

Warranted Characteristics

This section lists the various *warranted characteristics* that describe the TDS 400A Digitizing Oscilloscopes. Included are electrical and environmental characteristics.

Warranted characteristics are described in terms of quantifiable performance limits which are warranted. This section lists only warranted characteristics. A list of *typical characteristics* starts on page 2–17.

NOTE. In these tables, those warranted characteristics that are checked in the procedure Performance Tests, found in Section 1, appear in **boldface type** under the column **Name**.

The electrical characteristics found in these tables of warranted characteristics apply when the oscilloscope is adjusted at an ambient temperature between +20° C and +30° C, has had a warm-up period of at least 20 minutes, and is operating at an ambient temperature between 0° C and +50° C (unless otherwise noted).

Table 2–9: Warranted Characteristics — Signal Acquisition System

Name	Description		
Accuracy, DC Voltage Measurement, Averaged	Measurement Type	DC Accuracy	
	Average of ≥ 16 waveforms	$\pm(1.5\% \times (\text{reading} - \text{Net Offset}^1) + \text{Offset Accuracy} + 0.06 \text{ div} \times \text{Vertical Scale})$	
	Delta volts between any two averages of ≥ 16 waveforms ²	$\pm(1.5\% \times \text{reading} + 0.3 \text{ mV} + 0.1 \text{ div} \times \text{Vertical Scale})$	
Accuracy, DC Gain ³	$\pm 1.5\%$		
Accuracy, Offset	Volts/Div Setting	Offset Accuracy	
	1 mV/div–9.95 mV/div	$\pm(0.4\% \times \text{Net Offset}^1 + (0.9 \text{ mV} + 0.1 \text{ div} \times \text{Vertical Scale}))$	
	10 mV/div–99.5 mV/div	$\pm(0.4\% \times \text{Net Offset}^1 + (1.5 \text{ mV} + 0.1 \text{ div} \times \text{Vertical Scale}))$	
	100 mV/div–995 mV/div	$\pm(0.4\% \times \text{Net Offset}^1 + (15 \text{ mV} + 0.1 \text{ div} \times \text{Vertical Scale}))$	
	1 V/div–10 V/div	$\pm(0.4\% \times \text{Net Offset}^1 + (150 \text{ mV} + 0.1 \text{ div} \times \text{Vertical Scale}))$	
Accuracy, Position ⁴	$\pm(1.5\% \times (\text{Position} \times \text{Volts/div}) + \text{Offset Accuracy} + 0.04 \text{ div})$		
Analog Bandwidth, DC-50 Ω Coupled to BNC and Bandwidth Selection is Full	Volts/Div	TDS 420A Bandwidth ⁵	TDS 430A and TDS 460A Bandwidth ⁵
	5 mV/div–10 V/div	DC–200 MHz	DC–400 MHz
	2 mV/div–4.98 mV/div	DC–150 MHz	DC–250 MHz
	1 mV/div–1.99 mV/div	DC–95 MHz	DC–100 MHz

Table 2–9: Warranted Characteristics — Signal Acquisition System (Cont.)

Name	Description	
Cross Talk (Channel Isolation)	Volts/Div	Isolation
	> 500 mV/div	≥40:1 at 50 MHz for any two channels having equal volts/division settings
	≤9.95 mV/div	≥40:1 at 50 MHz for any two channels having equal volts/division settings
	10 mV/div–500 mV/div	≥80:1 at 100 MHz and ≥30:1 at full bandwidth for any two channels having equal volts/division settings
Delay Between Channels, Full Bandwidth, Equivalent Time	≤200 ps between CH 1 and CH 2 and between CH 3 and CH 4 when both channels have equal volts/division and coupling settings	
	≤450 ps for any other combination of two channels with equal volts/division and coupling settings	
Input Impedance, DC-1 M Ω Coupled	1 M Ω \pm 0.5% in parallel with 15 pF \pm 2.0 pF. Matched between channels to within \pm 1% for resistance and \pm 1.0 pF for capacitance	
Input Impedance, DC-50 Ω Coupled (TDS 420A)	50 Ω \pm 1% with VSWR ≤1.2:1 from DC–200 MHz	
Input Impedance, DC-50 Ω Coupled (TDS 430A and TDS 460A)	50 Ω \pm 1% with VSWR ≤1.6:1 from DC–400 MHz	
Input Voltage, Maximum, DC-1 M Ω , AC-1 M Ω , or GND Coupled	Volt/Div	Rating
	0.1 V/div–10 V/div	300 V CAT II; derate at 20 dB/decade above 10 MHz until the minimum rating of \pm 5 V (DC + peak AC) is reached
	1 mV/div–99.9 mV/div	300 V CAT II; derate at 20 dB/decade above 10 kHz until the minimum rating of \pm 5 V (DC + peak AC) is reached
Input Voltage, Maximum, DC-50 Ω or AC-50 Ω Coupled	5 V _{RMS} , with peaks less than or equal to \pm 30 V	

Table 2-9: Warranted Characteristics — Signal Acquisition System (Cont.)

Name	Description
Lower Frequency Limit, AC Coupled	≤ 10 Hz when AC-1 M Ω coupled; ≤ 200 kHz when AC-50 Ω coupled ⁶
¹ Net Offset = Offset – (Position \times Volts/Div). Net Offset is the voltage level at the center of the A-D converter dynamic range. Offset Accuracy is the accuracy of this voltage level.	
² The samples must be acquired under the same setup and ambient conditions.	
³ DC Gain Accuracy is confirmed in the Performance Verification Procedure by passing the checks for Offset Accuracy and DC Voltage Measurement Accuracy (Averaged).	
⁴ Position Accuracy is confirmed in the Performance Verification Procedure by passing the checks for Offset Accuracy and DC Voltage Measurement Accuracy (Averaged).	
⁵ The limits given are for the ambient temperature range of 0° C to +30° C. Reduce the upper bandwidth frequencies by 2.5 MHz for each °C above +30° C.	
⁶ The AC Coupled Lower Frequency Limits are reduced by a factor of 10 when 10X, passive probes are used.	

Table 2-10: Warranted Characteristics — Time Base System

Name	Description
Accuracy, Long Term Sample Rate and Delay Time	± 150 ppm over any ≥ 1 ms interval
Accuracy, Absolute Time and Delay Time Measurements ^{1,2}	<p>For single-shot acquisitions using sample or high-resolution acquisition modes and a bandwidth limit setting of 100 MHz:</p> $\pm(1 \text{ WI} + 150 \text{ ppm of } \text{Reading} + 450 \text{ ps})$ <p>For single-shot acquisitions using sample or high-resolution acquisition modes and a bandwidth limit setting of 20 MHz:</p> $\pm(1 \text{ WI} + 150 \text{ ppm of } \text{Reading} + 1.3 \text{ ns})$ <p>For repetitive acquisitions using average acquisition mode with ≥ 8 averages and a bandwidth limit setting of FULL:</p> $\pm(1 \text{ WI} + 150 \text{ ppm of } \text{Reading} + 200 \text{ ps})$
Accuracy, Delta Time Measurement ^{1, 2}	<p>For single-shot acquisitions using sample or high-resolution acquisition modes and a bandwidth limit setting of 100 MHz:</p> $\pm(1 \text{ WI} + 150 \text{ ppm of } \text{Reading} + 650 \text{ ps})$ <p>For repetitive acquisitions using average acquisition mode with ≥ 8 averages and a bandwidth limit setting of FULL:</p> $\pm(1 \text{ WI} + 150 \text{ ppm of } \text{Reading} + 300 \text{ ps})$
¹ For input signals ≥ 5 divisions in amplitude and a slew rate of ≥ 2.0 divisions/ns at the delta time measurement points. Signal must have been acquired at a volts/division setting ≥ 5 mV/division and not in Events mode.	
² The WI (waveform interval) is the time between the samples in the waveform record. Also, see the footnotes for Sample Rate Range and Equivalent Time or Interpolated Waveform Rates in Table 2-3 on page 2-5.	

Table 2–11: Warranted Characteristics — Triggering System

Name	Description
Accuracy, Trigger Level or Threshold, DC Coupled	$\pm(2\% \text{ of } \text{Setting} - \text{Net Offset}^1 + 0.2 \text{ div} \times \text{volts/div setting} + \text{Offset Accuracy})$ for any channel as trigger source and for signals having rise and fall times $\geq 20 \text{ ns}$
Sensitivity, Edge-Type Trigger, DC Coupled²	0.35 division from DC to 50 MHz, increasing to 1 division at 350 MHz (TDS 420A) or 500 MHz (TDS 430A and TDS 460A) for any channel as trigger source
Sensitivity, Video-Type, TV Field and TV Line²	0.6 division of video sync signal
Pulse Width, minimum, Events-Delay	5 ns
Auxiliary Trigger Input, External Clock Input	Connector: BNC at rear panel Input Load: equivalent to three TTL gate loads Input Voltage (maximum): -5 VDC to $+10 \text{ VDC}$ (TTL levels recommended)
Auxiliary Trigger, Maximum Input Frequency	10 MHz Duty Cycle High and low levels must be stable for $\geq 50 \text{ ns}$
Frequency, External Clock	DC to 10 MHz High and low levels must be stable for $\geq 50 \text{ ns}$

¹ **Net Offset = Offset – (Position \times Volts/Div).** Net Offset is the voltage level at the center of the A-D converter dynamic range. Offset Accuracy is the accuracy of this voltage level.

² The minimum sensitivity for obtaining a stable trigger. A stable trigger results in a uniform, regular display triggered on the selected slope. The trigger point must not switch between opposite slopes on the waveform, and the display must not "roll" across the screen on successive acquisitions. The TRIG'D LED stays constantly lighted when the SEC/DIV setting is 2 ms or faster but may flash when the SEC/DIV setting is 10 ms or slower.

Table 2–12: Warranted Characteristics — Probe Compensator Output

Name	Description	
Output Voltage and Frequency, Probe Compensator	Characteristic	Limits
	Voltage	0.5 V (base-top) $\pm 5\%$ into a 1 M Ω load
	Frequency	1 kHz $\pm 5\%$

Table 2–13: Warranted Characteristics — Power Requirements

Name	Description
Source Voltage and Frequency	90 to 132 VAC _{RMS} CAT II, continuous range, for 48 Hz through 62 Hz 100 to 132 VAC _{RMS} CAT II, continuous range, for 48 Hz through 440 Hz 180 to 250 VAC _{RMS} CAT II, continuous range, for 48 Hz through 440 Hz
Power Consumption	$\leq 240 \text{ Watts}$ (370 VA)

Table 2–14: Warranted Characteristics — Environmental, Safety, and Reliability

Name	Description
Atmospherics	<p>Temperature¹:</p> <p>Operating, +0° C to +50° C (disk drive operation limited to +4° C minimum); Nonoperating, –22° C to +60° C</p> <p>Relative humidity:</p> <p>Operating without disk, to 80%, at or below +29° C; to 20%, at or below +50° C; Operating with disk, 20% (+4° C to +50° C) to 80% (+4° C to +29° C) ; Nonoperating, 20% (+4° C to +60° C) to 90% (+22° C to +40° C)</p> <p>Altitude:</p> <p>Operating, to 15,000 ft. (4570 m); Nonoperating, to 40,000 ft. (12190 m)</p>

¹ Maximum operating temperature is decreased 1° C per 1000 feet (305 meters) above 5000 feet (1525 meters).

Table 2–15: Certifications and compliances

EC Declaration of Conformity ^{1,2}	<p>Meets intent of Directive 89/336/EEC for Electromagnetic Compatibility and Low Voltage Directive 73/23/ECC for Product Safety. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:</p> <p>EN 50081-1 Emissions: EN 55022 Class B Radiated and Conducted Emissions</p> <p>EN 50082-1 Immunity: IEC 801-2 Electrostatic Discharge Immunity IEC 801-3 RF Electromagnetic Field Immunity IEC 801-4 Electrical Fast Transient/Burst Immunity IEC 801-5 Power Line Surge Immunity</p> <p>Low Voltage Directive 73/23/EEC: EN 61010-1 Safety requirements for electrical equipment for measurement, control, and laboratory use</p>
FCC Compliance	Emissions comply with FCC Code of Federal Regulations 47, Part 15, Subpart B, Class A Limits
Certifications	Underwriters Laboratories certified to Standard UL3111-1 for Electrical Measuring and Test Equipment.
	Canadian Standards Association certified to Standard CAN/CSA-C22.2 No. 1010.1-92, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use.
Temperature (operating)	+0° C to +50° C
Altitude (maximum operating)	2000 meters
Safety Class	Class I (as defined in IEC 1010–1, Annex H) – grounded product
CSA Certified Power Cords	CSA Certification includes the products and power cords appropriate for use in the North America power network. All other power cords supplied are approved for the country of use.
Overvoltage Category	<p>Category: Examples of Products in this Category:</p> <p>CAT I Signal levels in special equipment or parts of equipment, telecommunications, electronics</p> <p>CAT II Local-level mains, appliances, portable equipment</p> <p>CAT III Distribution-level mains, fixed installation</p>
Pollution Degree 2	Do not operate in environments where conductive pollutants may be present.

¹ To maintain emission requirements when connecting to the IEEE 488 GPIB interface of this oscilloscope, use only a high-quality, double-shielded (braid and foil) GPIB cable. The cable shield must have low impedance connections to both connector housings. Acceptable cables are Tektronix part numbers 012-0991-00, -01, -02 and -03. To maintain EMI performance use the following cables, or their equivalent: a shielded Centronics cable, 3 meters long, part number 012-1214-00, and a shielded RS-232 cable, 2.7 meters long, CA part number 0294-9.

² To maintain emission requirements when connecting to the VGA-compatible video output of this oscilloscope, use only a high-quality double-shielded (braid and foil) video cable with ferrite cores at both ends. The cable shield must have low impedance connections to both connector housings. An acceptable cable is LCOM part number CTL3VGAMM-5.