Tektronix®

TBS1000C Series Oscilloscopes
Series Digital Storage Oscilloscope

Technical Reference

077-1583-00

TBS1000C Series Oscilloscopes
Series Digital Storage Oscilloscope
Technical Reference

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.

Supports ABC Product Firmware V1.0 and above (where ABC is abbreviated product name)

www.tek.com
077-1583-00

Contacting Tektronix

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For product information, sales, service, and technical support:

- In North America, call 1-800-833-9200.
- Worldwide, visit *www.tek.com* to find contacts in your area.

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Example off vertical position accuracy test spreadsheet

Important safety information

This manual contains information and warnings that must be followed by the user for safe operation and to keep the product in a safe condition.

To safely perform service on this product, see the *Service safety summary* that follows the *General safety summary*.

General safety summary

Use the product only as specified. Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. Carefully read all instructions. Retain these instructions for future reference.

This product shall be used in accordance with local and national codes.

For correct and safe operation of the product, it is essential that you follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

The product is designed to be used by trained personnel only.

Only qualified personnel who are aware of the hazards involved should remove the cover for repair, maintenance, or adjustment.

Before use, always check the product with a known source to be sure it is operating correctly.

This product is not intended for detection of hazardous voltages.

Use personal protective equipment to prevent shock and arc blast injury where hazardous live conductors are exposed.

While using this product, you may need to access other parts of a larger system. Read the safety sections of the other component manuals for warnings and cautions related to operating the system.

When incorporating this equipment into a system, the safety of that system is the responsibility of the assembler of the system.

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. Do not disable the power cord grounding connection.

Ground-referenced oscilloscope use. Do not float the reference lead of this probe when using with ground-referenced oscilloscopes. The reference lead must be connected to earth potential (0 V).

Power disconnect. The power cord disconnects the product from the power source. See instructions for the location. Do not position the equipment so that it is difficult to operate the power cord; it must remain accessible to the user at all times to allow for quick disconnection if needed.

Connect and disconnect properly. Do not connect or disconnect probes or test leads while they are connected to a voltage source. Use only insulated voltage probes, test leads, and adapters supplied with the product, or indicated by Tektronix to be suitable for the product.

Observe all terminal ratings. To avoid fire or shock hazard, observe all rating and markings on the product. Consult the product manual for further ratings information before making connections to the product. Do not exceed the Measurement Category (CAT) rating and voltage or current rating of the lowest rated individual component of a product, probe, or accessory. Use caution when using 1:1 test leads because the probe tip voltage is directly transmitted to the product.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Do not float the common terminal above the rated voltage for that terminal.

Do not operate without covers. Do not operate this product with covers or panels removed, or with the case open. Hazardous voltage exposure is possible.

Avoid exposed circuitry. Do not touch exposed connections and components when power is present.

Do not operate with suspected failures. If you suspect that there is damage to this product, have it inspected by qualified service personnel.

Disable the product if it is damaged. Do not use the product if it is damaged or operates incorrectly. If in doubt about safety of the product, turn it off and disconnect the power cord. Clearly mark the product to prevent its further operation.

Before use, inspect voltage probes, test leads, and accessories for mechanical damage and replace when damaged. Do not use probes or test leads if they are damaged, if there is exposed metal, or if a wear indicator shows.

Examine the exterior of the product before you use it. Look for cracks or missing pieces.

Use only specified replacement parts.

Do not operate in wet/damp conditions. Be aware that condensation may occur if a unit is moved from a cold to a warm environment.

Do not operate in an explosive atmosphere.

Keep product surfaces clean and dry. Remove the input signals before you clean the product.

Provide proper ventilation. Refer to the installation instructions in the manual for details on installing the product so it has proper ventilation.

Slots and openings are provided for ventilation and should never be covered or otherwise obstructed. Do not push objects into any of the openings.

Provide a safe working environment. Always place the product in a location convenient for viewing the display and indicators.

Avoid improper or prolonged use of keyboards, pointers, and button pads. Improper or prolonged keyboard or pointer use may result in serious injury.

Be sure your work area meets applicable ergonomic standards. Consult with an ergonomics professional to avoid stress injuries.

Probes and test leads

Before connecting probes or test leads, connect the power cord from the power connector to a properly grounded power outlet.

Keep fingers behind the protective barrier, protective finger guard, or tactile indicator on the probes.

Remove all probes, test leads and accessories that are not in use.

Use only correct Measurement Category (CAT), voltage, temperature, altitude, and amperage rated probes, test leads, and adapters for any measurement.

Beware of high voltages. Understand the voltage ratings for the probe you are using and do not exceed those ratings. Two ratings are important to know and understand:

- The maximum measurement voltage from the probe tip to the probe reference lead
- The maximum floating voltage from the probe reference lead to earth ground

These two voltage ratings depend on the probe and your application. Refer to the Specifications section of the manual for more information.

⚠ ***WARNING.*** *To prevent electrical shock, do not exceed the maximum measurement or maximum floating voltage for the oscilloscope input BNC connector, probe tip, or probe reference lead.*

Connect and disconnect properly. Connect the probe output to the measurement product before connecting the probe to the circuit under test. Connect the probe reference lead to the circuit under test before connecting the probe input. Disconnect the probe input and the probe reference lead from the circuit under test before disconnecting the probe from the measurement product.

Connect and disconnect properly. De-energize the circuit under test before connecting or disconnecting the current probe.

Connect the probe reference lead to earth ground only.

Do not connect a current probe to any wire that carries voltages or frequencies above the current probe voltage rating.

Inspect the probe and accessories. Before each use, inspect probe and accessories for damage (cuts, tears, or defects in the probe body, accessories, or cable jacket). Do not use if damaged.

Service safety summary

The *Service safety summary* section contains additional information required to safely perform service on the product. Only qualified personnel should perform service procedures. Read this *Service safety summary* and the *General safety summary* before performing any service procedures.

To avoid electric shock. Do not touch exposed connections.

Do not service alone. Do not perform internal service or adjustments of this product unless another person capable of rendering first aid and resuscitation is present.

Disconnect power. To avoid electric shock, switch off the product power and disconnect the power cord from the mains power before removing any covers or panels, or opening the case for servicing.

Use care when servicing with power on. Dangerous voltages or currents may exist in this product. Disconnect power, remove battery (if applicable), and disconnect test leads before removing protective panels, soldering, or replacing components.

Verify safety after repair. Always recheck ground continuity and mains dielectric strength after performing a repair.

Terms in the 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.*

Terms on the product

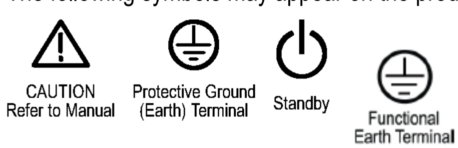
These terms may appear on the product:

- 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.

Symbols on the product

When this symbol is marked on the product, be sure to consult the manual to find out the nature of the potential hazards and any actions which have to be taken to avoid them. (This symbol may also be used to refer the user to ratings in the manual.)

The following symbols may appear on the product:



Specifications

Model overview

Model overview

	TBS1052C	TBS1072C	TBS1102C	TBS1202C
Bandwidth	50 MHz	70 MHz	100 MHz	200 MHz
Channels	2	2	2	2
Sample Rate	1 GS/s	1 GS/s	1 GS/s	1 GS/s
Record Length	20K points	20K points	20K points	20K points

Vertical system - analog channels

Vertical resolution	8 bits
Input sensitivity range	1 mV/Div to 10V/Div in 1-2-5 sequence with probe attenuation set to 1X
Maximum input voltage	300 V RMS, Installation Category II; derate above 4 MHz at 20dB per decade to 200 MHz
Vertical offset range	1 mV/div to 50 mV/div: +/- 1V 100 mV/div to 500 mV/div: +/- 10 V 1 V/div to 5 V/div: +/- 100 V
Bandwidth limit	20 MHz (Typ)
Input coupling	DC or AC
Input resistance, DC coupled	1 MΩ, ±2 %
Input capacitance, DC coupled	14pF ± 2 pF
Vertical zoom	Vertically expand or compress a live or a stopped waveform

Acquisition modes

Sample	Acquire sampled values
Peak Detect	Captures glitches as narrow as 3.5 ns at all sweep speeds.
Average	From 2 to 512 waveforms included in average.
Hi-Res	Averages multiple sample of one acquisition interval into one waveform point.
Roll	Scrolls waveforms right to left across the screen at sweep speeds slower than or equal to 40 ms/div

Horizontal systems - analog channel

Deskew range	+/- 100 ns with 1ns resolution
Horizontal zoom	Horizontally expand or compress a live or a stopped waveform
Timebase accuracy	50 ppm
Seconds\Division range	2 ns/div to 100 sec/div in a 1-2-4 sequence.

Signal acquisition system characteristics

No of input channels	Two
Input coupling	DC or AC AC coupling connects a capacitor in series with the input circuitry. The DC input impedance becomes very high, since capacitance is in series with all paths to ground.
Input impedance, DC coupled	1 MΩ, ±2 %
Input capacitance, DC coupled	14pF ± 2pF
Maximum input voltage	A300 V RMS, CAT II; derate above 4 MHz at 20 dB per decade to 200 MHz
Number of digitized bits	8 bits
Sensitivity range	1 mV/div to 10V/div in 1-2-5 sequence with probe attenuation set to 1X.
Probe scale factors	1X, 10X, 20X, 50X, 100X, 500X, 1000X voltage attenuation. 5, 1, 500 m, 200 m, 100 m, 20 m, 10 m, 1 m V/A current scale factor. This adjusts the display scale factor of the instrument to accommodate various probe types. Accuracy of the probe used must be added to the accuracy specifications of instrument. No automatic probe interface is provided, so you must verify that the settings match the probe characteristics. The probe check function allows setting of the proper attenuation for voltage probes.
Acquisition modes	Sample, Peak detect, Average
Retained front panel settings	Front panel settings are retained when the instrument power is turned off and on with the power switch. The settings are retained when the line power is turned off and on. The instrument periodically saves front panel settings after settings are changed. There is a delay of three seconds after the last change and before the storage of the settings in memory.

Math modes	Channel 1 – Channel 2 Channel 2 – Channel 1 Channel 1 + Channel 2 Channel 1 * Channel 2 FFT
Voltage measurement functions	Mean, Cycle Mean, Cursor Mean, Max, Min, RMS, Cycle RMS, Cursor RMS, Peak-to-Peak, Amplitude, Positive Overshoot, Negative Overshoot, High, Low.
DC balance	0.2 div at 1 mVdiv and up with the input 1 MW-DC coupled and 50 W terminated.
✓DC gain accuracy, Sample or Average acquisition	This is the difference between the measured DC gain and the nominal DC gain, divided by the nominal DC gain and expressed as a percent. +/-3.0% step gain, derated at 0.1%/°C above 30°C.
DC voltage measurement accuracy, average acquisition mode	This is the accuracy of DC voltage DC voltage measurements acquired using average of > 16 waveforms. Average of > 16 waveforms: ±((DC gain accuracy) X |reading - (offset - position)| + offset accuracy + 0.1 div + 1mV)
Analog bandwidth	Defined in Section 4.6 of IEEE std 1057. The difference between the upper and lower frequencies, at which the amplitude response, as seen in the data record, is 0.707 (-3 dB) of the response seen in the data record at the specified reference frequency. Specifies only the -3 dB point. It does not include the in-band response.
√ Analog bandwidth, DC coupled, Sample or Average	200 MHz models: DC to >200 MHz for 1 mV/div through 10 V/div. 100 MHz models: DC to >100 MHz for 1 mV/div through 10 V/div. 70 MHz models: DC to >70 MHz for 1 mV/div through 10 V/div. 50 MHz models: DC to >50 MHz for 1 mV/div through 10 V/div.
Analog bandwidth selections	20 MHz bandwidth limit ON/OFF
Upper-Frequency limit, 20 MHz bandwidth limited, typical	This is the upper frequency for Analog Bandwidth when the instrument has 20 MHz bandwidth limiting turned on. 20 MHz, ±25%

	Bandwidth of all trigger paths are similarly limited, except the Aux-In, which is not affected by BW Limit function. Each channel is separately limited, allowing different bandwidths on different channels of the same instrument.
Lower- Frequency limit, AC coupled	This is the lower frequency for Analog Bandwidth when the instrument is AC-coupled. ≤ 10 Hz.
Rise time, typical	See table below. Rise time is generally calculated from the following formula: Rise time in ns = 350 / Bandwidth in MHz
√ Vertical position accuracy, offset accuracy	This is the accuracy of the nominal voltage level represented by the code at the vendor of the A-D converter's dynamic range. ± (0.01 X |offset – position | + DC Balance)
Vertical position ranges	± 5 divisions
Common Mode Rejection Ratio (CMRR), typical	With the same signal applied to each channel, CMRR is the ratio of the acquired signal amplitude to the amplitude of the MATH difference waveform, either (Channel 1 - Channel 2), (Channel 2 - Channel 1)
Crosstalk (Channel Isolation)	Section 4.11.1 of IEEE std. 1057. It is the ratio of the level of a signal input into one channel to that of the same signal present in another channel due to stray coupling.

Rise time, typical:

Model	Expected full bandwidth rise time
TBS1202C	2.1 ns
TBS1102C	3.5 ns
TBS1072C	5.0 ns
TBS1052C	7.0 ns

Common Mode Rejection Ratio (CMRR), typical:

Model	Common Mode Rejection Ratio
TBS1202C TBS1102C TBS1072C TBS1052C	100:1 at 60 Hz, reducing to 10:1 with 50 MHz sine wave, with equal Volts/Div and Coupling settings on each channel.

Crosstalk (Channel Isolation):

Model	Common Mode Rejection Ratio
TBS1202C (200 MHz models)	>100:1 with 200 MHz sine wave and with equal V/div settings on each channel.
TBS1102C (100 MHz models)	>100:1 with 100 MHz sine wave and with equal V/div settings on each channel.
TBS1072C (70 MHz models)	>100:1 with 70 MHz sine wave and with equal V/div settings on each channel.
TBS1052C (50 MHz models)	>100:1 with 50 MHz sine wave and with equal V/div settings on each channel.

Waveform measurements

Automated measurements	32, of which up to six can be displayed on-screen at any one time. Measurements include: Period, Frequency, Rise Time, Fall Time, Positive Duty Cycle, Negative Duty Cycle, Positive Pulse Width, Negative Pulse Width, Burst Width, Phase, Positive Overshoot, Negative Overshoot, Peak to Peak, Amplitude, High, Low, Max, Min, Mean, Cycle Mean, RMS, Cycle RMS, Positive Pulse Count, Negative Pulse Count, Rising Edge Count, Falling Edge Count, Area, Cycle Area, Delay FR, Delay FF, Delay FR, and Delay RR.
Cursors	Time, Amplitude, Screen
Gating	Isolate the specific occurrence within an acquisition to take measurements on, using either the screen, between waveform cursors or full record length.

Time Base System

Sample-Rate range

This is 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. (IEEE 1057, 2.2.1)

1 GS/s all channels (TBS1202C, TBS1102C, TBS1072C, TBS1052C)

Waveform interpolation

Only (sin x)/x interpolation is provided.

Record length

This is the total number of samples contained in a single acquired waveform record (Memory Length in IEEE 1057.2.2.1).

20k, 2k and 1k samples per record.

Seconds/Division range

Model	Range
TBS1202C, TBS1102C	2 ns/div to 100 sec/div in a 1-2-4 sequence
TBS1072C, TBS1052C	

√ Long-Term sample rate and horizontal position time accuracy

This is the maximum, total, long-term error in sample-rate or horizontal position time accuracy, expressed in parts per million.

±25 x 10^{-6} over any ≥1 ms interval.

Zoom

The zoom function enables a user to select a part of the display to be magnified. Both the original waveform and the zoomed waveform are displayed. The user chooses the waveform with the Multipurpose knob.

Delta time measurement accuracy

This is the accuracy of delta time measurements made on any single waveform. The specification is related to the long-term sampling rate.

The following limits are given for signals having an amplitude ≥ 5 divisions, a slew rate at the measurement points of ≥ 2.0 divisions/ns, and acquired ≥ 10 mV/div.

Condition	Time measurement accuracy
Single shot, sample mode, full bandwidth selected	±(1 Sample Internal + 25 X 10^{-6} X |reading| + 0.6 ns)
> 16 averages, full bandwidth selected	±(1 Sample Internal + 25 X 10^{-6} X |reading| + 0.4 ns)

The Sample Interval is the time between the samples in the waveform record.

Time measurement functions

Frequency, Period , Rise, Fall, Pwidth, Nwidth, Pduty, Nduty, DelayRR, DelayRF, DelayFR, DelayFF, Burst width, Phase.

Waveform Math

Arithmetic

Add, Subtract, and Multiply waveforms

FFT

Spectral magnitude. Set FFT Vertical Scale to Linear RMS or dBV RMS, and FFT Window to Rectangular, Hamming, Hanning, or Blackman-Harris.

Triggering system

Trigger types

Edge	Positive or negative slope on any channel. Coupling includes DC, HF reject, LF reject, and noise reject.
Pulse Width	Trigger on width of positive or negative pulses that are >, <, =, or ≠ a specified period of time.
Runt	Trigger on a pulse that crosses one threshold but fails to cross a second threshold before crossing the first again.

Trigger source selection

Analog channels, Aux In (External), AC Line.

Horizontal trigger position

The trigger position is set by the Horizontal Position knob.

Aux In input impedance

1 MΩ ±2 %, 13 pF ±2 pF

Aux In maximum input voltage

300 V_{RMS}, Installation Category II; derate at 20 dB/decade above 100 kHz to 13 V peak AC at 3 MHz and above

Based on sinusoidal or DC input signal. The maximum viewable signal while DC coupled is ±50 V offset ±5 V/div at 4 divisions, or 70 V. AC coupling allows measuring signals on a DC level up to 300 V. For non sinusoidal waveforms, peak value must be less than 450 V. Excursions above 300 V should be less than 100 ms duration and the duty factor is limited to < 44%. RMS signal level must be limited to 300 V. If these values are exceeded, damage to the instrument may result.

Line trigger characteristics

Line Trigger mode provides a source to synchronize the trigger with the AC line input.

Input Amplitude requirements: 85 V_{AC} - 265 V_{AC}.

Input Frequency requirements: 45 Hz - 440 Hz.

Edge trigger

Trigger modes	Auto, Normal, Single sequence
Trigger coupling (analog channels)	AC, DC, Noise Reject, High Freq Reject, Low Freq Reject
	The Aun In path does not have a DC blocking capacitor ahead of the trigger input circuit. The roll off associated with AC coupling happens after the input circuit. When attempting to trigger on an AC signal that has a DC offset, use care to avoid overloading the input of the Aux In circuit. For signals that have a large DC offset, using Channel 1 or Channel 2 with AC coupling is preferred.
Trigger slope	Rising edge, Falling edge

√ Sensitivity, Edge-Type trigger, DC coupled

Measurement Style A: The minimum signal levels for achieving stable frequency indication on the Trigger Frequency Counter within 1% of correct indication.

Measurement Style B: Section 4 10.2 in IEEE Std. #1057. The minimum signal levels required for stable edge triggering of an acquisition when the trigger Source is DC coupled.

Trigger source		Sensitivity (Measurement style A), typical	Sensitivity (Measurement style B)
Channel inputs	All products	0.4 division from DC to 50 MHz 0.6 divisions >50 MHz to 100 MHz 0.8 divisions >100 MHz to 200 MHz	0.8 div from DC to 10 MHz > 2 mV/div) 2.5 div from DC to 10 MHz (2 mV/Div)
	TBS1072C	3 div between 10 MHz and 70 MHz	1.5 div between 10 MHz and 70 MHz
	TBS1102C	3 div between 10 MHz and 100 MHz	1.5 div between 10 MHz and 100 MHz
	TBS1052C	3 div between 10 MHz and 50 MHz	1.5 div between 10 MHz and 50 MHz
	TBS1202C	3 div between 10 MHz and 200 MHz	1.5 div from 10 MHz and 100 MHz 2.0 div above 100 MHz to 200 MHz
Aux In		300 mV from DC to 100 MHz	200 mV from DC to 100 MHz
		500 mV from 100 MHz to 200 MHz	350 mV from 100 MHz to 200 MHz
		TBS1202C	TBS1202C

Trigger frequency feadout typically stabilizes at 50% more signal than generates a stable visual display.

Sensitivity, Edge-Type trigger, not-DC coupled, typical	**Trigger coupling** / **Typical sensitivity** AC coupled: Same as DC coupled limits for frequencies 50 Hz and above Noise rej: Effective in Sample or Average Mode, > 10 mV/div to 5 V/div. Reduces DC coupled trigger sensitivity by 2X. HF rej: Same as DC coupled limits from DC to 7 kHz. LF rej: Same as DC coupled limits for frequencies above 300 kHz.

Sensitivity, Edge-Type trigger, not-DC coupled, typical

Trigger coupling	Typical sensitivity
AC coupled	Same as DC coupled limits for frequencies 50 Hz and above
Noise rej	Effective in Sample or Average Mode, > 10 mV/div to 5 V/div. Reduces DC coupled trigger sensitivity by 2X.
HF rej	Same as DC coupled limits from DC to 7 kHz.
LF rej	Same as DC coupled limits for frequencies above 300 kHz.

Lowest frequency for successful operation of "Set Level to 50%" function, typical.

This is the typical lowest frequency for which the “Set Level to 50%” function will successfully determine the 50% point of the trigger signal.

50 Hz.

Trigger level ranges, typical

Input Channels: +/-4.90 divisions from center screen

Aux In: +/-6.25 V, 1X probe attenuation, +/- 12.50 V, 10X probe attenuation

Trigger signal frequency readout

Provides a frequency readout of the trigger source

Trigger frequency counter accuracy

±25 x 10-6 including all reference errors and +/-1 count errors

Trigger frequency counter frequency range

12 Hz minimum to rated bandwidth

Trigger frequency counter resolution

3 digits

Trigger frequency counter signal source

Edge selected trigger source only

Trigger level accuracy, DC coupled, typical

This is the amount of deviation allowed between the level on the waveform at which triggering occurs and the level selected for DC-coupled triggering signals. A sine wave with 20 ns rise time corresponds to about 18 MHz.

±0.2 div for signals within ±4 divisions from the center screen, having rise and fall times of ≥ 20 ns.

Aux In: ±(6% of setting + 40 mV) for signals less than ±800 mV

Pulse-Width trigger

Pulse-Type trigger, minimum pulse, rearm time, minimum transition time	Minimum pulse width: 2ns Minimum re-arm time: 2ns
Time range for pulse width	2 ns to 8 s
Time accuracy for pulse width triggering	± 2 ns
Pulse-Width trigger modes	< (Less than), > (Greater than), = (Equal), ≠ (Not equal)
Pulse width trigger edge	Falling edge for positive polarity pulse. Rising edge for negative polarity pulse.
Pulse width range	33 ns ≤ width ≤ 10 seconds
Pulse width resolution	16.5 ns or 1 part per thousand, whichever is larger

Equal guardband	t > 330 ns: ±5% < guardband < ±(5.1% + 16.5 ns) t ≤ 330 ns: guardband = ±16.5 ns.
	All pulses, even from the most stable sources, have some amount of jitter. To avoid disqualifying pulses that are intended to qualify but are not absolutely correct values, Tektronix provides an arbitrary guardband. Any measured pulse width within the guardband will qualify. If you are looking for pulse width differences that are smaller than the guardband width, offsetting the center should allow discriminating differences down to the guardband accuracy.
Not equal guardband	330 ns < 1: ±5% ≤ guardband < ±(5.1% + 16.5 ns) 165 ns < 1 < 330 ns: guardband = -16.5 ns/+33 ns t ≤ 165 ns: guardband = ±16.5 ns
	All pulses, even from the most stable sources, have some amount of jitter. To avoid disqualifying pulses that are intended to qualify but are not absolutely correct values, Tektronix provides an arbitrary guardband. Any measured pulse width outside the guardband will qualify. If you are looking for pulse width differences that are smaller than the guardband width, offsetting the center should allow discriminating differences down to the guardband accuracy. Not equal has slightly better ability to deal with small pulse widths than equal. The accuracy is not better.
Pulse-Width trigger point	**Equal**: The oscilloscope triggers when the trailing edge of the pulse crosses the trigger level.
	Not Equal: If the pulse is narrower than the specified width, the trigger point is the trailing edge. Otherwise, the oscilloscope triggers when a pulse continues longer than the time specified as the Pulse Width.
	Less than: The trigger point is the trailing edge.
	Greater than (also called the time out trigger): The oscilloscope triggers when a pulse continues longer than the time specified as the Pulse Width.

Display specifications

Display type	7 inch TFT Liquid Crystal Display (LCD).
Display Resolution	This is the number of individually addressable pixels 800 horizontal by 480 vertical displayed pixels
Format	YT and XY
Waveform styles	Vectors, variable persistence, and Infinite persistence.
Luminance, typical	300 cd/m^2, typical.
Contrast ratio and control, typical	Available black room contrast ratio, full black to full white. 400 minimum, 500 typical.

Interfaces and output ports specifications

USB Interface	1 High Speed USB2.0 Host and 1 High Speed USB2.0 Device connector are standard in all models.
Kensington style lock	Rear-Panel security slot connects to standard Kensington-style lock
Probe compensator, output voltage and frequency, typical	The Probe compensator output voltage is in peak-to-peak volts and frequency is in Hertz. 0-5V amplitude +/- 10%, 1 kHz +/- 10%

Data handling characteristics

Retention of front panel settings	Front panel settings are stored periodically in memory. The settings are not lost when the instrument is turned off or if there is a power failure.
Stored waveforms and multiple front panel settings	Two Channel 1, Channel 2, or Math waveforms can be stored in nonvolatile waveform memory A or B. One, both, or neither of A or B waveform memories can be displayed. Ten user setups of the current instrument settings can be saved and restored from nonvolatile memory. Additional storage is available when an appropriate mass storage device is connected via USB.

Power distribution system

Power consumption	30 W (typ)
Source voltage	Full range: 100 to 240 VACRMS ± 10%, Installation Category II (covers range of 90 to 264 V_{AC})
Power source	100 to 240 VAC RMS ±10%
Power source frequency	45 Hz to 65 Hz (100 to 240 V). 360 Hz to 440 Hz (100 to 132 V).
Fuse rating	3.15 Amps, T rating, 250 V; IEC and UL approved.

Mechanical characteristics

Weight

	kg	Lb
Instrument only	1.979	4.36
Instrument with accessories	3.112	6.86

Cooling clearance 50 mm (2 in) required on left side, right side and rear of instrument.

RM2000B rackmount

	mm	In
Height	177.8	7.0
Width	482.6	19.0
Depth	108.0	4.25

Shipping dimensions

	mm	In
Height	266.7	10.5
Width	476.2	18.75
Depth	228.6	9.0

Dimensions

	mm	In
Height- Handle folded down	154.95	6.1
Height-Handle up	213.36	8.4
Width	325.12	12.8
Depth	106.68	4.2

Cooling method Convection cooled

Environmental performance

Temperature	
Operating:	0° C to +50° C (32 °F to 122 °F)
Non-operating:	–30° C to +71° C (–40 °F to 159.8 °F), with 5° C/minute maximum gradient
Humidity	
Operating:	5% to 90% relative humidity (% RH) at up to +30° C 5% to 60% RH above +30 °C up to +50 °C, non-condensing.
Non-operating:	5% to 90% RH (Relative Humidity) at up to +30 °C, 5% to 60% RH above +30° C up to +60° C, non-condensing
Altitude	
Operating:	Up to 3,000 meters (9,842 feet)
Non-operating:	Up to 12,000 meters (39,370 feet).
Regulatory	
Electromagnetic	EC Council Directive 2014/30/EU
Compatibility	UL61010-1, UL61010-2-030, CAN/CSA-C22.2 No. 61010.1, CAN/CSA-C22.2 No. 61010-2:030
Safety	Compiles with the Low Voltage Directive 2014/35/EU for Product Safety

Performance verification

This chapter contains performance verification procedures for the specifications marked with the check mark. The following equipment, or a suitable equivalent, is required to complete these procedures.

Required equipment

Table 1: Performance verification

Description	Minimum requirements	Examples
DC voltage source	17.5 mV to 7 V, ±0.5% accuracy	Wavetek 9100 Universal Calibration System with Oscilloscope Calibration Module (Option 250) Fluke 5500A Multi-product Calibrator with Oscilloscope Calibration Option (Option 5500A-SC)
Leveled sine wave Generator	50 kHz and 200 MHz, ±3% amplitude accuracy	
Time mark generator	10 ms period, ±10 ppm accuracy	
50Ω BNC cable	BNC male to BNC male, ≈ 1 m (36 in) long	Tektronix part number 012-0482-XX
50Ω BNC cable	BNC male to BNC male, ≈ 25 cm (10 in) long	Tektronix part number 012-0208-XX
50 Ω feed through termination	BNC male and female connectors	Tektronix part number 011-0049-XX
Dual banana to BNC adapter	Banana plugs to BNC female	Tektronix part number 103-0090-XX
BNC T adapter	BNC male to dual BNC female connectors	Tektronix part number 103-0030-XX
Splitter, power	Frequency range: DC to 4 GHz. Tracking: >2.0%	Tektronix part number 015-0565-XX
Adapter (four required)	Male N-to-female BNC	Tektronix part number 103-045-XX
Adapter	Female N-to-male BNC	Tektronix part number 103-0058-XX
Leads, 3 black	Stacking banana plug patch cord, ≈ 45 cm (18 in) long	Pomona #B-18-0
Leads, 2 red	Stacking banana plug patch cord, ≈ 45 cm (18 in) long	Pomona #B-18-2

Test record

Table 2: Test record

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

Instrument performance test	Minimum	Incoming	Outgoing	Maximum
Channel 1 DC Gain Accuracy	5 mV/div	33.6 mV		36.4 mV
	200 mV/div	1.358 V		1.442 V
	2 V/div	13.58 V		14.42 V
Channel 2 DC Gain Accuracy	5 mV/div	33.6 mV		36.4 mV
	200 mV/div	1.358 V		1.442 V
	2 V/div	13.58 V		14.42 V
Channel 1 Bandwidth		2.12 V		— [1]
Channel 2 Bandwidth		2.12 V		— [1]
Sample Rate and Delay Time Accuracy		-2 divs		+2 divs
Channel 1 Edge Trigger Sensitivity		Stable trigger		— [2]
Channel 2 Edge Trigger Sensitivity		Stable trigger		—[2]
Aux In Edge Trigger Sensitivity		Stable trigger		—[2]
Channel 1 Vertical Position Accuracy, Minimum margin		0		—
Channel 2 Vertical Position Accuracy, Minimum margin		0		—

1 The bandwidth test does not have a high limit.
2 The limits vary by model. Check the procedure for the correct limits.

Performance verification procedures

Before beginning these procedures, two conditions must be met:

- The oscilloscope must have been operating continuously for twenty minutes within the operating temperature range specified in the Environmental Performance table.
- You must perform the Self Calibration operation described below. If the ambient temperature changes by more than 5 °C, you must perform the Self Calibration operation again.

The time required to complete the entire procedure is approximately one hour.

⚠ ***WARNING.*** *Some procedures use hazardous voltages. To prevent electrical shock, always set voltage source outputs to 0 V before making or changing any interconnections.*

Self test

This internal procedure is automatically performed every time the oscilloscope is powered on. No test equipment or hookups are required. Verify that no error messages are displayed before continuing with this procedure.

Signal calibration

The self calibration routine lets you quickly optimize the oscilloscope signal path for maximum measurement accuracy. You can run the routine at any time, but you should always run the routine if the ambient temperature changes by 5 °C or more.

1. Disconnect all probes and cables from the channel input connectors (channels 1 and 2).
2. Push the Utility button and select the Do Self Cal option to start the routine. The routine takes approximately one minute to complete.
3. Verify that self calibration passed.

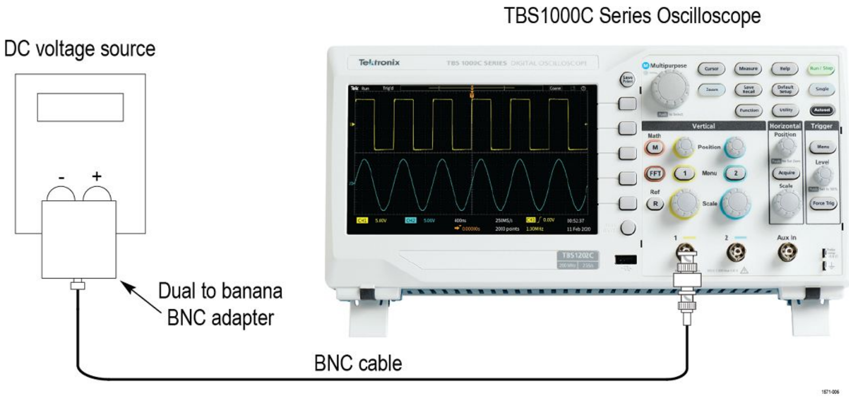
Check DC gain accuracy

This test checks the DC gain accuracy of all input channels.

1. Set the DC voltage source output level to **0 V**.
2. Set up the oscilloscope using the following table:

Push menu button	Select menu option	Select setting
Default Setup	-	-
Channel 1	Probe	1X
Acquire	Average	16
Measure	Source	Channel under test
	Measurements	Mean

3. Connect the oscilloscope channel under test to the DC voltage source as shown in the following figure:



4. For each vertical scale (volts/division) setting in the following table, perform the following steps:
   a. Set the DC voltage source output level to the positive voltage listed and then record the mean measurement as V_{pos}.
   b. Reverse the polarity of the DC voltage source and record the mean measurement as V_{neg}.
   c. Calculate $V_{diff} = V_{pos} - V_{neg}$ and compare V_{diff} to the accuracy limits in the following table:

Vertical Scale (volts/div)setting	DC voltage source output levels	Accuracy limits for V_{diff}
5 mV/div	+17.5 mV, -17.5 mV	33.6 mV to 36.4 mV
200 mV/div	+700 mV, -700 mV	1.358 V to 1.442 V
2 V/div	+7.00 V, -7.00 V	13.58 V to 14.42 V

5. Set DC voltage source output level to **0 V**.
6. Disconnect the test setup.
7. Repeat steps 1 through 6 for all input channels.

Check bandwidth

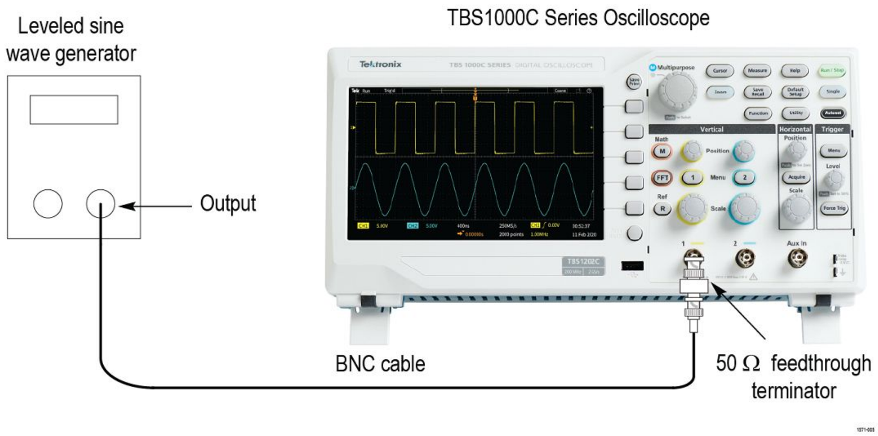
This test checks the bandwidth of all input channels.

1. Set up the oscilloscope using the following table:

Push menu button	Select menu option	Select setting
Default Setup	-	-
Channel 1	Probe	1X
Acquire	Average	16
Trig Menu	Coupling	Noise Reject

Push menu button	Select menu option	Select setting
Measure	Source	Channel under test
	Measurements	Peak-Peak

2. Connect the oscilloscope channel under test to the leveled sine wave generator as shown in the following figure:



3. Set the oscilloscope **Vertical Scale** (volts/division) to **500 mV/div**.
4. Set the oscilloscope **Horizontal Scale** (seconds/division) to **10 µs/div**.
5. Set the leveled sine wave generator frequency to **50 kHz**.
6. Set the leveled sine wave generator output level so the peak-to-peak measurement is between **2.98 V** and **3.02 V**.
7. Set the leveled sine wave generator frequency to:
   - **200 MHz** if you are checking a TBS1202C
   - **100 MHz** if you are checking a TBS1102C
   - **70 MHz** if you are checking a TBS1072C
   - **50 MHz** if you are checking a TBS1052C
8. Set the oscilloscope Horizontal Scale (seconds/division) to **10 ns/div**.
9. Check that the peak-to-peak measurement is ≥ **2.12 V**.
10. Disconnect the test setup.
11. Repeat steps 1 through 10 for all input channels.

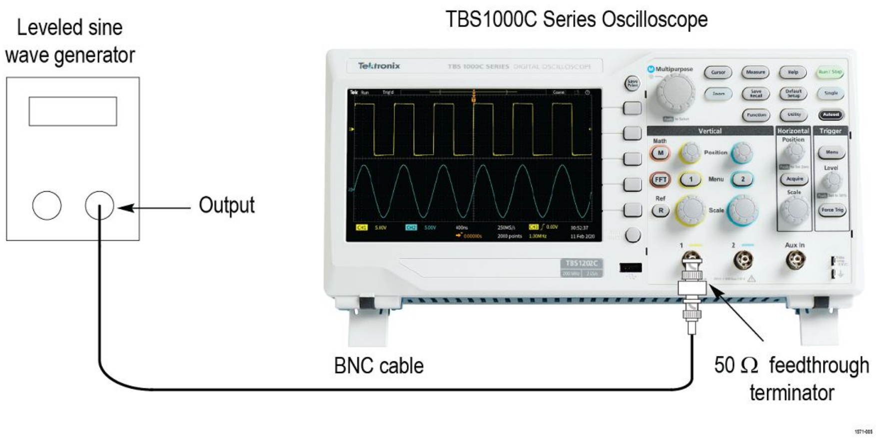
Check sample rate accuracy and delay time accuracy

This test checks the sample rate and delay time accuracy (time base).

1. Set up the oscilloscope using the following table:

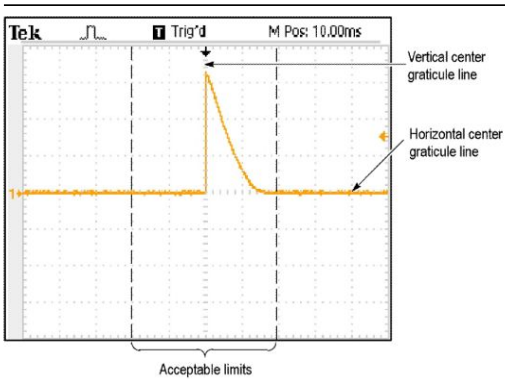
Push menu button	Select menu option	Select setting
Default setup	-	-
Channel 1	Probe	1X

2. Connect the oscilloscope to the time mark generator as shown in the following figure:



3. Set the time mark generator period to **10 ms**.
4. Set the oscilloscope **Vertical Scale** (volts/division) to **500 mV/div**.
5. Set the oscilloscope **Main Horizontal Scale** (seconds/division) to **1 ms/div**.
6. Push the **Trigger Level** knob to activate the **Set To 50%** feature.
7. Use the **Vertical Position** control to center the test signal on screen.
8. Use the **Horizontal Position** control to set the position to **10.00 ms**.
9. Set the oscilloscope **Horizontal Scale** (seconds/division) to **200 ns/div**.
10. Check that the rising edge of the marker crosses the center horizontal graticule line within ±2 divisions of the vertical center graticule line, as shown in the following figure:

***NOTE.** One division of displacement from graticule center corresponds to a 25 ppm time base error.*



11. Disconnect the test setup.

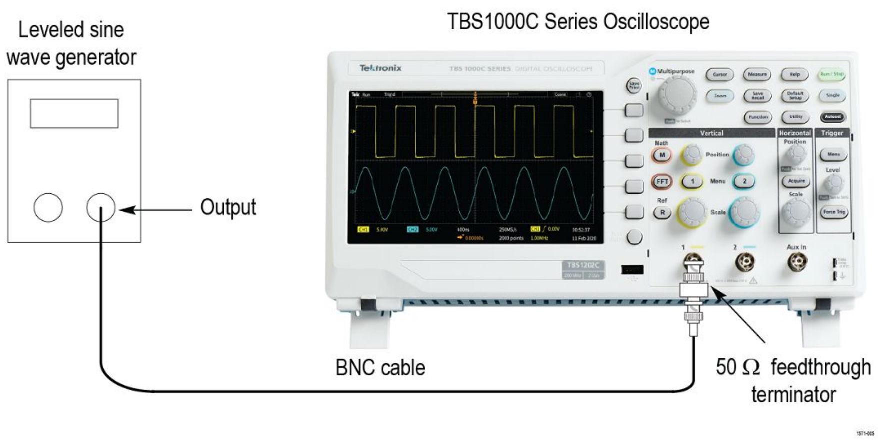
Check edge trigger sensitivity

This test checks the edge trigger sensitivity for all input channels.

1. Set up the oscilloscope using the following table:

Push menu button	Select menu option	Select setting
Default setup	-	-
Channel 1	Probe	1X
Trig Menu	Mode	Normal
Acquire	Sample	-
Measure	Source	Channel under test
	Measurements	Peak-Peak

2. Connect the oscilloscope channel under test to the leveled sine wave generator as shown in the following figure:



3. Set the oscilloscope **Vertical Scale** (volts/division) to **500 mV/div**.
4. Set the oscilloscope **Horizontal Scale** (seconds/division) to **20 ns/div**.
5. Set the leveled sine wave generator frequency to **10 MHz**.
6. Set the leveled sine wave generator output level to approximately **500 mV$_{p-p}$** so that the measured amplitude is approximately 500 mV. (The measured amplitude can fluctuate around 500 mV.)
7. Push the **Trigger Level** knob to activate the **Set To 50%**. Rotate the **Trigger Level** knob to adjust the trigger level as necessary and then check that triggering is stable.
8. Set the leveled sine wave generator frequency to:
   - **200 MHz** if you are checking a TBS1202C
   - **100 MHz** if you are checking a TBS1102C
   - **70 MHz** if you are checking a TBS1072C
   - **50 MHz** if you are checking a TBS1052C
9. Set the oscilloscope **Horizontal Scale** (seconds/division) to **4 ns/div**.
10. Set the leveled sine wave generator output level to approximately **750 mV$_{p-p}$** so that the measured amplitude is approximately 750 mV. (The measured amplitude can fluctuate around 750 mV.)

11. Push the **Trigger Level** knob to activate the **Set To 50%** feature. Rotate the **Trigger Level** knob to adjust the trigger level as necessary and then check that triggering is stable.
12. For the TBS1202C model, set the frequency to 150 MHz, and increase the amplitude to 1 Vp-p. Verify stable triggering.
13. Set the oscilloscope **Horizontal Scale** (seconds/division) to **2 ns/div**.
14. Change the oscilloscope setup using the following table:

Push menu button	Select menu option	Select setting
Trig menu	Slope	Falling

15. Push the **Trigger Level** knob to activate the **Set To 50%** feature. Rotate the **Trigger Level** knob to adjust the trigger level as necessary and then check that triggering is stable.
16. Disconnect the test setup.
17. Repeat steps 1 through 16 for all input channels.

Check Aux In edge trigger sensitivity

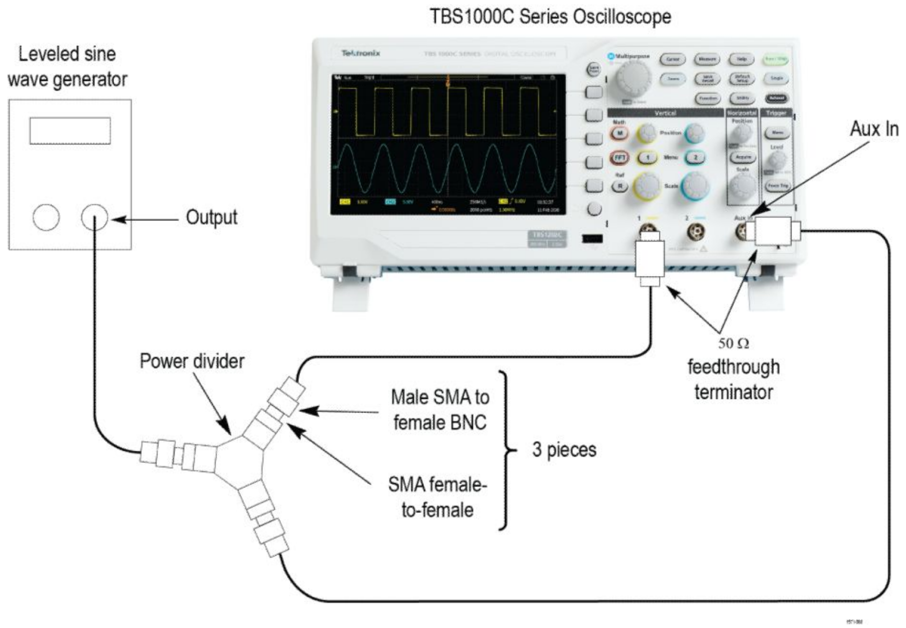
This test checks the edge trigger sensitivity for the Aux In.

1. Set up the oscilloscope using the following table:

Push menu button	Select menu option	Select setting
Default setup	-	-
Channel 1	Probe	1X
Trig Menu	Source	Aux In
	Mode	Normal
Acquire	Sample	-

Push menu button	Select menu option	Select setting
Measure	Source	CH1
	Measurements	Peak-Peak

2. Connect the oscilloscope to the leveled sine wave generator as shown in the following figure, using channel **1** and **AUX IN**.



3. Set the oscilloscope **Vertical Scale** (volts/division) to **100 mV/div**.
4. Set the oscilloscope **Horizontal Scale** (seconds/division) to **20 ns/div**.
5. Set the leveled sine wave generator frequency to **10 MHz**.
6. Set the sine wave generator output level to approximately **300 mV_{p-p}** into the power splitter. This is about **200 mV_{p-p}** on channel 1 of the oscilloscope.

   The **AUX IN** input will also be receiving approximately **200 mV_{p-p}**. Small deviations from the nominal 200 mV_{p-p} oscilloscope display are acceptable.
7. Set the leveled sine wave generator frequency to:
   - **200 MHz** if you are checking a TBS1202C
   - **100 MHz** if you are checking a TBS1102C
   - **70 MHz** if you are checking a TBS1072C
   - **50 MHz** if you are checking a TBS1052C
8. Set the oscilloscope **Horizontal Scale** (seconds/division) to **4 ns/div**.
9. Push the Trigger Level knob to activate the Set To 50% feature. Rotate the Trigger Level knob to adjust the trigger level as necessary and then check that triggering is stable.
10. Set the oscilloscope **Horizontal Scale** (seconds/division) to **2 ns/div**.
11. Push the Trigger Level knob to activate the Set To 50% feature. Rotate the Trigger Level knob to adjust the trigger level as necessary and then check that triggering is stable.

12. Change the oscilloscope setup using the following table:

Push menu button	Select menu option	Select setting
Trig menu	Slope	Falling

13. Push the **Trigger Level** knob to activate the **Set To 50%** feature. Rotate the **Trigger Level** knob to adjust the trigger level as necessary and then check that triggering is stable.

14. Disconnect the test setup.

Check Vertical Position Accuracy

The results of this test and the DC Gain Accuracy test together define the DC Measurement Accuracy of the oscilloscope. The DC Measurement Accuracy specification encompasses two different ranges of operation over two different attenuator settings.

- DC Gain Accuracy: Identifies errors, mostly from the A/D converter, when the vertical position (known as offset in these oscilloscopes) is set to 0 divisions (or a grounded input will show screen center)
- Vertical Position Accuracy: Identifies errors, mostly from the position control, made when the vertical position is set to a non-zero value.

The two attenuator settings operate identically, so verification of the attenuation range from -1.8 V to 1.8 V also verifies the attenuation range of -45 V to 45 V.

1. Set up the oscilloscope as shown in the following table:

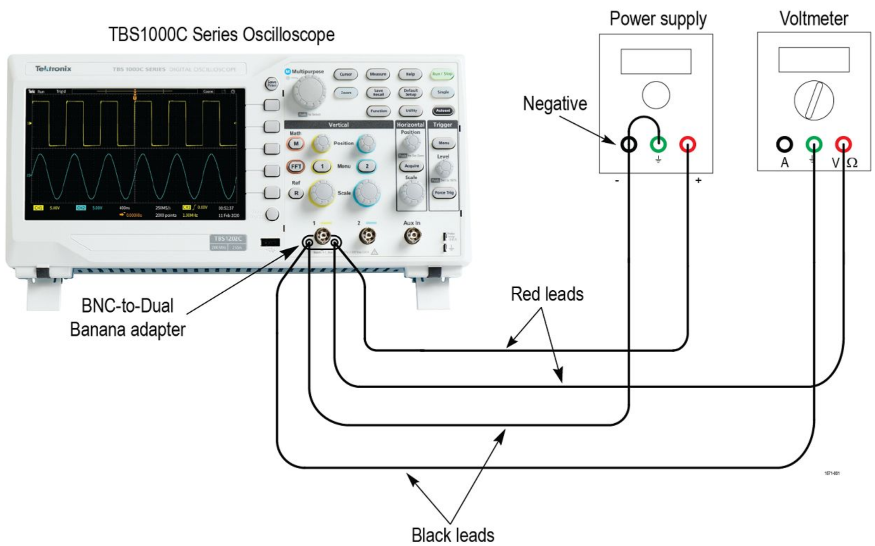
Push menu button	Select menu option	Select setting
Default Setup	-	-
Channels 1, 2	Probe	1X
Channels 1, 2	Volts/Div	50 mV/div
Trig Menu	Source	Aux In [1]
	Mode	Mode
Acquire	Sample	-
Measure	Source	Channel under test
	Measurements	Mean

2. Make a spreadsheet approximately as shown in the example in Appendix A. You only need to enter the values for column A and the equations. The values in columns B, C, D, E, F, and G are examples of the measured or calculated values.

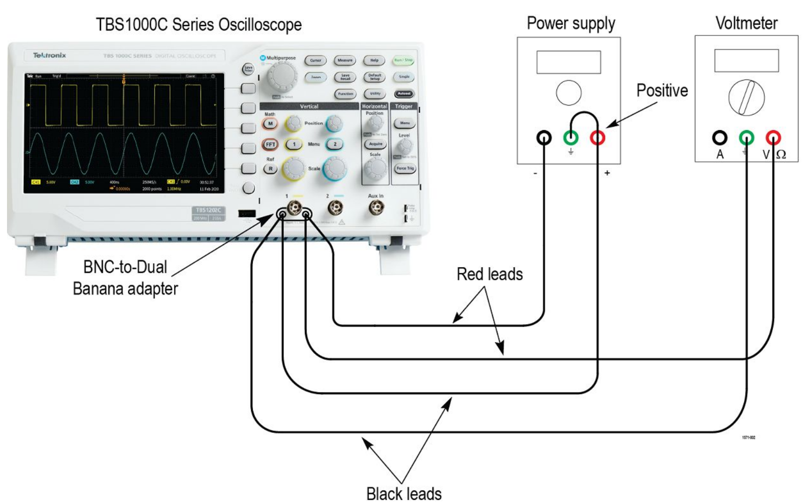
The PDF version of the technical reference manual (which you can download from www.tektronix.com/manuals), includes an empty spreadsheet for your convenience. To access and save the test spreadsheet, see the instructions in Appendix. A: Example of a Vertical Position Accuracy test spreadsheet on page A-1.

[1] The test operates without a trigger. To maintain uniformity and to avoid false triggering on noise, the Aux In is the recommended source.

3. Connect the oscilloscope, power supply, and voltmeter as shown in the following figure:



4. Set the power supply to the 1.8 V value shown in column A, the Approximate Test Voltage.
5. Adjust the vertical position knob for the DC line to position the line in the center of the screen.
6. Enter the voltage on the voltmeter and on the oscilloscope into the spreadsheet in the appropriate columns, B and C.
7. Repeat steps 4 through 6 for the values of 1.72 V through 0 V in 0.08 V steps.
8. Swap the connections to the positive terminal of the power supply with those at the negative terminal as shown in the following figure:



9. Repeat steps 4 through 6 for the values of -0.08 V through -1.8 V in -0.08 V steps.
10. Enter the Minimum Margin number (cell I16) for the channel tested in the test record.
11. Repeat steps 1 through 10 for all input channels.

Data verification

To verify data, set the spreadsheet to present a line graph of columns D, E, and F. Verify that no error values (the blue line in the center) go above the yellow line (upper line), or below the purple line (lower line). For calculations involved in this example, refer to the data in the previous table (see step 1).

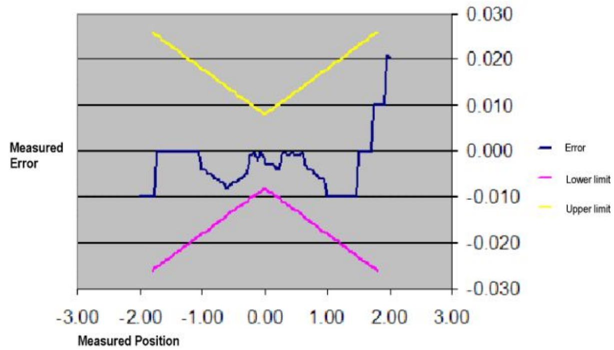


Figure 1: Example of a line graph for the Vertical Position Accuracy test

Example off vertical position accuracy test spreadsheet

This appendix contains a filled-in example of the vertical position accuracy (VPA) test spreadsheet that is used.

The PDF version of this technical reference manual (Tektronix part number 077-1583-xx) includes an empty VPA test spreadsheet for your convenience. To access and save the test spreadsheet:

1. Go to the Tektronix manuals Web site, www.tektronix.com/manuals.
2. Enter **077158300** in the **Search Manuals** field and click **Go**.
3. Click Download for the TBS1000C Series Digital Storage Oscilloscopes Technical Reference Manual (Tektronix part number 077-1571-xx) and follow the instructions to download the file to your PC.
4. Open the PDF file in Adobe Reader (version 7 or later).
5. Click the **Attachments** tab or click **View** > **Navigation Panels** > **Attachments** to display the Attachments panel.
6. Double-click the **VPA Test Table.xls** file.
7. Click **OK** in the **Launch Attachment** dialog box. The test spreadsheet opens in your spreadsheet application and shows the **Blank Test Record** spreadsheet tab.
8. Click **File** > **Save As** to save the file to a name and location that you enter. You can now use the spreadsheet to enter values for the vertical position accuracy test.

Sample Filled-In Vertical Position Accuracy

Table 3: Vertical position accuracy test spreadsheet

	A	B	C	D	E	F	G	H	I
1	Approximate Test Voltage	DVM Measured Voltage	Oscilloscope Measured Voltage	Error	Lower Limit	Upper Limit	Margin		
2	2.00			0.000	+	+	+	Volts/div	0.05
3	1.96			0.000	+	+	+		
4	1.92			0.000	+	+	+	Offset as a fractional division	0.1
5	1.88			0.000	+	+	+	Offset in volts	0.005
6	1.84			0.000	+	+	+	Total voltage offset	0.01=I2*I4+I5
7	1.80	1.80	1.79	0.010	-0.028	0.028	0.018		
8	1.72	1.72	1.72	0.000	-0.0272	0.0272	0.027	Gain error	1%
9	1.64	1.64	1.64	0.000	-0.0264	0.0264	0.026	Equation for cell D7	=B7-C7
10	1.56	1.56	1.56	0.000	-0.0256	0.0256	0.026	Equation for cell E7	=-F7
11	1.48	1.48	1.49	-0.010	-0.0248	0.0248	0.015	Equation for cell F7	=(ABS(B7)*I8 + I6)

	A	B	C	D	E	F	G	H	I
12	1.40	1.4	1.41	-0.010	-0.024	0.024	0.014	Equation for cell G7	=MIN (D7-E7,F7-D7)
13	1.32	1.32	1.33	-0.010	-0.0232	0.0232	0.013	Minimum margin	0.007=MIN (G7:G97)
14	1.24	1.24	1.25	-0.010	-0.0224	0.0224	0.012		
15	1.16	1.16	1.17	-0.010	-0.0216	0.0216	0.012		
16	1.08	1.08	1.09	-0.010	-0.0208	0.0208	0.011		
17	1.00	1	1.01	-0.010	-0.02	0.02	0.010		
18	0.92	0.92	0.926	-0.006	-0.0192	0.0192	0.013		
19	0.84	0.84	0.845	-0.005	-0.0184	0.0184	0.013		
20	0.76	0.76	0.764	-0.004	-0.0176	0.0176	0.014		
21	0.68	0.68	0.683	-0.003	-0.0168	0.0168	0.014		
22	0.60	0.6	0.6	0.000	-0.016	0.016	0.016		
23	0.52	0.52	0.521	-0.001	-0.0152	0.0152	0.014		
24	0.44	0.44	0.44	0.000	-0.0144	0.0144	0.014		
25	0.36	0.36	0.361	-0.001	-0.0136	0.0136	0.013		
26	0.28	0.28	0.281	-0.001	-0.0128	0.0128	0.012		
27	0.20	0.2	0.204	-0.004	-0.012	0.012	0.008		
28	0.12	0.12	0.123	-0.003	-0.0112	0.0112	0.008		
29	0.04	0.04	0.043	-0.003	-0.0104	0.0104	0.007		
30	-0.04	-0.04	-0.039	-0.001	-0.0104	0.0104	0.009		
31	-0.12	-0.12	-0.118	-0.002	-0.0112	0.0112	0.009		
32	-0.20	-0.199	-0.198	-0.001	-0.01199	0.01199	0.011		
33	-0.28	-0.279	-0.274	-0.005	-0.01279	0.01279	0.008		
34	-0.36	-0.359	-0.353	-0.006	-0.01359	0.01359	0.008		
35	-0.44	-0.439	-0.432	-0.007	-0.01439	0.01439	0.007		
36	-0.52	-0.52	-0.513	-0.007	-0.0152	0.0152	0.008		
37	-0.6	-0.6	-0.592	-0.008	-0.016	0.016	0.008		
38	-0.68	-0.68	-0.673	-0.007	-0.0168	0.0168	0.010		
39	-0.76	-0.76	-0.754	-0.006	-0.0176	0.0176	0.012		
40	-0.84	-0.84	-0.835	-0.005	-0.0184	0.0184	0.013		
41	-0.92	-0.92	-0.915	-0.005	-0.0192	0.0192	0.014		
42	-1.00	-1	-0.996	-0.004	-0.02	0.02	0.016		
43	-1.08	-1.08	-1.08	0.000	-0.0208	0.0208	0.021		
44	-1.16	-1.16	-1.16	0.000	-0.0216	0.0216	0.022		
45	-1.24	-1.24	-1.24	0.000	-0.0224	0.0224	0.022		
46	-1.32	-1.32	-1.32	0.000	-0.0232	0.0232	0.023		
47	-1.40	-1.4	-1.4	0.000	-0.024	0.024	0.024		

	A	B	C	D	E	F	G	H	I
48	-1.48	-1.48	-1.48	0.000	-0.0248	0.0248	0.025		
49	-1.56	-1.56	-1.56	0.000	-0.0256	0.0256	0.026		
50	-1.64	-1.64	-1.64	0.000	-0.0264	0.0264	0.026		
51	-1.72	-1.72	-1.72	0.000	-0.0272	0.0272	0.027		
52	-1.80	-1.8	-1.79	-0.010	-0.028	0.028	0.018		
53	-1.84				+	+	+		
54	-1.88				+	+	+		
55	-1.92				+	+	+		
56	-1.96				+	+	+		
57	-2.00				+	+	+		

Index