
User's Guide



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For Safety Information and Regulatory information,
see the pages at the end of this manual.

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**Welec 2012A, 2022A, 2014A and 2024A
Oscilloscopes**

Choose from a variety of oscilloscopes for capturing long, non-repeating signals with 1 GSa/s sample rate and 16 KBytes of deep memory per channel.

- **Welec 2012A**- 2-channel, 100-MHz bandwidth
- **Welec 2014A**- 4-channel, 100-MHz bandwidth
- **Welec 2022A**- 2-channel, 200-MHz bandwidth
- **Welec 2024A**- 4-channel, 200-MHz bandwidth

Display shows current input signals

- All channels displayed in main and delayed mode
- Indicators for channel, time base, channel activity, trigger and acquisition status
- Softkey labels
- Measurement results
- Turn channels on or off individually

Run control keys begin and end data acquisition

- Run/Stop starts and stops continuous acquisitions
- Single performs one acquisition
- Infinite persistence accumulates and displays the results of multiple acquisitions

General controls measure, save and restore results, and configure the oscilloscope

- Waveform math including FFT, subtract, add and multiply,
- Use Quick Meas to make automatic measurements with Quick Meas.
- Use cursors to make manual measurements
- Save or recall up to 80x 16K points 2/4 channels measurement configurations and previous results
- Autoscale performs simple one-button setup of the oscilloscope

Horizontal Controls select sweep speed and delay parameters

- Sweep speeds from 10 ns/div to 5 s/div
- Delay control moves waveform display to point of interest
- Delayed mode and delay allow zooming in to show a portion of waveform in detail (split screen)

Trigger keys define what data the oscilloscope will trigger on

- Source key allows conventional oscilloscope triggering
- Modes include Edge, Pulse Width, and TV triggering

Softkeys extend the functionality of command keys

Select measurement types, operating modes, trigger specifications, label data, and more

Utilities

- Dedicated USB port for PC Application Software and other useful data protocols

Dimensions

- World-slimmest oscilloscope in its class (92mm thick)
- World-lightest oscilloscope in its class (2.5Kg)

Made in the E.U.

Welec GmbH, Germany

Notices

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Print History

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Safety Notices

This apparatus has been designed and tested in accordance with IEC Publication 1010, Safety Requirements for Measuring Apparatus, and has been supplied in a safe condition. This is a Safety Class I instrument (provided with terminal for protective earthing). Before applying power, verify that the correct safety precautions are taken (see the following warnings). In addition, note the external markings on the instrument that are described under "Safety Symbols."

Warnings

- Before turning on the instrument, you must connect the protective earth terminal of the instrument to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. You must not negate the protective action by using an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.
- Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short-circuited fuseholders. To do so could cause a shock or fire hazard.
- If you energize this instrument by an auto transformer (for voltage reduction or mains isolation), the common terminal must be connected to the earth terminal of the power source.
- Whenever it is likely that the ground protection is impaired, you must make the instrument inoperative and secure it against any unintended operation.
- Service instructions are for trained service personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so. Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

- Do not install substitute parts or perform any unauthorized modification to the instrument.
- Capacitors inside the instrument may retain a charge even if the instrument is disconnected from its source of supply.
- Do not operate the instrument in the presence of flammable gasses or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.
- Do not use the instrument in a manner not specified by the manufacturer.

To clean the instrument

If the instrument requires cleaning: (1) Remove power from the instrument. (2) Clean the external surfaces of the instrument with a soft cloth dampened with a mixture of mild detergent and water. (3) Make sure that the instrument is completely dry before reconnecting it to a power source.

Safety Symbols



Instruction manual symbol: the product is marked with this symbol when it is necessary for you to refer to the instruction manual in order to protect against damage to the product.



Hazardous voltage symbol.



Earth terminal symbol: Used to indicate a circuit common connected to grounded chassis.

In This Book

This manual will guide you in using the oscilloscopes. This manual is organized in the following chapters:

Chapter 1 Getting Started—inspecting, cleaning, and setting up your oscilloscope.

Chapter 2 Front-panel Overview—A quick start guide to get you familiarize you with the front-panel operation.

Chapter 3 Triggering the Oscilloscope—how to trigger the oscilloscope using all the various modes.

Chapter 4 Oscilloscope Operation—acquiring waveforms, horizontal and vertical operation, using channels.

Chapter 5 Making Measurements—capturing data, using math function, making measurement with cursors and automatic measurements.

Chapter 6 Utilities—attaching the PC to run the PC Application Software, Zero Lines Calibration, Firmware Update and programmable Hardware Update via USB

Chapter 7 Performance Characteristics

FFT

Points	Fixed at 1024 points
Source of FFT	Input channels 3 or 4 (or 1 or 2 for W20x2A), 3+4, 3-4, 3*4
Window	Rectangular
Noise Floor	-70 to -100 dB depending on averaging
Amplitude Display	In dBV
Frequency Resolution:	0.1/(time per div)
Maximum Frequency	100/(time per div)

Storage

Save/Recall	(non-volatile) 16 setups and 64x 16k point traces can be saved and recalled internally
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I/O

RS-232 (serial) standard port	1 port, 8 data bits; 1 stop bits; parity=none
USB	V2.0

General Characteristics

Physical:	
Size	33 cm wide x 17 cm high x 92 mm deep
Weight	2.5 kgs
Calibrator Output	Frequency ~1.0 kHz; Amplitude ~500mV

Power Requirements

Line Voltage Range	100 - 240 VAC ±10%, CAT II, automatic selection
Line Frequency	47 to 440 Hz
Power Usage	35 W max

Environmental Characteristics

Ambient Temperature	Operating -10 ° C to +55 ° C Non-operating -51 ° C to +71 ° C
Humidity	Operating 95% RH at 40 ° C for 24 hr Non-operating 90% RH at 65 ° C for 24 hr
Pollution degree 2	Normally only dry non-conductive pollution occurs. Occasionally a temporary conductivity caused by condensation must be expected.
Indoor use only	This instrument is rated for indoor use only
Installation categories	CAT I: Mains isolated CAT II: Line voltage in appliance and to wall outlet

External (EXT) Triggering

Input Resistance	1 M Ω \pm 3%
Input Capacitance	~15pF
Maximum Input	CAT I 300 Vrms, 400 Vpk CAT II 100 Vrms, 400 Vpk with probe switched 10:1 CAT I 500 Vpk, CAT II 400 Vpk
Range	\pm 10 V
Sensitivity	dc to 25 MHz, < 75 mV 25 MHz to max bandwidth, < 150 mV

Display System

Display	Color TFT LCD
Size	6.5"
Resolution	VGA 640 x 480 dots
Controls	Grid off/on, 33%, 66% intensity selectable Vectors on/off, infinite persistence on/off
Languages	German, English, French, Spanish, Portuguese Russian, Italian

Measurement Features

Automatic Measurements	Measurements are continuously updated Cursors track current measurement
Voltage	Peak-to-Peak, Maximum, Minimum, Average, Top, Base, RMS (DC)
Time	Frequency, Period, +Width, -Width, and Duty Cycle on any channels. Rise time, Fall time, Delay, and Phase.
Threshold Definition	Variable by percent and absolute value; 10%, 50%, 90% default for time measurements
Cursors	Manually or automatically placed readout of Horizontal (X, Δ X, 1/ Δ X) and Vertical (Y, Δ Y).
Waveform Math	3-4, 3*4, FFT, differentiate, integrate. Source of FFT: differentiate, integrate, input channels 3 or 4 (or 1 or 2 for W20x2A), 3-4, 3+4, 3*4

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DC Vertical Gain Accuracy	±2.0% full scale
DC Vertical Offset Accuracy	<200 mV/div: ±0.1 div ±1.0 mV ±0.5% offset ≥200 mV/div: ±0.1 div ±1.0 mV ±1.5% offset

Horizontal

Range	10 ns/div to 5 s/div
Delay Range	
Pre-trigger (negative delay)	variable selectable over the 16 k points
Post-trigger (positive delay)	variable selectable over the 16 k points
Delay Jitter	10 ppm
RMS Jitter	0.025% screen width + 30 ps
Modes	Main, Delayed, Roll, XY
XY	
Bandwidth	Max bandwidth
Phase error @ 1 MHz	2 degrees

Trigger System

Sources:	Ch 1, 2, 3, 4, line, ext
Modes	Auto, Auto level, Triggered (normal), Single
Holdoff Time	~40 ns to 300 seconds
Selections	Edge, Pulse Width, TV
Edge	Trigger on a rising or falling edge of any source.
Pulse Width	Trigger when a positive-going pulse is less than, greater than, or within a specified range on any of the source channels.
TV	Trigger on channel 1. TV trigger sensitivity: 0.5 division of synch signal.

Welec W20x4A Performance Characteristics

*) Denotes Warranted Specifications, all others are typical. Specifications are valid after a 30-minute warm-up period and $\pm 10^{\circ}\text{C}$ from firmware calibration temperature.

Acquisition

Max Sample rate	1 GSa/s per channel
Max Memory Depth	16k points per channel
Vertical Resolution	8 bits
Filter	<50ns/div, Sinx/x interpolation with vectors on.

Vertical System

Input channels	Ch1, 2, 3 and 4 simultaneous acquisition
Bandwidth (-3dB)*	W2014A: dc to 100 MHz W2024A: dc to 200 MHz
ac coupled	W2014A: 10 Hz to 100 MHz W2024A: 10 Hz to 200 MHz
Calculated rise time (= 0.35/bandwidth)	W2014A: ~3.5 ns W2024A: ~1.8 ns
Single Shot Bandwidth	W2014A: 100 MHz W2024A: 200 MHz
Range	10 mV/div to 5 V/div
Maximum Input	CAT I 300 Vrms, 400 Vpk CAT II 100 Vrms, 400 Vpk with probe switched 10:1 CAT I 500 Vpk, CAT II 400 Vpk
Offset Range	± 5 V on ranges <10 mV/div ± 25 V on ranges 10 mV/div to 199 mV/div ± 100 V on ranges ≥ 200 mV/div
Dynamic Range	Lesser of ± 8 div or ± 32 V
Input Resistance	1 M Ω $\pm 1\%$
Input Capacitance	~15pF
Coupling	ac, dc, ground
BW Limit	20MHz selectable
Probes	1:1/10:1 switchable shipped standard for each channel and one for external channel
ESD Tolerance	± 2 kV
Noise Peak-to-Peak	2% full scale or 1 mV, whichever is greater
Common Mode Rejection	Ratio 20 dB @ 50 MHz

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FFT

Points	Fixed at 1024 points
Source of FFT	Input channels 1 or 2 (or 3 or 4 for W20x4), 1+2, 1-2, 1*2
Window	Rectangular
Noise Floor	-70 to -100 dB depending on averaging
Amplitude Display	In dBV
Frequency Resolution:	0.1/(time per div)
Maximum Frequency	100/(time per div)

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Input Capacitance	~15pF
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Range	\pm 10 V
Sensitivity	dc to 25 MHz, < 75 mV 25 MHz to max bandwidth, < 150 mV

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Display	Color TFT LCD
Size	6.5"
Resolution	VGA 640 x 480 dots
Controls	Grid off/on, 33%, 66% intensity selectable Vectors on/off, infinite persistence on/off
Languages	English

Measurement Features

Automatic Measurements	Measurements are continuously updated Cursors track current measurement
Voltage	Peak-to-Peak, Maximum, Minimum, Average, Top, Base, RMS (DC)
Time	Frequency, Period, +Width, -Width, and Duty Cycle on any channels. Rise time, Fall time, Delay, and Phase.
Threshold Definition	Variable by percent and absolute value; 10%, 50%, 90% default for time measurements
Cursors	Manually or automatically placed readout of Horizontal (X, Δ X, 1/ Δ X) and Vertical (Y, Δ Y).
Waveform Math	1-2, 1+2, 1*2, FFT.

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DC Vertical Gain Accuracy	±2.0% full scale
DC Vertical Offset Accuracy	<200 mV/div: ±0.1 div ±1.0 mV ±0.5% offset ≥200 mV/div: ±0.1 div ±1.0 mV ±1.5% offset

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Modes	Main, Delayed, Roll, XY
XY	
Bandwidth	Max bandwidth
Phase error @ 1 MHz	2 degrees

Trigger System

Sources:	Ch 1, 2, line, ext
Modes	Auto, Auto level, Triggered (normal), Single
Holdoff Time	~40 ns to 300 seconds
Selections	Edge, Pulse Width, TV
Edge	Trigger on a rising or falling edge of any source.
Pulse Width	Trigger when a positive-going pulse is less than, greater than, or within a specified range on any of the source channels.
TV	Trigger on channel 1. TV trigger sensitivity: 0.5 division of synch signal.

Welec W20x2A Performance Characteristics

*) Denotes Warranted Specifications, all others are typical. Specifications are valid after a 30-minute warm-up period and $\pm 10^{\circ}\text{C}$ from firmware calibration temperature.

Acquisition

Max Sample rate	1 GSa/s per channel
Max Memory Depth	16k points per channel
Vertical Resolution	8 bits
Filter	<50ns/div, Sinx/x interpolation with vectors on.

Vertical System

Input channels	Ch1 and 2 simultaneous acquisition
Bandwidth (-3dB)*	W2012A: dc to 100 MHz W2022A: dc to 200 MHz
ac coupled	W2012A: 10 Hz to 100 MHz W2022A: 10 Hz to 200 MHz
Calculated rise time (= 0.35/bandwidth)	W2012A: ~3.5 ns W2022A: ~1.8 ns
Single Shot Bandwidth	W2012A: 100 MHz W2022A: 200 MHz
Range	10 mV/div to 5 V/div
Maximum Input	CAT I 300 Vrms, 400 Vpk CAT II 100 Vrms, 400 Vpk with probe switched 10:1 CAT I 500 Vpk, CAT II 400 Vpk
Offset Range	± 5 V on ranges <10 mV/div ± 25 V on ranges 10 mV/div to 199 mV/div ± 100 V on ranges ≥ 200 mV/div
Dynamic Range	Lesser of ± 8 div or ± 32 V
Input Resistance	1 M Ω $\pm 1\%$
Input Capacitance	~15pF
Coupling	ac, dc, ground
BW Limit	20MHz selectable
Probes	1:1/10:1 switchable shipped standard for each channel and one for external channel
ESD Tolerance	± 2 kV
Noise Peak-to-Peak	2% full scale or 1 mV, whichever is greater
Common Mode Rejection	Ratio 20 dB @ 50 MHz

Getting Started

Getting Started

When you use the oscilloscopes to help test and troubleshoot your systems, you may do the following:

- Prepare the oscilloscope by connecting it to power and setting up the handle as desired.
- Define the measurement problem by understanding the parameters of the system you wish to test, and the expected system behavior.
- Set up channel inputs by connecting the probes to the appropriate signal and ground nodes in the circuit under test.
- Define the trigger to reference the waveform data at a specific event of interest.
- Use the oscilloscope to acquire data, either in continuous or single-shot fashion.
- Examine the data and make measurements on it using various features.
- Save the measurement or configuration for later re-use or comparison with other measurements.

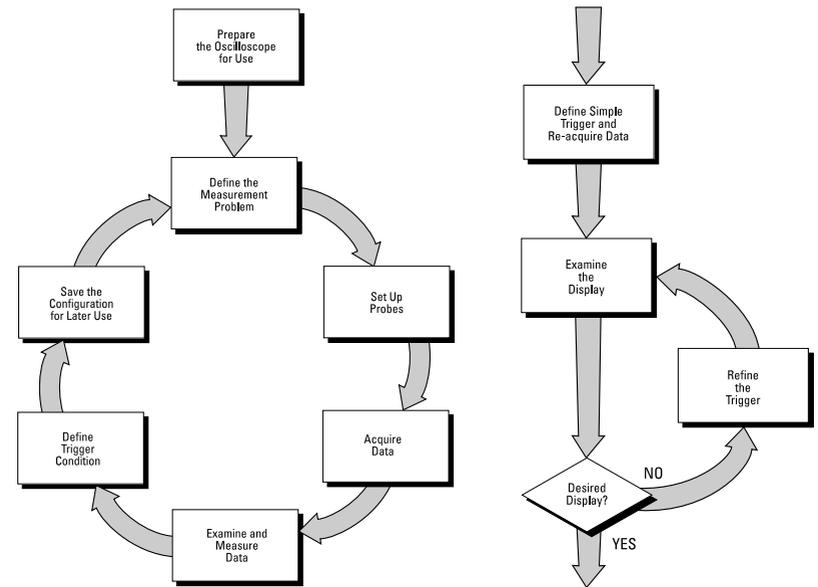
Repeat the process as necessary until you verify correct operation or find the source of the problem.

Performance Characteristics

This chapter lists the performance characteristics for the Welec W20x2A-series and W20x4-series oscilloscopes.

- The W20x2A-series performance characteristics start on page 7-2. The W20x4A-series performance characteristics start on page 7-13.

The oscilloscope's high-speed display can be used to isolate infrequently changing signals. You can then use the characteristics of these signals to help refine the trigger specification. For more information on triggering, data acquisition, data examination and measurement, and configuration, see the later chapters.



Using the Oscilloscope, and Refining the Trigger Specification

Performance Characteristics

Setting up the Oscilloscope

To prepare your oscilloscope for use, you need to do the following tasks. After you have completed them, you will be ready to use the oscilloscope.

In the following topics you will:

- inspect package contents
- inspect options and accessories
- learn how to clean the oscilloscope
- adjust the handle
- power-on the oscilloscope
- connect the oscilloscope probes
- verify basic oscilloscope operation
- get started using the oscilloscope interface

User Cal Status

Pressing the **User Cal Status** softkey displays the following summary results of the previous User Cal.

Results:

Failure:

Comments:

Self test

Pressing the **Start Self Test** softkey performs a series of internal procedures to verify that the oscilloscope is operating properly.

It is recommended you run Self Test:

- after experiencing abnormal operation.
- for additional information to better describe an oscilloscope failure.
- to verify proper operation after the oscilloscope has been repaired.

Successfully passing Self Test does not guarantee 100% of the oscilloscope's functionality. Self Test is designed to provide an 80% confidence level that the oscilloscope is operating properly.

About Oscilloscope

Pressing the **About Oscilloscope** softkey displays information about your oscilloscope model number, serial number, firmware revision and ROM revision.

To inspect package contents

❑ Inspect the shipping container for damage.

If your shipping container appears to be damaged, keep the shipping container or cushioning material until you have inspected the contents of the shipment for completeness and have checked the oscilloscope mechanically and electrically.

❑ Verify that you received the following items and any optional accessories in the oscilloscope packaging (see figure following).

- W20xxA-Series Oscilloscope:
W2012A, W2022A, W2014A or W2024A
- 1:1/10:1 switchable passive probes with id
 - (2) W201 (100MHz) for W2012A
 - (4) W201 (100MHz) for W2014A
 - (2) W202 (200MHz) for W2022A
 - (4) W202 (200MHz) for W2024A

- Power cord

- RS232 and USB cable

A Firmware Update Software allows you to update the oscilloscope's firmware, when a new release becomes available on our web site.

A Windows application "W2000A Data Capture" that makes it very easy for you to download images, waveform data, or oscilloscope setups from the oscilloscope to your pc.

This application software and Firmware Update Software for W2000A-series Oscilloscopes is available free on the web at:

www.Welec.de

After installation the application software, a tool bar in these Microsoft applications will make connection and data transfer from the oscilloscope very simple.

- Welec W2000A Data Capture

W2000A Data Capture is a standalone program for downloading waveform data from the oscilloscopes to your PC via USB or RS-232 interface. It provides the capability to transfer deep memory data out of the oscilloscope allowing up to 16KB per channels. The application for W2000A-Series does not limit the size of acquisition data available regardless of actual number of acquisition points on the LCD screen. It provides the following functionality:

- Download waveform data and display the data as a simple chart
- Save the data as binary, JPG, XLS or text files
- Copy the chart and a selected portion of the data to the clipboard.
- Load saved waveform data back into the application

If anything is missing, contact your nearest Welec Sales Office or authorized Distributor. If the shipment was damaged, contact the carrier, then contact the nearest Welec Sales Office or authorized Distributor.

□ Inspect the oscilloscope

- If there is mechanical damage or a defect, or if the oscilloscope does not operate properly or does not pass the performance tests listed in the Service Guide, notify your Welec Sales Office or authorized Distributor.
- If the shipping container is damaged, or the cushioning materials show signs of stress, notify the carrier and your Welec Sales Office or authorized Distributor. Keep the shipping materials for the carrier's inspection. The Welec Sales Office or authorized Distributor will arrange for repair or replacement at Welec's option, without waiting for claim settlement.

To perform service functions

The Service menu allows you to:

- perform User Cal on the oscilloscope
- view User Cal status
- perform instrument Self Test
- view information about your oscilloscope model number, code revision information, and User Cal status.

User Cal

User Cal performs an internal self-alignment routine to optimize the signal path in the oscilloscope. The routine uses internally generated signals to optimize circuits that affect channel sensitivity, offset, and trigger parameters.

Disconnect all inputs and allow the oscilloscope to warm up before performing this procedure.

User Cal should be performed at least once a year, any time the ambient temperature of the oscilloscope has changed more than 10°C since the last User Cal, or after any repair.

Performing User Cal will not invalidate your Certificate of Calibration. Successful completion of User Cal does not certify this oscilloscope with a National Institute of Standards and Technology (NIST) calibration.

To set up the I/O port to use a controller

Use the I/O menu to make settings if you have a controller connected to the oscilloscope.

- 1 Press the **Controller** softkey to set the controller interface to RS-232 or USB.

The RS-232 configuration to the connector on the side panel is:

- Data bits - 8
- Stop bits - 1
- Parity -none

The USB configuration to the connector on the side panel is USB 1.1.

- 2 Only use either the serial RS-232 or USB cable shipped with this instrument. Any other cable could damage the interfaces.

W2000A-Series Oscilloscope



Signal Probes

- 2 pcs Model W20x2A
- 4 pcs Model W20x4A



Power Cord

RS232 and USB Cable



Package contents for W2000A-Series Oscilloscopes

To inspect options and accessories

- Verify that you received the options and accessories you ordered and that none were damaged.**

If anything is missing, contact your nearest Welec Sales Office. If the shipment was damaged, or the cushioning materials show signs of stress, notify the carrier and your Welec Sales Office.

Contact your Welec Sales Office for a complete list of options and accessories available for the W2000A-Series Oscilloscopes.

To update your instrument to the latest firmware

When updates to the instrument application software occur, an updated application firmware file can be downloaded from:

www.Welec.de for any W2000A model

or call Welec Direkt or an authorized Distributor and request the latest application firmware for your instrument.

To configure Quick Help languages

Different Language Menu will is not available until V2.0 will be released.

To clean the oscilloscope

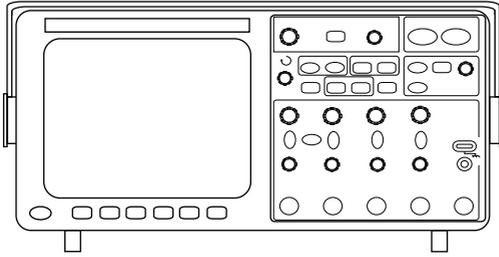
- 1 Disconnect power from the instrument

CAUTION Do not use too much liquid in cleaning the oscilloscope. Water can enter the front-panel keyboard, control knobs damaging sensitive electronic components.

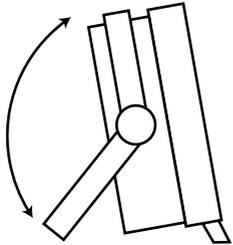
- 2 Clean the oscilloscope with a soft cloth dampened with a mild soap and water solution.
- 3 Make sure that the instrument is completely dry before reconnecting to a power source.

To adjust the handle

- 1 When the handle is in up right position, it is used to carry the scope securely.



- 2 Swivel the handle to the desired position. Continue pivoting the handle until it clicks into a set position.



Utilities

The Utility menu allows you to:

- select other languages for viewing Quick Help
- to update your instrument to the latest application firmware
- set up the oscilloscope I/O ports for controller operation
- perform service functions such as User Cal and Self Test

Utilities

To connect the oscilloscope probe

The analog input impedance of these oscilloscopes is 1 M Ω . This impedance is for use with probes and for general purpose measurements. The high impedance minimizes the loading effect of the oscilloscope on the circuit under test.

- 1 Connect the supplied 1.2-meter, 1:1/10:1 switchable oscilloscope probe to an analog channel BNC connector input on the oscilloscope.

Maximum input voltage for analog inputs:



CAT I 300 Vrms, 400 Vpk

CAT II 100 Vrms, 400 Vpk

- 2 Connect the retractable hook tip on the probe tip to the circuit point of interest. Be sure to connect the probe ground lead to a ground point on the circuit. The probe ground lead is connected to the oscilloscope chassis and the ground wire in the power cord. If you need to connect the ground lead to a point in the circuit that cannot be grounded to power ground, consider using a differential probe.

RMS

RMS (dc) is the root-mean-square value of the waveform over one or more full periods. If less than one period is displayed, RMS (dc) average is calculated on the full width of the display. The X cursors show what interval of the waveform is being measured.

$$\text{RMS (dc)} = \sqrt{\frac{\sum_{i=1}^n x_i^2}{n}}$$

Top

The Top of a waveform is the mode (most common value) of the upper part of the waveform, or if the mode is not well defined, the top is the same as Maximum. The Y cursor shows the value being measured.

Measurement definitions

Average

Average is the sum of the waveform samples divided by the number of samples over one or more full periods. If less than one period is displayed, Average is calculated on the full width of the display. The X cursors show what portion of the displayed waveform is being measured.

$$\text{Average} = \frac{\sum x_i}{n}$$

Where

x_i =value at i th point being measured

n =number of points in measurement interval

Base

The Base of a waveform is the mode (most common value) of the lower part of the waveform, or if the mode is not well defined, the base is the same as Minimum. The Y cursor shows the value being measured.

Maximum

Maximum is the highest value in the waveform display. The Y cursor shows the value being measured.

Minimum

Minimum is the lowest value in the waveform display. The Y cursor shows the value being measured.

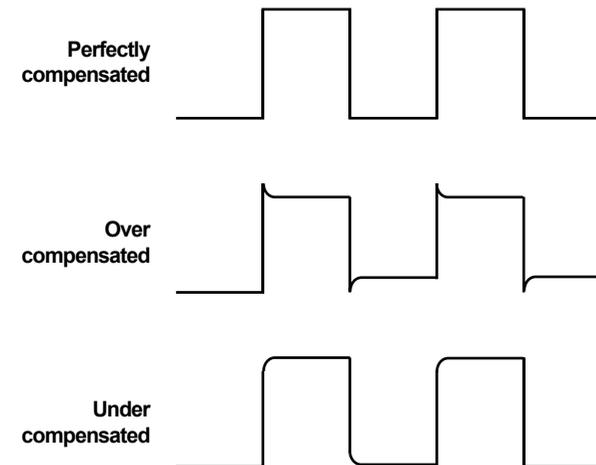
Peak-Peak

The peak-to-peak value is the difference between Maximum and Minimum values. The Y cursors show the values being measured.

To compensate your probe

You should compensate your probes to match their characteristics to the oscilloscope. A poorly compensated probe can introduce measurement errors. To compensate a probe, follow these steps:

- 1 Connect the probe from channel 1 to the Probe Comp signal on the lower-right corner of the front panel.
- 2 Press **Autoscale**
- 3 Use a nonmetallic tool to adjust the trimmer capacitor on the probe for the flattest pulse possible.



Refer to the operator's manual of the probe for more information about how to compensate the signal probe.

To connect an RS-232 or USB cable

The oscilloscope can be connected to a controller or a pc through the RS-232 or USB connector on the side of the oscilloscope. An RS-232 and USB cable is shipped with each oscilloscope.

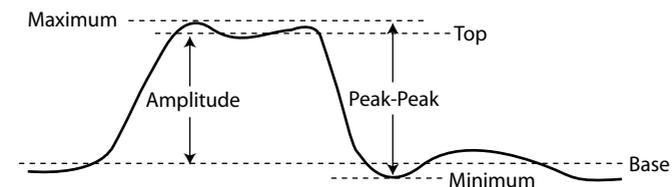
- 1 Attach the 9-pin “D” connector on the RS-232 cable to the RS-232 connector on the side of the oscilloscope. Tighten the thumbscrews on the cable connector to secure the cable. Or attach the USB cable to the oscilloscope.
- 2 Attach the other end of the cable to your controller or pc.
- 3 To select the RS-232 or USB port on the oscilloscope press the **Utility** key, then press the **I/O** softkey select **RS-232** or **USB**.

For more information on RS-232/USB configuration, refer to the “Utilities” chapter.

Making voltage measurements automatically

Measurement units for each input channel is set to Volts . A scale unit of **U** (undefined) will be displayed for math function 1-2, and when 1-2 or 1+2 is the selected source if channel 1 and channel 2 are set to dissimilar units in the channel **Probe Units** softkey.

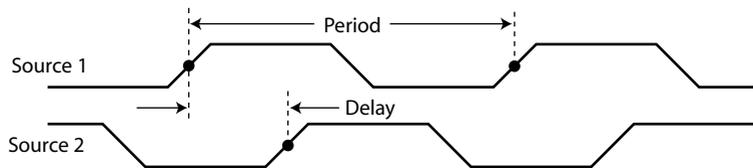
The following figure shows the voltage measurement points.



Phase

Phase is the calculated phase shift from source 1 to source 2, expressed in degrees. Negative phase shift values indicate that the rising edge of source 1 occurred after the rising edge of source 2. Press the **Settings** softkey to select the source channels for the phase measurement.

$$\text{Phase} = \frac{\text{Delay}}{\text{Source 1 Period}} \times 360$$

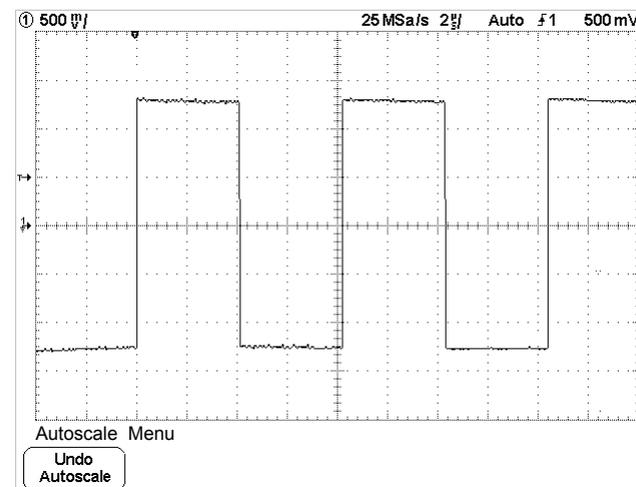


- Press the **Settings** softkey to select the source 1 and source 2 channels for the phase measurement.

The default Phase settings measure from channel 1 to channel 2.

To verify basic oscilloscope operation

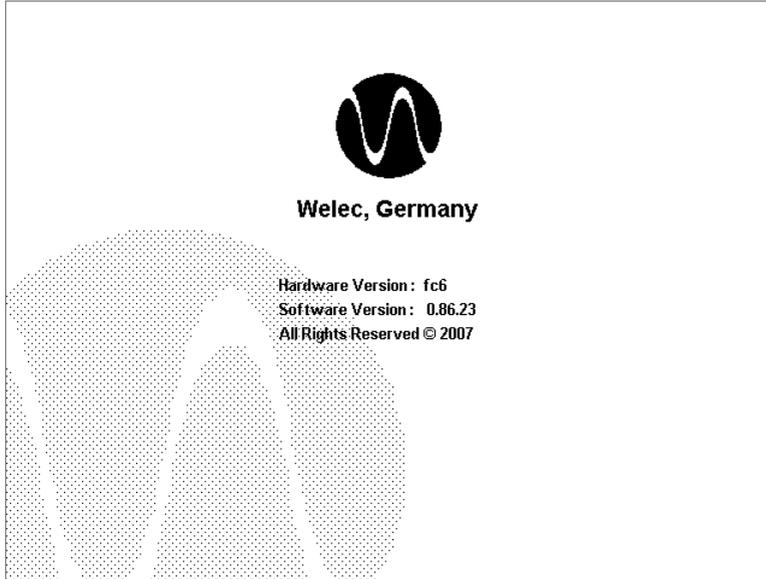
- 1 Connect an oscilloscope probe to channel 1.
- 2 Attach the probe to the **Probe Comp** output on the lower-right side of the front panel of the oscilloscope.
- 3 Press the **Save/Recall** key on the front panel, then press the **Default Setup** softkey under the display. The oscilloscope is now configured to its default settings.
- 4 Press the **Autoscale** key on the front panel. You should then see a square wave with peak-to-peak amplitude of about 5 divisions and a period of about 4 divisions as shown below (or similar). If you do not see the waveform, ensure your power source is adequate, the oscilloscope is properly powered-on, and the probe is connected securely to the front-panel channel input BNC and to the Probe Comp calibration output.



Verifying Basic Oscilloscope Operation

Getting started using the oscilloscope interface

When the oscilloscope is first turned on, a startup screen is displayed as shown below.

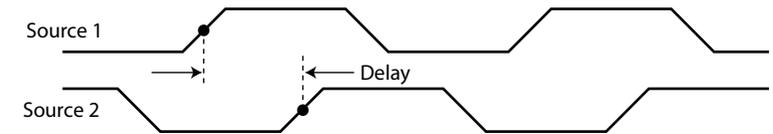


This screen is only visible for approx. 30 seconds when the oscilloscope first starts up.

Making Delay and Phase Measurements

Delay

Delay measures the time difference from the selected edge on source 1 and the selected edge on source 2 closest to the trigger reference point at the middle threshold points on the waveforms. Negative delay values indicate that the selected edge of source 1 occurred after the selected edge of source 2.



- Press the **Settings** softkey to select the source channels and slope for the delay measurement.
The default Delay settings measure from the rising edge of channel 1 to the rising edge of channel 2.

+ Width

+Width is the time from the middle threshold of the rising edge to the middle threshold of the next falling edge. The X cursors show the pulse being measured. The Y cursor shows the middle threshold point.

– Width

– Width is the time from the middle threshold of the falling edge to the middle threshold of the next rising edge. The X cursors show the pulse being measured. The Y cursor shows the middle threshold point.

- The following symbols are used in the oscilloscope softkey menus:

 Use the Entry knob labeled to adjust the parameter.

 Press the softkey to display a pop up with a list of choices.
Repeatedly press the softkey until your choice is selected.

 Use the Entry knob labeled or press the softkey to adjust the parameter.

 Option is selected and operational.

 Feature is on. Press the softkey again to turn the feature off.

 Feature is off. Press the softkey again to turn the feature on.

 Links you to another menu.

 Press the softkey to view the menu.

 Press the softkey to return to the previous menu.

Fall Time

The fall time of a signal is the time difference between the crossing of the upper threshold and the crossing of the lower threshold for a negative-going edge. The X cursor shows the edge being measured. For maximum measurement accuracy, set the sweep speed as fast as possible while leaving the complete falling edge of the waveform on the display. The Y cursors show the lower and upper threshold points.

Rise Time

The rise time of a signal is the time difference between the crossing of the lower threshold and the crossing of the upper threshold for a positive-going edge. The X cursor shows the edge being measured. For maximum measurement accuracy, set the sweep speed as fast as possible while leaving the complete rising edge of the waveform on the display. The Y cursors show the lower and upper threshold points.

Measurement definitions

Measurement thresholds for time measurements

The default lower, middle, and upper measurement thresholds are 10%, 50%, and 100% between Top and Base values. See the previous topic “Setting measurement thresholds” for other percentage threshold and absolute value threshold settings.

Duty Cycle

The duty cycle of a repetitive pulse train is the ratio of the positive pulse width to the period, expressed as a percentage. The X cursors show the time period being measured. The Y cursor shows the middle threshold point.

$$\text{Duty cycle} = \frac{\text{+Width}}{\text{Period}} \times 100$$

Frequency

Frequency is defined as 1/Period. Period is defined as the time between the middle threshold crossings of two consecutive, like-polarity edges. A middle threshold crossing must also travel through the lower and upper threshold levels which eliminates runt pulses. The X cursors show what portion of the waveform is being measured. The Y cursor shows the middle threshold point.

Period

Period is the time period of the complete waveform cycle. The time is measured between the middle threshold points of two consecutive, like-polarity edges. A middle threshold crossing must also travel through the lower and upper threshold levels which eliminates runt pulses. The X cursors show what portion of the waveform is being measured. The Y cursor shows the middle threshold point.

Front-Panel Overview

Before you make measurements using the Welec W2000A-series Oscilloscopes, you must first set up the instrument using front-panel controls. Then, make the measurement and read the display results.

These oscilloscopes operate much like an analog scope, but they can do much more. Spending a few minutes to learn some of these capabilities will take you a long way toward more productive troubleshooting. The “Oscilloscope Operation” chapter has more detail on the things to consider while operating your oscilloscope. The keys on the front panel bring up softkey menus on the display that allow access to oscilloscope features. Many softkeys use the Entry knob  to select values.

Throughout this book, the front-panel keys and softkeys are denoted by a change in the text type. For example, the Cursors key is on the front panel and the Normal softkey appears at the bottom of the display directly above its corresponding key. Other softkey graphic conventions used on the oscilloscope and throughout this guide are shown in the “Getting started using the oscilloscope interface” topic in chapter 1.

Important Oscilloscope Considerations

Using Single versus Run/Stop

The oscilloscopes have a **Single** key and a **Run/Stop** key. When you press **Run** (key is illuminated in green), the screen update rate varies over time-base selection. The memory depth is always 16K points per channel and does not change whether Single or Run acquisition is selected.

Using Auto trigger mode versus Normal trigger mode

Normal trigger mode requires a trigger to be detected before an acquisition can complete. In many cases, a triggered display is not needed to check signal levels or activity. For these applications, use Auto trigger mode. If you only want to acquire specific events as specified by the trigger settings, use Normal trigger mode. For more detailed discussion of Auto trigger mode and Normal trigger mode, refer to Chapter 3, “Triggering the Oscilloscope.”

Viewing signal detail with acquire mode

Remember how you had to constantly adjust the brightness on old analog scopes to see a desired level of detail in a signal, or to see the signal at all? With the Welec W2000A-series oscilloscopes, this is not necessary. You can control the detail by selecting an Acquire mode: Normal or Average as described in the following paragraphs.

Normal acquire mode

Normal mode is the acquisition mode that you will probably use for acquiring samples most of the time. It compresses up to 16K acquisition points per channel into a 600-pixel column display record. The W2000A-series 1 GSa/s sampling speed specification means that samples are taken every 1 ns. If you press the **Stop** key, and pan and zoom through the waveform by using the Horizontal and Vertical knobs, only the last trigger’s acquisition will be displayed. Whether the oscilloscope is stopped or running, you see more detail as you zoom in, and less as you zoom out. Zoom means you expand the waveform using either the main or delayed sweep window. Panning the waveform means you use the Horizontal Delay time knob (◀▶) to move it horizontally.

Making time measurements automatically

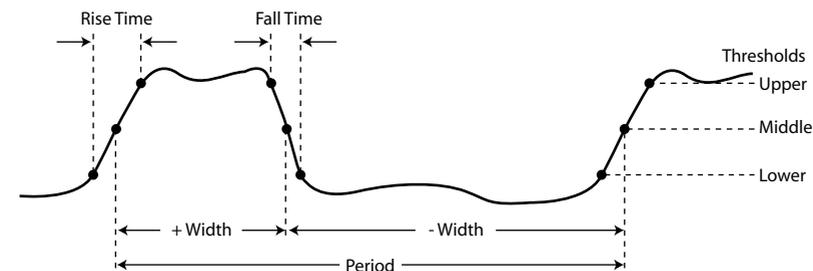
FFT measurements

When you make an X at Max or X at Min measurement on a math FFT function, the resultant units will be in Hertz. No other time related automatic measurement can be made on the FFT math function. Use the cursors to make other measurements on FFT.

Measurement thresholds for time measurements

The default lower, middle, and upper measurement thresholds are 10%, 50%, and 100% between Top and Base values. See the previous topic “Setting measurement thresholds” for other percentage threshold and absolute value threshold settings.

The following figure shows time measurement points.



- 4 Press the **Lower** softkey, then turn the Entry knob to set the lower measurement threshold value.

Increasing the lower value beyond the set middle value will automatically increase the middle value to be more than the lower value. The default lower threshold is 10% or 800mV.

If threshold **Type** is set to % the lower threshold value can be set from 5% to 93%.

- 5 Press the **Middle** softkey, then turn the Entry knob to set the middle measurement threshold value.

The middle value is bounded by the values set for lower and upper thresholds. The default middle threshold is 50% or 1.20 V.

- If threshold **Type** is set to % the middle threshold value can be set from 6% to 94%.

- 6 Press the **Upper** softkey, then turn the Entry knob to set the upper measurement threshold value.

Decreasing the upper value below the set middle value will automatically decrease the middle value to be less than the upper value. The default upper threshold is 90% or 1.50 V.

- If threshold **Type** is set to % the upper threshold value can be set from 7% to 95%.

Average acquire mode

Averaging is a way to pull a repetitive signal out of noise. Averaging works better than either a brightness control or a bandwidth limit because the bandwidth is not reduced.

Realtime acquire mode

Realtime mode is permanently set and the only existing acquire mode on the W2000A-series oscilloscopes. The oscilloscope produces the waveform display from samples collected during one trigger event. The sample rate is 1 GSa/s per channel. To accurately reproduce a sampled waveform, the sample rate should be at least five times the highest frequency component of the waveform. If not, it is possible for the reconstructed waveform to be distorted or aliased. Aliasing is most commonly seen as jitter on fast edges. Realtime acquisition is used to capture infrequent triggers, unstable triggers, or complex changing waveforms, such as eye diagrams.

Using Vectors (Display menu)

One of the most fundamental choices you must make about your display is whether to draw vectors (connect the dots) between the samples, or simply let the samples fill in the waveform. To some degree, this is a matter of personal preference, but it also depends on the waveform.

- You will probably operate the oscilloscope most often with vectors on. Complex analog signals like video and modulated signals show analog like intensity information with vectors on.
- Turn vectors off when the maximum display rate is required, or when highly complex or multi-valued waveforms are displayed. Turning vectors off may aid the display of multivalued waveforms such as eye diagrams.

Delayed Sweep

Delayed sweep is a simultaneous display of the waveform at two different sweep speeds. Because of the deep memory, it is possible to capture the main display at 1 ms/div, and redisplay the same trigger in the delayed display at any desired faster time base. There is no limit imposed on the zoom ratio between the main and delayed displays. There is, however, a useful limit when the samples are spaced so far apart that they are of little value.

Post Acquisition Processing

In addition to changing display parameters after the acquisition, you can do all of the measurements and math functions after the acquisition. Measurements and math functions will be recalculated as you pan and zoom and turn channels on and off. As you zoom in and out on a signal using the horizontal sweep speed knob and vertical volts/division knob, you affect the resolution of the display. Because measurements and math functions are performed on displayed data, you affect the resolution of functions and measurements.

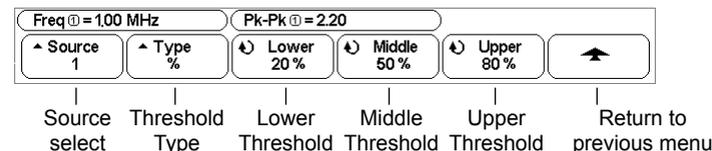
Setting measurement thresholds

Setting measurement thresholds defines the vertical levels where measurements will be taken on a channel.

Changing default thresholds may change measurement results

The default lower, middle, and upper threshold values are 10%, 50%, and 90% of the value between Top and Base. Changing these threshold definitions from the default values may change the returned measurement results for Average, Delay, Duty Cycle, Fall Time, Frequency, Overshoot, Period, Phase, Preshoot, Rise Time, RMS, +Width, and -Width.

- 1 Press the **Thresholds** softkey in the **Quick Meas** menu to set channel measurement thresholds.
- 2 Press the **Source** softkey to select the channel source from which you want to change measurement thresholds. Each channel can be assigned unique threshold values.



- 3 Press the **Type** softkey to set the measurement threshold to **%** (percentage of Top and Base value) or to **Absolute** (absolute value.)
 - Percentage thresholds can be set from 5% to 95%.
 - The units for absolute threshold for each channel is set in the channel probe menu.

Absolute threshold hints

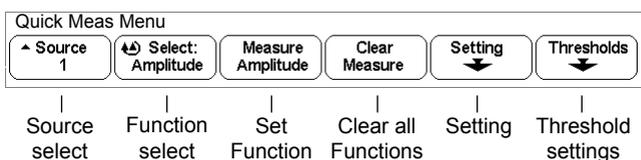
- Absolute thresholds are dependent on channel scaling, probe attenuation, and probe units. Always set these values first before setting absolute thresholds.
- The minimum and maximum threshold values are limited to on-screen values.
- If any of the absolute threshold values are above or below the minimum or maximum waveform values, the measurement may not be valid.

Making automatic measurements

Quick Meas makes automatic measurements on any channel source or any running math function. The results of the last three measurements selected are displayed on the dedicated line above the softkeys, or in the display area when some menus are selected. Quick Meas also makes measurements on stopped waveforms when you are panning and zooming.

Cursors are turned on to show the portion of the waveform being measured for the most recently selected measurement (right-most on the measurement line).

- 1 Press the **Quick Meas** key to display the automatic measurement menu.



- 2 Press the **Source** softkey to select the channel or running math function on which the quick measurements will be made.

Only channels or math functions that are displayed are available for measurements. If you choose an invalid source channel for a measurement, the measurement will default to the nearest in the list that makes the source valid.

If a portion of the waveform required for a measurement is not displayed or does not display enough resolution to make the measurement, the result will display “No Edges”, “Clipped”, “Low Signal”, “< value”, or “>value”, or a similar message to indicate that the measurement may not be reliable.

- 3 Press the **Clear Meas** softkey to stop making measurements and to erase the measurement results from the display line above the softkeys.

When **Quick Meas** is pressed again, the default measurements will be Frequency and Peak-Peak.

- 4 Press the **Select** softkey then rotate the Entry knob to select a measurement to be made.

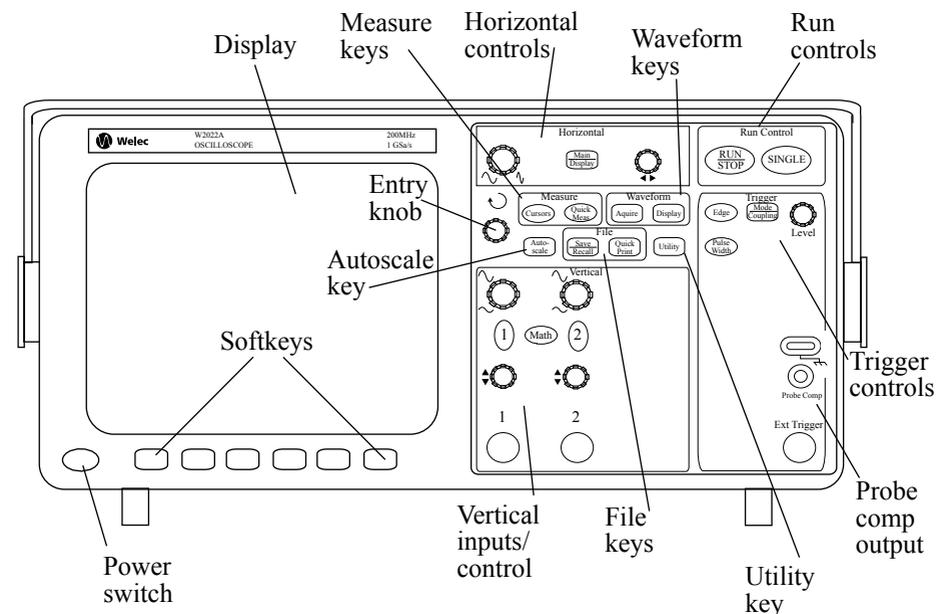
- 5 The **Settings** softkey will be available to make additional measurement settings on some measurements.

- 6 Press the **Measure** softkey to make the measurement.

- 7 To turn off **Quick Meas**, press the **Quick Meas** key again until it is not illuminated.

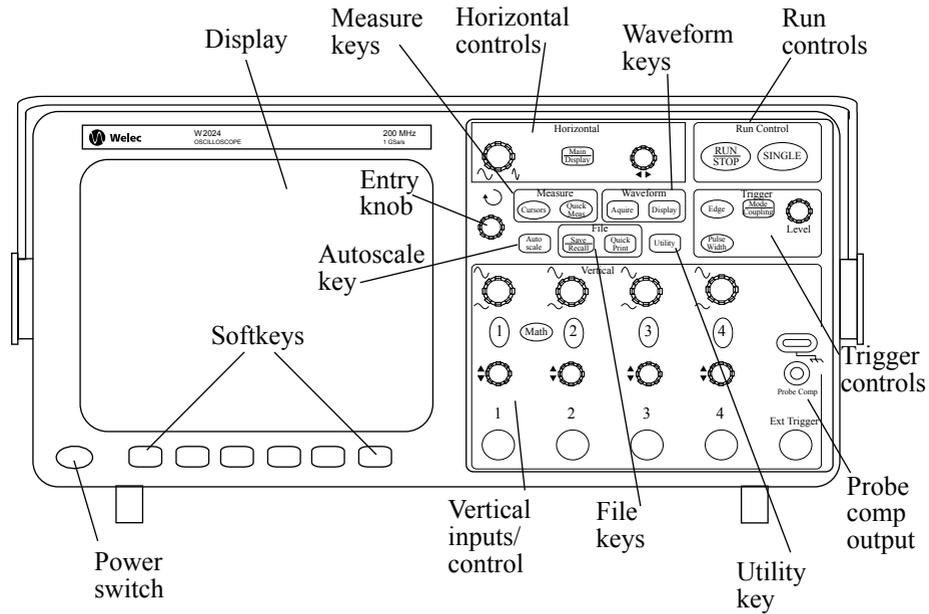
W20x2A/W20x4A-series Oscilloscope Front Panels

Figure 2-1



W2012A and W2022A 2-Channel Oscilloscopes Front Panel

Figure 2-2



W2014A and W2024A 4-Channel Oscilloscopes Front Panel

Automatic Measurements

The following automatic measurements can be made in the **Quick Meas** menu.

Time Measurements

- Duty Cycle
- Frequency
- Period
- Rise Time
- Fall Time
- +Width
- - Width

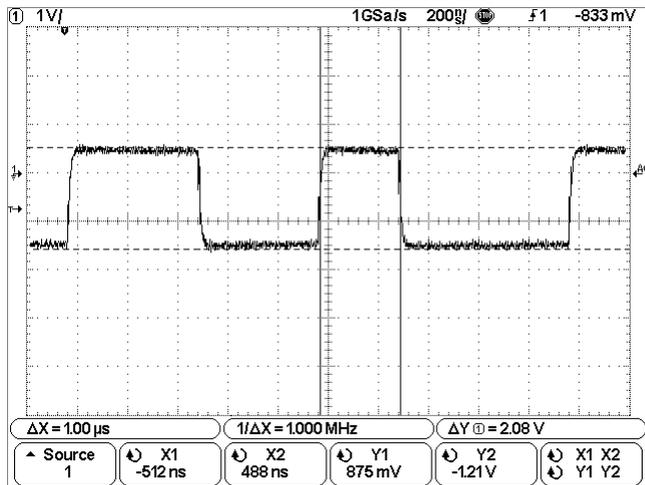
Phase and Delay

- Phase
- Delay

Voltage Measurements

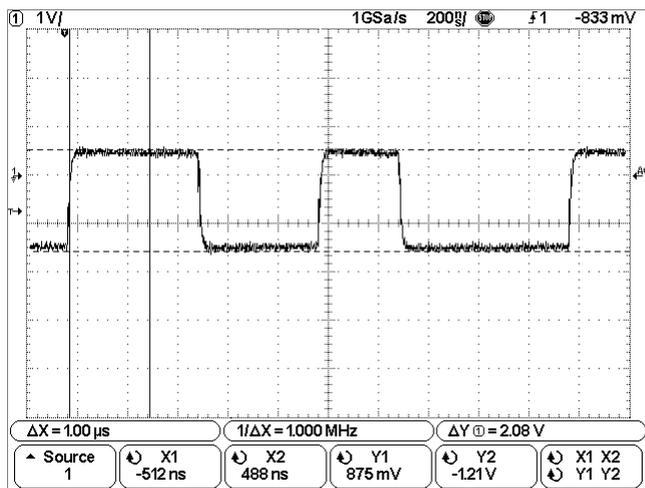
- Average
- Base
- Maximum
- Minimum
- Peak-to-Peak
- RMS
- Top

Put the **X1** cursor on one side of a pulse and the **X2** cursor on the other side of the pulse.



Measuring pulse width with cursors

Press the **X1 X2** softkey and move the cursors together to check for pulse width variations in a pulse train.



Moving the cursors together to check pulse width variations

Front-Panel Operation

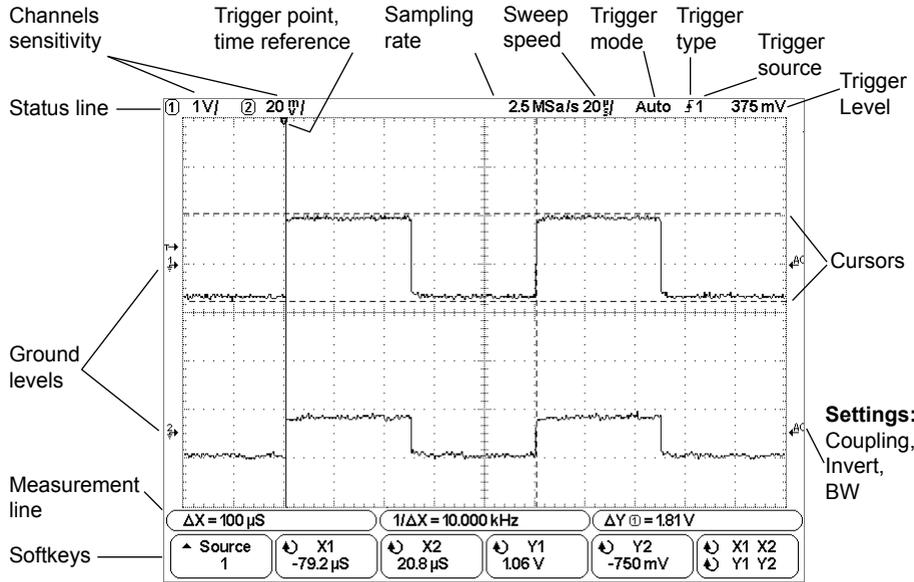
This chapter provides a brief overview of interpreting information on the display and an introduction to operating the front-panel controls. Detailed oscilloscope operating instructions are provided in later chapters.

W2012A, W2022A, W2014A, and W2024A

Because all of the oscilloscopes in the W2000A-series have analog channels either 100MHz and 200MHz analog bandwidth, the analog channel topics in this chapter apply to all instruments.

Interpreting the display

The oscilloscope display contains channel acquisitions, setup information, measurement results, and softkeys for setting up parameters.



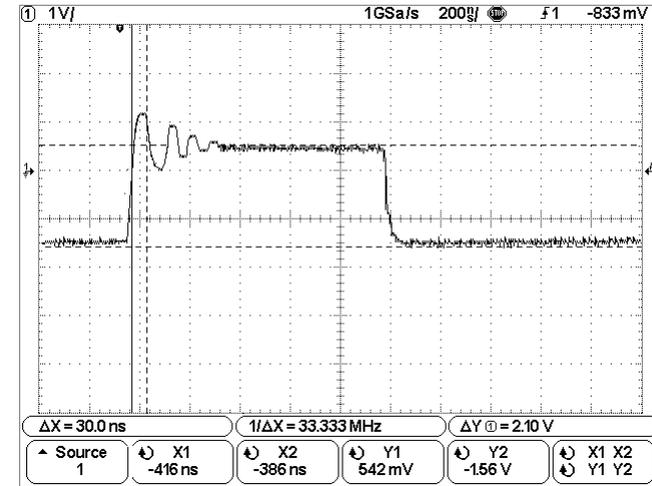
Interpreting the display

Status line The top line of the display contains vertical, horizontal, and trigger setup information.

Display area The display area contains the waveform acquisitions, channel identifiers, and trigger and ground level indicators.

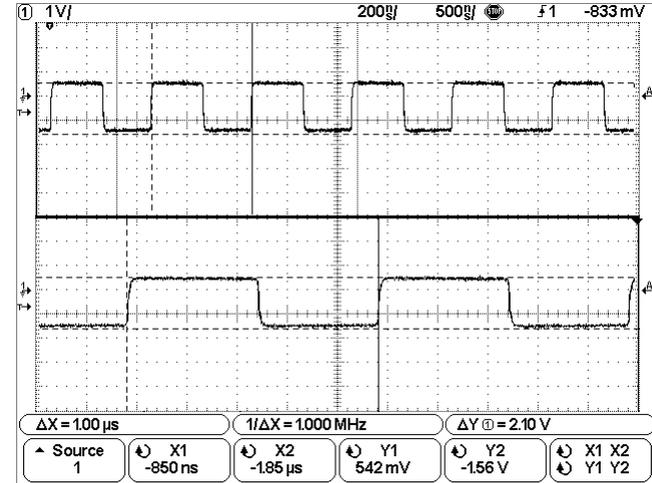
Measurement line This line normally contains automatic measurement and cursor results, but can also display advanced trigger setup data and menu information.

Softkeys The softkeys allow you to set up additional parameters for front-panel keys.



Cursors measure frequency of pulse ringing

Expand the display with delayed sweep, then characterize the event of interest with the cursors.



Cursors track delayed sweep

Y1 and Y2 The Y1 cursor (short-dashed horizontal line) and Y2 cursor (long-dashed horizontal line) adjust vertically and indicate values relative to the waveform's ground point, except math FFT where the values are relative to 0 dB. In XY horizontal mode, the Y cursors display channel 2 values Volts. The cursor values for the selected waveform source are displayed within the Y1 and Y2 softkeys.

The difference between Y1 and Y2 (ΔY) is displayed on the dedicated line above the softkeys or in the display area when some menus are selected.

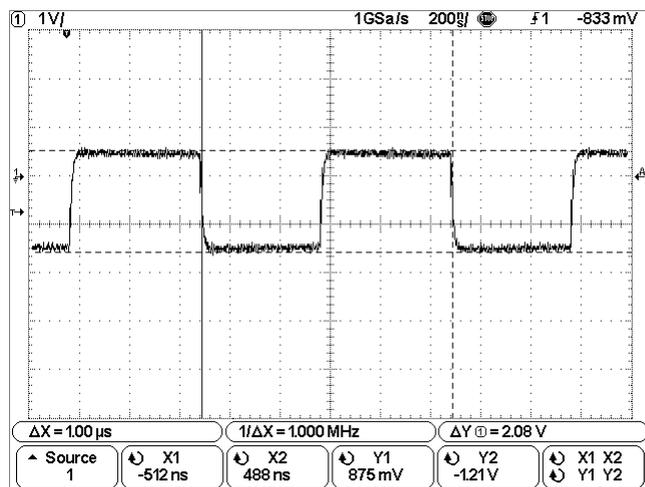
Turn the Entry knob to adjust the Y1 or Y2 cursor when its softkey is selected.

X1 X2 Press this softkey to adjust the X1 and X2 cursors together by turning the Entry knob. The ΔX value will remain the same since the cursors adjust together.

You can adjust the X cursors together to check for pulse width variations in a pulse train.

Y1 Y2 Press this softkey to adjust the Y1 and Y2 cursors together by turning the Entry knob. The ΔY value will remain the same since the cursors adjust together.

Cursor Examples



Cursors measure pulse widths

To use channels to view a signal

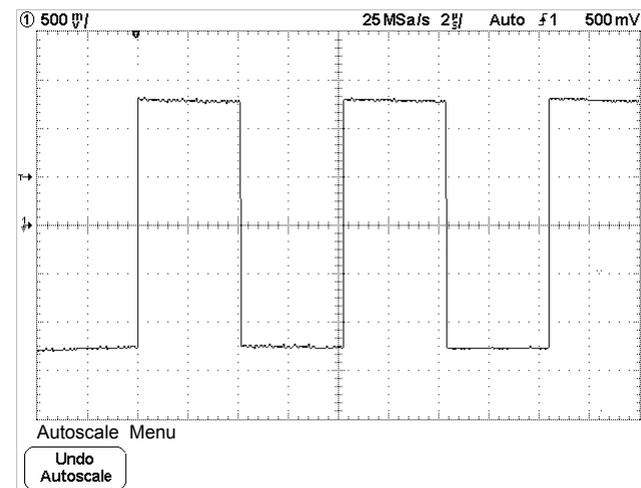
- To configure the oscilloscope quickly, press the **Autoscale** key to display the connect signal.
- To undo the effects of Autoscale, press the **Undo Autoscale** softkey before pressing any other key.

This is useful if you have unintentionally pressed the Autoscale key or do not like the settings Autoscale has selected and want to return to your previous settings.

- To set the instrument to the factory-default configuration, press the **Save/Recall** key, then press the **Default Setup** softkey.

Example

Connect the oscilloscope probe for channel 1 to the Probe Comp output on the front panel of the instrument. Be sure to connect the probe ground leads to the lug above the Probe Comp output. Set the instrument to the factory default configuration by pressing the **Save/Recall** key, then the **Default Setup** softkey. Then press the **Autoscale** key. You should see a display similar to the following.



Autoscale with channels

To display signals automatically using Autoscale

- To configure the instrument quickly, press the **Autoscale** key.

Autoscale displays all connected signals that have activity.

To undo the effects of Autoscale, press the **Undo Autoscale** softkey before pressing any other key.

How Autoscale Works

Autoscale automatically configures the oscilloscope to best display the input signal by analyzing any waveforms connected to the external trigger and channel inputs. Autoscale finds, turns on, and scales any channel with a repetitive waveform with a frequency of at least 50 Hz, a duty cycle greater than 0.5%, and an amplitude of at least 100 mV peak-to-peak. Any channels that do not meet these requirements are turned off.

The trigger source is selected by looking for the first valid waveform starting with external trigger, then continuing with the highest number analog channel down to the lowest number analog channel.

During Autoscale, the delay is set to 0.0 seconds, the sweep speed setting is a function of the input signal (about 2 periods of the triggered signal on the screen), and the triggering mode is set to edge. Vectors remain in the state they were before the Autoscale.

Undo Autoscale

Press the **Undo Autoscale** softkey to return the oscilloscope to the settings that existed before you pressed the **Autoscale** key.

This is useful if you have unintentionally pressed the **Autoscale** key or do not like the settings Autoscale has selected and want to return to your previous settings.

To make cursor measurements

The following steps guide you through the front-panel Cursors key. You can use the cursors to make custom voltage or time measurements on the signal.

- 1 Connect a signal to the oscilloscope and obtain a stable display.

- 2 Press the **Cursors** key, then press the **Mode** softkey.

X and Y cursor information is displayed on the softkeys. ΔX , $1/\Delta X$, and ΔY , values are displayed on the line above the softkeys.

ΔX , $1/\Delta X$, and ΔY values are displayed. ΔX is the difference between the X1 and X2 cursors and ΔY is the difference between the Y1 and Y2 cursors.

- 3 Press the **Source** softkey to select the channel or math source on which the Y cursors will indicate measurements.

The source cursor can be any channel or math source.

- 4 Select the X and Y softkeys to make a measurement.

XY Press this softkey to select either X cursors or Y cursors for adjustment. The cursor currently assigned to the Entry knob displays brighter than the other cursors.

X cursors are vertical dashed lines that adjust horizontally and normally indicate time relative to the trigger point. When used with the FFT math function as a source, the X cursors indicate frequency.

Y cursors are horizontal dashed lines that adjust vertically and normally indicate Volts or Amps, dependent on the channel Probe Units setting. When math functions are used as a source, the measurement units correspond to that math function.

X1 and X2 The X1 cursor (short-dashed vertical line) and X2 cursor (long-dashed-vertical line) adjust horizontally and indicate time relative to the trigger point for all sources except math FFT (frequency is indicated). In XY horizontal mode, the X cursors display channel 1 values Volts. The cursor values for the selected waveform source are displayed within the X1 and X2 softkeys.

The difference between X1 and X2 (ΔX) and $1/\Delta X$ are displayed on the dedicated line above the softkeys or in the display area when some menus are selected.

Turn the Entry knob to adjust the X1 or X2 cursor when its softkey is selected.

Cursor Measurements

You can measure waveform data using cursors. Cursors are horizontal and vertical markers that indicate X-axis values (usually time) and Y-axis values (usually voltage) on a selected waveform source. The position of the cursors can be moved turning the Entry knob. When you press the **Cursors** key, it will illuminate and the cursors will turn on. To turn cursors off, press this key again until it is not illuminated, or press the **Quick Meas** key.

Cursors are not always limited to the visible display. If you set a cursor, then pan and zoom the waveform until the cursor is off screen, its value will not be changed, and if you pan the waveform back again it will have the cursor in the original place.

To apply the default factory configuration

- To set the instrument to the factory-default configuration, press **Save/Recall** key, then press the **Default Setup** softkey.

The default configuration returns the oscilloscope to its default settings. places the oscilloscope in a known operating condition. The major default settings are:

Horizontal main mode, 500 ns/div scale, 0 s delay, center time reference

Vertical (Analog) Channel 1 on, 5V/div scale, dc coupling, 0V position, 1M Ω impedance, probe factor to 1.0.

Trigger Edge trigger, Auto sweep mode, 0V level, channel 1 source, coupling, rising edge slope, 40 ns holdoff time

Display Vectors on, 66% grid intensity, infinite persistence off

Other Acquire mode normal, Run/Stop to Run, cursors and measurements

To adjust analog channel vertical scaling and position

This exercise guides you through the vertical keys, knobs, and status line.

1 Center the signal on the display using the position knob.

The position knob () moves the signal vertically; the signal is calibrated.

Notice that the ground reference symbol () at the left edge of the display moves with the position knob.

Measurement Hints

If the channel is DC coupled, you can quickly measure the DC component of the signal by simply noting its distance from the ground symbol.

If the channel is AC coupled, the DC component of the signal is removed, allowing you to use greater sensitivity to display the AC component of the signal.

2 Change the vertical setup and notice that each change affects the status line differently. You can quickly determine the vertical setup from the status line in the display.

- Change the vertical sensitivity with the large volts/division knob in the Vertical section of the front panel and notice that it causes the status line to change.
- Press the **1** key.

If channel 1 was not turned on, a softkey menu appears on the display, and the channel turns on (the **1** key will be illuminated).

If channel 1 was already turned on, but another menu was being displayed, the softkeys will now display the channel 1 menu.

The volts/div knob can change the channel sensitivity in a 1-2-5 step sequence. The sensitivity value is displayed in the status line at the top of the display.

- To turn the channel off, press the channel **1** key until the key is not illuminated.

FFT Measurement Hints - Continued

While the FFT spectrum is displayed, use the **Math** and **Cursors** keys to switch between measurement functions and frequency domain controls in FFT menu.

Decreasing the effective sampling rate by selecting a slower sweep speed will increase the low frequency resolution of the FFT display and also increase the chance that an alias will be displayed. The resolution of the FFT is one-half of the effective sample rate divided by the number of points in the FFT. The actual resolution of the display will not be this fine as the shape of the window will be the actual limiting factor in the FFT's ability to resolve two closely spaced frequencies. A good way to test the ability of the FFT to resolve two closely spaced frequencies is to examine the sidebands of an amplitude modulated sine wave. For example, at 2 MSa/s effective sampling rate, a 1 MHz AM signal can be resolved to 2 kHz. Increasing the effective sampling rate to 4 MSa/s increases the resolution to 5 kHz for a set 2048 point FFT.

For the best vertical accuracy on peak measurements:

- Make sure the probe attenuation is set correctly. The probe attenuation is set from the Channel menu if the operand is a channel.
- Set the source sensitivity so that the input signal is near full screen, but not clipped.
- Use the Flat Top window.
- Set the FFT sensitivity to a sensitive range, such as 2 dB/division.

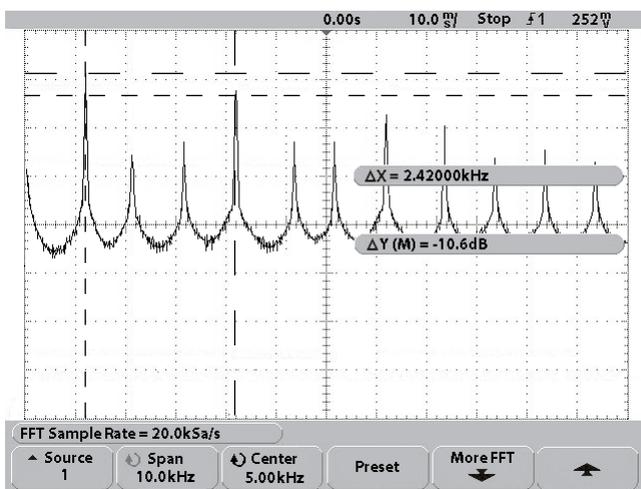
For best frequency accuracy on peaks:

- Use the Hanning window.
- Use Cursors to place an X cursor on the frequency of interest.
- Adjust frequency span for better cursor placement.
- Return to the Cursors menu to fine tune the X cursor.

- To make other measurements, press the **Quick Meas** key and set the **Source** softkey to **Math**.

You can make peak-to-peak, maximum, minimum, and average dB measurements on the FFT waveform. You can also find the frequency value at the first occurrence of the waveform maximum by using the X at Max measurement.

The following FFT spectrum was obtained by connecting the front panel Probe Comp signal ~1.0 kHz to channel 1. Set sweep speed to 10ms/div, vertical sensitivity to 1 V/div, Units/div to 10 dB, Offset to -28.0 dB, Center frequency to 5.00 kHz, frequency Span to 10.0 kHz, and window to Hanning.



FFT measurements

FFT Measurement Hints

It is easiest to view FFTs with Vectors set to On. The Vector display mode is set in the Display menu.

The number of points acquired for the FFT record 2048 and when frequency span is at maximum, all points are displayed. Once the FFT spectrum is displayed, the frequency span and center frequency controls are used much like the controls of a spectrum analyzer to examine the frequency of interest in greater detail. Place the desired part of the waveform at the center of the screen and decrease frequency span to increase the display resolution. As frequency span is decreased, the number of points shown is reduced, and the display is magnified.

To set the vertical expand reference for the signal

When changing the volts/division for analog channels, you can have the signal expand (or compress) about the signal ground point on the display. This works well with two signals displayed, because you can position and see them both on the screen while you change the amplitude.

When you turn the volts/division knob, the ground level of the waveform remains at the same point on the display, while the non-ground portions of the waveform expand or contract.

To set analog channel probe attenuation factor

Press the **Probe** softkey, then turn the Entry knob  to set the attenuation factor for the connected probe. The attenuation factor can be set from 1:1 to 100:1 in a 1-2-5 sequence.

The probe correction factor must be set properly for measurements to be made correctly.

To operate the time base controls

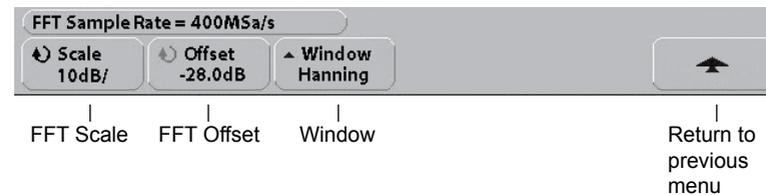
The following exercise guides you through the time base keys, knobs, and status line.

- Turn the Horizontal sweep speed (time/division) knob and notice the change it makes to the status line.

The sweep speed knob changes the sweep speed from 10 ns/div to 5 s/div in a 1-2-5 step sequence, and the value of the sweep speed is displayed in the status line at the top of the display.

- All events displayed left of the trigger point ▼ happened before the trigger occurred, and these events are called pre-trigger information. You will find this feature very useful because you can now see the events that led up to the trigger point. Everything to the right of the trigger point ▼ is called post-trigger information. The amount of delay range (pre-trigger and post-trigger information) available depends on the sweep speed selected.

- 2 Press the **More FFT** softkey to display additional FFT settings.



Scale allows you to set your own vertical scale factors for FFT expressed in dB/div (decibels/division). Press the **Scale** softkey, then turn the Entry knob to rescale your math function.

Offset allows you to set your own offset for the FFT. The offset value is in dB and is represented by the center graticule of the display. Press the **Offset** softkey, then turn the Entry knob to change the offset of your math function.

Scale and offset considerations

If you do not manually change the FFT scale or offset settings, when you turn the horizontal sweep speed knob, the span and center frequency settings will automatically change to allow optimum viewing of the full spectrum. If you do manually set scale or offset, turning the sweep speed knob will not change the span or center frequency settings, allowing you see better detail around a specific frequency. Pressing the FFT Preset softkey will automatically rescale the waveform and span and center will again automatically track the horizontal sweep speed setting.

Window selects a window to apply to your FFT input signal:

Hanning - window for making accurate frequency measurements or for resolving two frequencies that are close together.

Flat Top - window for making accurate amplitude measurements of frequency peaks.

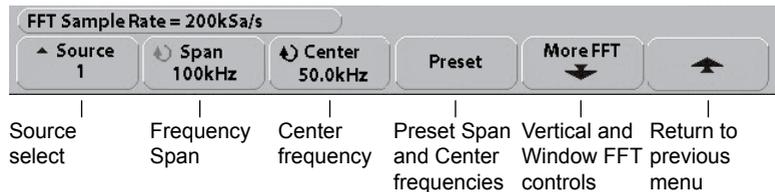
Rectangular - good frequency resolution and amplitude accuracy, but use only where there will be no leakage effects. Use on self-windowing waveforms such as pseudo-random noise, impulses, sine bursts, and decaying sinusoids.

- 3 To make cursors measurements, press the **Cursors** key and set the **Source** softkey to **Math**

Use the X1 and X2 cursors to measure frequency values and difference between two frequency values (ΔX). Use the Y1 and Y2 cursors to measure amplitude in dB and difference in amplitude (ΔY).

FFT Operation

- 1 Press the **Math** key, press the **FFT** softkey, then press the **Settings** softkey to display the FFT menu.



Source selects the source for the FFT. The source can be any channel, or math functions 1+2, 1-2, and 1*2.

Span sets the overall width of the FFT spectrum that you see on the display (left graticule to right graticule). Divide span by 10 to calculate the number of Hertz per division. It is possible to set Span above the maximum available frequency, in which case the displayed spectrum will not take up the whole screen. Press the **Span** softkey, then turn the Entry knob to set the desired frequency span of the display.

Center sets the FFT spectrum frequency represented at the center graticule on the display. It is possible to set the Center to values below half the span or above the maximum available frequency, in which case the displayed spectrum will not take up the whole screen. Press the **Center** softkey, then turn the Entry knob to set the desired center frequency of the display.

Preset sets the frequency Span and Center to values that will cause the entire available spectrum to be displayed. The maximum available frequency is half the effective FFT sample rate, which is a function of the time per division setting. The current FFT sample rate is displayed above the softkeys.

To start and stop an acquisition

- When the **Run/Stop** key is illuminated in green, the oscilloscope is in continuous running mode.

You are viewing multiple acquisitions of the same signal similar to the way an analog oscilloscope displays waveforms.

- When the **Run/Stop** key is illuminated in red, the oscilloscope is stopped.

“Stop” is displayed in the trigger mode position in status line at the top of the display. You may now pan and zoom the stored waveform by turning the Horizontal and Vertical knobs.

The stopped display may contain several triggers worth of information, but only the last trigger acquisition is available for pan and zoom. To ensure the display does not change, use the **Single** key to be sure you have acquired only one trigger.

To make a single acquisition

The Single run control key lets you view single-shot events without subsequent waveform data overwriting the display.

- 1 First set trigger **Mode/Coupling Mode** softkey to **Normal**. This keeps the oscilloscope from autotriggering immediately.
- 2 Turn the Trigger Level knob to the trigger threshold where you think the trigger should work.
- 3 To begin a single acquisition, press the **Single** key. When you press Single, the display is cleared, the trigger circuitry is armed, the Single key is illuminated, and the oscilloscope will wait until a trigger condition occurs before it displays a waveform. When the oscilloscope triggers, the single acquisition is displayed and the oscilloscope is stopped (**Run/Stop** key is illuminated in red). Press **Single** again to acquire another waveform.

To use delayed sweep

Delayed sweep is an expanded version of main sweep. When Delayed mode is selected, the display divides in half. The top half displays the main sweep and the bottom half displays the delayed sweep.

The following steps show you how to use delayed sweep. Notice that the steps are very similar to operating the delayed sweep in analog oscilloscopes.

- 1 Connect a signal to the oscilloscope and obtain a stable display.
- 2 Press **Main/Delayed**.
- 3 Press the **Delayed** softkey.

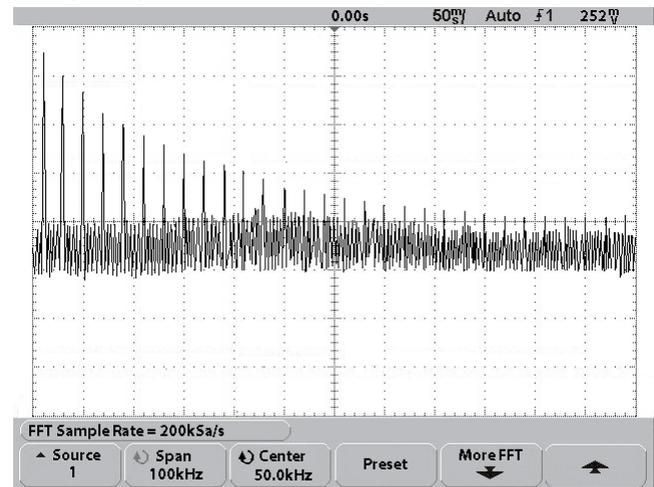
To change the sweep speed for the delayed sweep window, turn the sweep speed knob. As you turn the knob, the sweep speed is highlighted in the status line above the waveform display area.

The area of the main display that is expanded is intensified and marked on each end with a vertical marker. These markers show what portion of the main sweep is expanded in the lower half. The Horizontal knobs control the size and position of the delayed sweep. The delay value is momentarily displayed in the upper-right portion of the display when the delay time (◀▶) knob is turned.

Delayed sweep is a magnified portion of the main sweep. You can use delayed sweep to locate and horizontally expand part of the main sweep for a more detailed (higher-resolution) analysis of signals.

To change the sweep speed for the main sweep window, press the **Main** softkey, then turn the sweep speed knob.

The following figure illustrates aliasing. This is the spectrum of a 1 kHz square wave, which has many harmonics. The sample rate is set to 200 kSa/s, and the oscilloscope displays the spectrum. The displayed waveform shows the components of the input signal above the Nyquist frequency to be mirrored (aliased) on the display and reflected off the right edge.



Aliasing

Since the frequency span goes from ≈ 0 to the Nyquist frequency, the best way to prevent aliasing is to make sure that the frequency span is greater than the frequencies of significant energy present in the input signal.

Spectral Leakage The FFT operation assumes that the time record repeats. Unless there is an integral number of cycles of the sampled waveform in the record, a discontinuity is created at the end of the record. This is referred to as leakage. In order to minimize spectral leakage, windows that approach zero smoothly at the beginning and end of the signal are employed as filters to the FFT. The FFT menu provides three windows: Hanning, flat top, and rectangular.

FFT Measurement

FFT is used to compute the fast Fourier transform using input channels or math functions 1+2, 1-2, or 1*2. FFT takes the digitized time record of the specified source and transforms it to the frequency domain. When the FFT function is selected, the FFT spectrum is plotted on the oscilloscope display as magnitude in dBV versus frequency. The readout for the horizontal axis changes from time to frequency (Hertz) and the vertical readout changes from volts to dB.

Use the FFT function to find crosstalk problems, to find distortion problems in analog waveforms caused by amplifier non-linearity, or for adjusting analog filters.

FFT Units 0 dBV is the amplitude of a 1V_{rms} sinusoid. When the FFT source is channel 1 or channel 2 (or channel 3 or 4 on the W20x4), FFT units will be displayed in dBV when channel units is set to Volts and channel impedance is 1 MΩ.

FFT units will be displayed as dB for all FFT sources.

DC Value The FFT computation produces a DC value that is incorrect. It does not take the offset at center screen into account. The DC value is not corrected in order to accurately represent frequency components near DC.

Aliasing When using FFTs, it is important to be aware of frequency aliasing. This requires that the operator have some knowledge as to what the frequency domain should contain, and also consider the effective sampling rate, frequency span, and oscilloscope vertical bandwidth when making FFT measurements. The FFT sample rate is displayed directly above the softkeys when the FFT menu is displayed.

Aliasing happens when there are frequency components in the signal higher than half the effective sample rate. Since the FFT spectrum is limited by this frequency, any higher components are displayed at a lower (aliased) frequency.

To make cursor measurements

You can use the cursors to make custom voltage or time measurements on scope signals.

- 1 Connect a signal to the oscilloscope and obtain a stable display.
- 2 Press the **Cursors** key. View the cursor functions in the softkey menu:

Mode Set the cursors results to measure voltage and time.

Source selects a channel or math function for the cursor measurements.

X Y Select either the X cursors or the Y cursors for adjustment with the Entry knob .

X1 and X2 adjust horizontally and normally measure time.

Y1 and Y2 adjust vertically and normally measure voltage.

X1 X2 and Y1 Y2 move the cursors together when turning the Entry knob.

For more information about using cursors for measurements, refer to the “Making Measurements” chapter.

To make automatic measurements

You can use automatic measurements on any channel source or any running math function. Cursors are turned on to focus on the most recently selected measurement (right-most on the measurement line above the softkeys on the display).

1 Press the **Quick Meas** key to display the automatic measurement menu.

2 Press the **Source** softkey to select the channel or running math function on which the quick measurements will be made.

Only channels or math functions that are displayed are available for measurements. If you choose an invalid source channel for a measurement, the measurement will default to the nearest in the list that makes the source valid.

If a portion of the waveform required for a measurement is not displayed or does not display enough resolution to make the measurement, the result will be displayed with a message such as greater than a value, less than a value, not enough edges, not enough amplitude, incomplete, or waveform is clipped to indicate that the measurement may not be reliable.

3 Press the **Clear Meas** softkey to stop making measurements and to erase the measurement results from the measurement line above the softkeys.

When **Quick Meas** is pressed again, the default measurements on an analog channel will be Frequency and Peak-Peak.

4 Choose what measurement you want on that source by pressing the **Select** softkey, then turn the Entry knob  to select the desired measurement from the popup list.

5 Press the **Measure** softkey to make the selected measurement.

6 To turn off **Quick Meas**, press the **Quick Meas** key again until it is not illuminated.

For detailed information about making automatic measurements, refer to the “Making Measurements” chapter.

Subtract

When you select **1-2** channel 2 voltage values are subtracted from channel 1 voltage values point by point, and the result is displayed.

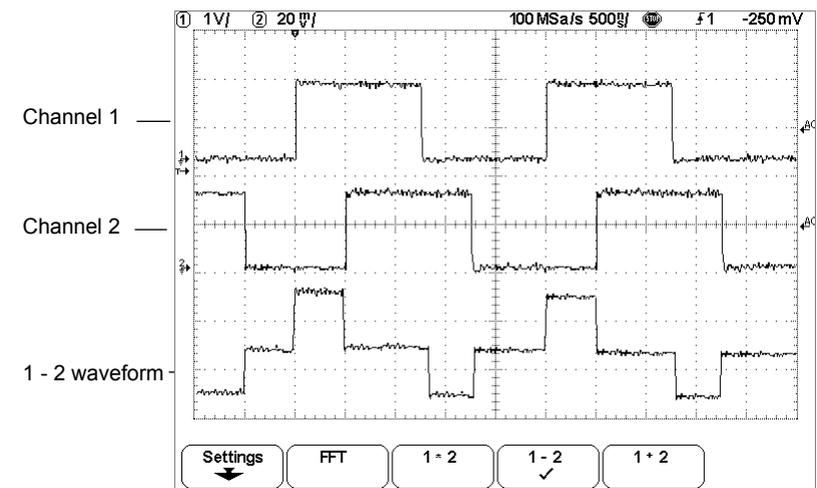
You can use **1-2** to make a differential measurement or to compare two waveforms. You may need to use a true differential probe if your waveforms have DC offsets larger than the dynamic range of the oscilloscope’s input channel. To perform the addition of channel 1 and channel 2, select **Invert** in the Channel 2 menu and perform the **1-2** math function.

- Press the **Math** key, press the **1-2** softkey, then press the **Settings** softkey if you want to change the scaling or offset for the subtract function.

Scale allows you to set your own vertical scale factors for subtract, expressed as V/div (Volts/division). Units are set in the channel **Probe** menu. Press the **Scale** softkey, then turn the Entry knob to rescale **1-2**.

Offset allows you to set your own offset for the **1-2** math function. The offset value is in Volts and is represented by the center graticule of the display. Press the **Offset** softkey, then turn the Entry knob to change the offset for **1-2**.

The figure below shows an example of subtract.



Subtract

Multiply

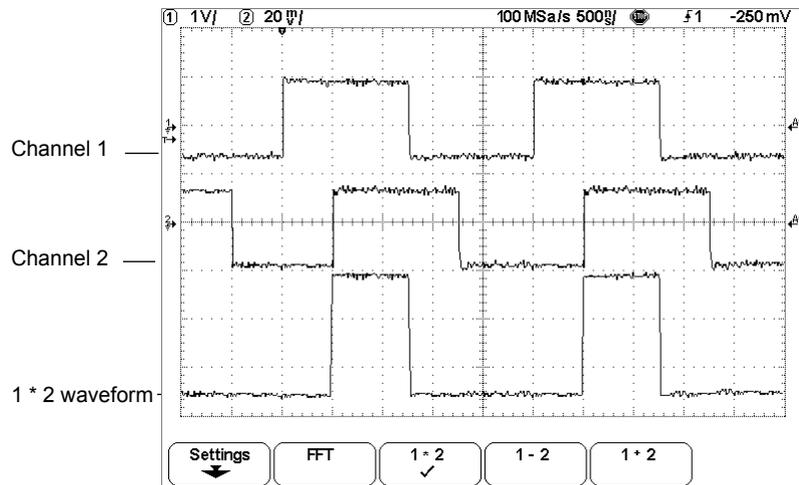
When you select **1*2** channel 1 and channel 2 voltage values are multiplied point by point, and the result is displayed. **1*2** is useful for seeing power relationships when one of the channels is proportional to the current.

- Press the **Math** key, press the **1*2** softkey, then press the **Settings** softkey if you want to change the scaling or offset for the multiply function.

Scale allows you to set your own vertical scale factors for multiply expressed as V^2/div (Volts-squared/division). Units are set in the channel **Probe** menu. Press the **Scale** softkey, then turn the Entry knob to rescale **1*2**.

Offset allows you to set your own offset for the multiply math function. The offset value is in V^2 (Volts-squared) and is represented by the center graticule of the display. Press the **Offset** softkey, then turn the Entry knob to change the offset for **1*2**.

The figure below shows an example of multiply.



Multiply

To modify the display grid

- 1 Press the **Display** key.
- 2 Turn the Entry knob to change the intensity of the displayed grid. The intensity level is shown in the **Grid** softkey and is adjustable from 0 to 100%.

Each major division in the grid (also known as graticule) corresponds to the sweep speed time shown in the status line on the top of the display.

To print the display

You can print the complete display, including the status line and softkeys, to a computer attached to the serial USB or RS232 port by pressing the **Quick Print** key. You can stop printing by pressing the **Cancel Print** softkey.

For more information on printing, refer to the “Utilities” chapter.

Math Scale and Offset

Any math function may be manually scaled by pressing the **Settings** softkey, and then adjusting the Scale or Offset value.

Math Scale and Offset are Set Automatically

Any time the currently displayed math function definition is changed, the function is automatically scaled for optimum vertical scale and offset. If you manually set scale and offset for a function, select a new function, then select the original function, the original function will be automatically rescaled.

- 1 Press the **Settings** softkey in the Math menu to set your own scale factors (units/division) or offset (units) for the selected math function. Units for each input channel can be set to Volts using the channel **Probe Units** softkey. Scale and offset units are:

Math function	Units
FFT	dB *) (decibels)
1*2	V ²
1-2	V
1+2	V

*) When the FFT source is channel 1 or channel 2 (or channel 3 or 4 on the W20x4), FFT units will be displayed in dBV when channel units is set to Volts and channel impedance is set to 1 MΩ. FFT units will be displayed in dBm when channel units is set to Volts. FFT units will be displayed as dB for all other FFT sources.

A scale unit of **U** (undefined) will be displayed for math function 1-2 and for d/dt, and ∫dt when 1-2 or 1+2 is the selected source if channel 1 and channel 2 are set to dissimilar units in the channel Probe Units softkey.

- 2 Press the **Scale** or **Offset** softkey, then turn the Entry knob to rescale or change the offset value for your math function.

Triggering the Oscilloscope

Math Functions

The Math menu allows you to display math functions on the channels. You can:

- subtract (–) or multiply (*) the signals acquired on the channels 1 and 2, then display the result.
- perform an FFT on the signal acquired on any channel or on math functions 1*2, 1–2, or 1+2, then display the result.
- Press the **Math** key on the front panel to display the Math menu. After selecting a math function, press the **Settings** softkey to display settings for the selected math function if you want to change the Y scaling.



Math Operating Hints

- If the channel or math function is clipped (not fully displayed on screen,) the resulting displayed math function will also be clipped.
- Once the function is displayed, the channel(s) may be turned off for better viewing.
- The vertical scaling and offset of each math function can be adjusted for ease of viewing and measurement considerations.
- Each function can be measured in the **Cursors** and **Quick Meas** menus.
- Note that when any of the math function is active, respectively the display refresh rate becomes very slow.

Triggering the Oscilloscope

The Welec W2000A-series Oscilloscopes provide a full set of features to help automate your measurement tasks, including Pan & Zoom features to help you capture and examine the stored waveforms of interest, even untriggered

waveforms. With these oscilloscopes you can:

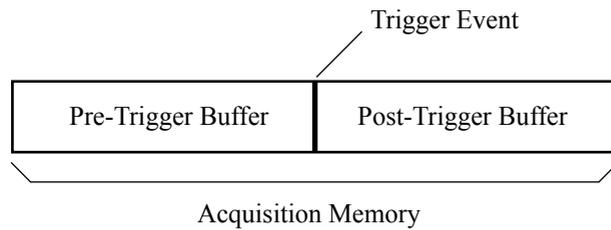
- modify the way the oscilloscope acquires data.
- set up simple or complex trigger conditions, as needed, to capture only the sequence of events you want to examine.

The oscilloscopes all have common triggering functionality:

- Trigger modes
 - Auto
 - Normal
- Coupling (including high frequency and noise rejection)
- Holdoff
- Trigger Level
- External Trigger input
- Trigger types
 - Edge (slope)
 - Pulse width (glitch)

Selecting Trigger Modes and Conditions

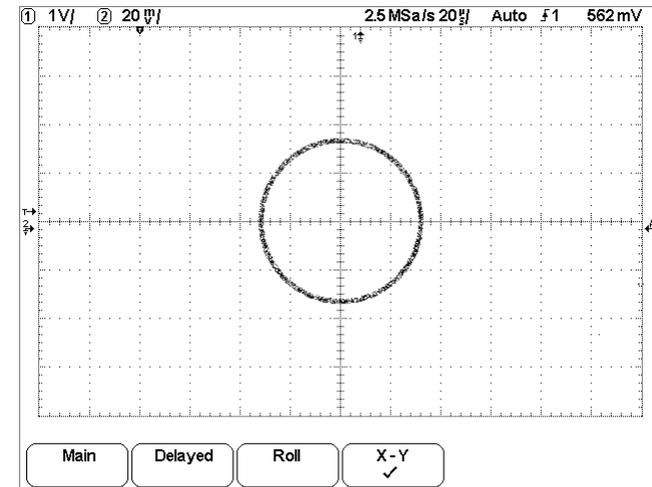
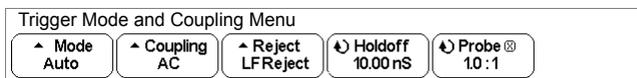
The trigger mode affects the way in which the oscilloscope searches for the trigger. The figure below shows the conceptual representation of acquisition memory. Think of the trigger event as dividing acquisition memory into a pre-trigger and post-trigger buffer. The position of the trigger event in acquisition memory is defined by the time reference point and the delay setting.



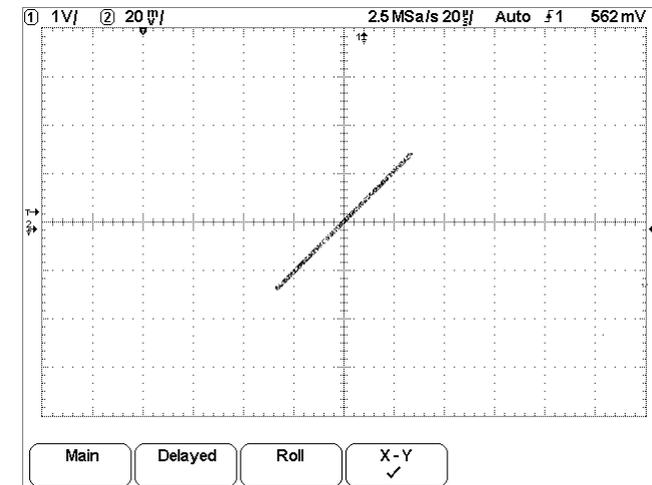
Acquisition Memory

To select the Mode and Coupling menu

- Press the **Mode/Coupling** key in the Trigger section of the front panel.



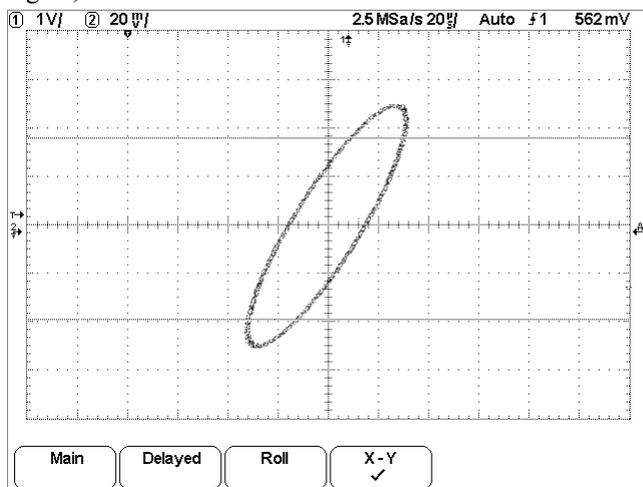
Signal are 90° out of phase



Signals are in phase

- 6 Move the Y1 and Y2 cursors to the intersection of the signal and the Y axis.

Again, note the ΔY value.



Cursors set to center of signal

- 7 Calculate the phase difference using the formula below.

$$\sin \theta = \frac{\sin \text{second } \Delta Y}{\text{first } \Delta Y} = \frac{0.648}{1.20} ; \theta = 32.68 \text{ degrees of phase shift}$$

To select a trigger mode: Normal and Auto

- 1 Press the **Mode/Coupling** key.
- 2 Press the Mode softkey, then select Normal or Auto
 - **Normal** mode displays a waveform when the trigger conditions are met, otherwise the oscilloscope does not trigger and the display is not updated.
 - **Auto** mode is the same as Normal mode, except it forces the oscilloscope to trigger if the trigger conditions are not met.

Auto mode

Use the auto trigger mode for signals other than low-repetitive-rate signals and for unknown signal levels. To display a dc signal, you must use one the auto trigger mode since there are no edges on which to trigger.

When you select **Run**, the oscilloscope operates by first filling the pre-trigger buffer. It starts searching for a trigger after the pre-trigger buffer is filled, and continues to flow data through this buffer while it searches for the trigger. While searching for the trigger, the oscilloscope overflows the pre-trigger buffer; the first data put into the buffer is the first pushed out (FIFO). When a trigger is found, the pre-trigger buffer will contain the events that occurred just before the trigger. If no trigger is found, the oscilloscope generates a trigger and displays the data as though a trigger had occurred.

When you select **Single**, the oscilloscope will fill pre-trigger buffer memory, and continue flowing data through the pre-trigger buffer until the auto trigger overrides the searching and forces a trigger. At the end of the trace, the scope will stop and display the results.

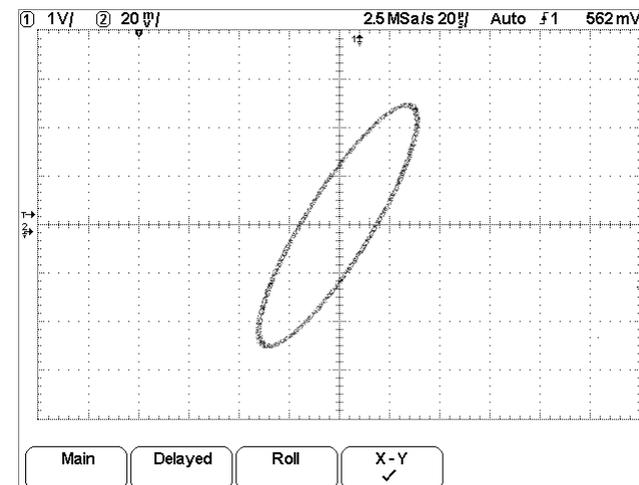
Normal mode

Use Normal trigger mode for low repetitive-rate signals or when Auto trigger is not required. In this mode, the oscilloscope has the same behavior whether the acquisition was initiated by pressing **Run/Stop** or **Single**.

In Normal mode the oscilloscope must fill the pre-trigger buffer with data before it will begin searching for a trigger event. The trigger mode indicator on the status line flashes to indicate the oscilloscope is filling the pre-trigger buffer. While searching for the trigger, the oscilloscope overflows the pre-trigger buffer; the first data put into the buffer is the first pushed out (FIFO). When the trigger event is found, the oscilloscope will fill the post-trigger buffer and display the acquisition memory. If the acquisition was initiated by **Run/Stop**, the process repeats.

In either Auto or Normal mode, the trigger may be missed completely under certain conditions. This is because the oscilloscope will not recognize a trigger event until the pre-trigger buffer is full. Suppose you set the Time/Div knob to a slow sweep speed, such as 100 ms/div. If the trigger condition occurs before the oscilloscope has filled the pre-trigger buffer, the trigger will not be found. If you use Normal mode and wait for the trigger condition before causing the action in the circuit, the oscilloscope will always find the trigger condition correctly.

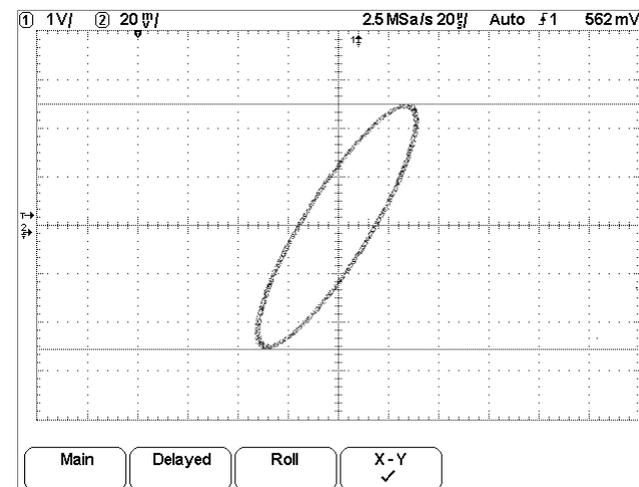
Some measurements you want to make will require you to take some action in the circuit under test to cause the trigger event. Usually, these are single-shot acquisitions, where you will use the **Single** key.



Signal centered on the display

- 4 Press the **Cursors** key.
- 5 Set the Y2 cursor to the top of the signal, and set Y1 to the bottom of the signal.

Note the ΔY value at the bottom of the display. In this example, we are using the Y cursors, but you could have used the X cursors instead.



Cursors set on displayed signal

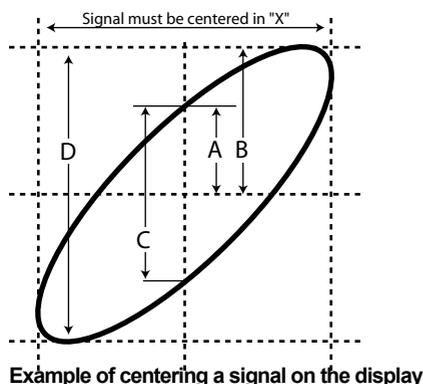
To use the XY horizontal mode

The XY horizontal mode converts the oscilloscope from a volts-versus-time display to a volts-versus-volts display using two input channels. Channel 1 is the X-axis input, channel 2 is the Y-axis input. You can use various transducers so the display could show strain versus displacement, flow versus pressure, volts versus current, or voltage versus frequency. This exercise shows a common use of the XY display mode by measuring the phase difference between two signals of the same frequency with the Lissajous method.

- 1 Connect a sine wave signal to channel 1, and a sine wave signal of the same frequency but out of phase to channel 2.
- 2 Press the **Autoscale** key, press the **Main/Delayed** key, then press the **XY** softkey.
- 3 Center the signal on the display with the channel 1 and 2 position (↔) knobs. Use the channel 1 and 2 volts/div knobs.

The phase difference angle (θ) can be calculated using the following formula (assuming the amplitude is the same on both channels):

$$\sin \theta = \frac{A}{B} \text{ or } \frac{C}{D}$$



To select trigger Coupling

- 1 Press the **Mode/Coupling** key.
- 2 Press the **Coupling** softkey, then select DC, AC or Ground coupling.
 - **DC** coupling allows dc and ac signals into the trigger path.
 - **AC** coupling places a high-pass filter (3.5 Hz for all inputs) in the trigger path removing any DC offset voltage from the trigger waveform. Use AC coupling to get a stable edge trigger when your waveform has a large DC offset.
 - **GROUND** display a virtual zero line.

To select LF Reject and HF Reject

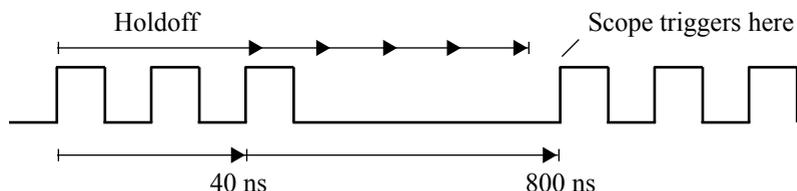
- 1 Press the **Mode/Coupling** key.
- 2 Press the **Reject** softkey to select LF Reject or the HF Reject softkey to select frequency reject.
 - **LF** (low frequency) **Reject** coupling places a 50-kHz high-pass filter in series with the trigger waveform. Low frequency reject removes any unwanted low frequency components from a trigger waveform, such as power line frequencies, that can interfere with proper triggering. Use this coupling to get a stable edge trigger when your waveform has low frequency noise.
 - **HF Reject** adds a 50 kHz low-pass filter in the trigger path to remove high frequency components from the trigger waveform. You can use HF Reject to remove high-frequency noise, such as AM or FM broadcast stations or from fast system clocks, from the trigger path.

To set holdoff

- 1 Press the **Mode/Coupling** key.
- 2 Turn the Entry knob  to increase or decrease the trigger holdoff time shown in the **Holdoff** softkey.

Holdoff sets the amount of time that the oscilloscope waits before re-arming the trigger circuitry. Use Holdoff to stabilize the display of complex waveforms.

To get a stable trigger on the pulse burst shown below, set the holdoff time to be >40 ns but <800 ns.



By setting the Holdoff, you can synchronize triggers. The oscilloscope will trigger on one edge of the waveform, and ignore further edges until the holdoff time expires. The oscilloscope will then re-arm the trigger circuit to search for the next edge trigger. This allows the oscilloscope to trigger on a repeating pattern in a waveform.

Holdoff Operating Hints

Holdoff keeps a trigger from occurring until after a certain amount of time has passed since the last trigger. This feature is valuable when a waveform crosses the trigger level multiple times during one period of the waveform.

Without holdoff, the scope could trigger on each of the crossings, producing a confusing waveform. With holdoff set correctly, the scope always triggers on the same crossing. The correct holdoff setting is typically slightly less than one period. Set the holdoff to this time to generate a unique trigger point. This action works even though many waveform periods pass between triggers, because the holdoff circuit operates on the input signal continuously.

Changing the time base settings does not affect the holdoff number. In contrast, the holdoff in analog oscilloscopes is a function of the time base setting, making it necessary to re-adjust the holdoff each time you change the time base setting.

Notice when pressing the **Holdoff** softkey, you may jump quickly to the next higher setting. The minimum is setting is 40 ns and the maximum setting is 300 sec.

To use the Roll horizontal mode

- Press the **Main/Delayed** key, then press the **Roll** softkey.

Roll mode causes the waveform to move slowly across the screen from right to left. It only operates on time base settings of 500ms/div and slower. If the current time base setting is faster than the 500 ms/div limit, it will be set to 500ms/div when Roll mode is entered.

In Normal horizontal mode, signal events occurring before the trigger are plotted to the left of the trigger point (▼) and signal events after the trigger plotted to the right of the trigger point.

In Roll mode there is no trigger. The fixed reference point on the screen is the right edge of the screen and refers to the current moment in time. Events that have occurred are scrolled to the left of the reference point. Since there is no trigger, no pretrigger information is available.

If you would like to clear the display and restart an acquisition in Roll mode, press the **Single** key.

Use Roll mode on low-frequency waveforms to give a display much like a strip chart recorder. It allows the waveform to roll across the display.

3 Characterize the glitch with delayed sweep.

To characterize the glitch with delayed sweep, follow these steps:

- Press the **Main/Delayed** key, then press the **Delayed** softkey.
- To obtain a better resolution of the glitch, expand the time base. Use the horizontal delay time knob (◀▶) to pan through the waveform to set the expanded portion of the main sweep around the glitch. To characterize the glitch, use the cursors or the automatic measurement capabilities of the oscilloscope.

External Trigger Input

External Trigger can be used as a source in several of the trigger types. The external trigger BNC input is on the front panel and is labeled **Ext Trigger**.

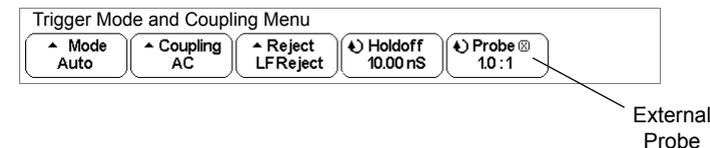
Maximum input voltage for the external trigger input:

- CAT I 300 Vrms, 400 Vpk
- CAT II 100 Vrms, 400 Vpk

External Trigger Probe Settings

You can set probe attenuation, units, and input impedance for the external trigger input.

- 1 Press the **Mode/Coupling** key in the Trigger section of the front panel.



Probe Attenuation Turn the Entry knob to set the attenuation factor displayed in the **Probe** softkey for the connected probe. The attenuation factor can be set from 1:1 to 100:1 in a 1-2-5 sequence.

The probe correction factor must be set properly for measurements to be made correctly.

The W2000A-series oscilloscope external trigger input impedance is always 1 MΩ. 1M Ohm is for use with probes and for general purpose measurements. The high impedance minimizes the loading effect of the oscilloscope on the circuit under test.

To capture glitches or narrow pulses with infinite persistence

A glitch is a rapid change in the waveform that is usually narrow as compared to the waveform. To capture glitches or narrow pulses:

- 1 Connect a signal to the oscilloscope and obtain a stable display.
- 2 To find the glitch, press the **Display** key then press the **Persist** softkey.

Infinite persistence updates the display with new acquisitions but does not erase previous acquisitions. New sample points are shown at normal intensity while previous acquisitions are displayed in minimum intensity. Waveform persistence is not kept beyond the display area boundary. Any time you change a waveform setting such as sweep speed, delay time, vertical sensitivity, or offset, the previous acquisitions will be erased, then begin to accumulate again.

Use infinite persistence to measure noise and jitter, to see the worst-case extremes of varying waveforms, to look for timing violations, or to find infrequent events.

Press the **Clear Display** softkey to erase previously acquired points. The display will again accumulate points until **Clear Display** is pressed or ∞ Persist is turned off.

Trigger Types

The oscilloscope allows you to synchronize the display to the actions of the circuit under test by defining a trigger condition. You can use any input channel or the Ext Trigger BNC for the source for most trigger types.

Pan & Zoom feature Simplifies Triggering

With the built-in Pan & Zoom feature, you can simply Autoscale the waveforms, then stop the scope to capture a waveform. You can then pan and zoom through the data using the Horizontal and Vertical knobs to find a stable trigger point. Autoscale often produces a triggered display.

These trigger types are available and are presented in the following order in this chapter:

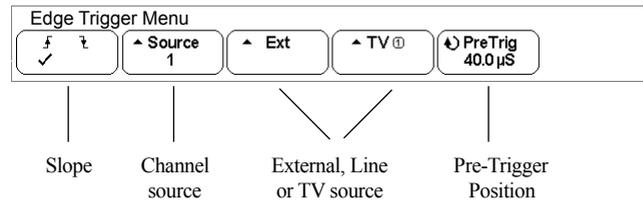
- Edge trigger
- Pulse Width (glitch) trigger
- TV trigger

Changes to the trigger specification are applied when you make them. If the oscilloscope is stopped when you change a trigger specification, the scope will use the new specification when you press **Run/Stop** or **Single**. If the oscilloscope is running when you change a triggering specification, it uses the new trigger definition when it starts the next acquisition. You select the trigger type by pressing the key associated with the desired trigger type.

To use Edge triggering

The Edge trigger type identifies a trigger by looking for a specified slope and voltage level on a waveform. You can define the trigger source and rising or falling edge in this menu. The trigger type and source is displayed in the upper-right corner of the display.

- 1 Press the **Edge** key in the Trigger section of the front panel to display the Edge trigger menu.



- 2 Press the **Slope** softkey (**f** **F**) and select either rising edge or falling edge. This determines whether the trigger will occur on the rising edge or the falling edge of the input signal.

Slope Selects rising edge (**f**) or falling edge (**F**) for the selected trigger source. The selected slope is displayed in the upper-right corner of the display.

- 3 Select **1** or **2** as the trigger source.

The trigger source can also be set to channel 3 and 4 on the 4-channel oscilloscope. You can choose a channel that is turned off as the source for the edge trigger. The selected trigger source is displayed in the upper-right corner of the display next to the slope symbol:

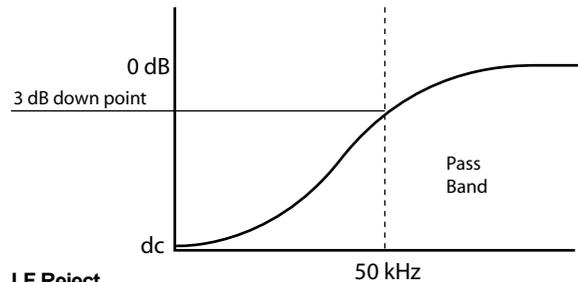
- 1** through **4** = channels
- XL** = External trigger (LF Reject)
- XH** = External trigger (HF Reject)
- L** = Line trigger
- TV** = TV Trigger

- 3 Use averaging to reduce noise on the displayed waveform.

- Press the **Acquire** key, then press the **Averaging** softkey.

Averaging lets you average multiple triggers together to reduce noise and increase resolution. Averaging of multiple triggers requires a stable trigger.

Low-frequency reject (LF reject) adds a high-pass filter with the 3-dB point at 50 kHz. Use LF reject to remove low-frequency signals, such as power line noise, from the trigger path.



LF Reject

Noise reject increases the trigger hysteresis band. By increasing the trigger hysteresis band, you reduce the possibility of triggering on noise. However, this also decreases the trigger sensitivity so that a slightly larger signal is required to trigger the oscilloscope.

Source Press the channel source softkey to select an analog source. Adjust the trigger level for the selected analog channel by turning the Trigger Level knob. The position of the trigger level for the analog channel is indicated by the trigger level icon **T** (if the analog channel is on) at the far left side of the display when DC coupling is selected. The value of the analog channel trigger level is displayed in the upper-right corner of the display.

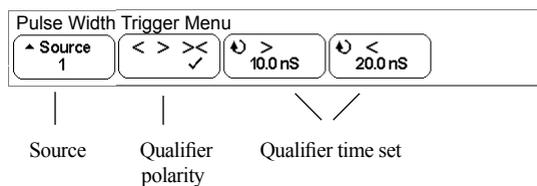
External/Line source Ext (external trigger) and **Line** (triggers off the power line frequency) trigger share the same softkey on the display. Toggle the softkey to select the source you want.

Adjust the external trigger level for the selected analog channel by turning the Trigger Level knob. The trigger level for Line is not adjustable.

To use Pulse Width triggering

Pulse Width (glitch) triggering sets the oscilloscope to trigger on a positive pulse of a specified width.

- 1 Press the **Pulse Width** key in the Trigger section of the front panel to display the Pulse Width trigger menu.



- 2 Press the **Source** softkey to select a channel source for the trigger.

The channel you select is shown in the upper-right corner of the display next to the polarity symbol.

The source can be any channel available on your oscilloscope.

External trigger may also be specified as a source when using the 2-channel and 4-channel oscilloscopes.

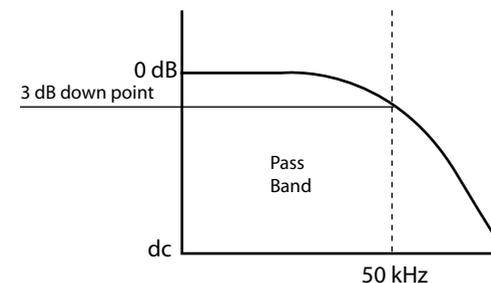
Adjust the trigger level for the selected analog channel source by turning the Trigger **Level** knob. The position of the trigger level for the analog channel is indicated by the trigger level icon **T▶** (if the channel is on) at the far left side of the display when DC coupling is selected. The value of the trigger level is displayed in the upper-right corner of the display.

To reduce the random noise on a signal

If the signal you are applying to the oscilloscope is noisy, you can set up the oscilloscope to reduce the noise on the displayed waveform. First, you stabilize the displayed waveform by removing the noise from the trigger path. Second, you reduce the noise on the displayed waveform.

- 1 Connect a signal to the oscilloscope and obtain a stable display.
- 2 Remove the noise from the trigger path by turning on high-frequency reject.

High-frequency reject (HF reject) adds a low-pass filter with the 3-dB point at 50 kHz. You use HF reject to remove high-frequency noise, such as AM or FM broadcast stations, from the trigger path.



HF Reject

Delayed sweep is an expanded version of main sweep. When Delayed mode is selected, the display divides in half. The top half displays the main sweep and the bottom half displays the delayed sweep.

- 4 Turn the horizontal sweep speed knob and delay time knob and note how the waveform expands, contracts, and moves on the display.

The area of the main display that is expanded is intensified and marked on each end with a vertical marker. These markers show what portion of the main sweep is expanded in the lower half. The Horizontal knobs control the size and position of the delayed sweep. The delay value is momentarily displayed in the upper-right portion of the display when the delay time (◀▶) knob is turned.

To change the sweep speed for the delayed sweep window, turn the sweep speed knob. As you turn the knob, the sweep speed is highlighted in the status line above the waveform display area. To change the sweep speed for the main sweep window, press the **Main** softkey, then turn the sweep speed knob.

- 3 Press the qualifier softkey (<>><) to select the time qualifier.

The Qualifier softkey can set the oscilloscope to trigger on a pulse width that is:

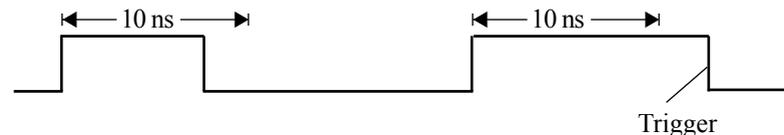
- less than a time value (<).

For example, for a positive pulse, if you set $t < 10$ ns:



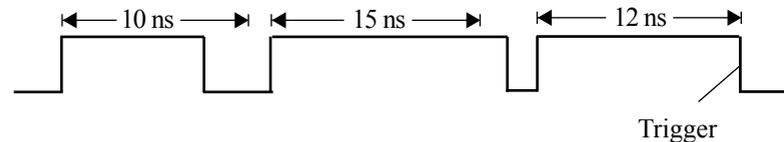
- greater than a time value (>).

For example, for a positive pulse, if you set $t > 10$ ns:



- within a range of time values (><).

For example, for a positive pulse, if you set $t > 10$ ns and $t < 15$ ns:



- 4 Select the qualifier time set softkey (< or >), then rotate the Entry knob to set the pulse width qualifier time.

The qualifiers can be set as follows:

- 10 ns to 10s for > or < qualifier
- 10 ns to 10s for >> qualifier, with minimum difference of 5 ns between upper and lower settings

< qualifier time set softkey

- When the less than (<) qualifier is selected, the Entry knob sets the oscilloscope to trigger on a pulse width less than the time value displayed on the softkey.
- When the time range (>>) qualifier is selected, the Entry knob sets the upper time range value.

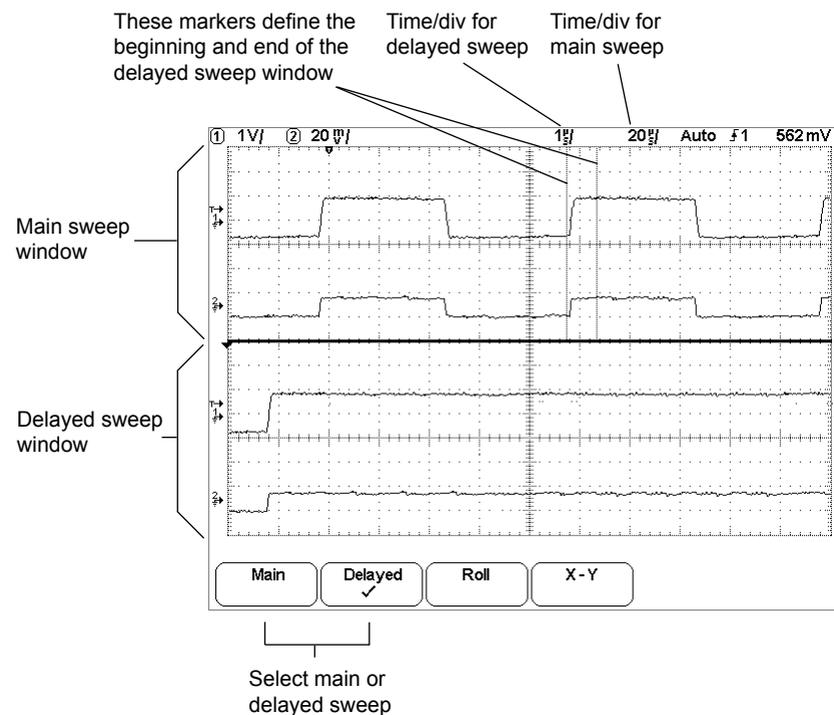
> qualifier time set softkey

- When the greater than (>) qualifier is selected, the Entry knob sets the oscilloscope to trigger on a pulse width greater than the time value displayed on the softkey.
- When the time range (>>) qualifier is selected, the Entry knob sets the lower time range value.

To use delayed sweep

You can use the delayed sweep window to locate and horizontally expand part of the main sweep for a more detailed (high-resolution) analysis of signals.

- 1 Connect a signal to the oscilloscope and obtain a stable display.
- 2 Press the **Main/Delayed** key.
- 3 Press the **Delayed** softkey.



Delayed sweep display

Capturing Data

In the oscilloscope, an 8-bit A/D converter converts the input waveform into an evenly-spaced series of voltage readings. These readings are made once for each channel, and are stored into memory as an array of voltages with implicit times.

Main and Delayed Sweep

The delayed sweep display function magnifies the contents of sample memory - data used by the main and delayed sweep windows is acquired on a single acquisition; the data corresponds to the same trigger event. Using the delayed sweep window, you can zoom in on a portion of the waveform and examine it in greater detail.

The delayed sweep operation is based on W2000A technology. Unlike analog oscilloscopes, the oscilloscope's delayed sweep is not a second acquisition, but an expansion of the same data displayed in the main sweep.

The technology makes this possible because of its deep memory. It is possible to capture the main display at 100ms/div, and redisplay the same trigger in the delayed display at 10 μ s/div - a 1000:1 zoom ratio.

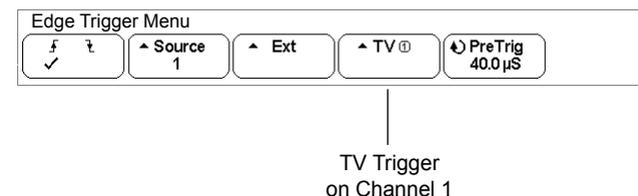
When you enable the delayed sweep view, the oscilloscope divides the display into two portions. The upper part shows the waveform according to the main time base; the lower shows a small portion of the waveform magnified according to a second time base (the delayed sweep window). In the delayed sweep window, the horizontal time/division knob adjusts the magnification of the delayed sweep portion. The delayed sweep time base must be at least twice as fast as the main time base, and can vary up to the maximum sweep speed of 10 ns/div.

To use TV triggering

TV triggering is used to capture the complicated waveforms of television (TV) equipment. The trigger circuitry detects the vertical and horizontal interval of the waveform and produces triggers based on the TV trigger settings you have selected.

The oscilloscope's Pan & Zoom features gives you bright, easily viewed displays of any part of the video waveform. Analysis of video waveforms is simplified by the oscilloscope's ability to trigger on any selected line of the video signal.

- 1 Press the **Mode/Coupling** key in the Trigger section of the front panel and press the **TV CH1** softkey to open TV trigger popup.



TV trigger on Channel 1

Note that the TV trigger is available on channel 1 only.

Provide Correct Matching

Many TV signals are produced from 75 Ω sources. To provide correct matching to these sources, a 75 Ω terminator should be connected to the oscilloscope input.

Making Measurements

By now you are familiar with the Vertical/Analog, Horizontal, and Trigger groups of the front-panel keys. You should also know how to determine the setup of the oscilloscope by looking at the status line at the top of the display.

We recommend you perform all of the following exercises so you become familiar with the powerful measurement capabilities of the oscilloscope.

This chapter is organized into the following sections starting on these pages:

Capturing Data 5-2

Math Functions 5-16

Cursor Measurements 5-30

Automatic Measurements 5-35

Oscilloscope Operation

This chapter gives an overview of some oscilloscope concepts that will help you make better measurements. It discusses the relationship between the time base setting and other time-dependent oscilloscope functions, explains how to achieve the most accurate signal fidelity through good probing practices, and describes how glitch detection works.

Recalling the factory default setup

- 1 Press the **Save/Recall** key to display the Save/Recall menu.
- 2 Press **Default Setup** softkey.

This returns the oscilloscope to its factory default settings and places the oscilloscope in a known operating condition. The major default settings are:

Horizontal main mode, 100 us/div scale, 0 s delay, center time reference

Vertical Channel 1 on, 5 V/div scale, dc coupling, 0 V position, probe factor to 1.0

Trigger Edge trigger, Auto sweep mode, 0 V level, channel 1 source, dc coupling, rising edge slope

Display Vectors on, 66% grid intensity, infinite persistence off

Other Acquire mode normal, Run/Stop to Run, cursor measurements off

To recall traces and setups from internal memory

- 1 Press the **Save/Recall** key in the File section of the front panel to display the Save/Recall menu.
- 2 Turn the Entry knob  to select an internal memory to be recalled from.
Select 1 of 80 file locations to recall from. Each time you select an internal memory and recall, the displayed waveforms are replaced by the recalled files.
- 3 When you have selected the memory location to be recalled, press the **Recall** softkey to recall the saved setup and waveform traces from the file.
Notice that the “BUSY” flag is displayed while the oscilloscope is busy to recall the files. This can take up to 30 seconds.

Recalling overwrites current settings

Because recalling a setup and waveforms will overwrite the oscilloscope's current settings, you may want to save the existing setup first.

- 4 To clear the display of any recalled trace, press the **Clear Display** softkey.

Deep Memory

The primary advantage of a deep-memory oscilloscope is sustained sample rate, allowing you to capture at the maximum sample rate and still capture a long time window. For example, you may want to capture a fast digital event, such as an interrupt line being asserted, while being able to look far out in time to see when the line was de-asserted.

This may require a fast sample rate to examine the signal fidelity of the interrupt edge, and also long-time capture to determine how long the interrupt line was asserted.

Another advantage is the ability to capture relatively longer periods of time or slow time-per-division settings at an adequate sample rate. This allows you to capture a long event, such as an oscillator starting up, or two events separated by a long time, such that you can see the entire time frame of interest. To see the event, the oscilloscope must have captured the information at a fast enough sample rate so that you can see the interesting details.

Memory depth values

All W2000A series oscilloscopes have 16k point per channel deep memory.

Oscilloscope Responsiveness

Please note the W2000A Series Oscilloscope have a relatively low responsiveness because of its low-cost architecture. It does not respond as fast as other scopes on the market. Please keep in mind that the low end price of your scope is in direct dependance to the chosen architecture inside the unit.

To save traces and setups to internal memory

- 1 Press the **Save/Recall** key in the File section of the front panel to display the Save/Recall menu.
- 2 Turn the Entry knob  to select an internal memory to be overwritten or saved.
Select 1 of 80 file locations to save to. Each time you select an internal memory and save, the existing file will be overwritten. All currently channels with 16k points memory depth are saved to this file.
- 3 When you have selected the memory location to be overwritten, press the **Save** softkey to save your current setup and waveform trace to the file.
Notice that the “BUSY” flag is displayed while the oscilloscope is busy to save the files. This can take up to 30 seconds.

Saving and Recalling Traces and Setups

You can save your current setup and waveform trace to the internal memory, then recall the setup and waveform trace.

When you save a setup, all settings including measurements, cursors, math functions, and horizontal, vertical, and trigger settings are saved to the file you have selected.

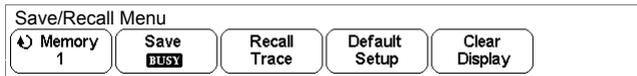
Making a hardcopy print

To make a hardcopy of the complete screen image including the status line and softkeys, or full 16k points per channel, use the **Quick Print** key. You have to have a computer attached to a serial port to be able to make hardcopy printings.

Saving a trace allows you to save the 16k points per channel of the acquisition for later recall and comparison with other measurements.

The normal application for a recalled trace is quick comparison of measurement results. For example, you might make a measurement on a known good system, save the result in internal trace memory, then make the same measurement on a test system and recall trace to see the differences.

- Press the **Save/Recall** key to display the Save/Recall menu.

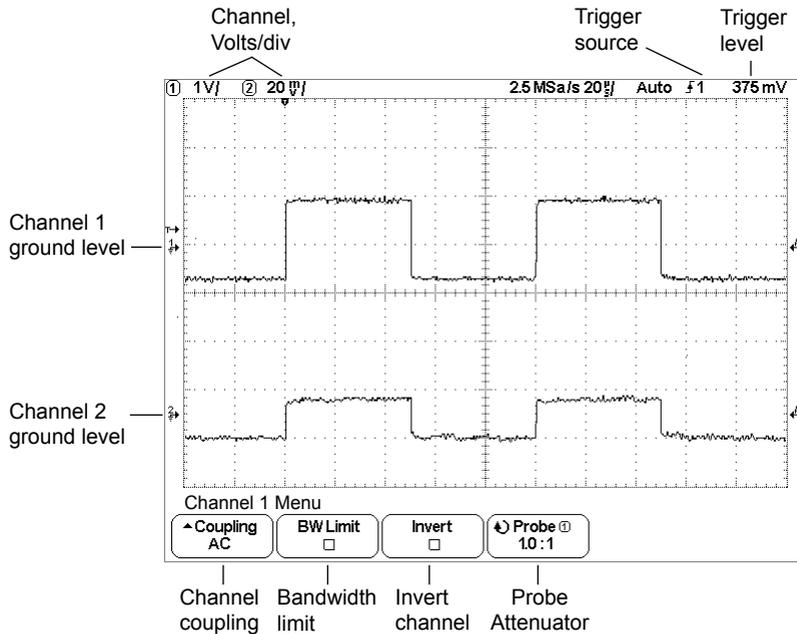


Display Update Rate

Please note the W2000A Series Oscilloscope have a relatively low display update rate because of its low-cost architecture. It does not perform as fast as other scopes on the market. Please keep in mind that the low end price of your scope is in direct dependance to the chosen architecture inside the unit.

To setup the channels

- 1 Press the **1** key in the Vertical section of the front panel to display the channel 1 menu.



Pressing a channel key turns the display of the channel on or off. The channel is displayed when the key is illuminated.

Turning channels off

If more than one channel is turned on (channel keys are illuminated), you must be viewing the menu for a channel before you can turn it off. For example, if channel 1 and channel 2 are turned on and the menu for channel 2 is being displayed, to turn channel 1 off, press 1 to display channel 1 menu, then press 1 again to turn channel 1 off.

To use infinite persistence

With infinite persistence, the oscilloscope updates the display with new acquisitions, but does not erase the results of previous acquisitions.

Infinite persistence is useful in a number of applications, including:

- Display the worst-case extremes of varying waveforms.
- Capture and store waveforms.
- Measure noise and jitter.
- Capture events that occur infrequently.

To use infinite persistence to store multiple repetitive events

- 1 Connect a signal to the oscilloscope.
- 2 Press the **Display** key, then press **Persist** to turn on infinite persistence.
The display will begin accumulating multiple acquisitions. Previous acquisitions will be displayed in minimum intensity.
- 3 Press the **Clear Display** softkey to erase previous acquisitions.
The oscilloscope will again start to accumulate acquisitions.
- 4 Turn off infinite persistence, then press the **Clear Display** key to return the oscilloscope to the normal display mode.

Clearing stored infinite persistence waveforms

In addition to clearing the display by pressing the **Clear Display** softkey, the display is also cleared of previous acquisitions any time you make a setting that will change the display, including changing sweep speed, volts/division, delay time, or channel position controls.

To capture a single event

To capture a single event, you need some previous knowledge of the signal to set up the trigger level and slope. For example, if the event is derived from TTL logic, a trigger level of 2 volts should work on a rising edge. These steps show you how to use the oscilloscope to capture a single event.

- 1 Connect a signal to the oscilloscope.
- 2 Set up the trigger.
 - a Define an edge, pulse width, or other advanced trigger type.
 - b Press the **Mode/Coupling** key and set trigger **Mode** to **Normal**.
 - c If you are using the channels to capture the event, turn the trigger Trigger Level knob to the trigger threshold where you think the trigger should work.
- 3 Press the Single key.

Pressing the **Single** key arms the trigger circuit and the **Single** key will be illuminated. When the trigger conditions are met, data appears on the display, representing the data points that the oscilloscope obtained with one acquisition and the **Run/Stop** key will be illuminated red. Pressing the **Single** key again re-arms the trigger circuit and erases the display.

Operating Hints

When Trigger Mode is set to Auto (auto-single mode), each time **Single** is pressed the oscilloscope will wait for a valid trigger. If no trigger is found after about 40ms, the oscilloscope will force a trigger, acquiring whatever signal is present. This is a handy mode to look for totally unknown situations.

When Trigger mode set to Normal, pressing **Single** will arm the trigger circuit and do a single acquisition when a valid trigger is seen.

You can use recalled traces to compare several single-shot events. See the "Saving and Recalling Traces and Setups" section later in this chapter.

Vertical sensitivity Turn the large knob above the channel key to set the sensitivity (volts/division) for the channel. The volts/division knob changes the analog channel sensitivity from 10 mV to 5 V in a 1-2-5 step sequence with a 1:1 probe attached. The channel Volts/Div value is displayed in the status line.

Ground level The ground level of the signal for each displayed channel is identified by the position of the  icon at the far-left side of the display.

Channel position Turn the small channel position knob () to move the channel waveform up or down on the display.

- 2 Press the **Coupling** softkey to select the input channel coupling.

Coupling changes the channel's input coupling to either **AC** (alternating current), **DC** (direct current), or **Ground**. AC coupling places a 3.5 Hz high-pass filter in series with the input waveform that removes any DC offset voltage from the waveform. When **AC** is selected, "AC" appears next to the ground level () icon.

- DC coupling is useful for viewing waveforms as low as 0 Hz that do not have large DC offsets.
- AC coupling is useful for viewing waveforms with large DC offsets, or with slowly moving DC offsets.
- Ground coupling is useful for removing clutter on screen, estimating the baseline noise contribution by the oscilloscope, and measuring the difference between oscilloscope ground and device-under-test ground.

3 Input Impedance

The oscilloscope analog channel input impedance is always 1 M Ω .

- 1M Ohm is for use with probes and for general-purpose measurements. The high impedance minimizes the loading effect of the oscilloscope on the circuit under test.

4 Press the **BW Limit** softkey to turn on bandwidth limiting.

Pressing the **BW Limit** softkey turns the bandwidth limit on or off for the selected channel. When bandwidth limit is on, the maximum bandwidth for the channel is approximately 20 MHz. For waveforms with frequencies below this, turning bandwidth limit on removes unwanted high frequency noise from the waveform. Bandwidth limit also limits the trigger signal path if the channel you are configuring is the trigger source.

When **BW Limit** is selected, BW appears next to the ground level () icon.

5 Press the **Invert** softkey to inverted the selected channel.

When Invert is selected, the voltage values of the displayed waveform are inverted. Invert affects how a channel is displayed, but does not affect triggering. If the oscilloscope is set to trigger on a rising edge, it remains set to trigger on a same edge (triggers at the same point on the waveform) after the channel is inverted.

Inverting a channel will also change the result of any function selected in the Math menu or any measurement.

When **Invert** is selected, INV appears next to the ground level () icon.

6 **Probe Attenuation** press the **Probe** softkey and turn the Entry knob to set the attenuation factor for the connected probe.

The attenuation factor can be set from 1:1 to 100:1 in a 1-2-5 sequence.

The probe correction factor must be set properly for measurements to be made correctly.

To run and stop an acquisition

- To begin an acquisition, press **Run/Stop** (key is illuminated green when running). The instrument begins acquiring data while searching for a trigger condition. If a trigger occurs, the acquired data is shown in the display.
- To stop an acquisition in process, press **Run/Stop** (key is illuminated red when stopped).

The instrument stops acquiring data and  symbol is displayed in the trigger mode position of the status line in the upper-right corner of the display. If the instrument was triggered (even by auto triggering) and the pre-trigger and post-trigger buffers are full, the results are displayed on the screen. If the buffers are not full (that is, no triggers occurred), the waveform display area will show nothing.

To take a single trace

- Press the **Single** key. The **Single** key will illuminate. The oscilloscope starts the acquisition system and begins searching for the trigger condition. When the oscilloscope is in infinite persistence display mode (see “To use Infinite Persistence” topic) pressing **Single** erases the results of previous acquisitions from the current display contents.

Auto Single

Auto-trigger will generate a trigger for you if one is not found in the predetermined time from when the trigger system is armed. To take a single-shot acquisition, and you are not particularly interested in triggering the acquisition (for example, if you are probing a DC level), set Trigger Mode/Coupling mode to Auto and press the **Single** key. If a trigger exists, it will be used; if a trigger does not exist, an untriggered acquisition will be taken.

Run/Stop/Single/Infinite Persistence Operation

During an acquisition, the oscilloscope examines the input voltage at each input probe.

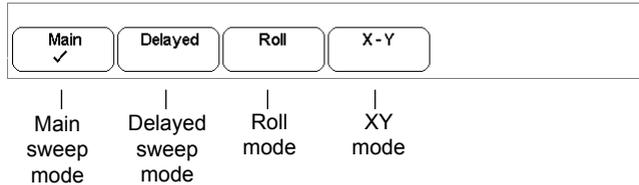
- The input voltage is determined by the vertical volts/division settings.

To control the acquisition process, you can do the following:

- Perform continuous acquisitions by pressing **Run/Stop** (key is illuminated green), and stop the acquisitions by pressing **Run/Stop** again (key is illuminated red).
- Take exactly one acquisition, then stop by pressing the **Single** key
- Store the results of several acquisitions by using infinite persistence when the scope is running.
- Erase the results of all acquisitions by pressing **Clear Display** in the Display menu.

To setup the Horizontal time base

- 1 Press the **Main/Delayed** key in the Horizontal section of the front panel.



The Main/Delayed menu allows you to select the horizontal mode (Main, Delayed, Roll, or XY).

Main mode

- 2 Press the **Main** softkey to select Main horizontal mode.

Main horizontal mode is the normal viewing mode for the oscilloscope. When the oscilloscope is stopped, you can use the Horizontal knobs to pan and zoom the waveform.

- 3 Turn the large knob (time/division) in the Horizontal section and notice the change it makes to the status line.

When the oscilloscope is running in Main mode, use the large Horizontal knob to change sweep speed and use the small knob (◀▶) to move horizontal through the entire memory depth. Notice that a browse window opens to indicate the position of the memory window while you turn the knob. When the oscilloscope is stopped, use these knobs to pan and zoom your waveform. The time/division knob changes the sweep speed from 10ns to 5s in a 1-2-5 step sequence. The sweep speed (seconds/division) value is displayed in the status line.

To pan and zoom a waveform

- 1 Press the **Run/Stop** key to stop acquisitions. The **Run/Stop** key is illuminated red when the oscilloscope is stopped.
- 2 Turn the sweep speed knob to zoom horizontally and turn the volts/division knob to zoom vertically.
The ▼ symbol at the top of the display indicates the time reference point where the zoom-in/zoom-out is referenced.
- 3 Turn the Delay time knob (◀▶) to pan horizontally and turn the channel position knob (⬆) to pan vertically.

Pan and Zoom

Pan and Zoom

The ability to pan (move horizontally) and zoom (expand or compress horizontally) an acquired waveform is important because of the additional insight it can reveal about the captured waveform. This additional insight is often gained from seeing the waveform at different levels of abstraction. You may want to view both the big picture and the specific little picture details.

The ability to examine waveform detail after the waveform has been acquired is a benefit generally associated with digital oscilloscopes. Often this is simply the ability to freeze the display for the purpose of measuring with cursors or printing the screen. Some digital oscilloscopes go one step further by including the ability to further examine the signal details after acquiring them by panning and zooming through the waveform.

There is no limit imposed on the zoom ratio between the sweep speed used to acquire the data and the sweep speed used to view the data. There is, however, a useful limit. This useful limit is somewhat a function of the signal you are analyzing.

In normal display mode, with vectors (connect-the-dots) off, you can zoom in to the point where there are no samples on the screen. Obviously, this is far beyond the useful limit. Likewise, with vectors on, you can see the linear interpolation between the points, but again, this is of very limited value.

- 4 Turn the position knob (◀▶) and notice that the memory window is displayed in the browse window.

Changing the positioning moves the sweep horizontally and indicates how far the trigger point (▼) is from memory window.

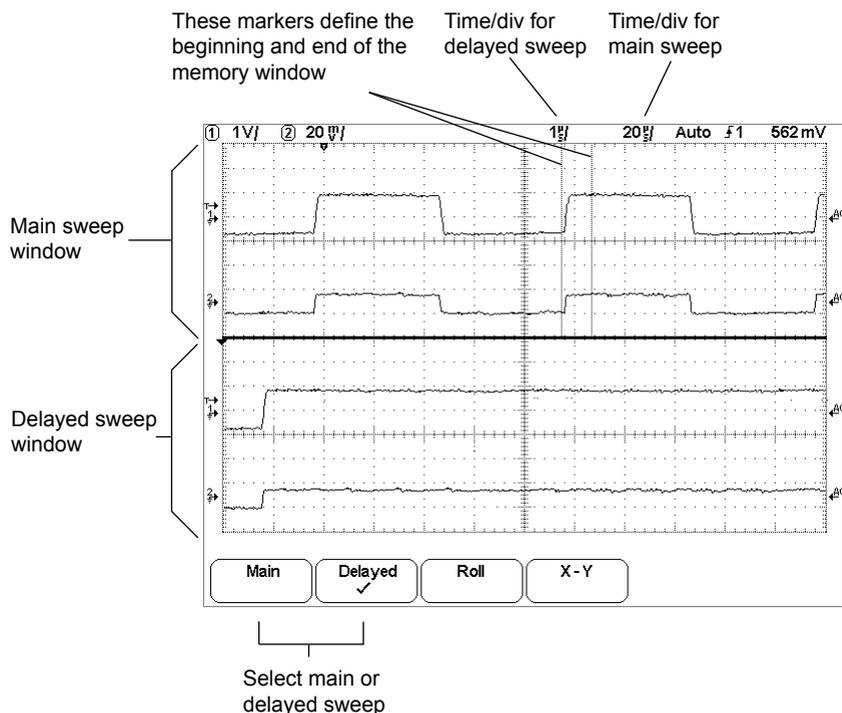
All events displayed left of the trigger point (▼) happened before the trigger occurred, and these events are called pre-trigger information. You will find this feature very useful because you can now see the events that led up to the trigger point. Everything to the right of the trigger point (▼) is called post-trigger information. The amount of delay range (pre-trigger and post-trigger information) available depends on the sweep speed selected. This range is much larger than that on an oscilloscope without deep memory.

You can permanent set the memory browse window to display the memory position by preessing the **Display** key and the respective **Browse** softkey.

To move the trigger position press the **Edge** key and use the entry knob ↻. Notice that the trigger position jumps into the memory window, when it is outside the window range.

Delayed mode

Delayed sweep is an expanded version of main sweep. When Delayed mode is selected, the display divides in half. The top half of the display has the main sweep and the bottom half has the delayed sweep.



The area of the main display that is expanded is intensified and marked on each end with a vertical marker. These markers show what portion of the main sweep is expanded in the lower half. The Horizontal knobs control the size and position of the delayed sweep. Use the positioning knob (◄►) to move the vertical markers.

Vectors On/Off

The W2000A-series oscilloscopes have been designed from the ground up to operate in Vectors On mode. This mode gives the most realistic waveforms in most every situation.

When enabled, **Vectors** draws a line between consecutive waveform data points.

- Vectors give an analog look to a digitized waveform.
- Vectors allow you to see steep edges on waveforms, such as square waves.
- Vectors on allows subtle detail of complex waveforms to be viewed, much like an analog scope trace, even when the detail is just a small number of pixels in size.

Turn vectors off to prevent misconnections at fast sweep speeds (<50 ns/div) when viewing changing waveforms, such as eye diagrams.

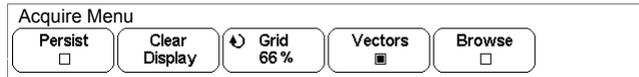
Turn vectors off to remove any interpolation artifacts of Single or Realtime acquire modes. Vectors off mode displays only actual A/D samples.

Browse On/Off

This feature permanently display the memory positioning window. Use the positioning knob ◄► to move within the entire memory depths.

Display Modes

- Press the **Display** key to view the Display menu.



Infinite Persistence

Infinite persistence (**Persist** softkey) updates the display with new acquisitions but does not erase previous acquisitions. New sample points are shown at normal intensity. Waveform persistence is not kept beyond the display area boundary.

Use infinite persistence to measure noise and jitter, to see the worst-case extremes of varying waveforms, to look for timing violations, or to find infrequent events.

Press the **Clear Display** softkey to erase previously acquired points.

The display will again accumulate points until **Clear Display** is pressed or infinite persistence is turned off.

More information on infinite persistence applications is given in the “Run/Stop/Single/Infinite Persistence/Clear Operation” topic later in this chapter.

Clear display

Clear Display erases the display of all previous acquisitions and erases any traces recalled from the oscilloscope internal memory or storage memory. The internal memory will still retain the traces.

If the oscilloscope is running, the display will again begin to accumulate waveform data if infinite persistence is turned on.

Grid

The intensity of the 10 x 12-division display grid can be set from 0% (off) to 100% (full brightness) in 4 steps by turning the Entry knob. The value of grid intensity is displayed in the **Grid** softkey.

To change the sweep speed for the delayed sweep window, turn the sweep speed knob. As you turn the knob, the sweep speed is highlighted in the status line above the waveform display area.

When the horizontal mode is set to Main, the delay positions the main sweep relative to the trigger. This delay is a fixed number. Changing this delay value does not affect the sweep speed. When the horizontal mode is set to Delayed, the delay controls the position of the delayed sweep window inside the main sweep display. This delayed delay value is independent of sampling interval and sweep speed.

To change the sweep speed for the main sweep window, press the **Main** softkey, then turn the sweep speed knob.

For information about using delayed mode for measurements, refer to the “Making Measurements” chapter.

Roll mode

Roll mode causes the waveform to move slowly across the screen from right to left. It only operates on time base settings of 500ms/div and slower. If the current time base setting is faster than the 500 ms/div limit, it will be set to 500ms/div when Roll mode is entered.

In Normal horizontal mode, signal events occurring before the trigger are plotted to the left of the trigger point (▼) and signal events after the trigger are plotted to the right of the trigger point.

In Roll mode there is no trigger. The fixed reference point on the screen is the right edge of the screen and refers to the current moment in time.

Events that have occurred are scrolled to the left of the reference point.

Since there is no trigger, no pre-trigger information is available.

If you would like to clear the display and restart an acquisition in Roll mode, press the **Single** key.

Use Roll mode on low-frequency waveforms to yield a display much like a strip chart recorder. It allows the waveform to roll across the display.

Realtime Mode

The oscilloscope produces the waveform display from samples collected during one trigger event. The sample rate is 1 GSa/s on every channel. All 16 K points are stored to the memory.

Average Mode

Averaging lets you average multiple triggers together to reduce noise and increase resolution. Averaging of multiple triggers requires a stable trigger.

XY mode

XY mode changes the display from a volts-versus-time display to a volts-versus-volts display. The time base is turned off, and Channel 1 amplitude is plotted on the X-axis and Channel 2 amplitude is plotted on the Y-axis.

You can use XY mode to compare frequency and phase relationships between two signals. XY mode can also be used with transducers to display strain versus displacement, flow versus pressure, volts versus current, or voltage versus frequency.

Use the cursors to make measurements on XY mode waveforms.

Note that the Zero Lines are fixed and many functions are not available in this mode.

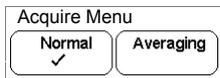
For more information about using XY mode for measurements, refer to the “Making Measurements ” chapter.

Acquisition Modes

Remember how when using your analog oscilloscope you had to constantly adjust the brightness? You did this to see the desired level of detail in a signal, or sometimes to see the signal at all!

Using the W2000A series digital storage oscilloscopes, intensity is no longer an issue. All recorded signal details are always displayed as solid waveforms. The following selecting acquisition mode is available:

- Normal
 - Average
- Press the **Acquire** key to display the Acquire menu.



Normal Mode

For the majority of use models and signals, Normal acquisition mode yields the best oscilloscope picture of the waveform.

Each channel can have up to 16 thousand samples per channel behind the 600-pixel column oscilloscope display. Some compression of samples to display points is obviously necessary, but due to the high plot rate (up to 64 thousand vectors/second), the compression is much less than previous oscilloscopes. This means the signal will look “right” at many more operating points.

All points displayed after Single or Stop

After a Single acquisition or when the oscilloscope has been stopped, all acquired points are displayed.