

LeCroy[®]

WAVESURFER[®]

Xs SERIES OSCILLOSCOPES



Operator's Manual
OCTOBER, 2008



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INTRODUCTION

How to Use On-line Help

TYPE STYLES

Activators of pop-up text and images appear as green, underlined, italic: Pop-up. To close pop-up text and images after opening them, touch the pop-up text again.

Links jump you to other topics, URLs, or images. They take you out of the current Help screen. Link text appears blue and underlined: [Link](#). After making a jump, you can touch the **Back** icon in the toolbar at the top of the Help window to return to the Help screen you just left. With each touch of the **Back** icon, you return to the preceding Help screen.

INSTRUMENT HELP

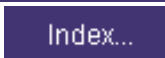
When you press the front panel Help button  (if available), or touch the on-screen **Help** button , you will be presented with a menu: you can choose either to have information found for you automatically or to search for information yourself.

If you want context-sensitive Help, that is, Help related to what was displayed on the screen when you requested Help, touch  **Control Help** in the drop-down menu, then touch the on-screen control (or front panel button or knob) that you need information about. The instrument will automatically display Help about that control.

If you want information about something not displayed on the screen, touch one of the buttons inside the drop-down menu to display the on-line Help manual:



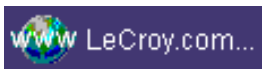
Contents displays the Table of Contents.



Index displays an alphabetical listing of keywords.



Search locates every occurrence of the keyword that you enter.



www.LeCroy.com connects you to LeCroy's Web site where you can find Lab Briefs, Application Notes, and other useful information. This feature requires that the instrument be connected to the internet through the Ethernet port on the oscilloscope's rear panel. Refer to Remote Communication for setup instructions.



About opens the Utilities **Status** dialog, which shows software version and other system information.

Once opened, the Help window will display its navigation pane: the part of the window that shows the Table of Contents and Index. When you touch anywhere outside of the Help window, this navigation pane will disappear to

reveal more of your signal. To make it return, touch the **Show**  icon at the top of the Help window or touch inside the Help information pane.

Windows Help

In addition to instrument Help, you can also access on-line Help for Microsoft® Windows®. This help is accessible by minimizing the oscilloscope application, then touching the **Start** button in the Windows task bar at the bottom of the screen and selecting **Help**.

Returning a Product for Service or Repair

If you need to return a LeCroy product, identify it by its model and serial numbers. Describe the defect or failure, and give us your name and telephone number.

For factory returns, use a Return Authorization Number (RAN), which you can get from customer service. Write the number clearly on the outside of the shipping carton.

Return products requiring only maintenance to your local customer service center.

If you need to return your oscilloscope for any reason, use the original shipping carton. If this is not possible, be sure to use a rigid carton. The oscilloscope should be packed so that it is surrounded by a minimum of four inches (10 cm) of shock absorbent material.

Within the warranty period, transportation charges to the factory will be your responsibility. Products under warranty will be returned to you with transport prepaid by LeCroy. Outside the warranty period, you will have to provide us with a purchase order number before the work can be done. You will be billed for parts and labor related to the repair work, as well as for shipping.

You should prepay return shipments. LeCroy cannot accept COD (Cash On Delivery) or Collect Return shipments. We recommend using air freight.

Technical Support

You can get assistance with installation, calibration, and a full range of software applications from your customer service center. Visit the LeCroy Web site at <http://www.lecroy.com> for the center nearest you.

Staying Up-to-Date

To maintain your instrument's performance within specifications, have us calibrate it at least once a year. LeCroy offers state-of-the-art performance by continually refining and improving the instrument's capabilities and operation. We frequently update both firmware and software during service, free of charge during warranty.

You can also install new purchased software options in your oscilloscope yourself, without having to return it to the factory. Simply provide us with your instrument serial number and ID, and the version number of instrument software installed. We will provide you with a unique option key that consists of a code to be entered through the Utilities' **Options** dialog to load the software option.

SPECIFICATIONS

Note: Specifications are subject to change without notice.

Vertical System

- **Bandwidth @ 50 ohms (-3 dB):**

WaveSurfer 24Xs	10 mV/div to 1 V/div	200 MHz
	5 mV/div to 9.9 m/div	200 MHz
	2 mV/div to 4.95 m/div	150 MHz

WaveSurfer 44Xs	10 mV/div to 1 V/div	400 MHz
	5 mV/div to 9.9 m/div	400 MHz
	2 mV/div to 4.95 m/div	150 MHz
WaveSurfer 42Xs	10 mV/div to 1 V/div	400 MHz
	5 mV/div to 9.9 m/div	400 MHz
	2 mV/div to 4.95 m/div	150 MHz
WaveSurfer 64Xs	10 mV/div to 1 V/div	600MHz
	5 mV/div to 9.9 m/div	500 MHz
	2 mV/div to 4.95 m/div	150 MHz
WaveSurfer 62Xs	10 mV/div to 1 V/div	600 MHz
	5 mV/div to 9.9 m/div	500 MHz
	2 mV/div to 4.95 m/div	150 MHz
WaveSurfer 104Xs	10 mV/div to 1 V/div	1 GHz
	5 mV/div to 9.9 m/div	800 MHz
	2 mV/div to 4.95 m/div	350 MHz

- **Bandwidth @ 1 Mohms (-3 dB) -- typical:**

WaveSurfer 24Xs	10 mV/div to 10 V/div	200 MHz	
WaveSurfer 44Xs	10 mV/div to 10 V/div	400 MHz	
WaveSurfer 42Xs	10 mV/div to 10 V/div	400 MHz	
WaveSurfer 64Xs	10 mV/div to 10 V/div	500 MHz	
WaveSurfer 62Xs	10 mV/div to 10 V/div	500 MHz	
WaveSurfer 104Xs	5 mV/div to 10 V/div	500 MHz	

- **Input Channels:** 4 (models 42Xs and 62Xs: 2)
- **Calculated Rise Time (10 mV/div to 1 V/div):**

WaveSurfer 24Xs	1.75 ns
-----------------	---------

WaveSurfer 44Xs	875 ps
WaveSurfer 42Xs	875 ps
WaveSurfer 64Xs	625 ps
WaveSurfer 62Xs	625 ps
WaveSurfer 104Xs	400 ps

- **Bandwidth Limiters:**
 - o Full
 - o 200 MHz (except model 24Xs)
 - o 20 MHz
- **Input Capacitance, using PP009 probe:** < 9.5 pF (typical)
- **Input Capacitance of Channel (1/1, 1/10, 1/100):** < 20 pF (typical)
- **Input Impedance:** 1 Mohms // 16 pF or 50 ohms; model 104Xs: 1 Mohms // 20 pF or 50 ohms
- **Input Coupling:** AC, DC, GND (50 ohms: DC, GND)
-  **Max Input Voltage -- 1 Mohms:** 400 V max. (DC + Peak AC <= 10 kHz); model 104Xs: 250 V max.
- **Installation (Overvoltage) Category:** CAT I
- **Channel-to-Channel Isolation:** > 40 dB @ < 100 MHz (> 30 dB @ full bandwidth)
- **Vertical Resolution:** 8 bits; up to 11 bits with enhanced resolution (ERES)
- **Sensitivity:** 50 ohms: 2 mV to 1 V/div fully variable; 1 Mohms: 2 mV to 10 V/div fully variable
- **DC Gain Accuracy:** $\pm 1.0\%$ of full scale (typical); $\pm 1.5\%$ of full scale, ≥ 10 mV/div (warranted)
- **Offset Range:** ± 1 V (2 to 50 mV/div), ± 10 V (100 mV to 1 V/div), ± 100 V (2 to 10 V/div)
- **Offset Accuracy:** Fixed gain setting < 2 V/div: $\pm(1.5\%$ of offset value + 0.5% of full scale value + 1 mV)
Variable gain and settings ≥ 2 V/div: $\pm(1.5\%$ of offset value + 1.0% of full scale value + 1 mV)
- **Probing System:** BNC or ProBus

Horizontal System

- **Timebases:** Internal timebase common to all input channels; an external clock can be applied at the auxiliary input
- **Time/div Range:** Real time: 200 ps/div to 1000 s/div; Roll mode: 500 ms/div to 1000 s/div
- **Math & Zoom Traces:** 4 math/zoom traces standard
- **Clock Accuracy:** 10 ppm
- **Jitter Noise Floor:** 2 ps rms typical @ 100 mV/div
- **Time Interval Accuracy:** Clock Accuracy + Jitter Noise Floor
- **Sampling Rate & Delay Time Accuracy:** equal to Clock Accuracy
- **Trigger & Interpolator Jitter:** ≤ 3 ps rms (typical)

- **Channel-to-Channel Deskew Range:** $\pm 9 \times$ time/div setting
- **Interpolator Resolution:** 1.2 ps
- **Roll Mode:** User selectable; available at lower time/div settings

Acquisition System

- **Single-shot Sample Rate/Ch:** 2.5 GS/s
Interleaved Max. Sampling Rate: 5 GS/s (WS104Xs only)
- **Memory:**

	Maximum Acquisition Points/Ch 4 Ch
Standard	2.5M
VL Memory Option	10M

- **Random Interleaved Sampling (RIS):** 50 GS/s
- **Trigger Rate:** 1,250,000 waveforms per second

ACQUISITION MODES

- **Single-shot:** For transient and repetitive signals: 20 ps/div to 1000 s/div

ACQUISITION PROCESSING

- **Time Resolution (minimum, single-shot):** 200 ps (5 GS/s); 100 ps (10 GS/s)
- **Averaging:** Summed averaging to 1 million sweeps; Continuous averaging to 1 million sweeps
- **Enhanced Resolution (ERES):** from 8.5 to 11 bits vertical resolution
- **Envelope (Extrema):** Envelope, floor, or roof for up to 1 million sweeps
- **Interpolation:** Linear, (sinx)/x

Triggering System

- **Modes:** Normal, Auto, Single, and Stop
- **Sources:** Any input channel, External, Ext/10, or line; slope and level are unique to each source (except line)
- **Coupling Mode:** DC, AC, HFRej, LFRej
- **Pre-trigger Delay:** 0 to 100% of full scale
- **Post-trigger Delay:** 0 to 10,000 divisions
- **Holdoff by Time or Events:** 1 ns to 20 s or from 1 to 99,999,999 events
- **Internal Trigger Range:** ± 4.1 div from center (typical)
- **Trigger and Interpolator Jitter:** ≤ 3 ps_{rms} (typical)
- **Maximum Trigger Sensitivity with Edge Trigger (Ch1-Ch4 + external):**

24Xs	42Xs	44Xs	64Xs	62Xs	104Xs
1 div @ < 200 MHz	2 div @ < 400 MHz 1 div @ < 200 MHz	2 div @ < 400 MHz 1 div @ < 200 MHz	2 div @ < 600 MHz 1 div @ < 200 MHz	2 div @ < 600 MHz 1 div @ < 200 MHz	2 div @ < 600 MHz 1.5 div @ < 500 MHz 1 div @ < 200 MHz

- **Maximum Trigger Frequency with SMART Trigger (Ch1-Ch4 + external):**

24Xs	42Xs	44Xs	64Xs	62Xs	104Xs
200 MHz max. @ ≥ 10 mV	400 MHz max. @ ≥ 10 mV	400 MHz max. @ ≥ 10 mV	600 MHz max. @ ≥ 10 mV	600 MHz max. @ ≥ 10 mV	1 GHz max. @ ≥ 10 mV

- **Trigger Level DC Accuracy:** $\pm 4\%$ of full scale ± 2 mV (typical)
- **External Trigger Range:** EXT/10 ± 4 V; EXT ± 400 mV

STANDARD TRIGGERS

- **Edge:** Triggers when signal meets slope (positive, negative, or Window) and level condition.

- **Glitch:** Triggers on positive or negative glitches with widths selectable from 500 ps to 20 s or on intermittent faults. Includes exclusion mode (trigger on intermittent faults by specifying the nominal width period).
- **Width:** Triggers on positive or negative pulse widths selectable from 500 ps to 20 s or on intermittent faults. Includes exclusion mode (trigger on intermittent faults by specifying the nominal width period).
- **Logic (Pattern):** Logic combination (AND, NAND, OR, NOR) of 5 inputs (4 channels and external trigger input; 2 Ch+EXT on WaveSurfer 62Xs). Each source can be high, low, or don't care. The High and Low level can be selected independently.
- **TV-Composite Video:** Triggers selectable fields (1, 2, 4, or 8), Positive or Negative slope for NTSC, PAL, SECAM, or non-standard video (up to 1500 lines).

OPTIONAL SMART TRIGGERS (WSXs-ADVTRG OPTION)

- **Runt:** Triggers on positive or negative runs defined by two voltage limits and two time limits. Select between 1 ns and 20 s. Includes exclusion mode (trigger on intermittent faults by specifying the nominal width or period).
- **Slew Rate:** Triggers on edge rates. Select limits for dV, dt, and slope. Select edge limits between 1 ns and 20 s. Includes exclusion mode (trigger on intermittent faults by specifying the nominal width period).
- **Interval (Signal or Pattern):** Triggers on intervals selectable from 1 ns to 20 s.
- **Dropout:** Triggers if signal drops out for longer than selected time between 1 ns and 20 s. Includes exclusion mode (trigger on intermittent faults by specifying the nominal width or period).
- **Qualified (State or Edge):** Triggers on any input source only if a defined state or edge occurred on another input source. Delay between sources is 1 ns to 20 s, or 1 to 99,999,999 events. Includes exclusion mode (trigger on intermittent faults by specifying the nominal width or period).
- **HDTV:** Triggers on 1080i, 1080p, and 720p formats along with non-standard formats up to 2000 lines.

Automatic Setup

- **Autosetup:** Automatically sets timebase, trigger, and sensitivity to display a wide range of repetitive signals.
- **Vertical Find Scale:** Automatically sets the vertical sensitivity and offset for the selected channels to display a waveform with maximum dynamic range.

Probes

Probes: One PP009 probe per channel standard (model 104Xs: one PP011 per channel); optional passive and active probes are available.

Probe System -- ProBus: Automatically detects and supports a wide variety of compatible probes.

Scale Factors: Automatically or manually selected depending on probe used.

Color Waveform Display

- **Type:** Color 10.4-inch flat panel TFT LCD with high-resolution touch screen
- **Resolution:** SVGA; 800 x 600 pixels; maximum external monitor output resolution of 2048 x 1536 pixels
- **Real Time Clock:** Date, hours, minutes, and seconds displayed with waveform; accurate to ± 50 ppm; SNTP support to synchronize to precision internet clocks
- **Number of Traces:** Maximum of eight traces; simultaneously displays channel, zoom, memory, and math traces

- **Grid Styles:** Single, XY, Single+XY
- **Waveform Display Styles:** Sample dots joined or dots only

WAVESTREAM FAST VIEWING MODE

- **Intensity:** 256 Intensity Levels, 1-100% adjustable via front panel control
- **Number of Channels:** up to 4 simultaneously
- **Max. Sampling Rate:** 2.5 GS/s
- **Waveforms/second (continuous):** up to 8000 waveforms/second
- **Operation:** Front panel toggle between real-time mode and LeCroy WaveStream Fast Viewing mode

ANALOG PERSISTENCE DISPLAY

- **Analog and Color-graded Persistence:** Variable saturation levels; stores each trace's persistence data in memory
- **Persistence Selections:** Select analog or color
- **Trace Selection:** Activate Analog Persistence on all or any combination of traces
- **Persistence Aging Time:** From 500 ms to infinity
- **Sweeps Displayed:** All accumulated or all accumulated with last trace highlighted

ZOOM EXPANSION TRACES

Display up to 4 Math/Zoom traces

INTERNAL WAVEFORM MEMORY

Waveform: M1, M2, M3, M4 (Store full-length waveforms with 16 bits/data point.) Or save to any number of files (limited only by data storage media).

SETUP STORAGE

Front Panel and Instrument Status: Save to the internal hard drive or to a USB-connected peripheral device.

Interface

- **Remote Control:** Through Windows® Automation or LeCroy remote command set
- **GPIO Port (optional):** Supports IEEE-488.2
- **Ethernet Port:** 10/100Base-T Ethernet interface (RJ-45 connector)
- **USB Ports:** 5 USB ports (one at front of oscilloscope) support Windows compatible devices.
- **External Monitor Port (standard):** 15-pin D-Type SVGA compatible DB-15; connect a second monitor to use dual monitor display mode
- **Parallel Port:** 1 standard
- **Serial Port:** DB-9 COM1 port (not for remote control of oscilloscope)

AUXILIARY INPUT

Signal Types: Select External Trigger or Clock input on front panel.

AUXILIARY OUTPUT

Signal Types: Select from calibrator signal on front panel or control signals output from rear panel BNC.

Calibrator Signal: 1 kHz, 1 V

Math Tools (standard)

Display up to four math function traces (F1 to F4). The easy-to-use graphical interface simplifies setup of up to two operations on each function trace. Function traces can be chained together to perform math-on-math.

- Sum
- Difference
- Product
- Ratio
- FFT (power spectrum)

Measure Tools (standard)

Display any 8 parameters together with statistics, including their average, high, low, and standard deviations. Histicons provide a fast, dynamic view of parameters and wave shape characteristics.

- Amplitude
- Area
- Base (low)
- Delay
- Duty
- Fall Time (90-10%)
- Fall Time (80-20%)
- Frequency
- Maximum
- Mean
- Minimum
- Overshoot+
- Overshoot-
- Period
- Peak-Peak
- Phase
- Rise Time (10-90%)
- Rise Time (20-80%)
- RMS
- Skew
- Standard Deviation

- Top (high)
- Width+
- Width-

PASS/FAIL TESTING

Test multiple parameters against selectable parameter limits at the same time. Pass or fail conditions can initiate actions including: document to local or networked files, email the image of the failure, save waveforms, or send a pulse out at the rear panel auxiliary BNC output.

General

- **Auto Calibration:** Ensures specified DC and timing accuracy is maintained for 1 year minimum.
- **Power Requirements:** Single phase, 100 to 240 V_{rms} (±10%) at 50/60 Hz (±5%); or single phase, 100 to 120 V_{rms} (±10%) at 400 Hz (±5%); Automatic AC voltage selection

Voltage Range:	90 to 264 V _{rms}	90 to 132 V _{rms}
Frequency Range:	47 to 63 Hz	380 to 420 Hz

- **Power Consumption:** 4-channel models: 340 W max. (340 VA); all 2-channel models (WS62Xs, WS42XS): 290 W max. (290 VA), depending on accessories installed (probes, PC port plug-ins, etc.); Standby State: 12 watts
- **Physical Dimensions (HWD):** 260 mm x 340 mm x 152 mm (10.2 in. x 13.4 in. x 6.0 in.); height measurement excludes foot pads
- **Weight:** 6.95 kg (15.3 lbs.)

WARRANTY AND SERVICE

3-year warranty; calibration recommended yearly

Optional service programs include extended warranty, upgrades, and calibration services.

ENVIRONMENTAL CHARACTERISTICS

TEMPERATURE

- **Operating:** 5 to 40 °C
- **Storage (non-operating):** -20 to +60 °C

HUMIDITY

- **Operating:** Maximum relative humidity 80% for temperatures up to 31 °C decreasing linearly to 50% relative humidity at 40 °C.
- **Storage (non-operating):** 5 to 95% RH (non-condensing) as tested per MIL-PRF-28800F

ALTITUDE

- **Operating:** Up to 2,000 m
- **Storage (non-operating):** 12,192 m (40,000 ft)

RANDOM VIBRATION

- **Operating:** 5 Hz to 500 Hz, overall level: 0.31 g_{rms}, 15 minutes in each of 3 orthogonal axes
- **Non-operating:** 5 Hz to 500 Hz, overall level: 2.4 g_{rms}, 15 minutes in each of 3 orthogonal axes

SHOCK

Functional Shock: 20 g_{peak}, half sine, 11 ms pulse, 3 shocks (positive and negative) in each of 3 orthogonal axes, 18 shocks total



CERTIFICATIONS

CE Compliant, UL and cUL Listed

CE DECLARATION OF CONFORMITY

The oscilloscope meets requirements of EMC Directive 89/336/EEC for Electromagnetic Compatibility and Low Voltage Directive 73/23/EEC for Product Safety.

EMC Directive:	EN 61326/A3:2003 EMC requirements for electrical equipment for measurement, control, and laboratory use.
Electromagnetic Emissions:	EN 55011/A2:2002, Radiated and conducted emissions (Class A)*
	EN 61000-3-2/A2:2005 Harmonic Current Emissions (Class A)
	EN 61000-3-3/A2:2005 Voltage Fluctuations and Flickers (Pst = 1)

* To conform to Radiated Emissions standard, use properly shielded cables on all I/O terminals.



WARNING

This is a Class A product. In a domestic environment this product may cause radio interference, in which case the user may be required to take appropriate measures.

Electromagnetic Immunity:	EN 61000-4-2/A2:2001* Electrostatic Discharge (4 kV contact, 8 kV air, 4 kV vertical/horizontal coupling planes)
	EN 61000-4-3/A1:2003* RF Radiated Electromagnetic Field (3 V/m, 80-1000 MHz)
	EN 61000-4-4:2004* Electrical Fast Transient/Burst (1 kV AC Mains, 0.5 kV I/O signal/control)
	EN 61000-4-5/A1:2001* Surges (1 kV AC Mains, 0.5 kV I/O signal/control)
	EN 61000-4-6/A1:2001* RF Conducted Electromagnetic Field (1 kV / 0.5 kV common mode / differential mode - AC Mains)
	EN 61000-4-11:2004 [†] Mains Dips and Interruptions (1 cycle voltage dip, 100% short interruption)

* Meets Performance Criteria "B" limits during the disturbance, product undergoes a temporary degradation or loss of function of performance which is self recoverable.

† Meets Performance Criteria "C" limits during the disturbance, product undergoes a temporary degradation or loss of function of performance which requires operator intervention or system reset.

Low Voltage Directive:	EN 61010-1:2001
	Safety requirements for electrical equipment for measurement, control, and laboratory use.
	The oscilloscope has been qualified to the following EN 61010-1 limits: • Installation Categories II (Mains Supply Connector) & I (Measuring Terminals) • Pollution Degree 2 (Normally only dry non-conductive pollution occurs. Occasionally a temporary conductivity caused by condensation must be expected.) • Protection Class I (Provided with terminal for protective ground)

UL and cUL Certifications:	UL Standard: UL 61010-1 2 nd Edition
	Canadian Standard: CSA-C22.2 No. 61010-1-04

Warranty

The instrument is warranted for normal use and operation, within specifications, for a period of three years from shipment. LeCroy will either repair or, at our option, replace any product returned to one of our authorized service centers within this period. However, in order to do this we must first examine the product and find that the defect is due to workmanship or materials and not due to misuse, neglect, accident, or abnormal conditions or operation.

LeCroy shall not be responsible for any defect, damage, or failure caused by any of the following: a) attempted repairs or installations by personnel other than LeCroy representatives, or b) improper connection to incompatible equipment, or c) for any damage or malfunction caused by the use of non-LeCroy supplies. Furthermore, LeCroy shall not be obligated to service a product that has been modified or integrated where the modification or integration increases the task duration or difficulty of servicing the oscilloscope. Spare and replacement parts, and repairs, all have a 90-day warranty.

The oscilloscope's firmware has been thoroughly tested and is presumed to be functional. Nevertheless, it is supplied without warranty of any kind covering detailed performance. Products not made by LeCroy are covered solely by the warranty of the original equipment manufacturer.

Windows License Agreement

LeCroy's agreement with Microsoft prohibits users from running software on LeCroy X-Stream oscilloscopes that is not relevant to measuring, analyzing, or documenting waveforms.

End-User License Agreement For LeCroy® X-Stream Software

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8.8 Acknowledgment. Licensee acknowledges that (a) it has read and understands this EULA, (b) it has had an opportunity to have its legal counsel review this EULA, (c) this EULA has the same force and effect as a signed agreement, and (d) issuance of this EULA does not constitute general publication of the Software Product or other Confidential Information.

SAFETY REQUIREMENTS

This section contains information and warnings that must be observed to keep the instrument operating in a correct and safe condition. You are required to follow generally accepted safety procedures in addition to the safety precautions specified in this section.

SAFETY SYMBOLS AND TERMS

Where the following symbols or terms appear on the instrument's front or rear panels, or in this manual, they alert you to important safety considerations.



This symbol is used where caution is required. Refer to the accompanying information or documents in order to protect against personal injury or damage to the instrument.



This symbol warns of a potential risk of shock hazard.



This symbol is used to denote the measurement ground connection.



This symbol is used to denote a safety ground connection.



This symbol shows that the switch is a On/Standby switch. When it is pressed, the DSO's state toggles between Operating and Standby state. This switch is not a disconnect device. To completely remove power to the DSO, the power cord must be unplugged from the AC outlet after the DSO is placed in Standby state.



This symbol is used to denote "Alternating Current."

CAUTION The CAUTION sign indicates a potential hazard. It calls attention to a procedure, practice or condition which, if not followed, could possibly cause damage to equipment. If a CAUTION is indicated, do not proceed until its conditions are fully understood and met.

WARNING The WARNING sign indicates a potential hazard. It calls attention to a procedure, practice or condition which, if not followed, could possibly cause bodily injury or death. If a WARNING is indicated, do not proceed until its conditions are fully understood and met.

CAT I Installation (Overvoltage) Category rating per EN 61010-1 safety standard and is applicable for the oscilloscope front panel measuring terminals. CAT I rated terminals must only be connected to source circuits in which measures are taken to limit transient voltages to an appropriately low level.

Operating Environment

The instrument is intended for indoor use and should be operated in a clean, dry environment. Before using this product, ensure that its operating environment will be maintained within these parameters:

Temperature: 5 to 40 °C

Humidity: Maximum relative humidity 80% for temperatures up to 31 °C decreasing linearly to 50% relative humidity at 40 °C.

Altitude: Up to 2,000 m

Note: Direct sunlight, radiators, and other heat sources should be taken into account when assessing the ambient temperature.



WARNING

The DSO must not be operated in explosive, dusty, or wet/damp atmospheres.

The design of the instrument has been verified to conform to EN 61010-1 safety standard per the following limits:

Installation (Overvoltage) Categories II (Mains Supply Connector) & I (Measuring Terminals)

Pollution Degree 2

Protection Class I

Note:

Installation (Overvoltage) Category II refers to local distribution level, which is applicable to equipment connected to the mains supply (AC power source).

Installation (Overvoltage) Category I refers to signal level, which is applicable to equipment measuring terminals that are connected to source circuits in which measures are taken to limit transient voltages to an appropriately low level.

Pollution Degree 2 refers to an operating environment where normally only dry non-conductive pollution occurs. Occasionally a temporary conductivity caused by condensation must be expected.

Protection Class 1 refers to a grounded equipment, in which protection against electric shock is achieved by Basic Insulation and by means of a connection to the protective ground conductor in the building wiring.



CAUTION

Protect the DSO's display touch screen from excessive impacts with foreign objects.



CAUTION

Do not exceed the maximum specified front panel terminal (CH1, CH2, CH3, CH4, EXT) voltage levels. Refer to Specifications for more details.



CAUTION

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

Cooling Requirements

The instrument relies on forced air cooling with internal fans and ventilation openings. Care must be taken to avoid restricting the airflow around the apertures (fan holes) at the sides, front, and rear of the DSO. To ensure adequate ventilation it is required to leave a 15 cm (6 inch) minimum gap around the sides, front, and rear of the instrument.



CAUTION

Do not block the ventilation holes located on both sides and rear of the DSO.



CAUTION

Do not allow any foreign matter to enter the DSO through the ventilation holes, etc.

AC Power Source

The instrument operates from a single-phase, 100 to 240 V_{rms} (+/-10%) AC power source at 50/60 Hz (+/-5%), or single-phase 100 to 120 V_{rms} (+/-10%) AC power source at 400 Hz (+/-5%).

No manual voltage selection is required because the instrument automatically adapts to line voltage.

Depending on the accessories installed (front panel probes, PC port plug-ins, etc.), the instrument can draw up to 340 W (340 VA). All 2-channel models (WS62Xs, WS42XS): 290 W (290 VA)

Note: The instrument automatically adapts itself to the AC line input within the following ranges:

Voltage Range:	90 to 264 V _{rms}	90 to 132 V _{rms}
Frequency Range:	47 to 63 Hz	380 to 420 Hz

Power and Ground Connections

The instrument is provided with a grounded cord set containing a molded three-terminal polarized plug and a standard IEC320 (Type C13) connector for making line voltage and safety ground connection. The AC inlet ground terminal is connected directly to the frame of the instrument. For adequate protection against electrical shock hazard, the power cord plug must be inserted into a mating AC outlet containing a safety ground contact. Use only the power cord specified for this instrument and certified for the country of use.

The DSO should be positioned to allow easy access to the socket-outlet. To completely remove power to the DSO, unplug the instrument's power cord from the AC outlet after the DSO is placed in Standby state.

In Standby state the DSO is still connected to the AC supply. The instrument can only be placed in a complete Power Off state by physically disconnecting the power cord from the AC supply. It is recommended that the power cord be unplugged from the AC outlet if the DSO is not being used for an extended period of time.

See On/Standby Switch for more information.

On/Standby Switch

The front panel On/Standby switch controls the operational state of the DSO. This toggle switch is activated by momentarily pressing and releasing it.

There are two basic DSO states: On or Standby. In the "On" state, the DSO, including its computer subsystems (CPU, hard drive, etc.) is fully powered and operational. In the "Standby" state, the DSO, including computer subsystems, is powered off with the exception of some "housekeeping" circuitry (approximately 12 watts dissipation).

Always use the On/Standby switch to place the DSO in Standby state so that it executes a proper shutdown process (including a Windows shutdown) to preserve settings before powering itself off. This can be accomplished by pressing and holding in the On/Standby switch for approximately 5 seconds.



WARNING

Electric Shock Hazard!

Any interruption of the protective conductor inside or outside of the DSO, or disconnection of the safety ground terminal creates a hazardous situation.

Intentional interruption is prohibited.



CAUTION

The outer shells of the front panel terminals (CH1, CH2, CH3, CH4, EXT) are connected to the instrument's chassis and therefore to the safety ground.

Note: To power off, place the DSO in Standby state, then disconnect the power cord.

Calibration

The recommended calibration interval is one year. Calibration should be performed by qualified personnel only.

Cleaning

Clean only the exterior of the instrument, using a damp, soft cloth. Do not use chemicals or abrasive elements. Under no circumstances allow moisture to penetrate the instrument. To avoid electrical shock, unplug the power cord from the AC outlet before cleaning.



WARNING

Electric Shock Hazard!

No operator serviceable parts inside. Do not remove covers.

Refer servicing to qualified personnel.

Abnormal Conditions

Operate the instrument only as intended by the manufacturer.

If you suspect the DSO's protection has been impaired, disconnect the power cord and secure the instrument against any unintended operation.

The DSO's protection is likely to be impaired if, for example, the instrument shows visible damage or has been subjected to severe transport stresses.

Proper use of the instrument depends on careful reading of all instructions and labels.

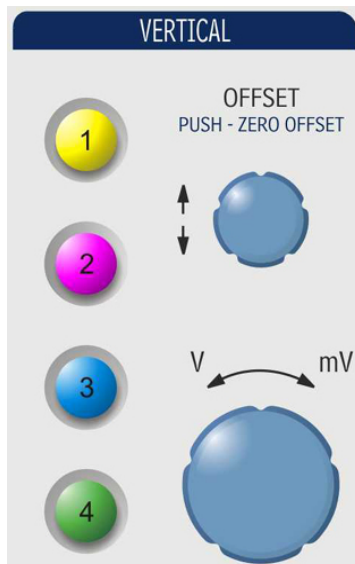


WARNING

Any use of the DSO in a manner not specified by the manufacturer may impair the instrument's safety protection. The instrument and related accessories should not be directly connected to human subjects or used for patient monitoring.

FRONT PANEL CONTROLS

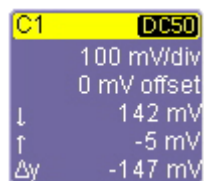
Vertical Controls



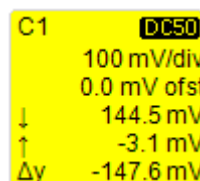
Vertical Controls are multiplexed for each channel. The lighted channel button indicates which channel the controls are *active* for.

- To turn a channel ON, simply press the channel button.
- To make a channel *active*, simply press the channel button again.
- To turn a channel OFF, press the channel button to make it active, then press it again to turn it OFF

When a channel is active, its descriptor label changes appearance.



Inactive Channel

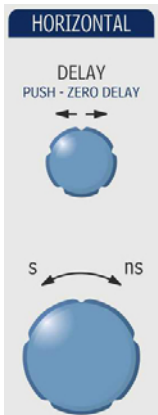


Active Channel

When a channel is turned OFF, the next channel in sequence becomes the active channel.

If no front panel channel buttons are lit, it means either that no channels are turned ON, or that a Math, Zoom, or Memory trace is active. In that case, the vertical offset and sensitivity knobs adjust the vertical position and vertical scale of the Math, Zoom, or Memory (Reference Waveform) trace.

Horizontal Controls



Set up the timebase by using the front panel **Horizontal** controls, just as for analog oscilloscopes. The WaveSurfer Xs oscilloscope will allocate memory as needed to maintain the highest sample rate possible for the timebase setting.

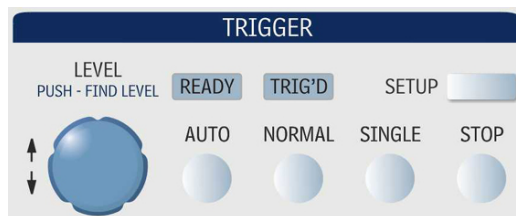
ACQUISITION MODE

The WaveSurfer Xs oscilloscope can acquire in either Real-Time (up to 2.5 GS/s), Random Interleaved Sampling (RIS, up to 50 GS/s), or Roll mode (up to 100 kS/s).

At certain very low time/division settings, the oscilloscope will default to RIS mode of operation to maintain the highest sample rate.

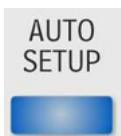
At high time/division settings, the oscilloscope defaults to Roll mode of operation so the on-screen display is not delayed by the long acquisition time. Maximum sample rate in Roll mode of operation is 100 kS/s.

Trigger Controls



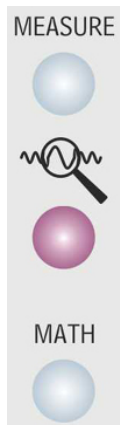
Stop	Cancels the capture in Auto, Normal, or Single trigger mode
Auto	Triggers the oscilloscope after a time-out, even if the trigger conditions are not met.
Normal	Triggers the oscilloscope each time a signal is present that meets the conditions set for the type of trigger selected.
Single	Arms the oscilloscope to trigger once (single-shot acquisition) when the input signal meets the trigger conditions set for the type of trigger selected. If the oscilloscope is already armed, it will force a trigger.
Setup	Displays the Trigger setup screen.

AutoSetup Button



Automatically sets timebase, trigger, and sensitivity to display a wide range of repetitive signals.

Measure, Zoom, and Math Quick Buttons

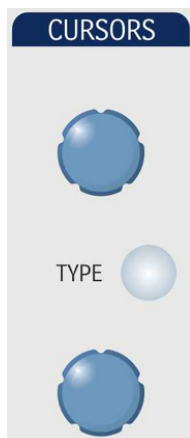


Measure – Press once to open the measure menu. Press again to close the menu.

QuickZoom () – Press once to create zooms of all displayed channels. Press again to unzoom.

Math – Press once to turn on the Math trace, and display the Math Setup menu. Press again to close the menu.

Cursor Knobs and Buttons



The WaveSurfer Xs oscilloscope has dedicated dual cursor knobs for cursor control. Cursors always default to a “relative” state (two cursors ON).

Knobs – Rotate to adjust cursor position. If Cursors are OFF, rotating either knob will turn Cursors ON. Push to set to the default position.

Type Button – Pressing the Type button once will turn Cursors ON to Horizontal (Time) measurements. Pressing again will change to Vertical (Amplitude) measurements. Pressing a third time will turn Cursors OFF.

Adjust Knob



The **Adjust** knob can be used to make adjustments to a value when a menu is open and the selected control has a yellow highlight.

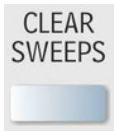
Push the knob in to toggle between coarse and fine adjustments.

Print Button



The **Print** button can be programmed to print the displayed screen to a file, a printer, or the clipboard; or to send it as an e-mail attachment. Select the device and format it in the **Utilities** → **Hardcopy** dialog.

Clear Sweeps



Clears data from multiple sweeps (acquisitions) including: persistence displays, parameter (measurement) statistics, and averaged traces.

Touch Screen



The Touch Screen lighted pushbutton indicates if the oscilloscope touch screen is operational. If the button is lighted, the touch screen is ON. If the button is not lighted, the touch screen is turned OFF. The button toggles between these two states.

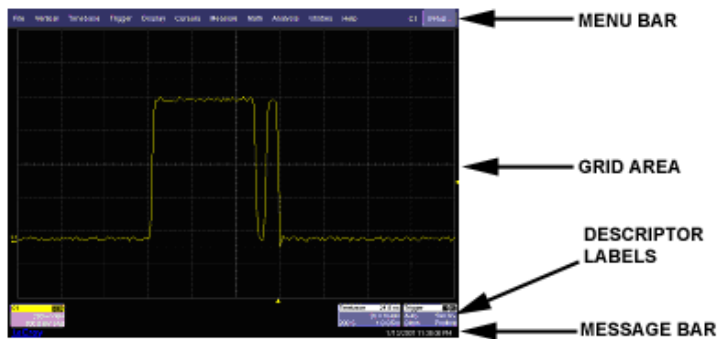
Intensity/Acquisition Mode



The **INTENSITY** knob adjusts the brightness of your trace. Pushing the button toggles between WaveStream fast-viewing mode (indicator lamp on) and real-time mode (lamp off).

ON-SCREEN TOOLBARS, ICONS, AND DIALOG BOXES

The WaveSurfer Xs oscilloscope's display contains valuable information about the current settings of your Vertical (channel), Horizontal (Timebase), and Trigger controls. In addition, there are many shortcuts that are available by using the touch screen capability of your display to quickly access information or to open menus.



Top Menu Bar ("File" menu)

The Top Menu Bar provides access to various software menus. It is very similar to the "File" menu on any Windows program. For common oscilloscope operations, you will not need to use the Top Menu Bar, since you can access most menus from the Front Panel or from the Descriptor Labels. However, it is the only way to access setup or other menus for the following:

- Display Setup
- Save or Recall Waveform
- Save or Recall Setups
- Print Setup
- Vertical (Channel), Horizontal, or Trigger Status

- Memory (Reference Waveform) Setup
- Pass/Fail Setup
- Utilities and Preferences Setup
- Help Access



At the right-hand end of the Top Menu Bar is an Undo button. This button will appear after the AutoSetup front panel button is pressed, and after Zooming is performed. If you want to perform an Undo operation, it must be the very next operation after you perform the Autosetup or Zoom operation.

Grid Area

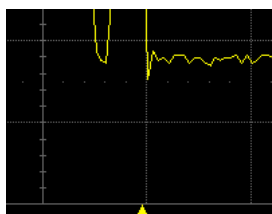


The grid area is divided into 8 vertical divisions and 10 horizontal divisions, just like any other oscilloscope. There are several indicators on the grid to help you understand the following:

- Trigger Delay setting
- Trigger Level Setting
- Trace Zero Level

These indicators are color-coded to the same color as the channel that the oscilloscope is currently set to trigger on.

TRIGGER DELAY INDICATOR

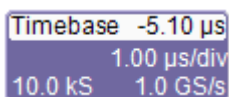


The trigger delay Indicator is a color-coded triangle that is positioned horizontally on the grid.

Trigger delay horizontally positions the oscilloscope trace on the display so you can observe the signal prior to the trigger time. It adjusts the pre- and post-trigger time.

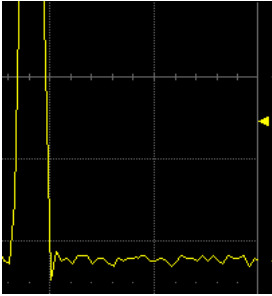


Post-trigger delay is indicated by a color-coded arrow pointing to the left.



All trigger delay values (including post-trigger delay, shown here) are displayed in the timebase descriptor label.

TRIGGER LEVEL INDICATOR

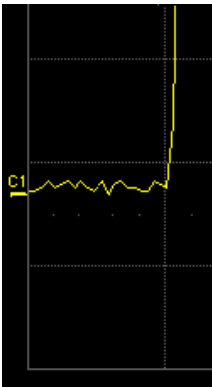


The trigger level Indicator is a color-coded triangle that is positioned vertically on the grid.

In Stop trigger mode, the solid triangle will also appear with a hollow triangle of the same color if the level is changed at that time. The hollow triangle indicates what the trigger level will be for the next valid trigger.

The trigger level indicator will not be displayed if the triggering channel is not displayed.

ZERO LEVEL INDICATOR

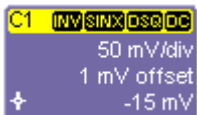


The zero volts level indicator is a color-coded label that is positioned vertically on the grid.

To change the zero level, use the front panel **OFFSET** knob in the VERTICAL control area. Rotate this knob to adjust, or push to set to zero volts. Push again to toggle back to the previous offset setting.

Descriptor Labels

Information is contained in rectangular boxes called descriptor labels. These labels contain status information, and also act as shortcuts to the full menu when you touch them. Channel descriptor labels are displayed only for channels that are turned on. Timebase and trigger descriptor labels are always displayed.



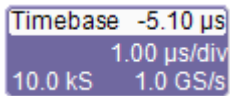
Channel trace labels show the vertical settings for the signal. The title bar (colored area) of the label shows the channel number on the far left. Other information will be indicated in the title bar, as follows:

- Coupling (AC 1M Ω , DC 1M Ω , DC 50 Ω , GND)
- Deskew (DSQ) set to non-zero value
- Bandwidth Limiting (BWL) ON
- Averaging (AVG) ON
- Interpolation
- Inversion
- Probe attenuation
- Enhanced Resolution (ERES) ON

Some of these indicators may be abbreviated if several are on at one time.

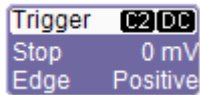
Touch a channel descriptor label once to make the front panel vertical controls active for that channel. Touch it again to open the software menu for further adjustment.

If cursors are ON, cursor information for this channel will appear in this trace label.



The title bar of the **TimeBase** (Horizontal) label shows the trigger delay setting at the far right. Time per division, sample rate, and number of samples are indicated below the title bar.

Touch the timebase descriptor label once to open the software menu for further adjustment.



The title bar of the **Trigger** label shows the triggered channel and the trigger coupling at the far right. Trigger mode (Stopped), trigger type (Edge), level (0 mV), and slope (Positive) are indicated below the title bar.

Touch the trigger descriptor label once to open the software menu for further adjustment.

Descriptor labels are also displayed for the math trace, zoom traces, and memory (reference waveform) traces. These descriptor labels are only displayed when their traces are turned ON.

Message Bar

At the bottom of the oscilloscope display is a narrow message bar. The current date and time are displayed at the far right. Status, error, or other messages will also be displayed in this area.

Alternate Access Methods

The instrument often gives you more than one way to access dialogs and menus.

MOUSE AND KEYBOARD OPERATION

In the procedures we focus on touch-screen operation, but if you have a mouse connected to the instrument, you can also click on objects. Likewise, if you have a keyboard connected, you can use it instead of the virtual keyboard provided by the instrument.

TOOL BAR BUTTONS

The procedures also focus on the use of the menu bar at the top of the screen to access dialogs and menus. However, on several dialogs common functions are accessible from a row of buttons that save you a step or two in accessing their dialogs. For example, at the bottom of the channel setup dialog, these buttons perform the following functions:

	Opens the Measure menu. You can then select a parameter from this menu without leaving the channel setup dialog. The parameter automatically appears below the grid.
--	--

	Creates a Zoom trace of the channel trace whose dialog is currently displayed.
	Opens the Math menu. You can then select a math function from this menu without leaving the channel setup dialog. A math trace of the channel whose dialog is currently open is automatically displayed.
	Loads the channel trace into the next available memory (Store) location (M1 to M4).
	Automatically performs a vertical scaling that fits the waveform into the grid.
	Opens a Labeling pop-up menu that allows user-defined labels tied to the waveform.

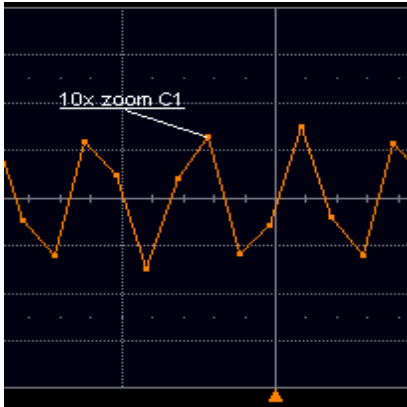
Another example is these buttons that appear at the bottom of the Measure **Px** dialogs. Each button opens a menu from which to choose a math trace (F1 to Fx The number of math traces available depends on the software options loaded on your oscilloscope. See specifications.) to display the functions named in the buttons:



By using these buttons you can remain in the **Measure** dialog to set up other options.

Trace Annotation

The instrument gives you the ability to add an identifying label, bearing your own text, to a waveform display:



For each waveform, you can create multiple labels and turn them all on or all off. Also, you can position them on the waveform by dragging or by specifying an exact horizontal position.

ANNOTATING A WAVEFORM

1. Touch the waveform you want to annotate, and then **Set label...** in the pop-up menu. A dialog box opens in which to create the label. If you are creating a label for the first time for this waveform, **Label1** is displayed with default text. If you are modifying an existing label, under **Labels** touch the label you want to change.

PLEASE NOTE THE FOLLOWING:

- If the dialog for the trace you want to annotate is currently displayed, you can touch the label button at the bottom to display the Trace Annotation setup dialog.



- You may place a label anywhere you want on the waveform. Labels are numbered sequentially according to the order in which they are added, and not according to their placement on the waveform.

- If you want to change the label's text, touch inside the **Label Text** field. A pop-up keyboard appears for you to enter your text. Touch **O.K.** on the keyboard when you are done. Your edited text will automatically appear in the label on the waveform.
- To place the label precisely, touch inside the **Horizontal Pos.** field and enter a horizontal value, using the pop-up numeric keypad.
- To add another label, touch the **Add label** button. To delete a label, select the label from the list, then touch the **Remove label** button.
- To make the labels visible, touch the **View labels** checkbox.

Turning on a Channel Trace Label

Note: If you want to display each trace on its own grid automatically, enable Autogrid by touching **Display** in the menu bar, then Autogrid in the drop-down menu.



On the front panel, press a channel select button, such as , to display the trace label for that input channel and turn on the channel.

To turn on a math function trace, touch **Math** in the menu bar, then **Math Setup...** in the drop-down menu. Touch the **On** checkbox for the trace you want to activate.

You can also quickly create traces (and turn on the trace label) for math functions and memory traces, without leaving the **Vertical Adjust** dialog, by touching the icons at the bottom of the **Vertical Adjust** dialog:



Whenever you turn on a channel, math, or memory trace via the menu bar, the dialog at the bottom of the screen automatically switches to the vertical setup or math setup dialog for that selection. You can configure your traces from here, including math setups.

The channel number appears in the **Vertical Adjust** tab of the **Vertical Adjust** dialog, signifying that all controls and fields are dedicated to the selected trace.

INSTALLATION

Power-Up



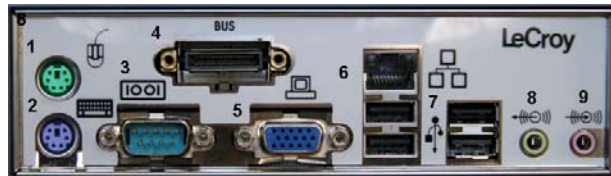
Press the power switch at bottom-left of the front of the oscilloscope to apply or remove power. Hibernate mode is not supported.



CAUTION

Do not change the **System standby** and **System hibernates** settings from their default **Never** selections in the Windows® "Power Options" dialog.

Hardware Connections



Numbers on the previous picture correspond as follows:

1. Mouse	3. RS-232-C Port	6. Ethernet Port	8. Speakers
2. Keyboard	4. LeCroy Bus (LBus)	7. USB Ports (4)	9. Line In
	5. External VGA Monitor		

Software Status

You can find out the oscilloscope's software and hardware configuration as follows:

1. In the menu bar, touch **Utilities**.
2. In the dialog area, touch **Status**.

Adding a New Option

To add a software option you will need a code to enable the option. Call LeCroy Customer Support to place an order and receive the code.

Restoring Software

RESTARTING THE APPLICATION

Upon initial power-up, the oscilloscope will load the instrument application software automatically.

- If you exit the application and want to reload it, touch the shortcut icon on the desktop:



- If you minimize the application, touch the desktop icon to maximize it:



RESTARTING THE OPERATING SYSTEM

If you need to restart the Windows® operating system, you will have to reboot the oscilloscope by pressing the power switch, then turning the power back on after a ten-second wait.

Default Settings

Touch **File → Recall Setup...** from the menu bar.

Touch the **Recall Setup** tab in the dialog.

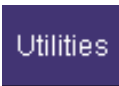
Then touch the on-screen **Recall Default** button.



Adding a New Option

To add a software option you need a key code to enable the option. Call LeCroy Customer Support to place an order and receive the code.

Add software options by doing the following:

1. In the menu bar, touch .
2. In the dialog area, touch the  tab.
3. Touch .
4. Use the pop-up keyboard to type the key code. Touch **O.K.** on the keyboard to enter the information.
5. The name of the feature you just installed is shown below the list of key codes. You can use the scroll buttons to see the name of the option installed with each key code listed:



Restoring Software

RESTARTING THE APPLICATION

Upon initial power-up, the oscilloscope will load the instrument application software automatically.

- If you exit the application and want to reload it, touch the shortcut icon on the desktop:



- If you minimize the application, touch the appropriate task bar or desktop button to maximize it:



RESTARTING THE OPERATING SYSTEM

If you need to restart the Windows® operating system, you will have to reboot the oscilloscope by pressing and holding in the power switch for 10 seconds, then turning the power back on.

CONNECTING TO A SIGNAL

ProBus Interface

LeCroy's ProBus probe system provides a complete measurement solution from probe tip to oscilloscope display. ProBus allows you to control transparent gain and offset directly from your front panel. It is particularly useful for voltage, differential, and current active probes. It uploads gain and offset correction factors from the ProBus EPROMs and automatically compensates to achieve fully calibrated measurements.

This intelligent interconnection between your instrument and a wide range of accessories offers important advantages over standard BNC and probe ring connections. ProBus ensures correct input coupling by auto-sensing the probe type, thereby eliminating the guesswork and errors that occur when attenuation or amplification factors are set manually.

Auxiliary Output Signals

In addition to a calibration signal, the following signals can be output through the AUX OUTPUT connector at the rear of the instrument:

	Trigger Out – can be used to trigger another oscilloscope
	Trigger Enabled – can be used as a gating function to trigger another instrument when the oscilloscope is ready
	Pass/Fail – allows you to set a pulse duration from 1 ms to 500 ms; generates a pulse when pass/fail testing is active and conditions are met.
	Aux Output Off – turns off the auxiliary output signal

Auxiliary Output Setup

1. In the menu bar, touch **Utilities**, then **Utilities Setup...** in the drop-down menu.
2. Touch the **Aux Output** tab.
3. Touch one of the buttons under **Use Auxiliary Output For**.
4. If you selected **Pass/Fail**, touch inside the **Pulse Duration** field and enter a value from 1 ms to 500 ms, using the pop-up numeric keypad.

PROBES

Your WaveSurfer Xs oscilloscope is supplied with one PP009 passive probe for each channel. The PP009 is a miniature high impedance passive probe. Its high input resistance and low capacitance make it ideal for general purpose probing of signals with frequency content from DC through several hundred MHz. The PP009 has a large selection of connection accessories, supplied standard with the probe and available from LeCroy as optional accessories.

The PP009 is designed for use with 600 MHz and lower LeCroy WaveSurfer Xs series oscilloscopes. Refer to the *PP009 Instruction Manual*.

LeCroy also offers a variety of passive and active probes for use with your WaveSurfer Xs Series oscilloscope. Visit www.lecroy.com for specifications and ordering information.

Current

Current Probes measure the current passing through a wire; current probes do not use the

Probes	"traditional" probing style of placing a tip onto a test point. Rather, a wire is placed inside of the "jaw" of the probe, which then allows the probe to measure the current (in Amps).
Active Probes	There are two different types of active probes: "single-ended" and "differential." Single-ended: A single-ended active probe is associated with measuring voltages at high frequencies. Measurement with an active probe requires a test point and a ground point. The ground (also called earth) acts as a zero reference for the test point measurement.
Differential Probes	Differential active probes are like two probes in one. Instead of measuring a test point in relation to a ground point (like single-ended active probes), differential probes measure the difference in voltage of a test point in relation to another test point.
Passive Probes	Passive probes measure voltages at lower frequencies (<400 MHz). They have higher input capacitance (input C) and do not need power to operate (unlike active probes). At higher frequencies, higher input capacitance loads the test circuit, attenuating the signal. This is why active probes are used in high frequency applications. Passive probes also measure voltage in reference to ground.
High Voltage Probes	These are active single ended probes that are designed to measure high voltages (safely). They measure the voltage in reference to ground.

Probe Compensation

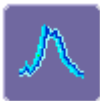
Passive probes must be compensated to flatten overshoot. This is accomplished by means of a trimmer at the connector end of the probe.

1. Attach the connector end of your PP009 probe to any channel.
2. Connect the probe end to the CAL output connector at the front of the oscilloscope.
3. Adjust the trim pot at the connector end of the probe until the square wave is as flat as possible.



SAMPLING MODES

Depending on your timebase, the following sampling modes are available:



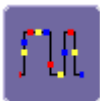
WaveStream Mode -- This fast viewing mode provides brightness-graded intensity with a decay time similar to the action of phosphor on an analog screen. WaveStream mode operates at up to 10 GS/s with an update rate up to 8000 waveforms/second for better capture of higher frequency abnormal events.



Real Time Mode -- A single-shot (real time) acquisition is a series of digitized voltage values sampled on the input signal at a uniform rate.



Roll Mode -- This mode is invoked automatically for slow acquisitions when the time per division is 200 ms/div or greater. Roll mode will sample at 2 MS/s (depending on memory availability).



RIS Mode -- Random Interleaved Sampling is an acquisition technique that allows effective sampling rates higher than the maximum single-shot sampling rate. It is used on repetitive waveforms with a stable trigger

Selecting a Sampling Mode

1. In the menu bar, touch **Timebase**, then **Horizontal Setup...** in the drop-down menu.
2. In the **Horizontal** dialog, touch a **Sample Mode** button.

Single-shot Sampling Mode

BASIC CAPTURE TECHNIQUE

A single-shot acquisition is a series of digitized voltage values sampled on the input signal at a uniform rate. It is also a series of measured data values associated with a single trigger event. The acquisition is typically stopped a defined number of samples after this event occurs: a number determined by the selected trigger delay and

measured by the timebase. The waveform's horizontal position (and waveform display in general) is determined using the trigger event as the definition of time zero.

You can choose either a pre- or post-trigger delay. Pre-trigger delay is the time from the left-hand edge of the display grid forward to the trigger event, while post-trigger delay is the time back to the event. You can sample the waveform in a range starting well before the trigger event up to the moment the event occurs. This is 100% pre-trigger, and it allows you to see the waveform leading up to the point at which the trigger condition was met and the trigger occurred. (The instrument offers up to the maximum record length of points of pre-trigger information.) Post-trigger delay, on the other hand, allows you to sample the waveform starting at the equivalent of 10,000 divisions after the event occurred.

Because each instrument input channel has a dedicated ADC (Analog-to-Digital Converter), the voltage on each is sampled and measured at the same instant. This allows very reliable time measurements between the channels.

On fast timebase settings, the maximum single-shot sampling rate is used. But for slower timebases, the sampling rate is decreased and the number of data samples maintained.

The relationship between sample rate, memory, and time can be simply defined as:

$$\text{Capture Interval} = \frac{1}{\text{Sample Rate}} \times \text{Memory}$$

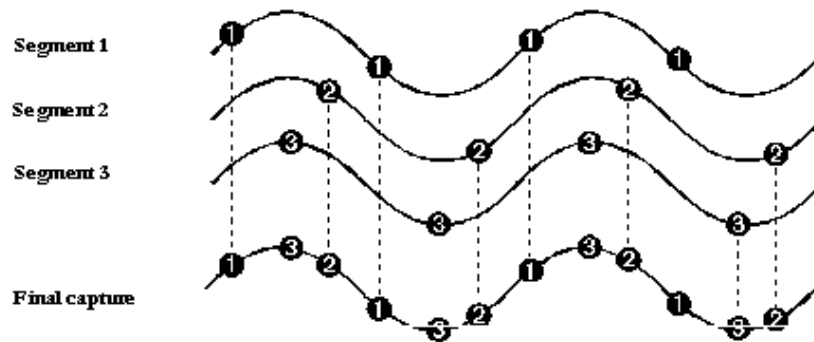
and

$$\frac{\text{Capture Interval}}{10} = \text{Time Per Division}$$

RIS Sampling Mode -- For Higher Sampling Rates

RIS (Random Interleaved Sampling) is an acquisition technique that allows effective sampling rates higher than the maximum single-shot sampling rate. It is used on repetitive waveforms with a stable trigger. The maximum effective sampling rate of 50 GS/s can be achieved with RIS by making 100 single-shot acquisitions at 500 MS/s. The bins thus acquired are positioned approximately 20 ps apart. The process of acquiring these bins and satisfying the time constraint is a random one. The relative time between ADC sampling instants and the event trigger provides the necessary variation, measured by the timebase to 5 ps resolution.

The instrument requires multiple triggers to complete an acquisition. The number depends on the sample rate: the higher the sample rate, the more triggers are required. It then interleaves these segments (see figure) to provide a waveform covering a time interval that is a multiple of the maximum single-shot sampling rate. However, the real-time interval over which the instrument collects the waveform data is much longer, and depends on the trigger rate and the amount of interleaving required. The oscilloscope is capable of acquiring approximately 40,000 RIS segments per second.



Note: RIS mode is not available when the oscilloscope is operating in Fixed Sample Rate mode.

Roll Mode

Roll mode can be selected when the timebase mode is real time, time per division is > 200 ms/div, and the sampling rate is < 200 kS/s.

Roll mode is not selected automatically when the above criteria are met. You must select Roll mode manually from the **Timebase** dialog each time you want to invoke it.

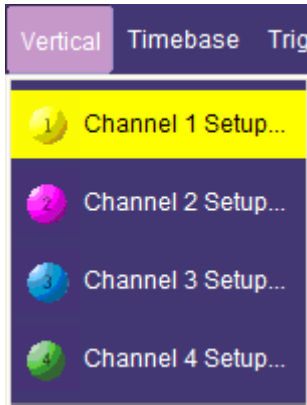
Roll mode displays, in real time, incoming points in single-shot acquisitions that have a sufficiently low data rate. The oscilloscope rolls the incoming data continuously across the screen until a trigger event is detected and the acquisition is complete. The parameters or math functions connected to each channel are updated every time the roll mode buffer is updated, as if new data is available. This resets statistics on every step of Roll mode that is valid because of new data.

Note: If the processing time is greater than the acquire time, the data in memory gets overwritten. In this case, the instrument issues the warning: Channel data is not continuous in ROLL mode!!! and rolling will start over again.

VERTICAL SETTINGS AND CHANNEL CONTROLS

Adjusting Sensitivity and Position

SENSITIVITY ADJUSTMENT



1. Touch **Vertical** in the menu bar, then **Channel 1**, for example, in the drop-down menu.

Touch inside the **Trace On** checkbox to display the trace. Or, use the VERTICAL front panel buttons to turn it on.

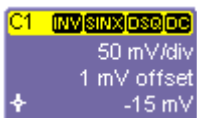
2. Turn the volts per division knob. Or you can touch inside the **Volts/Div** field and type in a value using the pop-up keypad.



Variable Gain

Variable Gain lets you change the granularity with which the gain is incremented. For example, when **Variable Gain** is disabled, the gain will increase or decrease in preset increments of 10 or 100 mV each time you touch the **Up/Down** buttons.

However, when **Variable Gain** is enabled, you can increase or decrease the gain in increments as small as 1 mV, depending on the scale of the waveform.



The voltage that you set is displayed in the **Volts/Div** field and in the trace descriptor label.

Adjusting the Waveform's Position



Turn the vertical offset adjust knob directly above the channel button whose waveform you want to move vertically. Or you can touch inside the **Offset** field and type in a value on the pop-up keypad. To set the vertical offset to zero, press the vertical offset adjust knob for the channel you want to adjust:

Bandwidth Limit

Reducing the bandwidth also reduces the signal and system noise, and prevents high frequency aliasing.

BANDWIDTH LIMITING SETUP

To set bandwidth limiting:

1. In the menu bar, touch **Vertical**, then select a channel from the drop-down menu.
2. Touch inside the **Bandwidth** field and select a bandwidth limit value from the pop-up menu.

The options are

- o Full
- o 200 MHz
- o 20 MHz

Invert

Touch the **Invert** checkbox to invert the waveform for the selected channel.

Coupling

The choices of coupling are as follows:

- DC 50 Ω
- GROUND
- DC 1 M Ω
- AC 1 M Ω

Note: The coupling choices for a channel will change if a ProBus probe is connected to a channel.

OVERLOAD PROTECTION

The maximum input voltage is 5 V_{rms}. Whenever the voltage exceeds this limit, the coupling mode automatically switches from DC 50 to GROUND. You will then have to manually reset the coupling to DC 50 ohms, as described next.

COUPLING SETUP

1. In the menu bar, touch the **Vertical** button, then **Channel X Setup...** in the drop-down menu.
2. Touch inside the **Coupling** field and select a coupling mode from the pop-up menu.

Channel Deskew

Unlike the Deskew math function, channel Deskew does no resampling, but instead adjusts the horizontal offset by the amount that you enter. The valid range is dependent on the current timebase +/- 9 divisions.

CHANNEL DESKEW SETUP

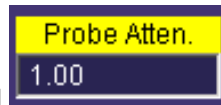
1. In the menu bar, touch **Vertical**; from the drop-down menu, select a channel to set up.
2. Touch inside the **Deskew** field and enter a value using the pop-up numeric keypad.

Probe Attenuation

PROBE ATTENUATION SETUP

LeCroy's ProBus system automatically senses probes and sets their attenuation for you. If you want to set the attenuation manually:

1. In the menu bar, touch **Vertical**, then select a channel from the drop-down menu.



2. Touch inside the **Probe Atten.** field
3. Touch a divide-by menu selection or touch **Var** (variable). If you choose **Var**, type in a value using the pop-up numeric keypad.

Averaging

The WaveSurfer Xs oscilloscope allows you the opportunity to continuously average your signal to reduce signal noise and aid in signal evaluation. If you want to use averaging, select a value here by touching inside the **Averaging** field and entering a value up to 1 million sweeps on the pop-up keypad.

Linear and (SinX)/X Interpolation

Linear interpolation, which inserts a straight line between sample point, is best used to reconstruct straight-edged signals such as square waves. (Sinx)/x interpolation, on the other hand, is suitable for reconstructing curved or irregular waveshapes, especially when the sample rate is 3 to 5 times the system bandwidth.

INTERPOLATION SETUP



1. Touch the button for the channel you want to set up,  for example.
2. In the dialog area, touch inside the **Interpolation** field under **Pre-Processing**. "Pre-Processing" means before Math processing.
3. Touch inside the **Interpolation** field. A pop-up menu appears offering **Linear** or **Sinx/x** interpolation. Touch the button for the type of interpolation you want.

Noise Filtering (ERES)

The instrument's enhanced resolution feature improves vertical resolution by a fixed amount for each filter. This real increase in resolution occurs whether or not the signal is noisy, or your signal is single-shot or repetitive. The signal-to-noise ratio (SNR) improvement you gain is dependent on the form of the noise in the original signal. The enhanced resolution filtering decreases the bandwidth of the signal, filtering out some of the noise.

QuickZoom

QuickZoom automatically displays a zoom of the channel or trace on a new grid.

TURNING ON A ZOOM



Touch the **Zoom** button in the **Vertical Adjust** dialog.

Finding Scale

You can access the **Find Scale** button from the **Vertical Adjust** dialog. This feature automatically calculates peak-to-peak voltage, and chooses an appropriate Volts/Div scale to fully display the waveform.

USING FIND SCALE

1. Touch the trace label for the waveform you desire.
2. Touch the **Find Scale** icon.

TIMEBASE AND ACQUISITION SYSTEM

Timebase Setup and Control

Set up the timebase by using the front panel **Horizontal** controls, just as for analog oscilloscopes.

For additional timebase setups:

1. Touch **Timebase** in the menu bar, then **Horizontal Setup...** in the drop-down menu. The **Horizontal** dialog appears.
2. Touch inside the **Time/Division** field and enter a value using the pop-up numeric keypad, or use the up/down arrows to adjust the value.
3. Touch inside the **Delay** field and type in a value, using the pop-up keypad. Touch the **Set To Zero** button to set the delay to zero.

4. Under **Real Time Memory** touch inside the Max Sample Points field and make a selection from the pop-up menu:

Realtime Mode	WaveStream Mode
2.5 MS 500 kS 10 kS	2.5 MS 500 kS 10 kS 500 S

Autosetup

When channels are turned on, Autosetup operates only on those turned-on channels. If no channels are turned on, all channels are affected. When more than one channel is turned on, the first channel in numerical order with a signal applied to it is automatically set up for edge triggering.



You can perform an autosetup of all these functions together by simply pressing  on the front panel, or by

touching **Autosetup**  in the **Vertical**, **Timebase**, or **Trigger** drop-down menu.

TRIGGERING

Trigger Setup Considerations

TRIGGER MODES

- **Auto mode** causes the oscilloscope to sweep even without a trigger. An internal timer triggers the sweep so that the display remains, even when the signal does not cause a trigger.
- In **Normal** mode, the oscilloscope sweeps only if the input signal reaches the set trigger point. Otherwise it continues to display the last acquired waveform.
- In **Single** mode, only one sweep occurs each time you press the button.
- **Stop** mode inhibits all sweeps until you select one of the other three modes.

TRIGGER TYPES

The Advanced Trigger package (WSXs-ADVTRIG) is required for:

- **Runt**
- **Slew Rate**
- **Interval**
- **Dropout**
- **Qualified (State or Edge)**

Edge A simple trigger, Edge trigger is activated by basic waveform features or conditions such as positive or negative slope, and holdoff.



Width Width trigger allows you to define a positive- or negative-going pulse width bounded by a voltage level, above or below which a trigger will occur. Or you can specify a pulse width and voltage range, within or outside of which a trigger will occur.



Glitch Glitch trigger is a simpler form of Width trigger. Use Glitch trigger when you want to define a fixed pulse-width time or time range only. Glitch trigger makes no provision for voltage levels or ranges.



Interval While Glitch trigger performs over the width of a pulse, Interval trigger performs over the width of an interval -- the signal duration (the period) separating two consecutive edges of the same polarity: positive to positive or negative to negative. Use interval trigger to capture intervals that fall short of, or exceed, a given time limit. In addition, you can define a width range to capture any interval that is



itself inside or outside the specified range -- an Exclusion trigger by interval.

Qualified The Qualified (A-B) trigger allows arming of the trigger on Event A and triggering on Event B. If the arming event is a Pattern that occurs once (Pattern) or that occurs and stays satisfied (PatState), the triggering event can be an Edge, Width, Glitch, or Interval condition.



State The State trigger is a level-qualified trigger which requires that the qualifying signal remain above or below a specified voltage level for a trigger to occur. For State trigger, you specify the time or number of events after the signal has gone above or below the voltage level when you want the trigger to occur.



Dropout Used primarily in single-shot applications, and usually with a pre-trigger delay, Dropout trigger can detect lost signals. The trigger is generated at the end of the timeout period following the last trigger source transition. You can select a timeout period from 2 ns to 20 s.



Logic Logic trigger enables triggering on a logical combination (pattern) of five inputs: CH1, CH2, CH3, CH4, EXT. You have a choice of four Boolean operators (AND, NAND, OR, NOR), and you can stipulate the high or low voltage logic level for each input independently.



TV TV triggers provide stable triggering on standard or custom composite video signals. Use them on PAL, SECAM, or NTSC systems. Optional HDTV trigger support for 1080i, 1080p, and 720p formats.



Serial Trigger and Decode Serial trigger allows a serial trigger condition to be set from within the oscilloscope, using an easy-to-understand interface.



Slew Rate Slew rate trigger activates a trigger when the rising or falling edge of a pulse crosses two threshold levels: an upper level and a lower level. The pulse edge must cross the thresholds faster or slower than a selected period of time. You can select both thresholds within a range of 2 ns to 20 s.



Runt The runt trigger is programmed to occur when a pulse crosses a first threshold line and fails to cross a second threshold line before recrossing the first. You can select both voltage thresholds within a time range of 100 ps to 20 s. Other defining conditions for this trigger are the edge (triggers on the slope opposite to that selected) and runt width.



Determining Trigger Level, Slope, Source, and Coupling

1. **Level** defines the source voltage at which the trigger circuit will generate an event: a change in the input signal that satisfies the trigger conditions. The selected trigger level is associated with the chosen trigger source.

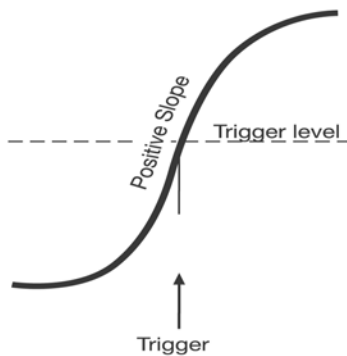
Trigger level is specified in volts and normally remains unchanged when you change the vertical gain or offset.

The amplitude and range of the trigger level are limited as follows:

- o ± 5 screen divisions with a channel as the trigger source
 - o ± 400 mV with EXT as the trigger source
 - o ± 4 V with EXT/10 as the trigger source
 - o ± 40 mV with EXT*10 as the trigger source
 - o None with LINE as the trigger source (zero crossing is used).
2. **Coupling** refers to the type of signal coupling at the input of the trigger circuit. Because of the instrument's very high bandwidth, there is only one choice of trigger coupling: DC 50 ohms. However, as a visual check of where ground is, you may switch the channel to ground coupling at any time while testing.

With DC coupling, all of the signal's frequency components are coupled to the trigger circuit for high-frequency bursts.

3. **Slope** determines the direction of the trigger voltage transition used for generating a particular trigger event. You can choose a positive, negative, or windowed slope. Like coupling, the selected slope is associated with the chosen trigger source.



Edge trigger works on the selected edge at the chosen level. The slope (positive or negative) is specified in the Trigger label permanently displayed below-right of the grid.

Trigger Source

- The **Trigger Source** source may be one of the following:
- The acquisition channel signal (CH 1, CH 2, CH 3 or CH 4) conditioned for the overall voltage gain, coupling, and bandwidth.
- The line voltage that powers the oscilloscope (LINE). This can be used to provide a stable display of signals synchronous with the power line. Coupling and level are not relevant for this selection.
- The signal applied to the EXT BNC connector (EXT). This can be used to trigger the oscilloscope within a range of ± 400 mV on EXT, ± 4 V with EXT/10 as the trigger source.
- A logic pattern.

Level

Level defines the source voltage at which the trigger circuit will generate an event (a change in the input signal that satisfies the trigger conditions). The selected trigger level is associated with the chosen trigger source. Note that the trigger level is specified in volts and normally remains unchanged when the vertical gain or offset is modified.

The Amplitude and Range of the trigger level are limited as follows:

- ± 5 screen divisions with a channel as the trigger source
- ± 400 mV with EXT as the trigger source
- ± 4 V with EXT/10 as the trigger source
- none with LINE as the trigger source (zero crossing is used)

Note: Once specified, Trigger Level and Coupling are the only parameters that pass unchanged from trigger mode to trigger mode for each trigger source.

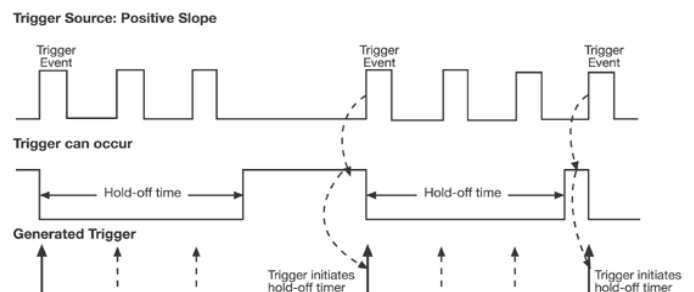
Holdoff by Time or Events

Holdoff is an additional condition of Edge trigger. It can be expressed either as a period of time or an event count. Holdoff disables the trigger circuit for a given period of time or number of events after the last trigger occurred. Events are the number of occasions on which the trigger condition is met. The trigger will again occur when the holdoff has elapsed and the trigger's other conditions are met.

Use holdoff to obtain a stable trigger for repetitive, composite waveforms. For example, if the number or duration of sub-signals is known you can disable them by choosing an appropriate holdoff value. Qualified triggers operate using conditions similar to holdoff.

HOLD OFF BY TIME

Sometimes you can achieve a stable display of complex, repetitive waveforms by placing a condition on the time between each successive trigger event. This time would otherwise be limited only by the input signal, the coupling, and the instrument's bandwidth. Select a positive or negative slope, and a minimum time between triggers. The trigger is generated when the condition is met after the selected holdoff time, counted from the last trigger. Any time between 1 ns and 20 s can be selected. The delay is initialized and started on each trigger.

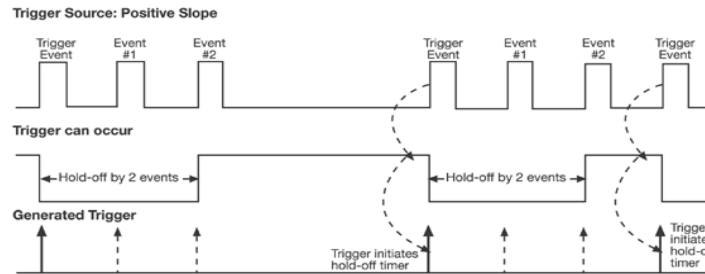


Edge Trigger with Holdoff by Time. The bold edges on the trigger source indicate that a positive slope has been selected. The broken upward-pointing arrows indicate potential triggers, which would occur if other conditions are met. The bold arrows indicate where the triggers actually occur when the holdoff time has been exceeded.

HOLD OFF BY EVENTS

Select a positive or negative slope and a number of events. An event is the number of times the trigger condition is met after the last trigger. A trigger is generated when the condition is met after this number, counted from the

last trigger. The count is restarted on each trigger. For example, if the event number is two, the trigger will occur on the third event. From one to 99,999,999 events can be selected.



Edge Trigger with Holdoff by Events (in this example, two events). The bold edges on the trigger source indicate that a positive slope has been selected. The broken, upward-pointing arrows indicate potential triggers, while the bold ones show where triggers actually occur after the holdoff expires.

Simple Triggers

EDGE TRIGGER ON SIMPLE SIGNALS

The instrument uses many waveform capture techniques that trigger on features and conditions that you define. These triggers fall into two major categories:

1. **Edge** -- activated by basic waveform features or conditions such as a positive or negative slope, and hold-off
2. **SMART Trigger** -- sophisticated triggers that enable you to use basic or complex conditions for triggering.

Use Edge Triggers for simple signals, and the SMART Triggers for signals with rare features, like glitches.

CONTROL EDGE TRIGGERING

Horizontal: Turn the Delay knob in the HORIZONTAL control group to adjust the trigger's horizontal position. Or, touch inside the **Delay** field in the timebase setup dialog and enter a value, using the pop-up keypad.

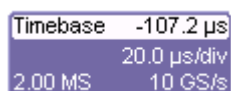
The trigger location is shown by a marker below the grid:



Post-trigger delay is indicated by a left-pointing arrow below-left of the grid:



The time value is given in the title line of the TimeBase label below-right of the grid:



Vertical: Turn the **LEVEL** knob in the TRIGGER control group to adjust the trigger's vertical threshold.

Turn this knob to adjust the level of the trigger source or the highlighted trace. Level defines the source voltage at which the trigger will generate an event a change in the input signal that satisfies the trigger conditions.

Alternatively, in the **Trigger** dialog, you can touch inside the **Level** field and type in a value, using the pop-up numeric keypad. To quickly set a level of zero volts, touch the **Zero Level** button directly below the **Coupling** field.

An arrow on the left side of the grid shows the threshold position. This arrow is only visible if the trigger source is displayed.

EDGE TRIGGER SETUP

CHANNEL SETUP

1. In the menu bar, touch **Trigger**, then select **Trigger Setup...** from the drop-down menu.



2. Touch the **Edge** trigger button under the **Trigger** tab.
3. Touch inside the **Trigger Source** field and select an input from the pop-up menu.
4. Touch inside the **Level** field:



5. In the pop-up numeric keypad, enter a value in millivolts or use the up/down buttons to increase or decrease the value in increments of 1 mV. Or, touch one of the preset value buttons:



6. Select the holdoff by touching the **Time** or **Events** buttons

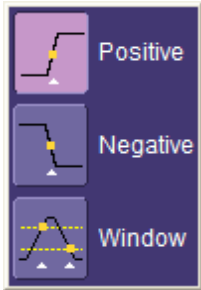


7. Using the pop-up numeric keypad, enter a value and specify the unit of time:



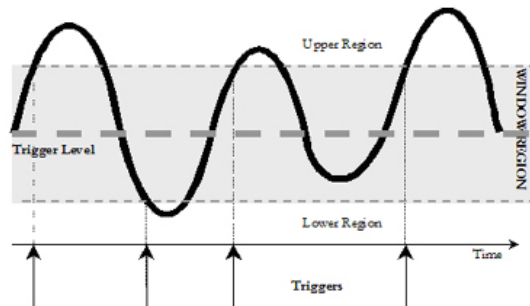
8. Or, use the up/down buttons to increase or decrease the time value in increments of 100 μs. Or, touch one of the preset value buttons:





9. Choose **Positive**, **Negative**, or **Window** slope.

Window slope sets a threshold above and below the trigger level beyond which the signal must pass to generate a trigger. The slope can be either positive or negative.



Width Trigger

HOW WIDTH TRIGGER WORKS

Width trigger allows you to define a positive- or negative-going pulse width bounded by a voltage level, above or below which a trigger will occur. You can specify a pulse width and voltage range, within or outside of which a trigger will occur.

WIDTH TRIGGER SETUP

1. Touch the **Trigger** descriptor label.



2. Touch the **Width** trigger button
3. Touch inside the **Trigger Source** field and select a source on which to trigger.
4. Touch inside the **Level** field and enter a value using the pop-up numeric keypad.
5. Select **Positive** or **Negative** polarity.
6. Touch the **Less Than** button and enter a pulse-width value in the **Upper Limit** field.
 - o Or touch the **Greater Than** button and enter a pulse-width value in the **Lower Limit** field.



- o Or touch the **InRange** button. Touch the **Delta** button to set up a nominal range, plus or minus a delta value in seconds. Touch inside the **Nominal Width** and **Delta** fields and enter values



using the pop-up numeric keypads. Alternatively, touch the **Limits** button to set up a precise pulse-width range. Touch inside the **Lower Limit** and **Upper Limit** fields and enter values using the pop-up keypads.

- o Or touch the **Out Of Range** button and perform the same range setups as for In Range triggering.

Qualified Trigger

HOW QUALIFIED TRIGGERS WORK

Use a signal's transition above or below a given level (its validation) as an enabling (qualifying) condition for a second signal that is the trigger source. These are Qualified triggers. For Edge Qualified triggers (the default) the transition is sufficient and no additional requirement is placed on the first signal. For State Qualified triggers the amplitude of the first signal must remain in the desired state until the trigger occurs. A qualified trigger can occur immediately after the validation, or following a predetermined time delay or number of potential trigger events. The time delay or trigger count is restarted with every validation.



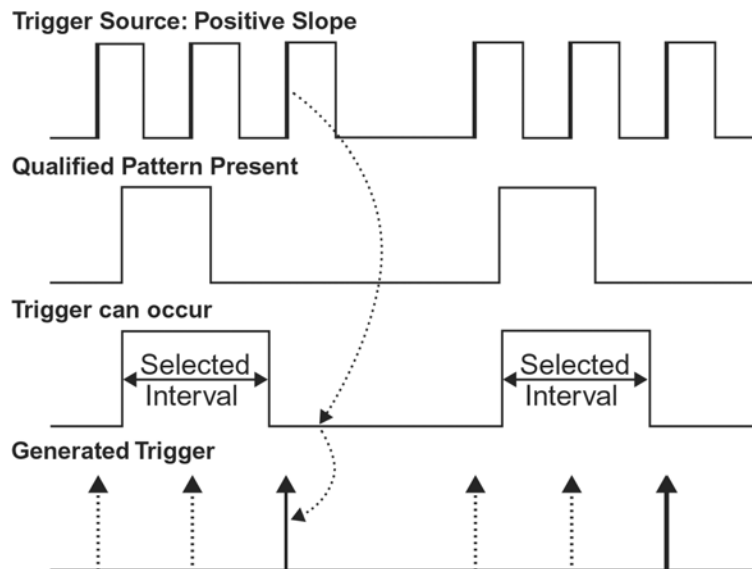
Within Time creates a time window within which a trigger can occur.



Wait Time determines a delay from the start of the desired pattern. After the delay (timeout) and while the pattern is present, a trigger can occur. The timing for the delay is restarted when the selected pattern begins.



Events determines a minimum number of events of the trigger source. An event is generated when a trigger source meets its trigger conditions. On the selected event of the trigger source and while the pattern is present, a trigger can occur. The count is initialized and started whenever the selected pattern begins, and continues while the pattern remains. When the selected count is reached, the trigger occurs.



Edge Qualified and Wait: Trigger after timeout. The broken upward-pointing arrows indicate potential triggers, while the bold ones show where the actual triggers occur.

QUALIFIED FIRST TRIGGER

- Qualified First trigger is intended to be used exclusively in Sequence Mode to speed up the trigger rate. With Qualified First trigger, a single valid trigger is sufficient to acquire a full sequence. Other than in Sequence Mode, Qualified First is identical to the Qualified triggers.
- In data storage applications, the index pulse can be defined as the qualifier signal and the servo gate signal as the trigger source.

EDGE QUALIFIED TRIGGER SETUP

1. Touch the **Trigger** descriptor label.

2. Touch the **Qualified** trigger button.
3. Under "Arm trigger on Event 'A'" select Edge as the condition on which to arm the trigger. The **Edge** condition will automatically be selected under "Then trigger on Event 'B'" also.
4. Under "When 'B' occurs", select a wait condition (time or events) and set a value.
5. Touch the **Event 'A' Edge** tab.
6. Select a trigger source under "Qualifier Setup."
7. Set a trigger voltage level in the **Level** field. Then select a slope and coupling.
8. Touch the **Event 'B' Edge** tab and make the same setups for the dependent trigger.

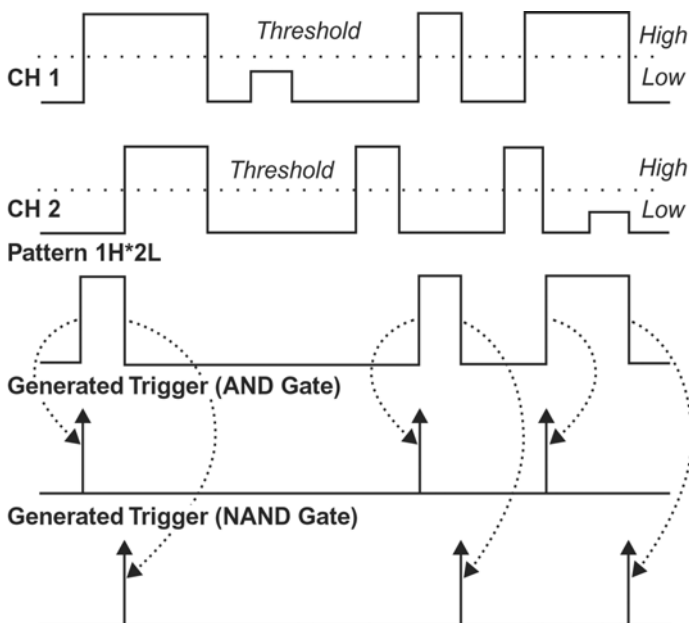
Pattern (Logic) Trigger

HOW LOGIC TRIGGER WORKS

Logic Trigger enables triggering on a logical combination of up to five inputs: CH 1, CH 2, CH 3, CH 4, and EXT. The combination of inputs is referred to as a pattern. There are four logic gates available: AND, NAND, OR, NOR.

A trigger state is either high or low: high when a trigger source is greater than the trigger level (threshold) and low when less than it. For example, an AND pattern could be defined as true when the trigger state for CH 1 is high, CH 2 is low, and EXT is irrelevant (X or don't care). If any one of these conditions is not met, the pattern state is considered false.

LOGIC APPLICATIONS



Logic Trigger can be used in digital design for the testing of complex logic inputs or data transmission buses.

LOGIC TRIGGER SETUP

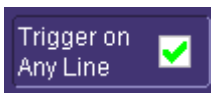
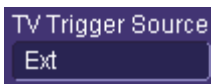
1. Touch the **Trigger** descriptor label.
2. In the **Trigger** dialog, touch the **Pattern** trigger button.
3. If you want to hold off the trigger (either in time or events) when the pattern becomes true, touch one of the **Holdoff By:** buttons. Then touch inside the holdoff data entry field and enter a value, using the pop-up keypad.
4. If applicable, touch the **Pattern** tab. For each input you want to include in the logic pattern, touch inside the **State** field and select a logic state: **Low** or **High**. Select **Don't Care** for all other inputs.
5. Touch inside the **Level** data entry field for each input included in the pattern, and enter a voltage level threshold, using the pop-up keypad.

TV Trigger

TV triggers provide stable triggering on standard or custom composite video signals. Use them on PAL, SECAM, or NTSC systems.

TV TRIGGER SETUP

1. Touch the **Trigger** descriptor label.
2. In the Trigger dialog, touch the **TV** trigger button



3. Touch one of these buttons (NTSC or PAL/SECAM) to select a television standard.

4. Touch inside **TV Trigger Source** and select the Ext (location of Trigger Out cable) from the pop-up menu.

Note: The channel that you have the VT75 Module connected to is automatically designated TV Signal in the menu.

5. Touch inside **Polarity** and select positive or negative polarity. This selection is independent of the polarity selected for Edge trigger (positive) in the "Trigger" setup dialog.

6. Check the **Trigger on Any Line** checkbox if you do not want to specify one. In this case the oscilloscope will trigger on any sync pulse.

7. Touch inside **# of Fields** and make a selection (1 to 8) from the pop-up menu.

8. Touch inside **Line** and enter a line number, using the pop-up keypad. The maximum line number that you can enter depends on the television standard (NTSC/PAL/SECAM) and the interlace factor selected. For NTSC, line 526 is the same as line 1; for PAL, line 626 is the same as line 1.

9. Touch inside **Field** and make a selection from the pop-up menu. The maximum field number that you can select is limited by your selection in **# of Fields**. If # of Fields above is set to **1**, this selection is disabled.

CUSTOM TRIGGER SETUP

CUSTOM

of Lines
526

Hz
60Hz

Interlace
2:1

1. Touch the **Custom** button to select Custom mode.
2. Touch inside **# of Lines**, and enter a value up to 1500, using the pop-up keypad.
3. Touch inside **Hz** and select 50 or 60 Hz from the pop-up menu.
4. Touch inside **Interlace** and select an interlacing factor from the pop-up menu.

Note: A selection from this menu of 1:1 will reset the # of Fields selection to 1, since interlacing does not apply to a single field. The maximum allowable interlace factor is equal to the # of Fields set.

SMART Triggers

Glitch Trigger

HOW GLITCH TRIGGER WORKS

Glitch trigger can be used to catch glitches. You can specify a pulse width or a pulse width range.

Pulse smaller than selected pulse width: Set a maximum pulse width. This glitch trigger is generated on the selected edge (positive or negative) when the pulse width is less than or equal to the set width.

The timing for the width is initialized and restarted on the opposite slope to that selected.

Note: If the glitch's width is narrower than the signal's width, set the trigger to a narrower width than that of the signal. The signal's width, as determined by the instrument trigger comparator, depends on the DC trigger level. If that level were to be set at the middle of a sine wave, for example, the width could then be considered as the half period. But if the level were higher, the signal's width would be considered to be less than the half period.

Trigger Source



Trigger can occur



Generated Trigger



Glitch Trigger: In this example triggering on a pulse width less than or equal to the width selected. The broken upward-pointing arrow indicates a potential trigger, while the bold one shows where the actual trigger occurs.

GLITCH TRIGGER SETUP

1. Touch the Trigger descriptor label.
2. If applicable, touch the Smart trigger button, then the Glitch trigger button.
3. Touch inside the trigger Source field and select a source on which to trigger.
4. Touch inside the Level data entry field and enter a value using the pop-up keypad.
5. Select Positive or Negative polarity.

Define the width of the glitch you are looking for. You can trigger on any glitch less than a chosen pulse-width (Upper Limit); or you can trigger on a chosen range. When you touch the Less Than button; the Upper Limit data entry field alone is displayed. When you touch the In Range button; the Upper Limit and Lower Limit fields are displayed.

6. Touch inside the limit fields and enter a time value, using the pop-up keypad.

INTERVAL TRIGGER

HOW INTERVAL TRIGGERS WORK

While Glitch trigger performs over the width of a pulse, Interval trigger performs over the width of an interval, with the signal duration (period) separating two consecutive edges of the same polarity: positive to positive or negative to negative. Use Interval trigger to capture intervals that fall short of, or exceed, a given time limit. In addition, you can define a width range to capture any interval that is itself inside or outside the specified range: an exclusion trigger by interval.

- **Interval Less Than:** For this Interval Trigger, generated on a time interval smaller than the one that you set, choose a maximum interval between two like edges of the same slope (positive, for example).

The trigger is generated on the second (positive) edge if it occurs within the set interval. The instrument initializes and restarts the timing for the interval whenever the selected edge occurs.

Trigger Source: Positive Slope



Trigger can occur



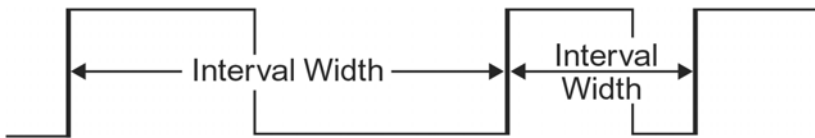
Generated Trigger



Interval Trigger that triggers when the interval width is smaller than the selected interval. The broken, upward-pointing arrow indicates a potential trigger, while the bold one shows where the actual trigger occurs on the positive edge within the selected interval.

- **Interval Greater Than:** For this Interval Trigger, generated on an interval larger than the one that you set, select a minimum interval between two edges of the same slope. The instrument generates the trigger on the second edge if it occurs after the set interval. The timing for the interval is initialized and restarted whenever the selected edge occurs.

Trigger Source: Positive Slope



Trigger can occur



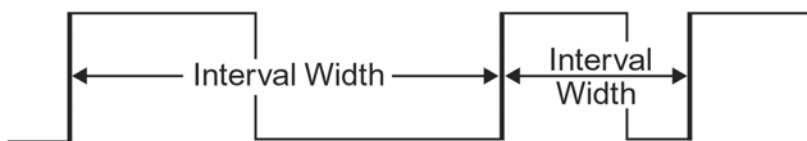
Generated Trigger



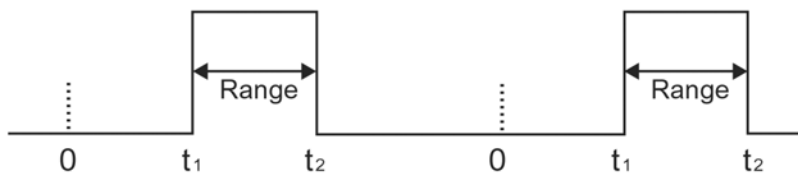
Interval Trigger that triggers when the interval width is larger than the set interval. The broken upward-pointing arrow indicates a potential trigger, while the bold one shows where the actual trigger occurs on the positive edge after the selected interval.

- **Interval In Range:** This Interval Trigger is generated whenever an interval between two edges of the same slope falls within a selected range. The instrument initializes and restarts the timing for the interval whenever the selected edge occurs.

Trigger Source: Positive Slope



Trigger can occur



Generated Trigger



Interval Trigger that triggers when the interval falls within the selected range:

t_1 = range's lower time limit; t_2 = range's upper limit. The broken upward-pointing arrow indicates a potential trigger, while the bold one indicates where the actual trigger occurs on the positive edge within the selected range.

INTERVAL TRIGGER SETUP

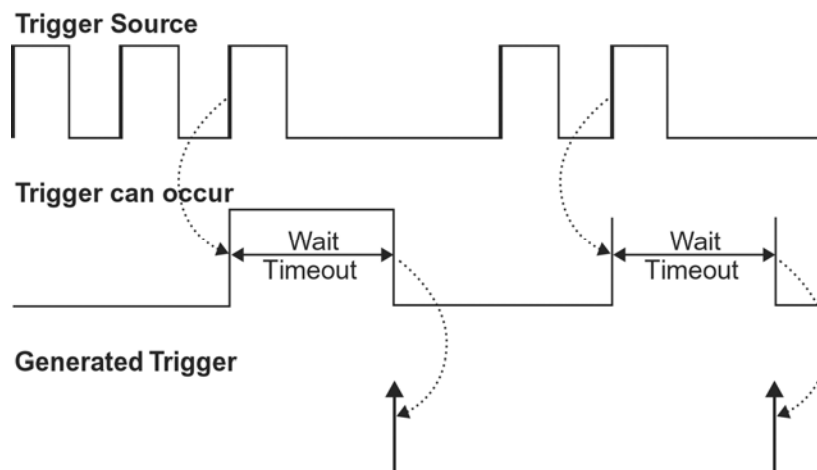
1. Touch the **Trigger** descriptor label.

2. If applicable, touch the **Smart** trigger button, then the **Interval** trigger button.
3. Touch inside the **Trigger Source** field and select a source on which to trigger.
4. If available, touch inside the **Coupling** field and select a coupling mode.
5. Touch inside the **Level** field and enter a value using the pop-up numeric keypad.
6. Select positive or negative polarity.
7. Touch the **LessThan** button and enter a pulse-width value in the **Upper Limit** field.
 - o Or touch the Greater Than button and enter a value in the Lower Limit data entry field.
 - o Or touch the In Range button.
8. Touch the Delta button to set up a nominal range, plus or minus a delta value in seconds. Touch inside the
7. Nominal Width and Delta data entry fields and enter values using the pop-up numeric keypads. Touch the Limits button to set up a precise range. Touch inside the Lower Limit and Upper Limit data entry fields and enter values using the pop-up numeric keypads.
 - o Or, if available, touch the Out Of Range button and perform the same Delta or Limits setup as for In Range triggering.

Dropout Trigger

Used primarily in single-shot applications, and usually with a pre-trigger delay, Dropout trigger can detect lost signals. The trigger is generated at the end of the timeout period following the last trigger source transition.

HOW DROPOUT TRIGGER WORKS



Dropout Trigger: occurs when the timeout has expired. The bold upward-pointing arrows show where the trigger occurs.

DROPOUT TRIGGER SETUP

1. Touch the **Trigger** descriptor label.
2. If applicable, touch the **Smart** trigger button, then the **Dropout** trigger button.
3. Select **Positive** or **Negative** polarity.
4. Touch inside the **Trigger after** timeout data entry field and enter a time value, using the pop-up keypad.
5. Enter a voltage level in the **Level** field.

Runt Trigger

The Runt trigger is programmed to occur when a pulse crosses a first threshold line and fails to cross a second threshold line before recrossing the first. You can select both voltage thresholds within a time range of 100 ps to 20 s. Other defining conditions for this trigger are the edge (triggers on the slope opposite to that selected) and runt width.

RUNT TRIGGER SETUP

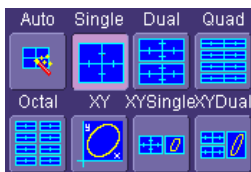
1. Touch the **Trigger** descriptor label.
2. If applicable, touch the **Smart** trigger button, then touch the Runt trigger button.
3. Touch inside the trigger **Source** field and select a source on which to trigger. If
4. you select an external trigger source, you will also need to set a coupling mode.
5. Touch inside the **Level** data entry field and enter a value, using the pop-up keypad.
6. Select Positive or **Negative** polarity.
7. Touch the **Less Than** button and enter a pulse-width value in the **Upper Limit** field.
 - o Or touch the **Greater Than** button and enter a pulse-width value in the **Lower Limit** field.
 - o Or touch the **In Range** button. Then touch the **Delta** button to set up a nominal range, plus or minus a delta value in seconds. Touch inside the **Nominal Width** and **Delta** fields and enter values, using the pop-up numeric keypads. Alternatively, touch the **Limits** button to set up a precise pulse-width range by setting **Lower Limit** and **Upper Limit** values, using the pop-up keypads.
 - o Or touch the **Out Of Range** button and perform the same range setups as for **In Range** triggering.

Slew Rate Trigger

1. Touch the **Trigger** descriptor label.
2. If applicable, touch the **Smart** trigger button, then touch the Slew Rate trigger button.
3. Touch inside the trigger **Source** field and select a source on which to trigger. If
4. you select an external trigger source, you will also need to set a coupling mode.
5. Touch inside the **Level** data entry field and enter a value, using the pop-up keypad.
6. Select **Positive** or **Negative** polarity.
7. Touch the **Less Than** button and enter a pulse-width value in the **Upper Limit** field.
 - o Or touch the **Greater Than** button and enter a pulse-width value in the **Lower Limit** field.
 - o Or touch the **In Range** button. Then touch the **Delta** button to set up a nominal range, plus or minus a delta value in seconds. Touch inside the **Nominal Width** and **Delta** fields and enter values, using the pop-up numeric keypads. Alternatively, touch the **Limits** button to set up a precise pulse-width range by setting **Lower Limit** and **Upper Limit** values, using the pop-up keypads.
 - o Or touch the **Out Of Range** button and perform the same range setups as for In Range triggering.

DISPLAY FORMATS

1. In the menu bar, touch **Display**; then touch **Display Setup** in the drop-down menu.
2. Touch one of the **Grid** combination buttons. **Autogrid** automatically adds or deletes grids as you select more or fewer waveforms to display.



3. Touch inside the **Grid Intensity** field and enter a value from 0 to 100 using the pop-up keypad.



4. Touch the **Grid on Top** checkbox if you want to superimpose the grid over the waveform. Depending on the grid intensity, some of your waveform may be hidden from view when the grid is placed on top. To undo, simply uncheck **Grid on Top**.

5. Touch the **Axis Labels** checkbox to permanently display the values of the top and bottom grid lines (calculated from volts/div) and the extreme left and right grid lines (calculated from the timebase).
6. Choose a line style for your trace: solid **Line** or **Points**:



Persistence Setup

The analog Persistence feature helps you display your waveform and reveal its idiosyncrasies or anomalies for a repetitive signal. Use Persistence to accumulate on-screen points from many acquisitions to see your signal change over time. The instrument persistence modes show the most frequent signal path "three-dimensionally" in intensities of the same color, or graded in a spectrum of colors.

You can show persistence for up to eight inputs for any channel, math function, or memory location (M1 to M4).

SATURATION LEVEL

The Persistence display is generated by repeated sampling of the amplitudes of events over time, and the accumulation of the sampled data into "3-dimensional" display maps. These maps create an analog-style display. User-definable persistence duration can be used to view how the maps evolve proportionally over time. Statistical integrity is preserved because the duration (decay) is proportional to the persistence population for each amplitude or time combination in the data. In addition, the instrument gives you post-acquisition saturation control for a more detailed display.



When you select **Analog** mode from the **Persistence** dialog, each channel is assigned a single color. As a persistence data map develops, different intensities of that color are assigned to the range between a minimum and a maximum population. The maximum population automatically gets the highest intensity, the minimum population gets the lowest intensity, and intermediate populations get intensities in between these extremes.

The information in the lower populations (for example, down at the noise level) could be of greater interest to you than the rest. The Analog persistence view highlights the distribution of data so that you can examine it in detail.

You can select a saturation level as a percentage of the maximum population. All populations above the saturation population are then assigned the highest color intensity: that is, they are saturated. At the same time, all populations below the saturation level are assigned the remaining intensities. Data populations are dynamically updated as data from new acquisitions is accumulated.



Color mode persistence, selected by touching **Color**, works on the same principle as the Analog persistence feature, but instead uses the entire color spectrum to map signal intensity: violet for minimum population, red for maximum population. A saturation level of 100% spreads the intensity variation across the entire distribution; at lower saturation levels the intensity will saturate (become the brightest color) at the percentage value specified. Lowering this percentage causes the pixels to be saturated at a lower population, and makes visible those rarely hit pixels not seen at higher percentages.

Show Last Trace

For most applications, you may not want to show the last trace because it will be superimposed on top of your persistence display. In those cases turn off **Show Last Trace** by touching the checkbox. However, if you are doing mask testing and want to see where the last trace is falling, turn **Show Last Trace** on.

Persistence Time

You can control the duration of persistence by setting a time limit, in seconds, after which persistence data will be erased: 0.5 s, 1 s, 2 s, 5 s, 10 s, 20 s, or infinity.

Persistence Setup

1. In the menu bar touch **Display**, then touch **Persistence Setup...** in the drop-down menu.
2. Touch the **Persistence On** checkbox.



3. Touch one of the mode buttons
4. Then touch the **Show last trace** checkbox if you want the last trace displayed.
5. Touch inside the **Saturation** field and enter a whole number integer, using the pop-up numeric keypad.
6. Touch inside the **Persistence Time** field and make a selection from the pop-up menu.
7. To turn off persistence for all channels, uncheck the **Persistence On** checkbox.

Screen Saver

The Windows screen saver is activated in the same way as for any PC.

1. Minimize the instrument display by touching **File** in the menu bar, then **Minimize** in the drop-down menu.
2. Touch **Start** down in the task bar.
3. Touch **Settings** in the pop-up menu.
4. Touch Control Panel.
5. Touch **Display**.
6. Touch the **Screen Saver** tab.

ZOOMING YOUR CHANNELS

Overview

LeCroy offers extremely powerful, yet simple to use, zooming capability in the WaveSurfer Xs oscilloscope. The large, bright 10.4" display with touch screen lends itself very well to quickly creating zooms, and being able to see how they relate to the original channels.

There are a number of different ways to zoom in a WaveSurfer Xs oscilloscope:

- **Drawing a box** around the area to be zoomed, using either your finger or a mouse/pointing device.
- Using the front panel **QuickZoom** button.
- Using the software toolbar **Zoom** button that is in the Channel menu.

The operating behavior for all three methods is basically the same, with some minor differences.

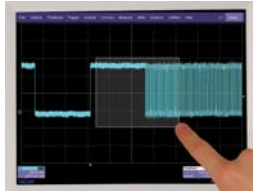
In all cases, the zoomed channels are displayed in a separate half-height grid at the bottom of the display (separate from the channels). If you also have a Math trace displayed when you zoom, there will be three grids on the display, each one-third height.

The zoomed traces are nearly the same color as the original channel traces to make comparison easy. The zoomed area is shown in white on the original channel trace. All zooms share a common horizontal zoom scale and position. Each zoom has an independent vertical zoom capability. All zooms are calculated to 16-bit vertical resolution. Therefore, you can vertically scale the zoom traces and still maintain very high resolution when viewing signal detail.

Creating Zooms

There are three ways to create channel zooms as follows:

TOUCH SCREEN ZOOMING



You can draw a box around the area that you wish to zoom simply by dragging your finger, fingernail, or pointing device around the area of the waveform that you want to zoom.

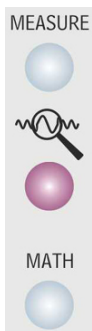
If there is only one channel ON when you draw a box, the zoom will be created instantly. If more than one channel is ON, you will be prompted for which channels you want to zoom.

To UNDO your zoom, touch the **UNDO** button in the upper right corner of the display.

You can also use touch screen zoom to change the zoom scale of an existing Zoom, Math, or Memory (reference waveform) trace.

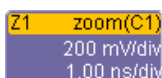


FRONT PANEL QUICKZOOM BUTTON



- Press the front panel **QuickZoom** button.
- Zoom traces will be created for all of the channels currently displayed.
- To turn off a Zoom trace individually, touch the Zoom descriptor label twice to open the Zoom trace menu, then uncheck the ON checkbox.
- To UNDO your zoom at any time, simply press the front panel QuickZoom button again.

Note: If you turn a channel ON while the QuickZoom is displayed, the new channel will not be zoomed.



TOOLBAR ZOOM



- Press the Toolbar **Zoom** button in the Channel Toolbar located in the Channel menu.
- A Zoom trace will be created for that channel only.
- To UNDO your zoom, press the **UNDO** button in the upper right corner of the display.

Zoom Descriptor Label

When a Zoom trace is ON, there is a descriptor label on the display for it, much like for the channels, math trace, and memories (reference waveforms).

Z1 zoom(C1)
200 mV/div
1.00 ns/div

- The top line contains information about the Zoom trace (in this case, it's a Zoom of Channel 1).
- The 2nd line contains vertical scaling information.
- The 3rd line contains horizontal scaling information.

If the descriptor label is a solid color (as shown below), then the Zoom trace is ACTIVE, which means that the Horizontal and Vertical front panel controls are set to adjust that specific zoom trace, and not any of the channels. In this case, the scale and position of the Zoom trace can be changed by adjusting the horizontal and vertical controls on the front panel.

Z1 zoom(C1)
200 mV/div
1.00 ns/div

Note that the Horizontal scales and position is the same for all Zoom traces, but Vertical scale and position can be adjusted individually.

If the Zoom trace is not ACTIVE, and you wish to make it ACTIVE, simply touch the descriptor label once and it will become active. Touch the descriptor label again, and it will open the Zoom trace menu.

Note: When a Zoom trace is active, no channel buttons will be lighted, which tells you that a Zoom trace may be currently active.

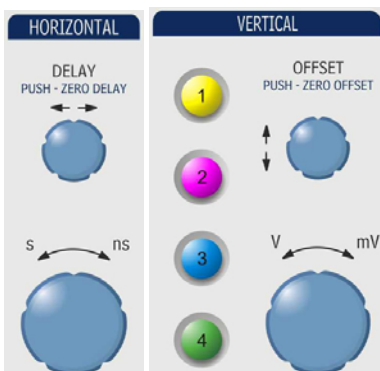
Adjusting Zoom Scale and Position

USING FRONT PANEL CONTROLS

It is easy to adjust your Zoom trace scale and position. The WaveSurfer Xs oscilloscope multiplexes the Vertical and Horizontal Front Panel controls to control the zoom scale and position. This is done automatically after you have created the zoom trace, and remains this way until you make a Channel, Math trace, or Memory (reference waveform) active.

Z1 zoom(C1)
200 mV/div
1.00 ns/div

If the Zoom trace you wish to adjust is not active, touch the Descriptor Label once to make it active.



Then use the front panel horizontal and vertical controls to adjust position and scale. The operation of the knobs will feel natural. Use the table below as a guide.

Note: When a Zoom trace is active, no channel buttons will be lighted, which tells you that a Zoom trace may be currently active.

Panel Control	Zoom Control Action
Delay	Zooms horizontal position
Timebase	Zooms horizontal scale
Offset	Zooms vertical position
Gain / Sensitivity	Zooms vertical scale
Push – Zero Delay	Resets horizontal zoom to 10:1 scale, and resets to default horizontal position
Push – Zero Offset	Resets vertical zoom to 1:1 scale, and resets to default vertical position

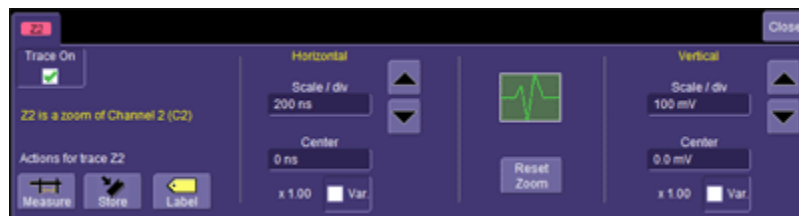
USING ZOOM MENU CONTROLS

You can also use the Zoom menu controls to adjust zoom.

	Touch the descriptor label twice to open the Zoom Menu.
---	---

Then use the software zoom controls to change the horizontal and vertical position and scale.

Horizontal scale adjustments always apply to all waveforms.



SAVE AND RECALL

Saving and Recalling Oscilloscope Settings

You can save or recall oscilloscope settings to or from hard disk, floppy disk, or LAN location.

SAVING OSCILLOSCOPE SETTINGS

1. In the menu bar, touch **File**; then touch **Save Setup...** in the drop-down menu. Or, press the Save/Recall front panel button, then touch the **Save Setup** tab.
2. To **Save To File**, touch inside the **Save Instrument Settings** field and use the pop-up keyboard to enter the



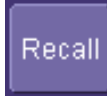
path to the destination folder. Or touch **Browse** to navigate to the destination folder. Then touch below the field. To save to folder **Internal Setups** on the oscilloscope's hard drive, touch inside a **SetupX**

field and use the pop-up keyboard to enter a file name. Touch  alongside the field. The file is deposited in **D:\Internal Setups**, and the current date is displayed above the field.

RECALLING OSCILLOSCOPE SETTINGS

1. In the menu bar, touch **File**; then touch **Recall Setup...** in the drop-down menu.
2. To **Recall From File**, touch inside the **Recall panels from file** field and use the pop-up keyboard to enter the

path to the source folder. Or touch **Browse** to navigate to the source folder. Then touch .

To recall settings from folder **D:\ Internal Setups** on the oscilloscope's hard drive, touch  alongside the file you want to recall.

RECALLING DEFAULT SETTINGS

1. In the menu bar, touch **File**; then touch **Recall Setup...** in the drop-down menu.

2. Touch the button under **Recall Default Setup** .

Saving Screen Images

You can send images to a hard copy printer or to storage media. Both types of output are done from the same dialog.

1. In the menu bar, touch **Utilities**, then **Utilities Setup...** in the drop-down menu.
2. Touch the **Hardcopy** tab.
3. Touch the **File** button.
4. Touch inside the **File Format** field and select a file type.
5. Under **Colors**, touch the **Use Print Colors** checkbox if you want your waveforms to print in color with a white background. A white background saves printer toner.
6. Touch inside the **Directory** field and type in the path to the directory where you want the image stored, using the pop-up keyboard. Or you can touch the browse button and navigate there.
7. Touch inside the **File Name** field and type in a name for your image, using the pop-up keyboard.
8. Under **Hardcopy Area**, touch the **Grid Area Only** checkbox if you do not want to include the dialog area in the image.
9. Touch the **Printer** button.

Saving and Recalling Waveforms

SAVING WAVEFORMS

1. In the menu bar, touch **File**; then touch **Save Waveform...** in the drop-down menu.

2. In the **Save Waveform** dialog, touch the **Save To**  or  button.

3. Touch inside the **Source** field and select a source from the pop-up menu. The source can be any trace; for example, a channel (C1-C4), math function (F1-F4), or a waveform stored in memory (M1-M4).
4. Touch inside the **Trace Title** field if you want to change the default name of your waveforms. Use the pop-up keyboard to type in the new name.

Note: You can change the name but not the sequence number.

CAUTION

- If you use a name that ends in a number instead of a letter, the instrument may truncate the number. This is because, by design, the first waveform is automatically numbered 0, the second 1, etc. For example, if you want to use waveform name "XYZ32" but it is not preceded by waveforms XYZ0 through XYZ31, the waveform will be renumbered with the next available number in the sequence.
- If you need to use a number in your waveform's name, it is recommended that you append an alpha character at the end of the number : "XYZ32a" for example.
- If you are saving to file, touch the **Data Format** field and select a format type from the pop-up menu:



- If you select **ASCII** or **Excel**, also touch the **SubFormat** field and select either **Time Data** or **Time & Ampl.**. Then touch the **Delimiter** field and select a delimiter character from the pop-up menu: comma, space, semicolon, or tab.
5. Touch the **Browse** button for the **Save file in directory** field and browse to the location where you want the file saved. The file name is assigned automatically and is shown below the field.



6. Touch **AUTO SAVE**

You can also enable Auto Save from this dialog by touching one of the Auto Save buttons



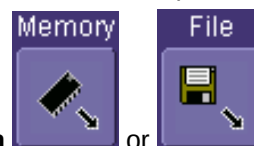
: **Wrap** (old files overwritten) or **Fill** (no files overwritten).

CAUTION

If you select Fill, you can quickly use up all disk space on your hard disk.

RECALLING WAVEFORMS

1. In the menu bar, touch **File**; then touch **Recall Waveform...** in the drop-down menu.



2. In the **Recall Waveform** dialog, touch the **Recall From** button or button.
3. If you selected **Memory**, touch inside the **Source** field and select a memory location: **M1** to **M4**.
4. If you selected **File**, touch inside the **Destination** field and select a memory location in which to store the file.

5. Touch inside the **Show only files** field and select an area to limit the search to: channels, math functions, or memory.
6. Touch inside the **Recall files from directory** field and enter the path, using the pop-up keyboard. Or touch the **Browse** button to navigate to the file.
7. Touch inside the **Next file will be recalled from** field and enter the path, using the pop-up keyboard. Or touch the **Browse** button to navigate to the file.



8. Touch

Disk Utilities

Use the **Disk Utilities** dialog to delete files or create folders.

DELETING A SINGLE FILE

1. Touch **File** in the menu bar, then **Disk Utilities...** in the drop-down menu.



2. Touch the **Delete** button in the **Disk Utilities** dialog.
3. Touch inside the **Current folder** field and use the pop-up keyboard to enter the path to the folder that contains the file you want to delete. Or touch the **Browse** button and navigate to the folder.
4. Touch inside the **File to be deleted** field and use the pop-up keyboard to enter the name of the file. Or touch the **Browse** button and navigate to the file.
5. Once you have located the file, touch the **Delete File** button.

DELETING ALL FILES IN A FOLDER

1. Touch **File** in the menu bar, then **Disk Utilities...** in the drop-down menu.



2. Touch the **Delete** button in the **Disk Utilities** dialog.
3. Touch inside the **Current folder** field and use the pop-up keyboard to enter the path to the folder that contains the file you want to delete. Or touch the **Browse** button and navigate to the folder.
4. Once you have located the folder, touch the **Empty Folder** button.

CREATING A FOLDER

1. Touch **File** in the menu bar, then **Disk Utilities...** in the drop-down menu.



2. Touch the **Create** button in the **Disk Utilities** dialog.
3. Touch inside the **Current folder** field and use the pop-up keyboard to enter the path to the directory you want to create the folder in, and the name of the folder.
4. Touch the **Create Folder** button.

PRINTING AND FILE MANAGEMENT

Print, Plot, or Copy

The instrument gives you the ability to output files to a printer or plotter, to print to file, or to e-mail your files. Any Windows 2000 supported printer is supported by your instrument.

Printing

PRINTER SETUP

1. In the menu bar, touch **File**, then **Print Setup...** in the drop-down menu. The Utilities **Hardcopy** dialog opens.



2. In the dialog area, touch the **Printer** icon.
3. Under **Colors**, touch the **Use Print Colors** checkbox if you want the traces printed on a white background. A white background saves printer toner. (You can change the printer colors in the **Preference** dialog.)
4. Touch inside the **Select Printer** field. From the touch pad pop-up choose the printer you want to print to. Touch the **Properties** button to see your printer setup.
5. Touch the icon for the layout **Orientation** you want: portrait or landscape.
6. Touch the **Grid Area Only** checkbox if you do not need to print the dialog area and you only want to show the waveforms and grids.

PRINTING

You can print in one of three ways:

1. Press the printer button on the front panel:
2. In the menu bar, touch **File**, then **Print** in the drop-down menu.
3. Touch the **Print Now** button in the **Hardcopy** dialog

ADDING PRINTERS AND DRIVERS

Note: If you want to add a printer driver, the driver must first be loaded on the oscilloscope.

1. In the menu bar, touch **File**, then **Print Setup...** in the drop-down menu. The Utilities **Hardcopy** dialog opens.



2. In the dialog area, touch the **Printer** icon.
3. Touch the **Add Printer** button. An MS Windows® window with which to add a printer will open.
4. Touch the **Properties** button to change printer properties such as number of copies.

CHANGING THE DEFAULT PRINTER

If you want to change the default printer:

1. Minimize the instrument application by touching **File** in the menu bar, then **Minimize** in the drop-down menu.
2. Touch the **Start** button in the task bar at the bottom of the screen.
3. Select **Settings**, then **Printers**.
4. Touch the printer you want to set as the default printer, then touch **File, Set as Default Printer**.

Managing Files

Use the instrument's utilities to create waveform files on USB memory, internal hard drive or network drives. You can copy files from your hard drive to floppy disk. You also can give your files custom names and create directories for them.

HARD DISK PARTITIONS

The instrument's hard disk is partitioned into drive **C:** and drive **D:**. Drive C: contains the Windows operating system and the instrument application software. Drive D: is intended for data files.

100BASE-T ETHERNET CONNECTION

Connecting to a Network

Use the Ethernet connector (item **7** below) to connect the instrument to a network.



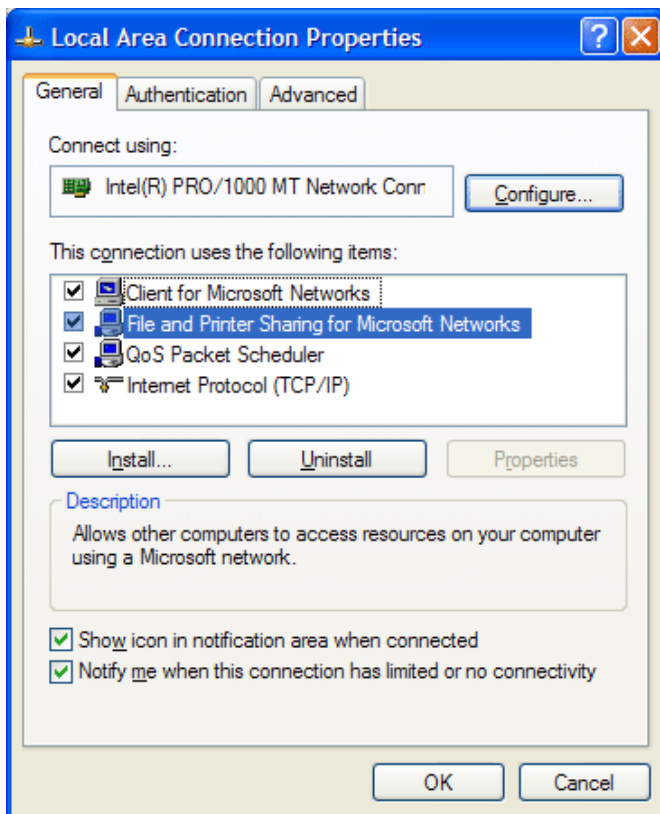
Communicating over the Network

The instrument uses Dynamic Host Configuration Protocol (DHCP) as its addressing protocol. Therefore, there is no factory set IP address.

File and Printer Sharing over a Network

By default, this feature is disabled. To re-enable network File and Printer Sharing,

1. Minimize the oscilloscope application to reveal the underlying desktop.
2. From the toolbar select **Start → Control Panel → Network Connections → Local Area Connection**.
3. Touch the Properties button, and then check the **File and Printer Sharing for Microsoft Networks** checkbox.



Windows Setups

Instruments that are required to participate in a Windows Network Domain will need to be "joined" to the domain by a network administrator (the procedure typically requires an administrator username and password).

Domain membership is not required to use the instrument on a network, but will generally make it easier to access network shared drive and printer resources.

Guidelines for Working in Windows

Although the instrument has an open architecture, avoid modifying the Windows operating system, since this may cause problems for the instrument's user interface. Please follow these recommendations:

- Do not load any version of Windows not provided by LeCroy. Windows service packs and critical updates are generally safe, and LeCroy does encourage you to install them to keep your oscilloscope safe from network-borne viruses and worms. However, LeCroy cannot guarantee that any update distributed by Microsoft will not adversely affect the operation of your instrument. Any compatibility issues detected by LeCroy will be posted on our DSO Security Web site at <http://www.lecroy.com/dsosecurity>. It is advisable to check this site before applying updates.
- If the instrument powers up in Windows Safe Mode, the touch screen will not function. You may need a mouse or keyboard to restore normal operation.
- Avoid modifying Control Panel settings.
- Do not change the color resolution (24 bit) or screen size (800 x 600 pixel) settings.
- After you load third-party software applications, if your oscilloscope does not work properly try reloading the instrument software from the CD shipped with the device. If your instrument is not equipped with a CD drive, you will need a USB CD-ROM to do this (not supplied by LeCroy). This does not apply to WaveSurfer or WaveRunner 6000A models, which can be recovered from their internal hard drives.
- Do not modify or remove any system fonts; doing so may affect the readability of the dialogs.
- Do not change any display properties like Background, Appearance, Effects, or Settings. Functionality of the oscilloscope or screen saver may be affected.
- Do not make any changes to the Windows folder.
- Do not make any changes to the BIOS settings.
- Do not make any changes to the Windows power management system.

System Restore

Although the oscilloscope creates regularly scheduled restore points automatically, before you install any hardware or software on your instrument LeCroy strongly recommends that you manually create a restore point. The restore point resides on the oscilloscope's hard drive, so no external storage medium (floppy disk, USB memory stick, etc.) is required.

CREATING A SYSTEM RESTORE POINT

1. From the **File** menu, minimize or Window the oscilloscope display to reveal the task bar.
2. In the task bar, select Start, Programs, Accessories, System Tools, System Restore.
3. Touch the **Create a restore point** radio button, then touch **Next**.
4. In the **Restore point description** box, indicate what software or hardware is going to be added after the restore point is created, then touch **Next**.
5. The restore point will be created and a confirmation message will be displayed.

WAVEFORM MEASUREMENTS

Measuring with Cursors

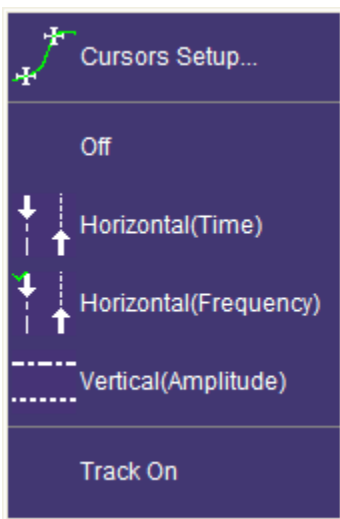
Cursors are important tools that aid you in measuring signal values. Cursors are markers — lines, cross-hairs, or arrows — that you can move around the grid or the waveform itself. Use cursors to make fast, accurate measurements and to eliminate guesswork. There are two basic types:

1. **Horiz(ontal)** (generally Time or Frequency) cursors are markers that you move horizontally along the waveform. Place them at a desired location along the time axis to read the signal's amplitude at the selected time.
2. **Vert(ical)** (Voltage) cursors are lines that you move vertically on the grid to measure the amplitude of a signal.

Cursors Setup

QUICK DISPLAY

At any time, you can change the display of cursor types (or turn them off), without invoking the **Cursors Setup** dialog as follows:



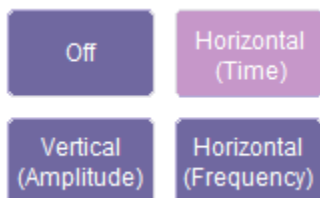
In the menu bar, touch **Cursors**, then **Off**, **Horizontal (Time)**, **Horizontal (Frequency)**, or **Vertical (Amplitude)**.

The cursors displayed will assume the positions previously set up. If you want to change their position or measurement mode, in the menu bar touch **Cursors**, then **Cursors Setup** in the drop-down menu.

FULL SETUP

In the menu bar, touch **Cursors**, then **Cursors Setup**. The **Standard Cursors** dialog opens and cursors are displayed automatically.

Select a **Cursor Type**. If an FFT math function is displayed, the **Horizontal (Frequency)** button will be available.



Use the Cursors knobs on the front panel to place the cursors; or, you can enter a value in the **Position 1** and **Position 2** fields to place the cursors precisely. Touch the **Find** buttons to quickly place the cursors 2.5 divisions left and right of center.



If you would like both cursors to move in unison as you adjust the position, touch the **Track** checkbox to enable tracking.

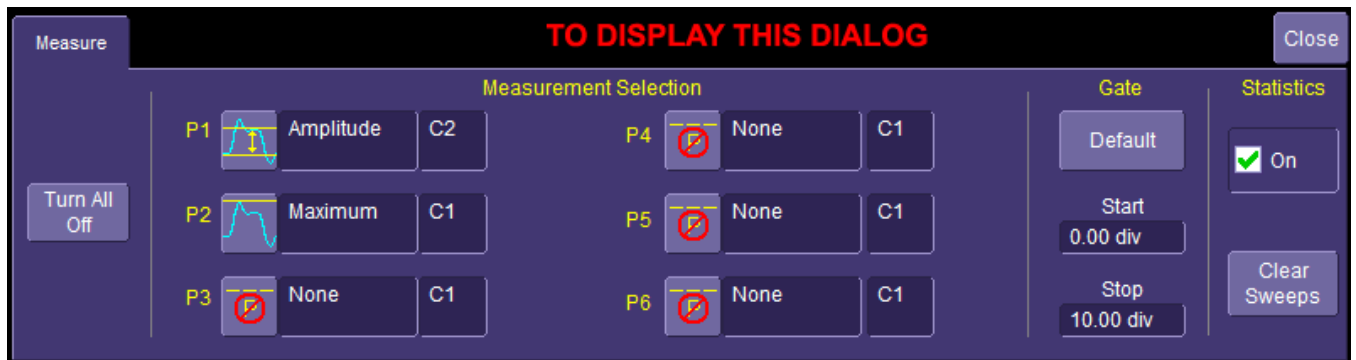
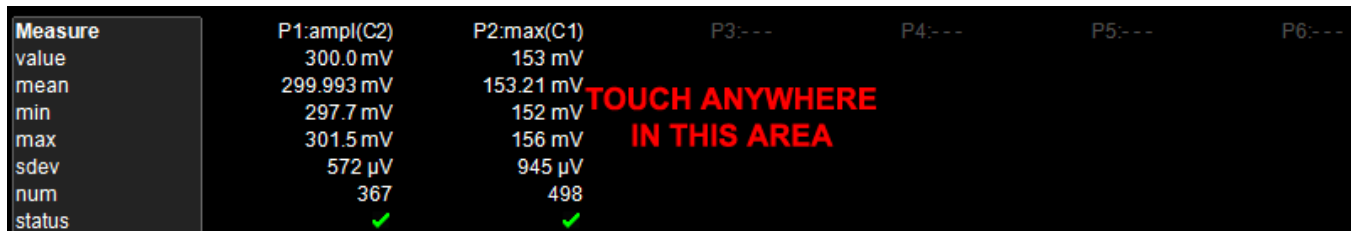
Overview of Parameters

Parameters are measurement tools that determine a wide range of waveform properties. Use them to automatically calculate many attributes of your waveform, like rise-time, rms voltage, and peak-to-peak voltage, for example.

There are parameter modes for the amplitude and time domains, custom parameter groups, and parameters for pass and fail testing. You can make common measurements on one or more waveforms.

TURNING ON PARAMETERS

You can quickly gain access to the parameter setup dialog by touching anywhere in the parameter readout area below the grid:



STATUS SYMBOLS

Below each parameter appears a symbol that indicates the status of the parameter, as follows:

	A green check mark means indicates that the oscilloscope is returning a valid value.
	A crossed-out pulse means that the oscilloscope is unable to determine top and base; however, the measurement could still be valid.

	A downward pointing arrow indicates an underflow condition.
	An upward pointing arrow indicates an overflow condition.
	An upward-and-downward pointing arrow indicates an underflow and overflow condition.

USING X-STREAM BROWSER TO OBTAIN STATUS INFORMATION

Example:

Here is a case of an overflow condition, in which the amplitude of the waveform cannot be determined:



1. Minimize the oscilloscope display by selecting **File** → **Minimize** from the menu bar.



2. Touch the **X-Stream Browser** desktop icon to open the browser.
3. Touch the left oscilloscope icon (Connect to a local X-Stream DSO device) in the X-Stream Browser toolbar:



4. Select Measure Parameter in error (P1) Out Result

XStream Browser - Online, browsing LeCroy.XStreamDSO

File Edit Help

LeCroy.XStreamDSO

- Acquisition
- Cursors
- CustomDSO
- Display
- HardCopy
- Help
- Math
- Measure
 - P1
 - Operator
 - Out
 - Result
 - Statistics
 - P2
 - P3

Name	Value	Type
ExtendedStatus	0	Property
FirstEventTime	10699933597047.0523	Property
HorizontalResolution	0.000000000001	Property
HorizontalUnits	5	Property
LastEventTime	10699933597047.0523	Property
NumFrameDimensions	2	Property
Status	0.0098	Property
StatusDescription	Data overflow, Greater than, Not a pulse.	Property
UpdateTime	10699933598577.582	Property
Value	0.289474614623108	Property
ValueArray	(Array)	Property
VerticalResolution	2.20972988261915E-03	Property
VerticalUnits	V	Property

- Read the status information in line **StatusDescription**.

Statistics

By touching the **Statistics On** checkbox in the **Measure**, you can display statistics for standard vertical or horizontal parameters, or for custom parameters. The statistics that are displayed are as follows:

value (last)
mean
min.
max.
sdev
num

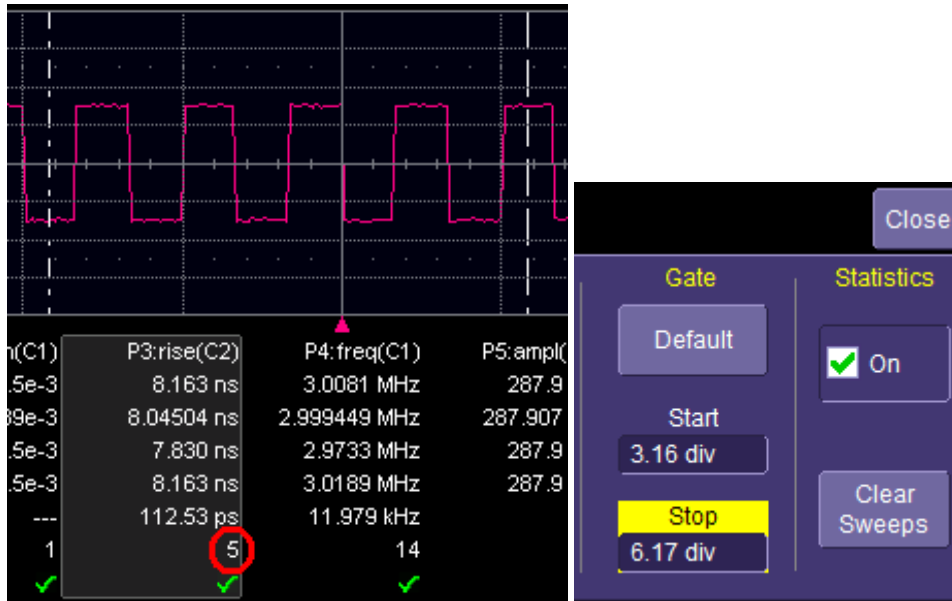
The values displayed in the **num** row is the number of measurements computed. For any parameter that computes on an entire waveform (like edge@level, mean, minimum, maximum, etc.) the value displayed represents the number of sweeps.

For any parameter that computes on every event, the value displayed is equal to the number of events per acquired waveform. If x waveforms were acquired, the value represents x times the number of cycles per waveform. Also, the "value" is equal to the measurement of the last cycle on the last acquisition.

Measure Gate

Using Measure Gate, you can narrow the span of the waveform on which to perform parameter measurements, allowing you to focus on the area of greatest interest. You have the option of dragging the gate posts horizontally along the waveform, or specifying a position down to hundredths of a division. The default starting positions of the gate posts are 0 div and 10 div, which coincide with the left and right ends of the grid. The gate, therefore, initially encloses the entire waveform.

Note: If you have Grid On Top enabled, you will not see the gate posts in their default position at each end of the grid. But if you touch either end of the grid, a drag cursor  will appear, indicating that you have control of the post and can now drag it.



In this example, you can see that the Measure Gate includes only five rising edges. Therefore, parameter calculations for rise time are performed only on the five pulses bounded by the gate posts. The position of the gate posts is shown in the **Start** and **Stop** fields in the accompanying dialog.

MEASURE GATE SETUP

1. In the menu bar, touch **Measure Setup...**

Note: Be sure that the signal you are measuring is displayed. Otherwise, the measure gate cursors will not be visible.

2. Touch inside the **Start** field and enter a value, using the pop-up numeric keypad. Or, you can simply touch the leftmost grid line and drag the gate post to the right.
3. Touch inside the **Stop** field and enter a value, using the pop-up numeric keypad. Or, you can simply touch the rightmost grid line and drag the gate post to the left.

Customizing a Parameter

FROM A VERTICAL SETUP DIALOG



1. In the **Cx Vertical Adjust** dialog, touch the Measure button.
2. Select a parameter from the pop-up menu. (**Assign To** goes into the next available Px location, or the last one if all are used.)
3. Select another parameter or touch **Close**.

FROM A MATH SETUP DIALOG



1. In the **Fx** dialog, touch the Measure button.
2. Select a parameter from the pop-up menu. (**Assign To** goes into the next available Px location, or the last one if all are used.)
3. Select another parameter or touch **Close**.

Parameter Calculations

PARAMETERS AND HOW THEY WORK

DETERMINING TOP AND BASE LINES

Proper determination of the top and base reference lines is fundamental for ensuring correct parameter calculations. The analysis begins by computing a histogram of the waveform data over the time interval spanned by the left and right time cursors. For example, the histogram of a waveform transitioning in two states will contain two peaks. The analysis will attempt to identify the two clusters that contain the largest data density. Then the most probable state (centroids) associated with these two clusters will be computed to determine the top and base reference levels: the top line corresponds to the top and the base line to the bottom centroid.

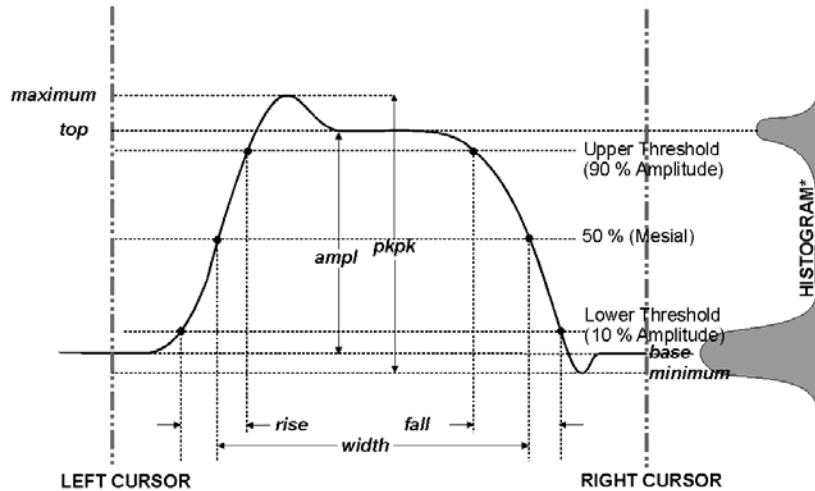


Figure 1

DETERMINING RISE AND FALL TIMES

Once top and base are estimated, calculation of the rise and fall times is easily done. The 90% and 10% threshold levels are automatically determined, using the amplitude (ampl) parameter.

Threshold levels for rise or fall time can also be selected using absolute or relative settings (r@level, f@level). If absolute settings are chosen, the rise or fall time is measured as the time interval separating the two crossing points on a rising or falling edge. But when relative settings are chosen, the vertical interval spanned between the base and top lines is subdivided into a percentile scale (base = 0 %, top = 100 %) to determine the vertical position of the crossing points.

The time interval separating the points on the rising or falling edges is then estimated to yield the rise or fall time. These results are averaged over the number of transition edges that occur within the observation window.

Rising Edge Duration:

$$\frac{1}{M_r} \sum_{i=1}^{M_r} (Tr_i^{90} - Tr_i^{10})$$

Falling Edge Duration:

$$\frac{1}{M_f} \sum_{i=1}^{M_f} (Tf_i^{10} - Tf_i^{90})$$

Where Mr is the number of leading edges found, Mf the number of trailing edges found, Tr_i^x the time when rising edge i crosses the $x\%$ level, Tf_i^x and the time when falling edge i crosses the $x\%$ level.

DETERMINING TIME PARAMETERS

Time parameter measurements such as width, period and delay are carried out with respect to the mesial reference level (see Figure 2), located halfway (50%) between the top and base reference lines.

Time-parameter estimation depends on the number of cycles included within the observation window. If the number of cycles is not an integer, parameter measurements such as rms or mean will be biased. However, only the last value is actually displayed, the mean being available when statistics are enabled. To avoid these bias effects, the instrument uses cyclic parameters, including crms and cmean, that restrict the calculation to an integer number of cycles.

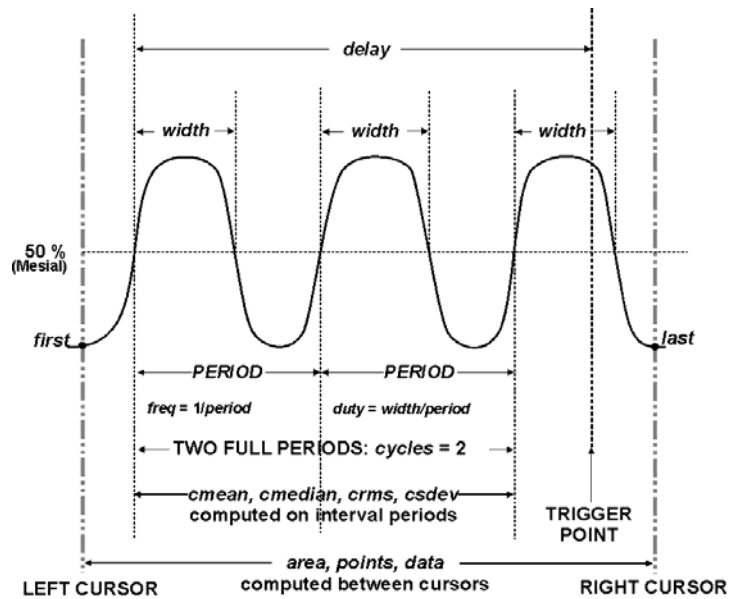


Figure 2

List of Parameters

The following table describes the instrument parameters. Availability of some parameters depends on the options installed. See the comments in the **Notes** column of the table.

Parameter	Description	Definition	Notes
Amplitude	Measures the difference between upper and lower levels in two-level signals. Differs from pkpk in that noise, overshoot, undershoot, and ringing do not affect the measurement.	top - base	On signals not having two major levels (such as triangle or saw-tooth waves), returns same value as pkpk. Standard parameter.
Ampl asym	Amplitude asymmetry between taa+ and taa-	$1 - (taa+ - taa-) / (taa+ + taa-)$	Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
ACSN	Auto-correlation Signal-to-Noise provides a signal-to-noise ratio for periodic waveforms.		Available with DDM2 option. Standard in DDA-5005A.
Area	Integral of data: Computes area of waveform between cursors relative to zero level. Values greater than zero contribute positively to the area; values less than zero negatively.	Sum from first to last of data multiplied by horizontal time between points	Standard parameter.
Base	Lower of two most probable states (higher is top). Measures lower level in two-level signals. Differs from min in that noise, overshoot, undershoot, and ringing do not affect measurement.	Value of most probable lower state	On signals not having two major levels (triangle or saw-tooth waves, for example), returns same value as min. Standard parameter.
Cycles	Determines number of cycles of a periodic waveform lying between cursors. First cycle begins at first transition after the left cursor. Transition may be positive- or negative-going.	Number of cycles of periodic waveform	Standard parameter.

Parameter	Description	Definition	Notes
cyclic	Cyclic mean: Computes the average of waveform data. Contrary	Average of data values of an integral number	Choose this parameter by selecting Mean from the

Mean	to mean, computes average over an integral number of cycles, eliminating bias caused by fractional intervals.	of periods	parameter table, then touching the Cyclic checkbox. Standard parameter.
cyclic Median	Cyclic median: Computes average of base and top values over an integral number of cycles, contrary to median, eliminating bias caused by fractional intervals.	Data value for which 50% of values are above and 50% below	Choose this parameter by selecting Median from the parameter table, then touching the Cyclic checkbox. Standard parameter.
cyclic RMS	Cyclic root mean square: Computes square root of sum of squares of data values divided by number of points. Contrary to rms, calculation is performed over an integral number of cycles, eliminating bias caused by fractional intervals.	$\sqrt{\frac{1}{N} \sum_{i=1}^N (v_i)^2}$	Where: v_i denotes measured sample values, and N = number of data points within the periods found. Choose this parameter by selecting RMS from the parameter table, then touching the Cyclic checkbox. Standard parameter.
cyclic Std dev	Cyclic standard deviation: Standard deviation of data values from mean value over integral number of periods. Contrary to sdev, calculation is performed over an integral number of cycles, eliminating bias caused by fractional intervals.	$\sqrt{\frac{1}{N} \sum_{i=1}^N (v_i - \text{mean})^2}$	Where: v_i denotes measured sample values, and N = number of data points within the periods found. Choose this parameter by selecting Std dev from the parameter table, then touching the Cyclic checkbox. Standard parameter.
Delay	Time from trigger to transition: Measures time between trigger and first 50% crossing after left cursor. Can measure propagation delay between two signals by triggering on one and determining delay of other.	Time between trigger and first 50% crossing after left cursor	Standard parameter.

Parameter	Description	Definition	Notes
Delta delay	delay: Computes time between 50% level of two sources.	Time between midpoint transition of two sources	Standard parameter.

Dperiod@level	Adjacent cycle deviation (cycle-to-cycle jitter) of each cycle in a waveform		Reference levels and edge-transition polarity can be selected. Hysteresis argument used to discriminate levels from noise in data. Available with JTA2 and XMAP options.
Dtime@level	t at level: Computes transition between selected levels or sources.	Time between transition levels of two sources, or from trigger to transition level of a single source This measurement gives the time of the source 2 edge minus the time of the source 1 edge.	Reference levels and edge-transition polarity can be selected. Hysteresis argument used to discriminate levels from noise in data. Standard parameter.
Duration	For single sweep waveforms, dur is 0; for sequence waveforms: time from first to last segment's trigger; for single segments of sequence waveforms: time from previous segment's to current segment's trigger; for waveforms produced by a history function: time from first to last accumulated waveform's trigger.	Time from first to last acquisition: for average, histogram or sequence waveforms	Standard parameter.
Duty@level	Percent of period for which data are above or below a specified level.		Reference levels and edge-transition polarity can be selected. Hysteresis argument used to discriminate levels from noise in data. Available with JTA2 and XMAP options.

Parameter	Description	Definition	Notes															
Duty cycle	Duty cycle: Width as percentage of period.	width/period	Standard parameter.															
Dwidth@level	Difference of adjacent width above or below a specified level.		Reference levels and edge-transition polarity can be selected. Hysteresis argument used to discriminate levels from noise in data. Available with JTA2 and XMAP options.															
Edge@level	Number of edges in waveform.		Reference levels and edge-transition polarity can be selected. Hysteresis argument used to discriminate levels from noise in data. Available with JTA2 and XMAP options.															
Excel	Performs measurements in Excel by transferring one or two waveforms and reading the resulting parameter value.		Available with XMAP option. Excel must be loaded on the instrument.															
Fall time	Fall time: Duration of falling edge from 90-10%. <table><tr><td>Thresh.</td><td>Remote</td><td>Lower Limit</td><td>Upper Limit</td><td>Default</td></tr><tr><td>Lower</td><td>Low</td><td>1 %</td><td>45 %</td><td>10 %</td></tr><tr><td>Upper</td><td>High</td><td>55 %</td><td>99 %</td><td>90 %</td></tr></table> Threshold arguments specify two vertical values on each edge used to compute fall time. Formulas for upper and lower values: lower = lower thresh. x amp/100 + base upper = upper thresh. x amp/100 + base	Thresh.	Remote	Lower Limit	Upper Limit	Default	Lower	Low	1 %	45 %	10 %	Upper	High	55 %	99 %	90 %	Time at upper threshold minus Time at lower threshold averaged over each falling edge	On signals not having two major levels (triangle or saw-tooth waves, for example), top and base can default to maximum and minimum, giving, however, less predictable results. Standard parameter.
Thresh.	Remote	Lower Limit	Upper Limit	Default														
Lower	Low	1 %	45 %	10 %														
Upper	High	55 %	99 %	90 %														

Parameter	Description	Definition	Notes
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Fall 80-20%	Fall 80-20%: Duration of pulse waveform's falling transition from 80% to 20%, averaged for all falling transitions between the cursors.	Average duration of falling 80-20% transition	On signals not having two major levels (triangle or saw-tooth waves, for example), top and base can default to maximum and minimum, giving, however, less predictable results. Standard parameter.
Fall@level	Fall at level: Duration of pulse waveform's falling edges between user-specified transition levels. See also Rise@level.	Duration of falling edge between transition levels	On signals not having two major levels (triangle or saw-tooth waves, for example), top and base can default to maximum and minimum, giving, however, less predictable results. Standard parameter.
First	Indicates value of horizontal axis at left cursor.	Horizontal axis value at left cursor	Indicates location of left cursor. Cursors are interchangeable: for example, the left cursor may be moved to the right of the right cursor and first will give the location of the cursor formerly on the right, now on left. Standard parameter.
Frequency	Frequency: Period of cyclic signal measured as time between every other pair of 50% crossings. Starting with first transition after left cursor, the period is measured for each transition pair. Values then averaged and reciprocal used to give frequency.	1/period	Standard parameter.

Parameter	Description	Definition	Notes
Freq@level	Frequency at a specific level and slope for every cycle in		Reference levels and edge-transition polarity can be

	waveform.		selected. Hysteresis argument used to discriminate levels from noise in data. Available with JTA2 and XMAP options.
FWHM	Measures the width of the largest area histogram peak at half of the population of the highest peak.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
FWxx	Measures the width of the largest area histogram peak at xx% of the population of the highest peak.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
Half period	Half period of a waveform.		Reference levels and edge-transition polarity can be selected. Hysteresis argument used to discriminate levels from noise in data. Available with JTA2 and XMAP options.
Hist ampl	Difference in value between the two most populated peaks in a histogram.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
Hist base	Value of the left-most of the two most populated histogram peaks.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
Hist maximum	Value of the highest (right-most) populated bin in a histogram.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
Hist mean	Average or mean value of data in the histogram.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.

Parameter	Description	Definition	Notes
Hist median	Value of the "X" axis of a histogram that divides the population into two equal halves.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
Hist minimum	Value of the lowest (left-most) populated bin in a histogram.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
Hist rms	Root mean square of the values in a histogram.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
Hist sdev	Standard deviation of values in a histogram.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
Hist top	Value of the right-most of the two most populated histogram peaks.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
Hold time	Time from the clock edge to the data edge. You can set levels, slope, and hysteresis independently for Hold Clock and Hold Data. See also Setup parameter.		Reference levels and edge-transition polarity can be selected. Hysteresis argument used to discriminate levels from noise in data. Available with JTA2 and XMAP options.
Last	Time from trigger to last (rightmost) cursor.	Time from trigger to last cursor	Indicates location of right cursor. Cursors are interchangeable: for example, the right cursor may be moved to the left of the left cursor and first will give the location of the cursor formerly on the left, now on right. Standard parameter.

Parameter	Description	Definition	Notes
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Level@X	Gives the vertical value at the specified x position. If the x position is between two points, it gives the interpolated value. When the Nearest point checkbox is checked, it gives the vertical value of the nearest data point.		Standard parameter.
Local base	Value of the baseline for a local feature.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
Local bsep	Local baseline separation, between rising and falling slopes.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
Local max	Maximum value of a local feature.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
Local min	Minimum value of a local feature.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.

Parameter	Description	Definition	Notes
Local number	Number of local features (peak/trough pairs).		Hysteresis argument used to discriminate levels from noise in data.

			Available with DDM2 option. Standard in DDA-5005A.
Local pkpk	Vertical difference between the peak and trough of a local feature ($I_{max} - I_{min}$).		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
Local tbe	Time between events (between local peak and next trough or local trough and next peak).		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
Local tbp	Time between a local feature peak and the next local peak.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
Local tbt	Time between a local feature trough and the next local trough.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.

Parameter	Description	Definition	Notes
Local tmax	Time of the maximum value of a local feature.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
Local tmin	Time of the minimum value of a local feature.		Hysteresis argument used to discriminate levels from noise

			in data. Available with DDM2 option. Standard in DDA-5005A.
Local tot	Time a local feature spends over a user specified percentage of its peak-to-trough amplitude.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
Local tpt	Time between local feature peak and trough.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
Local ttp	Time between local feature trough and the next local peak.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
Local tut	Time a local feature spends under a user specified percentage of its peak-to-trough amplitude.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
Parameter	Description	Definition	Notes
Mathcad	Produces a parameter using a user-specified Mathcad function.		Available with XMAP option. Mathcad 2001i or later must be loaded on the instrument.
MATLAB	Produces a parameter using a user-specified MATLAB function.		Available with XMAP option. MATLAB must be loaded on the instrument.
Maximum	Measures highest point in waveform. Unlike top, does not assume waveform has two levels.	Highest value in waveform between cursors	Gives similar result when applied to time domain waveform or histogram of data of same waveform. But with histograms, result may include contributions from more than

			one acquisition. Computes horizontal axis location of rightmost non-zero bin of histogram - not to be confused with maxp. Standard parameter.
Max populate	Peak with maximum population in a histogram.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
Mean	Average of data for time domain waveform. Computed as centroid of distribution for a histogram.	Average of data	Gives similar result when applied to time domain waveform or histogram of data of same waveform. But with histograms, result may include contributions from more than one acquisition. Standard parameter.
Median	The average of base and top values.	Average of Base and Top.	Standard parameter.

Parameter	Description	Definition	Notes
Minimum	Measures the lowest point in a waveform. Unlike base, does not assume waveform has two levels.	Lowest value in waveform between cursors	Gives similar result when applied to time domain waveform or histogram of data of same waveform. But with histograms, result may include contributions from more than one acquisition. Standard parameter.
Mode	Position of the highest histogram peak.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
Nb phase	Provides a measurement of the phase at a specific frequency of a waveform (narrow band).		Available with DDM2 and XMAP options. Standard in DDA-5005A.

Nb Power	Provides a measurement of the power at a specific frequency of a waveform (narrow band).		Available with DDM2 and XMAP options. Standard in DDA-5005A.
N-cycle jitter	Peak-to-peak jitter between edges spaced n UI apart.	Compares the expected time to the actual time of leading edges n bits apart.	Available in SDA analyzers.
NLTS	Provides a measurement of the nonlinear transition shift for a prml signal.		Available with DDM2 option. Standard in DDA-5005AA.
Npts	Number of points in the waveform between the cursors.		Standard parameter.
Overshoot-	Overshoot negative: Amount of overshoot following a falling edge, as percentage of amplitude.	$(\text{base} - \text{min.})/\text{ampl} \times 100$	Waveform must contain at least one falling edge. On signals not having two major levels (triangle or saw-tooth waves, for example), may not give predictable results. Standard parameter.

Parameter	Description	Definition	Notes
Overshoot+	Overshoot positive: Amount of overshoot following a rising edge specified as percentage of amplitude.	$(\text{max.} - \text{top})/\text{ampl} \times 100$	Waveform must contain at least one rising edge. On signals not having two major levels (triangle or saw-tooth waves, for example), may not give predictable results. Standard parameter.
Overwrite	Ratio of residual-to-original power of a low frequency waveform overwritten by a higher frequency.		Available with DDM2 option. Standard in DDA-5005A.
Param Script	Visual Basic or Java script that produces a measurement from one or two input waveforms.		Available with XMAP option. Standard in DDA-5005A.
Peaks	Number of peaks in a histogram.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
Peak to peak	Peak-to-peak: Difference between highest and lowest points in waveform. Unlike ampl, does not assume the waveform has two levels.	maximum - minimum	Gives a similar result when applied to time domain waveform or histogram of data of the same waveform. But with histograms, result may include contributions from more than one acquisition. Standard parameter.
Percentile	Horizontal data value that divides a histogram so the population to the left is xx% of the total.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.

Parameter	Description	Definition	Notes
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Period	Period of a cyclic signal measured as time between every other pair of 50% crossings. Starting with first transition after left cursor, period is measured for each transition pair, with values averaged to give final result.	$\frac{1}{M_r} \sum_{i=1}^{M_r} (Tr_i^{50} - Tr_i^{50})$	Where: M_r is the number of leading edges found, M_f the number of trailing edges found, Tr_i^x the time when rising edge i crosses the $x\%$ level, and Tf_i^x the time when falling edge i crosses the $x\%$ level. Standard parameter.
Period@level	Period at a specified level and slope for every cycle in waveform.		Reference levels and edge-transition polarity can be selected. Hysteresis argument used to discriminate levels from noise in data. Available with JTA2 and XMAP options.
Phase	Phase difference between signal analyzed and signal used as reference. You can set the output type to percent, degrees, or radians. After setting up the reference, touch the More tab for signal setups.	Phase difference between signal and reference	Standard parameter.
Pop@X	Population at bin for specified horizontal coordinate. You can place the cursor at any bin and use either Absolute, Reference, or Difference cursor shape.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
PW50	Average pulse width at the 50% point between the local baseline and the local peak or trough.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.

Parameter	Description	Definition	Notes
PW50-	Average pulse width at the 50% point between the local		Hysteresis argument used to discriminate levels from noise

	baseline and the local trough.		in data. Available with DDM2 option. Standard in DDA-5005A.															
PW50+	Average pulse width at the 50% point between the local baseline and the local peak.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.															
Range	Calculates range (max - min) of a histogram.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.															
Resolution	Ratio of taa for a high and low frequency waveform	taa (HF)/mean taa (LF)*100	Hysteresis argument used to discriminate levels from noise in data. Standard parameter.															
Rise	Rise time: Duration of rising edge from 10-90%. <table><tr><td>Thresh.</td><td>Remote</td><td>Lower Limit</td><td>Upper Limit</td><td>Default</td></tr><tr><td>Lower</td><td>Low</td><td>1 %</td><td>45 %</td><td>10 %</td></tr><tr><td>Upper</td><td>High</td><td>55 %</td><td>99 %</td><td>90 %</td></tr></table> Threshold arguments specify two vertical values on each edge used to compute rise time. Formulas for upper and lower values: lower = lower thresh. x amp/100 + base upper = upper thresh. x amp/100 + base	Thresh.	Remote	Lower Limit	Upper Limit	Default	Lower	Low	1 %	45 %	10 %	Upper	High	55 %	99 %	90 %	Time at lower threshold minus Time at upper threshold averaged over each rising edge	On signals not having two major levels (triangle or saw-tooth waves, for example), top and base can default to maximum and minimum, giving, however, less predictable results. Standard parameter.
Thresh.	Remote	Lower Limit	Upper Limit	Default														
Lower	Low	1 %	45 %	10 %														
Upper	High	55 %	99 %	90 %														
Parameter	Description	Definition	Notes															
Rise 20-80%	Rise 20% to 80%: Duration of pulse waveform's rising transition from 20% to 80%, averaged for all rising transitions between the cursors.	Average duration of rising 20-80% transition	On signals not having two major levels (triangle or saw-tooth waves, for example), top and base can default to maximum and minimum, giving, however, less															

			predictable results. Standard parameter.
Rise@level	Rise at level: Duration of pulse waveform's rising edges between transition levels.	Duration of rising edges between transition levels	On signals not having two major levels (triangle or saw-tooth waves, for example), top and base can default to maximum and minimum, giving, however, less predictable results. Standard parameter.
RMS	Root Mean Square of data between the cursors - about same as sdev for a zero-mean waveform.	$\sqrt{\frac{1}{N} \sum_{i=1}^N (v_i)^2}$	Gives similar result when applied to time domain waveform or histogram of data of same waveform. But with histograms, result may include contributions from more than one acquisition. Where: v_i denotes measured sample values, and N = number of data points within the periods found up to maximum of 100 periods. Standard parameter.
Setup	Time from the data edge to the clock edge.		Reference levels and edge-transition polarity can be selected. Hysteresis argument used to discriminate levels from noise in data. Available with JTA2 and XMAP options.

Parameter	Description	Definition	Notes
Skew	Time of clock1 edge minus time of nearest clock2 edge.		Reference levels and edge-transition polarity can be selected. Hysteresis argument used to discriminate levels from noise in data. Hysteresis on a measurement (if set to 500 mdiv) requires that the signal must transition one way 1/2 division (total swing)

			across the threshold for the measurement to be valid. Available with JTA2 and XMAP options.
Std dev	Standard deviation of the data between the cursors - about the same as rms for a zero-mean waveform.	$\sqrt{\frac{1}{N} \sum_{i=1}^N (v_i - \text{mean})^2}$	Gives similar result when applied to time domain waveform or histogram of data of same waveform. But with histograms, result may include contributions from more than one acquisition. Where: v_i denotes measured sample values, and N = number of data points within the periods found up to maximum of 100 periods. Standard parameter.
TAA	Average peak-to-trough amplitude for all local features.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
TAA-	Average local baseline-to-trough amplitude for all local features.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
Parameter	Description	Definition	Notes
TAA+	Average local baseline-to-peak amplitude for all local features.		Hysteresis argument used to discriminate levels from noise in data. Available with DDM2 option. Standard in DDA-5005A.
TIE@level	Difference between the measured times of crossing a given slope and level and the ideal expected time. For Slope you can choose positive, negative, or both. For output	Cutoff Freq = $(1/1.667e3) \times$ Clock Freq	Reference levels and edge-transition polarity can be selected. Hysteresis argument used to discriminate levels from noise in data.

	units you can choose time or unit interval (UI). A unit interval equals one clock period. The Virtual Clock setup gives you a choice of Standard (1.544 MHz) or Custom reference clocks. You can also use a mathematically derived Golden PLL to filter low frequency jitter. The cutoff frequency is user selectable.		Available with JTA2 and XMAP options.
Time@level	Time at level: Time from trigger (t=0) to crossing at a specified level.	Time from trigger to crossing level	Reference levels and edge-transition polarity can be selected. Hysteresis argument used to discriminate levels from noise in data. Standard parameter.
Top	Higher of two most probable states, the lower being base; it is characteristic of rectangular waveforms and represents the higher most probable state determined from the statistical distribution of data point values in the waveform.	Value of most probable higher state	Gives similar result when applied to time domain waveform or histogram of data of same waveform. But with histograms, result may include contributions from more than one acquisition. Standard parameter.
Parameter	Description	Definition	Notes
Total Pop	Total population of a histogram.		Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
Width	Width of cyclic signal determined by examining 50% crossings in data input. If first transition after left cursor is a rising edge, waveform is considered to consist of positive pulses and width the time between adjacent rising and falling edges.	Width of first positive or pulse averaged for all similar pulses	Similar to fwhm, though, unlike width, that parameter applies only to histograms. Standard parameter.
Width@level	Width measured at a specific		Reference levels and edge-transition polarity can be

	level.		selected. Hysteresis argument used to discriminate levels from noise in data. Available with DDM2, JTA2, and XMAP options. Standard in DDA-5005A.
WidthN	Width measured at the 50% level and negative slope.		Standard parameter.
X at max	Determines the horizontal axis location of the maximum value between the cursors.		Restricted to time and frequency waveforms only.
X at min	Determines the horizontal axis location of the minimum value between the cursors.		Restricted to time and frequency waveforms only.
X at peak	The value of the nth highest histogram peak.		Applies only to histograms. Available with JTA2 and XMAP options. Standard in DDA-5005A.

WAVEFORM MATH

Introduction to Math Traces and Functions

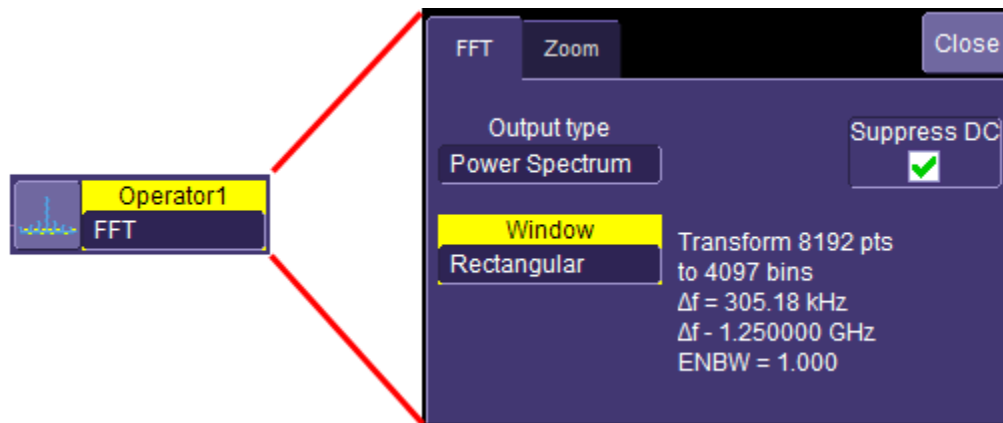
With the instrument's math tools you can perform mathematical functions on a waveform displayed on any channel, on a zoom trace, or on a trace recalled from any of the four reference memories M1 to M4. You can also set up a math trace to do math on parameter measurements P1 to P6.

Math Function Setup

This setup mode allows you to quickly apply frequently used math functions.

1. In the menu bar, touch **Math**, then **Math setup...** in the drop-down menu.
2. Touch inside the **Source1** field and select a channel trace, zoom trace, or memory trace from the pop-up menu.
3. Touch the **single** function button  if you want to perform just one math function on the trace; or, if available, touch the **dual** function button  to perform math on math.
4. Touch inside the **Operator1** field and select a math function from the pop-up menu. If available, touch inside the **Operator2** field and select a math function from the pop-up menu.

Depending on the math functions selected, a dialog box will open at the right end of the screen in which additional settings can be made.



Rescaling and Assigning Units

This feature allows you to apply a multiplication factor (*a*) and additive constant (*b*) to your waveform: $aX + b$. You can do it in the unit of your choice, depending on the type of application.

Allowable unit abbreviations are as follows:

(blank)	no units
A	Ampere
C	Coulomb
CYCLE	cycles
DB	Decibel
DBC	Decibel referred to carrier
DBM	Decibel Milliwatt
DBV	Decibel Volts
DBUZ	Decibel Microamp
DEC	Decade
DIV	Divisions
Event	Events
F	Farad
G	Gram
H	Henry
HZ	Hertz
J	Joule
K	Degree Kelvin
CEL	Degree Celsius
FAR	Degree Fahrenheit
L	Liter
M	Meter

FT	Foot
IN	Inch
YARD	yard
MILE	mile
N	Newton
OHM	Ohm
PAL	Pascal
PCT	Percent
POISE	Poise
PPM	parts per million
RAD	Radian
DEG	Degree (of arc)
MNT	Minute (of arc)
SAMPLE	sample
SWEEP	sweeps
SEC	Second (of arc)
S	Second
SIE	Siemens
T	Tesla
UI	Unit interval
V	Volt
VA	Volt amps
W	Watt
WB	Weber
MIN	min

HOUR	Hour
DAY	Day
WEEK	Week

You can also enter combinations of the previous units following the SI rules:

- for the quotient of two units, the character / should be used
- for the product of two units, the character . should be used
- Exponents can be represented by a digit appended to the unit without a space

For example,

- Acceleration can be entered as M/S2 for meters per second squared
- volts per seconds can be entered as V.S
- In some cases, the units entered may be converted to simple units – such as entering V.A displaying W (watts)

RESCALING SETUP

5. In the menu bar, touch **Math**, then **Math Setup...** in the drop-down menu.
6. Touch a math function trace tab **F1** through **Fx** The number of math traces available depends on the software options loaded on your oscilloscope. See Specifications..
7. Touch the **single** function button.
8. Touch inside the **Source1** field and select a source: channel, math trace, memory location.
9. Touch inside the **Operator1** field and select **Rescale** from the **Functions** category.
10. In the dialog on the right, touch the **Rescale** tab.
11. Touch inside the **First multiply by** checkbox and enter a value for *a*, the multiplication factor.
12. Touch inside the **then add:** field and enter a value for *b*, the additive constant.
13. Touch inside the **Override units** checkbox to disregard the source waveform's units, using the pop-up keyboard.

Averaging Waveforms

SUMMED VS. CONTINUOUS AVERAGING

For Summed averaging, you specify the number of acquisitions to be averaged. The averaged data is updated at regular intervals and presented on the screen.

On the other hand, Continuous averaging (the system default) helps to eliminate the effects of noise by continuously acquiring new data and adding the new waveforms into the averaging buffer. You determine the importance of new data vs. old data by assigning a weighting factor. Continuous averaging allows you to make adjustments to a system under test and to see the results immediately.

Note: Continuous Averaging is accessible from the channel Vertical Adjust dialog under **Pre-Processing**, and from the math function menu.

SUMMED AVERAGING

Summed Averaging is the repeated addition, with equal weight, of successive source waveform records. If a stable trigger is available, the resulting average has a random noise component lower than that of a single-shot record. Whenever the maximum number of sweeps is reached, the averaging process stops.

An even larger number of records can be accumulated simply by changing the number in the dialog. However, the other parameters must be left unchanged or a new averaging calculation will be started. You can pause the averaging by changing the trigger mode from NORM/AUTO to STOP. The instrument resumes averaging when you change the trigger mode back to NORM/AUTO.

You can reset the accumulated average by pushing the CLEAR SWEEPS button or by changing an acquisition parameter such as input gain, offset, coupling, trigger condition, timebase, or bandwidth limit. The number of current averaged waveforms of the function, or its zoom, is shown in the acquisition status dialog. When summed averaging is performed, the display is updated at a reduced rate to increase the averaging speed (points and events per second).

CONTINUOUS AVERAGING

Continuous Averaging, the default setting, is the repeated addition, with unequal weight, of successive source waveforms. It is particularly useful for reducing noise on signals that drift very slowly in time or amplitude. The most recently acquired waveform has more weight than all the previously acquired ones: the continuous average is dominated by the statistical fluctuations of the most recently acquired waveform. The weight of 'old' waveforms in the continuous average gradually tends to zero (following an exponential rule) at a rate that decreases as the weight increases.

The formula for continuous averaging is

$$\text{new average} = (\text{new data} + \text{weight} * \text{old average}) / (\text{weight} + 1)$$

This is also the formula used to compute summed averaging. But by setting a **sweeps** value, you establish a fixed weight that is assigned to the old average once the number of **sweeps** is reached.

For example, for a sweeps (weight) value of 4:

1st sweep (no old average yet): new average = (new data + 0 * old average) / (0 + 1) = new data only

2nd sweep: new average = (new data + 1 * old average) / (1 + 1) = 1/2 new data + 1/2 old average

3rd sweep: new average = (new data + 2 * old average) / (2 + 1) = 1/3 new data + 2/3 old average

4th sweep: new average = (new data + 3 * old average) / (3 + 1) = 1/4 new data + 3/4 old average

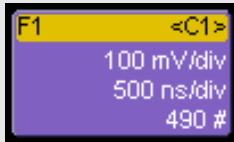
5th sweep: new average = (new data + 4 * old average) / (4 + 1) = 1/5 new data + 4/5 old average

6th sweep: new average = (new data + 4 * old average)/(4 + 1) = 1/5 new data + 4/5 old average

7th sweep: new average = (new data + 4 * old average)/(4 + 1) = 1/5 new data + 4/5 old average

In this way, for sweeps > 4 the importance of the old average begins to decrease exponentially.

Note: The number of sweeps used to compute the average will be displayed in the bottom line of the trace descriptor label:



CONTINUOUS AVERAGING SETUP

1. In the menu bar, touch **Math**, then **Math Setup...** in the drop-down menu.
2. Select a function tab from **F1** through **Fx**. The number of math traces available depends on the software options loaded on your oscilloscope. See Specifications...
3. Touch inside the **Source1** field and select a source waveform from the pop-up menu.
4. Touch inside the **Operator1** field and select **Average** from the **Select Math Operator** menu.
5. Touch the **Average** tab in the dialog to the right of the **Fx** dialog, touch the **Continuous** button.
6. Touch inside the **Sweeps** field and enter a value using the pop-up keypad. The valid range is 1 to 1,000,000 sweeps.

SUMMED AVERAGING SETUP

7. In the menu bar, touch **Math**, then **Math Setup...** in the drop-down menu.
8. Select a function tab from **F1** through **Fx**. The number of math traces available depends on the software options loaded on your oscilloscope. See Specifications...
9. Touch inside the **Source1** field and select a source waveform from the pop-up menu.
10. Touch inside the **Operator1** field and select **Average** from the **Select Math Operator** menu.
11. Touch the **Average** tab in the dialog to the right of the **Fx** dialog, then touch the **Summed** button.
12. Touch inside the **Sweeps** field and type in a value using the pop-up keypad. The valid range is 1 to 1,000,000 sweeps.

Enhanced Resolution

ERES (Enhanced Resolution) filtering increases vertical resolution, allowing you to distinguish closely spaced voltage levels. The functioning of the instrument's ERES is similar to smoothing the signal with a simple, moving-average filter. However, it is more efficient concerning bandwidth and pass-band filtering. Use ERES on single-shot waveforms, or where the data record is slowly repetitive (when you cannot use averaging). Use it to reduce noise when your signal is noticeably noisy, but you do not need to perform noise measurements. Also use it when you perform high-precision voltage measurements: zooming with high vertical gain, for example.

HOW THE INSTRUMENT ENHANCES RESOLUTION

The instrument's enhanced resolution feature improves vertical resolution by a fixed amount for each filter. This real increase in resolution occurs whether or not the signal is noisy, or your signal is single-shot or repetitive. The signal-to-noise ratio (SNR) improvement you gain is dependent on the form of the noise in the original signal. The enhanced resolution filtering decreases the bandwidth of the signal, filtering out some of the noise.

The instrument's constant phase FIR (Finite Impulse Response) filters provide fast computation, excellent step response in 0.5 bit steps, and minimum bandwidth reduction for resolution improvements of between 0.5 and 3 bits. Each step corresponds to a bandwidth reduction factor of two, allowing easy control of the bandwidth resolution trade-off. The parameters of the six filters are given in the following table.

Resolution increased by	-3 dB Bandwidth (× Nyquist)	Filter Length (Samples)
0.5	0.5	2
1.0	0.241	5
1.5	0.121	10
2.0	0.058	24
2.5	0.029	51
3.0	0.016	117

With low-pass filters, the actual SNR increase obtained in any particular situation depends on the power spectral density of the noise on the signal.

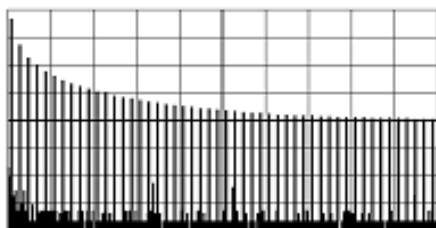
The improvement in SNR corresponds to the improvement in resolution if the noise in the signal is white -- evenly distributed across the frequency spectrum.

If the noise power is biased towards high frequencies, the SNR improvement will be better than the resolution improvement.

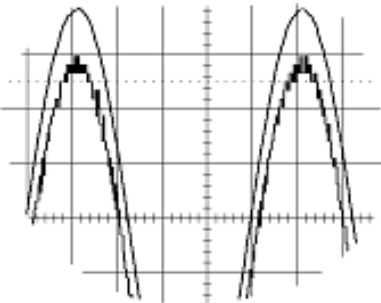
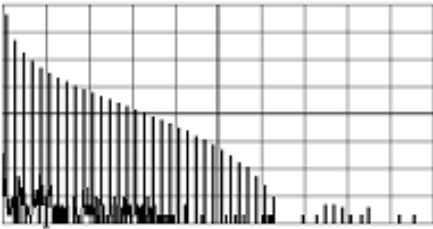
The opposite may be true if the noise is mostly at lower frequencies. SNR improvement due to the removal of coherent noise signals -- feed-through of clock signals, for example -- is determined by the fall of the dominant frequency components of the signal in the pass band. This is easily ascertained using spectral analysis. The filters have a precisely constant zero-phase response. This has two benefits. First, the filters do not distort the relative position of different events in the waveform, even if the events' frequency content is different. Second, because the waveforms are stored, the delay normally associated with filtering (between the input and output waveforms) can be exactly compensated during the computation of the filtered waveform.

The filters have been given exact unity gain at low frequency. Enhanced resolution should therefore not cause overflow if the source data is not overflowed. If part of the source trace were to overflow, filtering would be allowed, but the results in the vicinity of the overflowed data -- the filter impulse response length -- would be incorrect. This is because in some circumstances an overflow may be a spike of only one or two samples, and the energy in this spike may not be enough to significantly affect the results. It would then be undesirable to disallow the whole trace.

The following examples illustrate how you might use the instrument's enhanced resolution function.



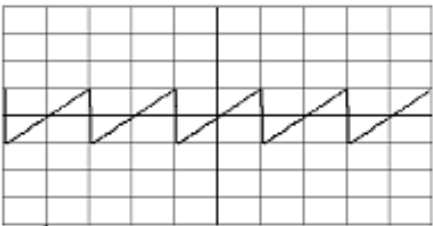
In low-pass filtering: The spectrum of a square signal before (left top) and after (left bottom) enhanced resolution processing. The result clearly illustrates how the filter rejects high-frequency components from the signal. The higher the bit enhancement, the lower the resulting bandwidth.



To increase vertical resolution: In the example at left, the lower ("inner") trace has been significantly enhanced by a three-bit enhanced resolution function.



To reduce noise: The example at left shows enhanced resolution of a noisy signal. The original trace (left top) has been processed by a 2-bit enhanced resolution filter. The result (left bottom) shows a "smooth" trace, where most of the noise has been eliminated.



Note: Enhanced resolution can only improve the resolution of a trace; it cannot improve the accuracy or linearity of the original quantization. The pass-band will cause signal attenuation for signals near the cut-off frequency. The highest frequencies passed may be slightly attenuated. Perform the filtering on finite record lengths. Data will be lost at the start and end of the waveform: the trace will be slightly shorter after filtering. The number of samples lost is exactly equal to the length of the impulse response of the filter used: between 2 and 117 samples. Normally this loss (just 0.2 % of a 50,000 point trace) is not noticed. However, you might filter a record so short there would be no data output. In that case, however, the instrument would not allow you to use the ERES feature.

Enhanced Resolution (ERES) Setup

1. In the menu bar, touch **Math**, then **Math Setup...** in the drop-down menu.
2. Touch inside the **Operator1** field.
3. Select **Eres** from the **All Functions** or **Filter** group of Math functions.
4. Touch the **Trace On** checkbox.

5. Touch the **Eres** tab in the right-hand dialog, then touch inside the **bits** field and make a selection from the pop-up menu:



FFT

Why Use FFT?

For a large class of signals, you can gain greater insight by looking at spectral representation rather than time description. Signals encountered in the frequency response of amplifiers, oscillator phase noise and those in mechanical vibration analysis, for example, are easier to observe in the frequency domain.

If sampling is done at a rate fast enough to faithfully approximate the original waveform (usually five times the highest frequency component in the signal), the resulting discrete data series will uniquely describe the analog signal. This is of particular value when dealing with transient signals because, unlike FFT, conventional swept spectrum analyzers cannot handle them.

Spectral analysis theory assumes that the signal for transformation is of infinite duration. Since no physical signal can meet this condition, a useful assumption for reconciling theory and practice is to view the signal as consisting of an infinite series of replicas of itself. These replicas are multiplied by a rectangular window (the display grid) that is zero outside of the observation grid.

An FFT operation on an N-point time domain signal can be compared to passing the signal through a comb filter consisting of a bank of N/2 filters. All the filters have the same shape and width and are centered at N/2 discrete frequencies. Each filter collects the signal energy that falls into the immediate neighborhood of its center frequency. Thus it can be said that there are N/2 frequency bins. The distance in Hz between the center frequencies of two neighboring bins is always the same: Delta f.

Power (Density) Spectrum

Because of the linear scale used to show magnitudes, lower amplitude components are often hidden by larger components. In addition to the functions offering magnitude and phase representations, the FFT option offers power density and power spectrum density functions. These latter functions are even better suited for characterizing spectra. The power spectrum (V^2) is the square of the magnitude spectrum. (Zero dBm corresponds to voltage equivalent to 1 mW into 50 ohms.) This is the representation of choice for signals containing isolated peaks — periodic signals, for instance.

The power density spectrum (V^2/Hz) is the power spectrum divided by the equivalent noise bandwidth of the filter associated with the FFT calculation. This is best employed for characterizing broadband signals such as noise.

MEMORY FOR FFT

The amount of acquisition memory available will determine the maximum range (Nyquist frequency) over which signal components can be observed. Consider the problem of determining the length of the observation window and the size of the acquisition buffer if a Nyquist rate of 500 MHz and a resolution of 10 kHz are required. To obtain a resolution of 10 kHz, the acquisition time must be at least:

$$T = 1/\Delta f = 1/10 \text{ kHz} = 100 \text{ ms}$$

For a digital oscilloscope with a memory of 100 kB, the highest frequency that can be analyzed is:

$$\Delta f \times N/2 = 10 \text{ kHz} \times 100 \text{ kB}/2 = 500 \text{ MHz}$$

FFT Pitfalls to Avoid

Take care to ensure that signals are correctly acquired: improper waveform positioning within the observation window produces a distorted spectrum. The most common distortions can be traced to insufficient sampling, edge discontinuities, windowing or the "picket fence" effect.

Because the FFT acts like a bank of band-pass filters centered at multiples of the frequency resolution, components that are not exact multiples of that frequency will fall within two consecutive filters. This results in an attenuation of the true amplitude of these components.

Picket Fence and Scallop

The highest point in the spectrum can be 3.92 dB lower when the source frequency is halfway between two discrete frequencies. This variation in spectrum magnitude is the picket fence effect. The corresponding attenuation loss is referred to as scallop loss. LeCroy oscilloscopes automatically correct for the scallop effect, ensuring that the magnitude of the spectra lines correspond to their true values in the time domain.

If a signal contains a frequency component above Nyquist, the spectrum will be aliased, meaning that the frequencies will be folded back and spurious. Spotting aliased frequencies is often difficult, as the aliases may ride on top of real harmonics. A simple way of checking is to modify the sample rate and observe whether the frequency distribution changes.

Leakage

FFT assumes that the signal contained within the time grid is replicated endlessly outside the observation window. Therefore if the signal contains discontinuities at its edges, pseudo-frequencies will appear in the spectral domain, distorting the real spectrum. When the start and end phase of the signal differ, the signal frequency falls within two frequency cells, broadening the spectrum.

The broadening of the base, stretching out in many neighboring bins, is termed leakage. Cures for this are to ensure that an integral number of periods is contained within the display grid or that no discontinuities appear at the edges. Another is to use a window function to smooth the edges of the signal.

Choosing a Window

The choice of a spectral window is dictated by the signal's characteristics. Weighting functions control the filter response shape, and affect noise bandwidth as well as side lobe levels. Ideally, the main lobe should be as narrow and flat as possible to effectively discriminate all spectral components, while all side lobes should be infinitely attenuated. The window type defines the bandwidth and shape of the equivalent filter to be used in the FFT processing.

In the same way as one would choose a particular camera lens for taking a picture, some experimenting is generally necessary to determine which window is most suitable. However, the following general guidelines should help.

Rectangular windows provide the highest frequency resolution and are thus useful for estimating the type of harmonics present in the signal. Because the rectangular window decays as a $(\sin x)/x$ function in the spectral domain, slight attenuation will be induced. Alternative functions with less attenuation (Flat Top and Blackman-Harris) provide maximum amplitude at the expense of frequency resolution; whereas, Hamming and Von Hann are good for general purpose use with continuous waveforms.

Window Type	Applications and Limitations
Rectangular	These are normally used when the signal is transient (completely contained in the time-domain window) or known to have a fundamental frequency component that is an integer multiple of the fundamental frequency of the window. Signals other than these types will show varying amounts of spectral leakage and scallop loss, which can be corrected by selecting another type of window.
Hanning (Von Hann)	These reduce leakage and improve amplitude accuracy. However, frequency resolution is also reduced.
Hamming	These reduce leakage and improve amplitude accuracy. However, frequency resolution is also reduced.
Flat Top	This window provides excellent amplitude accuracy with moderate reduction of leakage, but with reduced frequency resolution.
Blackman–Harris	It reduces the leakage to a minimum, but with reduced frequency resolution.

FFT Window Filter Parameters				
Window Type	Highest Side Lobe (dB)	Scallop Loss (dB)	ENBW (bins)	Coherent Gain (dB)
Rectangular	-13	3.92	1.0	0.0
von Hann	-32	1.42	1.5	-6.02
Hamming	-43	1.78	1.37	-5.35
Flat Top	-44	0.01	2.96	-11.05
Blackman-Harris	-67	1.13	1.71	-7.53

Improving Dynamic Range

Enhanced resolution uses a low-pass filtering technique that can potentially provide for three additional bits (18 dB) if the signal noise is uniformly distributed (white). Low-pass filtering should be considered when high frequency components are irrelevant. A distinct advantage of this technique is that it works for both repetitive and transient signals. The SNR increase is conditioned by the cut-off frequency of the ERES low-pass filter and the noise shape (frequency distribution).

LeCroy digital oscilloscopes employ FIR digital filters so that a constant phase shift is maintained. The phase information is therefore not distorted by the filtering action.

Record Length

Because of its versatility, FFT analysis has become a popular analysis tool. However, some care must be taken with it. In most instances, incorrect positioning of the signal within the display grid will significantly alter the

spectrum. Effects such as leakage and aliasing that distort the spectrum must be understood if meaningful conclusions are to be arrived at when using FFT.

An effective way to reduce these effects is to maximize the acquisition record length. Record length directly conditions the effective sampling rate of the oscilloscope and therefore determines the frequency resolution and span at which spectral analysis can be carried out.

FFT Algorithms

A summary of the algorithms used in the oscilloscope's FFT computation is given here in a few steps:

The data are multiplied by the selected window function.

FFT is computed, using a fast implementation of the DFT (Discrete Fourier Transform):

$$X_n = \frac{1}{N} \sum_{k=0}^{N-1} x_k \times W^{nk}$$

where: x_k is a complex array whose real part is the modified source time domain waveform, and whose imaginary part is 0; X_n is the resulting complex frequency-domain waveform; $W = e^{-2\pi j/N}$; and N is the number of points in x_k and X_n .

The generalized FFT algorithm, as implemented here, works on N , which need *not* be a power of 2.

The resulting complex vector X_n is divided by the coherent gain of the window function, in order to compensate for the loss of the signal energy due to windowing. This compensation provides accurate amplitude values for isolated spectrum peaks.

The real part of X_n is symmetric around the Nyquist frequency, that is

$$R_n = R_{N-n}$$

while the imaginary part is asymmetric, that is

$$I_n = -I_{N-n}$$

The energy of the signal at a frequency n is distributed equally between the first and the second halves of the spectrum; the energy at frequency 0 is completely contained in the 0 term.

The first half of the spectrum (Re, Im), from 0 to the Nyquist frequency is kept for further processing and doubled in amplitude:

$$R'_n = 2 \times R_n \quad 0 \leq n < N/2$$

$$I'_n = 2 \times I_n \quad 0 \leq n < N/2$$

The resultant waveform is computed for the spectrum type selected.

If "Magnitude" is selected, the magnitude of the complex vector is computed as:

$$M_n = \sqrt{R_n'^2 + I_n'^2}$$

Steps 1 to 5 lead to the following result:

An AC sine wave of amplitude 1.0 V with an integral number of periods N_p in the time window, transformed with the rectangular window, results in a fundamental peak of 1.0 V magnitude in the spectrum at frequency $N_p \times \Delta f$. However, a DC component of 1.0 V, transformed with the rectangular window, results in a peak of 2.0 V magnitude at 0 Hz.

The waveforms for the other available spectrum types are computed as follows:

Phase: $\text{angle} = \arctan (I_n/R_n) _ M_n > M_{min}$

$\text{angle} = 0 \qquad M_n \leq M_{min}$

Where M_{min} is the minimum magnitude, fixed at about 0.001 of the full scale at any gain setting, below which the angle is not well defined.

The dBm Power Spectrum:

$$dBm PS = 10 \times \log_{10} \left(\frac{M_n^2}{M_{ref}^2} \right) = 20 \times \log_{10} \left(\frac{M_n}{M_{ref}} \right)$$

where $M_{ref} = 0.316$ V (that is, 0 dBm is defined as a sine wave of 0.316 V peak or 0.224 V rms, giving 1.0 mW into 50 ohms).

The dBm Power Spectrum is the same as dBm Magnitude, as suggested in the above formula.

dBm Power Density:

$$dBm PD = dBm PS - 10 \times \log_{10} (ENBW \times \Delta f)$$

where $ENBW$ is the equivalent noise bandwidth of the filter corresponding to the selected window, and Δf is the current frequency resolution (bin width).

The FFT Power Average takes the complex frequency-domain data R'_n and I'_n for each spectrum generated in Step 5, and computes the square of the magnitude:

$$M_n^2 = R_n'^2 + I_n'^2,$$

then sums M_n^2 and counts the accumulated spectra. The total is normalized by the number of spectra and converted to the selected result type using the same formulas as are used for the Fourier Transform.

FFT Glossary

This section defines the terms frequently used in FFT spectrum analysis and relates them to the oscilloscope.

Aliasing If the input signal to a sampling acquisition system contains components whose frequency is greater than the Nyquist frequency (half the sampling frequency), there will be less than two samples per signal period. The result is that the contribution of these components to the sampled waveform is indistinguishable from that of components below the Nyquist frequency. This is **aliasing**.

The timebase and transform size should be selected so that the resulting Nyquist frequency is higher than the highest significant component in the time-domain record.

Coherent Gain The normalized coherent gain of a filter corresponding to each window function is 1.0 (0 dB) for a rectangular window and less than 1.0 for other windows. It defines the loss of signal energy due to the multiplication by the window function. This loss is compensated for in the oscilloscope. The following table lists the values for the implemented windows.

Window Frequency Domain Parameters				
Window Type	Highest Side Lobe (dB)	Scallop Loss (dB)	ENBW (bins)	Coherent Gain (dB)
Rectangular	-13	3.92	1.0	0.0
von Hann	-32	1.42	1.5	-6.02

Hamming	-43	1.78	1.37	-5.35
Flat Top	-44	0.01	2.96	-11.05
Blackman-Harris	-67	1.13	1.71	-7.53

ENBW Equivalent Noise BandWidth (ENBW) is the bandwidth of a rectangular filter (same gain at the center frequency), equivalent to a filter associated with each frequency bin, which would collect the same power from a white noise signal. In the table on the previous page, the ENBW is listed for each window function implemented, given in bins.

Filters Computing an N-point FFT is equivalent to passing the time-domain input signal through N/2 filters and plotting their outputs against the frequency. The spacing of filters is $\Delta f = 1/T$, while the bandwidth depends on the window function used (see Frequency Bins).

Frequency Bins The FFT algorithm takes a discrete source waveform, defined over N points, and computes N complex Fourier coefficients, which are interpreted as harmonic components of the input signal.

For a real source waveform (imaginary part equals 0), there are only N/2 independent harmonic components.

An FFT corresponds to analyzing the input signal with a bank of N/2 filters, all having the same shape and width, and centered at N/2 discrete frequencies. Each filter collects the signal energy that falls into the immediate neighborhood of its center frequency. Thus it can be said that there are N/2 "frequency bins."

The distance in hertz between the center frequencies of two neighboring bins is always:

$$\Delta f = 1/T$$

where T is the duration of the time-domain record in seconds.

The width of the main lobe of the filter centered at each bin depends on the window function used. The rectangular window has a nominal width at 1.0 bin. Other windows have wider main lobes (see table).

Frequency Range The range of frequencies computed and displayed is 0 Hz (displayed at the left-hand edge of the screen) to the Nyquist frequency (at the rightmost edge of the trace).

Frequency Resolution In a simple sense, the frequency resolution is equal to the bin width Δf . That is, if the input signal changes its frequency by Δf , the corresponding spectrum peak will be displaced by Δf . For smaller changes of frequency, only the shape of the peak will change.

However, the effective frequency resolution (that is, the ability to resolve two signals whose frequencies are almost the same) is further limited by the use of window functions. The ENBW value of all windows other than the rectangular is greater than Δf and the bin width. The table of Window Frequency-Domain Parameters lists the ENBW values for the implemented windows.

Leakage In the power spectrum of a sine wave with an integral number of periods in the (rectangular) time window (that is, the source frequency equals one of the bin frequencies), the spectrum contains a sharp component whose value accurately reflects the source waveform's amplitude. For intermediate input frequencies this spectral component has a lower and broader peak.

The broadening of the base of the peak, stretching out into many neighboring bins, is termed *leakage*. It is due to the relatively high side lobes of the filter associated with each frequency bin.

The filter side lobes and the resulting leakage are reduced when one of the available window functions is applied. The best reduction is provided by the Blackman-Harris and Flattop windows. However, this reduction is offset by a broadening of the main lobe of the filter.

Number of Points The FFT is computed over the number of points (Transform Size) whose upper bounds are the source number of points, and by the maximum number of points selected in the menu. The FFT generates spectra of $N/2$ output points.

Nyquist Frequency The Nyquist frequency is equal to one half of the effective sampling frequency (after the decimation): $\Delta f \times N/2$.

Picket Fence Effect If a sine wave has a whole number of periods in the time domain record, the power spectrum obtained with a rectangular window will have a sharp peak, corresponding exactly to the frequency and amplitude of the sine wave. Otherwise the spectrum peak with a rectangular window will be lower and broader.

The highest point in the power spectrum can be 3.92 dB lower (1.57 times) when the source frequency is halfway between two discrete bin frequencies. This variation of the spectrum magnitude is called the *picket fence effect* (the loss is called the scallop loss).

All window functions compensate for this loss to some extent, but the best compensation is obtained with the Flattop window.

Power Spectrum The power spectrum (V^2) is the square of the magnitude spectrum.

The power spectrum is displayed on the dBm scale, with 0 dBm corresponding to:

$$V_{\text{ref}}^2 = (0.316 V_{\text{peak}})^2,$$

where V_{ref} is the peak value of the sinusoidal voltage, which is equivalent to 1 mW into 50 ohms.

Power Density Spectrum The power density spectrum (V^2/Hz) is the power spectrum divided by the equivalent noise bandwidth of the filter, in hertz. The power density spectrum is displayed on the dBm scale, with 0 dBm corresponding to ($V_{\text{ref}}^2/\text{Hz}$).

Sampling Frequency The time-domain records are acquired at sampling frequencies dependent on the selected time base. Before the FFT computation, the time-domain record may be decimated. If the selected maximum number of points is lower than the source number of points, the effective sampling frequency is reduced. The effective sampling frequency equals twice the Nyquist frequency.

Scallop Loss This is loss associated with the picket fence effect.

Window Functions All available window functions belong to the sum of cosines family with one to three non-zero cosine terms:

$$W_k = \sum_{m=0}^{M-1} a_m \cos \left(\frac{2\pi k m}{N} \right) \quad 0 \leq k < N$$

where: $M = 3$ is the maximum number of terms, a_m are the coefficients of the terms, N is the number of points of the decimated source waveform, and k is the time index.

The table of Coefficients of Window Functions lists the coefficients a_m . The window functions seen in the time domain are symmetric around the point $k = N/2$.

Coefficients of Window Functions			
Window Type	a_0	a_1	a_2
Rectangular	1.0	0.0	0.0

von Hann	0.5	-0.5	0.0
Hamming	0.54	-0.46	0.0
Flat Top	0.281	-0.521	0.198
Blackman-Harris	0.423	-0.497	0.079

FFT Setup

SETTING UP AN FFT

1. In the menu bar touch **Math**, then **Math Setup...** in the drop-down menu.
2. Touch the **Single**  or **Dual** (function of a function)  button if the FFT is to be of the result of another math operation.
3. Touch inside the **Source1** field and select a channel, memory, or math trace on which to perform the FFT.
4. Touch inside the **Operator1** field and select **FFT**  from the pop-up menu if you selected **Single** function. Select another math function if you selected **Dual** function. Then touch inside the **Operator2** field and select **FFT** from the pop-up menu.
5. In the right-hand dialog, touch the **FFT** tab.
6. Touch the **Suppress DC** checkbox if you want to make the DC bin go to zero. Otherwise, leave it unchecked.
7. Touch inside the **Output type** field, and make a selection from the pop-up menu.
8. Touch inside the **Window** field, select a window type.

ANALYSIS

Pass/Fail Testing

Mask Tests



You have the choice to do mask testing by using an existing mask, or by using a mask created from your actual waveform, with vertical and horizontal tolerances that you define. Existing masks can be loaded from a floppy disk or from a network.

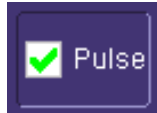
You can set your mask test to be True for waveforms All In, All Out, Any In, or Any Out. For example, if you select All In, the test will be False if even a single waveform falls outside the mask.

Masks that you create from your waveform can be confined to just a portion of the trace by use of a measure gate. (See Measure Gate for an explanation of how this feature works.)

ACTIONS

You can decide the actions to occur upon your waveforms' passing or failing, by selecting one or all of the following:

- **stop**
- **audible alarm**
- **print image of display**
- **emit pulse**
- **save waveform**



The selection **Pulse** causes a pulse to be output through the **Aux Out** connector at the rear of the oscilloscope. This pulse can be used to trigger another oscilloscope.

Setting Up Pass/Fail Testing

INITIAL SETUP

1. Touch **Analysis** in the menu bar, then **Pass/Fail Setup...** in the drop-down menu.
2. Touch inside the **Source1** field and select signal source from the pop-up menu.

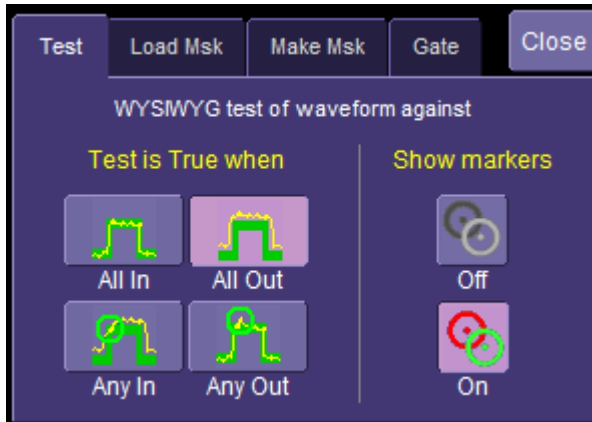


3. Under **If**, touch either the **Pass** or **Fail** button to set the actions to occur upon your waveform's passing or failing the test.
4. Under **Then**, touch the actions you want to occur: stop test, sound alarm, print result, emit pulse, or save the waveform. If you want to have the results printed and your scope is not equipped with a printer, make sure it's connected to a local or network printer.

If you want to save your waveform automatically, touch the **Save Setup**. This will take you out of the current dialog and will open the **Save Waveform** dialog. See "Saving and Recalling Waveforms."

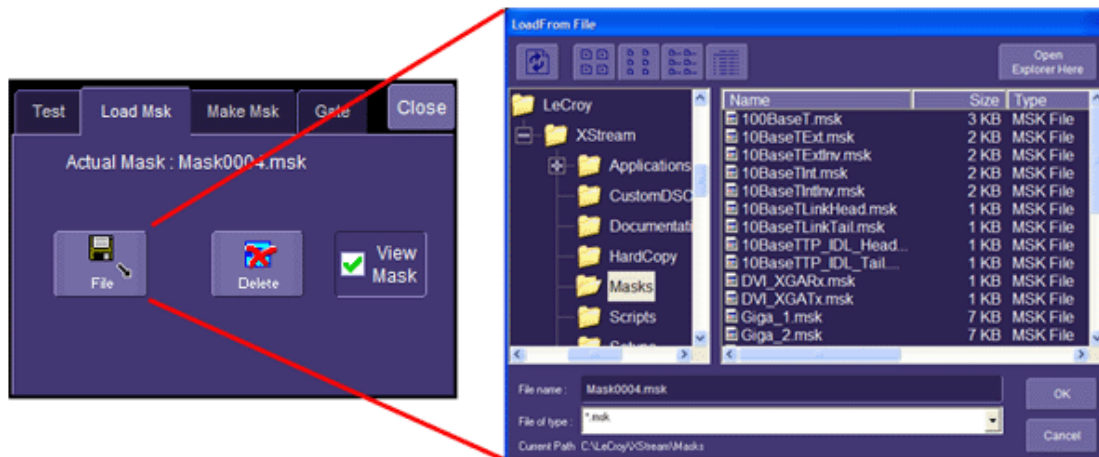
MASK TESTING

1. Touch **Analysis** in the menu bar, then **Pass/Fail Setup...** in the drop-down menu.
2. Touch inside the **Source1** field and select a source from the pop-up menu.
3. From the **Test** right-hand dialog, make a selection in the **Test is True when** group of buttons:

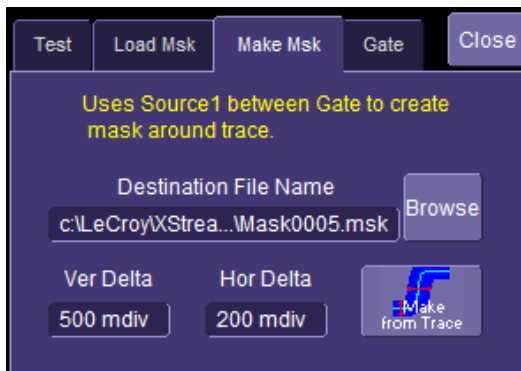


This selection means, for example, that if you select **All In** the test will be False if even a single waveform falls outside the mask.

4. From **Show Markers**, choose whether or not to have mask violations displayed.
5. If you are loading a pre-existing mask, touch the **Load Msk** tab, then the **File** button. You can then enter the file name or browse to its location.

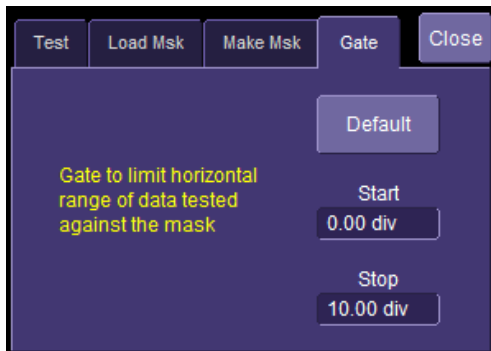


6. If you want to make a mask from your waveform, touch the **Make Msk** tab.



7. Touch inside the **Ver Delta** and **Hor Delta** fields and enter boundary values, using the pop-up numeric keypad. Then touch the **Make from Trace** button.

8. Touch the **Browse** button to create a file name and location for the mask if you want to save it.
9. Touch the **Gate** tab, then enter values in the **Start** and **Stop** fields to constrain the mask to a portion of the waveform. Or, you can simply touch and drag the Gate posts, which initially are placed at the extreme left and right ends of the grid.



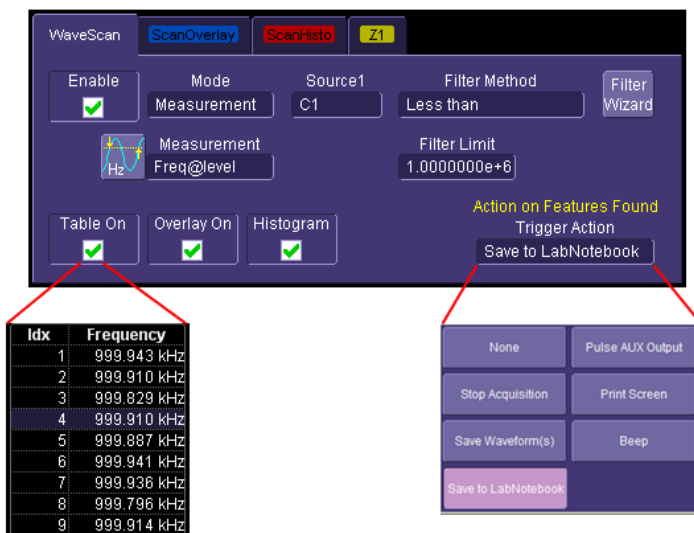
WAVESCAN

Introduction to WaveScan

WaveScan enables you to search for unusual events in a single capture, or to scan for an event in many acquisitions over a long period of time. You can select from more than 20 search modes (frequency, rise time, runt, duty cycle, etc.), apply a search condition (slope, level, threshold, hysteresis), and begin scanning in a post-acquisition environment. Since the scanning modes are not simply copies of the hardware triggers, but "software triggers," the capability is much greater.

For instance, there is no "frequency" trigger in any oscilloscope, yet WaveScan allows frequency to be quickly scanned for. You can accumulate a data set of unusual events that are separated by hours or days, enabling faster debugging. The events are time stamped and indexed in a table from which you can select them for viewing individually.

You can also set actions to occur automatically when unusual events are found: stop the acquisition, emit an audible beep, output a pulse, print the screen, or save the waveform.



SIGNAL VIEWS

WaveScan provides distinct views of your signal:

- **Source view** highlights all occurrences of edges that meet your criteria.

- **Zoom view** allows you to expand a waveform feature vertically and horizontally; to apply further processing; to store it, or to apply a descriptive label to the feature.

Note: The number of grids displayed varies from one to three grids depending on which views are enabled. WaveScan handles this function automatically, and there is no option to move traces from one grid to another, as would be the case under normal (non-WaveScan) operation.

SEARCH MODES

Search modes are used to locate anomalies during acquisition.

- **Edge** - for detecting the occurrence of edges; selectable slope and level
- **Non-monotonic** - for detecting threshold re-crosses; selectable slope, hysteresis, and level
- **Runt** - for detecting pulses that fail to cross a threshold; selectable polarity and thresholds
- **Measurement** - for filtering and performing parameter measurements

PARAMETER MEASUREMENTS

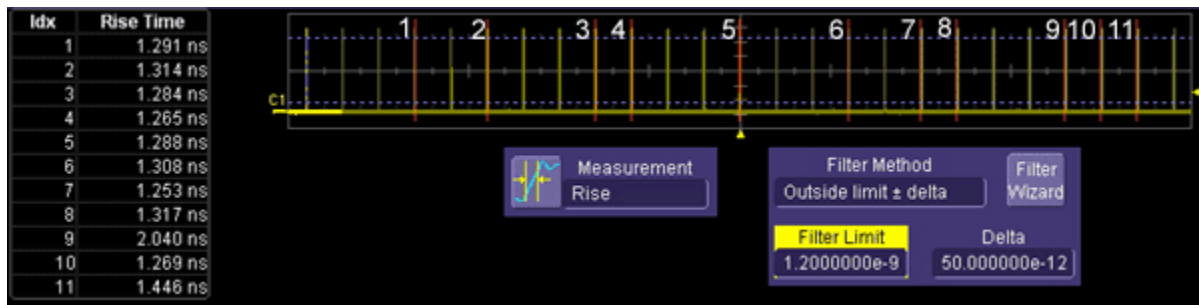
Besides parameter measurements made during acquisition, post-acquisition measurements can also be made. The number of parameters available depends on the options loaded on your instrument. Measurements are made only on the events defined by your filter (search criteria). A Filter Wizard is provided to quickly establish statistical criteria such as ± 1 , 3, or 5 sigma.

SAMPLING MODE

Whenever WaveScan is enabled, the instrument reverts to Real-time sampling mode.

Source View

The top trace on the screen is the source (channel, math, memory) trace. This trace shows all captured edges and highlights those that fit your search criteria. For example, in this figure we are searching for slow rising edges that fall outside a time window:



In this acquisition, WaveScan has located eleven edges that fit the search criteria (filter) of greater than 1.2 ns with a delta of 50 ps. Each of the found edges is highlighted with a red rectangle, and indexed to a table entry at left. Rise time values are also included in the table.

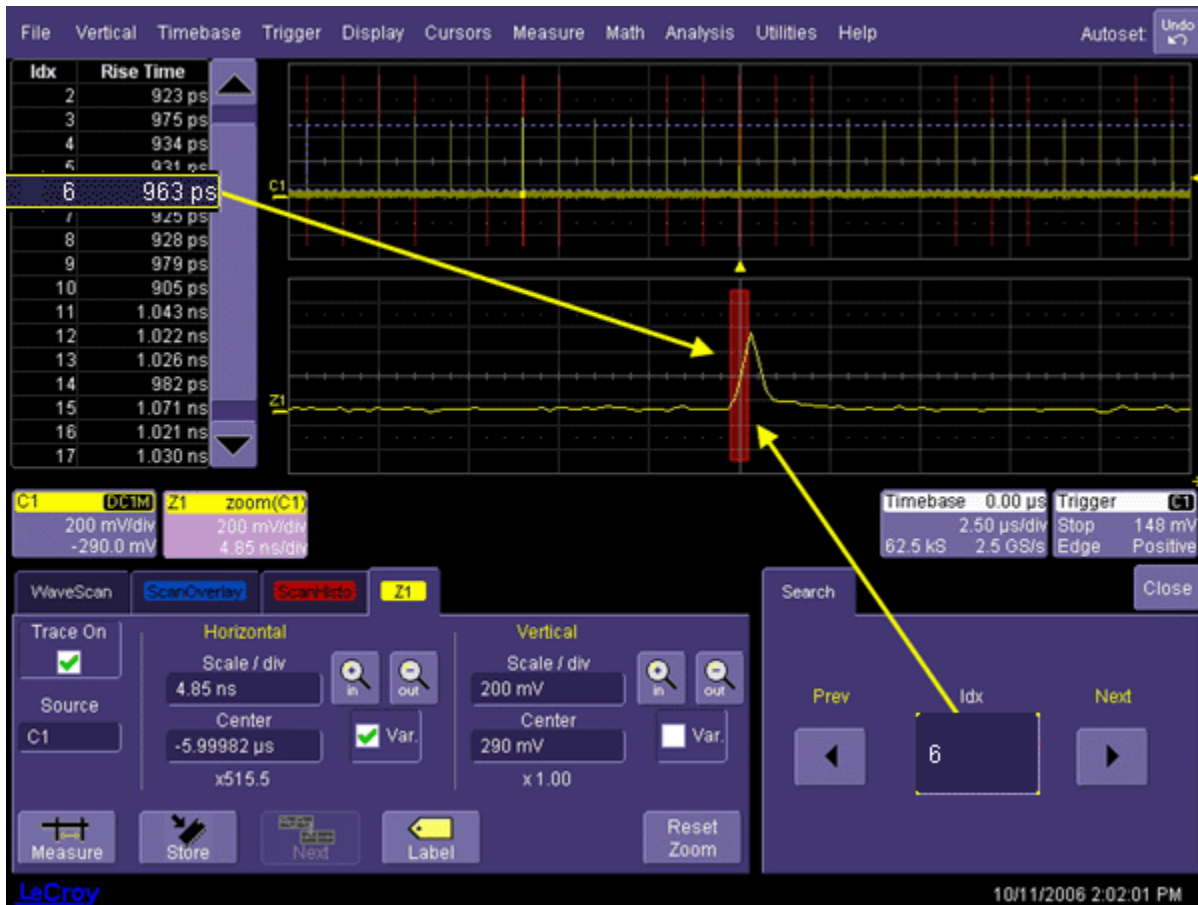
LEVEL MARKERS

Markers are provided on the source trace to show measurement criteria such as level and thresholds. In the example above, the level markers indicate 10% and 90% for the standard Rise Time parameter measurement.

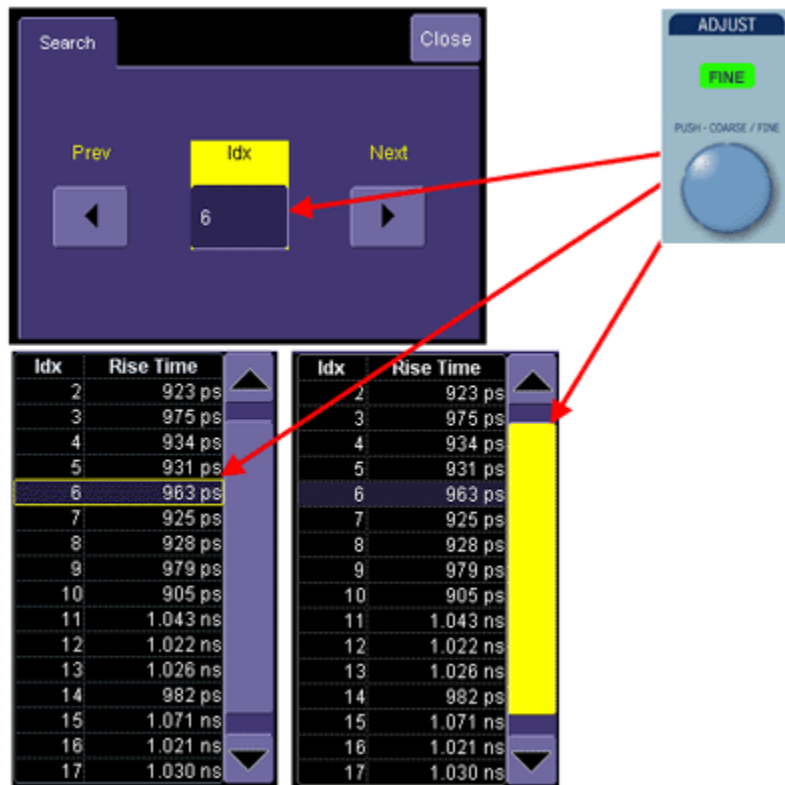
Level markers are displayed only while the oscilloscope is in WaveScan mode. Once the WaveScan Enable checkbox is unchecked, the level markers disappear.

Zoom View

An individual edge can be zoomed by selecting it from the table of found events at the left of the screen. You can also scroll through the table using the **Prev/Next** scroll buttons in the **Search** dialog, or select an event by touching inside the **Idx** field and entering an index number, using the pop-up keypad.



When the Idx field is active, or when an edge is selected in the table, you can use the front panel **ADJUST** knob to advance through the table contents, one line at a time.



When the table contents are too numerous to fit in a single table display, a scroll bar will appear. By touching the scroll bar to highlight it, you can use the Adjust knob to quickly scroll through the table. In this case, however, the selection of edge will not change.

Note: Press the **Adjust** knob for fine resolution (green LED lights). This will enable you to scroll through the table one line at a time. In the coarse resolution mode, the edge selection jumps several lines at once for each click of the **Adjust** knob.

Front panel Zoom controls can be used to vary the magnification and position of the zoomed trace. Or, you can use the on-screen In/Out buttons.

In Zoom View, you can also apply further processing, store, or apply a descriptive label to the zoom trace.

WaveScan Search Modes

EDGE MODE

This search mode locates all edges in an acquisition and presents them time-stamped in a table. You can select positive, negative, or both edges. When the acquisition is stopped, scan filters contained in Measurements mode can be applied to the edges to find specific characteristics.

A level marker, corresponding to 50% in this case, is displayed in the source trace at top.

As with other search modes, a trigger action can be set for Edge mode also.

Table 1: Edge Data

Idx	Edge Time
1	-11.999782 μ s
2	-11.999841 μ s
3	-10.999794 μ s
4	-10.999864 μ s
5	-9.999804 μ s
6	-9.999867 μ s
7	-8.999809 μ s
8	-8.999877 μ s
9	-7.999820 μ s
10	-7.999879 μ s
11	-6.999825 μ s
12	-6.999874 μ s
13	-5.999841 μ s
14	-5.999887 μ s
15	-4.999836 μ s
16	-4.999804 μ s

WaveScan Settings:

- WaveScan: ☒ Enable
- Mode: Edge
- Source1: C1
- Table On: ☒
- Overlay On: ☒
- Histogram: ☐

Edge Settings:

- Slope: Pos
- Percent level: 50 %
- Level is: Percent
- Hysteresis is fixed at 0.5 divisions

Action on Features Found Trigger Action:

- Stop Acquisition

Bottom Menu:

- None
- Pulse AUX Output
- Stop Acquisition
- Print Screen
- Save Waveform(s)
- Beep
- Save to LabNotebook

NON-MONOTONIC MODE

The Non-monotonic search mode looks for edges that cross a threshold more than once between high and low levels. All events that meet the criteria of slope, hysteresis, and level are presented in a table and highlighted in the source trace. The value displayed in the table is the difference of the max. and min. of the non-monotonicity. This can be confirmed with cursors:

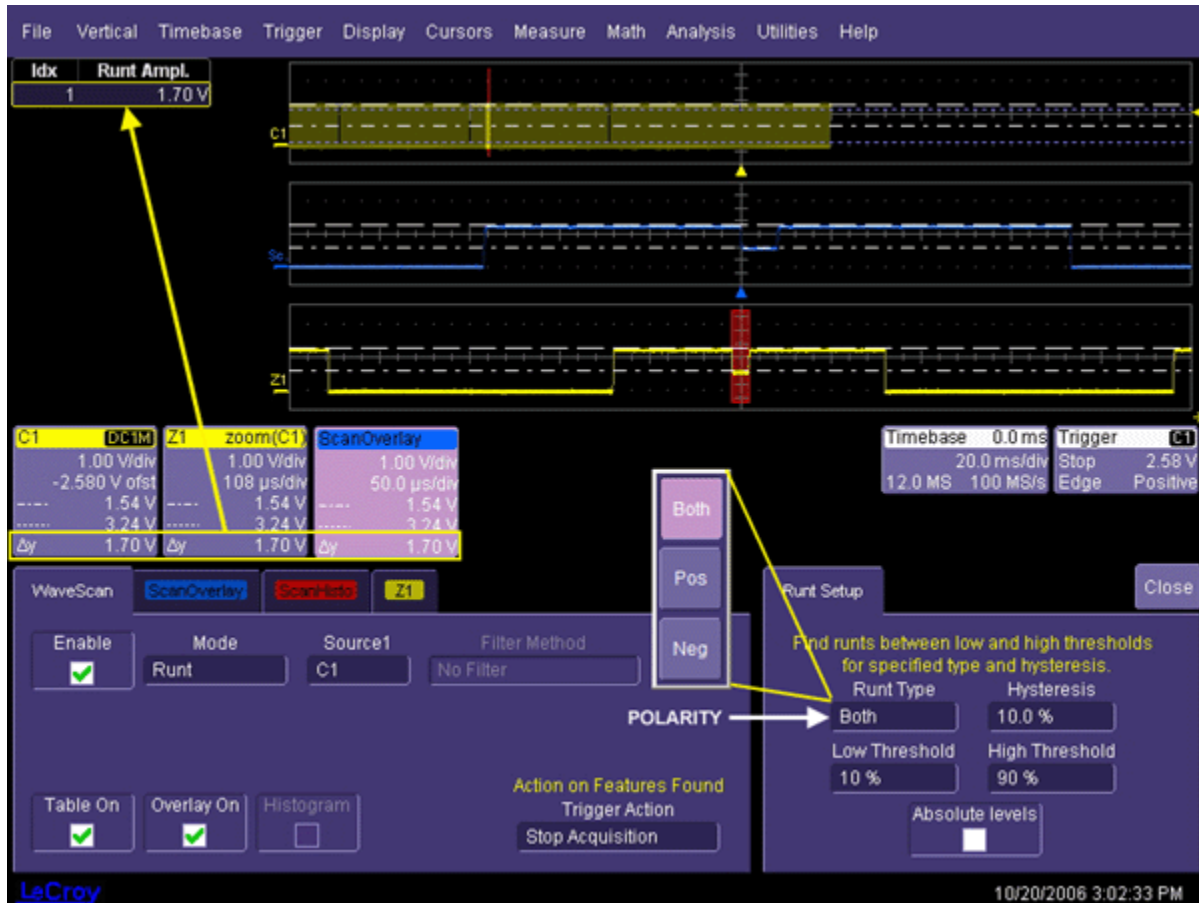


The hysteresis value is used to eliminate noise. A non-monotonicity is detected only when its amplitude is greater than the hysteresis. Therefore, when setting a hysteresis level, set a value that is greater than the amplitude of the noise.

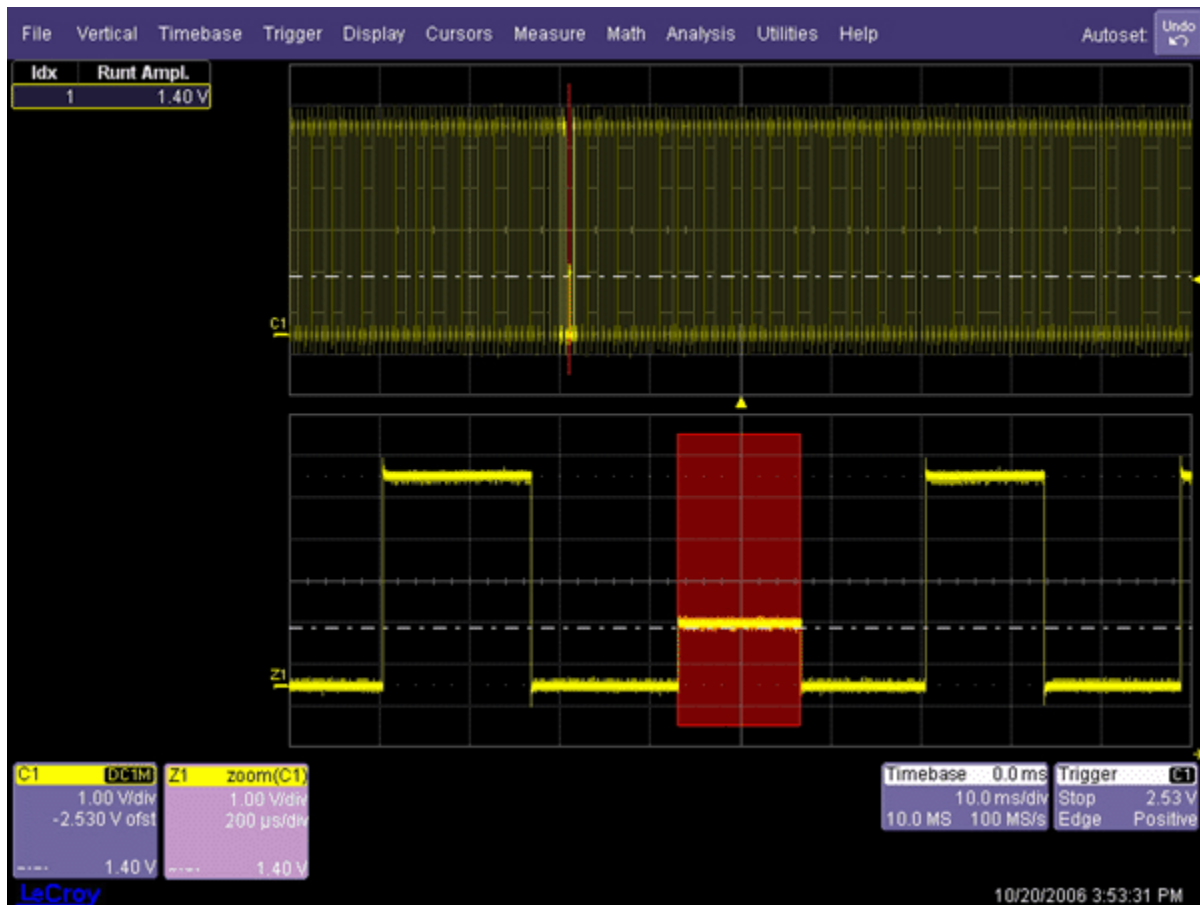
RUNT MODE

This search mode looks for pulses that fail to transit a given region. You can search for positive-going or negative-going runs, or both. An adjustable hysteresis band is provided to eliminate noise.

In the case of negative-going runt pulses, the value displayed in the table is the difference (delta) of the high level of the signal and the runt amplitude, i.e., where the runt bottoms out. This can be confirmed by placing cursors on the runt pulse and reading the delta Y value in the trace labels:



In the case of positive-going runt pulses, the value displayed in the table is the absolute value of the amplitude of the runt pulse:



MEASUREMENT MODE

This search and scan mode lets you apply filters to your acquisitions to highlight only the features of interest. Post-acquisition, you can apply other filters to the acquisition, or make different parameter measurements on it.

For example, in this acquisition a **Rise** time (10-90%) parameter measurement is applied to fast edges during acquisition. We are interested only in edges with a rise time slower than 1 ns. Therefore, the **Greater Than** filter method is selected, with a value of 1 ns; four edges pass during acquisition:



SCAN FILTERS

But, now we want to look at fall times greater than 3 ns; fifteen falling edges from the same acquisition pass this new filter:



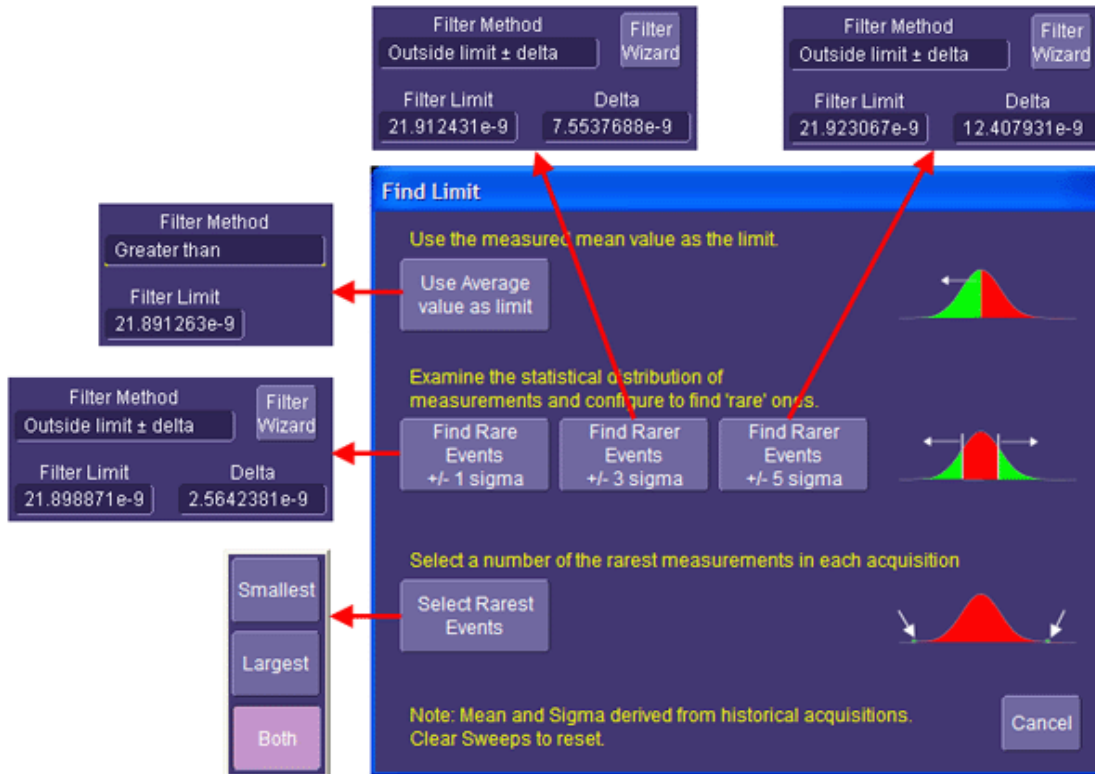
You can also decide how anomalous the features located should be by using the Filter Wizard to select the average value as the limit, to search for rarest events, or to apply statistical criteria.

WaveScan Filtering

FILTER WIZARD

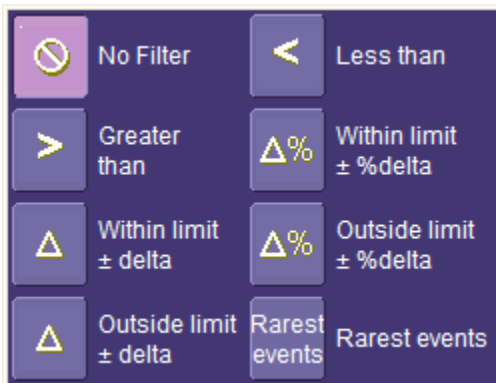
You can decide how anomalous the features searched or scanned for should be by using the average value as the limit, by searching for rarest events, or by applying statistical criteria: ± 1 , 3, or 5 sigma.

In the example below, there were several slow edges in a repetitive waveform. For each filtering method selectable from the wizard, the rise time used as the filter limit and delta are calculated automatically.



FILTER METHODS

While the Filter Wizard provides a quick way to apply filtering criteria automatically, the "Filter Method" menu and related fields let you manually set up filtering criteria. And unlike the Filter Wizard selections, which are restricted to absolute deltas, the "Filter Method" menu offers deltas in percent also:



UTILITIES

Status

The status read-only dialog displays system information including serial number, firmware version, and installed software and hardware options.

ACCESSING THE STATUS DIALOG

- In the menu bar, touch **Utilities**.
- Touch the **Status** tab.

Remote communication

The **Remote** dialog is where you can select a network communication protocol, establish network connections, and configure the Remote Control Assistant log. The choice of communication protocols is limited to TCP/IP and GPIB.

PLEASE NOTE THE FOLLOWING:

- GPIB is an option and requires a GPIB card to be installed in a card slot at the rear of the oscilloscope.
- The instrument uses Dynamic Host Configuration Protocol (DHCP) as its addressing protocol. Therefore, it is not necessary to set up an IP address if your network supports DHCP. If it does not, you can assign a static address in the standard Windows 2000 network setup menu.

The Remote Control Assistant monitors communication between your PC and oscilloscope when you are operating the instrument remotely. You can log all events, or errors only. This log can be invaluable when you are creating and debugging remote control applications.

REMOTE COMMUNICATION SETUP

If you are connecting the oscilloscope to a network, first contact your Information Systems administrator. If you are connecting the oscilloscope directly to your PC, connect a GPIB or Ethernet cable between them.

1. In the menu bar touch **Utilities**, then **Utilities Setup...** in the drop-down menu.



2. Touch the **Remote** tab.
3. Make a **Port** selection: **TCP/IP** (transmission control protocol/Internet protocol) or **GPIB** (general purpose interface bus). If you do not have a GPIB card installed, the GPIB selection will not be accessible.
4. If you are using GPIB, set a GPIB address by touching inside the **GPIB Address** field and enter an address.
5. Press the **Net Connections** button; the Windows **Network and Dial-up Connections** window appears.
6. Touch **Make New Connection** and use the Windows Network Connection Wizard to make a new connection. Or, touch Local Area Connection to reconfigure the oscilloscope's connection if it is already connected to the network.

SECURITY SETUP

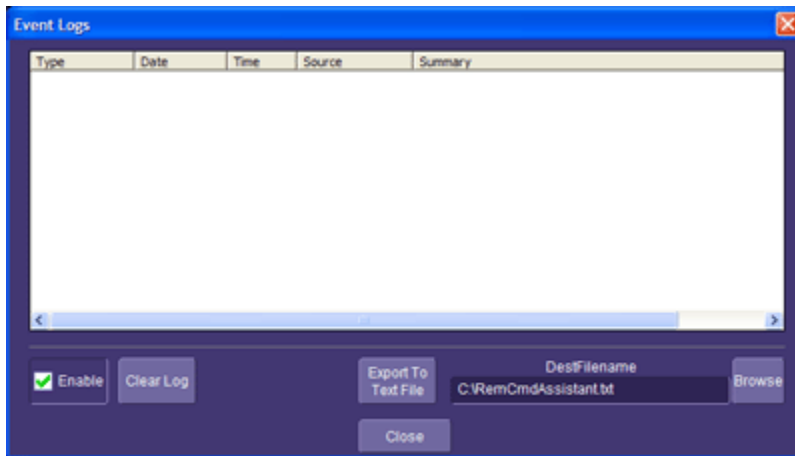
Your instrument allows you to restrict remote control access to certain clients.

- Under **Security** touch the **Yes** button to enable the feature.

- Enter the IP addresses or domain name server names, separated by a comma.

CONFIGURING THE REMOTE CONTROL ASSISTANT EVENT LOG

1. In the menu bar touch **Utilities**, then **Utilities Setup...** in the drop-down menu.
2. Touch the **Remote** tab.
3. Touch inside the **Log Mode** field.
4. Select **Off**, **Errors Only**, or **Full Dialog** from the pop-up menu.
5. To export the contents of the event log to an ASCII text file, touch the **Show Remote Control Log** button: the **Event Logs** popup window appears. Touch inside the **DestFilename** field and enter a file name, using the pop-up keyboard. Then touch the **Export to Text File** button.



Hardcopy Printing



For print setup, refer to **Printing and File Management** on page 77.

Clipboard



This selection prints to the clipboard so you can paste a file into another application (like MS Word, for example).

PRINTING FROM THE CLIPBOARD

1. In the menu bar touch **Utilities**, then **Utilities Setup...** in the drop-down menu.
2. Touch the **Hardcopy** tab.
3. Under **Colors**, touch the **Use Print Colors** checkbox if you want the traces printed on a white background.
4. Touch inside the **Hardcopy Area** field and make a selection from the pop-up menu: **Grid Area Only**, **DSO Window**, or **Full Screen**. In the event the oscilloscope window is minimized or reduced, the **Full Screen** selection also copies the underlying desktop.
5. Touch the **Print** button



File



Choose **File** if you want to output the screen image to storage media such as floppy drive or hard drive. When outputting to floppy disk, be sure to use a preformatted disk.

PRINTING TO A FILE

1. In the menu bar touch **Utilities**, then **Utilities Setup...** in the drop-down menu.
2. Touch the **Hardcopy** tab, then the **File** icon.
3. Touch inside the **File Format** field and select a graphic file format from the pop-up menu.
4. Under **Colors**, touch the **Use Print Colors** checkbox if you want the traces printed on a white background. A white background saves printer toner.
5. Touch inside the **Directory** field and type the path to the folder you want to print to, using the pop-up keyboard. Or touch the **Browse** button and navigate to the folder.
6. Touch inside the **File Name** field and enter a name for the display image, using the pop-up keyboard.
7. Touch inside the **Hardcopy Area** field and make a selection from the pop-up menu: **Grid Area Only**, **DSO Window**, or **Full Screen**. In the event that the oscilloscope window is minimized or reduced, the Full Screen selection also copies the underlying desktop.
8. Touch the print button



E-Mail



The instrument also gives you the option to e-mail your screen images, using either the MAPI or SMTP protocols. Before you output to e-mail from the **Utilities** dialog, you first have to set up the e-mail server and recipient address in **Preference Setup**.

SENDING E-MAIL

9. In the menu bar touch **Utilities**, then **Utilities Setup...** in the drop-down menu.
10. Touch the **Hardcopy** tab, then the **E-mail** button.
11. Touch inside the **File Format** field and select a graphic file format from the pop-up menu.
12. Under **Colors**, touch the **Use Print Colors** checkbox if you want the traces printed on a white background. A white background saves printer toner.
13. Touch the **Prompt for message to send with mail** checkbox if you want to include remarks with the image.
14. Touch inside the **Hardcopy Area** field and make a selection from the pop-up menu: **Grid Area Only**, **DSO Window**, or **Full Screen**. In the event that the oscilloscope window is minimized or reduced, the Full Screen selection also copies the underlying desktop.
15. Touch the print button



Aux Output

Refer to the **Auxiliary Output Signals** topic on page 46.

Setting the Date and Time

The instrument gives you the choice of manually setting the time and date or getting it from the Internet. If you elect to get the time and date from the Internet, you need to have the oscilloscope connected to the Internet through the LAN connector on the rear panel. You can also set time zones and daylight savings time.

MANUALLY SETTING THE DATE AND TIME

1. Touch **Utilities** → **Utilities Setup...** from the menu bar.
2. Touch the **Date/Time** tab.
3. Touch inside each of the **Hour**, **Minute**, **Second**, **Day**, **Month**, and **Year** fields and enter a value, using the pop-up numeric keypad.
4. Touch the **Validate Changes** button.

SETTING THE DATE AND TIME FROM THE INTERNET

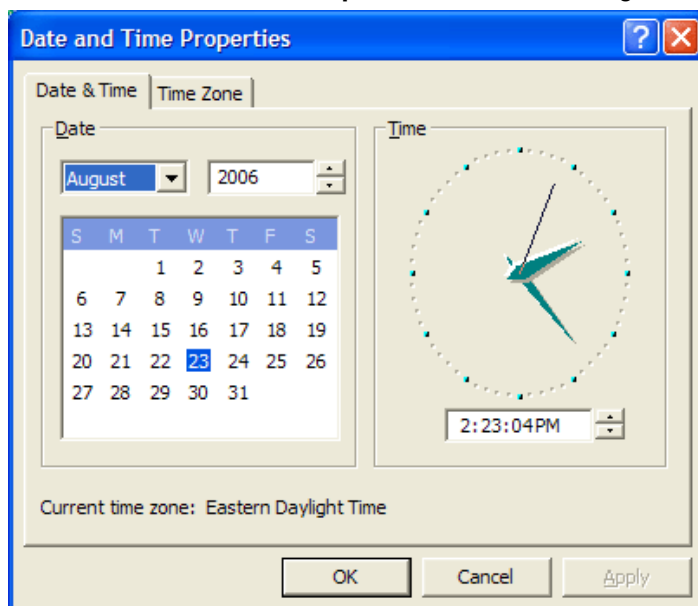
1. The Simple Network Time Protocol (SNTP) is used.
2. Ensure the oscilloscope is connected to the Internet through the LAN connector on the back of the device.
3. Touch **Utilities** → **Utilities Setup...** from the menu bar.
4. Touch the **Date/Time** tab.
5. Touch the **Set from Internet** button.

SETTING THE DATE AND TIME FROM WINDOWS

1. Touch **Utilities** → **Utilities Setup...** from the menu bar.
2. Touch the **Date/Time** tab.
3. Touch the **Windows Date/Time** button.



Use the **Date and Time Properties** window to configure the time, including time zone.



Options

Use this dialog to add or remove software options. For information about software options, contact your local LeCroy Sales and Service office, or visit our Web site at <http://www.lecroy.com/options>.

Options that you purchase, such as WSXs-MathSurf, add performance to your instrument. This added performance is seen in the new math functions or parameters that you can choose from when doing Measure or Math setups.

Preferences

AUDIBLE FEEDBACK

You can elect to have audible confirmation each time you touch a screen or front panel control.

- In the menu bar touch **Utilities**, then touch **Preferences** in the drop-down menu.
- Touch the Audible Feedback **Enable** checkbox so the oscilloscope emits a beep with each touch of the screen or front panel control.

AUTO-CALIBRATION

You can choose to have your instrument automatically recalibrate itself whenever there is a significant change in ambient temperature. If you do not enable this option, the oscilloscope only recalibrates at startup and whenever you make a change to certain operating conditions.

- In the menu bar touch **Utilities**; then touch **Preferences** in the drop-down menu.
- Touch the Automatic Calibration **Enable** checkbox.

UI LANGUAGE

The **Language** field allows you to select a language, other than English, for the UI at any time. To change the current selection, touch inside the "Language" field and select a language from the pop-up menu.

Acquisition

OFFSET SETTING CONSTANT

As you change the gain, this control allows you to either keep the vertical offset level indicator stationary (when **Div** is selected) or to have it move with the actual voltage level (when **Volts** is selected). The advantage of selecting **Div** is that the waveform will remain on the grid as you increase the gain; whereas, if **Volts** is selected, the waveform could move off the grid.

Note: Regardless of whether you select Volts or Div, the Offset shown in the channel setup dialog always indicates volts. However, when Div is selected for the Offset Control, the offset in volts is scaled proportional to the change in gain, thereby keeping the division on the grid constant.

1. In the menu bar touch **Utilities**; then touch **Preferences** in the drop-down menu.
2. Touch the **Offset/Delay** tab.
3. Under **Offset Setting constant in:**, touch either the **Div** or **Volts** button.

DELAY SETTING CONSTANT

As you change the timebase, this control allows you to either keep the horizontal offset indicator stationary (when **Div** is selected) or to have it move with the trigger point (when **Time** is selected). The advantage of selecting **Div** is that the trigger point will remain on the grid as you increase the timebase; whereas, if **Time** is selected, the trigger point could move off the grid.

Note: Regardless of whether you select Time or Div, the Delay shown in the timebase setup dialog always indicates time. However, when Div is selected for Delay In, the delay in time is scaled proportional to the change in timebase, thereby keeping the division on the grid constant.

1. In the menu bar touch **Utilities**; then touch **Preferences** in the drop-down menu.
2. Touch the **Offset/Delay** tab.
3. Under **Delay Setting constant in:**, touch either the **Div** or **Volts** button.

TRIGGER COUNTER

Checking the **Reset trigger counter before starting a new acquisition** checkbox clears the trigger counter each time the oscilloscope issues an arm acquisition command. This applies when you have set a trigger Holdoff condition in the **Trigger** dialog in either time or events:



The default condition of this control is off (unchecked).

E-mail

Before you can send e-mail from the oscilloscope, it must first be configured.

1. In the menu bar touch **Utilities**, then **Preference Setup...** in the drop-down menu.
2. Touch the **E-mail** tab.
3. Choose an e-mail server protocol: **MAPI** (Messaging Application Programming Interface) is the Microsoft interface specification that allows different messaging and workgroup applications (including e-mail, voice mail, and fax) to work through a single client, such as the Exchange client included with Windows 95 and Windows NT. MAPI uses the default Windows e-mail application (usually Outlook Express). **SMTP** (Simple Mail Transfer Protocol) is a TCP/IP protocol for sending messages from one computer to another through a network. This protocol is used on the Internet to route e-mail. In many cases no account is needed.
4. If you chose MAPI, touch inside the **Originator Address (From:)** field and use the pop-up keyboard to type in the instrument's e-mail address. Then touch inside the **Default Recipient Address (To:)** field and use the pop-up keyboard to enter the recipient's e-mail address.
5. If you chose SMTP, touch inside the **SMTP Server** field and use the pop-up keyboard to enter the name of your server. Touch inside the **Originator Address (From:)** field and use the pop-up keyboard to type in the instrument's e-mail address. Then touch inside the **Default Recipient Address (To:)** field and use the pop-up keyboard to enter the recipient's e-mail address.
6. You can send a test e-mail text message by touching the **Send Test Mail** button. The test message reads "Test mail from [name of oscilloscope's email address]."

Acquisition Status

A summary of setups can be viewed for each general category of oscilloscope operation. These setups are accessed from the menu bar drop-down menus (not from the Utilities menu). The categories are as follows:

- **Acquisition**
- **Trigger Time**

- Channels
- Math Setups
- Zooms
- XY Setup
- Memory Setups

Service



This button provides access to service dialogs, which are for the sole use of LeCroy service personnel. A security code is required to gain access.

Show Windows Desktop



Touching the **Show Windows Desktop** button in the main **Utilities** dialog minimizes the instrument application to reveal the underlying desktop. To maximize the application, touch the appropriate shortcut icon:



Touch Screen Calibration



Touching the **Touch-Screen Calibration** button starts the calibration procedure. During the procedure, you will be prompted to touch the center of a small cross in 5 key locations on the touch screen. Because sufficient accuracy cannot be achieved using your finger, use a stylus instead for this procedure. The calibration has a ten-second timeout in case no cross is touched.

To avoid parallax errors, be sure to place your line of sight directly in front of each cross before touching it.