# Specification

This Chapter begins with a general description of the traits of the TDS 400A Digitizing Oscilloscopes. Three sections follow, one for each of three classes of traits: *nominal traits, warranted characteristics,* and *typical characteristics*.

## General

The TDS 400A Digitizing Oscilloscopes are portable, four-channel instruments suitable for use in a variety of test and measurement applications and systems. Table 2–1 lists key features.

**Table 2–1: Key Features of the TDS 400A Oscilloscopes**

| Feature | Description |
|---|---|
| Digitizing rate, maximum | 100 MS/s on each channel simultaneously |
| Analog bandwidth | TDS 460A: 400 MHz<br>TDS 420A: 200 MHz<br>TDS 410A: 200 MHz |
| Channels | TDS 460A: Four, each with 8-bit resolution<br>TDS 420A: Four, each with 8-bit resolution<br>TDS 410A: Two, each with 8-bit resolution |
| Record lengths, maximum | 30,000 samples (120,000 with option 1M) |
| Acquisition modes | Sample, envelope, average, high-resolution, and peak-detect |
| Trigger modes | Edge<br>With Option 05, video trigger modes include:<br>NTSC, SECAM, PAL, and Custom |
| Display Modes | Infinite and variable persistence, roll, fit to screen, and dual waveform zoom |
| Storage | NVRAM storage for saving waveforms, hardcopies, and setups<br>With Option 1F, 1.44 Mbyte, 3.5 inch, DOS 3.3-or-later floppy disk |
| I/O | Full GPIB programmability<br>Hardcopy output using GPIB and, with Option 13, RS-232 or Centronics ports |
| Math | Including: invert, add, subtract, multiply, and with Option 2F, integral, differential, and FFT |
| User interface | A graphical user interface, on-line help. and a logical front-panel layout |

# Nominal Traits

Nominal traits are described using simple statements of fact such as "Four, all identical" for the trait "Input Channels, Number of," rather than in terms of limits that are performance requirements.

**Table 2–2: Nominal Traits — Signal Acquisition System**

| Name | Description | |
|---|---|---|
| Bandwidth Selections | 20 MHz, 100 MHz, and FULL (TDS 410A and TDS 420A: 200 MHz, TDS 460A: 400 MHz) | |
| Digitizers, Number of | TDS 410A: Two, both identical<br>TDS 420A and TDS 460A: Four, all identical | |
| Digitized Bits, Number of | 8 bits[1] | |
| Digitized Resolution, Hi Res Mode | Clock, Internal:<br>$\text{Resolution}_{\text{HiRes}} \cong 8 \leq \left[ 8 + 0.5 \ \text{Log}_2 \left( \frac{\text{time/div}}{500 \cdot 10^{-9}} \right) \right] \leq 15 \text{ bits}$<br>Clock, External:<br>$\text{Resolution}_{\text{HiRes}} \cong 8 \leq \left[ 8 + 0.5 \ \text{Log}_2 \left( \frac{100,000,000}{\textit{ClockExternalMenu}} \right) \right] \leq 11.8 \text{ bits}$ | |
| Bandwidth, Hi Res Mode | Clock, Internal:<br>For $1 \mu s/div$ and slower, $\text{BW}_{\text{HiRes}} \cong 0.44 \cdot \left( \frac{50}{\text{time/div}} \right)$ Hz<br>Clock, External:<br>$\text{BW}_{\text{HiRes}} \cong 44 \cdot \left( \frac{\textit{ClockExternalMenu}}{100} \right)$ Hz | |
| Input Channels, Number of | TDS 410A: Two, both identical, called CH 1 and CH 2<br>TDS 420A and TDS 460A: Four, all identical, called CH 1 through CH 4 | |
| Input Coupling | DC, AC, or GND | |
| Input Resistance Selections | 1 MΩ or 50Ω | |
| Ranges, Offset, All Channels | **Volts/Div Setting** | **Offset Range** |
| | 1 mV/div to 99.5 mV/div | ±1 V |
| | 100 mV/div to 995 mV/div | ±10 V |
| | 1 V/div to 10 V/div | ±100 V |
| Range, Position | ±5 divisions | |
| Range, Sensitivity[2] | 1 mV/div to 10 V/div | |

**Table 2–2: Nominal Traits — Signal Acquisition System (Cont.)**

| Name | Description | |
|---|---|---|
| Rise Time[3] (TDS 410A and TDS420A) | **Volts/Div Setting** | **Rise Time** |
| | 5 mV/div–10 V/div | 1.75 ns |
| | 2 mV/div–4.98 mV/div | 2.33 ns |
| | 1 mV/div–1.99 mV/div | 3.68 ns |
| Rise Time[3] (TDS 460A) | **Volts/Div Setting** | **Rise Time** |
| | 5 mV/div–10 V/div | 875 ps |
| | 2 mV/div–4.98 mV/div | 1.4 ns |
| | 1 mV/div–1.99 mV/div | 3.5 ns |

1 **Displayed vertically with 25 digitization levels (DLs) per division and 10.24 divisions dynamic range with zoom off. A DL is the smallest voltage level change resolved by the 8-bit A-D Converter with the input scaled to the volts/division setting of the channel used. Expressed as a voltage, a DL is equal to 1/25 of a division times the volts/division setting.**

2 **The sensitivity ranges from 1 mV/div to 10 V/div in a 1–2–5 sequence of coarse settings. Between consecutive coarse settings, the sensitivity can be finely adjusted with a resolution of 1% of the more sensitive setting. For example, between 50 mV/div and 100 mV/div, the volts/division can be set with 0.5 mV resolution.**

3 **Rise time is defined by the following formula:** $$Rise\ Time\ (ns) = \frac{350}{BW\ (MHz)}$$

**Table 2–3: Nominal Traits — Time Base System**

| Name | Description |
|---|---|
| Range, Sample-Rate[1,3] | 2.5 Samples/s to 100 MSamples/s |
| Range, Equivalent Time or Interpolated Waveform Rate[2,3] | 200 MSamples/s to 50 GSamples/s |
| Range, Seconds/Division | 1 ns/div to 20 s/div |
| Range, Time Base Delay Time | 0 to 20 seconds |
| Reference Frequency, Time Base | 100 MHz |
| Record Length Selection | 500, 1,000, 2,500, 5,000, 15,000, and 30,000 points. Record lengths of 60,000 and 120,000 points are available with Option 1M[4] |
| Sampling Edge, External Clock | Negative edge, with TTL threshold and tolerances |
| Hi Res Averaging Period, External Clock | Hi Res averaging done over period 1/(maximum external clock rate[5]), but within <100 ns to 2 µs. External clock edge before this period ends, produces an invalid sample |

1 **The range of real-time rates, expressed in samples/second, at which a digitizer samples signals at its inputs and stores the samples in memory to produce a record of time-sequential samples.**

2 **The range of waveform rates for equivalent time or interpolated waveform records.**

3 **The Waveform Rate (WR) is the equivalent sample rate of a waveform record. For a waveform record acquired by real-time sampling of a single acquisition, the waveform rate is the same as the real-time sample rate; for a waveform created by interpolation of real-time samples from a single acquisition or by equivalent-time sampling of multiple acquisitions, the waveform rate is faster than the real time sample rate. For all three cases, the waveform rate is 1/(Waveform Interval) for the waveform record, where the waveform interval (WI) is the time between the samples in the waveform record.**

4 **In Hi Res, the maximum Option 1M record length is 60,000 points.**

5 **You set the maximum external clock rate using the Horizontal Clock menu. The Hi Res samples are averaged over a 10 to 40 ns shorter period than shown by the readout.**

**Table 2–4: Nominal Traits — Triggering System**

| Name | Description | |
|---|---|---|
| Range, Events Delay | 1 to 9,999,999 | |
| Ranges, Trigger Level or Threshold | **Source** | **Range** |
| | Any Channel | ±12 divisions from center of screen |
| | Line | ±400 Volts |

**Table 2–5: Nominal Traits — Display System**

| Name | Description |
|---|---|
| Video Display Resolution | 640 pixels horizontally by 480 pixels vertically in a display area of 5.04 inches horizontally by 3.78 inches vertically |
| Waveform Display Graticule | A single graticule 401 × 501 pixels (8 × 10 divisions, with divisions that are 1 cm by 1 cm) |
| Waveform Display Grey Scale | 16 levels in variable-persistence display style |

**Table 2–6: Nominal Traits — Data Storage**

| Name | Description |
|---|---|
| Capacity, Nonvolatile Waveform Memory | Total capacity is 120,000 points (one to four waveforms acquired with any combination of record lengths that add up to 120,000 points). For available record lengths, see ***Record Length Selection*** on page 2–5 of this chapter |
| Capacity, Nonvolatile Setup Memory | Ten setups |
| Batteries[1] Required | Two lithium poly-carbon monofluoride. Both are type BR2/3A, UL listed. Both are rated at 3.0 volt, 1.2 amp-hour |

1 **Batteries are not accessible from the outside of the instrument; therefore, a service technician must replace them.**

**Table 2–7: Nominal Traits — GPIB Interface, Video Output, and Power Fuse**

| Name | Description |
|---|---|
| Interface, GPIB | GPIB interface complies with IEEE Std 488.1-1987 and IEEE Std 488.2-1987 |
| Interface, RS-232 (Option 13 only) | RS-232 interface complies with EIA/TIA 574 |
| Interface, Centronics (Option 13 only) | Centronics interface complies with Centronics interface standard C332-44 Feb 1977, REV A |
| Power Supply, Printer (Option 13 only) | Supply Voltage: +6.5 VDC<br>Maximum Current: 2 Amps, DC continuous<br>4 Amps DC maximum for durations < 10 msec |
| Output, Video | Provides a video signal[1], non-interlaced, with levels that comply with ANSI RS343A. Output is through a rear-panel DB-15 connector |
| Fuse Rating | Either of two fuses[2] may be used: a 0.25″ × 1.25″ (UL 198.6, 3AG): 5 A FAST, 250 V, or a 5 mm × 20 mm, (IEC 127): 4 A (T), 250 V |

1 **VGA compatible at 30.6 kHz sync rate.**

2 **Each fuse type requires its own fuse cap.**

**Table 2–8: Nominal Traits — Mechanical**

| Name | Description |
|---|---|
| Cooling Method | Forced-air circulation with no air filter |
| Construction Material | Chassis parts constructed of aluminum alloy; front panel constructed of plastic laminate; circuit boards constructed of glass-laminate. Plastic parts are polycarbonate |
| Finish Type | Tektronix Blue textured vinyl finish on aluminum cabinet |
| Weight | Standard digitizing oscilloscope<br>8.6 kg (19.0 lbs), oscilloscope only<br>10.2 kg (22.5 lbs), with front cover, accessories, and accessories pouch installed<br>14.5 kg (32.0 lbs), when packaged for domestic shipment<br>Rackmount digitizing oscilloscope<br>8.2 kg (18.0 lbs) plus the weight of rackmount parts, for the rackmounted digitizing oscilloscope (Option 1R)<br>16.3 kg (36.0 lbs), when the rackmounted digitizing oscilloscope is packaged for domestic shipment<br>Rackmount conversion kit<br>4.5 kg (10.0 lbs), parts only; 7.9 kg (17.5 lbs), parts plus package for domestic shipping<br>Option 1F<br>225 grams (0.5 lbs) Floppy Disk Drive only<br>Option 3P<br>11.3 kg (25 lbs), for the instrument and Printer Pack; includes a pouch, a printer with a full roll of paper, all cables, and three additional rolls of paper<br>4.5 kg (10 lbs), for Printer Pack when packaged for domestic shipping; includes a pouch, a printer as received from the vendor, a Tektronix manual, cables, and five rolls of paper |

**Table 2–8: Nominal Traits — Mechanical (Cont.)**

| Name | Description | |
|---|---|---|
| Overall Dimensions | Standard digitizing oscilloscope | |
| | Height | 191 mm (7.5 in), when feet and accessories pouch are installed. 165 mm (6.5 in), without the accessories pouch installed |
| | Width | 381 mm (15 in), with handle |
| | Depth | 471 mm (18.55 in), oscilloscope only; 490 mm (19.28 in), with optional front cover installed; 569 mm (22.4 in), with handle fully extended |
| | Rackmount digitizing oscilloscope | |
| | Height | 178 mm (7.0 in) |
| | Width | 483 mm (19.0 in) |
| | Depth | 472 mm (18.6 in), without front-panel handles; 517 mm (20.35 in), with front-panel handles installed |
| | Option 3P | |
| | Height | 241 mm (9.5 in) |
| | Width | 381 mm (15.0 in) |
| | Depth | 569 mm (22.4 in) |

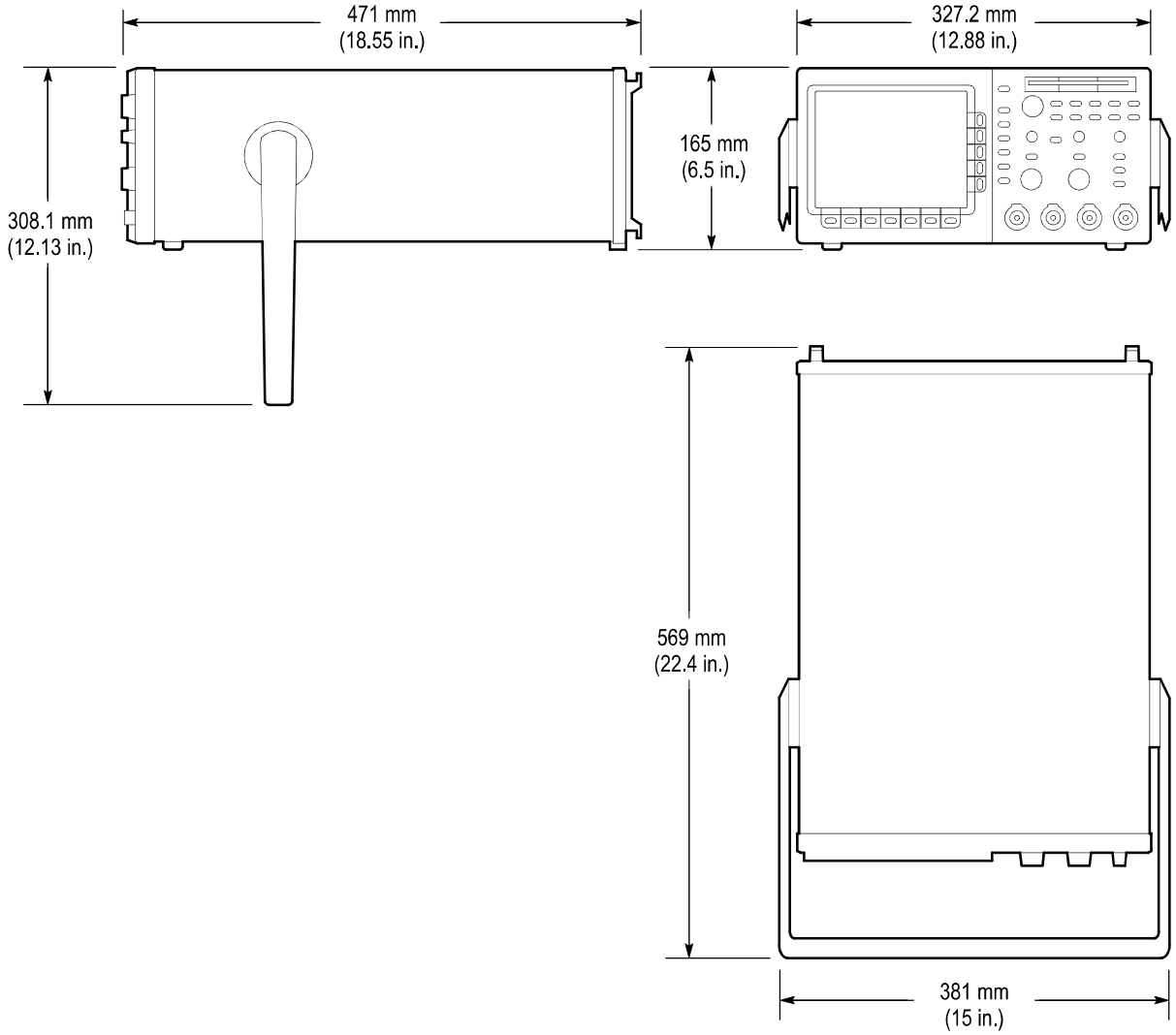


**Figure 2–1: TDS 400A Dimensional Drawing**

# 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**.

## 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 2–9: Warranted Characteristics — Signal Acquisition System**

| Name | Description | |
|---|---|---|
| **Accuracy, DC Voltage Measurement, Averaged** | **Measurement Type** | **DC Accuracy** |
| | Average of ≥16 waveforms | ±(1.5% × \| (reading – Net Offset[2])\| + Offset Accuracy + 0.06 div) |
| | Delta volts between any two averages of ≥16 waveforms[3] | ±(1.5% × \|reading\| + 0.1 div + 0.3 mV) |
| **Accuracy, DC Gain[4]** | ±1.5% | |
| **Accuracy, Offset** | **Volts/Div Setting** | **Offset Accuracy** |
| | 1 mV/div–9.95 mV/div | ±(0.4% × \|Net Offset[2]\| + ( 0.9 mV + 0.1 div × Vertical Scale)) |
| | 10 mV/div–99.5 mV/div | ±(0.4% × \|Net Offset[2]\| + (1.5 mV + 0.1 div × Vertical Scale)) |
| | 100 mV/div–995 mV/div | ±(0.4% × \|Net Offset[2]\| + ( 15 mV + 0.1 div × Vertical Scale)) |
| | 1 V/div–10 V/div | ±(0.4% × \|Net Offset[2]\| + (150 mV + 0.1 div × Vertical Scale) |
| **Accuracy, Position[5]** | ±(1.5% × (Position × Volts/div) + Offset Accuracy + 0.04 div) | |

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

| Name | Description | | |
|---|---|---|---|
| **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 MΩ 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 |
| 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<br>≤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 MΩ Coupled | 1 MΩ ±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 MΩ, AC-1 MΩ, 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 2–9: Warranted Characteristics — Signal Acquisition System (Cont.)**

| Name | Description |
|---|---|
| Lower Frequency Limit, AC Coupled | ≤10 Hz when AC–1 MΩ coupled; ≤200 kHz when AC-50 Ω coupled[7] |

1 **See *Analog Bandwidth* on page 2–17 for the typical analog bandwidth with the standard-accessary probe.**

2 **Net Offset = Offset – (Position × 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 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] | For single-shot acquisitions using sample or high-resolution acquisition modes and a bandwidth limit setting of 100 MHz:<br>±(1 WI + 150 ppm of \|Reading\| + 450 ps)<br>For single-shot acquisitions using sample or high-resolution acquisition modes and a bandwidth limit setting of 20 MHz:<br>±(1 WI + 150 ppm of \|Reading\| + 1.3 ns)<br>For repetitive acquisitions using average acquisition mode with ≥8 averages and a bandwidth limit setting of FULL:<br>±(1 WI + 150 ppm of \|Reading\| + 200 ps) |
| **Accuracy, Delta Time Measurement[1, 2]** | For single-shot acquisitions using sample or high-resolution acquisition modes and a bandwidth limit setting of 100 MHz:<br>±(1 WI + 150 ppm of \|Reading\| + 650 ps)<br>For repetitive acquisitions using average acquisition mode with ≥8 averages and a bandwidth limit setting of FULL:<br>±(1 WI + 150 ppm of \|Reading\| + 300 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** | ±(2% of \|Setting – Net Offset[1]\| + 0.2 div × volts/div setting + Offset Accuracy) for any channel as trigger source and for signals having rise and fall times ≥ 20 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<br>Input Load: equivalent to three TTL gate loads<br>Input Voltage (maximum): –5 VDC to +10 VDC (TTL levels recommended) |
| **Auxiliary Trigger, Maximum Input Frequency** | 10 MHz<br>Duty Cycle High and low levels must be stable for ≥ 50 ns |
| **Frequency, External Clock** | DC to 10 MHz High and low levels must be stable for ≥ 50 ns |

1 **Net Offset = Offset – (Position × 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) ±5% into a 1 MΩ load |
| | Frequency | 1 kHz ±5% |

**Table 2–13: Warranted Characteristics — Power Requirements**

| Name | Description |
|---|---|
| Source Voltage and Frequency | 90 to 132 $VAC_{RMS}$, continuous range, for 48 Hz through 62 Hz<br>100 to 132 $VAC_{RMS}$, continuous range, for 48 Hz through 440 Hz<br>180 to 250 $VAC_{RMS}$, continuous range, for 48 Hz through 440 Hz |
| Power Consumption | ≤240 Watts (370 VA) |

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

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

**Table 2–14: Warranted Characteristics — Environmental, Safety, and Reliability (Cont.)**

| Name | Description |
|---|---|
| Susceptibility | Meets or exceeds the requirements of the following standards:<br>EN50082-1 European Community Requirements<br>IEC 801-3 Radiated Susceptibility 3 V/meter from 27 MHz to 500 MHz unmodulated<br>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<br>IEC 801-2 Electrostatic Discharge, Performance Criteria B<br>Option 3P:<br>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 |
| Dynamics | Random vibration[4,5]:<br>0.31 g rms, from 5 to 500 Hz, 10 minutes each axis, operating;<br>2.46 g rms, from 5 to 500 Hz, 10 minutes each axis, non-operating |
| Third Party Certification | Conforms to and is certified where appropriate to:<br>UL 1244, Second Edition<br>CAN/CSA–C22.2 No. 231-M89 |

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.**

# Typical Characteristics

This section contains tables that list the various *typical characteristics* that describe the TDS 400A Digitizing Oscilloscopes.

Typical characteristics are described in terms of typical or average performance. Typical characteristics are not warranted.

This subsection lists only typical characteristics. A list of warranted characteristics starts on page 2–11.

**Table 2–15: Typical Characteristics — Signal Acquisition System**

| Name | Description | | |
|---|---|---|---|
| Accuracy, DC Voltage Measurement, Not Averaged | **Measurement Type** | **DC Accuracy** | |
| | Any Sample | ±(1.5% × (\|reading – Net Offset[1]\|) + Offset Accuracy + 0.13 div + 0.6 mV) | |
| | Delta Volts between any two samples[2] | ±(1.5% × \|reading\| + 0.26 div + 1.2 mV) | |
| Frequency Limit, Upper, 100 MHz Bandwidth Limited | 100 MHz | | |
| Frequency Limit, Upper, 20 MHz Bandwidth Limited | 20 MHz | | |
| Nonlinearity | < 1 DL, differential; ≤ 1 DL, integral, independently based[3] | | |
| Analog Bandwidth, DC-1 MΩ Coupled with Standard-Accessory Probe Attached | **Volts/Div** | **TDS 410A and TDS 420A Bandwidth** | **TDS 460A Bandwidth** |
| | 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–100 MHz | DC–100 MHz |

**Table 2–15: Typical Characteristics — Signal Acquisition System (Cont.)**

| Name | Description | | | | |
|---|---|---|---|---|---|
| Step Response Settling Error | **Volts/Div Setting** | **Step Amplitude** | **Settling Error (%)[4]** | | |
| | | | **20 ns** | **500 ns** | **20 ms** |
| | 1 mV/div–99.5 mV/div | ≤2 V | ≤0.5 | ≤0.2 | ≤0.1 |
| | 100 mV/div–995 mV/div | ≤20 V | ≤2.0 | ≤0.5 | ≤0.2 |
| | 1 V/div–10 V/div | ≤200 V | ≤2.0 | ≤0.5 | ≤0.2 |

1 **Net Offset = Offset – (Position x 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 **A DL (digitization level) is the smallest voltage level change that can be resolved by the 8-bit A-D Converter with the input scaled to the volts/division setting of the channel used. Expressed as a voltage, a DL is equal to 1/25 of a division times the volts/division setting.**

4 **The values given are the maximum absolute difference between the value at the end of a specified time interval after the mid-level crossing of the step and the value one second after the mid-level crossing of the step, expressed as a percentage of the step amplitude.**

**Table 2–16: Typical Characteristics — Time Base System**

| Name | Description | |
|---|---|---|
| Aperture Uncertainty | For real-time or interpolated records having duration ≤1 minute:<br>≤(50 ps + 0.03 ppm × Record Duration) RMS<br>For equivalent time records:<br>≤(50 ps + 0.06 ppm × WI[1]) RMS | |
| Fixed Error in Sample Time | ≤50 ps | |
| External Clock sampling uncertainty | ±8 ns | |
| External Clock Edge to Sampling Time Delay | Sample | –20 ns (Sample edge is delayed relative the the sample moment.) |
| | Hi Res | Hi Res averaging starts within ± 8 ns of the clock edge. Averaging stops after 1/(maximun external clock rate[2]) |
| | Peak Detect | Runs continuously at 100 MS/s |
| External Clock Minimum Prerecord points | 55 points before the first visible sample in the record at the maximum clock speed<br>35 points before the first visible sample in the record at slow clock speeds | |
| External Clock Minimum Postrecord points | 25 points after the last visible sample in the record | |

1 **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.**

2 **You set the maximum external clock rate using the Horizontal Clock menu.**

**Table 2–17: Typical Characteristics — Triggering System**

| Name | Description | | |
|---|---|---|---|
| Error, Trigger Position, Edge Triggering | **Acquire Mode** | **Trigger-Position Error[1,2]** | |
| | Sample, Hi-Res, Average | ±(1 WI + 1 ns) | |
| | Peak Detect, Envelope | ±(2 WI + 1 ns) | |
| Holdoff, Variable, Main Trigger, Internal Clock and non TV Trigger | **Main Horizontal Scale** | **Minimum Holdoff** | **Maximum Holdoff** |
| | ≤100 ns/div | 1 µs | 5 × Min Holdoff |
| | ≥100 ms/div | 1 s | 5 × Min Holdoff |
| | Otherwise | 10 × sec/div | 5 × Min Holdoff |
| Holdoff, Variable, External Clock | 0 to 100 ms | | |
| Lowest Frequency for Successful Operation of "Set Level to 50%" Function | 20 Hz | | |
| Sensitivity, Edge Trigger, Not DC Coupled[3] | **Trigger Coupling** | **Typical Signal Level for Stable Triggering** | |
| | AC | Same as DC-coupled limits[4] for frequencies above 60 Hz. Attenuates signals below 60 Hz | |
| | Noise Reject | Three and one-half times the DC-coupled limits[4] | |
| | High Frequency Reject | One and one-half times the DC-coupled limits[4] from DC to 30 kHz. Attenuates signals above 30 kHz | |
| | Low Frequency Reject | One and one-half times the DC-coupled limits[4] for frequencies above 80 kHz. Attenuates signals below 80 kHz | |
| Video Mode (Option 05 Equipped Instruments Only) | Line Rate Class: Four classes are provided as follows<br>■ NTSC, which provides a default line rate compatible with the NTSC standard (525/60)<br>■ PAL, which provides a default line rate compatible with the PAL standard (625/50)<br>■ SECAM, which provides a default line rate compatible with the SECAM standard (625/50)<br>■ Custom, which provides user selectable line rate ranges (see ***Custom Line Rate Ranges*** below)<br>Custom Line Rate Ranges: 15 kHz–20 kHz, 20 kHz–25 kHz, 25 kHz–35 kHz, and 35 kHz–64 kHz<br>Holdoff: Automatically adjusts to 58 ms (nominal) for NTSC class; to 150 ms (nominal) for PAL and SECAM<br>Triggerable on Field Selections: Odd, Even, or Both<br>Delayed Acquisition: Settable for delay by line number or runs after time delay | | |
| Frequency, Maximum for Events Delay[5] | 90 MHz | | |

**Table 2–17: Typical Characteristics — Triggering System (Cont.)**

| Name | Description |
|---|---|
| Width, Minimum Pulse and Rearm, Events Delay[6] | 5 ns |

1 **The trigger position errors are typically less than the values given here. These values are for triggering signals having a slew rate at the trigger point of ±0.5 division/ns.**

2 **The waveform interval (WI) is the time between the samples in the waveform record. Also, see the footnote for the characteristics *Sample Rate Range* and *Equivalent Time or Interpolated Waveform Rates* in Table 2–3 on page 2–5.**

3 **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.**

4 **See the characteristic *Sensitivity, Edge-Type Trigger, DC Coupled* in Table 2–11, which begins on page 2–14.**

5 **The maximum frequency for a delaying events input.**

6 **The minimum pulse width and rearm width required for recognizing a delaying event.**

**Table 2–18: Typical Characteristics — Data Handling**

| Name | Description |
|---|---|
| Time, Data-Retention, Nonvolatile Memory[1,2] | Internal batteries, installed at time of manufacture, have a life of ≥5 years when operated and/or stored at an ambient temperature from 0° C to 50° C. Retention time of the nonvolatile memories is equal to the remaining life of the batteries |
| Nonvolatile Memory Save Time | 10 seconds |
| Floppy Disk Drive Capacity, Opt 1F only | 3.5 in. floppy disk, 720 KB or 1.44 MB, compatible with DOS 3.3 format for storing waveforms, hard copies, and instrument setups |

1 **The time that reference waveforms, stored setups, and calibration constants are retained when there is no power to the oscilloscope.**

2 **Data is maintained by lithium poly-carbon monofluoride.**