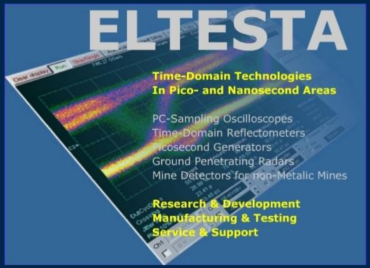

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pico® Technology

PicoScope 9200A

New USB connected sampling oscilloscopes featuring 12-GHz electrical, 8-GHz optical bandwidth, and 100-ps TDR/TDT.

Olympiaturm 2011

PICO TECHNOLOGY 1991 - 2011 20 YEARS LEADING THE WAY IN TEST AND MEASUREMENT

Brief introduction to Pico Technology

- Company Name: Pico Technology Limited
- Founded: 1991
- Headquarters: Cambridge, UK
- Distributor in Germany: Meilhaus Electronic GmbH
- Here today at Olympiaturm 2011

Further enquiries:
Chris Stacey (Meilhaus)

Tel: +49/(0)89/890166-34

Email: c.stacey@meilhaus.com

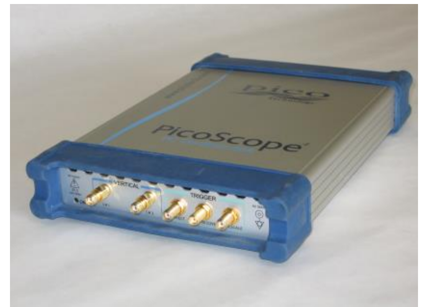
PicoScope 9200A

PicoScope 9200A Family Structure

	9201A	9211A	9221A	9231A
12 GHz sampling oscilloscope	✔	✔	✔	✔
USB port	✔	✔	✔	✔
LAN port		✔		✔
Clock recovery trigger		✔	✔	✔
Pattern sync trigger		✔	✔	✔
Dual signal generator outputs		✔		✔
Electrical TDR/TDT capability		✔		✔
8 GHz optical-electrical converter			✔	✔

Family Members

PicoScope 9201A:
Two 12-GHz electrical channels
10 GHz trigger
USB & LAN interfaces



PicoScope 9231A:
Two 12-GHz electrical channels
100-ps normalized TDR/TDT
10 GHz trigger
Clock recovery trigger
Pattern sync trigger
USB & LAN interfaces

PicoScope 9221A:
Two 12-GHz electrical channels
8-GHz optical channel
10 GHz trigger
Clock recovery trigger
Pattern sync trigger
USB interface

PicoScope 9231A:
Two 12-GHz electrical channels
8-GHz optical channel
100-ps normalized TDR/TDT
10 GHz trigger
Clock recovery trigger
Pattern sync trigger
USB & LAN interfaces

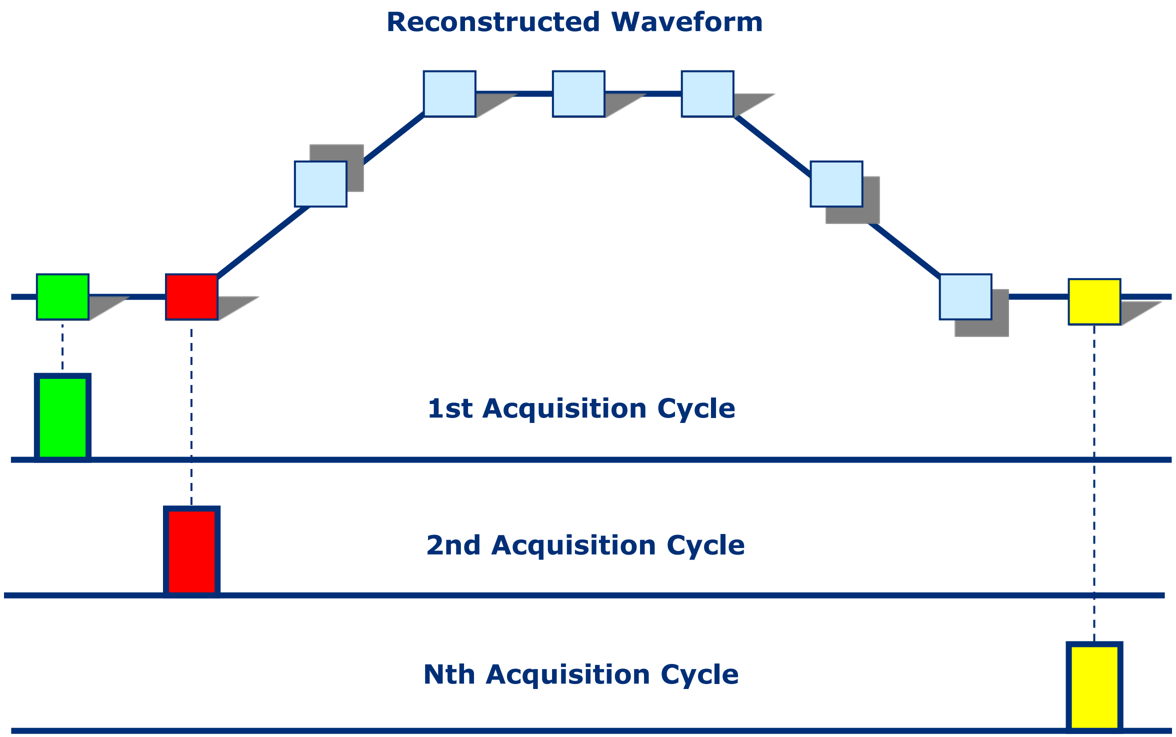
Key Specifications

12 GHz **Electrical BW** ***8 GHz*** **Optical BW**	***16-bit*** **ADC** ***200 fs*** **Time Resolution**	***2%*** **Vertical and** ***0.2%*** **Horizontal Accuracy**
10 GHz **Trigger Bandwidth**	***100 ps*** **Normalized TDR/TDTR**	***<2 mV max*** **RMS Noise**
2 mV/div **Best Sensitivity**	***10 ps/div*** **Faster Time Base**	***200 ks/s*** **Acquisition Speed**

The The instrument provides fast acquisition, repeatable waveform performance analysis with:

- Automated direct or statistical measurements
- Markers
- Histograms
- Math and FFT analysis
- Color-Graded Display
- Parametric Limit Testing
- Eye Diagram Measurements
- Mask Template Testing

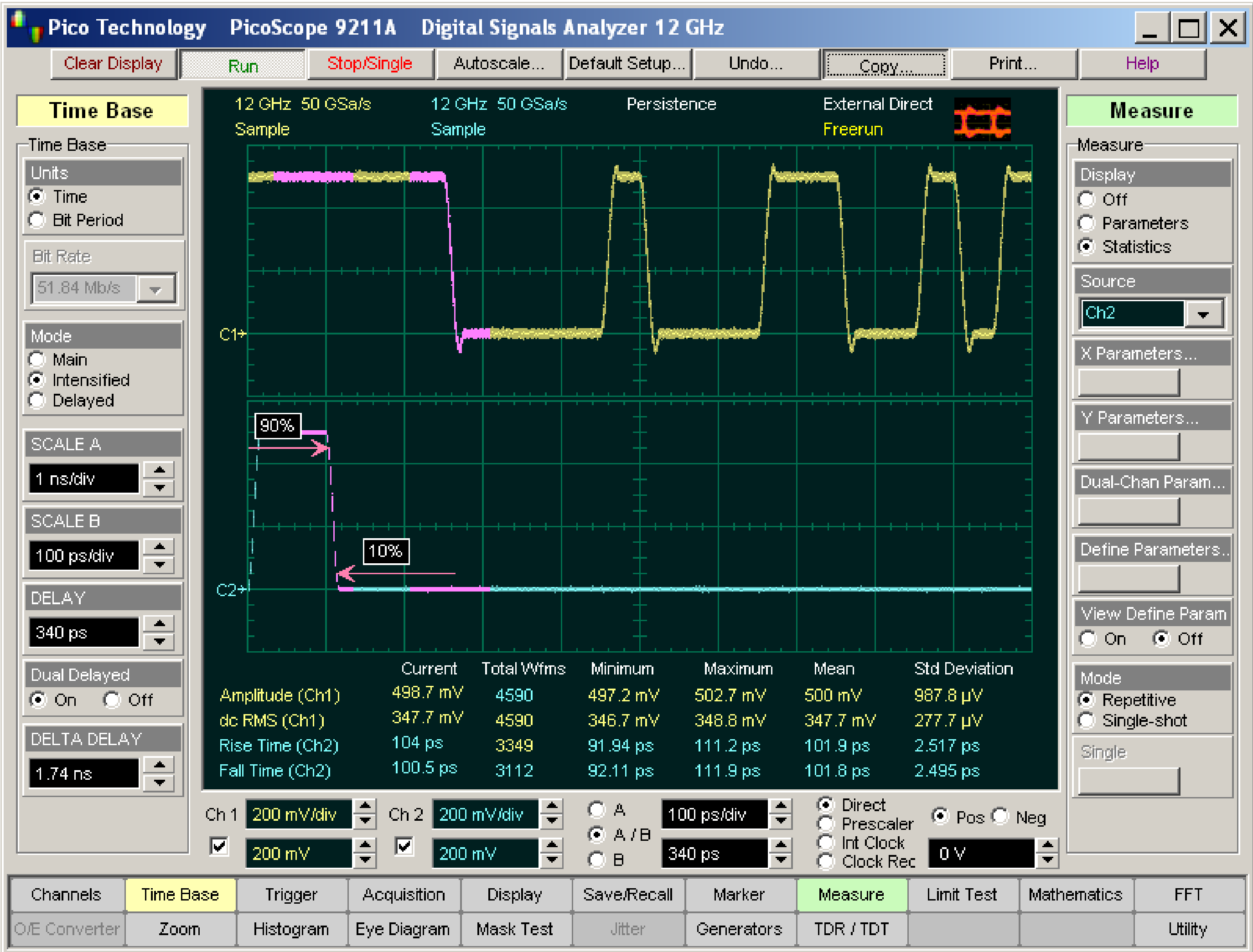
Sequential Sampling Acquisition



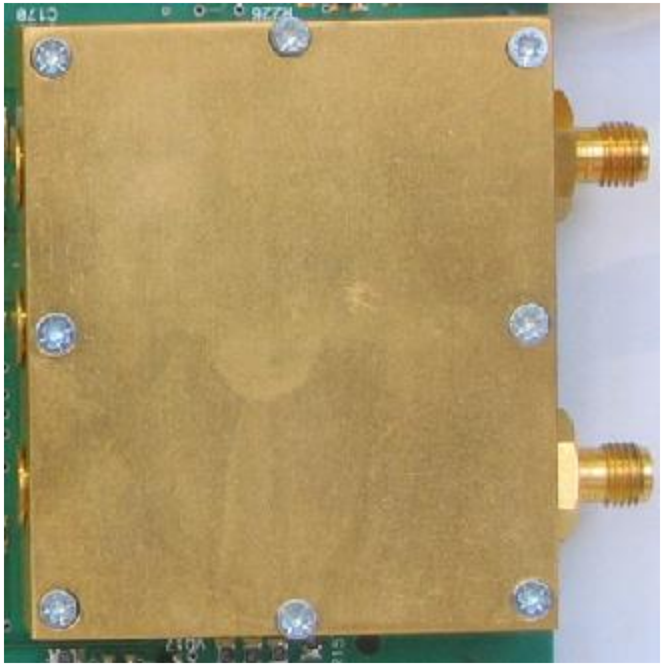
Sequential Sampling Technique means:

- Wide Bandwidth Applications (> 10 GHz)
- 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

User Interface



Dual-Channel 12-GHz Miniature Sampler



Key Specifications of the Sampler

- Number of Channels - 2 (Simultaneous acquisition).
- Bandwidth (-3dB): Full BW: DC to 12 GHz,
  Narrow BW: DC to 8 GHz.
- Rise Time (10%-90%): Full BW: ≤29.2 ps,
  Narrow BW: ≤43.8 ps.
- RMS Noise (max): Full BW: ≤ 2.0 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 - SMA-type, 3.5 x 1.52 (f).
- Dimensions: 48 x 50 x 17 mm).

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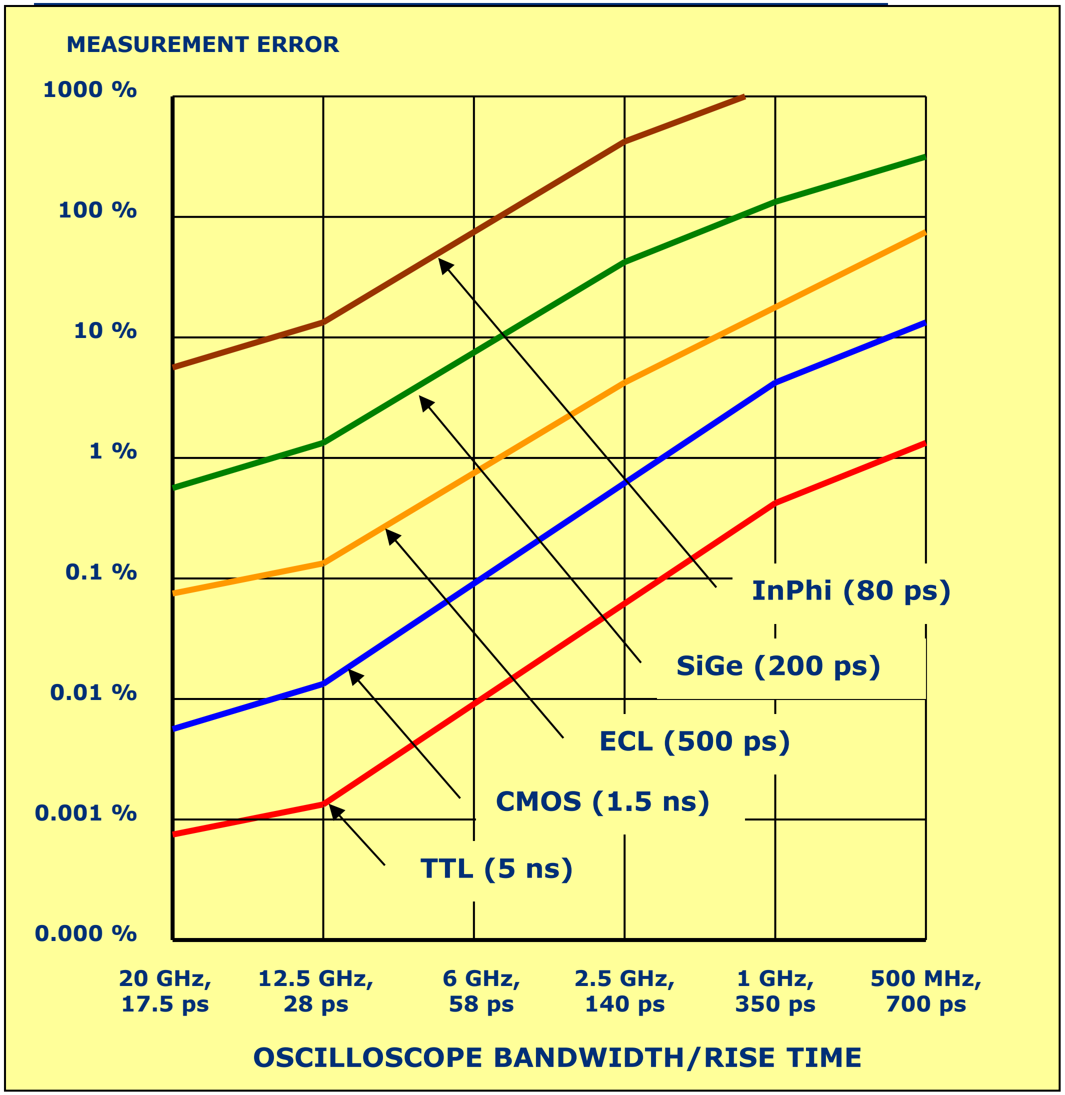
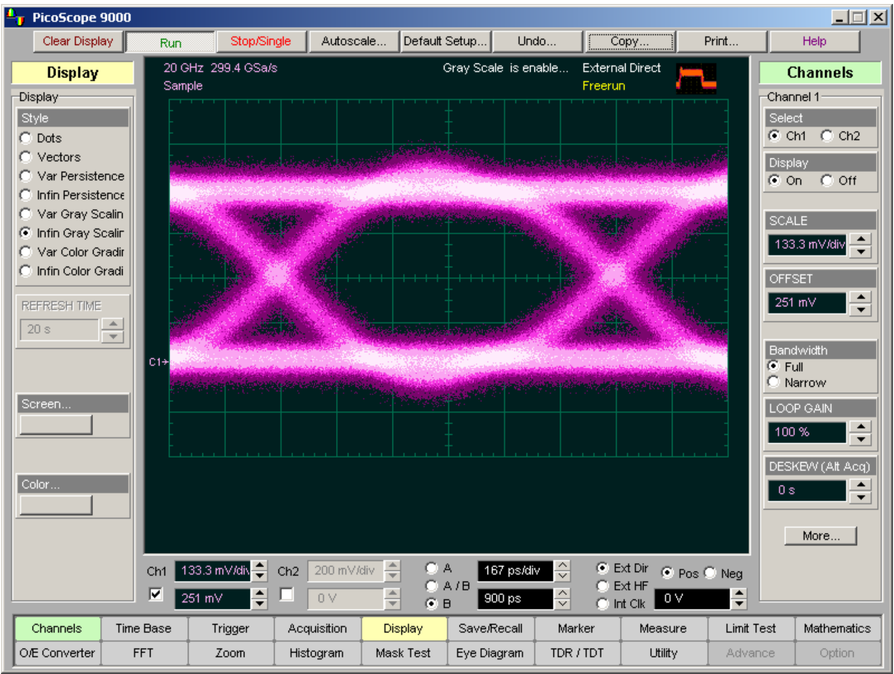
Electrical Rise Time Measurement Error vs. Oscilloscope Bandwidth

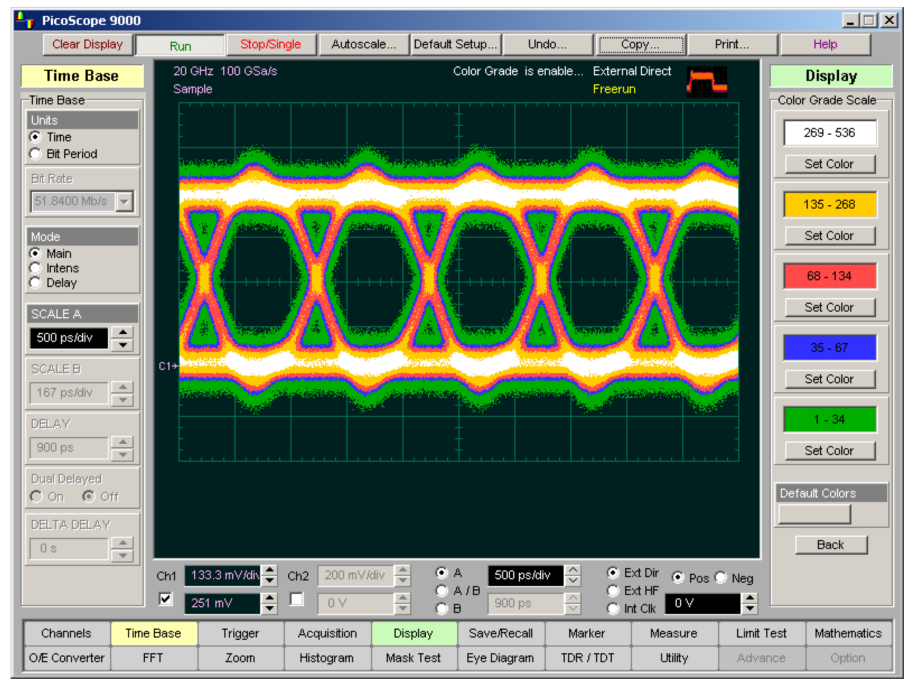


When the Scope Bandwidth (BW)	Rise Time Slowing Error
Equal to Signal Edge BW	▶ 41%
Twice as fast as Signal Edge BW	▶ 12%
Three times as fast as Signal Edge BW	▶ 5%
Five times as fast as Signal Edge BW	▶ 2%

Informative Waveform Display



Get valuable insight into your device behavior with gray scaling display. View pattern dependencies and different rare versus common events



The Color Graded display allows you clearly view any point of interest on the 1-GHz eye-diagram.

Measurements and Test

Types of Measurements

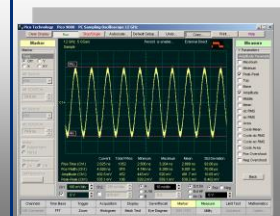
Graticule Measurements

10 by 8 display graticule with Grid, Axes, Frame and Off options

Marker Measurements

Two X, Y, or XY markers provide absolute, delta or ratiometric measurements

Pulse Measurements



19 *Amplitude*, 29 *Timing* and 5 *FFT Measurements* can be performed automatically

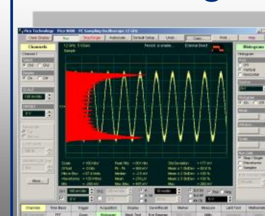
NRZ Eye Measurements

Measurement list includes 42 NRZ eye parameters

RZ Eye Measurements

43 automatic measurements are built for characterization of RZ signals

Histogram Measurements



Up to 15 statistic measurements of vertical and horizontal histogram

Types of Measurement Test

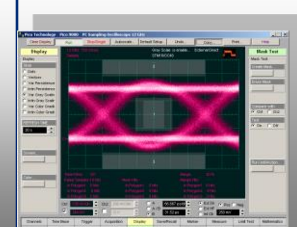
Limit Test

Allows you to automatically compare up to 4 measurement results with pass or fail limits

Mask Test

Standard, auto- or custom mask can be used for mask test

Mask Margin Test



Test is used to determine the margin of compliance for a standard or scaled mask

Automatic Measurements

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The PicoScope 9200A provides accurate Automatic Measurements. They make the measurement process fast and easy, while reducing human errors, particularly essential for repetitive test. All measurements conform to the *IEEE standards*. Measurements cover *Voltage*, *Timing* and *FFT.*

The PicoScope 9200A measures up to 10 parameters simultaneously on 8 sources with maximum time resolution of *0.2 ps* and *2%* vertical accuracy

19 Amplitude Measurements are made on vertical parameters. They typically mean voltage. They are: ● Maximum, ● Minimum, ● Peak-Peak, ● Top, ● Base, ● Amplitude, ● Middle, ● Mean, ● dc RMS, ● ac RMS, ● Area, ● Cycle Middle, ● Cycle Mean, ● Cycle dc RMS, ● Cycle ac RMS, ● Cycle Area, ● Pos. Overshoot, ● Neg. Overshoot, ● Gain.

29 Timing Measurements are made on horizontal parameters. They typically mean seconds or hertz. Main of them are: ● Period, ● Frequency, ● Pos. Width, ● Neg.Width, ● Rise Time, ● Fall Time, ● Pos.Duty Cycle, ● Neg. Duty Cycle, ● Pos Crossing, ● Neg Crossing, ● Burst Width, ● Cycles, ● Time@Maximum, ● Time@Minimum, ● Delay.

5 FFT Measurements are made on both vertical and horizontal parameters. They typically mean volts and hertz. They are: ● FFT Magnitude, ● FFT Delta Magnitude, ● THD, ● FFT Frequency, ● FFT Delta Frequency.

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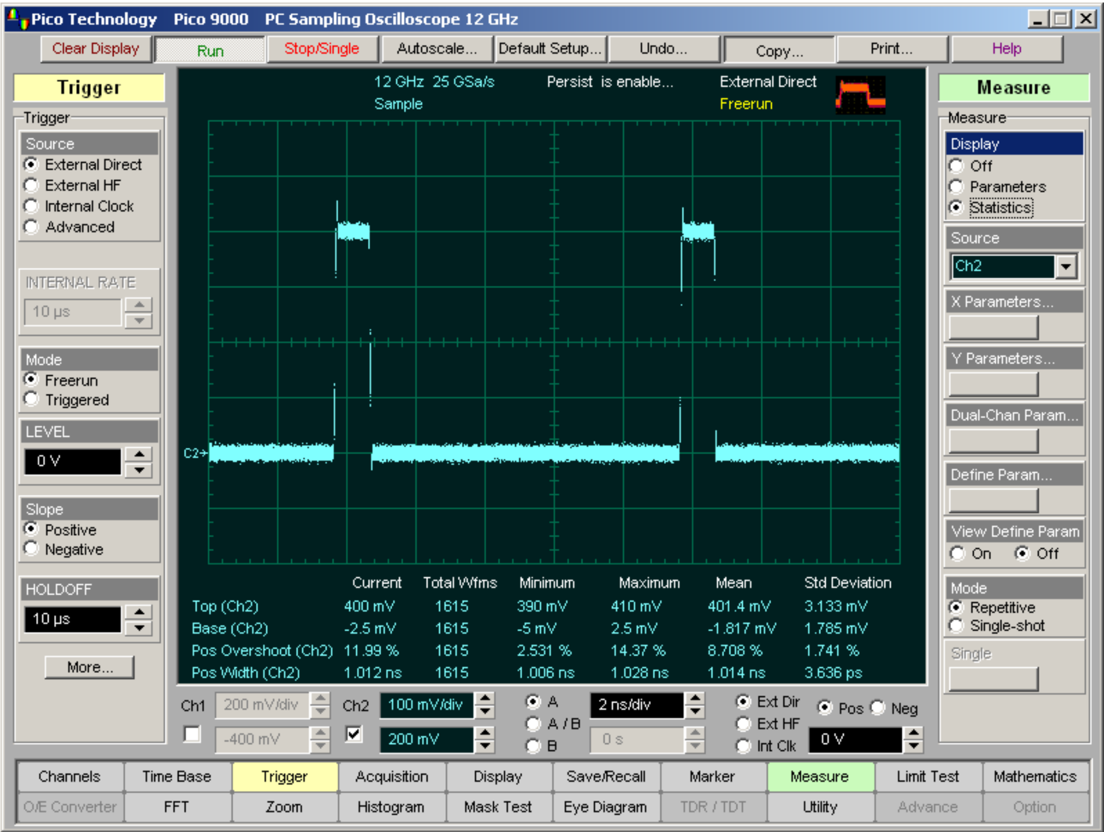
Statistics Measurements

The PicoScope 9200A measures up to 4 statistics parameters simultaneously

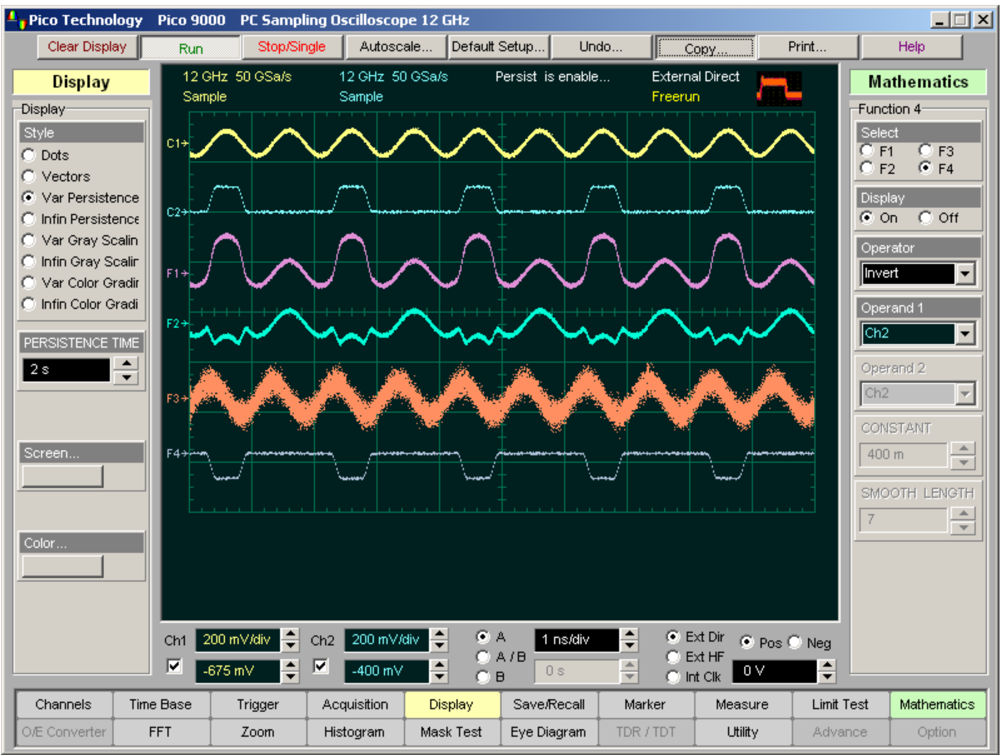


- The Statistics function calculates the following values of the automatic measurement results:
  - Minimum
  - Maximum
  - Mean
  - Standard Deviation
  - Current Value
  - Amount of measurements
- Minimum and maximum are the absolute extremes of the automatic measurements.
- Mean and standard deviation calculates the mean and standard deviation of the automatic measurement results.
- Mean is the statistical average of all results for a particular measurement.
- Standard deviation measures the dispersion of those measurement results.

Simultaneous statistics measurements of Top, Base, Positive Overshot and Positive Width of a pulse signal.

Mathematics

The PicoScope 9200A supports up to four simultaneous mathematical combination and functional transformation of waveforms that is acquires.



An examples of PicoScope 9200A Math Functions.

F1=Ch1+Ch2 F2=Ch1-Ch2

F3=Diff(Ch1) F4=Inv(Ch2)

Source (operand) waveform (Ch1) | Math function (operator, Divide) | Math function (waveform F1)

Functional transformation of an acquired waveform

You can select any of the math functions as a math operator to act on the operand or operands. A waveform math operator is a math function that requires either one or two sources.

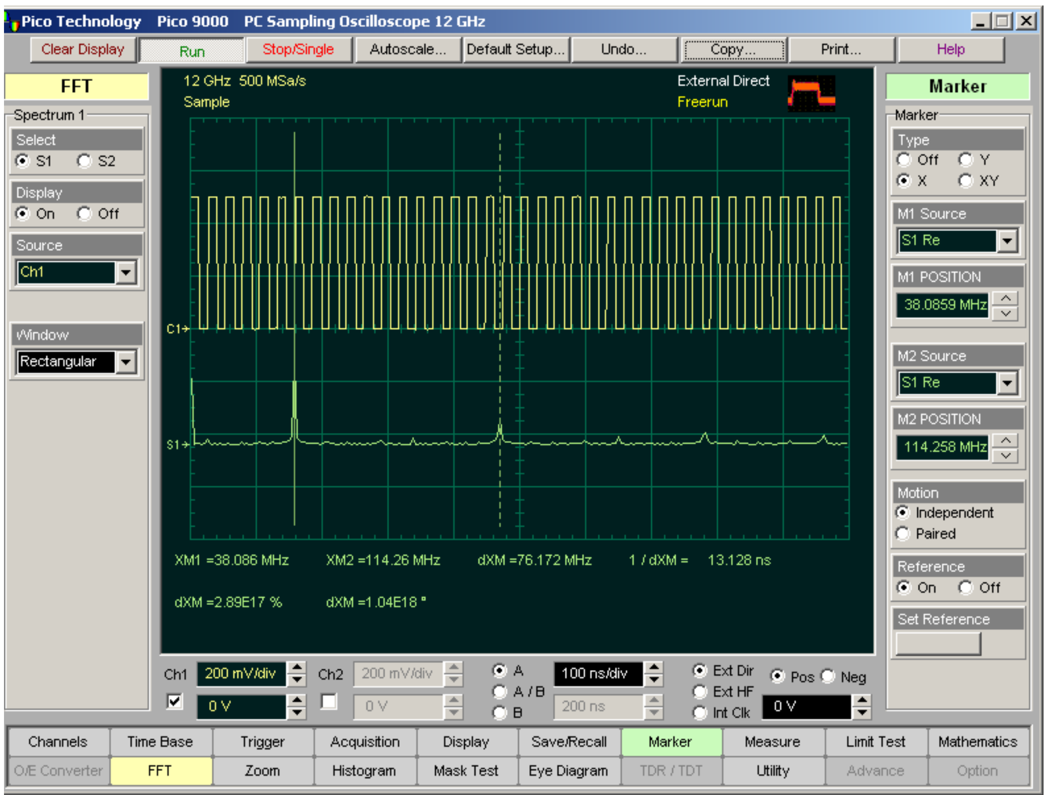
The operators that involve two waveform sources are:
● Add, ● Subtract,
● Multiply, and ● Divide.

The operators that involve one waveform source are:
● Invert, ● Absolute, ● Exponent (e), ● Exponent (10),
● Logarithm (e), ● Logarithm (10),
● Differentiate, ● Integrate, ● Inverse FFT, ● Linear Interpolation, ● Smoothing, ● Trend and ● Sin(x)/x Interpolation.

Fast Fourier Transform

The math option of the PicoScope 9200A includes FFT capabilities for examine the harmonic content of high-frequency signals. You can perform FFT on any waveform. The record length of the waveform can be up to maximum *4096 points*.

- Use the FFT function to:
  - Find cross-talk problems.
  - Find distortion problems in analogue waveforms caused by non-linear amplifiers.
  - Adjust filter circuits designed to filter out certain harmonics in a waveform.

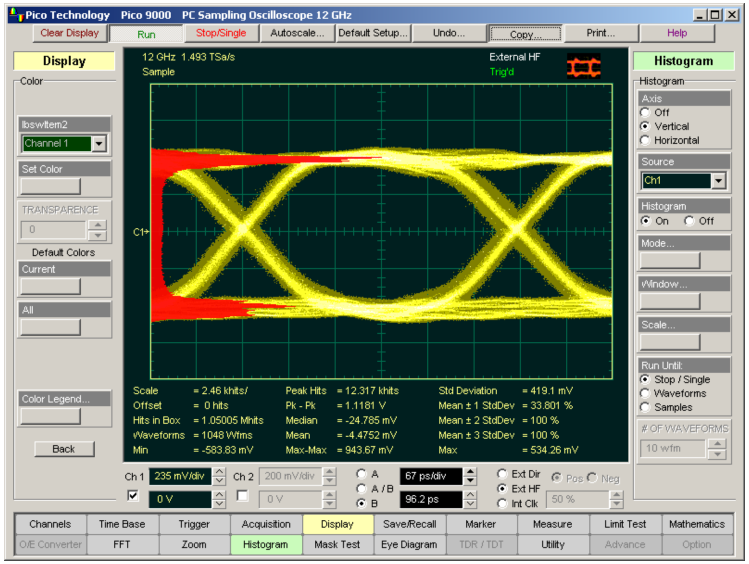


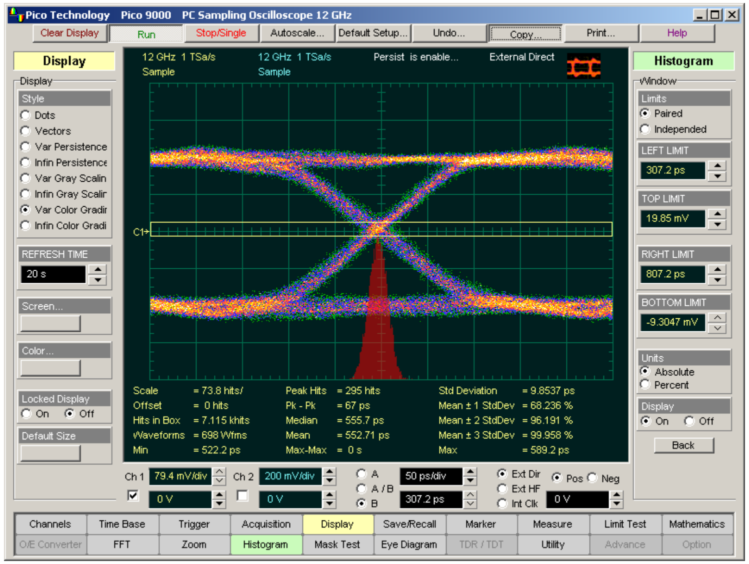
FFT analysis provides an extra dimension of performance with simultaneous displays in the time and frequency domain.

- To compensates some of the limitations of FFT analysis You can use windowing. The window type defines the bandwidth and shape of the equivalent filter associated with the FFT processing.

- The PicoScope 9200A supports six types of windows:
  - Rectangular FFT window, which does not taper the time domain data,
  - Five tapering FFT windows of different shapes –
    - Hamming window
    - Hanning window
    - Flattop window
    - Blackman-Harris window
    - Kaiser-Bessel window

Histograms





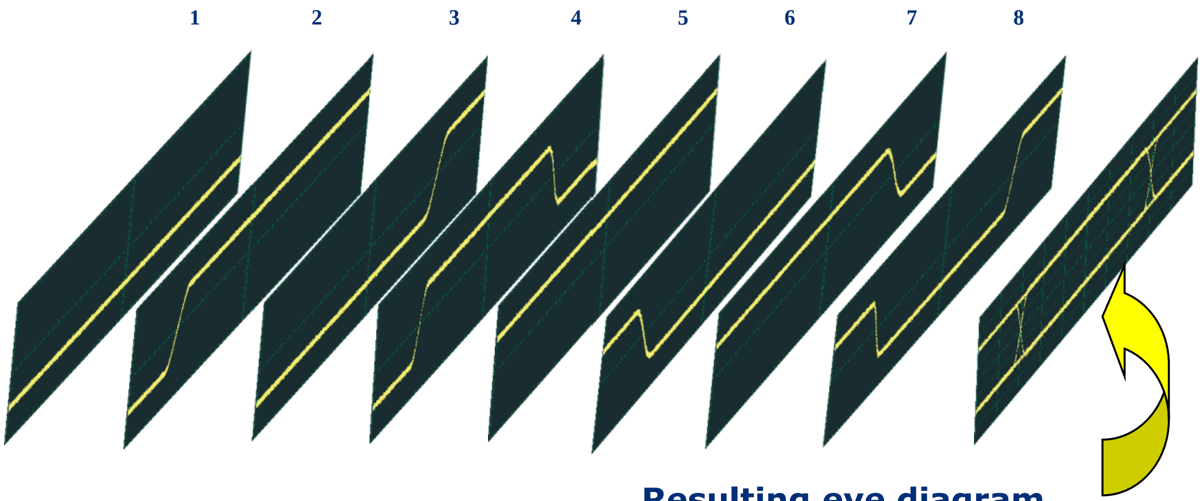
A histogram is a probability distribution that shows the distribution of acquired data from a source within a user-definable histogram window.

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 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.

Eye Diagram



Resulting eye diagram

Process of building Eye Diagram includes serial acquisitions of waveform data base

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 is ±350 mV
- Random Noise and pattern dependent, deterministic errors mask each other

A typical PicoScope 9200A Eye Diagram with Mask, Margins and Histogram

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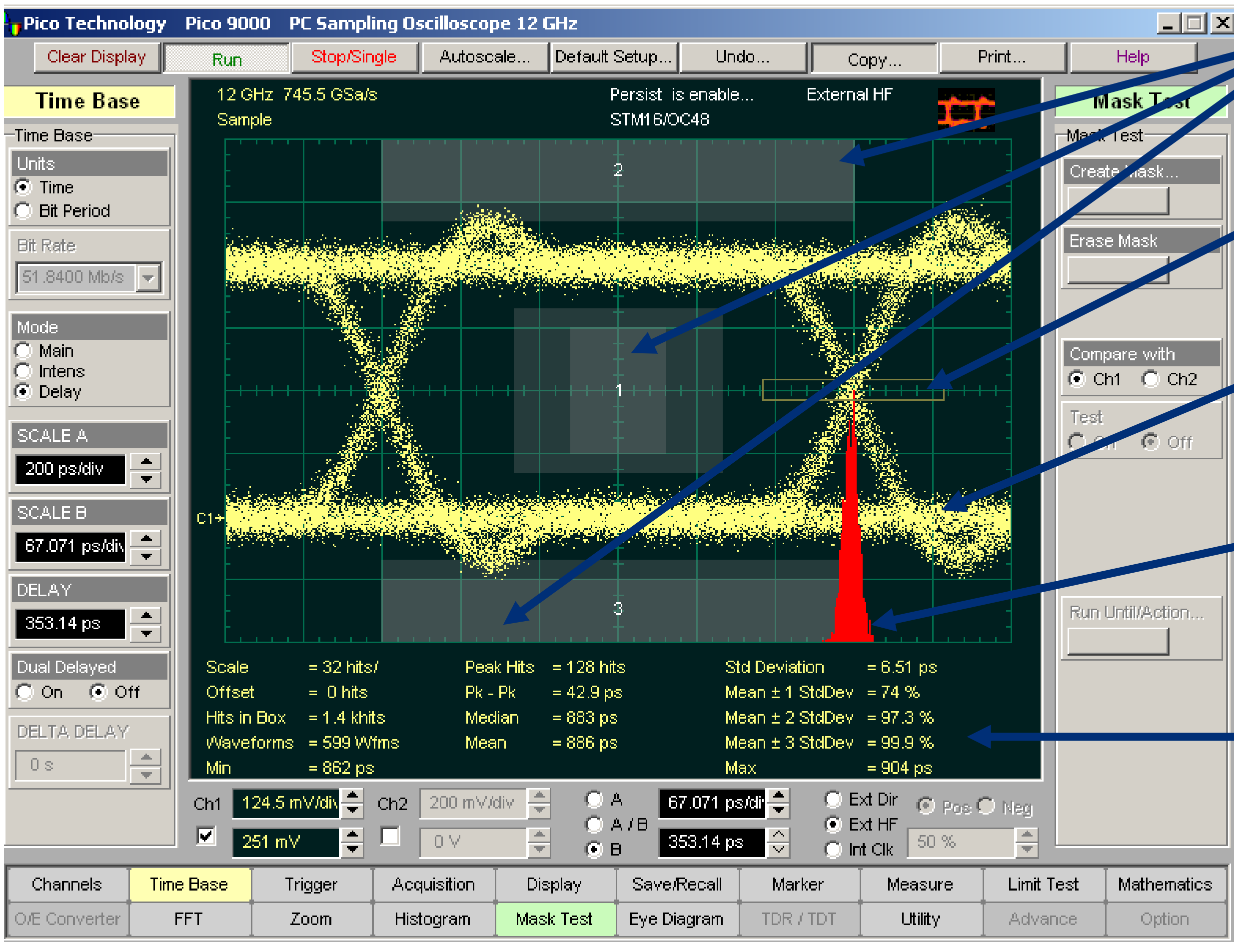

Customizable Mask with Margins

Histogram window

2.5-Gb/s Eye Diagram

Using Histogram on the eye crossing to characterize jitter

Histogram measurement results

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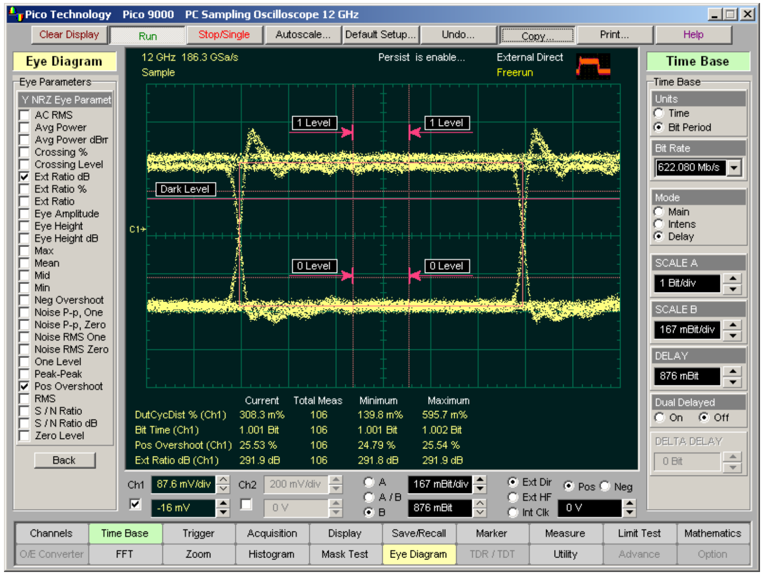
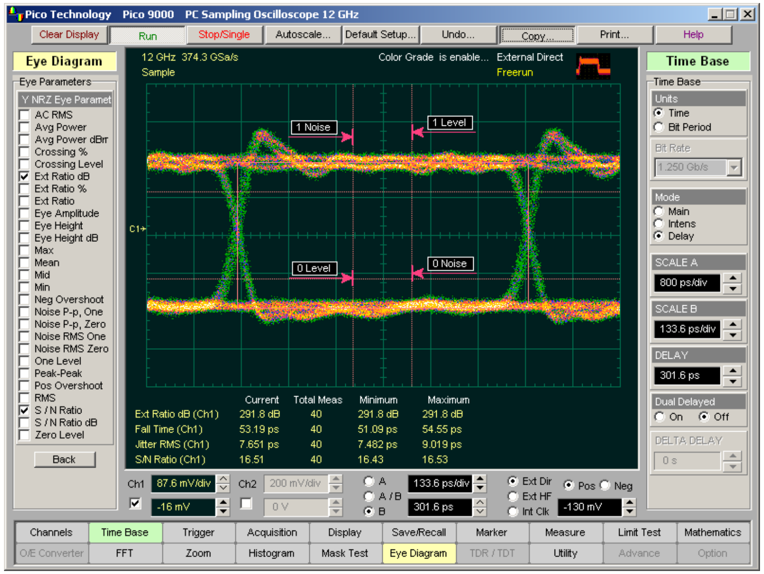
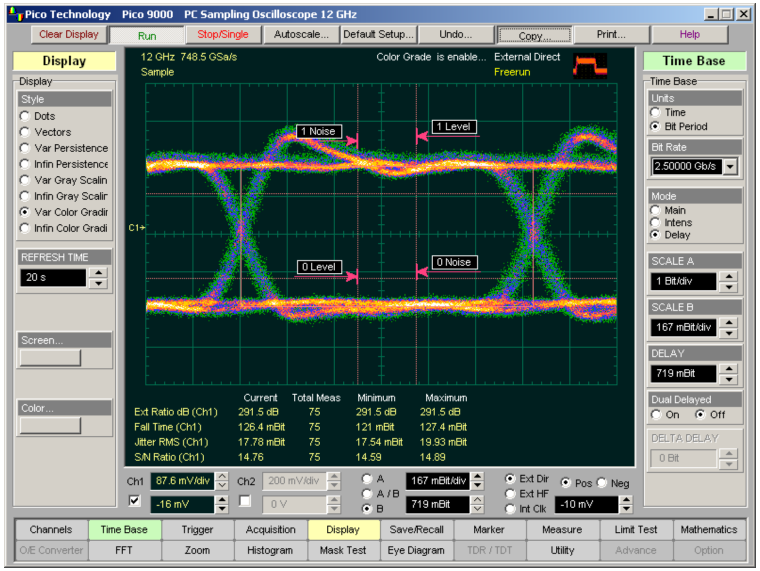
Examples of NRZ Measurements



Measurements of 622-Mbit Eye Diagram

Measurements of 1.25-Gbit Eye Diagram

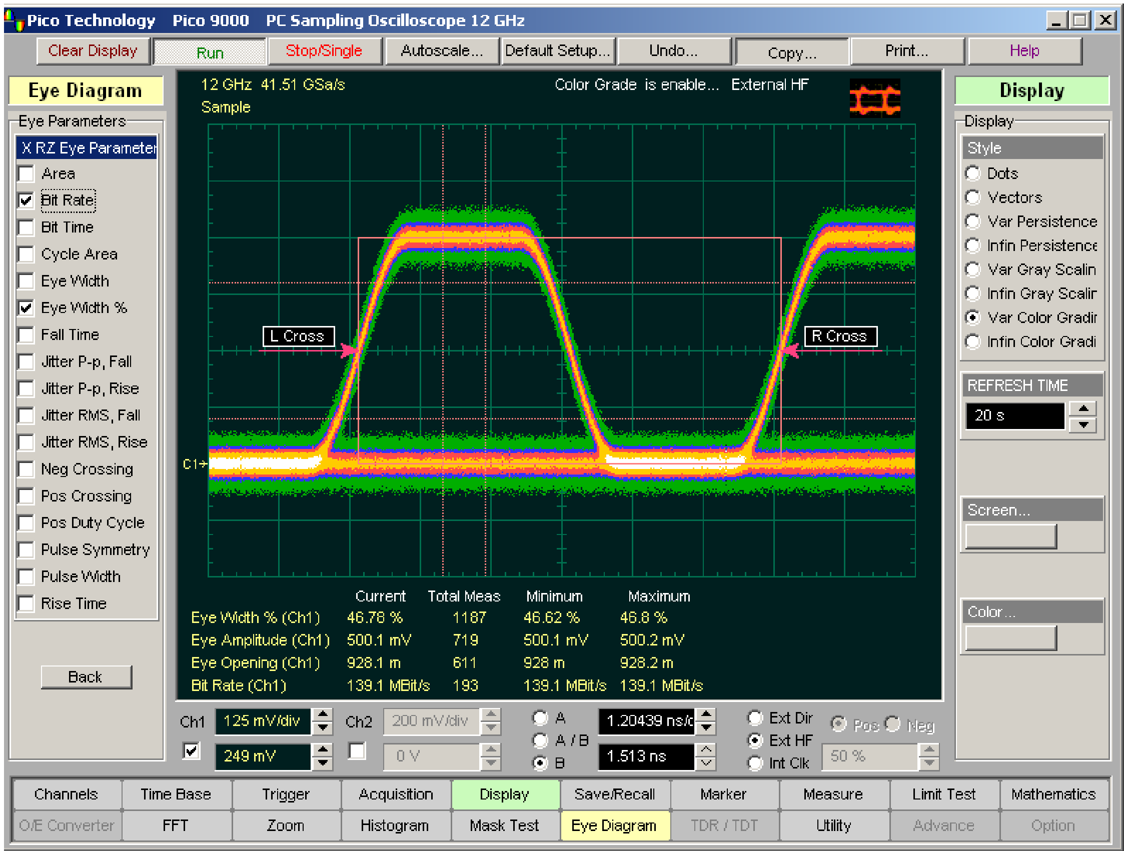




Measurements of 2.5-Gbit Eye Diagram

RZ Eye-Diagram Analysis

The PicoScope 9200A quickly measures 43 fundamental parameters used to characterize an return-to-zero (RZ) signals. Up to four parameters can be measured simultaneously.



The PicoScope 9201 measures 139-Mbit RZ eye-diagram

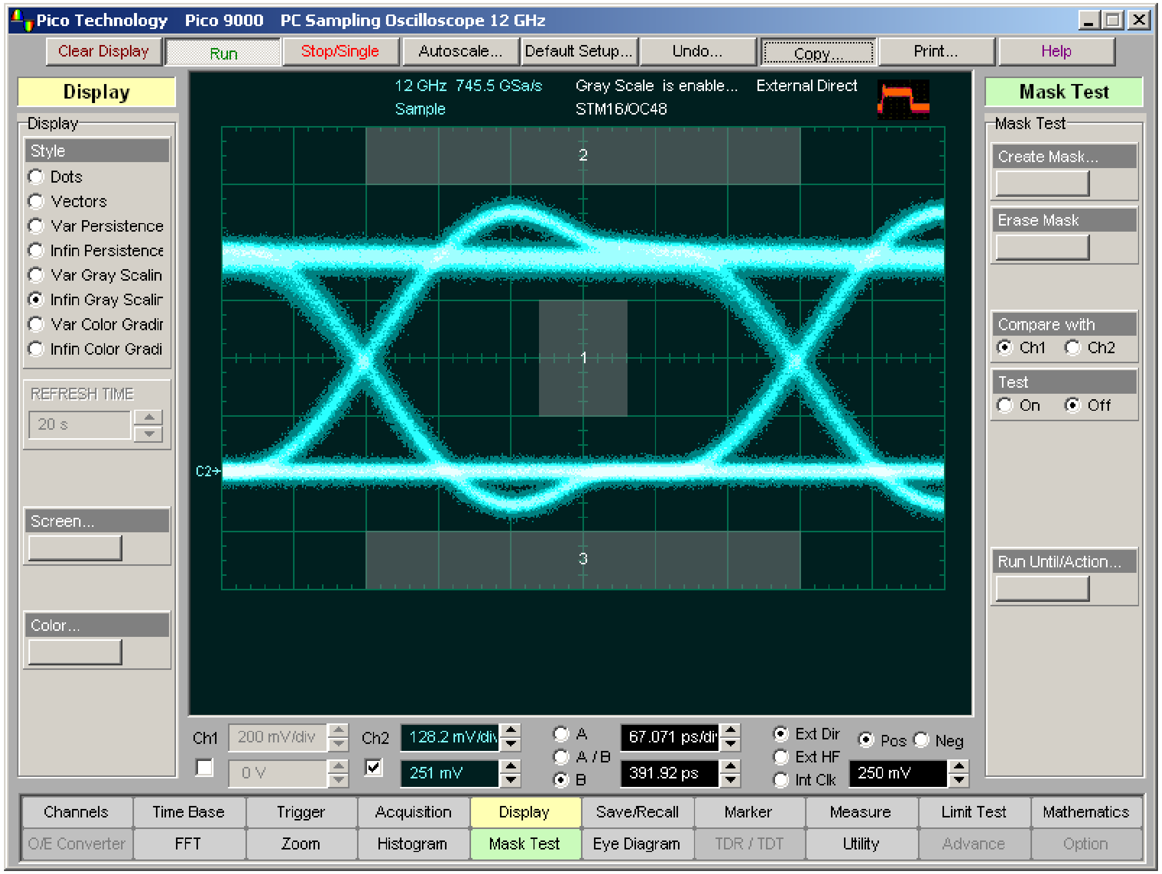
Mask Test

For eye-diagram masks, such as those specified by the SONET and SDH standards, the PicoScope 9200A 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

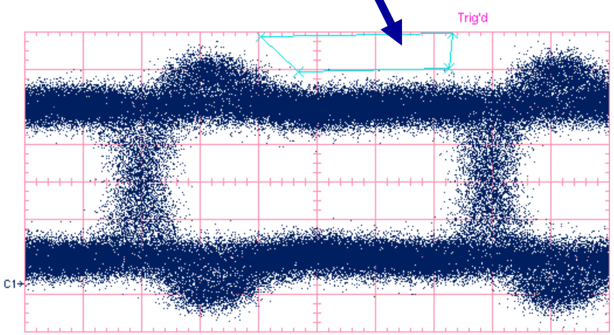
On-board mask drawing capability allows simple, operator-independent visual comparison of signal to standard mask. Picture demonstrates a SONET/SDH (OC64/STM16) signal compared with the standard mask, showing a compliant waveform.



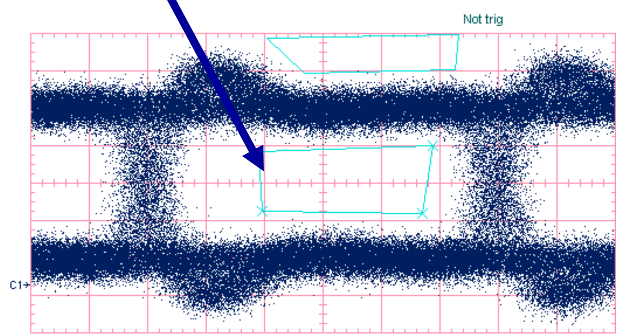
Creating Custom Mask

Five pictures below demonstrate how PicoScope 9200A builds Custom Mask for NRZ waveform

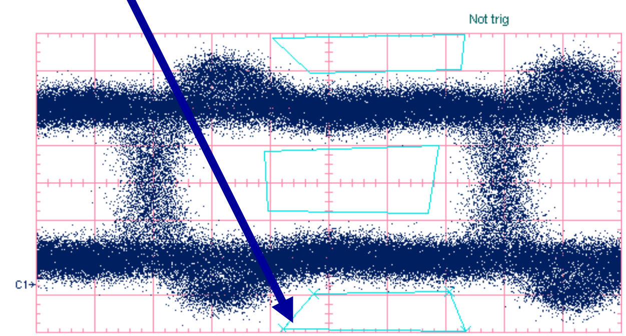
1. Create the top Polygon of the Mask

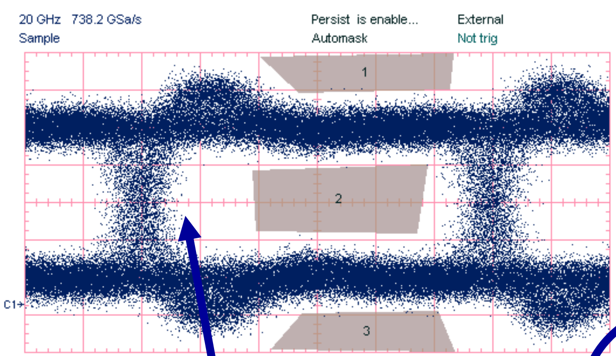


2. Create the center Polygon of the Mask

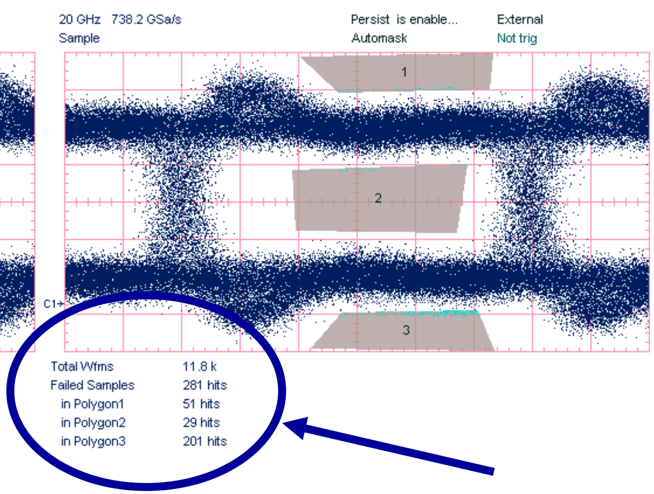


3. Create the bottom Polygon of the Mask





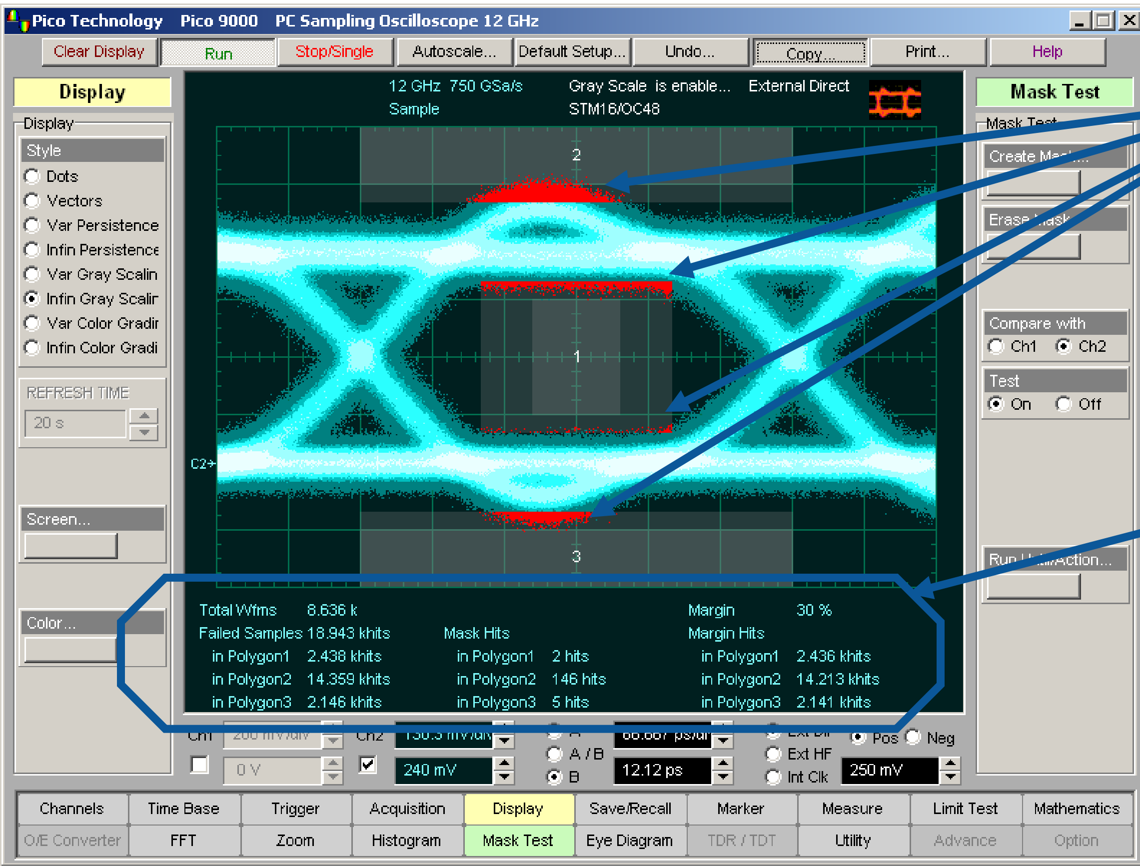
4. Create full Mask



5. Perform Mask Test

Mask Margins

Mask Margins are used to determine the margin of compliance for a standard or scaled mask. The PicoScope 9200A goes beyond basic testing with mask margin analysis for process monitoring.

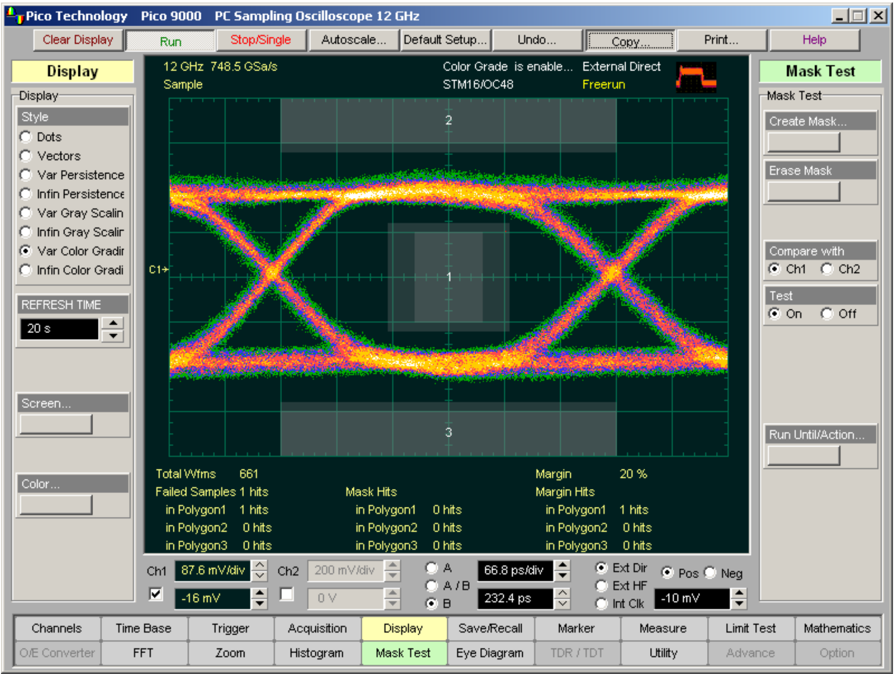


- Mask hits/failures are easily viewed with red pixels.

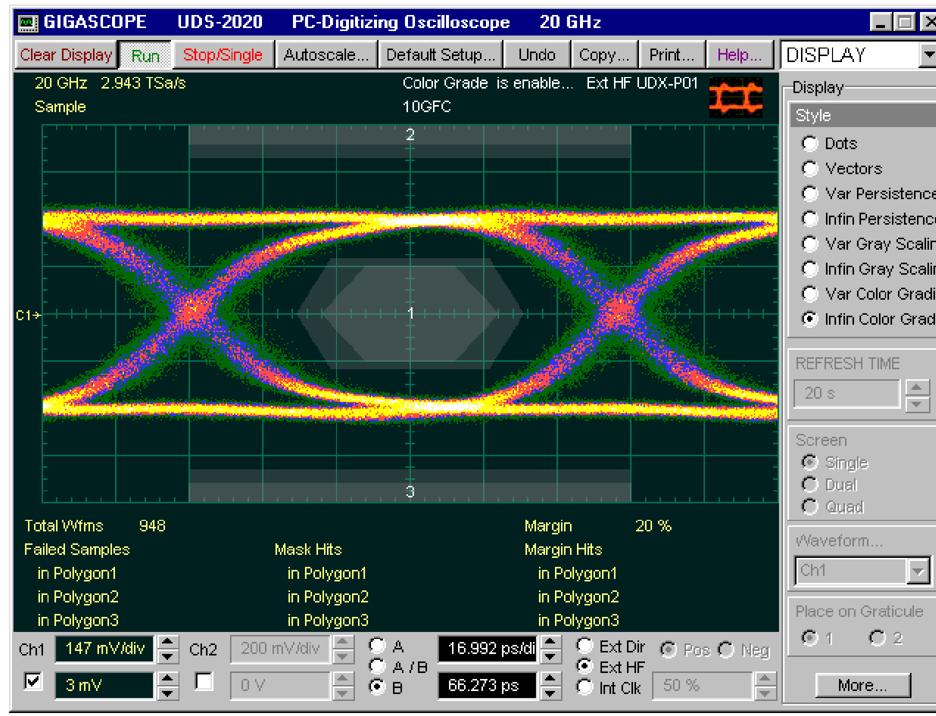
- Mask Test results show:
  - Total Waveforms
  - Failed Samples
  - Mask Hits
  - Mask Margin Value
  - Margin Hits
  - Margin Hits In Polygon

Mask margins are used to determine the margin of compliance for a standard 2.5 Gbps STM16/OC48 eye-diagram or scaled mask.

Examples of Mask Test

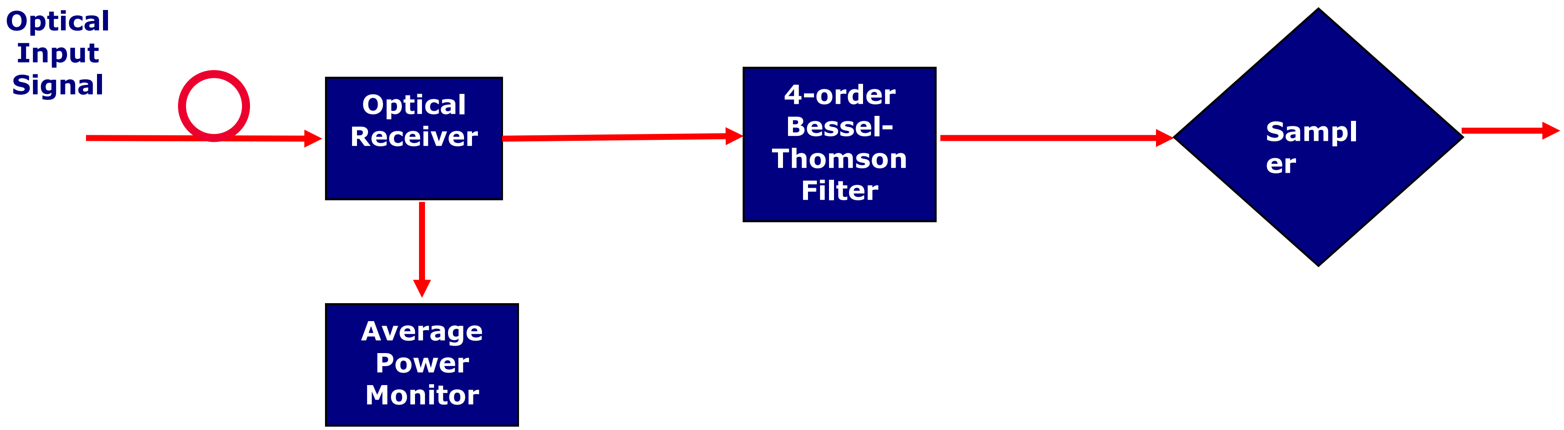


Mask Test and 20-% Margin Test performed for a standard 2.5 Gbps STM16/OC48 eye-diagram.



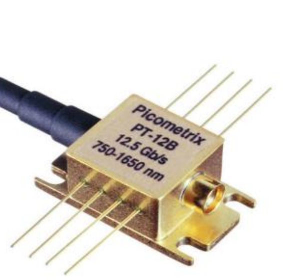
Mask Test and 20-% Margin Test performed for a standard 9.5 Gbps STM64/OC192 eye-diagram.

Integrated Optical Channel



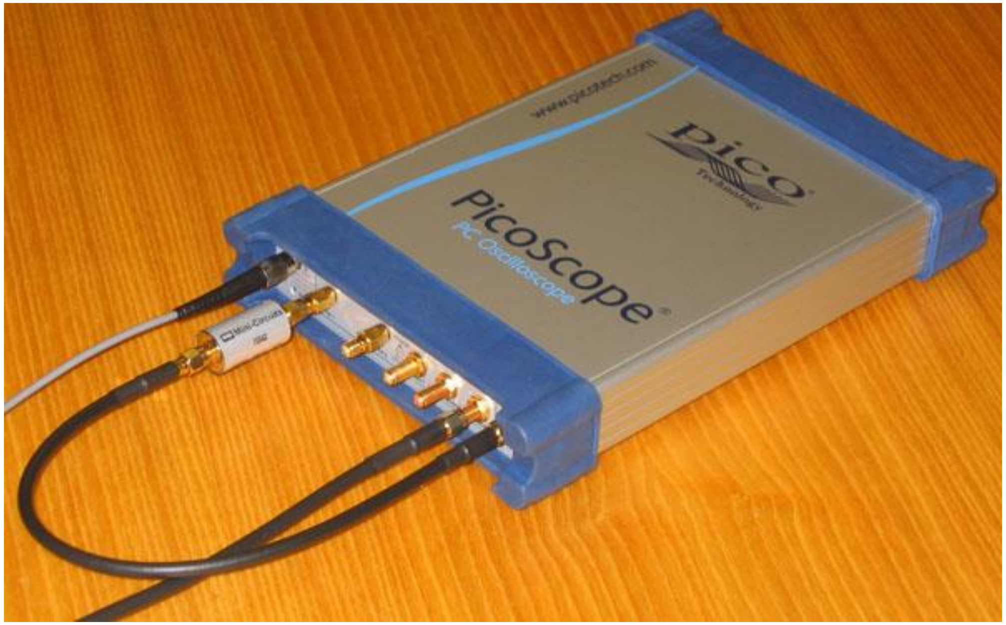
- The integrated optical channel can be used as a fully calibrated SONET/SDH/Gigabit Ethernet or Fibre Channel reference receiver or as a wide-bandwidth receiver.

GPO Module



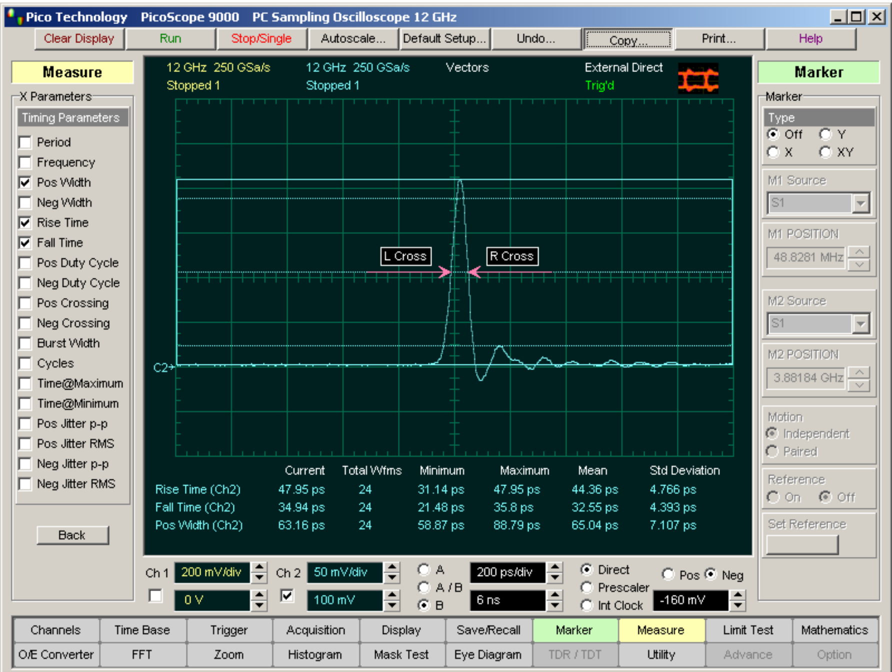
- 9 GHz PIN/TIA module for 12.5 Gb/s rates
- 62.5 µm MM fiber, SMA or GPO output
- 780 nm through 1550 nm applications
- Low frequency response to DC
- Adjustable DC output level
- 400 V/W / Conversion Gain (1310 nm)
- 450 V/A Transimpedance Gain

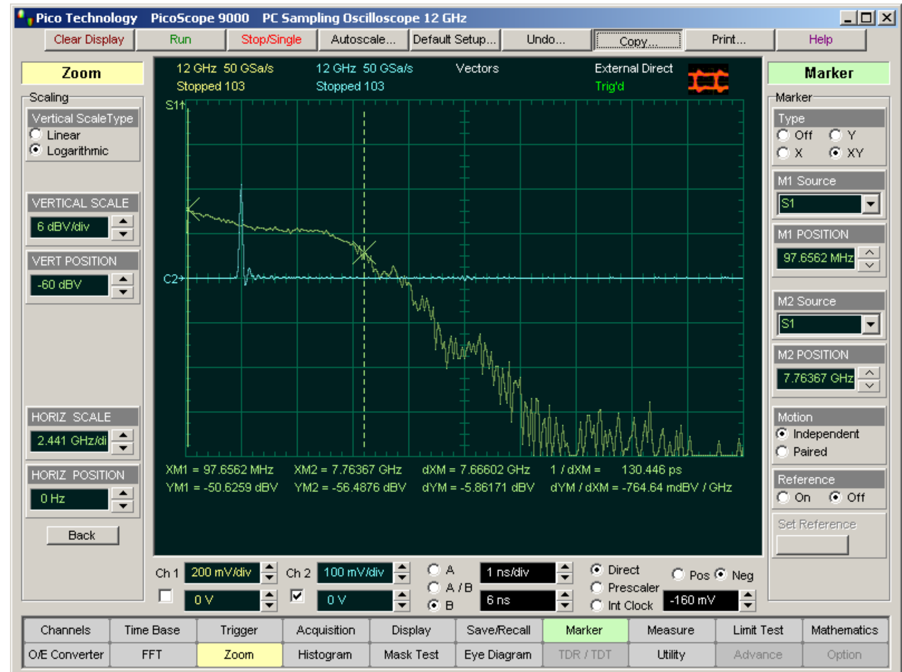
Optimal Optical Receiver. Bessel-Thomson Filters



- Filters are used with optical channels for compliance testing.
- For example, SONET/SDH, Gigabit Ethernet, and Fiber Channel standards have defined the compliance tests for consistency in standard measurements. These tests must be performed in a specific bandwidth. This bandwidth is achieved using the filters in the optical channels.
- The compliance tests then verify the performance of the input signal in that bandwidth.
- The filters concur with specific SONET/SDH, Fiber Channel, or Gigabit Ethernet data rates.
- The filters available for the optical channel in the PicoScope 9200A are remote and optional. They should be placed between the output of the O/E converter and the input of the selected electrical channel (see Figure above).

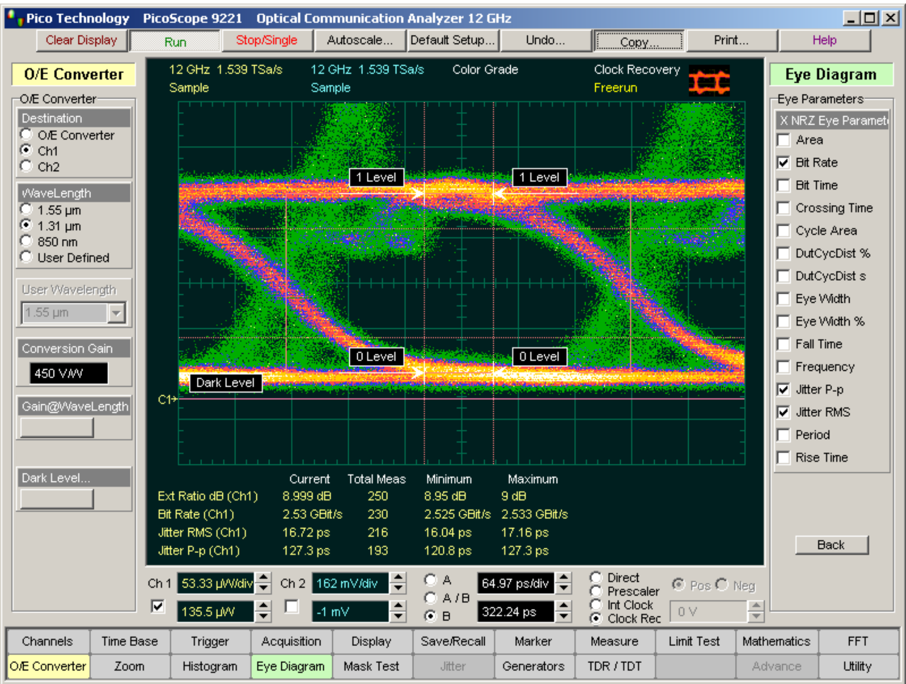
Optical Bandwidth





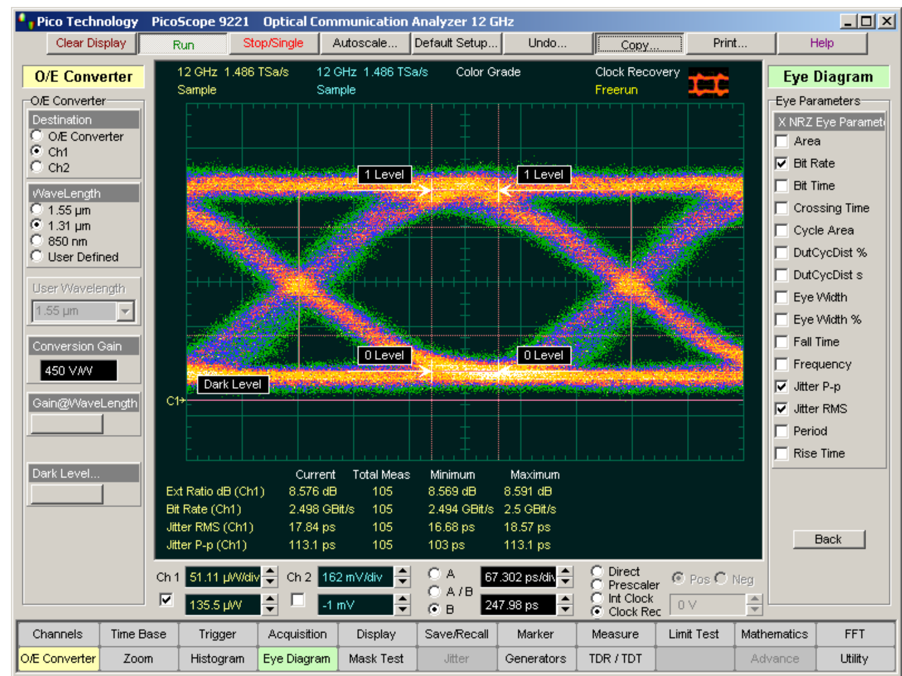
Impulse (left) and Frequency (right) Response of the PS9200A.
Typical Unfiltered Optical Bandwidth: 8 GHz.

Eye Diagram Measurements of Optical Signals

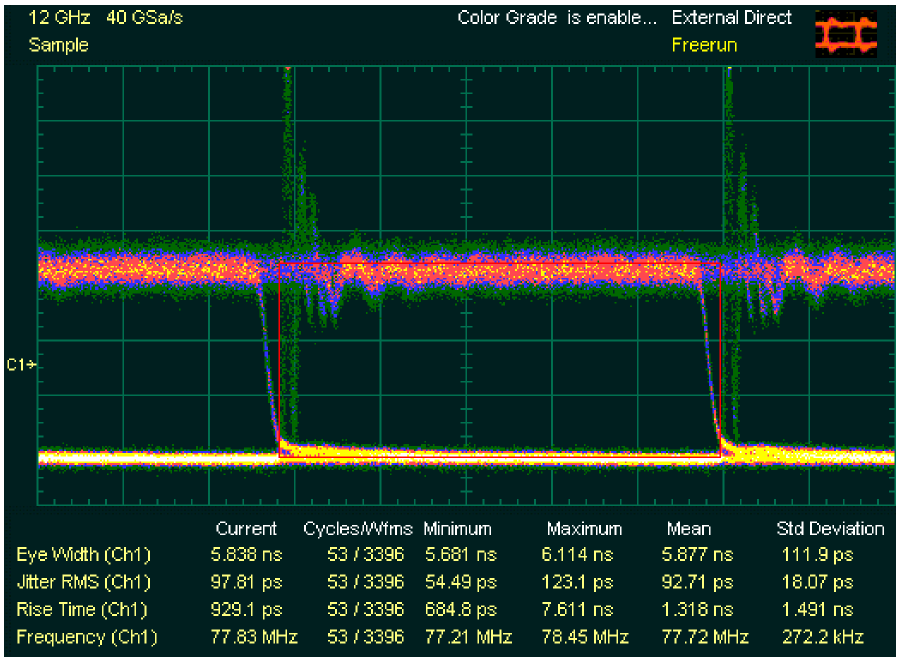


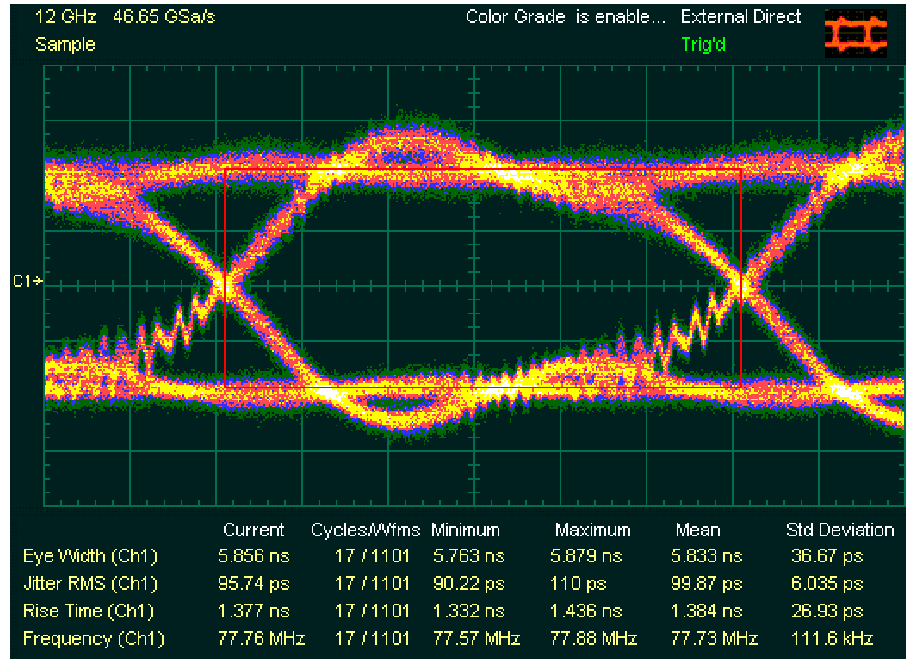
Optical OC-48 2.5 Gbps Eye-Diagram Measurements with No LP-Filtering

Optical OC-48 2.5 Gbps Eye-Diagram Measurements with LP-Filtering.
LP-Filter: Mini-Circuits Model NLP-2950
(-3 dB BW about 3 GHz)



OC-3 Laser Measurements



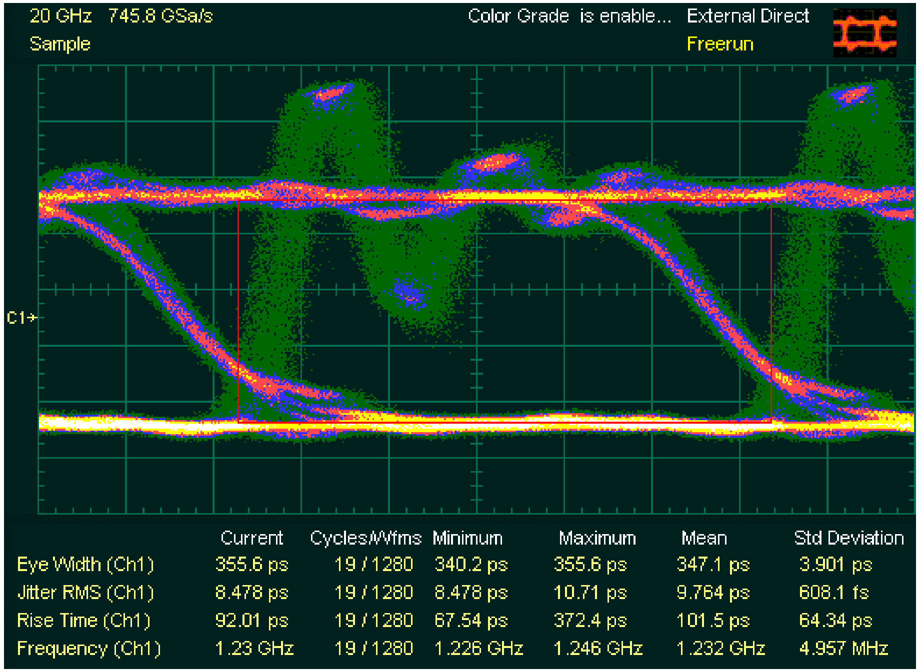


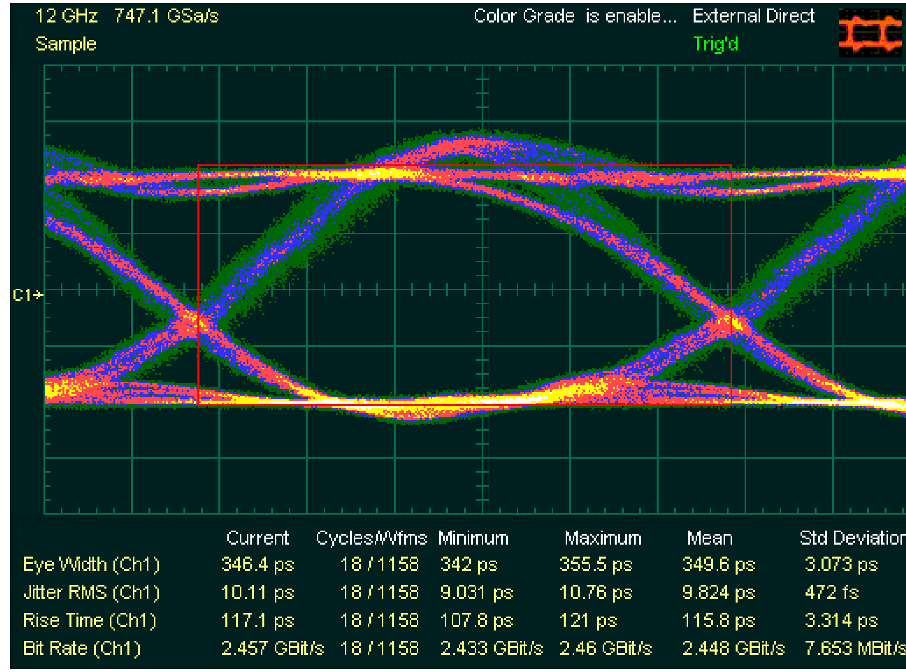
Eye-Diagram Measurements without (left) and with LP-Filtering.

Source: Anritsu 1570A Sonet/SDH Analyzer, Signal: Optical 1,31 um, -8 dBm, OC3, Trigger: Locked to signal
OE-Converter: IR 10 GHz, S/N IC-0001, Filter: Mini-Circuits Model NLP-200

MEILHAUS ELECTRONIC

OC-48 Laser Measurements

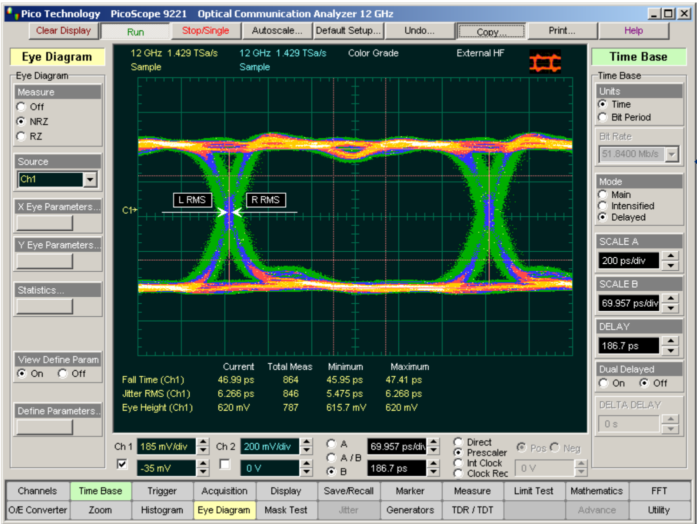




Eye-Diagram Measurements without (left) and with LP-Filtering.

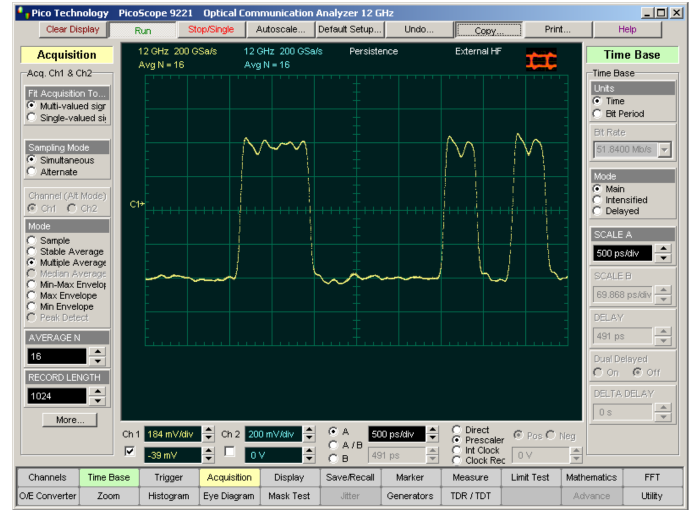
Source: Anritsu 1570A Sonet/SDH Analyzer, Signal: Optical 1,31 um, -4 dBm, OC48, Trigger:156MHz.l
OE-Converter: IR 10 GHz, S/N IC-0001, Filter: Mini-Circuits Model NLP-2950

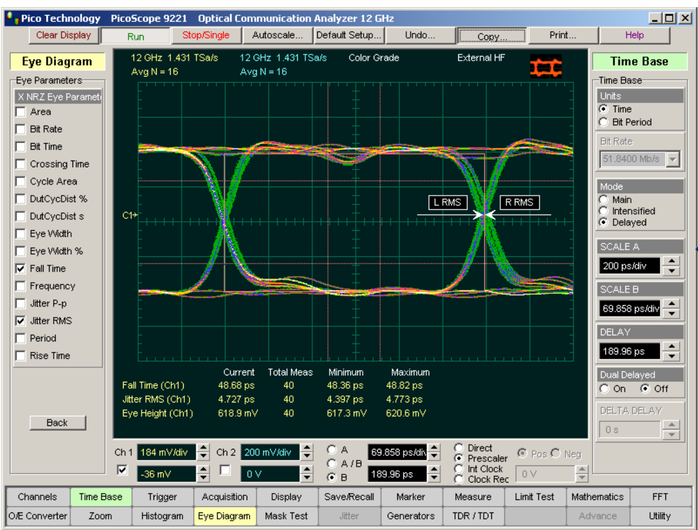
Pattern Sync Trigger
(Averaged Eye Diagram in Eye Line Mode)



Initial Eye Diagram

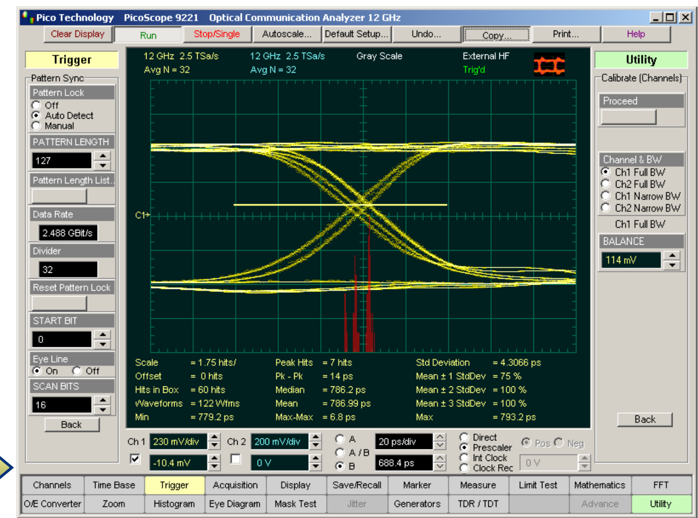
Data Pattern acquired in Pattern Sync Trigger



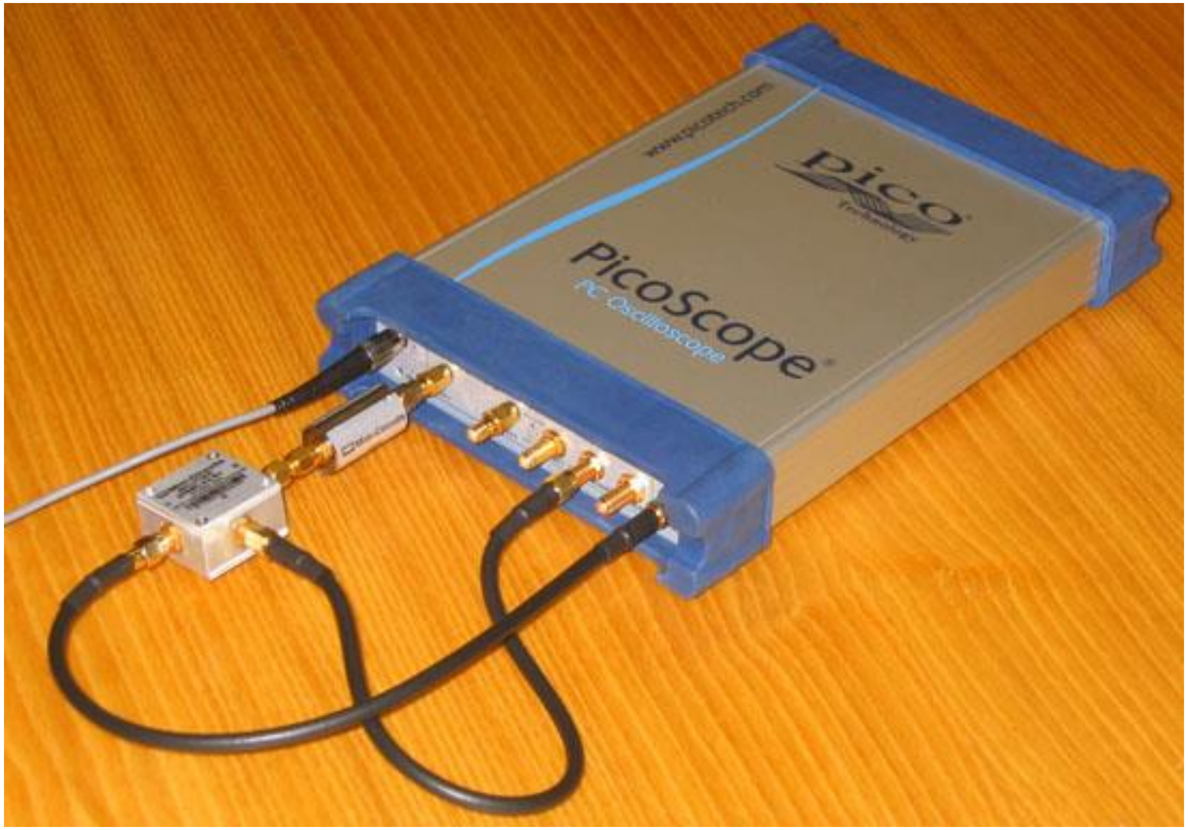


Averaged Eye Diagram acquired in Eye Line Mode

Precise Eye Jitter Determination



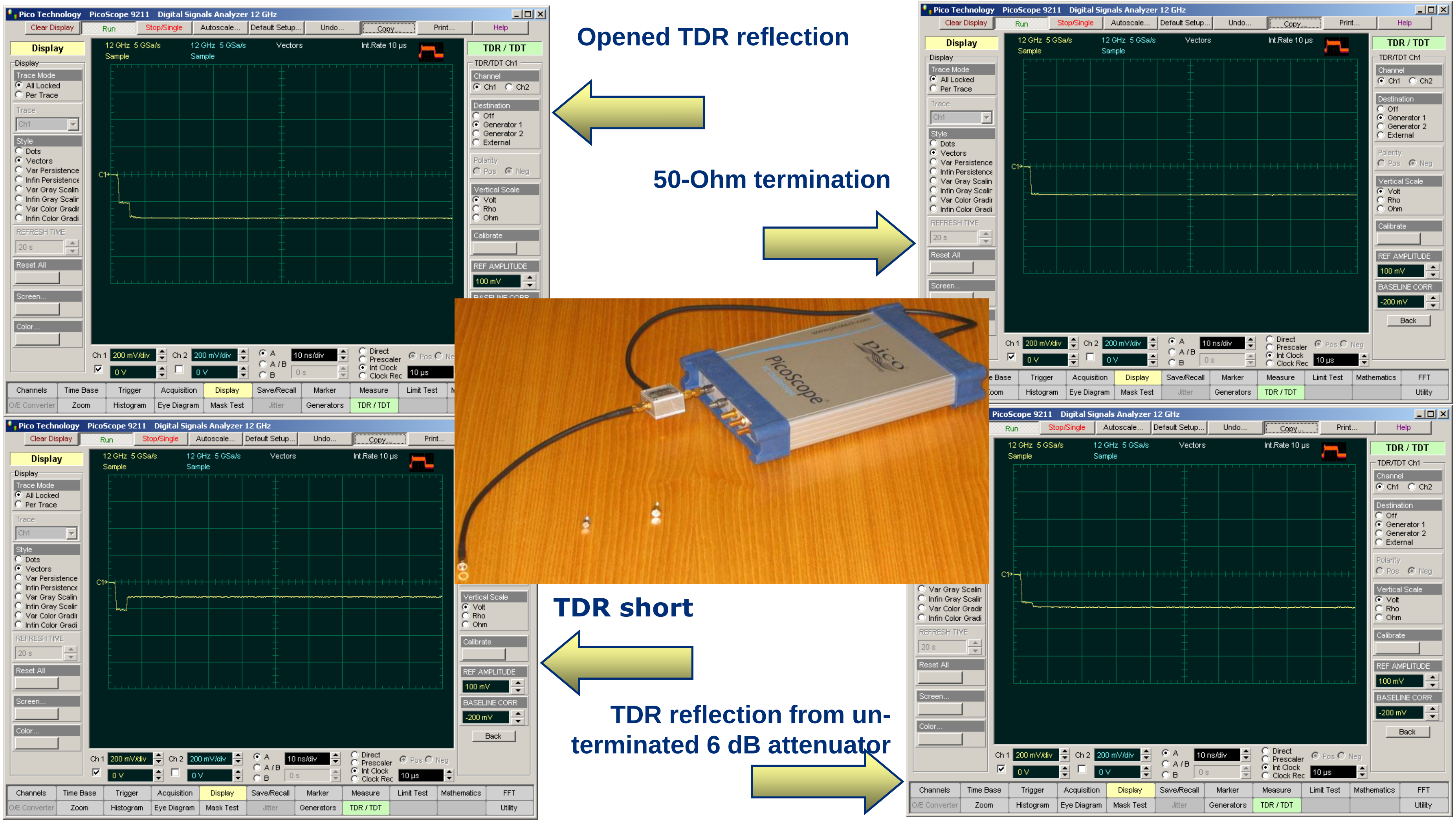
Optical Test Setup with built-in Clock Recovery



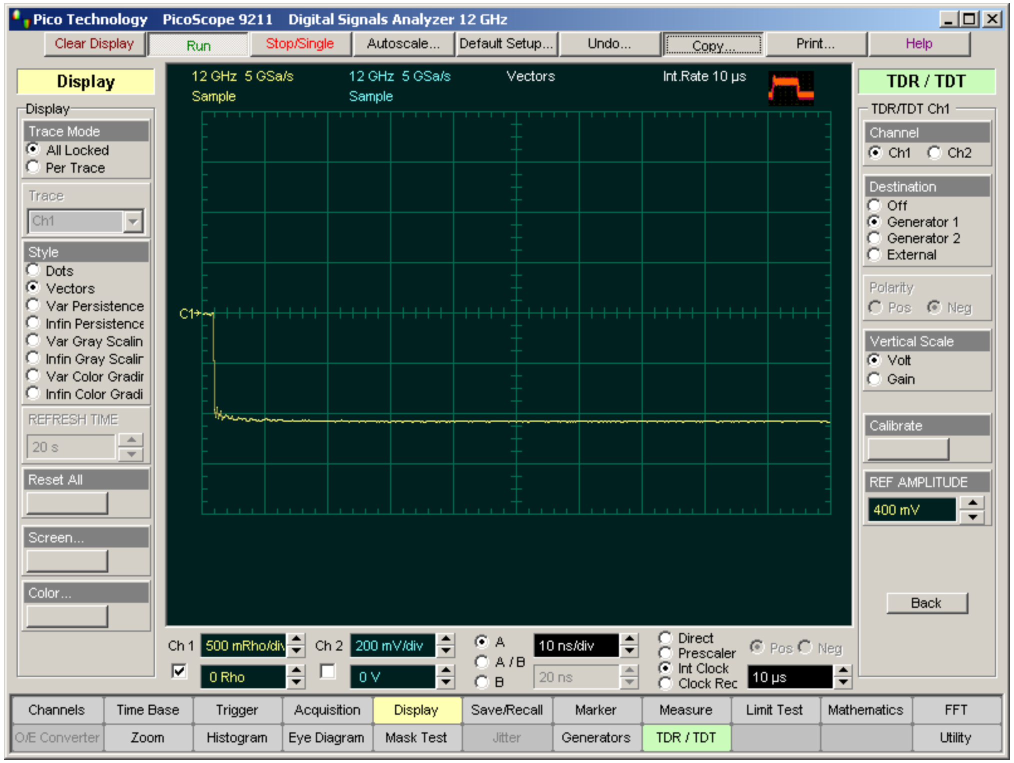
Use the clock recovery trigger when the trigger signal is a NRZ data pattern with any data rate between 12.3 Mb/s and 2.7 Gb/s.

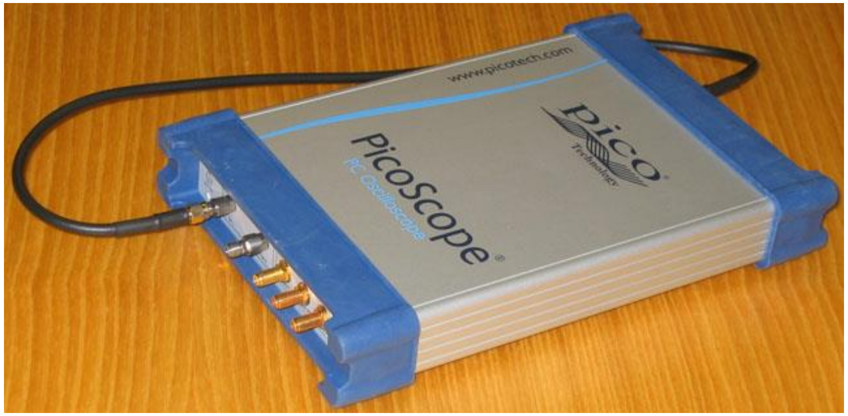
TDR Measurements

Time Domain Reflectometry (TDR) is a method of characterizing a transmission line or network by sending a signal into one end and monitoring the electrical reflections.



TDT Measurements



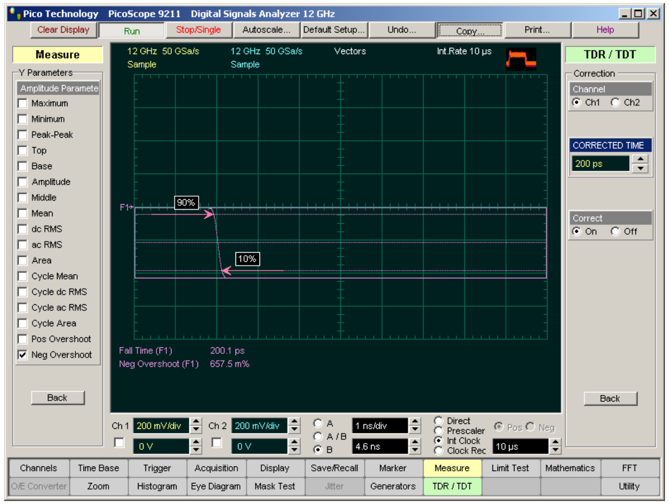


- The internal generator generates an approximately 400-mV negative step.
- As in TDR the Reference Plane is a physical location where the transmission line (the end of 80-cm precision coaxial cable) is connected to the DUT.

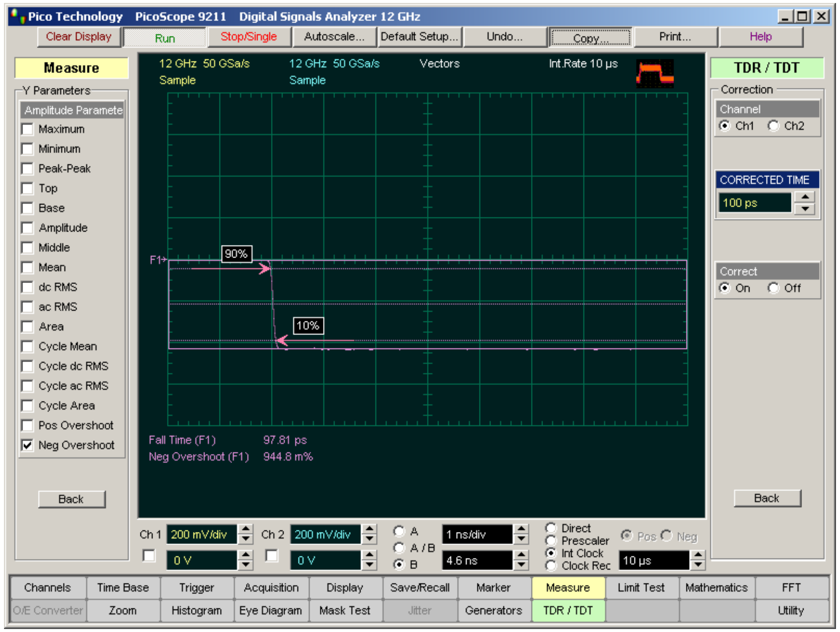
TDR/TDT Correction

- The **Correction** allows you to change the rise time of the corrected step for TDR or for TDT on each of the channels, and also to turn on or off the display of the normalized TDR or TDT trace (function).

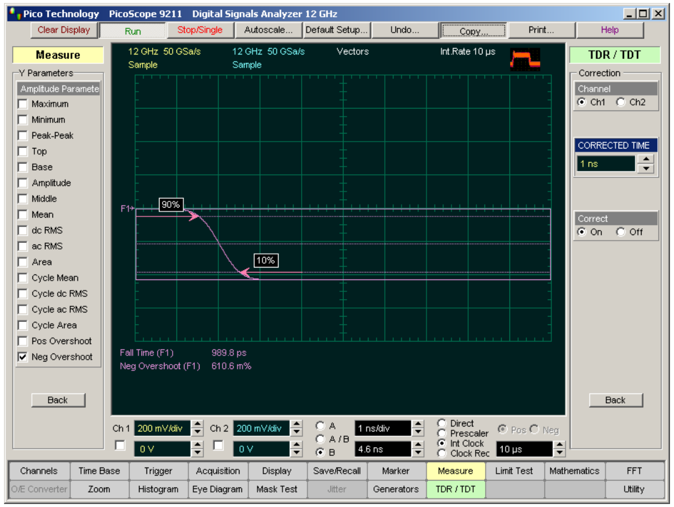
- Correction procedure corrects for sources of measurement errors concerned with TDR response. By using correction, the results become more reliable, repeatable, and accurate. In addition, performing a correction allows the instrument to simulate stimulus steps with different effective rise times. This allows you to view the effect of actual signal rise times on the magnitude of reflections from discontinuities.



- **200-ps normalized time gives 0.7% ringing**



- **100-ps normalized time gives 1% ringing**



- **1-ns normalized time gives 0.6% ringing**

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→ WAVEPRO 7 ZI SERIES, LECROY

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- Infiniium 9000 Series Oscilloscopes, Agilent Technologies
- MSO70000 Series Mixed-Signal Oscilloscopes, Tektronix
- PicoScope 9211 PC Oscilloscopes, Pico Technology
- WaveMaster 830Zi Oscilloscope, LeCroy
- ZT4420, ZT4430, and ZT4440 Series Modular Oscilloscopes, ZTEC Instruments

The End

Thank You for Your time

Questions?

info@picotech.com

Application Notes available @ www.picotech.com