PicoScope® 9400 Series

SXRTO Sampler-extended real-time oscilloscopes

Key features

5 GHz bandwidth, 70 ps transition time
1 TS/s (1 ps) equivalent-time sampling
Four 12-bit 500 MS/s ADCs
Up to 2 million triggered captures per second
Pulse, eye and mask testing to 70 ps and 3 Gb/s
Logical, intuitive and configurable touch-compatible Windows user interface
Comprehensive built-in measurements, zooms, data masks and histograms
±800 mV full-scale input range into 50 ohms
±10 mV/div to ±0.25 V/div ranges provided by digital gain
Up to 250 kS trace length, shared between channels

Product overview

The PicoScope 9404 has four high-bandwidth 50 Ω input channels with market-leading ADC, timing and display resolutions for accurately measuring and visualizing high-speed analog and data signals. It is ideal for capturing pulse and step transitions to 70 ps, impulse down to 140 ps, clocks and data eyes to 3 Gb/s. Most high-bandwidth applications involve repetitive signals or clock-related data streams that can be readily analyzed by equivalent-time sampling (ETS).

The SXRTO is fast: ETS, persistence displays and statistics all build quickly, with fast acquisitions running at up to 2 million triggered captures per second.

The PicoScope 9404 has a built-in full-bandwidth trigger on every channel, with pretrigger ETS capture to well above the Nyquist sampling rate. The oscilloscope has 5 GHz bandwidth behind a 50 ohm SMA(f) input, and there are three acquisition modes—real time, ETS and roll—all capturing at 12-bit resolution into a shared memory of up to 250 kS.

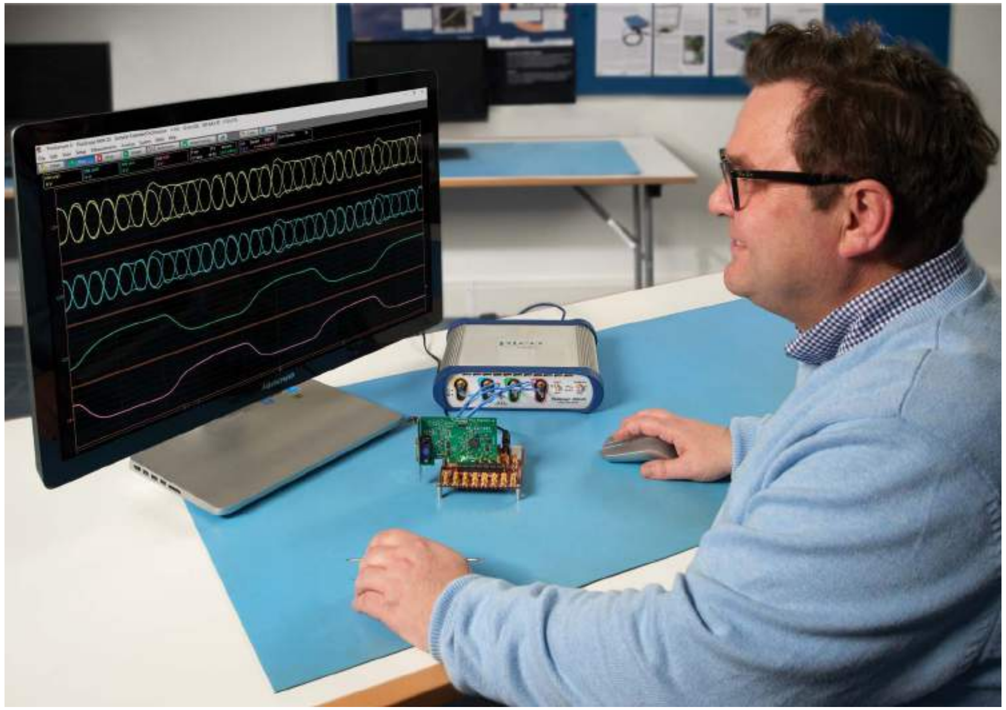
The PicoSample 4 software is derived from our existing PicoSample 3 and PicoScope 9000 products, which together embody over ten years of development, customer feedback and optimization.

The high-resolution display can be resized to fit any window, filling 4k and even larger or multiple monitors. Four independent zoom channels can show you different views of your data down to a resolution of 1 ps. Most of the controls and status panels can be shown or hidden according to your application, allowing you to make optimal use of the display area.

The oscilloscope has a 2.5 GHz direct trigger that can be driven from any input channel, and a built-in prescaler can extend the trigger bandwidth to 5 GHz. The price you pay for your PicoScope SXRTO is the price you pay for everything – we don't charge you for software features or updates.

Typical applications

- Telecom and radar test, service and manufacturing
- Optical fiber, transceiver and laser testing (optical to electrical conversion not included)
- RF, microwave and gigabit digital system measurements
- Signal, eye, pulse and impulse characterization
- Precision timing and phase analysis
- Digital system design and characterization
- Eye diagram, mask and limits test to 3 Gb/s
- Ethernet, HDMI 1, PCI, SATA and USB 2.0
- Semiconductor characterization
- Signal, data and pulse/impulse integrity and pre-compliance testing



ETS (equivalent-time sampling)

PicoScope 9400 Series SXRTOs use equivalent-time sampling (ETS) to capture high-bandwidth repetitive or clock-derived signals without the expense or jitter of a very high-speed real-time oscilloscope. The 5 GHz bandwidth is matched by a guaranteed 70 ps rise time, better than some instruments with equal or even higher bandwidths. ETS mode enables timing resolution down to 1 ps, and can quickly build waveforms with up to 2 million triggers per second.

Frequency counter

A dedicated frequency counter shows signal frequency (or period) at all times, regardless of measurement and timebase settings, with a resolution of 1 ppm.

Trigger modes

Simply feed your signal into one of the input channels

The oscilloscope has a 2.5 GHz direct trigger that can be driven from any input channel, and a built-in prescaler can extend the trigger bandwidth to 5 GHz.

Bandwidth limit filters

A selectable analog bandwidth limiter (100 or 500 MHz) on each input channel can be used to reject high frequencies and associated noise. The narrow setting can be used as an anti-alias filter.

SXRTO explained

The basic real-time oscilloscope

Real-time oscilloscopes (RTOs) are designed with a high enough sampling rate to capture a transient, non-repetitive signal with the instrument's specified analog bandwidth. According to Nyquist's sampling theorem, for accurate capture and display of the signal the scope's sampling rate must be at least twice the signal bandwidth. Typical high-bandwidth RTOs exceed this sampling rate by perhaps a factor of two, achieving up to four samples per cycle, or three samples in a minimum-width impulse.

Equivalent-time sampling

For signals close to or above the RTO's Nyquist limit, many RTOs can switch to a mode called equivalent-time sampling (ETS). In this mode the scope collects as many samples as it can after a trigger event, and then continues to collect samples on subsequent trigger events. Because the scope's sampling clock is independent of the trigger event, each trigger has a random time offset relative to the scope's clock. The scope measures this offset and displays the samples at their correct times. After a large number of trigger events the scope has enough samples to display the waveform with the desired time resolution, called the effective sampling resolution (the inverse of the effective sampling rate), which is many times higher than is possible in real-time (non-ETS) mode. As this technique relies on a random relationship between trigger events and the sampling clock, it is more correctly called *random equivalent-time sampling* (or sometimes *random interleaved sampling*, RIS). It can only be used for repetitive signals – those that vary little from one trigger event to the next.

Uniquely, the PicoScope 9404 SXRTO has a maximum effective sampling rate in ETS of 1 TS/s. This corresponds to a timing resolution of only 1 ps, 20,000x higher than its actual maximum sampling rate.

The sampler-extended real-time oscilloscope (SXRTO)

Now that we have a technique (ETS) for extending the sampling rate of a real-time oscilloscope, we find that we can achieve an effective sampling rate far higher than is needed to match the instrument's analog bandwidth. In order to make better use of these high effective sampling rates, we can increase the analog bandwidth of the scope. Pico has developed a way to achieve this at a moderate cost, compared to the very high cost of increasing the real-time sampling rate. The result is the sampler-extended real-time oscilloscope (SXRTO).

The PicoScope 9404-05 SXRTO has an analog bandwidth of 5 GHz. This means that it requires a sampling rate of at least 10 GS/s, but for an accurate reconstruction of wave shape without interpolation, we need far higher than this. The 9404 gives us 200 sample points in a single cycle at 5 GHz and 140 points in a minimum-width impulse.

So is the SXRTO a sampling scope?

All this talk of sampling rates and sampling modes may suggest that the SXRTO is a type of sampling scope, but this is not the case. The name sampling scope, by convention, refers to a different kind of instrument. A sampling scope uses a programmable delay generator to take samples at regular intervals after each trigger event. The technique is called *sequential equivalent-time sampling* and is the principle behind the PicoScope 9300 Series sampling scopes. These scopes can achieve very high effective sampling rates but have two main drawbacks: they cannot capture data before the trigger event, and they require a separate clock signal – either from an external source or from a built-in clock-recovery module.

	Real-time scope	SXRTO	Sampling scope
Model	PicoScope 6407	PicoScope 9404-05	PicoScope 9300 Series
Analog bandwidth	1 GHz*	5 GHz	20 GHz
Real-time sampling?	1 GS/s	500 MS/s	1 MS/s
Sequential equivalent-time sampling?	No	No	15 TS/s
Random equivalent-time sampling?	100 GS/s	1 TS/s	250 MS/s
Trigger on input channel?	Yes	Yes	No** – requires external clock or internal clock recovery option
Pretrigger capture?	Yes	Yes	No**
Vertical resolution	8 bits	12 bits	16 bits
Cost†	$10k	$15k	$22k

* Higher-bandwidth real-time oscilloscopes are available from other manufacturers. For example, a 5 GHz analog bandwidth, 25 GS/s sampling model is available for about $57,000.
**These functions are possible at low sampling rates, up to 1 MS/s.
†2019 prices

We've compiled a table to show the differences between the types of scopes mentioned on this page. The example products are all compact, 4-channel, USB PicoScopes.

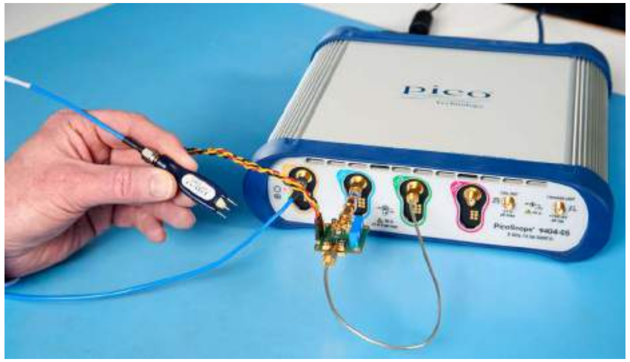
PicoConnect® 900 Series high-frequency passive probes

The PicoConnect 900 Series is a range of minimally invasive, high-frequency passive probes, designed for microwave and gigabit applications up to 9 GHz and 18 Gb/s. They deliver unprecedented performance and flexibility at a low price and are an obvious choice to use alongside the PicoScope 9400 Series scopes.

Features of the PicoConnect 900 Series probes

- Extremely low loading capacitance of < 0.3 pF typical, 0.4 pF upper test limit for all models
- Slim, fingertip design for accurate and steady probing or solder-in at fine scale
- Interchangeable SMA probe heads at division ratios of 5:1, 10:1 and 20:1, AC or DC coupled
- Accurate probing of high-speed transmission lines for $Z_0 = 0\ \Omega$ to $100\ \Omega$
- Class-leading uncorrected pulse/eye response and pulse/eye disturbance

The PicoScope 9404 is supplied either without probes or with a PicoConnect 910 kit consisting of all six PicoConnect 4 to 5 GHz RF microwave and pulse probes to support probing at three division ratios (/5, /10, /20) and either AC or DC coupled models and cables.



Software

Application-configurable PicoSample 4 oscilloscope software

The PicoSample 4 workspace takes full advantage of your available simgle or multiple display size and resolution, allowing you to resize the window to fit any display resolution supported by Windows.

You decide how much space to give to the trace display and the measurements display, and whether to open or hide the control menus. The user interface is fully touch- or mouse-operable, with grabbing and dragging of traces, cursors, regions and parameters. In touchscreen mode, an enlarged parameter control is displayed to assist adjustments on smaller touchscreen displays.

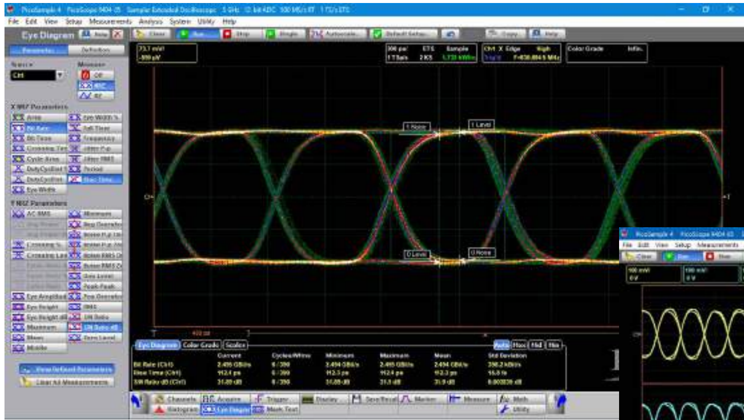
To zoom, either draw a zoom window or use the numerical zoom and offset controls. You can display up to four different zoomed views of the displayed waveforms.

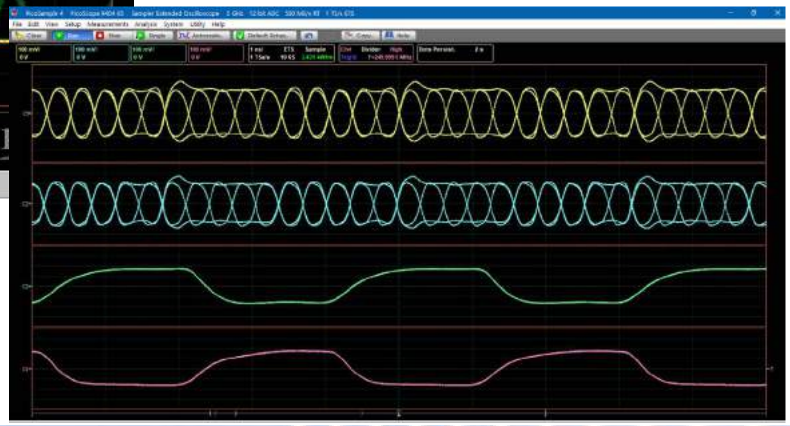
“Hidden trace” icons show a live view of any channels that are not visible on the main display.

The interaction of timebase, sampling rate and capture size is normally handled automatically, but there is also an option to override this and specify the order of priority of these three parameters.

A choice of screen formats

When working with multiple traces, you can display them all on one grid or separate them into two or four grids. You can also plot signals in XY mode with or without additional voltage-time grids. The persistence display modes use color-contouring or shading to show statistical variations in the signal. Trace display can be in either dots-only or vector format and display settings can be independent, trace by trace. Custom trace labelling is also available.





PicoSample 4 software

The PicoSample 4 software interface provides access to commands that control all of the instrument features and functions.

Display area
Within this area you can view live, reference and math waveforms. You can drag to waveforms to reposition them and draw zoom boxes. A **T** icon can be dragged to change the trigger level for the selected trigger source. You can also drag markers to measure waveforms on the screen. On-screen controls can be hidden to increase display area.

System controls
You can select whether the oscilloscope is running or stopped. Other buttons allow oscilloscope reset to default status, **Autoscale** or erase waveforms from the display.

Status area
This area displays acquisition status, mode and number of acquisitions. Also displayed are trigger status, date, time and quick reference to record length and horizontal parameters.

Histogram window
This window determines which part of the database is used to analyze and display the histogram (in red). You can set the size and position of this window within the horizontal and vertical scaling limits of the oscilloscope.

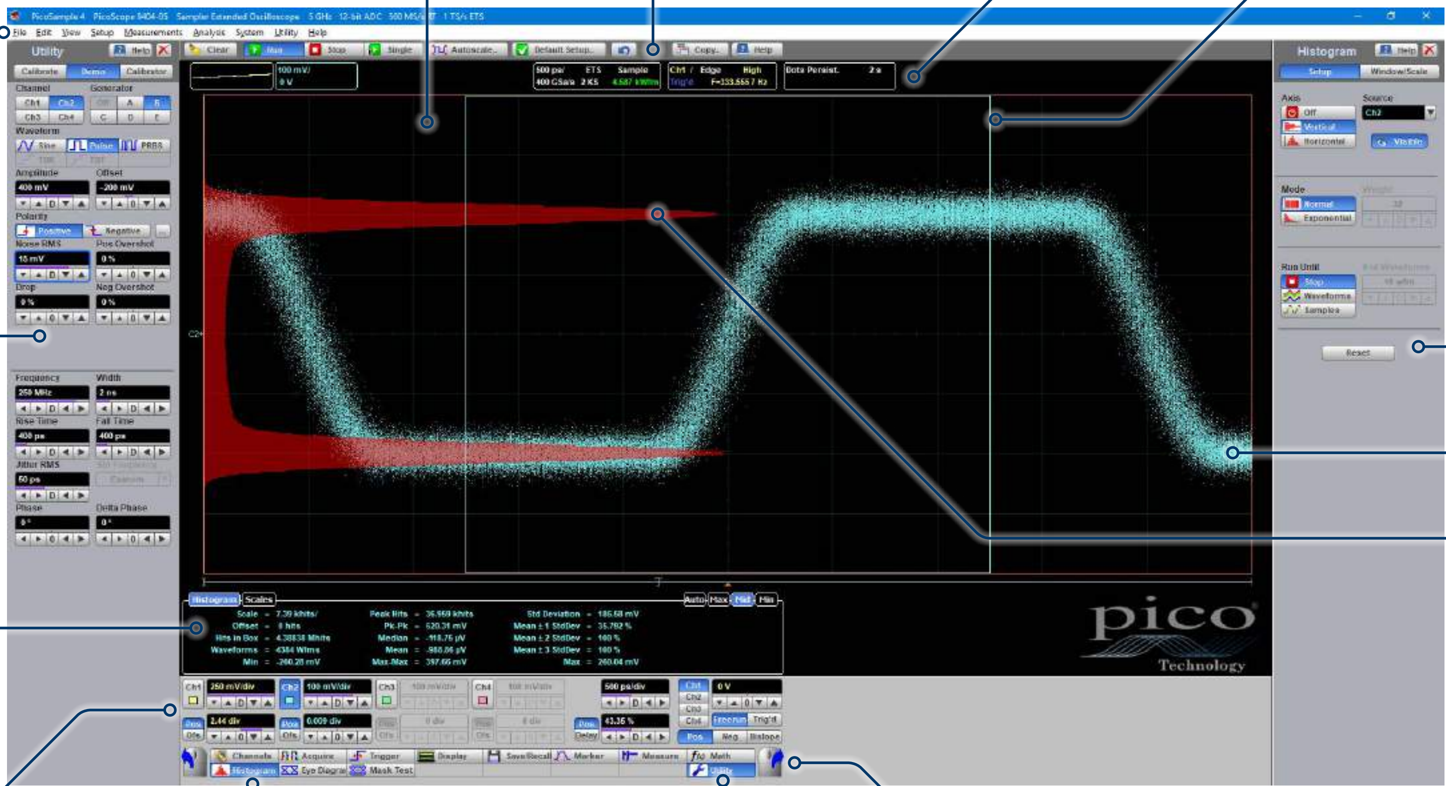
Main menu
Provides access to commands that control all instrument features and functions.

Left side menu
Left-click a button on the **Toolbar** to add the specified menu to the left side menu area.

Measurement area
Allows you to view measurement results within the following tabs:

- Scales
- Color grade
- Marker
- Measure
- Histogram
- Eye diagram
- Mask test

The area required to show as much or as little data as you require can be set.



Right side menu
Right-click a button on the **Toolbar** to add the specified menu to the right side menu area.

Waveform

Vertical histogram
Both horizontal and vertical (illustrated) histograms with periodically updated measurements allow statistical distributions to be analyzed and displayed over and region of the signal.

Permanent controls
The most common fuctions that affect the waveform can be found here.

Histogram currently selected by a right mouse click to show as a right side menu.

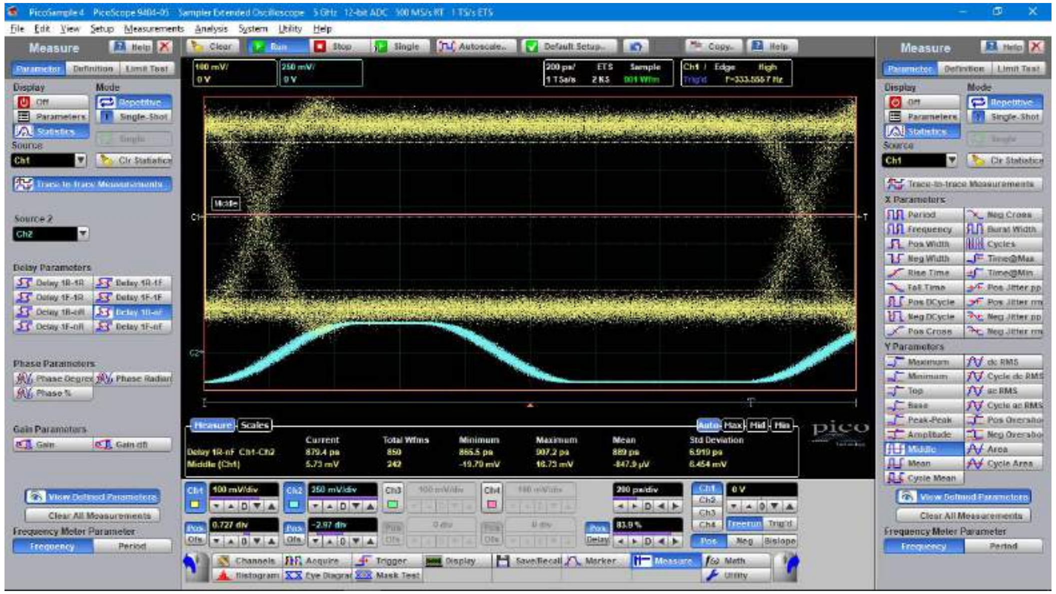
Utility currently selected by a left mouse click to show as a left side menu

Toolbar
12 buttons are used to set up oscilloscope operating modes: **Channels**, **Acquire**, **Trigger** and **Display**. Set up and execute waveform measurements: **Marker**, **Measure**, **Histogram** and **Eye Diagram**. Control file management tasks (**Save/ Recall**) and perform waveform analysis (**Math** and **Mask Test**). Set up and execute instrument calibration and use the demonstration mode (**Utility**).
Left clicking on any button with a mouse left click (or tap on a touch screen) displays the left side menu and right clicking the mouse on any button (or long-press on a touch screen) displays the right side menu.

Measurements

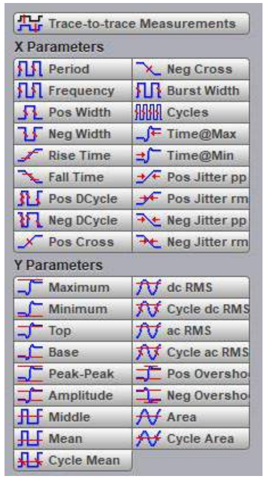
Standard waveforms and eye parameters

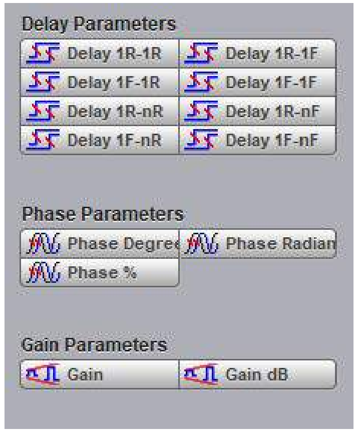
The PicoScope 9400 Series oscilloscopes quickly measure well over 40 standard waveforms and over 40 eye parameters, either for the whole waveform or gated between markers. The markers can also make on-screen ruler measurements, so you don't need to count graticules or estimate the waveforms position. Up to ten simultaneous measurements are possible. The measurements conform to IEEE standard definitions, but you can edit them for non-standard thresholds and reference levels using the advanced menu, or by dragging the on-screen thresholds and levels. You can apply limit tests to up to four measured parameters.

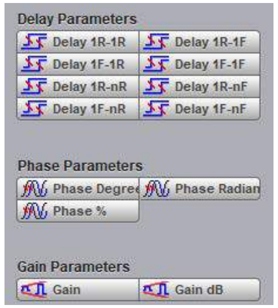


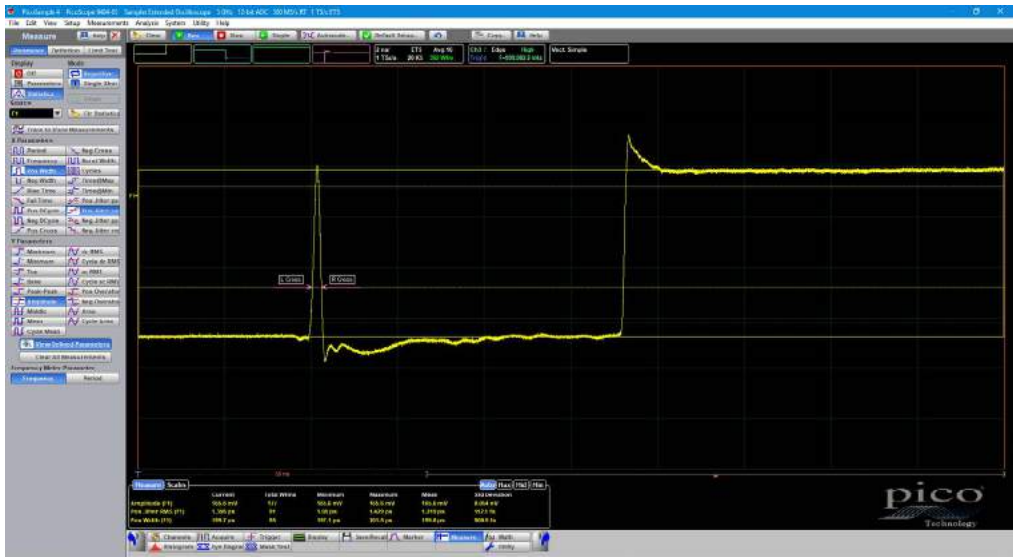
Waveform measurements with statistics

Over 40 standard waveform parameters can be measured in both X and Y axes including X period, frequency, negative or positive cross and jitter. In the Y axis measurements such as max, min, DC RMS and cycle mean are available.



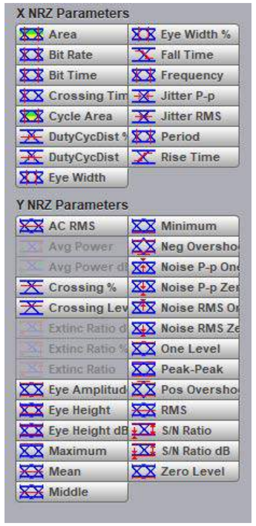


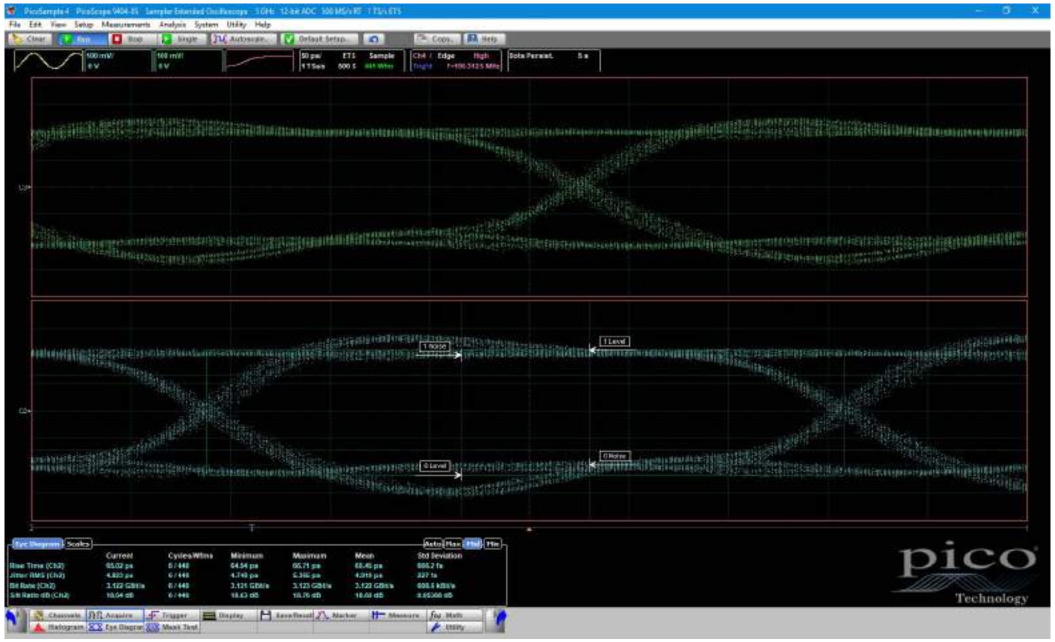




Eye diagram measurements

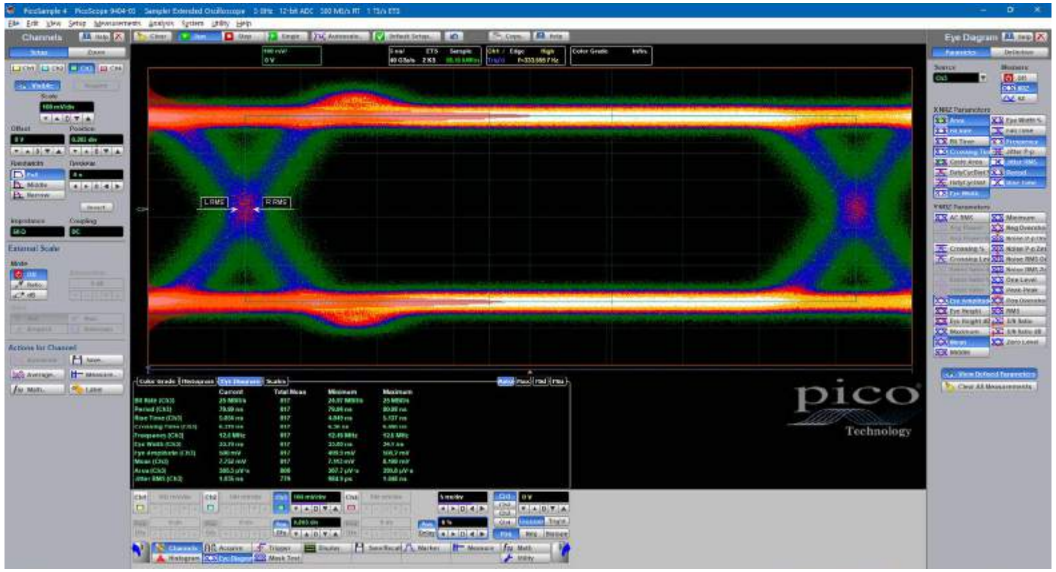
The PicoScope 9400 Series scopes quickly measure more than 70 fundamental parameters used to characterize non-return-to-zero (NRZ) signals and return-to-zero (RZ) signals. Up to ten parameters can be measured simultaneously, with comprehensive statistics also shown.





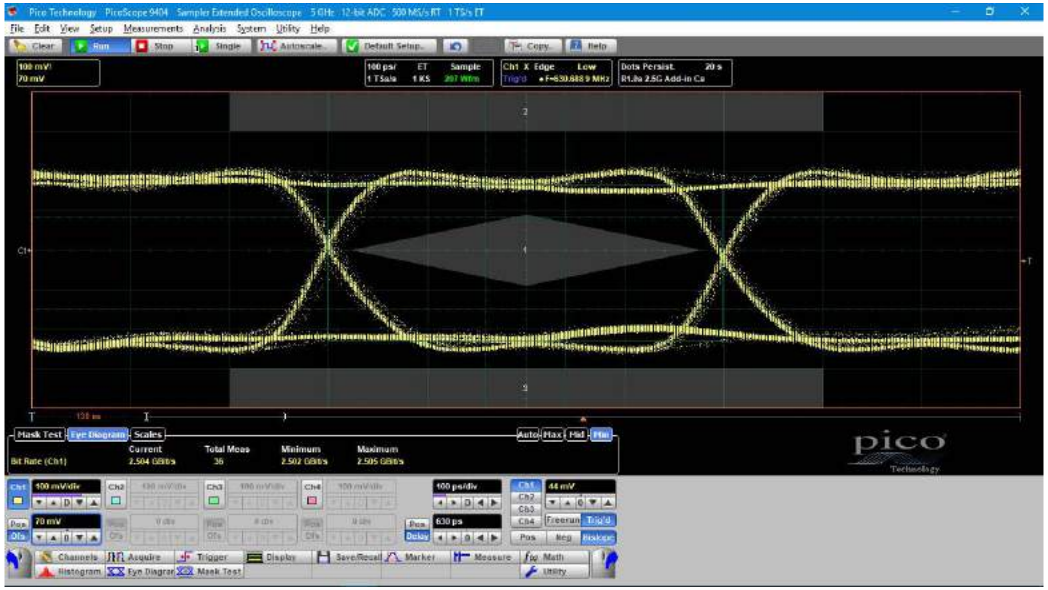
Eye diagram analysis can display data including: bit rate, period, crossing time, frequency, eye width, eye amplitude, mean, area and jitter RMS. Also shown on the graph are left and right RMS jitter markers. These measurements are selectable from within the Eye Diagram side menu and are listed on screen below the graph.

The measurement points and levels used to generate each parameter can optionally be drawn on the trace.



Eye-diagram analysis can be made even more powerful with the addition of mask testing, as described below.

Mask testing



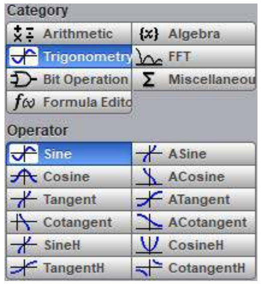
PicoSample 4 has a built-in library of over 130 masks for testing data eyes. It can count or capture mask hits or route them to an alarm or acquisition control. You can stress-test against a mask using a specified margin, and locally compile or edit masks.

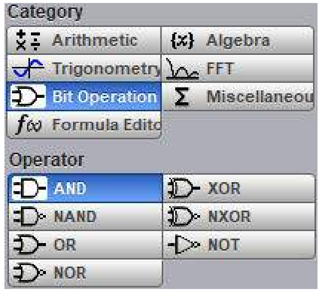
There’s a choice of gray-scale and color-graded display modes, and a histogramming feature, all of which aid in analyzing noise and jitter in eye diagrams. There is also a statistical display showing a failure count for both the original mask and the margin.

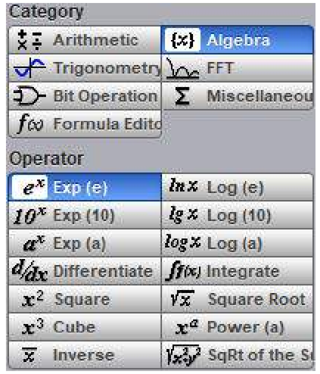
The extensive menu of built-in test waveforms is invaluable for checking your mask test setup before using it on live signals.

Mask test features:	Masks:
• Standard predefined mask	• Ethernet (7 masks)
• Automask	• SONET/SDH (8 masks)
• Mask saved on disk	• Fibre channel (23 masks)
• Create new mask	• PCI Express (29 mask)
• Edit any mask.	• InfiniBand (12 masks)
	• XAUI (4 masks)
	• RapidIO (9 masks)
	• Serial ATA (24 masks)
	• ITU G.703 (14 masks)
	• ANSI T1.102 (7 masks)
	• USB

Powerful mathematical analysis



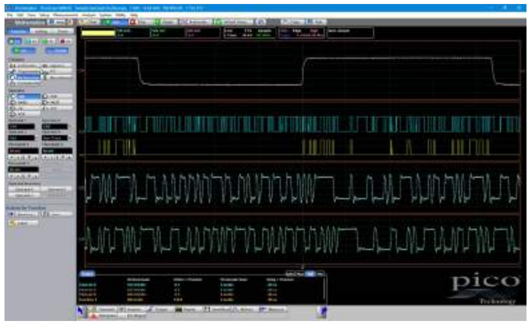




The PicoScope 9400 Series scopes support up to four simultaneous mathematical combinations or functional transformations of acquired waveforms.

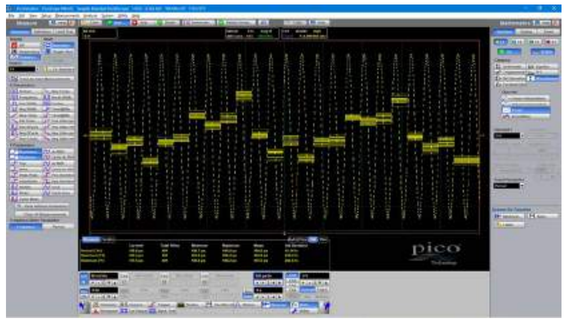
You can select any of the mathematical functions to operate on either one or two sources. All functions can operate on live waveforms, waveform memories or even other functions. There is also a comprehensive equation editor for creating custom functions of any combination of source waveforms.

- Choose from 60 math functions, or create your own.
- Add, subtract, multiply, divide, invert, absolute, exponent, logarithm, differentiate, integrate, inverse, FFT, interpolation, smoothing and trending.

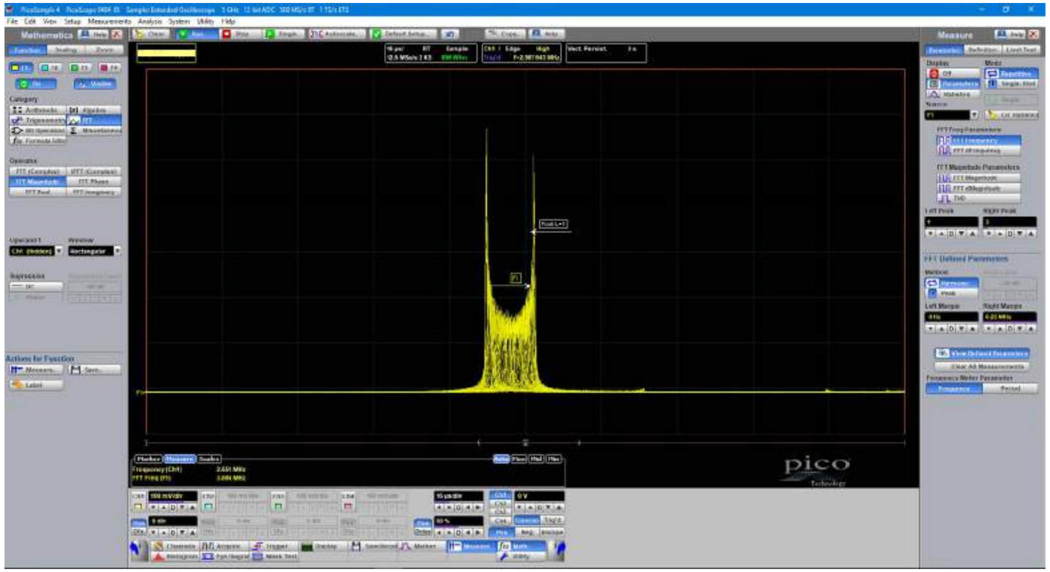


Trending

Trending allows you to plot a measured parameter, such as pulse width, as an additional trace.

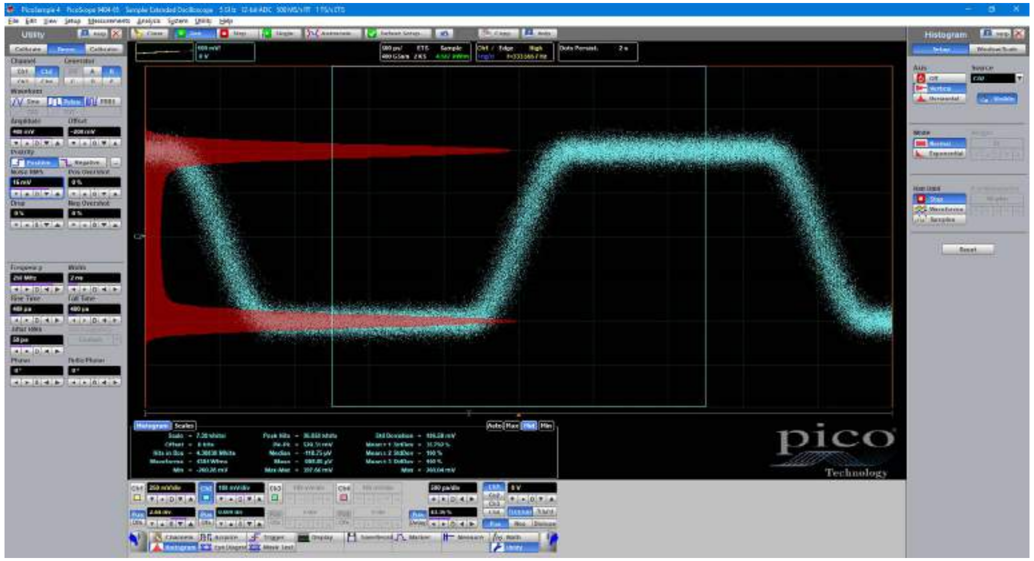


FFT analysis



All PicoScope 9400 Series oscilloscopes can calculate real, imaginary and complex Fast Fourier and Inverse Fast Fourier Transforms of input signals using a range of windowing functions. The results can be further processed using the math functions. FFTs are useful for finding crosstalk and distortion problems, adjusting filter circuits, testing system impulse responses and identifying and locating noise and interference sources.

Histogram analysis



Behind the powerful measurement and display capabilities of the 9400 Series lies a fast, efficient data histogram capability. A powerful visualization and analysis tool in its own right, the histogram is a probability graph that shows the distribution of acquired data from a source within a user-definable window.

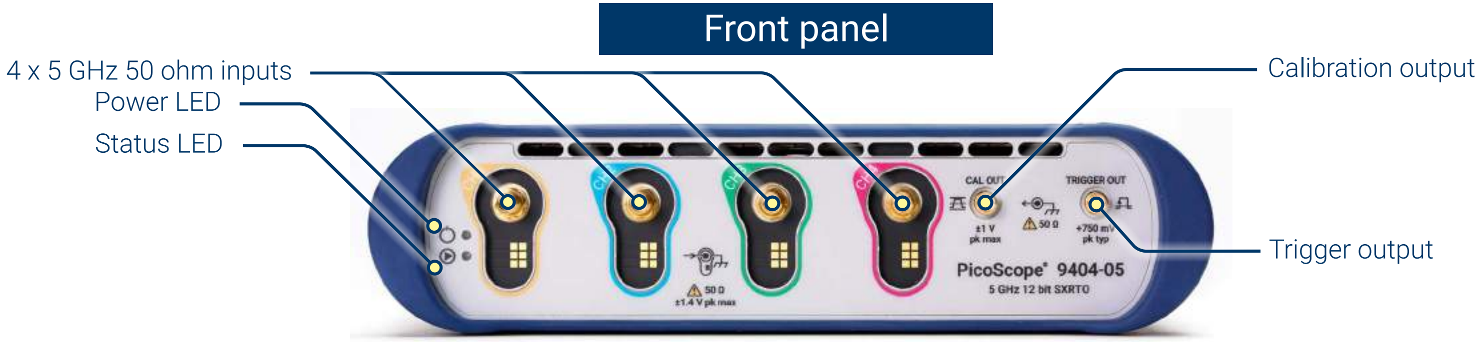
Histograms can be constructed on waveforms on either the vertical or horizontal axes. The most common use for a vertical histogram is measuring and characterizing noise and pulse parameters. A horizontal histogram is typically used to measure and characterize jitter.

Software development kit

The PicoSample 4 software can operate as a standalone oscilloscope program or under ActiveX remote control. The ActiveX control conforms to the Windows COM interface standard so that you can embed it in your own software. Unlike more complex driver-based programming methods, ActiveX commands are text strings that are easy to create in any programming environment. Programming examples are provided in Visual Basic (VB.NET), MATLAB, LabVIEW and Delphi, but you can use any programming language or standard that supports the COM interface, including JavaScript and C. National Instruments LabVIEW drivers are also available. All the functions of the PicoScope 9400 and the PicoSample software are accessible remotely.

We supply a comprehensive programmer's guide that details every function of the ActiveX control. The SDK can control the oscilloscope over the USB or the LAN port.

PicoScope 9400 Series inputs, outputs and indicators



Power LED: Glows green under normal operation

Status LED: Indicates connection progress

Channel inputs: The PicoScope 9404 has four input channels: Ch 1 to Ch 4. You can enable any number of channels without affecting the sampling rate; only the capture memory (250 kS) is shared between the enabled channels.

Built-in CAL test signal: The calibrator output (CAL) provides a DC, 1 kHz square wave or meander output. This can be used to verify the scope's inputs.

TRIGGER OUT: Can be used to synchronize an external device to the PicoScope 9404's rising edge, falling edge and end of holdoff triggers.

RST (reset button)

USB: The USB 2.0 port is used to connect the oscilloscope to the PC. If no USB host is found, the oscilloscope tries to connect through the LAN port.

LAN: LAN settings must be supplied initially by connecting to the USB port. Once configured, the oscilloscope uses the LAN port if no USB host is detected.

PicoSample 4 can control up to eight PicoScope 9400 Series units through the LAN port.

12 V DC input: A suitable mains adaptor is supplied with the oscilloscope

PicoScope 9404 specifications

Vertical	
Number of input channels	Four channels. All channels are identical and digitized simultaneously.
***Analog bandwidth (−3 dB)[1]**	Full: DC to 5 GHz Middle: DC to 450 MHz Narrow: DC to 100 MHz
***Passband flatness**	Full: ±1 dB to 3 GHz
Calculated rise time (Tr), typical	Calculated from the bandwidth. 10% to 90%: calculated from Tr = 0.35/BW 20% to 80%: calculated from Tr = 0.25/BW Full: 10% to 90%: ≤ 70 ps, 20% to 80%: ≤ 50 ps Middle: 10% to 90%: ≤ 780 ps, 20% to 80%: ≤ 560 ps Narrow: 10% to 90%: ≤ 3.5 ns. 20% to 80%: ≤ 2.5 ns
Step response, typical	Overshoot and ringing, full bandwidth: 6% to 10 ns, 3% to 400 ns, 1% thereafter.
***RMS noise**	Full: 1.8 mV, maximum, 1.6 mV, typical Middle: 0.8 mV, maximum, 0.65 mV, typical Narrow: 0.6 mV, maximum, 0.45 mV, typical
Scale factors (sensitivity)	10 mV/div to 250 mV/div Full scale is 8 vertical divisions Adjustable in a 10-12.5-15-20-25-30-40-50-60-80-100-125-150-200-250 mV/div sequence. Also adjustable in 1% fine increments or better. With manual or calculator data entry the increment is 0.1 mV/div.
***DC gain accuracy**	±2% of full scale. ±1.5% of full scale, typical
Position range	±4 divisions from center screen
DC offset range	Adjustable from −1 V to +1 V in 10 mV increments (coarse). Also adjustable in fine increments of 2 mV. With manual or calculator data entry the increment is 0.01 mV for offset between −99.9 and 99.9 mV, and 0.1 mV for offset between −999.9 and 999.9 mV. Referenced to the center of display graticule.
*** Offset accuracy**	±2 mV ±2% of offset setting. ±1 mV ±1% of offset setting, typical
Operating input voltage	±800 mV
Vertical Zoom and Position	For all input channels, waveform memories, or functions Vertical factor: 0.01 to 100 Vertical position: ±800 divisions maximum of zoomed waveform
Channel-to-channel crosstalk (channel isolation)	≥ 50 dB (316:1) for input frequency DC to 1 GHz ≥ 40 dB (100:1) for input frequency > 1 GHz to 3 GHz ≥ 36 dB (63:1) for input frequency > 3 GHz to ≤ 5 GHz
Delay between channels	≤ 10 ps, typical Between any two channels, full bandwidth, equivalent time
ADC resolution	12 bits
Hardware vertical resolution	0.4 mV/LSB without averaging

Overvoltage protection	±1.4 V (DC + peak AC)
*** Input impedance**	(50 ±1.5) Ω. (50 ±1) Ω, typical
Input match	Reflections for 70 ps rise time: 10% or less, -20 dB typical
Input coupling	DC
Input connectors	SMA female
Internal probe power	9.6 W maximum
Probe power per probe	3.3 V: 100 mA max. 12 V: 150 mA max.
Attenuation	Attenuation factors may be entered to scale the oscilloscope for external attenuators connected to the channel inputs.
Range	0.0001:1 to 1 000 000:1
Units	Ratio or dB
Scale	Volt, Watt, Ampere, or unknown
Horizontal	
Timebase	Internal timebase common to all input channels.
Timebase range	Full horizontal scale is 10 divisions Real time sampling: 10 ns/div to 1000 s/div Random equivalent time sampling: 50 ps/div to 5 µs/div Roll: 100 ms/div to 1000 s/div Segmented: Total number of segments: 2 to 1024. Dead time between segments: 2 µs.
Horizontal zoom and position	For all input channels, waveform memories, or functions Horizontal factor: From 1 to 2000 Horizontal position: From 0% to 100% non-zoomed waveform
Timebase clock accuracy	Frequency: 500 MHz Initial set tolerance: ±10 ppm @ 25 °C ±3 °C * Overall frequency stability: ±50 ppm over operating temperature range
Aging	±7 ppm over 10 years @ 25 °C
Timebase resolution	1 ps at random equivalent time sampling
*** Delta time measurement accuracy**	±(50 ppm * reading + 0.1% * screen width + 5 ps)
Pre-trigger delay	Record length ÷ current sampling rate (when delay = 0)
Post-trigger delay	0 to 4.28 s. Coarse increment is one horizontal scale division, fine increment is 0.1 horizontal scale division, manual or calculator increment is 0.01 horizontal scale division.
Channel-to-channel deskew range	±50 ns range. Coarse increment is 100 ps, fine increment is 10 ps. With manual or calculator data entry the increment is four significant digits or 1 ps.

Acquisition	
Sampling modes	Real time: Captures all of the sample points used to reconstruct a waveform during a single trigger event Random equivalent time: Acquires sample points over several trigger events, requiring the input waveform to be repetitive Roll: Acquisition data will be displayed in a rolling fashion starting from the right side of the display and continuing to the left side of the display (while the acquisition is running)
Segmented	Segmented memory optimizes available memory for data streams that have long dead times between activity. Number of segments: up to 1024. Rearm time - as fast as 2 µs (minimum time between trigger events).
Maximum sampling rate	Real time: 500 MS/s per channel simultaneously Random equivalent time: Up to 1 TS/s or 1 ps trigger placement resolution
Record length	Real time sampling: From 50 S/ch to 250 kS/ch for one channel, to 125 kS/ch for two channels, to 50 kS/ch for three and four channels Random equivalent time sampling: From 500 S/ch to 250 kS/ch for one channel, to 125 kS/ch for two channels, to 50 kS/ch for three and four channels
Duration at highest sample rate	0.5 ms for one channel, 0.25 ms for two channels, 0.125 ms for three and four channels
Acquisition modes	Sample (normal): Acquires first sample in decimation interval and displays results without further processing Average: Average value of samples in decimation interval. Number of waveforms for average: 2 to 4096. Envelope: Envelope of acquired waveforms. Minimum, Maximum or both Minimum and Maximum values acquired over one or more acquisitions. Number of acquisitions is from 2 to 4096 in ×2 sequence and continuously. Peak detect: Largest and smallest sample in decimation interval. Minimum pulse width: 1/(sampling rate) or 2 ns @ 50 µs/div or faster for single channel. High resolution: Averages all samples taken during an acquisition interval to create a record point. This average results in a higher-resolution, lower-bandwidth waveform. Resolution can be expanded to 12.5 bits or more, up to 16 bits.
Trigger	
Trigger sources	Internal from any channel
Trigger mode	Freerun: Triggers automatically but not synchronized to the input in absence of trigger event. Normal (triggered): Requires trigger event for oscilloscope to trigger. Single: SW button that triggers only once on a trigger event. Not suitable for random equivalent time sampling.
Trigger coupling	DC
Trigger style	Edge: Triggers on a rising and falling edge of any source from DC to 2.5 GHz. Divider: The trigger source is divided down four times (/4) before being applied to the trigger system. It has a trigger frequency range up to 5 GHz.
Trigger holdoff mode	Time or random
Trigger holdoff range	Holdoff by time: Adjustable from 500 ns to 15 s in a 1-2-5-10 sequence or in 4 ns fine increments. Random: This mode varies the trigger holdoff from one acquisition to another by randomizing the time value between triggers. The randomized time values can be between the values specified in the Min Holdoff and Max Holdoff.
Bandwidth and sensitivity	Low sensitivity: 100 mV p-p DC to 100 MHz increasing linearly from 100 mV p-p at 100 MHz to 200 mV p-p at 5 GHz. Pulse Width: 100 ps @ 200 mV p-p typical. * High sensitivity: 30 mV p-p DC to 100 MHz increasing linearly from 30 mV p-p at 100 MHz to 70 mV p-p at 5 GHz. Pulse Width: 100 ps @ 70 mV p-p.
Trigger level range	–1 V to 1 V in 10 mV increments (coarse). Also adjustable in fine increments of 1 mV.

Edge trigger slope	**Positive**: Triggers on rising edge **Negative**: Triggers on falling edge **Dual slope**: Triggers on both edges of the signal
*** Internal RMS trigger jitter**	Combined trigger and interpolator jitter Edge and divided trigger: 2 ps + 0.1 ppm of delay, maximum
Display	
Persistence	**Off**: No persistence **Variable persistence**: Time that each data point is retained on the display. Persistence time can be varied from 100 ms to 20 s. **Infinite persistence**: In this mode, a waveform sample point is displayed forever. **Variable Gray Scaling**: Five levels of a single color that is varied in saturation and luminosity. Refresh time can be varied from 1 s to 200 s. **Infinite Gray Scaling**: In this mode, a waveform sample point is displayed forever in five levels of a single color. **Variable Color Grading**: With Color Grading selected, historical timing information is represented by a temperature or spectral color scheme providing “z-axis” information about rapidly changing waveforms. Refresh time can be varied from 1 to 200 s. **Infinite Color Grading**: In this mode, a waveform sample point is displayed forever by a temperature or spectral color scheme.
Style	**Dots**: Displays waveforms without persistence, each new waveform record replaces the previously acquired record for a channel. **Vector**: This function draws a straight line through the data points on the display. Not suited to multi-value signals such as a displayed eye diagram.
Graticule	**Full** Grid, **Axes** with tick marks, **Frame** with tick marks, **Off** (no graticule).
Format	**Auto**: Automatically places, adds or deletes graticules as you select more or fewer waveforms to display. **Single XT**: All waveforms are superimposed and are eight divisions high. **Dual YT**: With two graticules, all waveforms can be four divisions high, displayed separately or superimposed. **Quad YT**: With four graticules, all waveforms can be two divisions high, displayed separately or superimposed. When you select dual or quad screen display, every waveform channel, memory and function can be placed on a specified graticule. **XY**: Displays voltages of two waveforms against each other. The amplitude of the first waveform is plotted on the horizontal X axis and the amplitude of the second waveform is is plotted on the vertical Y axis. **XY + YT**: Displays both XY and YT pictures. The YT format appears on the upper part of the screen, and the XY format on the lower part of the screen. The YT format display area is one screen and any displayed waveforms are superimposed. **XY + 2YT**: Displays both YT and XY pictures. The YT format appears on the upper part of the screen, and the XY format on the lower part of the screen. The YT format display area is divided into two equal screens. **Tandem**: Displays graticules to the left and to the right.
View Color	You may choose a default color selection, or select your own color set. Different colors are used for displaying selected items: background, channels, functions, waveform memories, FFTs, TDR/TDTs, and histograms.
Trace annotation	The instrument gives you the ability to add an identifying label, bearing your own text, to a waveform display. For each waveform, you can create multiple labels and turn them all on or all off. Also, you can position them on the waveform by dragging or by specifying an exact horizontal position.
Save/Recall	
Management	Store and recall setups, waveforms and user mask files to any drive on your PC. Storage capacity is limited only by disk space.

File extensions	Waveform files: .wfm for binary format .txt for verbose format (text) .txty for Y values formats (text) Database files: .wdb Setup files: .set User mask files: .pcm
Operating system	Microsoft Windows 7, 8 and 10, 32-bit and 64-bit.
Waveform save/recall	Up to four waveforms may be stored into the waveform memories (M1 to M4), and then recalled for display.
Save to/recall from disk	You can save or recall your acquired waveforms to or from any drive on the PC. To save a waveform, use the standard Windows Save as dialog box. From this dialog box you can create subdirectories and waveform files, or overwrite existing waveform files. You can load, into one of the Waveform Memories, a file with a waveform you have previously saved and then recall it for display.
Save/recall setups	The instrument can store complete setups in the memory and then recall them.
Screen image	You can copy a screen image into the clipboard with the following formats: Full Screen, Full Window, Client Part, Invert Client Part, Oscilloscope Screen and Oscilloscope Screen.
Autoscale	Pressing the Autoscale key automatically adjusts the vertical channels, the horizontal scale factors, and the trigger level for a display appropriate to the signals applied to the inputs. The Autoscale feature requires a repetitive signal with a frequency greater than 100 Hz, duty cycle greater than 0.2%, amplitudes greater than 100 mV p-p. Autoscale is operative only for relatively stable input signals.
Marker	
Marker type	**X-Marker**: vertical bars (measure time) **Y-Marker**: horizontal bars (measure volts) **XY-Marker**: waveform markers
Marker measurements	Absolute, Delta, Volt, Time, Frequency and Slope
Marker motion	**Independent**: both markers can be adjusted independently. **Paired**: both markers can be adjusted together.
Ratiometric measurements	Provide ratiometric measurements between measured and reference values. These measurements give results in such ratiometric units as %, dB, and degrees.
Measure	
Automated measurements	Up to ten simultaneous measurements are supported at the same time.
Automatic parametric	48 automatic measurements available.
Amplitude measurements	Maximum, Minimum, Top, Base, Peak-Peak, Amplitude, Middle, Mean, Cycle Mean, DC RMS, Cycle DC RMS, AC RMS, Cycle AC RMS, Positive Overshoot, Negative Overshoot, Area, Cycle Area.
Timing measurements	Period, Frequency, Positive Width, Negative Width, Rise Time, Fall Time, Positive Duty Cycle, Negative Duty Cycle, Positive Crossing, Negative Crossing, Burst Width, Cycles, Time at Maximum, Time at Minimum, Positive Jitter p-p, Positive Jitter RMS, Negative Jitter p-p, Negative Jitter RMS.
Inter-signal measurements	Delay (8 options), Phase Deg, Phase Rad, Phase %, Gain, Gain dB.
FFT measurements	FFT Magnitude, FFT Delta Magnitude, THD, FFT Frequency, FFT Delta Frequency.
Measurement statistics	Displays current, minimum, maximum, mean and standard deviation on any displayed waveform measurements.
Method of top-base definition	Histogram, Min/Max, or User-Defined (in absolute voltage).
Thresholds	Upper, middle and lower horizontal bars settable in percentage, voltage or divisions. Standard thresholds are 10–50–90% or 20–50–80%.

Margins	Any region of the waveform may be isolated for measurement using left and right margins (vertical bars).
Measurement mode	**Repetitive** or **Single-shot**
Mathematics	
Waveform math	Up to four math waveforms can be defined and displayed using math functions F1 to F4
Categories and math operators	Arithmetic: Add, Subtract, Multiply, Divide, Ceil, Floor, Fix, Round, Absolute, Invert, Common, Rescale Algebra: Exponentiation (e), Exponentiation (10), Exponentiation (a), Logarithm (e), Logarithm (10), Logarithm (a), Differentiate, Integrate, Square, Square Root, Cube, Power (a), Inverse, Square Root of the Sum Trigonometry: Sine, Cosine, Tangent, Cotangent, ArcSine, Arc Cosine, ArcTangent, Arc Cotangent, Hyperbolic Sine, Hyperbolic Cosine, Hyperbolic Tangent, Hyperbolic Cotangent FFT: Complex FFT, FFT Magnitude, FFT Phase, FFT Real part, FFT Imaginary part, Complex Inverse FFT, FFT Group Delay Bit operator: AND, NAND, OR, NOR, XOR, XNOR, NOT Miscellaneous: Autocorrelation, Correlation, Convolution, Track, Trend, Linear Interpolation, Sin(x)/x Interpolation, Smoothing Formula editor: You can build math waveforms using the Formula Editor control window.
Operands	Any channel, waveform memory, math function, spectrum, or constant can be selected as a source for one of two operands.
FFT	FFT frequency span: Frequency Span = Sample Rate / 2 = Record Length / (2 × Timebase Range) FFT frequency resolution: Frequency Resolution = Sample Rate / Record Length FFT windows: The built-in filters (Rectangular, Hamming, Hann, Flattop, Blackman–Harris and Kaiser–Bessel) allow optimization of frequency resolution, transients, and amplitude accuracy. FFT measurements: Marker measurements can be made on frequency, delta frequency, magnitude, and delta magnitude. Marker measurements can be made on frequency, delta frequency, magnitude, and delta magnitude. Automated FFT Measurements include: FFT Magnitude, FFT Delta Magnitude, THD, FFT Frequency, and FFT Delta Frequency.
Histogram	
Histogram axis	Vertical, Horizontal or Off Both vertical and horizontal histograms, with periodically updated measurements, allow statistical distributions to be analyzed over any region of the signal.
Histogram measurement set	Scale, Offset, Hits in Box, Waveforms, Peak Hits, Pk-Pk, Median, Mean, Standard Deviation, Mean ±1 Std Dev, Mean ±2 Std Dev, Mean ±3 Std Dev, Min, Max-Max, Max
Histogram window	The histogram window determines which part of the database is used to plot the histogram. You can set the size of the histogram window to be any size that you want within the horizontal and vertical scaling limits of the scope.
Eye diagram	
Eye diagram	The PicoScope 9400 can automatically characterize an NRZ and RZ eye pattern. Measurements are based upon statistical analysis of the waveform.
NRZ measurement set	X: Area, Bit Rate, Bit Time, Crossing Time, Cycle Area, Duty Cycle Distortion (%, s), Eye Width (%, s), Fall Time, Frequency, Jitter (p-p, RMS), Period, Rise Time Y: AC RMS, Crossing %, Crossing Level, Eye Amplitude, Eye Height, Eye Height dB, Max, Mean, Mid, Min, Negative Overshoot, Noise p-p (One, Zero), Noise RMS (One, Zero), One Level, Peak-Peak, Positive Overshoot, RMS, Signal-to-Noise Ratio, Signal- to-Noise Ratio dB, Zero Level
RZ measurement set	X: Area, Bit Rate, Bit Time, Cycle Area, Eye Width (%, s), Fall Time, Jitter P-p (Fall, Rise), Jitter RMS (Fall, Rise), Negative Crossing, Positive Crossing, Positive Duty Cycle, Pulse Symmetry, Pulse Width, Rise Time Y: AC RMS, Contrast Ratio (dB, %, ratio), Eye Amplitude, Eye High, Eye High dB, Eye Opening Factor, Max, Mean, Mid, Min, Noise P-p (One, Zero), Noise RMS (One, Zero), One Level, Peak-Peak, RMS, Signal-to-Noise, Zero Level

Mask test	
Mask test	Acquired signals are tested for fit outside areas defined by up to eight polygons. Any samples that fall within the polygon boundaries result in test failures. Masks can be loaded from disk, or created automatically or manually.
Standard mask	Standard predefined optical or standard electrical masks can be created. SONET/SDH: OC1/STMO (51.84 Mb/s) to FEC 2666 (2.6666 Gb/s) Fibre Channel: FC133 Electrical (132.8 Mb/s) to FC2125E Abs Gamma Tx.mask (2.125 Gb/s) Ethernet: 100BASE-BX10 (125 Mb/s) to 3.125 Gb/s 10GBase-CX4 Absolute TP2 (3.125 Gb/s) InfiniBand: 2.5G InfiniBand Cable mask (2.5 Gb/s) to 2.5G InfiniBand Receiver mask (2.5 Gb/s) InfiniBand (2.5 Gb/s) XAUI: 3.125 Gb/s XAUI Far End (3.125 Gb/s) to XAUI-E Near (3.125 Gb/s) ITU G.703: DS1, 100 Ω twisted pair (1.544 Mb/s) to 155 Mb 1 Inv, 75 Ω coax (155.520 Mb/s) ANSI T1/102: DS1, 100 Ω twisted pair, (1.544 Mb/s) to STS3, 75 Ω coax, (155.520 Mb/s) RapidIO: RapidIO Serial Level 1, 1.25G Rx (1.25 Gb/s) to RapidIO Serial Level 1, 3.125G Tx SR (3.125 Gb/s) PCI Express: R1.0a 2.5G Add-in Card Transmitter Non-Transition bit mask (2.5 Gb/s) to R1.1 2.5G Transmitter Transition bit mask (2.5 Gb/s) Serial ATA: Ext Length, 1.5G 250 Cycle, Rx Mask (1.5 Gb/s) to Gen1m, 3.0G 5 Cycle, Tx Mask (3 Gb/s)
Mask margin	Available for industry-standard mask testing
Automask creation	Masks are created automatically for single-valued voltage signals. Automask specifies both delta X and delta Y tolerances. The failure actions are identical to those of limit testing.
Data collected during test	Total number of waveforms examined, number of failed samples, number of hits within each polygon boundary
Calibrator output	
Calibrator output mode	DC, 1 kHz square, Meander with frequency from 15.266 Hz to 500 kHz
Output DC level	Adjustable from –1 V to +1 V into 50 Ω. Coarse increment: 50 mV, fine increment: 1 mV.
* Output DC level accuracy	±1 mV ±0.5% of output DC level
Output impedance	50 Ω nominal
Rise/fall time	150 ns, typical
Output connectors	SMA female
Trigger output	
Timing	Positive transition equivalent to acquisition trigger point
Low level	(–0.2 ±0.1) V. Measured into 50 Ω
Amplitude	(900 ±200) mV. Measured into 50 Ω
Rise time	10% to 90%: ≤ 0.45 ns 20% to 80%: ≤ 0.3 ns
RMS jitter	2 ps or less
Output delay	4 ±1 ns
Output coupling	DC coupled
Output connectors	SMA female
Power requirement	
Power supply voltage	+12 V ±5%
Power supply current	PicoScope 9404: 2.6 A max
Protection	Auto shutdown on excess or reverse voltage

AC-DC adaptor	Universal adaptor supplied
PC connection	
PC connection	USB 2.0 (high speed). Also compatible with USB 3.0. LAN
Physical characteristics	
Dimensions	Width: 245 mm Height: 60 mm Depth: 232 mm
Net weight	1.4 kg (PicoScope 9404)
Environmental conditions	
Temperature	Operating: +5 °C to +40 °C for normal operation, +15 °C to +25 °C for quoted accuracy Storage: –20 °C to +50 °C
Humidity	Operating: Up to 85 %RH (non-condensing) at +25 °C Storage: Up to 95 %RH (non-condensing)

*** Specifications marked with (*) are checked in the Performance Verification chapter.**

[1] These specifications are valid after a 30-minute warm-up period and ±2 °C from firmware calibration temperature.

Kit contents and accessories

Your PicoScope 9400 Series oscilloscope kit contains the following items:

- PicoScope 9400 Series sampler-extended real-time oscilloscope (SXRTO)
- PicoSample 4 software (supplied on a USB stick and also available as a free download from www.picotech.com)
- Quick start guide
- 12 V power supply, universal input
- 3 x localized IEC mains leads
- USB cable, 1.8 m
- SMA / PC3.5 / 2.92 wrench
- Storage / carry case
- LAN cable, 1 m

Optional accessories

Order code	Description	
Adaptors		
TA313	3 GHz SMA(f)-BNC(m) interseries adaptor	  
TA314	18 GHz SMA(f) to N(m) interseries adaptor	
TA170	18 GHz 50 Ω SMA(m-f) connector saver adaptor	
TA172	18 GHz, 50 Ω N(f) to SMA(m) interseries adaptor	
Bessel-Thomson reference filters		
TA124	Bessel-Thomson reference filter 2.488 Gb/s / 2.5 Gb/s	
TA123	Bessel-Thomson reference filter 1.25 Gb/s	
TA121	Bessel-Thomson reference filter 155 Mb/s	
TA120	Bessel-Thomson reference filter 51.8 Mb/s	
TA122	Bessel-Thomson reference filter 622 Mb/s	
PicoConnect 900 Series passive probes		
TA274	PicoConnect 911 20:1 960 Ω AC-coupled 4 GHz RF, microwave and pulse probe	
TA275	PicoConnect 912 20:1 960 Ω DC-coupled 4 GHz RF, microwave and pulse probe	
TA278	PicoConnect 913 10:1 440 Ω AC-coupled 4 GHz RF, microwave and pulse probe	
TA279	PicoConnect 914 10:1 440 Ω DC-coupled 4 GHz RF, microwave and pulse probe	
TA282	PicoConnect 915 5:1 230 Ω AC-coupled 5 GHz RF, microwave and pulse probe	

Optional accessories

Order code	Description	
PicoConnect 900 Series Kits		
PQ067	PicoConnect 910 Kit: all six microwave and pulse probe heads with two cables	
PQ066	PicoConnect 920 Kit: all six gigabit probe heads with two cables	
TA315	PicoConnect probe tips and solder in kit	
Tetris high-impedance 10:1 active probe		
TA223	2.5 GHz 0.9 pF probe, 50 Ω SMA(m) output, with accessory kit and BNC adaptor	
Attenuators		
TA181	Attenuator 3 dB 10 GHz 50 ohm SMA (m-f)	
TA261	Attenuator 6 dB 10 GHz 50 ohm SMA (m-f)	
TA262	Attenuator 10 dB 10 GHz 50 ohm SMA (m-f)	
TA173	Attenuator 20 dB 10 GHz 50 ohm SMA (m-f)	
Coaxial cable assemblies		
TA263	Precision high-flex unsleeved coaxial cable 60 cm SMA(m-m) 1.9 dB loss @ 13 GHz	
TA264	Precision high-flex unsleeved coaxial cable 30 cm SMA(m-m) 1.1 dB loss @ 13 GHz	
TA265	Precision sleeved coaxial cable 30 cm SMA(m-m) 1.3 dB loss @ 13 GHz	
TA312	Precision sleeved coaxial cable 60 cm SMA(m-m) 2.2 dB loss @ 13 GHz	
Tools		
TA356	Dual-break torque wrench SMA/PC3.5/K, 1 N·m (8.85 in·lb)	

PicoScope 9400 Series ordering information

Description	Bandwidth (GHz)	Channels	Order code
PicoScope 9404-05 sampler-extended real-time oscilloscope	5	4	PQ181

* Prices correct at time of publication. Sales taxes not included. Please contact Pico Technology for the latest prices before ordering.

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