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Tektronix®

MSO2000B and DPO2000B Series Oscilloscopes

User Manual



077-0724-00

Tektronix®

MSO2000B and DPO2000B Series Oscilloscopes

User Manual

www.tek.com

077-0724-00

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Contacting Tektronix

Tektronix, Inc.
14150 SW Karl Braun Drive
P.O. Box 500
Beaverton, OR 97077
USA

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.

Warranty

Tektronix warrants that the product will be free from defects in materials and workmanship for a period of five (5) years from the date of original purchase from an authorized Tektronix distributor. If the product proves defective during this warranty period, Tektronix, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product. Batteries are excluded from this warranty. Parts, modules and replacement products used by Tektronix for warranty work may be new or reconditioned to like new performance. All replaced parts, modules and products become the property of Tektronix.

In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, shipping charges prepaid, and with a copy of customer proof of purchase. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Tektronix shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Tektronix representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; c) to repair any damage or malfunction caused by the use of non-Tektronix supplies; or d) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

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[W19 – 03AUG12]

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Tektronix warrants that this product will be free from defects in materials and workmanship for a period of one (1) year from the date of shipment. If any such product proves defective during this warranty period, Tektronix, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product. Parts, modules and replacement products used by Tektronix for warranty work may be new or reconditioned to like new performance. All replaced parts, modules and products become the property of Tektronix.

In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, with shipping charges prepaid. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Tektronix shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Tektronix representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; c) to repair any damage or malfunction caused by the use of non-Tektronix supplies; or d) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

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[W2 – 15AUG04]

P6316 Probe

Warranty

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In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, shipping charges prepaid, and with a copy of customer proof of purchase. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Tektronix shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Tektronix representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; c) to repair any damage or malfunction caused by the use of non-Tektronix supplies; or d) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

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[W15 – 15AUG04]

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General safety summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

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.

Connect and disconnect properly. Do not connect or disconnect probes or test leads while they are connected to a voltage source.

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

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.

Observe all terminal ratings. To avoid fire or shock hazard, observe all ratings and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Connect the probe reference lead to earth ground only.

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

Power disconnect. The power cord disconnects the product from the power source. Do not block the power cord; it must remain accessible to the user at all times.

Do not operate without covers. Do not operate this product with covers or panels removed.

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

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

Do not operate in wet/damp conditions.

Do not operate in an explosive atmosphere.

Keep product surfaces clean and dry.

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

Terms in this 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.*

Symbols and 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.

The following symbol(s) may appear on the product:



Compliance Information

This section lists the EMC (electromagnetic compliance), safety, and environmental standards with which the instrument complies.

EMC Compliance

EC Declaration of Conformity – EMC

Meets intent of Directive 2004/108/EC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:

EN 61326-1:2006, EN 61326-2-1:2006. EMC requirements for electrical equipment for measurement, control, and laboratory use. [1] [2] [3]

- CISPR 11:2003. Radiated and conducted emissions, Group 1, Class A
- IEC 61000-4-2:2001. Electrostatic discharge immunity
- IEC 61000-4-3:2002. RF electromagnetic field immunity [4]
- IEC 61000-4-4:2004. Electrical fast transient/burst immunity
- IEC 61000-4-5:2001. Power line surge immunity
- IEC 61000-4-6:2003. Conducted RF immunity [5]
- IEC 61000-4-11:2004. Voltage dips and interruptions immunity [6]

EN 61000-3-2:2006. AC power line harmonic emissions

EN 61000-3-3:1995. Voltage changes, fluctuations, and flicker

European Contact.
Tektronix UK, Ltd.
Western Peninsula
Western Road
Bracknell, RG12 1RF
United Kingdom

1 **This product is intended for use in nonresidential areas only. Use in residential areas may cause electromagnetic interference.**

2 **Emissions which exceed the levels required by this standard may occur when this equipment is connected to a test object.**

3 **To ensure compliance with the EMC standards listed here, high quality shielded interface cables should be used.**

4 **Trace bloom not exceeding 4 divisions pk-to-pk may be induced under the conditions of the IEC 61000-4-3 test.**

5 **Trace bloom not exceeding 1 division pk-to-pk may be induced under the conditions of the IEC 61000-4-6 test.**

6 **Performance Criterion C applied at the 70%/25 cycle Voltage-Dip and the 0%/250 cycle Voltage-Interruption test levels (IEC 61000-4-11).**

Australia / New Zealand Declaration of Conformity – EMC

Complies with the EMC provision of the Radiocommunications Act per the following standard, in accordance with ACMA:

- CISPR 11:2003. Radiated and Conducted Emissions, Group 1, Class A, in accordance with EN 61326-1:2006 and EN 61326-2-1:2006.

Safety Compliance

EC Declaration of Conformity – Low Voltage

Compliance was demonstrated to the following specification as listed in the Official Journal of the European Communities:

Low Voltage Directive 2006/95/EC.

- EN 61010-1: 2001. Safety requirements for electrical equipment for measurement control and laboratory use.

U.S. Nationally Recognized Testing Laboratory Listing

- UL 61010-1:2004, 2nd Edition. Standard for electrical measuring and test equipment.

Canadian Certification

- CAN/CSA-C22.2 No. 61010-1:2004. Safety requirements for electrical equipment for measurement, control, and laboratory use. Part 1.

Additional Compliances

- IEC 61010-1: 2001. Safety requirements for electrical equipment for measurement, control, and laboratory use.

Equipment Type

Test and measuring equipment.

Safety Class

Class 1 – grounded product.

Pollution Degree Description

A measure of the contaminants that could occur in the environment around and within a product. Typically the internal environment inside a product is considered to be the same as the external. Products should be used only in the environment for which they are rated.

- Pollution Degree 1. No pollution or only dry, nonconductive pollution occurs. Products in this category are generally encapsulated, hermetically sealed, or located in clean rooms.
- Pollution Degree 2. Normally only dry, nonconductive pollution occurs. Occasionally a temporary conductivity that is caused by condensation must be expected. This location is a typical office/home environment. Temporary condensation occurs only when the product is out of service.
- Pollution Degree 3. Conductive pollution, or dry, nonconductive pollution that becomes conductive due to condensation. These are sheltered locations where neither temperature nor humidity is controlled. The area is protected from direct sunshine, rain, or direct wind.
- Pollution Degree 4. Pollution that generates persistent conductivity through conductive dust, rain, or snow. Typical outdoor locations.

Pollution Degree

Pollution Degree 2 (as defined in IEC 61010-1). Note: Rated for indoor use only.

Installation (Overvoltage) Category Descriptions

Terminals on this product may have different installation (overvoltage) category designations. The installation categories are:

- Measurement Category IV. For measurements performed at the source of low-voltage installation.
- Measurement Category III. For measurements performed in the building installation.
- Measurement Category II. For measurements performed on circuits directly connected to the low-voltage installation.
- Measurement Category I. For measurements performed on circuits not directly connected to MAINS.

Overvoltage Category

Overvoltage Category II (as defined in IEC 61010-1).

Environmental Considerations

This section provides information about the environmental impact of the product.

Product End-of-Life Handling

Observe the following guidelines when recycling an instrument or component:

Equipment Recycling. Production of this equipment required the extraction and use of natural resources. The equipment may contain substances that could be harmful to the environment or human health if improperly handled at the product's end of life. In order to avoid release of such substances into the environment and to reduce the use of natural resources, we encourage you to recycle this product in an appropriate system that will ensure that most of the materials are reused or recycled appropriately.



This symbol indicates that this product complies with the applicable European Union requirements according to Directives 2002/96/EC and 2006/66/EC on waste electrical and electronic equipment (WEEE) and batteries. For information about recycling options, check the Support/Service section of the Tektronix Web site (www.tektronix.com).

Mercury Notification. This product uses an LCD backlight lamp that contains mercury. Disposal may be regulated due to environmental considerations. Please contact your local authorities or, within the United States, refer to the E-cycling Central Web page (www.eiae.org) for disposal or recycling information.

Restriction of Hazardous Substances

This product has been classified as Monitoring and Control equipment, and is outside the scope of the 2002/95/EC RoHS Directive.

Preface

This manual describes the installation and operation of the following oscilloscopes:

MSO2024B	MSO2022B	MSO2014B	MSO2012B	MSO2004B	MSO2002B
DPO2024B	DPO2022B	DPO2014B	DPO2012B	DPO2004B	DPO2002B

Key Features

MSO2000B and DPO2000B series oscilloscopes can help you verify, debug, and characterize electronic designs. Key features include:

- 200 MHz, 100 MHz, and 70 MHz bandwidths
- 2 channel and 4 channel models
- Sample rates up to 1 GS/s on all analog channels
- 1 M points record length on all channels
- 5,000 waveforms/second waveform capture rate
- I^2C, SPI, CAN, LIN, RS-232, RS-422, RS-485, and UART bus triggering and analysis (with the appropriate application module and model oscilloscope)
- Wave Inspector controls for managing long record lengths, with zoom and pan, play and pause, search and mark
- Large 178 mm (7 inch) WQVGA wide screen color display
- Small and lightweight, at 140 mm (5.5 inch) deep and 3.6 kg (7 lbs, 14 oz)
- FilterVu provides a variable low pass filter to block unwanted noise while still displaying high frequency events
- USB flash drive port for quick and easy storage of measurement results
- Direct printing to any PictBridge compatible printer
- Ethernet port for remote programmability with the optional connectivity module
- Video Out port to display the oscilloscope screen on an external monitor with the optional connectivity module
- USB 2.0 Device port for direct PC control of the oscilloscope using USBTMC protocol
- OpenChoice documentation software for simple transfer of screen shots and waveform data to a PC
- Remote viewing and control with e*Scope
- Remote control with VISA connectivity
- TekVPI Versatile Probe Interface supports active, differential, and current probes for automatic scaling and units

MSO2000B series of mixed signal oscilloscopes also offer:

- 16 digital channels
- Parallel bus triggering and analysis
- Easy connection to your device-under-test through the convenient design of the P6316 digital probe

Conventions Used in This Manual

The following icons are used throughout this manual.

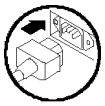
Sequence Step



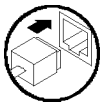
Front panel power



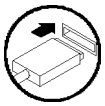
Connect power



Network



USB



Installation

Before Installation

Unpack the oscilloscope and check that you received all items listed as standard accessories. The following pages list recommended accessories and probes, instrument options, and upgrades. Check the Tektronix Web site (www.tektronix.com) for the most current information.

Standard Accessories

Accessory	Description	Tektronix part number
MSO2000B and DPO2000B Series Oscilloscopes Installation and Safety Manual	Safety and compliance information along with hardware installation instructions.	071-3078-XX
MSO2000B and DPO2000B Series Oscilloscopes Documentation Browser CD	Electronic versions of documents, including the User Manual, Programmer Manual and the Technical Reference.	063-4472-XX
Tektronix OpenChoice Desktop PC Communications CDs	Connectivity and documentation software.	063-4402-XX
Calibration certificate documenting traceability to national metrology institute(s), and ISO9001 quality system registration.		——
Front panel overlay	French (Option L1)	335-2020-00
	Italian (Option L2)	335-2021-00
	German (Option L3)	335-2022-00
	Spanish (Option L4)	335-2023-00
	Japanese (Option L5)	335-2024-00
	Portuguese (Option L6)	335-2025-00
	Simple Chinese (Option L7)	335-2026-00
	Traditional Chinese (Option L8)	335-2027-00
	Korean (Option L9)	335-2028-00
	Russian (Option L10)	335-2029-00
For MSO2000B and DPO2000B series: Probes	For models ≥ 100 MHz bandwidth: One 200 MHz, 10X passive voltage probe with 10 MΩ input resistance per channel	TPP0200
	For models < 100 MHz bandwidth: One 100 MHz, 10X passive voltage probe with 10 MΩ input resistance per channel	TPP0100
For MSO2000B series: Digital probe	One, 16-channel digital probe	P6316
For MSO2000B series: Accessories pouch	Pouch that attaches to the handle for carrying probes and other accessories.	016-2008-00
Five year warranty	For details, refer to the warranty in the front of this manual	——

Standard Accessories (cont.)

Accessory	Description	Tektronix part number
Power cord	North America (Option A0)	161-0348-00
	Universal Euro (Option A1)	161-0343-00
	United Kingdom (Option A2)	161-0344-00
	Australia (Option A3)	161-0346-00
	Switzerland (Option A5)	161-0347-00
	Japan (Option A6)	161-0342-00
	China (Option A10)	161-0341-00
	India (Option A11)	161-0349-00
	Brazil (Option A12)	161-0356-00
	No power cord or AC adapter (Option A99)	——

Optional Accessories

Accessory	Description	Tektronix part number
DPO2EMBD	The embedded serial triggering and analysis module enables triggering on packet level information on I²C and SPI serial buses, as well as bus views, bus decoding, search tools, and packet decode tables with timestamp information	DPO2EMBD
DPO2AUTO	The automotive serial triggering and analysis module enables triggering on packet level information on CAN and LIN serial buses, as well as bus views, bus decoding, search tools, and packet decode tables with timestamp information	DPO2AUTO
DPO2COMP	The computer triggering and analysis module enables triggering on RS-232, RS-422, RS-485 and UART serial buses, search tools, bus views, bus decoding in hex, binary, and ASCII, and decode tables with timestamp information	DPO2COMP
DPO2CONN	The connectivity module adds an Ethernet port for remote programmability and a Video Out port to display the oscilloscope screen on an external monitor	DPO2CONN
NEX-HD2HEADER	Adapter that routes the channels from a Mictor connector to 0.1 inch header pins	NEX-HD2HEADER
TekVPI probes that work with MSO/DPO2000B Series oscilloscopes Note: These probes require the use of the TekVPI external power adapter listed below.	Visit the Oscilloscope Probe and Accessory Selector Tool on the Tektronix website at www.tektronix.com.	
TekVPI external power adapter	Supplies external power to a TekVPI probe	119-7465-XX
TPA-BNC Note: This adapter requires the use of the TekVPI external power adapter listed above.	TekVPI to TekProbe II BNC Adapter	TPA-BNC
Deskew pulse generator	Deskew pulse generator and signal source with TekVPI oscilloscope interface	TEK-DPG
Power measurement deskew and calibration fixture	Converts TEK-DPG pulse generator output into a series of test point connections	067-1686-00
TEK-USB-488 Adapter	GPIB to USB Adapter	TEK-USB-488
Rackmount kit	Adds rackmount brackets	RMD2000
Soft transit case	Case for carrying an oscilloscope	ACD2000
Hard transit case	Traveling hard case, which requires use of the soft transit case (ACD2000)	HCTEK4321

Optional Accessories (cont.)

Accessory	Description	Tektronix part number
MSO2000B and DPO2000B Series Oscilloscopes Service manual	Service information on MSO2000B and DPO2000B series oscilloscopes	077-0737-XX
MSO2000B/DPO2000B and MSO2000/DPO2000 Series Oscilloscopes Application Module Installation	Describes how to install application modules in MSO/DPO2000B and MSO/DPO2000 series oscilloscopes	071-2330-XX

The MSO2000B and DPO2000B series oscilloscopes work with multiple optional probes. (See page 8, *Connecting Probes*.) Check the Tektronix Web site (www.tektronix.com) for the most current information.

Related Documentation

Accessory	Description	Tektronix part number
MSO2000B and DPO2000B Series Oscilloscopes User Manual	English	077-0724-XX
	French	077-0725-XX
	Italian	077-0726-XX
	German	077-0727-XX
	Spanish	077-0728-XX
	Japanese	077-0729-XX
	Portuguese	077-0730-XX
	Simple Chinese	077-0731-XX
	Traditional Chinese	077-0732-XX
	Korean	077-0733-XX
	Russian	077-0735-XX
MSO2000B and DPO2000B Series Oscilloscopes Programmer Manual	Describes commands for remote control of the oscilloscope; available electronically on the Documentation Browser CD or for download from www.tektronix.com/manuals	077-0738-XX
MSO2000B and DPO2000B Series Oscilloscopes Technical Reference Manual	Describes the oscilloscope specifications and performance verification procedure; available electronically on the Documentation Browser CD or for download from www.tektronix.com/manuals	077-0735-XX

Operating Considerations

MSO2000B and DPO2000B Series Oscilloscopes

Power Supply Input Voltage: 100 V to 240 V ± 10%

Power Supply Input Power Frequency:
50/60 Hz at 100 V to 240 V
400 Hz at 115 V

Power Consumption: 80 W maximum

Weight: 3.6 kg (7 lbs 14 oz), stand-alone oscilloscope

Height, including the feet but not the handle:
175 mm (6.885 inch)

Width: 377 mm (14.85 inch)



DPO2000B series

Depth: from the feet to the front of the knobs: 134 mm (5.3 inch)
Depth: from the feet to the front of the front cover: 139 mm (5.47 inch)

Clearance: 50 mm (2 inch)

Input Voltage (between the signal and reference):
300 V_{RMS} CAT II
Installation Category II - for measurements performed on circuits directly connected to the low-voltage installation

Temperature:
Operating: 0 °C to +50 °C
Nonoperating: -20 °C to +60 °C



MSO2000B series

Humidity:
Operating: High: 40 °C to 50 °C, 10% to 60% RH
Operating: Low: 0 °C to 40 °C, 10% to 90% RH
Non-operating: High: 40 °C to 60 °C, 5% to 60% RH
Non-operating: Low: 0 °C to 40 °C, 5% to 90% RH

Altitude:
Operating: 3,000 m (9,842 ft)
Nonoperating Altitude: 12,000 m (39,370 ft)

Random Vibration:
Operating: 0.31 G_{RMS}, 5 - 500 Hz, 10 minutes per axis, 3 axes (30 minutes total)
Non-operating: 2.46 G_{RMS}, 5 - 500 Hz, 10 minutes per axis, 3 axes (30 minutes total)

Pollution Degree: 2, Indoor use only



CAUTION. *To ensure proper cooling, keep the sides and rear of the oscilloscope clear of obstructions.*

TPP0200/TPP0100 Passive Probe

Single-ended voltage probe (ground referenced):
300 V_{RMS} CAT II safety requirements
Installation Category II - for measurements performed on circuits directly connected to the low-voltage installation

Temperature:
Operating: -10 °C to +55 °C (+14 °F to +131 °F)
Nonoperating: -51 °C to +71 °C (-60 °F to +160 °F)

Pollution Degree: 2, Indoor use only

Humidity: 5% to 95% RH

MSO2000B Series Oscilloscope with a P6316 Digital Probe

Threshold Accuracy: ±(100 mV + 3% of threshold)

Threshold Range: ±20 V

Maximum nondestructive input signal to probe: ±40 V

Minimum signal swing: 500 $mV_{peak\text{-}to\text{-}peak}$

Input resistance: 101 kΩ

Input capacitance: 8.0 pF

Temperature:
Operating: 0 °C to +50 °C (+32 °F to +122 °F)
Nonoperating: -40 °C to +71 °C (-40 °F to +160 °F)

Altitude:
Operating: 3,000 m (9,843 ft) maximum
Nonoperating: 12,000 m (39,370 ft) maximum

Pollution Degree: 2, Indoor use only

Humidity:

5% to 95% relative humidity

Cleaning

Inspect the oscilloscope and probes as often as operating conditions require. To clean the exterior surface, perform the following steps:

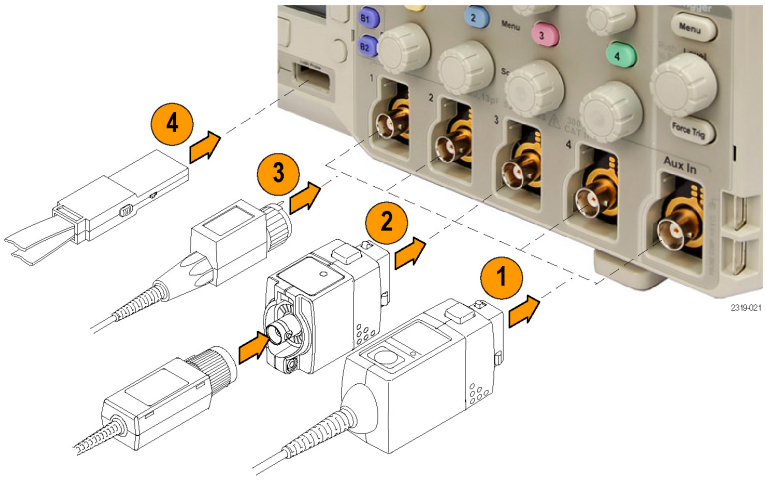
1. Remove loose dust on the outside of the oscilloscope and probes with a lint-free cloth. Use care to avoid scratching the clear glass display filter.
2. Use a soft cloth dampened with water to clean the oscilloscope. Use an aqueous solution of 75% isopropyl alcohol for more efficient cleaning.



CAUTION. *To avoid damage to the surface of the oscilloscope or probes, do not use any abrasive or chemical cleaning agents.*

Connecting Probes

The oscilloscope supports probes with the following:



1. Tektronix Versatile Probe Interface (TekVPI)

   These probes support two-way communication with the oscilloscope through on-screen menus and remotely through programmable support. The remote control is useful in applications like an ATE (automated test environment) where you want the system to preset probe parameters.

NOTE. *For more information on the many probes available for use with MSO2000B and DPO2000B Series oscilloscopes, visit the Oscilloscope Probe and Accessory Selector tool on the Tektronix website.*

2. TPA-BNC Adapter

   The TPA-BNC Adapter allows you to use Tek Probe II probe capabilities, such as providing probe power, and passing scaling and unit information to the oscilloscope.

NOTE. *To use a TekVPI probe and a TPA-BNC adapter, connect a TekVPI external power adapter (Tektronix part number 119-7465-XX) to the side panel* ***Probe Power*** *connector.*

3. Plain BNC Interfaces

   Some probes use TekProbe capabilities to pass the waveform signal and scaling to the oscilloscope. Other probes only pass the signal and there is no communication.

4. Digital Probe Interface (MSO2000B series only)

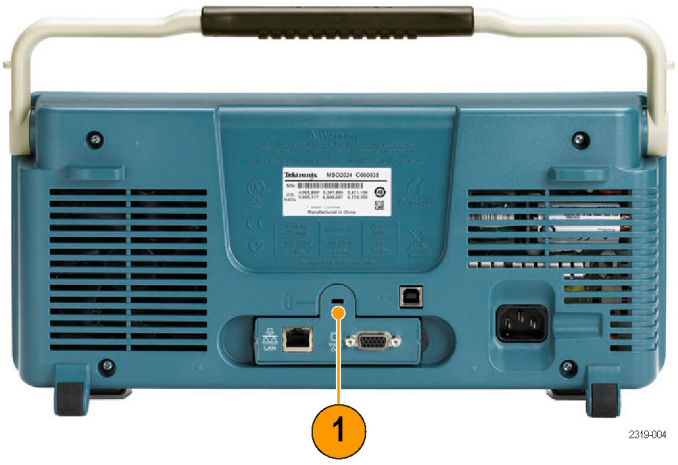
   The P6316 probe provides 16 channels of digital (on or off state) information.

For more information on the many probes available for use with MSO2000B and DPO2000B series oscilloscopes, refer to www.tektronix.com.

Securing the Oscilloscope

1. Use a standard laptop computer style security lock to secure your oscilloscope to your location.

   This photo also shows the optional DPO2CONN module installed. The module provides an Ethernet port and a Video Out port for the oscilloscopes.



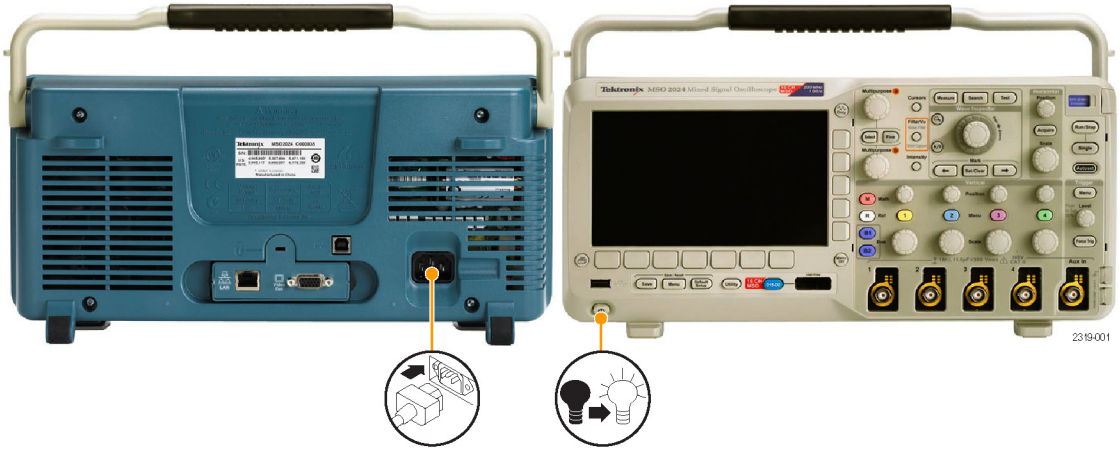
Powering On the Oscilloscope

Ground the Oscilloscope and Yourself

Before pushing the power switch, connect the oscilloscope to an electrically neutral reference point, such as earth ground. Do this by plugging the three-pronged power cord into an outlet grounded to earth ground.

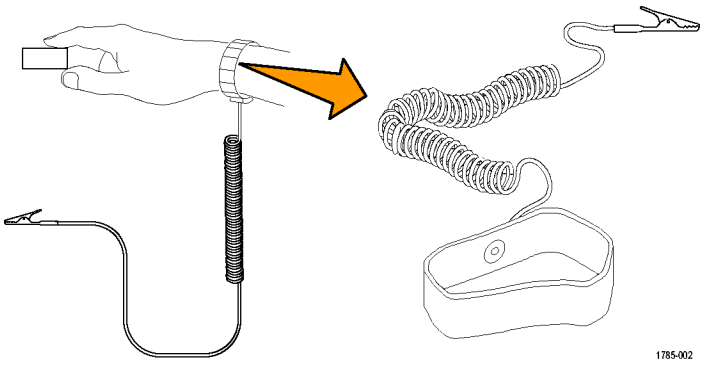
Grounding the oscilloscope is necessary for safety and to take accurate measurements. The oscilloscope needs to share the same ground as any circuits that you are testing.

To connect the power cord and power on the oscilloscope:



Quick Tips

If you are working with static sensitive components, ground yourself. Static electricity that builds up on your body can damage static-sensitive components. Wearing a grounding strap safely sends static charges on your body to earth ground.



Powering Off the Oscilloscope

To power off the oscilloscope and remove the power cord:



Functional Check

Perform this quick functional check to verify that your oscilloscope is operating correctly.

1. Connect the oscilloscope power cable as described in *Powering On the Oscilloscope*. (See page 10.)

2. Power on the oscilloscope.



3. Connect the TPP0200/TPP0100 probe tip and reference lead to the **PROBE COMP** connectors on the oscilloscope.



4. Push **Default Setup**.



5. Push **Autoset**. The screen should now display a square wave, approximately 5 V at 1 kHz.



NOTE. For best performance, it is recommended that you set the Vertical scale to 1 V.

If the signal appears but is misshapen, perform the procedures for compensating the probe. (See page 12.)

If no signal appears, rerun the procedure. If this does not remedy the situation, have the oscilloscope serviced by qualified service personnel.

Compensating a Passive Voltage Probe

Whenever you attach a passive voltage probe for the first time to any input channel, compensate the probe to match it to the corresponding oscilloscope input channel.

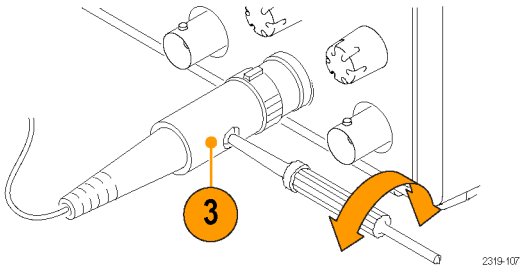
To properly compensate your passive probe:

1. Follow the steps for the functional check. (See page 11.)

2. Check the shape of the displayed waveform to determine if your probe is properly compensated.

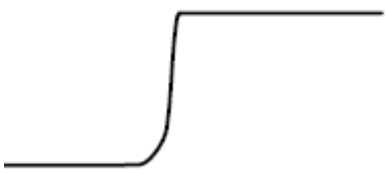


3. If necessary, adjust your probe. Repeat as needed.



Quick Tips

Use the shortest possible ground lead and signal path to minimize probe-induced ringing and distortion on the measured signal.



Signal with a short ground lead



Signal with a long ground lead

Application Module Free Trial

A 30-day free trial is available for all application modules not installed in your oscilloscope. The trial period begins when you power on the oscilloscope for the first time.

After 30 days, you must purchase the module if you want to continue using the application. To see the date when your free trial period expires, push the front panel **Utility** button, push the lower-bezel **Utility Page** button, use multipurpose knob **a** to select **Config**, and push the lower-bezel **About** button.

Installing an Application Module

CAUTION. *To avoid damage to the oscilloscope or application module, observe ESD (electrostatic discharge) precautions. (See page 10, Powering On the Oscilloscope.)*

Turn off the oscilloscope power while removing or adding an application module.

(See page 11, Powering Off the Oscilloscope.)

Optional application module packages extend the capability of your oscilloscope. You can install one or two application modules at one time. An application module goes into the slot with a window in the upper right corner of the front panel. Another slot is directly behind the one that you can see. To use this slot, install the module with the label facing away from you.

For more information on how to install and test application modules, refer to the *MSO/DPO2000B and MSO/DPO2000 Series Oscilloscopes Application Module Installation* manual.

NOTE. *If you remove an application module, the features provided by the application module become unavailable. To restore the features, turn off the oscilloscope power, reinstall the module and turn on the oscilloscope power.*

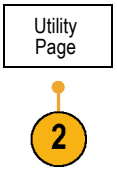
Changing the User Interface Language

To change the language of the oscilloscope user interface, and to change the front-panel button labels through the use of an overlay:

1. Push **Utility**.

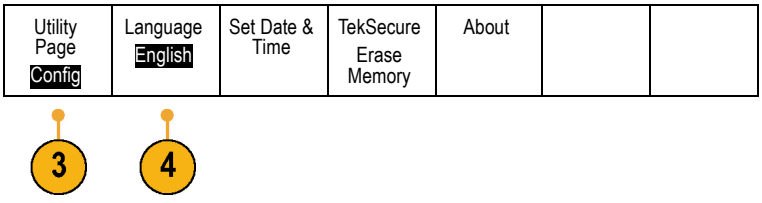


2. Push **Utility Page**.



3. Turn multipurpose knob **a** and select **Config**.

4. Push **Language** from the resulting lower-bezel menu.

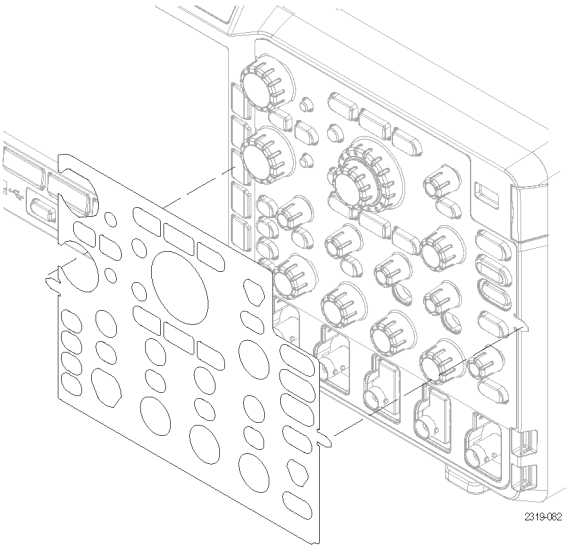


5. Turn multipurpose knob **a** and select the desired language. Choose among: English, French, German, Italian, Spanish, Brazilian Portuguese, Russian, Japanese, Korean, Simplified Chinese, and Traditional Chinese.



6. If you choose to use English, be sure that the plastic front-panel overlay is removed.

   If you choose a language other than English, place the plastic overlay for the language that you desire over the front panel to display labels in that language.



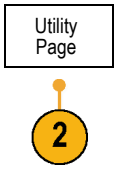
Changing the Date and Time

To set the internal clock with the current date and time:

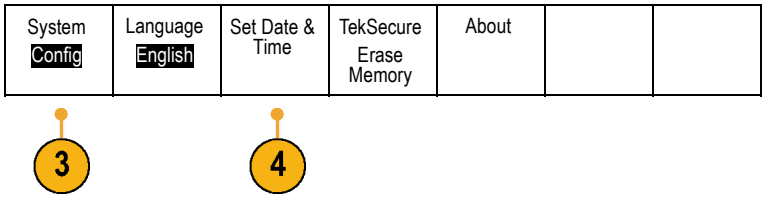
1. Push **Utility**.



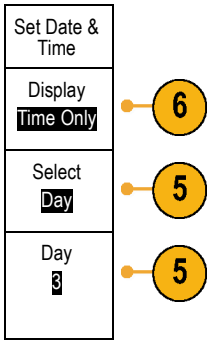
2. Push **Utility Page**.



3. Turn multipurpose knob **a** and select **Config**.
4. Push **Set Date & Time**.



5. Push the side-bezel buttons and use multipurpose knobs **a** and **b** to set the **Day**, **Month**, **Year**, **Hour**, and **Minute** values.
6. Push **Display** and turn multipurpose knob **a** to choose **Date & Time**, **Date Only**, **Time Only**, or **None**.



7. Push **OK Enter Date & Time**.



Signal Path Compensation

Signal Path Compensation (SPC) corrects for DC inaccuracies caused by temperature variations and/or long-term drift. You should run the SPC whenever the ambient temperature has changed by more than 10 °C or once a week if you use vertical settings of 5 mV per division or less. Failure to do so may result in the oscilloscope not meeting warranted performance levels at those volts per division settings.

To compensate the signal path:

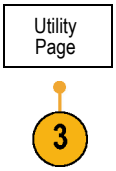
1. Warm up the oscilloscope for at least 20 minutes. Remove all input signals (probes and cables) from channel inputs. Input signals with AC components adversely affect SPC.



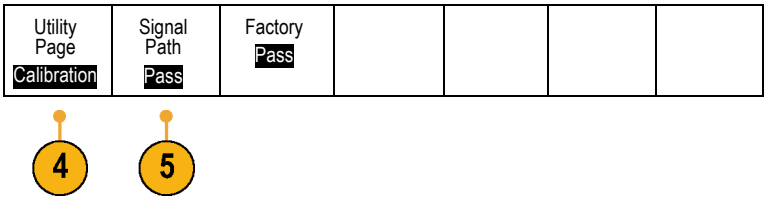
2. Push **Utility**.



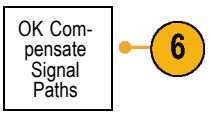
3. Push **Utility Page**.



4. Turn multipurpose knob **a** and select **Calibration**.
5. Push **Signal Path** from the lower-bezel menu.



6. Push **OK Compensate Signal Paths** from the resulting side-bezel menu.



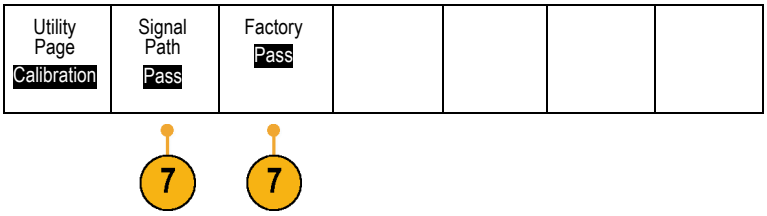
The oscilloscope displays a message when the calibration is complete. Push **Menu Off** to remove the message.



7. After calibration, verify that the status indicator on the lower-bezel menu displays **Pass**.

   If it does not, then recalibrate the oscilloscope or have the oscilloscope serviced by qualified service personnel.

   Service personnel use the factory calibration functions to calibrate the internal voltage references of the oscilloscope using external sources. Refer to your Tektronix field office or representative for assistance with factory calibration.

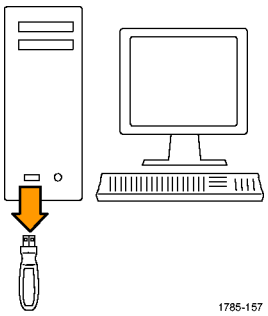


NOTE. Signal Path Compensation does not include calibration to the probe tip. (See page 12, Compensating a Passive Voltage Probe.)

Upgrading Firmware

To upgrade the firmware of the oscilloscope:

1. Open up a Web browser and go to www.tektronix.com/software. Proceed to the software finder. Download the latest firmware for your oscilloscope on your PC.



   Unzip the files and copy the firmware.img file into the root folder of a USB flash drive.

2. Power off your oscilloscope.



3. Insert the USB flash drive into the front-panel USB port on your oscilloscope.



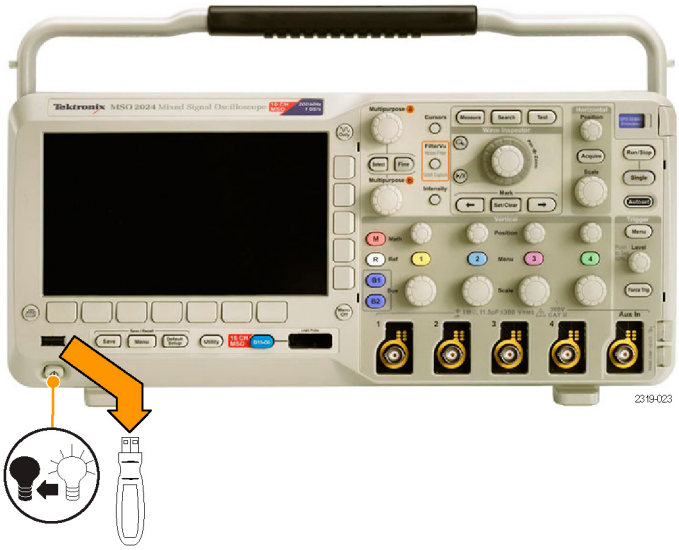
4. Power on the oscilloscope. The oscilloscope automatically recognizes and installs the replacement firmware.

   If the oscilloscope does not install the firmware, rerun the procedure. If the problem continues, try a different model of USB flash drive. Finally, if needed, contact qualified service personnel.

NOTE. *Do not power off the oscilloscope or remove the USB flash drive until the oscilloscope finishes installing the firmware.*



5. Power off the oscilloscope and remove the USB flash drive.



6. Power on the oscilloscope.



7. Push **Utility**.



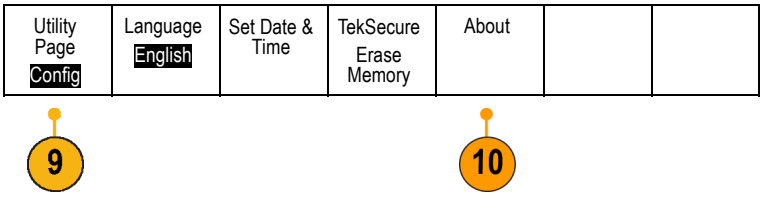
8. Push **Utility Page**.



9. Turn multipurpose knob **a** and select **Config**.

10. Push **About**. The oscilloscope displays the firmware version number.

11. Confirm that the version number matches that of the new firmware.



Connecting Your Oscilloscope to a Computer

You may want to document your work for future reference. Instead of saving screen images and waveform data to a USB flash drive and generating a report later, you may want to get a copy of the image or waveform data directly from a remote PC for analysis. You may also want to control an oscilloscope at a remote location from your computer. (See page 113, *Saving a Screen Image*.) (See page 114, *Saving and Recalling Waveform Data*.)

Two ways to connect your oscilloscope to a computer are through the VISA (Virtual Instrument Software Architecture) drivers and the e*Scope Web-enabled tools. Use VISA to communicate with your oscilloscope from your computer through a software application. Use e*Scope to communicate with your oscilloscope through a Web browser.

Using VISA

VISA lets you use your MS-Windows computer to acquire data from your oscilloscope for use in an analysis package that runs on your PC, such as Microsoft Excel, National Instruments LabVIEW, or a program of your own creation. You can use a common communications connection, such as USB or Ethernet, to connect the computer to the oscilloscope.

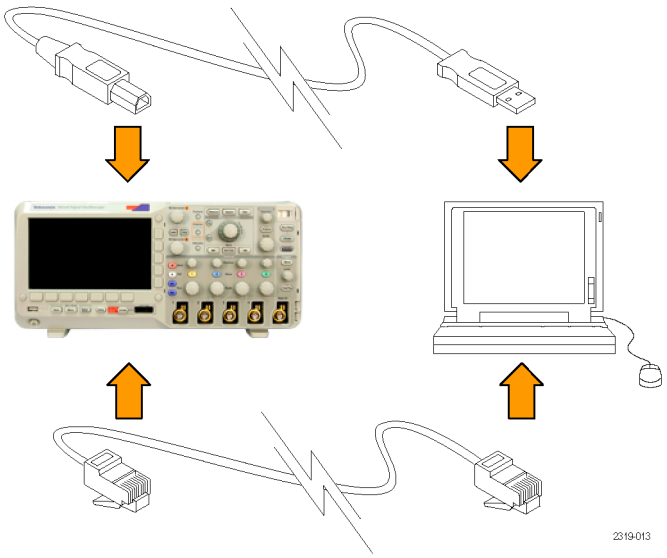
To set up VISA communications between your oscilloscope and a computer:

1. Load the VISA drivers on your computer.

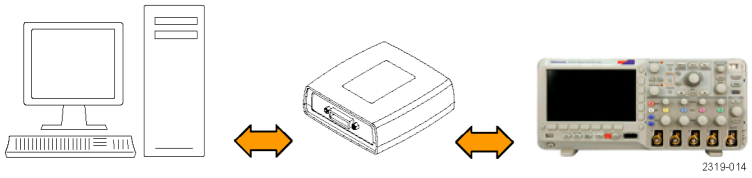
   You will find the drivers on the appropriate CD that comes with your oscilloscope or at the Tektronix software finder Web page (www.tektronix.com).

2. Connect the oscilloscope to your computer with the appropriate USB or Ethernet cable.

NOTE. You need a DPO2CONN module to make the Ethernet connection.



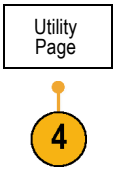
To communicate between the oscilloscope and a GPIB system, connect the oscilloscope to the TEK-USB-488 GPIB-to-USB Adapter with a USB cable. Then connect the adapter to your GPIB system with a GPIB cable. Cycle the power on the oscilloscope.



3. Push **Utility**.



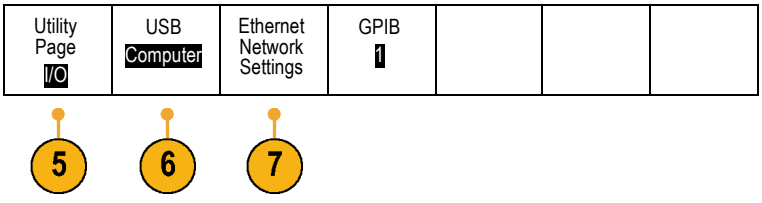
4. Push **Utility Page**.



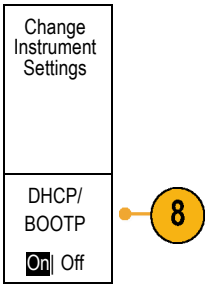
5. Turn multipurpose knob **a** and select **I/O**.

6. If a USB cable is connected between the oscilloscope and your computer, the oscilloscope automatically sets itself up for you.

   Check the **USB** on the lower-bezel menu to be sure it is enabled. If it is not enabled, push **USB** and make an appropriate selection in the side-bezel menu.

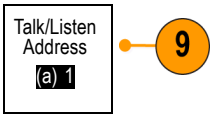


7. To use Ethernet, push **Ethernet Network Settings**.
8. On the side-bezel menu, if you are on a DHCP Ethernet network and using a through cable, set DHCP to **On**. If you are using a cross-over cable, set it to **Off** and set a hard coded TCPIP address.



9. If you are using GPIB, push **GPIB**. Enter the GPIB address on the side-bezel menu, using multipurpose knob **a**.

   This will set the GPIB address on an attached TEK-USB-488 Adapter.



10. Run your application software on your computer.

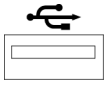


Quick Tips

- The CDs that are shipped with your oscilloscope include a variety of Windows-based software tools designed to ensure efficient connectivity between your oscilloscope and your computer. There are toolbars that enhance connectivity with Microsoft Excel and Word. There is also a stand-alone acquisition program called the OpenChoice Desktop.

USB Host port

Use the front-panel USB 2.0 Host port for USB flash drives and keyboards.



USB Device port

Use the rear-panel USB 2.0 Device port for PCs or PictBridge printers.



Using e*Scope

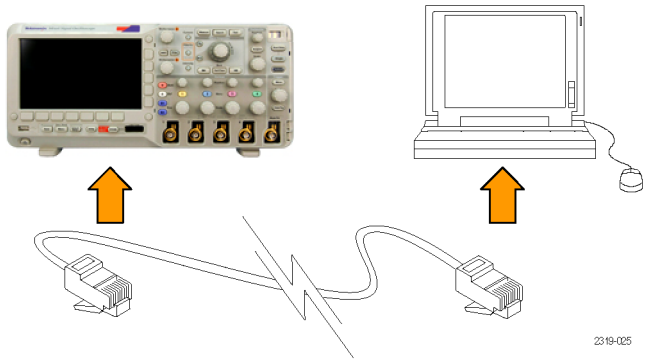
e*Scope lets you access any Internet-connected MSO2000B or DPO2000B series oscilloscope from a browser on your workstation, PC, or laptop computer. No matter where you are, your oscilloscope is as close as the nearest browser.

To set up e*Scope communications between your oscilloscope and a Web browser running on a remote computer:

1. Connect the oscilloscope to your computer network with the appropriate Ethernet cable.

NOTE. You need a DPO2CONN module to make the Ethernet connection.

If you are connecting directly to your computer, you need a Crossover Ethernet Cable. If you are connecting to a network or a hub, you need a Straight Through Ethernet Cable.



2. Push **Utility**.

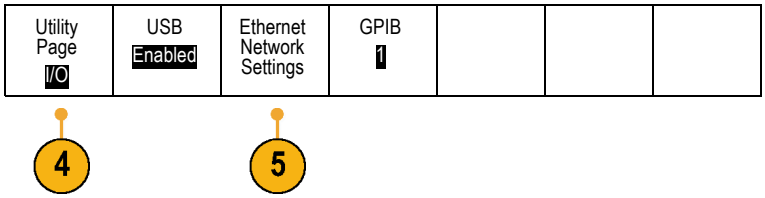


3. Push **Utility Page**.

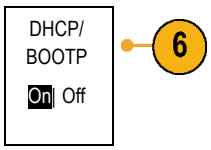


4. Turn multipurpose knob **a** and select **I/O**.

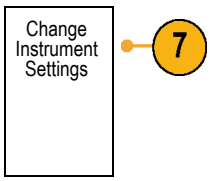
5. Push **Ethernet Network Settings**.



6. On the side-bezel menu, if you are on a DHCP Ethernet network and using dynamic addressing, set DHCP to **On**. If you are using static addressing, set it to **Off**.



7. Push **Change Instrument Settings**. If you are using DHCP, note the Ethernet address and instrument name. If you are using Static addressing, enter the Ethernet address you will be using.



NOTE. Depending on the type and speed of network to which your oscilloscope is connected, you may not see the DHCP/BOOTP field update instantaneously after pressing the DHCP/BOOTP button. It may take a few seconds to update.

8. Start your browser on your remote computer. In the browser address line, enter the IP address or, if DHCP is set to **On** in the oscilloscope, simply enter the instrument name.

   You should now see the e*Scope screen showing the oscilloscope display on your Web browser. If e*Scope does not work, rerun the procedure. If it still does not work, contact qualified service personnel.

Connecting a USB Keyboard to Your Oscilloscope

You can connect a USB keyboard to the USB Host port on the front panel of the oscilloscope. The oscilloscope will detect the keyboard, even if it is plugged in while the oscilloscope is powered on. (See page 41, *Labeling Channels and Buses*.)

Getting Acquainted with the Oscilloscope

Front-Panel Menus and Controls

The front panel has buttons and controls for the functions that you use most often. Use the menu buttons to access more specialized functions.

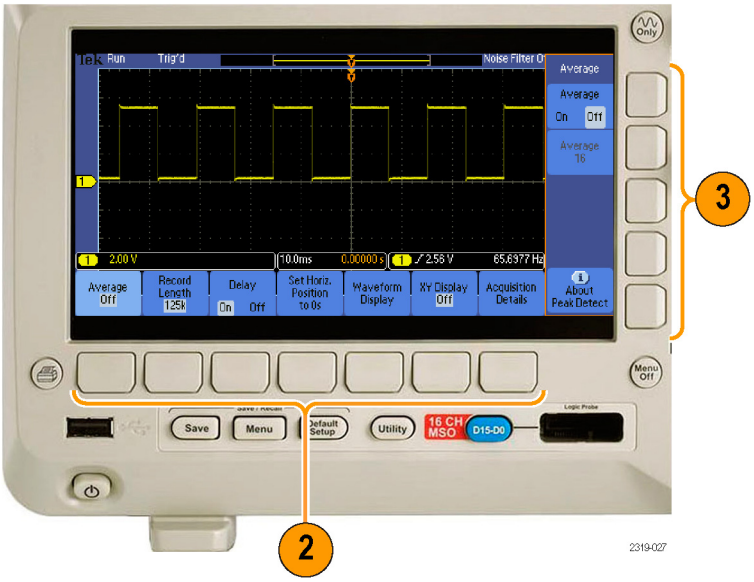
Using the Menu System

To use the menu system:

1. Push a front-panel menu button to display the menu that you want to use.



2. Push a lower-bezel button to select a menu item. If a pop-out menu appears, turn multipurpose knob **a** to select the desired choice. If a pop-up menu appears, press the button again to select the desired choice.



3. Push a side-bezel button to choose a side-bezel menu item.

   If the menu item contains more than one choice, push the side-bezel button repeatedly to cycle through the choices.

   If a pop-out menu appears, turn multipurpose knob **a** to select the desired choice.

4. To remove a side-bezel menu, push the lower-bezel button again or push **Menu Off**.



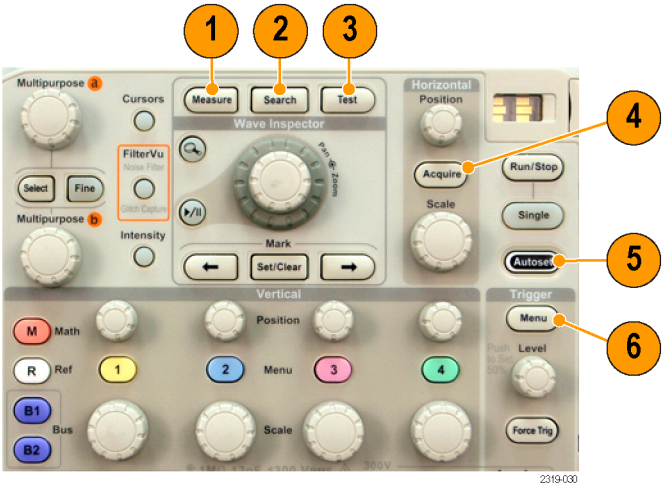
5. Certain menu choices require you to set a numeric value to complete the setup. Use the upper and lower multipurpose knobs **a** and **b** to adjust values.
6. Push **Fine** to turn off or on the ability to make smaller adjustments.

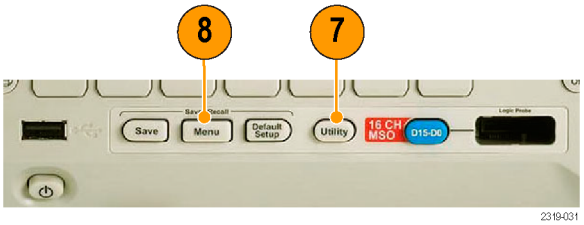


Using the Menu Buttons

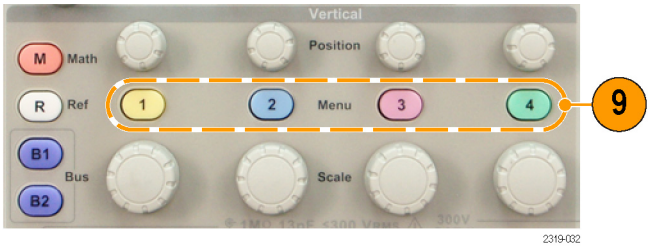
Use the menu buttons to perform many functions in the oscilloscope.

1. **Measure**. Push to perform automated measurements on waveforms or to configure cursors.
2. **Search**. Push to search through an acquisition for user-defined events/criteria.
3. **Test**. Push to activate advanced or application-specific testing features.
4. **Acquire**. Push to set the acquisition mode and adjust the record length.
5. **Autoset**. Push to perform an automatic setup of oscilloscope settings.
6. **Trigger Menu**. Push to specify trigger settings.
7. **Utility**. Push to activate the system utility functions, such as selecting a language or setting the date/time.
8. **Save / Recall Menu**. Push to save and recall setups, waveforms, and screen images to internal memory, or a USB flash drive.





9. Channel **1**, **2**, **3**, or **4 Menu**. Push to set vertical parameters for input waveforms and to display or remove the corresponding waveform from the display.



10. **B1** or **B2**. Push to define and display a serial bus if you have the appropriate module application keys. The DPO2AUTO module supports CAN and LIN buses. The DPO2EMBD module supports I²C and SPI. The DPO2COMP module supports RS-232, RS-422, RS-485, and UART buses.

    Parallel bus support is available on MSO2000B products.

    Also, push the **B1** or **B2** button to display or remove the corresponding bus from the display.

11. **R**. Push to manage reference waveforms, including the display or removal of each reference waveform from the display.

12. **M**. Push to manage the math waveform, including the display or removal of the math waveform from the display.



Using Other Controls

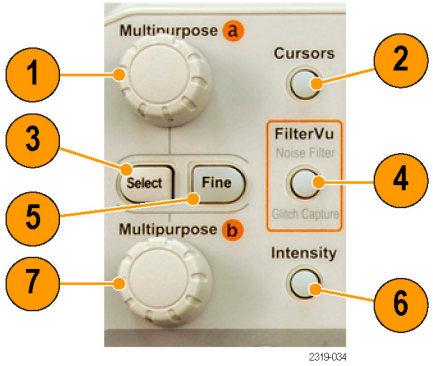
These buttons and knobs control waveforms, cursors, and other data input.

1. Turn the upper multipurpose knob **a**, when activated, to move a cursor, to set a numerical parameter value for a menu item, or to select from a pop-out list of choices. Push the **Fine** button to toggle between coarse and fine adjustment.

   Screen icons tell you when **a** or **b** are active.

2. **Cursors**. Push once to activate the two vertical cursors. Push again to turn on the two vertical and two horizontal cursors. Push again to turn off all cursors.

   When the cursors are on, you can turn the multipurpose knobs to control their position.



3. **Select**. Push to activate special functions.

   For example, when using the two vertical cursors (and no horizontal ones are visible), you can push this button to link or unlink the cursors. When the two vertical and two horizontal cursors are both visible, you can push this button to make either the vertical cursors or the horizontal cursors active.

4. **FilterVu**. Push to filter unwanted noise from your signal and still capture glitches.

5. **Fine**. Push to toggle between making coarse and fine adjustments with the vertical and horizontal position knobs, the trigger level knob, and many operations of multipurpose knobs **a** and **b**.

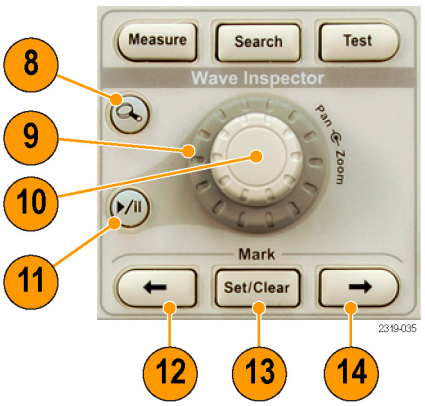
6. **Intensity**. Push to enable multipurpose knob **a** to control waveform display intensity and knob **b** to control graticule intensity.

7. Turn the lower multipurpose knob **b**, when activated, to move a cursor or set a numerical parameter value for a menu item. Push **Fine** to make adjustments more slowly.

8. **Zoom** button. Push to activate zoom mode.

9. **Pan** (outer knob). Turn to scroll the zoom window through the acquired waveform.

10. **Zoom** (inner knob). Turn to control the zoom factor. Turning it clockwise zooms in further. Turning it counterclockwise zooms out.



11. **Play-pause** button. Push to start or stop the automatic panning of a waveform. Control the speed and direction with the pan knob.

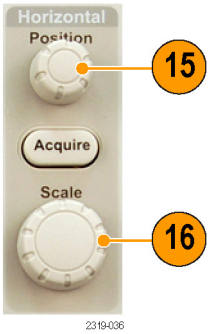
12. ← **Prev**. Push to jump to the previous waveform mark.

13. **Set/Clear Mark**. Push to establish or delete a waveform mark.

14. → **Next**. Push to jump to the next waveform mark.

15. **Horizontal Position**. Turn to adjust the trigger point location relative to the acquired waveforms. Push **Fine** to make smaller adjustments.

16. **Horizontal Scale**. Turn to adjust the horizontal scale (time/division).



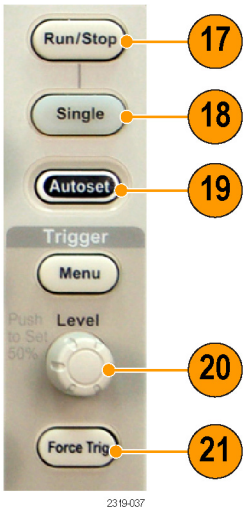
17. **Run/Stop**. Push to start or stop acquisitions.

18. **Single**. Push to make a single acquisition.

19. **Autoset**. Push to automatically set the vertical, horizontal, and trigger controls for a usable, stable display.

20. **Trigger Level**. Turn to adjust the trigger level.

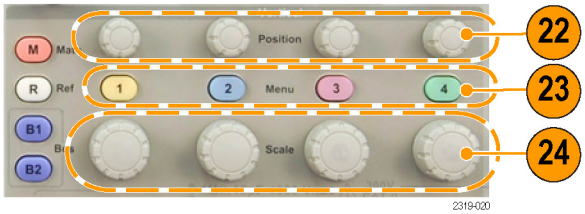
    Push Level to Set 50%. Push the Trigger level knob to set the trigger level to the midpoint of the waveform.



21. **Force Trig**. Push to force an immediate trigger event.

22. **Vertical Position**. Turn to adjust the vertical position of the corresponding waveform. Push **Fine** to make smaller adjustments.

23. **1, 2, 3, 4 Menu**. Push to display or remove the corresponding waveform from the display and access the vertical menu.



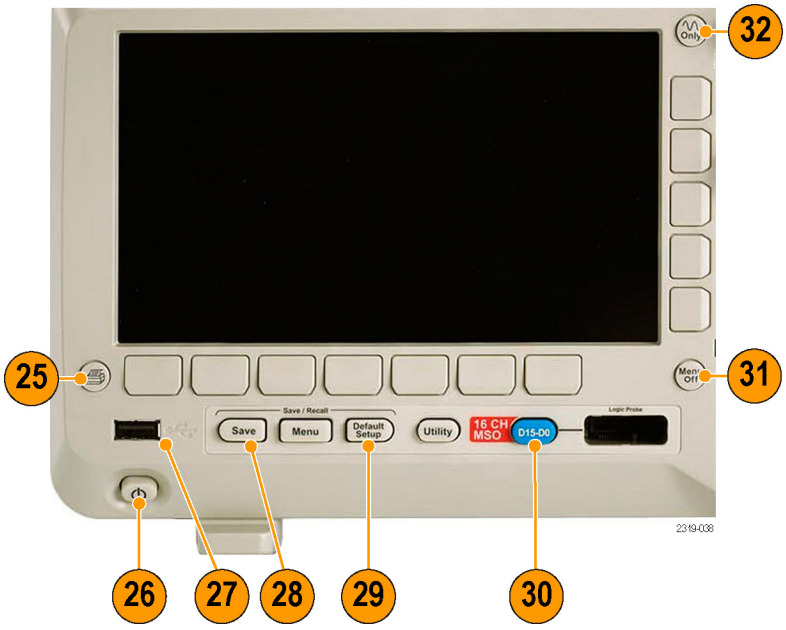
24. **Vertical Scale**. Turn to adjust the vertical scale factor of the corresponding waveform (volts/division).

25. **Print**. Push to print to a PictBridge printer.

26. **Power** switch. Push to power on or off the oscilloscope.

27. **USB 2.0 Host port**. Insert a USB peripheral to the oscilloscope, such as a keyboard or a flash drive.

28. **Save**. Push to perform an immediate save operation. The save operation uses the current save parameters, as defined in the Save / Recall menu.



29. **Default Setup**. Push to perform an immediate restore of the oscilloscope to the default settings.

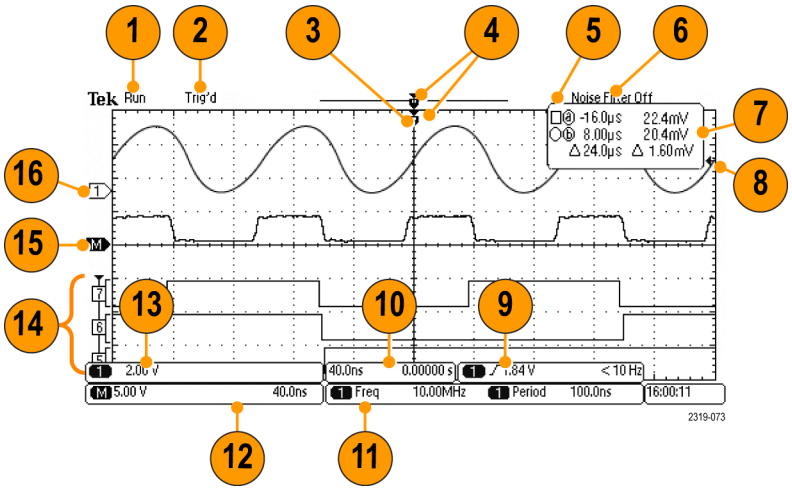
30. **D15 - D0**. Push to display or remove the digital channels from the display, and to access the digital channel setup menu (MSO2000B series only).

31. **Menu Off**. Push to clear a displayed menu from the screen.

32. **Waveform Only**. Push to remove menu and readout information from the screen so the oscilloscope only displays the waveform or bus. Push a second time to recall the previous menu and readout information.

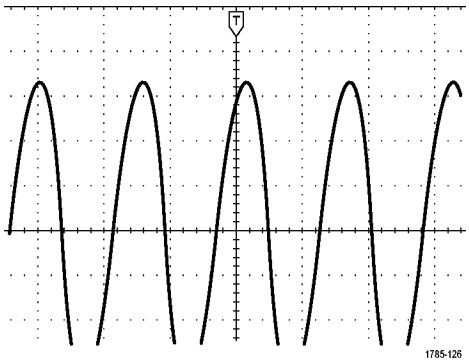
Identifying Items in the Display

The items shown to the right may appear in the display. Not all of these items are visible at any given time. Some readouts move outside the graticule area when menus are turned off.

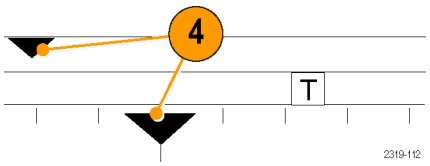


1. The acquisition readout shows when an acquisition is running, stopped, or when acquisition preview is in effect. Icons are:
   - Run: Acquisitions enabled
   - Stop: Acquisitions not enabled
   - Roll: In Roll mode (40 ms per division or slower)
   - PreVu: In this state, the oscilloscope is stopped or between triggers. You can change the horizontal or vertical position or scale to see approximately what the next acquisition will look like.
2. The trigger status readout shows trigger status. Status conditions are:
   - Trig'd: Triggered
   - Auto: Acquiring untriggered data
   - PrTrig: Acquiring pretrigger data
   - Trig?: Waiting for trigger

3. The trigger position icon shows where the trigger occurred in the acquisition.



4. The expansion point icon (an orange triangle) shows the point that the horizontal scale expands and compresses around.



5. The waveform record view shows the trigger location relative to the waveform record. The line color corresponds to the selected waveform color.

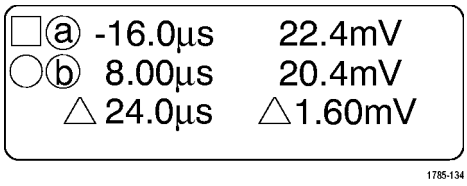


6. The FilterVu indicator shows if the variable low pass filter is active.

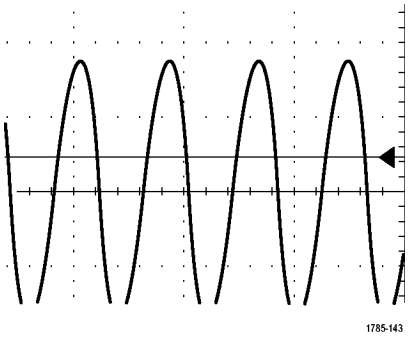
7. The cursor readout shows time, amplitude, and delta (Δ) values for each cursor.

   For FFT measurements, it shows frequency and magnitude.

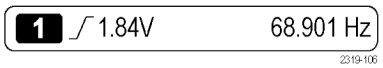
   For serial buses, the readout shows the decoded values.



8. The trigger level icon shows the trigger level on the waveform. The icon color corresponds to the trigger source color.



9. The trigger readout shows the trigger source, slope, level, and frequency for an Edge trigger. The trigger readouts for other trigger types show other parameters.

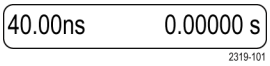


10. The horizontal position/scale readout shows on the top line the horizontal scale (adjust with the **Horizontal Scale** knob).

With **Delay Mode** on, the bottom line shows the time from the T symbol to the expansion point icon (adjust with the **Horizontal Position** knob).

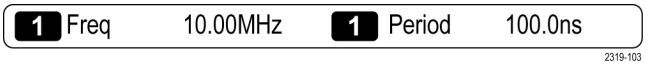
Use horizontal position to insert added delay between when the trigger occurs and when you actually capture the data. Insert a negative time to capture more pretrigger information.

With **Delay Mode** off, the bottom line shows the time location of the trigger within the acquisition, as a percentage.

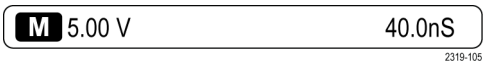


11. Measurement readouts show the selected measurements. You can select up to four measurements to display at one time.

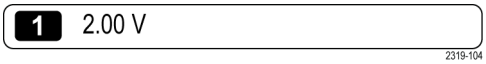
A ⚠ symbol appears instead of the expected numerical measurement if a vertical clipping condition exists. Part of the waveform is above or below the display. To obtain a proper numerical measurement, turn the vertical scale and position knobs to make all of the waveform appear in the display.



12. The auxiliary waveform readouts show the vertical and horizontal scale factors of the math and reference waveforms.



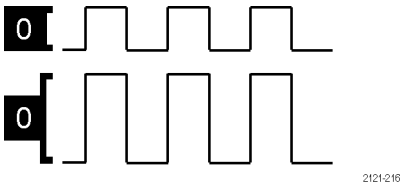
13. The channel readout shows the channel scale factor (per division), coupling, invert, and bandwidth status. Adjust with the **Vertical Scale** knob and the channel **1**, **2**, **3**, or **4** menus.



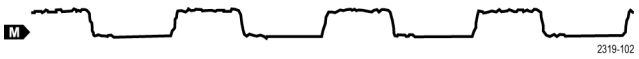
14. For digital channels (MSO2000B series only), the baseline indicators label the channel, and point to the high and low levels. The colors follow the color code used on resistors. The D0 indicator is black, the D1 indicator is brown, the D2 indicator is red, and so on.

The bus display shows decoded packet level information for serial buses or for parallel buses (MSO2000B series only). The bus indicator shows the bus number and bus type.

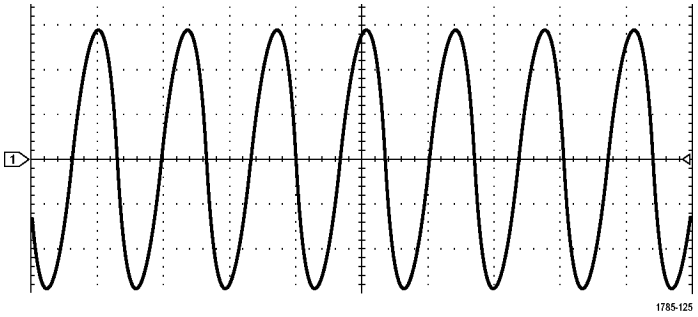
Not shown in this illustration, the Timing Resolution readout shows the timing resolution of the digital channels. To see the readout, push the D15-D0 front panel button.



15. For math channels, the waveform baseline indicator shows the zero-volt level of a waveform.



16. For analog channels, the waveform baseline indicator shows the zero-volt level of a waveform (ignoring the effect of offset). The icon colors correspond to the waveform colors.

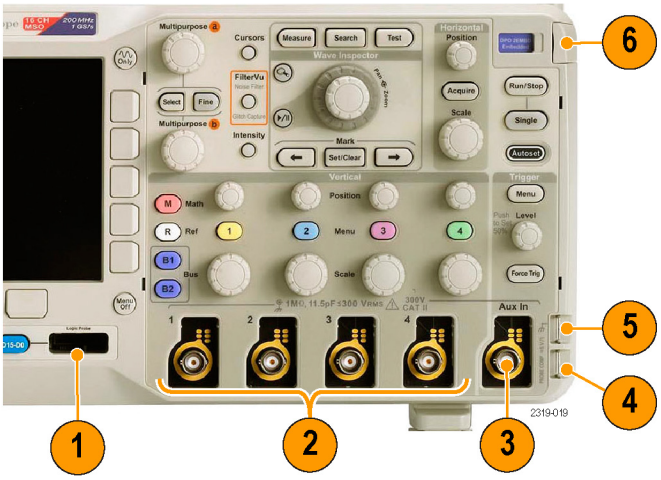


Front-Panel Connectors

1. Digital Probe Connector (MSO2000B series only).
2. Channel **1**, **2**, (**3**, **4**). Channel inputs with TekVPI Versatile Probe Interface.
3. **Aux In**. Trigger level range is adjustable from +12.5 V to –12.5 V.
4. **PROBE COMP**. Square wave signal source to compensate probes.

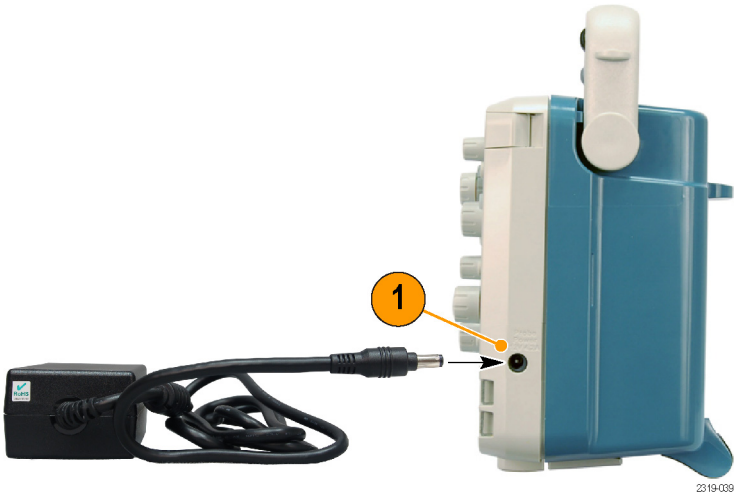
   Output voltage: 0 V to 5 V

   Frequency: 1 kHz
5. Ground.
6. Application Module Slots.

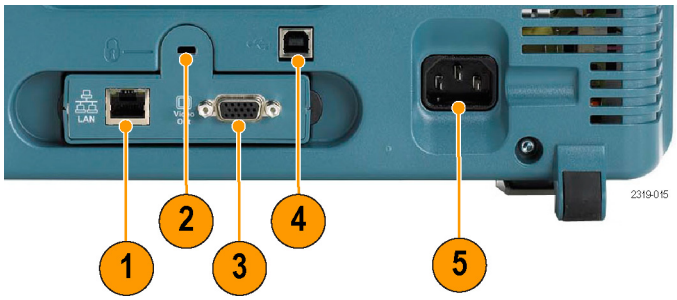


Side-Panel Connector

1. TekVPI external power supply connector. Use the connector for the TekVPI external power supply (Tektronix part number 119-7465-XX) when additional power is needed for TekVPI probes.



Rear-Panel Connectors



1. **LAN**. Use the LAN (Ethernet) port (RJ-45 connector) to connect the oscilloscope to a 10/100 Base-T local area network. The port is available on the optional connectivity module (DPO2CONN).
2. **Lock**. Use to secure the oscilloscope and optional connectivitiy module.
3. **Video Out**. Use the Video Out port (DB-15 female connector) to show the oscilloscope display on an external monitor or projector. The port is available on the optional connectivity module (DPO2CONN).
4. **USB 2.0 Device port**. Use the USB 2.0 Full Speed Device port to connect a PictBridge compatible printer, or for direct PC control of the oscilloscope using USBTMC protocol.

NOTE. *The cable connected from the USB 2.0 Device port to the host computer must meet the USB2.0 specification for high speed operation when connected to a high speed host controller.*

5. **Power** input. Attach to an AC power line with integral safety ground. (See page 5, *Operating Considerations*.)

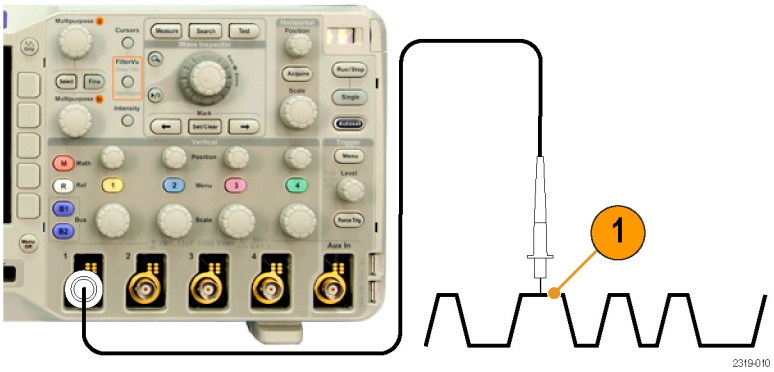
Acquire the Signal

This section describes concepts of and procedures for setting up the oscilloscope to acquire the signal as you want it to.

Setting Up Analog Channels

Use front-panel buttons and knobs to set up your oscilloscope to acquire signals using the analog channels.

1. Connect a TPP0200/TPP0100 probe or a TekVPI probe to the input signal source.

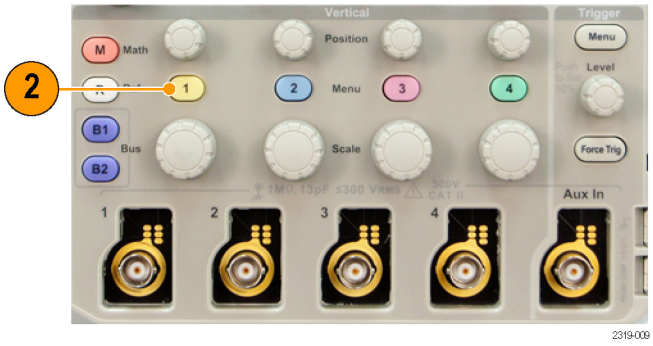


2. Push **Default Setup**.

*NOTE. If you are using a probe that does not supply probe encoding, set the attenuation (probe factor) on the oscilloscope vertical menu to match the probe. The default attenuation for the oscilloscope is 10X and is set in the **Probe Setup** lower-bezel menu of any analog channel.*

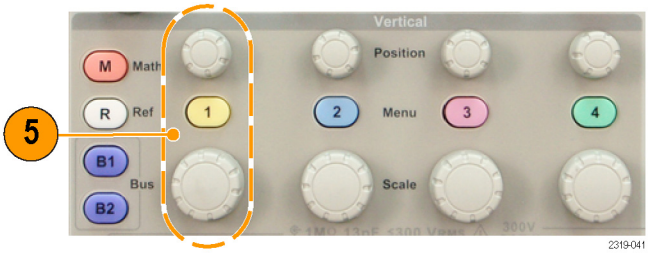


3. Select the input channel by pushing the front-panel buttons.



4. Push **Autoset**.

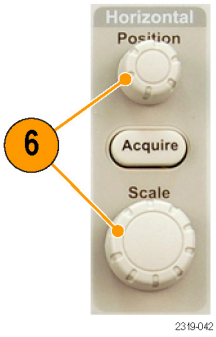
5. Push the desired channel button. Then adjust the vertical position and scale.



6. Adjust the horizontal position and scale.

   The horizontal position determines the number of pretrigger and posttrigger samples.

   The horizontal scale determines the size of the acquisition window relative to the waveform. You can scale the window to contain a waveform edge, a cycle, several cycles, or thousands of cycles.



Quick Tip

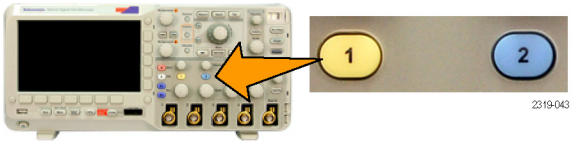
- Use the zoom feature to see multiple cycles of your signal in the upper part, and a single cycle in the lower part of the display. (See page 105, *Using Wave Inspector to Manage Long Record Length Waveforms*.)

Labeling Channels and Buses

You can add a label to the channels and buses shown on the display for easy identification. The label is placed on the waveform baseline indicator in the left side of the screen. The label can have up to 32 characters.

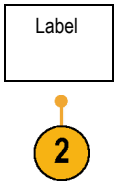
To label a channel, push a channel input button for an analog channel to label a channel.

1. Push a front panel button for an input channel or a bus.

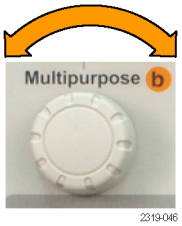




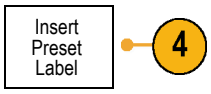
2. Push a lower-bezel button to create a label, such as for channel 1 or B1.



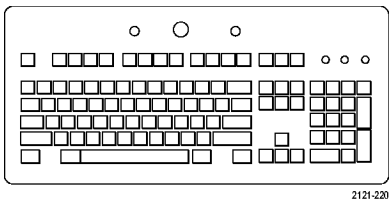
3. Turn multipurpose knob **b** to scroll through the list to find a suitable label. You can edit the label after you insert it if necessary.



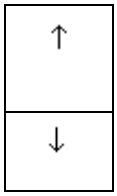
4. Push **Insert Preset Label** to add the label.

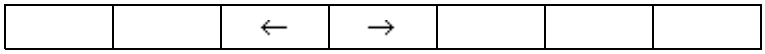


If you are using a USB keyboard, use the arrow keys to position the insertion point and edit the inserted label, or type in a new label. (See page 25, *Connecting a USB Keyboard to Your Oscilloscope*.)



5. If you do not have a USB keyboard connected, push the side- and lower-bezel arrow keys to position the insertion point.





6. Turn multipurpose knob **a** to scroll through the list of letters, numbers, and other characters to find the character in the name that you want to enter.



ABCDEFGHIJKLMNOPQRSTUVWXYZ

abcdefghijklmnopqrstuvwxyz

0123456789_=+-!@#$%^&*()[]{}<>/~'"\|:;,.?

7. Push **Select** or **Enter Character** to let the oscilloscope know that you have picked the proper character to use.



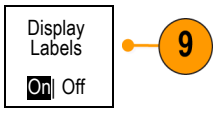
You can use the lower-bezel buttons to edit the label as needed.

Enter Character		←	→	Back Space	Delete	Clear

8. Continue scrolling and pushing **Select** until you have entered all the desired characters.

   For another label, push the side- and lower-bezel arrow keys to reposition the insertion point.

9. Push **Display Labels** and select **On** to see the label.



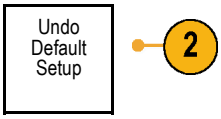
Using the Default Setup

To return the oscilloscope to its default settings:

1. Push **Default Setup**.



2. If you change your mind, push **Undo Default Setup** to undo the last default setup.



Using Autoset

Autoset adjusts the oscilloscope (acquisition, horizontal, trigger, and vertical controls) such that it displays four or five waveform cycles for analog channels with the trigger near the middle level, and ten cycles for digital channels.

Autoset works with both the analog and digital channels.

1. Connect the analog probe, and then select the input channel. (See page 40, *Setting Up Analog Channels*.)



   Connect the digital probe and select the input channel. (See page 59, *Setting Up Digital Channels (MSO2000B Series Only)*.)



2. Push **Autoset** to execute an Autoset.



3. If desired, push **Undo Autoset** to undo the last Autoset.



You can also disable the Autoset function if you want to set up a waveform manually. To disable or enable the Autoset function:

1. Push and hold **Autoset**.

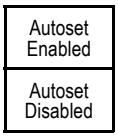


2. Push and hold **Menu Off**.



3. Release **Menu Off**, and then release **Autoset**.

4. Select the desired side-bezel setting.



Quick Tips

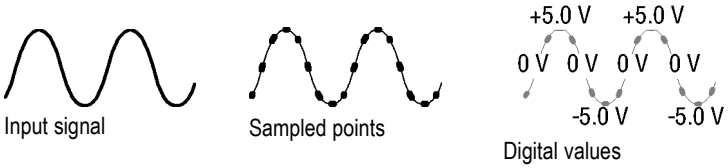
- To position the waveform appropriately, Autoset may change the vertical position. Autoset always sets vertical offset to 0 V.
- If you use Autoset when no channels are displayed, the oscilloscope turns on channel one (**1**) and scales it.
- If you use Autoset and the oscilloscope detects a video signal, the oscilloscope automatically sets the trigger type to video and makes other adjustments to display a stable video signal.
- To manually set the oscilloscope to view a video signal in an IRE graticule:
  1. Set the **Trigger Type** to **Video**.
  2. Set the **Vertical Scale** to 143mV/div.
  3. Select the proper input channel **Attenuation** for the probe or cable being used to feed the video signal to the oscilloscope.
  4. If necessary, connect a 75 ohm pass-through terminator to the oscilloscope input. For example, you need to add a terminator when you use a 75-ohm cable between the video signal and the oscilloscope.

Acquisition Concepts

Before a signal can be displayed, it must pass through the input channel where it is scaled and digitized. Each channel has a dedicated input amplifier and digitizer. Each channel produces a stream of digital data from which the oscilloscope extracts waveform records.

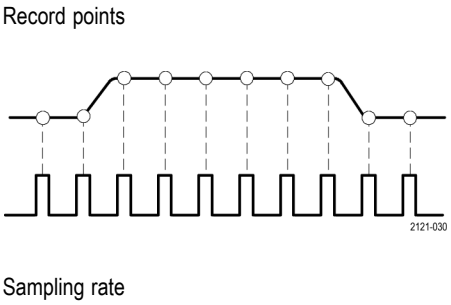
Sampling Process

Acquisition is the process of sampling an analog signal, converting it into digital data, and assembling it into a waveform record, which is then stored in acquisition memory.



Real-Time Sampling

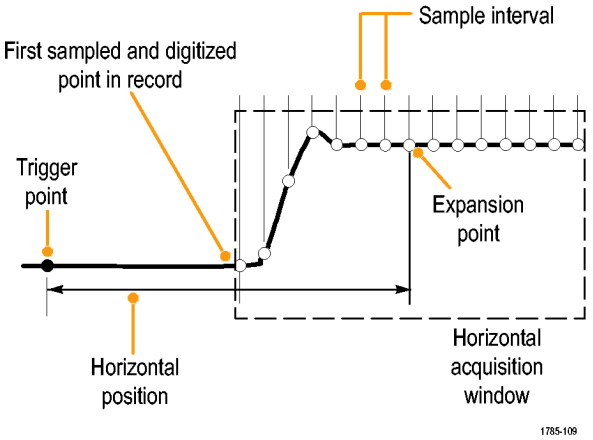
MSO2000B and DPO2000B series oscilloscopes use real-time sampling. In real-time sampling, the oscilloscope digitizes all of the points it acquires using a single trigger event.



Waveform Record

The oscilloscope builds the waveform record through the use of the following parameters:

- Sample interval: The time between recorded sample points. Adjust this by turning the **Horizontal Scale** knob or changing the record length with the bezel buttons.
- Record length: The number of samples required to fill a waveform record. Set this by pushing the **Acquire** button and using the resulting lower- and side-bezel menus.



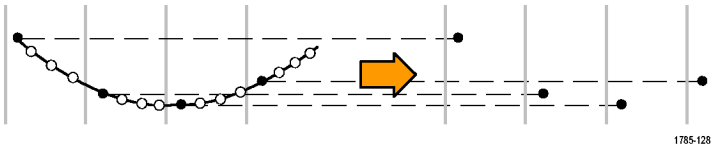
- Trigger point: The zero time reference in a waveform record. It is shown on the screen by an orange T.
- Horizontal position: When the **Delay** mode is on, this is the time from the trigger point to the expansion point. Adjust this by turning the **Horizontal Position** knob.

  When the **Delay** mode is off, the expansion point is fixed to the trigger point. (Push the Acquire front panel button to set the Delay mode.)

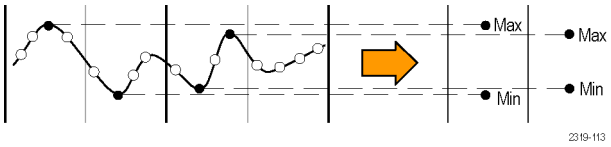
  Use a positive time to acquire the record after the trigger point. Use a negative time to acquire it before the trigger point.
- Expansion point: The point that the horizontal scale expands and contracts around. It is shown by an orange triangle.

How the Analog Acquisition Modes Work

FilterVu Noise Filter Foreground mode retains the first sampled point from each acquisition interval. This mode is also called Sample in other oscilloscopes. This is the default mode.



FilterVu Glitch Capture Background mode uses the highest and lowest of all the samples contained in two consecutive acquisition intervals. At fast time per division settings, the Glitch Capture Background mode is unavailable. This mode is also called Peak Detect in other oscilloscopes.



Average mode calculates the average value for each record point over a user-specified number of acquisitions. Average uses Sample mode for each individual acquisition. Use Average mode to reduce random noise.



Changing the Acquisition Mode, Record Length, and Delay Time

Use this procedure to change the acquisition mode.

1. Push **Acquire**.

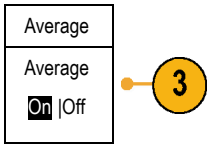


2. Push **Average**.

Average	Record Length	Delay	Set Horiz. Position to 10%	Waveform Display	XY Display	Acquisition Details
Off	100k	On | Off			Off	



3. Set the Average acquisition mode from the side-bezel menu. You can chose how many samples on which to average: 2, 4, 8, 16, 32, 64, 128, 256, or 512.



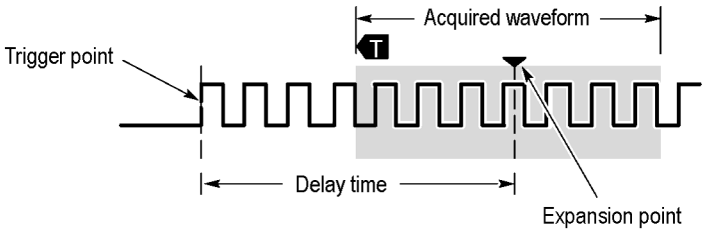
4. Turn multipurpose knob **a** to set the number of waveforms to average over.



5. Push **Record Length**.

   Choose 100 k or 1.00 M points. The selections depend on the horizontal time per division setting. 125 k and 1.25 M records lengths are available at slower time per division settings.

6. Push the lower-bezel **Delay** button to select **On** when you want to delay the acquisition relative to the trigger event.



With **Delay** set to **On**, turn the **Horizontal Position** knob counterclockwise to increase the delay. The trigger point will move to the left and ultimately outside of the acquired waveform. Then you can adjust the **Horizontal Scale** knob to acquire more detail around the area of interest at the center of the screen.

When this delay is on, the trigger point separates from the horizontal expansion point. The horizontal expansion point stays at the center of the screen. The trigger point can move off the screen. When this happens, the trigger marker turns to point in the direction of the trigger point.

Use the delay feature when you want to acquire waveform detail that is separated from the trigger event by a significant interval of time. For example, you can trigger on a sync pulse that occurs once every 10 ms and then look at high-speed signal characteristics that occur 6 ms after the sync pulse.

When the delay feature is set to **Off**, the expansion point is tied to the trigger point so that scale changes are centered around the trigger point.

Using Roll Mode

Roll mode gives a display similar to a strip chart recorder for low-frequency signals. Roll mode lets you see acquired data points without waiting for the acquisition of a complete waveform record.

Roll mode is enabled when the trigger mode is auto and the horizontal scale is set to 40 ms/division or slower.

Quick Tips

- Roll mode is disabled when you switch to Average acquisition mode, use digital channels, use math waveforms, turn on a bus, switch to Normal trigger, or set the horizontal scale to 20 ms per division or faster.
- Zoom is disabled when you use Roll mode.
- Push **Run/Stop** to halt Roll mode.



Setting Up a Serial or Parallel Bus

Your oscilloscope can decode and trigger on:

- I²C and SPI serial buses if the DPO2EMBD application module is installed
- CAN and LIN serial buses if the DPO2AUTO application module is installed
- RS-232, RS-422, RS-485, and UART serial buses if the DPO2COMP application module is installed
- Parallel buses if you are using an MSO2000B series oscilloscope

(See page 13, *Application Module Free Trial*.)

Using Buses in Two Steps

To quickly use serial bus triggering:

1. Push **B1** or **B2** and enter parameters of the bus to trigger on.

   You can separately use **B1** and **B2** to view two different buses.



2. Push Trigger **Menu** and enter trigger parameters. (See page 67, *Choosing a Trigger Type*.)

   You can display bus information without triggering on the bus signal.



Setting Up Bus Parameters

NOTE. *For all serial bus sources, use any combination of channels 1 through 4, and D15 through D0.*

To trigger on serial or parallel bus conditions, refer to Triggering on Buses. (See page 70, *Triggering on Buses*.)

To set up bus parameters:

1. Push **B1** or **B2** to bring up the lower-bezel bus menu.



2. Push **Bus**. Turn multipurpose knob **a** to scroll through the list of bus types and select the desired bus: Parallel (MSO2000B series only), I²C, SPI, CAN, RS-232, or LIN.

   The actual menu items shown will depend on your model oscilloscope and the application modules installed.

B1 Parallel	Define Inputs	Thresholds		B1 Label Parallel	Bus Display	Event Table



3. Push **Define Inputs**. The choices depend on the selected bus.

   Use the side-bezel buttons to define parameters for the inputs, such as specific signals to an analog or digital channel.

   If you select **Parallel**, push the side-bezel button to enable or disable **Clocked Data**.

   Push the side-bezel button to select the **Clock Edge** on which to clock data: rising edge, falling edge, or both edges.

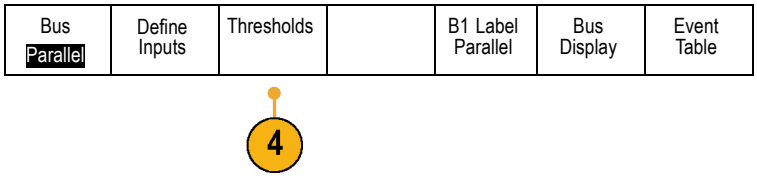
   Turn multipurpose knob **a** to select the **Number of Data Bits** in the parallel bus.

   Turn multipurpose knob **a** to select the desired bit to define.

   Turn multipurpose knob **b** to select the desired analog or digital channel as the source for the bit.

Define Inputs
Clocked Data Yes|No
Clock Edge ⎍ ⎎ ⎍⎎
Number of Data Bits (a) 16
Define Bits (a) Bit 15 (b) D15

4. Push **Thresholds**.



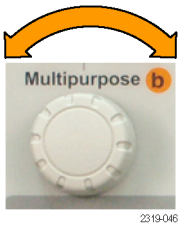
You can set the threshold for all channels in the parallel or serial bus from a list of preset values. The values are based on common types of integrated circuits. The preset values are:

- 1.4 V for TTL
- 2.5 V for 5.0 V CMOS
- 1.65 V for 3.3 V CMOS
- 1.25 V for 2.5 V CMOS
- -1.3 V for ECL
- 3.7 V for PECL
- 0 V

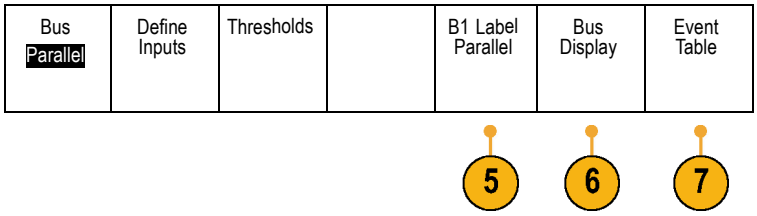
Alternately, you can set the threshold to a specific value for the signals that makes up the parallel or serial bus. To do so, push the **Select** side-bezel button and turn multipurpose knob **a** to select a Bit or a Channel number (Signal name).



Then, turn multipurpose knob **b** to define the voltage level above which the oscilloscope treats the signal as high and below which as low.

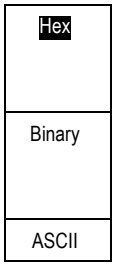


5. Push **B1 Label** to edit the label for the bus. (See page 41, *Labeling Channels and Buses*.)

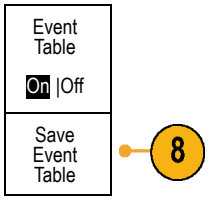


6. Push **Bus Display** and use the side-bezel menu to define how to display the parallel or serial bus.

   Push the desired side-bezel menu choice to display the bus data in hex, binary, or ASCII (RS-232 only) format.



7. Push **Event Table** and select **On** to display a list of I²C, SPI, CAN, or LIN bus packets with timestamps.



   For a clocked parallel bus, the table lists the value of the bus at each clock edge. For an unclocked parallel bus, the table lists the value of the bus whenever any one of its bits changes.

   For an RS-232 bus, the table lists decoded bytes, or packets.

8. Push **Save Event Table** to save the event table data in a .csv (spreadsheet) formatted file on the currently selected storage device.

   This example of an Event Table is from an RS-232 bus.

   RS-232 event tables display one line for each 7- or 8-bit byte when Packets are set to Off. RS-232 event tables display one line for each packet when Packets are set to On.

   I²C, SPI, CAN, and LIN event tables display one line for each packet.

Tektronix	version v1.2(	
Bus Definition: RS232		
Time	Tx	Rx
-4.77E-02	E	
-4.44E-02	n	
-4.10E-02	g	
-3.75E-02	i	
-3.41E-02	n	
-3.08E-02	e	
-2.73E-02	e	
-2.39E-02	r	
-2.06E-02	i	
-1.71E-02	n	
-1.37E-02	g	
-1.03E-02	,	
-6.92E-03	SP	
-3.49E-03	P	
-5.38E-05	o	
3.28E-03	r	
6.71E-03	t	
1.69E-02	l	
2.02E-02	a	
2.43E-02	n	
2.82E-02	d	
3.16E-02		

2319-085

9. Push **B1** or **B2** and turn multipurpose knob **a** to move the bus display up or down on the screen.

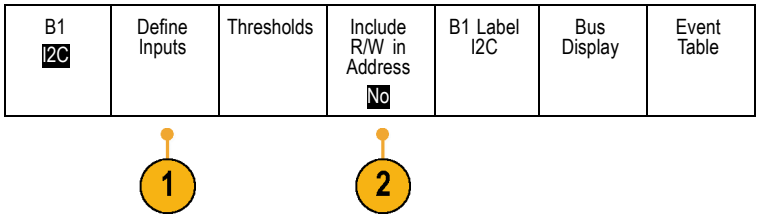
To acquire data from an I²C bus, you need to also set up these items:

1. If you select **I2C**, push **Define Inputs** and the desired side-bezel menu choices.

   You can assign the predefined **SCLK Input** or **SDA Input** to the channel connected to the signal.

2. Push **Include R/W in Address** and then push the desired side-bezel button.

   This control determines how the oscilloscope shows the I²C addresses in bus decode traces, cursor readouts, Event Table listings, and trigger settings.



If you select Yes, the oscilloscope displays 7-bit addresses as eight bits, where the eighth bit (LSB) is the R/~W bit.

If you select No, the oscilloscope displays 7-bit addresses as seven bits, and 10-bit addresses as ten bits.

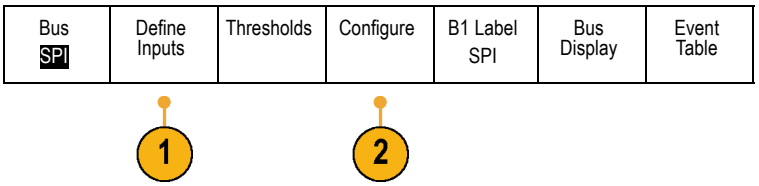
The oscilloscope also displays 10-bit addresses as 11 bits. The first two bits are the two MSBs of the address. The next bit is the R/~W bit. The last eight bits are the eight LSBs of the address. (In the physical layer of the I²C protocol, 10 bit I²C addresses are preceded by the five bit code, 11110. The oscilloscope never includes these five bits in address readouts.)

To acquire data from an SPI bus, you need to also set up these items:

1. If you selected **SPI**, push **Define Inputs** and the desired side-bezel menu choices.

   You can set the **Framing** to SS (Slave Select) or to Idle Time.

   You can assign the predefined **SCLK**, **SS**, **MOSI**, or **MISO** signals to any channel.



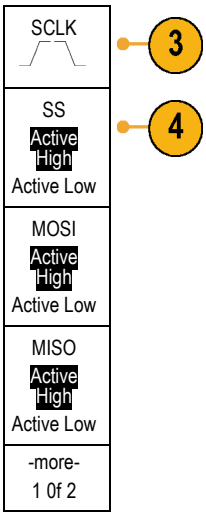
2. Push **Configure** and the desired side-bezel menu choices.

3. Push **SCLK** to set the edge of the signal to match the SPI bus being acquired.

4. Set the level of the SS, MOSI, and MISO signals to match the SPI bus.

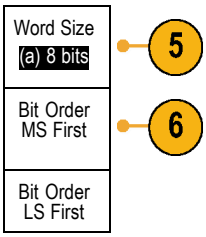
   Active High means that a signal is considered active when the signal is greater than the threshold value.

   Active Low means that the signal is considered active when the signal is lower than the threshold value.



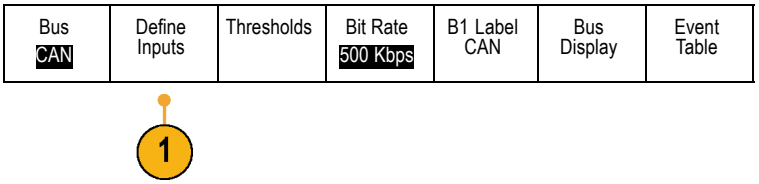
5. Use multipurpose knob **a** to set the number of bits to match the Word Size of the SPI bus.

6. Push either side bezel button to set the bit order to match the SPI bus.

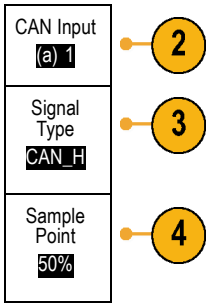


To acquire data from a CAN bus, you need to also set up these items:

1. If you selected **CAN**, push **Define Inputs** and the desired side-bezel menu choices.

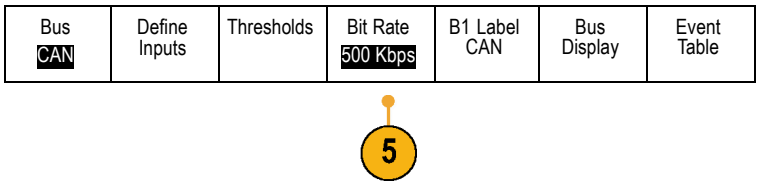


2. Turn multipurpose knob **a** to select the channel connected to the CAN bus source.
3. Turn multipurpose knob **a** to select the type of CAN signal to match the source of the CAN bus: CAN_H, CAN_L, Rx, Tx, or Differential.
4. Turn multipurpose knob **a** to set the **Sample Point** from 5% to 95% of the position within the bit period or the unit interval.



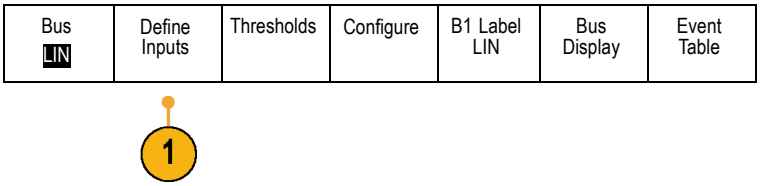
5. Push **Bit Rate** and turn multipurpose knob **a** to select from the list of predefined bit rates.

   Alternately, you can set the bit rate to a specific value. To do so, select **Custom**, and then turn multipurpose knob **b** to set the bit rate from 10000 to 1000000.

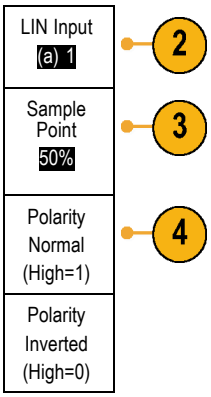


To acquire data from a LIN bus, you need to also set up these items:

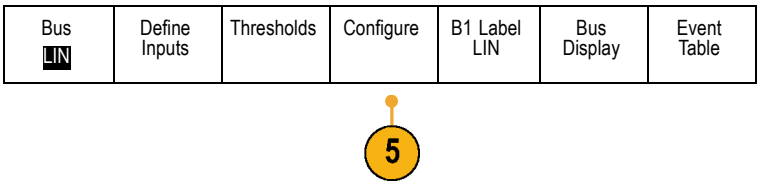
1. If you selected **LIN**, push **Define Inputs** and the desired side-bezel menu choices.



2. Turn multipurpose knob **a** to select the channel connected to the LIN bus source.
3. Turn multipurpose knob **a** to set the **Sample Point** from 5% to 95% of the position within the bit period or the unit interval.
4. Select the **Polarity** to match the LIN bus being acquired.



5. Push **Configure** and the desired side-bezel menu choices.

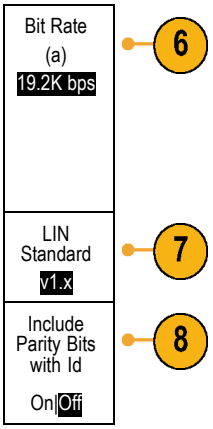


6. Push **Bit Rate**, and turn multipurpose knob **a** to select from the list of predefined bit rates.

   Alternately, you can set the bit rate to a specific value. To do so, select **Custom**, and then turn multipurpose knob **b** to set the bit rate from 800 bps to 100000 bps.

7. Push **LIN Standard**, and turn multipurpose knob **a** to select the appropriate standard.

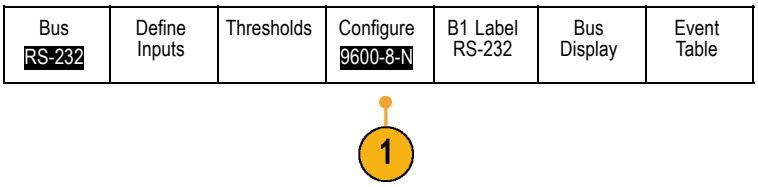
8. Push **Include Parity Bits with Id** to select whether or not to include parity bits.



To acquire data from a RS-232 bus, you need to also set up these items:

1. If you selected **RS-232**, push **Configure** and the desired side-bezel menu choices.

   Use the side-bezel menu to configure the bus. Use Normal polarity to trigger on RS-232 signals and Inverted polarity to trigger on RS-422, RS-485, and UART signals.



2. Push **Bit Rate**, and turn multipurpose knob **a** to select the appropriate bit rate.

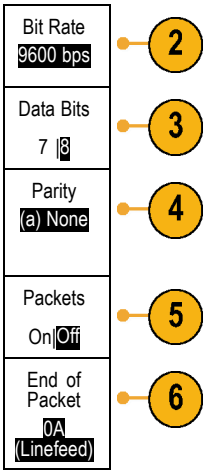
3. Push **Data Bits** and select the number to match the bus.

4. Push **Parity** and turn multipurpose knob **a** to match the polarity used by the bus as None, Odd, or Even.

5. Push **Packets** and select On or Off.

6. Turn multipurpose knob **a** to select an end-of-packet character.

   RS-232 decoding displays a stream of bytes. You can organize the stream into packets with an end-of-packet character



Physical Layer Bus Activity

Oscilloscope waveform traces from analog channels 1 to 4, digital channels D15 to D0, and the traces you see when you choose to display a bus always show the physical layer bus activity. In the physical layer display, bits that were transmitted earlier are to the left, and bits that were transmitted later are to the right.

- I2C, and CAN buses transmit the MSB (most significant bit) first
- SPI buses do not specify a bit order
- RS-232 and LIN buses transmit the LSB (least significant bit) first

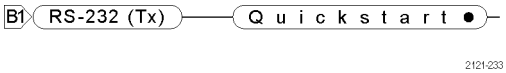
NOTE. *The oscilloscope displays the decode traces and event tables for all buses with the MSB on the left and LSB on the right.*

For example, an RS-232 signal (after the start bit) might be high, high, high, low, high, low, low, and high. Since the RS-232 protocol uses high for zero and low for one, this value would be 0001 0110.

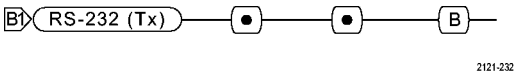
Since the decode displays the MSB first, the oscilloscope reverses the order of the bits and displays 0110 1000. If the bus display is set to hex, the value displays as 68. If the bus display is set to ASCII, the value displays as h.

RS-232

If you defined an end-of-packet character to use for RS-232 decoding, the stream of bytes will be displayed as packets.



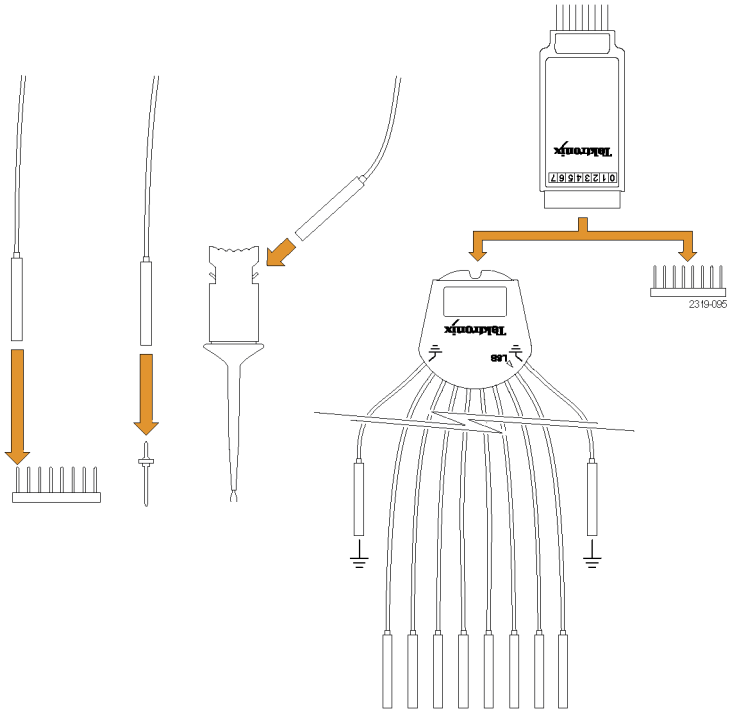
When decoding an RS-232 bus in ASCII mode, a large dot indicates that the value represents a character outside the printable ASCII range.



Setting Up Digital Channels (MSO2000B Series Only)

Use front-panel buttons and knobs to set up your oscilloscope to acquire signals using the digital channels available only on MSO2000B models.

1. Connect the P6316 digital probe to the input signal source.



2. Connect the ground lead or leads to the circuit ground.

   You can connect one or two of the common ground leads for each group of 8 channels (wires).

3. If needed, connect the appropriate grabber for each channel to the probe tip.
4. Connect each channel to the desired circuit test point.
5. Push the **D15 - D0** front panel button to display the menu.



6. Push the lower-bezel **D15 - D0** button to access the D15 - D0 On or Off menu.



7. Turn multipurpose knob **a** to scroll through the list of digital channels. Turn multipurpose knob **b** to position the selected channel.

   As you position channels close to each other on the display, the oscilloscope groups the channels, and adds the group to the pop-up list. You can select the group from the list to move all the channels in the group instead of individual channels.

8. Push the lower-bezel **Thresholds** button. You can assign a different threshold value to each pod.

9. Push the lower-bezel **Edit Labels** button and create the label. You can create labels through the front panel or with an optional USB keyboard. (See page 41, *Labeling Channels and Buses*.)

10. Push the lower-bezel **Height** button repeatedly to set the signal height. You only need to do this once to set the height for all of the digital channels.

Quick Tip

- Use the zoom feature to see multiple cycles of the signal in the upper part, and a single cycle in the lower part of the display. (See page 105, *Using Wave Inspector to Manage Long Record Length Waveforms*.)
- The lead for each digital channel has a color-coded band for easy identification. The ground leads are shorter and have black wires.
- Digital channels store a high or low state for each sample. The threshold that separates a high from a low can be set for all the channels in GROUP 1 or in GROUP 2. The threshold can not be set for individual channels.

Reducing Unwanted Noise With FilterVu

You can use FilterVu to filter unwanted noise from your signal and still capture glitches. The oscilloscope does this by superimposing a filtered foreground waveform over a glitch capture background waveform.

The filtered waveform uses a variable low-pass filter to block out noise, yielding a cleaner waveform. When the noise filter is adjusted to the minimum bandwidth setting, no more than 1% of high-frequency content that could cause the oscilloscope to alias will pass through the filter.

The glitch capture waveform shows signal details up to the full bandwidth of the oscilloscope. The oscilloscope captures pulses as narrow as 5 ns, using peak detect min/max sampling.

When your signal is filtered, the glitch capture waveform changes color to distinguish it from the filtered waveform. When the signal is filtered, you can independently adjust the intensity of the glitch capture waveform. When the signal is not filtered, the intensity of the glitch capture waveform depends on the overall intensity (under the Intensity button on the oscilloscope front panel).

FilterVu, Bandwidth Limit, and Averaging

You can use FilterVu, Bandwidth Limits, or Average mode to reduce noise in your signal. Each has benefits.

NOTE. *FilterVu does not apply to triggering. To reduce the effects of noise on your signal while triggering, use Bandwidth Limits or use Coupling settings.*

Use FilterVu when you want to do the following:

- Adjust your filter frequency with more granularity than the Bandwidth Limit provides.
- Adjust all channels to the same frequency.
- Acquire a non-repetitive or a single-shot signal.

Use Bandwidth Limit when you want to do the following:

- Filter only one channel.
- Trigger on a filtered signal.
- Acquire a non-repetitive or a single-shot signal.

Use Average mode when you want to do the following:

- Acquire a repetitive signal.
- Noise on your signal is random (not correlated with the trigger).
- Increase the vertical precision of your acquisition.

NOTE. *You can use FilterVu with Bandwidth Limit. You cannot use FilterVu with Average mode.*

Quick Tips

- You can choose to save to a file with full resolution (every point that was captured) or reduced resolution (fewer points). When your signal is filtered, only the reduced-resolution waveform is guaranteed to be filtered to the chosen frequency. Sometimes, the filter is unable to produce a full-resolution waveform with a frequency as low as the chosen frequency. The frequency of the full-resolution waveform is shown in the saved file.

  When the glitch capture background is on, a saved waveform file includes both the foreground and the background data.

- Reference waveforms can be filtered; the chosen noise filter frequency also applies to references. Reference waveforms also have a glitch capture background.

  Reference waveforms are always saved at full resolution. Unlike saving a waveform to a file, there is no reduced resolution option.

- When the signal is not filtered, most measurements are taken on the foreground waveform. The min, max, and peak-to-peak measurements are taken on the glitch capture background, because they measure the smallest and largest amplitudes in the waveform.

  When the signal is filtered, all measurements are taken from the filtered waveform.

- Dual-waveform math can be filtered; the chosen noise filter frequency also applies to math. Dual-waveform math does not have a glitch capture background.

- Search uses the glitch capture background, when available. This lets you better search for spikes and other anomalies.
- Serial bus decode uses a full-resolution sample (foreground) waveform. When filtering is active, that waveform might not be filtered to the chosen frequency.

Using FilterVu

By default, the noise filter cutoff frequency is set to the full bandwidth of the oscilloscope when you use FilterVu. To invoke the variable low-pass filter (noise filter), turn the multipurpose knob counterclockwise. The oscilloscope passes lower frequency signals which results in a cleaner-looking waveform. The noise frequency readout displays frequencies that the oscilloscope includes in the foreground waveform. The oscilloscope displays higher frequency components in the background waveform, up to the bandwidth of the MSO2000B or DPO2000B model.

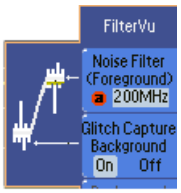
NOTE. *The oscilloscope always displays the noise filter cutoff frequency in the upper right part of the screen. The cutoff frequency reflects the -3 dB point.*

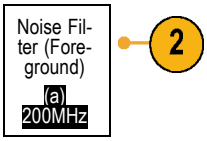
1. Push the **FilterVu** button.



2. Turn multipurpose knob **a** to adjust the **Noise Filter (Foreground)** value.



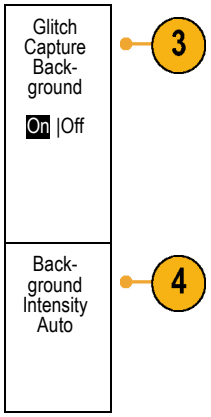




3. Push **Glitch Capture Background** to turn off the background waveform that contains the higher frequency components of the signal.

   With Glitch Capture set to Off, the oscilloscope displays only the noise filter (foreground) waveform.

4. With Glitch Capture set to On, turn multipurpose knob **b** to adjust the intensity of the Glitch Capture (background) waveform. You can only adjust the intensity when filtering.



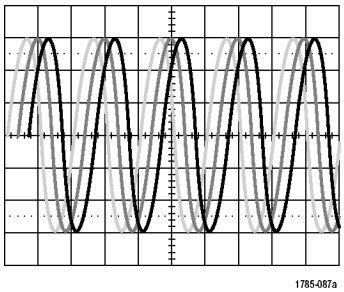
Trigger Setup

This section contains concepts and procedures for setting up the oscilloscope to trigger on your signal.

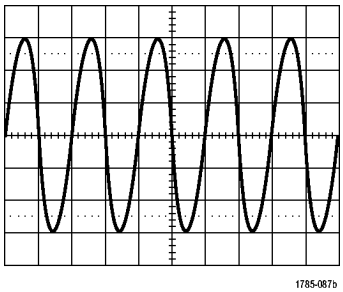
Triggering Concepts

Trigger Event

The trigger event establishes the time-reference point in the waveform record. All waveform record data is located in time with respect to that point. The oscilloscope continuously acquires and retains enough sample points to fill the pretrigger portion of the waveform record. That is the part of the waveform that is displayed before, or to the left of, the triggering event on screen. When a trigger event occurs, the oscilloscope starts acquiring samples to build the posttrigger portion of the waveform record, that is, the part displayed after or to the right of the trigger event. After a trigger is recognized, the oscilloscope will not accept another trigger until the acquisition is complete and the holdoff time has expired.



Untriggered display



Triggered display

Trigger Modes

The trigger mode determines how the oscilloscope behaves in the absence of a trigger event:

- Normal trigger mode enables the oscilloscope to acquire a waveform only when it is triggered. If no trigger occurs, the last waveform record acquired remains on the display. If no last waveform exists, no waveform is displayed.
- Auto trigger mode enables the oscilloscope to acquire a waveform even if a trigger does not occur. Auto mode uses a timer that starts when the acquisition is started, and the pretrigger information is obtained. If a trigger event is not detected before the timer times out, the oscilloscope forces a trigger. The length of time it waits for a trigger event depends on the time base setting.

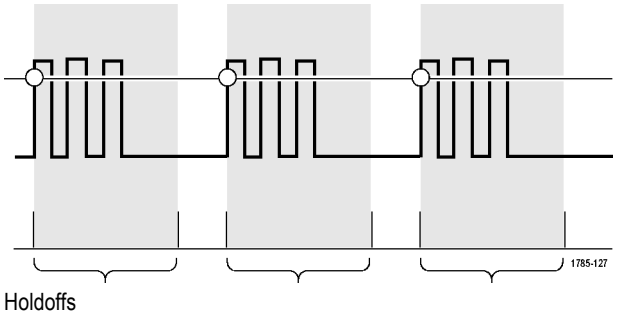
  Auto mode, when forcing triggers in the absence of valid triggering events, does not synchronize the waveform on the display. The waveform will appear to roll across the screen. If valid triggers occur, the display will become stable.

You can also force the oscilloscope to trigger. To do so, push the front-panel **Force Trig** button.

Trigger Holdoff

Adjust holdoff to obtain stable triggering when the oscilloscope is triggering on undesired trigger events.

Trigger holdoff can help stabilize triggering, since the oscilloscope does not recognize new triggers during the holdoff time. When the oscilloscope recognizes a trigger event, it disables the trigger system until acquisition is complete. In addition, the trigger system remains disabled during the holdoff period that follows each acquisition.



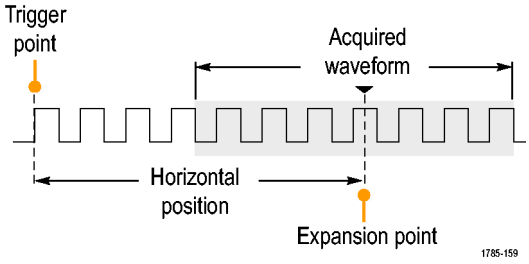
Trigger Coupling

Trigger coupling determines what part of the signal is passed to the trigger circuit. Edge triggering can use all available coupling types: DC, Low Frequency Rejection, High Frequency Rejection, and Noise Rejection. All other trigger types use DC coupling only.

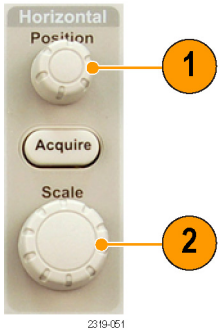
The cutoff frequency for low frequency rejection is 65 kHz. The cutoff frequency for high frequency rejection is 85 kHz.

Horizontal Position

When **Delay Mode** is on, use horizontal position to acquire waveform detail in a region that is separated from the trigger location by a significant interval of time.



1. Adjust the position (delay) time by rotating the **Horizontal Position** knob.
2. Turn the horizontal **Scale** knob to acquire the detail that you need around the position (delay) expansion point.

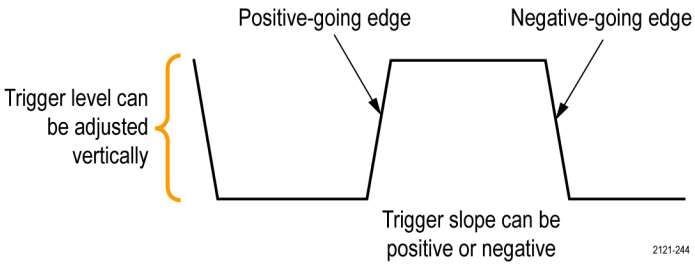


The part of the record that occurs before the trigger is the pretrigger portion. The part that occurs after the trigger is the posttrigger portion. Pretrigger data can help you troubleshoot. For example, to find the cause of an unwanted glitch in your test circuit, you can trigger on the glitch and make the pretrigger period large enough to capture data before the glitch. By analyzing what happens before the glitch, you may uncover information that helps you find the source of the glitch. Alternatively, to see what is happening in your system as a result of the trigger event, make the posttrigger period large enough to capture data after the trigger.

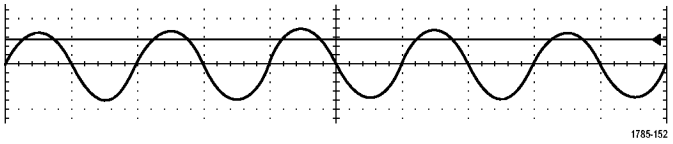
Slope and Level

The slope control determines whether the oscilloscope finds the trigger point on the rising or the falling edge of a signal.

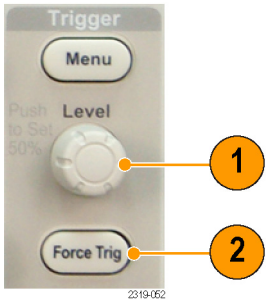
The level control determines where on that edge the trigger point occurs.



The oscilloscope provides a long horizontal bar or bars across the graticule to temporarily show the trigger level.



1. Turn the front-panel Trigger **Level** knob to adjust the trigger level without going to a menu.
2. Push the **Force Trig** button to force the oscilloscope to trigger.



Choosing a Trigger Type

To select a trigger:

1. Push Trigger **Menu**.



2. Push **Type** to bring up the list of Trigger Types.

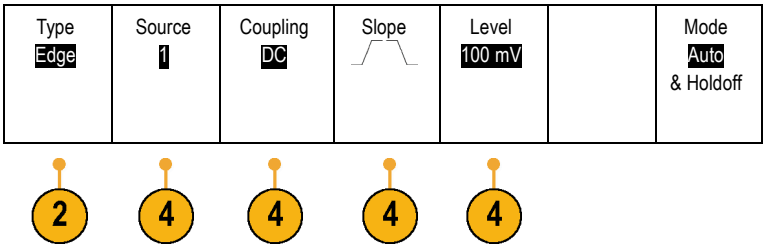
NOTE. *The bus trigger in the MSO2000B series works on parallel buses even without an application module. Using the bus trigger on other buses requires use of the DPO2EMBD, DPO2AUTO, or DPO2COMP application module.*

3. Turn multipurpose knob **a** to select the desired trigger type.

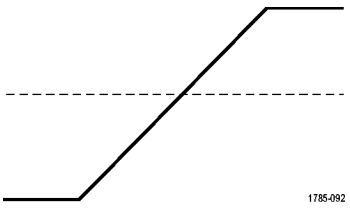
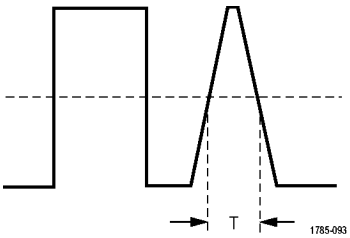
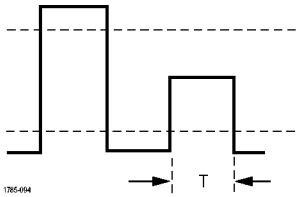
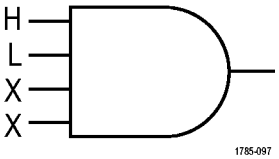
   The trigger types are: Edge, Pulse Width, Runt, Logic, Setup & Hold, Rise/Fall Time, Video, and Bus.

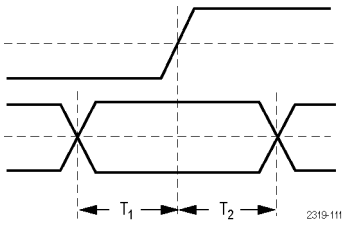
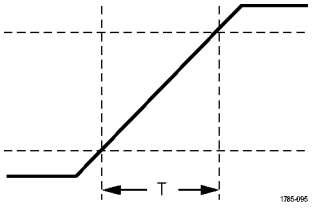
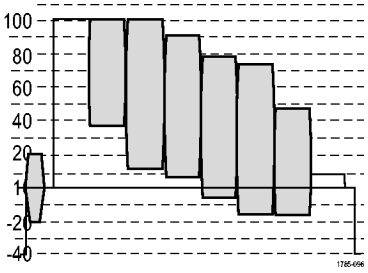
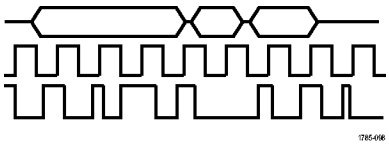


4. Complete the trigger setup using the lower-bezel menu controls displayed for the trigger type. The controls to set up the trigger vary depending on the trigger type.



Selecting Triggers

Trigger type		Trigger conditions
Edge		Trigger on a rising or falling edge, as defined by the slope control. Coupling choices are DC, LF Reject, HF Reject, and Noise Reject. Edge triggers are the simplest and most commonly used trigger type, with both analog and digital signals. An edge trigger event occurs when the trigger source passes through a specified voltage level in the specified direction.
Pulse Width		Trigger on pulses that are less than, greater than, equal to, or not equal to a specified time. You can trigger on positive or negative pulses. Pulse width triggers are primarily used on digital signals.
Runt		Trigger on a pulse amplitude that crosses one threshold but fails to cross a second threshold before recrossing the first. You can detect positive or negative (or either) runts, or only those wider than, less than, greater than, equal to, or not equal to a specified width. Runt triggers are primarily used on digital signals.
Logic		Trigger when all channels transition to the specified state. Use multipurpose knob **a** to select a channel. Push the appropriate side-bezel button to set that channel's state to **High (H)**, **Low (L)**, or **Don't Care (X)**. Use the **Clock** side-bezel button to enable clocked (state) triggering. You can have at most a single clock channel. Push the **Clock Edge** bottom bezel button to change the polarity of the clock edge. Turn off clocked triggering and return to unclocked (pattern) triggering by selecting the clock channel and setting it to high, low, or don't care. For unclocked triggering, by default, triggering occurs when the selected condition goes true. You can also select triggering when the condition goes false, or time-qualified triggering. You can use up to 20 channels for a logic trigger (4 analog and 16 digital) with MSO2000B series oscilloscopes.

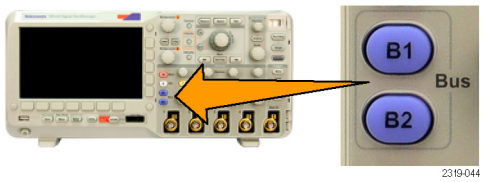
Trigger type		Trigger conditions
Setup and Hold		Trigger when a logic data input changes state inside of the setup or hold time relative to a clock edge. Setup is the amount of time that data should be stable and not change before a clock edge occurs. Hold is the time that data should be stable and not change after a clock edge occurs. MSO2000B series oscilloscopes are capable of multiple channel Setup and Hold triggering, and can monitor the state of an entire bus for setup and hold violations. You can use up to 20 channels for a Setup and Hold trigger (4 analog and 16 digital) with MSO2000B series oscilloscopes. Use the **Clock** side-bezel button to select the clock channel. Use the **Select** control, **Data**, and **Not used** buttons to select one or more channels you want to monitor for setup and hold violations.
Rise/Fall Time		Trigger on rise and fall times. Trigger on pulse edges that traverse between two thresholds at faster or slower rates than the specified time. Specify pulse edges as positive or negative or either.
Video		Trigger on specified fields or lines of a composite video signal. Only composite signal formats are supported. Trigger on NTSC, PAL, or SECAM. Works with Macrovision signals.
Bus		Trigger on various bus conditions. I2C requires a DPO2EMBD module. SPI requires a DPO2EMBD module. CAN requires a DPO2AUTO module. LIN requires a DPO2AUTO module. RS-232, RS-422, RS-485, and UART require a DPO2COMP module. Parallel requires an MSO2000B series oscilloscope. (See page 13, *Application Module Free Trial*.)

Triggering on Buses

You can use your oscilloscope to trigger on CAN, I²C, SPI, RS-232, RS-422, RS-485, UART, and LIN buses, if you have the appropriate DPO2AUTO, DPO2EMBD, or DPO2COMP application module installed. The MSO2000B series can trigger on parallel buses without an application module. The oscilloscope can display both physical layer (as analog waveforms) and protocol level information (as digital and symbolic waveforms).

To set up the bus trigger:

1. If you have not already defined your bus using the front-panel **B1** and **B2** buttons, do so now. (See page 49, *Setting Up a Serial or Parallel Bus*.)



2. Push Trigger **Menu**.



3. Push **Type**.

4. Turn multipurpose knob **a** to scroll through the list of trigger types until you select **Bus**.

Type	Source	Trigger On	Address		Direction	Mode
Bus	Bus B1 (I2C)	Address	07F		Write	Auto & Holdoff
3	5	6	7		7	

5. Push **Source Bus** and turn multipurpose knob **a** to scroll through the source bus side menu until you select the bus that you want to trigger on.

B1 (I2C)
B2 (Parallel)

6. Push **Trigger On** and turn multipurpose knob **a** to scroll through the side-bezel menu until you select the desired trigger on feature.

   If you are using the parallel bus trigger, you can trigger on a binary or hex data value. Push the lower-bezel **Data** button and enter the parameters of interest with multipurpose knobs **a** and **b**.

   If you are using the I2C bus trigger, you can trigger on **Start**, **Repeated Start**, **Stop**, **Missing Ack**, **Address**, **Data**, or **Address/Data**.

   If you are using the SPI bus trigger, you can trigger on **SS Active**, **MOSI**, **MISO**, or **MOSI & MISO**.

   If you are using the CAN bus trigger, you can trigger on **Start of Frame**, **Type of Frame**, **Identifier**, **Data**, **Id & Data**, **End of Frame**, **Missing Ack**, or **Bit Stuffing Error**.

   If you are using the RS-232 bus trigger, you can trigger on **Tx Start Bit**, **Rx Start Bit**, **Tx End of Packet**, **Rx End of Packet**,**Tx Data**, **Rx Data**, **Tx Parity Error**, or **Rx Parity Error**.

   If you are using the LIN bus trigger, you can trigger on **Sync**, **Identifier**, **Data**, **Id & Data**,**Wakeup Frame**, **Sleep Frame**, or **Error**.

7. If you are setting up an I2C trigger and have made a **Trigger On** selection of **Address** or **Address/Data**, push the lower-bezel **Address** button to access the I2C Address side-bezel menu.

   Push the side-bezel **Addressing Mode** button and select **7 bit** or **10 bit**. Push the side-bezel **Address** button. Enter the address parameters of interest with multipurpose knobs **a** and **b**.

   Then push the lower-bezel menu **Direction** button and select the direction of interest: **Read**, **Write**, or **Read or Write**.

If you have made a **Trigger On** selection of **Data** or **Address/Data**, push the lower-bezel **Data** button to access the I²C Data side-bezel menu.

Push the **Number of Bytes** button and enter the number of bytes with multipurpose knob **a**.

Push the side-bezel **Addressing Mode** button and select **7 bit** or **10 bit**. Push the side-bezel **Data** button. Enter the data parameters of interest with multipurpose knobs **a** and **b**.

For more information on the I²C address formats, refer to item 2 under *Setting Up Bus Parameters*.

8. If you are setting up an SPI trigger and have made a **Trigger On** selection of **MOSI** or **MISO**, push the lower-bezel **Data** button, push the side-bezel MOSI (or MISO) button, and enter the data parameters of interest with multipurpose knobs **a** and **b**.

   Then push the **Number of Bytes** button and enter the number of bytes with multipurpose knob **a**.

   If you select **MOSI & MISO**, push the lower-bezel **Data** button and enter the parameters of interest in the side-bezel menus.

9. If you are setting up a CAN trigger and have made a **Trigger On** selection of **Type of Frame**, push the lower-bezel **Frame Type** button, and select Data Frame, Remote Frame, Error Frame, or Overload Frame.

   If you have made a **Trigger On** selection of **Identifier**, push the lower-bezel **Identifier** button, and select a **Format**. Then push the **Identifier** side-bezel button, and enter a binary or hex value with multipurpose knobs **a** and **b**.

   Push the lower-bezel menu **Direction** button and select the direction of interest: **Read**, **Write**, or **Read or Write**.

   If you have made a **Trigger On** selection of **Data**. Push the lower-bezel **Data** button and enter the parameters of interest with multipurpose knobs **a** and **b**.

10. If you are setting up an RS-232 trigger and have made a **Trigger On** selection of **Tx Data** or **Rx Data**, push the lower-bezel **Data** button.

    Push the **Number of Bytes** button and enter the number of bytes with multipurpose knob **a**.

    Push the side-bezel **Data** button, and enter the parameters of interest with multipurpose knobs **a** and **b**.

11. If you are setting up an LIN trigger and have made a **Trigger On** selection of **Identifier**, **Data**, or **Identifier & Data**, push the lower-bezel **Identifier** or **Data** buttons and enter the parameters of interest on the resulting side-bezel menu.

    If you have made a **Trigger On** selection of **Error**, push the lower-bezel **Error Type** button and enter the parameters of interest on the resulting side-bezel menu.

I²C, SPI, CAN, and LIN Bus Trigger Data Matching

Rolling window byte matching for I²C, and SPI. To use a rolling window to trigger on data, you define the number of bytes to match. Then the oscilloscope uses a rolling window to find any match within a packet, with the window rolling one byte at a time.

For example, if the number of bytes is one, the oscilloscope will attempt to match the first byte, second byte, third, and so on within the packet.

If the number of bytes is two, the oscilloscope will try to match any two consecutive bytes, such as one and two, two and three, three and four, and so on. If the oscilloscope finds a match, it will trigger.

Specific byte matching (non-rolling window matching for a specific position in the packet) for I²C, SPI, and CAN. You can trigger on a specific byte for I²C, SPI, and CAN in several ways:

- For I²C and SPI, enter the number of bytes to match the number of bytes in the signal. Then use don't cares (X) to mask the bytes that you are not interested in.
- For I²C, push the lower-bezel **Trigger On** to trigger on **Address/Data**. Push **Address**. On the side-bezel menu, push **Address**, and turn multipurpose knobs **a** and **b** as needed. Set the address to don't cares (X) if you want to mask the address. The data will be matched starting at the first byte without using a rolling window.
- For CAN, triggering occurs when the user-selected data input matches the data and qualifier in the signal starting at the first byte. Set the number of bytes to match the number of bytes of interest. Use the data qualifier to perform: =, !=, <, >, >=, and <= operations. Triggering on identifier and data always matches the identifier and data selected by the user, with the data starting at the first byte. No rolling window is used.

RS-232 Bus Trigger Data Matching

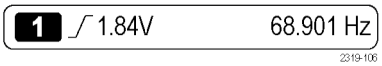
You can trigger on a specific data value for RS-232 bytes. If you defined an end-of-packet character to use for RS-232 bus decoding, you can use the same end-of-packet character as a data value for trigger data matching. To do so, choose the Tx End of Packet or the Rx End of Packet character as the Trigger On selection.

Parallel Bus Trigger Data Matching

Optimum parallel bus trigger performance is achieved by using only analog channels or only digital channels (MSO2000B series only).

Checking Trigger Settings

To quickly determine the settings of some key trigger parameters, check the Trigger readout at the bottom of the display. The readouts differ for edge and the advanced triggers.



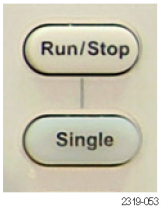
Edge trigger readout

1. Trigger source = channel 1.
2. Trigger slope = rising.
3. Trigger level = 1.84 V.
4. 6-Digit Trigger Frequency Readout = 68.901 Hz.

Starting and Stopping an Acquisition

After you have defined the acquisition and trigger parameters, start the acquisition with **Run/Stop** or **Single**.

- Push **Run/Stop** to start acquisitions. The oscilloscope acquires repeatedly until you push the button again to stop the acquisition.
- Push **Single** to take a single acquisition. Single sets the trigger mode to **Normal** for the single acquisition.



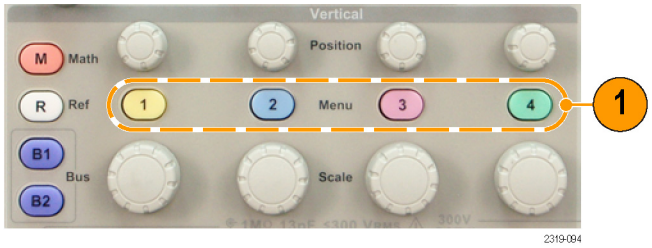
Display Waveform Data

This section contains concepts and procedures for displaying the acquired waveform.

Adding and Removing a Waveform

1. To add or remove a waveform from the display, push the corresponding front-panel channel button or the D15-D0 button.

   You can use the channel as a trigger source whether or not it is displayed.



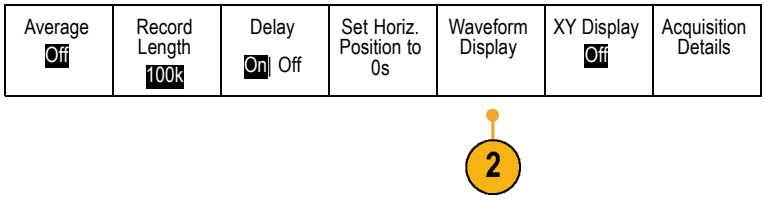


Setting the Display Style and Persistence

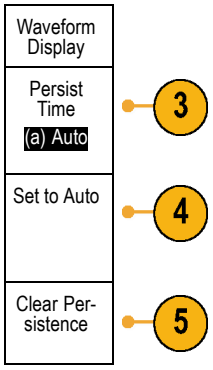
1. To set the display style, push **Acquire**.



2. Push **Waveform Display**.



3. Push **Persist Time**, and turn multipurpose knob **a** to have waveform data remain on screen for a user-specified amount of time.
4. Push **Set to Auto** to have the oscilloscope automatically determine a persistence time for you.
5. Push **Clear Persistence** to reset the persistence information.



Quick Tips

- Variable persistence accumulates sampled waveform points for a specified time interval. Each sampled waveform decays independently according to the time interval. Use variable persistence for displaying infrequently appearing signal anomalies, such as glitches.
- Infinite persistence continuously accumulates record points until you change one of the acquisition display settings. Use infinite persistence for displaying unique signal anomalies, such as glitches.

XY Display Mode

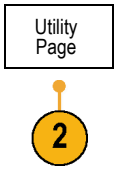
The XY Display mode graphs the data in fixed pairs of waveforms against one another. You can use CH1 versus CH2, and REF1 versus REF2. On four-channel models, you can also use CH3 versus CH4.

Setting the Graticule Style

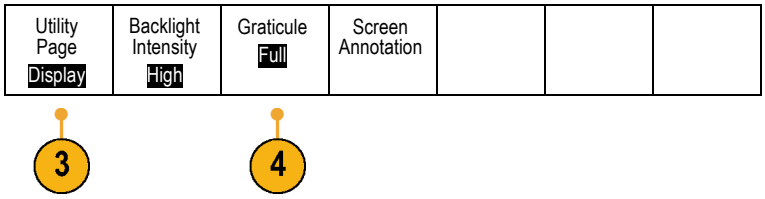
1. To set the graticule style, push **Utility**.



2. Push **Utility Page**.



3. Turn multipurpose knob **a** and select **Display**.



4. Push **Graticule** from the lower-bezel menu.

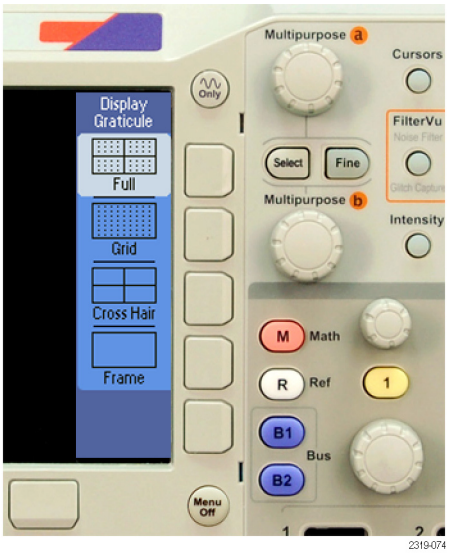
5. Select the desired style from the resulting side-bezel menu.

   Use the **Full** graticule for quick estimates of waveform parameters.

   Use the **Grid** graticule for full-screen measurements with cursors and automatic readouts when cross hairs are not needed.

   Use the **Cross Hair** graticule for making quick estimates of waveforms while leaving more room for automatic readouts and other data.

   Use the **Frame** graticule with automatic readouts and other screen text when display features are not needed.



Quick Tips

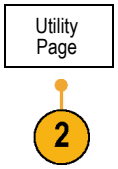
- You can display IRE and mV graticules. To do this, set the trigger type to video and set the vertical scale to 143 mV/division. (The 143 mV/division selection is available in the coarse vertical scale settings for the channel when you set the trigger type to video.) The oscilloscope will automatically display the IRE graticule for NTSC signals, and the mV graticule for other video signals (PAL, SECAM, and custom).

Setting the LCD Backlight

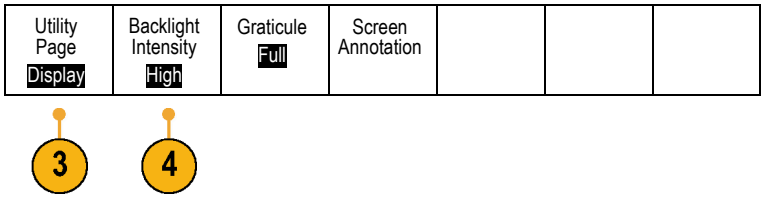
1. Push **Utility**.



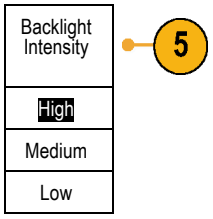
2. Push **Utility Page**.



3. Turn multipurpose knob **a** and select **Display**.
4. Push **Backlight Intensity**.



5. Select the intensity level from the resulting side-bezel menu. Choices are: **High**, **Medium**, and **Low**.

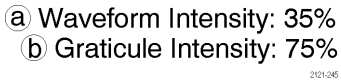


Setting Waveform Intensity

1. Push the front-panel **Intensity** button.



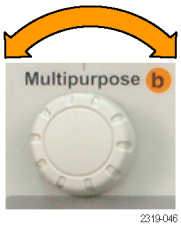
This will bring up the intensity readout on the display.



2. Turn multipurpose knob **a** to select the desired intensity for the waveform.



3. Turn multipurpose knob **b** to select the desired intensity for the graticule.



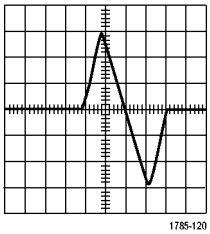
4. Push **Intensity** again to clear the intensity readout from the display.



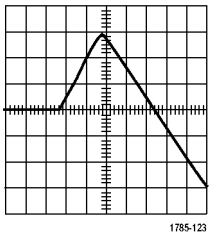
Scaling and Positioning a Waveform

Use the horizontal controls to adjust the time base, adjust the trigger point, and to examine waveform details more closely. You can also use the Wave Inspector Pan and Zoom controls to adjust the display of waveforms. (See page 105, *Using Wave Inspector to Manage Long Record Length Waveforms*.)

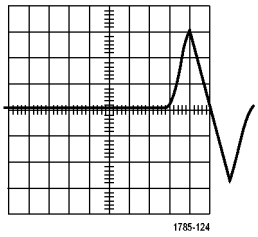




Original waveform



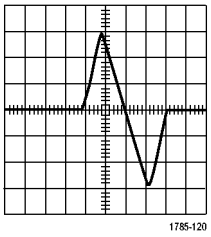
Scaled horizontally



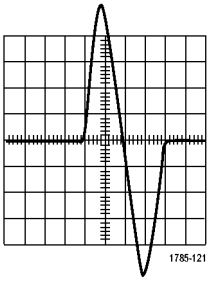
Positioned horizontally

Use the vertical controls to select waveforms, adjust the waveform vertical position and scale, and set input parameters. Push a channel menu button (**1**, **2**, **3**, or **4**) as many times as needed and the associated menu items to select, add, or remove a waveform.

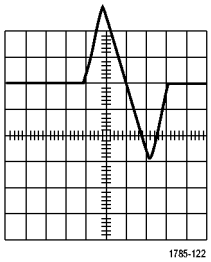




Original waveform



Scaled vertically



Positioned vertically

Quick Tips

- **Preview.** If you change the Position or Scale controls when the acquisition is stopped or when it is waiting for the next trigger, the oscilloscope rescales and repositions the relevant waveforms in response to the new control settings. It simulates what you will see when you next push the **RUN** button. The oscilloscope uses the new settings for the next acquisition.

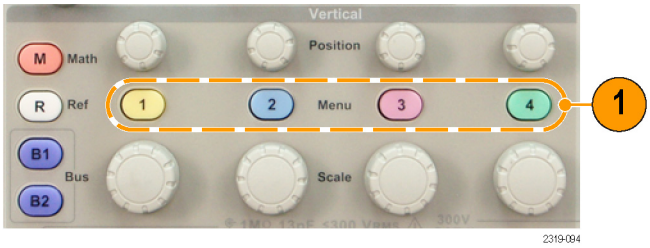
  You may see a clipped waveform if the original acquisition went off the screen.

  The math waveform, cursors, and automatic measurements remain active and valid when using preview.

Setting Input Parameters

Use the vertical controls to select waveforms, adjust the waveform vertical position and scale, and set input parameters.

1. Push a channel menu button **1**, **2**, **3**, or **4** to bring up the vertical menu for the designated waveform. The vertical menu only affects the selected waveform.



   Pushing a channel button will also select or cancel that waveform selection.

2. Push **Coupling** repeatedly to select the coupling to use.

   Use DC coupling to pass both AC and DC components.

   Use AC coupling to block the DC component and show only the AC signal.

   Use Ground (GND) to display the reference potential.

3. Push **Invert** to invert the signal.

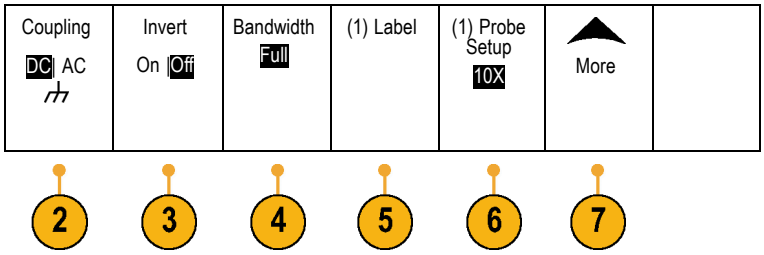
   Select **Off** for normal operation and **On** to invert the polarity of the signal in the preamplifier.

4. Push **Bandwidth**, and select the desired bandwidth from the resulting side-bezel menu.

   The default choices are Full and 20 MHz. Additional choices may appear, depending on the probe that you use.

   Select **Full** to set the bandwidth to the full oscilloscope bandwidth.

   Select **20 MHz** to set the bandwidth to 20 MHz.



5. Push **Label** to create a label for the channel. (See page 41, *Labeling Channels and Buses*.)
6. Push **Probe Setup** to define probe parameters.

   On the resulting side-bezel menu:

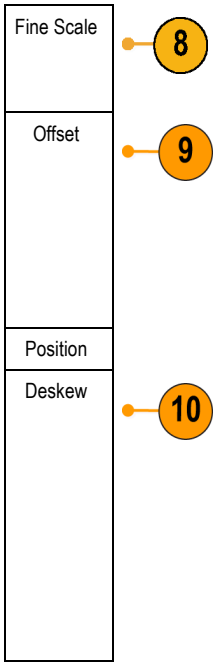
   - Select **Voltage** or **Current** to set the probe type for probes that do not have the TekProbe II or TekVPI interface.
   - Use multipurpose knob **a** to set the attenuation to match the probe.
7. Push **More** to access additional side-bezel menus.

8. Select **Fine Scale** to enable multipurpose knob **a** to make fine vertical scale adjustments.
9. Select **Offset** to enable multipurpose knob **a** to make vertical offset adjustments.

   On the side-bezel menu, choose **Set to 0 V** to set the vertical offset to 0 V.

   For more information on offset, see **Quick Tips**. (See page 83, *Quick Tips*.)

10. Select **Deskew** to set the time skew correction for the channel. Turn multipurpose knob **a** to adjust the time skew (deskew) correction for the probe attached to the selected channel. This shifts acquisition and display of the waveform left or right, relative to the trigger time. Use this to compensate for differences in cable lengths or probe types.



Quick Tips

- **Using Probes with the TekProbe II and TekVPI Interfaces.** When you attach a probe with the TekProbe II or the TekVPI interface, the oscilloscope sets the channel sensitivity, coupling, and termination resistance automatically to match the probe requirements. Tek Probe II probes require use of the TPA-BNC Adapter. TekVPI probes require the use of a 119-7465-XX external power supply.
- **The Difference Between Vertical Position and Offset.** Vertical position is a display function. Adjust the vertical position to place the waveforms where you want to see them. The waveform baseline locations track adjustments made to their positions.

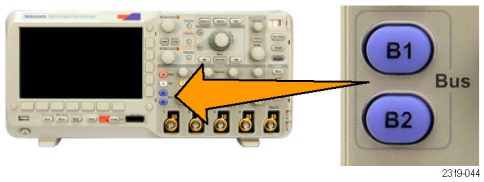
  When you adjust vertical offset, you see a similar effect, but it is actually quite different. Vertical offset is applied before the oscilloscope preamplifier and can be used to increase the effective dynamic range of the inputs. For example, you can use vertical offset to look at small variations in a large DC voltage. Set the vertical offset to match the nominal DC voltage and the signal appears in the center of the screen.

Positioning and Labeling Bus Signals

After you set up a serial or parallel bus, you can position and label the bus signals. (See page 49, *Setting Up a Serial or Parallel Bus*.)

To position bus signals, follow these steps:

1. Push the appropriate front-panel bus button to select that bus.

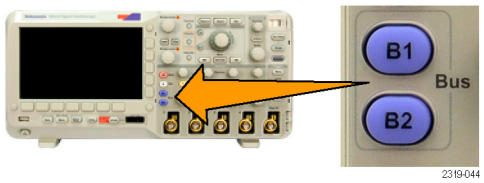


2. Turn multipurpose knob **a** to adjust the vertical position of the selected bus.

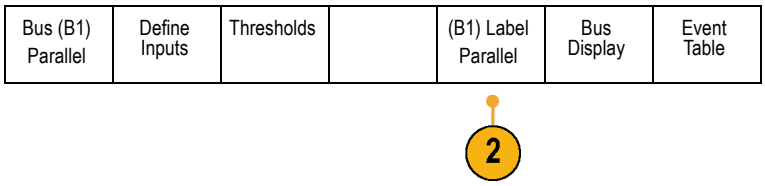


To label a bus, follow these steps:

1. Push the appropriate front-panel bus button.



2. Push **Label**. (See page 41, *Labeling Channels and Buses*.)



Positioning, Scaling, and Grouping Digital Channels

To display digital channels, follow these steps:

1. Push the front-panel **D15–D0** button.

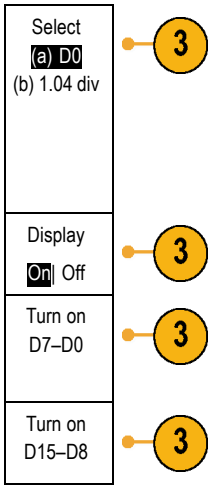


2. Push the lower-bezel **D15–D0 On/Off** menu item.



3. Push **Select**, and turn multipurpose knob **a** to select a channel from the list. Then push **Display** to turn on (or turn off) the waveform.

   You can see groups at the end of the list by turning multipurpose knob **a** fully counterclockwise.



   Push the appropriate side-bezel button to turn on all the channels in the D7–D0 group or in the D15–D8 group.

To position and group digital channels, follow these steps:

1. Push the front-panel **D15–D0** button.



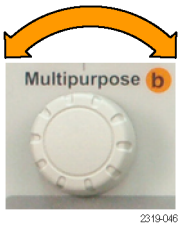
2. Turn multipurpose knob **a** to select the channel or group to move.



3. To group some or all of the channels, select and move the channels next to each other in the display.

4. Turn multipurpose knob **b** to move the selected channel or group.

NOTE. The display of the channel (or group) only moves after you stop rotating the knob.



To scale and label digital channels, follow these steps:

1. Push the front-panel **D15–D0** button.



2. To change the scale (height) of the digital channels, push the lower-menu **Height** button.

	D15 – D0 On/Off	Thresholds	Edit Labels	Height S | M L		



*NOTE. The **S** (Small) selection will display each waveform at 0.2 divisions tall. The **M** (Medium) selection will display each waveform at 0.5 divisions tall. The **L** (Large) selection will display each waveform at 1 division tall. **L** only works if there is enough room in the display to display the waveforms. You can display up to 8 **L** waveforms at one time.*

3. You can label individual digital channels for easier identification. (See page 41, *Labeling Channels and Buses*.)

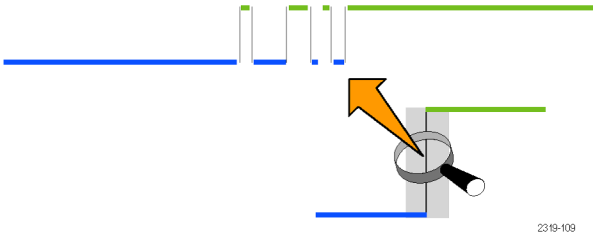
Viewing Digital Channels

The various ways of displaying data from the digital channels help you analyze the signals. Digital channels store a high or low state for each sample.

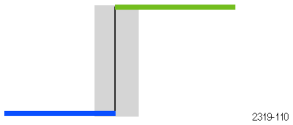
Logic high levels are displayed in green. Logic low levels are displayed in blue. When a single transition occurs during the time represented by one pixel column, the transition (edge) is displayed in gray.

When multiple transitions occur during the time represented by one pixel column, the transition (edge) is displayed in white.

When the display shows a white edge, indicating multiple transitions, you may be able to zoom in and see the individual edges.



When you are zoomed in so far that there is more than one pixel column per sample, the uncertainty of the edge position is indicated by light gray shading.



Annotating the Screen

You can add your own text to the screen by doing the following:

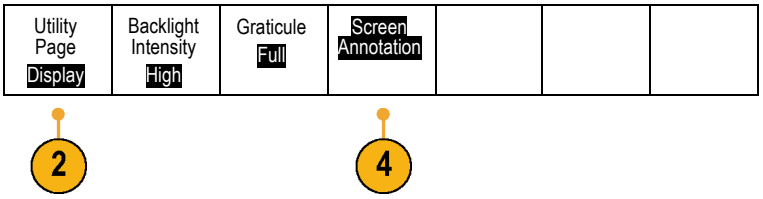
1. Push **Utility**.



2. Push **Utility Page**.



3. Turn multipurpose knob **a** and select **Display**.
4. Push **Screen Annotation** from the resulting lower-bezel menu.



5. Push **Display Annotation** to select **On** from the side-bezel menu.

   The annotation window now appears. Position it by turning multipurpose knobs **a** and **b**.
6. Push **Edit Annotation** from the side-bezel menu. You can add up to 1,000 characters or a full screen.
7. Turn multipurpose knob **a** to scroll through the list of letters, numbers, and other characters to select each desired character.

   Alternatively, use a USB keyboard to type in characters. (See page 25, *Connecting a USB Keyboard to Your Oscilloscope*.)

   To reposition the annotated text, press the side-bezel **Position** button and turn multipurpose knobs **a** and **b**, as desired.

Analyze Waveform Data

After having properly set up the acquisition, triggering, and display of your desired waveform, you can then analyze the results. Select from features such as cursors, automatic measurements, math, and FFT.

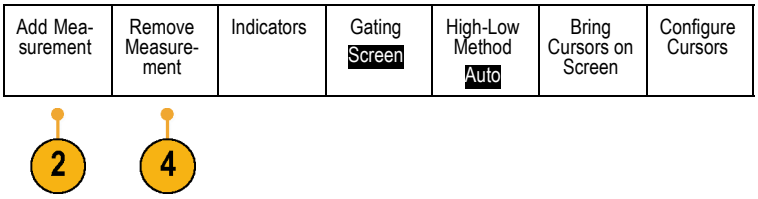
Taking Automatic Measurements

To take an automatic measurement:

1. Push **Measure**.



2. Push **Add Measurement**.



3. Turn multipurpose knob **a** to select the specific measurement. If needed, then turn multipurpose knob **b** to select the channel to measure on. Then push **OK Add Measurement**.



4. To remove a measurement, push **Remove Measurement**. Then push the side-bezel menu for the measurement you want to remove, or **Remove All**. Then push **OK Remove Measurement**.

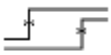
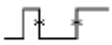
Quick Tips

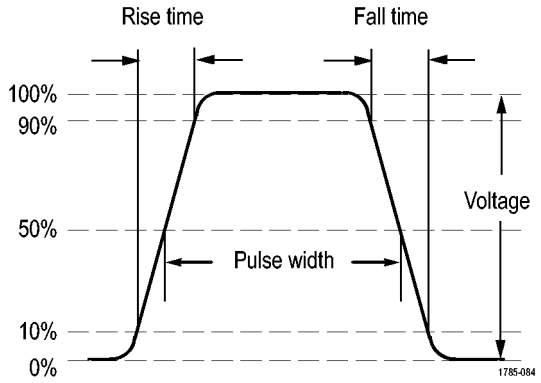
- To remove all measurements, select **Remove All Measurements**.
- A ⚠ symbol appears instead of the expected numerical measurement if a vertical clipping condition exists. Part of the waveform is above or below the display. To obtain a proper numerical measurement, turn the vertical scale and position knobs to make all of the waveform appear in the display.

Selecting Automatic Measurements

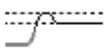
The following tables list each automatic measurement by category: time or amplitude. (See page 89, *Taking Automatic Measurements*.)

Time Measurements

Measurement		Description
Frequency		The first cycle in a waveform or gated region. Frequency is the reciprocal of the period; it is measured in hertz (Hz) where one Hz is one cycle per second.
Period		The time required to complete the first cycle in a waveform or gated region. Period is the reciprocal of frequency and is measured in seconds.
Rise Time		The time required for the leading edge of the first pulse in the waveform or gated region to rise from the low reference value to the high reference value of the final value.
Fall Time		The time required for the falling edge of the first pulse in the waveform or gated region to fall from the high reference value to the low reference value of the final value.
Delay		The time between the mid reference (default 50%) amplitude point of two different waveforms. See also *Phase*.
Phase		The amount of time that one waveform leads or lags another waveform, expressed in degrees where 360° makes up one waveform cycle. See also *Delay*.
Positive Pulse Width		The distance (time) between the mid reference (default 50%) amplitude points of a positive pulse. The measurement is made on the first pulse in the waveform or gated region.
Negative Pulse Width		The distance (time) between the mid reference (default 50%) amplitude points of a negative pulse. The measurement is made on the first pulse in the waveform or gated region.
Positive Duty Cycle		The ratio of the positive pulse width to the signal period expressed as a percentage. The duty cycle is measured on the first cycle in the waveform or gated region.
Negative Duty Cycle		The ratio of the negative pulse width to the signal period expressed as a percentage. The duty cycle is measured on the first cycle in the waveform or gated region.
Burst Width		The duration of a burst (a series of transient events) and is measured over the entire waveform or gated region.

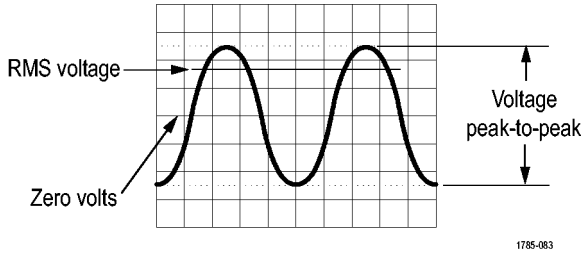


Amplitude Measurements

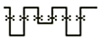
Measurement		Description
Peak-to-peak		The absolute difference between the maximum and minimum amplitude in the entire waveform or gated region.
Amplitude		The high value less the low value measured over the entire waveform or gated region.
Max		The most positive peak voltage. Max is measured over the entire waveform or gated region.
Min		The most negative peak voltage. Min is measured over the entire waveform or gated region.
High		This value is used as 100% whenever high reference, mid reference, or low reference values are needed, such as in fall time or rise time measurements. Calculate using either the min/max or histogram method. The min/max method uses the maximum value found. The histogram method uses the most common value found above the midpoint. This value is measured over the entire waveform or gated region.
Low		This value is used as 0% whenever high reference, mid reference, or low reference values are needed, such as in fall time or rise time measurements. Calculate using either the min/max or histogram method. The min/max method uses the minimum value found. The histogram method uses the most common value found below the midpoint. This value is measured over the entire waveform or gated region.
Positive Overshoot		This is measured over the entire waveform or gated region and is expressed as: Positive Overshoot = (Maximum – High) / Amplitude x 100%.
Negative Overshoot		This is measured over the entire waveform or gated region and is expressed as: Negative Overshoot = (Low – Minimum) / Amplitude x 100%.
Mean		The arithmetic mean over the entire waveform or gated region.
Cycle Mean		The arithmetic mean over the first cycle in the waveform or the first cycle in the gated region.

Amplitude Measurements (cont.)

Measurement		Description
RMS		The true Root Mean Square voltage over the entire waveform or gated region.
Cycle RMS		The true Root Mean Square voltage over the first cycle in the waveform or the first cycle in the gated region.



Miscellaneous Measurements

Measurement		Description
Positive Pulse Count		The number of positive pulses that rise above the mid reference crossing in the waveform or gated region.
Negative Pulse Count		The number of negative pulses that fall below the mid reference crossing in the waveform or gated region.
Rising Edge Count		The number of positive transitions from the low reference value to the high reference value in the waveform or gated region.
Falling Edge Count		The number of negative transitions from the high reference value to the low reference value in the waveform or gated region.
Area		A voltage over time measurement. The measurement returns the area over the entire waveform or gated region in volt-seconds. Area measured above ground is positive; area measured below ground is negative.
Cycle Area		A voltage over time measurement. The measurement is the area over the first cycle in the waveform or the first cycle in the gated region expressed in volt-seconds. The area above the common reference point is positive, and the area below the common reference point is negative.

Customizing an Automatic Measurement

You can customize automatic measurements by using gating, taking a snapshot, or setting the high and low levels.

Gating

Gating confines the measurement to a certain portion of a waveform. To use:

1. Push **Measure**.



2. Push **Gating**.

Add Measurement	Remove Measurement	Indicators	Gating Screen	High-Low Method Auto	Bring Cursors On Screen	Configure Cursors



3. Position the gates from the side-bezel menu options.

Gating
Off (Full Record)
Screen
Between Cursors

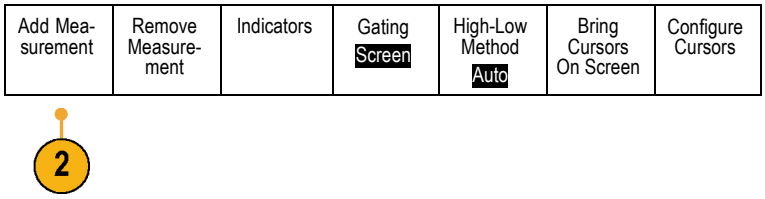
Snapshot All

To see all the single-sourced measurements at one time:

1. Push **Measure**.



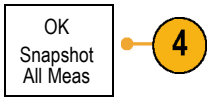
2. Push **Add Measurement** .



3. Turn multipurpose knob **a** to select the **Measurement Type** of **Snapshot All**.



4. Push **OK Snapshot All Meas**.



5. View results.

Snapshot on 1

Period	: 312.2µs	Freq	: 3.203kHz
+Width	: 103.7µs	–Width	: 208.5µs
Burst W	: 936.5µs		
Rise	: 1.452µs	Fall	: 1.144µs
+Duty	: 33.23%	–Duty	: 66.77 %
+Over	: 7.143%	–Over	: 7.143 %
High	: 9.200 V	Low	: -7.600 V
Max	: 10.40 V	Min	: -8.800 V
Ampl	: 16.80 V	Pk-Pk	: 19.20 V
Mean	: -5.396 V	CycleMean	: -5.396 V
RMS	: 7.769 V	CycleRMS	: 8.206 V
Area	: -21.58mVs	CycleArea	: -654.6µVs
+Edges	:7	–Edges	:7
+Pulses	:6	–Pulses	:6

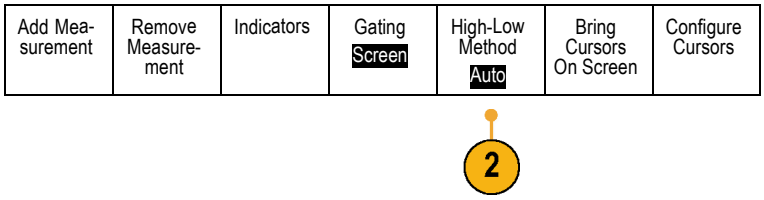
High and Low Levels

The High-Low Method determines the high (100%) and the low (0%) values of the waveform or gated region. For descriptions of how measurements use the high and low levels, refer to *Selecting Automatic Measurements*. (See page 90.)

1. Push **Measure**.



2. Push **High-Low Method**.



3. Set the levels from the side-bezel menu.

Auto Select
Histogram (best for pulses)
Min-Max (all other wave-forms)

Use the Histogram method for pulses.

Use the Min-Max method for all other waveforms.

For descriptions of the high and low measurements, refer to the table of Amplitude Measurements under *Selecting Automatic Measurements*. (See page 91.)

Taking Manual Measurements with Cursors

Cursors are on-screen markers that you position in the waveform display to take manual measurements on acquired data. They appear as horizontal and/or as vertical lines. To use cursors on analog or digital channels:

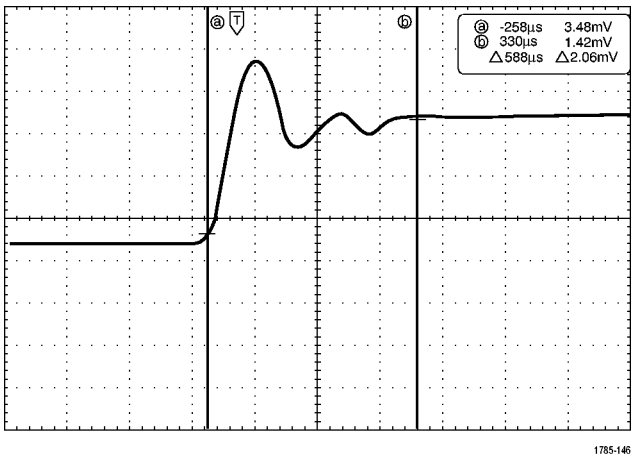
1. Push **Cursors**.



This changes the cursor state. The three states are:

- No cursors appear on the screen.
- Two vertical waveform cursors appear. They are attached to the selected analog waveform or digital waveforms.
- Four screen cursors appear. Two are vertical and two are horizontal. They are no longer specifically attached to a waveform.

2. Push **Cursors** again.



In the example, two vertical cursors appear on the selected screen waveform. As you turn multipurpose knob **a**, you move one cursor to the right or left. As you turn knob **b**, you move the other cursor.

If you change the selected waveform by pushing the front-panel **1**, **2**, **3**, **4**, **M**, **R**, or **D15-D0** button, both cursors jump to the new selected waveform.

3. Push **Select**.

   This turns the cursor linking on and off. If linking is on, turning multipurpose knob **a** moves the two cursors together. Turning multipurpose knob **b** adjusts the time between the cursors.



4. Push **Fine** to toggle between a coarse and a fine adjustment for multipurpose knobs **a** and **b**.

   Pushing **Fine** also changes the sensitivity of other knobs as well.

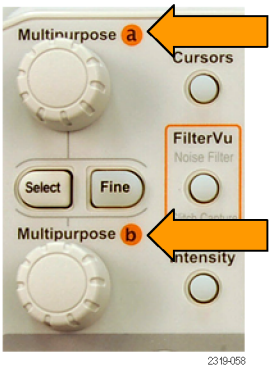


5. Push **Cursors** again.

   This will put the cursors into screen mode. Two horizontal bars and two vertical bars span the graticule.



6. Turn multipurpose knobs **a** and **b** to move the pair of horizontal cursors.



7. Push **Select**.

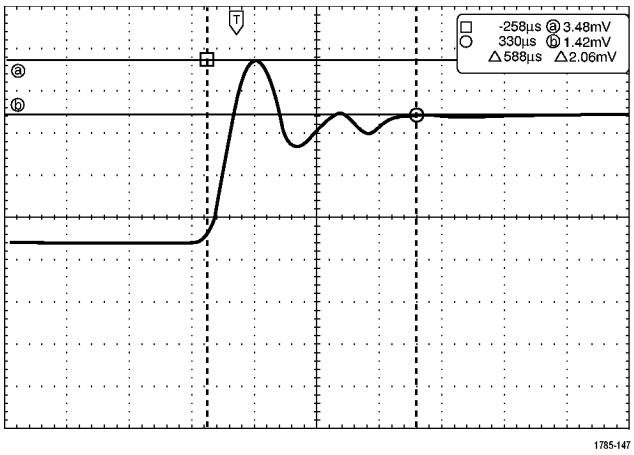
   This makes the vertical cursors active and the horizontal ones inactive. Now, as you turn the multipurpose knobs, the vertical cursors will move.

   Push **Select** again to make the horizontal cursors active again.



8. View the cursor and the cursor readout.

   You can take timing measurements with cursors on digital channels, but not amplitude measurements.



9. Push **Cursors** again. This will turn off the cursor mode. The screen will no longer display the cursors and the cursor readout.



Using Cursor Readouts

Cursor readouts supply textual and numeric information relating to the current cursor positions. The oscilloscope always shows the readouts when the cursors are turned on.

Readouts appear in the upper right corner of the graticule. If Zoom is on, the readout appears in the upper right corner of the zoom window.

When a bus is selected, the readout shows the decoded bus data in the format you have selected, hexadecimal, binary, or ASCII (RS-232 only). When a digital channel is selected, the cursors show the values of all displayed digital channels.

NOTE. *When buses are selected, the data value at that point is displayed in the cursor readout.*

Δ Readout:

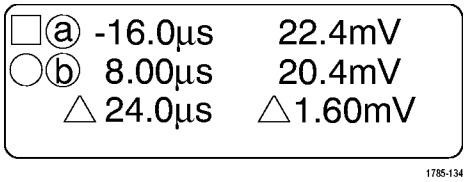
The Δ readouts indicate the difference between the cursor positions.

a Readout:

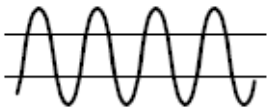
Indicates that the value is controlled by multipurpose knob **a**.

b Readout:

Indicates that the value is controlled by multipurpose knob **b**.



The horizontal cursor lines on the display measure the vertical parameters, typically voltage.



The vertical cursor lines on the display measure horizontal parameters, typically time.



The square and circle shapes in the readout map to the multipurpose knobs when both vertical and horizontal cursors are present.

Using XY Cursors

When the XY Display mode is on, the cursor readouts will appear to the right of the lower graticule (XY). You can choose which readouts to display: rectangular, polar, product, or ratio.

NOTE. *Push the* ***Measure*** *button for additional cursor menu options, such as* ***Bring Cursors On Screen*** *and* ***Configure Cursors****.*

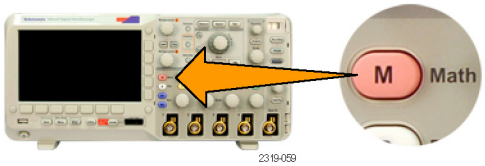
Using Math Waveforms

Create math waveforms to support the analysis of your channel and reference waveforms. By combining and transforming source waveforms and other data into math waveforms, you can derive the data view that your application requires.

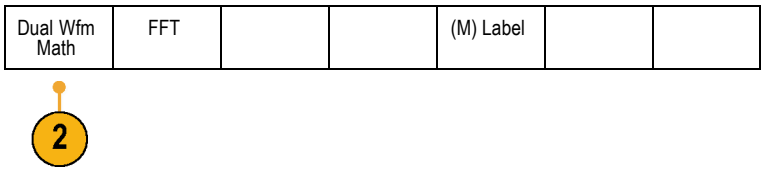
NOTE. *Math waveforms are not available for use with serial buses.*

Use the following procedure for executing simple (+, –, ×) math operations on two waveforms:

1. Push **M** for the Math menu.

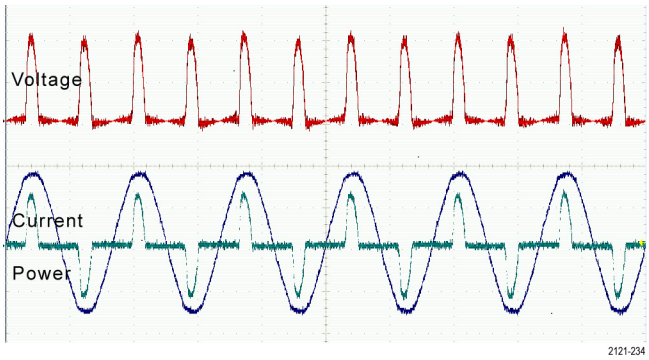


2. Push **Dual Wfm Math**.



3. On the side-bezel menu, set the sources to channel **1**, **2**, **3**, **4**, or to reference waveforms **R1** or **R2**. Choose the **+**, **–**, or **x** operators.

For example, you might calculate power by multiplying a voltage waveform and a current waveform.



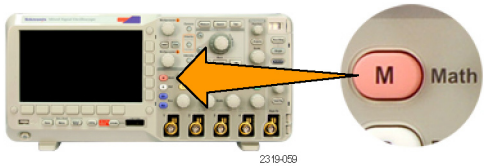
Quick Tips

- Math waveforms can be created from channel or reference waveforms or a combination of them.
- Measurements can be taken on math waveforms in the same way as on channel waveforms.
- Math waveforms derive their horizontal scale and position from the sources in their math expressions. Adjusting these controls for the source waveforms also adjusts the math waveform.
- You can zoom in on math waveforms using the inner knob of the Pan-Zoom control. Use the outer knob for positioning the zoomed area. (See page 105, *Using Wave Inspector to Manage Long Record Length Waveforms*.)
- Both math sources must have the same record length.

Using FFT

An FFT breaks down signals into component frequencies, which the oscilloscope uses to display a graph of the frequency domain of a signal, as opposed to the oscilloscope's standard time domain graph. You can match these frequencies with known system frequencies, such as system clocks, oscillators, or power supplies.

1. Push **Math**.

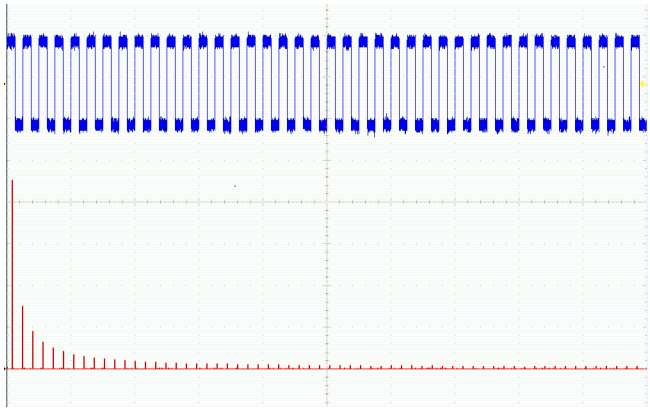


2. Push **FFT**.

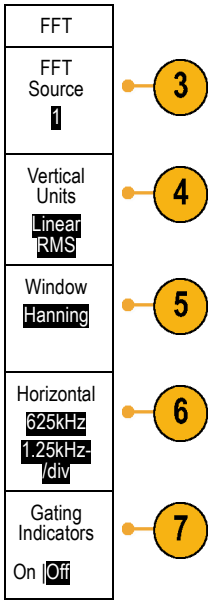
Dual Wfm Math	FFT		About FFT	(M) Label		



The FFT will appear on the display.



3. Push the side-bezel menu **FFT Source** button and turn multipurpose knob **a** to set the source to channel **1**, **2**, **3**, or to **4**.
4. Push **Vertical Units** and turn multipurpose knob **a** to select dBV RMS or Linear RMS.
5. Push **Window** and turn multipurpose knob **a** to select Rectangular, Hamming, Hanning, or Blackman-Harris.
6. Push the side-bezel **Horizontal** button to activate multipurpose knobs **a** and **b** to pan and zoom the FFT display.
7. Push the side-bezel **Gating Indicators** button to activate the visual gating indicators, which show the FFT area of analysis.



These are some important details about operating the FFT feature on this oscilloscope:

- The area of the source waveform used to calculate the FFT is usually slightly less than one screen width of data. To see this area, turn on the gating indicators.
- The FFT is calculated from 5,000 points (typical) of the source waveform. When the input area contains more than 5,000 points, the area is reduced in resolution (that is, the number of samples is reduced).
- When the input area is off the screen, the FFT cannot be calculated. To display your waveform on screen, push **Acquire -> Set Horiz. Position to 0s**.

Aliasing

The largest frequency in the FFT spectrum is called the Nyquist frequency. Frequency components above the Nyquist frequency will appear on screen to be below the Nyquist frequency. This is called aliasing. To eliminate aliases, try the following remedies:

- Set up the FFT so that the Nyquist frequency is above the major frequency components of your signal. To do this, adjust the Horizontal time/div, which affects the Nyquist frequency.
- Use the FilterVu low-pass filter to remove aliases from the source waveform. To do this, set the filter frequency to its minimum value (while zoom is off and acquisitions are running). Aliased frequencies are reduced to no more than 1% of their original amplitude. Using a filter frequency above the minimum can reduce, but not eliminate, aliasing.
- Recognize and ignore the aliased frequencies.

NOTE. *The Nyquist frequency is one-half the sample rate. When the FFT is taken from a reduced-resolution waveform, the Nyquist frequency will be half of the reduced sample rate of the waveform, not half of the full sample rate of the oscilloscope.*

Quick Tips

- If desired, use the zoom feature along with the horizontal **Position** and **Scale** controls to magnify and position the FFT waveform.
- Use the default dBV RMS scale to see a detailed view of multiple frequencies, even if they have very different amplitudes. Use the linear RMS scale to see an overall view of how all frequencies compare to each other.
- The FFT feature provides four windows. Each is a trade-off between frequency resolution and magnitude accuracy. What you want to measure and your source signal characteristics help determine which window to use. Use the following guidelines to select the best window.

Description	Window
Hanning This is a very good window for measuring amplitude accuracy but less so for resolving frequencies. Use Hanning for measuring sine, periodic, and narrow band random noise. This window works on transients or bursts where the signal levels before and after the event are significantly different.	
Rectangular This is the best type of window for resolving frequencies that are very close to the same value but worst for accurately measuring the amplitude of those frequencies. It is the best type for measuring the frequency spectrum of nonrepetitive signals and measuring frequency components near DC. Use Rectangular for measuring transients or bursts where the signal level before and after the event are nearly equal. Also, use this window for equal-amplitude sine waves with frequencies that are very close and for broadband random noise with a relatively slow varying spectrum.	
Hamming This is a very good window for resolving frequencies that are very close to the same value with somewhat improved amplitude accuracy over the rectangular window. It has a slightly better frequency resolution than the Hanning. Use Hamming for measuring sine, periodic, and narrow band random noise. This window works on transients or bursts where the signal levels before and after the event are significantly different.	

Description	Window
Blackman-Harris This is the best window for measuring the amplitude of frequencies but worst at resolving frequencies. Use Blackman-Harris for measuring predominantly single frequency waveforms to look for higher order harmonics.	

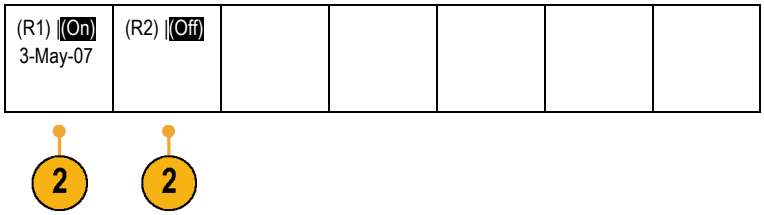
Using Reference Waveforms

Create a reference waveform to store a waveform. For example, you might do this to set up a standard against which to compare other waveforms. To use the reference waveforms:

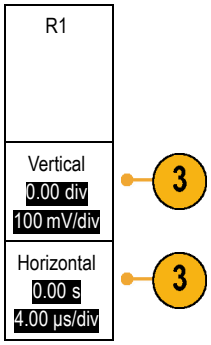
1. Push **Ref R**. This brings up the lower-bezel reference menu.



2. Use the resulting lower-bezel menu selections to display or select a reference waveform.



3. Use the side-bezel menu and the multipurpose knobs to adjust the vertical and horizontal settings of the reference waveform.



Quick Tips

- Selecting and Displaying Reference Waveforms. You can display all the reference waveforms at the same time. Push the appropriate screen button to select a particular reference waveform.
- Removing Reference Waveforms from the Display. To remove a reference waveform from the display, push the front-panel **R** button to access the lower-bezel menu. Then push the associated button from the lower-bezel menu to turn it off.
- Scaling and Positioning a Reference Waveform. You can position and scale a reference waveform independently from all other displayed waveforms. Select the reference waveform and then adjust it with a multipurpose knob. You can do this whether acquisition is running or not.

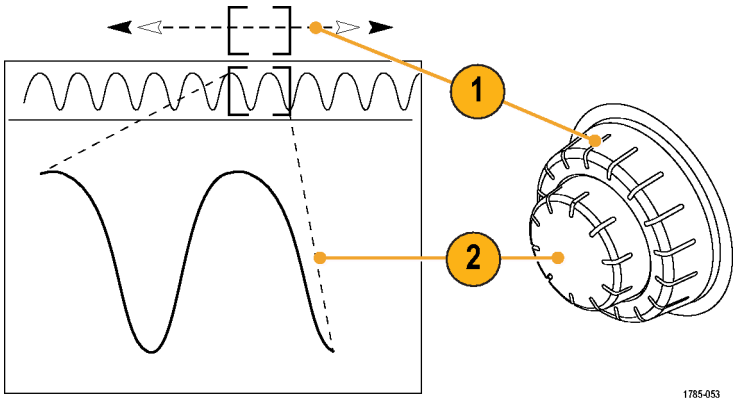
  If a reference waveform is selected, scaling and repositioning of the reference waveform operates the same way whether zoom is turned on or off.

Using Wave Inspector to Manage Long Record Length Waveforms

The Wave Inspector controls (zoom/pan, play/pause, marks, search) help you to efficiently work with long record length waveforms. To magnify a waveform horizontally, turn the Zoom knob (center knob). To scroll through a zoomed waveform, turn the Pan knob.

The Pan-Zoom Control consists of:

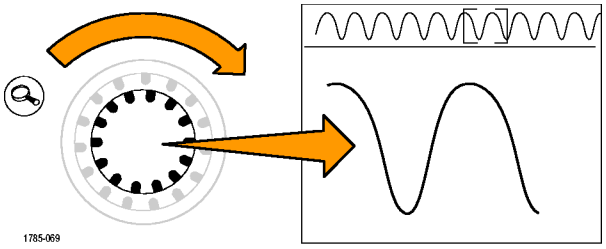
1. An outer pan knob
2. An inner zoom knob



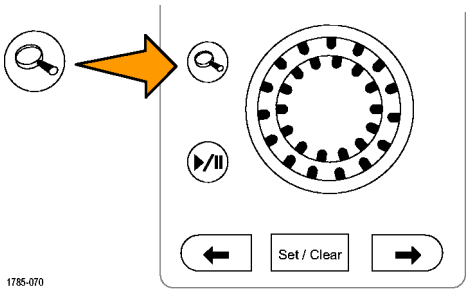
Zooming a Waveform

To use zoom:

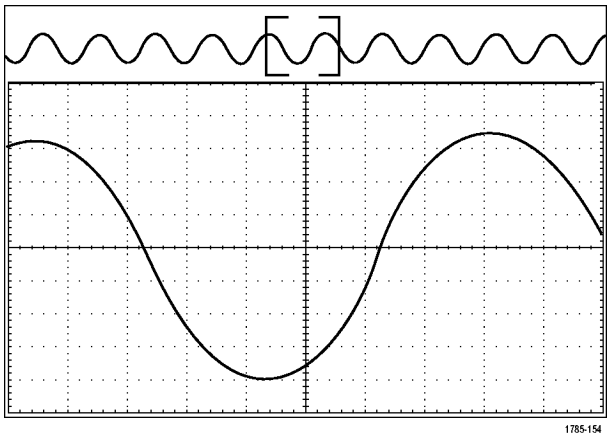
1. Turn the inner knob on the Pan-Zoom control clockwise to zoom in on a selected portion of the waveform. Turn the knob counterclockwise to zoom back out.



2. Alternatively, enable or disable the zoom mode by pushing the zoom button.



3. Examine the zoomed view of the waveform that appears on the larger, lower portion of the display. The upper portion of the display will show the position and size of the zoomed portion in the waveform, within the context of the overall record.

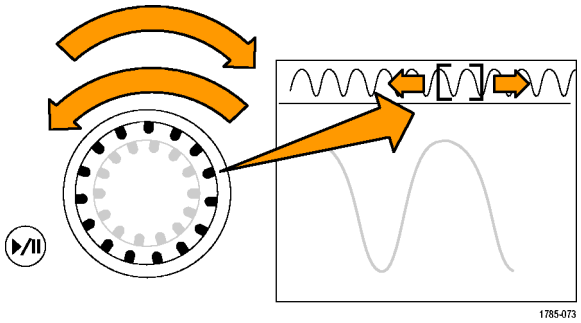


Panning a Waveform

While the zoom feature is on, you can use the pan feature to quickly scroll through the waveform. To use pan:

1. Turn the pan (outer) knob of the pan-zoom controls to pan the waveform.

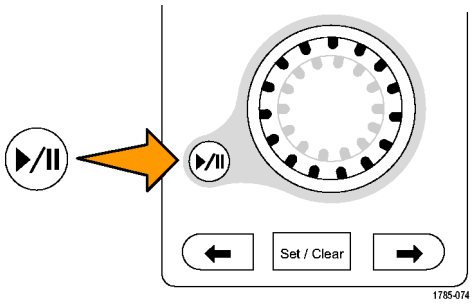
   Turn the knob clockwise to pan forward. Turn it counterclockwise to pan backwards. The further you turn the knob, the faster the zoom window pans.



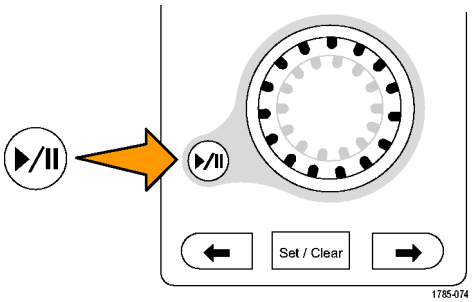
Playing and Pausing a Waveform

Use the play-pause feature to automatically pan through a waveform record. To use it:

1. Enable the play-pause mode by pushing the play-pause button.
2. Adjust the play speed by turning the pan (outer) knob further. The further you turn it, the faster it goes.



3. Change the play direction by reversing the direction that you are turning the pan knob.
4. During play, up to a point, the more you turn the ring, the faster the waveform accelerates. If you turn the ring as far as it can go, the play speed does not change, but the zoom box quickly moves in that direction. Use this maximum rotation feature to replay a portion of the waveform that you just saw and want to see again.
5. Pause the play-pause feature by pushing the play-pause button again.



Searching and Marking Waveforms

You can mark locations of interest in the acquired waveform. These marks help you limit your analysis to particular regions of the waveform. You can mark areas of the waveform automatically, if they meet some special criteria, or you can manually mark each item of interest. You can use arrow keys to jump from mark to mark (area of interest to area of interest). You can automatically search and mark many of the same parameters that you can trigger on.

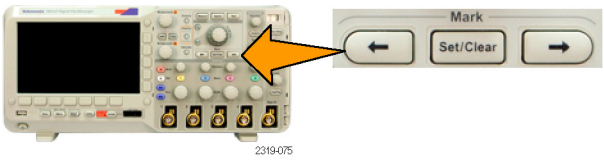
Search marks provide a way to mark a waveform region for reference. You can set marks automatically with search criteria. You can search for and mark regions with particular edges, pulse widths, runts, logic states, rise/fall times, setup and hold, and bus search types.

To manually set and clear (delete) marks:

1. Move (the zoom box) to the area on the waveform where you want to set (or clear) a search mark by turning the pan (outer) knob.

   Push the next (→) or previous (←) arrow button to jump to an existing mark.
2. Push **Set/Clear**.

   If no search mark is at the screen center, the oscilloscope will add one.



3. Investigate your waveform by moving from search mark to search mark. Use the next (→) or previous (←) arrow button to jump from one marked location to another, without adjusting any other controls.

4. Delete a mark. Push the next (→) or previous (←) arrow button to jump to the mark you want to clear. To remove the current, center-positioned mark, push **Set/Clear**. It works on both manually and automatically created marks.

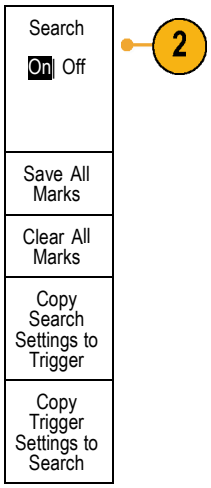
To automatically set and clear (delete) search marks:

1. Push **Search**.

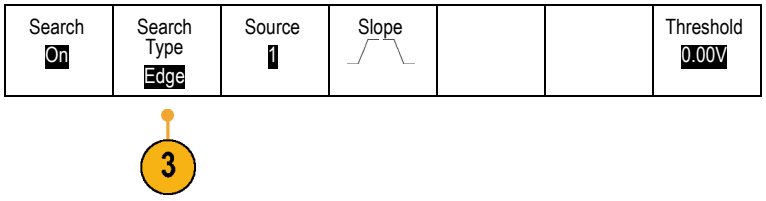


2. Push the **Search** lower bezel menu and select **On**.

   The search menu is similar to the trigger menu.



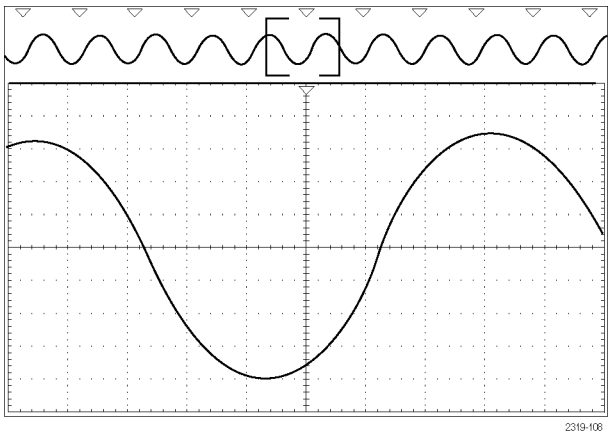
3. Push **Search Type**.



Turn multipurpose knob **a** to select the search type: Edge, Pulse Width, Runt, Logic, Setup & Hold, Rise/Fall Time, or Bus.



On the screen, hollow triangles show the location of automatic marks and solid triangles show the custom (user-defined) locations. These appear on both normal and zoomed waveform views.



4. You can quickly investigate your waveform by moving from search mark to search mark with the next (→) and previous (←) arrow buttons. No other adjustments are needed.

Quick Tips.

- You can copy trigger settings to search for other locations in your acquired waveform that meet the trigger conditions.
- You can also copy search settings to your trigger.
- Custom (User) marks are saved with the waveform when the waveform is saved and when the setup is saved.
- Automatic search marks are not saved with the waveform when the waveform is saved. However, you can easily recapture them by reusing the search function.
- The search criteria are saved in the saved setup.

The Wave Inspector includes the following search capabilities:

Search	Description
Edge	Searches for edges (rising or falling) with a user-specified threshold level.
Pulse Width	Searches for positive or negative pulse widths that are >, <, =, or ≠ a user specified pulse width.
Runt	Searches for positive or negative pulses that cross one amplitude threshold but fail to cross a second threshold before crossing the first again. Search for all runt pulses or only those with a duration >, <, =, or ≠ a user specified time.
Logic	Search for a logic pattern (AND or NAND) across multiple waveforms with each input set to either High, Low, or Don't Care. Search for when the event goes true, goes false, or stays valid for >, <, =, or ≠ a user specified time. Additionally, you can define one of the inputs as a clock for synchronous (state) searches.
Setup & Hold	Search for violations of user specified Setup and Hold times.

Search	Description
Rise/Fall Time	Search for rising and/or falling edges that are >, <, =, or ≠ a user specified time.
Bus	Parallel: Search for a binary or hex value (MSO2000B series only). I^2C: Search for Start, Repeated Start, Stop, Missing Ack, Address, Data, or Address and Data. SPI: Search for SS Active, MOSI, MISO, or MOSI & MISO CAN: Search for Start of Frame, Type of Frame (Data, Remote, Error, Overload), Identifier (standard or extended), Data, Identifier and Data, End of Frame, Missing Ack, or Bit Stuffing Error RS-232, RS-422, RS-485, UART: Search for Tx Start Bit, Rx Start Bit, Tx End of Packet, Rx End of Packet, Tx Data, Rx Data, Tx Parity Error, or Rx Parity Error. LIN: Search for Synch, Identifier, Data, ID & Data, Wakeup Frame, Sleep Frame, or Error

Save and Recall Information

The oscilloscope provides permanent storage for setups, waveforms, and screen images. Use the internal storage of the oscilloscope to save setup files and reference waveform data.

Use external storage, such as USB flash drives, to save setups, waveforms, and screen images. Use the external storage to carry data to remote computers for further analysis and for archiving.

External File Structure. If you are saving information to external storage, select the appropriate menu (such as the **To File** side-bezel menu to save setups and waveforms) and turn multipurpose knob **a** to scroll through the external file structure. Drive E is the USB flash drive plugged into the USB Host port on the front of the oscilloscope.

Use multipurpose knob **a** to scroll through the list of files. Use the **Select** front panel button to open and close folders.

Naming Your File. The oscilloscope gives the files it creates a default name in the following format:

- tekXXXXX.set for individual setup files where XXXXX is an integer from 00000 to 99999; the name is shortened to tXXXXX.set for setup files saved with the Save All function
- tekXXXXX.png, tekXXXXX.bmp, or tekXXXXX.tif for individual image files; the name is shortened to tXXXXX.png, tXXXXX.bmp, or tXXXXX.tif for image files saved with the Save All function
- tXXXXYYY.csv for all spreadsheet files or tXXXXYYY.isf for all internal format files

For waveform and for internal format files, the XXXX is an integer from 0000 to 9999. The YYY is the channel of the waveform, and can be one of the following:

- CH1, CH2, CH3, or CH4 for the analog channels
- D00, D01, D02, D03, and so on through D15 for the digital channels
- MTH for a math waveform
- RF1 or RF2 for reference memory waveforms
- ALL for a single spreadsheet file containing multiple channels when you select Save All Waveforms

NOTE. *Only analog channels and waveforms derived from analog channels (such as math and reference) can be saved to an ISF file. When saving all channels in ISF format, a group of files will be saved. Each will have the same value for XXXXX, but the YYY values will be set to the different channels that were turned on when the Save All Waveforms was performed.*

For example, the first time you save a file, that file is named tek00000 for a setup or image file, and t0000 for a waveform or internal format file. The next time you save the same type of file, the file will be named tek00001 or t0001 respectively.

For bus event tables, the XXXX is an integer from 0000 to 9999. The YYY is the type of bus, and can be one of the following:

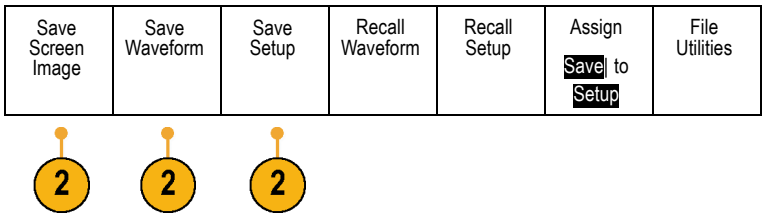
- RS2 (designates RS-232, RS-422, RS-485 or UART buses), I2C, SPI, CAN, or LIN for a serial bus
- PAR for a parallel bus

Editing File, Directory, Reference Waveform, or Oscilloscope Setup Names. Give files descriptive names that you can recognize at a later date. To edit file names, directory names, reference waveform and oscilloscope setup labels:

1. Push **Save / Recall Menu**.



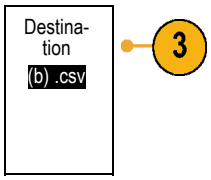
2. Push **Save Screen Image**, **Save Waveform**, or **Save Setup**.



3. For setup files, enter the file manager by pushing the side-bezel menu **To File** item.



For waveform files, set the **Destination** to a file. Turn multipurpose knob **b** to select **Spreadsheet File (.csv)** or **Internal File (.isf)**. Push the **Save ...** side-bezel button to enter the file manager.



4. Turn multipurpose knob **a** to scroll through the file structure. (See page 111, *External File Structure*.)



5. Push **Select** to open or close file folders.

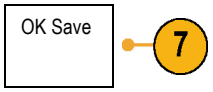


6. Push **Edit File Name**.

   Edit the file name the same way you edit labels for channels. (See page 41, *Labeling Channels and Buses*.)

7. Push the **Menu Off** button to cancel the save operation, or push a side-bezel menu **OK Save** item to complete the operation.

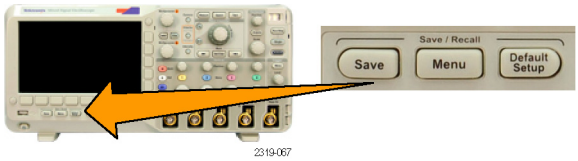




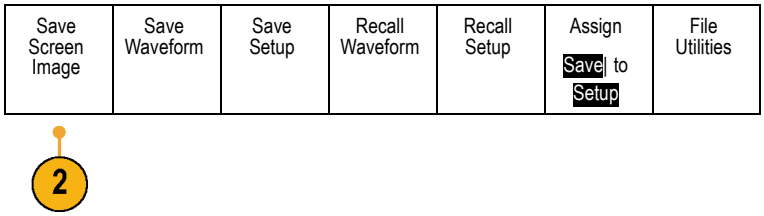
Saving a Screen Image

A screen image consists of a graphical image of the oscilloscope screen. This is different from waveform data, which consists of numeric values for each point in the waveform. To save a screen image:

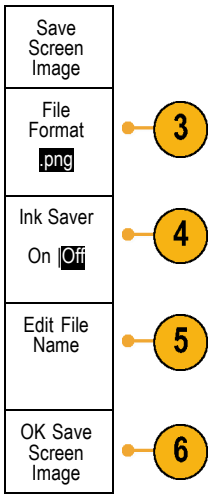
1. Push **Save / Recall Menu**.



2. Push **Save Screen Image** from the lower-bezel menu.



3. From the side-bezel menu, push **File Format** repeatedly to select .tif, .bmp, and .png formats.
4. Push **Ink Saver** to turn the **Ink Saver** mode on or off. When on, this mode provides a white background.
5. Push **Edit File Name** to create a custom name for the screen image file. Skip this step to use a default name.
6. Push **OK Save Screen Image** to write the image to the selected media.

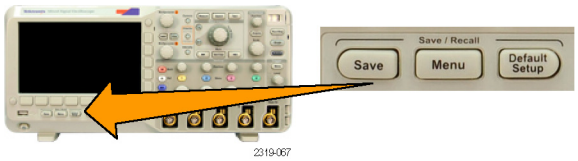


For information on printing screen images of waveforms, go to *Printing a Hard Copy*. (See page 120, *Printing a Hard Copy*.)

Saving and Recalling Waveform Data

Waveform data consists of the numeric values for each point in the waveform. It copies the data, as opposed to a graphical image of the screen. To save the current waveform data or to recall previously stored waveform data:

1. Push **Save / Recall Menu**.



2. Push **Save Waveform** or **Recall Waveform** from the lower-bezel menu.

Save Screen Image	Save Waveform	Save Setup	Recall Waveform	Recall Setup	Assign Save to Waveform	File Utilities
	2		2			

NOTE. The oscilloscope can save digital waveforms to .csv files, not reference memories. The oscilloscope cannot recall digital waveforms.

3. Select one waveform or all waveforms.
4. From the resulting side-bezel menu, select the location to save the waveform data to or to recall it from.

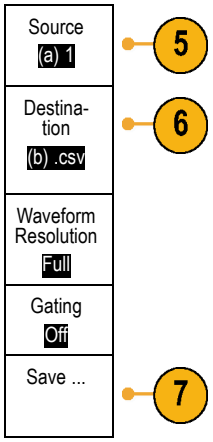
   Save the information externally to a file on a USB flash drive. Alternatively, save the information internally to one of the two reference memory files.

5. Push **Source** and turn multipurpose knob **a** to select a waveform to save.
6. Push **Destination** and turn multipurpose knob **b** to select a reference waveform or a file.

   Set the Waveform Resolution for .csv files only.

   Set the Gating to save information with files.
7. Push **Save** to save to a USB flash drive.

   This brings up the file manager screen. Use it to define a custom file name. Skip this step to use the default name and location.



Saving a Waveform to File. When you push the **Destination** side-bezel menu button and turn multipurpose knob **b**, the side-bezel menu changes. The following table describes the selections for saving waveform data to a mass storage file.

Side-bezel menu button	Description
Internal File Format (.ISF)	Sets the oscilloscope to save waveform data from analog channels (and math and reference waveforms derived from analog channels), in internal waveform save file (.isf) format. This format is the fastest to write and creates the smallest-sized file. Use this format if you intend to recall a waveform to reference memory for viewing or measuring. The oscilloscope cannot save digital waveforms in an .isf file format.
Spreadsheet File Format (.CSV)	Sets the oscilloscope to save waveform data as a comma-separated data file compatible with popular spreadsheet programs. This file cannot be recalled to reference memory.

Saving an Analog Waveform to Reference Memory. To save an analog waveform to nonvolatile memory inside the oscilloscope, select the waveform that you want to save, push the **Save Waveform** screen button, and then select one of the reference waveform locations. Two-channel and four-channel models have two reference locations.

Saved waveforms contain only the most recent acquisition. Gray-scale information, if any, is not saved.

Displaying a Reference Waveform. To display a waveform stored in nonvolatile memory:

1. Push **Ref R**.



2. Push **R1** or **R2**.

(R1) [On]	(R2) [Off]					

Removing a Reference Waveform from the Display. To remove a reference waveform from the display:

1. Push **Ref R**.



2. Push the **R1** or **R2** lower-bezel button to remove the reference waveform from the display.

   The reference waveform is still in nonvolatile memory and can be displayed again.

(R1) [On]	(R2) [Off]					

Saving and Recalling Setups

Setup information includes acquisition information, such as vertical, horizontal, trigger, cursor, and measurement information. It does not include communications information, such as GPIB addresses. To save the setup information:

1. Push **Save / Recall Menu**.



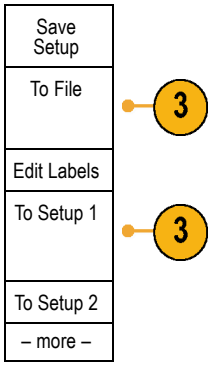
2. Push **Save Setup** or **Recall Setup** from the lower-bezel menu.

Save Screen Image	Save Waveform	Save Setup	Recall Waveform	Recall Setup	Assign Save to Setup	File Utilities

3. From the resulting side-bezel menu, select the location to save the setup to or to recall it from.

   To save setup information to one of the ten internal setup memories in the oscilloscope, push the appropriate side-bezel button.

   To save setup information to a USB file, push the **To File** button.



4. If you are saving information to a USB flash drive, turn multipurpose knob **a** to scroll through the file structure. (See page 111, *External File Structure*.)



   Push **Select** to open or close file folders.



   Push the **Menu Off** button to cancel the save operation.



5. Push the **Save to Selected File** button to save the file.



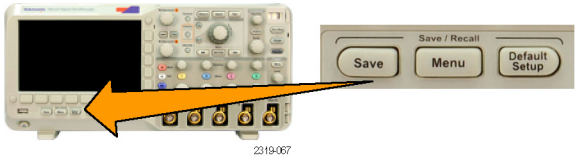
Quick Tips

- **Recalling the Default Setup.** Push the front-panel **Default Setup** button to initialize the oscilloscope to a known setup. (See page 43, *Using the Default Setup*.)

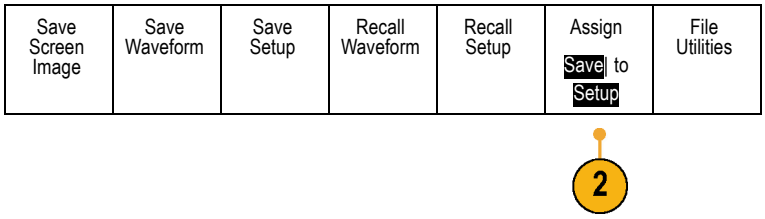
Saving with One Button Push

After you have defined the save/recall parameters with the Save/Recall Menu button and menu, you can save files with a single push of the **Save** button. For example, if you have defined the save operation to save waveform data to a USB drive, then each push of the **Save** button will save current waveform data to the defined USB drive.

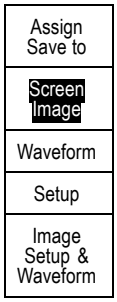
1. To define the Save button behavior, push **Save/Recall Menu**.



2. Push **Assign Save to** button.



3. Push the action to assign to the **Save** button.



4. From now on, when you push **Save** the oscilloscope will perform the action that you just specified rather than requiring you to navigate through the menus each time.



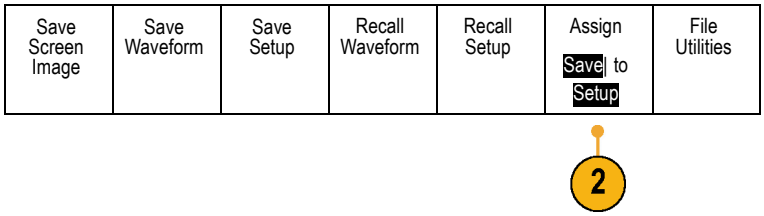
Saving Setup, Screen Image, and Waveform Files

To save setup, screen image, and waveform files at the same time, you can use the Assign Save to All function.

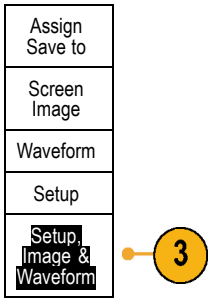
1. To define the Save button behavior, push **Save/Recall Menu**.



2. Push **Assign Save to** button.



3. Push the **Setup, Image & Waveform** button.



4. From now on, when you push **Save** the oscilloscope creates three files: setup, screen image, and waveform.



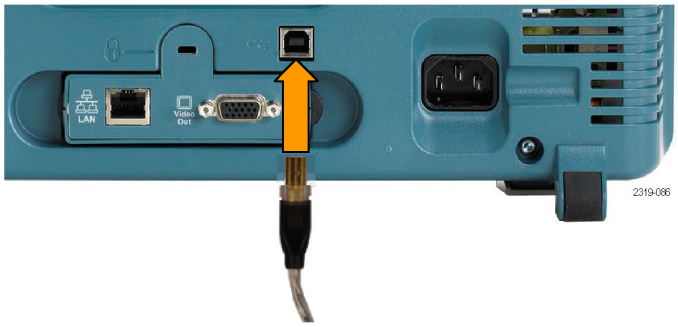
Printing a Hard Copy

To print an image of what appears on the oscilloscope screen, do the following procedure.

Connect a Printer to Your Oscilloscope

When you connect the oscilloscope to a PictBridge compatible printer, the oscilloscope and printer can be powered on or off.

1. Connect a USB cable to the rear-panel USB port.
2. Insert the other end of the cable into the appropriate port on a PictBridge compatible printer. Refer to the product documentation for your printer to locate the port.
3. To test the connection, set up the oscilloscope to print as described in the next procedure.



NOTE. *The oscilloscope recognizes the printer only when the printer is powered on.*

If the oscilloscope asks you to connect to a printer and a printer is connected, you need to power on the printer.

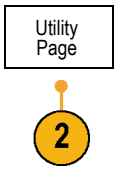
Setting Up Print Parameters

To set up the oscilloscope to print hard copies:

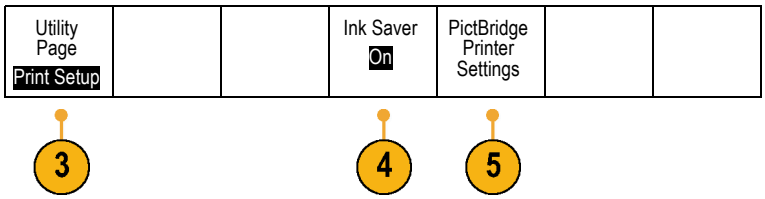
1. Push **Utility**.



2. Push **Utility Page**.

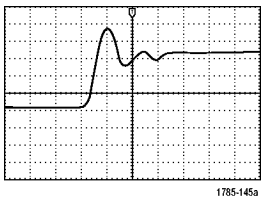


3. Turn multipurpose knob **a** and select **Print Setup**.

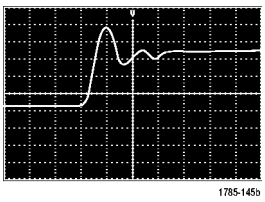


4. Choose **Ink Saver On** or **Off**.

   The **On** selection will print out a copy with a clear (white) background.



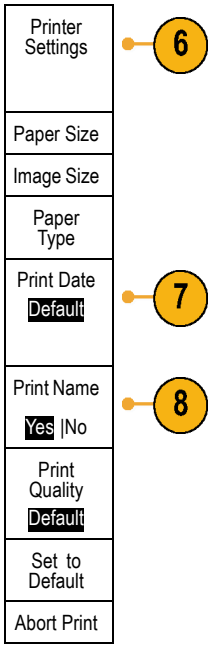
Ink Saver on



Ink Saver off

5. Push **PictBridge Printer Settings**.
6. Set the side bezel menus to match your printer.

   The side-bezel menus display settings available on your PictBridge compatible printer.



7. Push **Print Date** to include the date of the print. The list is based on the choices available for your printer.
8. Push **Print Name** to include the name of the file.

9. To print a screen image, push the Print front-panel button.

   The settings of your printer and print speed determine how long it takes to print the data. Additional time may be required according to the format selected.



10. If printing fails, check that the USB cable is connected to the PictBridge port on the printer, and try again.

Quick Tips

- Push **Set To Defaults** to have the oscilloscope match the print settings to the default settings of your printer.
- The oscilloscope displays an error message when the oscilloscope detects a mismatched setting. In some cases, the oscilloscope can correct the mismatch and will send the image to the printer, such as for mismatched paper sizes.

Printing with One Button Push

Once you have connected a printer to your oscilloscope and set up print parameters, you can print current screen images with a single push of a button:

Push the printer icon button in the lower left corner of the front panel.



Erasing Oscilloscope Memory

You can erase all setup and waveform information saved in the nonvolatile oscilloscope memory with the TekSecure function. If you have acquired confidential data on your oscilloscope, you may want to execute the TekSecure function before you return the oscilloscope to general use. The TekSecure function:

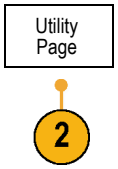
- Replaces all waveforms in all reference memories with null values
- Replaces the current front-panel setup and all stored setups with the default setup
- Displays a confirmation or warning message, depending on whether the verification is successful or unsuccessful

To use TekSecure:

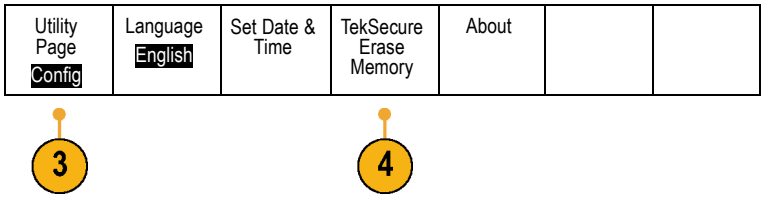
1. Push **Utility**.



2. Push **Utility Page**.

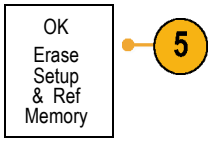


3. Turn multipurpose knob **a** and select **Config**.



4. Push **TekSecure Erase Memory**.

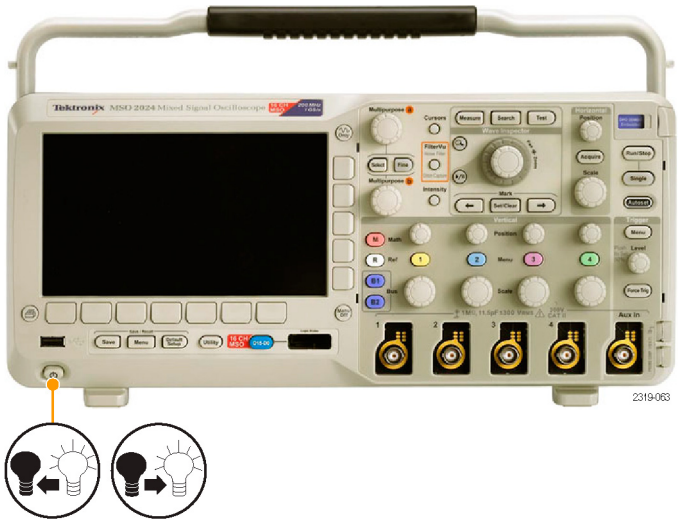
5. Push **OK Erase Setup and Ref Memory** from the side-bezel menu.



To cancel the procedure, push **Menu Off**.



6. Power off the oscilloscope, and then power it back on to complete the process.



Using Application Modules

Optional application module packages extend the capability of your oscilloscope. (See page 13, *Application Module Free Trial*.) You can install up to two application modules at one time. (See page 14, *Installing an Application Module*.)

Refer to the *MSO/DPO2000B and MSO/DPO2000 Series Oscilloscopes Application Module Installation* that came with your application module for instructions on installing and testing an application module. Some modules are described in the following list. Additional modules may be available. Contact your Tektronix representative or visit our Web site at www.tektronix.com for more information.

- The **DPO2EMBD Embedded Serial Triggering and Analysis Module** adds triggering on packet level information in serial buses used in embedded designs (I^2C and SPI), as well as analytical tools to help you efficiently analyze your serial bus. These include bus views, packet decoding, search tools, and event tables with timestamp information.
- The **DPO2AUTO Automotive Serial Triggering and Analysis Module** adds triggering on packet level information in serial buses used in automotive designs (CAN and LIN), as well as analytical tools to help you efficiently analyze your serial bus. These include bus views, packet decoding, search tools, and event tables with timestamp information.
- The **DPO2COMP Computer Serial Triggering and Analysis Module** adds triggering on byte or packet level information in RS-232, RS-422, RS-485, and UART buses, and analytical tools to help you efficiently analyze your serial bus. These include bus views, packet decoding, search tools, and event tables with timestamp information.

Appendix: Warranted Specifications

Analog bandwidth	Oscilloscope	5 mV/div to 5 V/div with an ambient temperature of 0 °C to 40 °C (0 °F to 104 °F)	5 mV/div to 5 V/div with an ambient temperature of 0 °C to 50 °C (0 °F to 122 °F)	<5 mV/div
	MSO2024B, MSO2022B, DPO2024B, DPO2022B	DC to ≥200 MHz	DC to ≥160 MHz	20 MHz
	MSO2014B, MSO2012B, DPO2014B, DPO2012B	DC to ≥100 MHz		20 MHz
	MSO2004B, MSO2002B DPO2004B, DPO2002B	DC to ≥70 MHz		20 MHz
Input impedance, DC coupled	1 MΩ ±2% in parallel with 11.5 pF ±2 pF			
DC Balance	±(1 mV + 0.1 div)			
DC gain accuracy	±3%, 5 V/div through 10 mV/div ±4%, 5 mV/div and 2 mV/div			
Offset accuracy	± [0.01 × | offset – position | + DC Balance] ***NOTE.*** *Both the position and constant offset term must be converted to volts by multiplying by the appropriate volts/div term.*			
Long-term sample rate and delay time accuracy	±25 ppm over any >1 ms interval			
Digital Channel Threshold Accuracy, MSO2000B series only	± [100 mV + 3% of the threshold setting after calibration]			

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