WFM4000 and WFM5000
Waveform Monitors
Specifications and Performance Verification

Technical Reference

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This document applies to firmware version 3.0.

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

Tektronix

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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.

THIS WARRANTY IS GIVEN BY TEKTRONIX WITH RESPECT TO THE PRODUCT IN LIEU OF ANY OTHER WARRANTIES, EXPRESS OR IMPLIED. TEKTRONIX AND ITS VENDORS DISCLAIM ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. TEKTRONIX' RESPONSIBILITY TO REPAIR OR REPLACE DEFECTIVE PRODUCTS IS THE SOLE AND EXCLUSIVE REMEDY PROVIDED TO THE CUSTOMER FOR BREACH OF THIS WARRANTY. TEKTRONIX AND ITS VENDORS WILL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IRRESPECTIVE OF WHETHER TEKTRONIX OR THE VENDOR HAS ADVANCE NOTICE OF THE POSSIBILITY OF SUCH DAMAGES.

[W2 – 15AUG04]

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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.

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
Refer to Manual

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).

Perchlorate Materials. This product contains one or more type CR lithium coin cell batteries. According to the state of California, CR lithium coin cells are classified as perchlorate materials and require special handling. See www.dtsc.ca.gov/hazardouswaste/perchlorate for additional 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.

Preface

This manual contains specifications and performance verification procedures for the WFM4000 and WFM5000 waveform monitors.

Related User Documents

The following product related user documents are available:

- *Release Notes* (Tektronix part number 061-2444-XX). This document describes any known problems or behaviors that you might encounter while using the instrument. This document is provided as a standard accessory when you order a new instrument. If you upgrade your instrument firmware from the Tektronix Web site, an updated version of this document is provided.

- *User Manual* (Tektronix part numbers: English, 071-2438-XX; Japanese 071-2440-XX; Simplified Chinese, 071-2441-XX). This document is electronic and contains detailed operating information for the instrument.

- *Quick Start Reference* (Tektronix part number 071-2476-XX). This document contains a quick, visual guide to basic instrument turn on, turn off, and menu navigation.

- *Service Manual* (Tektronix part number 077-2442-XX). This document provides servicing information for the instrument and is intended for qualified service personnel only.

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.

Specifications

The tables in this section list the specifications for the Tektronix WFM4000 and WFM5000 Waveform Monitors. Items listed in the Performance Requirement column are generally quantitative and can be tested by conducting the appropriate *Performance Verification* procedure in 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 and has been operating continuously for at least 20 minutes within this range.

Electrical Specifications

Table 1: SDI input waveform vertical characteristics

Characteristic		Performance requirement	Reference information
Vertical Measurement Accuracy			Using graticule. 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 1.8X, typical (multiply by fixed gain to get total gain).
Frequency Response - HD			
	Luminance Channel (Y)	50 kHz to 30 MHz, ± 0.5%	
	Chrominance Channels (Pb, Pr)	50 kHz to 15 MHz, ± 0.5%	
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)
	Overshoot		
		SD	≤ 0.3% peak (2T5 bar)
		HD	≤ 0.5% peak (2T30 bar)
	Ringing		
		SD	≤ 0.8% peak-peak (2T5 bar)
		HD	≤ 0.8% peak-peak (2T30 bar)
			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)
			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, Typical			
	Field Rate		0% typical, 0.1% max
	Line Rate		0% typical, 0.1% max
Off Screen Recovery, Typical			0% typical, 0.1% max variation in baseline of a 5 MHz modulated pulse when positioned anywhere on screen at any gain setting.

Table 2: 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
Rates			1 or 2 line, or 1 or 2 field, depending on mode
Line Select			In 2-line sweep, the selected line is the first displayed line.

Table 3: Component Vector Mode

Characteristic		Performance requirement	Reference information
Vertical Bandwidth, Typical			
	SD		800 kHz
	HD		3.4 MHz
Vertical Gain Accuracy		± 0.5%	Fully digital system
Horizontal Gain Accuracy		± 0.5%	Fully digital system
Display to Graticule Registration		0.5 box diameter	1 box is 2%
			Measured using color bars
Vector Display			P_B is displayed on horizontal axis and P_R is displayed on vertical axis

Table 4: 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

Table 5: Diamond Mode

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

Table 5: Diamond Mode (cont.)

Characteristic		Performance requirement	Reference information
Electronic Graticule Display			RGB deflection axis indicated. Upper and lower halves are separated, to see negative signals
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 6: Arrowhead Mode (NTSC/PAL composite limit display)

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 Area Threshold Range			0% to 10%
Luma Limit Detection Range	High		90 to 108%, 0.5% steps
	Low		+5 to –6%, 0.5% steps
Luma Limit Detection Level Accuracy			Detection level = ± 7 mV of cursor level, nominal
Luma Limit Area Threshold Range			0% to 10%

Table 7: 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
		In HD formats, the full screen picture is downsampled to fit in 1024 x 768 size
		In Low Frame Rate formats, frames are repeated as needed to achieve XGA frame rate; similar to 3:2 pulldown on some frame rates

Table 7: Picture Mode (cont.)

Characteristic	Performance requirement	Reference information
Pix Border On/Off		Allows user to mask or show the inactive portions of the raster such as ANC area for digital
		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

Table 8: Data error detection (EDH / Status, Under STATUS Button)

Characteristic		Performance requirement	Reference information
Data Integrity			
	SD	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
	HD	Field rate Resolution, separate reporting for errors in Y or Color Difference data streams	Error icon asserted for 1 second after any error

Table 9: Audio Bar Displays

Characteristic	Performance requirement	Reference information
Channel Mode		Any 8 channels configured into 4 pairs with phase correlation meters between pairs
		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
Audio Sources		Monitoring the signal levels and stereo phase of AES/EBU digital audio and digital audio embedded in serial digital video
		Digital Audio (direct and embedded) may be PCM (decoded) or Dolby digital (detected, but not decoded)
Level Meter Resolution		0.056 dB steps at 30 dB scale, from full scale to –20 dB FS
		XGA Full Screen mode = 510 steps

Table 9: 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 9: 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
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"
Digital Adjustable Peak Program Level	Range 0 to –31 dBFS	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

Table 9: Audio Bar Displays (cont.)

Characteristic	Performance requirement	Reference information
Digital Adjustable Test Level	Range 0 to –31 dBFS	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
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 10: Audio Bar and Lissajous Display

Characteristic	Performance requirement	Reference information
Description		In combination with Bar mode can have Lissajous Display (See Table 9.)
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 (See Table 9.)

Table 11: AES Audio Inputs

Characteristic	Performance requirement	Reference information
Inputs		2 channels each, 32-192 kHz, 24 bit, meets requirements of AES-3ID and SMPTE 276M-1995
Input Connector		BNC, terminated, unbalanced
Input Impedance		75 Ω
Input Return Loss	>25 dB relative to 75 Ω , from 0.1 to 6 MHz	
Input Amplitude Range		0.1 V to 2 V peak-to-peak
Input Sample Rate	32k to 192k samples/sec	

Table 11: AES Audio Inputs (cont.)

Characteristic	Performance requirement	Reference information
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%
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 attenuated additionally, as shown below. Sampling frequency refers to the 192 kHz upsampled data used for the bar ballistics For example: 1/12th of rate –0.30dB (16 kHz ± 5 Hz) 1/16th of rate –0.17dB (12 kHz ± 5 Hz) 1/20th of rate –0.11dB (9.6 kHz ± 5 Hz)	May not display full amplitude on fast transients due to sampled nature of digital signal
Audio Levels		Bars display signals up to 0 dBFS
		Must not exceed maximum power specification on analog outputs. Configure output attenuation if necessary

Table 12: Embedded Audio Extraction

Characteristic		Performance requirement	Reference information
Embedded Audio Formatting	SD	Extract 20-bit audio formatted according to SMPTE 272M	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)
	HD	Extract 20- or 24-bit audio formatting according to SMPTE299M (48 kHz audio sampling rate synchronized with video)	
Channel Numbering			Channel numbers per SMPTE 272M (1 through 16) will be correctly shown on all displays
Audio Rates			No support for SMPTE 272M levels C through J
Number of Channels Monitored for Presence			16 channels are monitored for presence
Maximum Number of Channels Monitored for Activity			Can only monitor channels set up for display
Audio levels		Bars display signals up to 0 dBFS	

Table 13: Headphone Output

Characteristic	Performance requirement	Reference information
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	± 0.1 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 14: 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
Pixel Defects		≤ 6 bad pixels	

Table 15: LTC Time Code Input / Ground Closures

Characteristic	Performance requirement	Reference information
LTC Input Connector		Balanced, unterminated via rear-panel GC remote connector. (See Table 20.)
LTC Input Impedance		Greater than 10 kΩ
LTC Signal Characteristics		Longitudinal Time Code per IEC Publication 461
LTC Signal Amplitude Range, Typical		0.2 V_{p-p} to 5.0 V_{p-p}, balanced differential or single-ended

Table 15: LTC Time Code Input / Ground Closures (cont.)

Characteristic	Performance requirement	Reference information
Ground Closure Input Signaling (Preset Selection)		TTL thresholds, 5 V maximum input, –0.5 V minimum input. Pull low to assert
		Has internal 10 kΩ pull-up to 5 V on each input
		Direct or encoded inputs must be asserted and stable for at least 150 ms to be recognized reliably. Inputs that are stable for 75 ms or less will never be recognized
		Inputs are sampled every 16.6 ms. Five consecutive samples must all have the same code for the code to be accepted
Ground Closure Output (Alarm Output) Type		One open collector output
		Pulled up by 10 kΩ resistor in series with a diode to +5 V. Pull down current is limited by 10 Ω resistor. Maximum current allowed is 100 mA

Table 16: Serial Digital Video Interface (Input A, Input B)

Characteristic		Performance requirement	Reference information
Video Inputs			Two inputs; only one input active at a time
Format			Each input compatible with SMPTE 292M/BTA-S004A and 270 Mb/s SMPTE 259M
Input Type			75 Ω BNC, passive loop-through
Cable Loss Accommodation		With 1/SQRT(f) characteristic at ½ of serial rate.	
	SD	0 to 30 dB attenuation	Equivalent to approximately 300 m of Belden 8281 at 270 Mb/s
	HD	0 to 20 dB attenuation	Equivalent to approximately 80 m of Belden 8281 at 1.485 Gb/s. Typical performance to 110 m
Launch Amplitude Accommodation, Typical	For Full Specification		800 mV ± 10%
	Typical performance		800 mV ± 30%, with up to 20 dB Cable Loss
Jitter Tolerance, Typical			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	
Isolation Between Inputs		> 45 dB to 1.5 GHz	
Time Base Range			>± 50ppm

Table 17: 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 formats listed in Tables 1-44 through 1-46. 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
Analog Sync Format	NTSC 1080i 59.94 Hz 1080p 23.98 Hz 1080p 24 Hz PAL 1080i 60 Hz 720p 59.94 Hz 720p 50 720p 60 1080i 50 1080sf 23.98 1080sf 24	
Input Signal Level, Typical		–6 dB to +6 dB
Low Frequency Input Impedance		20 kΩ
Maximum Operating Input Voltage, Typical		± 5 V DC
Absolute Maximum Input Voltage, Typical		± 5 V DC
Return Loss, Typical		> 40 dB to 6 MHz
		>35 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 18: Ethernet

Characteristic	Performance requirement	Reference information
Ethernet Purpose		Web page access and software upgrades. Web page enables download of screen shots, error and diagnostics logs, and upload/download of presets.
IP Address Mode		Supports manual and DHCP
Connector Type		RJ-45 LAN connector supporting 10/100 Base-T

Table 19: USB

Characteristic	Performance requirement	Reference information
Type		Host
Speed		Complies with USB 1.1 full speed specification
		Full speed operation is 12 Mb/s.

Table 20: Remote Port

Characteristic	Performance requirement	Reference information			
Connector Pin Assignments	1 GND (In)	*Hex*	*Binary Pins 15, 14, 13, 12, 11, 10*	*Direct mode selection*	*Encoded mode selection*
	2 Reserved (I/O)				
	3 Reserved (I/O)				
	4 Reserved (In)				
	5 Reserved (In)	F	111111	none	No action
	6 GND (In)	E	XX1110	Preset 1	CPS B
	7 Time Code Positive (LTC In)	D	XX1101	Preset 2	CPS A
	8 Time Code Negative (LTC In)	C	XX1100		SDI B
	9 Ground Closure (Alarm Out)	B	XX1011	Preset 3	SDI A
	10 Preset 1 (In)	A	XX1010		Channel B
	11 Preset 2 (In)	9	XX1001		Channel A
	12 Preset 3 (In)	8	XX1000		
	13 Preset 4 (In)	7	XX0111	Preset 4	
	14 Preset 5 (In)	6	XX0110		Factory Preset
	15 Preset 6 (In)	5	XX0101		Preset 5
		4	XX0100		Preset 4
		3	XX0011		Preset 3
		2	XX0010		Preset 2
		1	XX0001		Preset 1
		0	XX0000		Unused
		N/A	101111	Preset 5	N/A
		N/A	011111	Preset 6	N/A

Table 21: Power Source

Characteristic	Performance requirement	Reference information
Electrical Rating	12 VDC nominal	10.75 to 18.0 VDC min - max operating
Supply Connection		XLR 4 pin male connector. Pin 1 = V(-), Pin 4 = (V+), Pin 2,3 NC
Power Consumption, Typical		22 W typical, 30 W max

Table 21: Power Source (cont.)

Characteristic	Performance requirement	Reference information
Surge, Typical		25 amps peak 5 mA-sec, measured at half amplitude
Fuse Rating		4 amp internal self-resetting fuse
		Not operator replaceable. Refer servicing to qualified service personnel

Table 22: Miscellaneous

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

Physical Specifications

Table 23: Physical Characteristics

Characteristic		Standard
Dimensions		
	Height	5.2 inches (132.1 millimeters)
	Width	8.4 inches (213.4 millimeters)
	Depth (including BNCs and knobs)	5.5 inches (139.7 millimeters)
Weight		
	Net	3 pounds 7 ounces (1.56 kilograms)
	Shipping	9 pounds (4.08 kilograms), approximate

Table 24: 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		Variable Fan. Forced air circulation with no air filter.
Required Clearances		Do not block the bezel or rear panel vent holes, or more than half the vent holes on the sides

Certifications and Compliances

EC Declaration of Conformity – EMC

Meets intent of Directive 2004/108/EEC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:

EN 55103:1996. Product family standard for audio, video, audio-visual and entertainment lighting control apparatus for professional use. [1]

- Environment E2 – commercial and light industrial

- Part 1 Emission

  - EN 55022:2006. Class B radiated and conducted emissions

  - EN 55103-1:1996 Annex A. Radiated magnetic field emissions

  - EN 55103-1:1996 Annex B. Inrush current; I peak = 3.1 A

- Part 2 Immunity

  - IEC 61000-4-2:1999. Electrostatic discharge immunity

  - IEC 61000-4-3:2002. RF electromagnetic field immunity

  - IEC 61000-4-4:2004. Electrical fast transient / burst immunity

  - IEC 61000-4-5:2005. Power line surge immunity

  - IEC 61000-4-6:2003. Conducted RF Immunity

  - IEC 61000-4-11:2004. Voltage dips and interruptions immunity

  - EN 55103-2:1996 Annex A Radiated magnetic field immunity

EN 61000-3-2:2000. AC power line harmonic emissions

European Contact.
Tektronix UK, Ltd.
Western Peninsula
Western Road
Bracknell, RG12 1RF
United Kingdom

[1] Must use high-quality shielded cables to ensure compliance.

Australia / New Zealand Declaration of Conformity – EMC

Complies with the EMC provision of the Radiocommunications Act per the following standard:

- AS/NZS 2064.1/2 Industrial, Scientific, and Medical Equipment: 1992

FCC – EMC

Emissions are within the limits of FCC 47 CFR, Part 15, Subpart B for Class A equipment.

Supported Input Formats and Allowed References

An X in Tables 1-44 through 1-46 indicates that this combination is supported and verified. 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 25: 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 [1]	X		X			X
720p 50 Hz [1]	X		X			X
1080p 25 Hz [1]	X		X			X
1080sf 25 Hz [1]	X		X			X
1080i 50 Hz [1]	X		X			X
576i 50 Hz (625)	X		X			X

Table 26: 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 [1]	X			X	X	X			X
720p 29.97 Hz [1]	X			X					X
720p 59.94 Hz [1]	X			X	X	X			X
1080p 23.98 Hz [1]	X			X	X	X			X
1080sf 23.98 Hz [1]	X			X	X	X			X
1080p 29.97 Hz [1]	X			X					X
1080sf 29.97 Hz [1]	X			X					X
1035i 59.94 Hz [1]	X			X					X
1080i 59.94 Hz [1]	X			X					X
483i 59.94 Hz (525)	X			X					X

[1] HD only

Table 27: 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 [1]			X	X	X			X

Table 27: 24 Hz, 30 Hz, and 60 Hz Frame and Field Rates (cont.)

Input Format	Reference Format							
	720p 24	720p 30	720p 60	1080p 24	1080sf 24	1080p 30	1080sf 30	1080i 60
720p 30 [1]			X					X
720p 60 [1]			X	X	X			X
1080p 24 [1]			X	X	X			X
1080sf 24 [1]			X	X	X			X
1080p 30 [1]			X					X
1080sf 30 [1]			X					X
1035i 60 Hz [1]			X	X	X			X
1080i 60 Hz [1]			X	X	X			X

[1] HD

Table 28: Supported Standards

Image	System	Interface	Signal Type	Image system number for indicated field/frame rate							
				60	59.94	50	30	29.97	25	24	23.98
274M	1920 x 1080/P, PsF	292M	4:2:2 Y'C'$_B$C'$_R$								
	1920 x 1080/I	292M	4:2:2 Y'C'$_B$C'$_R$	X	X	X					
295M (1250/50)	1920 x 1080/I, P	Not supported									
240M 260M	1920 x 1035/I	292M	4:2:2 Y'C'$_B$C'$_R$	X	X						
296M	1280 x 720p	292M	4:2:2 Y'C'$_B$C'$_R$	X	X	X	X	X	X	X	X
ITU-R BT.601	720 x 576/I (625)	292M	4:2:2 Y'C'$_B$C'$_R$			X					
	720 x 483/I (525)	292M	4:2:2 Y'C'$_B$C'$_R$		X						
293M	720 x 480/P	Not supported									

Alarms

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

Table 29: 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 Unlocked	Indicates unable to lock to selected SDI input signal
External Reference Missing	Indicates that no signal is detected on the Ref input when REF EXT is selected
External Reference Unlocked	Indicates unable to lock to the Ref input signal when REF EXT is selected
Ref Format 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 Format Change	Indicates that a change occurred in the format of the selected video input signal
Video Format 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
Video Ref Mismatch	Indicates that the Ref signal format is not compatible with the Input signal format. See Tables 1-44, 1-45, and 1-46, Supported Input Formats and Allowed References
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 Placement Error	Indicates that the location of the EAV timing reference signal differs from that expected for the detected video format.
SAV Placement Error	Indicates that the location of the SAV timing reference signal differs from that expected for the detected video format
VITC TC Missing	Indicates that a break or discontinuity in the VITC has occurred
VITC TC Invalid	Indicates that the VITC was lost for one frame but has reappeared
LTC TC Missing	Indicates that a break or discontinuity in the LTC has occurred
LTC TC Invalid	Indicates that the LTC was lost for one frame but has reappeared
Anc TC Missing	Indicates that a break or discontinuity in the ANC timecode has occurred
Anc TC Invalid	Indicates that the ANC timecode was lost for one frame but has reappeared

Table 30: HD Specific Alarms

Alarm	Description
Video Not HD	Indicates that the selected SDI video input signal is not an HD format

Table 30: HD Specific Alarms (cont.)

Alarm	Description
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 31: 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 Alarm	Indicates that EDH (error detection and handling) has detected an error

Table 32: Audio Alarms

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 Lock	Indicates unlocked condition of an AES input
(Embedded) Audio Stream Missing	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
(Embedded) Group Sample Phase	Indicates embedded audio streams are not time-aligned due to asynchronous audio or data error

Performance Verification

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

- WFM4000 models

- WFM5000 models

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 and must be operating at an ambient temperature. (See Table 24 on page 14.)*

Test Records

Use the tables on the following pages 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 33: WFM4000 and WFM5000 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			
Front Panel LEDs			
POST			
Front Panel Test			
LCD Pixel and Defects			
Fan Test			
SDI Bit Integrity			
External Reference			
NTSC Lock			
Ref Missing			
Digital Audio Input			
AES Audio input A to Display Bar			
Embedded Audio to Display Bar			
Embedded Audio to Lissajous Display			
LTC Decode			
Ground Closure Remote			
Remote Input - Activate Preset			
Remote Output - Ground Closure			
Ethernet Functionality			

Test Record - HD only

If you are testing an SD-only instrument, skip this record.

Table 34: WFM4000 and WFM5000 Waveform Monitor Video Performance Test Record

Instrument Serial Number:		Certificate Number:		
Temperature:		RH %:		
Date of Calibration:		Technician:		
Performance Test	**Minimum**	**Incoming**	**Outgoing**	**Maximum**
HD SDI Input Level Low and High (HD)				
Input A, Low Level				90% (720 mV)
Input A, High Level	110% (880 mV)			
Input B, Low Level				90% (720 mV)
Input B, High Level	110% (880 mV)			
EDH and HD SDI Input Equalization Range (HD)				
EDH	Pass			
Input A	20 dB			
Input B	20 dB			
HD SDI Loop Through Isolation (HD)	Pass			
External Reference Formats supported: Tri-Level	Pass			
External Reference Lock in Presence of Hum: Tri-Level	Pass			

Test Record - SD Only

The following test record covers tests of SD functionality. These tests are valid for all instruments with SD.

Table 35: WFM4000 Waveform Monitor Video Performance Test Record

Instrument Serial Number:		Certificate Number:		
Temperature:		RH %:		
Date of Calibration:		Technician:		
Performance Test	**Minimum**	**Incoming**	**Outgoing**	**Maximum**
SD SDI Input Level Low and High				
Input A, Low Level				720 mV
Input A, High Level	880 mV			
Input B, Low Level				720 mV
Input B, High Level	880 mV			
SD SDI Input Equalization Range and EDH				
EDH	Pass			
Input A	30 dB			
Input B	30 dB			
External Reference Formats supported: Bi-Level	Pass			
External Reference Lock Range	–50 ppm			50ppm
External Reference Lock in Presence of Hum: Bi-Level	Pass			
LTC Decoding Functionality	Pass			

Test Record - Audio

Table 36: WFM4000 and WFM5000 Waveform Monitors Audio Test Record

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

Performance Test	**Minimum**	**Incoming**	**Outgoing**	**Maximum**
AES Audio Return Loss				
AES A	25 dB			
AES Audio Input Sample Rate				
AES A (1 kHz)	pass			
AES Audio Level Meter Accuracy Over Frequency				
AES A (1 kHz)	Pass			
AES A (19 kHz)	Pass			
AES A (100 Hz)	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

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, and must be operating at an ambient temperature. (See Table 24 on page 14.)

Use the following procedures to check the basic functionality of the instrument under test. The checks are arranged by model 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 37: Required Test Equipment (Incoming Inspection)

Test Equipment	Requirements	Example
75 Ω coaxial cables (3 required)	General purpose digital video	Belden 8281.
	Male-to-male BNC connectors 1 or 2 meters long	Tektronix part numbers 012-0159-00 or 012-0159-01
75 Ω Terminator for Analog Video	Male connector, Precision	Tektronix part number 011-0102-03
75 Ω Terminator for SDI signal (2)	Male, wideband	Tektronix part number 001-0163-00
SDI serial digital video test generator, with embedded audio and composite signal source	NTSC Black	Tektronix TG2000 with BG1 and additional modules indicated in the next three rows
	1080i 59.94 HD signals required: 100% color bars 10-bit shallow ramp SDI Matrix Split Field Pathological Signal 100% sweep	HDVG1 module for TG2000 (Embedded audio needed)
	525/270 SD signals required: 100% color bars 10-bit shallow ramp SDI Matrix Split Field Pathological Signal 100% sweep	DVG1 module for TG2000 (Embedded audio needed)

Table 37: Required Test Equipment (Incoming Inspection) (cont.)

Test Equipment	Requirements	Example
Audio Signal Analyzer and Generator	48 kHz, 24 bit word length signals	Rohde & Schwarz UPL06; Tektronix AM700 and AM70; or Rohde & Schwarz UPV with options UPV-B2, UPV-K4, and UPV-K22
Video Test Signals	SDI 525 10-bit shallow ramp SDI 525 100% sweep NTSC black NTSC SMPTE bars	Provided by Tektronix TG2000 as specified above
LTC generator		Horita TRG-50 or Adrienne AEC-Box-28
Voltmeter		Fluke 87 or equivalent
15-pin DSUB male connector and cable	Used to mate with the ground closure port	(See Figure 1 on page 46.)
Computer and Ethernet cable	Used to test Ethernet connection	Generic equipment

Incoming Inspection Tests

Basic Turn On and Self Test

1. Connect the AC power supply to the rear of the instrument and to a 100 to 240 VAC source.

2. Press the Power button on the front panel of the instrument.

3. Look at the front panel immediately after you apply power. Some of the front panel buttons will light up. After about 15 seconds, the Boot Loader will complete.

4. Record pass or fail in the test record for Front Panel LEDs.

5. After about 15 seconds, the power-on diagnostic page should appear on the monitor.

6. 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**.

NOTE. The Audio board temperature test will give a value instead of showing the word PASS.

7. 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.

8. Record Pass or Fail for the POST in the test record.

9. 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 above). 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 DVG1 to the SDI A input and terminate the loop-through.

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

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

5. Press each of the front panel 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.

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

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

8. Press **HELP** to exit help.

9. Record Pass or Fail for Buttons and Knobs 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 38.)

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.

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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 38: 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 2I 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.

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 - Check Output Validity and Bit Integrity

1. Connect a 525/270 10-bit shallow ramp matrix signal from the DVG1 module to the SDI A input of the instrument under test and terminate the loop-through.

2. Set the waveform monitor to the Factory Presets. (See page 28, *Restore the Factory Presets*.)

3. Set the display style to Parade (if the default display style is parade, do not perform this step):

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

    b. Select **Display Style**.

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

    d. Press the **WFM** button.

4. 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.

5. Set the display vertical gain:

    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. Position the waveform so that you can check the ramps.

7. Check a major division of both ramps in the signals. Check for 11 to 13 even vertical steps over a major division (10 mV). The steps should always step upward in a monotonic ramp.

8. Press the **GAIN** button on the waveform monitor so that the button is no longer lit. This returns the instrument to x1 gain.

9. Change the input signal to a 100% sweep.

10. Verify the sine waves are uniform and do not have steps. Also verify the amplitude is 700 mV.

11. Disconnect the signal from the SDI A input and reconnect it to the SDI B input.

12. Press the input **B** button.

13. Record Pass or Fail for SDI Bit Integrity in the test record.

External Reference

1. Restore the Factory Preset. (See page 28, *Restore the Factory Presets*.)

2. Connect a 525/270 10-bit shallow ramp signal from a DVG1 module to the SDI A input of the instrument under test and terminate the loop-through.

3. Apply an NTSC signal to the External Reference input from the Analog Signal Generator. Install a termination on the loopthrough.

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 **SWEEP** button.

7. Verify that the waveform is stable.

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

9. Remove the NTSC signal from the reference input.

10. The waveform 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.

Digital Audio Input

1. Restore the Factory Preset. (See page 28, *Restore the Factory Presets*.)

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

3. Press and hold the **Audio** 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 IN input.

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

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

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

9. Set the DVG1 module in the signal generator to 525/270 color bars.

10. Set the generator for embedded audio in 2 groups, starting with group 1, and then access and set its audio channels:

    a. Press **Modules** and select DVG1.

    b. Press **Test Signals** and select **Module Parameters**.

    c. Select **Embedded Audio** and set the audio channels as follows:

        – Channel 1: 50 Hz, –35 dB

        – Channel 2: 100 Hz, –30 dB

        – Channel 3: 150 Hz, –25 dB

        – Channel 4: 200 Hz, –20 dB

        – Channel 5: 250 Hz, –15 dB

        – Channel 6: 300 Hz, –10 dB

        – Channel 7: 400 Hz, –5 dB

        – Channel 8: 500 Hz, 0 dB

11. Connect the output of the DVG1 to the SDI A input of the instrument under test, making sure to terminate the loop-through if it is not already terminated.

12. Press and hold the **Audio** button to display the Audio pop-up menu.

13. Select **Audio Input > Embedded**.

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

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

NOTE. If level-meter bars indicate that audio is not present, set the generator module number of groups to 2, even if it appears to be set already.

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

17. Press and hold the **Audio** button to display the Audio pop-up menu.

18. Select **Phase Headphone Pair > 1 & 2**.

19. Go through the other phase pairs (3 & 4, 5 & 6, 7 & 8) and verify that the phase display changes in each one.

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

LTC Decode Test

1. Restore to Factory Presets. (See page 28, *Restore the Factory Presets*.)

2. You will need a custom cable for this procedure. Do this as follows:(See Figure 1 on page 46.)

   a. Solder wires to each of the pins of a male high density DB15 connector, and strip the insulation back approximately 1/4 inch on each of the wires.

   b. Make a shielded coaxial cable with a male RCA connector on one end. On the other end, connect the center coaxial conductor to pin 7 of the male DB15 connector and the outer (shield) conductor to pin 8 of the male DB15 connector.

NOTE. This is the same cable used to check Ground Closure functionality.

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

4. Select any NTSC signal for the AVG1.

5. Connect the TG2000 AVG1 composite output to the video input of the Timecode generator.

6. Connect a 525/270 color bar signal from the DVG1 module to the SDI A input of the instrument under test.

7. Press **CONFIG**.

8. Select **Aux Data Settings > Timecode Display if present > LTC**.

9. 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.

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

11. Disconnect the LTC generator from the custom cable.

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. (See Figure 1 on page 46.)

NOTE. This is the same cable used to check LTC functionality.

    a. Solder wires to pins 10, 11, 12, 13, 14, and 15 of a male high density DB15 connector, and strip the insulation back approximately 1/4 inch on each of the wires.

    b. Make a shielded coaxial cable with a male RCA connector on one end. On the other end, connect the center coax conductor to pin 7 of the male DB15 connector and the outer (shield) conductor to pin 8 of the male DB15 connector.

3. Connect the DSUB connector to the GCI connector on the waveform monitor.

Remote Input (Activate Preset).

4. Restore the Factory Preset. (See page 28, *Restore the Factory Presets*.)

NOTE. This test overwrites presets A1 through A6. Save any existing presets to USB flash memory before doing this procedure.

5. Press the **WFM** button to display a waveform.

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 as Preset **A1**.

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

7. Repeat steps 5 and 6 to create a preset with **Vector** display. Save as Preset **A2**.

8. Repeat steps 5 and 6 to create a preset with a **Picture** display. Save as Preset **A3**.

9. Repeat steps 5 and 6 to create a preset with an **Audio** display. Save as Preset **A4**.

10. Repeat steps 5 and 6 to create a preset with a **Gamut** display. Save as Preset **A5**.

11. Repeat steps 5 and 6 to create a preset with a **Status** display. Save as Preset **A6**.

12. Set the waveform monitor to the factory presets. (See page 28, *Restore the Factory Presets*.)

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

14. Preset **A1** should be restored so that a waveform is displayed. It may take several seconds for the display to change.

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

16. Preset **A2** should be restored so that a vector is displayed. It may take several seconds for the display to change.

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

18. Preset **A3** should be restored so that a picture is displayed. It may take several seconds for the display to change.

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

20. Preset **A4** should be restored so that audio is displayed. It may take several seconds for the display to change.

21. Short pins 1 and 14 together on the remote cable.

22. Preset **A5** should be restored so that gamut is displayed. It may take several seconds for the display to change.

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

24. Preset **A6** should be restored so that status is displayed. It may take several seconds for the display to change.

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

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

Test Ground Closure Out.

1. Restore the Factory Preset. (See page 28, *Restore the Factory Presets*.)

2. Connect a voltmeter or oscilloscope to monitor pin 9 of the DSUB connector.

3. Verify the voltage is greater than 4.5 V. This indicates the output is not asserted.

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

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

.

6. Use the arrow keys to select highlighting to the **Ground Closure** column of the **SDI Input Missing** row. This instructs the instrument to assert the ground closure if the input is not present.

7. Use the arrow keys to highlight the Return box, and then press **SEL** to dismiss the menu.

8. The voltmeter should read about 4.7 V on pin 9.

9. Remove the input signal from the SDI connector on the rear panel to assert ground closure.

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

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

Ethernet Test

1. Connect an Ethernet cable from the rear of the unit to a computer. The computer must have a Web browser installed.

2. Restore the Factory Preset. (See page 28, *Restore the Factory Presets*.)

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

4. Select **Network Settings** > **IP Configure Mode**.

5. Verify that the IP Config Mode is set to **Manual**.

6. Select **Network Settings** > **IP Address**.

7. Set the IP Address to be compatible with the computer:

   a. Use the left/right arrow keys to move the highlight to each box in the address.

   b. Use the up/down arrow keys to change the number in each box as required.

   c. To accept your changes, move the highlight to the Accept box and press **SEL**.

   d. Enable the ethernet connection from the Configuration menu by selecting **Network Settings** > **Web Enable** > **On**.

8. Open a Web browser on the computer.

9. From the computer, enter the IP address of the waveform monitor into the Web browser address line (for example, http://192.182.256.23).

10. You should see a Web page titled "Tektronix WFM4000/WFM5000 Remote Interface" or something similar. This means that the Ethernet function is working.

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

Video and General Performance Verification Procedures

This performance verification includes procedures that verify all instrument models.

Required Equipment

Table 39: Required Test Equipment (Video and General Performance)

Test Equipment	Requirements	Example
SDI serial digital video test generator with embedded audio and composite signal source	NTSC Black	Tektronix TG2000 with BG1 and additional modules indicated below:
	1080i 59.94 HD signals required for WFM5000:	HDVG1 module for TG2000 (Embedded audio needed for audio option DG)
	■ 75% and 100% color bars	
	■ SDI Matrix Split Field Pathological Signal	
	■ SDI Equalizer	
	HD signal with adjustable SDI amplitude required for WFM5000	HDST1 module for TG2000
	1080i 59.94 analog tri-level sync required for WFM5000	AWVG1 module for TG2000
	525/270 SD signals required for WFM4000:	DVG1 with option S1 module for TG2000 (Embedded audio needed for audio option DG)
	■ 75% and 100% color bars	
	■ SDI Matrix Pathological Signal	
	■ SDI Equalizer	
	■ Adjustable SDI amplitude	
HD Cable-clone cable simulator	Simulate 10 to 150 meters of 8281 equivalent in 10 m steps	Faraday FFC Kit
SD Cable-clone cable simulator	Simulate 0 to 400 meters of 8281 equivalent in 25 meters steps.	Faraday SC75A800B-G
75 Ω coaxial cables (3 required)	General purpose digital video	Belden 8281
	Male-to-male BNC connectors 1 or 2 meters long	Tektronix part numbers 012-0159-00 or 012-0159-01
75 Ω terminator for SDI signals (2)	Male, wideband	Tektronix part number 011-0163-00
75 Ω precision terminator	Male connector	Tektronix part number 011-0102-03

Table 39: Required Test Equipment (Video and General Performance) (cont.)

Test Equipment	Requirements	Example
75 Ω Network Analyzer or Spectrum Analyzer with Tracking Generator and Return Loss Bridge	Measure return loss. 60 dB range to 10 MHz, 40 dB range to 300 MHz 75 Ω test port; 50 Ω input and output test ports	Agilent 8712 75 Ω Tektronix 2712 Wide Band Engineering A57TUC with male 75 Ω BNC test port
75 Ω calibration kit		Maury 8580A 75 Ω BNC
LTC Generator		Horita TG-50 or Adrienne AEC-Box-28
RCA to 15-pin header custom cable	15-pin male DSUB connector (See Figure 1.), Tektronix part number 131-1164-00, RCA plug Allied 932-1098, and wire	
BNC barrel connector		

[1] The required custom signals are provided on the Product Documentation CD. These signals are also provided for an AVG1 module, if an 067-0465-00 (AVC1) is not available. Download the PVCustomSignals.zip file, unzip it, and install the signals on your TG2000.

[2] Note that the 067-0465-00 (AVC1) is not available outside of Tektronix. Other equipment can be substituted but it might not have sufficient accuracy to guarantee the specifications. For hum insertion, a general-purpose sine wave generator can be used to terminate and drive back into the video signal through appropriate impedance matching.

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

1. Connect the DC power supply to the rear of the waveform monitor.

2. Press the Power button on the front-panel to turn on the instrument. After approximately 40 seconds, boot up will complete. Allow at least 20 minutes for the waveform monitor to warm up before beginning any procedures.

HD Video Tests

The following tests apply to HD capable WFM5000 series instruments.

HD SDI Input Level Low and High

This test uses the serial output with adjustable level to verify that the waveform monitor can accept serial signals of various amplitudes.

1. Set the waveform monitor to the factory presets. (See page 28, *Restore the Factory Presets*.)

2. Connect a 75 Ω cable from a TG2000 HDVG1 output (Output 2) to the HDST1 video input.

3. Connect a 75 Ω cable from the HDST1 STRESS output to the SDI A input on the waveform monitor.

4. Terminate the loop-through with a 75 Ω terminator.

5. On the TG2000 HDVG1, set the output to the SDI Matrix signal.

6. You should see a waveform on the waveform monitor display. Press and hold the **STATUS** button, and select **Video Session** to display the status screen. The status screen should display OK for Y Chan CRC, C Chan CRC, Y Anc Checksum, and C Anc Checksum errors.

7. Press the **STATUS** button to close the menu.

8. On the TG2000 HDST1, adjust the serial amplitude downward to find the lowest level that does not generate any CRC errors in a 10 second period.

9. Record the HDST1 Amplitude Level in the test record.

10. Increase the HDST1 Amplitude Level to 130 %.

11. If any EDH errors are generated, reduce the amplitude until no errors are generated for a 10 second period.

12. Record the HDST1 Amplitude Level in the test record.

13. Move the input cable from the SDI A input to the SDI B input.

14. Repeat steps 8 through 12 for the SDI B input.

15. Record this level in the test record.

EDH and HD SDI Input Equalization Range

This test uses a cable clone to simulate cable. This verifies that the waveform monitorcan receive signals that have passed through long cables.

EDH.

1. Set the waveform monitor to the factory presets. (See page 28, *Restore the Factory Presets*.)

2. Connect the TG2000 HDVG1 output (Output 2) to the TG2000 HDST1 input.

3. Connect the TG2000 HDST1 STRESS output to the waveform monitor SDI A input.

4. If you do not have the video status screen displayed, press and hold the **STATUS** button, and select **Video Session** to display the status screen.

5. Press the **STATUS** button to close the menu.

6. Select the 1080i 59.94 SDI Equalizer Test signal from the TG2000 HDVG1.

7. Set the TG2000 HDST1 SDI parameters for a 1.0 error rate.

8. You should see errors under that Status column for Y Chan and C Chan CRC. Check under the Err Seconds column to verify that these readouts are accumulating errors at a rate of one per second.

9. Record Pass or Fail in the test record.

10. Press Reset on the HDST1 module.

Cable Length Accommodation.

1. Connect a cable from an output of the TG2000 HDVG1 to the 70 m section of the HD Cable clone.

2. Use a second cable to connect the other port of the cable clone section to the SDI A connector on the waveform monitor.

3. On the TG2000 HDVG1, set the output to the SDI Matrix signal.

4. Press the **PICT** button to see a stable picture, and then press the **WFM** button to see a stable waveform.

5. Press and hold the **STATUS** button and select **Video Session** from the pop-up menu to see the Status display.

6. You should see that all of the CRC parameters on the Status screen read Okay.

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

9. Record the value in the test record.

10. Repeat the test using SDI B input on the waveform monitor.

11. Record this level in the test record.

HD SDI Loop- through Isolation

This test looks for crosstalk between the two SDI inputs. One input is driven by a signal straight from the generator; the second input is driven through the cable clone, which simulates a long cable. The two sources are set to different rates to allow transitions of the serial signal to hit all possible phases. If the isolation is sufficient, the crosstalk will not introduce errors.

1. Set the waveform monitor to the factory presets. (See page 28, *Restore the Factory Presets*.)

2. If you do not have the video status screen displayed, press and hold the **STATUS** button to display the Status pop-up menu, and then select **Video Session**.

3. Press the **STATUS** button to close the menu.

4. Connect a cable to any output on the TG2000 HDVG1.

5. Connect the other end of the cable to the 70 m section of the HD Cable clone.

6. Connect a second cable to the other port of the cable clone section.

7. Connect a cable from the cable clone to the SDI A input connector.

8. Connect an output from the DVG1 to the SDI B input connector.

9. Set the signal driving the SDI B input to 100% color bars.

10. Set the time base on the second signal to 1 ppm high.

11. Verify that there are no CRC errors on the SDI A input.

12. Record a Pass or Fail as appropriate in the test record.

13. Disconnect the test setup.

External Reference Formats Supported: Tri-Levels

Check that the unit under test can reference to NTSC and PAL while viewing digital signals.

1. Connect a 525/270 color bars signal from the DVG1 module to the SDI A input on the rear panel of the instrument and terminate the loop-through.

2. Press the **EXT REF** button to select the external reference mode.

3. Route the Video In cable from the AVC1 module to the output of the AWVG1 module.

4. Connect the Video Out cable from the AVC1 module to the External Reference input on the instrument and terminate the loop-through.

5. On the AWVG1 module, set the signal to a 1080i 59.94 Tri-level sync signal.

6. Check that the lower-level corner of the instrument display shows the proper standard for the reference.

7. Press the **WFM** button and check that the waveform is locked.

8. Press the **Vector** button and check that the vector waveform is locked.

9. Log either Pass or Fail in the test record.

External Reference Lock in Presence of Hum, Tri-Level

Apply a 0 dB hum signal to the Reference and verify the waveform monitor still locks correctly.

1. Set the AVC1 for 0 dB of 60 Hz hum.

2. Press the **WFM** button and check that the signal is locked and that the waveform is stable.

3. Press the **Vector** button and check that the signal is locked and that the vector waveform is stable.

4. Record Pass or Fail in the test record.

5. Disconnect the test setup.

SD Video Tests

SD SDI Input Level Low and High

This test uses the serial output with adjustable level to verify that the waveform monitor can accept serial signals of various amplitudes.

1. Set the waveform monitor to the factory presets. (See page 28, *Restore the Factory Presets*.)

2. Connect a cable to the Opt S1 output of the TG2000 DVG1. The Opt S1 output is typically the second BNC from the top of that module.

3. Connect the other end of the cable to the SDI A input connector on the waveform monitor and terminate the loop-through.

4. On the TG2000 DVG1, set the output to the SDI Matrix signal.

5. You should see a waveform on the waveform monitor display.

6. Press and hold the **STATUS** button and select **Display Type > Video Session**.

7. In the Status Display, you should see OK for all the EDH parameters.

8. On the TG2000, adjust the serial amplitude downward to find the lowest level that does not generate any EDH errors in a 10 second period.

9. Record the DVG1 amplitude level in the test record.

10. Increase the serial amplitude to 115%.

11. If any EDH errors are generated, reduce the amplitude until no errors are generated for a 10 second period.

12. Record the DVG1 amplitude level in the test record.

13. Repeat the steps 8 to 12, using the SDI B input on the waveform monitor.

SD SDI Input Equalization Range and EDH

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

1. Set the waveform monitor to the factory presets. (See page 28, *Restore the Factory Presets*.)

EDH.

2. Connect the TG2000 DVG1 Normal output (not the Opt S1 output) to the Cable Clone input. Typically the Normal output is the top BNC on the DVG1 module.

3. Connect the Cable Clone output to the waveform monitor SDI A input and terminate the loop-through.

4. Press and hold the **STATUS** button to display the Status pop-up menu.

5. Select **Display Type** and then **Video Session**.

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

7. Select the 525 270 SDI Equalizer Test signal from the TG2000 DVG1.

8. Set all switches on the Cable Clone to the *out* position.

9. While watching the EDH Error display Statistics column on the Video Session screen, rapidly toggle the +1 switch on the Cable Clone between the out and the in position until errors are observed.

10. The EDH Error display on the Video Session screen should indicate an EDH Error on at least one of the switch transitions.

11. Record Pass or Fail in the test record.

Cable Length Accommodation.

10. Set the cable clone for minimum cable length (all switches to the "out" position.)

11. On the TG2000 DVG1, set the output to the SDI Matrix signal.

12. You should see a waveform on the waveform monitor display. All the EDH parameters on the Video Session Status screen should read OK.

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

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

15. Record the value in the test record.

16. Repeat the test using SDI B input on the waveform monitor.

17. Record this level in the test record.

External Reference Formats Supported: Bi-Level

Check that the unit under test can reference to NTSC and PAL while viewing digital signals.

1. Set the waveform monitor to the factory presets. (See page 28, *Restore the Factory Presets*.)

2. Press the **EXT REF** button to select the external reference mode.

3. Connect a 525/270 color bars signal from a DVG1 module to the SDI A input of the instrument under test and terminate the loop-through.

4. Apply an NTSC 0% Flat Field signal from the AVG1 output to the Reference input of the waveform monitor. Terminate the other Reference input with a precision termination.

5. Check that the lower-left corner of the waveform monitor display shows the proper standard for the reference.

6. Check that the Waveform display is locked. Press the **Vector** button to check that the Vector display is locked.

7. Log either Pass or Fail in the test record.

8. Leave test setup as is for the next test.

External Reference Lock Range

Vary the time base of the reference to measure lock range.

1. Adjust the AVG1 time base offset to –50 ppm. Verify that the readout in the lower-left corner of the waveform monitor display does not indicate an unlocked signal. It is normal for the system to momentarily lose lock when the time base is changed.

NOTE. The waveform display will not be stable because the SDI time base is not in sync with the reference.

2. Increase the negative time base offset until the waveform monitor cannot sustain lock. Record the maximum offset capability in the test record.

3. Repeat steps 1 and 2, but use positive offsets to test the positive end of the lock range.

4. Reset the AVG1 Module parameters to remove the timebase offset.

External Reference Lock in Presence of Hum, Bi-Level

Apply a 0 dB hum signal to the Reference and verify that the waveform monitor still locks correctly.

1. Set the waveform monitor to the factory presets. (See page 28, *Restore the Factory Presets.*)

2. Connect the TG2000 black burst signal to the video input of the AVC1. Route the video output of the AVC1 (not the precision video output) to one of the waveform monitor REF inputs. Terminate the other REF input.

3. Connect a 525/270 color bars signal from the DVG1 module of the TG2000 to the SDI A input of the waveform monitor and terminate the loop-through.

4. Set the AVC1 for 0 dB of 60 cycle hum.

5. Press the **EXT REF** button to select the external reference mode.

6. Check that the signal is locked and the waveform display is stable. Press the **Vector** button to check that the Vector display is stable.

7. Record Pass or Fail in the test record.

8. Disconnect the test setup.

LTC Decoding Functionality

Apply an LTC signal and verify it is correctly decoded.

An LTC is input through the 15-pin GCI connector on the rear panel. To input an LTC signal, you need to construct a custom connector. This cable has nine wires from the DB15 connector, with two of them also connected to an RCA connector. Pin 7 of the DB15 connector is connected to the center pin of the RCA connector, and pin 8 is connected to the shield of the RCA connector. (See Figure 1.)
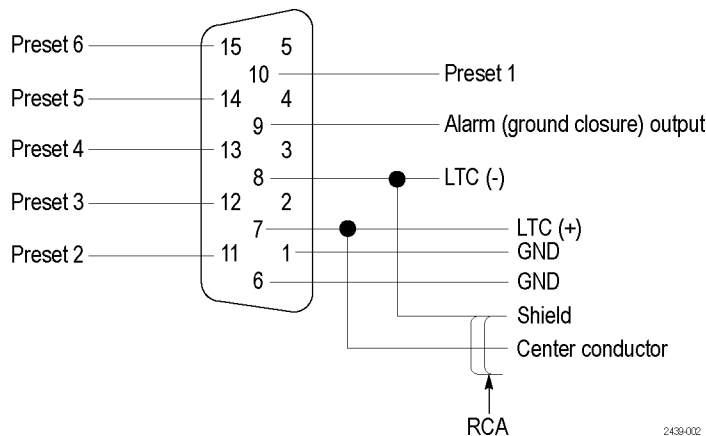

Figure 1: Wiring diagram for LTC input/Ground Closure cable

NOTE. Apply a signal to only one connector at a time.

1. Set the waveform monitor to the factory presets. (See page 28, *Restore the Factory Presets*.)

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

3. Press the **CONFIG** button, select **Aux Data Settings > Timecode Display if present > LTC**. This will set the timecode source to LTC.

4. If using a Horita TRG50 LTC generator, set the switches to:

Control or Setting	Value
V-Size	LRG
V-Pos	TOP
Mode	GEN
Data	TC

5. It may be necessary to reset the LTC generator via the mode switch. Momentarily move the Mode switch to SET, and back to GEN.

6. Verify that the Decoded LTC is displayed in the lower right corner of the display.

7. Record Pass or Fail in the test record.

Audio Performance Verification Procedures

Required Equipment

Table 40: Required Test Equipment (Audio)

SDI serial digital video test generator with embedded audio	Generates the following signals:	Tektronix TG2000 with the following modules:
	HD: 1080i 59.94 100% color bars with two or more groups of embedded audio	HDVG1 module for TG2000
	SD: 525/270 100% color bars with two or more groups of embedded audio	DVG1 module for TG2000
Sine wave generator	Capable of 0.8 Vp-p at 6 MHz into a 50 Ω load	Rohde & Schwarz SMT03 Opt. SM-B2
Test Oscilloscope	Amplitude measurements of a 6 Mhz sine wave	Tektronix TDS7404B
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; Rohde & Schwarz UPV with options UPV-B2, UPV-K4, and UPV-K22
Precision 75 Ω -to-50 Ω adapter	1.5% impedance and attenuation accuracy	Tektronix AMT75
75 Ω terminator for SDI signals (2 required)	Male, wideband	Tektronix part number 011-0163-00
75 Ω coaxial cables (2 required)	General purpose digital video Male-to-male BNC connectors 3' long	Belden 8281
50 Ω coaxial cables (2 required)	Male-to-male BNC connectors 36 inches long	Tektronix part number 012-0482-00
Return loss bridge	75 Ω test port 50 Ω input and output ports	Wide Band Engineering A57TUC with male 75 Ω BNC test port
Audio test cable	1/4 inch phono to 2 XLR	Sound Professionals SP-XLRM-MINI-1 with adapter SP-PHONE-MINI-ST
Calculator	Logarithmic function	

The following tests verify that the Audio module for the WFM4000 and WFM5000 waveform monitors meets the warranted characteristics listed in the Specifications chapter. Characteristics with typical specifications (not warranted) are also checked with pass/fail criteria.

Audio Tests

AES Return Loss   This test verifies the return loss of the AES Inputs and Outputs. It uses a return loss bridge and compares the reflected amplitude between an open circuit and when terminated by the port under test.

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 28, *Restore the Factory Presets*.)

2. Press the **AUDIO** button to view the Audio display.

3. Install the 50 Ω N-to-BNC adapter on the sine wave generator output.

4. Connect the sine wave generator output to the input of the return loss bridge using a 50 Ω cable.

5. Connect the output of the return loss bridge to the 50 Ω input of the test oscilloscope using a 50 Ω cable. Do not connect the test port of the bridge at this time.

6. Set the sine wave generator as follows:

Control or Setting	Value
Frequency	6 MHz
Phase Modulation	OFF
Frequency Modulation	OFF
Output Power	+2.0 dBm (0.8 V p-p)
RF Output	ON

7. Adjust the test oscilloscope to obtain a stable display of the 6 MHz sinewave from the sinewave generator. The following oscilloscope settings normally provide a usable display:

Control or Setting	Value
Vertical Scale	50 mV
Horizontal Scale	100 ns/div
Bandwidth Limit	On

8. Measure the amplitude of the signal on the test oscilloscope. Note this measurement as the reference level.

NOTE. *The reference level should be between 150 mV and 200 mV. Adjust the output level of the sine wave generator if necessary to obtain the correct output level.*

---

9. Select the AES IN input:

    a. Press the **CONFIG** button and select **Audio Inputs/Outputs**.

    b. Select **AES A**.

10. Connect the test port of the Return Loss Bridge directly to the AES IN connector. Do not use any cables or adapters.

11. Set the vertical scale on the test oscilloscope to 1 mV/div, and measure the amplitude of the signal on the test oscilloscope. Note this as the Reflection level.

12. Calculate the return loss with the formula below using the measured values from steps 8 and 11.

$$Input\ Return\ Loss = 20 \times log\left(\frac{Reference}{Reflection}\right)$$

13. Check that the calculated return loss is >25 dB and record it in the test record.

14. Move the return loss bridge to the AES IN connector and repeat steps 10 through 13.

15. Disconnect the test setup.

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 28, *Restore the Factory Presets*.)

2. If the audio display is not selected, press the **AUDIO** button.

3. Connect the digital audio generator unbalanced (UNBAL) output to the AES 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

Control or Setting	Value
Sample Frequency	96 kHz
Unbalanced V$_p$-p	1.000 V (Carrier Level)

5. Select the AES IN 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. 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.

7. 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 28, *Restore the Factory Presets*.)

2. If the audio tile is not selected, press the **AUDIO** 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. Select the AES IN 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 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. Set the digital audio generator as follows:

Control or Setting	Value
Sample Frequency	48 kHz

Control or Setting	Value
Output Level	–6 dB FS Sine
Frequency	1 kHz

8. Repeat step 6.

9. Set the digital audio generator as follows:

Control or Setting	Value
Sample Frequency	48 kHz
Output Level	–6 dB FS Sine
Frequency	19 kHz

10. Repeat step 6.

11. 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 28, *Restore the Factory Presets*.)

2. If the audio tile is not selected, press the **AUDIO** 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
Ch1 Common	FLOAT
Ch1 Range	AUTO

Control or Setting	Value
START COND	AUTO
Delay	0.0000 s
INPUT DISP	OFF
FUNCTION	RMS on UPV
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 IN 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 Sine
Frequency	1 kHz

16. Repeat steps 11 through 12.

17. Set the digital audio generator as follows:

Control or Setting	Value
Sample Frequency	48 kHz
Output Level	–6 dB FS Sine
Frequency	19 kHz

18. Repeat steps 11 through 12.