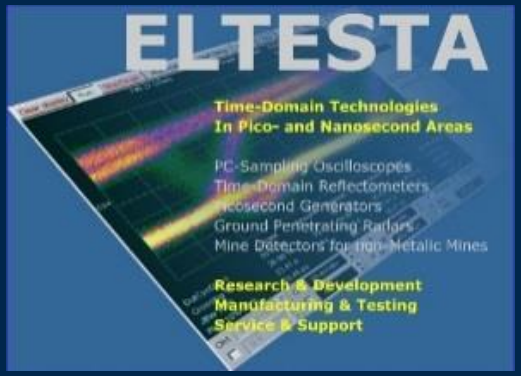
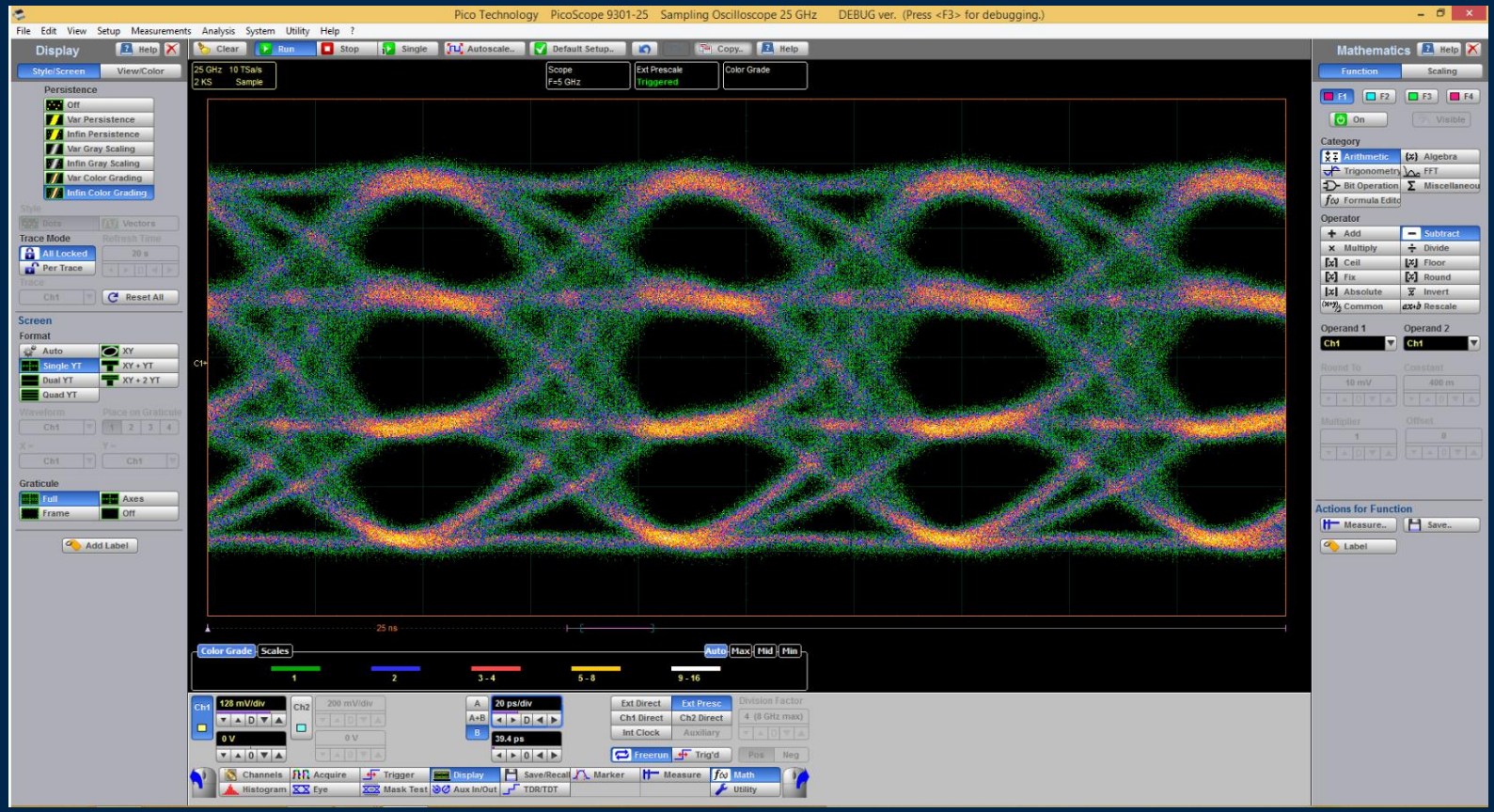
Jakovas Rososkis

High-performance electronic oscilloscopes and pulse generators





Vilnius, 2nd CERN Baltic Conference (CBC 2022), October, 10, 2022

Serial Products

Electrical and Optical Sampling Oscilloscopes. TDR. 15, 20, 25 and 30 GHz

One-, two- or four-channel Digital Storage Oscilloscopes 5 and 16 GHz / 500 Msa/s / channel

Real-time Oscilloscopes 2 an 2.5 GHz / 5 Gsa/s

Picosecond Pulse Generators 35 ps / 200 mV 55 ps / 6 V 45 ps / 8 V

PicoScope 9300
Sampling Oscilloscopes

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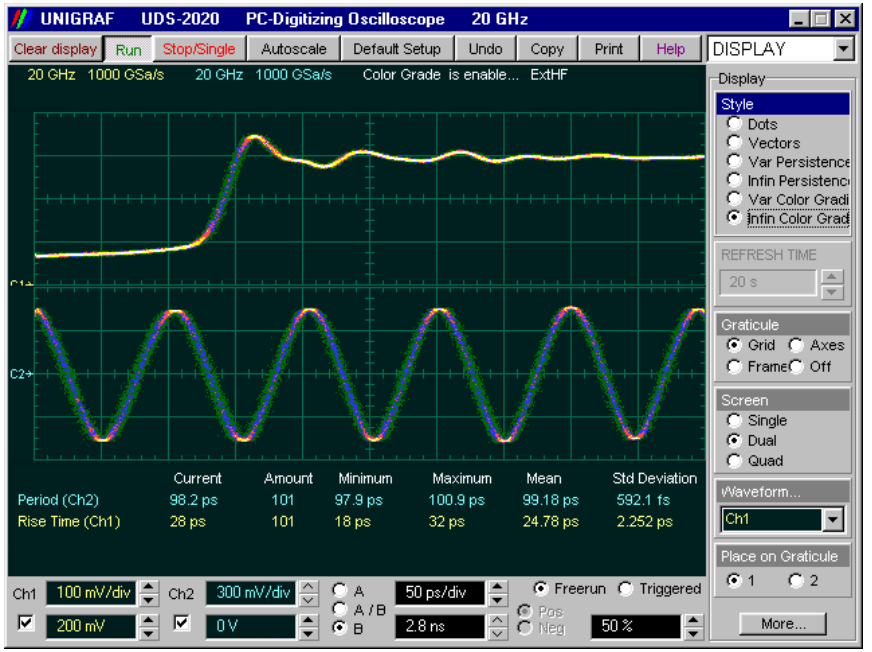
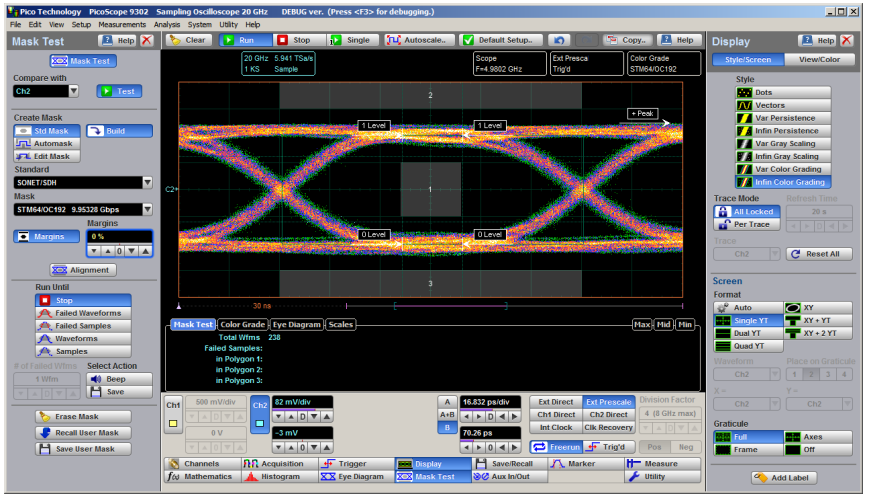


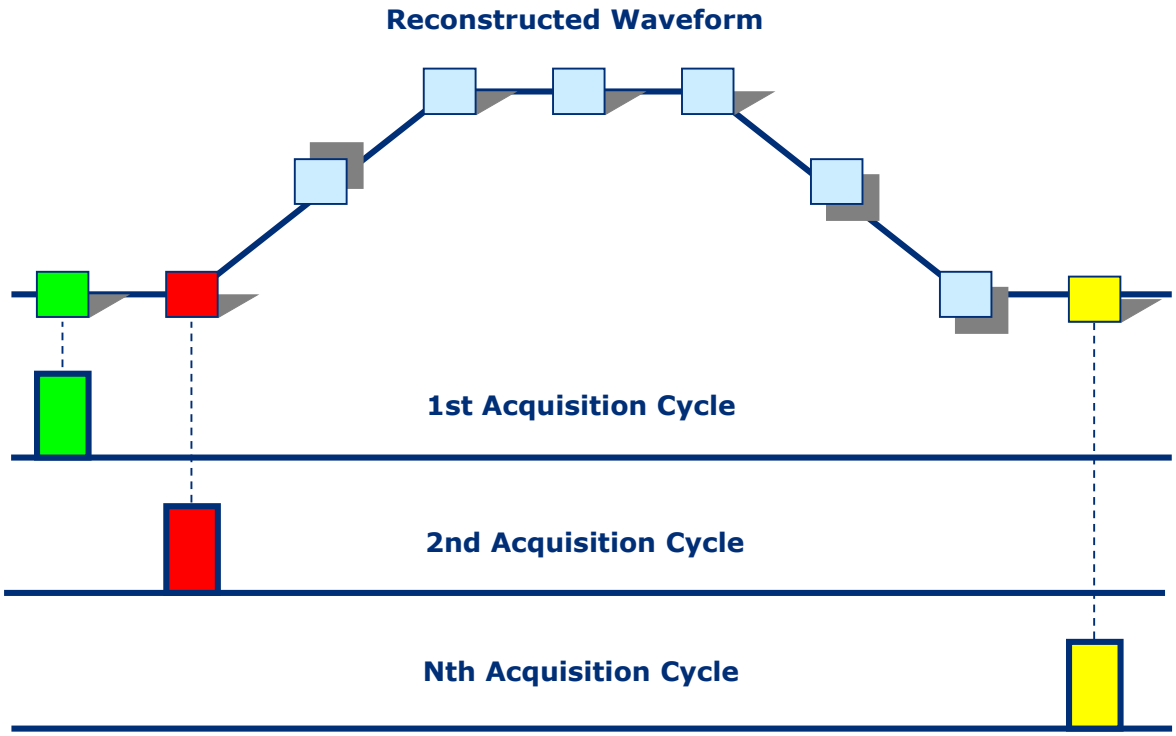


Sampling Oscilloscopes. Introduction

Key specifications:

- Up to 30 GHz (11.7 ps) electrical bandwidth on 2 or 4 channels
- 10 GHz typical optical bandwidth
- 64 fs, ~15 THz effective sample rate
- 18 GHz prescaled trigger, 2.5 GHz direct trigger and 100 MHz internal trigger
- 11.3 Gbps clock recovery trigger
- 5 ps/div to 1 s/div time base scales
- Pattern trigger of length 7 to 2^{23}-1
- Typical RMS Jitter <1.8 ps
- 16 bit, 60 dB dynamic range
- 55 ps rise time / 6 V TDR/TDT differential pulse generator
- 35 ps rise time / 200 mV TDR/TDT differential pulse generator
- 1 MS/s sample rate to 32 kS store
- Sequential equivalent time, Real time, Random equivalent sampling and Roll acquisition modes
- Automated direct or statistical measurements, Markers, Histogram, Math or FFT analysis, TDR/TDT analysis, Color-Graded Display, Parametric Limit Testing, Eye Diagram Measurements, Mask Template Testing

Sequential equivalent time sampling



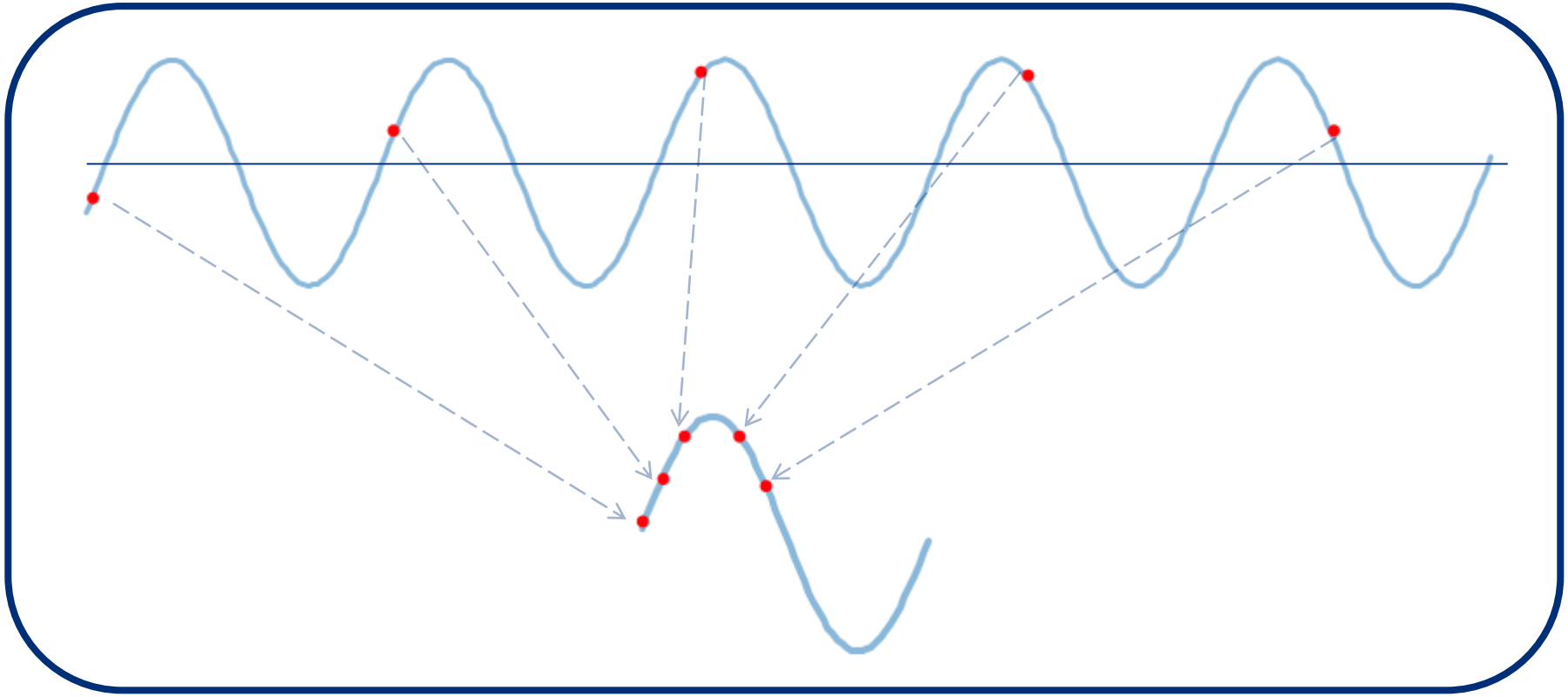
Sequential Sampling Technique means:

- Wide Bandwidth Applications (>30 GHz bandwidth)
- Used with Repetitive Signals, NRZ or RZ signals.
- One sample is taken for each trigger
- Multiple Trigger Events Build Up Waveform
- No Pre-Trigger Information

PS9300 Sequential equivalent time sampling: 5 ps/div to 3.2 ms/div

Equivalent Time Sampling

Sequential Sampling



- Data points are acquired sequentially from many cycles to build one screen image
  - PicoScope 9300 sample rate is 1 MS/s, bandwidth is 20 GHz

Real-time Scope vs Sampling Scope

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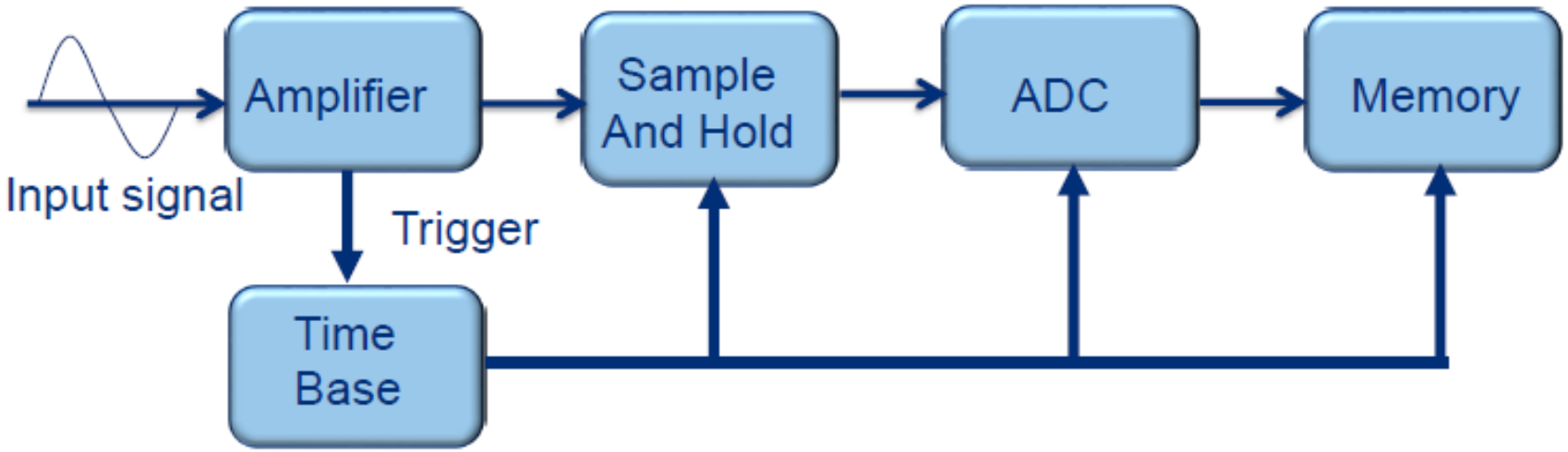
Real-time Oscilloscopes

- Can capture single instantaneous or repetitive events
- Lower ADC resolution, but high sample rate increases error
- Long record length
- Advanced triggers to capture intermittent events
- Serial bus decoding
- Ideal for general use and fault diagnosis
- Real-time GS/s sampling is EXPENSIVE

Sampling Oscilloscopes

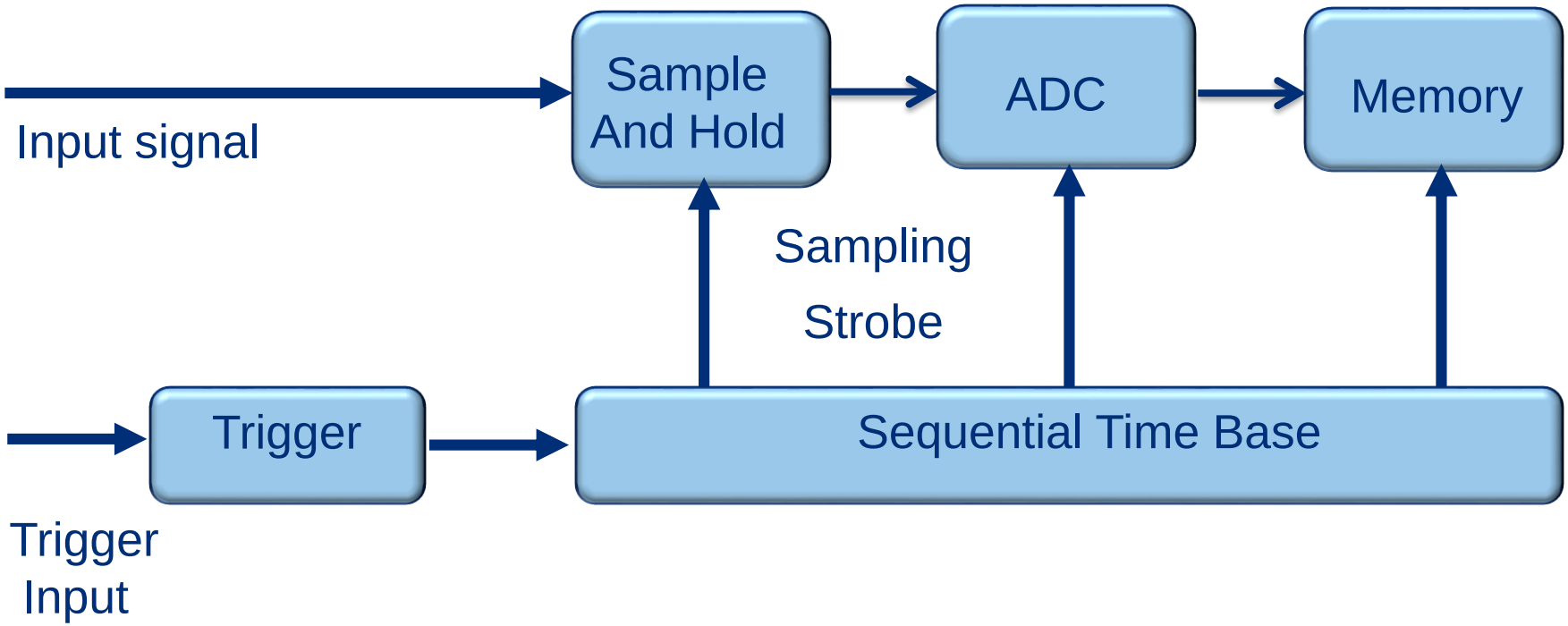
- Can capture cyclic signals
  repeating patterns
  steady data rate
- Have lower sample rate
  (expanded in next slide)
- Wider bandwidth for lower budget
- Lower intrinsic jitter and noise
- Eye diagrams and mask testing
- Best choice for TDR/TDT
- Lower cost of ownership

Real-time Digital Oscilloscope

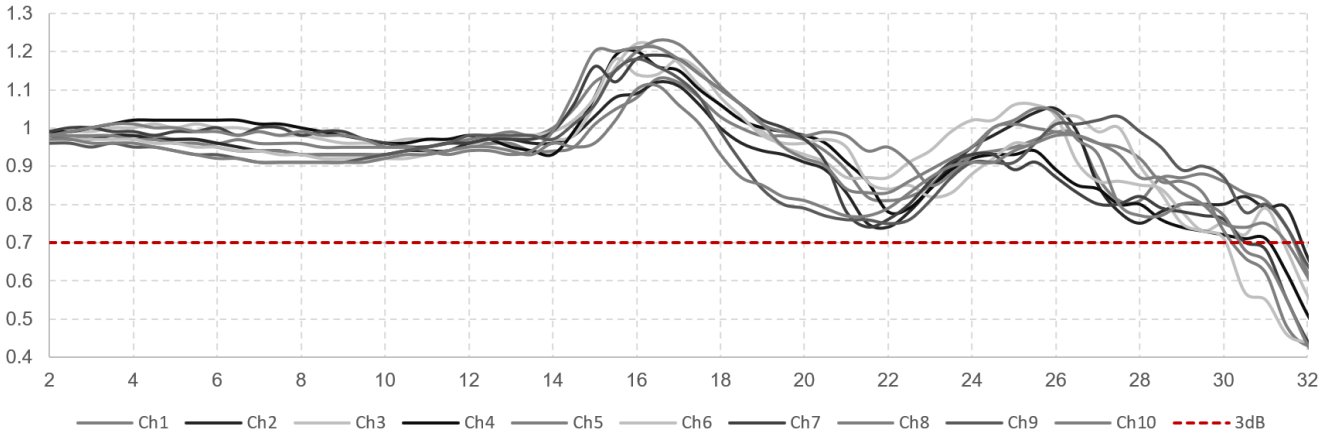


Real-time Digital Oscilloscope

Sequential equivalent time sampling

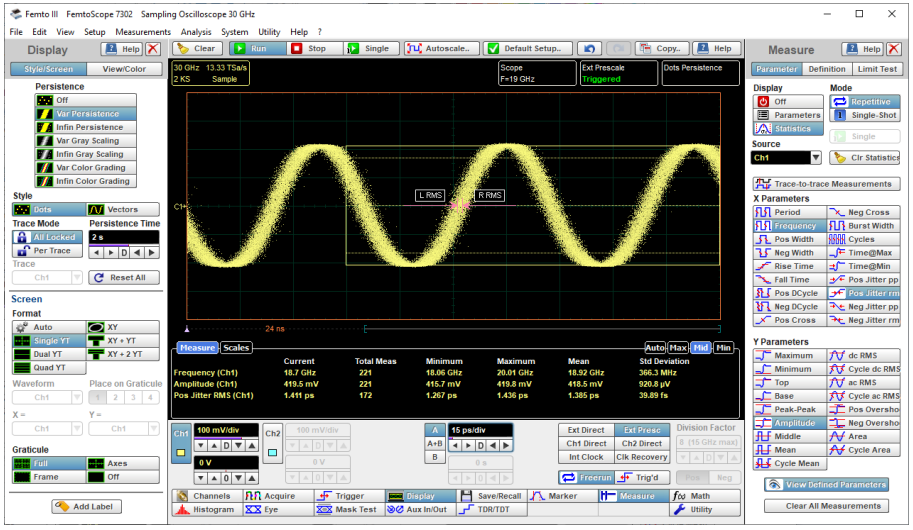


PicoScope 9300: Bandwidth and Rise Time



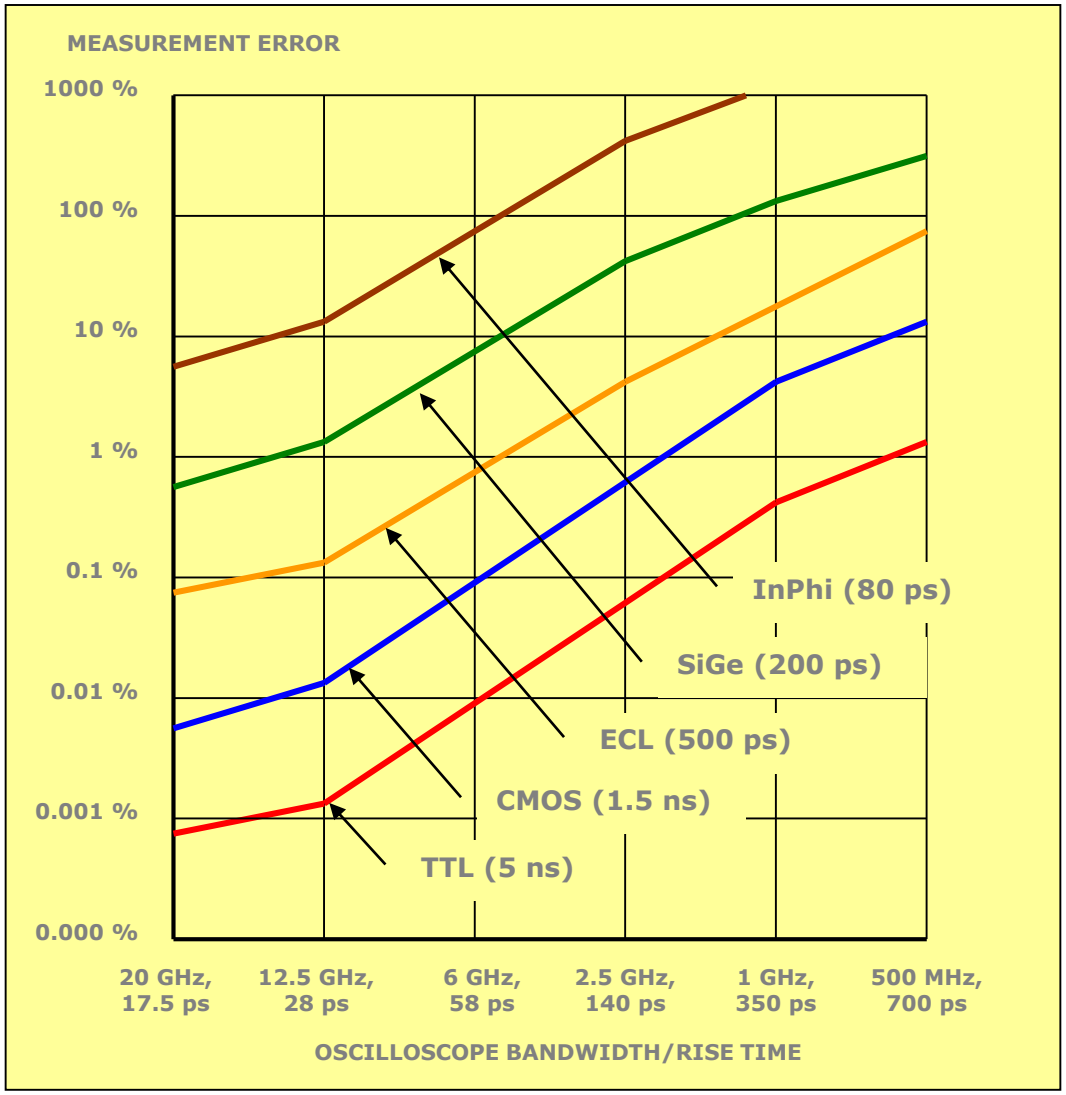
30 GHz bandwidth test (10 channels)

PicoScope 9301-20: 12 ps transient response with Keysight N2806A Calibration Pulse Generator (own rise time <9 ps)



19 GHz sinewave trigger

Electrical Rise Time Measurement Error vs. Oscilloscope Bandwidth



When the Scope Bandwidth (BW) is:	Rise Time Slowing Error is:
Equal to Signal Edge BW	▶ 41%
Twice as fast as Signal Edge BW	▶ 12%
Three times as fast as Signal Edge BW	▶ 5%
Five times as fast as Signal Edge BW	▶ 2%

Sampling Oscilloscopes Series

PicoScope 9200 Series
2 channels,
12 GHz Electrical Bandwidth,
8 GHz Optical Bandwidth
120 ps TDR/TDT

PicoScope 9300 Series
2 or 4 channels,
15, 20, 25 or 30 GHz Electrical Bandwidth,
10 GHz Optical Bandwidth
40 ps or 60 ps Differential TDR/TDT

The PicoScope 9300: Models

The PS9301: Dual-channel, 15-20-25-30 GHz Bandwidth

The PS9302: Dual-channel, 15-20-25-30 GHz Bandwidth with 11.3 Gbps clock recovery trigger

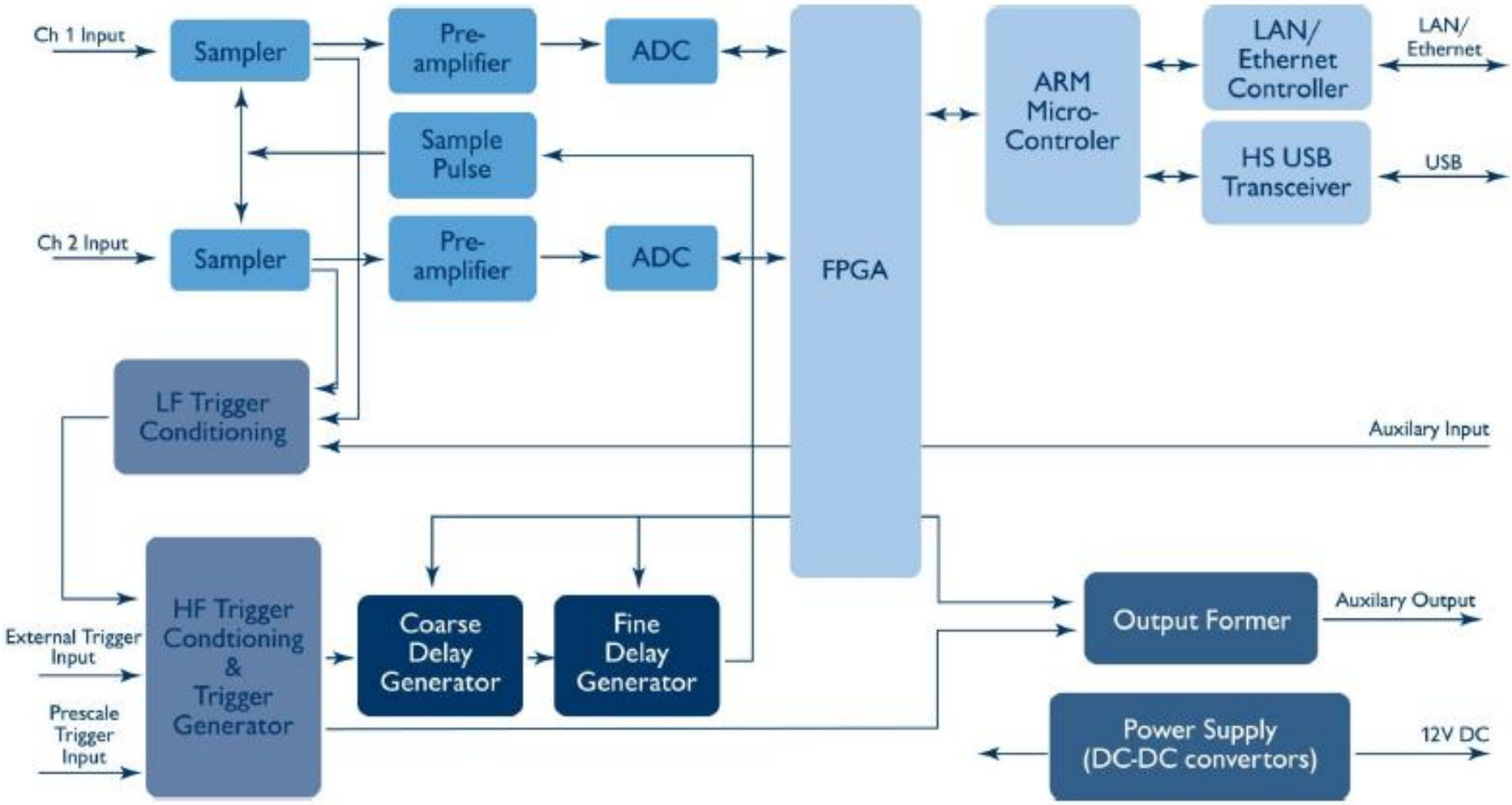
The PS9311: Dual-channel, 20 GHz Bandwidth with 55 ps rise time / 6 V TDR/TDT differential pulse generator

The PS9321: Dual-channel, 20 GHz bandwidth with 35 ps rise time / 200 mV TDR/TDT differential pulse generator

The PS9321: Dual-channel, 20 GHz bandwidth with 10 GHz optical bandwidth and 11.3 Gbps clock recovery trigger

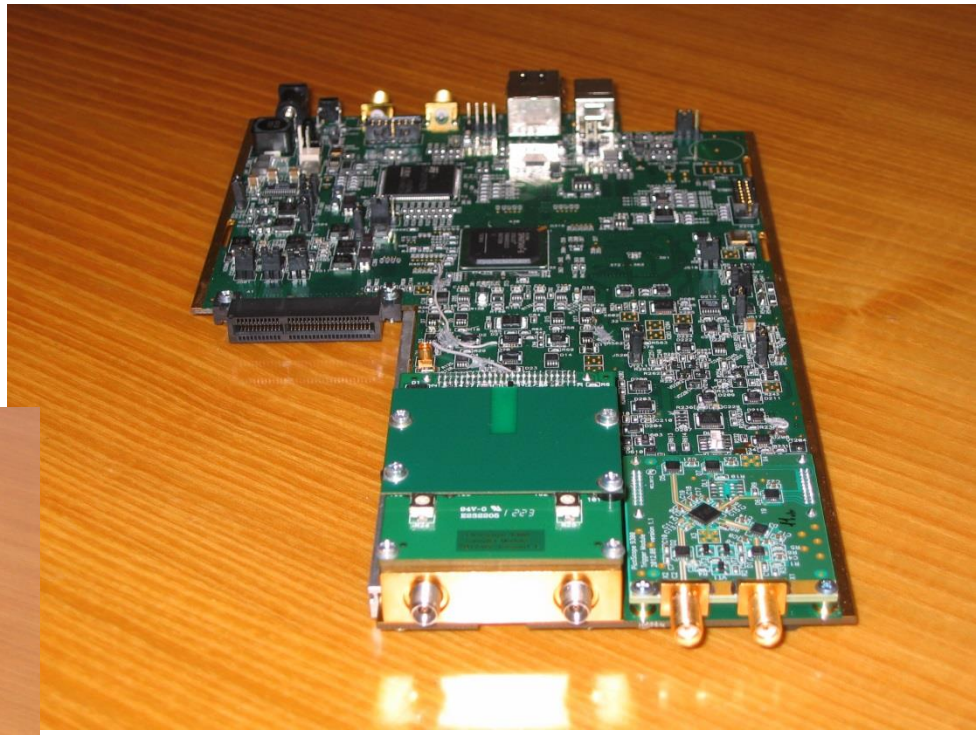
The PS9341: Four-channel, 15-20-25-30 GHz Bandwidth

PS9301 Block Diagram



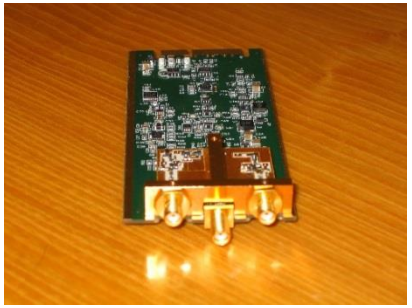
PicoScope 9300: Modules

Dual-channel Sampler Module



Acquisition Board with Dual-channel Sampler and Trigger modules

Acquisition Board with Dual-channel Sampler and Trigger modules, also with optical/CDR module



TDR Module

PicoScope 9300:
30 GHz Miniature Sampling Module

The PicoScope 9300 includes a dual-channel sampler. This sampler is designed for precise measurements on high speed, low amplitude signals and low-loss testing in applications such as microwave systems research and development, digital device characterisation, and high-speed digital communications circuit design. It provides an acquisition rise time up to of 11.7 ps, with a typical 30-GHz equivalent bandwidth, and maximum RMS noise 2 mV to ensure clean, undistorted signals. The electrical channel has both a 30 (25 – 20 – 15) GHz mode for better waveform fidelity, and near 10 GHz mode for optimum noise performance. Changing the bias on the sampling bridge alters the bandwidth of both channels.

Key Specifications of the Sampler

- Number of Channels - 2 (Simultaneous acquisition)
- Bandwidth (-3dB) – Full BW: up to 30 GHz,
  Narrow BW: up to 12 GHz
- Rise Time (10%-90%) - Full BW: ≤11.7 ps,
  Narrow BW: ≤35 ps
- RMS Noise (maximum) - Full BW: ≤ 2 mV,
  Narrow BW: ≤ 1.5 mV
- Maximum operating input voltage - 1.0 V p-p at ± 1 V range
- Maximum Safe Input Voltage - 16 dBm, or ±2 V (dc+peak ac)
- Nominal Input Impedance - (50 ± 1) Ω
- Input connectors - 2.92 mm (K) female, SMA-compatible

PicoScope 9300: Time Base

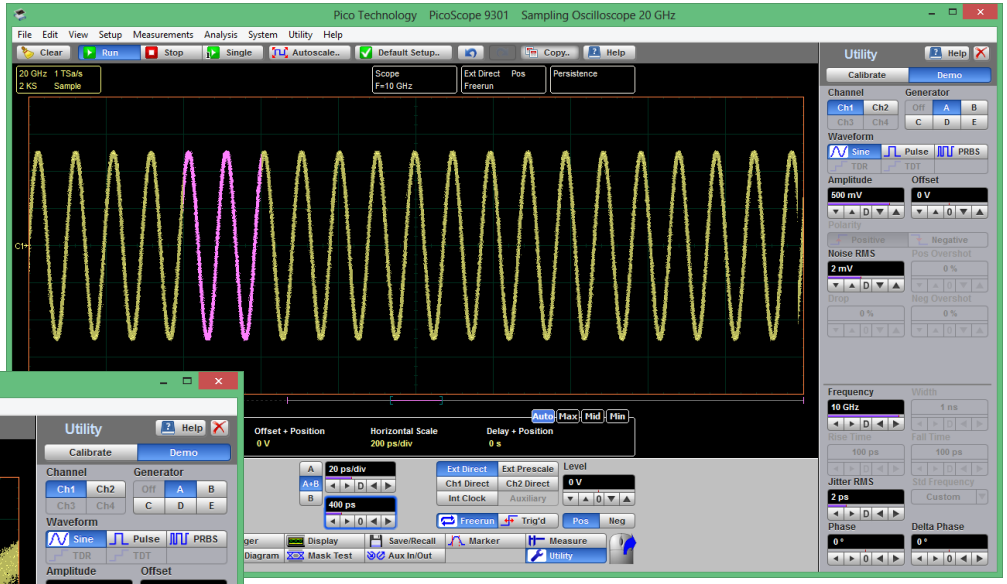
The PicoScope 9300 provides four acquisition modes: Sequential Equivalent Time Sampling, Real Time Sampling, Random Equivalent Time Sampling, Roll Sampling

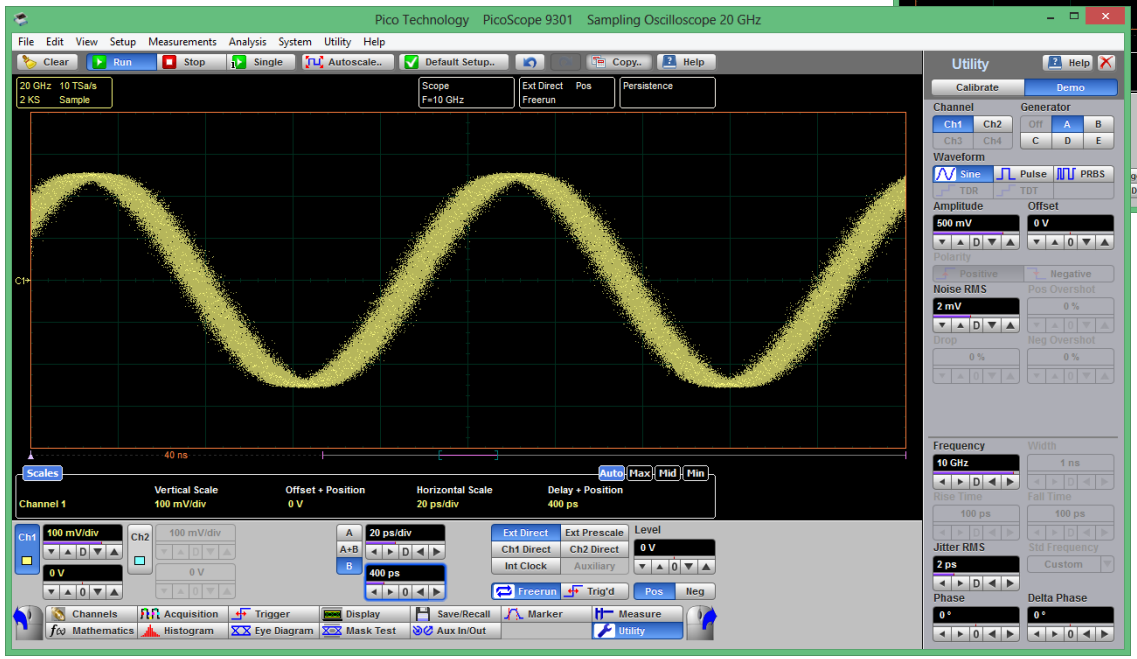
Sequential equivalent time:
5 ps/div to 3.2 ms/div

Real Time Sampling:
2 us/div to 100 ms/div (1 us resolution)

Random Equivalent Time Sampling:
50 ns/div to 50 us/div (4 ns resolution)

Roll Sampling:
200 ms/div to 10 s/div





PicoScope 9300: Direct Trigger

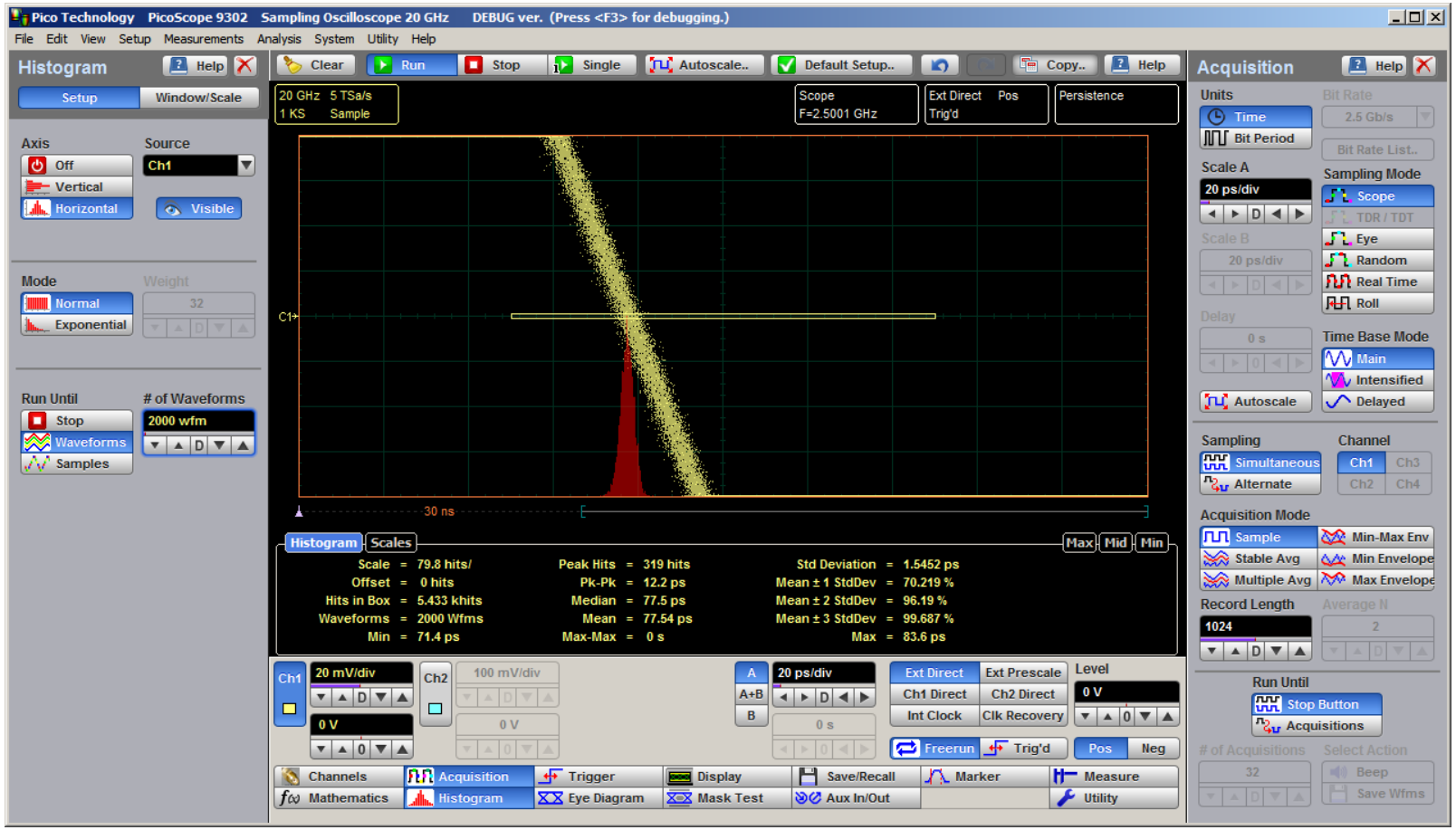
The power of wide-bandwidth sampling oscilloscopes is largely useless without fast, low-jitter triggering. The PicoScope 9300 is equipped with built-in direct trigger for signals up to 2.5 GHz repetitive rates without using an external trigger unit.

A typical picture of 2.5 GHz signal by using Direct Trigger

Key specifications of Direct Trigger:

- DC to 2.5 GHz trigger bandwidth
- 100 mV p-p DC to 100 MHz, 200 mV p-p at 2.5 GHz sensitivity
- <1.8 ps typical RMS jitter

PicoScope 9300: Direct Trigger Jitter



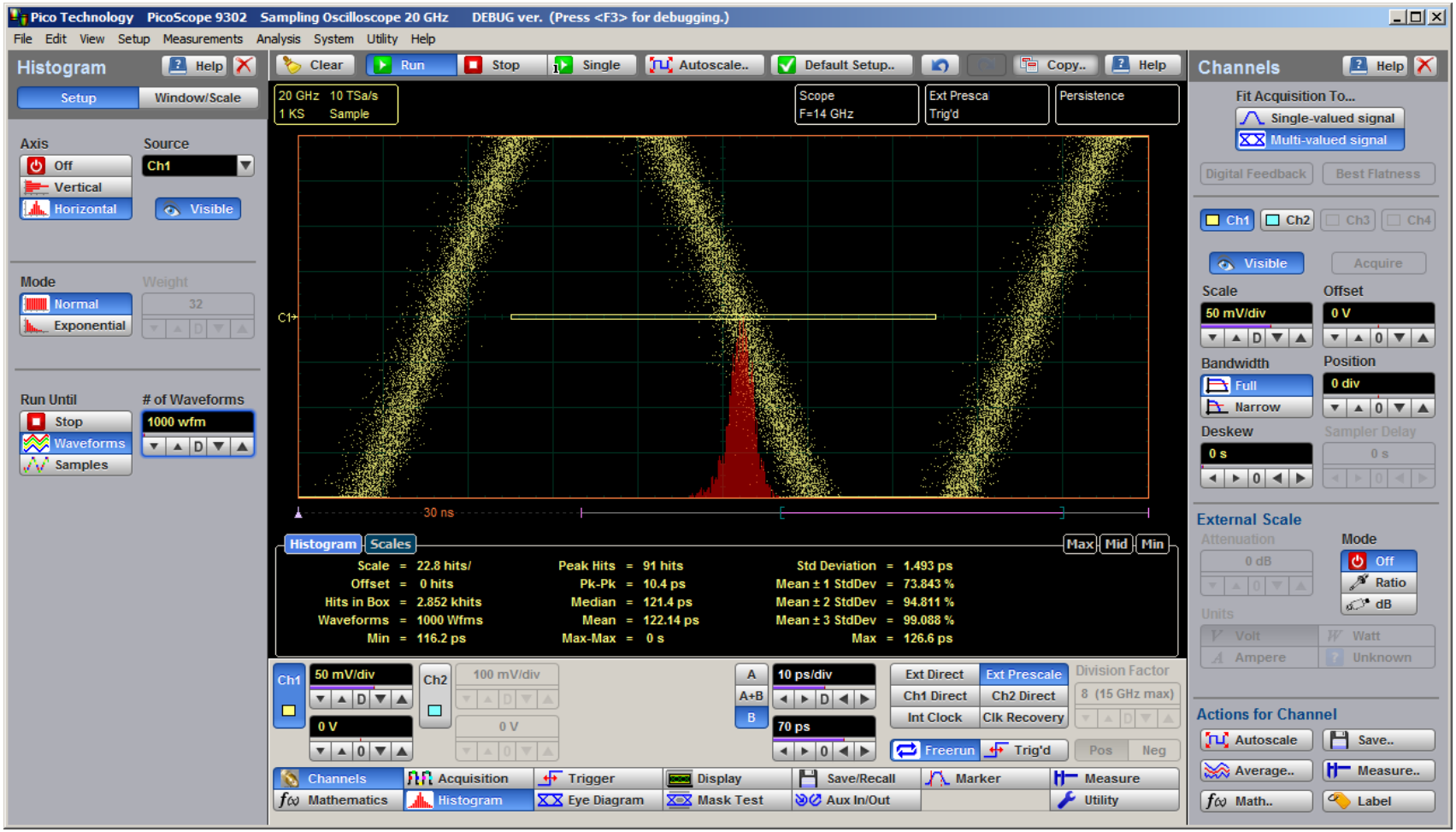
A typical picture showing 1.54 ps RMS Direct Trigger Jitter with 2.5 GHz sine wave

PicoScope 9300: Prescaled Trigger

The PicoScope 9300's Prescaled trigger is an AC-coupled 18-GHz prescaler for triggering on high-speed data without cumbersome manual adjustment. The heart of the trigger is a low-noise GaAs frequency divider. Low RMS jitter <1.8 ps typ is available.

14-GHz Prescaled Trigger shown at 50 ps/div time base

PicoScope 9300: Prescaled Trigger Jitter



Prescaled trigger with less than 1.5 ps rms jitter

PicoScope 9300: Bandwidth and Rise Time

Choose a scope with enough bandwidth for the application:

- Signal transition time
- Signal clock or data rate
- Signal rise and fall time
- Signal narrowest pulse

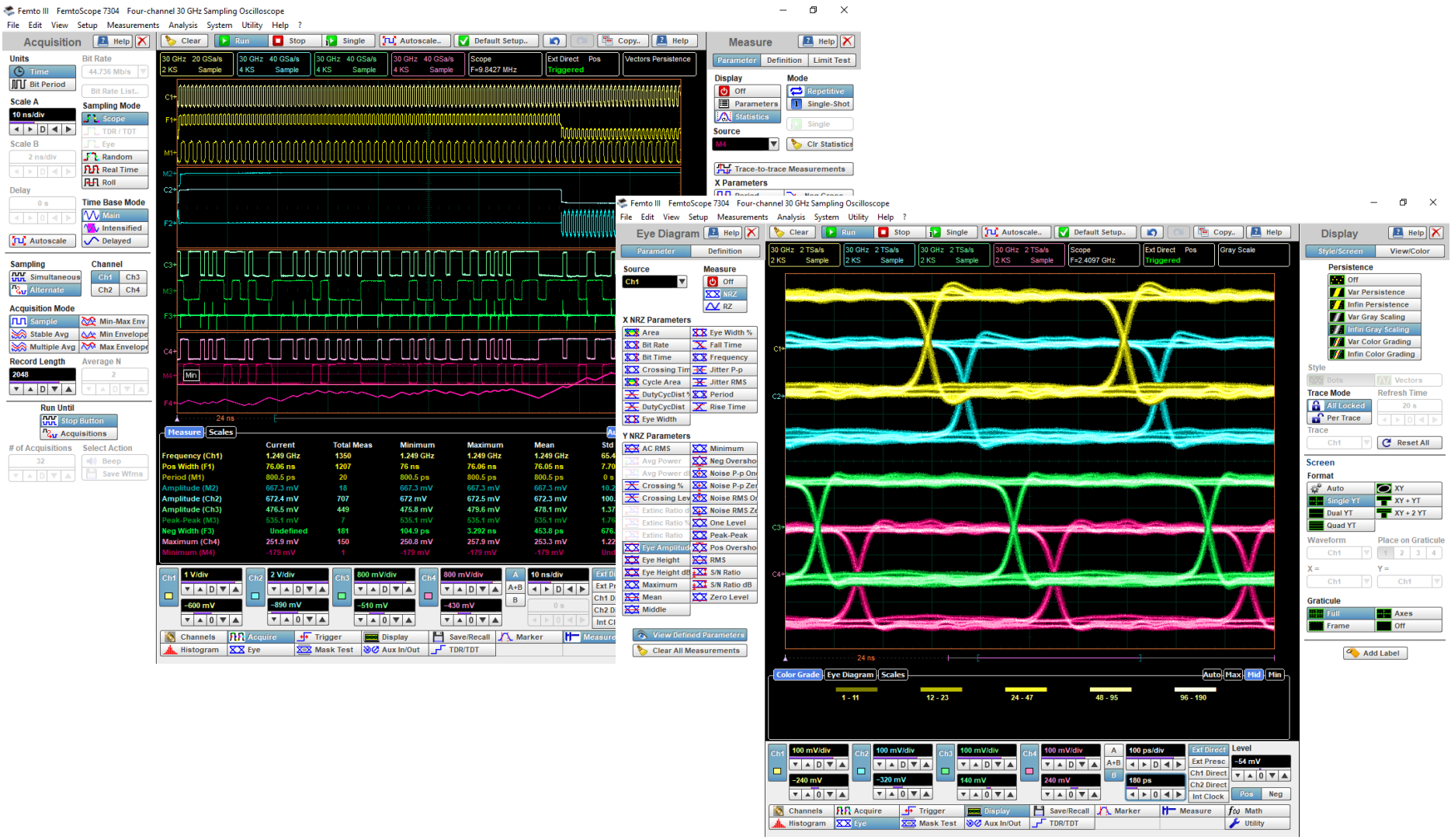
Effects of too little bandwidth:

- Amplitude and timing errors
- Loss of high frequency aberrations and detail

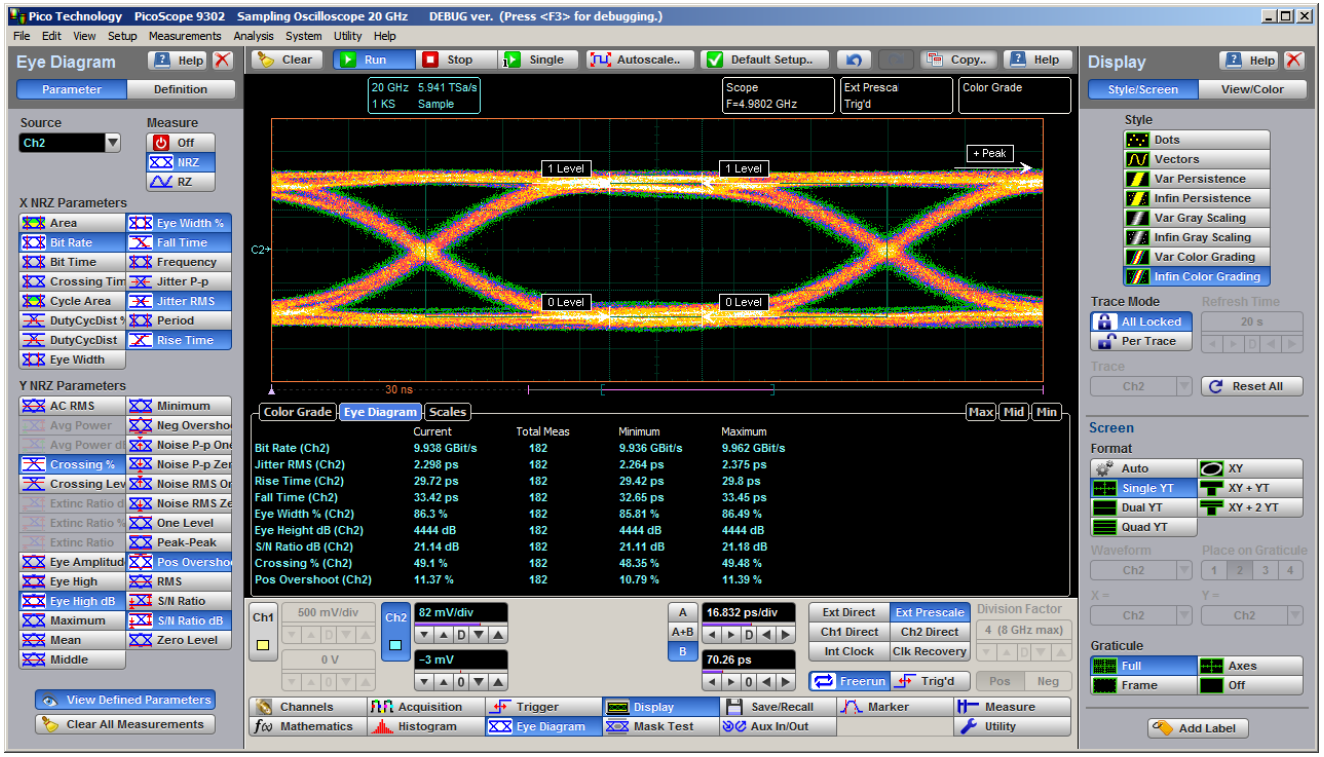
PicoScope 9300: Data Pattern

6.25-Gbps Data Pattern

PicoScope 9300: Multi-channel Display



PicoScope 9300:
Eye Diagram Measurements



10-Gbps eye-diagram acquired at 16.8 ps/div time base

Why Eye-diagram?

Eye Diagram is valuable because of comprehensive view of all signal integrity faults(except clock jitter):

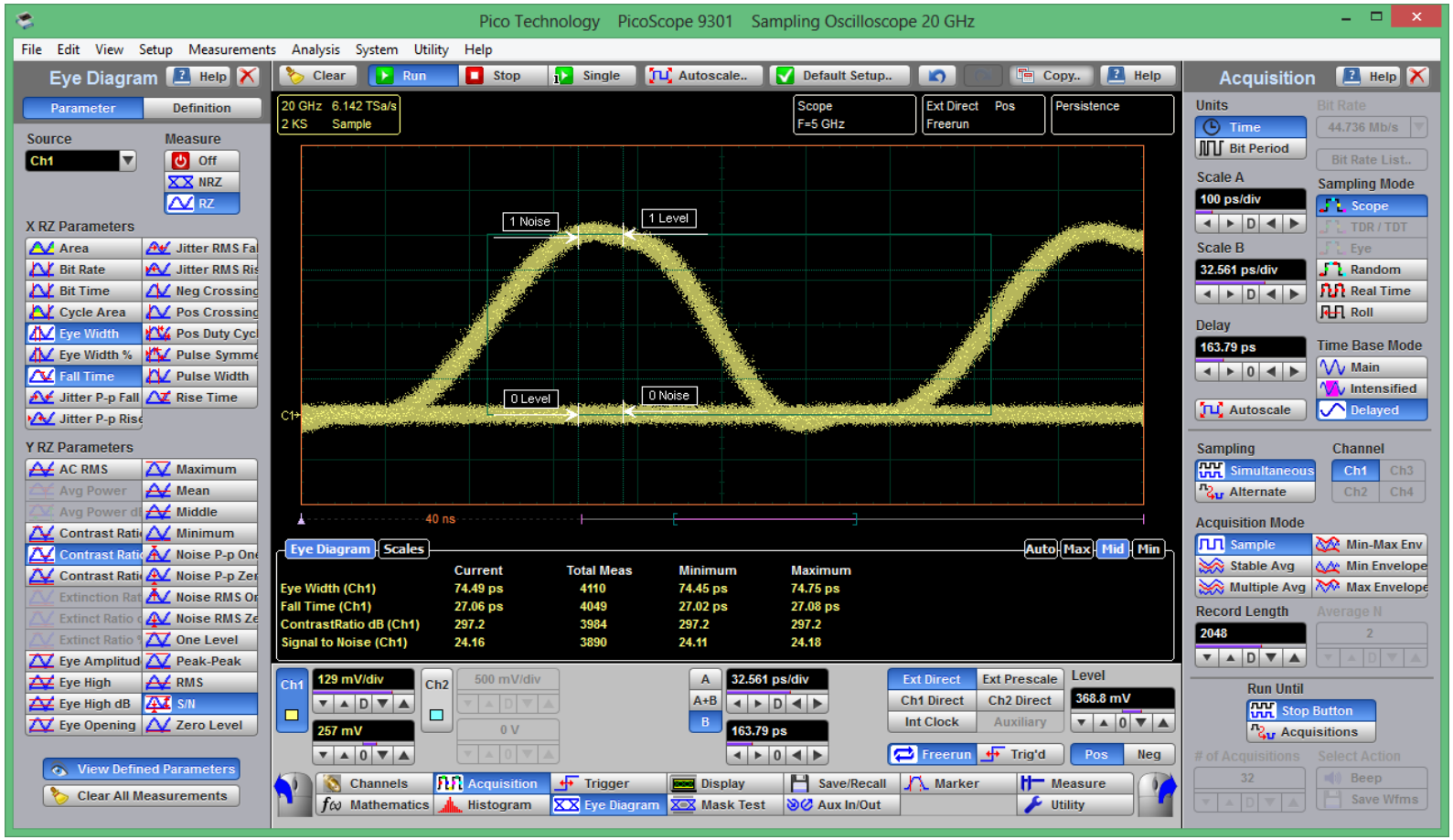
- Noise
- Jitter
- Reflections
- Ringing
- Inter-symbol interference
- Power and ground coupling

Eye Diagram Problems with Sequential Sampling Oscilloscope:

- It is not possible to resolve pattern dependencies
- Averaging is not available
- Input Dynamic Range ±400mV
- Random Noise and pattern dependent, deterministic errors mask each other

PicoScope 9300:
RZ Eye-Diagram Analysis

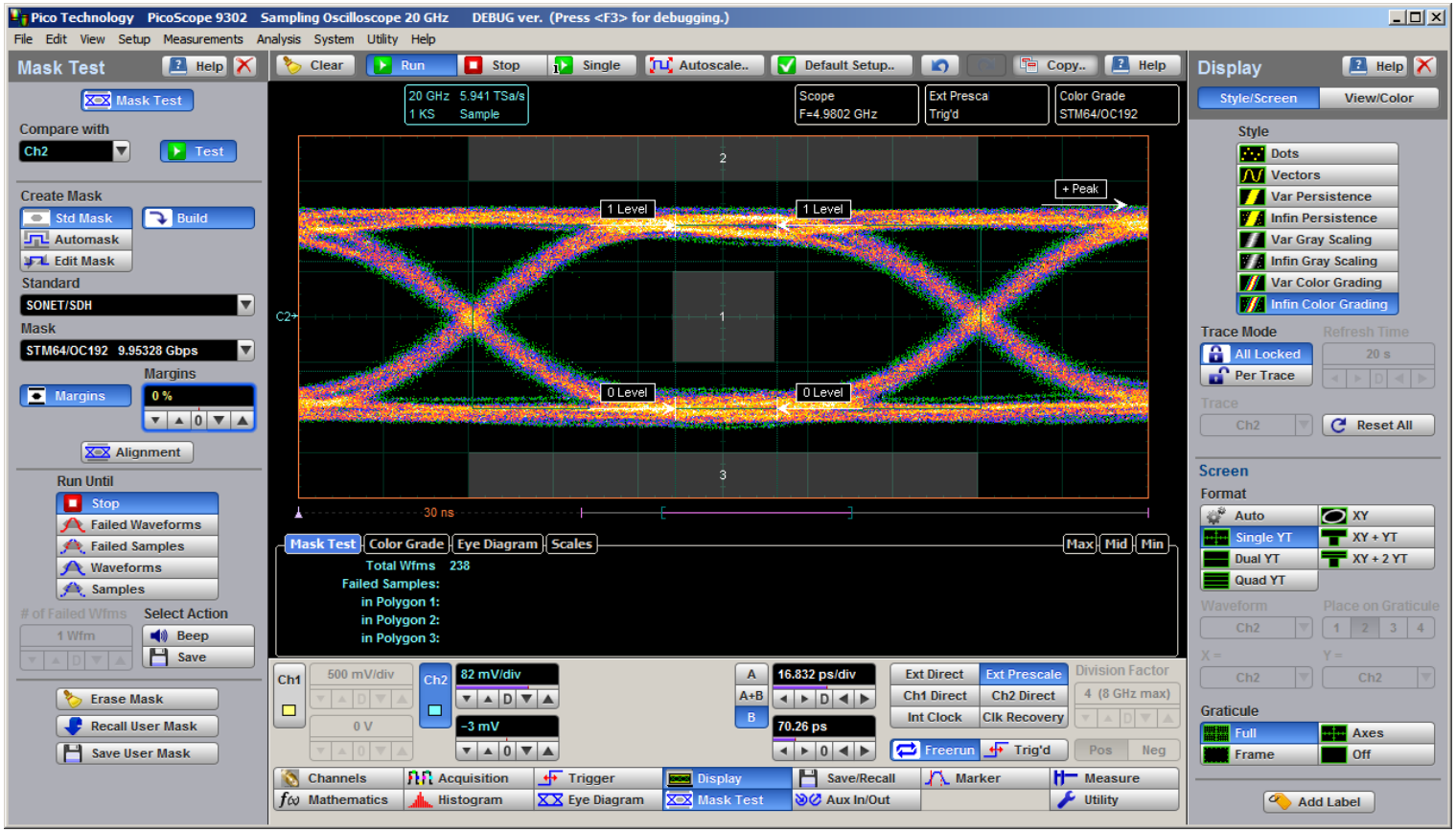
The PicoScope 9300 quickly measures more than forty fundamental parameters used to characterize an return-to-zero (RZ) signals. Up to ten parameters can be measured simultaneously.



The PicoScope 9301 measures 5-Gbps RZ eye-diagram

PicoScope 9300: Mask Test

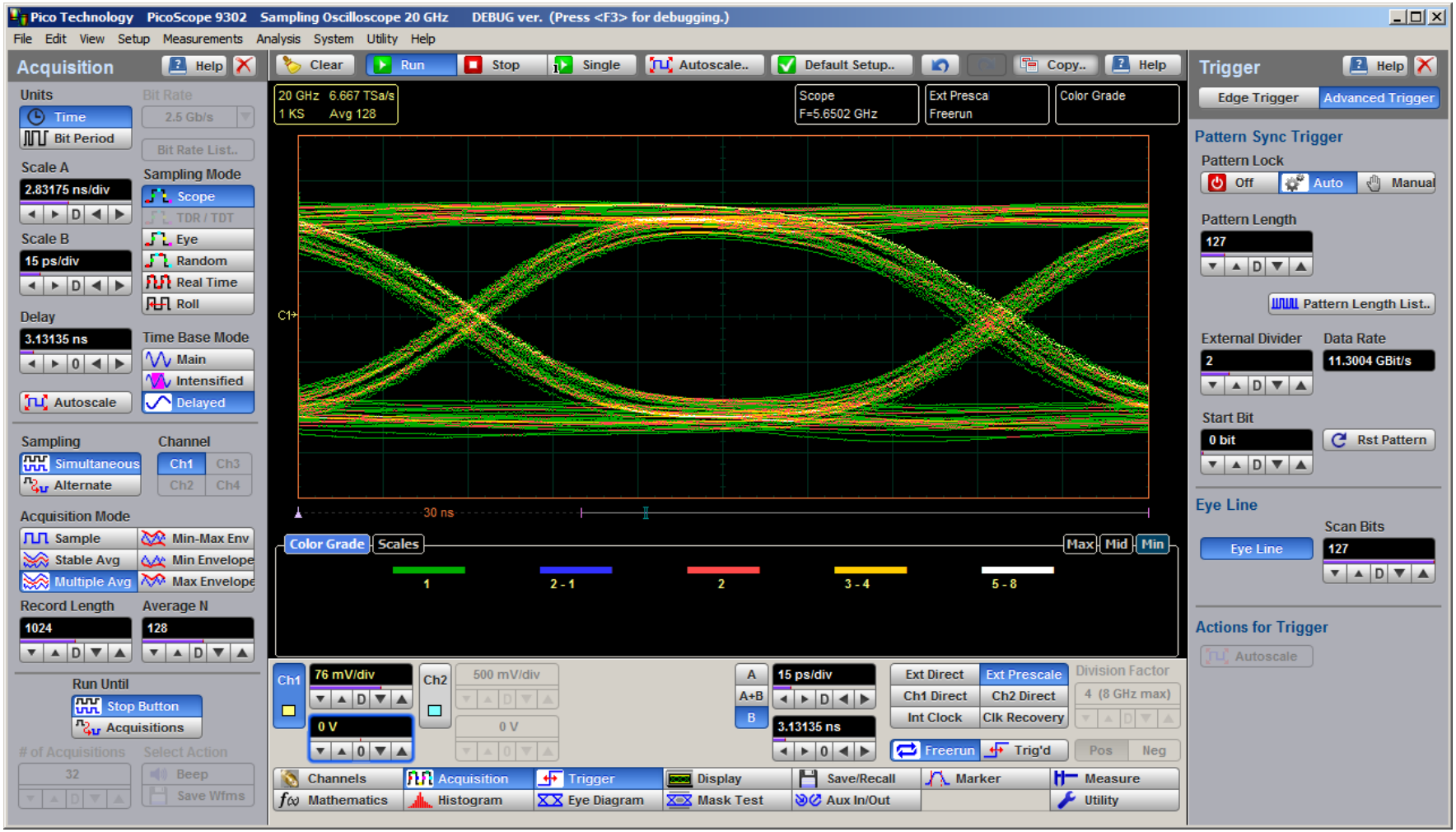
For eye-diagram masks, such as those specified by the SONET and SDH standards, the PicoScope 9300 supports on-board mask drawing for visual comparison. The display can create gray scaled or color-graded display to aid in analyzing noise and jitter in eye-diagrams.



- **Mask Test quickly characterizes:**
  - **Noise**
  - **Jitter**
  - **Aberrations**
  - **Rise Time**
  - **Fall Time**

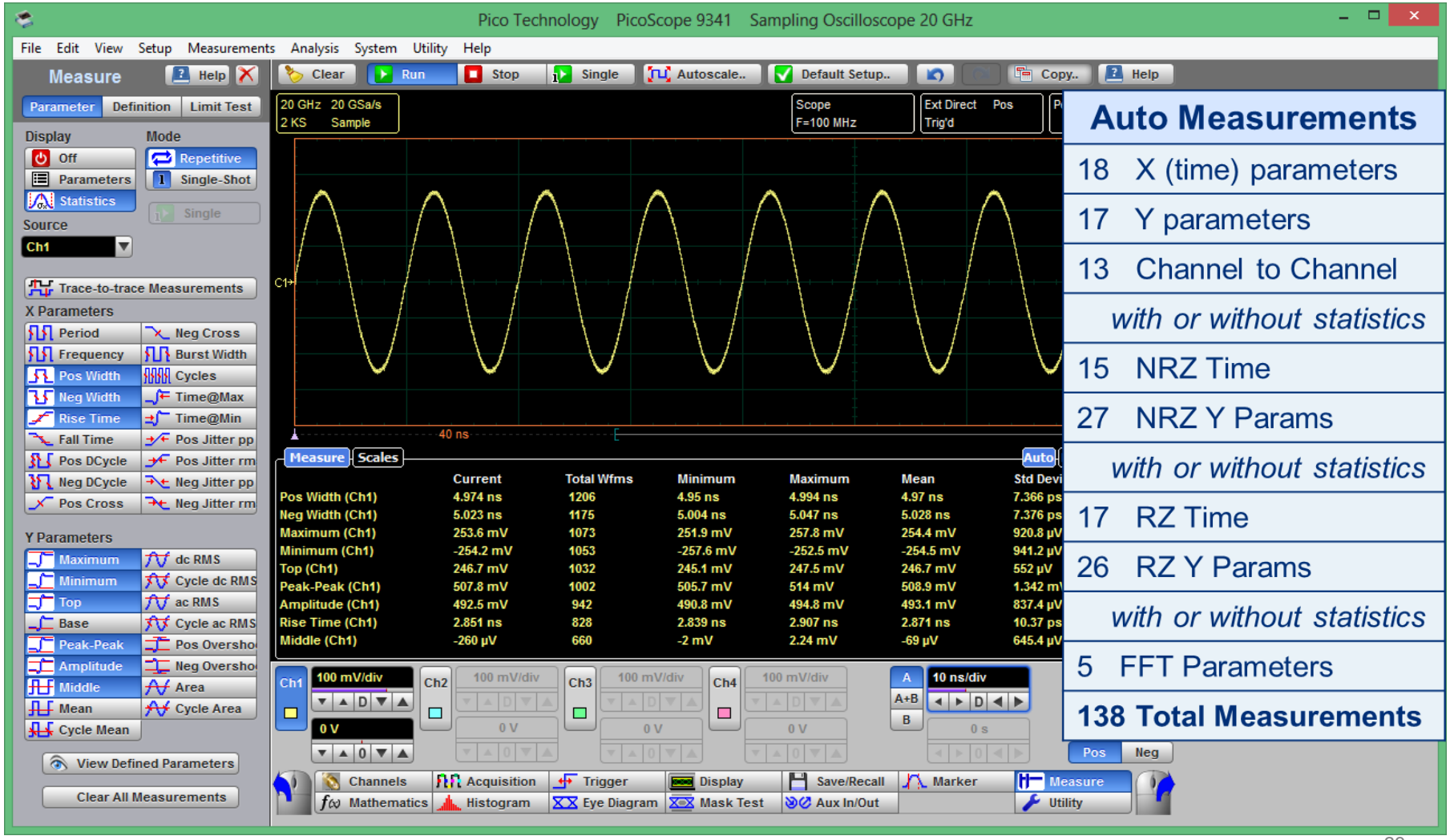
On-board mask drawing capability allows simple, operator-independent visual comparison of signal to standard mask. Picture demonstrates a 9.95 Gbps SONET/SDH (OC64/STM16) eye-diagram compared with the standard mask, showing a compliant waveform.

PicoScope 9300: Eye Line Mode

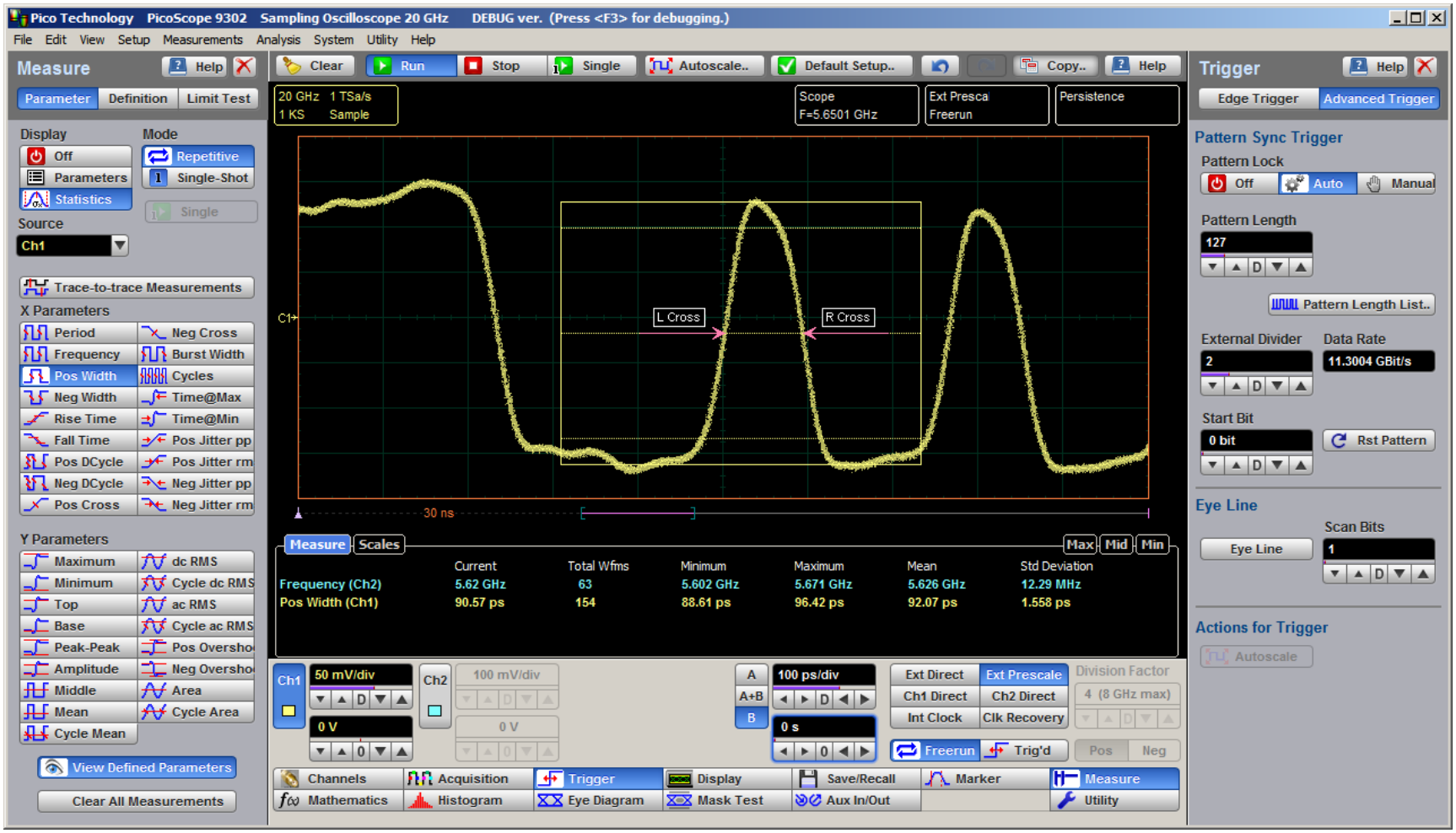


10-Gbps Averaged Eye Diagram acquired in Eye Line Mode

PicoScope 9300:
Automatic Measurements



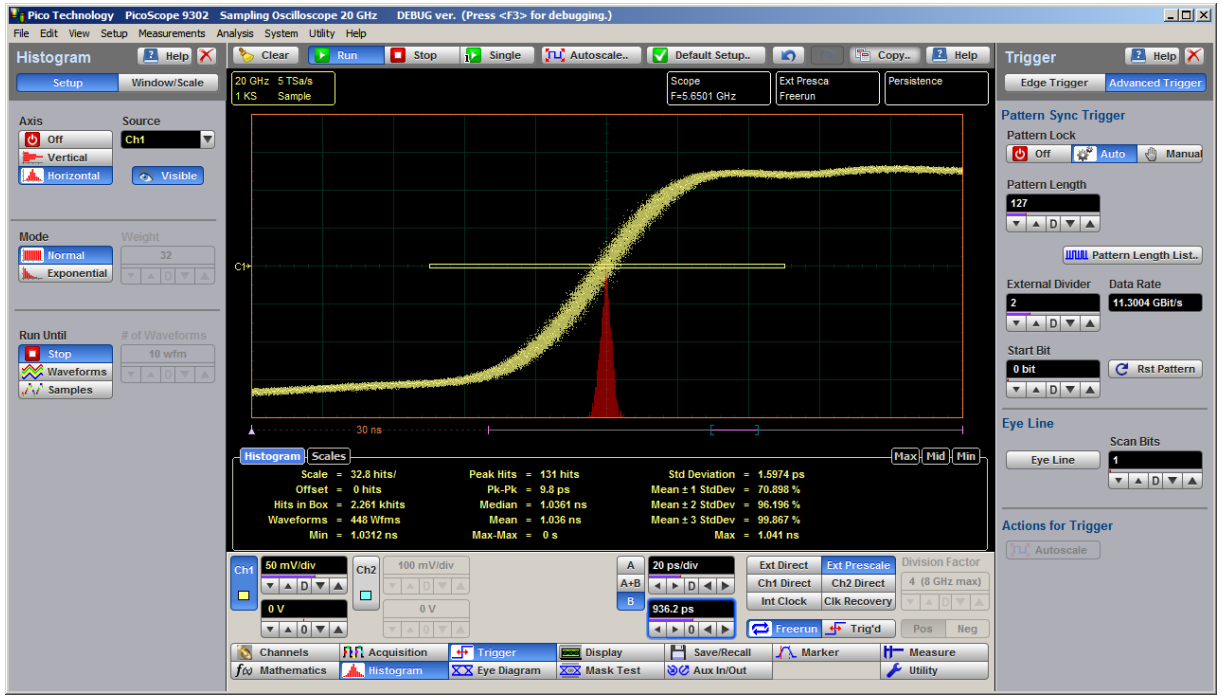
PicoScope 9300: Defined Measurements



The PicoScope 9300 measures 92-ps width of selected pulse inside 11.3-Gbps pattern

PicoScope 9300: Horizontal Histogram

A histogram is a probability distribution that shows the distribution of acquired data from a source within a user definable histogram window. The information gathered by the histogram is used to perform statistical analysis on the source. The most common use for vertical histogram is measuring and characterizing noise and jitter on displayed waveforms.

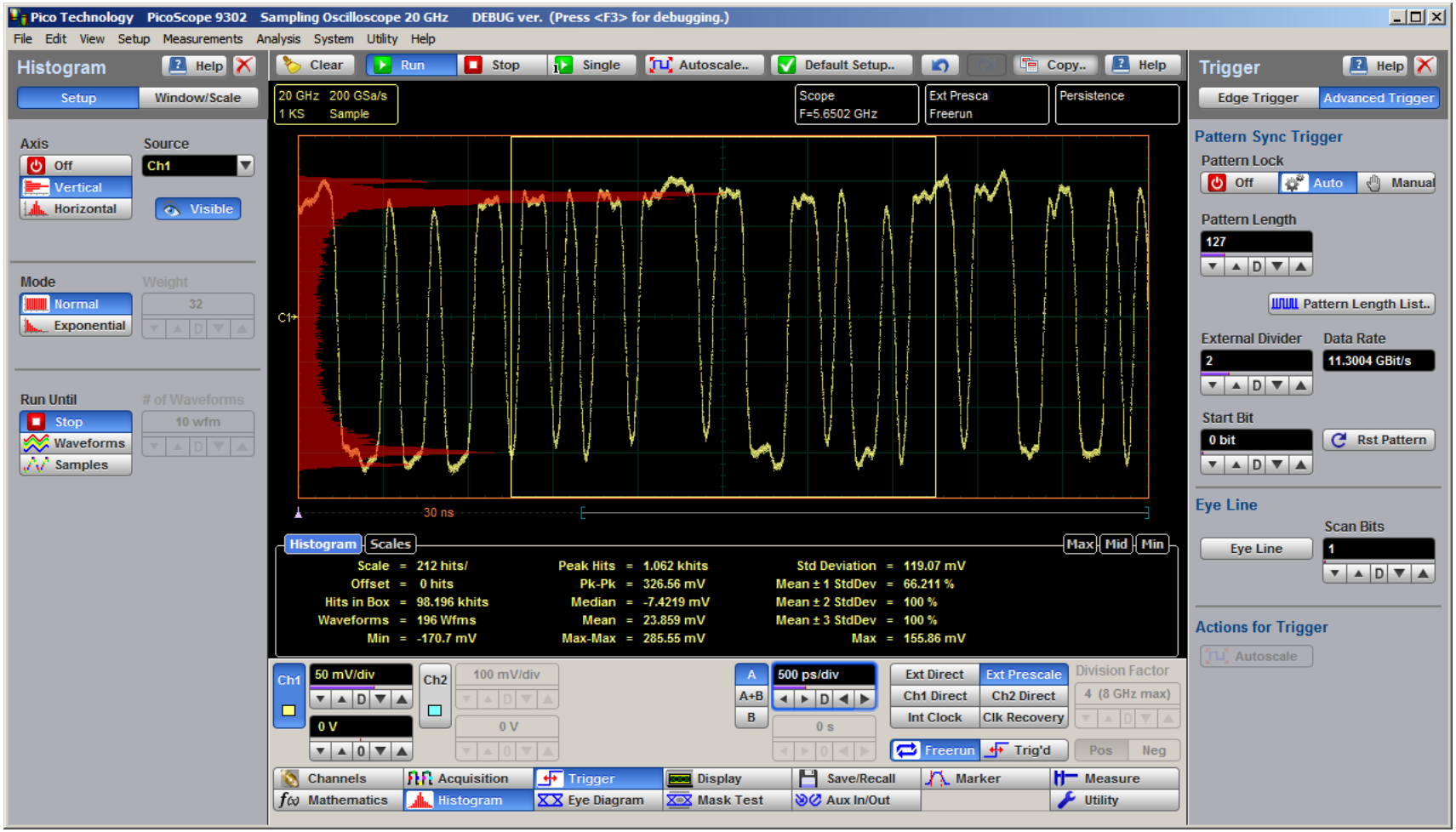


The PicoScope 9300 measures 1.59 ps RMS jitter of step response having near 40 ps rise time

The list of histogram statistics includes:

- Scale lists the display scale in hits per division or dB per division.
- Offset lists the offset in hits or dB. Offset is the number of hits or dB at the bottom of the display, as opposed to the center of the display.
- Hits in Box-The total number of samples included in the histogram box.
- Waveforms - Displays the number of waveforms that have contributed to the histogram.
- Peak Hits - The number of hits in the histogram's greatest peak.
- Pk – Pk - The width of histogram.
- Median - 50 % of the histogram samples are above the median and 50% are below the median.
- Mean - Mean is the average value of all the points in the histogram.
- StdDev - The Standard deviation (σ) value of the histogram.
- $\mu \pm 1$ StdDev, $\mu \pm 2$ StdDev, $\mu \pm 3$ StdDev - The percentage of points that are within $\pm 1\sigma$, $\pm 2\sigma$, or $\pm 3\sigma$ of the mean value.

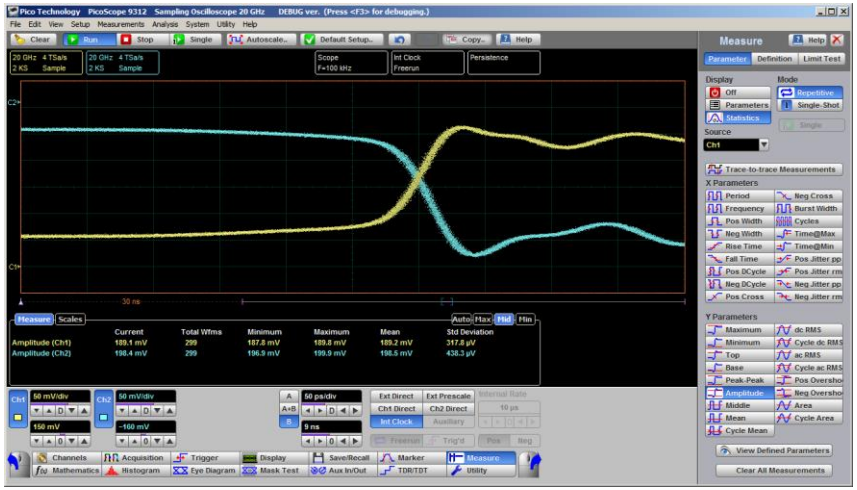
PicoScope 9300: Vertical Histogram



The PicoScope 9300 measures vertical histogram of data pattern

PicoScope 9300:
35-ps Differential Pulse Generator

35-ps step at 2 ns/div time base

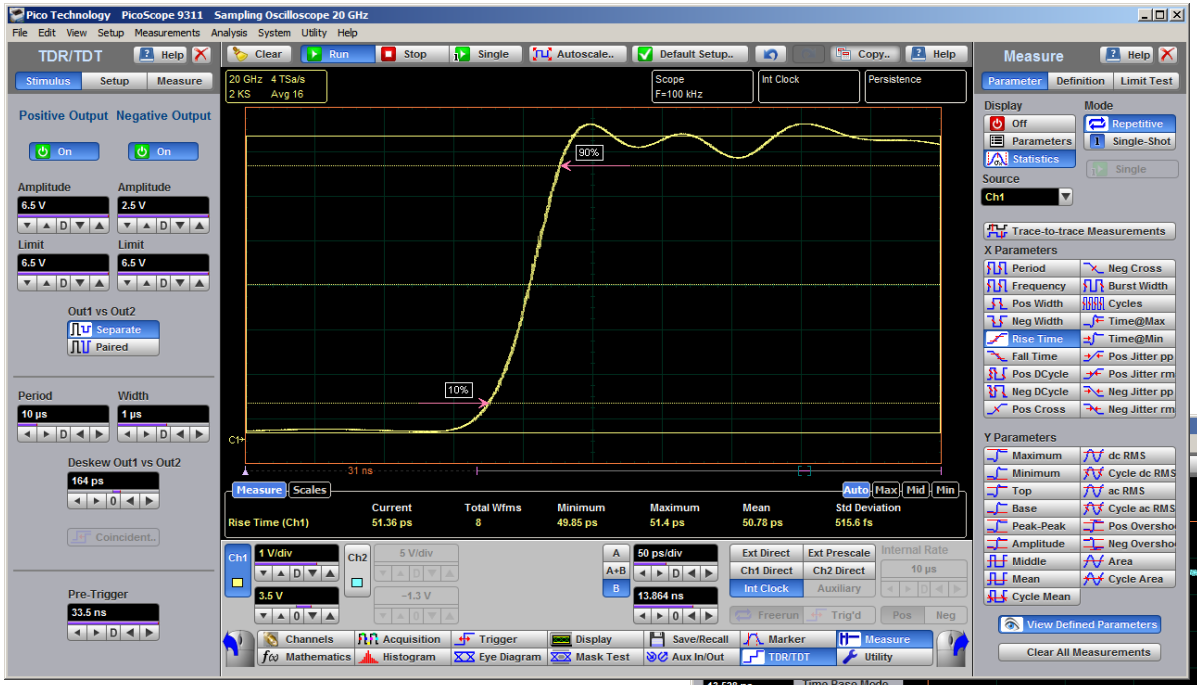


35-ps differential steps at 50 ps/div time base

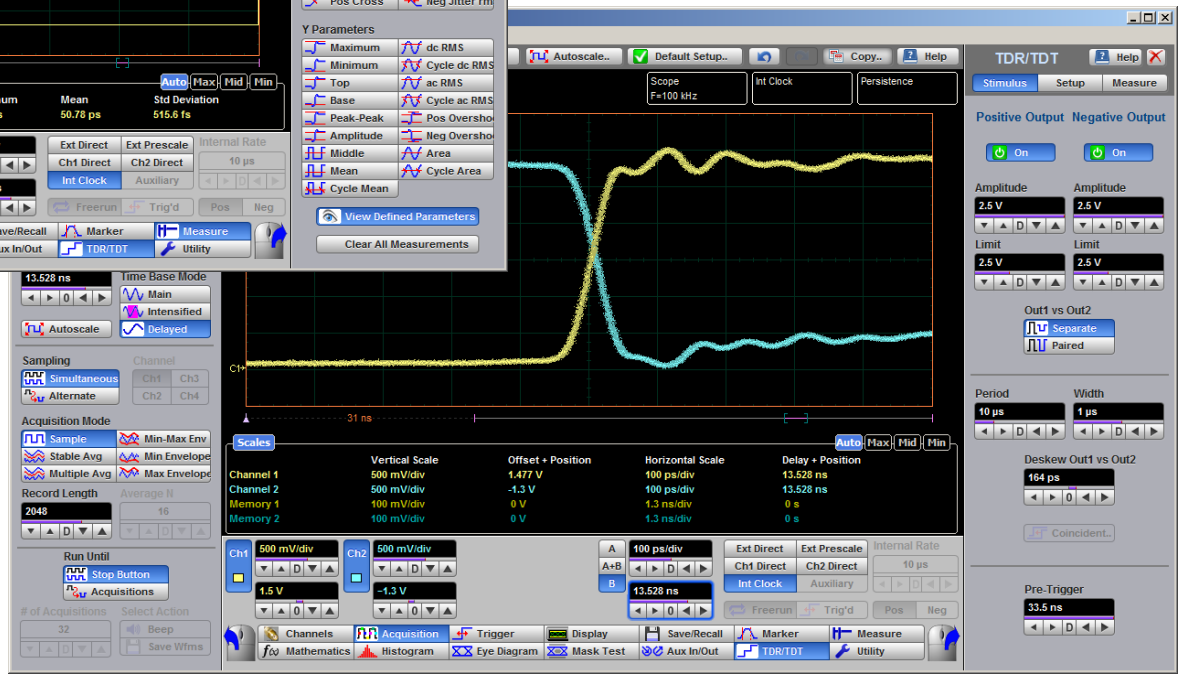
Transient response shows 24.07 ps step rise time and 16.84% overshot

40.44 ps step rise time having 2.48 ps RMS jitter

PicoScope 9300:
55-ps / 6 V Differential Pulse Generator

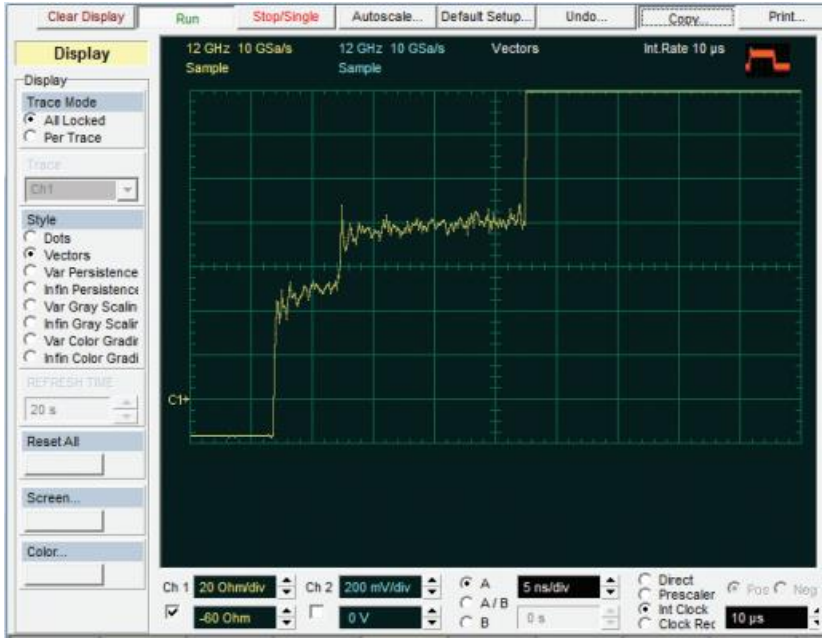


50.76 ps step at 50 ps/div time base



55-ps differential steps at 100 ps/div time base

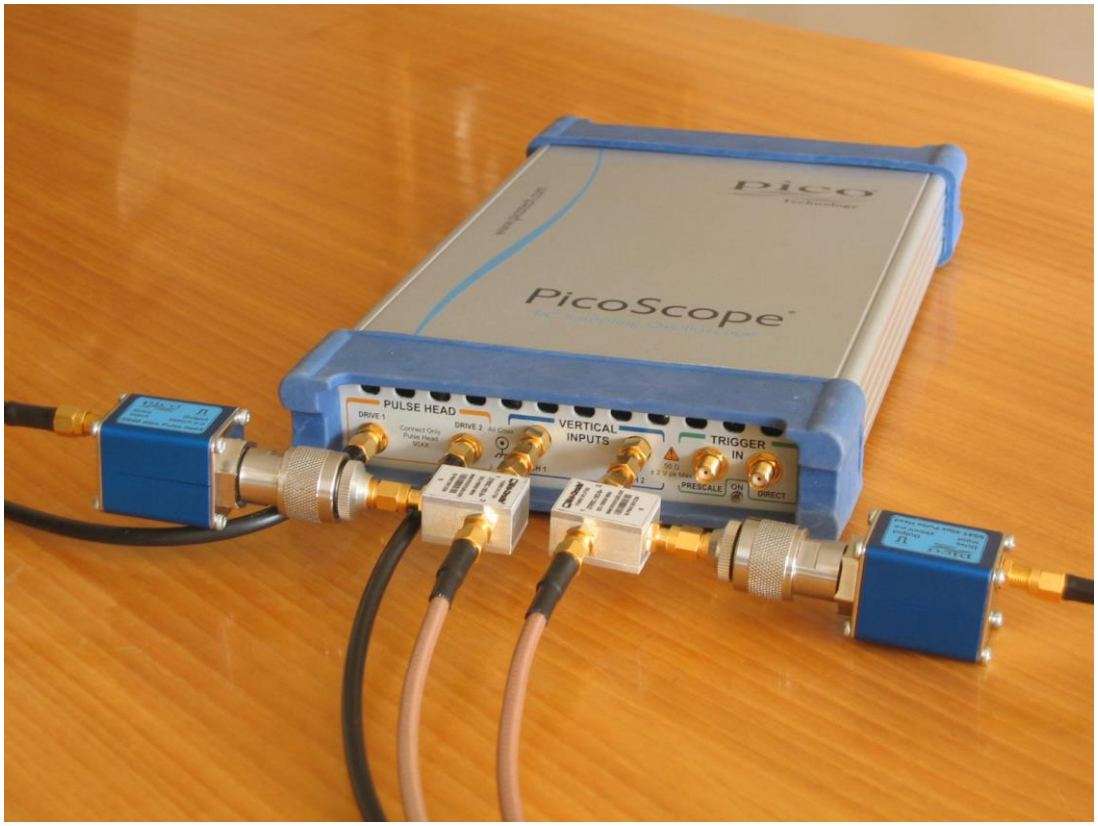
PicoScope 9300: TDR / TDT



- Differential TDR
- 55 ps, 6 V step generator
- Built in 40 ps, 200 mV external pulse heads
- Plot voltage, impedance or reflection coefficient against time or distance

35

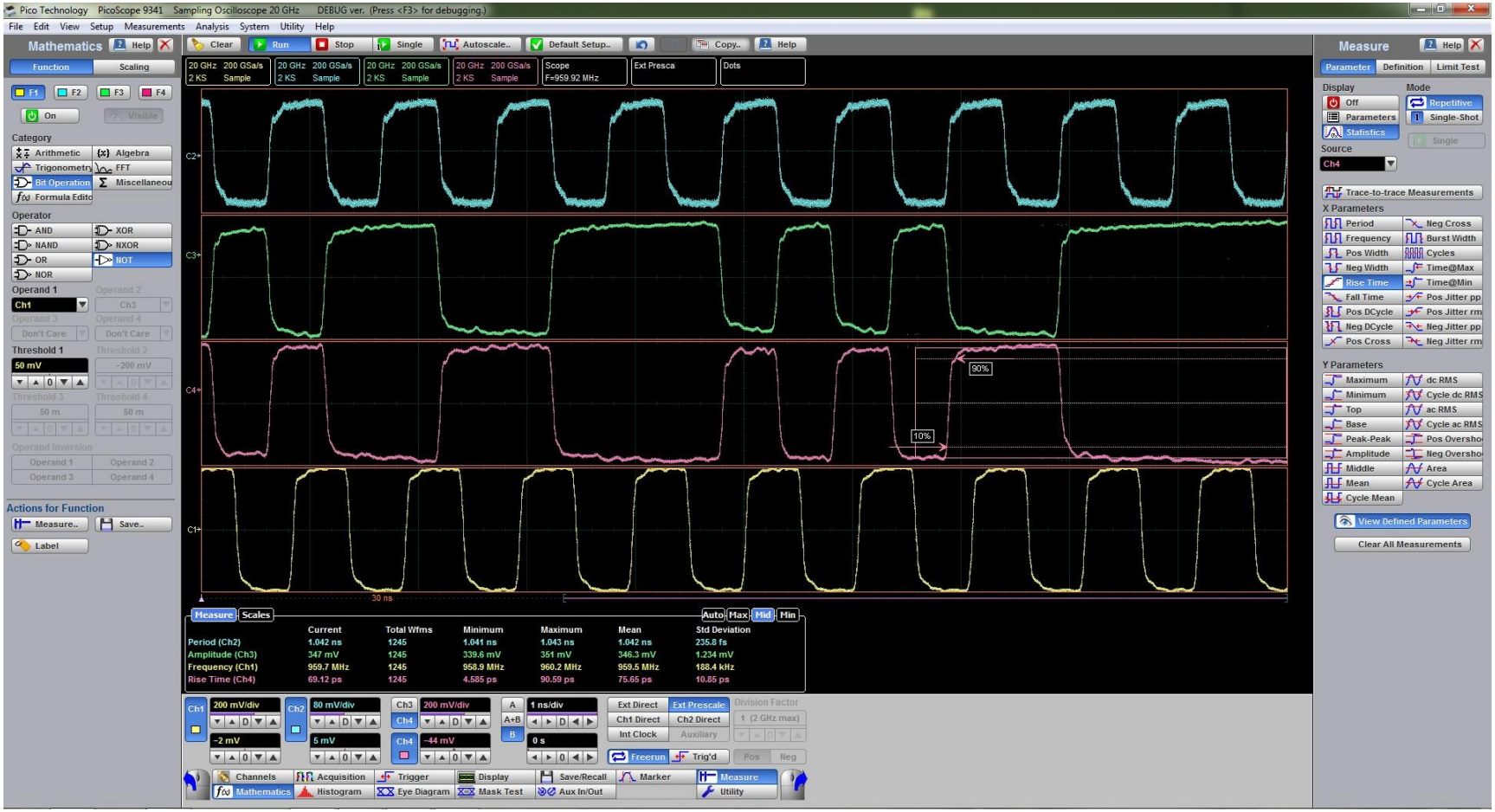
PicoScope 9300: 40-ps TDR / TDT



PicoScope 9312

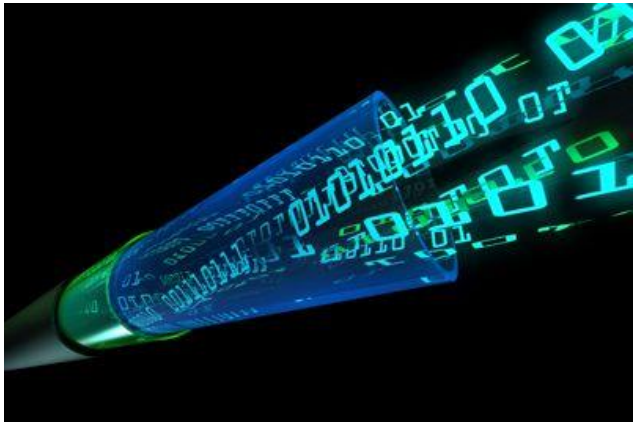
- Differential TDR
- 40 ps, 200 mV step generator
- Plot voltage, impedance or reflection coefficient against time or distance

PicoScope 9341: Four-channel sampling oscilloscope

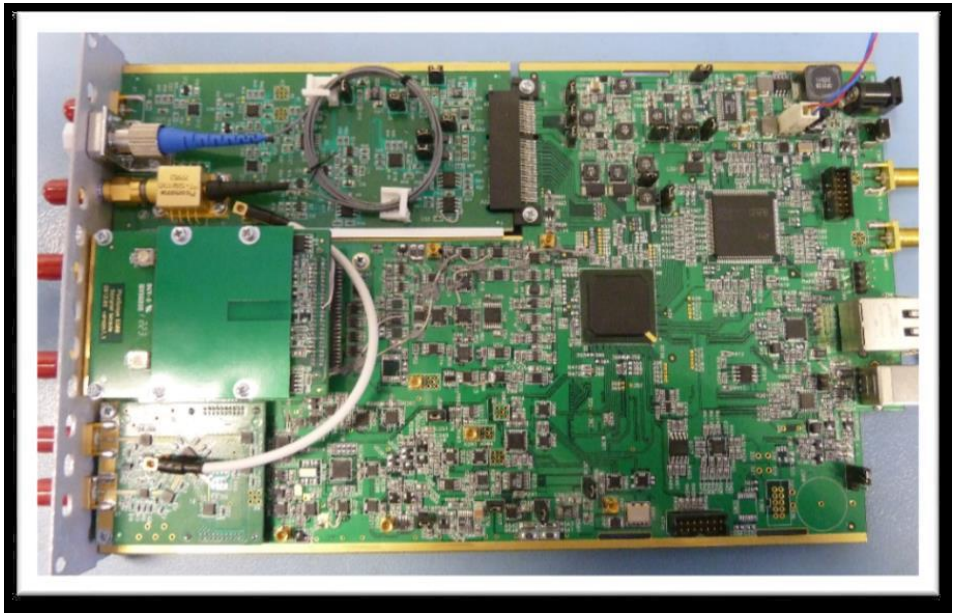


1 Gbps patterns and clocks on 4-channels PicoScope 9341 sampling oscilloscope

PS9321: Optical Sampling Oscilloscope



- 10 GHz precision O/E converter
- SM & MM connectors
- 750 to 1650 nm
- Automatic measurements
  - Extinction ratio
  - S/N ratio
  - Eye height & width



PicoScope 9300: Key Applications

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SIGNAL ANALYSIS

- Electrical standards compliance testing
- Eye-diagram analysis

RF COMPONENT TESTING

- RF components
- Cables and connectors
- Pulsed RF switches

R & D

- Microwave & RF characterisation
- High-energy physics
- Digital design

HIGH-SPEED DIGITAL COMMUNICATIONS

- Design and verification of telecom and datacoms elements
- Manufacturing and testing for ITU / ANSI conformance
- Mask testing

SEMICONDUCTOR TESTING

- Microwave & RF characterisation
- High-energy physics
- Digital design
- Informative waveform displays

MANUFACTURING

- Limit and mask testing
- Testing for ITU / ANSI conformance
- Automatic test systems
- Auto-calibration routine

FemtoScope 3000/2000/1000 Series

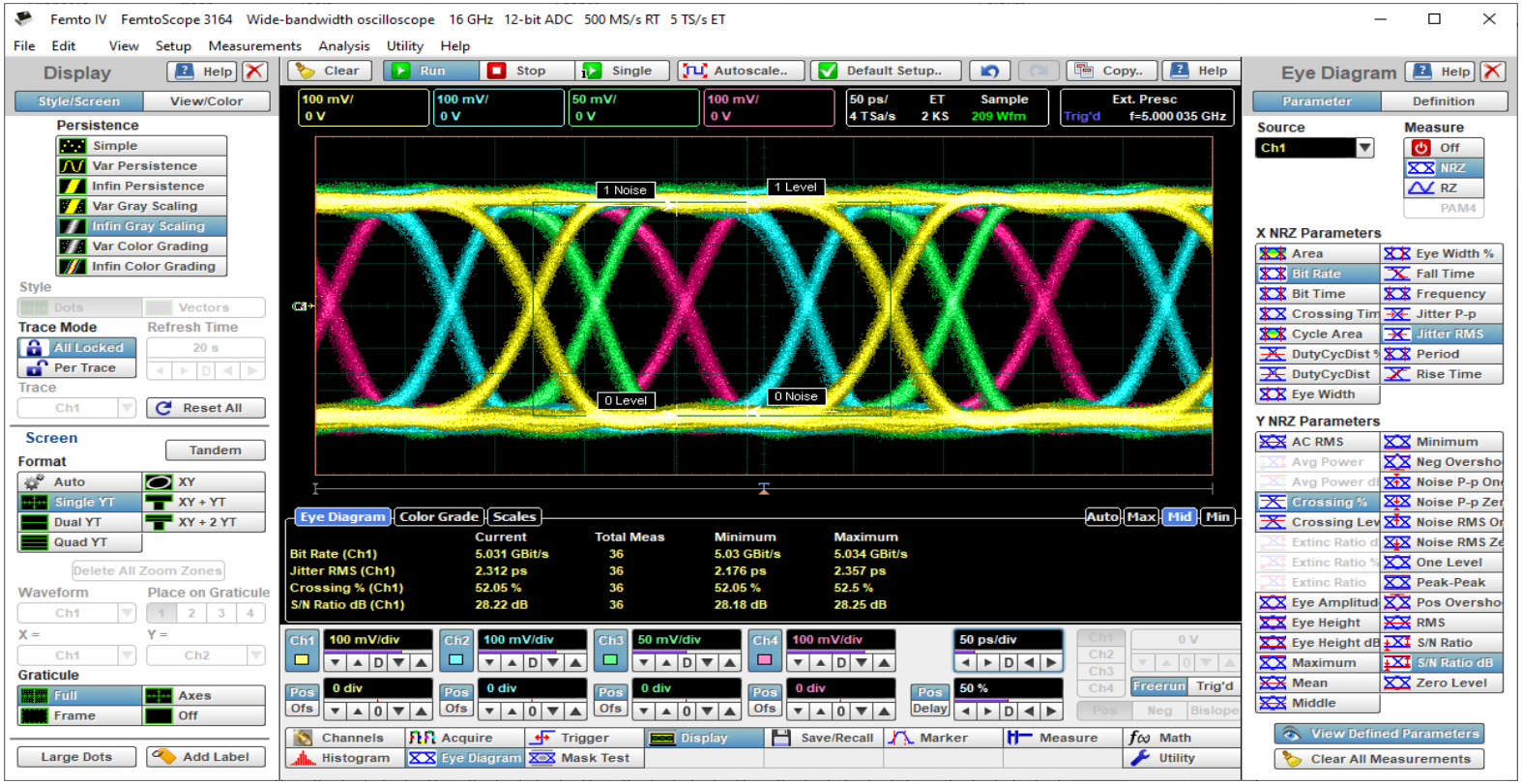
One-, two- or four-channel Digital Storage Oscilloscopes 5 and 16 GHz / 500 Msa/s / channel

FemtoScope 3000/2000/1000: Features

Features

- 4 channels configuration.
- The industry's widest 5 or 16 GHz PC oscilloscope bandwidth available to match your measurement application,
- The industry's lowest typical intrinsic jitter for PC oscilloscope - 1.2 ps rms for standard time base and 0.25 ps rms for precision time base.
- 12-bit Analog-to-Digital Converter with 500 MSa/s real time sampling rate per channel.
- Up to ±1% of full-scale DC gain accuracy.
- Industry's highest equivalent time sampling rate up to 5 TSA/s for standard time base and 25 TSA/s for precision time base.
- 10 ps/div fastest time base scale for standard time base and 2 ps/div for precision time base.
- Up to ±2 ps delta time measurement accuracy and ±0.2% of clock period for precision time base.
- Up to 16 GHz trigger bandwidth enables capture and analysis wide-bandwidth complex signals.
- Up to 11.3 Gb/s clock recovery trigger data rate.
- Pattern lock trigger and Eye line mode.
- Powerful SW and flexible, simple and intuitive user interface with built-in Online Help and demo training signals.
- Color graded display, automatic measurements, eye diagrams, mask test, histograms, waveform mathematics, 7-digit built-in trigger frequency counter, spectrum analysis with FFT, autoscale, store waveforms and setups.
- USB and LAN connection.
- Less than 33 W power consumption.
- Less than 1.52 kg weight
- Less than 5.69 sq.dm. footprint.
- Economical price starting from € 10 990.

FemtoScope 3000/2000/1000: Overview



The *FemtoScope* 3164 provides best solutions for fast eye diagram measurements

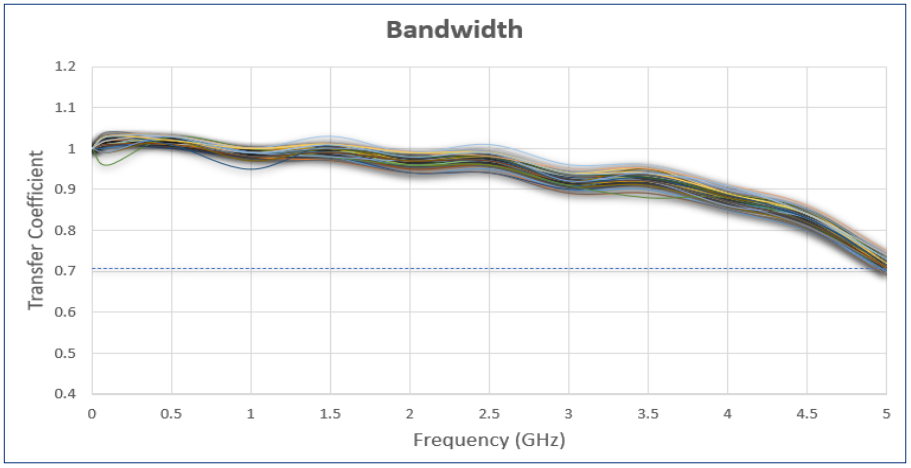
More recently, if you needed an oscilloscope with a bandwidth of more than 5 GHz, you had to accept the need for significant financial costs. The *FemtoScope* 3000 models set a new price/performance ratio standard for gigahertz frequency PC oscilloscopes. These four-channel instruments, having a bandwidth of 5 or 16 GHz and triggering over the entire frequency range, provide the acquisition, display, measurement and analysis of complex waveforms in the range from picoseconds to hundreds of seconds.

FemtoScope 3000/2000/1000:
Model comparison chart

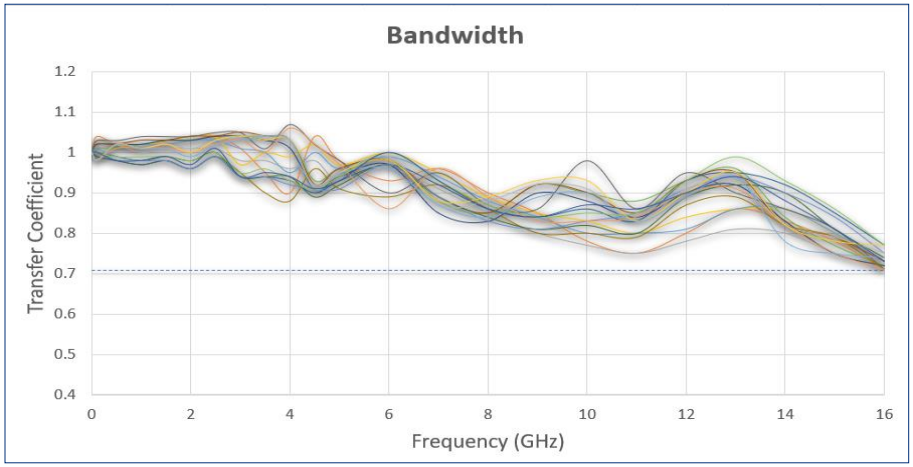
Parameters	FemtoScope 3000	FemtoScope 2000	FemtoScope 1000
			
Channels	4	2	1
Bandwidth	5 & 16 GHz	5 & 16 GHz	5 & 16 GHz
Vertical Sensitivity	10-250 mV/div	10-250 mV/div	10-250 mV/div
DC gain accuracy	±2 % of FS	±2 % of FS	±2 % of FS
RMS Noise, max	1.8 mV @ 5 GHz 2.4 mV @ 16 GHz	1.8 mV @ 5 GHz 2.4 mV @ 16 GHz	1.8 mV @ 5 GHz 2.4 mV @ 16 GHz
Minimum Time Base Scale	50 ps/div @ 5 GHz 10 ps/ @ 16 GHz	50 ps/div @ 5 GHz 10 ps/ @ 16 GHz	50 ps/div @ 5 GHz 10 ps/ @ 16 GHz
Trigger BW	5 GHz @ 5 GHz 16 GHz @ 16 GHz	5 GHz @ 5 GHz 16 GHz @ 16 GHz	5 GHz
Trigger Jitter	1.5 ps	1.5 ps	1.5 ps
RT Sample Rate	0.5 GSa/s / ch	0.5 GSa/s / ch	0.5 GSa/s / ch
ADC resolution	12 bits	12 bits	12 bits
Memory Depth	250 Kpts	250 Kpts	250 Kpts

FemtoScope 3000/2000/1000: Bandwidth

The *FemtoScope* 3000 Series oscilloscopes have 0me, two or four input channels, 5 GHz or 16 GHz bandwidth (Figures 3 and 4) 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 70 or 22 ps, impulses down to 140 or 80 ps and clocks and data eyes to 5 or 11.3 Gb/s. Most high-bandwidth applications involve repetitive signals or clock-related data streams that can be readily analyzed with these oscilloscopes by equivalent-time sampling.
The heart of each of the channel is a wide-bandwidth track-and-hold amplifier, which stores the analog voltage at the channel input at a time determined by the arrival of a 500-MHz sampling pulse. The inputs include wide-bandwidth symmetrical resistive voltage divider. One half of the signal goes to the THA, the other to the trigger comparator. The input impedance of the channel is (50 ± 1.5) Ohms. With a maximum permissible input voltage of ±2 V, the dynamic range of the input signals is ±1 V.



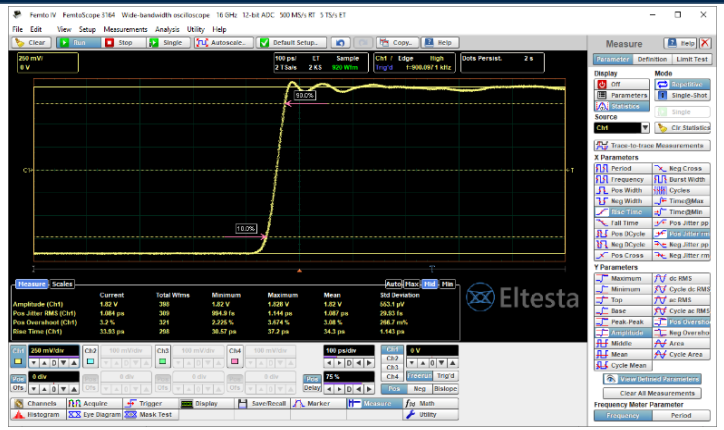
Frequency response of forty 5-GHz input channels



Frequency response of twenty 16-GHz input channels

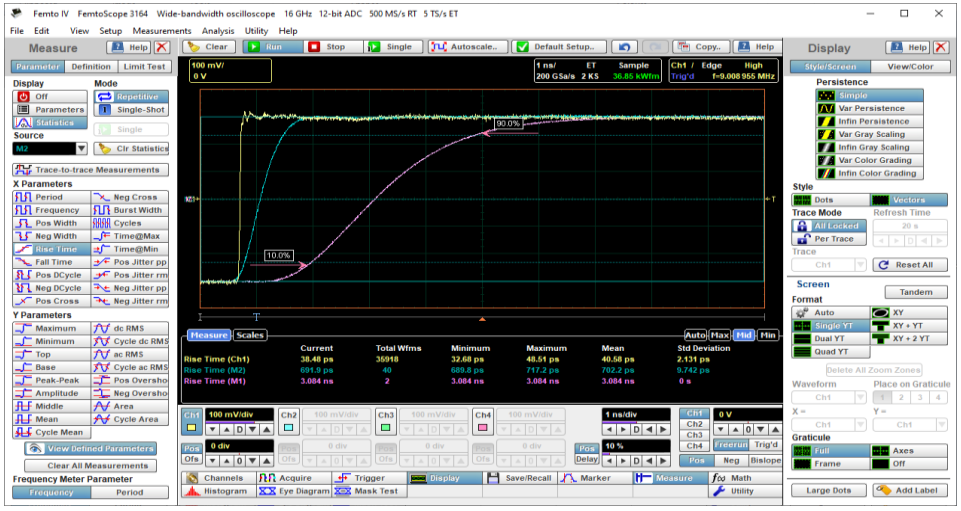
FemtoScope 3000/2000/1000: Transient Response

Transient response of the *FemtoScope* 3164 tested with Keysight N2806A Calibration Generator. Total measured fall time is 24.9 ps, RMS rms jitter is 1.292 ps, and negative overshot is 3.514%.



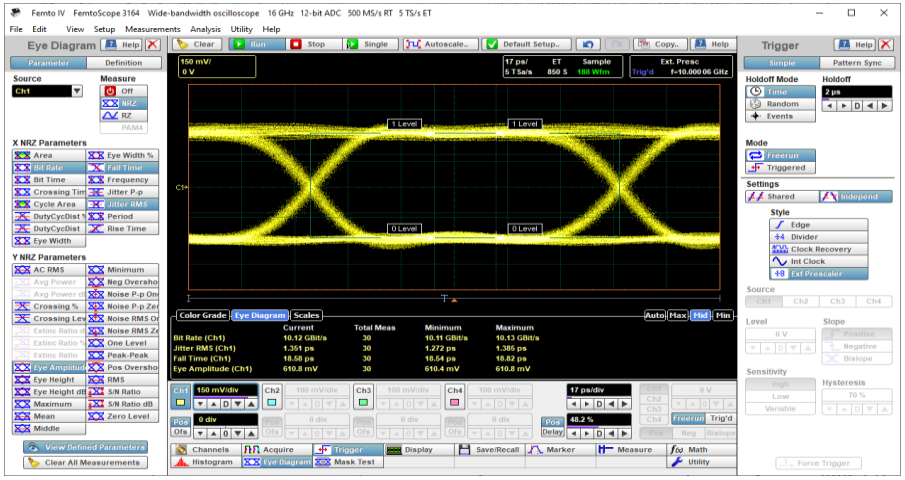
Transient response of the *FemtoScope* 3164 tested with 1.82 V step having 25 ps own rise time (signal source - Tektronix 1251 PPG). Step response shows 34.3 ps rise time, 1.087 ps rms jitter and 3.08% positive overshot.

Comparative transient response of the *FemtoScope* 3164 made for three different bandwidths.
Yellow trace shows 40.58 ps rise time acquired in the full 16 GHz bandwidth.
Blue trace shows 702 ps rise time acquired in the middle 500 MHz bandwidth.
Violet trace shows 3.084 ns rise time acquired in the narrow 100 MHz bandwidth.



FemtoScope 3000/2000/1000: Noise Level

The FemtoScopes **provide three possible bandwidth ranges – full (5 GHz or 16 GHz), middle (500 MHz) or narrow (100 MHz).**
In full bandwidth mode, the instruments provide typical rms noise level less than 1.6 mV (for 5 GHz bandwidth) and 2.2 mV (for 16 GHz bandwidth). In 500 MHz mode, the THA operates in the "transparency" mode, providing 500 MHz bandwidth with less than 0.65 mV typical rms noise. This opens possibility to perform more sensitive measurements. Right figure 9 shows wide opened 800 Mb/s eye diagram acquired in 500 MHz bandwidth mode that demonstrates extremely good response characteristics.
In 100 MHz bandwidth mode, the *FemtoScopes* provide typical rms noise less than 0.45 mV. Narrow bandwidth setting can also be used as an anti-alias filter.



10 Gb/s data rate and 610 mV amplitude eye diagram acquired with the *FemtoScope* 3164. Eye rms jitter = 1.365 ps. Eye fall time = 18.82 ps maximum. Signal source: Anritsu MP1800A Signal Quality Analyzer.

800 Mb/s wide opened eye diagram acquired in narrow bandwidth mode with the *FemtoScope* 3164 shows good response characteristics.

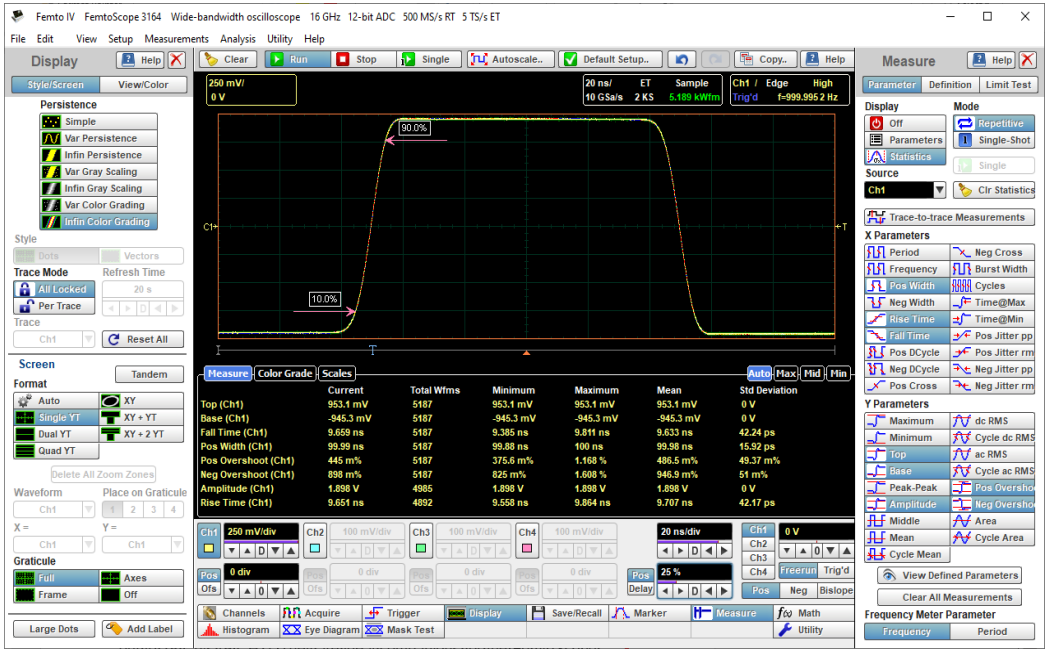
FemtoScope 3000/2000/1000: Vertical channels and probes

Eltesta

Providing up to 12 bits of vertical resolution the *FemtoScope* allows to control vertical sensitivity between 10 mV/div and 250 mV/div. Full scale is defined as 8 vertical divisions, and further zooming may increase sensitivity in 100 times. With ±1% guaranteed and even ±0.5% typical DC gain accuracy the *FemtoScope* 3000 also provides ±1 V DC offset and wide input dynamic range between -1 V and +1 V.

Figure 10 shows 1.9 V amplitude pulse symmetrical to zero. With rise time faster than 10 ns it has very small ringing (0.95%) and high amplitude measurement accuracy ±0,105%. With 50 Ω channel input impedance all the oscilloscopes used standard SMA female connector providing ±2 V (DC + peak AC) maximum input voltage.

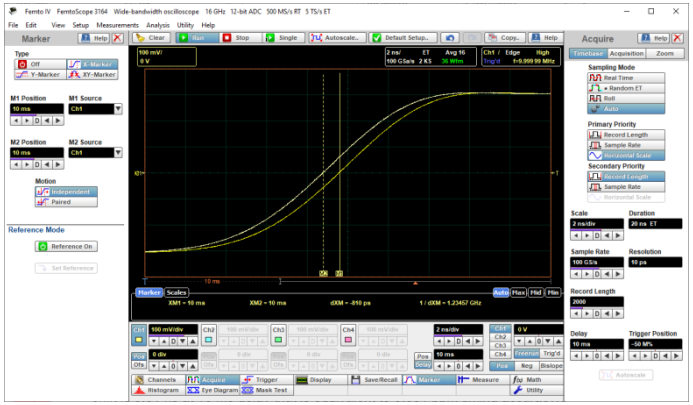
You can use wide range of high-bandwidth low-impedance probes. The PicoConnect 900 family of high performance, ultra-low capacitance passive probes tailored to low invasive probing of high-speed data lines out to 18 Gb/s (9 GHz). They are ideal companions for the *FemtoScope* 3000 Series, allowing cost-effective fingertip browsing of fast signals. Two series are available: RF, microwave and pulse probes for broadband signals up to 5 GHz (10 Gb/s), and Gigabit probes for data streams.



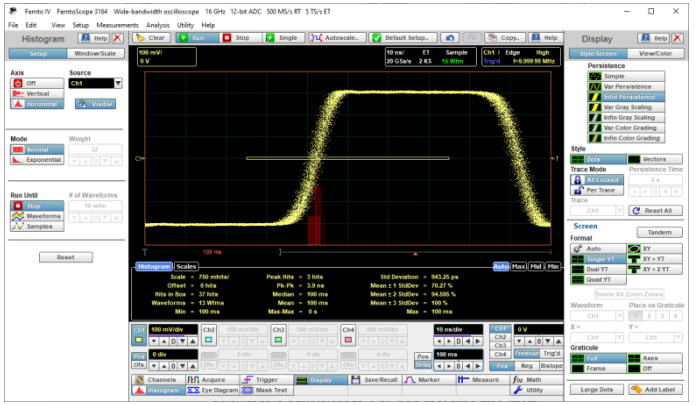
Symmetrical to zero 100-ns pulse having less than 10 ns rise/fall time and 1.9 V amplitude shows amplitude measurement accuracy better than 0.105% and ringing less than ±1%. Signal source: Keysight 33500B Waveform Generator.

FemtoScope 3000/2000/1000: Acquisition and time base

The *FemtoScope* 3000 oscilloscopes used real-time, equivalent-time and roll sampling acquisition modes. Real-time sampling mode is designed with a high enough sampling rate to capture a transient, non-repetitive signal with the instrument's specified analog bandwidth up to 200 MHz. According to Nyquist's sampling theorem, for accurate capture and display of the signal the scope's sampling rate must be at least twice the signal bandwidth. Typical high-bandwidth real-time oscilloscopes 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.
Several acquisition modes let you choose how the oscilloscope will create points in the waveform record. Average calculates the average values for each record point over many waveform records. It is available in real-time and equivalent-time modes. Min-Max, Min and Max Envelope use the highest and lowest samples across several waveform records. These are also available in real-time and equivalent-time modes. Peak Detect mode alternates between saving the highest sample in one acquisition interval and the lowest sample in the next acquisition interval. It is available in real-time only. High Resolution mode averages all samples taken during an acquisition interval to create a record point. This average results in a higher-resolution, lower-bandwidth waveform that works with real-time mode.



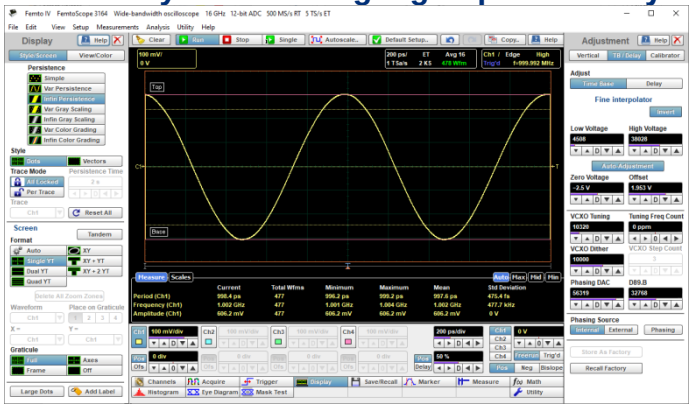
The *FemtoScope* 3164 demonstrates real time base accuracy. Timing shift is 0.81 ns at 10 ms delay that is equivalent to 0.081 ppm timing accuracy.



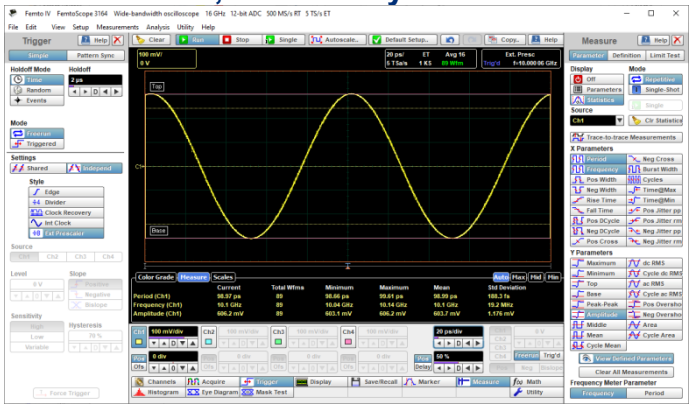
. The *FemtoScope* 3164 measures real-time base "long-time" jitter from a stable 10 MHz clock source. RMS jitter value shows 943 ps at 100 ms horizontal delay that is equivalent to 9.43 ppb real-time rms jitter.

FemtoScope 3000/2000/1000: Acquisition and time base (cont.)

For signals close to or above Nyquist limit, the *FemtoScope* 3000 can be switched into equivalent-time sampling mode. In this mode the scope acquires 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 acquire enough samples to display the waveform with the desired time resolution. This is called the effective sampling resolution, which is many times higher than is possible in real-time mode. As an example, the *FemtoScope* 3164 has 0.2 ps timing resolution that is equivalent to 5 TSa/s equivalent-time sampling rate. As this technique relies on a random relationship between trigger events and the sampling clock, more correctly to call it "random equivalent-time sampling" (or sometimes "random interleaved sampling", RIS). It can be used for repetitive signals or for data pattern when you want to build an eye diagram.
Equivalent-time sampling mode is the most actual for signal integrity measurements when you need very accurate results for such parameters as rise time or jitter. Precise picosecond time base and low intrinsic trigger jitter are necessary for ensuring high-speed test system reliability. With more low value, the better you'll be able to characterize



The *FemtoScope* 3164 tests accuracy of 200 ps/div horizontal scale with 1 GHz sinewave (1 ns period). Mean value of measured period is 997.6 ps.



The *FemtoScope* 3164 tests accuracy of 20 ps/div horizontal scale with 10 GHz sinewave (100 ps period). Mean value of measured period is 98.99 ps.

FemtoScope 3000/2000/1000: Zoom

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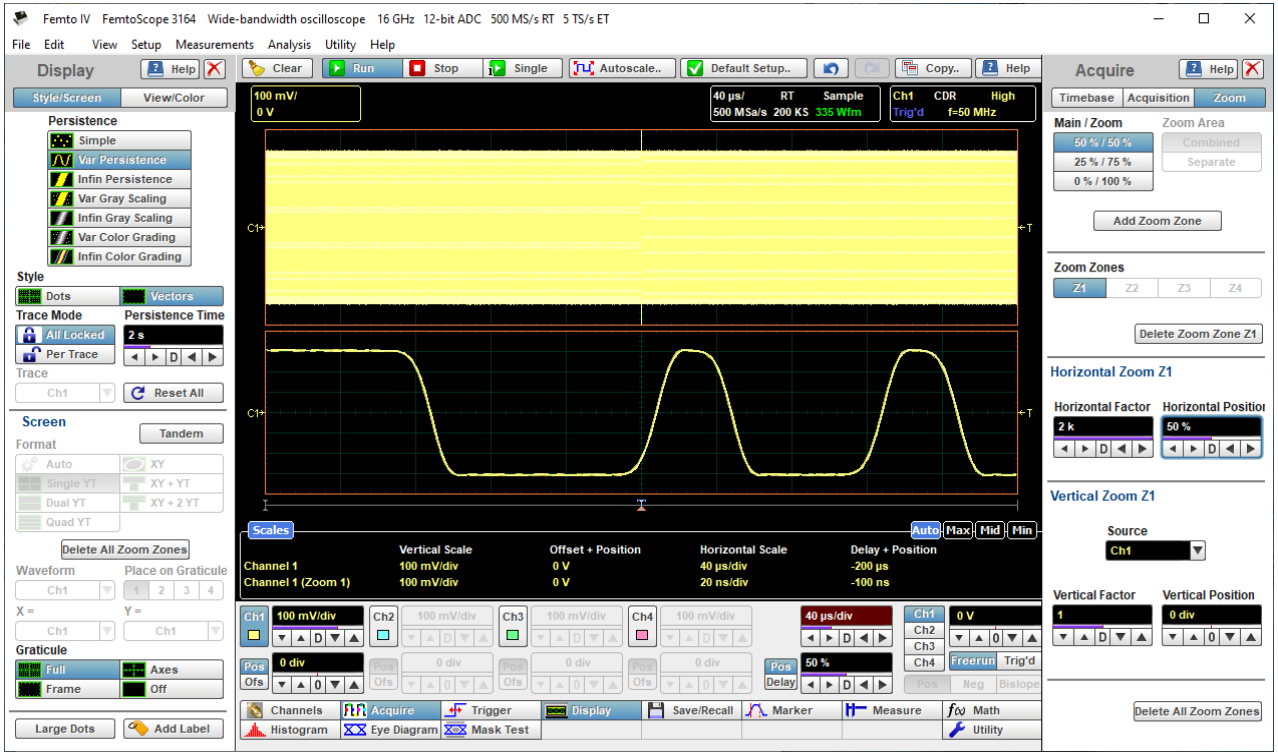
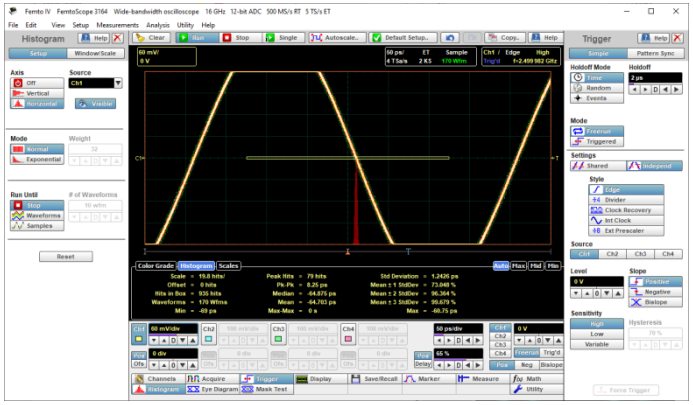
Due to the long memory, the zoom allows you to view and compare up to four vertically and horizontally enlarged waveform sections simultaneously. At the same time, it is possible to shift any of zoomed zones both vertically and horizontally (Fig. 15). The maximum vertical zoom is 100, and maximum horizontal zoom is 2048.



50 Mb/s data pattern is acquired at 500 MSa/s sampling rate, 50 us/div time base and 250 KB record length (top). With 2K horizontal zoom you have possibility to measure the details of the waveform at 25 ns/div time base (bottom).

FemtoScope 3000/2000/1000: Trigger

One of the most important properties of wide-bandwidth oscilloscopes is their ability to provide extremely low-jitter trigger in wide frequency range. The difficulties in providing such properties were primarily associated with the following reasons.
First, the *FemtoScope* 3000s are not a fully real-time oscilloscopes that meets the Nyquist criterion in full bandwidth range. Therefore, the use of the so-called software trigger is not possible.
Secondly, the trigger electronics was not supposed to be designed as a custom IC, which would significantly increase the cost of development. As a result, the trigger was created on the basis of the fastest logic ICs having up to 10 GHz clock frequency and an output voltage slope of more than 4 V/ns.
All the models of the oscilloscopes provide full-function internal or external direct trigger typically up to 3 GHz. Input high-speed comparators allow you to adjust the trigger level and hysteresis, providing trigger sensitivity better than 40 mV. It is possible to select any of the trigger slope, as well as use the bi-slope trigger, which allows you to acquire the so-called pseudo-eye diagrams.
A distinctive feature of all the *FemtoScope* 3000 models is their ability to trigger from extremely short pulses. This is important both when you acquire simple pulse waveforms and when you want to analyse fast data patterns. Figure 19 shows how the *FemtoScope* 3164 internally triggers with a short pulse having 35.3 ps width and 90 mV amplitude. Such pulses were extracted from 28 Gb/s data pattern.
Basically, you can trigger your oscilloscope from 30 mV signal at 100 MHz to 70 mV signal at 6 GHz.



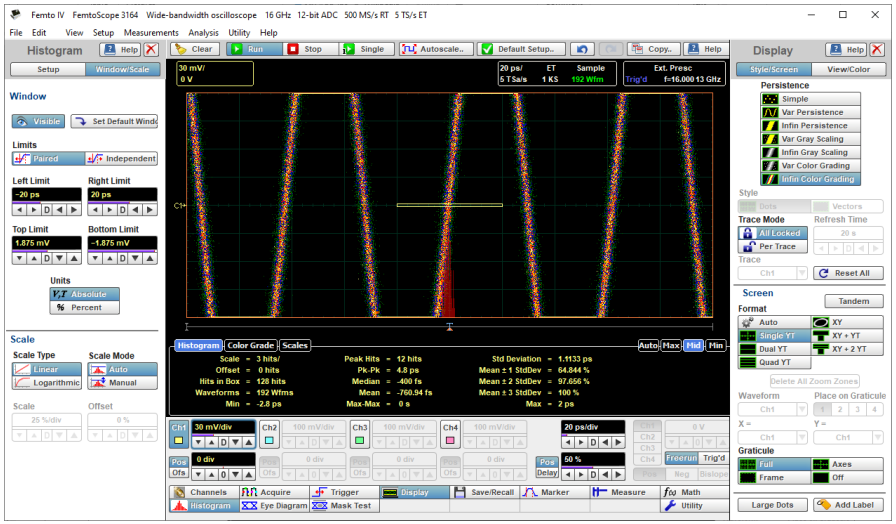
Internal direct trigger from 2.5 GHz sine wave with 1.24 ps rms jitter.

The *FemtoScope* 3164 demonstrates internal direct trigger from pulse having 35.3 ps width and 98 mV amplitude. Signal source: Anritsu MP1800A Signal Quality Analyzer

FemtoScope 3000/2000/1000: Trigger (cont.)

To expand the internal trigger frequency range up to 7 GHz, all the models provide a frequency divider mode. This mode is especially relevant for measurements on such popular clock ranges as 3.25 GHz and 5 GHz.
And finally the *FemtoScope* 3164 provides external prescaled trigger within full 16-GHz bandwidth. This trigger is realized by using high-frequency divider with fixed /8 division factor, as well as a small additive phase noise, which helps to achieve a low trigger jitter level.

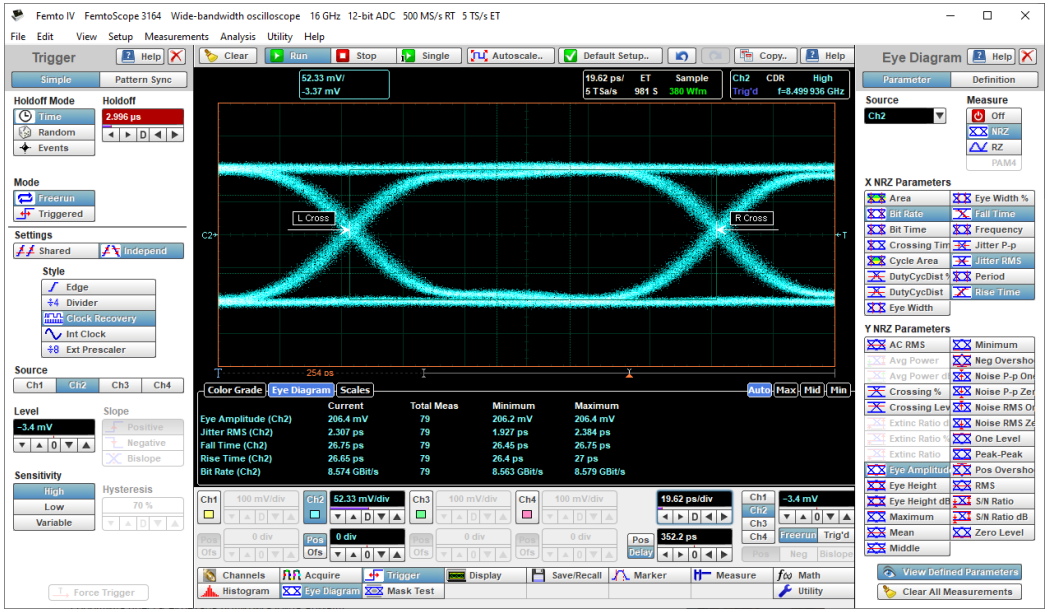
Internal divided trigger from 6 GHz sine wave with 1.34 ps rms jitter.



External prescaled trigger from 16 GHz sine wave with 1.11 ps rms jitter.

FemtoScope 3000/2000/1000: Clock Recovery Trigger

The *FemtoScope* oscilloscopes provide clock recovery trigger. This trigger mode is necessary when you need to display an eye diagram based on a clock recovered from input data pattern. The *FemtoScope* 3054 allows you to recover clock for up to 5 Gb/s data rate, while the *FemtoScope* 3164 provides this style of trigger up to 11.3 Gb/s, thereby ensuring the overlap of the most popular clock frequencies of data- and telecommunication standards. Figure 20 shows an eye diagram of 8-Gb/s data pattern acquired with clock recovery trigger.



The *FemtoScope* 3164 acquires 8 Gb/s eye diagram with clock recovery trigger.

FemtoScope 3000/2000/1000: Pattern Sync Trigger

Pattern Sync trigger is the ability of the *FemtoScope* 3000 to internally generate and lock onto a right pattern trigger. The pattern trigger is derived from the supplied clock by automatically detecting all of the following parameters: data rate, pattern length and trigger divide ratio.

The *FemtoScope* 3000 can generate a pattern trigger from any of trigger source: internal or external (up to 7 GHz), clock recovery (up to 11.3 Gb/s) and external prescaled (up to 16 GHz).

When Pattern Lock is switched to Auto Detect the oscilloscope automatically detects data rate, pattern length, and trigger divide ratio and generates the pattern trigger (see Figure 21). To get correct pattern lock you need to check the Pattern Length List. The pattern length you want to detect can be added to this list if necessary.

The *FemtoScope* used Pattern Lock trigger to generate pattern trigger from 2.5 GHz clock.

The oscilloscope also can manually detect data rate, pattern length, and trigger divide ratio and generates the pattern trigger. Enter the length of the test pattern in bits, which can be any value between 7 and 8388607 (2^23–1). Use manual entry when you do not have any information about data pattern length.

The *FemtoScope* 3000 used internal frequency counter that constantly measures the data rate taking into account the trigger divide ratio. You can use Start Bit control to specify the starting bit location for the scan. When Auto Detect is selected in the Pattern Lock menu, Start Bit specifies an offset in data bits from the pattern trigger. Because the internally generated pattern trigger is synchronized to an unknown bit number in the data pattern, Start Bit does not specify an absolute bit in the data pattern. You can use this feature to step the triggering through each bit of a pattern when Eye Line mode is off. This is a relative setting from an arbitrary reference pattern bit.

FemtoScope 3000/2000/1000: Precision Time Base

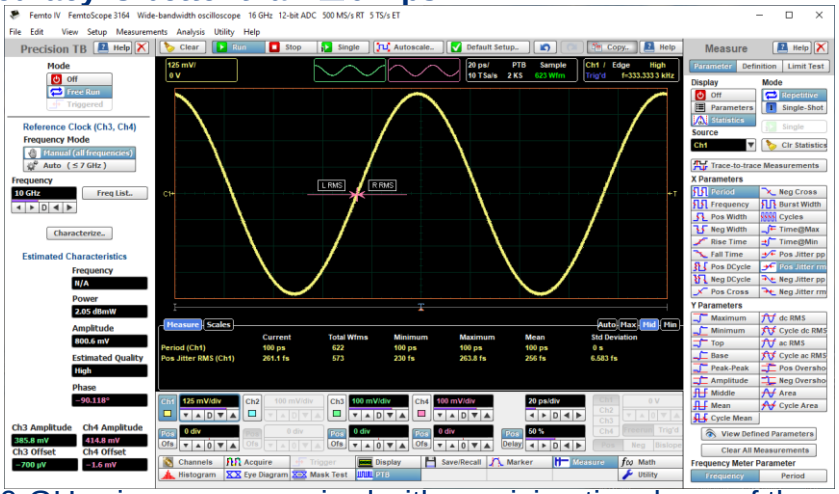
When developing multi-Gb/s devices, even a small amount of inherent scope jitter can become significant since 16 Gb/s waveforms only have a bit period of 62.5 ps. Scope jitter of 1.5 ps RMS can result in 9 to 12 ps of peak-to-peak jitter, causing eye closure even if your signal is jitter-free.

The new *FemtoScope* 3164-PTB having precision time base option represents significant improvements in wide-bandwidth oscilloscopes. Jitter performance has been reduced by almost an order of magnitude to 250 fs RMS. The reduced jitter of the precision time base allows you to measure the true jitter of your signal. The *FemtoScope* 3164-PTB requires a 5-to-16 GHz electrical reference clock that is synchronous with the signal under test. Time base resolution has also been improved from 10 ps/division to 2 ps/division, a 5 times improvement. The equivalent time sampling rate is also improved 5 times – from 5 TSA/s to 25 TSA/s.

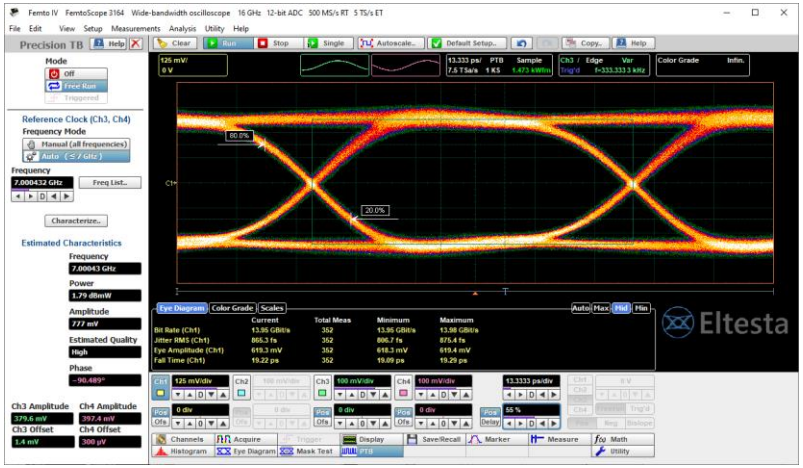
Precision time base hardware has been integrated with the waveform front-end track-and-hold system. Additional accessory kit includes symmetrical 50-Ω Resistive Power Splitter and two precision 30-cm wide-bandwidth coaxial cables.

The *FemtoScope* 3164-PTB can be used in tandem with free electrical channels (Ch1 or Ch2) of the oscilloscope or with the remote optical-to-electrical converters.

Precision time base provides very high timing accuracy better than ±0.2% of clock period. For 10 GHz clock timing accuracy is better than ±0.2 ps.

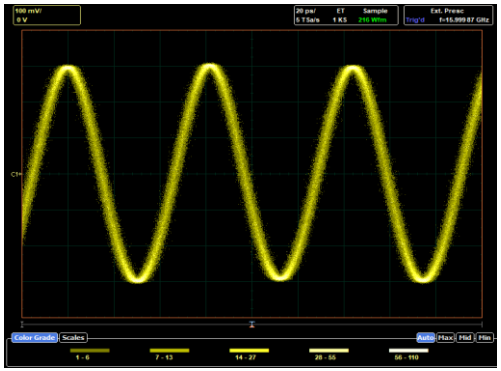


10-GHz sine wave acquired with precision time base of the *FemtoScope* 3164-PTB shows 256 fs RMS jitter.

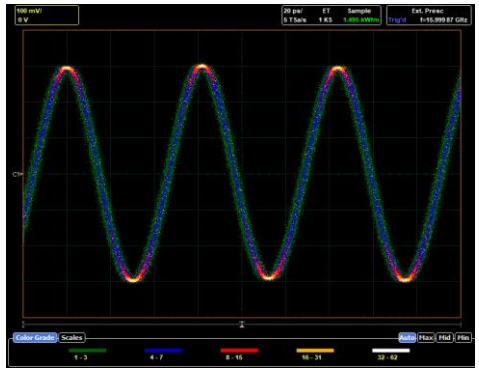


14 Gb/s eye diagram acquired with precision time base of the *FemtoScope* 3164-PTB shows 875 fs eye RMS jitter.

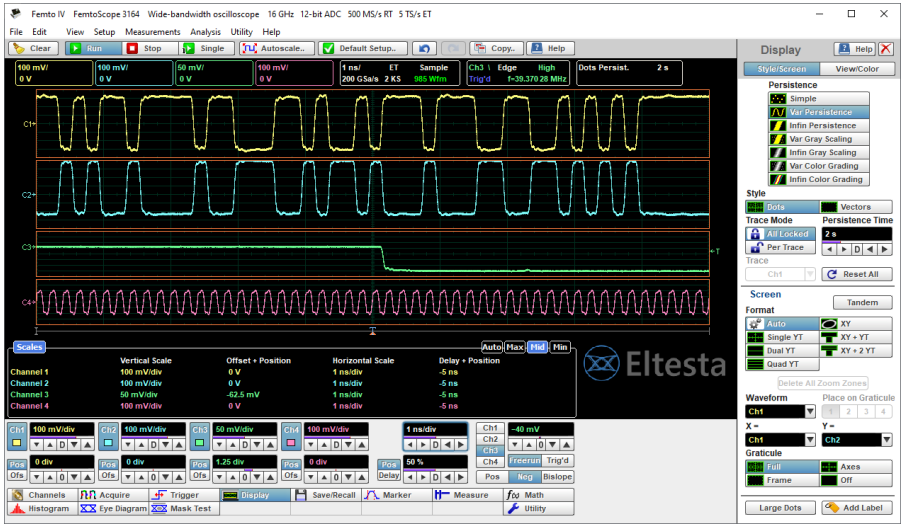
FemtoScope 3000/2000/1000: Display



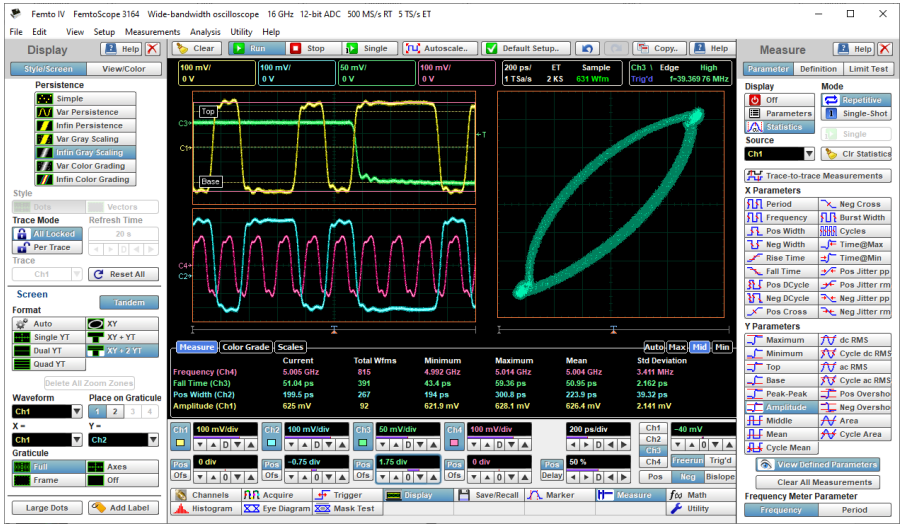
The *FemtoScope* 3000 displayed a 16-GHz sinewave in “grey-scaling” format.



The *FemtoScope* 3000 displayed a 16-GHz sinewave in “color-grading” format.



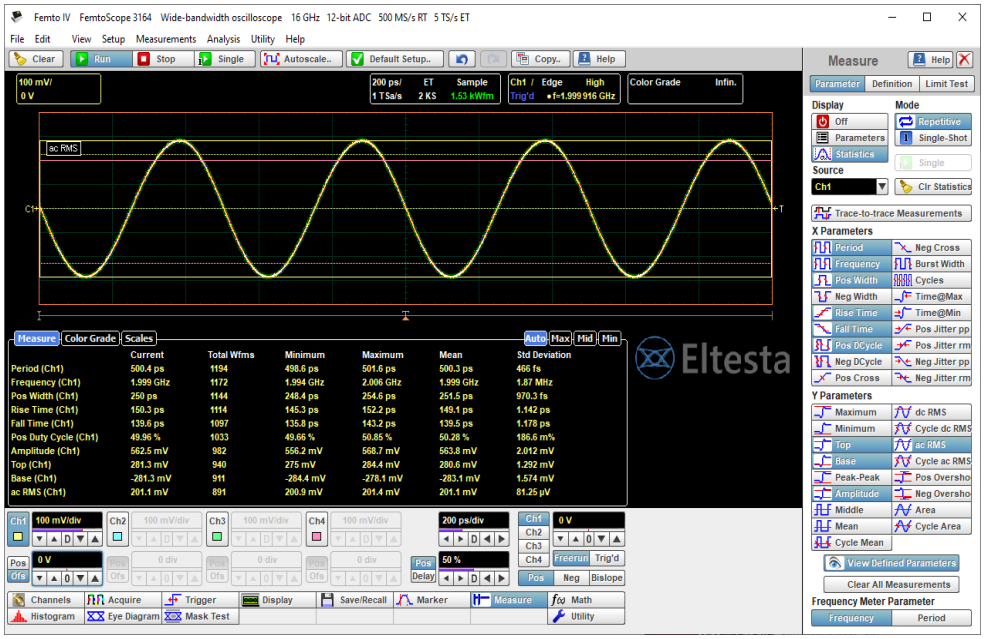
Display with four graticules



XY and “Tandem” display formats

FemtoScope 3000/2000/1000: Automatic measurements

The *FemtoScope* oscilloscopes provide a wide range of automatic measurements. More than 50 types of standard automatic oscilloscope measurements give you quick access to powerful functions. They are separated into four categories: amplitude, time, inter-channel and spectral measurements.
Each of the measurement can be performed on live signals, saved waveforms or math functions. Up to 10 measurements continuously updated with statistics. With statistical measurements, the scope measures the minimum, maximum, average and current values, as well as the standard deviation.

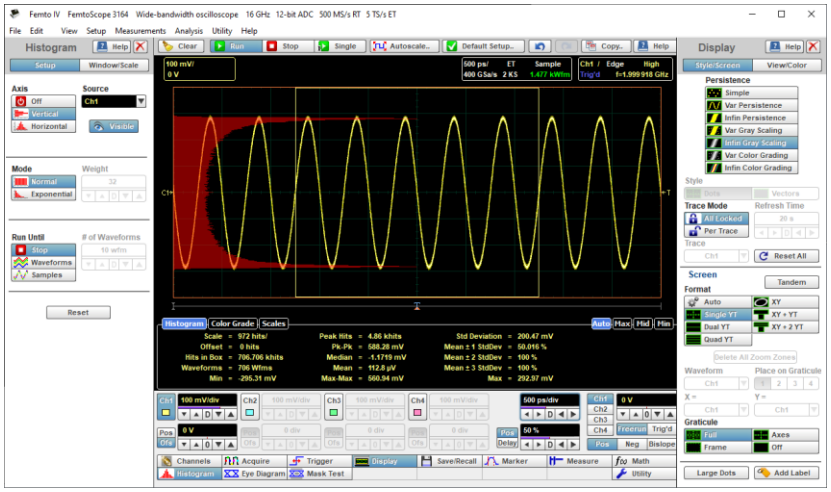


Up to ten individual measurements can be displayed on the screen simultaneously

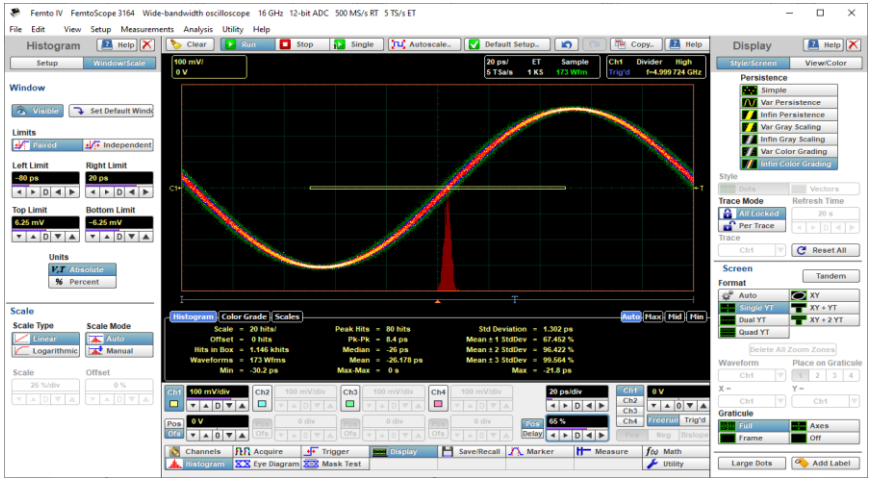
Amplitude measurements include 17 parameters such as maximum, minimum, top, base, peak-peak, amplitude, middle, mean, cycle mean, rms, etc.
Timing measurements include 18 parameters such as period, frequency, positive or negative pulse width, rise or fall time, duty cycle, etc.
Inter-channel measurements are those performed on two signals. These include delay, phase, and gain.
Spectral measurements are performed with FFT and include FFT magnitude and delta magnitude, total harmonic distortion, FFT frequency and delta frequency.
All measurement algorithms are based on several auxiliary parameters such as top and base vertical levels, threshold values, as well as horizontal margins
The statistical top and base levels can be determined by a histogram, set by the minimum and maximum of the waveform, or selected by the operator. Thresholds are used when measuring rise and fall time or pulse width, they can be set as a percentage of the amplitude, units of the vertical scale or in divisions. Standard thresholds are 10% -50% -90% and 20% -50% -80%. Measurements can be gated with the margins defined by arbitrary horizontal markers inside which measurements are taken.

FemtoScope 3000/2000/1000: Histogram

Histograms are a statistical representation of a signal or its measurement results. The *FemtoScope* oscilloscopes use two types of histograms - vertical and horizontal. You can turn on the histogram to live signals, saved waveforms or math functions. Color grade display usually used with histogram on a waveform to add statistical view. A vertical histogram is a probabilistic distribution of data collected about a signal along a vertical axis within a given histogram window. The information collected by such a histogram is used in the statistical analysis of the signal source. A vertical histogram is the most acceptable way to measure the noise characteristics of the waveforms. Noise is measured by sizing the histogram window to a narrow portion of time and observing a vertical histogram that measures the noise on an edge.



Vertical histogram of 2.5-GHz sinewave measures 560.94 mV amplitude (Max-Max value).



Horizontal histogram measures 1.302 ps rms jitter of 5-GHz sinewave (Std Deviation value).

The parameters of both the vertical and horizontal histograms include the display scale in hits per division or dB per division, the offset in hits or dB (the number of hits or dB at the bottom of the display, as opposed to the center of the display), the total number of samples included in the histogram box, the number of waveforms that have contributed to the histogram, the number of hits in the histogram's greatest peak, the width, median and mean of histogram, the standard deviation (σ) value of the histogram, also the percentage of points that are within ± 1σ, ± 2σ and ± 3σ of the mean value, etc.

The most common use for horizontal histogram is measuring and characterizing timing jitter on displayed waveforms. Jitter is

FemtoScope 3000/2000/1000 Eye Diagram

An eye diagram is an effective graphical method for evaluating the quality of a digital pattern. The results of its measurements are integral characteristics that describe the quality of the data channel and its ability to reproduce waveforms in undistorted form. Eye diagram helps to visualize signal integrity.

The relationship between the required oscilloscope bandwidth and the maximum data rate is known. To acquire the third harmonic of the stream, this ratio is 1.8, and for the fifth harmonic it is already 3.

Following these relationships 16-GHz *FemtoScope* 3164 will acquire the third harmonic of the 8.8 Gb/s data pattern and the fifth harmonic of the 5.3 Gb/s data pattern. At the same time 5-GHz *FemtoScope* 3054 will acquire the third harmonic of the 2.5 Gb/s data pattern and the fifth harmonic of the 1.7 Gb/s data pattern.

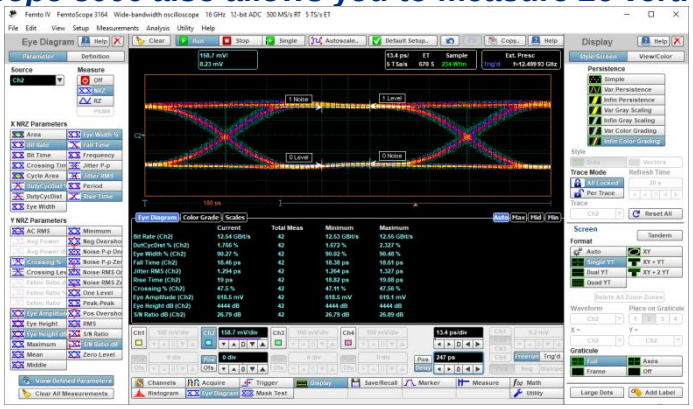
In general, eye diagrams are multilevel waveforms. The *FemtoScope* 3000 measures two-level eye diagrams, such as NRZ ("No return to zero") or RZ ("Return to zero").

A high-quality eye diagram on the *FemtoScope* 3000 screen can be obtained in two ways.

The first method is available when measuring data pattern is fed to the channel input, and it is also selected as the synchronization source. "Clock recovery" should be selected as the trigger style. With this method, the data rate range reaches 11.3 Gb/s for the *FemtoScope* 3164, and 5 Gb/s for the *FemtoScope* 3054.

Eye-diagram measurements include such parameters as eye height, eye width, jitter rms, crossing percentage, Q factor, and duty-cycle distortion. Totally the *FemtoScope* 3000 can measure 27 vertical and 15 horizontal parameters of NRZ eye diagram, ten of them can be measured simultaneously.

The *FemtoScope* 3000 also allows you to measure 26 vertical and 17 horizontal parameters of the RZ eye diagram.



The *FemtoScope* 3164 acquire and measures 10 parameters of 12.5 Gb/s NRZ eye diagram.

Disclosed 2.5 Gb/s eye diagram

FemtoScope 3000/2000/1000: Mask Test

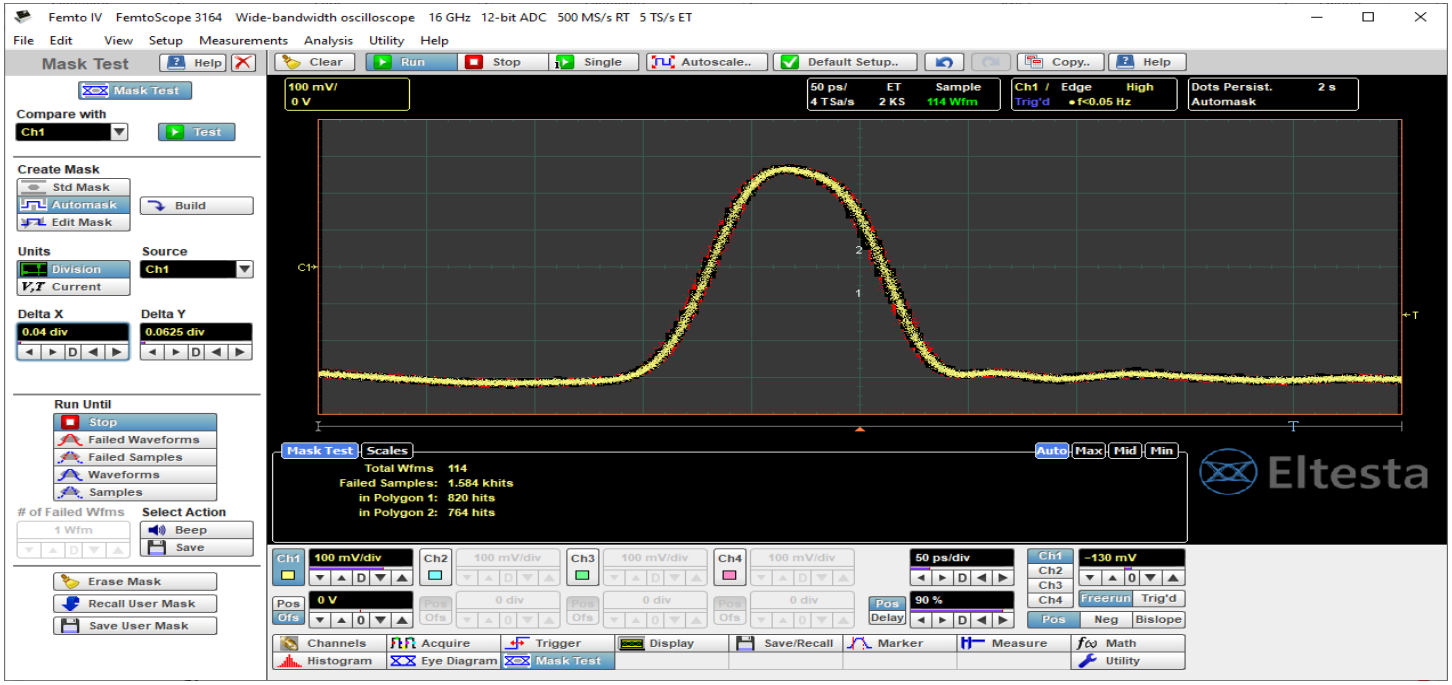
This test is used when it is necessary to control the shape of the measured waveform. Such waveforms can be quite complex as, and example, eye diagrams, and the number of possible waveform anomalies can be significant, which makes it difficult to perform standard measurements.
Mask test is widely used in production, in the control of quality, as well as in its testing for compliance with the requirements of standards. It is useful when you need to validate the stability of your electronic components and systems. The test works on a good/bad basis.
Masks are geometric templates that show acceptable areas of the screen into which testing waveform should not fall. The *FemtoScope* uses three types of masks - standard, automatic and arbitrary.
The shape of standard masks depends on the type of standard and its data rate. The oscilloscopes will allow to analyze standard masks of the following international standards - SONET / SDH, Ethernet, RapidIO, G.984.2, Fiber Channel, ITU G.703, PCI Express, ANSI T1.102, InfiniBand, Serial ATA and XAUI. The shape of standard masks is usually a quad or hexagon. There are options for editing standard masks (Fig. 38).
Depending on bandwidth specifications the *FemtoScope* 3000 provides up to 161 types of standard masks.

The principle of mask test is to determine if the waveform hits the mask, which violates the boundaries of the mask. Such a hit detects the exceeding the specified limits. This is fixed by changing the color of the waveform to red, which indicates an error in its shape.
Statistical test results include information about errors registered within standard templates, registered within additional margins, as well as full error information.

The *FemtoScope* 3164 makes 2.5 Gb/s SONET/SDH standard mask test.

FemtoScope 3000/2000/1000: Mask Margins

Other commonly used is an automask. An automatic mask is constructed according to the shape of tested waveform by adding to it certain preset tolerances vertically and horizontally.
Figure 39 shows an automatic mask constructed for a short 80-ps pulse. The mask consists of two patterns that seamlessly repeat the waveform on both sides of it. Figure also shows an automask test under the influence of noise. Acquired points on a pulse that go beyond tolerances are marked in red. In this example, horizontal tolerance limit is ±5 ps.
The last is arbitrary type of mask. It can be created directly by the user. Moreover, the number of templates can be up to eight, and their shape can be freely edited and saved.



An example of 80-ps pulse automask performed by the *FemtoScope* 3164

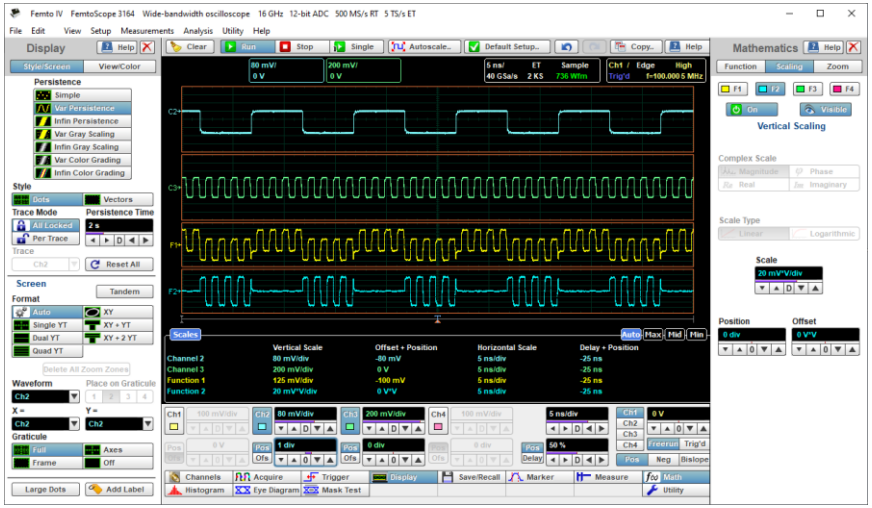
FemtoScope 3000/2000/1000: Mathematics

Based on the data on acquired waveform, the *FemtoScope* 3000 allows the simultaneous calculation of up to four mathematical functions. Any mathematical function can be selected as an operator for one or two operands (sources). For example, inversion is a one-operand function, while addition is a two-operand function. Live waveforms, stored waveforms, or other mathematical functions can be selected as an operand.

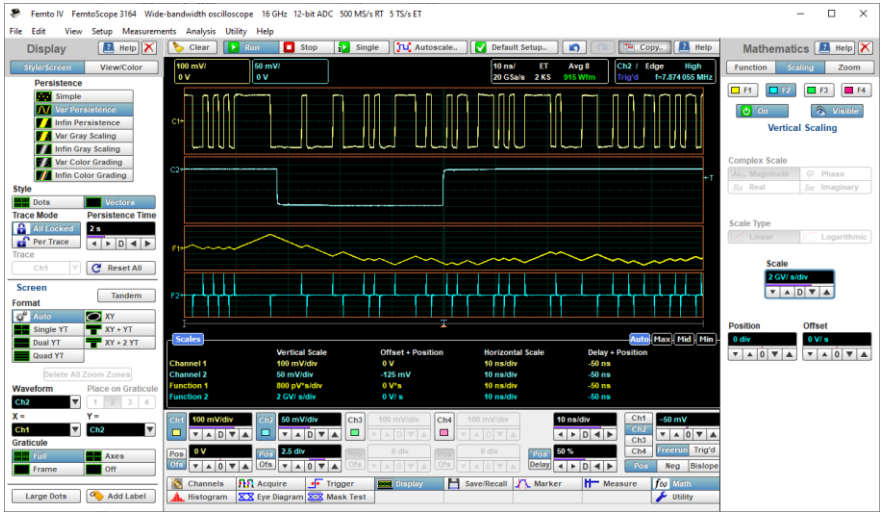
Arithmetic functions include such as addition, subtraction, multiplication, division, absolute value, inversion, half-sum, scaling, etc.

Algebraic functions include functions such as the exponent on the base e, 10 or on an arbitrary base, the logarithm, differentiation, integration, square, cube, square root, etc.

Trigonometric functions include functions such as sine, cosine, tangent, cotangent, arcsine, arccosine, arctangent, arc tangent, hyperbolic tangent and hyperbolic cotangent.



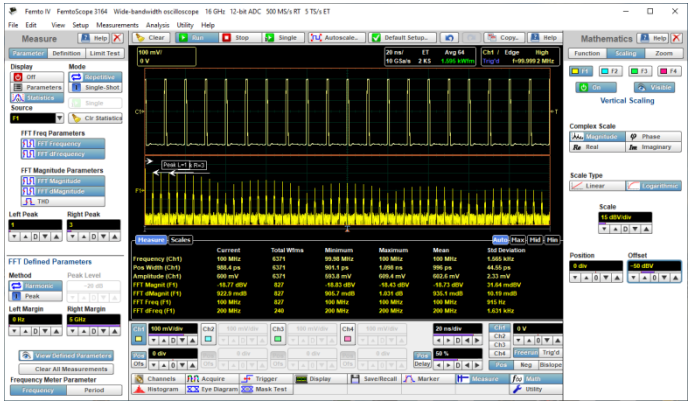
Example of arithmetic functions (from top to bottom): a) channel 2, b) channel 3, c) a sum channel 2 + channel 3, d) multiplication channel 2 x channel 3.



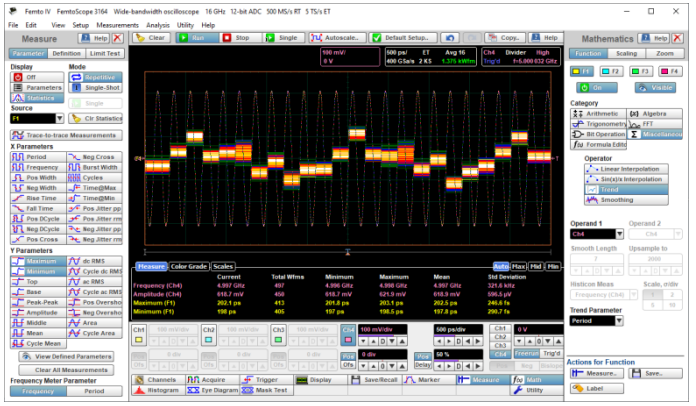
Example of algebraic functions (from top to bottom): a) channel1 (data pattern), b) channel 2 (trigger), c) integral of channel 1 d) differential of channel 1

FemtoScope 3000/2000/1000: Mathematics (cont.)

FFT includes FFT magnitude and phase, the real and imaginary parts, also the inverse FFT (Fig. 42).
To compensate for the inherent limitations of the FFT, the operator must use the FFT windows. The type of window determines the bandwidth and slope of the corresponding mathematical filter. The oscilloscope supports six types of FFT windows. A rectangular FFT window does not change the signal data acquired in the time domain. Other five FFT windows have different filter characteristics in the time domain. They are Hamming window, Hanning window, flat window, Blackman-Harris window and Kaiser-Bessel window.
The oscilloscopes used several categories of mathematical functions. These are arithmetic (12 functions), algebraic (14 functions), trigonometric (12 functions), spectral (6 functions), logical (7 functions), etc. It is also possible to use the formula editor.
Logical functions include such functions as AND, AND-NOT, OR, OR-NOT, exclusive OR, exclusive OR-NOT, and also NOT.
In real time, when relation between sampling rate and the input frequency may significantly decrease, aliasing distortions occur. To avoid such distortions the oscilloscope provides linear or Sin (x)/x interpolation functions. The Sin (x)/x interpolation function effectively restores the shape of the input signal.
The oscilloscopes used trend as a mathematical function that shows the nature of the variation in the signal parameter over time. The vertical axis shows the value of the selected parameter, and the horizontal axis shows the period of the signal for which this parameter was calculated.
In the example on Figure 43, the oscilloscope measures the period of the harmonic signal used to calibrate the sweep (purple). The trend function of the measured period (blue) is the mathematical function of this signal. Amplitude measurements of the trend function show the evolution of the change in the period value, i.e. show the magnitude of the non-linearity of the sweep at various horizontal points of the scale.

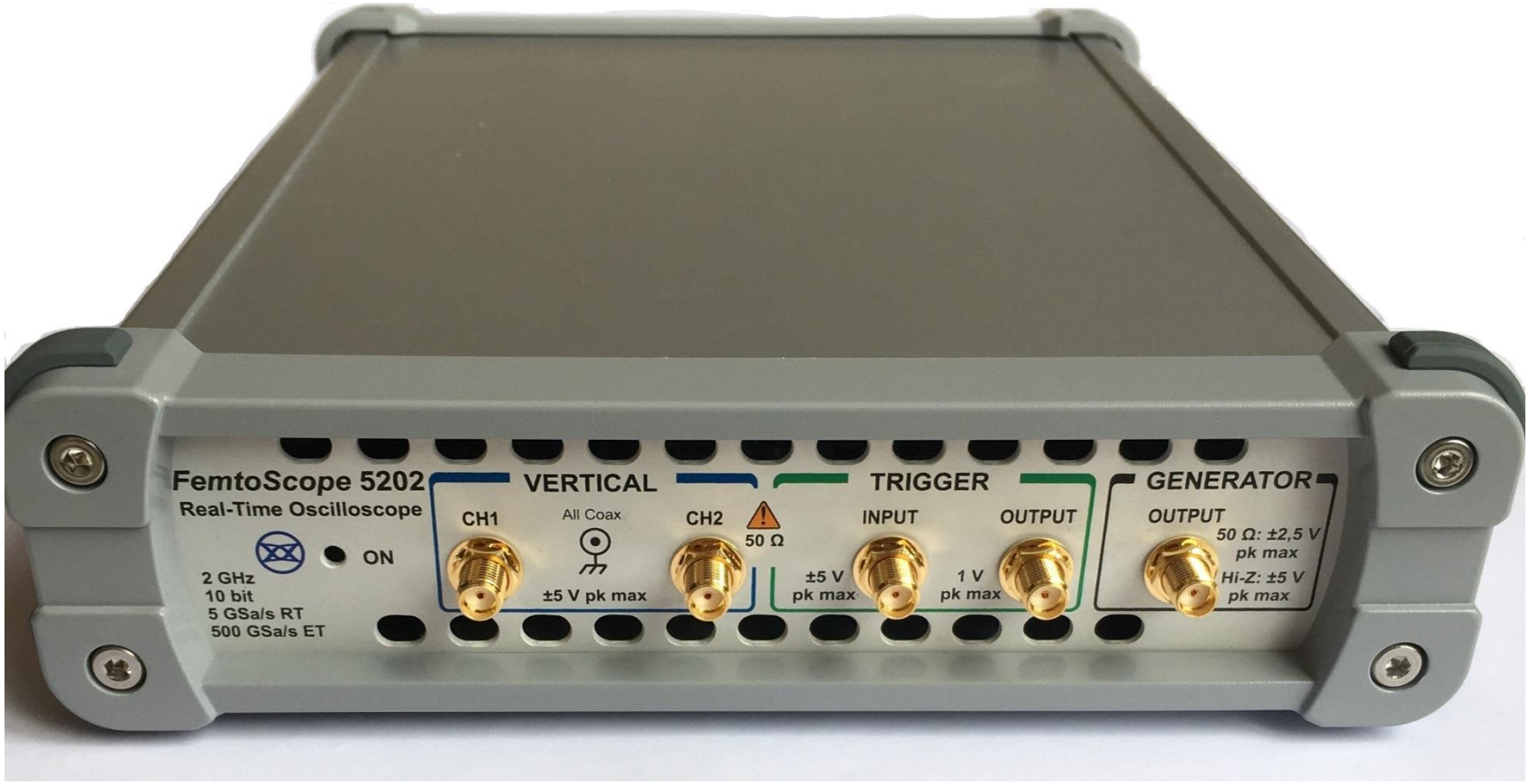


The *FemtoScope* 3164 performs Fast Fourier Transform with 100 MHz waveform having 1 ns pulse width. The first measured FFT harmonic is 100 MHz at -18.73 dBV magnitude.



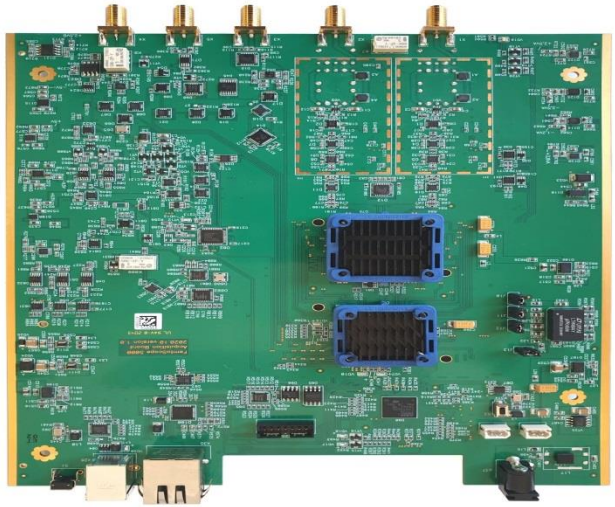
Trend of period measures nonlinearity of oscilloscope time base with 5-GHz sine wave. Maximum trend of period = 202.5 ps. Minimum trend of period = 197.8 ps. Peak-peak nonlinearity is within +2.5/-2.3 ps at 5 ns timing window

Up to 2.5 GHz Real-time Oscilloscopes



FemtoScope 5000 Real-time Oscilloscopes

FemtoScope 5252
2 channels, 5 GHz Bandwidth, 5 GSS/s Sampling Rate



FemtoScope 5202
2 channels, 2.5 GHz Bandwidth, 5 GSS/s Sampling Rate

Features & Benefits

- 2.5 GHz or 2 GHz Bandwidth.
- Sample Rate up to 5 GS/s.
- 2 Channels.
- 2% Vertical Accuracy.
- 10-Bit Vertical Resolution,
- 14 Bits with Hi-res mode
- 5 mV/div to 1 V/div Sensitivity.
- **50 Ω Input impedance**
- Channel Deskew
- Record Lengths to 1M Points
- 2.5 GHz Triggering
- Automatic Measurements and Measurement Statistics.
- FFT and Advanced Math.
- Histograms and Histogram Statistics.
- Eye Diagram Measurements.

Features & Benefits (cont.)

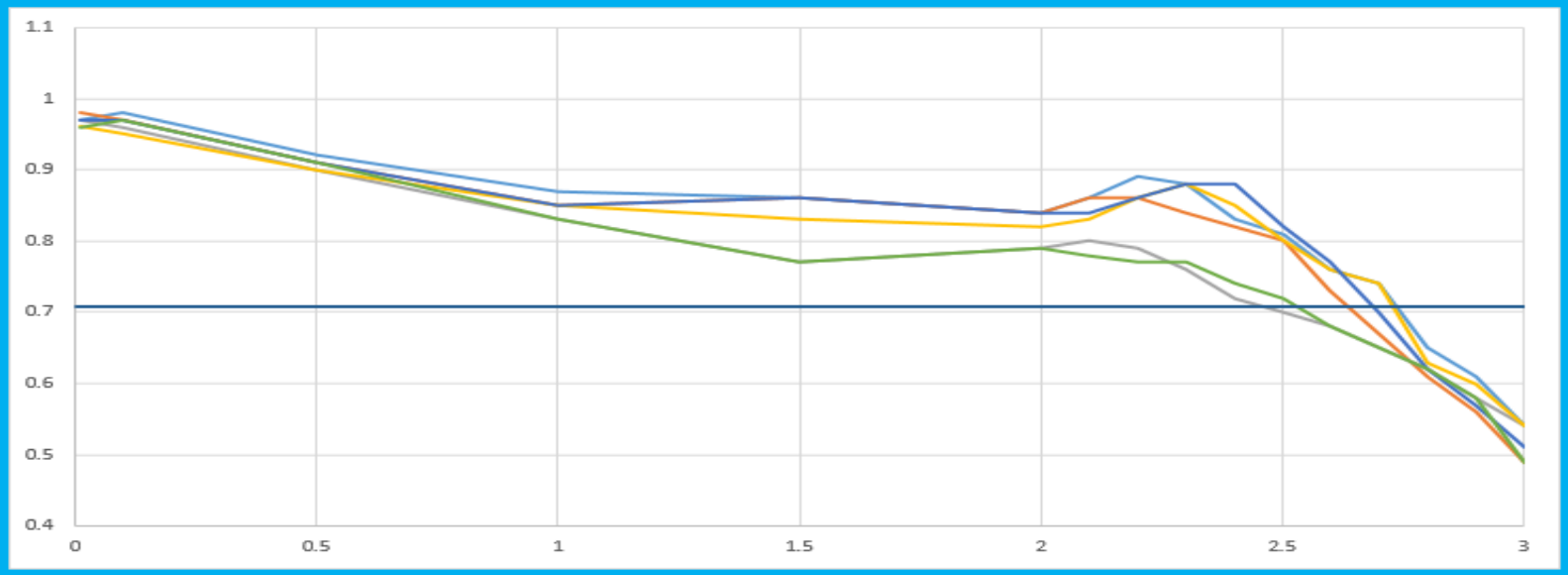
- Mask Test
- Limit Test.
- Internal 125 MHz Pulse/Pattern Generator
- USB or LAN Interface
- 5 years warranty

Applications

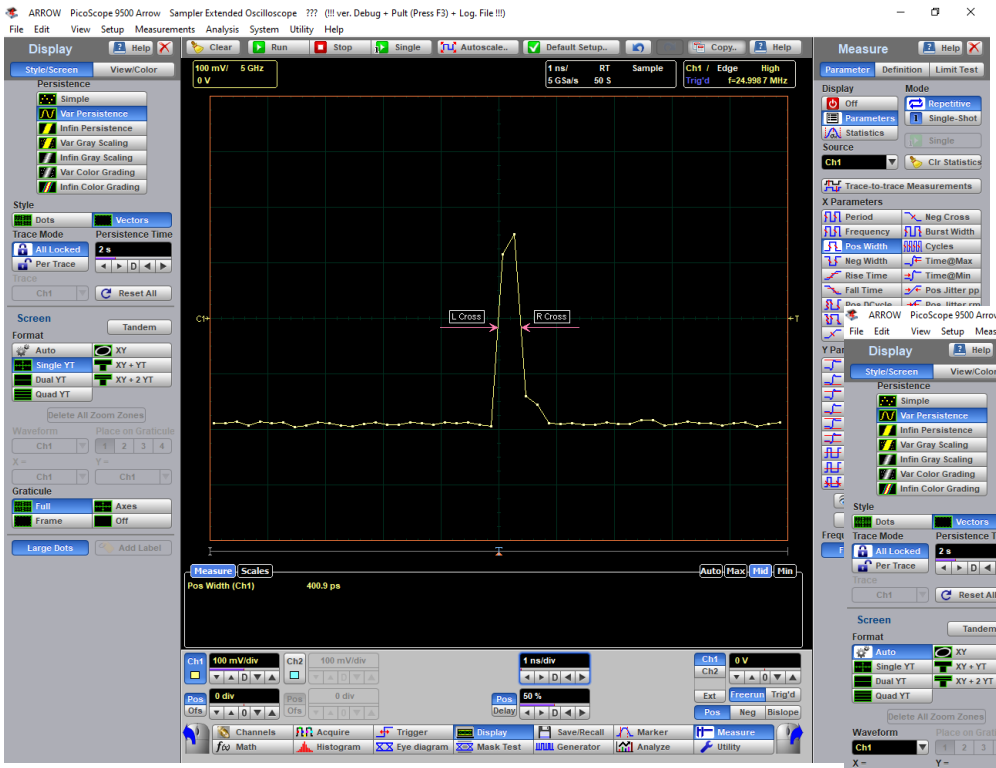
- Communication Compliance Testing
- Design Development and Compliance Testing of Serial Data Streams Up to 2.5 Gb/s Rates for Telecom and Datacom Industry Standards.
- Jitter and Timing Analysis.
- Fast Edge Characterization.
- Signal Integrity.
- Spectral Analysis.

FemtoScope 5000. Bandwidth Test

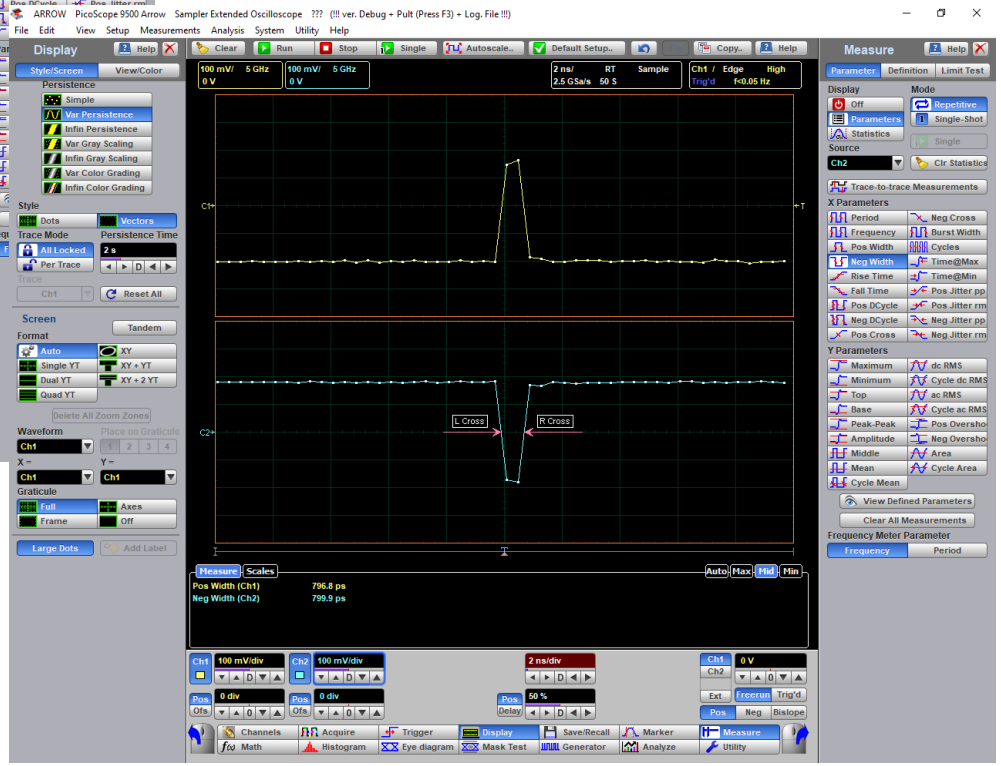
	Ch1			Ch2		
	5 uW	103 uW	400 uW	5 uW	103 uW	400 uW
GHz	10mv/	100mv/	200m/	10mv/	100mv/	200m/
0.01	0.97	0.98	0.97	0.96	0.97	0.96
0.1	0.98	0.97	0.96	0.95	0.97	0.97
0.5	0.92	0.91	0.9	0.9	0.91	0.91
1	0.87	0.85	0.83	0.85	0.85	0.83
1.5	0.86	0.86	0.77	0.83	0.86	0.77
2	0.84	0.84	0.79	0.82	0.84	0.79
2.1	0.86	0.86	0.8	0.83	0.84	0.78
2.2	0.89	0.86	0.79	0.86	0.86	0.77
2.3	0.88	0.84	0.76	0.88	0.88	0.77
2.4	0.83	0.82	0.72	0.85	0.88	0.74
2.5	**0.81**	**0.8**	**0.7**	**0.8**	**0.82**	**0.72**
2.6	0.76	0.73	0.68	0.76	0.77	0.68
2.7	0.74	0.67	0.65	0.74	0.7	0.65
2.8	0.65	0.61	0.62	0.63	0.62	0.62
2.9	0.61	0.56	0.58	0.6	0.57	0.58
3	0.54	0.49	0.54	0.54	0.51	0.49



FemtoScope 5000. Singe-shot Acquisition

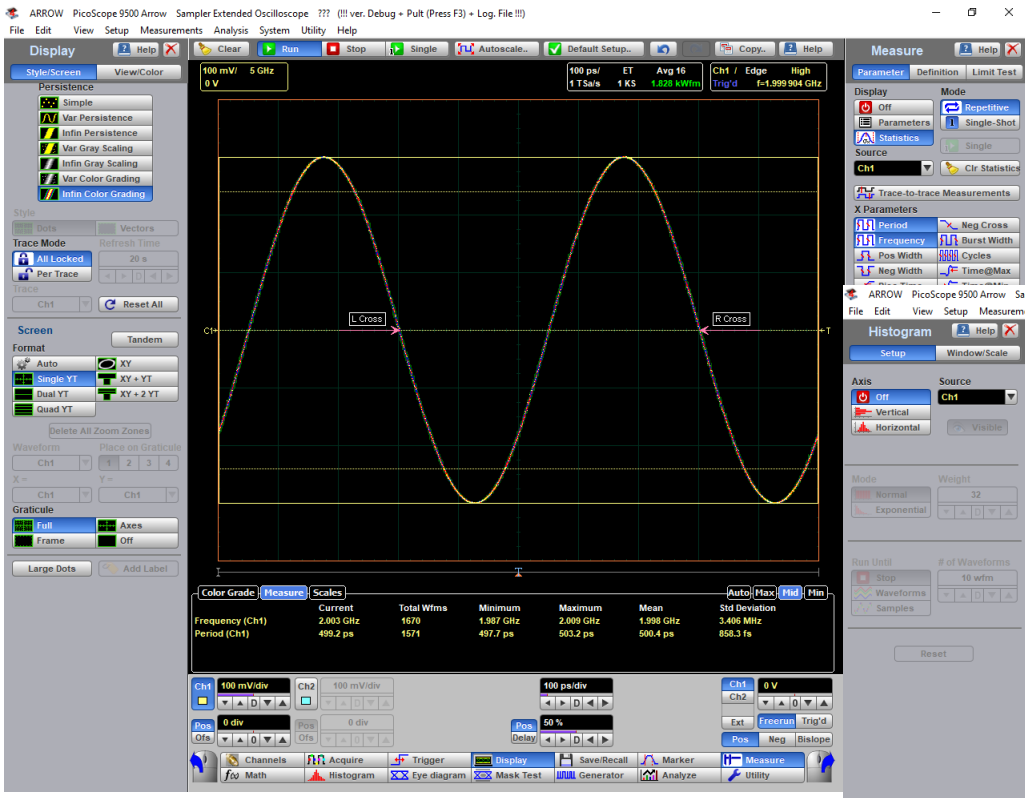


Single-channel single-shot pulse with 400 ps pulse width acquired at 5 GS/s sampling rate.
Time base = 1 ns/div
Vertical scale = 100 mV/div

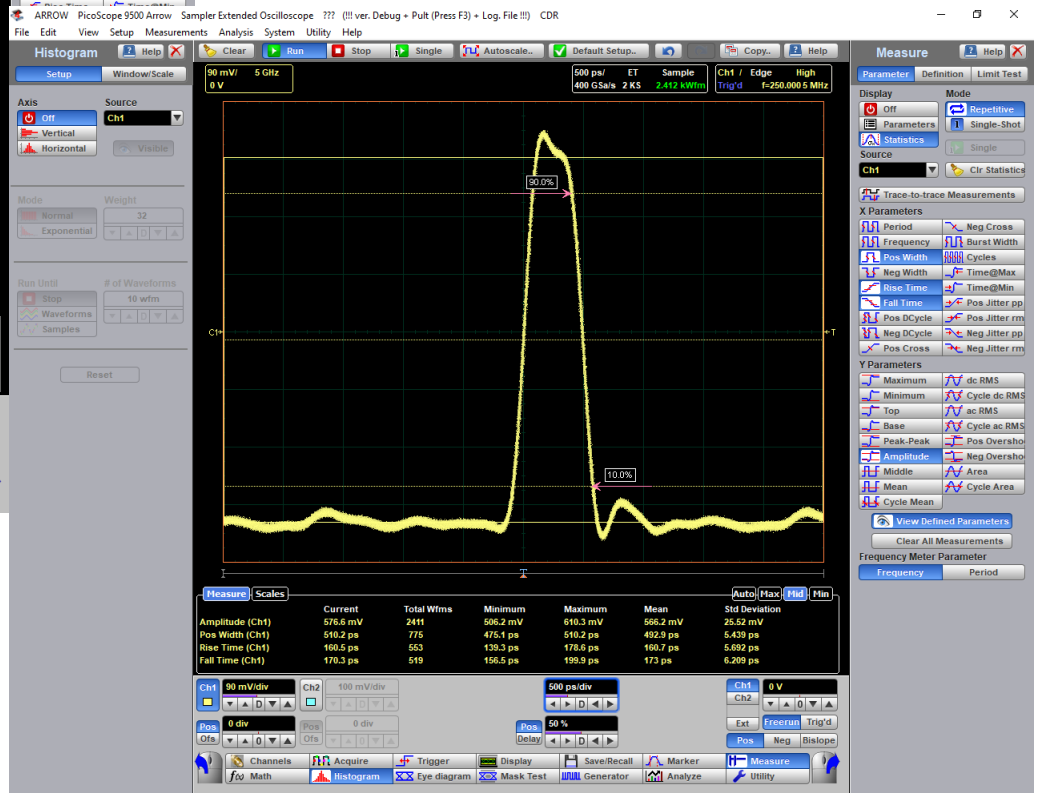


Dual-channel single-shot differential pulse with 800 ps pulse width acquired at 2.5 GS/s sampling rate.
Time base = 1 ns/div
Vertical scale = 100 mV/div

FemtoScope 5000. Repetitive Acquisition



2-GHz sine-wave signal acquired with Internal trigger
Equivalent time sampling rate = 1 TS/s
Time base = 100 ps/div. Vertical scale = 100 mV/div
Measurements: Frequency = 1.998 GHz, Period = 600.4 ps



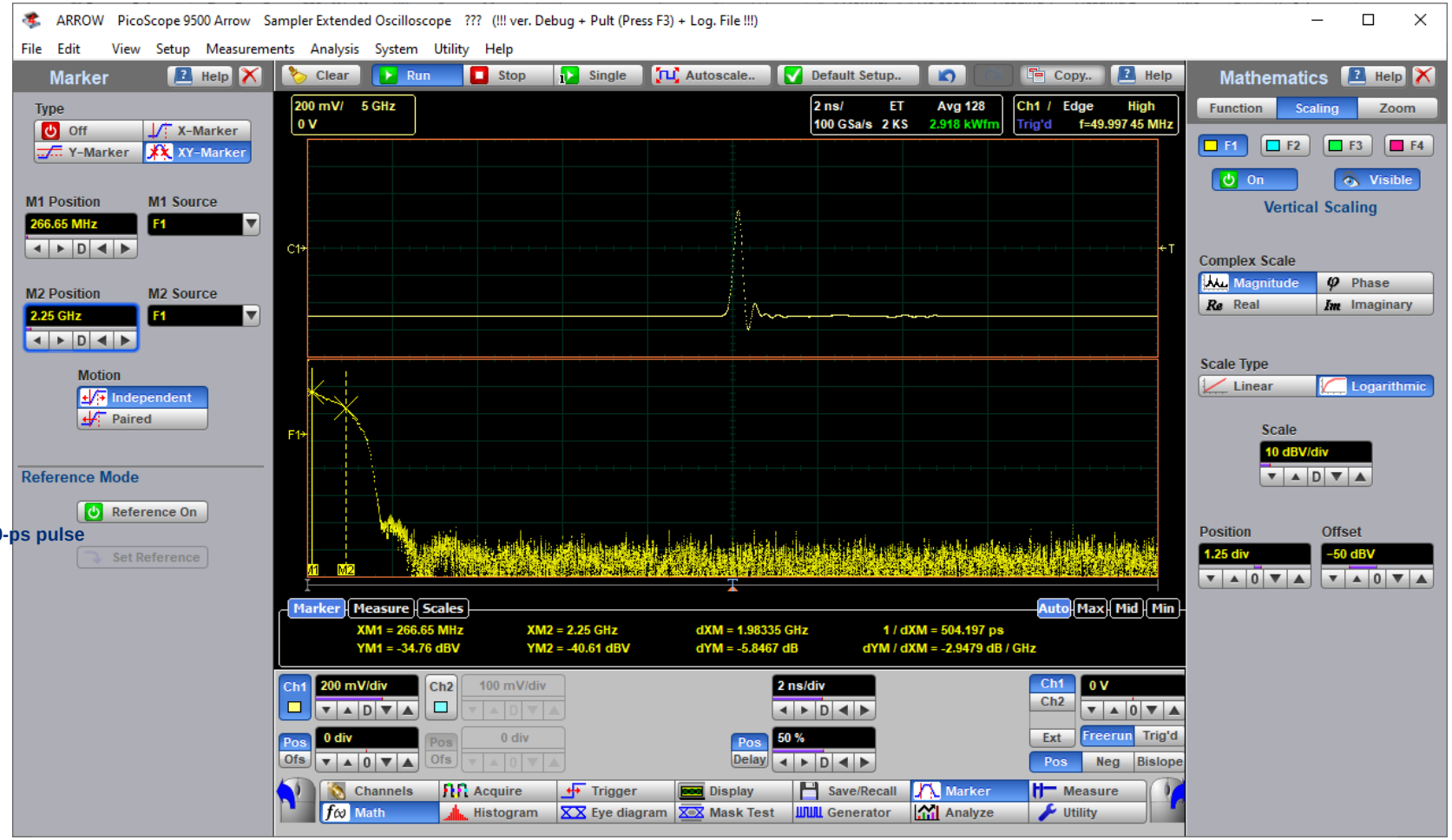
Acquisition of pulse having 500 ps pulse width.
Equivalent time sampling rate = 400 GS/s
Time base = 500 ps/div. Vertical scale = 90 mV/div
Measurements: Amplitude = 566.2 mV, Width = 492.9 ps,
Rise time = 160.7 ps, Fall time = 173 ps

FemtoScope 5000:
Trigger and Horizontal channel

Jitter measurements of 2-GHz sinewave shows 4.15 ps RMS trigger jitter.
Equivalent time sampling rate = 1 TS/s
Time base = 50 ps/div. Vertical scale = 20 mV/div

Time base clock accuracy measurements with 2-GHz sinewave shows 3.5 ns timing shift at 10 ms delay that is equivalent to 0.35 ppm accuracy.
Equivalent time sampling rate = 50 GS/s.
Time base = 10 ns/div. Vertical scale = 100 mV/div

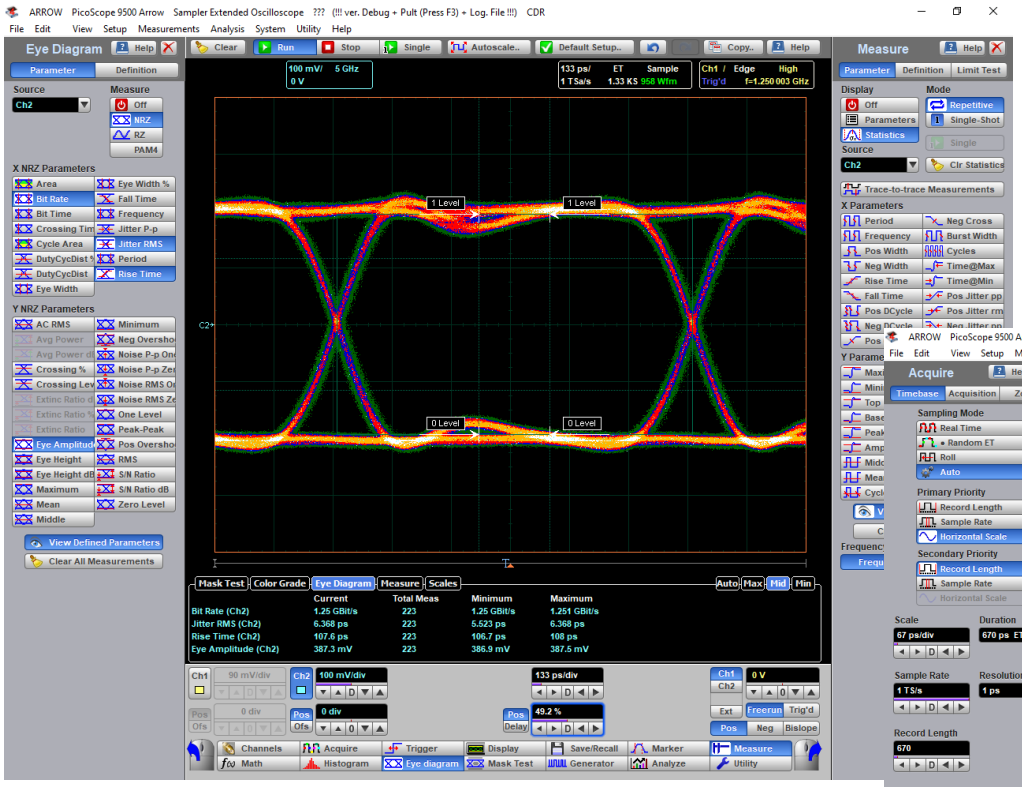
FemtoScope 5000. FFT



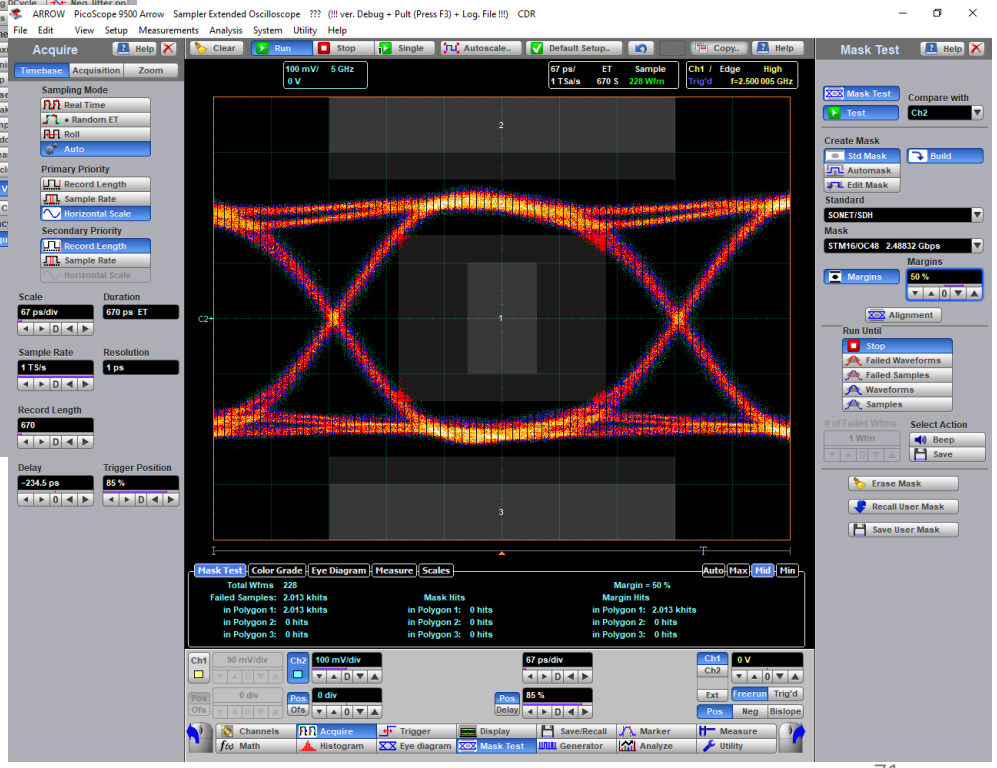
FFT of 400-ps pulse

FFT (bottom) of pulse having 400 ps pulse width (top). Spectrum shows 1.98 GHz at -5.84 dB level. Equivalent time sampling rate = 100 GS/s. Time base = 2 ns/div. Vertical scale = 200 mV/div

FemtoScope 5000: Eye diagram and Mask Test



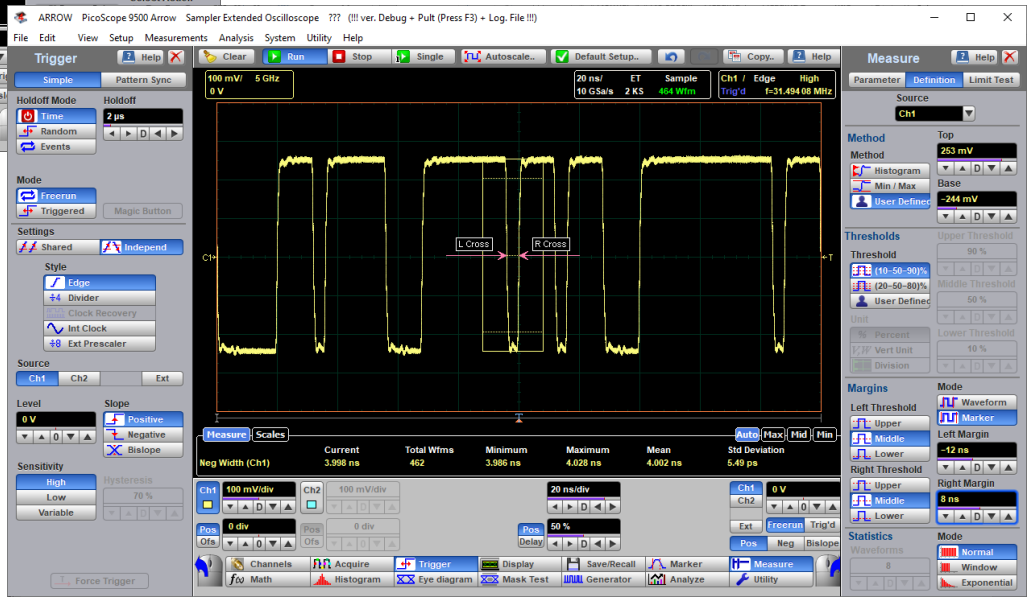
Measurements of 1.25 GB/s NRZ eye diagram.
Equivalent time sampling rate = 1 TS/s
Time base = 133 ps/div. Vertical scale = 100 mV/div
Measurements: Bit rate = 1.251 GB/s, Jitter = 6.368 ps RMS, Rise time = 108 ps, Eye Amplitude = 387.5 mV



SONET/SDH STM16/OC48 2.488 GB/s Mask Test.
Equivalent time sampling rate = 1 TS/s,
Time base = 67 ps/div. Vertical scale = 100 mV/div
Mask Margins = 50%

FemtoScope 5000. Pulse/pattern generator

Automask measurements of a pulse having 150 ps fall time



Internal pulse/pattern generator with 125 MS/s data rate

Picosecond Pulse Generators

Parameters	PG901	PG911	PG912	PG914
Channels	1	2	2	4
SRD step rise time	45 ps max	55 ps max	N/A	55 ps max
TD step rise time	N/A	N/A	35 ps	35 ps
SRD step amplitude	8 V max	6 V max	N/A	6 V max
RMS Trigger Jitter	2 ps max	2 ps max	2 ps max	2 psmax
Repetition Rate	1 MHz max	1 MHz max	1 MHz max	1 MHz max
Min. Pulse Width	200 ns min	200 ns min	200 ns min	200 nsmin

PicoSource
PG911/PG912/PG914

PicoSource PG901

FemtoScope 4401: Frequency Counter

Parameters	
Frequency Range	0.5-to-40 GHz
Timebase accuracy	±0.4 ppm
Prescaler ratios	1-to-127
Power	From USB
Dimensions	W114 mm x 41.8 mm (with feet) x H162 mm (w/o connectors)
Weight	95 g

EDN Hot 100 products of 2013.
Hot 100 products in Test & measurement

Eltesta

- **Access Master MT9083x2 OTDRs**
"...allows field technicians to conduct accurate measurements of fiber cables, connections, and splices when installing and maintaining high-speed optical fiber networks."
Anritsu

- **AirMagnet Spectrum ES wireless spectrum analyzer**
"... connects to a Windows laptop or a Surface tablet that displays the local wireless spectrum produced by Wi-Fi routers, macrocells, microcells, femtocells, and picocells."
Fluke Networks

- **AQ6150 series optical wavelength meters**
"...[uses] an extended-life internal reference laser with an estimated life span of 40,000 hours."
Yokogawa Electric

- **ESR26 EMI test receiver**
...[can] perform standard-compliant measurements up to 6000 times faster than other testers, completing EMI measurements in just seconds.
Rohde & Schwarz

- **InfiniiVision 4000 X-Series DSOs**
"...lets you substitute virtually any tablet device for the scopes' built-in displays and many of their front-panel controls."
Agilent Technologies

- **Model 2450 source measure unit**
"...offers a capacitive touchscreen graphical user interface."
Keithley Instruments

- **N9322C spectrum analyzer**
"Intended for cost-constrained applications in R&D, manufacturing, maintenance, education labs, and bench repair."
Agilent Technologies

- **PA4000 power analyzer**
"...features a proprietary Spiral Shunt design, which includes dual internal spiral shunts in each module for stable measurements from micro-amps to high-current motor drives."
Tektronix

- **PicoScope 9300 PC sampling oscilloscope**
"... offers 20-GHz bandwidth on two channels and a sampling rate of 1 Msample/s for analyzing high-speed electrical signals."
Pico Technology

- **USB-2405 signal-acquisition module**
"...a USB 2.0-based dynamic signal-acquisition module equipped with four analog-input channels that simultaneously sample at rates of up to 128 ksamples/s with 24-bit resolution."
Adlink Technology

EDN NETWORK

Compact PC sampling oscilloscopes offer 20-GHz bandwidth

Susan Nordyk - July 9, 2013

A space-saving alternative to conventional bench instruments, the PicoScope 9300 series of PC-based oscilloscopes from Pico Technology offers 20-GHz bandwidth on two channels and a sampling rate of 1 Msample/s for analyzing high-speed electrical signals, including 10-Gbps Ethernet, 10x Fibre Channel, InfiniBand, and PCI Express. In addition, the small size of the sequential-sampling scopes allows them to be positioned next to the device under test, minimizing cable losses and eliminating the need for expensive active probes or pull-out sampling modules.

Key specifications include an effective sampling rate of over 15 terasamples/s, an input rise time of 17.5 ps, dual time bases from 5 ps/div, and a prescaled trigger bandwidth of up to 14 GHz. A built-in signal generator has a minimum bit interval of 4 ns in PRBS (pseudo-random binary sequence) mode and a minimum waveform period of 8 ns in pulse mode. The oscilloscopes also provide LAN and USB interfaces, as well as display features like density profiling, multiple trace windows, histograms, and statistics.

Best-in-Test 2014: Signal Integrity/High-Speed

Eltesta

2014 Best-in-Test Finalists

Here are the finalists for EDN's Best-in-Test awards in the Signal Integrity/High-Speed Test category. Please give them a review, then follow the links to vote or to return to the name Best-in-Test page to see finalists in other categories.

MP1800A Signal Quality Analyzer, Anritsu

The MP1800A BERT now has a high-sensitivity error detector (ED) that features an Auto Adjust function, as well as 4PAM/8PAM converters and MP1825B 32 Gbit/s 4Tap Emphasis. The enhanced MP1800A meets complex signal integrity measurement requirements associated with physical layer devices and modules with transmission speeds up to 32Gbps.

PicoScope 9312 20 GHz sampling scope with 40 ps differential TDR/TDT, Pico Technology

The PicoScope 9312 evolved from the PicoScope 9200 series. It features 20GHz bandwidth, two channels, clock recovery up to 11.3Gb/S, built in pattern generator with extensive automated measurements, statistics, histograms, and mask testing. All of this is in a compact, portable, PC connected device. The PicoScope 9312 allows the user to plot voltage, impedance or reflection coefficient against time or distance as well as characterize transmission lines, PCB traces, connectors & cables. It provides support for popular industry standards: PCIe, SATA, SONET/SDH, Ethernet, RapidIO, and InfiniBand plus user-defined masks. With the PicoScope 9312, you would be able to measure:Clock distribution, Signal path design, Stubs, Noise margin, Impedances and loading, Transmission line effects, Signal path return currents, Termination, Decoupling, Power distribution and more.

NI PXIe-5162 Digitizer, National Instruments

The NI PXIe-5162, 1.5 GHz digitizer uses updates to the LabVIEW Jitter Analysis Toolkit to enhance the PXI platform for traditional oscilloscope applications. The NI PXIe-5162 digitizer's PXI platform and flexibility make it an ideal general-purpose instrument for test and measurement applications. The high-speed, high-channel, and high-resolution measurements offered by the NI PXIe-5162 digitizer lets traditional oscilloscope users move beyond traditional box instruments. Pairing the four-channel NI PXIe-5162 digitizer with the PXI platform, engineers can build an oscilloscope with up to 68 channels in a single chassis with tight synchronization.

MSO/DPO70000DX Series Performance Oscilloscopes, Tektronix

The MSO/DPO70000DX Series offers 23, 25 & 33GHz models that enable complete system visibility of high speed serial bus system designs. With 16 digital channels on all Tektronix MSO's, engineers can observe a greater amount of their design's electrical behavior at one time, shortening debug cycles and system validation. The MSO70000DX instruments provide 80ps timing resolution on its 16 digital channels. This enables engineers evaluate logic or protocol performance for serial buses like USB, I^2C, and SPI in real-time while performing analog validation of high speed DDR memory on the 4 analog channels.

EE Times 2014.02.14. Vilnius: Oscilloscope Capital of Eastern Europe

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Vilnius: Oscilloscope Capital of Eastern Europe

Martin Rowe, Senior Technical Editor
2/14/2014 10:41 AM EST
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The Lithuanian capital is still the home of oscilloscope development. This pictorial essay takes you through the development of oscilloscopes behind the former Iron Curtain.

Every so often, we hear about oscilloscopes and test equipment built in the Soviet Union and later Russia, but most of the oscilloscopes come from Vilnius, the capital of Lithuania. How did Vilnius become the center of life for oscilloscopes in Eastern Europe? Learn the story from Jakovas Rososkis and Aleksandr Denisov who are still involved in the design and manufacture of oscilloscopes in Vilnius.

Through a pictorial essay, Rososkis and Denisov take you on a tour of oscilloscopes that came from the Soviet Union. Their company is what remains of the oscilloscope business in Vilnius, but engineers are still designing and building modern USB oscilloscopes for UK manufacturer Pico Technology.

See some 40 photos at A history of oscilloscope development in Vilnius.

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Duane Benson David - That's funny. I do recall reading that one. The other annoyance I've been tripped by is the occasionsal the-terminal regulator with a different pin-out. I've seen these...

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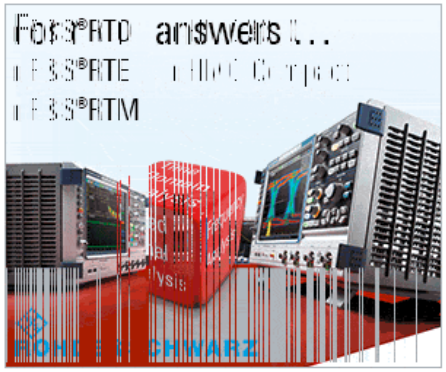

Radio

EDN 2014.02.14. A history of oscilloscope development in Vilnius

Eltesta

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A history of oscilloscope development in Vilnius

Aleksandr Denisov & Jakovas Rososkis -February 14, 2014

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During the Soviet era that ended in 1991, trade between the Soviet Union and the outside world was largely blocked. Some test equipment managed to get in or out but by and large, the Soviet Union developed and manufactured its own oscilloscopes. The center of oscilloscope design and manufacturing was, for many years, in Vilnius, now the capital of Lithuania. Through the following photos, we've assembled a history of oscilloscopes designing and manufactured in Vilnius, both during and after the Soviet era.

Before WWII: Poland

The first electronics company in Vilnius was established in 1925. At that time, Vilnius was a provincial capital of Poland. The first Elektrit factory was built in 1934 on Shepticky Street in the Naujamiestis district. Before WWII, this was the largest factory in Vilnius, designing and producing radio receivers for civil use. It occupied 10,000m² and had its own power station, six assembly lines, and 1100 engineers and workers. The plant produced 54,000 radio receivers annually at a total cost of USD 1.2 million. **Figure 1** shows a radio and **Figure 2** shows the factory.

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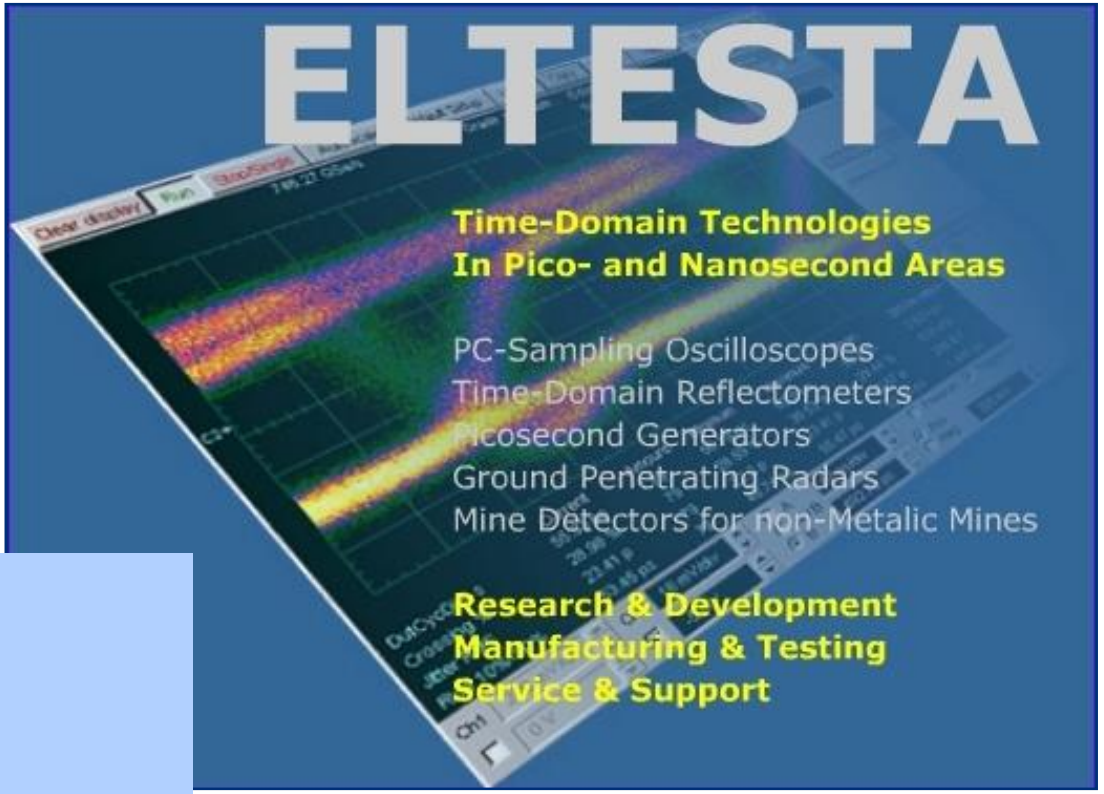
Apdovanojimai "Verslo diena 2014"

On Thursday, 2014.11.22 through the „Business Day“ organized by Ministry of Economy the best of businessmen of the country were awarded "For merits in business". The event was opened by Prime Minister Algirdas Butkevitcius and the Minister of Economy Evaldas Gustas. From the applications received, the commission established by the Ministry of Economy has selected three best companies in each of nine nominations. Readers also could vote through portal DELFI.

The best company in category "Innovative solutions leader" was elected "Eltesta." Vilnius-based company is well-known as a manufacturer of T&M electronic instruments such as sampling an digital storage oscilloscopes, picosecond pulse generators, underground radars and non-metallic mine detectors.

The End



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