

Characteristic	Performance requirement	Reference information
Output Sample Rate		Locked to embedded sample rate (nominally 48 kHz) for embedded source, to AES incoming rate for AES source, and to 48 kHz for analog source.
Output Jitter, Typical		3.5 ns peak with 700 Hz high pass filter per AES specification
		AES3 rev. 1997 specification is 4.1 ns peak for 48 kHz audio.
Rise and Fall Time, Typical		37 ns from 10% to 90% as per AES3 for 48 kHz sampling < 12 ns for 96 kHz and 192 kHz sampling.
Analog input to AES output levels, Typical		Analog input of +24 dBu translates to 0 dBFS digital signal.
		Accuracy governed by analog input accuracy spec.

1   The AES B connectors can be configured for input or output functionality.

Table 26: Embedded audio extraction

Characteristic	Performance requirement	Reference information
Embedded Audio Formatting		24-bit Embedded audio is not supported (no AUX bits are extracted), only 20 most significant bits will be extracted. Supports SMPTE 272M Operation Level B only (48 kHz audio sampling rate synchronized with video).
	SD	Extract 20-bit audio formatted according to SMPTE 272M.
	HD	Extract 20 or 24 bit audio formatting according to SMPTE299M.
Channel Numbering		Channel numbers per SMPTE 272M (1 through 16) will be correctly shown on all displays.
Audio Rates		Supports 48 kHz audio sample rate.
Number of Channels Monitored for Presence		16 channels are monitored for presence. With Simultaneous inputs or dual link formats, 16 channels of each selected SDI input are monitored for presence.
Maximum Number of Channels Monitored for Activity		Monitoring done by audio board only. Can only monitor channels set up for display.
Audio levels		Bars display signals up to 0 dBFS.
		Must not exceed maximum power specification on analog outputs. Configure output attenuation if necessary.

Table 27: Analog audio inputs

Characteristic	Performance requirement	Reference information
Number of Channels		Provides up to two sets of six channels of professional balanced differential inputs for each video input, 12 channels total.
Input Connector		Balanced, unterminated via rear panel connector.
		Use 62 pin, 3 row, DSUB connector, only 2 rows of 42 pins are connected.
Level Meter Accuracy over Frequency	±0.3 dB from 20 Hz to 20 kHz, 24 dBu to –16 dBu sine wave input, Peak Ballistic mode. Within 5 Hz of some submultiples of the sampling frequency it may be additionally attenuated.	
	Sampling frequency refers to the 192 kHz upsampled data used for the bar ballistics. For example:	
	1/12th of rate –0.30 dB (16 kHz ±5 Hz)	
	1/16th of rate –0.17 dB (12 kHz ±5 Hz)	
	1/20th of rate –0.11 dB (9.6 kHz ±5 Hz)	
Cross Talk, Typical		≤ –90 dB from 20 Hz to 20 kHz, inputs driven from < 600 Ω source impedance.
		Defined as the displayed bar level in any channel that results from a full scale signal on a different input pair than that input.
Maximum Input Levels	+ 24 dBu ±0.3 dBu (see Level Meter Accuracy over Frequency above)	Must not exceed maximum power specification on analog outputs. Configure output attenuation if necessary.
Resolution Sampling		24 bits at 48 kHz
Input Impedance		24 kΩ
Off Isolation		≤ –90 dB, from 20 Hz to 20 kHz. Unused input driven from < 600 Ω source impedance.
		Defined as the displayed bar level that results from a full scale signal on any pair of the unused input.
Analog Input to Digital Output Distortion (THD+N), Typical		< 0.03% from full scale to –30 dBFS, 20 Hz to 20 kHz.

Table 28: Analog audio outputs

Characteristic	Performance requirement	Reference information
Audio Modes		*Balanced*: provides a full-scale output of 24 dBu and is designed for professional balanced applications.
		Unbalanced: Designed to drive the unbalanced inputs of consumer amplifiers, in which case the negative output pin must be grounded.
Audio Sources		The channels routed to the line outputs may include: Embedded audio source, AES audio source, Analog audio source, and Decoded Dolby.
Number of Channels		Provides up to eight channels.
Output Connections		Balanced, unterminated via rear panel connector.
		62 pin, 3 row, DSUB connector, but only 2 rows of 42 pins are connected.
		Ground negative output to support unbalanced mode.
Maximum Output Levels	+24 dBu ±0.5 dBu	When one output is grounded to achieve unbalanced mode, the other output will be driven to a larger amplitude. You can reduce the level by adding attenuation in the Audio Settings menu. Do not exceed the maximum rated output power in either mode.
Input to Output Gain		0 dB to –120 dB in 0.5 dB steps.
Digital Input to Analog Output Gain Accuracy over Frequency	± 0.5 dB, 20 Hz to 20 kHz, 0 to –40 dBFS, 20 or 24 bit input	
Analog Input to Analog Output Gain Accuracy over Frequency	± 0.8 dB, 20 Hz to 20 kHz, 24 dBu to –16 dBu	
Output Impedance		50 Ω
		Intended to drive ≥600 Ω load. Drivers are capable of driving a minimum load impedance of 300 Ω but may overheat. DO NOT exceed maximum rated output power.
Digital Input to Analog Output Distortion (THD + N)		≤0.01% from full scale to –20 dBFS, 20 Hz to 20 kHz.
Analog Input to Analog Output Distortion (THD + N)		≤0.02% from full scale to –20 dBFS, 20 Hz to 20 kHz.
Digital Input to Analog Output Crosstalk, Typical		< –90 dB, 20 Hz to 20 kHz, 24 dBu or 0 dBFS input.
		< –100 dB, 20 Hz to 2 kHz, 24 dBu or 0 dBFS input.
		Defined as cross talk within a pair.

Table 28: Analog audio outputs (cont.)

Characteristic	Performance requirement	Reference information
Output Power Capability, Typical		Capable of continuously driving a –10 dBFS sinewave into 600 Ω or –13 dB into 300 Ω.
		This is 25 mW RMS in the load per output pair. Live audio may reach full voltage level as long as the duty cycle is such that the RMS power is less than 25 mW averaged over any 10 second period. If an overtemp condition is detected, the output attenuation may be increased automatically to prevent damage.
Meter Level to Headphone Output Gain		0 dB to –63 dB in 0.5 dB steps relative to maximum output level.
Digital Input to Headphone Output Gain Accuracy over Frequency	± 1.0 dB, 20 Hz to 20 kHz, 0 to –40 dBFS	
Digital Input to Headphone Output Distortion (THD + N), Typical		<0.05% at –10 dBFS, 20 Hz to 20 kHz, into 32 Ω.
		<0.2% at full scale into 32 Ω.
		<2% at full scale into 16 Ω.
Headphone Output Power Capability		Capable of continuously driving a 6.25 dBu sinewave into 32 Ω or 16 Ω.

Table 29: Dolby E and Dolby Digital (AC-3) compressed audio monitoring (Option DPE)

Characteristic	Performance requirement	Reference information
Compressed Audio Input Format		Decodes audio and metadata from Dolby data stream transported through AES or 48 kHz embedded audio source, streams 0 through 7. Supports 16-bit professional mode on Channel 1 or 2.
Decoded Audio Outputs		Up to eight decoded channels including all surround sound channels plus down mix may be output on AES B or Analog Outputs.
Dolby Audio Status Display		Displays extensive Dolby D and Dolby E status and bit stream meta-data.
Alarms		(See page 38, *Alarms*.)

Table 30: Analog picture monitor outputs (Pix Mon)

Characteristic		Performance requirement	Reference information
Signal Format			Y, Pb, Pr with sync on Y, RGB with sync on all, HD and SD. HD sync is tri-level, also have TTL H and V drive. Component mode only available for SDI input mode. With 1080P 148.5 MHz formats, combined links are down-converted to the related 1080i format. 4:4:4 dual link formats are down-converted to 4:2:2.
			Does not support 720p 30, 720p 29.97, 720p 25, 720p 24 or 720p 23.98 formats.
			No H and V sync outputs when sourcing 1080p sf 23.98 or 24, just tri-level sync on Green/Y.
Pix Mon Connector			Standard female 15-pin HD-15 RGBHV "VGA" connector.
DAC Resolution			10 bit
Impedance, Typical			75 Ω unbalanced
Active Video Accuracy		700 mV ±5% peak-peak	YPbPr or RGB modes.
Black (blanking) Output Level		0 mV ±50 mV for HD and SD	
Frequency Response, Typical	SD		±1%, −5% to 5.5 MHz, Y, G, B, and R
	HD		±1%, −12% to 30 MHz, Y, G, B, and R
Non-Linearity, Typical			≤1.5%
Rise and Fall Time, Typical	SD		250 ns for Y, R, G, B and 500 ns for Pb, Pr
	HD		35 ns for Y, R, G, B and 70 ns for Pb, Pr
Overshoot and Undershoot, Typical			1.25%
K Factor, Typical			1%
Interchannel Timing Match, Typical	SD		Y-to-Pb and Y-to-Pr ±5.0 ns
	HD		Y-to-Pb and Y-to-Pr ±4.0 ns
Sync Amplitude Accuracy, Typical	SD		−300 mV
	HD		300 mV on positive and negative excursions.
Signal to Noise Ratio, Typical	SD		70 dB to 5.5 MHz, 58 dB to 100 MHz. RMS noise on quiet line, relative to 700 mV.
	HD		58 dB to 30 MHz, 55 dB to 250 MHz. RMS noise relative to 700 mV.
Return Loss, Typical			>20 dB to 30 MHz
Transcoder Accuracy			9 bit

Table 31: LCD display

Characteristic		Performance requirement	Reference information
Display Area	Horizontal		13 cm
	Vertical		10 cm
Resolution			1024 (H) x 768 (V) pixels
Color Palette			6 bits per component. LSB is dithered to improve picture.
Pixel Defects		≤ 6 bad pixels	

Table 32: External display output (EXT DISPLAY)

Characteristic	Performance requirement	Reference information
Content		Identical to front-panel LCD display.
Display Format		1024 (H) x 768 (V) pixels at 60 Hz (XGA)
Digital Output Format		Single link T.M.D.S.
Connector		Female DVI-I
Analog Output Format		RGB
Analog Output Levels		0.7 V or 1 V for RGB signals, selectable. Fixed 5 V for H and V sync signals.
Hot Plug Detection		Not supported.
DDC Function		Not supported.
Color Palette		6 bits per component.

Table 33: LTC time code input

Characteristic	Performance requirement	Reference information
LTC Input Connector		Balanced, unterminated via rear-panel GCI remote connector. (See Table 40.)
LTC Input Impedance		Greater than 10 kΩ.
LTC Signal Characteristics		Linear Time Code per IEC Publication 461.
LTC Signal Amplitude Range, Typical		$0.2\ V_{p\text{-}p}$ to $5.0\ V_{p\text{-}p}$, balanced differential or single-ended.

Table 34: VITC decoding

Characteristic	Performance requirement	Reference information
Sources		Composite input A or B, SDI input A or B.

Table 35: Serial digital video interface (input A, input B)

Characteristic	Performance requirement	Reference information
Video Inputs		Two inputs.

Table 35: Serial digital video interface (input A, input B) (cont.)

Characteristic		Performance requirement	Reference information
Format			1.5 Gb/s: compatible with SMPTE 292M/BTA-S004A.
			270 Mb/s: compatible with 270 Mb/s SMPTE 259M.
			3 Gb/s: compatible with SMPTE 424/M and SMPTE 425M.
Input Type			75 Ω BNC, internally terminated.
Cable Loss Accommodation		With 1/SQRT(f) characteristic at ½ of serial rate.	
	270 Mb/s	0 to 23 dB attenuation	Equivalent to approximately 330 m of Belden 1694A.
	1.5 Gb/s, 3 Gb/s	0 to 20 dB attenuation	Equivalent to approximately 120 m of Belden 1694A at 1.485 Gb/s, 80 m of Belden 1694A at 2.97 Gb/s.
Launch Amplitude Accommodation, Typical	For Full Specification		800 mV ± 10%
	Up to 20 dB Cable Loss		800 mV ± 30%
Jitter Tolerance, Typical	SD	0.35 UI_{p-p} above 50 kHz. Increases proportional to 1/f below 50 kHz	
	HD	0.35 UI_{p-p} above 1 MHz. Increases proportional to 1/f below 1 MHz	
Return Loss, Typical			> 15 dB to 1.5 GHz, > 10 dB to 3 GHz.
Isolation Between Inputs		> 45 dB to 1 GHz	
Time Base Range			>± 50 ppm

Table 36: Serial video output (Serial Out/SDI PixMon)

Characteristic	Performance requirement	Reference information
Format		3 Gb/s, 1.4835 Gb/s, or 270 Mb/s same as selected input. With Simultaneous inputs, configurable to be Channel 1 or Channel 2.
		With 1080P148.5 MHz formats, content is down-converted to the related 1080i 4:2:2 format.

Table 36: Serial video output (Serial Out/SDI PixMon) (cont.)

Characteristic		Performance requirement	Reference information
Content			Selectable as loop out A or loop out B or Digital version of RGB/YPbPr analog pix monitor output, or test signal generator output. Gamut and/or line select brightups optionally displayable. For dual link formats, Pix Mon may be configured to display picture from link A alone, link B alone, or links A and B combined.
			Gamut error brightups appear one line below error.
Output Level		800 mV, ± 10% into 75 Ω load	
Rise and Fall Time, Typical	SD		400 ps minimum, 800 ps maximum, 20% to 80%.
	HD		135 ps maximum, 20% to 80%.
Return Loss, Typical			>15 dB to 1.5 GHz.
			>10 dB to 3.0 GHz.

Table 37: External reference

Characteristic	Performance requirement	Reference information
Input Type		Passive loop-through, 75 Ω compensated.
Operational		Locks to analog bi-level and tri-level signals of supported formats. (See Table 45.) (See Table 46.) (See Table 47.) Reference must have a frame rate compatible with input. WFM mode and Line Select derive timing from the external sync information.
		Picture mode and Data mode do not use timing from the external reference.
		With Simultaneous inputs, External Reference settings apply to both channels.
Analog Sync Format		Composite analog NTSC and PAL. Analog tri-level sync for supported 1080 and 720 line formats.
Input Signal Level, Typical		1 V ± 6 dB
Maximum Operating Input Voltage, Typical		± 5 V DC
Absolute Maximum Input Voltage, Typical		± 5 V DC
Return Loss, Typical		> 30 dB to 30 MHz
Hum Tolerance, Typical		Operates with 500 mV$_{p-p}$ at 50 or 60 Hz.
Signal/Noise Tolerance, Typical		Operates to 25 dB.

Table 38: Ethernet

Characteristic	Performance requirement	Reference information
IP Address Mode		Supports manual and DHCP.
Rates	1000 Base-T, 100 Base-Tx, and 10 Base-T	
SNMP		For instrument control and feedback of status. Complies with SNMP version 2.
Connector Type		RJ-45 LAN connector supporting 10/100 Base-T.

Table 39: USB

Characteristic	Performance requirement	Reference information
Type		Host
Speed		Complies with USB 1.1 and USB 2.0 Full and Low-Speed specification. Full Speed operation in accordance with USB 2.0 spec is 12 Mb/s.

Table 40: Remote port

Characteristic	Performance requirement	Reference information
GCI Connector		The GCI (ground closure interface) uses ground closures to control remote functions. The connector provides input/output for the following functions: LTC Time Code input ground closure alarm preset inputs
Connector Type		Female HD-15

Table 40: Remote port (cont.)

Characteristic	Performance requirement	Reference information	
Connector Pin Assignments		**Pin**	**Assignment**
		1	GND
		2 - 5	Reserved for future use
		6	GND
		7	Time code (+) input
		8	Time code (–) input
		9	Alarm ground closure output
		10	Preset A1 recall
		11	Preset A2 recall
		12	Preset A3 recall
		13	Preset A4 recall
		14	Preset A5 recall
		15	Preset A6 recall
Ground Closure Input Signalling		TTL thresholds, 5 V max input, –0.5 V min input; pull low to assert; internal 10 kΩ pull-up to 5 V on each input.	
Ground Closure Input Timing		Inputs must be asserted and stable for at least 150 ms to be reliably recognized.	
Ground Closure Output Characteristics		Open collector output; pulled up to 5 V by 10 kΩ in series with a diode; pull down current is limited by series 10 Ω resistor; max current is 100 mA.	
LTC Characteristics		(See Table 33.)	

Table 41: Power source

Characteristic	Performance requirement	Reference information
Electrical Rating	100 - 240 VAC ±10%, 50/60 Hz 140 Watts max	
Supply Connection		Detachable cord set
Power Consumption, Typical		100 to 140 W
		50 to 110 VA at 110 or 240 VAC.
Surge, Typical		7.5 Amps at 90 V, 10 Amps at 240 V.
Fuse Rating		T3.5, 250 V
		Not operator replaceable. Refer servicing to qualified service personnel.

Table 42: Miscellaneous

Characteristic	Performance requirement	Reference information
Real-time Clock Battery Life		>10 year

Physical Specifications

Table 43: Physical characteristics

Characteristic		Standard
Dimensions	Height	5.25 inches (133.4 millimeters)
	Width	8.5 inches (215.9 millimeters)
	Depth	18.125 inches (460.4 millimeters)
Weight	Net	12 pounds (5.5 kilograms), maximum
	Shipping	21 pounds (9.6 kilograms), approximate

Table 44: Environmental performance

Category		Standards or description
Temperature	Operating	0 °C to +40 °C
	Non Operating	−20 °C to +60 °C
Humidity	Operating	20% to 80% relative humidity (% RH) at up to +40 °C, non-condensing.
	Non Operating	5% to 90% RH (relative humidity) at up to +60 °C, non-condensing.
Altitude	Operating	Up to 9,842 feet (3,000 meters).
	Non Operating	Up to 40,000 feet (12,192 meters).
Cooling		The variable fans provide forced air circulation. Do not block ventilation openings.
	Bare instrument (no optional sleeves)	To ensure proper airflow, there must be at least 2 inches of clearance on both sides of the instrument, at least 2 inches of clearance from the rear of the instrument, and at least a 0.5 inch of clearance from the top of the instrument.
	Portable cabinet	Use only Tektronix portable cabinet, WFMF02, to ensure proper airflow with this instrument. When using the portable cabinet, the same minimum clearances as the Bare Instrument apply.
	Rack cabinet	Use only the Tektronix rackmount insert, WFM7F00, with the Tektronix Dual Rack Adapter WFM7F05 for this instrument. To ensure proper airflow when installing the Dual Rack Adapter in a closed rack with solid walls, there must be at least 2 inches of clearance from both sides of the rack adapter frame to the rack side walls, at least 3 inches of clearance from the rear of the rack adapter frame to the rack's back wall, and at least a 0.5 inch of clearance from the top of the rack adapter to another rack adapter or installed instrument. The rack intake air to the side vents must not exceed 40 °C.

Supported Input Formats and Allowed References

An X in the following three tables indicates that this combination is supported. Other combinations within each of these tables may work, but are unverified and only supported on a best effort basis.

Operation with an input from one of these three tables and a reference from another table is not supported (for example, a 1080i 50 input will not work with a 1080i 60 reference). Such mismatches may be reported on the display, and/or the display will "roll" due to the inherent incompatibility between the standards.

Table 45: 25 Hz and 50 Hz frame and field rates

Input format	Reference format					
	PAL	720p 25	720p 50	1080p 25	1080sf 25	1080i 50
720p 25 Hz	X		X			X
720p 50 Hz	X		X			X
1080p 25 Hz	X		X			X
1080sf 25 Hz	X		X			X
1080i 50 Hz	X		X			X
1080p 50 Hz	X		X			X
576i 50 Hz (625)	X		X			X
PAL 50 Hz	X					

Table 46: 59.94 Hz, 23.98 Hz, and 29.97 Hz frame and field rates

Input format	Reference format								
	NTSC	720p 23.98	720p 29.97	720p 59.94	1080p 23.98	1080sf 23.98	1080p 29.97	1080sf 29.97	1080i 59.94
720p 23.98 Hz	X			X	X	X			X
720p 29.97 Hz	X			X					X
720p 59.94 Hz	X			X	X	X			X
1080p 23.98 Hz	X			X	X	X			X
1080sf 23.98 Hz	X			X	X	X			X
1080p 29.97 Hz	X			X					X
1080sf 29.97 Hz	X			X					X
1035i 59.94 Hz	X			X					X
1080i 59.94 Hz	X			X					X
1080p 59.94 Hz	X			X					X
483i 59.94 Hz (525)	X			X					X
NTSC 59.94 Hz	X								

Table 47: 24 Hz, 30 Hz, and 60 Hz frame and field rates

Input format	Reference format							
	720p 24	720p 30	720p 60	1080p 24	1080sf 24	1080p 30	1080sf 30	1080i 60
720p 24			X	X	X			X
720p 30			X					X
720p 60			X	X	X			X
1080p 24			X	X	X			X
1080sf 24			X	X	X			X
1080p 30			X					X
1080sf 30			X					X
1035i 60 Hz			X	X	X			X
1080i 60 Hz			X	X	X			X
1080p 60 Hz			X					X

Option 3G is required for operation over SMPTE 424M/425M interfaces. Standard and Interface designators are SMPTE unless otherwise noted.

Table 48: Supported digital standards

Standard	Image format	Signal structure	Interface	Frame (P, sF) or field (I) rates supported							
				60	59.94	50	30	29.97	25	24	23.98
428-9 (D-Cinema)	2048 x 1080/P,PsF	4:4:4 XYZ / 12 bit	424M/425M							X	
			372M							X	
274M	1920 x 1080/P	4:2:2 YCbCr / 10 bit	424M/425M	X	X	X					
			372M	X	X	X					
	1920 x 1080/P,PsF	4:4:4 YCbCr / 10 bit 4:4:4:4 YCbCr+A / 10-bit 4:4:4 RGB / 10 bit 4:4:4:4 RGB+A / 10 bit	424M/425M				X	X	X	X	X
			372M				X	X	X	X	X
		4:4:4 YCbCr / 12 bit 4:4:4 RGB / 12 bit	424M/425M				X	X	X	X	X
			372M				X	X	X	X	X
		4:2:2 YCbCr / 12 bit 4:2:2:4 YCbCr+A / 12 bit	424M/425M				X	X	X	X	X
			372M				X	X	X	X	X
		4:2:2 YCbCr / 10 bit	292M				X	X	X	X	X

Table 48: Supported digital standards (cont.)

Standard	Image format	Signal structure	Interface	Frame (P, sF) or field (I) rates supported							
				60	59.94	50	30	29.97	25	24	23.98
Z74M	1920 x 1080/I	4:4:4 YCbCr / 10 bit	424M/425M	X	X	X					
			372M	X	X	X					
		4:4:4:4 YCbCr+A / 10-bit									
		4:4:4 RGB / 10 bit									
		4:4:4:4 RGB+A / 10 bit									
		4:4:4 YCbCr / 12 bit	424M/425M	X	X	X					
			372M	X	X	X					
		4:4:4 RGB / 12 bit									
		4:2:2 YCbCr / 12 bit	424M/425M	X	X	X					
			372M	X	X	X					
		4:2:2:4 YCbCr+A / 12 bit									
		4:2:2 YCbCr	292M	X	X	X					
260M	1920 x 1035/I	4:2:2 YCbCr	292M	X	X						
296M	1280 x 720/P	4:2:2 YCbCr	292M	X	X	X	X	X	X	X	X
ITU-R BT.601	720 x 576/I (625)	4:2:2 YCbCr	259M-C			X					
ITU-R BT.601	720 x 483/I (525)	4:2:2 YCbCr	259M-C		X						

Alarms

The following tables list the alarms that may be set for the waveform monitors.

Table 49: Common alarms

Alarm	Description
HW Fault	Indicates a system fault occurred. May require service.
SDI Input Missing	Indicates that no signal is detected on the selected SDI input.
SDI Input Signal Lock	Indicates unable to lock to selected SDI input signal.
Reference Missing	Indicates that no signal is detected on the Ref input when REF EXT is selected.
Ref Lock	Indicates unable to lock to the Ref input signal when REF EXT is selected.
Ref Fmt Mismatch	Indicates that the signal format detected on Ref input differs from the configured External Ref format.
RGB Gamut Error	Indicates that the selected video input signal contains colors that violate the configured Diamond gamut thresholds.
Composite Gamut Error	Indicates that the selected video input signal contains colors that violate the configured Arrowhead gamut thresholds.
Luma Gamut Error	Indicates that the selected video input signal contains luminance levels that violate the configured Luma gamut thresholds.
Video Fmt Change	Indicates that a change occurred in the format of the selected video input signal.
Video Fmt Mismatch	Indicates that the signal format detected on the selected video input differs from the configured Input Format or that the format detected differs from that indicated by the signal's SMPTE 352 payload identifier.
Vid/Ref Mismatch	Indicates that the Ref signal format is not compatible with the Input signal format. (See Table 45.) (See Table 46.) (See Table 47.)
Line Length Error	Indicates that the length of a video line differs from that expected for the detected video format.
Field Length Error	Indicates that the length of a video field differs from that expected for the detected video format.
EAV Place Error	Indicates that the location of the EAV timing reference signal differs from that expected for the detected video format.
SAV Place Error	Indicates that the location of the SAV timing reference signal differs from that expected for the detected video format.
Timecode Vitc Missing	Indicates that a break or discontinuity in the VITC has occurred.
Timecode Vitc Invalid	Indicates that the VITC was lost for one frame but has reappeared.
Timecode Ltc Missing	Indicates that a break or discontinuity in the LTC has occurred.
Timecode Ltc Invalid	Indicates that the LTC was lost for one frame but has reappeared.
Timecode Anc Missing	Indicates that a break or discontinuity in the ANC timecode has occurred.
Timecode Anc Invalid	Indicates that the ANC timecode was lost for one frame but has reappeared.
Closed Caption Missing	Indicates that the configured Closed Caption Transport stream or streams are not present in the selected video input signal.
CC Service(s) Missing	Indicates that one or more configured EIA 608 Required Services is not present in the closed caption data stream.

Table 49: Common alarms (cont.)

Alarm	Description
EIA608 Caption Error	Indicates a data error in an EIA608 data stream, excluding Extended Data Services and EIA708 Caption Data Packet errors.
V-Chip Presence Error	Indicates that no content advisory packet has been detected in the selected video input signal for at least 4 seconds.
V-Chip Format Error	Indicates that a content advisory packet contained illegal data or was formatted incorrectly.
Extended Data Services Error	Indicates a data error in Extended Data Services of an EIA608 data stream.
Caption Data Packet Error	Indicates a Caption Data Payload error in the EIA708 stream carrying EIA608 data.
Line 21 presence Error	Indicates no VBI caption signal was found on the configured Line and Timing of the selected video input signal.
ANC CC Presence Error	Indicates no caption ancillary data (SMPTE334M) was found in the selected video input signal.
TSID Missing	Indicates no Transmission Signal Identifier was found in the selected video input signal.
TSID Format Error	Indicates detected Transmission Signal Identifier is not an allowed value.

Table 50: HD specific alarms

Alarm	Description
Video Not HD	Indicates that the selected SDI video input signal is not an HD format.
Line Number Error	Indicates that the encoded line number differs from the counted line number.
Y Chan CRC Error	Indicates that the encoded CRC for a line's Y (luminance) samples differs from the calculated CRC.
C Chan CRC Error	Indicates that the encoded CRC for a line's C (chrominance) samples differs from the calculated CRC.
Y Anc Checksum Error	Indicates that the encoded checksum in a Y (luminance) ancillary data packet differs from the calculated checksum.
C Anc Checksum Error	Indicates that the encoded checksum in a C (chrominance) ancillary data packet differs from the calculated checksum.

Table 51: SD specific alarms

Alarm	Description
AP CRC Error	Indicates that encoded AP (active picture) CRC differs from the calculated CRC.
FF CRC Error	Indicates that encoded FF (full field) CRC differs from the calculated CRC.
EDH Error	Indicates that EDH (error detection and handling) has detected an error.

Table 52: Composite specific alarms (Option CPS)

Alarm	Description
Cmpst Input Missing	Indicates that no signal is detected on the selected composite video input.
Cmpst Lock	Indicates unable to lock to the selected composite video input.

Table 53: Audio alarms (Options AD and DPE)

Alarm	Description
Over	Indicates that the signal has exceeded the level specified by the Over Level setting for the period of time specified by the Duration for Over setting.
Silence	Indicates that the signal has fallen below the level specified by the Silence Level setting for the period of time specified by the Duration for Silence setting.
Clip	Indicates that the number of consecutive, full-scale digital audio samples monitored has exceeded the value specified by the Number of Samples for Clip setting.
Mute	Indicates that the number of consecutive "0" digital audio samples monitored has exceeded the Number of Samples for Mute setting.
AES Unlocked	Indicates unlocked condition of an AES input.
CRC Error	Indicates that the AES channel status CRC as calculated by the instrument does not agree with the CRC embedded in the channel status bytes.
V Bit	Indicates that the Validity bit is set high for one or more AES audio samples. In the AES/EBU standard, a set validity bit indicates that the sample is not suitable for conversion to audio.
AES Parity	Indicates incorrect parity in one or more AES audio samples.
AES Sync Error	Indicates a timing error of greater than 25% of an audio frame between the monitored AES input and the selected AES reference input.
Emb. Audio Presence	Indicates that no embedded audio stream is detected in the selected SDI input.
(Embedded) Checksum	Indicates that the checksum present in the embedded audio stream does not match the calculated checksum.
(Embedded) Parity	Indicates incorrect parity in one or more embedded audio samples.
Emb. Group Sample Phase	Indicates embedded audio streams are not time-aligned due to asynchronous audio or data error.

Table 54: Additional audio alarms (Option DPE)

Alarm	Description
Dolby Format	Indicates Dolby audio Format is not as expected.
Dolby E /Video Frame Rate Error	Indicates that the Dolby E stream frame rate is not the same as the video frame rate.

Performance Verification

This section contains a collection of manual procedures for verifying that the following waveform monitor products perform as warranted:

- WFM8200 models and their options

- WFM8300 models and their options

This chapter is divided into two sections: *Incoming Inspection Procedures* and *Performance Verification Procedures*. The test procedures in this chapter provide for an extensive confirmation of performance and functionality.

NOTE. *Before performing any of the procedures and tests in this manual, the waveform monitor must have been operating for a warm-up period of at least 20 minutes. (See Table 44 on page 33.)*

Test Records

Use the following tables to record the measured performance or Pass/Fail status for each step of the specified test procedure. In cases where a measurement is made in different units than specified in the manual, the actual measured values that correspond to the specification limits are shown in parentheses.

Test Record - Function Tests

Table 55: WFM8200 and WFM8300 Waveform Monitor functional test record

Instrument Serial Number:		Certificate Number:	
Temperature:		RH %:	
Date of Calibration:		Technician:	

Functional test (incoming inspection)	Incoming	Outgoing	Comments
Basic Turn On and Self Test			
POST			
Front Panel Test			
LCD Pixel and Defects			
Diagnostics Tests			
Power Up Diagnostics			
Advanced Diagnostics			
Fan Test			
SDI Input Operation			
SDI A, 270 Mb/s			
SDI B, 270 Mb/s			
SDI B, 1.5 Gb/s			
SDI A, 1.5 Gb/s			
SDI A, 3 Gb/s (Option 3G)			
SDI B, 3 Gb/s (Option 3G)			
Waveform Stuck Bit Test			
External Reference			
NTSC Lock			
Ref Missing			
EYE (Options EYE and PHY)			
270 Mb/s Eye Waveform			
270 Mb/s Jitter Waveform (WFM8300 Option PHY)			
1.5 Gb/s Eye Waveform			
1.5 Gb/s Jitter Waveform (WFM8300 Option PHY)			

Table 55: WFM8200 and WFM8300 Waveform Monitor functional test record (cont.)

Functional test (incoming inspection)	Incoming	Outgoing	Comments
3 Gb/s Eye Waveform (Option 3G)			
3 Gb/s Jitter Waveform (WFM8300 Option PHY with 3G)			
Composite Input (Option CPS)			
CMPST A, WFM with NTSC			
CMPST A, Vector with NTSC			
CMPST A, Picture with NTSC			
CMPST B, WFM with NTSC			
CMPST B, Vector with NTSC			
CMPST B, Picture with NTSC			
Analog Audio Input (Options AD and DPE)			
Analog Audio input A ports 1-6			
Analog Audio input B ports 1-6			
Analog Audio Output (Options AD and DPE)			
Digital Audio Input (Options AD and DPE)			
AES A Input			
AES B Input			
Embedded to Bar Display			
Embedded to Lissajous Display			
Digital Audio Output (Options AD and DPE)			
AES B 1-2 Audio Output			
AES B 3-4 Audio Output			
AES B 5-6 Audio Output			
AES B 7-8 Audio Output			
Dolby Decode (Options AD and DPE)			
LTC Waveform and Decode			
LTC Waveform			
LTC Decode			
Ground Closure Remote			
Activate Preset			
Ground Closure Alarm			
Ethernet Functionality			
Simultaneous Input Operation (WFM8300 only)			
Dual Link Format Operation			
A/V Delay (WFM8300 only)			

Video Performance Test Record

The following test record applies to all instruments.

Table 56: WFM8200 and WFM8300 Waveform Monitor video performance test record

Instrument Serial Number:		Certificate Number:		
Temperature:		RH %:		
Date of Calibration:		Technician:		
Performance test	**Minimum**	**Incoming**	**Outgoing**	**Maximum**
SDI Input Equalization Range				
270 Mb/s Input Equalization Range				
Slot 1 Input A	23 dB			
Slot 1 Input B	23 dB			
1.5 Gb/s Input Equalization Range				
Slot 1 Input A	20 dB			
Slot 1 Input B	20 dB			
3 Gb/s Input Equalization Range				
Slot 1 Input A	20 dB			
Slot 1 Input B	20 dB			
SDI Serial Output Amplitude				
(test limits assume ±3.5% gain uncertainty in test oscilloscope)				
Mainframe Serial Output				
270 Mb/s	745 mV			849 mV
1.5 Gb/s	745 mV			849 mV
3 Gb/s (option 3G only)	745 mV			849 mV
Slot 1 Serial Outputs				
A Out 270 Mb/s	745 mV			849 mV
A Out 1.5 Gb/s	745 mV			849 mV
A Out 3 Gb/s (option 3G only)	745 mV			849 mV
B Out 270 Mb/s	745 mV			849 mV
B Out 1.5 Gb/s	745 mV			849 mV
B Out 3 Gb/s (option 3G only)	745 mV			849 mV
Eye Gain (option EYE or PHY)				
(test limits assume ±0.1% amplitude uncertainty in square wave signal source)				
SDI A input	761 mV			839 mV

Table 56: WFM8200 and WFM8300 Waveform Monitor video performance test record (cont.)

Performance test	Minimum	Incoming	Outgoing	Maximum
SDI B input	761 mV			839 mV
Analog Picture Monitor Gain and Offset				
Test oscilloscope gain cal				
TG700 CH1_DC0				
TG700 CH1_DC1				
TG700 CH1_V1				
Cursor ΔV				
Test Limit Vmax				
Test Limit Vmin				
SD Pix Mon Gain and Offset				
Y gain	Vmin			Vmax
Pb gain	Vmin			Vmax
Pr gain	Vmin			Vmax
G gain	Vmin			Vmax
B gain	Vmin			Vmax
R gain	Vmin			Vmax
G offset	Pass			
B offset	Pass			
R offset	Pass			
Y offset	Pass			
Pb offset	Pass			
Pr offset	Pass			
HD Pix Mon Gain and Offset				
Y gain	Vmin			Vmax
Pb gain	Vmin			Vmax
Pr gain	Vmin			Vmax
G gain	Vmin			Vmax
B gain	Vmin			Vmax
R gain	Vmin			Vmax
G offset	Pass			
B offset	Pass			
R offset	Pass			
Y offset	Pass			
Pb offset	Pass			
Pr offset	Pass			

Test Record - Option CPS

Table 57: WFM8200 and WFM8300 Waveform Monitor video performance test record (Options CPS)

Instrument Serial Number: Certificate Number:

Temperature: RH %:

Date of Calibration: Technician:

Performance Test	Minimum	Incoming	Outgoing	Maximum
Composite Analog Frequency Response	99% (–7 mV)			101% (+7 mV)
Composite Analog Delay Variation Over Frequency (Group Delay)	–10 ns (–7.1 mV)			+10 ns (+7.1 mV)
Composite Analog Pulse to Bar Ratio	99% (–7 mV)			101% (+7 mV)
Composite Analog Field Rate Tilt	–0.5% (–3.5 mV)			+0.5% (+3.5 mV)
Composite Analog Line Rate Tilt	-0.5% (–3.5 mV)			+0.5% (+3.5 mV)
Added Hum for DC Restore Tests	665 mV			735 mV
DC Restore Fast Hum Attenuation	0% (0 mV)			5% (35 mV)
DC Restore Slow Hum Attenuation	90% (643 mV)			110% (785 mV)
Composite Analog Vertical Measurement Accuracy	707.1 mV			721.4 mV

Test Record - Options AD and DPE

Table 58: WFM8200 and WFM8300 Waveform Monitor audio options AD and DPE test record

Instrument Serial Number: Certificate Number:

Temperature: RH %:

Date of Calibration: Technician:

Performance test	Minimum	Incoming	Outgoing	Maximum
AES Audio Input Sample Rate				
AES A 1-2 In (96 kHz)	pass			
AES A 3-4 In (96 kHz)	pass			
AES A 5-6 In (96 kHz)	pass			

Table 58: WFM8200 and WFM8300 Waveform Monitor audio options AD and DPE test record (cont.)

Performance test	Minimum	Incoming	Outgoing	Maximum
AES A 7-8 In (96 kHz)	pass			
AES A 1-2 In (35 kHz)	pass			
AES A 3-4 In (35 kHz)	pass			
AES A 5-6 In (35 kHz)	pass			
AES A 7-8 In (35 kHz)	pass			
AES Audio Output Amplitude				
AES B 1-2 I/O	0.9 V			1.1 V
AES B 3-4 I/O	0.9 V			1.1 V
AES B 5-6 I/O	0.9 V			1.1 V
AES B 7-8 I/O	0.9 V			1.1 V
AES Audio Output Jitter				
AES B 1-2 I/O	Pass			
AES B 3-4 I/O	Pass			
AES B 5-6 I/O	Pass			
AES B 7-8 I/O	Pass			
AES Audio Level Meter Accuracy Over Frequency				
AES A 1 In (100 Hz)	Pass			
AES A 2 In (100 Hz)	Pass			
AES A 3 In (100 Hz)	Pass			
AES A 4 In (100 Hz)	Pass			
AES A 5 In (100 Hz)	Pass			
AES A 6 In (100 Hz)	Pass			
AES A 7 In (100 Hz)	Pass			
AES A 8 In (100 Hz)	Pass			
AES A 1 In (1 kHz)	Pass			
AES A 2 In (1 kHz)	Pass			
AES A 3 In (1 kHz)	Pass			
AES A 4 In (1 kHz)	Pass			
AES A 5 In (1 kHz)	Pass			
AES A 6 In (1 kHz)	Pass			
AES A 7 In (1 kHz)	Pass			
AES A 8 In (1 kHz)	Pass			
AES A 1 In (19 kHz)	Pass			
AES A 2 In (19 kHz)	Pass			
AES A 3 In (19 kHz)	Pass			
AES A 4 In (19 kHz)	Pass			
AES A 5 In (19 kHz)	Pass			

Table 58: WFM8200 and WFM8300 Waveform Monitor audio options AD and DPE test record (cont.)

Performance test	Minimum	Incoming	Outgoing	Maximum
AES A 6 In (19 kHz)	Pass			
AES A 7 In (19 kHz)	Pass			
AES A 8 In (19 kHz)	Pass			
Headphone Level Accuracy Over Frequency				
Left (100 Hz)	–0.75 dBu			1.25 dBu
Right (100 Hz)	–0.75 dBu			1.25 dBu
Left (1 kHz)	–0.75 dBu			1.25 dBu
Right (1 kHz)	–0.75 dBu			1.25 dBu
Left (19 kHz)	–0.75 dBu			1.25 dBu
Right (19 kHz)	–0.75 dBu			1.25 dBu
Analog Audio Level Meter Accuracy Over Frequency				
Analog Input A1 (100 Hz)	17.5 dBu			18.5 dBu
Analog Input A2 (100 Hz)	17.5 dBu			18.5 dBu
Analog Input A3 (100 Hz)	17.5 dBu			18.5 dBu
Analog Input A4 (100 Hz)	17.5 dBu			18.5 dBu
Analog Input A5 (100 Hz)	17.5 dBu			18.5 dBu
Analog Input A6 (100 Hz)	17.5 dBu			18.5 dBu
Analog Input A1 (1 kHz)	17.5 dBu			18.5 dBu
Analog Input A2 (1 kHz)	17.5 dBu			18.5 dBu
Analog Input A3 (1 kHz)	17.5 dBu			18.5 dBu
Analog Input A4 (1 kHz)	17.5 dBu			18.5 dBu
Analog Input A5 (1 kHz)	17.5 dBu			18.5 dBu
Analog Input A6 (1 kHz)	17.5 dBu			18.5 dBu
Analog Input A1 (19 kHz)	17.5 dBu			18.5 dBu
Analog Input A2 (19 kHz)	17.5 dBu			18.5 dBu

Table 58: WFM8200 and WFM8300 Waveform Monitor audio options AD and DPE test record (cont.)

Performance test	Minimum	Incoming	Outgoing	Maximum
Analog Input A3 (19 kHz)	17.5 dBu			18.5 dBu
Analog Input A4 (19 kHz)	17.5 dBu			18.5 dBu
Analog Input A5 (19 kHz)	17.5 dBu			18.5 dBu
Analog Input A6 (19 kHz)	17.5 dBu			18.5 dBu
Analog Input B1 (100 Hz)	17.5 dBu			18.5 dBu
Analog Input B2 (100 Hz)	17.5 dBu			18.5 dBu
Analog Input B3 (100 Hz)	17.5 dBu			18.5 dBu
Analog Input B4 (100 Hz)	17.5 dBu			18.5 dBu
Analog Input B5 (100 Hz)	17.5 dBu			18.5 dBu
Analog Input B6 (100 Hz)	17.5 dBu			18.5 dBu
Analog Audio Level Meter Accuracy Over Frequency				
Analog Input B1 (1 kHz)	17.5 dBu			18.5 dBu
Analog Input B2 (1 kHz)	17.5 dBu			18.5 dBu
Analog Input B3 (1 kHz)	17.5 dBu			18.5 dBu
Analog Input B4 (1 kHz)	17.5 dBu			18.5 dBu
Analog Input B5 (1 kHz)	17.5 dBu			18.5 dBu
Analog Input B6 (1 kHz)	17.5 dBu			18.5 dBu
Analog Input B1 (19 kHz)	17.5 dBu			18.5 dBu
Analog Input B2 (19 kHz)	17.5 dBu			18.5 dBu
Analog Input B3 (19 kHz)	17.5 dBu			18.5 dBu
Analog Input B4 (19 kHz)	17.5 dBu			18.5 dBu

Table 58: WFM8200 and WFM8300 Waveform Monitor audio options AD and DPE test record (cont.)

Performance test	Minimum	Incoming	Outgoing	Maximum
Analog Input B5 (19 kHz)	17.5 dBu			18.5 dBu
Analog Input B6 (19 kHz)	17.5 dBu			18.5 dBu
Digital Input to Analog Output Gain Accuracy Over Frequency				
Analog Output 1 (100 Hz)	17.5 dBu			18.5 dBu
Analog Output 2 (100 Hz)	17.5 dBu			18.5 dBu
Analog Output 3 (100 Hz)	17.5 dBu			18.5 dBu
Analog Output 4 (100 Hz)	17.5 dBu			18.5 dBu
Analog Output 5 (100 Hz)	17.5 dBu			18.5 dBu
Analog Output 6 (100 Hz)	17.5 dBu			18.5 dBu
Analog Output 7 (100 Hz)	17.5 dBu			18.5 dBu
Analog Output 8 (100 Hz)	17.5 dBu			18.5 dBu
Analog Output 1 (1 kHz)	17.5 dBu			18.5 dBu
Analog Output 2 (1 kHz)	17.5 dBu			18.5 dBu
Analog Output 3 (1 kHz)	17.5 dBu			18.5 dBu
Analog Output 4 (1 kHz)	17.5 dBu			18.5 dBu
Analog Output 5 (1 kHz)	17.5 dBu			18.5 dBu
Analog Output 6 (1 kHz)	17.5 dBu			18.5 dBu
Analog Output 7 (1 kHz)	17.5 dBu			18.5 dBu
Analog Output 8 (1 kHz)	17.5 dBu			18.5 dBu
Analog Output 1 (19 kHz)	17.5 dBu			18.5 dBu
Analog Output 2 (19 kHz)	17.5 dBu			18.5 dBu

Table 58: WFM8200 and WFM8300 Waveform Monitor audio options AD and DPE test record (cont.)

Performance test	Minimum	Incoming	Outgoing	Maximum
Analog Output 3 (19 kHz)	17.5 dBu			18.5 dBu
Analog Output 4 (19 kHz)	17.5 dBu			18.5 dBu
Analog Output 5 (19 kHz)	17.5 dBu			18.5 dBu
Analog Output 6 (19 kHz)	17.5 dBu			18.5 dBu
Analog Output 7 (19 kHz)	17.5 dBu			18.5 dBu
Analog Output 8 (19 kHz)	17.5 dBu			18.5 dBu
Analog Input to Analog Output Gain Accuracy Over Frequency				
Analog Output 1 (100 Hz)	Pass			
Analog Output 2 (100 Hz)	Pass			
Analog Output 3 (100 Hz)	Pass			
Analog Output 4 (100 Hz)	Pass			
Analog Output 5 (100 Hz)	Pass			
Analog Output 6 (100 Hz)	Pass			
Analog Output 7 (100 Hz)	Pass			
Analog Output 8 (100 Hz)	Pass			
Analog Output 1 (1 kHz)	Pass			
Analog Output 2 (1 kHz)	Pass			
Analog Output 3 (1 kHz)	Pass			
Analog Output 4 (1 kHz)	Pass			
Analog Output 5 (1 kHz)	Pass			
Analog Output 6 (1 kHz)	Pass			

Table 58: WFM8200 and WFM8300 Waveform Monitor audio options AD and DPE test record (cont.)

Performance test	Minimum	Incoming	Outgoing	Maximum
Analog Output 7 (1 kHz)	Pass			
Analog Output 8 (1 kHz)	Pass			
Analog Output 1 (19 kHz)	Pass			
Analog Output 2 (19 kHz)	Pass			
Analog Output 3 (19 kHz)	Pass			
Analog Output 4 (19 kHz)	Pass			
Analog Output 5 (19 kHz)	Pass			
Analog Output 6 (19 kHz)	Pass			
Analog Output 7 (19 kHz)	Pass			
Analog Output 8 (19 kHz)	Pass			

Incoming Inspection

This section contains functional/operational checks appropriate to an incoming inspection.

The waveform monitor must have been operating for a warm-up period of at least 20 minutes. (See Table 44 on page 33.)

Use the following procedures to check the basic functionality of WFM8200 and WFM8300 Waveform Monitors. The checks are arranged by model and option so that you can choose the sections that are appropriate for your instrument. The last two sections are for less critical waveform monitor features: the ground closure and Ethernet ports. You need only test these if you intend to use them. In general, you should test in the order presented, since later tests might depend on items checked in the earlier tests.

Required Equipment

The following equipment is required to perform the incoming inspection procedure.

Table 59: Required equipment – functional tests

Test equipment	Requirements	Example
Video test signal generator	1080p 59.94 3Gb/s HD signals (required for option 3G)	Tektronix TG700 with HD3G7 module
	■ 100% color bars	
	■ 4 CH embedded audio (Group 1)	
	1080i 59.94 1.5 Gb/s HD signals	Tektronix TG700 with HDVG7 modules
	■ 100% color bars	
	■ 10-bit shallow ramp matrix	
	■ 100% sweep 1-15 MHz	
	■ 4 CH embedded audio (Group 1)	
	525i 59.94 270 Mb/s SD signals	Tektronix TG700 with DVG7 module
	■ 100% color bars	
	■ SMPTE color bars	
	■ 8 CH embedded audio (Groups 1&2)	
	■ A/V Delay test mode	
	NTSC Composite Analog signals	Tektronix TG700 with AVG7 module
	■ 0% Flat Field or Black Burst	
	■ 100% color bars	
	■ SMPTE color bars	
	1080i 59.94 SMPTE 372M Dual Link signals	Tektronix TG700 with HDLG7 module
	■ 100% color bars, format YCbCr+A 4:4:4 10-bit	
	■ 100% color bars, format GBR 4:4:4 10-bit	
75 Ω coaxial cables (2 required)	RG-6 type coaxial cable with male BNC connectors, 1 to 2 meters long, suitable for use to 1500 MHz.	Belden 8281 or 1694A. Tektronix part numbers 012-0159-00 or 012-0159-01.
Precision 75 Ω terminator for Analog Video	75 Ω ±0.025% to 6 MHz, male BNC connector.	Tektronix part number 011-0102-03.

Table 59: Required equipment – functional tests (cont.)

Test equipment	Requirements	Example
Waveform Monitor	SMPTE 259-C (270 Mb/s) and SMPTE 292M (1.5 Gb/s) inputs with EDH/CRC checking.	Tektronix WFM8300
3 Gb/s Waveform Monitor (Option 3G)	SMPTE 424M /425M (3 Gb/s) input with CRC checking.	Tektronix WFM7120 or WFM8300 *NOTE. Only one waveform monitor is needed for the tests, so a 270M/1.5G/3G monitor will meet both of the above requirements.*
Analog Audio Breakout cable (Options AD and DPE)	DB62 to XLR I/O	Tektronix part number 012-1688-00
Analog Audio Signal Generator (Options AD and DPE)	2 channel balanced XLR outputs, +18 dBu output capability, ±0.1 dB output level accuracy, less than 50 Ω output impedance.	Rohde & Schwarz UPL06
AES Audio Signal Generator (Options AD and DPE)	48 kHz, 24-bit word length signals.	Rohde & Schwarz UPL06
AES Audio Signal Analyzer (Options AD and DPE)	1 unbalanced AES input, -40 dBFS to 0 dBFS measurement range.	Rohde & Schwarz UPL06
Dolby bit-stream generator (Option DPE)	Generate Dolby Digital, Dolby E, and PCM bit streams at 48 kHz. AES3ID-1995 / SMPTE 276M output (75 Ω BNC).	Dolby Laboratories DM100 Bitstream Analyzer
LTC (Timecode) generator	Complies with SMPTE 12M LTC specifications, capable of being locked to an NTSC composite analog video source.	Horita TG-50
HD-15 male connector with custom cable	Plugs into the REMOTE port, used to make the LTC and ground closure interface tests.	See "LTC Waveform" and "Ground Closure Remote" functional tests for cable construction details.
Voltmeter	0 V to 5 V range, 2% or better accuracy.	Fluke model 87
Computer and Ethernet Cable	Computer with web browser and Ethernet port; appropriate length Ethernet cable (8 conductor RJ-45 terminations, either straight through or crossover).	Used for Ethernet test.

Incoming Inspection Tests

Basic Turn On and Self Test

1. Connect the AC line cord to the rear of the instrument and to a 100 to 240 VAC source. Press the **Power** button to turn the instrument on.

2. After about 30 seconds, the power-on diagnostic page should appear on the screen.

3. Verify that all self tests pass. Any failures will be shown in red. The results of the power-on diagnostics are erased from the screen, but you can view the results by selecting **CONFIG > Utilities > View Diagnostics Log > SEL**.

4. After the diagnostics are finished, the instrument state is restored. When the progress indicator in the status bar is finished, the instrument has finished initializing.

5. Record Pass or Fail for the POST (Power On Self Test) in the test record.

6. If it is still open, exit the Diagnostics Log.

Restore the Factory Presets

1. Follow these steps to reset the waveform monitor to the Factory Presets:

   a. Press and hold the **PRESET** button.

   b. Select **Recall Preset > Recall Factory Preset**.

   c. Press the **SEL** button.

Front Panel Test

1. Set the waveform monitor to the Factory Presets. (See *Restore Factory Presets.*) Wait for the process to complete as indicated by the progress indicator. Record Pass or Fail in the test record.

2. Connect a 525/270 color bar signal from the TG700 DVG7 to the SDI A input.

3. Press **FULL** to set the active tile to full screen.

4. Turn the **HORIZONTAL** and **VERTICAL** knobs and verify the waveform moves appropriately.

5. Press **HELP** to display the online help.

6. Press each of the front panel buttons, except for the **HELP** and **POWER** buttons.

   Each button should flash as you press it. Most buttons will bring up help text related to that button in the right pane of the help screen. Some buttons, such as the presets, all bring up the same information, so you may need to alternate between preset buttons and another button to see the text change. The navigation keys (the four arrow keys and the **SEL** key) do not bring up help text. They are used to navigate the help panes and content.

7. Press the right arrow key until the Help Contents pane in the upper-left corner is highlighted.

8. Turn the **GENERAL** knob and verify the selector box moves up and down the list of topics.

9. Press **HELP** to exit help.

10. Record Pass or Fail for Front Panel Test in the test record.

LCD Pixel Defects

1. Set the waveform monitor to display a white screen:

    a. Press the **CONFIG** button.

    b. Select **Utilities > Screen Solid Color > Select Color > White**.

    c. Press the **SEL** button.

2. Count any pixels stuck low (not white).

3. While the screen is all white, inspect for visible defects that exceed the limits. (See Table 60.)

NOTE. Inspection should be done from 18″ away from the display, under normal room lighting. Loose dust on the front of the screen does not constitute a defect.

4. Press the **SEL** button to cancel the white screen.

5. Set the waveform monitor for an all black screen:

    a. Select **Utilities > Screen Solid Color > Select Color > Black**.

    b. Press the **SEL** button.

6. Count any pixels stuck high (not black).

7. Press the **SEL** button to cancel the black screen.

8. Check that the total number of pixels counted in steps 2 and 6 is less than six.

Table 60: LCD visual defects

Defect type [1]	Allowable defect	
Circular Defect [2]	>0.020″	None
	0.015″ to 0.020″	Maximum of two allowed within a 2l circle
Black Defect (opaque)	>0.005″	None
Linear Defect (Scratches)	>0.004″ width	None
	0.003″ to 0.004″wide	Max length 0.500″
	0.0021″ to 0.0030″wide	Max length 1.000″
	0.0010″ to 0.0020″wide	Max length 1.500″
Stains, discolorations, streaks, scuffs	Allowed if they fade when backlit	

[1] Defects should be visible from 18" under normal lighting. If you have to hold it closer or use special lighting to see the defect, it is not a rejectable defect.

[2] For irregular defects, use (LengthxWidth)/2.

9. Record pass or fail for Pixel Defect in the test record.

10. Press the **CONFIG** button to close the configuration menu.

Diagnostics Test

1. Run the Diagnostics:

    a. Press the **CONFIG** button.

    b. Select **Utilities > Run Diagnostics**.

    c. Press the **SEL** button. The diagnostics screen will appear.

    d. Use the left/right arrow keys to select "Run Power Up Diagnostics", then press **SEL**.

2. Verify that all the tests have a green Pass status. Record pass or fail for "Power Up Diagnostics" in the test record.

3. Use the left/right arrow keys to select "Run Advanced Diagnostics", then press **SEL**.

4. Verify that all the tests have a green Pass status. Record pass or fail for "Advanced Diagnostics" in the test record.

Fan Test

You should be able to hear the fans and feel air coming out the back of the instrument. At low temperatures the fans will turn slowly and be very quiet. Record Pass or Fail for Fan Test in the test record.

SDI Input Operation Test

1. Set the video test generator to output the following SDI signals:

    a. 270 Mb/s: 525i 59.94, 100% Color Bars, Group 1 AES embedded audio ON

    b. 1.5 Gb/s: 1080i 59.94, 100% Color Bars, Group 1 AES embedded audio ON

    c. (Option 3G only) 3 Gb/s: 3G Level A, 1080p 59.94 YCbCr 10 bit, 100% Color Bars, Group 1 AES embedded audio ON

2. Perform the following steps to set the TG700 DVG7 module (270 Mb/s):

    a. Restore the Factory Preset.

    b. Press the **MODULE** button until DVG7 appears.

    c. Press the **FORMAT** button until 525-270 appears and then press **ENTER**.

    d. Press the **CANCEL** button.

    e. Press the up/down arrows until Audio (Embedded) appears. If Group 1 is not indicated then press the right/left arrows until Group 1 appears. Press **ENTER**.

      f. Use the right/left arrows until Status: Enable appears, then press **ENTER**.

      g. Repeatedly press the **COLOR BAR** button until 100% Color Bars appears.

3. Perform the following steps to set the TG700 HDVG7 module (1.5 Gb/s):

      a. Press the **MODULE** button until HDVG7 appears.

      b. Press the **FORMAT** button until 1080 59.94i appears and then press **ENTER**.

      c. Press the **CANCEL** button.

      d. Press the up/down arrows until Audio (Embedded) appears. If Group 1 is not indicated then press the right/left arrows until Group 1 appears. Press **ENTER**.

      e. Use the right/left arrows until Status: Enable appears, then press **ENTER**.

      f. Repeatedly press the **COLOR BAR** button until 100% Color Bars appears.

4. (Option 3G only) Perform the following steps to set the TG700 HD3G7 module (3 Gb/s):

      a. Press the **MODULE** button until HDVG7 appears.

      b. Press the **FORMAT** button until 1080 59.94p appears and then press **ENTER**.

      c. Press the **CANCEL** button.

      d. Press the up/down arrows until Audio (Embedded) appears. If Group 1 is not indicated then press the right/left arrows until Group 1 appears. Press **ENTER**.

      e. Use the right/left arrows until Status: Enable appears, then press **ENTER**.

      f. Repeatedly press the **COLOR BAR** button until 100% Color Bars appears.

5. Connect the 525/270 color bar signal from the DVG7 to the SDI A input. Connect the SDI A Out to the input of a second waveform monitor that has 270 Mb/s EDH/CRC check capability.

6. Set the waveform monitor to the Factory Preset. (See page 56, *Restore the Factory Presets*.)

7. Press **Display Select 2** to select tile 2.

8. Press and hold the **STATUS** button. Select **Display Type > Video Session**. Press **STATUS** to close the menu.

9. A 4-tile display consisting of waveform, video session status, picture, and audio level bars should appear. Check that:

   a. The waveform display shows a stable YPbPr parade, with all three components present and each being 700 mVp-p.

   b. The Video Session screen indicates "OK" for CRC errors.

   c. A full field color bar waveform appears in the Picture display.

   d. Audio bars appear for Channels 1-4 (nominally at –20 dBFS), if the audio option is present.

   e. The lower left corner readout indicates "525i 59.94".

10. On the second waveform monitor, check that a color bar signal is being received and that no EDH/CRC errors are present. Repeat steps 7 and 8 above.

11. Record Pass or Fail for SDI A, 270 Mb/s in the test record.

12. Move the generator test signal from the SDI A input to the SDI B input. Move the cable connected to the second waveform monitor from the SDI A Out to the SDI B/CLK Out. Select **Input 1B**.

13. Repeat step 9 above. Record pass or fail for SDI B, 270 Mb/s in the test record.

14. Connect the 1.5 Gb/s 1080i/59.94 color bar signal from the HDVG7 to the SDI B input. Connect the SDI B/CLK Out to the input of a second waveform monitor that has 1.5 Gb/s CRC check capability. Input 1B should be selected.

15. A 4-tile display consisting of waveform, video session status, picture, and audio level bars should appear. Check that:

   a. The waveform display shows a stable YPbPr parade, with all three components present and each being 700 mVp-p.

   b. The Video Session screen indicates "OK" for CRC errors.

   c. A full field color bar waveform appears in the Picture display.

   d. Audio bars appear for Channels 1-4 (nominally at –20 dBFS), if the audio option is present.

   e. The lower left corner readout indicates "1080i 59.94".

16. On the second waveform monitor, check that a color bar signal is being received and that no CRC errors are present.

17. Record Pass or Fail for SDI B, 1.5 Gb/s in the test record.

18. Repeat steps 13 through 15 above for the SDI A input. Record Pass or Fail for SDI A, 1.5 Gb/s in the test record. Skip to the next section unless Option 3G is installed.

19. (Option 3G only) Connect the 3 Gb/s 1080p/59.94 color bar signal from the HD3G7 to the SDI A input. Connect the SDI A Out to the input of a second

waveform monitor that has 3 Gb/s CRC check capability. Input 1A should be selected.

20. A 4-tile display consisting of waveform, video session status, picture, and audio level bars should appear. Check that:

    a. The waveform display shows a stable YPbPr parade, with all three components present and each being 700 mVp-p.

    b. The Video Session screen indicates "OK" for CRC errors.

    c. A full field color bar waveform appears in the Picture display.

    d. Audio bars appear for Channels 1-4 (nominally at –20 dBFS), if the audio option is present.

    e. The lower left corner readout indicates "1080p 59.94".

21. On the second waveform monitor, check that a color bar signal is being received and that no CRC errors are present.

22. Record Pass or Fail for SDI A, 3Gb/s in the test record.

23. Repeat steps 19 through 22 above for the SDI B input. Record Pass or Fail for SDI B, 3 Gb/s in the test record.

Waveform Signal Path Stuck Bit Test.

1. Connect a 1.5 Gb/s 1080i 59.94 10-bit shallow ramp matrix signal from the HDVG7 module to the SDI A input of the instrument under test. (The shallow ramp matrix signal can be found under the LINEARITY button).

2. Set the waveform monitor to Factory Presets. (See page 56, *Restore the Factory Presets*.) A YPbPr parade should be displayed in Tile 1.

3. Turn off the Pb waveform:

    a. Press and hold the **WFM** button to display the waveform menu.

    b. Select **Pb**.

    c. Use the **SEL** button to select **Off**.

    d. Press the **WFM** button to close the menu.

4. Press the **FULL** button to expand the waveform tile to full screen.

5. Inspect the Y and Pr waveforms. Each should contain a series of equally spaced shallow ramps. Each ramp should increase monotonically. Stuck bits will show as coarse steps or discontinuities in the ramps. The standard HDVG7 signal set will show 11 ramps of 70 mV each.

    a. Press and hold the **GAIN** button to display the Gain menu.

    b. Select **Gain Settings**.

       c. Use the arrow keys to select **x10**.

       d. Press the **GAIN** button once to close the Gain menu. The **GAIN** button should remain lit.

6. Inspect one shallow ramp in each of the Y and Pr waveforms. Small steps will be visible in the ramp. The steps should always step upward in equal increments over the entire ramp. Check for 11 to 13 even vertical steps over a major division (10 mV).

7. Press the **GAIN** button to return the instrument to x1 gain.

8. Change the input signal to a 100% sweep 1-15 MHz.

9. Verify that the sine waves are uniform and do not have steps. Also check that the amplitude is 700 mV.

10. Move the input signal to the SDI B input and press the Input **1B** button. Select the shallow ramp matrix on the test signal generator.

11. Repeat steps 5 through 9 for the SDI B input.

12. Record Pass or Fail for the Waveform Stuck Bit Test in the test record.

External Reference

1. Restore the Factory Preset. (See page 56, *Restore the Factory Presets*.)

2. Connect a 525/270 color bars signal from a DVG7 module to the SDI A input of the instrument under test.

3. Apply an NTSC 0% Flat Field signal from an AVG7 module to the REF LOOP input. The AVG7 and DVG7 must be installed in the same TG700 mainframe or, if not, the signals must be genlocked. Install a 75 Ω termination on the other side of the REF LOOP loop-through.

4. Press **EXT REF** on the instrument front panel.

5. The status bar in the lower left-hand corner of the display should display Ref: NTSC.

6. Press the Display Select **4** button, then the **WFM** button, and then the **SWEEP** button.

7. Verify that both WFM tiles are stable.

8. Record Pass or Fail for NTSC Lock in the test record.

9. Remove the NTSC signal from the REF LOOP input.

10. Both WFM tiles should "unlock" and scroll.

11. The status bar in the lower left-hand corner of the display should display Ref: Ext. Missing.

12. Record Pass or Fail for Ref Missing in the test record.

Eye (WFM8300 Option PHY and WFM8200 Option EYE)

1. Restore the Factory Preset. (See page 56, *Restore the Factory Presets*.)

2. Connect a 525/270 color bar signal from a DVG7 module to the SDI A input of the instrument under test.

3. Press the **EYE** button.

4. Check for the presence of a stable eye diagram in tile 1. The actual wave shape depends on the generator signal. A bar graph showing p-p jitter should be active in the upper left corner of tile 1. Again, the measured jitter will depend on the generator signal but will typically be less than 0.2 UI from a high quality source.

5. Record Pass or Fail for 270 Mb/s Eye Waveform in the test record.

6. Proceed to the next step if you have a WFM8300 with option PHY. Otherwise, skip to step 10.

7. Set tile 2 to show the jitter waveform:

   a. Press **Display Select 2** to select tile 2.

   b. Press **EYE**. An eye pattern display like that in tile 1 should appear.

   c. Press and hold the **EYE** button to display the Eye waveform menu.

   d. Select **Display Type > Jitter Display**. The jitter waveform should appear.

   e. Press and hold the **GAIN** button and select **Gain Settings > x10**.

   f. Briefly press the **GAIN** button to dismiss the menu.

8. Check that the jitter waveform is active and that a jitter amplitude bar graph appears in the upper left corner. The measured jitter will depend on the generator signal but will typically be less than 0.2UI from a high quality source. The maximum peak-to-peak vertical signal variation shown in the jitter waveform should be similar to the bar graph reading.

9. Record pass or Fail for 270 Mb/s Jitter Waveform in the test record.

10. Connect a 1.5 Gb/s 1080i 59.94 color bar signal from a HDVG7 module to the SDI A input.

11. Check for the presence of a stable eye diagram in tile 1. The actual wave shape depends on the generator signal. A bar graph showing p-p jitter should be active in the upper left corner of tile 1. Again, the measured jitter will depend on the generator signal but will typically be less than 0.2 UI from a high quality source.

12. Record Pass or Fail for 1.5 Gb/s Eye Waveform in the test record.

13. Proceed to the next step if you have a WFM8300 with option PHY. Otherwise, skip to step 16.

14. Check that an active jitter waveform and bar graph appears in tile 2. The measured jitter will depend on the generator signal but will typically be less

than 0.2 UI from a high quality source. The maximum peak-to-peak vertical signal variation shown in the jitter waveform should be similar to the bar graph reading.

15. Record Pass or Fail for 1.5 Gb/s Jitter Waveform in the test record.

16. Proceed to the next step if you have option 3G. Otherwise, the test is complete.

17. Connect a 3 Gb/s 1080p 59.94 color bar signal from a HD3G7 module to the SDI A input.

18. Check for the presence of a stable eye diagram in tile 1. The actual wave shape depends on the generator signal. A bar graph showing p-p jitter should be active in the upper left corner of tile 1. Again, the measured jitter will depend on the generator signal but will typically be less than 0.2 UI from a high quality source.

19. Record Pass or Fail for 3 Gb/s Eye Waveform in the test record.

20. Proceed to the next step if you have a WFM8300 with option PHY. Otherwise, the test is complete.

21. Check that an active jitter waveform and bar graph appears in tile 2. The measured jitter will depend on the generator signal but will typically be less than 0.2 UI from a high quality source. The maximum peak-to-peak vertical signal variation shown in the jitter waveform should be similar to the bar graph reading.

22. Record Pass or Fail for 3 Gb/s Jitter Waveform in the test record.

Composite Input (Option CPS)

1. Restore the Factory Preset. (See page 56, *Restore the Factory Presets*.)

2. Apply an NTSC 100% color bar signal from the TG700 AVG7 module to the Composite A input (CMPST A). Install a 75 Ω termination on the loop through.

3. Press **Input 2A** to select the CMPST A input.

4. Observe the WFM display in tile 1. The signal should be stable and measure 100 IRE from blanking level to the white bar.

5. Record Pass or Fail for WFM with NTSC in the test record.

6. Observe the Vector in tile 2. The burst should be aligned with the burst marker that extends to the left of the vector center and the vectors should land in their target boxes.

7. Record Pass or Fail for Vector with NTSC in the test record.

8. Observe the picture in tile 3. It should be stable and show the color bar signal.

9. Record Pass or Fail for Picture with NTSC in the test record.

10. If desired, move the input to CMPST B and repeat steps 3 through 9.

Analog Audio Input (Options AD and DPE)

1. Restore the Factory Preset. (See page 56, *Restore the Factory Presets*.)

2. Set the analog audio generator to output a 1 kHz, 18 dBu sine wave.

3. Press and hold the **Display Select 4** button to display the Audio pop-up menu.

4. Select **Audio Input** and then select **Analog A**.

5. Press the **AUDIO** button briefly to dismiss the menu.

6. Using the audio breakout cable or equivalent, connect the analog audio generator to the first Line A input pair and verify that the output level of the generator signal is 18 dBu, as indicated on the audio bars.

7. Repeat step 6 for the second and third line A input pair.

8. Record Pass or Fail in the test record.

9. Press and hold the **Display Select 4** button to display the AUDIO pop-up menu.

10. Select **Audio Input** and then select **Analog B**.

11. Press the **AUDIO** button briefly to dismiss the menu.

12. Repeat step 6 for all three Line B input pairs.

13. Record Pass or Fail in the test record.

Analog Audio Output (Options AD and DPE)

1. Restore the Factory Preset. (See page 56, *Restore the Factory Presets*.)

2. Press and hold the **Display Select 4** button to display the AUDIO pop-up menu.

3. Select **Audio Input** and then select **Analog A**.

4. Press the **AUDIO** button briefly to dismiss the menu.

5. Using the audio breakout cable or equivalent, connect the first Line A input pair (Inputs A1 and A2) to the analog audio generator and verify that the output level of the generator is 18 dBu, as indicated on the audio bars.

6. Press **CONFIG** to display the **CONFIG** menu.

7. Select **Audio Inputs/Outputs > Atten Analog Out**.

8. Press **SEL** and use the **General** knob to adjust the value to 0 dB, then press **SEL** again to set the value.

9. While still in the Audio Inputs/Outputs submenu, select **Analog A > Analog Output Map**.

10. Press **SEL** to display the Analog Output to Analog "A" Bar Map.

11. Put an X in the first bar pair row for Analog Outputs 1&2, 3&4, 5&6, and 7&8. This replicates the audio signal present on bars 1 and 2 on all of the Analog Output pairs.

12. Press **CONFIG** to exit the CONFIG menu.

13. Connect the first analog output pair (Outputs 1 and 2) on the breakout cable to the second line A input pair (Inputs A3 and A4).

14. Verify on the level meter bars that the second set of bars is within 1 dB of the first set of bars.

15. Connect the second analog output pair (Outputs 3 and 4) on the breakout cable to the second line A input pair (Inputs A3 and A4).

16. Verify on the level meter bars that the second set of bars is within 1 dB of the first set of bars.

17. Connect the third analog output pair (Outputs 5 and 6) on the breakout cable to the second line A input pair (Inputs A3 and A4).

18. Verify on the level meter bars that the second set of bars is within 1 dB of the first set of bars.

19. Connect the fourth analog output pair (Outputs 7 and 8) on the breakout cable to the second line A input pair (Inputs A3 and A4).

20. Verify on the level meter bars that the second set of bars is within 1 dB of the first set of bars.

21. Record Pass or Fail in the test record.

Digital Audio Input (Options AD and DPE)

1. Restore the Factory Preset. (See page 56, *Restore the Factory Presets*.)

2. Set the digital audio generator to output a 1 kHz, –6 dBFS sine wave.

3. Press and hold the **Display Select 4** button to display the AUDIO pop-up menu.

4. Select **Audio Input > AES A**.

5. Connect the unbalanced output of the digital audio generator to the AES A 1-2 input.

6. Press the **AUDIO** button to dismiss the menu.

7. Verify that the first set of level meter bars indicates –6 dBFS.

8. Repeat steps 5 and 7 for AES A 3-4, AES A 5-6, and AES A 7-8.

9. Record Pass or Fail for AES A in the test record.

10. Press and hold the **Display Select 4** button to display the AUDIO pop-up menu.

11. Select **Audio Input > AES B**.

12. Press the **AUDIO** button to dismiss the menu.

13. Connect the output of the digital audio generator to the AES B I/O 1,2 input.

14. Verify that the first set of level meter bars indicates –6 dBFS.

15. Repeat steps 13 and 14 for AES B 3-4, AES B 5-6, and AES B 7-8.

16. Record Pass or Fail for AES B in the test record.

17. Set the video test signal generator to output a 270 Mb/s 525 line color bar signal with Group 1 and 2 embedded audio set as follows:

- Group 1, Channel 1 (Ch 1): 50 Hz, –35 dBFS

- Group 1, Channel 2:(Ch 2): 100 Hz, –30 dBFS

- Group 1, Channel 3 (Ch 3): 150 Hz, –25 dBFS

- Group 1, Channel 4 (Ch 4): 200 Hz, –20 dBFS

- Group 2, Channel 1 (Ch 5): 250 Hz, –15 dBFS

- Group 2, Channel 2 (Ch 6): 300 Hz, –10 dBFS

- Group 2, Channel 3 (Ch 7): 400 Hz, –5 dBFS

- Group 2, Channel 4 (Ch 8): 500 Hz, 0 dBFS

If using a TG700 DVG7 module, use the following procedure to configure the embedded audio:

a. Press **MODULE** repeatedly until DVG7 is displayed.

b. If 525-270 does not show, press **FORMAT** repeatedly until 525-270 is displayed and then press **ENTER**.

c. Press **CANCEL** to return to the top menu.

d. Press the up/down arrow keys until AUDIO (EMBEDDED) is displayed. Use the left/right arrow keys to select "Group 1", then press **ENTER**.

e. Press the up/down arrow keys until "Status" is displayed, then use the left/right arrow keys to select "Enable", then press **ENTER**.

NOTE. It is important to press the Enter key even if Status: Enable is displayed, to ensure that the Embedded Audio is actually turned on.

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f. Press the up/down arrow keys until "Channel" is displayed. Then press the left/right arrow keys until "Channel 1" appears. Press **ENTER**.

g. Press the up/down arrow keys until "Frequency" is displayed. Press the left/right arrow keys to select "50 Hz", then press **ENTER**.

h. Press the up/down arrow keys until "Amplitude" is displayed. Use the left / right arrow keys to select "–35 dBFS", then press **ENTER**.

i. Press the **CANCEL** key once to return to AUDIO:GRP-1:Channel. Use the left/right keys to select Channel:2, then press **ENTER**.

j. Following the procedure in steps g through i above, set channels 2, 3, and 4 to the values shown at the start of step 17.

k. After setting channels 1–4, press **CANCEL** twice to return to AUDIO (EMBEDDED). Press the left/right arrow keys to select "Group 2", then press **ENTER**.

l. Enable the Group 2 audio, following step e above.

m. Set Channels 1 through 4 in Group 2 to the values shown at the start of step 17, following the procedure in steps g through i above.

n. Press **CANCEL** twice to return to the AUDIO (EMBEDDED) menu.

o. Press **COLOR BAR** to return to the top level menu and select a color bar signal.

18. Connect the output of the DVG7 to the SDI A input of the instrument under test.

19. Press and hold the **Display Select 4** button to display the Audio pop-up menu.

20. Select **Audio Input > Embedded**.

21. Press the **AUDIO** button to clear the menu.

22. Verify that the level meter bars have a stair step pattern from –35 dB on channel 1 to 0 dB on channel 8.

23. Record Pass or Fail for Embedded to Bar Display in the test record.

24. Press and hold the **Display Select 4** button to display the AUDIO pop-up menu.

25. Select **Phase Pair > 1 & 2**.

26. Go through the other phase pairs (3 & 4, 5 & 6, 7 & 8) and verify that the phase display changes as each pair is selected.

27. Record Pass or Fail for Embedded to Lissajous Display in the test record.

Digital Audio Output (Options AD and DPE)

1. Restore the Factory Preset. (See page 56, *Restore the Factory Presets*.)

2. If you have just finished testing the Digital Audio Inputs, proceed to step 3, otherwise perform the *Digital Audio Input* test.

3. Press **CONFIG** to display the configuration menu.

4. Select **Audio Inputs/Outputs > AES B Config Port As > Output**.

5. Briefly press the **CONFIG** button to close the menu.

6. Connect the AES B 1-2 output to the Audio Signal Analyzer input.

7. Verify on the analyzer that the signal levels are at –35 dBFS for the left channel and –30 dBFS for the right.

8. Connect the AES B 3-4 output to the Audio Signal Analyzer input.

9. Verify on the analyzer that the signal levels are at –25 dBFS for the left channel and –20 dBFS for the right.

10. Connect the AES B 5-6 output to the Audio Signal Analyzer input.

11. Verify on the analyzer that the signal levels are at –15 dBFS for the left channel and –10 dBFS for the right.

12. Connect the AES B 7-8 output to the Audio Signal Analyzer input.

13. Verify on the analyzer that the signal levels are at –5 dBFS for the left channel and 0 dBFS for the right.

14. Record Pass or Fail for each output in the test record.

Dolby Decode (Option DPE)

1. Restore the Factory Preset. (See page 56, *Restore the Factory Presets*.)

2. Press and hold **Display Select 4** button to display the AUDIO pop-up menu.

3. Select **Audio Input > AES A**.

4. Press the **Display Select 4** button again to dismiss the pop-up.

5. Set the Dolby generator for a Dolby D output using the following steps:

   a. Press Gen to display the Gen Stream Sel message.

   b. Press the Up/Down buttons to select a Dolby D stream as indicated by the leading "D" in the bit stream name.

   c. Press **Enter** to activate the selected signal.

6. Connect the Digital Output of the Dolby generator to the AES A1-2 IN BNC with a 75 Ω cable.

7. Check for the "DOLBY D" message in bars 1 and 2 of the Audio display.

8. Press and hold the **Display Select 4** button to display the AUDIO pop-up menu.

9. Select **Audio Input > Dolby 2**. (This setting decodes Dolby streams from the AES A 1-2 input.)

10. Press the **Display Select 4** button again to dismiss the pop-up.

11. Check that the audio display shows the decoded Dolby signal.

12. Check that the Dolby program type shown in the top line of the audio display, for example "D 3/2 L", agrees with the Dolby generator setting.

13. Change the Dolby generator to a Dolby E output:

    a. Press the Up/Down buttons to select a Dolby E stream as indicated by the leading "E" in the bit stream name.

    b. Press **Enter** to activate the selected signal.

14. If option DPE is present, check that the audio display shows the decoded Dolby signal and that the Dolby program type shown in the top line of the audio display, for example "E 2+2", agrees with the Dolby generator setting.

15. If option DPE is not present, check for the "DOLBY E" message in bars 1 and 2 of the Audio display.

16. Record Pass or Fail for Dolby Decode in the test record.

LTC Waveform and Decode Test

1. Restore to Factory Presets. (See page 56, *Restore the Factory Presets*.)

2. You will need a custom cable for this step.

    a. Make a shielded coaxial cable with a male RCA connector on one end. On the other end connect the coax center conductor to pin 7 and the outer shield conductor to pin 8 of a male HD-15 connector.

3. Connect the RCA connector on the custom cable to the output of the Timecode generator. Connect the 15-pin connector to the REMOTE connector on the waveform monitor rear panel.

4. Connect the TG700 AVG7 CH1 output to the video input of the Timecode generator. Select any NTSC signal.

5. Connect a 525/270 color bar signal from the DVG7 module to the SDI A input of the instrument under test.

NOTE. The DVG7 and AVG7 must be installed in the same TG700 mainframe so that their outputs are synchronous.

6. Press **CONFIG**.

7. Select **Aux Data Settings > Timecode Source > LTC**.

8. Press the **OTHER** button to display the LTC waveform.

9. The LTC waveform should be displayed in the active tile. The amplitude will depend on the source. The sync packet should remain at a constant horizontal location on the sweep.

10. Record Pass or Fail for the LTC waveform in the test record.

11. In the lower-right corner of the screen, the time from the LTC input should be shown. It may be necessary to reset the LTC generator by using the reset switch.

12. Record Pass or Fail for LTC Decode in the test record.

13. Disconnect the LTC generator.

Ground Closure Remote

1. Connect a 525/270 color bar signal to the SDI A input.

2. You will need a custom cable for this step.

    a. Solder wires to pins 1, 2, 5, 6, 7, 8, and 9 of a male DB9 connector, and strip the insulation back approximately 1/4 inch on each of the wires.

3. Connect the HD-15 connector to the REMOTE connector on the waveform monitor.

Preset Recall Test.

4. Restore the Factory Preset. (See page 56, *Restore the Factory Presets*.)

NOTE. This test overwrites presets A1 through A4. Save any existing presets to USB flash memory before doing this procedure.

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5. Set the waveform monitor to display a picture in tile 1 and a waveform in the remaining tiles:

    a. Press the **Display Select 1** button and then press the **PICT** button.

    b. Press the **Display Select 2** button and then press the **WFM** button.

    c. Press the **Display Select 3** button and then press the **WFM** button.

    d. Press the **Display Select 4** button and then press the **WFM** button.

6. Save the current settings as preset A1:

    a. Press and hold the **PRESET** button to display the Preset Menu.

    b. Select **Save Preset > Select Group A > Save A1**.

    c. Press **SEL** to save the preset.

    d. Briefly press the **PRESET** button to close the Preset menu.

7. Repeat steps 5 and 6 to create a preset with picture in tile 2 and waveform in tiles 1, 3, and 4. Save as Preset **A2**.

8. Repeat steps 5 and 6 to create a preset with picture in tile 3 and waveform in tiles 1, 2, and 4. Save as Preset **A3**.

9. Repeat steps 5 and 6 to create a preset with picture in tile 4 and waveform in tiles 1, 2, and 3. Save as Preset **A4**.

10. Repeat steps 5 and 6 to create a preset with picture in tiles 1 and 4 and waveform in tiles 2 and 3. Save as Preset **A5**.

11. Repeat steps 5 and 6 to create a preset with picture in tiles 2 and 4 and waveform in tiles 1 and 3. Save as Preset **A6**.

12. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.)

13. Short pins 1 and 10 together on the remote cable.

14. Preset **A1** should be restored so that a picture is displayed in tile 1.

15. Short pins 1 and 11 together on the remote cable.

16. Preset **A2** should be restored so that a picture is displayed in tile 2.

17. Short pins 1 and 12 together on the remote cable.

18. Preset **A3** should be restored so that a picture is displayed in tile 3.

19. Short pins 1 and 13 together on the remote cable.

20. Preset **A4** should be restored so that a picture is displayed in tile 4.

21. Short pins 1 and 14 together on the remote cable. Preset **A5** should be restored with a picture in tiles 1 and 4.

22. Short pins 1 and 15 together on the remote cable. Preset **A6** should be restored with a picture in tiles 2 and 4.

23. Record Pass or Fail for Activate Preset in the test record.

24. Restore saved presets from the USB flash memory device (if saved before this procedure).

Ground Closure Alarm Test.

25. Connect a 525/270 color bar signal from the DVG7 to the SDI A input.

26. Restore the Factory Preset. (See page 56, *Restore the Factory Presets*.)

27. On a 15-pin, male HD-15 connector, solder wires or strip back insulation to gain access to pins 1 and 9 (pin 1 is a ground and pin 9 is the ground closure output signal).

NOTE. You can use the test cable prepared for the previous step.

28. Connect the HD-15 connector to the REMOTE connector on the waveform monitor.

29. Press the **CONFIG** button to display the CONFIG menu.

30. Select **Alarms > SDI Input**, then press the **SEL** button.

31. Use the arrow keys to move the selection highlighting to the **Ground Closure** column of the **SDI Input Missing** row, and then press **SEL** to put an X in

the box. This instructs the waveform monitor to assert the ground closure if the input is not present.

32. Connect the voltmeter (+) lead to the pin 9 wire and the (–) lead to the pin 1 wire. The voltmeter should read about 4.7 V.

33. Remove the video signal from the SDI A connector to assert the ground closure.

34. The voltmeter should now read a low voltage, below 0.5 V.

35. Record Pass or Fail for Ground Closure Alarm in the test record.

Ethernet Test

1. Connect the instrument's Ethernet port to a computer that has a web browser installed. You can use a Local Area Network (LAN) to interconnect the instrument and computer, or directly connect the instrument and computer Ethernet ports. LAN interconnection is recommended as this simplifies setting the IP address.

2. To interconnect with a LAN:

    a. Connect both the instrument and the computer to LAN ports using Ethernet cables.

    b. Press the **CONFIG** button to display the Configuration menu.

    c. Select **Network Settings > IP Config Mode**.

    d. Select **DHCP**. In this mode the network will assign an IP address to the instrument. The address fields should momentarily read "Waiting on DHCP" before the assigned addresses appear.

3. To use a direct connection between the instrument and computer:

    a. Connect the instrument and computer with an Ethernet cable. Either a direct or crossover cable may be used.

    b. Select compatible IP addresses for the instrument and computer. Either or both addresses may be changed. A suggested approach is to set the addresses the same for the first three fields, then setting the last field one digit different. For example:

    Instrument: 192.168.001.001
    Computer: 192.168.001.002

NOTE. On most Windows computers, using the command "ipconfig" in the Command Prompt window will show the computer IP address value. It may be manually set via Control Panel > Network Connections.

    c. To change the IP address on the instrument, press **CONFIG** and select **Network Settings > IP Config Mode > Manual**. Now select **Network**

Settings > IP Address. Use the left/right arrow keys to move the highlight to each box in the address. Use the up/down arrow keys to change the number in each box as required. Accept the changes by moving the highlight to the Accept box and press **SEL**.

4. Enable the instrument Web access from the Configuration menu by selecting **Network Settings > Web Enable > On**.

5. Open a Web browser on the computer.

6. From the computer, enter the IP address of the waveform monitor into the Web browser address line (for example, http://192.168.1.1). This is the address that appears in the field **CONFIG > Network Settings > IP Address**. Note that leading zeros are deleted in the address line.

7. You should see a Web page titled "Tektronix WFM8200/8300 Interface" or something similar. This means the Ethernet function is working.

8. Record Pass or Fail for Ethernet Functionality in the test record.

NOTE. While in Simultaneous Input mode, certain displays can be displayed either on the left or on the right, but not both at the same time.

Simultaneous Input Operation Test (WFM8300 Only)

1. Set up a signal generator with an HDVG7 module and a DVG7 module. Connect an output from the HDVG7 module to the SDI A input of the instrument under test.

2. Connect an output from the DVG7 module to the SDI B input of the instrument under test.

3. Set the HDVG7 module to output 1080 59.94i 100% color bars.

4. Set the DVG7 module to output 525-270 SMPTE color bars.

5. Restore the Factory Preset. (See page 56, *Restore the Factory Presets*.)

6. Press the **CONFIG** button.

7. Select **Input Mode > Simultaneous**.

8. Press the **CONFIG** button again to remove the menu.

9. Press **Display Select 2** to select tile 2.

10. Press the **WFM** button to select the waveform display in tile 2.

11. Press **Display Select 4** to select tile 4.

12. Press the **PICT** button to select the picture display.

13. Check that the left two tiles (tiles 1 and 3) show the signal from the SDI A input. Check that the right two tiles (tiles 2 and 4) show the signal from the SDI B input.

14. Check that the left portion of the Status Bar displays the status of the SDI A signal input. Check that the right portion of the Status Bar displays the status of the SDI B signal input.

15. Enter Pass or Fail in the test record.

Dual Link Format Verification Test

1. Set up a dual link signal generator (TG700 with HDLG7 module). Connect the Link A output on the module to the SDI A input of the instrument, and the Link B output to the SDI B input of the instrument.

2. Perform the following steps to set the HDLG7 module format to 1080 59.94i:

    a. Press the **MODULE** button until HDLG7 appears.

    b. On the signal generator, press the **FORMAT** button until 1080 59.94i appears and then press the **ENTER** button.

    c. Press the **CANCEL** button.

    d. Press the up/down arrows until Sample Structure/Depth appears.

    e. Press the left/right arrows until "YCbCr+A 4:4:4 10 bits" appears.

    f. Press the **ENTER** button.

    g. Press the **COLOR BAR** button until 100% color bars appears.

3. Restore the Factory Preset. (See page 56, *Restore the Factory Presets*.)

4. Press **Display Select 4** to select tile 4.

5. Press and hold the **STATUS** button.

6. Select **Display Type > Video Session**.

7. Press **Display Select 2** to select tile 2.

8. Press and hold the **VECTOR** button to display the Vector menu.

9. Select **Display Type > Lightning**.

10. Press the **VECTOR** button to close the menu.

11. Verify that the following are true in the specified tile or area:

    – Tile 1: YPbPrA parade waveform is displayed

    – Tile 2: Endpoints of Lightning display land within targets

    – Tile 3: Color bars picture displayed

    – Tile 4: Format indicates Auto 1080i 59.94 YCbCrA 4444 10 bit

12. On the signal generator, check that HDLG7 is displayed. Press the **CANCEL** button and then press the arrow button to select Sample Structure/Depth. Next, press the left arrow button to change the HDLG7 color space from YPbPr to GBR 4:4:4 10 bit.

13. Press the **ENTER** button.

14. Verify that the following are true in the specified tile or area:

  - Tile 1: YPbPr parade waveform displayed and automatically converted from RGB input signal

  - Tile 2: Endpoints of Lightning display land within targets

  - Tile 3: Color bars picture displayed

  - Tile 4: Format indicates RGB 444 10 bit

15. Record Pass or Fail in the test record.

A/V Delay Test (WFM8300 Option AD or DPE Only)

1. Connect a 270 Mb/s SDI video signal from the TG700 DVG7 module to the SDI A input of the waveform monitor.

2. Set the signal generator for AV Timing Mode as follows:

  - Press the **MODULE** button until **TG700:PRESET** appears and then press **ENTER**.

  - Press **<** to display **Factory Default**, then press **ENTER**.

  - Press **MODULE** until DVG7 appears.

  - Press ^ until **VIDEO** appears and then press **ENTER**.

  - Press ^ until **AV Timing Mode** appears.

  - Press **>** to select **ON** and then press **ENTER**.

  *NOTE. Press **ENTER** even if **ON** is already indicated.*

  - Press **CANCEL** to return to the previous menu.

  - Press ^ until **AUDIO (EMBEDDED)** appears.

  - Press **<** until **GROUP 1** appears and then press **ENTER**.

  - Press > until **STATUS: ENABLED** appears and then press **ENTER**.

  *NOTE. Press **ENTER** even if **ENABLED** is already indicated.*

3. On the waveform monitor, restore the Factory Preset. (See page 56, *Restore the Factory Presets*.)

4. Press and hold the **MEAS** button to display the Measure menu.

5. Select **Display Type > AV Delay**.

6. If the **AV Delay Enable** is **OFF**, use the navigation keys to set it to **ON**.

7. Briefly press the **MEAS** button to dismiss the menu.

8. Check that the AV Delay readout is green and that it indicates less than 0.005 s. The number in the Fields readout will depend on the video standard in use.

9. Record Pass or Fail in the test record.

10. To turn the AV Timing mode off in the TG700 DVG7:

   - Press **MODULE** until DVG7 appears.

   - Press ^ until **VIDEO** appears and then press **ENTER**.

   - Press ^ until **AV Timing Mode** appears.

   - Press < to select **OFF** and then press **ENTER**.

   - Press **MODULE** to return to the top level menu.

Video and General Performance Verification Procedures

This performance verification includes procedures that verify standard and option-equipped instruments.

Required Equipment

Table 61: Required test equipment (video and general performance)

Test equipment	Requirements	Example
Video test signal generator	1080p 59.94 3Gb/s HD signals (required for option 3G)	Tektronix TG700 with HD3G7 module
	■ 100% color bars	
	■ SDI Matrix Split Field Pathological Signal	
	1080i 59.94 1.5Gb/s HD signals	Tektronix TG700 with HDVG7 module
	■ 100% color bars	
	■ SDI Matrix Split Field Pathological Signal	
	625i 50 270 Mb/s SD signals	Tektronix TG700 with DVG7 module
	■ 100% color bars	
	525i 59.94 270 Mb/s SD signals	
	■ 100% color bars	
	■ SDI Matrix Split Field Pathological Signal	
	625i 50 GBR Component Analog signals with calibration feature to allow 0.1% amplitude accuracy determination	Tektronix TG700 with AVG7 module
	■ 100% color bars	
	NTSC Composite Analog signals with 1% or better amplitude accuracy	Tektronix TG700 with AVG7 module
	■ 75% color bars (option CPS)	
	Precision calibration signals for Option CPS and for Eye Gain test	Tektronix part number 067-0465-00 (AVC1) module installed in Tektronix TG2000 generator
	■ 800 mV ±0.1% 1 MHz square wave (Eye gain)	*NOTE. The part number 067-0465-00 is not available outside of Tektronix. Other equipment may be substituted but it might not have sufficient accuracy to guarantee the specifications.*
	■ 700 mV multiburst, flat within ±0.02 dB to 5.75 MHz (CPS)	
	■ 5.75 MHz 5T multipulse, 2 ns or less group delay error (CPS)	
	■ 2T Pulse and Bar, 1:1 ratio ±0.15% (CPS)	
	■ Field Square Wave, ≤0.05% field time error (CPS)	
	■ 100% Flat Field, ≤0.05% line time error (CPS)	

Table 61: Required test equipment (video and general performance) (cont.)

Test equipment	Requirements	Example
Video Hum insertion generator	Adds 700 mV 60 Hz hum to input video signal (option CPS).	Tektronix part number 067-0465-00 (AVC1) module installed in Tektronix TG2000 generator.
		NOTE. Hum addition may also be accomplished by using a 75 Ω output impedance sine wave generator as the loop through termination.
SD "Cable Clone" cable simulator	Simulate 0 to 300 meters of Belden 8281 equivalent in 25 meter steps.	Faraday SC75A800B-G
HD "Cable Clone" cable simulator	Simulate 0 to 150 meters of Belden 8281 equivalent in 10 meter steps, 300 kHz to 1.5 GHz range.	Faraday FFC010A075, FFC020A075, FFC040A075, and FFC080A075 (available as a boxed set of 4).
3G "Cable Clone" cable simulator	Simulate 0 to 150 meters of Belden 1694A equivalent in 10 meter steps, 0.3 MHz to 3 GHz range (required for option 3G).	Faraday FFE010D075, FFE020D075, FFE040D075, and FFE080D075 (available as a boxed set of 4).
75 Ω coaxial cables (3 required)	RG-6 type coaxial cable with male BNC connectors, 1 to 2 meters long, suitable for use to 1500 MHz.	Belden 8281 or 1694A. Tektronix part numbers 012-0159-00 or 012-0159-01.
BNC T adapter	50 or 75 Ω, 1 male BNC, 2 female BNCs	Tektronix part number 103-0030-00; Amphenol 31-208-RFX
BNC female to dual banana adapter	Standard (0.750 inch) banana plug spacing.	Tektronix part number 103-0090-00; Pomona Electronics model 1269.
Precision 75 Ω terminator for Analog Video	75 Ω ±0.025% to 6 MHz, male BNC connector	Tektronix part number 011-0102-03.
Digital Multimeter	At least 3 ½ digits, 0.1% or better DC voltage measurement accuracy at 700 mV.	Fluke model 83
Test Oscilloscope	>3 GHz bandwidth with 75 Ω input, >20 dB input return loss to 3 GHz, ±3.5% or better vertical gain accuracy.	Tektronix DPO70404 with TCA75 Impedance Conversion Adapter.
VGA to 5x BNC adapter cable	HD-15 VGA connector input, 5 male BNC connector outputs.	Tektronix part number 174-5126-00.

NOTE. Use a DVI-A adapter if you are connecting to an XGA monitor with a 15-pin RGBHV analog interface.

Basic Setup   Use the following setup for all tests unless otherwise specified.

1. Connect the power cord to the rear of the waveform monitor.

2. Connect an XGA monitor to rear of instrument.

3. Connect the power cord to the AC mains and allow at least 20 minutes for the waveform monitor to warm up before beginning any procedures.

Instrument Tests

The following procedures apply to all base instruments except where labeled for specific models. Do all tests except those that exclude your model.

Connect the power cord to the AC mains and allow at least 20 minutes for the waveform monitor to warm up before beginning any procedure.

SDI Input Equalization Range   This test uses a cable clone to simulate cable. This verifies that the waveform monitor can receive signals that have passed through long cables.

All models have an SDI interface with two inputs installed in Slot 1. Each SDI input should be checked.

270 Mb/s checks (all models).

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.)

2. Connect the TG700 DVG7 SIGNAL 1 output to the Slot 1 SDI A input.

NOTE. All signal connections are made with 75 Ω digital video coaxial cables.

3. Set the DVG7 to 525-270 format. Select the "100% Color Bars" signal. A Color Bar signal should be displayed by the waveform monitor.

4. Press the **Display Select 4** button, press and hold the **STATUS** button, select **Display Type** and then **Video Session**. Press the **STATUS** button to dismiss the menu.

5. Connect the cable clones as follows:

   a. Disconnect the DVG7 from the SDI A input. Connect the DVG7 SIGNAL 1 output to the SD Cable Clone Input.

   b. Use a second cable to connect the SD Cable Clone Output to the 80 m section of the HD Cable Clone Input (FFC model, Belden 8281, 300 kHz to 1.5 GHz).

   c. Connect the HD Cable Clone Output directly to the SDI A input.

NOTE. It is important to use the combination of SD and HD cable clones as described. Some SD cable clones do not properly simulate cable loss at very high frequencies. This can cause modern multi-rate SDI Equalizer circuits to malfunction. The 80 m HD Cable Clone isolates the Equalizer from the SD Cable Clone. If desired, an 80 m length of actual Belden 8281 coax can be substituted for the HD Cable Clone.

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6. Set all switches on the Cable Clone to the "out" position.

7. Select the "SDI Matrix" signal from the TG700 DVG7.

8. You should see a stable picture and waveform on the waveform monitor display. The FF and AP CRC Status on the Video Session screen should both read OK.

9. Adjust the cable clone switches to find the longest length of "cable" that does not generate any CRC errors in a 10 second period.

10. Read the switch settings to calculate the equivalent length of 8281 coax. To this value add 80 m for the HD Cable Clone. This sum is the total length of simulated 8281 cable.

11. Divide the total length of Belden 8281 cable by 10 to calculate the attenuation in dB at 135 MHz.

12. Record the value in the test record. Acceptable performance is 23 dB or greater.

13. Starting from 5, repeat the test for the SDI B input (Front Panel **Input 1B**).

1.5 Gb/s checks (all models).

1. Connect the TG700 HDVG7 SIGNAL 1 output to the Slot 1 SDI A input.

2. Set the HDVG7 to 1080 59.94i format. Select the "100% Color Bars" signal. On the waveform monitor select **Input 1A** . A Color Bar signal should be displayed.

3. Disconnect the HDVG7 from the SDI A input. Connect the cable from the HDVG7 to the 80 m HD Cable Clone Input (FFC model, Belden 8281, 300 kHz to 1.5 GHz).

4. Using a 75 Ω female-to-female BNC adapter and a second cable, connect the Cable Clone Output to the SDI A input.

NOTE. The 75 Ω BNC adapter should be included with the cable clone set.

5. Select the "SDI Matrix" signal from the TG700 HDVG7.

6. You should see a stable picture and waveform on the waveform monitor display. The Y Chan and C Chan CRC Error Status on the Video Session screen should both read OK.

7. Connect additional sections of the HD Cable Clone into the signal path to find the longest length of "cable" that does not generate any CRC errors in a 10-second period.

8. The HD Cable Clone set described in the Required Equipment List simulates up to 150 m of Belden 8281 when all four sections are connected. If your instrument does not appear to show CRC errors at this simulated cable length, reset the CRC Err Secs readout to zero (push the **SEL** button while **Display Sel 4** is active). After 60 seconds, check the CRC Err Secs readouts. A "0" reading for both CRCs indicates that the Cable Accommodation range is ≥150 m of Belden 8281.

NOTE. If additional HD Cable Clone sections are available, the test may be continued to find the point where CRC errors occur.

9. Add the HD Cable Clone section lengths to get the total length in meters of Belden 8281 cable. Divide by 4 to calculate attenuation in dB at 750 MHz.

10. Record the value in the test record. Acceptable performance is 20 dB or greater.

11. Starting from step 3, repeat the test for the SDI B input (Front Panel **Input 1B**).

3 Gb/s checks (Option 3G only).

1. Connect the TG700 HD3G7 SIGNAL 1 output to the Slot 1 SDI A input.

2. Set the HD3G7 to 1080 59.94p format. Select the "100% Color Bars" signal. On the waveform monitor select **Input 1A**. A Color Bar signal should be displayed.

3. Disconnect the HD3G7 from the SDI A input. Connect the cable from the HD3G7 to the 80 m 3G Cable Clone Input (FFE model, Belden 1694A, 0.3 MHz to 3 GHz).

4. Using a 75 Ω female-to-female BNC adapter and a second cable, connect the Cable Clone Output to the SDI A input.

NOTE. The 75 Ω BNC adapter should be included with the cable clone set.

---

5. Select the "SDI Matrix" signal from the TG700 HD3G7.

6. You should see a stable picture and waveform on the waveform monitor display. The Y Chan and C Chan CRC Error Status on the Video Session screen should both read OK.

7. Connect additional sections of the 3G Cable Clone into the signal path to find the longest length of "cable" that does not generate any CRC errors in a 10-second period.

8. The 3G Cable Clone set described in the Required Equipment List simulates up to 150 m of Belden 1694A when all four sections are connected. If your instrument does not appear to show CRC errors at this simulated cable length, reset the CRC Err Secs readout to zero (push the **SEL** button while **Display Sel 4** is active). After 60 seconds check the CRC Err Secs readouts. A "0" reading for both CRCs indicates that the Cable Accommodation range is ≥150 m of Belden 1694A.

NOTE. If additional 3G Cable Clone sections are available, the test may be continued to find the point where CRC errors occur.

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9. Add the 3G Cable Clone section lengths to get the total length in meters of Belden 1694A cable. Divide by 4 to calculate attenuation in dB at 1500 MHz.

10. Record the value in the test record. Acceptable performance is 20 dB or greater.

11. Starting from step 3, repeat the test for the SDI B input (Front Panel **Input 1B**).

This completes the SDI Input Equalization Range checks.

SDI Serial Output Amplitude

This test verifies that the Serial Output signal amplitudes are within specifications.

All instruments have an SDI OUT signal output on the mainframe rear panel. The content of this signal is determined by the **Config> Outputs> SDI Output** setting. In addition, the SDI interface card provides two serial outputs. All three serial outputs should be checked for proper amplitude.

Mainframe serial output check (all models).

1. Set the waveform monitor to the Factory Preset.

2. Connect the TG700 DVG7 SIGNAL 1 output to the Slot 1 SDI A input on the waveform monitor.

3. Set the DVG7 to provide a 525 270 Mb/s 100% color bar signal.

4. **Input 1A** should be selected on the waveform monitor. You should see a stable color bar picture and waveform display.

5. Install the TCA75 adapter in the test oscilloscope CH 1 input. Connect the waveform monitor mainframe SDI OUT to the oscilloscope CH 1 input.

6. Set the test oscilloscope as follows:

Parameter	Setting
CH 1 Vertical	Scale: 200 mV/div
	Position: 0.0 div
	Offset: 0.0 div
	Coupling: DC
	Bandwidth: 4.0 GHz
Horizontal:	Mode: Automatic
	Scale: 2 ns/div
	Delay mode: Off
FastAcq:	On/DPX
Trigger: A Event	Trigger Type: Glitch
	Source: CH 1
	Level: 0.0 V
	Width: 6.7 ns
	Glitch Width: Greater Than
	Polarity: Either
	Trigger if Glitch: Occurs
Trigger: A>B Seq	A only

7. Activate the test oscilloscope "H Bars" cursors. Set Cursor 1 to the middle of the bottom trace and Cursor 2 to the middle of the upper trace. Use the 7 ns wide region that does not contain transitions to align the cursors. See the following figure.
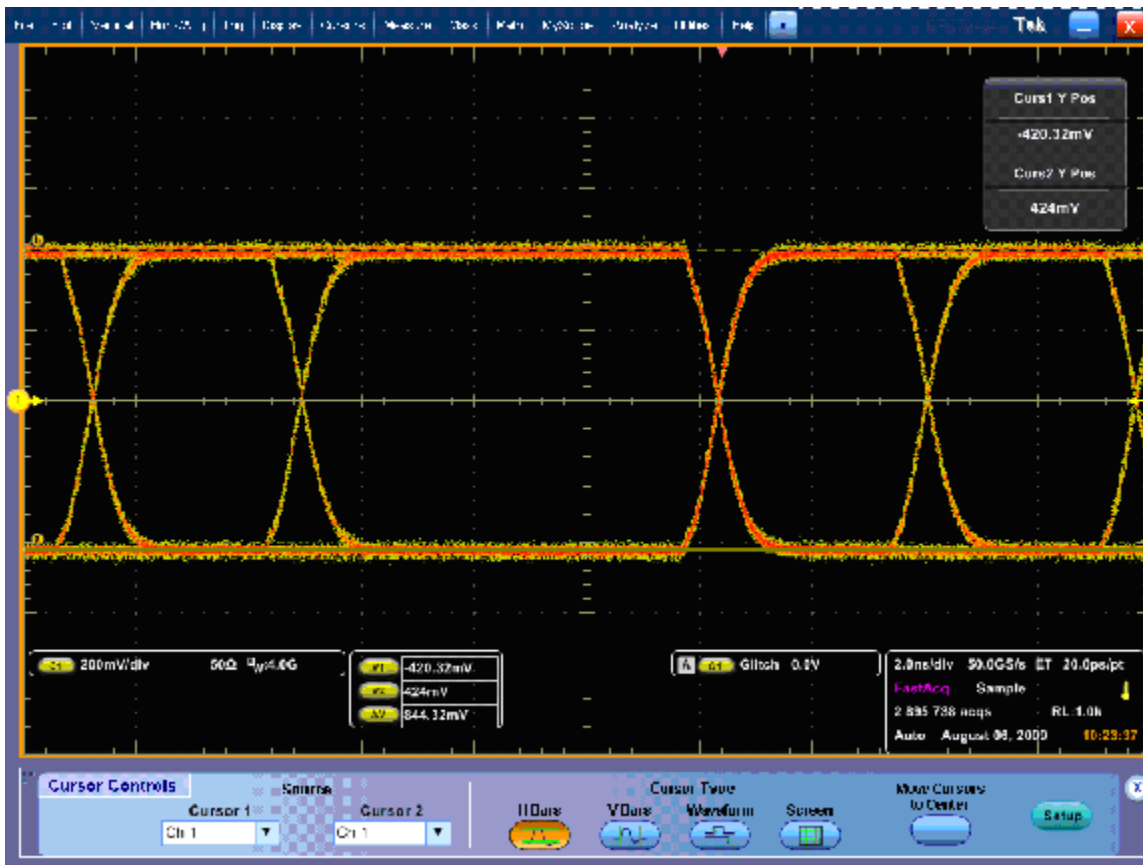
Figure 1: Serial Output at 270 Mb/s, using Glitch Trigger mode

8. Record the amplitude (ΔV) in the test record for 270 Mb/s. Amplitudes between 745 mV and 849 mV are acceptable.

NOTE. The specification range for the SDI outputs is 720 mV to 880 mV (800 mV ±10%). The test limits are narrower than this to allow for the ±3.5% amplitude uncertainty in the oscilloscope system (±2% for the oscilloscope mainframe and ±1.5% for the TCA75 adapter).

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9. Move the cable connection from the TG700 DVG7 to the HDVG7 SIGNAL 1 output. The waveform on the test oscilloscope will change, reflecting the 1.5 Gb/s serial rate. Select 100% color bars on the HDVG7.

10. Check the signal amplitude, using the 7 ns wide region without transitions. The amplitude should be very similar to that observed in step 7. Outside of the 7 ns region, check that the eye is open between transitions. See the following figure.
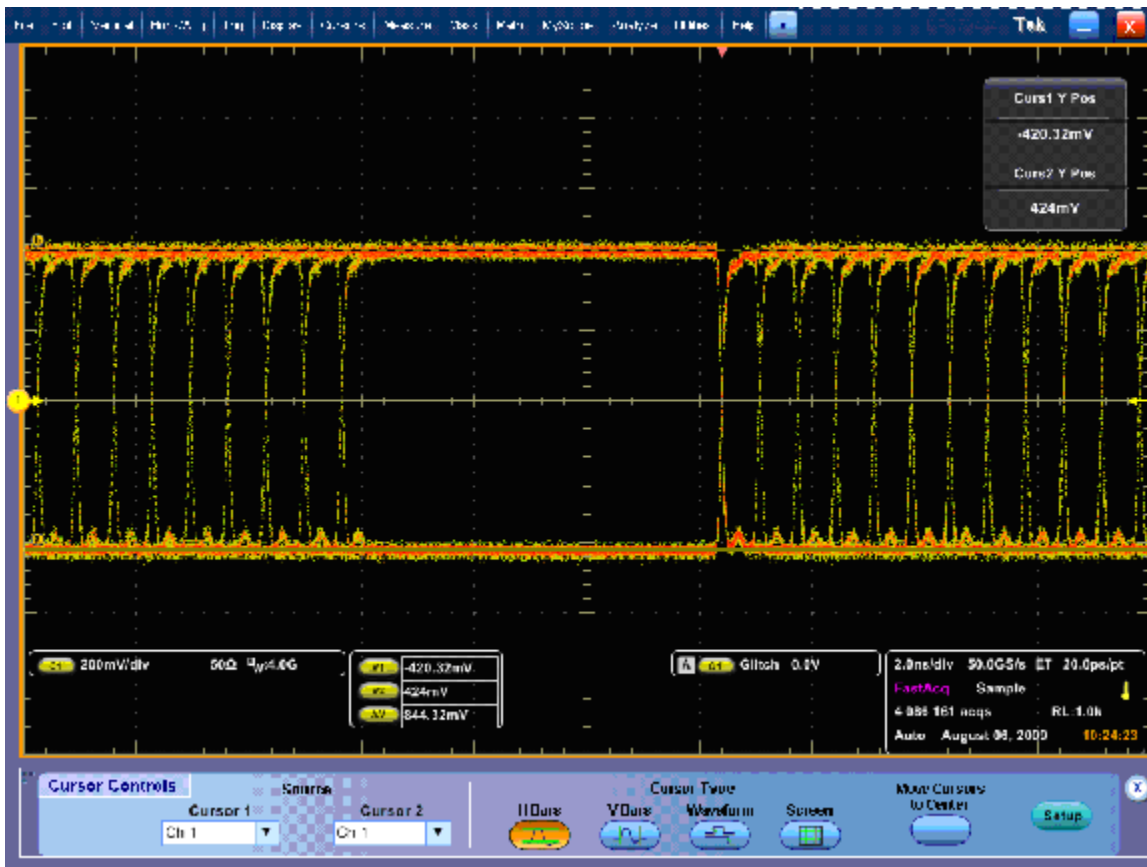
Figure 2: Serial Output at 1.5 Gb/s, using Glitch Trigger mode

11. Record the amplitude (ΔV) in the test record for 1.5 Gb/s. Amplitudes between 745 mV and 849 mV are acceptable.

12. If your instrument has Option 3G, perform steps 13 through 15. Otherwise skip to "Slot 1 serial output check". (See page 88.)

13. Move the cable connection from the TG700 HDVG7 to the HD3G7 SIGNAL 1 output. The waveform on the test oscilloscope will change, reflecting the 3 Gb/s serial rate. Select 100% color bars on the HD3G7.

14. Check the signal amplitude, using the 7 ns wide region without transitions. The amplitude should be very similar to that observed in step 7. Outside of the 7 ns region, check that the eye is open between transitions. See the following figure.
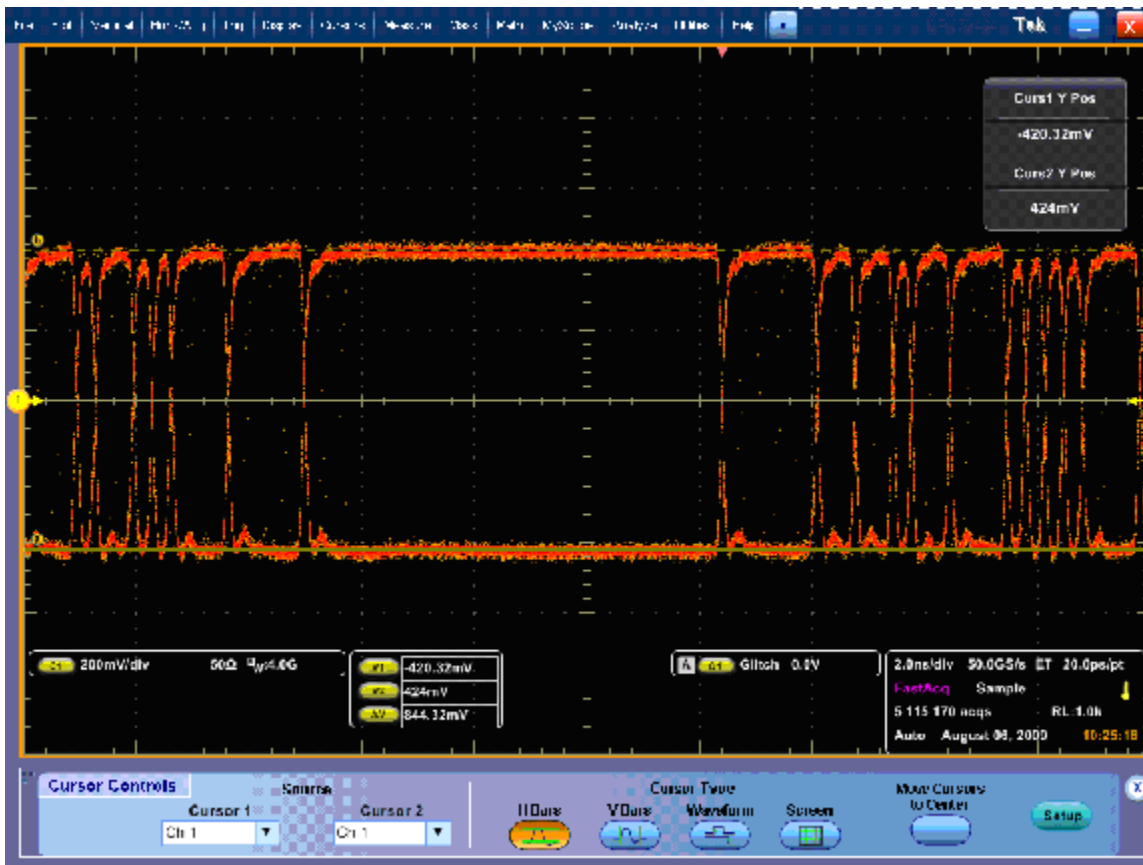
Figure 3: Serial Output at 3 Gb/s, using Glitch Trigger mode

15. Record the amplitude (ΔV) in the test record for 3 Gb/s. Amplitudes between 745 mV and 849 mV are acceptable.

Slot 1 serial output check.

1. Set the waveform monitor to the Factory Preset.

2. Connect a cable from the TG700 DVG7 to the Slot 1 SDI A input. Check that the DVG7 is set to 100% color bars. **Input 1A** on the waveform monitor should be selected, and a stable color bar signal should be displayed.

3. Connect a second cable from the Slot 1 SDI A Out to CH 1 of the test oscilloscope. A waveform should be observed on the test oscilloscope. (See Figure 1.).

4. Repeat steps 6 and 7 of the previous section to measure the serial signal amplitude.

5. Record the amplitude (ΔV) in the test record for 270 Mb/s. Amplitudes between 745 mV and 849 mV are acceptable.

6. Move the cable connection from the TG700 DVG7 to the HDVG7 SIGNAL 1 output. The waveform on the test oscilloscope will change, reflecting the 1.5 Gb/s serial rate. Check that the HDVG7 is set to 100% color bars.

7. Check the serial signal amplitude, using the 7 ns wide region without transitions. The amplitude should be very similar to that noted in step 5. Outside of the 7 ns region, check that the eye is open between transitions. (See Figure 2.)

8. Record the amplitude (ΔV) in the test record for 1.5 Gb/s. Amplitudes between 745 mV and 849 mV are acceptable.

9. If your instrument has Option 3G, perform steps 10 through 12. Otherwise skip to step 13.

10. Move the cable connection from the TG700 HDVG7 to the HD3G7 SIGNAL 1 output. The waveform on the test oscilloscope will change, reflecting the 3 Gb/s serial rate. Check that the HD3G7 is set to 100% color bars.

11. Check the signal amplitude, using the 7 ns wide region without transitions. The amplitude should be very similar to that observed in step 4. Outside of the 7 ns region, check that the eye is open between transitions. (See Figure 3.)

12. Record the amplitude (ΔV) in the test record for 3 Gb/s. Amplitudes between 745 mV and 849 mV are acceptable.

13. Repeat the procedure to check the Slot 1 SDI B output.

This completes the SDI Serial Output Amplitude checks.

Eye Pattern Vertical Gain Accuracy (Option EYE or PHY)

This test uses an 800 mV, 1 MHz square wave in conjunction with a special calibration mode to check the Eye Gain. This procedure uses the TG2000 AVC1 to generate an 800 mV ± 0.1% accurate square wave sourced from 75 Ω.

NOTE. Other square wave sources can be substituted but the amplitude accuracy must be established into a precision 75 Ω load. Any amplitude uncertainty in the square wave source must be subtracted from the test limits. For example, if there is ±1% uncertainty in the 800 mV test signal, then the Eye Gain test limits decrease from 800 mV ±5% to 800 mV ±4%.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.)

2. Set the waveform monitor to Eye Gain test mode:

    a. Press the **CONFIG** button.

    b. Select **Utilities**, **Calibration**, and then press the **SEL** button.

   c. Use the down arrow key to scroll through the Calibration status screen and select **Eye Gain Adjust SDI A**.

   d. Press the **SEL** button to start the calibration.

3. Connect the AVC1 Precision Video output to the SDI A input on the waveform monitor, and then select the 1 MHz squarewave signal.

4. **Option PHY:** Check that the Eye Amplitude reading in Tile 2 is between 761 mV and 839 mV.

5. Press **Display Select** 1, then **Full**, to view the unlocked calibration signal. Use **X5 Gain** and Voltage cursors to check that the waveform is between 761 mV and 839 mV. Record this level in the test record.

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*NOTE. If no waveform appears in the Eye Waveform tile, connect a 525/270 100% color bar signal to the **SDI B** input. Press the **Input 1B** button. After the 270 Mb/s eye pattern appears, select **Input 1A** again.*

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6. Press the **FULL** button to exit the full tile.

7. Press Display Select 4, select **Eye Gain Adjust SDI B** and press **SEL**.

8. Repeat steps 3 through 5 for the SDI B input.

9. When the calibration process is complete, press and hold the **STATUS** button and select **Exit** to exit calibration.

Analog Picture Monitor Gain and Offset

This test uses an oscilloscope to check the active video gain and black (blanking) levels at the Pixmon output for the RGB and YPbPr modes.

Test oscilloscope gain calibration. The pixmon active video gain is checked to ±5% limits. In many cases the test oscilloscope gain accuracy is a significant fraction of this 5% limit. This procedure determines the oscilloscope gain error at baseband video frequencies using a TG700 AVG7 module and a 0.1% accurate or better digital multimeter.

1. Use a 75 Ω BNC cable, BNC T connector, precision 75 Ω coaxial termination, and BNC female-to-dual banana adapter to connect the upper CH1 connector on the TG700 AVG7 module to the INPUT connector on the digital multimeter (DMM) as shown in the following figure.
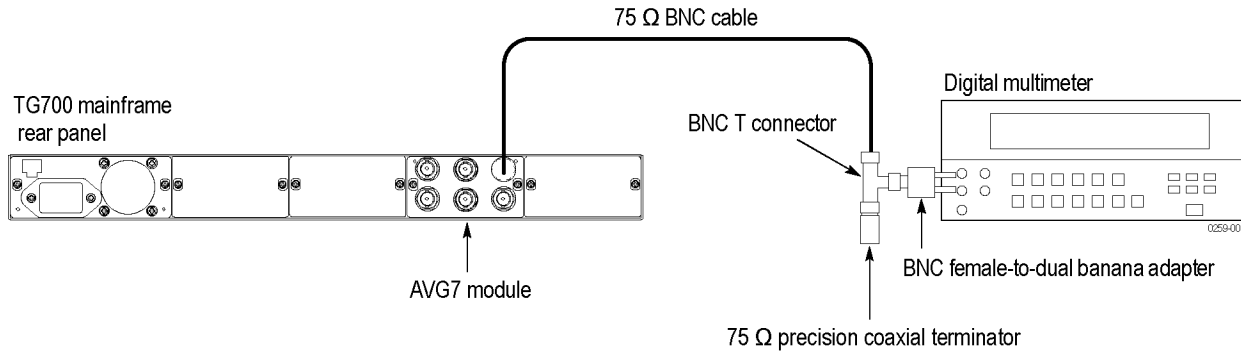
2. On the TG700, press the **MODULE, FORMAT**, and **FRONT PANEL ENABLE** buttons simultaneously, and then release the **MODULE** and **FORMAT** buttons to restart the instrument in Factory mode. Continue holding down the FRONT PANEL ENABLE button until the "TG700 start up with Factory Mode" message appears. Allow the TG700 to load and configure; it is finished when TG700:PRESET message appears.

3. Select the DAC Gain (GBR): 0 mV calibration signal as follows:

   a. Press the **MODULE** button to display the AVG7 main menu.

   b. Press the up (▲) arrow button to select CALIBRATION.

   c. Press the right (►) arrow button twice to select DAC Gain (GBR), and then press ENTER.

   d. Press the left (◄) or right (►) arrow button as needed to select 0 mV, and then press ENTER.

4. The DMM should read a value near 0 mV. Record this value in the test record in the CH1_DC0 location.

5. Select the DAC Gain (GBR): 700.397 mV calibration signal by pressing the right (►) arrow button five times, and then press ENTER.

6. The DMM should read a value near 700 mV. Record this value in the test record in the CH1_DC1 location.

7. Subtract CH1_DC0 from CH1_DC1 (CH1_DC1 − CH1_DC0). Record this value in the CH1_V1 location of the test record.

8. Exit the TG700 Factory mode by simultaneously pressing and then releasing the MODULE, FORMAT, and FRONT PANEL ENABLE buttons. Allow the TG700 to load and configure. Disconnect the DMM from the TG700.

9. Press CANCEL.

10. Connect the upper CH1 AVG7 output to the test oscilloscope 75 Ω input. Set the AVG7 Format to 625 GBR. Select 100% Color Bars.

11. Set the test oscilloscope to 100 mV/div, 20 us/div, CH 1 Edge Trigger, Auto, 50% level, FastAcq On. Adjust CH 1 position so that both the blanking and white levels are visible.

12. Using the test oscilloscope voltage cursors, measure the voltage difference between blanking and white. Align each cursor to the center of the waveform trace. Record the cursor ΔV value in the test record.

13. The ratio of the cursor ΔV value to the TG700 CH1_V1 value is the test oscilloscope gain error. Calculate the upper and lower Picture Monitor Gain test limits as follows:

    Pix Mon Upper test limit: Vmax = 735 mV x (cursor ΔV) / (TG700 CH1_V1)

    Pix Mon Lower test limit: Vmin = 665 mV x (cursor ΔV) / (TG700 CH1_V1)

    Enter the calculated Vmax and Vmin values into the test record. They will be used in the next two sections.

SD Analog Pix Mon Gain and Offset.

1. Set the waveform monitor to the Factory Preset.

2. Connect the TG700 DVG7 SIGNAL 1 to the waveform monitor **Slot 1 SDI A** input.

3. Set the DVG7 to 625-270 Format and select the 100% Color Bars signal.

4. Connect a VGA to 5x BNC adapter cable to the waveform monitor PIX MON output.

YPbPr Gain.

5. Set the SD Anlg PixMon to YPbPr:

   a. Press the **CONFIG** button.

   b. Select **Outputs**, **SD Anlg PixMon**, and then **YPbPr**.

6. Connect the Y/G channel of the VGA to 5x BNC adapter cable to the test oscilloscope CH 1 input. This should be the same 75 Ω input that was used in the earlier section. (See page 90, *Test oscilloscope gain calibration*.)

7. Set the test oscilloscope to 100 mV/div, 20 us/div, CH 1 Edge Trigger, Auto, 50% level, FastAcq On. Adjust CH 1 position so that both the blanking and white levels are visible.

8. Use the test oscilloscope cursors to measure the voltage difference from blanking (black) to white level. Record this value in the SD Y PixMon Gain location of the test record. An acceptable value will lie in the range between Vmin and Vmax (step 13 of the *Test oscilloscope gain calibration* procedure). (See page 90.)

9. Connect the Pb/B channel of the VGA to 5x BNC adapter cable to the test oscilloscope.

10. Measure the voltage difference between the most negative going and positive going portions of the waveform. Record this value in the SD Pb PixMon gain location of the test record. An acceptable value will lie between Vmin and Vmax.

11. Connect the Pr/R channel of the VGA to 5x BNC adapter cable to the test oscilloscope.

12. Measure the voltage difference between the most negative going and positive going portions of the waveform. Record this value in the SD Pr PixMon gain location of the test record. An acceptable value will lie between Vmin and Vmax.

RGB Gain

13. Set the SD Anlg PixMon to RGB:

    a. Press the **CONFIG** button.

    b. Select **Outputs**, **SD Anlg PixMon**, and then **RGB**.

14. Connect the Y/G channel of the VGA to 5x BNC adapter cable to the test oscilloscope CH 1 input.

15. Use the test oscilloscope cursors to measure the voltage difference from blanking (black) to white level. Record this value in the SD G PixMon Gain location of the test record. An acceptable value will lie in the range between Vmin and Vmax (step 13 of the *Test oscilloscope gain calibration* procedure). (See page 90.)

16. Repeat steps 14 and 15 for the B and R signals, using the Pb/B and Pr/R cables, respectively.

Offset Check

17. Remove the Pr/R cable from the test oscilloscope. Increase the test oscilloscope gain to 50 mV/div. Adjust the CH 1 vertical position to align the trace with the center graticule line.

18. Connect the Y/G channel of the VGA to 5x BNC adapter cable to the test oscilloscope CH 1.

19. Check that the G signal blanking level is within 1 division of the center graticule line (0 V ± 50 mV). Record pass or fail in the test record.

20. Repeat steps 18 and 19 with the B and R signals, using the Pb/B and Pr/R cables, respectively.

21. Set the SD Anlg PixMon to YPbPr:

    a. Press the **CONFIG** button.

    b. Select **Outputs**, **SD Anlg PixMon**, and then **YPbPr**.

22. Check that the Y, Pb, and Pr signal blanking levels are 0 V ± 50 mV, using the Y/G, Pb/B, and Pr/R cables, respectively. Record pass or fail in the test record.

HD Analog Pix Mon Gain and Offset

1. Set the waveform monitor to the Factory Preset.

2. Connect the TG700 HDVG7 SIGNAL 1 to the waveform monitor Slot 1 SDI A input.

3. Set the HDVG7 to 1080 59.94i Format and select the 100% Color Bars signal.

4. Connect a VGA to 5x BNC adapter cable to the waveform monitor PIX MON output.

YPbPr Gain

5. Set the HD Anlg PixMon to YPbPr:

    a. Press the **CONFIG** button.

    b. Select **Outputs**, **HD Anlg PixMon**, and then **YPbPr**.

6. Connect the Y/G channel of the VGA to 5x BNC adapter cable to the test oscilloscope CH 1 input. This should be the same 75 Ω input that was used in the earlier section. (See page 90, *Test oscilloscope gain calibration*.)

7. Set the test oscilloscope to 100 mV/div and 10 us/div.

8. Use the test oscilloscope cursors to measure the voltage difference from blanking (black) to white level. Record this value in the HD Y PixMon Gain location of the test record. An acceptable value will lie in the range between Vmin and Vmax (step 13 of the *Test oscilloscope gain calibration* procedure). (See page 90.)

9. Connect the Pb/B channel of the VGA to 5x BNC adapter cable to the test oscilloscope.

10. Measure the voltage difference between the most negative going and positive going portions of the waveform. Record this value in the HD Pb PixMon gain location of the test record. An acceptable value will lie between Vmin and Vmax.

11. Connect the Pr/R channel of the VGA to 5x BNC adapter cable to the test oscilloscope.

12. Measure the voltage difference between the most negative going and positive going portions of the waveform. Record this value in the HD Pr PixMon gain location of the test record. An acceptable value will lie between Vmin and Vmax.

RGB Gain

13. Set the HD Anlg PixMon to RGB:

   a. Press the **CONFIG** button.

   b. Select **Outputs**, **HD Anlg PixMon**, and then **RGB**.

14. Connect the Y/G channel of the VGA to 5x BNC adapter cable to the test oscilloscope CH 1 input.

15. Use the test oscilloscope cursors to measure the voltage difference from blanking (black) to white level. Record this value in the HD G PixMon Gain location of the test record. An acceptable value will lie in the range between Vmin and Vmax (step 13 of the *Test oscilloscope gain calibration* procedure). (See page 90.)

16. Repeat steps 14 and 15 for the B and R signals, using the Pb/B and Pr/R cables, respectively.

Offset Check

17. Remove the Pr/R cable from the test oscilloscope. Increase the test oscilloscope gain to 50 mV/div. Adjust the CH 1 vertical position to align the trace with the center graticule line.

18. Connect the Y/G channel of the VGA to 5x BNC adapter cable to the test oscilloscope CH 1.

19. Check that the G signal blanking level is within 1 division of the center graticule line (0 V ± 50 mV). Record pass or fail in the test record.

20. Repeat steps 18 and 19 with the B and R signals, using the Pb/B and Pr/R cables, respectively.

21. Set the HD Anlg PixMon to YPbPr:

   a. Press the **CONFIG** button.

   b. Select **Outputs**, **HD Anlg PixMon**, and then **YPbPr**.

22. Check that the Y, Pb, and Pr signal blanking levels are 0 V ± 50 mV, using the Y/G, Pb/B, and Pr/R cables, respectively. Record pass or fail in the test record.

Tests for Instruments with Option CPS (Option CPS only)

Composite Analog Frequency Response

Use Cursors to measure the reference, and the largest and smallest packets on a multi-burst signal. The greatest deviation from reference is the frequency response.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.)

2. Connect the precision video generator to one of the CMPST A input connectors and terminate the other connector with the precision terminator.

3. Set the precision generator for a 700 mV, 5.75 MHz Multiburst signal.

4. Press the **Input 2A** button.

5. Press the **FULL** button to make the WFM tile the full screen.

6. Adjust cursors to be near the top and zero portions of the waveform. Press the **CURSORS** button and use the **GENERAL** knob to adjust the **Volt1** or **Volt2** readouts. Use the arrow keys to select between them.

7. Press and hold the **GAIN** button, select **Gain Settings** and then **x5**.

8. Press the **GAIN** button to close the menu.

9. Adjust the lower cursor to align with the bottom of the reference step of the waveform.

10. Use the **Vert** knob to move the top of the waveform to the 0 IRE graticule. The second cursor should also be near the zero graticule mark.

11. Use the **General** knob to adjust the upper cursor to align with the top of the reference step of the waveform.

12. Check the cursor delta readout of the magnitude of the reference step. Note this number. It should be near 98 IRE.

13. Next, adjust the upper cursor to align with the top of the largest packet of the waveform.

14. Use the **Vert** knob to move the baseline of the waveform to the 0 IRE graticule. The other cursor should also be near the zero graticule mark.

15. Use the **General** knob to adjust the lower cursor to align with the bottom of the largest packet of the waveform.

16. Note the cursor delta value for the amplitude of the largest packet.

17. Adjust the lower cursor to align with the bottom of the smallest packet of the waveform.

18. Use the **Vert** knob to adjust the vertical position to align the top of the waveform to the 0 IRE graticule.

19. Use the **General** knob to adjust the upper cursor to align with the top of the smallest packet of the waveform.

20. Note the cursor delta value for the amplitude of the smallest packet.

21. In the test record, record the deviation from reference that has the largest magnitude, either largest-reference or smallest-reference.

Adjust.. If the Frequency Response is outside the specification, press the **CONFIG** button, select **Calibration**, and then press the **SEL** button. Use the down arrow to navigate to **Composite Freq Peak**, and then follow the on-screen instructions to adjust the response. Follow the instructions at the bottom of the screen to Save and Exit calibration mode. Afterwards, repeat the above test for Analog Frequency Response and record the new value in the test record.

Composite Analog Delay Variation Over Frequency (Group Delay)

Use a 5.75 MHz 5T multi-pulse signal and cursors to measure group delay. This signal is provided on the User Documents CD.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.)

2. Connect the precision video generator to one of the CMPST A input connectors and terminate the other connector with the precision terminator.

3. Set the precision generator for 5.75 MHz multi-pulse. This is a custom test signal with more packets for better coverage.

4. Press the **Input 2A** button to select the Composite A input.

5. Press the **FULL** button to make the WFM tile the full screen display.

6. Press the **CURSORS** button to turn on the cursor controls.

7. Use the arrow keys to navigate to Volt1 and Volt2. Adjust the cursors to be near the zero portions of the waveform using the **General** knob.

8. Press and hold the **GAIN** button, select **Gain Settings**, and then select **x10**.

9. Press the **GAIN** button to close the menu.

10. Use the cursors to measure the peak-to-peak deviation in the baseline of the multipulse packets. Use the arrow keys to navigate between **Volt1** and **Volt2** and use the **General** knob to adjust them.

11. The peak-to-peak deviation of the baseline is 0.1% per ns. For example, for a 10 ns deviation on a 100 IRE signal yields a deviation of 1 IRE. Record the measured value in the test record.

Composite Analog Pulse to Bar Ratio

Apply a pulse and bar signal and use cursors to measure the difference between the two.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.)

2. Connect the precision video generator to one of the CMPST A input connectors and terminate the other connector with the precision terminator.

3. Set the precision generator for a 2T Pulse and Bar.

4. Press the **Input 2A** button to select the Composite A input.

5. Press the **FULL** button to make the WFM tile the full screen display.

6. Press the **CURSORS** button to turn on the cursor controls.

7. Use the arrow keys to navigate between **Volt1** and **Volt2** and adjust the cursors to be near the top portions of the waveform. Use the **General** knob to adjust them.

8. Use the vertical knob to move the top of the waveform to the zero graticule.

9. Press and hold the **GAIN** button, select **Gain Settings**, and then **x10**.

10. Press the **GAIN** button to close the menu.

11. Place one cursor on the top of the "Bar." Use the **General** knob to adjust **Volt1** in the WFM tile.

12. Use the horizontal knob to put the "pulse" on the dotted line at the center of the screen.

13. Press and hold the **MAG** button and select **x50** to expand the pulse horizontally.

14. Press the **MAG** button to close the menu.

15. Position the second cursor on the top of the pulse. Select **Volt2** using the arrow keys and use the **General** knob to adjust it.

16. Record the cursor delta in the test record.

Composite Analog Field Rate Tilt

Apply a field rate square wave and use cursors to measure the tilt.

1. Set the waveform monitor to the factory presets. (See page 55, *Incoming Inspection Tests*.)

2. Connect the precision video generator to one of the CMPST A input connectors and terminate the other connector with the precision terminator.

3. Set the precision generator for Field Square Wave.

4. Press the **Input 2A** button to select the Composite A input.

5. Press the **FULL** button to make the WFM tile the full screen display. The bar signal should be approximately 700 mV amplitude.

   a. Press **SWEEP** to select a 1–Field sweep (2 ms/div).

   b. Turn the DC Restorer to **OFF**:

      - Press **CONFIG**.

      - Select **Composite Input** > **DC Restore** > **Off**.

      - Press **CONFIG** to dismiss the menu.

6. Press the **CURSORS** button to turn on the cursor controls.

7. Use the arrow keys to select **Volt1** and **Volt2** and adjust the cursors to be near the top of the waveform using the **General** knob.

8. Use the vertical knob to move the top of the waveform to the zero graticule.

9. Press and hold the **GAIN** button, select Gain Settings, and then select **x10**.

10. Press the **GAIN** button to close the menu.

11. Use the arrow keys to select **Volt1** and **Volt2** and use cursors to measure the tilt in the waveform using the **General** knob to adjust them.

12. Record the value in the test record.

Composite Analog Line Rate Tilt

Apply a 100% flat field signal and use cursors to measure the tilt.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.)

2. Connect the precision video generator to one of the CMPST A input connectors and terminate the other connector with the precision terminator.

3. Set the precision generator for 100% Flat Field.

4. Press the **Input 2A** button to select the Composite A input.

5. Press the **FULL** button to make the WFM tile the full screen display.

6. Press the **CURSORS** button to turn on the cursor controls.

7. Use the arrow keys to select **Volt1** or **Volt2** and adjust cursors to be near the top of the waveform using the **General** knob.

8. Use the **Vert** position knob to move the top of the waveform to the zero graticule.

9. Press and hold the **GAIN** button, select **Gain Settings**, and then select **x5**.

10. Press the **GAIN** button to close the menu.

11. Use the cursors to measure the tilt in the waveform, excluding the first and last 5 µs of the bar.

12. Record the value in the test record.

Composite Analog Input DC Restore Hum Attenuation

Apply hum, then measure the attenuation with clamp in all three modes.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.)

2. Connect an NTSC color bar signal to the video input of the AVC1. Route the video output of the AVC1 (not the precision video output) to the CMPST A input of the waveform monitor, and terminate the loopthrough in 75 Ω.

3. Press the **Input 2A** button.

4. Press the **FULL** button to make the WFM tile the full screen display.

5. Set the AVC1 for 0 dB of 60 Hz hum.

6. Press and hold the **SWEEP** button and select **2F**. If you cannot get 2 field, make sure the display style is set to Overlay (press and hold the WFM button and select Overlay).

7. Select input and switch DC Restore off:

    a. Press the **CONFIG** button.

    b. Select **Composite Input**, **DC Restore**, and then select **Off**.

    c. Press the **CONFIG** button to close the menu.

8. Press the **CURSORS** button to turn on the cursor controls.

9. Use the arrow keys to select **Volt1** or **Volt2** and measure the peak-to-peak hum with the cursors. Use the **General** knob to adjust them. The measurement should be about 100 IRE. Record the value in the test record under *Added Hum for DC Restore Tests*.

10. Switch DC Restore to Fast:

    a. Press the **CONFIG** button.

    b. Select **Composite Input**, **DC Restore**, and then select **Fast**.

11. Press and hold the **GAIN** button, select **GAIN Settings** and then **x10**. Press **GAIN** to dismiss the menu.

12. Use the arrow keys to select **Volt1** or **Volt2** and measure the peak-to-peak hum with the cursors. Use the **General** knob to adjust them. The measurement should be less than 5% of the measurement in step 9 (less than ~5 IRE).

13. Record the value in the test record.

14. Press the **GAIN** button, to return to X1 gain.

15. Switch DC Restore to Slow:

    a. Press the **CONFIG** button.

    b. Select **Composite Input**, **DC Restore**, and then select **Slow**.

16. Measure the peak-to-peak hum with the cursors. Touch the **Volt1** or **Volt2** touchable readout in the WFM tile and use the **General** knob to adjust them. It should be between 90% and 110% of the measurement in step 9.

17. Record the value in the test record.

Composite Analog Vertical Measurement Accuracy

Use 100% white and cursors to measure gain.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.)

2. Connect the precision video generator to one of the CMPST A input connectors and terminate the other connector with the precision terminator.

3. Set the Precision generator for a 100% Flat Field.

4. Press the **Input 2A** button to select the Composite A input.

5. Press the **FULL** button to make the WFM tile the full screen display.

6. Press the **CURSOR** button.

7. Use the arrow keys to select **Volt1** or **Volt2**. Use the **General** knob to adjust the cursors to be near the top and zero portions of the waveform.

8. Position the lower cursor on to the backporch of the waveform.

9. Press and hold the **GAIN** button, select **Gain Settings**, and then **x5** and adjust the vertical position to locate the top of the waveform at the 0 mV graticule. The second cursor should also be near the zero graticule.

10. Press the **GAIN** button to close the menu.

11. Position the upper cursor to be centered on the top of the waveform.

12. Cursor delta displays the magnitude of the waveform. It should be within 1% of nominal 714.3 mV. Record the amplitude in the test record.

NOTE. The limits shown in the test record assume a nominal 714.3 mV (100 IRE) white bar. If a 700 mV bar is used, the minimum and maximum limits are 693 mV and 707 mV, respectively.

Audio Performance Verification Procedures

Required Equipment

Table 62: Required test equipment (audio)

SDI serial digital video test generator with embedded audio	Generates the following signals:	Tektronix TG700 with the following modules:
	525/270 100% color bars with two or more groups of embedded audio.	DVG7 module for TG700
Test Oscilloscope	>20 MHz bandwidth with 75 Ω input, ±3.5% or better vertical gain accuracy.	Tektronix DPO70404 with TCA75 Impedance Conversion Adapter.
Analog/Digital audio generator/analyzer	35 kHz to 96 kHz sample rate range, jitter measurement per AES-3 (1997)	Rohde & Schwarz UPL06 Opt B22, B29
75 Ω coaxial cables (2 required)	General purpose digital video Male-to-male BNC connectors 3' long	Belden 8281
Audio test cable	1/4 inch phono to 2 XLR	Sound Professionals SP-XLRM-MINI-1 with adapter SP-PHONE-MINI-ST
Audio breakout cable	DB62 to XLR I/O required for Audio Options AD and DPE	Tektronix part number 012-1688-00

The following tests verify that the Audio module for the WFM8200 and WFM8300 waveform monitors meets the warranted characteristics listed in the Specifications chapter. Characteristics with typical specifications (not warranted) are also checked with pass/fail criteria.

Tests for Waveform Monitors Equipped with Audio Options

The tests in this section apply to instruments with Audio options installed. The tests will note when tests or their steps apply only to specific audio options; otherwise, they apply to all the audio options.

AES Sample Rate Range

This test verifies that each AES input locks to an input signal.

Typical Operation Check. This test checks for typical operation. Typical values are not guaranteed characteristics and are listed in the test record as pass/fail.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.)

2. If the audio display is not selected, press the **Display Select 4** button.

3. Connect the digital audio generator unbalanced (UNBAL) output to the AES A 1-2 In BNC connector using a 75 Ω cable.

4. Set the digital audio generator as follows:

Control or setting	Value
Frequency	1 kHz
Output Level	–20 dB FS Audio Tone
Sample Frequency	96 kHz
Unbalanced V_p-p	1.000 V (Carrier Level)

5. Select the AES A input:

   a. Press and hold the **AUDIO** button, select Audio Input, and then select **AES A**.

   b. Press the **AUDIO** button to close the menu.

6. Press the **FULL** button to make the audio tile the full screen display.

7. Check for an indication of –20 dB FS and no error messages in the corresponding bars, and record Pass or Fail in the test record.

8. Move the audio generator output to each of the remaining AES A In connectors and repeat step 7 for each connector.

9. Set the digital audio generator Sample Frequency to 35 kHz.

10. Check for an indication of –20 dB FS and no error messages in the corresponding bars, and record Pass or Fail in the test record.

11. Move the audio generator output to each of the remaining AES A In connectors and repeat step 10 for each connector.

12. Disconnect the test setup.

AES Output Amplitude This test verifies the amplitude of each AES output.

Performance Requirement. The AES output amplitude test verifies performance characteristics and is listed in the test record.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.) This sets **Audio Input** to **Follow Video, Embedded**.

2. If the audio tile is not selected, press the Display Select **4** button.

3. Select the AES B output:

   a. Press the **CONFIG** button.

   b. Select **Audio Inputs/Output**, then select **AES B**.

c. Select **Configure port as** and press the right arrow key to highlight **Output**.

d. Press the **CONFIG** button to close the menu.

4. Connect a 525/270 color bars signal from a DVG7 module to the SDI A input of the instrument under test.

5. Set the generator for embedded audio in 2 groups starting with group 1. Audio settings in the TG700 DVG7 are accessed as follows:

a. Press **MODULE** repeatedly until DVG7 is displayed.

b. Press the up/down arrow keys until AUDIO (EMBEDDED) is displayed. Use the left/right arrow keys to select "Group 1", then press **ENTER**.

c. Press the up/down arrow keys until **Status** is displayed, then use the left/right arrow keys to select **Enable** then press **ENTER**.

d. Press CANCEL to return to the Audio (Embedded) menu, then repeat steps b and c to enable Audio Group 2.

6. Check that "PPPP PPPP —- —-" is displayed in the lower right area of the status bar, indicating the presence of two groups of embedded audio.

7. Connect the AES B 1-2 I/O output to the 75 Ω input of the test oscilloscope using a 75 Ω cable. Use a 75 Ω -to-50 Ω adapter on the input of the test oscilloscope if necessary.

NOTE. A BNC T-adapter and 75 Ω terminator can be used on a 1 MΩ input oscilloscope, in place of the 75 Ω oscilloscope.

8. Set the test oscilloscope to view the signal. The following oscilloscope settings normally provide a usable display.

Control or setting	Value
Vertical Scale	200 mV/div
Horizontal Scale	100 ns/div
Horizontal Trigger Position	30%
Trigger Slope	Rising edge
Trigger Level	0 mV

9. Check that the amplitude of the waveform displayed on the oscilloscope is between 0.9 V and 1.1 V and record the value in the test record.

10. Move the cable to each of the remaining AES B I/O connectors and repeat step 9.

11. Disconnect the test setup.

AES Output Jitter   This test measures jitter at each AES output.

Typical Operation Check.   This test checks for typical operation. Typical values
are not guaranteed characteristics and are listed in the test record as pass/fail.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the
   Factory Presets*.)

2. If the audio tile is not selected, press the Display Select **4** button.

3. Select the AES B output:

   a. Press the **CONFIG** button.

   b. Select **Audio Inputs/Outputs**, then select AES B.

   c. Select **Configure port as** and press the right arrow key to highlight
      Output.

   d. Press the **CONFIG** button to close the menu.

4. Connect a 525/270 color bars signal from a DVG7 module to the SDI A input
   of the instrument under test.

5. Set the generator for embedded audio in 2 groups starting with group 1. If the
   previous test *AES Output Amplitude* has just been performed, the generator
   will already be set.

6. Check that "PPPP PPPP —- —-" is displayed in the upper right area of the
   status bar, indicating presence of two groups of embedded audio.

7. Connect the AES B 1-2 I/O connector to the digital audio analyzer unbalanced
   (UNBAL) input using a 75 Ω cable.

8. Set the audio analyzer for measurement of jitter per AES3-1992 (or 1997). To
   configure the R&S UPL06 Opt B22, B29 for jitter measurement:

   a. Press ANLR to display and configure the analyzer screen.

   b. Use the up/down arrow keys, keypad, and SELECT button to set the
      parameters in the ANALYZER panel as follows:

Control or setting	Value
INSTRUMENT	DIGITAL
Meas Mode	JITTER/PHAS
Input	UNBAL (BNC)
Jitter Ref	48.0 (PLL)
START COND	AUTO
Delay	0.0000 s
INPUT/PHAS	OFF
FREQ/PHAS	OFF
FUNCTION -	PEAK & S/N

Control or setting	Value
Meas Mode	PK abs
Intv Time	0.5000 s
Unit	s
Reference	GEN TRACK
Filter	JITTER wtd
SPEAKER -	OFF

9. Allow the jitter reading to settle for a few seconds.

10. Check for a typical Jitter Peak absolute reading of less than 3.5 ns over an interval of at least 5 seconds, and record Pass or Fail in the test record.

11. Move the cable to each of the remaining AES B I/O connectors and repeat steps 9 and 10 for each AES B I/O connector.

12. Disconnect the test setup.

AES Audio Level Meter Accuracy Over Frequency

This test measures AES level meter accuracy over the audio frequency range.

Typical Operation Check. This test checks for typical operation. Typical values are not guaranteed characteristics and are listed in the test record as pass/fail.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.)

2. If the audio tile is not selected, press the Display Select **4** button.

3. Set the digital audio generator as follows:

Control or setting	Value
Sample Frequency	48 kHz
Output Level	–6 dB FS Audio Tone
Frequency	100 Hz

4. Select the AES A input:

    a. Press and hold the **AUDIO** button, select **Audio Input**, and then select **AES A**.

    b. Press the **AUDIO** button to close the menu.

5. Connect the digital audio generator unbalanced (UNBAL) output to the AES A 1-2 In connector using a 75 Ω cable.

6. Check for an indication of –6 dB FS ±0.2 dB in the corresponding bars and record Pass or Fail in the test record.

7. Move the audio generator output to each of the remaining AES A In connectors and repeat step 6 for each connector.

8. Set the digital audio generator as follows:

Control or setting	Value
Sample Frequency	48 kHz
Output Level	–6 dB FS Audio Tone
Frequency	1 kHz

9. Repeat steps 5 through 7.

10. Set the digital audio generator as follows:

Control or setting	Value
Sample Frequency	48 kHz
Output Level	–6 dB FS Audio Tone
Frequency	19 kHz

11. Repeat steps 5 through 7.

12. Disconnect the test setup.

Headphone Output Level

This test measures the output level accuracy of the headphones.

Performance Requirement. This test verifies performance characteristics and is listed in the test record.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.)

2. If the audio tile is not selected, press the Display Select **4** button.

3. Set the digital audio generator as follows:

Control or setting	Value
Sample Frequency	48 kHz
Output Level	–6 dB FS Sine
Frequency	100 Hz

4. Set the parameters in the ANALYZER panel as follows:

Control or setting	Value
INSTRUMENT	ANLG 22 kHz
Min Freq	10 Hz
Ref Imped	100000 Ω
Channel	1
Ch1 Coupl	AC
Ch1 Input	BAL
Ch1 Imped	200 kΩ

Control or setting	Value
Ch1 Common	FLOAT
Ch1 Range	AUTO
START COND	AUTO
Delay	0.0000 s
INPUT DISP	OFF
FUNCTION	RMS & S/N
S/N Sequ	OFF
Meas Time	AUTO
Unit Ch1	DBu
Reference	VALUE: 1.0000 V
Sweep Mode	NORMAL
Notch (Gain)	OFF
Filter	OFF
Filter	OFF
Filter	OFF

5. Press and hold the **AUDIO** button, select **Audio Input**, and then select **AES A**.

6. Press the **AUDIO** button to close the menu.

7. Connect the digital audio generator unbalanced (UNBAL) output to the waveform monitor AES A IN 1-2 connector, using a 75 Ω cable.

8. Verify that the numbers 1,2 are visible under the headphone icon, in the audio tile.

9. Set the headphone output volume to maximum by turning the **Horz** (Volume) knob clockwise.

10. Connect the 1/4I male phono connector from the headphone test cable to the waveform monitor headphone jack.

11. Connect the XLR corresponding to the 'Left' channel to the analyzer balanced (BAL) analog input.

12. Check for 0.25 dBu ±1 dB RMS on the analog analyzer. Record the result in the test record.

13. Connect the XLR corresponding to the 'Right' channel to the analyzer balanced (BAL) analog input.

14. Check for 0.25 dBu ±1 dB RMS on the analog analyzer. Record the result in the test record.

15. Set the digital audio generator as follows:

Control or setting	Value
Sample Frequency	48 kHz
Output Level	–6 dB FS Audio Tone
Frequency	1 kHz

16. Repeat steps 9 through 12.

17. Set the digital audio generator as follows:

Control or setting	Value
Sample Frequency	48 kHz
Output Level	–6 dB FS Audio Tone
Frequency	19 kHz

18. Repeat steps 9 through 12.

Analog Audio Level Meter Accuracy Over Frequency

This test measures the Analog Input Level Meter Accuracy over the audio frequency range.

Performance Requirement. This test verifies performance characteristics and is listed in the test record.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.) Press the Display Select **4** button.

2. Press the **FULL** button to make the audio tile the full screen display.

3. Select the Analog A input:

    a. Press and hold the **AUDIO** button, select **Audio Input**, and then select **Analog A**.

    b. Press the **AUDIO** button to close the menu.

4. Install the audio breakout cable to the Analog Audio I/O connector.

5. Connect the generator balanced (BAL) analog output to the Input A1 XLR connector of the breakout cable.

6. Set the audio generator as follows:

Control or setting	Value
Channel	2=1
Frequency	100 Hz
Output Level	18 dBu audio tone
Output Impedance	10 Ω

7. Check for an indication of 18 dBu ±0.5 dB in the corresponding bar and record the value in the test record.

8. Change analog audio generator Frequency to 1 kHz.

9. Check for an indication of 18 dBu ±0.5 dB in the corresponding bar and record the value in the test record.

10. Change analog audio generator Frequency to 19 kHz.

11. Check for an indication of 18 dBu ±0.5 dB in the corresponding bar, and record the value in the test record.

12. Repeat steps 6 through 11 for each of the other five Input A XLR connectors in the breakout cable.

13. Select the Analog B input:

    a. Press and hold the **AUDIO** button, select **Audio Input**, and then select **Analog B**.

    b. Press the **AUDIO** button to close the menu.

14. Repeat steps 5 through 12 for the Input B XLR connectors on the audio breakout cable.

    If any of the Analog A Inputs failed to meet the specification, (or even if they are off by more than a few tenths of a dB) an input adjustment can be performed.

15. To perform an analog input adjust, follow steps 16 through 20; otherwise skip to step 21.

16. Set the analog audio generator as follows:

Control or setting	Value
Frequency	1 kHz
Output Level	18 dBu Audio Tone
Output Impedance	10 Ω

17. Connect the generator balanced (BAL) analog output to the Analog A input that requires adjustment.

18. Access the Calibration routine by pressing the **CONFIG** button, selecting **Utilities**, and then **Calibration**.

    a. Press the **SEL** button.

    b. Use the down arrow key to navigate to **Analog Audio Channel**.

    c. After the calibration process finishes, follow the directions on the screen and press the STATUS button to save and exit Calibration.

19. Check for an indication of −18 dBu in the newly adjusted audio bar.

20. If multiple inputs require adjustment, repeat steps 17 through 19 for each input.

21. Disconnect the test setup.

Digital Input to Analog Output Gain Accuracy Over Frequency

This test measures the Analog Output level meter accuracy over the audio frequency range, when using an AES or embedded input as the audio source.

Performance Requirement. This test verifies performance characteristics and is listed in the test record.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.) If the audio tile is not selected, press the Display Select **4** button.

2. Set the generator to Digital.

3. Set the Audio Output Attenuation to 0 dB:

    a. Press and hold the **AUDIO** button.

    b. Select **Analog Out Atten**.

    c. Press the right arrow button to select the attenuation setting.

    d. Use the **GENERAL** knob to set the attenuation to **0 dB**.

    e. Press the **AUDIO** button to close the menu.

4. Map Bar 1,2 to all Analog Audio Outputs:

    a. Press the **CONFIG** button.

    b. Select **Audio Inputs/Outputs**.

    c. Select **AES A**, **Analog Output Map**, and then press the **SEL** button.

    d. Use the arrow keys to navigate to the **Analog 1,2**; **Analog 3,4**; **Analog 5,6**; and **Analog 7,8** boxes across from **Bars 1,2**.

    e. Press the **SEL** key to place a check mark in those boxes.

    f. When finished, navigate to the **Return** box and press the **SEL** button to exit the mapping menu.

5. Set the audio Input to AES A:

    a. Press and hold the **AUDIO** button, select **Audio Input**, and then select **AES A**.

    b. Press the **AUDIO** button to close the menu.

6. Install the audio breakout cable on the Analog Audio I/O connector.

7. Set the analog audio analyzer to measure RMS level in dBu, and for an input impedance of 200 kΩ. This is done on the Rohde & Schwarz UPL06 as follows:

   a. Press ANLR to display and configure the ANALYZER panel.

   b. Set the parameters in the ANALYZER panel as follows:

Control or setting	Value
INSTRUMENT	ANLG 22 kHz
Min Freq	10 Hz
Ref Imped	100000 Ω
Channel	1
Ch1 Coupl	AC
Ch1 Input	BAL
Ch1 Imped	200 kΩ
Ch1 Common	FLOAT
Ch1 Range	AUTO
START COND	AUTO
Delay	0.0000 s
INPUT DISP	OFF
FUNCTION	RMS & S/N
S/N Sequ	OFF
Meas Time	AUTO
Unit Ch1	DBu
Unit Ch2	DBu
Reference	VALUE: 1.0000 V
Notch (Gain)	OFF
Filter	OFF
Filter	OFF
Filter	OFF

8. Connect the Rohde & Schwarz UPL06 Opt B22, B29 digital generator unbalanced (UNBAL) output to the AES A 1-2 In BNC using a 75 Ω cable.

9. Set the digital audio generator for a –6 dBFs, 100 Hz audio tone at 48 kHz sample rate. This is done on the Rohde & Schwarz UPL06 as follows:

   a. Press GEN to display and configure the GENERATOR panel.

   b. Set the parameters in the GENERATOR panel as follows:

Control or setting	Value
INSTRUMENT	DIGITAL
Channel	2 = 1
Unbal Out	AUDIO OUT
Cable Sim	OFF
Sync To	GEN CLK
Sample Freq	48 kHz
Sync Out	GEN CLK
Type	WORD CLK
Ref Out	REF GEN
Data	ALL ZERO
Audio Bits	24
Unbal Vpp	1.0000 V
Bal Vpp	4.0000 V
Max Volt	1.0000 FS
Ref Freq	1000.0 Hz
Ref Volt	1.0000 FS
PROTOCOL	STATIC
Ch Stat. L	FILE + CRC
Filename	R&S_AES3.PGC
Ch Stat. R	EQUAL L
AUX GEN	OFF
FUNCTION -	SINE
Frq Offset	OFF
DC Offset	OFF
Dither	OFF
Equalizer	OFF
SWEEP CTRL	OFF
FREQUENCY	100.0 Hz
VOLTAGE	0.5000 FS

10. Connect the Output 1 XLR of the breakout cable to the analyzer balanced (BAL) analog input.

11. Check for an indication of 18 dBu ±0.5 dB on the analog analyzer and record the result in the test record.

12. Change the digital audio generator FREQUENCY to 1000 Hz.

13. Check for an indication of 18 dBu ±0.5 dB on the analog analyzer and record the result in the test record.

14. Change the digital audio generator FREQUENCY to 19000 Hz.

15. Check for an indication of 18 dBu ±0.5 dB on the analog analyzer and record the result in the test record.

16. Repeat steps 8 through 15 for each of the other Output XLR connectors.

17. Disconnect the test setup.

Analog Input to Analog Output Gain Accuracy Over Frequency

This test measures the Analog Audio Output level accuracy over the audio frequency range, when using an Analog Input as the audio source.

Typical Operation Check.   This test checks for typical operation. Typical values are not guaranteed characteristics and are listed in the test record as pass/fail.

1. Set the waveform monitor to the factory presets. (See page 56, *Restore the Factory Presets*.) If the audio tile is not selected, press the Display Select **4** button.

2. Set the Audio Output Attenuation to 0 dB:

   a. Press and hold the **AUDIO** button.

   b. Select **Analog Out Atten**, and press the SEL button.

   c. Use the **GENERAL** knob to set the attenuation to 0 dB.

   d. Press the **AUDIO** button to close the menu.

3. Map Bar 1,2 to all Analog Audio Outputs:

   a. Press the **CONFIG** button.

   b. Select **Audio Inputs/Outputs**.

   c. Select **Analog A**, **Analog Output Map**, and then press the **SEL** button.

   d. Use the arrow keys to navigate to the **Analog 1,2**; **Analog 3,4**; **Analog 5,6**; and **Analog 7,8** boxes across from **Bars 1,2**.

   e. Press the **SEL** key to place a check mark in those boxes.

   f. When finished, navigate to the **Return** box and press the **SEL** button to exit the mapping menu.

4. Set the Audio Input to Analog Audio A:

   a. Press and hold the **Audio** button.

   b. Select **Audio Input**, then select **Analog A**.

   c. Press the **Audio** button to close the menu.

5. Set the analog audio generator as follows:

Control or setting	Value
Frequency	100 Hz
Output Level	18 dBu
Output Impedance	10 Ω

6. Connect the audio break out cable to the Analog Audio I/O connector.

7. Connect the generator balanced (BAL) analog output to the Input A1 XLR of the breakout cable.

8. Check for an indication of 18 dBu in the corresponding bar.

9. Connect the Output 1 XLR of the breakout cable to the analyzer balanced (BAL) analog input.

10. Check for an RMS indication of 18 dBu ±1.0 dB on the analog analyzer, and record Pass or Fail in the test record.

11. Repeat step 10 for Output 3, Output 5 and Output 7.

12. Connect the generator balanced (BAL) analog output to the Input A2 XLR of the breakout cable.

13. Check for an indication of 18 dBu in the corresponding bar.

14. Connect the Output 2 XLR of the breakout cable to the analyzer balanced (BAL) analog input.

15. Check for an RMS indication of 18 dBu ±1.0 dB on the analog analyzer, and record Pass or Fail in the test record.

16. Repeat step 15 for Output 4, Output 6, and Output 8.

17. Set the analog audio generator as follows:

Control or setting	Value
Frequency	1 kHz
Output Level	18 dBu
Output Impedance	10 Ω

18. Connect the generator balanced (BAL) analog output to the Input A1 XLR of the breakout cable.

19. Check for an indication 18 dbu in the corresponding bar.

20. Connect the Output 1 XLR of the breakout cable to the analyzer balanced (BAL) analog input.

21. Check for an RMS indication of 18 dBu ±1.0 dB on the analog analyzer and record Pass or Fail the result in the test record.

22. Repeat step 21 for Output 3, Output 5, and Output 7.

23. Connect the generator balanced (BAL) analog output to the Input A2 XLR of the breakout cable.

24. Check for an indication of 18 dBu in the corresponding bar.

25. Connect the Output 2 XLR of the breakout cable to the analyzer balanced (BAL) analog input.

26. Check for an RMS indication of 18 dBu ±1.0 dB on the analog analyzer and record Pass or Fail in the test record.

27. Repeat step 26 for Output 4, Output 6, and Output 8.

28. Set the analog audio generator as follows:

Control or setting	Value
Frequency	19 kHz
Output Level	18 dBu Audio Tone
Output Impedance	10 Ω

29. Connect the generator balanced (BAL) analog output to the Input A1 XLR of the breakout cable.

30. Check for an indication of 18 dbu in the corresponding bar.

31. Connect the Output 1 XLR of the breakout cable to the analyzer balanced (BAL) analog input.

32. Check for an RMS indication of 18 dBu ±1.0 dB on the analog analyzer and record Pass or Fail in the test record.

33. Repeat step 32 for Output 3, Output 5, and Output 7.

34. Connect the generator balanced (BAL) analog output to the Input A2 XLR of the breakout cable.

35. Check for an indication of 18 dBu in the corresponding bar.

36. Connect the Output 2 XLR of the breakout cable to the analyzer balanced (BAL) analog input.

37. Check for an RMS indication of 18 dBu ±1.0 dB on the analog analyzer, and record Pass or Fail in the test record.

38. Repeat step 37 for Output 4, Output 6, and Output 8.

This completes the Performance Verification procedures.