PicoScope 9400 Series - 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

Vertical	
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.

Vertical	
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 with 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	

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	
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	

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.

Display	
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	
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, 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

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:** 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 × Time base 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	
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.
Mask creation	Create the following masks: Standard predefined Mask, Automask, Mask saved on disk, Create new mask, Edit any mask.

Mask test	
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.

Trigger output	
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 of the *User's Guide*.
[1] These specifications are valid after a 30-minute warm-up period and ±2 °C from firmware calibration temperature.

Accessories