

Warranted Characteristics

Warranted characteristics are described in terms of quantifiable performance limits that are warranted. This subsection lists only warranted characteristics.

NOTE

*In these tables, those warranted characteristics that are checked in the Performance Tests, starting on page 6-11, appear in **boldface type** under the column **Name**.*

Performance Conditions

The electrical characteristics found in these tables of warranted characteristics apply when the oscilloscope has been 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 -10° C and +55° C (unless otherwise noted).

Table 4-1: Warranted Characteristics — Signal Acquisition System

Name	Description										
Accuracy, DC Voltage Measurement, Average Acquisition Mode	<table border="0"> <tr> <td>Measurement Type</td> <td>DC Accuracy</td> </tr> <tr> <td>Average of ≥16 waveforms</td> <td>$\pm(2.0\% \times (\text{reading} - \text{Net Offset}) + \text{Offset Accuracy} + 0.1 \text{ div})$</td> </tr> <tr> <td>Delta volts between any two averages of ≥16 waveforms acquired under the same setup and ambient conditions</td> <td>$\pm(2.0\% \times \text{reading} + 0.15 \text{ div} + 0.3 \text{ mV})$</td> </tr> </table>	Measurement Type	DC Accuracy	Average of ≥16 waveforms	$\pm(2.0\% \times (\text{reading} - \text{Net Offset}) + \text{Offset Accuracy} + 0.1 \text{ div})$	Delta volts between any two averages of ≥16 waveforms acquired under the same setup and ambient conditions	$\pm(2.0\% \times \text{reading} + 0.15 \text{ div} + 0.3 \text{ mV})$				
	Measurement Type	DC Accuracy									
Average of ≥16 waveforms	$\pm(2.0\% \times (\text{reading} - \text{Net Offset}) + \text{Offset Accuracy} + 0.1 \text{ div})$										
Delta volts between any two averages of ≥16 waveforms acquired under the same setup and ambient conditions	$\pm(2.0\% \times \text{reading} + 0.15 \text{ div} + 0.3 \text{ mV})$										
Accuracy, DC Gain, Sample or Average Acquisition Modes	±2%										
Pulse Response, Peak Detect and Envelope Mode	<table border="0"> <tr> <td>Sec/Div Setting</td> <td>Minimum Pulse Width</td> </tr> <tr> <td>5 s/div – 25 μs/div</td> <td>10 ns</td> </tr> <tr> <td>TDS 310: 10 μs/div – 10 ns/div</td> <td>The greater of 10 ns or</td> </tr> <tr> <td>TDS 320: 10 μs/div – 5 ns/div</td> <td>.02 × sec/div setting</td> </tr> <tr> <td>TDS 350: 10 μs/div – 2.5 ns/div</td> <td></td> </tr> </table>	Sec/Div Setting	Minimum Pulse Width	5 s/div – 25 μs/div	10 ns	TDS 310: 10 μs/div – 10 ns/div	The greater of 10 ns or	TDS 320: 10 μs/div – 5 ns/div	.02 × sec/div setting	TDS 350: 10 μs/div – 2.5 ns/div	
	Sec/Div Setting	Minimum Pulse Width									
	5 s/div – 25 μs/div	10 ns									
	TDS 310: 10 μs/div – 10 ns/div	The greater of 10 ns or									
TDS 320: 10 μs/div – 5 ns/div	.02 × sec/div setting										
TDS 350: 10 μs/div – 2.5 ns/div											

Warranted Characteristics

Table 4-1: Warranted Characteristics — Signal Acquisition System (Cont.)

Name	Description	
Accuracy, Offset	Volts/Div Setting 2 mV/div – 99.5 mV/div 100 mV/div – 995 mV/div 1 V/div – 10 V/div	Offset Accuracy $\pm(0.4\% \times \text{Net Offset}^1 + 3 \text{ mV} + 0.1 \text{ div} \times \text{V/div setting})$ $\pm(0.4\% \times \text{Net Offset}^1 + 30 \text{ mV} + 0.1 \text{ div} \times \text{V/div setting})$ $\pm(0.4\% \times \text{Net Offset}^1 + 300 \text{ mV} + 0.1 \text{ div} \times \text{V/div setting})$
	Analog Bandwidth, DC Coupled	TDS 310: DC – ≥ 50 MHz TDS 320: DC – ≥ 100 MHz TDS 350: DC – ≥ 200 MHz; DC – ≥ 180 MHz for 2 mV/div
	Cross Talk (Channel Isolation)	$\geq 100:1$ at 50 MHz with equal Volts/Div settings on each channel
Input Impedance, DC-Coupled	$1 \text{ M}\Omega \pm 1\%$ in parallel with $20 \text{ pF} \pm 2.0 \text{ pF}$	
Input Voltage, Maximum	$\pm 400 \text{ V}$ (DC + peak AC); derate at 20 dB/decade above 100 kHz to 13 V peak AC at 3 MHz and above	
Lower Frequency Limit, AC Coupled ²	$\leq 10 \text{ Hz}$	

¹Net 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.

²The AC Coupled Lower Frequency Limits are reduced by a factor of 10 when 10X, passive probes are used.

Table 4-2: Warranted Characteristics — Time Base System

Name	Description
Accuracy, Long Term Sample Rate and Delay Time	± 100 ppm over any ≥ 1 ms interval
Accuracy, Delta Time Measurements ^{1, 2}	For single-shot acquisitions using sample acquisition mode and a bandwidth limit setting of FULL: $\pm(1 \text{ WI} + 100 \text{ ppm} \times \text{Reading} + 0.6 \text{ ns})$ For repetitive acquisitions using average acquisition mode with ≥ 16 averages and a bandwidth limit setting of FULL: $\pm(1 \text{ WI} + 100 \text{ ppm} \times \text{Reading} + 0.4 \text{ ns})$

¹For input signals ≥ 5 divisions in amplitude and a slew rate of ≥ 2.0 divisions/ns at the delta time measurement points. Signal must be acquired at a volts/division setting ≥ 5 mV/division.

²The 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 4-11 on page 4-12.

Table 4-3: Warranted Characteristics — Triggering System

Name	Description	
Accuracy, Trigger Level, DC Coupled	Trigger Source	Sensitivity
	CH1 or CH2	$\pm(3\% \text{ of } \text{Setting} - \text{Net Offset} ^1 + 0.2 \text{ div} \times \text{volts/div setting} + \text{Offset Accuracy})$
	External	$\pm(6\% \text{ of } \text{Setting} + 20 \text{ mV})$
	External/10	$\pm(6\% \text{ of } \text{Setting} 200 \text{ mV})$
Sensitivity, Edge-Type Trigger, DC Coupled	Trigger Source	Sensitivity
	CH1 or CH2	TDS 310: 0.35 division from DC to 20 MHz, increasing to 1 div at 50 MHz TDS 320: 0.35 division from DC to 50 MHz, increasing to 1 div at 100 MHz TDS 350: 0.35 division from DC to 50 MHz, increasing to 1 div at 200 MHz
	External	TDS 310: 50 mV from DC to 20 MHz, increasing to 150 mV at 50 MHz TDS 320: 50 mV from DC to 50 MHz, increasing to 150 mV at 100 MHz TDS 350: 50 mV from DC to 50 MHz, increasing to 150 mV at 200 MHz
	External/10	TDS 310: 500 mV from DC to 20 MHz, increasing to 1.5 V at 50 MHz TDS 320: 500 mV from DC to 50 MHz, increasing to 1.5 V at 100 MHz TDS 350: 500 mV from DC to 50 MHz, increasing to 1.5 V at 200 MHz
Input Impedance, External Trigger	1 M Ω \pm 2% in parallel with 20 pF \pm 2 pF	
Maximum Input Voltage, External Trigger	\pm 400 V (DC + peak AC); derate at 20 dB/decade above 100 kHz to 13 V peak AC at 3 MHz and above	

¹Net 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.

Warranted Characteristics

Table 4-4: Power Requirements

Name	Description
Source Voltage and Frequency	90 to 132 VAC _{RMS} , continuous range, for 47 Hz through 440 Hz 132 to 250 VAC _{RMS} , continuous range, for 47 Hz through 63 Hz
Power Consumption	≤65 Watts (120 VA)

Table 4-5: Warranted Characteristics — Environmental, Safety, and Reliability

Name	Description
Atmospherics	Temperature: –10° C to +55° C, operating; –51° C to +71° C, non-operating Relative humidity: to 95%, at or below +40° C; to 75%, +41° C to +55° C Altitude: To 15,000 ft (4570 m), operating; to 40,000 ft (12190 m), non-operating
Dynamics	Random vibration: 0.31 g _{RMS} , from 5 to 500 Hz, 10 minutes each axis, operating; 2.46 g _{RMS} , from 5 to 500 Hz, 10 minutes each axis, non-operating
Emissions ¹	Meets or exceeds the requirements of the following standards: EN 50081–1 European Community Requirements EN 55022 radiated emissions EN 55022 Class B conducted emissions EN 60555–2 power harmonics VFG 0243 FCC Rules and Regulations, 47 CFR, Part 15, Subpart B, Class A
Susceptibility ²	TDS 310 and TDS 320: ≤±0.2 division waveform displacement, or ≤0.4 division increase in p-p noise. TDS 350: ≤±0.2 division waveform displacement, or ≤0.4 division increase in p-p noise below 200 MHz. ≤±0.3 division waveform displacement, or ≤±0.6 division increase in p-p noise from 200 MHz to 500 MHz. The instruments are subjected to the EMI specified in the following standards: EN 50082–1 European Community Requirements IEC 801–3 radiated susceptibility IEC 801–4 fast transients IEC 801–5 AC surge

¹To maintain emission requirements when connecting to the I/O interface of this oscilloscope, use only a high-quality, double-shielded (braid and foil) cable. The cable shield must have low impedance connections to both connector housings. The VGA cable must also have ferrite cores at either end. Acceptable cables are listed in Table 1-6 on page 1-6.

²Susceptibility test run with both channel inputs terminated with grounding caps, both channels set to 2 mV/Div, DC Coupling, the trigger source set to Line, the Acquisition Mode set to Peak Detect, and the time base set to 25 μs/Div.

Typical Characteristics

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

Table 4-6: Typical Characteristics — Signal Acquisition System

Name	Description			
Accuracy, DC Gain, Envelope Acquisition Mode	$\pm 3\%$ for sec/div settings from 5 Sec/Div to 25 $\mu\text{sec/div}$; $\pm 2\%$ for sec/div settings from 10 $\mu\text{s/div}$ to 10 ns/div (TDS 310); $\pm 2\%$ for sec/div settings from 10 $\mu\text{s/div}$ to 5 ns/div (TDS 320); $\pm 2\%$ for sec/div settings from 10 $\mu\text{s/div}$ to 2.5 ns/div (TDS 350)			
Accuracy, DC Voltage Measurement, Sample Acquisition Mode	Measurement Type	DC Accuracy		
	Any Sample	$\pm (2.0\% \times (\text{reading} - \text{Net Offset}^1) + \text{Offset Accuracy} + 0.13 \text{ div} + 0.6 \text{ mV})$		
	Delta Volts between any two samples ² acquired under the same set-up and ambient conditions	$\pm (2.0\% \times \text{reading} + 0.26 \text{ div} + 1.2 \text{ mV})$		
Frequency Limit, Upper, 20 MHz Bandwidth Limited	20 MHz			
Step Response Settling Error	Volts/Div Setting	Step Amplitude	Settling Error (%)³	
			100 ns	20 ms
	2 mV/div – 99.5 mV/div	$\leq 2 \text{ V}$	≤ 1.0	≤ 0.1
	100 mV/div – 995 mV/div	$\leq 20 \text{ V}$	≤ 1.5	≤ 0.2
	1 V/div – 10 V/div	$\leq 200 \text{ V}$	≤ 2.5	≤ 0.2
Common Mode Rejection Ratio (CMRR)	100:1 at 60 Hz, reducing to 20:1 at 50 MHz, with equal Volts/Div and Coupling settings on each channel.			

¹Net 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.

²The samples must be acquired under the same setup and ambient conditions.

³The 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.

⁴Reference is a 9-div p-p sine wave input sampled at 200 MS/s for the TDS 310, 500 MS/s for the TDS 320, and 1 GS/s for the TDS 350.

Typical Characteristics

Table 4-7: Typical Characteristics — Triggering System

Name	Description	
Error, Trigger Position, Edge Triggering	Acquire Mode	Trigger-Position Error^{1,2}
	Sample, Average	$\pm(1 \text{ WI} + 2 \text{ ns})$
	Peak Detect, Envelope	$\pm(2 \text{ WI} + 2 \text{ ns})$
Sensitivity, Video-Type Trigger	Source	Typical Sensitivity
	CH1 or CH2	0.6 division of video sync signal
	External	75 mV of video sync signal
	External/10	750 mV of video sync signal
Lowest Frequency for Successful Operation of "Set Level to 50%" Function	50 Hz	
Sensitivity, Edge Type 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 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.

¹The 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.

²The 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 4-11 on page 4-12.

³The 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.

⁴See the characteristic *Sensitivity, Edge-Type Trigger, DC Coupled* in Table 4-3, which begins on page 4-5.

Table 4-8: Typical Characteristics — Probe Compensator Output

Name	Description	
Output Voltage and Frequency, Probe Compensator	Characteristic	
	Voltage	5.0 V (low-high) into a 1 M Ω load
	Frequency	1 kHz

Table 4-9: Typical Characteristics — Data Handling

Name	Description
Time, Data-Retention, Nonvolatile Memory ^{1,2}	≥5 Years

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

²Data is maintained by a lithium poly-carbon monofluoride battery.

Nominal Traits

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

Table 4-10: Nominal Traits — Signal Acquisition System

Name	Description	
Bandwidth Selections	20 MHz and FULL	
Digitizers, Number of	Two, identical, digitized simultaneously	
Digitized Bits, Number of	8 bits ¹	
Input Channels, Number of	Two, identical, called CH 1 and CH 2	
Input Coupling	DC, AC, or GND	
Ranges, Offset, All Channels	Volts/Div Setting	Offset Range
	2 mV/div – 99.5 mV/div	±1 V
	100 mV/div – 995 mV/div	±10 V
	1 V/div – 10 V/div	±100 V
Range, Position	±5 divisions	
Range, Sensitivity ²	2 mV/div to 10 V/div	
Rise Time	TDS 310: 7 ns	
	TDS 320: 3.5 ns	
	TDS 350: 1.75 ns	
TekProbe Interface	Level one probe coding	

¹Displayed 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 that the 8-bit A-D Converter can resolve, 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.

²The sensitivity ranges from 2 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.

Nominal Traits

Table 4-11: Nominal Traits — Time Base System

Name	Description
Range, Sample-Rate ^{1,2}	TDS 310: 10 Samples/s to 200 MSamples/s in a 1–2–5 sequence TDS 320: 10 Samples/s to 500 MSamples/s in a 1–2–5 sequence TDS 350: 10 Samples/s to 1 GSamples/s in a 1–2–5 sequence
Range, Seconds/Division	TDS 310: 10 ns/div to 5 s/div in a 1–2.5–5 sequence TDS 320: 5 ns/div to 5 s/div in a 1–2.5–5 sequence TDS 350: 2.5 ns/div to 5 s/div in a 1–2.5–5 sequence
Range, Time Base Delay Time	16.5 ns to 50 seconds
Record Length	1,000 samples

¹The 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

²The 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 $1/(\text{Waveform Interval})$ for the waveform record, where the waveform interval (WI) is the time between the samples in the waveform record.

Table 4-12: Nominal Traits — Triggering System

Name	Description										
Range, Hold Off	500 ns minimum to 10 seconds maximum										
Ranges, Trigger Level	<table border="1"> <thead> <tr> <th>Source</th> <th>Range</th> </tr> </thead> <tbody> <tr> <td>Any Channel</td> <td>±12 divisions from center of screen</td> </tr> <tr> <td>External</td> <td>±1.5 Volts</td> </tr> <tr> <td>External /10</td> <td>±15 Volts</td> </tr> <tr> <td>Line</td> <td>±300 Volts</td> </tr> </tbody> </table>	Source	Range	Any Channel	±12 divisions from center of screen	External	±1.5 Volts	External /10	±15 Volts	Line	±300 Volts
Source	Range										
Any Channel	±12 divisions from center of screen										
External	±1.5 Volts										
External /10	±15 Volts										
Line	±300 Volts										
Formats and Field Rates, Video Trigger	Triggers from sync-negative composite video, 525 to 625 lines, 50 Hz to 60 Hz, interlaced or noninterlaced systems with scan rates from 15 kHz to 65 kHz – such as NTSC, PAL, or SECAM										
TekProbe Interface, External Trigger	Level one probe coding										

Table 4-13: Nominal Traits — Display System

Name	Description
CRT Type	7-inch (17.95 cm) diagonal, magnetic deflection; horizontal raster-scan; P31 green phosphor
Video Display Resolution	640 pixels horizontally by 480 pixels vertically Display area is 5.04 inch (12.92 cm) horizontally by 3.78 inch (9.69 cm) vertically

Table 4-13: Nominal Traits — Display System (Cont.)

Name	Description
Waveform Display Graticule	A single graticule 401 × 501 pixels (8 × 10 divisions, with divisions that are approximately 1 cm by 1 cm)
Intensity Levels	Dim and Bright, with adjustable Overall Intensity and Contrast

Table 4-14: Nominal Traits — I/O Interface Option

Name	Description
GPIB	Part of Option 14 I/O interface or TD3F14A I/O interface field upgrade kit; complies with IEEE Std 488–1987
RS-232	Part of Option 14 I/O interface or TD3F14A I/O interface field upgrade kit; a 9-pin male DTE RS-232 interface that complies with EIA/TIA 574–90
Centronics	Part of Option 14 I/O interface or TD3F14A I/O interface field upgrade kit; a 25-pin, IBM PC-type, parallel printer interface that complies electrically with Centronics C332–44, Rev A
Video Signal Output (Option 14 Only) (TDS310 and TDS 350, B020100 and above; TDS 320, B030100 and above)	DB-9 rear panel Video connector; non-interlaced, with levels that comply with ANSI RS343A VGA compatible at a 30.6 kHz sync rate
Power Supply, Printer (Option 14 Only) (TDS310 and TDS 350, B020100 and above; TDS 320, B030100 and above)	Power supply connector to supply power to the Option 3P Printer Pack

Table 4-15: Nominal Traits — Power Distribution System

Name	Description
Fuse Rating	5 mm × 20 mm, (UL 198 G): 3 A Slow, 250 V, (IEC 127): 3.15 A (T), 250 V

Table 4-16: Nominal Traits — Safety Characteristics

Name	Description
Safety Certification	Listed UL 1244; Category Certified CAN/CSA–C22.2 No. 231 Series-M89

Nominal Traits

Table 4-17: Nominal Traits — Mechanical Characteristics

Name	Description
Weight	
Standard Instrument	6.8 kg (15 lbs) stand-alone instrument; 8.4 kg (18.5 lbs) with front cover, accessories, and accessories pouch installed; 12.7 kg (28 lbs) when packaged for domestic shipment
Rackmount Instrument	4.5 kg (10 lbs) for the rackmount conversion kit only; 7.5 kg (17.5 lbs) when kit is packaged for domestic shipment; 6.4 kg (14 lbs), plus weight of rackmount parts, for the rack-mounted instrument (Option 1R); 14.5 kg (32 lbs) when the rackmounted instrument is packaged for domestic shipment
Overall Dimensions	
Standard Instrument (Figure 4-1)	<p>Height: 191 mm (7.5 in) with feet and accessories pouch installed 165 mm (6.5 in) without the accessories pouch installed</p> <p>Width: 362 mm (14.25 in) with handle</p> <p>Depth: 471 mm (18.55 in) stand-alone instrument 490 mm (19.28 in) with front cover installed 564 mm (22.2 in) with handle extended</p>
Rackmount Instrument	<p>Height: 178 mm (7 in) Width: 483 mm (19 in) Depth: 472 mm (18.6 in) without handles; 517 mm (20.35 in) including handles</p>

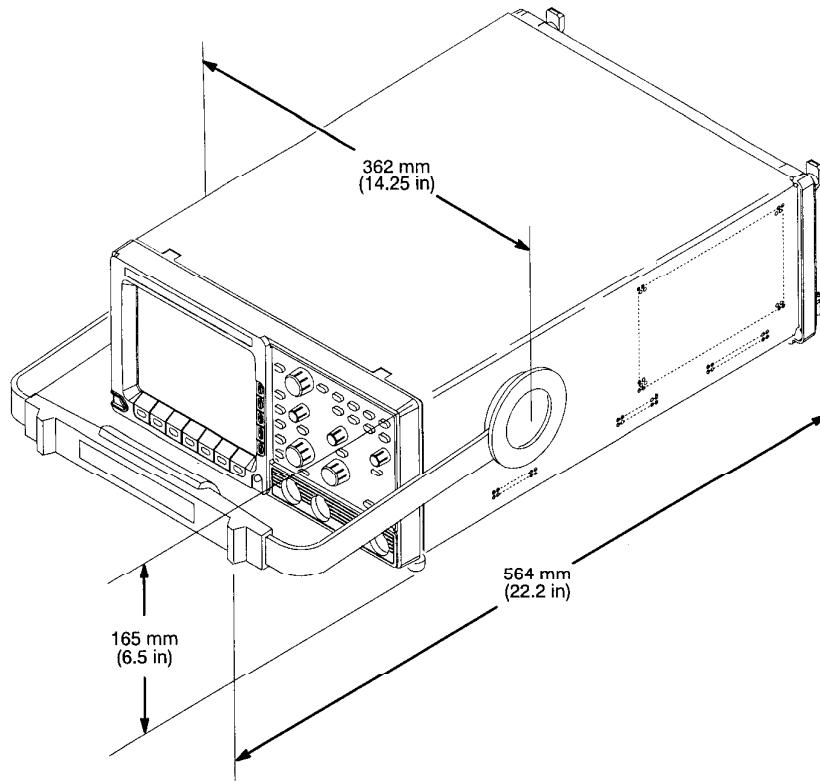


Figure 4-1: TDS 310, TDS 320, and TDS 350 Dimensions