pico Technology

# PicoScope® 9400A Series

## SXRTO sampler-extended real-time oscilloscopes

**6 GHz, 16 GHz, 25 GHz and 33 GHz bandwidths, 4 channels**


### PicoScope 9404A-33
33 GHz bandwidth, 11 ps transition time
5 TS/s (0.2 ps resolution) random sampling

### PicoScope 9404A-25
25 GHz bandwidth, 14 ps transition time
5 TS/s (0.2 ps resolution) random sampling

### PicoScope 9404A-16
16 GHz bandwidth, 22 ps transition time
2.5 TS/s (0.4 ps resolution) random sampling

### PicoScope 9404A-06
6 GHz bandwidth, 58 ps transition time
1 TS/s (1 ps resolution) random sampling

12-bit 500 MS/s ADCs, ±800 mV full-scale input range
Pulse, eye and mask testing down to 22 ps and up to 16 Gb/s
Intuitive and configurable touch-compatible Windows user interface
Comprehensive built-in measurements, zooms, data masks, histograms
10 mV/div to 250 mV/div digital gain ranges
Up to 250 kS trace length, shared between channels
Optional clock recovery trigger to 11.3 Gb/s
Optional recovered clock and data outputs

北京海洋兴业科技股份有限公司（股票代码：839145） | 电话：010-62178811 传真：010-62176619 | 网址：www.hyxyyq.com

## Product overview

The PicoScope 9400A Series sampler-extended real-time oscilloscopes (SXRTOs) have 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. They are ideal for capturing pulse and step transitions down to 11 ps, impulse down to 22 ps, and clocks and data eyes up to 16 Gb/s (with optional 11.3 Gb/s clock recovery).

The PicoScope SXRTOs offer random sampling, which can readily analyze high-bandwidth applications that involve repetitive signals or clock-related streams.

The SXRTO is fast: random sampling, persistence displays and statistics all build quickly.

The PicoScope 9400A Series has a built-in internal trigger on every channel, with pre-trigger random sampling to well above the Nyquist (real-time) sampling rate. Bandwidth is up to 33 GHz behind a 50 Ω 2.92 mm (K) female (compatible with SMA) input, and three acquisition modes—real-time, random and roll—all capture at 12-bit resolution into a shared memory of up to 250 kS.

The touch-compatible PicoSample 4 software embodies over ten years of development, customer feedback and optimization.

The display can be resized to fit any window and fully utilize available display resolution, 4K and even larger or across multiple monitors. Four independent zoom channels can show you different views of your data down to a resolution of 0.2 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.

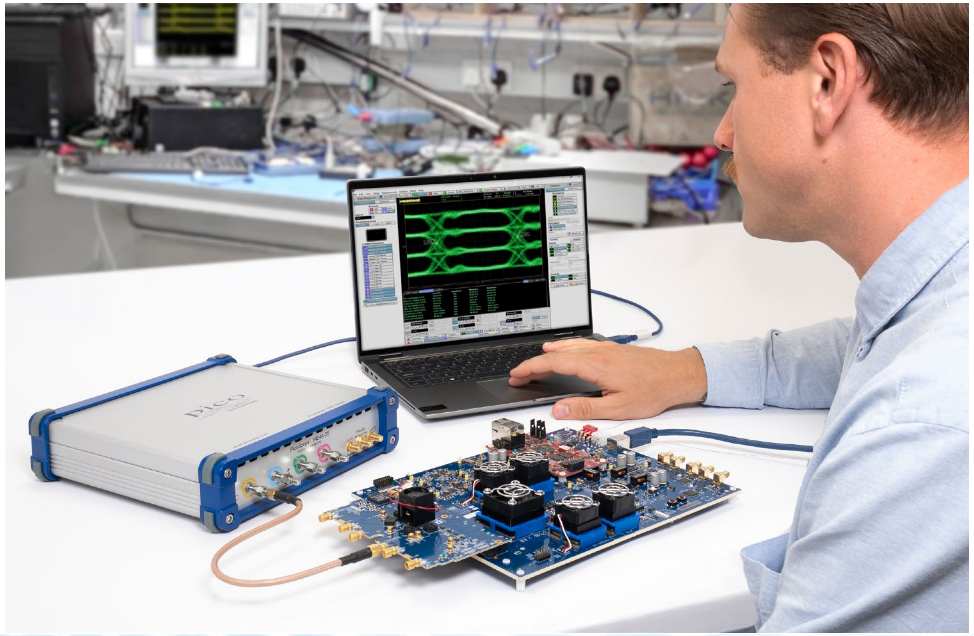
A 2.5 GHz direct trigger can be driven from any input channel, and a built-in divider can extend the off-channel trigger bandwidth to 6 GHz. On the 16, 25 and 33 GHz models a further external prescaled trigger input allows stable trigger from signals from 16 GHz (9404A-16) and 20 GHz (9404A-25 and 9404A-33) bandwidth respectively, and from the internal triggers, recovered clock trigger is available (if optional clock recovery is fitted) at up to 11.3 Gb/s. With this option, recovered clock and data are both available on SMA outputs on the rear panel.

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

These oscilloscopes are designed for engineers working both in research laboratories and in production environments, and who, above all, need characteristics associated with flexible measurements of wide-bandwidth signals:

- 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 up to 16 Gb/s
- Clock and data recovery at up to 11.3 Gb/s
- Ethernet, HDMI 1, PCI, SATA and USB 2.0
- Semiconductor characterization
- Signal, data and pulse/impulse integrity and pre-compliance testing



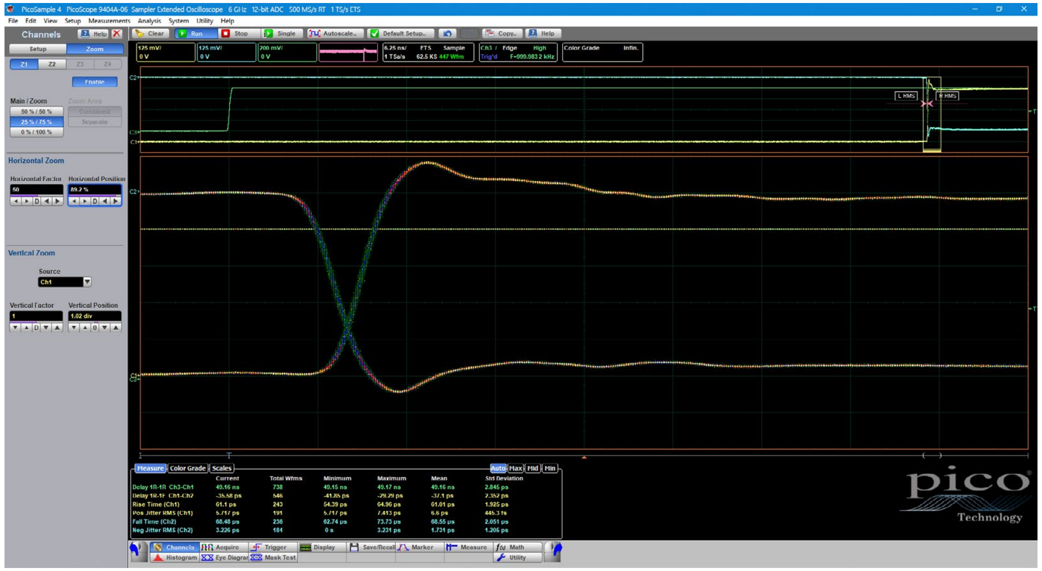
## Random equivalent-time sampling

PicoScope 9400A Series SXRTOs use random equivalent-time sampling to capture high-bandwidth repetitive or clock-derived signals without the expense or jitter of a very high-speed real-time oscilloscope.

They feature the industry's lowest 1.2 ps RMS intrinsic jitter for a PC oscilloscope, allowing these oscilloscopes to capture signals with minimal timing inaccuracies.

Random equivalent-time sampling acquires sample points over several trigger events and requires the input waveform to be repetitive. On each trigger event, the scope acquires more points and combines them with the previously acquired points. This creates a record of the waveform that has an effective sampling rate that is the inverse of the sample spacing.

On the 25 GHz and 33 GHz models, the transition time is 14 ps and 10.9 ps respectively. The 16 GHz model is 22 ps and on the 6 GHz model 70 ps. All are typically faster than competing equivalent bandwidth models. Random sampling enables timing resolution down to 0.2 ps, 0.4 ps and 1 ps respectively.



## Trigger modes

Simply feed your signal into one of the input channels.

The oscilloscopes have a DC to 2.5 GHz internal direct trigger from each input channel and 6 GHz from each channel via a divider. The 16 GHz model has a 16 GHz prescaled trigger and the 25 and 33 GHz models have external 18 and 20 GHz prescaled trigger inputs, respectively.

An optional clock recovery trigger is fed from the internal channel paths. With this option, clock and data signals are output on rear-panel SMA connectors.

## Clock and data recovery

Clock and data recovery (CDR) is available as a factory-fit optional trigger feature on all models.

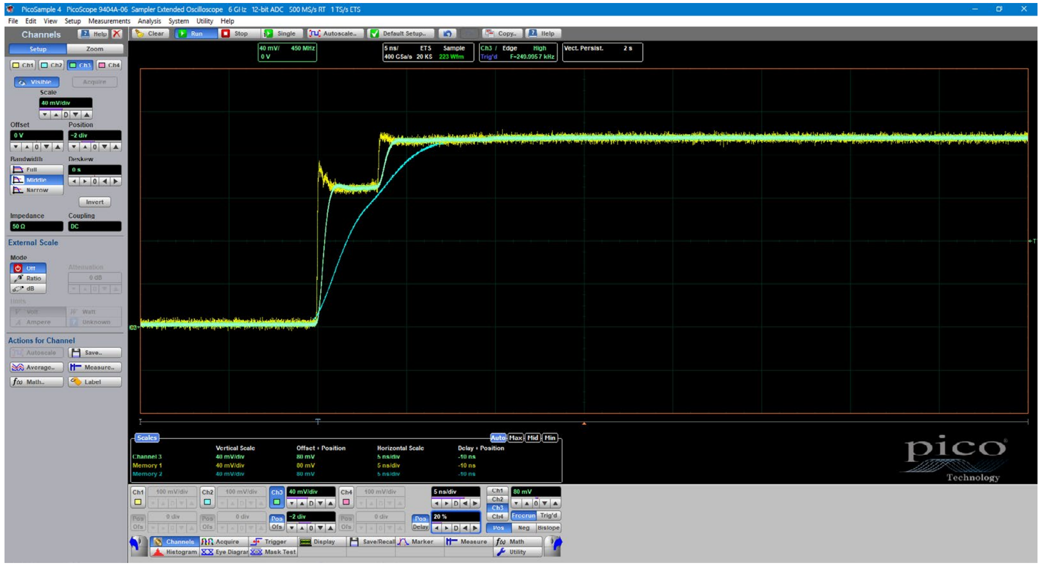
Associated with high-speed serial data applications, clock and data recovery will already be familiar to PicoScope 9300 users. While low-speed serial data can often be accompanied by its clock as a separate signal, at high speed this approach would accumulate timing skew and jitter between the clock and the data that could prevent accurate data decode. Thus high-speed data receivers will generate a new clock, and using a phase locked loop technique they will lock and align that new clock to the incoming data stream. This is the *recovered clock* and it can be used to decode and thus *recover data* accurately. We have also saved the cost of an entire clock signal path by now needing only the serial data signal.

In many applications requiring our oscilloscopes to view the data, the data generator and its clock will be close at hand and we can trigger off that clock. However, if only the data is available (at the far end of an optical fiber for instance), we will need the CDR option to recover the clock and then trigger off that instead. We may also need to use the CDR option in demanding eye and jitter measurements. This is because we want our instrument to measure as exactly as possible the signal quality that a recovered clock and data receiver will see.

When fitted, the PicoScope 9400A CDR option can be selected as the trigger source from any input channel. Additionally, for use by other instruments or by downstream system elements, two SMA(f) outputs present recovered clock and recovered data on the rear panel.

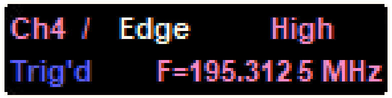

## Bandwidth limit filters

A selectable analog bandwidth limiter (100 or 500 MHz, model-dependent) 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 in real-time sampling modes.



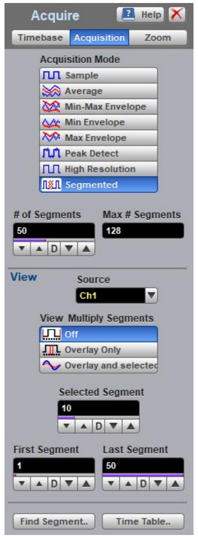
## Frequency counter

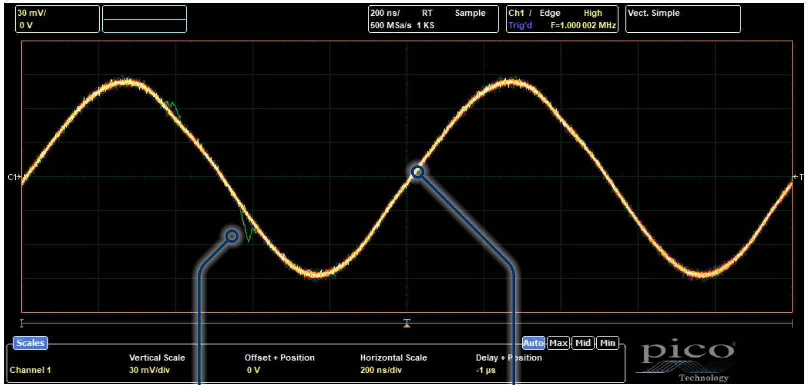
A built-in fast and accurate frequency counter shows signal frequency (or period) at all times, regardless of measurement and timebase settings and with a resolution of 1 ppm.



## Segmented acquisition mode

Segmented acquisition mode in the **Acquire** menu partitions the available trace memory length into multiple trace lengths (segments or buffers). Up to 1024 traces can then be captured and either layered or individually selected to display on screen. This is helpful for capturing and viewing rarely occurring events.

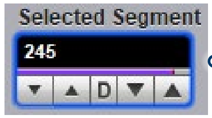


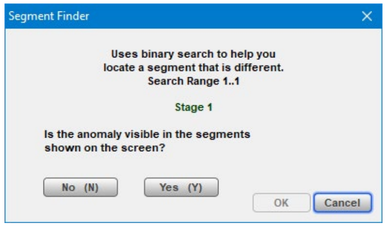
Anomaly

Trace overlays

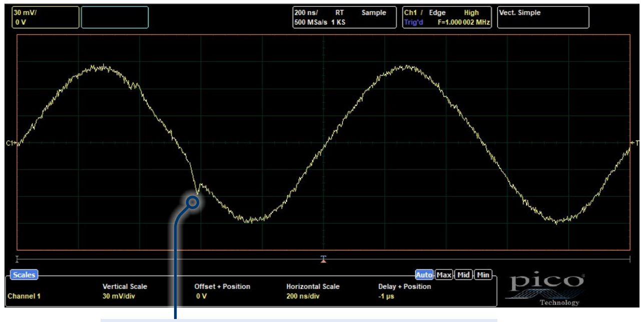
Having captured an anomalous event you can scroll through, or close gates around, an ever smaller block of overlaid traces, until the anomalous trace or traces are found. There is also a segment finder which uses a binary search method to address larger numbers of trace segments:




Selected segment spin-box




Segment finder



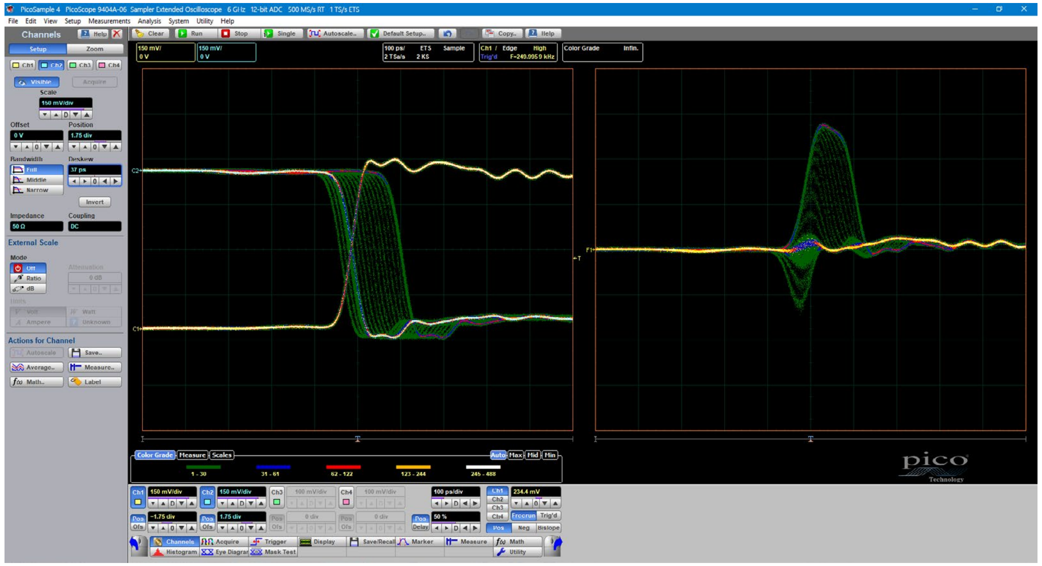
Selected segment with an anomaly

## Channel deskew

The deskew variable adjusts the horizontal position (time offset) of one active channel with respect to another on the instrument display. The deskew function has a ±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.

Use the deskew to compensate the time offset between two or more channels. This might result from different cable or probe lengths or might allow an aligned comparison of an input and output waveshape.

Below, deskew is used to precisely align a differential pair. Addition of the traces (right half of the waveform display) allows sensitive alignment for minimum common mode.



## 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. This will reveal a minimum width impulse, but is far from satisfactory in revealing its shape, let alone measurements and characterization. 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.

### Random sampling

For signals close to or above the RTO's Nyquist limit, many RTOs can switch to a mode called random sampling. In this mode the scope collects as many samples as it can for each of many trigger events, each trigger contributing more and more samples and detail in a reconstructed waveform. Critical to alignment of these samples is a separate and precise measurement of time between each trigger and the next occurring sample clock.

After a large number of trigger events the scope has enough samples to display the waveform with the desired time resolution. This is called the effective sampling resolution (the inverse of the effective sampling rate), which is many times higher than is possible in real-time mode.

This technique relies on a random relationship between trigger events and the sampling clock, and can only be used for repetitive signals – those with relatively stable waveshape around the trigger event.

### The sampler-extended real-time oscilloscope (SXRTO)

The maximum effective random-sampling rate of the PicoScope 9400A 25 and 33 GHz models is 5 TS/s, with a timing resolution of 0.2 ps, which is 5000 times higher than the scope's actual sampling rate.

With an analog bandwidth of up to 33 GHz, these SXRTOs would require a sampling rate exceeeding 50 GS/s to meet Nyquist's criterion and somewhat more than this (perhaps 125 GS/s) to reveal wave and pulse shapes.

Using random sampling, the 16 GHz models give us 200 sample points in a single cycle at the scope's rated bandwidth or a generous 70 samples between 10% and 90% of its fastest transition time.

### 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 trigger signal – either from an external source or from a built-in clock-recovery module.

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

| | Real-time scope | SXRTO (Sampler-extended real-time oscilloscope) | | | Sampling scope |
|---|---|---|---|---|---|
| Model | PicoScope 6426E | PicoScope 9404A-06 | PicoScope 9404A-16 | PicoScope 9404A-25 9404A-33 | PicoScope 9341-25 |
| Analog bandwidth | 1 GHz | 6 GHz | 16 GHz | 25 GHz/ 33 GHz | 25 GHz |
| Real-time sampling? | 5 GS/s | 500 MS/s | | | 1 MS/s |
| Sequential equivalent-time sampling? | No | No | | | 15 TS/s |
| Random sampling? | NA | 1 TS/s | 2.5 TS/s | 5 TS/s | 250 MS/s |
| Trigger on input channel? | Yes | Yes | | | Up to 100 MHz bandwidth – requires external trigger or internal clock recovery option |
| Pre-trigger capture? | Yes | Yes | | | No |
| Vertical resolution | 10 bits | 12 bits | | | 16 bits |

## 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 9400A 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 Ω to 100 Ω
- Class-leading uncorrected pulse/eye response and pulse/eye disturbance

The PicoConnect 910 kit includes six 4 to 5 GHz probes at the three division ratios and with AC (> 160 kHz) and DC couplings.


The PicoConnect 920 kit includes six 6 to 9 GHz gigabit probes at the three division ratios and with AC (> 160 kHz) and DC couplings.

All probes (chargeable additions) are available individually or as a kit and are supplied with precision low-loss cables, spare probe tips and a solder-in kit all within a convenient storage case.

Patent no. GB 2550398

## Software

### Application-configurable PicoSample 4 oscilloscope software

The PicoSample 4 workspace takes full advantage of your available single 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.

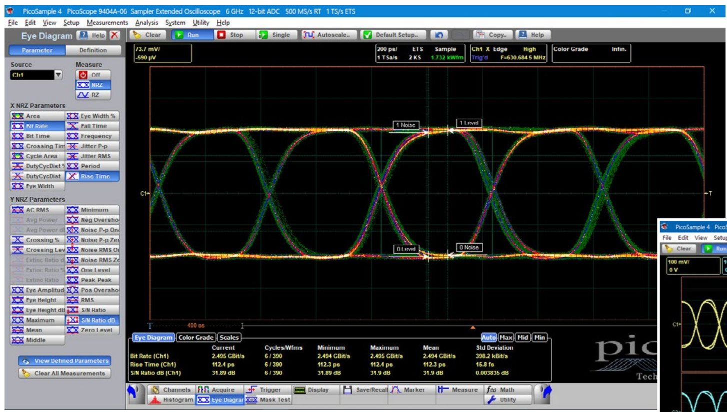
To zoom, either draw a zoom window or use the numerical zoom and offset controls. You can display up to four different zoomed views of the displayed waveforms.

"Hidden trace" icons show a live view of any channels that are not currently 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 all these display settings can be independent, trace by trace. Custom trace labeling is also available.



## PicoSample 4 software

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

**Display area**
View live, reference and math waveforms. Drag waveforms to reposition them and drag or draw zoom windows. You can drag markers, bounds and thresholds to configure measurements on the screen. On-screen controls can be hidden to increase trace area.

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

**Status area**
Displays acquisition status, mode and number of acquisitions. Also trigger status, date, time and a quick reference to record length and horizontal parameters.

**Histogram 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.

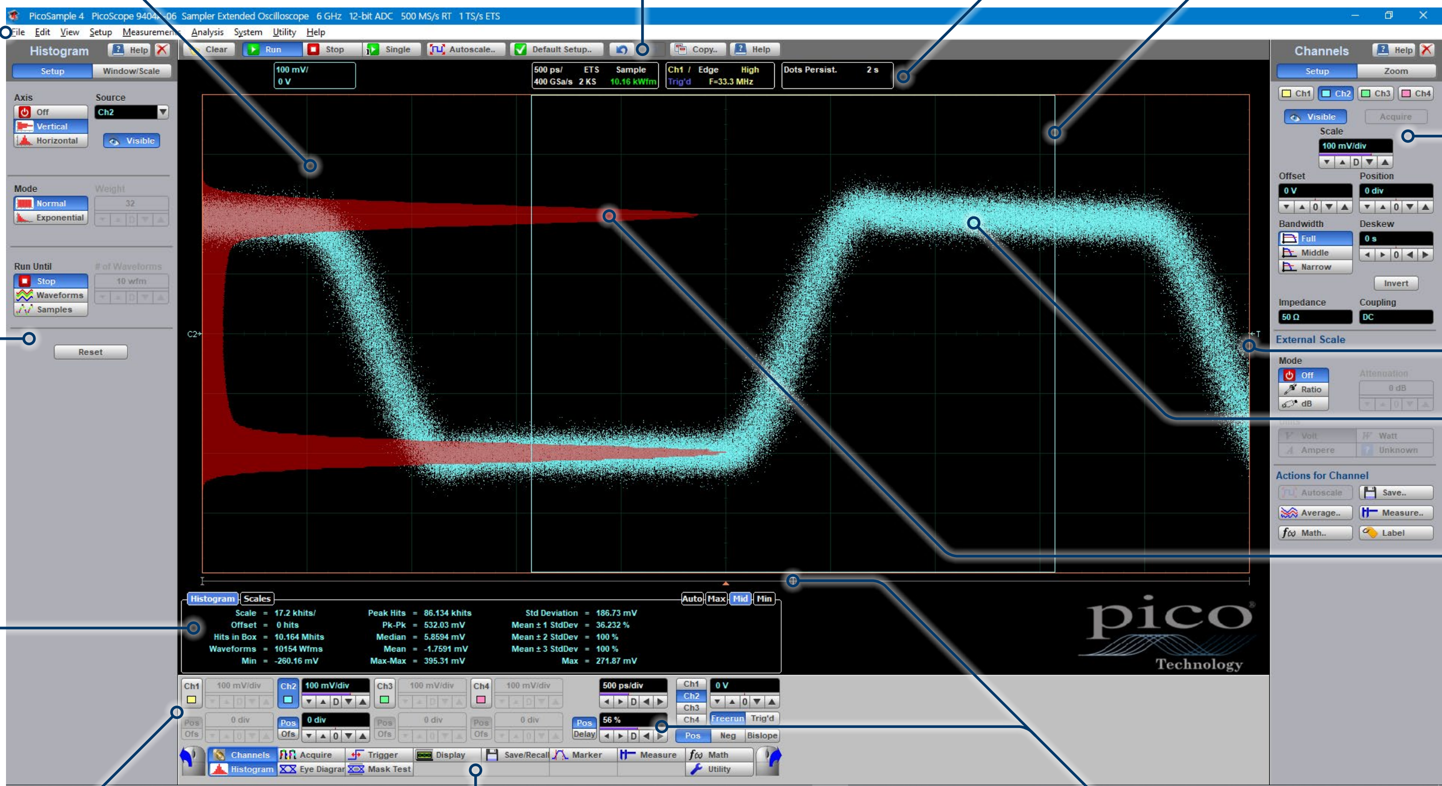
**Left side menu**
Left-click with your mouse, or tap a button on the **Toolbar** using a touch screen, to add the specified menu to the left side menu area.

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

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

Resize the display area using the **Auto**, **Max**, **Min** and **Mid** buttons to show as much or as little data as you require.

**Permanent controls**
The most common functions that affect the waveform display.




**Right side menu**
Right-click, or long-touch on a touch screen, a button on the **Toolbar** to add the specified menu to the right side menu area.

**Trigger level**
Click or tap and drag the **T** icon or use the **Trigger position** control to change the trigger level for the selected trigger source.

**Waveform**

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

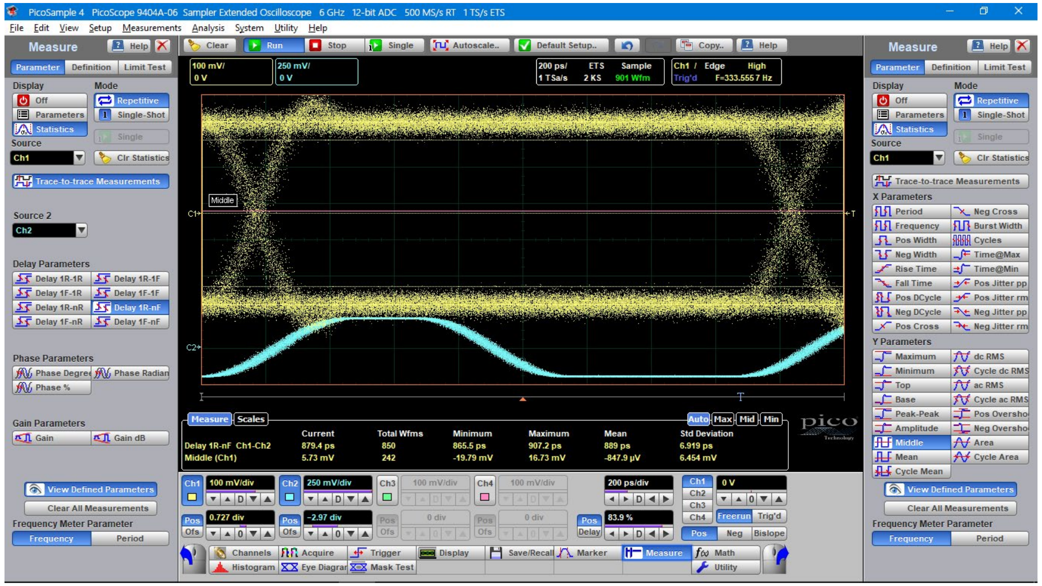
**Toolbar**
12 buttons to select and set-up oscilloscope operating modes: **Channels**, **Acquire**, **Trigger** and **Display**. You can also set up and execute waveform measurements: **Marker**, **Measure**, **Histogram** and **Eye Diagram**, control file management tasks (**Save/Recall**) and perform waveform analysis (**Math** and **Mask Test**). In addition you can set up and execute instrument calibration and use the demonstration mode (**Utility**).

**Trigger position**
This **T** icon represents the trigger position. You can move it by adjusting the **Trigger position** control.

# Measurements

## Standard waveforms and eye parameters

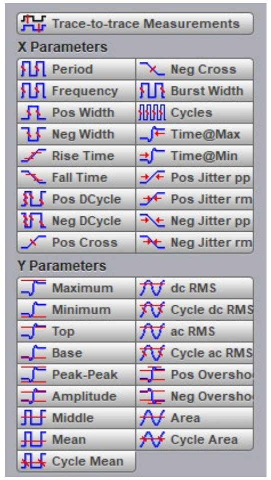
The PicoScope 9400A Series oscilloscopes quickly measure well over 40 standard waveforms and over 70 eye parameters, either for the whole waveform or gated between markers. The markers can also make on-screen ruler measurements, so you don't need to count graticules or estimate the waveform's position. 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.



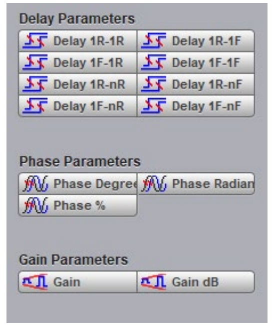
## Waveform measurements with statistics

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. Measurements can be within a single trace or trace-to-trace such as phase, delay and gain.

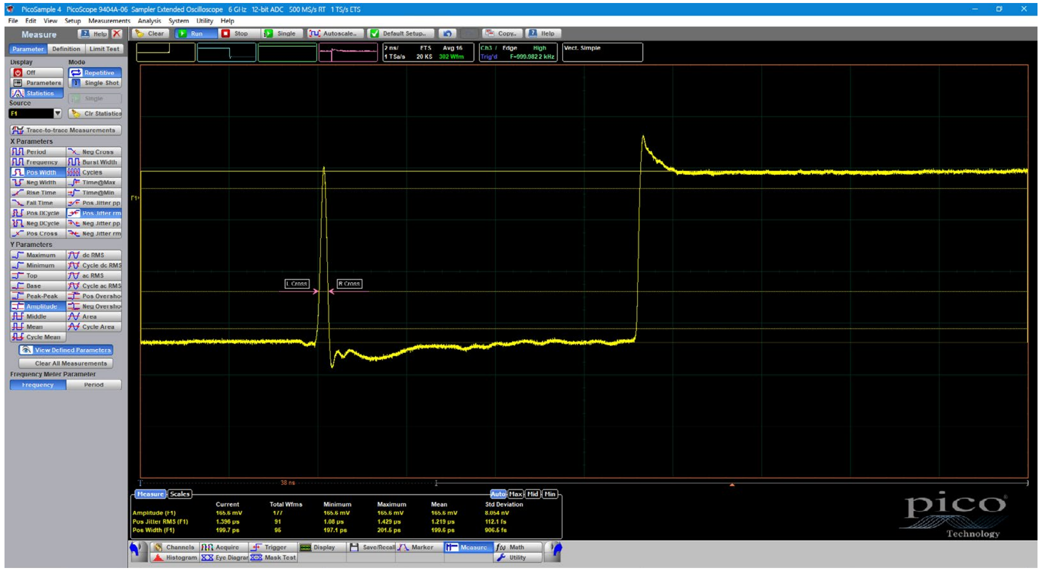
Selection of a measurement parameter displays its values, thresholds and bounds on the main display.




Single-trace measurements

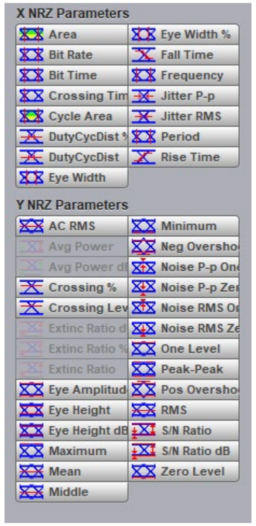



Trace-to-trace measurements

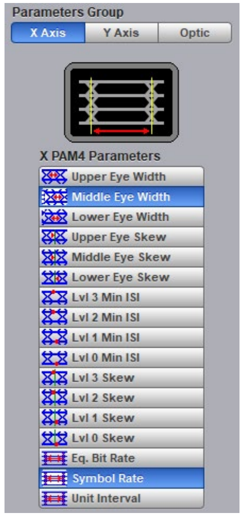


## Eye diagram measurements

The PicoScope 9400A Series scopes quickly measure more than 70 fundamental parameters used to characterize non-return-to-zero (NRZ) signals, return-to-zero (RZ) and pulse amplitude modulation with 4 levels (PAM4) signals.

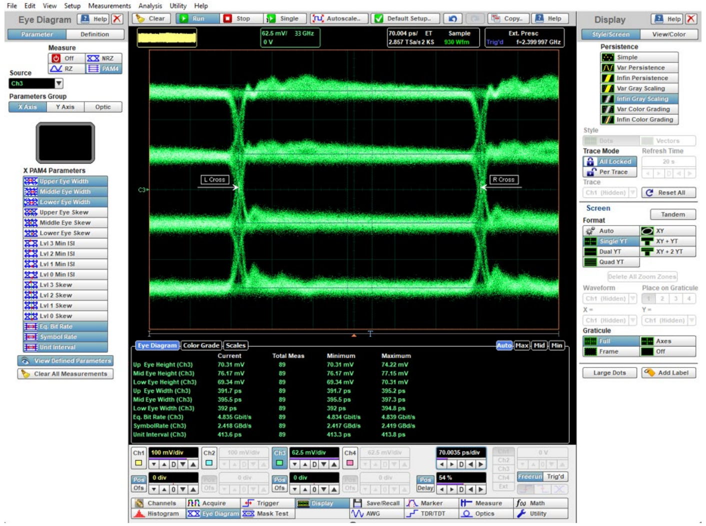




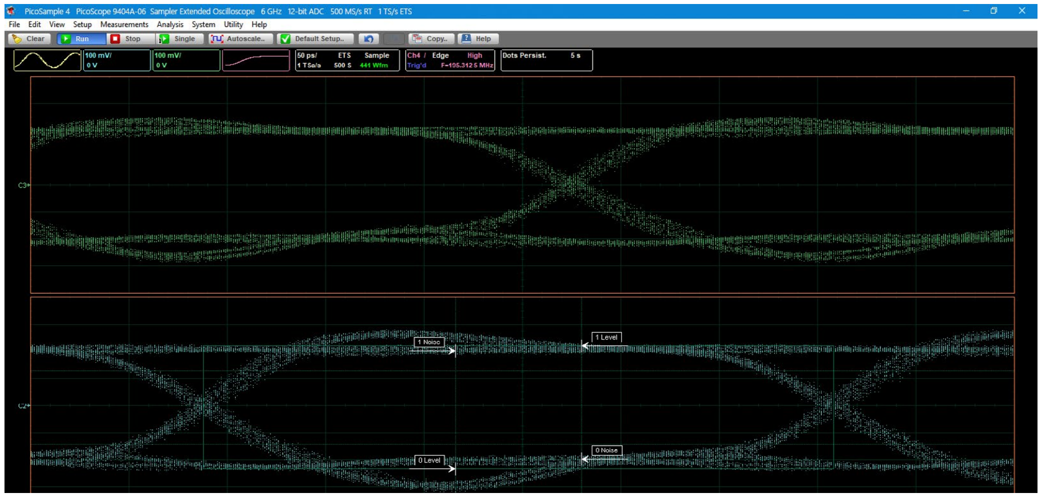



Eye diagram analysis can display data including: bit rate, period, crossing time, frequency, eye width, eye amplitude, mean, area and jitter RMS. Also shown on the graph are left and right RMS jitter markers. These measurements are selectable from within the Eye Diagram side menu and are listed on screen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

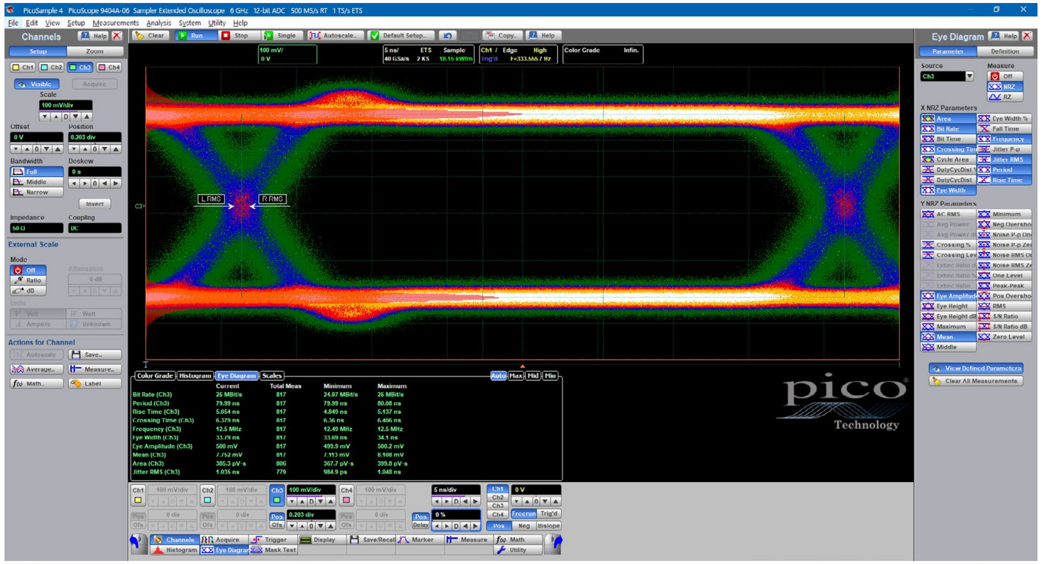
The measurement points and levels used to generate each parameter can optionally be drawn on the trace.



PAM4 signal eye diagram

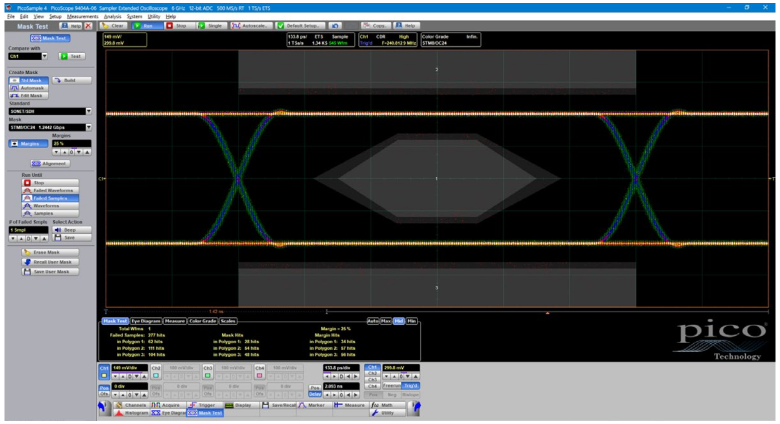


Measurement thresholds and bounds are displayed for the last selected measurement parameter.



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

## Mask testing



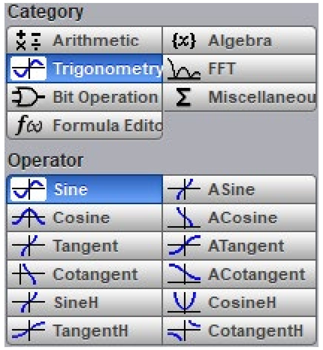
PicoSample 4 has a built-in library of over 200 masks for testing data eyes. It can count or capture mask hits or route them to an alarm or acquisition control. You can stress-test against a mask using a specified margin, and locally compile or edit masks.

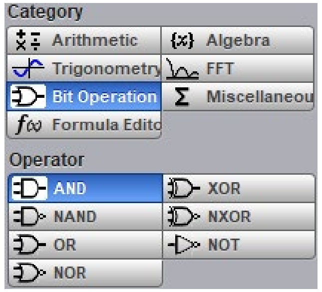
There's a choice of gray-scale and color-graded display modes, and a histogramming feature, all of which aid in analyzing noise and jitter in eye diagrams. There is also a statistical display showing a failure count for both the original mask and the margin.

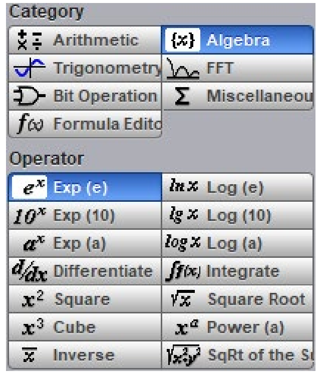
The extensive menu of built-in test waveforms is invaluable for checking your mask test setup before using it on live signals.

<table>
<tr><th rowspan="2">Mask test features</th><th rowspan="2">Masks</th><th colspan="4">Number of masks</th></tr>
<tr><th>9404A-06</th><th>9404-16</th><th>9404A-25</th><th>9404A-33</th></tr>
<tr><td rowspan="13">• Standard predefined mask<br>• Automask<br>• Mask saved on disk<br>• Create new mask<br>• Edit any mask</td><td>SONET/SDH</td><td>8</td><td>15</td><td colspan="2">23</td></tr>
<tr><td>Ethernet</td><td>7</td><td>18</td><td colspan="2">19</td></tr>
<tr><td>Fibre Channel</td><td>23</td><td colspan="3">31</td></tr>
<tr><td>PCI Express</td><td>29</td><td colspan="3">41</td></tr>
<tr><td>InfiniBand</td><td>13</td><td>17</td><td colspan="2">21</td></tr>
<tr><td>XAUI</td><td colspan="4">4</td></tr>
<tr><td>RapidIO</td><td colspan="4">9</td></tr>
<tr><td>Serial ATA</td><td colspan="4">24</td></tr>
<tr><td>ITU G.703</td><td colspan="4">14</td></tr>
<tr><td>ANSI T1.102</td><td colspan="4">7</td></tr>
<tr><td>USB</td><td>4</td><td colspan="3">8</td></tr>
<tr><td>CEI_OIF</td><td colspan="2">N/A</td><td colspan="2">2</td></tr>
<tr><td>SFF</td><td>N/A</td><td colspan="3">3</td></tr>
</table>

## Powerful mathematical analysis

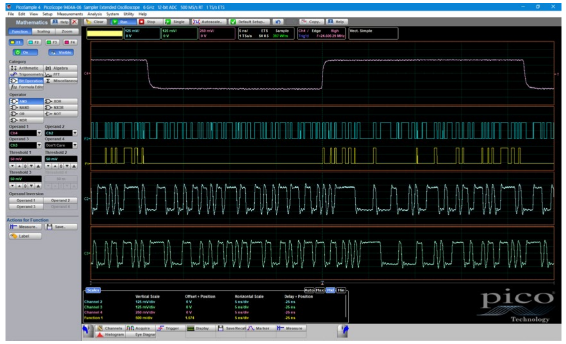



The PicoScope 9400A Series scopes support up to four simultaneous mathematical combinations or functional transformations of acquired waveforms.

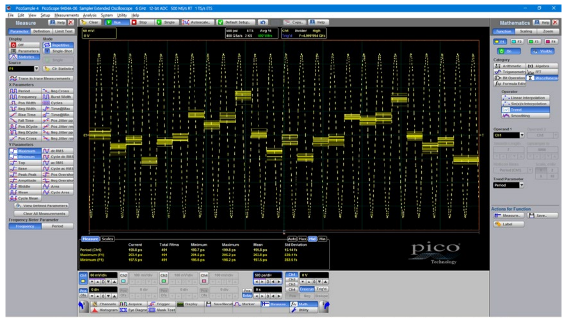
You can select any of the mathematical functions to operate on either one or two sources. All functions can operate on live waveforms, waveform memories or even other functions. There is also a comprehensive equation editor for creating custom functions of any combination of source waveforms.



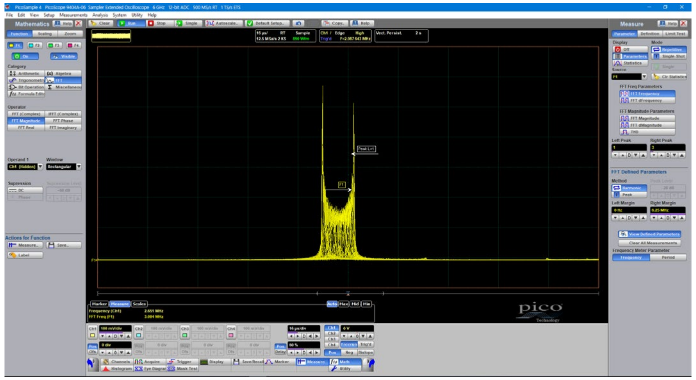
- Choose from 60 math functions, or create your own.
- Add, subtract, multiply, divide, invert, absolute, exponent, logarithm, differentiate, integrate, inverse, FFT, interpolation, smoothing, trending and boolean bit operation.

## Trending

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

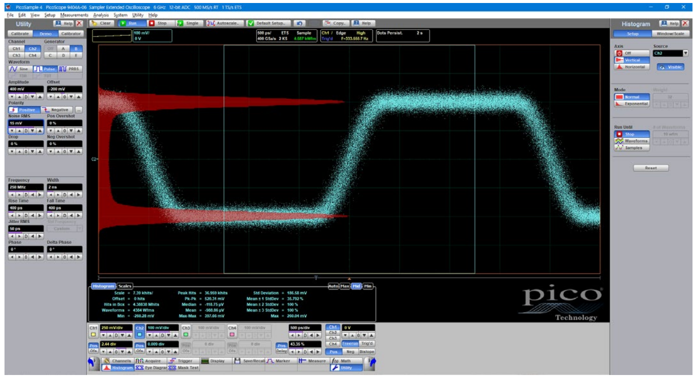


## FFT analysis



All PicoScope 9400A 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.

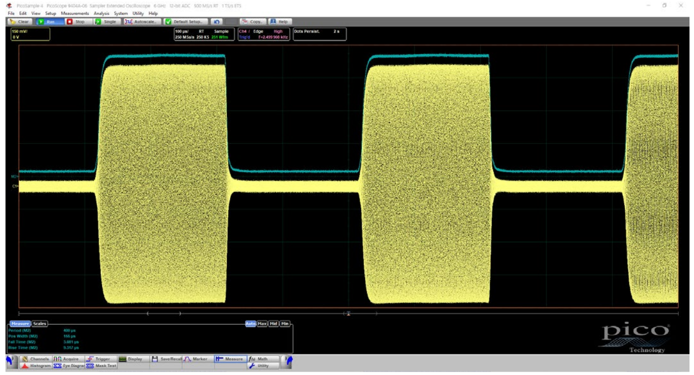
## Histogram analysis



Behind the powerful measurement and display capabilities of the PicoScope 9400A 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.

## Envelope acquisition



Pulsed RF carriers lie at the heart of our modern communications infrastructures, yet the shape, aberrations and timings of the final carrier pulse (at an antenna, for example) can be challenging to measure. If we choose demodulation, we are subject to the limitations of the demodulator; its bandwidth and distortions.

Envelope acquisition mode allows waveform acquisition and display showing the peak values of repeated acquisitions over a period of time.

Shown above on a PicoScope 9404A-06 SXRTO is a real-time capture of pulsed amplitude 2.4 GHz carrier.

The yellow trace is an alias of the 2.4 GHz carrier displayed at a timebase of 100 µs/div. The blue trace, offset slightly for clarity, is a **Max Envelope** capture of the yellow trace.

The enveloped waveform shows the maximum excursions of the carrier envelope and its pulse parameters can then be measured (bottom left of the image).

This measurement is limited by the maximum real-time sampling rate of the SXRTO (500 MS/s) and so has a Nyquist demodulation bandwidth of 250 MHz. Three other channels on the oscilloscope remain available to monitor, for example, modulating data and power supply voltages or currents feeding to the sourcing RF power amplifier.

## Software development kit (SDK)

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 9400A 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.

## Applications

### PAM4 (pulse amplitude modulation with four levels) benefits and challenges

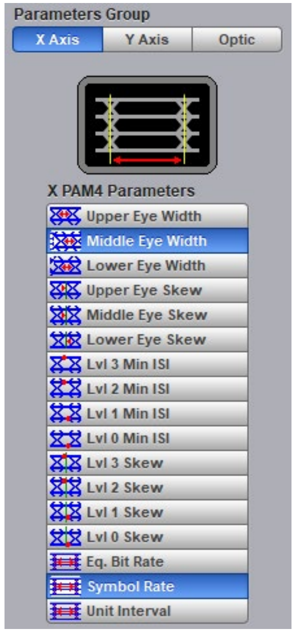
Traditionally, faster data transmission has been achieved by increasing the clock frequency. However, as technology approaches the practical limits of clock speed, and the demand for even higher data rates continues to grow, alternative methods of increasing throughput have become necessary.

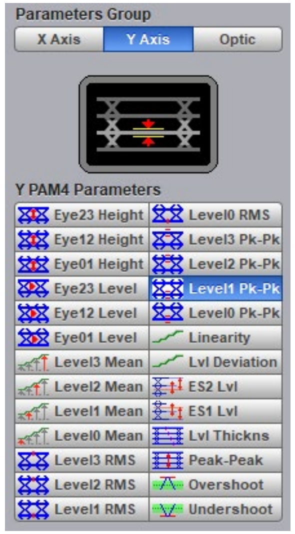
Pulse amplitude modulation, such as PAM4, increases the data rate by increasing the number of bits per symbol. Rather than just sending a 0 or 1, such as in NRZ, PAM4 encodes two bits into four amplitude levels.

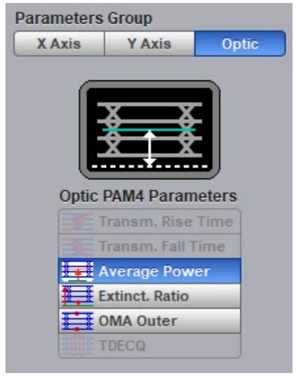
PAM4 eases some timing-related specifications such as jitter and rise time by slowing the demands on symbol rate. However, it introduces its own challenges. Inter-symbol interference caused by noise becomes a lot more more significant as the amplitude levels become closer.

Multiple different transitions between different signal levels can result in uneven eye openings, skew and asymmetrical data eyes, making decoding difficult and requiring more careful design to maintain the Baud rate.

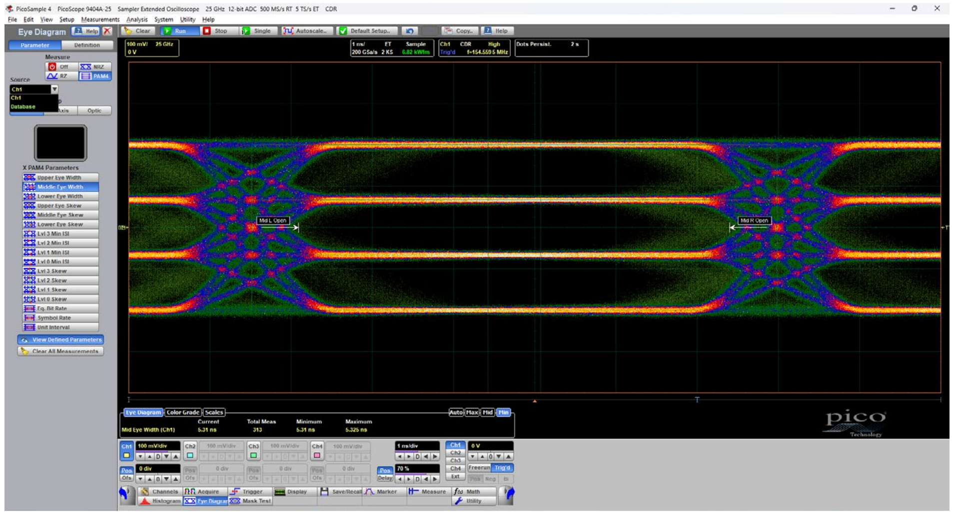
PicoSample 4 has a comprehensive suite of 49 automatic measurements for PAM4 eye diagrams, ensuring you can understand every aspect of your PAM4 physical layer.



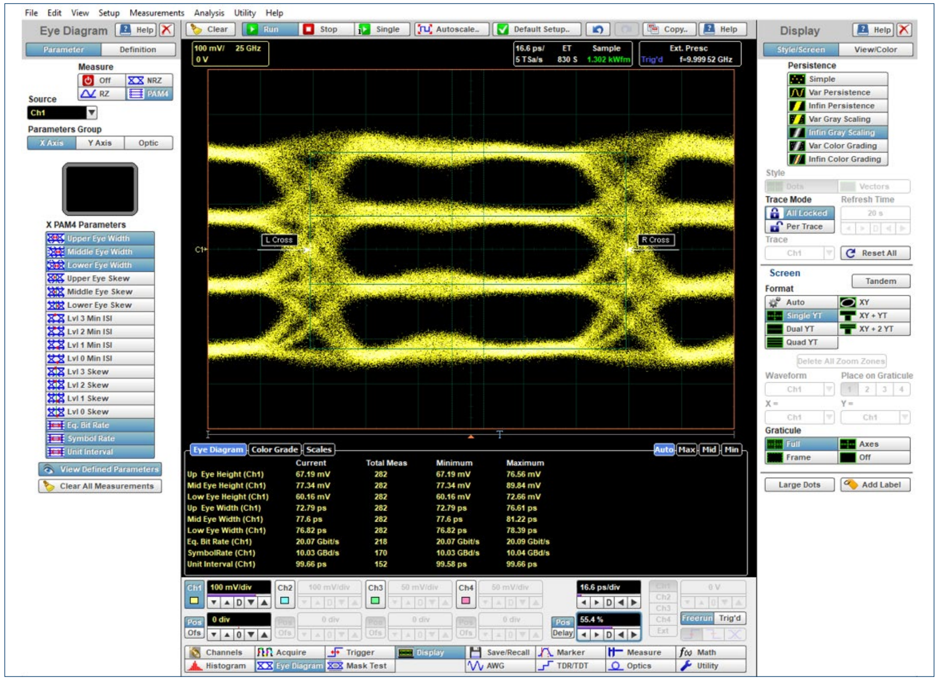




*Make automatic measurements of horizontal, vertical or optical parameters with 17 time measurements, 26 level measurements and six optic measurements.*



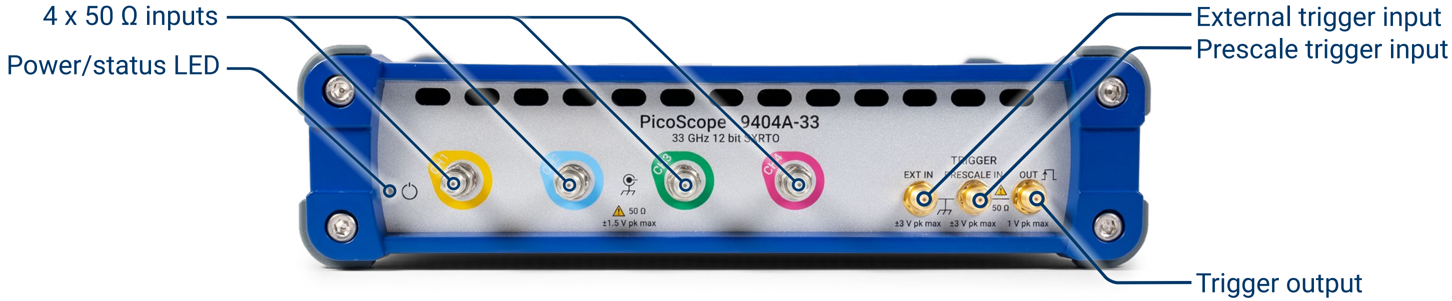
*Save PAM4 waveforms to a database and display both live and recorded data overlaid on the screen. Compare measurements of both datasets to quantify design changes quickly.*



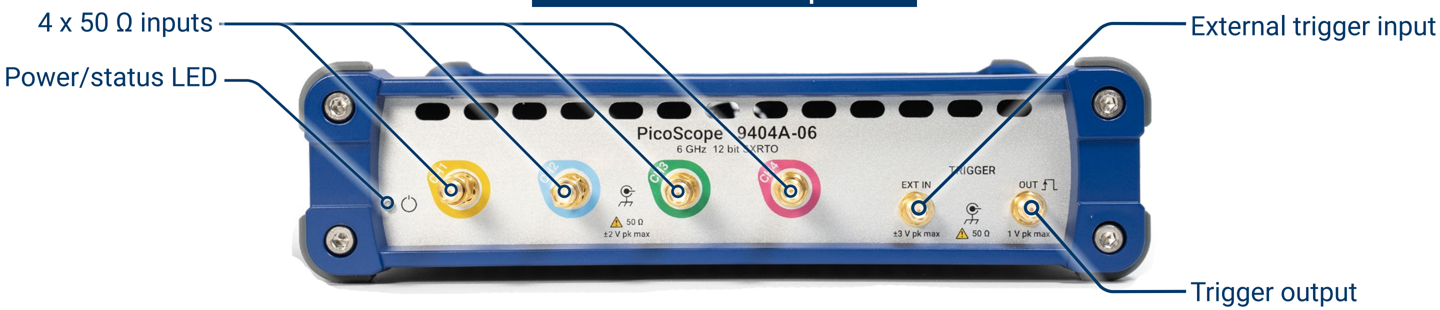
*Measure up to 10 parameters simultaneously, with markers indentifying key signal features, such as for this PAM waveform with a data rate of over 20 Gb/s*

## PicoScope 9404A models: inputs, outputs and indicators

### 9404A-16, -25 and -33 GHz front panel




### 9404A-06 front panel




**Power/status/trigger LED:** Green under normal operation. Also indicates connection progress and trigger.

**Channel inputs:** You can enable any number of channels without affecting the sampling rate; only the capture memory (250 kS) is shared between the enabled channels.

**EXT IN:** External direct trigger (up to 6 GHz)

**PRESCALE:** 20 GHz external prescaled trigger

**TRIGGER OUT:** Can be used to synchronize an external device to the PicoScope 9400A's rising edge, falling edge and end of holdoff triggers.

### Rear panel (all models)


**USB:** The USB 2.0 port (also compatible with USB 3.0) 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.

One of up to eight PicoScope 9400A units can be addressed from the PicoSample 4 software.

**CLK & DATA:** Recovered clock and data from the currently selected trigger source and the built-in clock recovery module (optional).

**12 V DC:** Power input. Use only the earthed mains adaptor supplied with the oscilloscope.

## PicoScope 9400A specifications

| | | PicoScope 9404A-06 | PicoScope 9404A-16 | PicoScope 9404A-25 | PicoScope 9404A-33 |
|---|---|---|---|---|---|
| **Vertical** | | | | | |
| **Number of input channels** | | 4 | | | |
| | | All channels are identical and digitized simultaneously | | | |
| **Analog bandwidth (−3 dB)†** | * Full bandwidth | DC to 6 GHz | DC to 16 GHz | DC to 25 GHz | DC to 33 GHz |
| | Middle bandwidth | DC to 500 MHz | DC to 500 MHz | N/A | N/A |
| | Narrow bandwidth | DC to 100 MHz | DC to 100 MHz | DC to 18 GHz | |
| **Passband flatness** | | ±1 dB to 3 GHz | ±1 dB to 5 GHz | ±1 dB to 4 GHz | ±1 dB to 8 GHz |
| **Calculated rise time (Tr), typical** | Full bandwidth | 10 to 90%: ≤ 58.4 ps<br>20 to 80%: ≤ 41.7 ps | 10 to 90%: ≤ 21.9 ps<br>20 to 80%: ≤ 15.6 ps | 10 to 90%: ≤ 14 ps<br>20 to 80%: ≤ 10 ps | 10 to 90%: ≤ 10.9 ps<br>20 to 80%: ≤ 7.8 ps |
| | Middle bandwidth | 10 to 90%: ≤ 700 ps<br>20 to 80%: ≤ 500 ps | 10 to 90%: ≤ 700 ps<br>20 to 80%: ≤ 500 ps | N/A | |
| | Narrow bandwidth | 10 to 90%: ≤ 3.5 ns<br>20 to 80%: ≤ 2.5 ns | 10 to 90%: ≤ 3.5 ns<br>20 to 80%: ≤ 2.5 ns | 10 to 90%: ≤ 19.5 ps<br>20 to 80%: ≤ 13.9 ps | N/A |
| | *Calculated from the bandwidth: 10% to 90%: calculated from Tr = 0.35/BW; 20% to 80%: calculated from Tr = 0.25/BW* | | | | |
| **RMS noise** | * Full bandwidth | 1.8 mV maximum, 1.6 mV typical | 2.4 mV maximum, 2.2 mV typical | 2.9 mV maximum, 2.7 mV typical | 2.95 mV, maximum, 2.8 mV, typical |
| | Middle bandwidth | 0.9 mV maximum, 0.75 mV typical | | N/A | |
| | Narrow bandwidth | 0.7 mV maximum, 0.6 mV typical | | 2.5 mV maximum, 2.3 mV typical | N/A |
| **Scale factors (sensitivity)** | | 10 mV/div to 250 mV/div. | | 10 mV/div to 200 mV/div. | |
| | | Adjustable in a 10-12.5-15-20-25-30-40-50-60-80-100-125-150-200-250 mV/div sequence.<br>Also adjustable in 1% fine increments or better.<br>With manual or calculator data entry the increment is 0.1 mV/div. | | | |
| *** DC gain accuracy** | | ±1.5% of full scale, warranted. ±1.0% of full scale, typical | | ±2.0% of full scale, warranted. ±1.5% of full scale, typical | ±2.5% of full scale, warranted. ±2.0% 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) or 2 mV increments (fine). | | Adjustable from −800 mV to +800 mV. | |
| | | Manual or calculator data entry: increment is 0.01 mV for offset −99.9 to +99.9 mV, and 0.01mV for offset -99.9mV to +99.9mV, 0.1 mV otherwise.<br>Referenced to the center of display graticule. | | | |
| *** Offset accuracy** | | ±2 mV ±1.5% of offset setting, maximum. ±1 mV ±1% of offset setting, typical | | ±2 mV ± 2.0% of offset setting, maximum. ±1 mV ± 1% of offset setting, typical | |
| **Operating input voltage** | | ±1 V | | ±800 mV | |
| **Vertical zoom and position** | | For all input channels, waveform memories, or functions<br>Vertical factor: 0.01 to 100<br>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<br>≥ 40 dB (100:1) for input frequency > 1 GHz to 3 GHz | | | |
| | | ≥ 36 dB (63:1) for input frequency > 3 GHz to 5 GHz: for 6 GHz and 16 GHz models | | ≥ 40 dB (100:1) for input frequency > 3 GHz to 16 GHz<br>≥ 36 dB (63:1) for input frequency > 16 GHz to 25 GHz | TBD |
| **Delay between channels** | | ≤ 10 ps, typical, between any two channels, full bandwidth, random sampling | | | |
| **ADC resolution** | | 12 bits | | | |
| **Hardware vertical resolution** | | 0.5 mV/LSB without averaging | | 0.4 mV/LSB without averaging | |

| | PicoScope 9404A-06 | PicoScope 9404A-16 | PicoScope 9404A-25 | PicoScope 9404A-33 |
|---|---|---|---|---|
| **Overvoltage protection** | ±1.4 V (DC + AC peak) | | ±1.5 V (DC + AC peak) | |
| *** Input impedance** | (50 ± 1.5) Ω. (50 ± 1) Ω, typical | | | |
| **Input match** | Reflections for 70 ps rise time: 10% or less | Reflections for 50 ps rise time: 10% or less | Reflections for 20 ps rise time: 10% or less | |
| **Input coupling** | DC | | | |
| **Input connectors** | SMA(f) | | 2.92 mm (K) female (compatible with SMA) | |
| **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) | 50 ps/div to 1000 s/div | 20 ps/div to 1000 s/div | 10 ps/div to 1000 s/div | |
| **Real-time sampling** | 10 ns/div to 1000 s/div | | | |
| **Random equivalent time sampling** | 50 ps/div to 5 µs/div | 20 ps/div to 5 µs/div | 10 ps/div to 5 µs/div | |
| **Roll** | 100 ms/div to 1000 s/div | | | |
| **Segmented** | Total number of segments: 2 to 1024. Rearm time between segments: <3 µs (trigger holdoff setting dependent) | | | |
| **Horizontal zoom and position** | For all input channels, waveform memories or functions<br>Horizontal factor: From 1 to 2000<br>Horizontal position: From 0% to 100% non-zoomed waveform | | | |
| **Timebase clock accuracy** | Frequency: 500 MHz | | | |
| **Initial set tolerance @ 25 ± 3 °C** | ±0.5 ppm | | | |
| **Overall frequency stability over operating temperature range** | ±2 ppm | | | |
| **Aging (over 10 years @ 25 °C)** | ±3 ppm | | | |
| **Timebase resolution (with random sampling)** | 1 ps | 0.4 ps | 0.2 ps | |
| *** Delta time measurement accuracy** | ±(0.5 ppm * reading + 0.1% * screen width + 2 ps) | | | |
| **Pre-trigger delay** | Record length / current sampling rate maximum at zero variable delay time | | | |
| **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 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 | | | |
| **Sampling modes** – Random | Acquires sample points over several trigger events, requiring the input waveform to be repetitive | | | |
| **Sampling modes** – Roll | Acquisition data is 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) | | | |
| **Sampling modes** – Segmented | Segmented memory optimizes available memory for data streams that have long rearm times between activity.<br>Number of segments: up to 1024.<br>Segments stamped with absolute and delta times. | | | |

| | | PicoScope 9404A-06 | PicoScope 9404A-16 | PicoScope 9404A-25 | PicoScope 9404A-33 |
|---|---|---|---|---|---|
| Maximum sampling rate | Real-time | 500 MS/s per channel simultaneously | | | |
| | Random | Up to 1 TS/s or 1 ps trigger placement resolution | Up to 2.5 TS/s or 0.4 ps trigger placement resolution. | Up to 5 TS/s or 0.2 ps trigger placement resolution. | |
| Record length | **Real-time** | 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** | 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 real-time sampling 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. | | | |
| | Segmented | Number of segments: 1 to 1024, rearm time: < 3 µs or user defined holdoff time, whichever is larger (minimum time between trigger events). User can view selected segment, overlaid segments or selected plus overlay. Search segments: step through, gated block and binary search. Segments are delta and absolute time-stamped. | | | |
| **Trigger** | | | | | |
| **Trigger sources** | | Internal from any of four channels, external direct, external prescaled | | | |
| **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 | Software button that triggers only once on a trigger event. Not suitable for random sampling. | | | |
| **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.<br>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. | | | |
| **Internal trigger** | | | | | |
| **Trigger style** | **Edge** | Triggers on a rising and falling edge of any source within frequency range DC to 2.5 GHz. | | | |
| | **Divide** | The trigger source is divided down four times (/4) before being applied to the trigger system. Maximum trigger frequency 6 GHz. | | | |
| | **Clock recovery (optional)** | Triggers on the rising edge of the recovered clock. | | | |
| | | 6.5 Mb/s to 5 Gb/s | 6.5 Mb/s to 8 Gb/s | 6.5 Mb/s to 11.3 Gb/s | |
| **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 6 GHz. Pulse Width: 80 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 6 GHz. Pulse Width: 80 ps @ 70 mV p-p. | | | |
| **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<br>**Negative**: Triggers on falling edge<br>**Bi-slope**: Triggers on both edges of the signal | | | |
| *** RMS jitter (Combined trigger and interpolator jitter)** | | 1.5 ps + 0.1 ppm of delay, maximum<br>1.2 ps + 0.1 ppm of delay, typical<br>Tested at 2.5 GHz/600 mV p-p sine wave for edge trigger, and at 6 GHz/600 mV p-p sine wave for divided trigger. | | | |
| | | Clock recovery trigger (optional): 2 ps + 1.0% of unit interval + 0.1 ppm delay, maximum | | | |
| **Coupling** | | DC | | | |

| | | PicoScope 9404A-06 | PicoScope 9404A-16 | PicoScope 9404A-25 | PicoScope 9404A-33 |
|---|---|---|---|---|---|
| **External prescaled trigger** | | | | | |
| Coupling | | N/A | 50 Ω, AC coupled, fixed level zero volts | | |
| *Bandwidth and sensitivity | | | 100 mV p-p from 1 GHz to 16 GHz | 100 mV p-p from 1 GHz to 20 GHz | 100 mV p-p from 1 GHz to 20 GHz |
| *RMS jitter | | | 1.5 ps, maximum, 1.2 ps, typical. For trigger input slope > 5 V/ns. Combined trigger and interpolator jitter. | | |
| Prescaler ratio | | | Divided by 8, fixed | | |
| Maximum safe input voltage | | | ±3 V (DC + AC peak) | | |
| Input connector | | | SMA(f) | | |
| **External direct trigger** | | | | | |
| Style | Edge | Triggers on a rising and falling edge of any source from DC to 2.5 GHz. | | | |
| | Divide | Trigger source divided by 4 before input to the trigger system.<br>Maximum trigger frequency 6 GHz. | | | |
| | Clock recovery (optional) | Triggers on the rising edge of the recovered clock | | | |
| | | From 6.5 Mb/s to 5 Gb/s | From 6.5 Mb/s to 8 Gb/s | From 6.5 Mb/s to 11.3 Gb/s | |
| Coupling | | DC | | | |
| Bandwidth and sensitivity | * Low sensitivity | 100 mV p-p DC to 100 MHz.<br>Increasing linearly from 100 mV p-p at 100 MHz to 200 mV p-p at 6 GHz.<br>Pulse width: 80 ps @ 200 mV p-p typical. | | | |
| | High sensitivity | 30 mV p-p DC to 100 MHz.<br>Increasing linearly from 30 mV p-p at 100 MHz to 70 mV p-p at 6 GHz.<br>Pulse width: 100 ps @ 70 mV p-p. | | | |
| Level range | | −1 V to 1 V.<br>10 mV coarse increments.<br>1 mV fine increments. | | | |
| Slope | | Rising, falling, bi-slope | | | |
| * RMS jitter, edge and divided | | 1.5 ps + 0.1 ppm of delay, maximum.<br>1.2 ps + 0.1 ppm of delay, typical.<br>Tested at 2.5 GHz/600 mV p-p sine wave for Edge trigger, and at 6 GHz/600 mV p-p sine wave for Divided trigger. | | | |
| RMS jitter, clock recovery (optional) | | 2 ps + 1.0% of unit interval + 0.1 ppm of delay, maximum | | | |
| Maximum safe input voltage | | ±3 V (DC + AC peak) | | | |
| Input connector | | SMA(f) | | | |
| **Display** | | | | | |
| Persistence | | **Simple**: No persistence<br>**Variable persistence**: Time that each data point is retained on the display. Persistence time can be varied from 100 ms to 20 s.<br>**Infinite persistence**: In this mode, a waveform sample point is displayed forever.<br>**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.<br>**Infinite Gray Scaling**: In this mode, a waveform sample point is displayed forever in five levels of a single color.<br>**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.<br>**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.<br>**Vector**: This function draws a straight line through the data points on the display. Not suited to multi-value signals such as an eye diagram. | | | |
| Graticule | | **Full** Grid, **Axes** with tick marks, **Frame** with tick marks, **Off** (no graticule) | | | |

| | PicoScope 9404A-06 | PicoScope 9404A-16 | PicoScope 9404A-25 | PicoScope 9404A-33 |
|---|---|---|---|---|
| Format | **Auto**: Automatically places, adds or deletes graticules as you select more or fewer waveforms to display.<br>**Single XT**: All waveforms are superimposed and are eight divisions high.<br>**Dual YT**: With two graticules, all waveforms can be four divisions high, displayed separately or superimposed.<br>**Quad YT**: With four graticules, all waveforms can be two divisions high, displayed separately or superimposed.<br>When you select dual or quad screen display, every waveform channel, memory and function can be placed on a specified graticule.<br>**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 plotted on the vertical Y axis.<br>**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.<br>**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.<br>**Tandem**: Displays graticules to the left and to the right. | | | |
| Colors | 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)<br>Database files: .wdb<br>Setup files: .set<br>User mask files: .pcm | | | |
| Operating system | Microsoft Windows 7, 8 and 10 (32-bit and 64-bit) and Windows 11 (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.<br>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 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.<br>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)<br>**Y-Marker**: horizontal bars (measure volts)<br>**XY-Marker**: waveform markers | | | |
| Marker measurements | Absolute, Delta, Volt, Time, Frequency and Slope | | | |
| Marker motion | **Independent**: both markers can be adjusted independently.<br>**Paired**: both markers can be adjusted together. | | | |
| Ratiometric measurements | Provide ratios between measured and reference values. Results in such ratiometric units as %, dB, and degrees. | | | |
| **Measure** | | | | |
| Automated measurements | Up to ten simultaneous measurements are supported. | | | |
| Automatic parametric | 53 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. | | | |

| | | PicoScope 9404A-06 | PicoScope 9404A-16 | PicoScope 9404A-25 | PicoScope 9404A-33 |
|---|---|---|---|---|---|
| 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** | | | |
| Counter (Built-in frequency counter) | Source | Internal from any of four channels, External, External Prescaled | | | |
| | Resolution | 7 digits | | | |
| | Maximum frequency | Internal or external direct trigger: 6 GHz | | | |
| | | External prescaled trigger: N/A | External prescaled trigger: 16 GHz | External prescaled trigger: 20 GHz | |
| | Measurement | Frequency, period | | | |
| | Time reference | Internal 250 MHz reference clock | | | |
| **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<br>**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<br>**Trigonometry:** Sine, Cosine, Tangent, Cotangent, ArcSine, Arc Cosine, ArcTangent, Arc Cotangent, Hyperbolic Sine, Hyperbolic Cosine, Hyperbolic Tangent, Hyperbolic Cotangent<br>**FFT:** Complex FFT, FFT Magnitude, FFT Phase, FFT Real part, FFT Imaginary part, Complex Inverse FFT, FFT Group Delay<br>**Bit operator:** AND, NAND, OR, NOR, XOR, XNOR, NOT<br>**Miscellaneous:** Trend, Linear Interpolation, Sin(x)/x Interpolation, Smoothing<br>**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)<br>FFT frequency resolution: Frequency Resolution = Sample Rate / Record Length<br>FFT windows: The built-in filters (Rectangular, Hamming, Hann, Flattop, Blackman–Harris and Kaiser–Bessel) allow optimization of frequency resolution, transients, and amplitude accuracy.<br>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.<br>Automated FFT Measurements include: FFT Magnitude, FFT Delta Magnitude, THD, FFT Frequency, and FFT Delta Frequency. | | | |
| **Histogram** | | | | | |
| Axis | | Vertical or horizontal. Both vertical and horizontal histograms, with periodically updated measurements, allow statistical distributions to be analyzed over any region of the signal. | | | |
| 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 | | | |
| 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 | | PicoScope can automatically characterize an NRZ and RZ eye pattern. Measurements are based upon statistical analysis of the waveform. | | | |
| NRZ measurements | X-axis | 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-axis | 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 | | | |

| | | PicoScope 9404A-06 | PicoScope 9404A-16 | PicoScope 9404A-25 | PicoScope 9404A-33 |
|---|---|---|---|---|---|
| RZ measurements | X-axis | 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-axis | 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 | | | |
| PAM4 measurements | X-axis | Upper Eye Width, Middle Eye Width, Lower Eye Width Upper Eye Skew, Middle Eye Skew, Lower Eye Skew, Lvl 3 Min ISI, Lvl 2 Min ISI, Lvl 1 Min ISI, Lvl 0 Min ISI, Lvl 3 Skew, Lvl 2 Skew, Lvl 1 Skew, Lvl 0 Skew, Eq. Bit Rate, Symbol Rate, Unit Interval | | | |
| | Y-axis | Eye23 Height, Eye12 Height, Eye01 Height, Eye23 Level, Eye12 Level, Eye01 Level, Level3 Mean, Level2 Mean, Level1 Mean, Level0 Mean, Level3 RMS, Level2 RMS, Level1 RMS, Level0 RMS, Level3 Pk-Pk, Level2 Pk-Pk, Level1 Pk-Pk, Level0 Pk-Pk, Linearity, Lvl Deviation, ES2 Lvl, ES1 Lvl, Lvl Thickns, Peak-Peak, Overshoot, Undershoot | | | |
| | Optic | Transm. Rise Time, Transm. Fall Time, Average Power, Extinct. Ratio, OMA Outer, TDECQ | | | |
| **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 masks | | Standard predefined optical or standard electrical masks can be created. | | | |
| | SONET/SDH | STMO/OC1 (51.84 Mb/s) to FEC 2666 (2.6666 Gb/s) | | | |
| | | N/A | OS19/STM64 (9.95328 Gb/s) to FEC1066 (10.864 Gb/s) | OTU2: 10.709 Gb/s) to DT_18FC_TEST (14.025 Gb/s) | |
| | Fibre Channel | FC133 Electrical (132.8 Mb/s) to FC2125E Abs Gamma Tx.mask (2.125 Gb/s) | | | |
| | | N/A | FC4250 Optical PI Rev13 (4.25 Gb/s) to FC4250E Abs Gamma Tx.mask (4.25 Gb/s) | | |
| | Ethernet | 100BASE-BX10 (125 Mb/s) to 3.125 Gb/s 10GBase-CX4 Absolute TP2 (3.125 Gb/s) | | | |
| | | N/A | | 10Gb Ethernet (9.953 Gb/s) to 10xGb Ethernet (12.5 Gb/s) | |
| | InfiniBand | 2.5 G driver test points (2.5 Gb/s). Ten masks, test points 1 to 10 | | | |
| | | N/A | 5.0G driver test point 1 (5 Gb/s)<br>5.0G driver test point 6 (5 Gb/s)<br>5.0G transmitter pins (5 Gb/s) | QDR 10.0 (10 Gb/s) to FDR_Stress_Out (10.0627 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 | Serial Level 1, 1.25G Rx (1.25 Gb/s) to 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) | | | |
| | | N/A | R2.0 5.0G Add-in Card 35 dB Transmitter Non-Transition bit mask (5 Gb/s) to R2.1 5.0G Transmitter Transition bit mask (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) | | | |
| | CEI_OIF | N/A | | CEI-11G-LR/MR 11.2 (11.1982 Gbps) to CEI-11G-SR 11.2 (11.1982 Gbps) | |
| | SFF | N/A | SFF-8431 Host Receiver Test Signal 10.3125 (10.3125 Gb/s) to SFF-8431 10.3125 (10.3125 Gb/s) Module Receiver Output 10.3125 (10.3125 Gbps) | | |
| | USB | USB 2.0 Low Speed (1.5 Mbps) to USB 3.1 Gen2 (10 Gb/s) | | | |
| | | N/A | USB 3.0 Gen 1 (5 Gb/s) | USB 3.1 Gen 2 (10 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 | | | |
| **Trigger output** | | | | | |
| Timing | | Positive transition equivalent to acquisition trigger point. Negative transition after user holdoff. | | | |
| Low level | | (−0.2 ± 0.1) V into 50 Ω | | | |
| Amplitude | | (900 ± 200) mV into 50 Ω | | | |

| | PicoScope 9404A-06 | PicoScope 9404A-16 | PicoScope 9404A-25 | PicoScope 9404A-33 |
|---|---|---|---|---|
| Rise time | 10 to 90%: ≤ 0.45 ns; 20 to 80%: ≤ 0.3 ns | | | |
| RMS jitter | ≤ 2 ps | | | |
| Output delay | 4 ± 1 ns | | | |
| Output coupling | DC | | | |
| Output connectors | SMA(f) | | | |
| **Clock recovery trigger - recovered data output (optional)** | | | | |
| Data rate | 6.5 Mb/s to 5 Gb/s | 6.5 Mb/s to 8 Gb/s | 6.5 Mb/s to 11.3 Gb/s | |
| Eye amplitude | 250 mV p-p, typical | | | |
| Eye rise/fall time, 20 to 80% | 75 ps, typical | 50 ps, typical | | |
| RMS jitter | 2 ps + 1% of unit interval | | | |
| Output coupling | AC | | | |
| Output connections | SMA(f) | | | |
| **Clock recovery trigger - recovered clock output (optional)** | | | | |
| Output frequency (half-full-rate clock output) | 3.25 MHz to 3 GHz | 3.25 MHz to 4 GHz | 3.25 MHz to 5.65 GHz | |
| Output amplitude | 250 mV p-p, typical | | | |
| Output coupling | AC | | | |
| Output connectors | SMA(f) | | | |
| **General** | | | | |
| Power supply voltage | +12 V ± 5% | | | |
| Power supply current | 2.7 A | 2.8 A | 2.4 A | 2.5 A |
| Protection | Automatic shutdown on excess or reverse voltage | | | |
| AC-DC adaptor | Universal adaptor supplied | | | |
| PC connection | USB 2.0 (high speed). Also compatible with USB 3.0. | | | |
| | Ethernet LAN | | | |
| Software | PicoSample 4: Windows 7, 8 and 10 (32-bit and 64-bit versions) and Windows 11 (64-bit) | | | |
| PC requirements | Processor, memory and disk space: as required by the operating system | | | |
| Temperature range | Operating: +5 to +40 °C for normal operation, +15 to +25 °C for quoted accuracy<br>Storage: −20 to +50 °C | | | |
| Humidity range | Operating: Up to 85 %RH (non-condensing) at +25 °C<br>Storage: Up to 95 %RH (non-condensing) | | | |
| Environment | Up to 2000 m altitude and EN61010 pollution degree 2: “only nonconductive pollution occurs except that occasionally a temporary conductivity caused by condensation is expected” | | | |
| Dimensions (W × H × D) | 244 × 54 × 233 mm | | | |
| Net weight | 1.52 kg | | | |
| Compliance | CFR-47 FCC (EMC), EN 61326-1 (EMC) and EN 61010-1 (LVD) | | | |
| Warranty | 3 years | | | |

* Specifications marked with (*) are checked during performance verification.
† These specifications are valid after a 30-minute warm-up period and ±2 °C from firmware calibration temperature.

## Kit contents and accessories

Your PicoScope 9400A Series oscilloscope kit contains the following items:

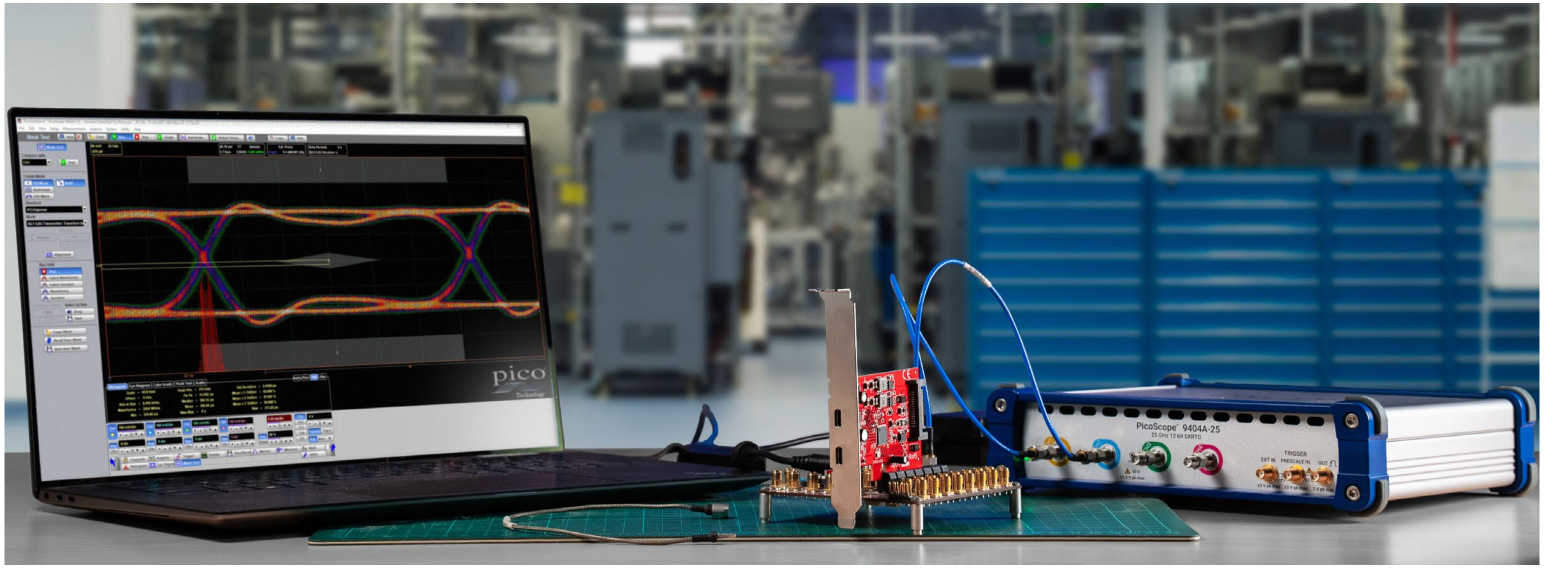
- PicoScope 9400A Series sampler-extended real-time oscilloscope (SXRTO)
- Free software and updates from www.picotech.com/downloads
- Quick start guide
- 12 V power supply, IEC inlet
- 4 x localized IEC mains leads (UK, EU, US, Australia/New Zealand)
- USB cable, 1.8 m
- Four connector savers (either SMA or K, model dependent)
- PicoWrench N / SMA / PC3.5 / K combination 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 | |
| TA571 | 40 GHz 50 Ω 2.92 mm (K) female (compatible with SMA) connector saver adaptor | |
| **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 |  |
| **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 | |
| TA283 | PicoConnect 916 5:1 230 Ω DC-coupled 5 GHz RF, microwave and pulse probe | |
| TA272 | PicoConnect 921 20:1 AC-coupled 6 GHz gigabit passive probe |  |
| TA273 | PicoConnect 922 20:1 DC-coupled 6 GHz gigabit passive probe | |
| TA276 | PicoConnect 923 10:1 AC-coupled 7 GHz gigabit passive probe | |
| TA277 | PicoConnect 924 10:1 DC-coupled 7 GHz gigabit passive probe | |
| TA280 | PicoConnect 925 5:1 AC-coupled 9 GHz gigabit passive probe | |
| TA281 | PicoConnect 926 5:1 DC-coupled 9 GHz gigabit passive probe | |

## Optional accessories

| Order code | Description | |
|---|---|---|
| **Attenuators** | | |
| TA181 | Attenuator 3 dB 10 GHz 50 Ω SMA (m-f) |  |
| TA261 | Attenuator 6 dB 10 GHz 50 Ω SMA (m-f) | |
| TA262 | Attenuator 10 dB 10 GHz 50 Ω SMA (m-f) | |
| TA173 | Attenuator 20 dB 10 GHz 50 Ω SMA (m-f) | |
| **Coaxial cable assemblies** | | |
| 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** | | |
| TA358 | Torque wrench N-type 1 N·m (8.85 in·lb) dual-break |  |
| TA356 | Torque wrench SMA/PC3.5/K, 1 N·m (8.85 in·lb) dual-break |  |



## PicoScope 9400A Series sampler-extended real-time oscilloscope ordering information

| Description | Bandwidth (GHz) | Channels | Order code |
|---|---|---|---|
| PicoScope 9404A-33 oscilloscope | 33 | 4 | PQ407 |
| PicoScope 9404A-25 oscilloscope | 25 | | PQ355 |
| PicoScope 9404A-16 oscilloscope | 16 | | PQ405 |
| PicoScope 9404A-06 oscilloscope | 6 | | PQ403 |

## More products from the Pico Technology range...

**PicoSource AS108 Series**
Agile, fast and portable frequency analyzer

- **Span:** 0.3 MHz to 8 GHz, +15 dBm to −15 dBm
- CW, Sweep or Step modes
- Programmable frequency, phase and amplitude
- **Settle Frequency:** < 55 µs to 10 ppm
- **Settle Amplitude:** < 200 µs to 0.1 dB
- Standalone power up mode

**PicoSource PG900 Series**
Differential picosecond pulse generators

- Integral 50 Ω SMA(f) Step recovery diode outputs
- < 60 ps transition time
- Dual 2.5 to 6 V variable amplitude outputs
- ±1 ns in 1 ps steps timing deskew
- 200 ns to 4 µs pulse width

**PicoScope 6000 Series**
Ultra-deep memory

- **Channels:** 4 or 8 + 16 digital MSO
- **SigGen/AWG:** 200 MS/s
- **Bandwidth:** Up to 3 GHz
- **Sampling:** Up to 10 GS/s
- **Resolution:** 8 to 12 bits
- **Capture memory:** 2 to 4 GS

**PicoVNA 100 Series**
Quad RX fast and portable vector network analyzer

- 300 kHz to 6 or 8.5 GHz operation
- High speed, up to 5500 dual-port S-parameters per second
- Quad RX four-receiver architecture for best accuracy
- Up to 124 dB dynamic range at 10 Hz bandwidth