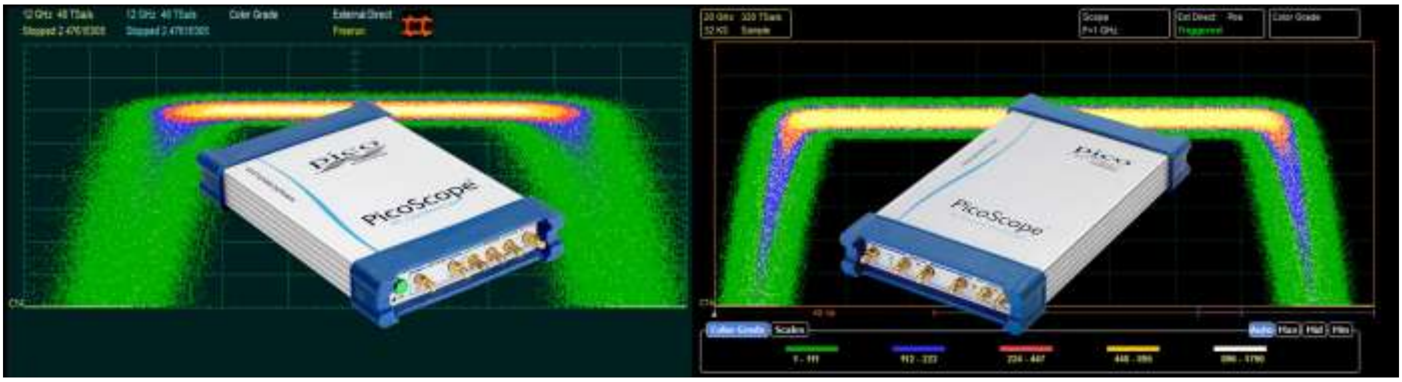
PicoScope 9300 Series migration guide



PicoScope sampling oscilloscopes since 2009

The PicoScope 9300 Series is a leading-edge product family resulting from a long program of product development. From late 2017, in the process of adding new 15 GHz and 25 GHz models, we will be discontinuing the PicoScope 9200 Series and the PicoScope 9312. If you are familiar with the PicoScope 9200 Series or the PicoScope 9312 and wish to use similar but updated technology in your next application, this guide will help you find the right PicoScope 9300 model.

In this migration guide we go beyond the headline specifications to discuss the improved hardware and software in the PicoScope 9300 Series. We also consider the PicoSource PG900 fast pulse generators, which use the same fast pulse technology found in the PicoScope 9300 Series sampling oscilloscopes.

Available product configurations

Leaving aside parameter specifications for a moment, you first need to decide on the hardware configuration—the combination of input and output channels—that best suits your requirements.

Figure 1 –PicoScope 9300 Series and PicoSource PG900 Series

As shown in Figure 1, the range of models that we offer is extensive. The 15 to 25 GHz PicoScope 9300 Series is available with and without TDR/TDT sources, optical-to-electrical converters and clock recovery capability. The PicoSource PG900 Series is available with built-in 60 ps outputs, external 40 ps outputs or both together.

Requirement	*Legacy model*	PicoScope 9300	PicoScope 9300 + PicoSource PG900
Two-channel sampling oscilloscope	*9201*	9301-15 9301-25	
Four-channel sampling oscilloscope *Often needed in differential applications*		9341-20 9341-25	9341-20 9341-25
Time domain network, cable, port or component analysis *TDT/TDR (time domain transmission/reflectometry)*	*9211*	9311-15 9311-20	Any 9300
Differential TDT or TDR		9311-15 9311-20	Any 9300
Optical fiber applications	*9221* *9231*	9321-20	9321-20
Recovery of clock from data in serial data applications	*9211 or 9231*	9302-15 9302-25 9321-20	9302-15 9302-25 9321-20
TDR/TDT with 60 ps transition time	*9312*	9311-20	
Approximate price range	*N/A*	$11k to $29k	$19k to $42k
Warranty		5 years	

Table 1 – Selection of model or configuration

Channel and trigger bandwidth, sampling rate and jitter

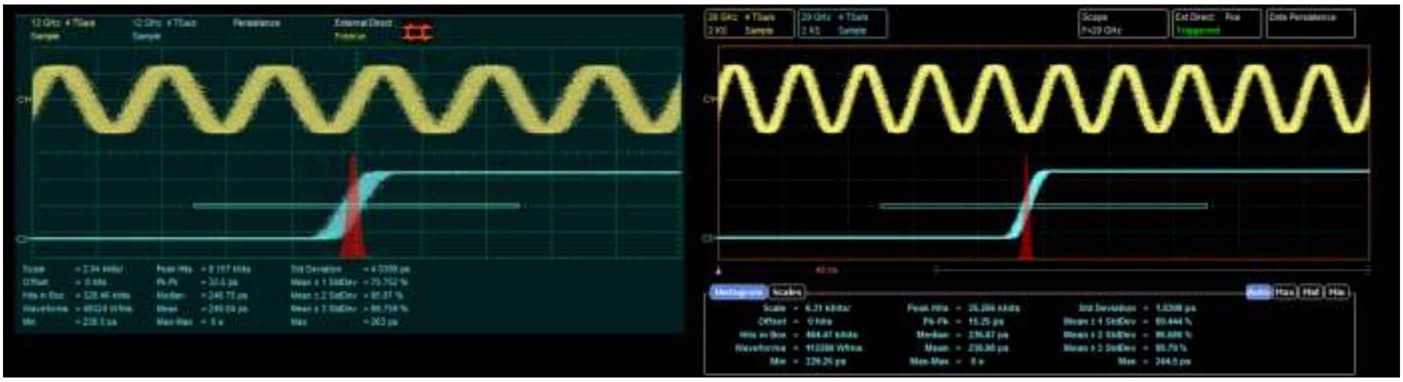


Figure 2 - More bandwidth and lower jitter with the PicoScope 9300
Left: PicoScope 9200. Right: PicoScope 9300

The bandwidth of your oscilloscope must be large enough for the signal speed or bandwidth (related to its frequency, data rate or transition time). Higher-bandwidth instruments also have faster triggers, shorter sampling interval (time resolution) and lower timing jitter. All PicoScope 9300 Series have higher bandwidth than the 9200 Series models they replace.

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Parameter	*Legacy PicoScope 9200 Series*	PicoScope 9300 Series
Channel input –3 dB bandwidth[1]	*12 GHz*	15 to 25 GHz
Data rate that can be viewed, max.[1]	*24 Gb/s*	30 to 50 Gb/s
Data interval or pulse width that can be viewed, min.[1]	*42 ps*	33 to 20 ps
Data rate that can be characterized to 3rd harmonic, max.	*8 Gb/s*	10.0 to 16.6 Gb/s
Data interval that can be characterized to 3rd harmonic, min.	*125 ps*	100 to 60 ps
Data rate that can be characterized to 5th harmonic, max.	*4.8 Gb/s*	6 to 10 Gb/s
Data interval that can be characterized to 5th harmonic, min.	*208 ps*	167 to 100 ps
Sampling interval (time resolution), min.	*0.2 ps*	0.064 ps
Effective sampling rate, max.	*5 TS/s*	15 TS/s
Sampling jitter *(time smear due to the oscilloscope in the displayed waveform or eye)*, max.	*4 ps RMS*	2.0 ps RMS
Microwave bands covered[1]	*I,G,P,L,S,C,X*	I,G,P,L,S,C,X,K

Note [1]: See also maximum trigger rate constraints below

Table 2 – Selection of input bandwidth and sampling parameters

A peculiarity of sampling oscilloscopes is that trigger bandwidth rarely matches channel or sampler bandwidth. To facilitate stable trigger (and hence waveform display) from very high signal frequencies, all PicoScope 9200 and 9300 sampling oscilloscopes feature a separate prescaled trigger input. Here the trigger rate is divided down to a rate that the sampling oscilloscope can accept. This is sufficient on a sampling oscilloscope as a repetitive signal and trigger are required anyway. You should therefore always consider prescaler bandwidth when selecting a product, noting that a further externally divided or subharmonic trigger signal will be required to view a stable waveform at higher frequencies than those listed in the table above.

Parameter	*Legacy PicoScope 9200 Series*	PicoScope 9300 Series
Trigger frequency (max.) for stable direct trigger	*1 GHz*	2.5 GHz
Clock period (min.) for stable direct trigger	*1 ns*	400 ps
Data rate (max.) for stable direct trigger	*2 Gb/s*	5 Gb/s
Trigger prescaler frequency (max.) for stable trigger	*10 GHz*	14 to 15 GHz
Trigger prescaler clock period (min.) for stable trigger	*100 ps*	71 to 67 ps
Trigger prescaler data rate (max.) for stable trigger	*20 Gb/s*	28 to 30 Gb/s

Table 3 – Selection of trigger and prescaler bandwidth

Serial data clock recovery and pattern sync trigger

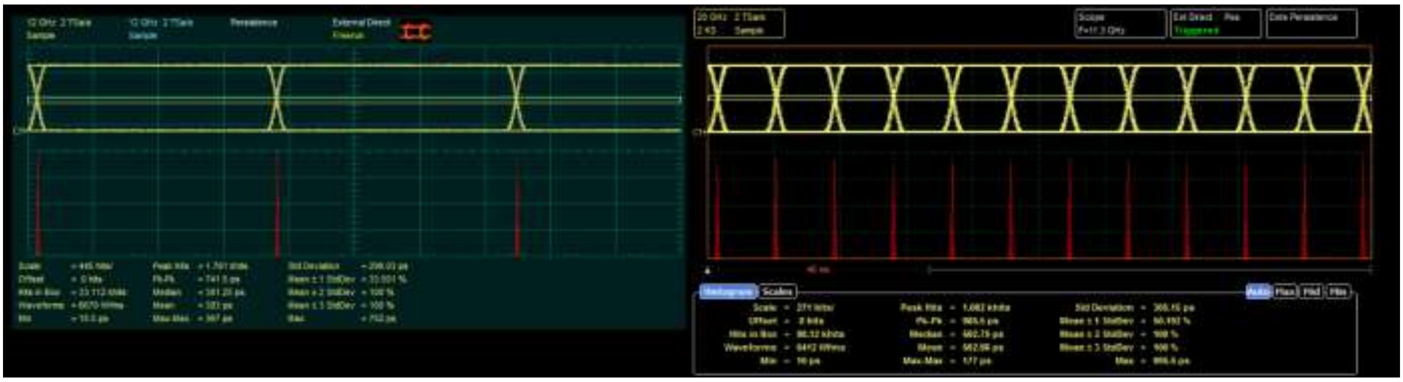


Figure 3 - Faster serial data clock recovery with the PicoScope 9300
Left: PicoScope 9200 Series. Right: PicoScope 9300 Series.

When working with data streams, the data clock is often not available. This is particularly common when working with serial data from an optical fiber, but also with many high-speed electrical data-only streams where clock recovery is used to eliminate clock-to-data skew or accumulated jitter. It is therefore usual to find a clock-recovered trigger capability provided with broadband oscilloscopes, and in the PicoScope 9000 Series this is offered on the models below.

	PicoScope 9211 and 9231	PicoScope 9302 and 9321
Clock recovery data rate	*12.3 Mb/s to 2.7 Gbs/s*	6.5 Mb/s to 11.3 Gb/s
Clock recovery frequency	*6.15 MHz to 1.35 GHz*	3.25 MHz to 5.65 GHz
Recovered clock trigger jitter	*< 1 ps + 1% of unit interval RMS*	< 1.5 ps RMS

Table 4 – Clock recovered trigger

When considering serial data applications, you may need to consider pattern sync (or trigger divide by N) capability. By counting and subdividing trigger rate, a sampling oscilloscope can synchronize to and create a stable display of a serial data pattern. You can then search the whole pattern for data or eye corruption using the eye line feature. The maximum rate and count length over which this can be achieved may also be important.

	Legacy PicoScope 9200 Series	PicoScope 9300 Series
Pattern sync (divide by N) trigger rate	*10 Mb/s to 8 Gb/s*	10 Mb/s to 11.3 Gb/s
Pattern sync (divide by N) length	*7 to $2^{16}-1$ (65 535)*	7 to $2^{23}-1$ (8 388 607)

Table 5 – Pattern sync trigger

Sampling analog to digital conversion, noise, resolution, speed and trace length

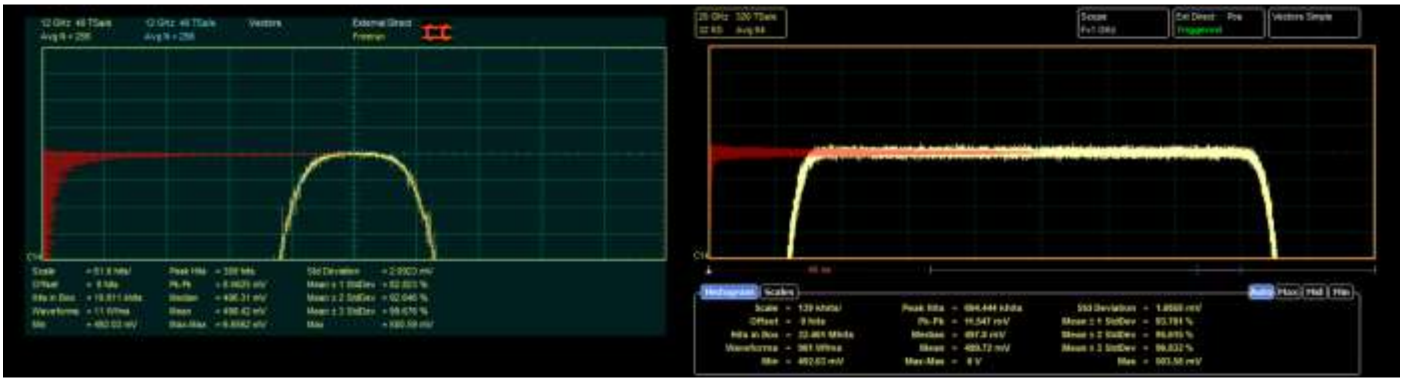


Figure 4 – Faster sampling and better sensitivity on PicoScope 9300
Left: PicoScope 9200 – 10 ps/div, 2 mV/div (200 fs and 40 µV resolution)
Right: PicoScope 9300 – 5 ps/div, 1 mV/div (64 fs and 40 µ resolution)

A sampling oscilloscope does not have the switched voltage ranges seen on a real-time oscilloscope. Instead it has a single fixed voltage range and a high-resolution analog to digital converter (16-bit in the PicoScope 9200 and 9300 Series). Full-scale range is ±1 V DC or AC peak. The converted signal is digitally scaled to achieve all other voltage ranges. Note that even at ±4 mV (1 mV/div), 8 ADC bits remain available.

A sampling oscilloscope (in its sequential sampling mode) gathers only one trace sample for each trigger event. It is therefore essential that it triggers, stores and rearms as fast as possible. In this respect the 9200 Series is typical amongst sampling oscilloscopes, while the PicoScope 9300 Series with its ARM processor and SPARTAN-6 FPGA stands out as one of the fastest available. Traces, eyes, graded persistence displays, measurements and statistical assessments are all as fast as they come on the 9300 Series!

Thanks to the faster sampling in the PicoScope 9300 Series, trace length can realistically be increased to an industry-leading 32k samples. This improves view and zoom detail, measurement resolution and resolution of mathematical functions such as FFT, and more closely matches the available vertical and horizontal resolutions. Additionally, both series take full advantage of a connected HD display size and resolution and can even stretch this waveform and persisted display detail (16 bits and 32k samples) across multiple monitors.

A sampling oscilloscope has no input amplification. Despite this, noise is still present in the system and limits the smallest signals that are viewable. The PicoScope 9300 Series front end is quieter than the 9200 Series despite its greater bandwidth. In practice, the minimum viewable signal level is similar at similar degrees of averaging. However, the faster PicoScope 9300 Series can average more deeply while achieving a similar update rate.

	PicoScope 9200 Series	PicoScope 9300 Series
ADC conversion resolution	*16 bits or < 40 µV/bit*	16 bits or < 40 µV/bit
Input RMS noise	*< 2 mV (58 nV/√Hz)*	-15: < 1.6 mV (13 nV/√Hz) -20: < 2.0 mV (14 nV/√Hz) -25: < 2.5 mV (16 nV/√Hz)
Input RMS noise with best averaging	*< 0.1 mV (2.9 nV/√Hz)*	-15: < 0.1 mV (0.8 nV/√Hz) -20: < 0.1 mV (0.7 nV/√Hz) -25: < 0.1 mV (0.6 nV/√Hz)
ADC sampling rate	*200 kS/s*	1 MS/s
Trace length	*4 kS*	32 kS

Table 6 – Comparison of ADC resolution, noise, speed and trace length

Optical signal bandwidths and data rates

The bandwidth of the optical to electrical converter (and any trigger or clock recovery pick-off applied) limits the bandwidth and data rate of any optically derived signal, as can be seen in the table below. Maximum clock recovery rate, pattern sync and trigger rate and their pick-off bandwidths may also need to be considered.

A further consideration is that optical to electrical receivers (and their transmitter counterparts) tend to distort the data eye, mainly because of their asymmetric transition times. Receivers, including the PicoScope 9000 Series sampling oscilloscopes, are provided with electrical lowpass filters to correct the eye at particular data rates. Typically these have a –3 dB cut-off of 0.75 x data rate, and oscilloscope bandwidth needs to be higher, about equal to the data rate. Please contact Pico Technology technical support if a particular data rate does not appear to be covered by the accessory filters listed for these products.

You should also check that the optical to electrical converter, common to the 9200 and 9300 Series, is compatible with the fiber mode and connector (single-mode, multimode, FC/PC), peak power +7 dBm and carrier wavelength of the application to be addressed. The wavelength ranges are 750 nm to 1650 nm, spot calibrated at 850 nm (MM), 1310 nm (MM/SM), 1550 nm (SM).

	PicoScope 9231	PicoScope 9321
Optical bandwidth via the optical to electrical converter	*8.5 GHz*	9.5 GHz
Bandwidth including trigger pick-off using supplied power divider	*4 GHz*	9 GHz
Data rate, max., for viewing *See also clock recovery rate and pattern sync ranges*	*17 Gb/s*	19 Gb/s
Data rate, max., for viewing, using supplied power divider	*8 Gb/s*	18 Gb/s
Data rate, max., for characterization	*12 Gb/s*	19 Gb/s
Data rate, max., for characterization, using supplied power divider	*8 Gb/s*	18 Gb/s

* including trigger pick-off using supplied power divider (faster divider available)

Table 7 – Comparison of optical signal bandwidth and data rates

Time domain network (TDR/TDT) analysis capability

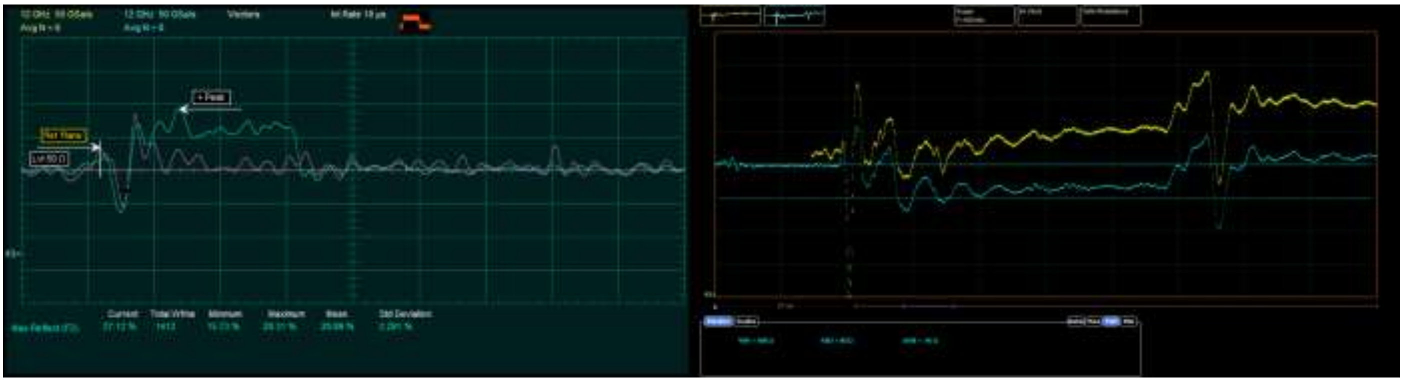


Figure 5 – More detail and differential TDR/TDT with the PicoScope 9300
Left: PicoScope 9200 – 250 mm 50 Ω and 75 Ω, coax cable TDR
Right: PicoScope 9300 – 500 mm 90 Ω SATA cable, differential TDR

Time domain transmission and reflectometry both apply a fast-edge pulse to an unknown single or multi-port network. This could be an electrical component, a cable, or a signal receive or transmit port. By measuring the pulse that reflects back (TDR) or the pulse that passes through (TDT), the transmission characteristic or mismatch can be analyzed.

Frequency domain or time domain?
Scalar or vector network analyzers perform a similar function but use a frequency-domain instead of a time-domain technique. These instruments inject and measure a sine wave, one frequency at a time. TDR/TDT instruments inject a fast pulse containing a wide spectrum of frequencies all at once.

TDR/TDT analysis tends to be faster, while scalar or vector analysis tends to have more dynamic range. Results, for essentially the same measurement, can be transposed between the two domains. Time-domain measurements are particularly effective at determining the physical location of a mismatch, fault or component. Physical distance is obtained simply by multiplying the timing of a reflection by its propagation velocity (close to the speed of light, *c*). Vector quantities such as s-parameters can theoretically be extracted from both techniques, but the PicoScope 9200 and 9300 Series extract only scalar quantities. The PicoVNA 106 vector network analyzer is an excellent choice for applications that require frequency-domain analysis.

Performance
System bandwidth or, more accurately, system transition time (that of the fast pulse, combined with that of the sampling oscilloscope and any interconnect) determines the time resolution and hence the physical distance that can be resolved. To resolve the magnitude of a mismatch, a complete rise time and fall time are needed to cleanly define a pulse amplitude. When detecting the presence or location of a mismatch, distance resolution can be around five times better than this. Resolution quantities given below assume typical PCB or coax propagation velocity of around 0.7 *c*.

Available pulse amplitude and variability of pulse amplitude can both be considerations, but not as significant as you might think. Usable pulse amplitude is limited in practice to the peak full-scale voltage that the oscilloscope can accept: in these instruments, 1 V pk from an open-circuit reflection or unimpeded transmission path. The benefit of large amplitude at the source (as with the PicoScope 9311) is that the test system source match can be improved by using an attenuator. Variable amplitude gives the opportunity to optimize signal level and thus dynamic range in any TDT/TDR measurement, and possibly reduce amplitude to keep within its device-under-test limits or, in the case of an active device, explore its nonlinearity.

Pulse distortions or aberrations at the pulse source or at the receiving oscilloscope and interconnect are not of primary importance in a TDT/TDR application because they are corrected by system port calibration into known short, open and load.

PicoScope 9300 Series advantages
The 9200 Series and 9311-15 are single-ended TDR/TDT instruments. The 9311-20 can generate differential and deskewable fast step waveforms and supports both single-ended and differential TDR/TDT measurements for transmission lines or ports with or without a physical ground. A further benefit of the PicoScope 9300 series is the inclusion of high- and variable-amplitude pulse generators based on step recovery diode technology.

As a configuration option, the TDR/TDT generator can be separated from the oscilloscope. There is a choice of three generators from the PicoSource PG900 family with either step recovery diode or tunnel diode generation, or both. These offer the flexibility of separately located transmit and receive TDT as well as stand-alone use. The PicoSource stand-alone fast-step PG900 Series generators are compatible with all models in the PicoScope 9300 series, allowing for instance the combination of TDR/TDT with optical, clock recovery or four-channel capability.

TDR/TDT functionality is substantially enhanced in the PicoSample 3 software supplied with the PicoScope 9300 Series. As noted in the table above, the PicoScope 9311-20 supports differential TDR/TDT, with full correction for differential coaxial (twinaxial) cable, and for parallel or twisted lines where no ground is present.

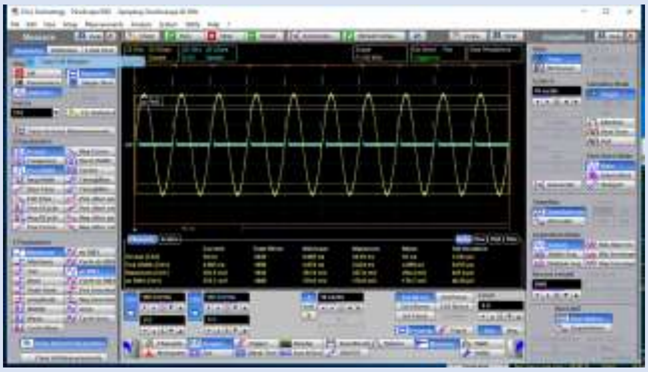
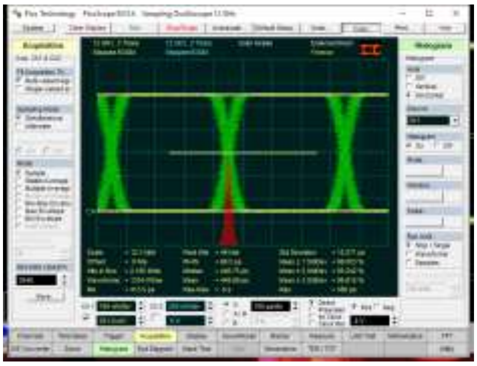
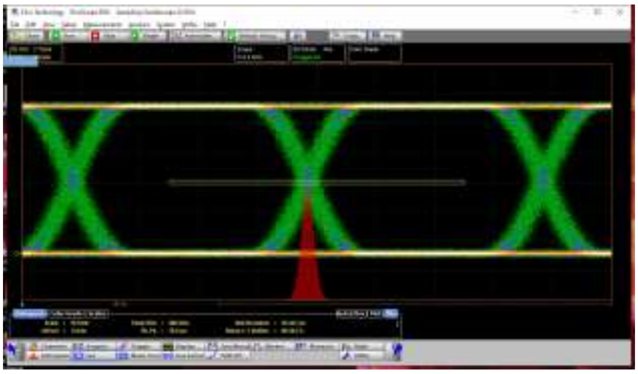
	Legacy		Available			
	PicoScope 9211 or 9231	***PicoScope 9312***	**PicoScope 9311-15**	**PicoScope 9311-20**	**PicoScope 9300-15 + PicoSource PG900**	**PicoScope 9300-20/25 + PicoSource PG900**
Single-ended (normal mode) TDR/TDT	*Yes*	*Yes, dual channel*	Yes, dual channel	Yes, dual channel	Yes	Yes
Differential mode TDR/TDT	*No*	*Yes*	No	Yes	Yes	Yes
System 10% to 90% transition time	*500 ps*	*50 ps*	65 ps	60 ps	65 ps	60 ps
Best effective system transition time after correction of system aberrations	*100 ps*	*40 ps*	45 ps	40 ps	45 ps	40 ps
Typical length for accurate impedance measurement	*40 mm*	*16 mm*	20 mm	16 mm	20 mm	16 mm
Typical fault or mismatch distance resolution	*8 mm*	*4 mm*	5 mm	4 mm	5 mm	4 mm
Maximum TDR / TDT analysis period	*600 ns*	*8 µs*	8 µs	8 µs	8 µs	8 µs
Typical maximum distance to fault in TDR**	*60 m*	*400 m*	400 m	400 m	400 m	400 m
TDT/TDR pulse amplitude (integrated)	*400 mV*	*N.A.*	2.5 to 7 V	2.5 to 7 V	2.5 to 6 V	2.5 to 6 V
TDT/TDR pulse amplitude with TD pulse head	*N.A.*	*200 mV*	N.A.	N.A.	200 mV	200 mV

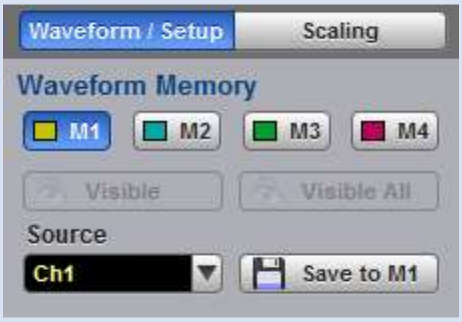
Table 8 – Time domain network (TDR/TDT) analysis capability

** Dependent on reflected signal losses in the transmission line. Note also that resolution reduces with the received bandwidth of the reflected signal.

Software evolution

The PicoScope 9200 and 9300 Series oscilloscopes were supplied with different software. PicoSample 3, supplied with the 9300 Series scopes, is the current, graphically enhanced, wide-format and touchscreen-enabled evolution of its predecessor, the PicoScope 9000 software supplied with the PicoScope 9200 Series. User interface and key feature enhancements in PicoSample 3 are highlighted in the comparison below. You can download both applications and use them in demonstration mode to explore the differences.

<table>
<tr><th>PicoScope 9200 Series and PicoScope 9000 software</th><th></th><th>PicoScope 9300 Series and PicoSample 3 software</th></tr>
<tr><td></td><td>General appearance of fully resizable Windows user interfaces</td><td>
Improved layout for widescreen monitors</td></tr>
<tr><td>
Select left and right menus according to application</td><td>Controls, traces and measurements areas configure to application</td><td>
Select any two menus or dismiss them to focus on traces and results</td></tr>
<tr><td>

Radio buttons, check boxes and submenus</td><td>Selection, action and submenu controls</td><td>

Graphic icons, drop-downs and tabs</td></tr>
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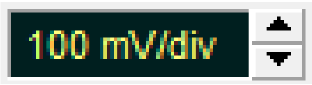
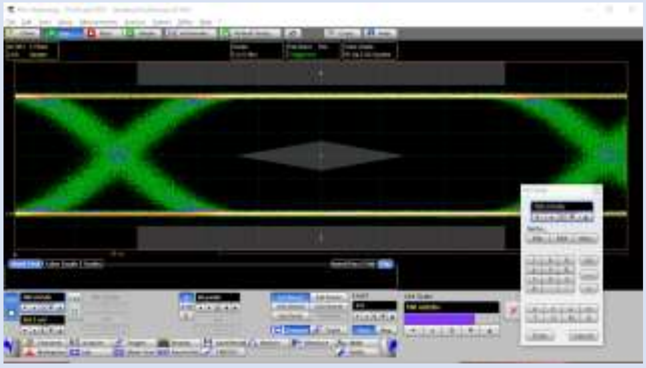
 Increment buttons and keyboard entry	Parameter controls	 Innovative coarse, fine, default, slidebar, keyboard and calculator entry in a single control
 Mouse click and limited drag function. No specific touchscreen enhancements.	Touchscreen support	 Click, drag, enlarged controls and calculator entry. Full touchscreen operation.
	Enhanced functions	 Math and FFT functions, display modes, trace labels, differential TDR/TDT

Table 9 – Software comparison

Remote control interface

As remarked above, the PicoSample 3 software that supports the PicoScope 9300 family of products is a development on the earlier PicoScope 9000 software supplied with the 9200 Series. Therefore the remote commands are largely common to both series. Likewise the more recent 9300 Series hardware is an evolution of the 9200 Series, so its functions are largely a superset of the older series. Migration of most remote automation cases from the 9200 Series to the 9300 Series should be straightforward. However, full remote emulation of the 9200 Series is not supported by the 9300 Series models and PicoSample 3 software. Pico Technology's respected technical support team stand ready to help should problems arise.

In migrating from 9200 Series to 9300 Series models the instrument ID changes and there are a few command changes that must be addressed:

I. The GUI commands:

Gui:RemoteLocal
Gui:RemoteOnly
Gui:Invisible

must be changed to:

Gui:Control:RemoteLocal
Gui:Control:RemoteOnly
Gui:Control:Invisible

II. The System commands:

**Run*	*(start continuous acquisition)*
**StopSingle Single*	*(start single acquisition)*
**StopSingle Stop*	*(stop acquisition)*

must be changed to:

*RunControl Run	(start continuous acquisition)
*RunControl Single	(start single acquisition)
*RunControl Stop	(immediately stop acquisition)