

Agilent Infiniium 90000 X-Series Oscilloscopes

User's Guide



Agilent Technologies

Notices

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Safety Notices

CAUTION

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WARNING

A **WARNING** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a **WARNING** notice until the indicated conditions are fully understood and met.

See also [Appendix A](#), “Safety Notices,” starting on page 59.

90000 X-Series Oscilloscopes—At a Glance

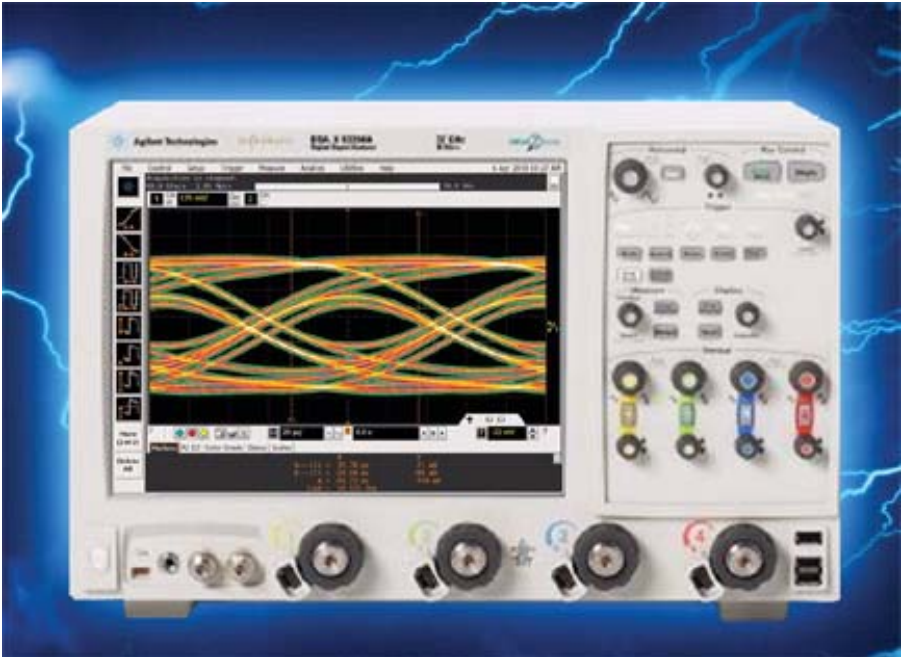


Table 1 90000 X-Series Oscilloscope Bandwidths, Sample Rates, and Memory Depths

	Analog Bandwidth		Sample rate		Max Memory depth
	2 channel	4 channel	2 channel	4 channel	4 channel
DSAX93204A	33 GHz	16 GHz	80 GS/s	40 GS/s	2 Gpts
DSO/MSOX93204A	33 GHz	16 GHz	80 GS/s	40 GS/s	2 Gpts
DSAX92804A	28 GHz	16 GHz	80 GS/s	40 GS/s	2 Gpts
DSO/MSOX92804A	28 GHz	16 GHz	80 GS/s	40 GS/s	2 Gpts
DSAX92504A	25 GHz	16 GHz	80 GS/s	40 GS/s	2 Gpts
DSO/MSOX92504A	25 GHz	16 GHz	80 GS/s	40 GS/s	2 Gpts
DSAX92004A	20 GHz	16 GHz	80 GS/s	40 GS/s	2 Gpts
DSO/MSOX92004A	20 GHz	16 GHz	80 GS/s	40 GS/s	2 Gpts
DSAX91604A	16 GHz	16 GHz	80 GS/s	40 GS/s	2 Gpts
DSO/MSOX91604A	16 GHz	16 GHz	80 GS/s	40 GS/s	2 Gpts
DSAX91304A	13 GHz	13 GHz	80 GS/s	40 GS/s	2 Gpts
DSO/MSOX91304A	13 GHz	13 GHz	80 GS/s	40 GS/s	2 Gpts

Ease of use with high performance

The Agilent Technologies Infiniium oscilloscopes combine unprecedented ease-of use with high-performance digitizing oscilloscope functionality to simplify your design and analysis measurement tasks.

- Traditional oscilloscope front-panel interface provides direct access to the controls needed for most troubleshooting tasks.
- Graphical user interface with menus, windows, dialog boxes, and toolbars provides easy access to dozens of configuration and analysis tools, ensuring you can set up and make the most complex measurements.
- Models with bandwidths from 13 GHz to 33 GHz.
- MSO models provide 10 GS/s at 16 channels and 20 GS/s at 8 channels.

Display shows waveforms and graphical user interface

- Graphical interface allows direct interaction with waveforms, including drag-and-drop positioning and instant waveform zoom.
- Touchscreen display allows oscilloscope operation without an external pointing device.
- Waveforms displayed in color, making correlation easy.
- Current configuration parameters displayed near the waveform display and are colorcoded to make identification easy.
- Graphical interface menus and toolbars simplify complex measurement setups.

Horizontal controls set sweep speed and position

- Intensified waveforms on main sweep window make it easy to see what will appear in the zoom window.

Acquisition and general controls start and stop the oscilloscope and do basic setup

- Run and stop controls for continuous or single acquisitions.
- Clear display before one or more acquisitions.
- Default setup and Autoscale set initial configuration.

Hard disk drive and USB 2.0 port for saving and restoring setups and measurement results

- Store measurement displays for inclusion in reports and test setup guides.
- Store oscilloscope setups to repeat tests another time.
- Hard disk stores oscilloscope operating system.

Trigger setup controls set mode and basic parameters

- Select Edge, Glitch, or Advanced Modes.
- Choose input source and slope.
- Use graphical user interface to simplify configuration of pattern, state, delay, and violation trigger modes.
- Use auxiliary trigger to increase triggering flexibility.

Vertical controls set attenuation and position

- Color-coded knobs make it easy to find the controls that affect each waveform.

Marker and quick measurements help measure waveform parameters

- Waveform markers A and B to check voltage or Δ -time at any point on the displayed waveform.

In This Book

This book gives you the information you need to begin using the Infiniium 90000 X-Series oscilloscopes. It contains three chapters, two appendixes, and an index:

Chapter 1, “Setting Up the Oscilloscope,” starting on page 11 contains inspection, power requirements, air flow, and setup information.

Chapter 2, “Using the Oscilloscope,” starting on page 25 gives an overview of the front and back panel inputs and outputs, front-panel controls, and graphical user interface, and tells you how to perform basic operations with the oscilloscope.

Chapter 3, “Using the Online Help,” starting on page 55 describes the Infiniium oscilloscope application’s online help contents and navigation. The online help describes how to use the Infiniium oscilloscope application in detail.

Appendix A provides safety notices.

Appendix B provides recommendations for working comfortably and safely while operating the Infiniium oscilloscope.

For More Information

- For detailed information on how the oscilloscope makes measurements and how to use the oscilloscope, see the Infiniium oscilloscope application’s online help.
- For information on controlling the oscilloscope from a remote computer, see the *Oscilloscopes Programmer’s Reference* found in the Infiniium oscilloscope application’s online help.
- For information on testing and servicing the oscilloscope, see the *Service Guide* manual found in the Infiniium oscilloscope application’s online help.

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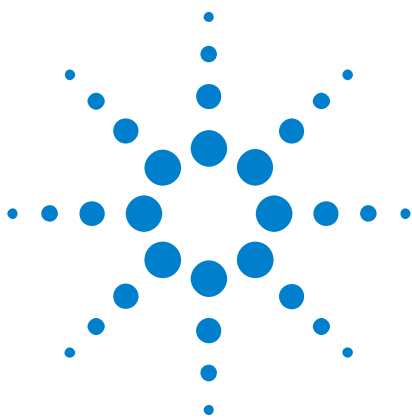
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This chapter shows you how to set up your Infiniium oscilloscope, connect power and accessories, and verify general operation.



Inspecting package contents

- ✓ Inspect the shipping container for damage.
 - 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.
 - If the shipping container is damaged, or the cushioning materials show signs of stress, notify the carrier and your Agilent Technologies Sales Office. Keep the shipping materials for the carrier's inspection. The Agilent Technologies Sales Office will arrange for repair or replacement at Agilent's option without waiting for claim settlement.

- ✓ Inspect the oscilloscope.

If there is mechanical damage or a defect, or if the oscilloscope does not operate properly or does not pass performance tests, notify your Agilent Technologies Sales Office.

- ✓ Verify that you received the following items in the Infiniium oscilloscope packaging.

- Infiniium oscilloscope
- Power cord
- Keyboard
- Mouse (USB optical)
- Touchscreen stylus
- Accessory pouch
- Front panel cover
- Calibration cable
- Connector saver collars (kit of 10)
- Connector assembly, 3.5mm f-f (quantity of 5)
- ESD wrist strap
- Quick Start Guide
- Digital channels cable (MSO models only)
- MSO calibrator board assembly (MSO models only)

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

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

For a complete list of options and accessories available for the 90000 X-Series oscilloscopes, see the [*Infiniium 90000 X-Series Oscilloscopes Data Sheet*](#).

Environmental conditions

Table 2 90000 X-Series Oscilloscope Environmental Characteristics

Environment	Indoor use only.
Temperature	Operating: 5 °C to + 40 °C Non-operating: –40°C to +65 °C
Humidity	Operating: up to 95% relative humidity (non-condensing) at +40 °C Non-operating: up to 90% relative humidity at +65 °C
Altitude	Operating: up to 4,000 meters (12,000 feet) Non-operating: up to 15,300 meters (50,000 feet)
Vibration	Operating random: 00.21 g(rms) Non-operating random: 2.0 g(rms) Swept sines: (0.50g)
Installation/ Measurement Category	Installation category: 2 Measurement category: 1
Power	100-240 V, 47-63 Hz; 800 W for 4-channel models. 100-240 V, 50 Hz; 100-208 V, 50/60 Hz; 800 W for 8-channel models
Weight	45.1 lbs (20.5 kg)
Dimensions	10.5 in. wide (27 cm), 16.75 in. tall (43 cm), and 18.7 in. deep (48 cm)
Safety	Meets IEC 61010-1 +A2, CSA certified to C22.2 No. 1010.1, self-certified to UL 3111
Voltage Fluctuations	Note that the mains supply voltage fluctuations are not to exceed +/-10% of the nominal supply voltage.
Pollution Degree	The Infiniium 90000 X-Series oscilloscopes may be operated in environments of Pollution Degree 2.

Pollution Degree Definitions	<p>Pollution Degree 1: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence. Example: A clean room or climate controlled office environment.</p> <p>Pollution Degree 2. Normally only dry non-conductive pollution occurs. Occasionally a temporary conductivity caused by condensation may occur. Example: General indoor environment.</p> <p>Pollution Degree 3: Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation which is expected. Example: Sheltered outdoor environment.</p>
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Positioning for proper airflow

- 1 Position the oscilloscope where it will have sufficient clearance for airflow around the top, back, and sides.

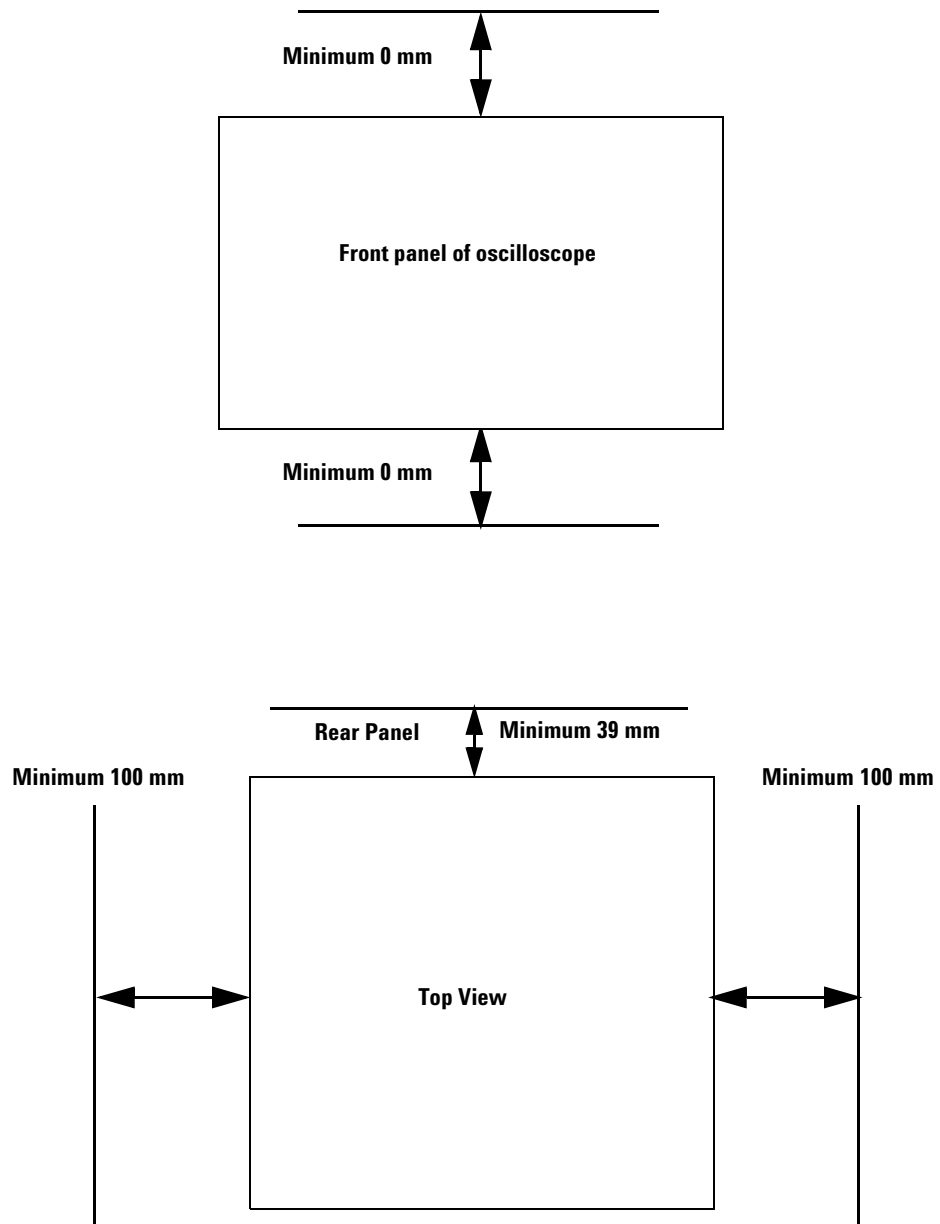


Figure 1 Positioning the 90000 X-Series Oscilloscope with Sufficient Clearance

CAUTION

Do not place the oscilloscope side-by-side with other instruments blowing warm air.

Connecting the mouse, keyboard, LAN cable, and MSO cable

Mouse and Keyboard A mouse and keyboard can be plugged into either USB host ports or the PS/2 ports.

There are several USB host ports on the back and front panel of the oscilloscope that can be used. (The USB device port is used for remote control of the oscilloscope from a PC.)

When using the PS/2 ports, the mouse and/or keyboard must be plugged in prior to turning on power to the oscilloscope.

LAN Cable Connect your LAN cable to the RJ-45 connector on the back panel of the oscilloscope.

NOTE

After you have connected to the LAN card, you must set up the network. Before you try to set up your network, you should exit the oscilloscope application.

If you do not know how to set up a network in the Windows 7 operating system, see your network administrator or use the Windows 7 operating system's online help.

MSO Cable If the oscilloscope is an MSO model, connect the digital channels cable to the MSO connector, making sure to orient the cable as shown on the drawing on the back panel.

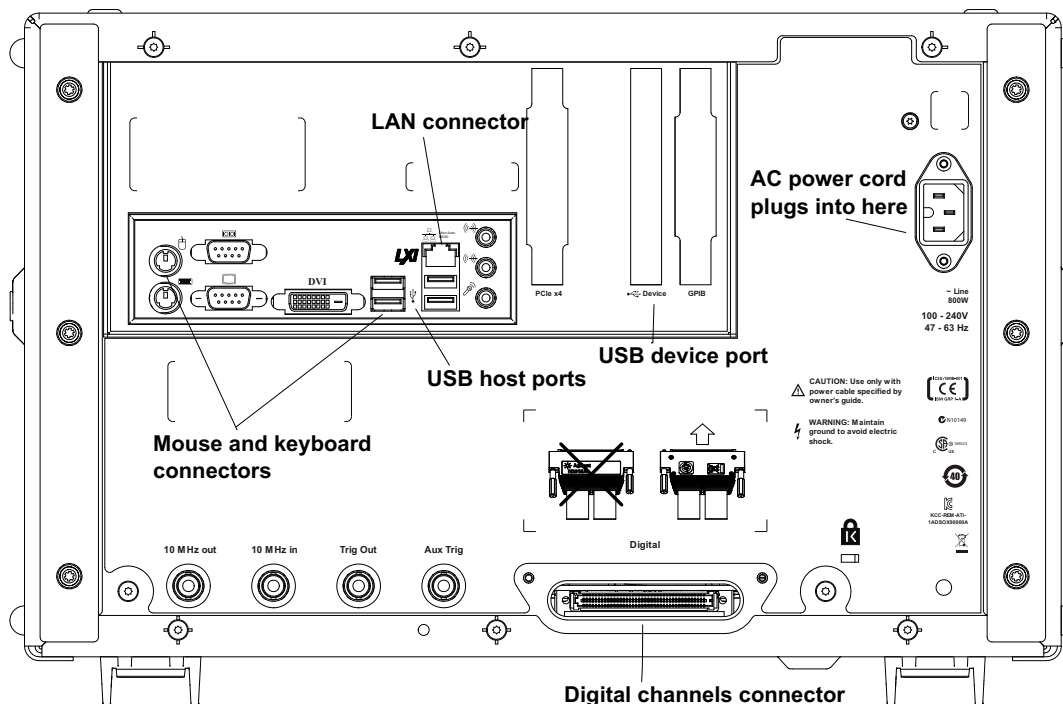


Figure 2 Back Panel

Connecting power

Table 3 Power Requirements

Power	100 - 240 VAC at 50/60 Hz Input power 800 Watts
-------	--

- 1 Connect the power cord to the rear of the oscilloscope, then to a suitable AC voltage source.

CAUTION



Use only power cords designed for your oscilloscope.

The line cord provided is matched by Agilent to the country of origin of the order.

WARNING



To avoid electric shock, be sure the oscilloscope is properly grounded.

NOTE

Note that the oscilloscope's power supply has a built-in safety feature that, after the oscilloscope is turned off, requires the oscilloscope to remain off for about 10 seconds before it is turned back on.

Power Supply Protection Features

The Infiniium 90000 X-Series oscilloscope's power supply has built-in protection features for over-voltage, over-current, and over-temperature fault conditions.

Green LEDs for AC and DC indicate normal operation. A red Fault LED indicates a fault condition.

When a fault occurs (and the power supply shuts down), you must unplug the power cord, wait 10 to 30 seconds, and plug the power cord back in to reset the protection latch and allow the oscilloscope to be powered on again.

If the power supply has overheated, you may need to wait longer so it can cool before you can power on the oscilloscope again.

Connecting oscilloscope probes

CAUTION



Do not exceed the maximum input voltage rating.

Oscilloscope channels 1-4 are rated for maximum input of $\pm 5V$ including transients.

The Infiniium 90000 X-Series oscilloscope channel 1-4 inputs have:

- 3.5 mm threaded RF connectors (like Agilent sampling oscilloscopes) to ensure the most reliable signal integrity.
- A convenient automatic torque mechanism that ensures a consistent 8 in-lbs connection.
- An AutoProbe II interface connector with pins that provide probe power, identification, and other communication signals.



Figure 3 90000 X-Series Oscilloscope Probe Connectors

The AutoProbe II interface works with the InfiniiMax III probing system. There are four different InfiniiMax III probe amplifiers ranging from 16 to 30 GHz. For more information, see [Agilent InfiniiMax III Probing System Data Sheet](#).

Before using the InfiniiMax III probes, review the *InfiniiMax III Probe Handling Guide* included with the probes. These probes are ESD sensitive devices and there is a proper order for connecting probe amplifiers to the oscilloscope, probe heads to the device under test (DUT), and probe heads to the amplifier. You can also find the *InfiniiMax III Probe Handling Guide* on the Agilent web site (www.agilent.com) or with other Agilent oscilloscope probes documentation in the Probe Resource Center (www.agilent.com/find/prc).

The N5442A Precision BNC 50 Ω adapter lets you use the InfiniiMax II probing system with the 90000 X-Series oscilloscopes.

Connecting threaded RF cables

You can connect 3.5 mm threaded RF cables to the Infiniium 90000 X-Series oscilloscope inputs using the automatic torque “clutch” mechanism to ensure a consistent 8 in-lbs connection.

The **Aux Out** and **Cal Out** connectors also work with 3.5 mm threaded RF cables.

Tilting the oscilloscope for easier viewing

Tabs under the oscilloscope's front feet can be flipped out to tilt the oscilloscope.



Figure 4 Flip-Out Tabs Under Front Feet

Turning on the oscilloscope

NOTE

The first time you turn on the oscilloscope, you must have a mouse connected to accept the Microsoft end-user license agreement for the Windows 7 operating system.

- 1 Press the power switch in the lower left corner of the oscilloscope front panel.

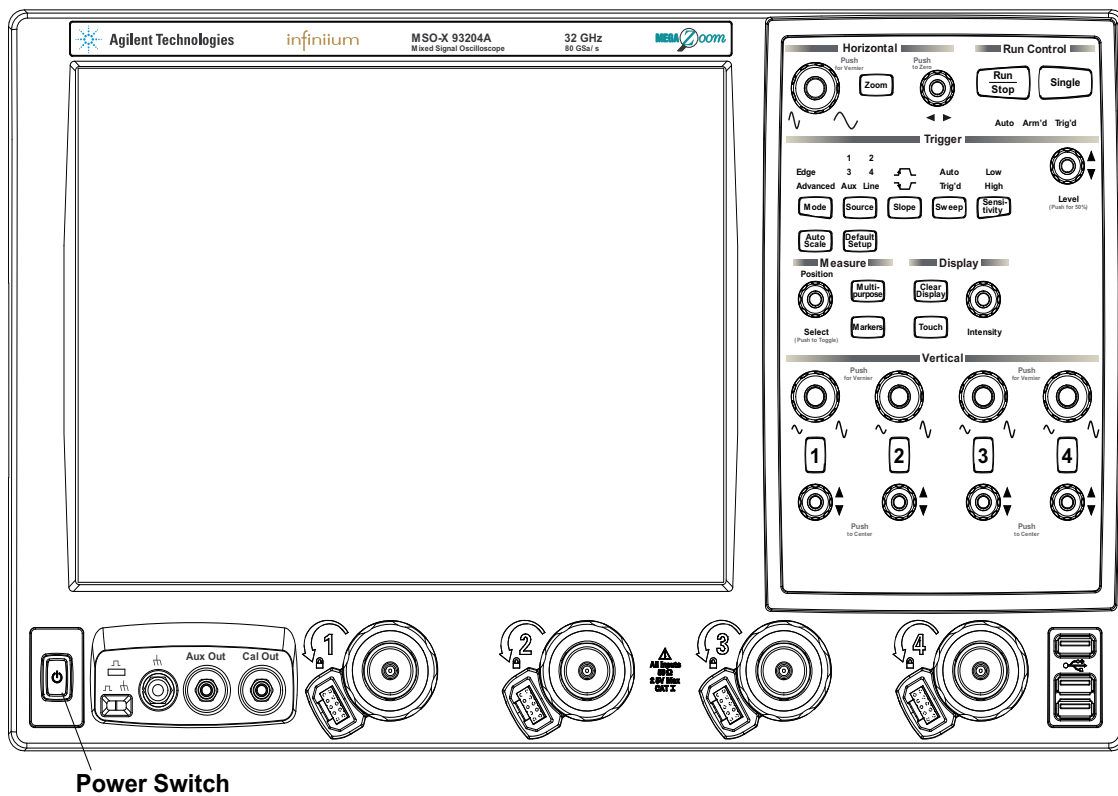


Figure 5 Turning on the Oscilloscope

After a short initialization period, the oscilloscope display appears. The oscilloscope is ready to use.

- 2 You can connect and disconnect probes and cables while the oscilloscope is turned on.

Verifying basic oscilloscope operation

- 1 Install the supplied connector savers to each channel input. Agilent recommends using the connector savers to protect the input connectors.
- 2 Connect one end of the 54916-61626 calibration cable to oscilloscope input channel 1.
- 3 Connect the other end of the calibration cable to the **Cal Out** connector on the front panel.

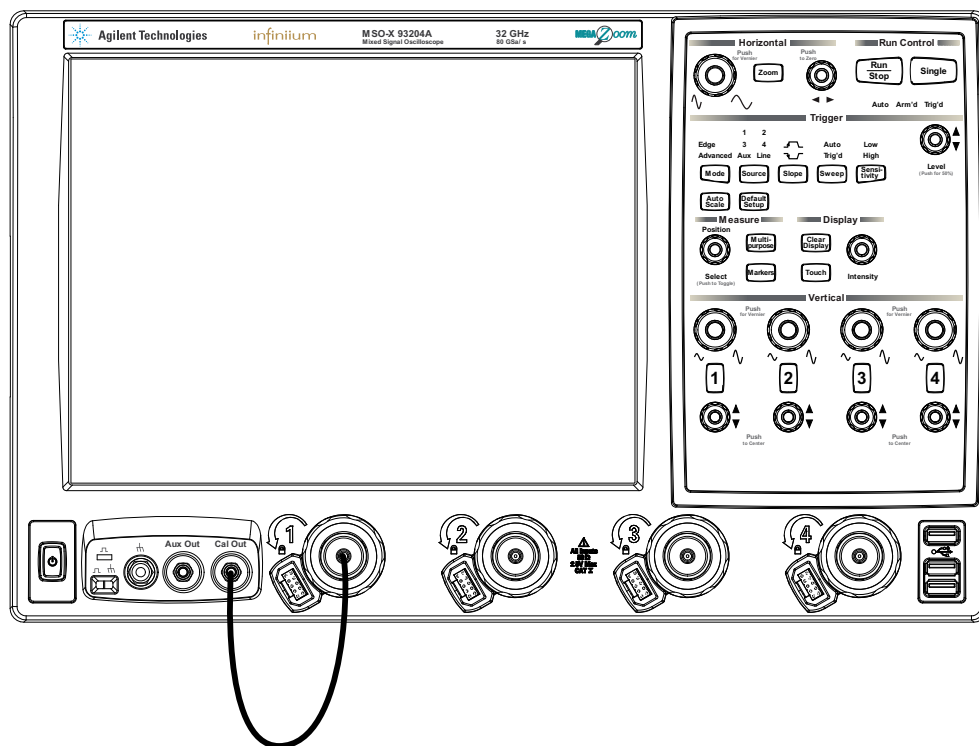


Figure 6 Verifying Basic Oscilloscope Operation

- 4 Press the **[Default Setup]** key on the front panel.

The display will pause momentarily while the oscilloscope is configured to its default settings.

- 5 Press the **[Auto Scale]** key on the front panel.

The display will pause momentarily while the oscilloscope adjusts the time/div setting and vertical scale. You should then see a square wave with about four cycles on screen and a peak-to-peak amplitude of approximately 4 divisions.

If you do not see the waveform, make sure your power source is adequate, the oscilloscope is properly powered on, and the probe is connected securely to the front-panel channel input and to the probe calibration output.

- 6 Move the mouse around the mouse surface and verify that the on-screen pointer follows the mouse movement.
- 7 Touch the pointer of the touch screen stylus to the surface of the screen and move it around while verifying that the pointer follows the movement.

Installing application programs on Infiniium

Infiniium has an open Windows operating system, which lets you install your own application software. Agilent has verified that the following applications are compatible with the Infiniium oscilloscope application.

- Agilent Vector Signal Analysis
- Agilent VEE Pro
- Microsoft Office
- MathWorks MATLAB
- Mathsoft MathCad 2001i
- McAfee VirusScan
- Symantec Norton AntiVirus

NOTE

Exit the oscilloscope application before installing any software.

If you install an application other than those Agilent has tested, it is possible that it could break the oscilloscope application. This would potentially require you to recover the oscilloscope hard drive.

Changing Windows Operating System Settings

NOTE

Exit the oscilloscope application before changing any Windows operating system settings outside of the oscilloscope application.

Many Windows operating system settings can be changed to suit your own personal preferences. However, some operating system settings should not be changed because doing so would interfere with the proper operation of the oscilloscope.

- Do not change the Power Options.
- Do not change the System Properties Hardware Tab settings.
- Do not change the Regional and Language Options Advanced Tab settings.
- Do not remove Fonts.
- Regarding Display Settings:
 - Do not change the screen resolution from 1024 by 768 pixels or the color quality from Highest (32 bit).
 - Do not change the Font size to Extra Large.
 - Do not use a Menu font size greater than 14 points.
- Do not use the Administrative Tools to enable or disable Internet Information Services (Web Server). Use the Infiniium Web Control dialog box to enable or disable the Web Server.
- Do not delete or modify the Infiniium Administrator user account.

Turning off the oscilloscope

- 1 Press the power switch at the lower left corner of the oscilloscope front panel. The oscilloscope will go through a normal Windows operating system shutdown process.

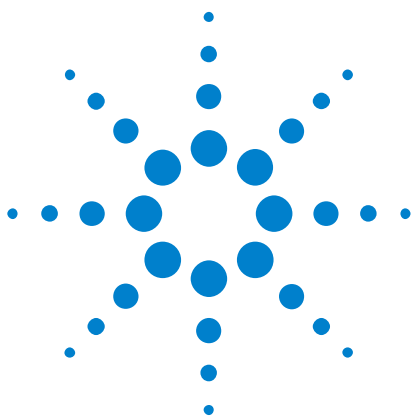
Cleaning the oscilloscope

Clean the oscilloscope with a soft cloth dampened with a mild soap and water solution.

CAUTION

Do not use too much liquid in cleaning the oscilloscope. Water can enter the Infiniium front panel, damaging sensitive electronic components.

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This chapter describes how to use the Infiniium 90000 X-Series oscilloscope's inputs and outputs, front-panel controls, and graphical user interface.

- The familiar front-panel oscilloscope interface with knobs and keys is optimized for common tasks and basic measurements.
- The Infiniium oscilloscope application's graphical interface with menus, windows, dialog boxes, and toolbars provides easy logical access to dozens of configuration and analysis tools, making it easy for you to set up and make the most complex measurements.
- You have the option of using either the front panel controls or the graphical user interface for many common tasks.



Front Panel Inputs and Outputs

On the Infiniium 90000 X-Series oscilloscopes, the channel inputs and the **Aux Out** and **Cal Out** outputs appear on the lower part of the front panel. The ground plug, probe compensation terminal, and three USB host ports are also located here.

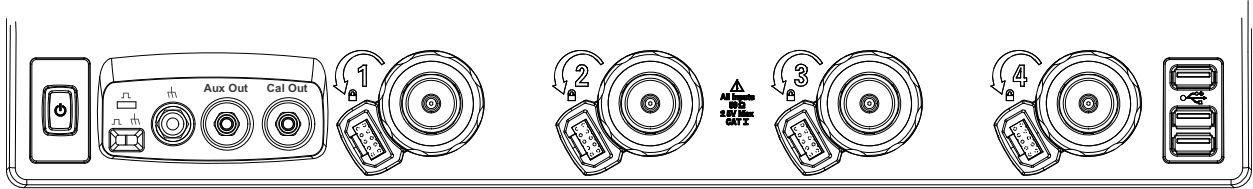


Figure 7 Infiniium 90000 X-Series Oscilloscope Front Panel I/O

Channel Inputs

The four channel inputs have:

- 3.5 mm threaded RF connectors.
- A convenient automatic torque mechanism.
- An AutoProbe II interface connector with pins that provide probe power, identification, and other communication signals.

The AutoProbe II interface works with the InfiniiMax III probing system. See [“Connecting oscilloscope probes”](#) on page 17.

You can also connect 3.5 mm threaded RF cables to the channel inputs.

Ground

The ground plug is convenient for ESD wrist straps.

Aux Out

This output signal is selected by the Infiniium oscilloscope application's Calibration Output dialog box. It can be a DC level, the probe compensation signal (a square wave used to adjust compensated passive probes), the trigger out signal, or a demo signal.

Cal Out

This calibration output is used when performing user calibration on the oscilloscope.

A calibration cable is included with the oscilloscope.

You can also use the Infiniium oscilloscope application's Calibration Output dialog box (**Utilities > Calibration Output**) to select other output signals, just like you can for the **Aux Out** output.

Probe Compensation Terminal

This terminal has a square wave signal that is used to adjust compensated passive probes. Be sure to use an N5449A high-impedance adapter.

You can also output a DC level on this terminal using the Infiniium oscilloscope application's Calibration Output dialog box.

USB Host Ports

There are three USB host ports on the right side of the front panel.

Back Panel Inputs and Outputs

The Infiniium 90000 X-Series oscilloscope's back panel has the motherboard I/O connectors, a USB device port, reference clock synchronization connectors, and BNC connectors. MSO models include an MSO connector.

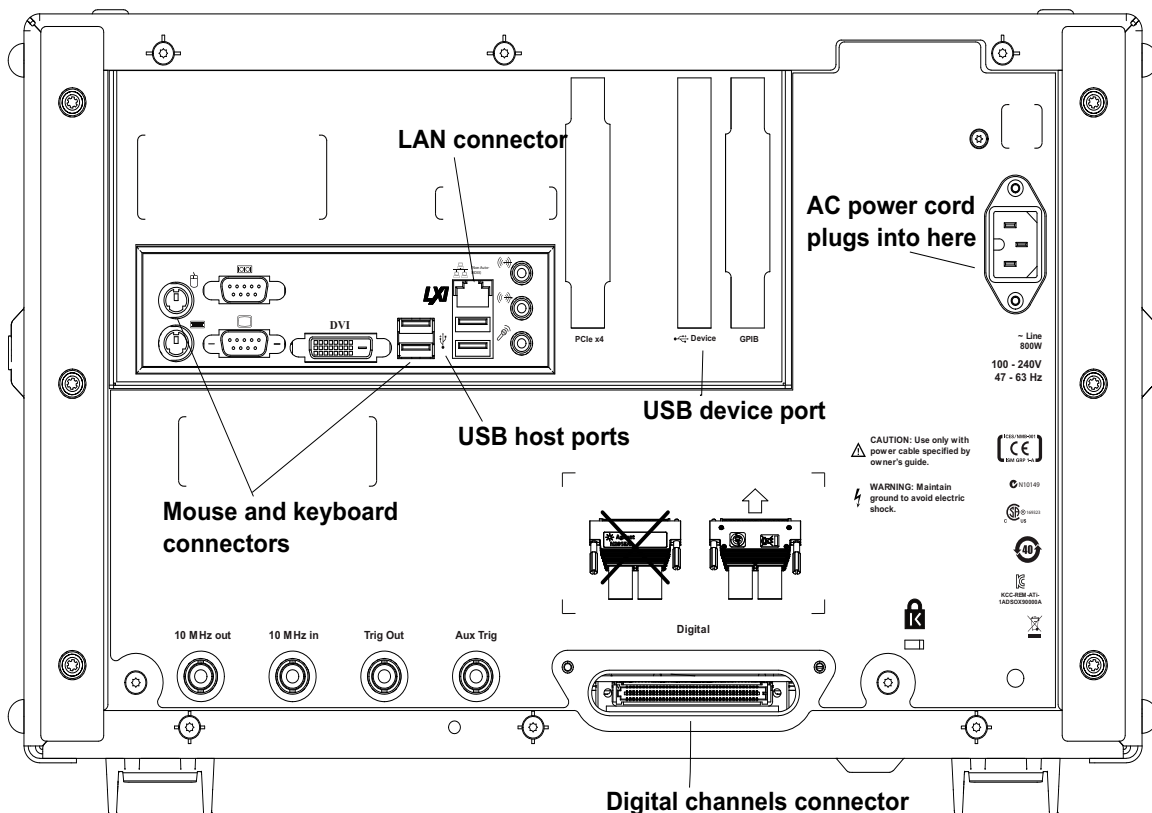


Figure 8 Infiniium 90000 X-Series Oscilloscope Back Panel I/O

Motherboard I/O

These are the inputs/outputs/ports provided by the motherboard in the oscilloscope: PS/2 mouse and keyboard connectors, external monitor connectors, serial interface, USB host ports, LAN port, speaker and microphone connectors, etc.

USB Device Port

The back panel USB device port can be used for remote control of the oscilloscope from a PC.

10 MHz In, 10 MHz Out

The 10 MHz In BNC connector is used to synchronize the oscilloscope's horizontal timebase system to a reference clock that you provide. The clock that you provide must meet the following specifications:

- Amplitude: 178 mV peak to 1 V peak.
- Frequency: 10 MHz \pm 5 ppm high-quality sine wave or square wave.

To use an external reference clock, connect the external clock to the 10 MHz In BNC connector; then, in the Infiniium oscilloscope application's Horizontal Setup dialog box (**Setup > Horizontal**), enable the 10 MHz External Reference Clock.

You can use the 10 MHz Out BNC connector to send the oscilloscope's 10 MHz reference clock output signal to another instrument's reference clock input.

Trig Out

Pulses corresponding to oscilloscope triggers can be sent to this BNC output.

Aux Trig

You can set up the oscilloscope to trigger on the auxiliary trigger signal connected to this BNC input.

Digital Channels Connector

MSO models include a connector for digital channel inputs.

CAUTION

Be sure to orient the cable as shown in the drawing on the back panel. Inserting the cable incorrectly could bend the pins or cause errors.

Front Panel Controls (Keys and Knobs) Overview

The Infiniium 90000 X-Series oscilloscope front panel gives you direct access to the functions needed to perform the most common measurements, using a traditional oscilloscope interface. Knobs and keys let you directly set vertical and horizontal parameters. The front panel also has a set of LED (Light-Emitting Diode) indicators; by using these and the display, you see the oscilloscope's configuration at a glance.

The oscilloscope uses color consistently throughout the front panel and user interface. For example, the color of the knob for channel 1 is the same color as the waveform for channel 1. All the configuration items and values related to channel 1 are displayed in the same color.

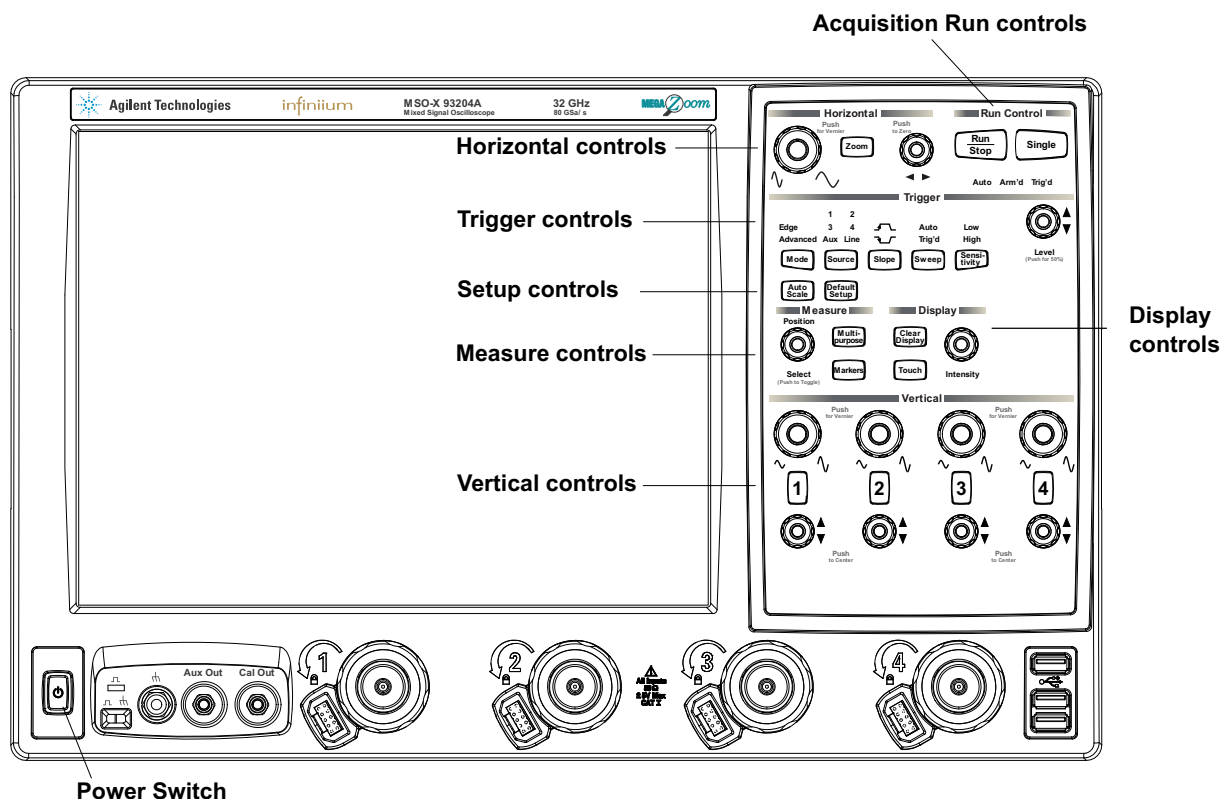


Figure 9 Infiniium 90000 X-Series Oscilloscope Front Panel

Graphical User Interface Overview

With the graphical interface for the Infiniium oscilloscope, you can access all the configuration and measurement features of the oscilloscope through an easy-to-use system of menus, toolbars, dialog boxes, icons, and buttons.

The graphical interface is arranged so the most common functions affecting the waveform display are located around the edge of the waveform viewing area.

Right-click menus pop up to provide quick access to commands and configuration items that relate only to the context of the graphical interface item in which they are found. These context-sensitive menus are available when you right-click in the memory bar, waveform display area, measurement toolbar, and horizontal and acquisition control regions.

The following three figures call out the areas and controls of the graphical interface.

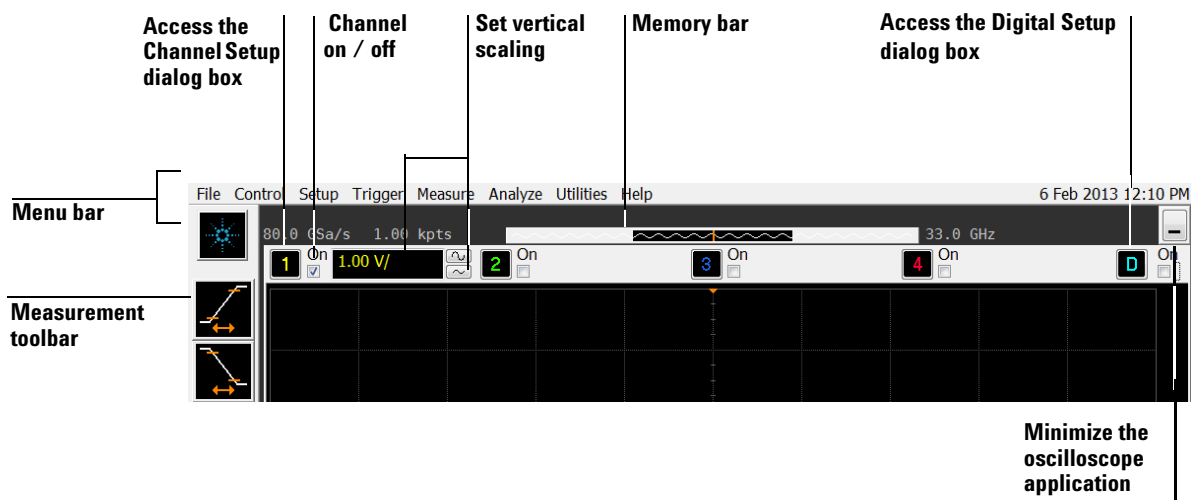


Figure 10 Infiniium Oscilloscope Top of Display

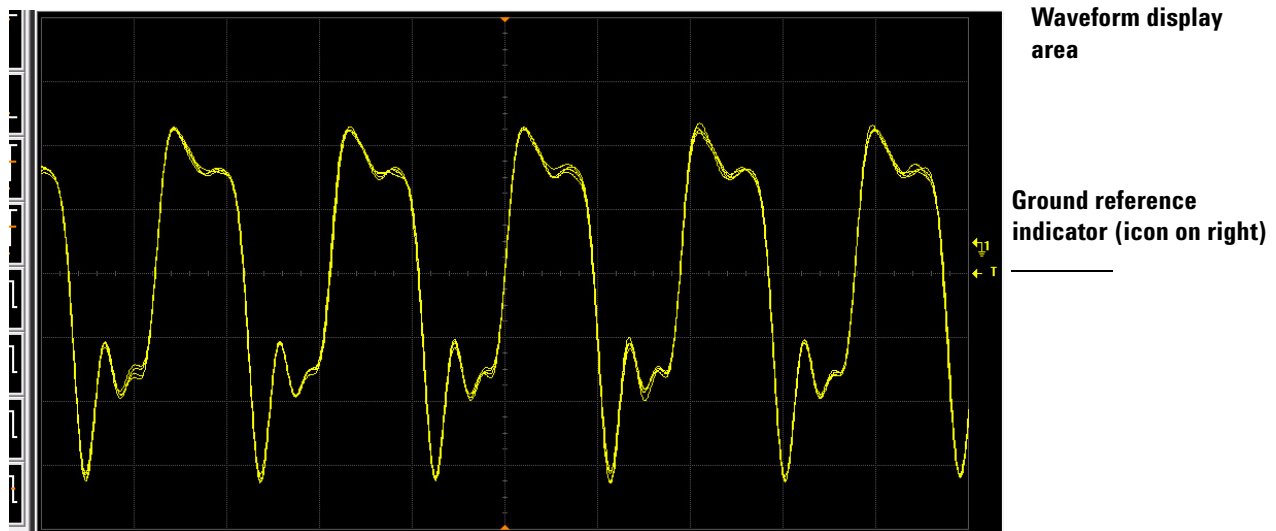


Figure 11 Infiniium Oscilloscope Waveform Display Area

The waveform display area shows the waveforms and, optionally, the results of your measurements. Several display options, including a grid, are available. You can use the mouse to click and drag waveforms to new vertical or horizontal positions. You can also click and drag a rectangular area on the display, then click the Waveform Zoom menu item to zoom on that section of displayed waveform.

NOTE

Avoid Overdriving Vertical Input Amplifiers

When zooming on a waveform with the oscilloscope running, be careful to keep the signal within the screen vertically to avoid overdriving the vertical input amplifiers. Overdriving causes waveform distortion and erroneous measurement results.

Ground reference indicators show channels, waveform memories, and functions for each waveform that is on. The symbol represents the ground reference point for each channel; it moves when you change the vertical offset. You can also drag this symbol up and down to change the vertical offset for that waveform.

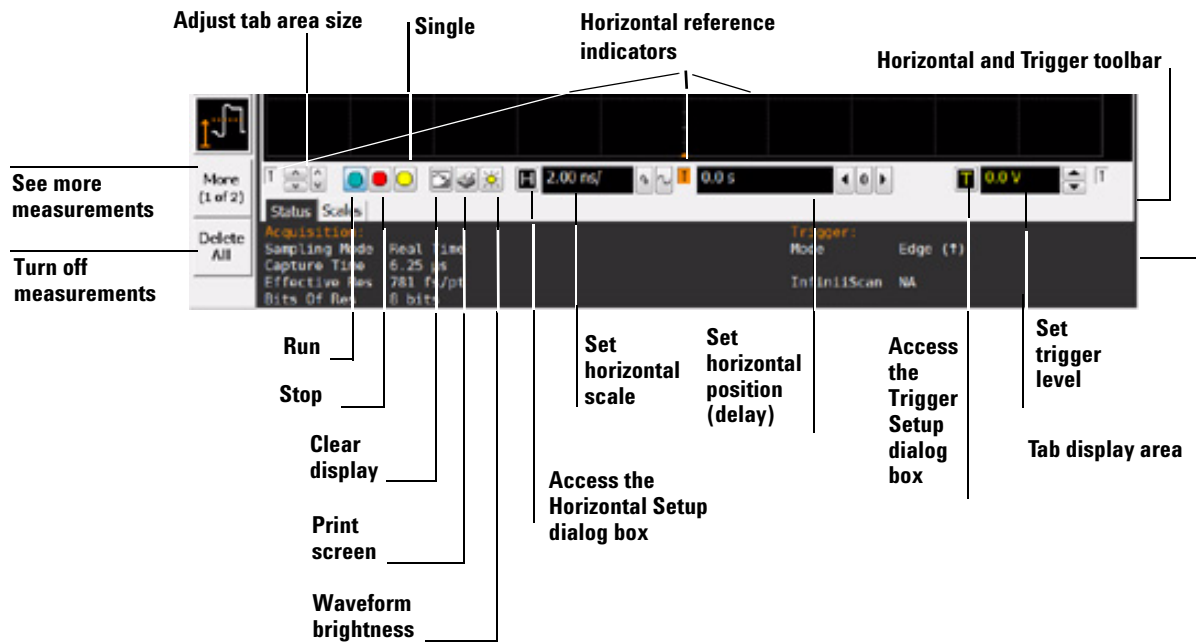


Figure 12 Infiniium Oscilloscope Bottom of Display

The tab display area in the very bottom of the display shows information and statistics for the selected tab. The type of markers shown in the waveform display area depend on the tab you have selected.

Depending on your settings, the tabs can show measurement results, mask test results, and vertical and horizontal scale and offset. You can even navigate through a serial data stream. If you have the optional EZJIT+ Jitter Analysis software, a Jitter tab shows the RJ DJ jitter measurement statistics.

Menu Overview

Menus are a part of the graphical user interface. You can use them to perform defined operations, set up measurement parameters, and access every function the oscilloscope provides.

File	Control	Setup	Trig	Control	Setup	Trigger	Measure	Anal	Setup	Trigger	Measure	Analyze	Utiliti
Load				Run			F5		1 Channel 1...			Ctrl+1	
Save				Stop			F6		2 Channel 2...			Ctrl+2	
Print...			Ctrl+P	Single			F10		3 Channel 3...			Ctrl+3	
E-mail Screen...				Clear Display			Alt+C		4 Channel 4...			Ctrl+4	
Minimize				Default Setup					D Digital...			Alt+D	
Exit				Factory Default					Probe Configuration...			Alt+P	
				Undo Default Setup					Probe Calibration...			Alt+P	
				Autoscale			Alt+A		Serial Decode...			Alt+S	
				Undo Autoscale			Alt+Shift+A		Serial Search...				
				Undo Zoom					H Horizontal...			Ctrl+H	
				Redo Zoom					Acquisition...			Ctrl+A	
				Tab Area					Display...			Ctrl+D	
									Waveform Memories...			Alt+M	

Trigger	Measure	Analyze	Utilities	Measure	Analyze	Utilities	Demos	He	Analyze	Utilities	Demos	Help
Setup Trigger...			Ctrl+T	Markers...			Ctrl+M		Math (FFT and more)...			
Shortcuts				QuickMeas			Ctrl+Q		Spectral (Basic)...			
Gallery...				Delete					Histogram...			
InfiniiScan...			Ctrl+I	Voltage					Mask Test...			
Trigger Save/Load...			Alt+T	Time					Measurement Analysis (EZJIT)...			
Conditioning...				Clock					Jitter / Noise (EZJIT Complete)...			
Trigger Action...				Data					Serial Data...			
Trigger Levels...				Mixed					Equalization...			
				Frequency Domain					De-embedding (InfiniiSim)...			
				Eye Pattern					Automated Test Apps			
				Histogram								
				Jitter / Noise (EZJIT Complete)...								
				Limit Test & Search...								
				Setup...								
				Thresholds...								
				Level Qualification...								

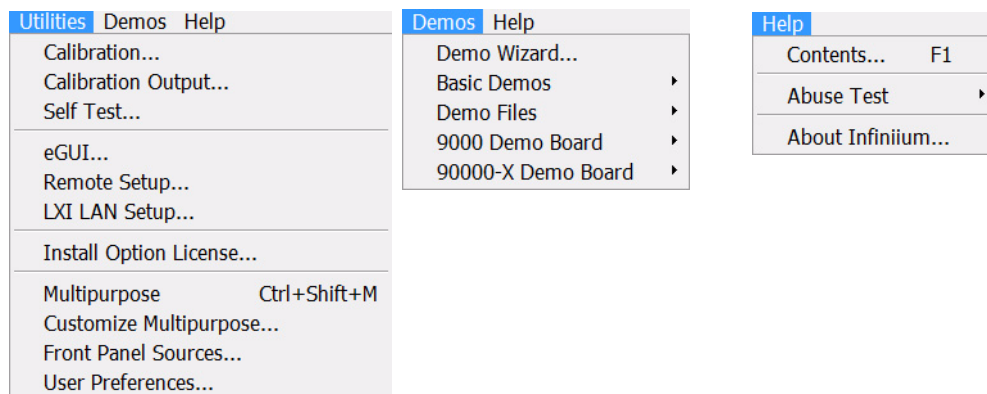


Figure 13 Infiniium Oscilloscope Menus

Look through the menus to get an overview of the many features and capabilities of your Infiniium oscilloscope. For example, the Demos menu selections include various demos that illustrate features of the scope.

Setting the Oscilloscope to a Known Starting Condition

You can set up the oscilloscope for many different kinds of complex measurements.



Figure 14 Setup Control Keys

- To automatically configure the oscilloscope for the current input signal(s), press the **[Auto Scale]** key or select **Control > Autoscale** from the menu bar.
- To reset the oscilloscope to its default setup, press the **[Default Setup]** key or choose **Control > Default Setup**.
- If you use the **[Default Setup]** key with the graphical interface enabled, you can choose **Control > Undo Default Setup** to return the oscilloscope to its original configuration.

NOTE

Save the Current Oscilloscope Configuration

Before using **[Default Setup]**, you may want to save the current oscilloscope configuration for later use. See the online help (described in chapter 3) for instructions on saving and recalling setups, and for information on the exact configuration that is set when you press **[Default Setup]**.

Starting and Stopping Waveform Acquisitions

Use the acquisition run controls to run and stop acquisitions or make a single acquisition. The highlighted area of the memory bar above the waveform display area shows how much of acquisition memory is displayed on the screen.

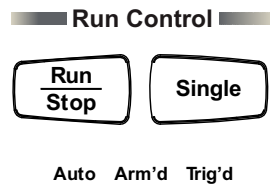


Figure 15 Front Panel Acquisition Run Control Keys

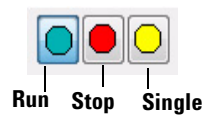


Figure 16 GUI Acquisition Run Control Buttons

The **[Run/Stop]** key is lit green and the blue-green Run button is highlighted when the oscilloscope is running (acquiring data). The **[Run/Stop]** key is red and the Stop button is highlighted when the acquisition is stopped.

- To start waveform acquisition, press the **[Run/Stop]** key or click the Run button.

The oscilloscope begins acquiring data. When it receives a trigger signal, it finishes acquiring data, updates the display, and then starts another acquisition cycle if it is in Trig'd or Auto trigger mode.

- To stop waveform acquisition, press the **[Run/Stop]** key or click the Stop button.

The oscilloscope stops acquiring data. Whatever data was last acquired remains on the screen.

- To make a single acquisition, press the **[Single]** key or click the Single button.

The **[Single]** key is lit yellow and the Single button is highlighted while the acquisition takes place.

- You can also choose the Run, Stop, and Single commands from the Control menu.
- To set up how you want the signals to be sampled, such as sampling rate and mode, choose **Setup > Acquisition**.

Adjusting the Horizontal Time Scale and Trigger Position

Use the horizontal controls to configure the oscilloscope's horizontal scale (time per division) and horizontal position of the waveform. You can also view a magnified section of the waveform using the zoom window.

You can use the horizontal scale and position knobs, the horizontal GUI controls, or the Horizontal Setup dialog box to adjust the horizontal scale and position.

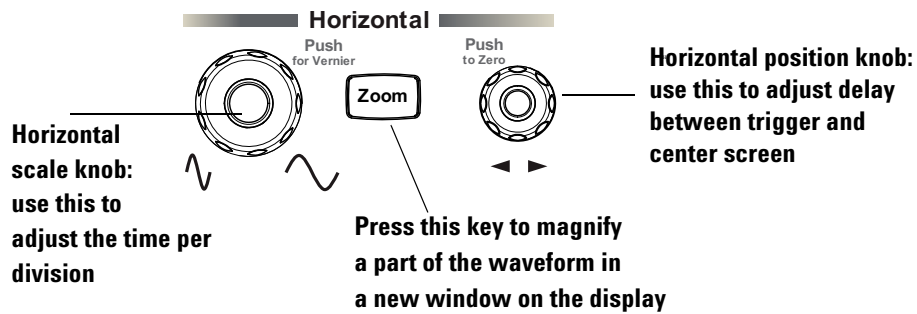


Figure 17 Horizontal Scale and Position Knobs, [Zoom] key

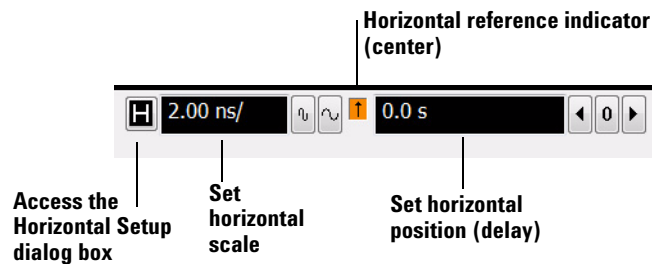


Figure 18 Horizontal GUI Controls

Adjusting the horizontal scale

- To stretch the waveform horizontally, turn the horizontal scale knob clockwise. To shrink it horizontally, turn the knob counter-clockwise.

The horizontal scale knob is the larger of the two horizontal control knobs. It is marked with a set of sine wave symbols. Stretching the waveform means there are fewer seconds displayed per division. Shrinking the waveform means there are more seconds displayed per division.

Push the horizontal scale knob to change the scaling in finer (Vernier) increments.

- You can also use the controls in the horizontal and trigger toolbar to adjust the horizontal scale. Click the horizontal scale field to display a pop-up numeric keypad that lets you set a particular horizontal scale.
- Or, you can use the two icons to the right. The left (smaller) icon shrinks the waveform, which decreases the horizontal scale and increases the time per division. The right icon stretches the waveform, which increases the horizontal scale and decreases the time per division.

Adjusting the horizontal trigger position (delay)

- To move the waveform to the right, turn the horizontal position knob clockwise. To move the waveform to the left, turn the knob counter-clockwise.

Moving the waveform to the right shows more of the pre-trigger data (data acquired before the trigger event). Moving the waveform to the left shows more of the post-trigger data (data acquired after the trigger event).

The horizontal position knob is the smaller of the two horizontal control knobs. It is marked with a set of arrows. There is a momentary pause at zero while you are turning the knob. Continuing to turn the knob will move the horizontal position through zero.

- When you click and drag the desired waveform, the horizontal position will change for all channels and functions on the display, but the waveform memories will not change.
- You can also use the controls in the horizontal and trigger toolbar to adjust the horizontal position. Click the horizontal position field to display a pop-up numeric keypad that lets you set a particular horizontal position (time relative to the trigger at the highlighted horizontal reference point). Or, you can use the three icons to the right. The left arrow moves the waveform to the left, the center “0” resets the horizontal position (delay) to zero, and the right arrow moves the waveform to the right.

Magnifying a part of the waveform using Zoom

- To turn on zoom, press the [Zoom] key.

The waveform display area splits into two regions. The top one is the main timebase. The bottom is the zoomed timebase, which represents an expansion of the acquired waveform data. A section of the waveform in the main sweep window is highlighted to indicate the part shown in the delayed sweep window.

The horizontal scale and horizontal position controls now change how the waveform is shown in the delayed sweep window. The horizontal scale will change the amount of magnification, while the position will change the part of the waveform in the main window that is shown in the zoomed window.


- Press the **[Zoom]** key again to turn it off.

Setting the horizontal reference point

- Click one of the three vertical arrows in the horizontal and trigger toolbar to set the horizontal position to the respective horizontal reference position on the display – left, center, or right. Assuming the horizontal position is at zero, left means the information on the display is post-trigger; center means the information to the left of center is pre-trigger and to the right is post-trigger; and right means the information is pre-trigger.
- A non-zero horizontal position value is the time relative to the trigger event at the selected horizontal reference point.

Using the Horizontal Setup dialog box

- You can use the Horizontal Setup dialog box to set scale, position, and the horizontal reference. You can also set up the delayed time base window, which presents a magnified view of an area of the waveform.

To access the Horizontal Setup dialog box, click the  in the Horizontal and Trigger toolbar, or choose **Setup > Horizontal** from the menu.

Adjusting the Vertical Settings

Use the vertical controls to set the vertical scaling (volts per division) and vertical offset for each analog channel. You can also turn the display on or off for a particular channel.

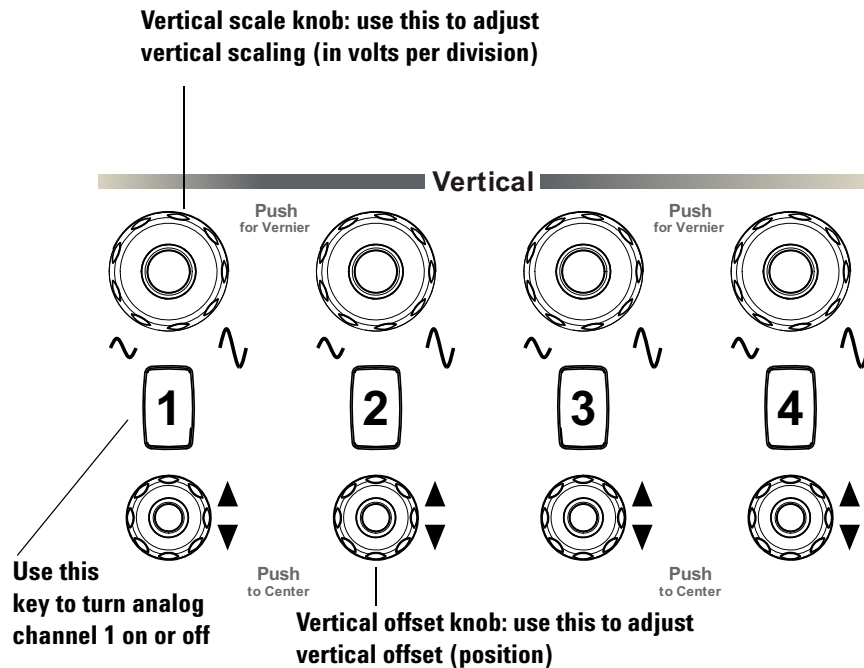


Figure 19 Channel Keys and Vertical Scale and Offset Knobs



Figure 20 GUI Vertical Controls

Turning an analog channel on or off

- To turn an analog channel on or off, press the channel number key or click the check box next to the channel number. When you turn off a channel, the current vertical scaling factor and scale buttons for that channel disappear.

If you are not using a particular analog channel, you can turn it off to simplify the waveform display and increase the display update rate. While an analog channel is turned off, data acquisition continues for that channel. Therefore, you can still use the analog channel as a source for functions.

NOTE

Using an Analog Channel as External Trigger

Any analog channel can be used as a trigger source. If you need an external trigger but do not need all analog channels, you can use an analog channel as an external trigger without displaying it by turning the analog channel display off.

Adjusting the analog channel's vertical scale and offset


- You can use the vertical scale and offset knobs, the vertical GUI controls, or the Channel Setup dialog box to adjust the vertical scale and offset.
- To make the waveform bigger (fewer volts per division), turn the vertical scale knob clockwise. To make it smaller (more volts per division), turn the knob counter-clockwise.

The vertical scale knob is the larger of the two knobs for a channel. It is marked with a set of sine wave symbols. Decreasing the vertical scale makes the waveform bigger, with fewer volts displayed per division. Increasing the vertical scale makes the waveform smaller, with more volts displayed per division.


- You can also click in the vertical scaling field to open a pop-up numeric keypad that lets you set an exact value for the scaling. Click the two icons next to the field to make the waveform bigger or smaller.
- To move the waveform toward the top of the display, turn the vertical offset knob clockwise. To move it toward the bottom of the display, turn the knob counter-clockwise. The vertical offset knob is the smaller of the two knobs for a channel. It is marked with a set of arrows.
- You can click and drag the ground reference indicator for the waveform you want to move to the desired offset.
- Choose **Setup > Channel N** from the menu bar or click a channel number to open the Channel Setup dialog box, in which you can set the vertical scaling, offset, skew, and labels. You can also specify the characteristics of a probe, or perform a probe calibration.

For Agilent Technologies probes that are compatible with AutoProbe II interfaces, the oscilloscope will automatically set these characteristics (except for skew) after identifying the probe when it is connected to the channel input.

Turning digital channels on or off

- To turn the digital channels on, click the check box next to the  at the right end of the toolbar.

Controlling digital channels

- If your oscilloscope is an MSO model, press the  button to open the Digital Setup dialog box so you can control the digital thresholds and four digital buses, enable active channels, turn on signal names, and change the vertical height of digital channels.

Setting Up Triggers

Use the trigger controls to set the conditions on which the oscilloscope will trigger and acquire an input signal. You can set up a variety of trigger conditions. Edge triggers and the parameters for edge triggering can be set up from the front panel.

Trigger configuration settings you make using the graphical interface are reflected in the front-panel status indicators, and will remain set unless you change them (either using the front panel or the graphical interface) or press the **[Default Setup]** key.

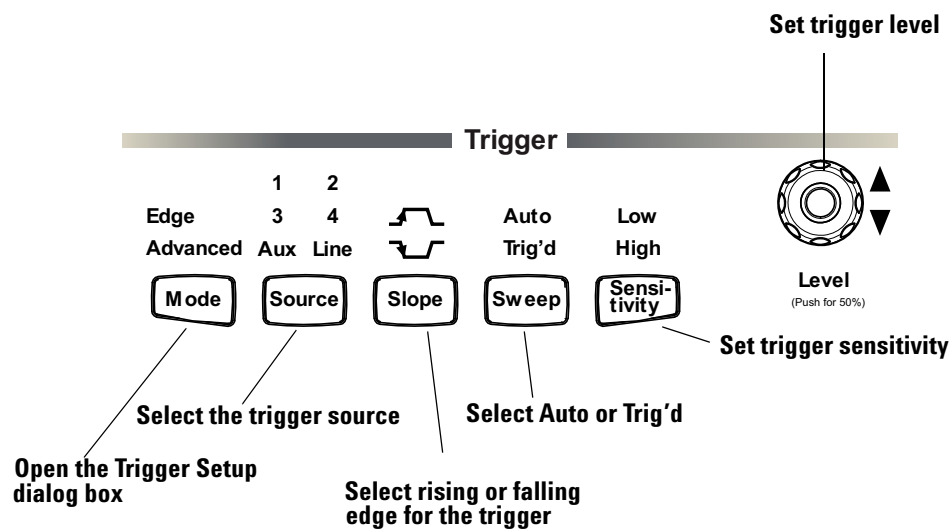


Figure 21 Trigger Controls and Indicators

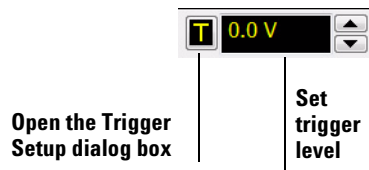


Figure 22 Trigger GUI Controls

Setting the oscilloscope to trigger on an edge

- 1 Press the **[Source]** key until the desired source LED is illuminated.

You can choose any of the channels or the **Aux Trig** or **Line** input as the source for an edge trigger.

- 2 Press the **[Slope]** key until the desired slope LED is illuminated.

You can have an edge trigger on a rising or falling edge.

- 3 Press the [**Sweep**] key until the Trig'd or Auto (select one) LED is lit.

When Trig'd is selected, the oscilloscope must find the trigger before saving and displaying captured data.

When Auto is selected, if a trigger does not occur within a certain amount of time, an acquisition is automatically saved and displayed. In Auto trigger mode, you are able to see your signals while setting up the desired trigger.

- 4 Turn the Level knob to adjust the voltage level at which the oscilloscope will trigger.

Use the Trigger Setup dialog box to select any of the different modes of triggering, the parameters and conditions for each trigger mode, and advanced configuration items.

You can also click in the Set Trigger Level field to open a pop-up numeric keypad so you can set a particular trigger level when the scope is set for edge trigger on a particular channel. You can also use the up and down arrows to the right of the setting, or click and drag the trigger reference indicator at the right side of the display.

Using Markers and Making a Measurement

With the measurement controls you can display and adjust markers, define a key to perform automatic measurements or perform other quick actions, and make measurements.

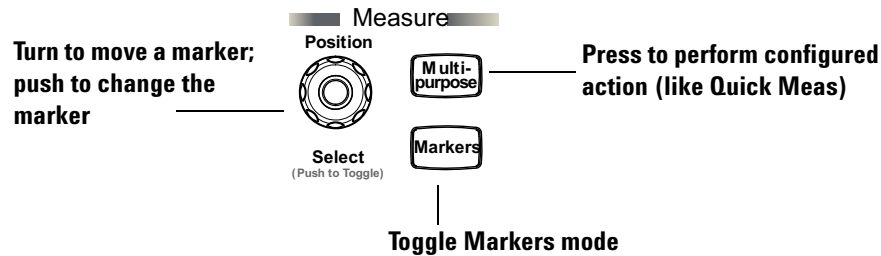


Figure 23 Measure Controls

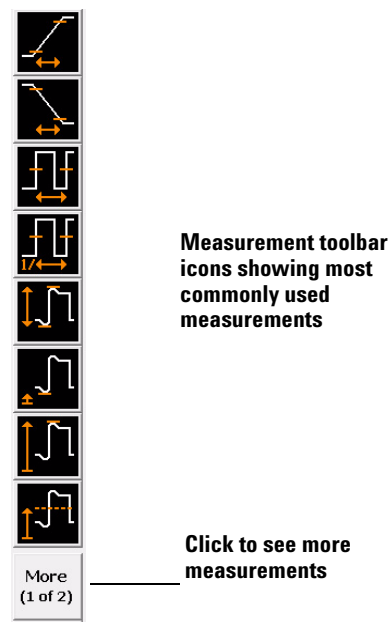


Figure 24 GUI Measurement Toolbar

Making a measurement on a waveform

- Click and drag a measurement icon to the waveform event you want to measure, or click a measurement icon and specify which source you want to measure in the dialog box that appears.

For measurements on waveform features, such as those that involve waveform edges, if you click the measurement icon and specify a source, the measurement defaults to using the feature closest to the

horizontal reference point. When you make the measurement using drag-and-drop, the measurement uses the waveform feature closest to the point where you drop the icon.

The most commonly used measurements are available on the toolbar. Others are available by selecting them from the Measure menu.

When you drag and drop a measurement icon on a waveform, the icon outline changes color to match the color of each waveform it touches so you can easily see which waveform will be measured when you release. The measurement results are also displayed in color so you can easily see which waveform source is being measured.

For edge-sensitive measurements, when you drop the measurement icon on a waveform, a geometric icon appears in the waveform marker color. This icon shows exactly where the measurement is being made. The icon is also displayed next to the measurement results readout to associate the readout with the waveform and feature being measured.

This feature helps you distinguish measurement results from each other when you make multiple measurements on the same waveform, but at different waveform features. For example, a series of rise time measurements on several different edges of the same waveform all have unique geometric icons to show each measurement's location. See Figure 25.

2 Using the Oscilloscope

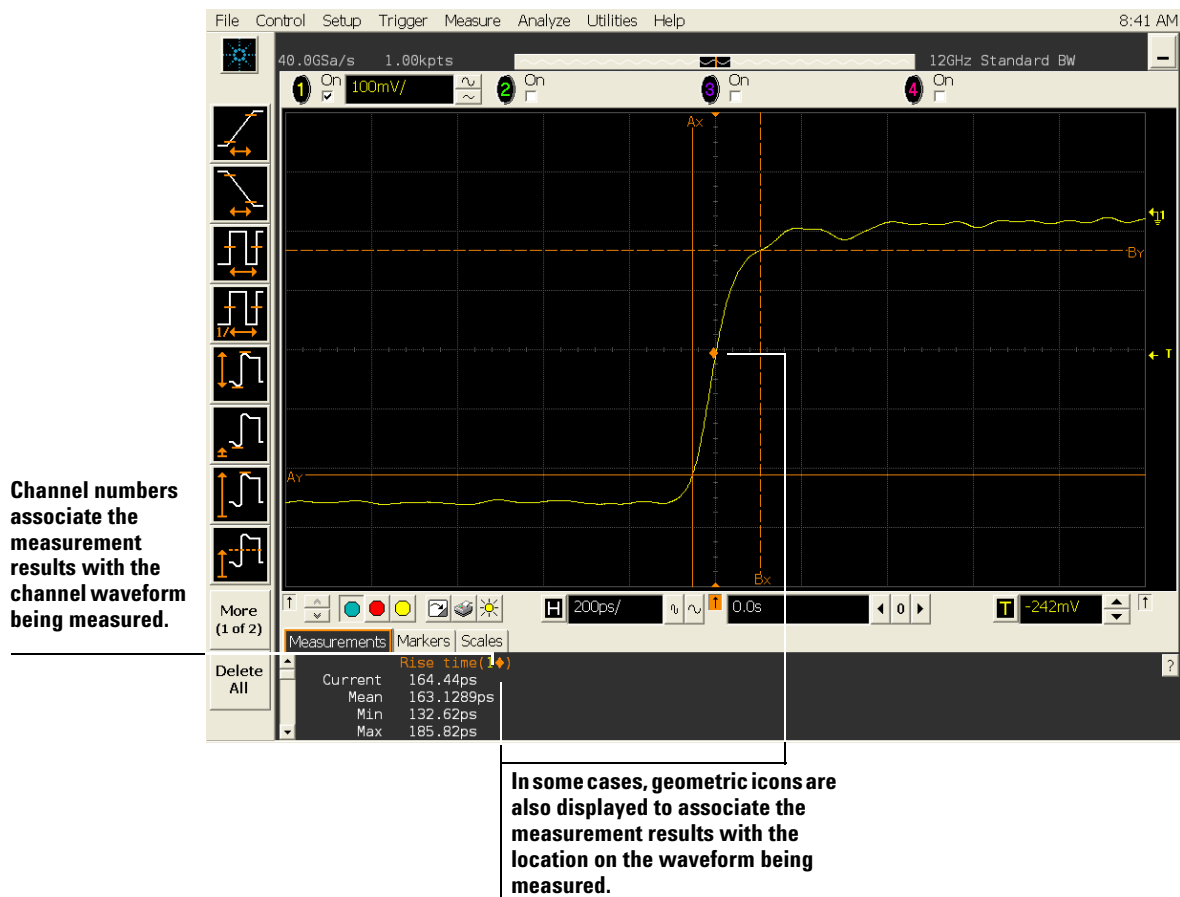


Figure 25 Waveform Measurements

Using quick measurements

- You can define the **[Multi Purpose]** key to perform one of these quick actions:
 - QuickMeas – performs automatic measurements
 - QuickPrint – prints the screen image to the default printer
 - QuickScreen – saves the screen image to a file
 - QuickSetup – loads a setup file
 - QuickWaveform – saves waveform data to a file
 - QuickE-mail – sends an e-mail of the current screen image
 - QuickExecute – runs an executable file
 - QuickControl – cycles through the possible front panel control sources

The action taken when the **[Multi Purpose]** key is pressed depends on the feature selected in the Customize Multipurpose dialog box. The default feature is QuickMeas (quick measurements).

- To turn on the quick measurement display, press the **[Multi Purpose]** key.

The five preset measurements defined in the Quick Measurement configuration are enabled and results are displayed on the screen for the first waveform source. The factory default measurements are: Vp-p, Period, Frequency, Rise time, and Fall time.

- To measure parameters for another waveform, press the **[Multi Purpose]** key until that waveform is the one shown in the measurement readout.

Continuing to press the **[Multi Purpose]** key cycles through each of the waveforms available.

- To turn off the quick measurement display, press and release the **[Multi Purpose]** key until the measurements are turned off.

The measurement results disappear from the screen.

See the Infiniium oscilloscope application's online help for information on how to configure the quick measurement capability, using the Customize Measurement feature of the graphical interface.

Using markers

Markers make it easier to make precise measurements because the marker measurement readouts show exact voltage and time positions for the markers. The measurements are based on actual waveform data from the acquisition system, not on approximations based on the display position, so you can be sure the values are highly accurate.

Using the marker and measurement controls, you control two sets of markers within the oscilloscope graticule. You use markers to make more accurate measurements of waveform events than you could make visually.

Both time and voltage differences between the markers are updated continuously on the screen. By default, the markers track the source waveform. Voltage measurements from the markers are the value of the waveform at the time set with the marker arrow keys.

- To select the type of marker mode you want to use, press the **[Markers]** key and select the mode in the pop-up dialog box. Do not close the dialog box.
- To turn on Marker A, push the Position knob until the marker you want to move appears in the pop-up dialog box.

Marker A has a solid line pattern on the waveform display. It is associated with the first available source on the display.

- To turn on Marker B, push the Position knob until the marker you want to move appears in the pop-up dialog box.

Marker B has a dashed line pattern on the waveform display. It is associated with the first available source on the display.

- To move a marker, turn the Position knob.

In Measurement Marker mode, the marker position cannot be changed.

Moving markers using the graphical interface

- 1 Turn on the markers either by pressing the [**Markers**] key on the front panel or by choosing **Measure > Markers**.
- 2 Click and drag one of the markers to the position you want on the waveform, then release.

Clicking and dragging a marker makes it easy to quickly move the marker to the desired waveform event. You can use the front-panel Position knob for fine adjustment, or choose the Markers command from the Measure menu and set the marker position precisely.

Controlling the Display

You can set the display to suit your preferences, such as by enabling the touch screen or adjusting the intensity of the displayed waveform.

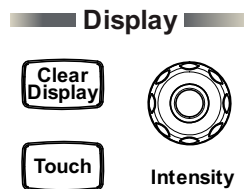


Figure 26 Display Control Keys and Knob

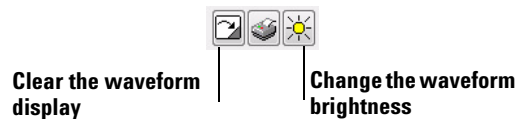


Figure 27 GUI Display Control Buttons

Enabling or disabling the touch screen

- Press the **[Touch]** key.
- Or, choose **Setup > Display** to open the Display Setup dialog box and click the Touch Screen check box.

Clearing the waveform display

- Press the **[Clear Display]** key or press the Clear Display button.

The oscilloscope clears acquired waveform data from the display in preparation for another acquisition. If the oscilloscope is in Run mode and is receiving triggers, it will update the display as it collects new waveform data.

Clearing the waveform display also resets averaging, infinite persistence, color grade persistence, histograms, and the mask testing database.

Adjusting the brightness of the displayed waveform

- Turn the Intensity knob or press the Waveform Brightness button.

Saving and Printing Data

- Choose **File > Save** from the menu bar to save your setup, composite, waveform, screen, or measurement data.
- Press the Print Screen button in the Horizontal and Trigger toolbar to print the screen to the default printer configuration selected in the Windows Control Panel.
- Choose **File > Print** from the menu bar to print waveform and setup data to a specified file.
- You can also customize the **[Multi Purpose]** key to perform a QuickPrint.

Forcing a Default Setup

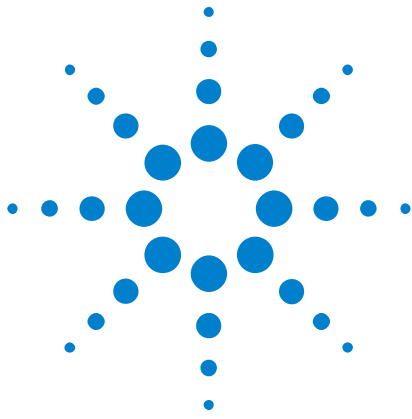
If your Infiniium oscilloscope is not working properly when you start it up and pressing **[Default Setup]** does not fix the problem, follow these steps to force a default setup and return the Infiniium to normal operation.

- 1 Turn off the Infiniium.
- 2 Turn on the Infiniium. If the oscilloscope does not successfully restart then try recycling the power again.
- 3 After the Windows 7 load screen disappears, press the **[Default Setup]** key on the front panel. If the oscilloscope still does not successfully restart, follow the instructions for recovering the hard drive.

Infiniium Hard Drive Recovery

Follow these steps to recover your Infiniium hard drive.

- 1 Turn off the Infiniium.
- 2 Connect the keyboard to the keyboard connector on the rear panel of the oscilloscope.
- 3 Connect the mouse to the mouse connector on the rear panel of the oscilloscope.
- 4 Turn on the Infiniium.
- 5 When you see the message **press F2 to boot the Infiniium Recovery System**, press F2 and follow the on-screen instructions.
- 6 Once the recovery process is finished and the oscilloscope is running, check in the About Infiniium dialog box under installed options to see if all of the options you ordered are installed. If the options are not installed, please install them using the license keys provided on the oscilloscope option license certificates you received, or refer to the rear panel of the oscilloscope.



3 Using the Online Help

- Accessing the online help 55
- Navigating through the online help 57
- Accessing context-sensitive information 57

Most of the information about using the Infiniium oscilloscope is included in the online help.

The online help is accessible from the menu bar and from dialog boxes. This chapter explains how to use the help to find the information you need to use the oscilloscope effectively.

Accessing the online help

- Select Contents from the Help menu.

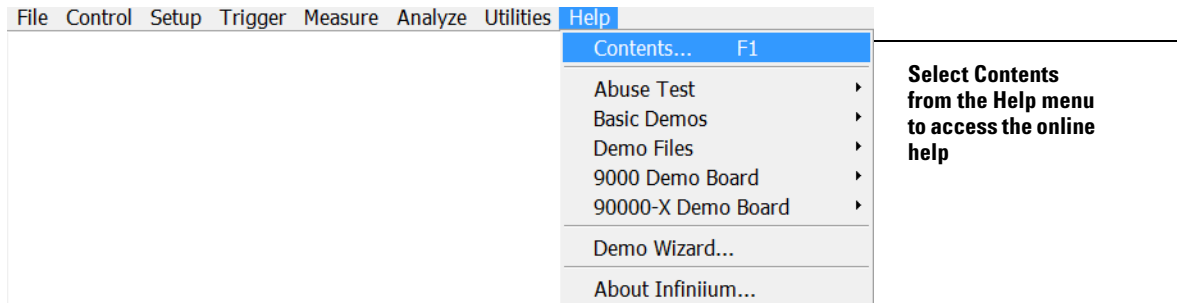


Figure 28 Help Menu

The Using the Oscilloscope topic appears on the home page. It looks like the following figure.



3 Using the Online Help

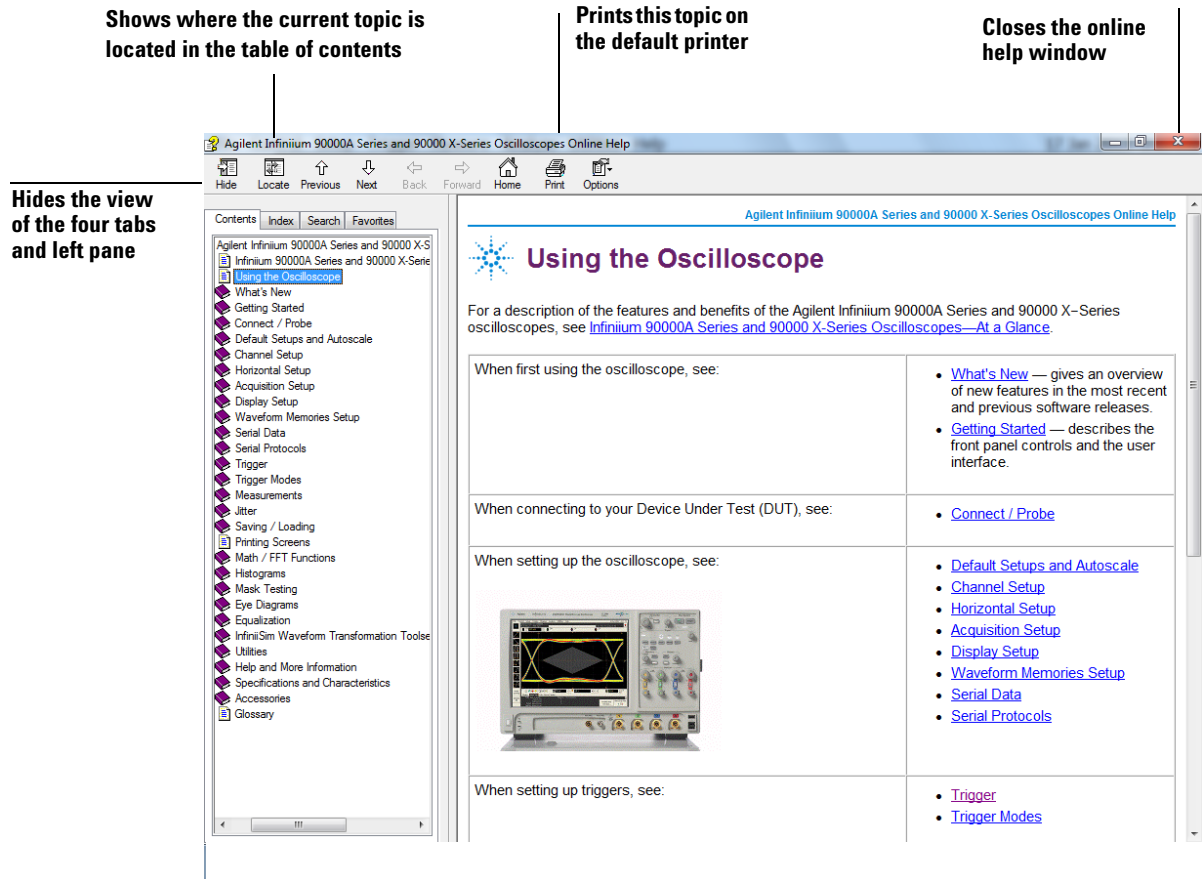


Figure 29 Online Help Home Page

NOTE

Viewing the Online Help Window

The online help window will always stay on top of the interface display, so you can refer to it while working with the oscilloscope. You can move the window around the screen or resize it to make it easier to use.

The online help provides several ways to find the information you need.

With the Contents tab you can browse topics in the help system by clicking topics in the left pane.

With the Index tab you can type in a keyword and search the index for that keyword or scroll through the list to find a topic.

With the Search tab you can type in a keyword and if that word exists in the online help, a list of topics containing the keyword appears.

With the Favorites tab you can add preferred help topics to a list for easy referral.

Hyperlinks throughout the online help allow you to reach the information you need. Most hyperlinks are in blue underlined text, but some hyperlinks also have buttons (many of the reference topics) or tabs (in setup guide topics). You can find out whether an item has a hyperlink by pointing to it; if it is a hyperlink, the pointer will change to a hand icon. Clicking once will make a new topic appear.

Navigating through the online help

Once you are in an online help window, you may need to navigate to find the information you need.

For most topics:

- To display information for another topic or category described in a hyperlink, click that hyperlink or the button icon next to it.
- To return to the previously visited topic, click the Back button near the top of the Help window.

Accessing context-sensitive information

- To see overview information for items in a dialog box, click the Help button in that dialog box.

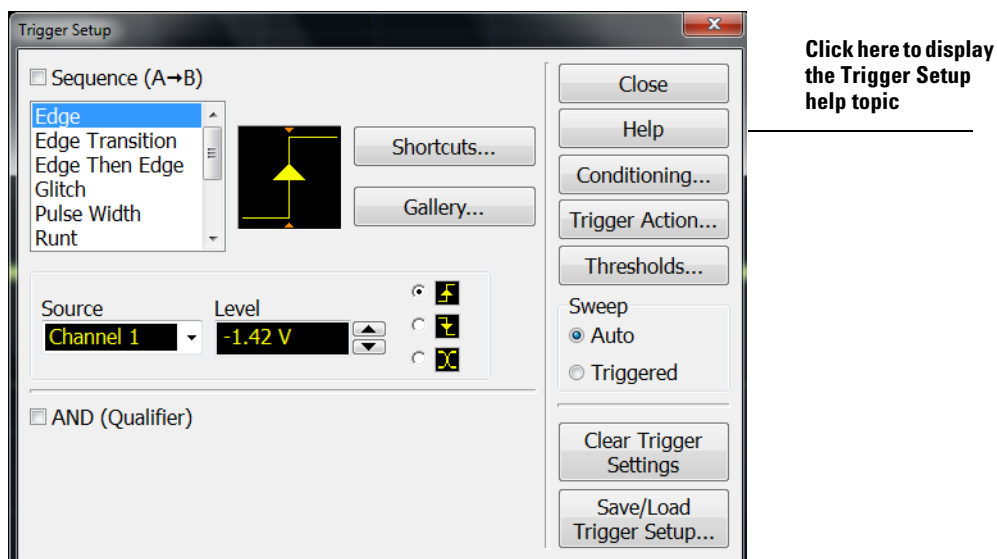
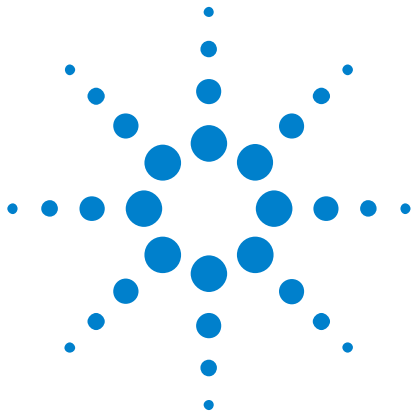


Figure 30 GUI Help Buttons for Context-Sensitive Help



A Safety Notices

Warnings 59

Safety Symbols 60

This apparatus has been designed and tested in accordance with UL 61010-1:2004 2nd Edition, 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

- The mains plug shall be inserted only 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.
- Whenever it is likely that the ground protection is impaired, you must make the instrument inoperative and secure it against any unintended operation.
- 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, or the protection provided by the equipment may be impaired.



Safety Symbols



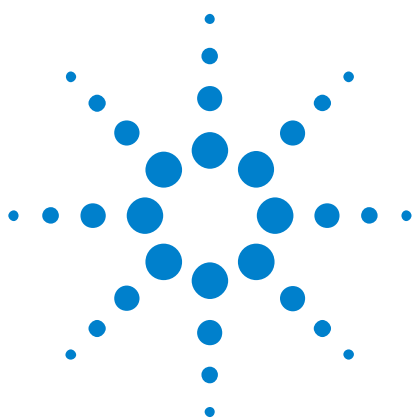
Instruction manual symbol: the product is marked with this symbol when it is necessary for you to refer to the instruction manual in order to protect against damage to the product.



Hazardous voltage symbol.



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



B Working in Comfort

About Repetitive Strain Injury [62](#)

Mice and Other Input Devices [63](#)

To optimize your comfort and productivity, it is important that you set up your work area correctly and use your Infiniium oscilloscope properly. With that in mind, we have developed some setup and use recommendations for you to follow based on established ergonomic principles.

Improper and prolonged use of keyboards and input devices are among those tasks that have been associated with repetitive strain injury (RSI) to soft tissues in the hands and arms. If you experience discomfort or pain while using the oscilloscope, discontinue use immediately and consult your physician as soon as possible. For more information on RSI, read the “About Repetitive Strain Injury” section, next.

Please study the recommendations offered here in this chapter. Included are references to relevant parts of international standards, regulations, and guidelines, such as ISO 9241 and the European Community Display Screen Equipment directive. You may also consult your employer's human resources department or other relevant departments for guidance specific to your company.



About Repetitive Strain Injury

Because your comfort and safety are our primary concern, we strongly recommend that you use the Infiniium oscilloscope in accordance with established ergonomic principles and recommendations. Scientific literature suggests that there may be a relationship between injury to soft tissues—especially in the hands and arms—and prolonged improper use of keyboards or other equipment requiring repeated motions of the hands and forearms. This literature also suggests that many other risk factors may increase the chance of such injury, commonly called Repetitive Strain Injury.

What is RSI?

Repetitive Strain Injury (RSI—also known as cumulative trauma disorder or repetitive motion injury) is a type of injury where soft tissues in the body, such as muscles, nerves, or tendons, become irritated or inflamed. RSI has been a reported problem for those who perform repetitive tasks such as assembly line work, meatpacking, sewing, playing musical instruments, and computer work. RSI also has been observed in those who frequently engage in activities such as carpentry, knitting, housework, gardening, tennis, windsurfing, and lifting children.

What causes RSI?

The specific causes of RSI have not been established. Nevertheless, the incidence of RSI has been associated with a variety of risk factors, including:

- Too many uninterrupted repetitions of an activity or motion
- Performing an activity in an awkward or unnatural posture
- Maintaining static posture for prolonged periods
- Failing to take frequent short breaks
- Other environmental and psychosocial factors

In addition, there have been reports associating the occurrence of RSI with the use of keyboards, mice, and other input devices. Also, certain medical conditions, such as rheumatoid arthritis, obesity, and diabetes, may predispose some people to this type of injury.

What if I experience discomfort?

If you are experiencing any discomfort, seek professional medical advice immediately. Typically, the earlier a problem is diagnosed and treated, the easier it is to resolve.

Mice and Other Input Devices

Various aspects of using mice and other input devices may increase your risk of discomfort or injury. Observing the following recommendations may reduce that risk.

- Try to keep your hand, wrist, and forearm in a neutral position while using your mouse or other input device.
- If you use your thumb to rotate the ball on a trackball or spaceball, keep it in a relaxed, natural shape, and maintain a neutral posture in your hand, wrist, and forearm.
- Hold the mouse gently by draping your fingers over it. Keep your hand relaxed and fingers loose. Do not grip the mouse tightly.
- It takes very little pressure or force from your fingers to activate the buttons or scroll wheel on your mouse, scrolling mouse, trackball, or other input device. Using too much force can place unnecessary stress on the tendons and muscles in your hands, wrists, and forearms.
- If you are using a scrolling mouse, be sure to keep your fingers and hand in a relaxed, neutral position when activating the scroll wheel. Also, this type of mouse features software that can minimize the number of mouse movements or button clicks.
- When using a mouse, trackball, or other input device, position it as close to the keyboard as possible, and keep it at the same level so you do not have to stretch while using it.
- Be sure to keep your mouse and trackball clean. Regular removal of accumulated dust and dirt helps ensure proper tracking and reduces unnecessary hand and wrist motions.

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