

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 B-17.

Performance Conditions

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 B-9: Warranted Characteristics — Signal Acquisition System

| Name | Description | | |
|--|---|---|---------------------------------|
| Accuracy, DC Voltage Measurement, Averaged | Measurement Type | DC Accuracy | |
| | Average of ≥ 16 waveforms | $\pm(1.5\% \times (\text{reading} - \text{Net Offset}^2) + \text{Offset Accuracy} + 0.06 \text{ div})$ | |
| | Delta volts between any two averages of ≥ 16 waveforms ³ | $\pm(1.5\% \times \text{reading} + 0.1 \text{ div} + 0.3 \text{ mV})$ | |
| Accuracy, DC Gain ⁴ | $\pm 1.5\%$ | | |
| Accuracy, Offset | Volts/Div Setting | Offset Accuracy | |
| | 1 mV/div–9.95 mV/div | $\pm(0.4\% \times \text{Net Offset}^2 + (0.9 \text{ mV} + 0.1 \text{ div} \times \text{Vertical Scale}))$ | |
| | 10 mV/div–99.5 mV/div | $\pm(0.4\% \times \text{Net Offset}^2 + (1.5 \text{ mV} + 0.1 \text{ div} \times \text{Vertical Scale}))$ | |
| | 100 mV/div–995 mV/div | $\pm(0.4\% \times \text{Net Offset}^2 + (15 \text{ mV} + 0.1 \text{ div} \times \text{Vertical Scale}))$ | |
| | 1 V/div–10 V/div | $\pm(0.4\% \times \text{Net Offset}^2 + (150 \text{ mV} + 0.1 \text{ div} \times \text{Vertical Scale}))$ | |
| Accuracy, Position ⁵ | $\pm(1.5\% \times (\text{Position} \times \text{Volts/div}) + \text{Offset Accuracy} + 0.04 \text{ div})$ | | |
| Analog Bandwidth, DC-50 Ω Coupled to BNC or to Recommended Active Probe and Bandwidth Selection is Full | Volts/Div | TDS 410A and TDS 420A Bandwidth ⁶ | TDS 460A Bandwidth ⁶ |
| | 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 |
| Analog Bandwidth, DC-1 M Ω Coupled with Standard-Accessory Probe and Bandwidth Selection is Full | Volts/Div | TDS 410A and TDS 420A Bandwidth ⁶ | TDS 460A Bandwidth ⁶ |
| | 5 mV/div–10 V/div | DC–200 MHz | DC–350 MHz ¹ |
| | 2 mV/div–4.98 mV/div | DC–150 MHz | DC–250 MHz |
| | 1 mV/div–1.99 mV/div | DC–100 MHz | DC–100 MHz |

Table B–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 (all models) and between CH 3 and CH 4 (TDS 420A and TDS 460A) 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 (TDS 420A and TDS 460A) | |
| Input Impedance, DC-1 M Ω Coupled | 1 M Ω ±0.5% in parallel with 15 pF ±2.0 pF. Matched between channels to within ±1% for resistance and ±1.0 pF for capacitance | |
| Input Impedance, DC-50 Ω Coupled (TDS 410A and TDS 420A) | 50 Ω ±1% with VSWR ≤1.2:1 from DC–200 MHz | |
| Input Impedance, DC-50 Ω Coupled (TDS 460A) | 50 Ω ±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 | ±400 V (DC + peak AC); derate at 20 dB/decade above 10 MHz until the minimum rating of ±5 V (DC + peak AC) is reached |
| | 1 mV/div–99.9 mV/div | ±400 V (DC + peak AC); derate at 20 dB/decade above 10 kHz until the minimum rating of ±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 ±30 V | |

Table B-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 ⁷ |

- ¹ See *Analog Bandwidth* on page B-17 for the typical analog bandwidth with the standard-accessory probe.
- ² **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.
- ³ The samples must be acquired under the same setup and ambient conditions.
- ⁴ DC Gain Accuracy is confirmed in the Performance Verification Procedure by passing the checks for Offset Accuracy and DC Voltage Measurement Accuracy (Averaged).
- ⁵ Position Accuracy is confirmed in the Performance Verification Procedure by passing the checks for Offset Accuracy and DC Voltage Measurement Accuracy (Averaged).
- ⁶ 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.
- ⁷ The AC Coupled Lower Frequency Limits are reduced by a factor of 10 when 10X, passive probes are used.

Table B-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> <p style="text-align: center;">$\pm(1 \text{ WI} + 150 \text{ ppm of } \text{Reading} + 450 \text{ ps})$</p> <p>For single-shot acquisitions using sample or high-resolution acquisition modes and a bandwidth limit setting of 20 MHz:</p> <p style="text-align: center;">$\pm(1 \text{ WI} + 150 \text{ ppm of } \text{Reading} + 1.3 \text{ ns})$</p> <p>For repetitive acquisitions using average acquisition mode with ≥ 8 averages and a bandwidth limit setting of FULL:</p> <p style="text-align: center;">$\pm(1 \text{ WI} + 150 \text{ ppm of } \text{Reading} + 200 \text{ ps})$</p> |
| 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> <p style="text-align: center;">$\pm(1 \text{ WI} + 150 \text{ ppm of } \text{Reading} + 650 \text{ ps})$</p> <p>For repetitive acquisitions using average acquisition mode with ≥ 8 averages and a bandwidth limit setting of FULL:</p> <p style="text-align: center;">$\pm(1 \text{ WI} + 150 \text{ ppm of } \text{Reading} + 300 \text{ ps})$</p> |

- 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 B-3 on page B-5.

Table B-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 Coupled ² | 0.35 division from DC to 50 MHz, increasing to 1 division at 350 MHz (TDS 410A and TDS 420A) or 500 MHz (TDS 460A) for any channel as trigger source |
| Sensitivity, Video-Type, TV Field and TV Line ² | 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 B-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 B-13: Warranted Characteristics — Power Requirements

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

Table B-14: Warranted Characteristics — Environmental, Safety, and Reliability

| Name | Description |
|--------------------------|--|
| Atmospherics | <p>Temperature¹:</p> <p>Standard Instrument: Operating, 0° C to +50° C; Nonoperating, -40° C to +75° C</p> <p>Instrument with Option 1F: Operating, +4° C to +50° C; Nonoperating, -22° C to +60° C</p> <p>Option 3P: Operating, 0° C to +40° C; Nonoperating, -20° C to +60° C</p> <p>Relative humidity:</p> <p>Standard Instrument: 0 to 95%, at or below +30° C; 0 to 75%, +31° C to +50° C</p> <p>Instrument with Option 1F: Operating without disk, to 80%, at or below +29° C; to 20%, at or below +50° C; Operating with disk, 20% to 80% at or below +32° C; Nonoperating, 20% to 30% at +45° C; To 90%, at or below +40° C; to 50%, at or below +50° C</p> <p>Option 3P: Operating, 30% to 80%; Nonoperating, 95%, at +40° C</p> <p>Altitude:</p> <p>Operating, to 15,000 ft. (4570 m); Nonoperating, to 40,000 ft. (12190 m)</p> |
| Emissions ^{2,3} | <p>Meets or exceeds the requirements of the following standards:</p> <p>Vfg. 243/1991 Amended per Vfg 46/1992</p> <p>FCC 47 CFR, Part 15, Subpart B, Class A</p> <p>EN50081-1 European Community Requirements</p> <p>EN55022 Radiated Emissions Class B</p> <p>EN55022 Conducted Emissions Class B</p> <p>With Option 3P: VDE 0871, Category B, Vfg. 1046/1984 FCC Rules and Regulations, Part 15, Subpart B, Class A</p> |

Table B–14: Warranted Characteristics — Environmental, Safety, and Reliability (Cont.)

| Name | Description |
|---------------------------|--|
| Susceptibility | <p>Meets or exceeds the requirements of the following standards:</p> <p>EN50082-1 European Community Requirements</p> <p>IEC 801-3 Radiated Susceptibility 3 V/meter from 27 MHz to 500 MHz unmodulated</p> <p>Performance Criteria: < + 0.2 division waveform displacement, or < 0.4 division increase in p-p noise when the oscilloscope is subjected to the EMI specified in the standard</p> <p>IEC 801-2 Electrostatic Discharge, Performance Criteria B</p> <p>Option 3P: The printer can withstand up to 5 kV with no change to settings or impairment of normal operations or up to 9 kV with no damage that prevents recovery of normal operations</p> |
| Dynamics | <p>Random vibration^{4,5}:</p> <p>0.31 g rms, from 5 to 500 Hz, 10 minutes each axis, operating;</p> <p>2.46 g rms, from 5 to 500 Hz, 10 minutes each axis, non-operating</p> |
| Third Party Certification | <p>Conforms to and is certified where appropriate to:</p> <p>UL 1244, Second Edition</p> <p>CAN/CSA–C22.2 No. 231-M89</p> |

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

² 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, and -02.

³ 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.

⁴ Does not apply to a rackmounted instrument.

⁵ Does not apply to an instrument with Option 1F.