Sampling Oscilloscope Training

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- Olympiaturm -

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Application Engineer

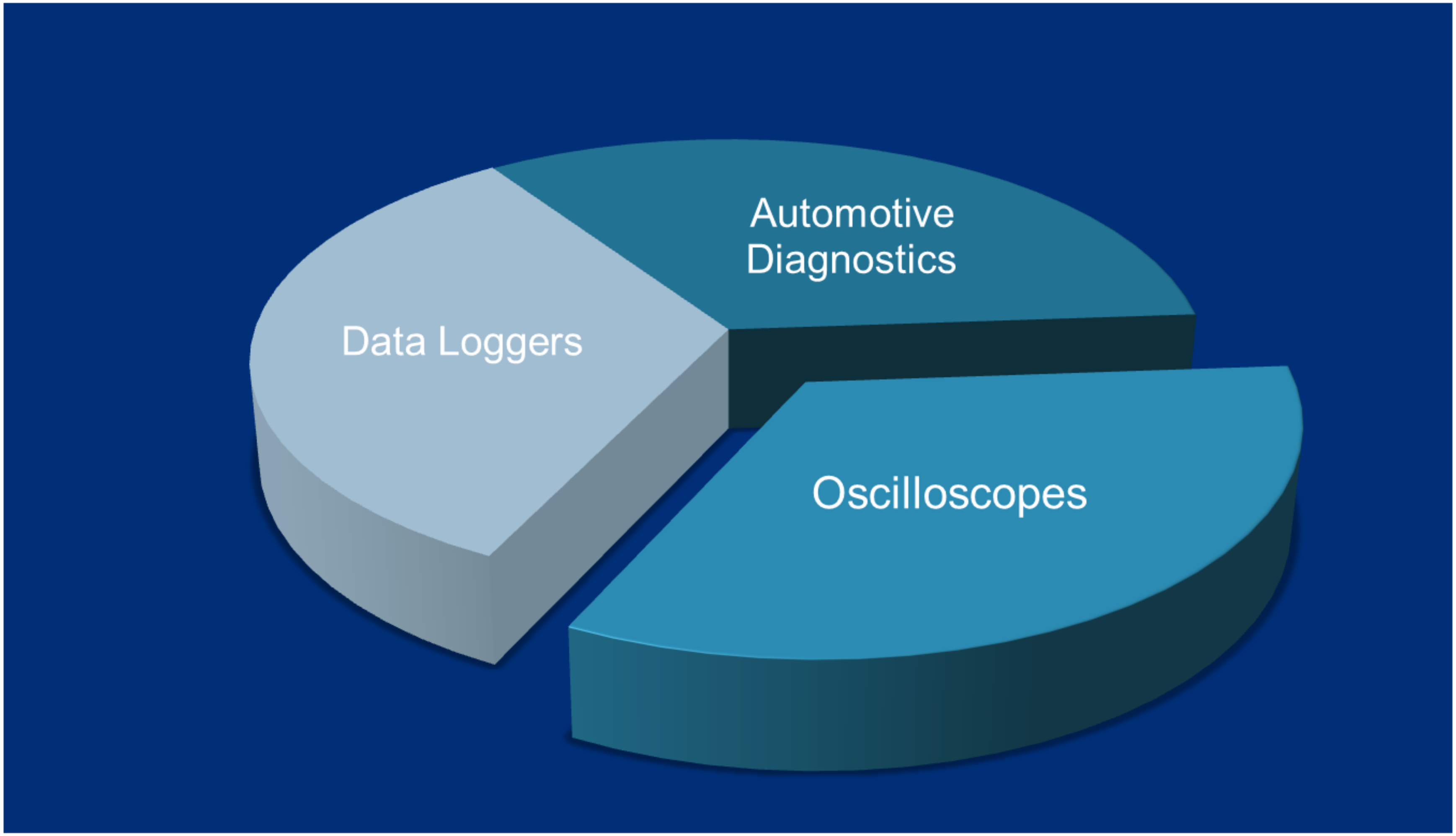
Brief introduction to Pico Technology

• Company Name	Pico Technology Limited
• Founded	1991
• Headquarters	Cambridge, UK
• Distributor in Germany	Meilhaus Electronic GmbH

PUT CONTACT INFO – Chris Stacey

- Here today at Olympiaturm

Pico Technology Product Areas



Introduction to sampling scopes

Real-time scope Vs Sampling scope

Real-time Oscilloscopes

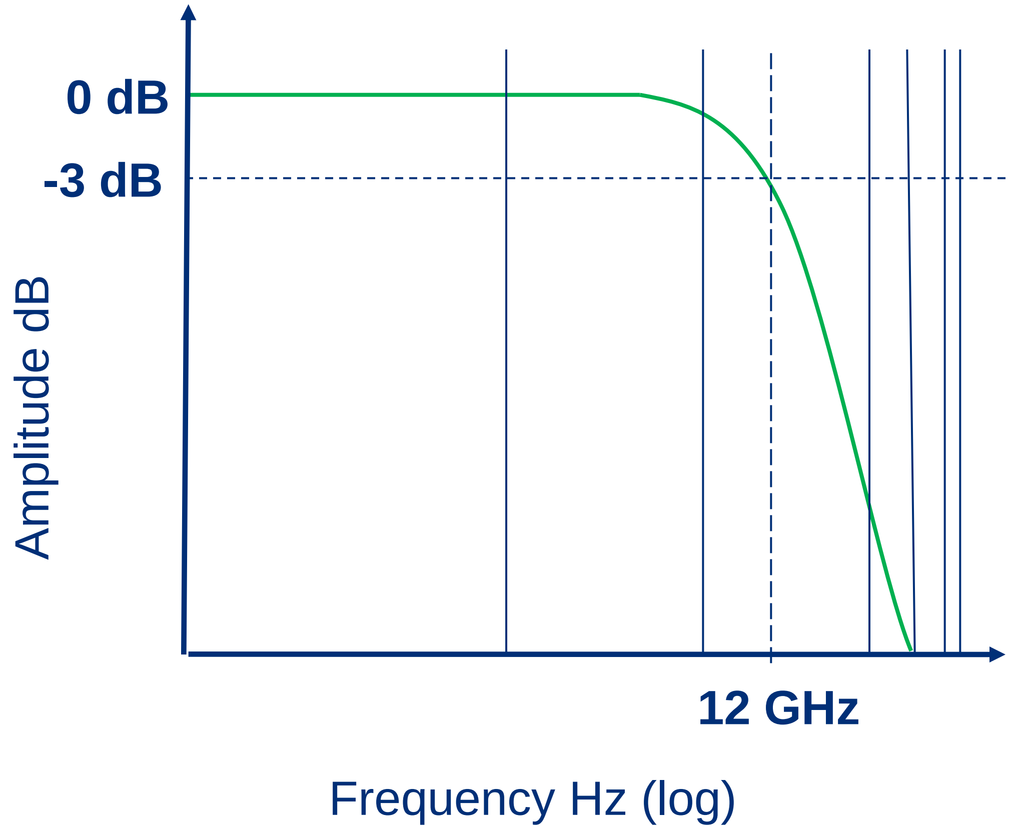
- Can capture single instantaneous or repetitive events
- Lower ADC resolution, but high sample rate increases error
- Long record length
- Advanced triggers to capture intermittent events
- Serial bus decoding
- Ideal for general use and fault diagnosis
- Real-time GS/s sampling is EXPENSIVE

Sampling Oscilloscopes

- Can only capture repetitive waveforms
- Have lower sample rate to increase ADC resolution
- Lower noise floor
- Wider bandwidth for lower budget
- Lower intrinsic jitter
- Eye diagrams and mask testing
- Best choice for TDR/TDT measurement
- Lower cost of ownership

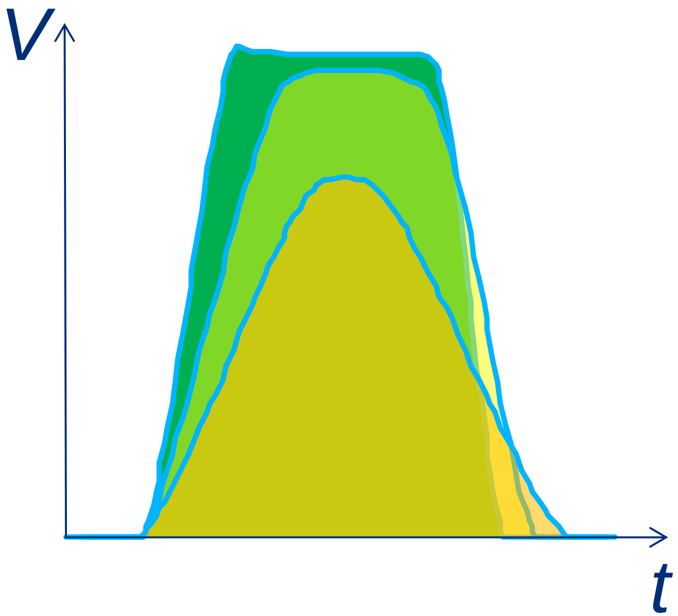
Analog bandwidth

"Analog bandwidth" is the maximum frequency that can pass through the front end of an oscilloscope



Bandwidth and rise time

- Choose a scope with enough bandwidth for the application:
  - Signal transition time
  - Signal slew rate and rise time
- Effects of too little bandwidth:
  - Amplitude and timing errors
  - Loss of high frequency aberrations
  - Errors in automatic measurements



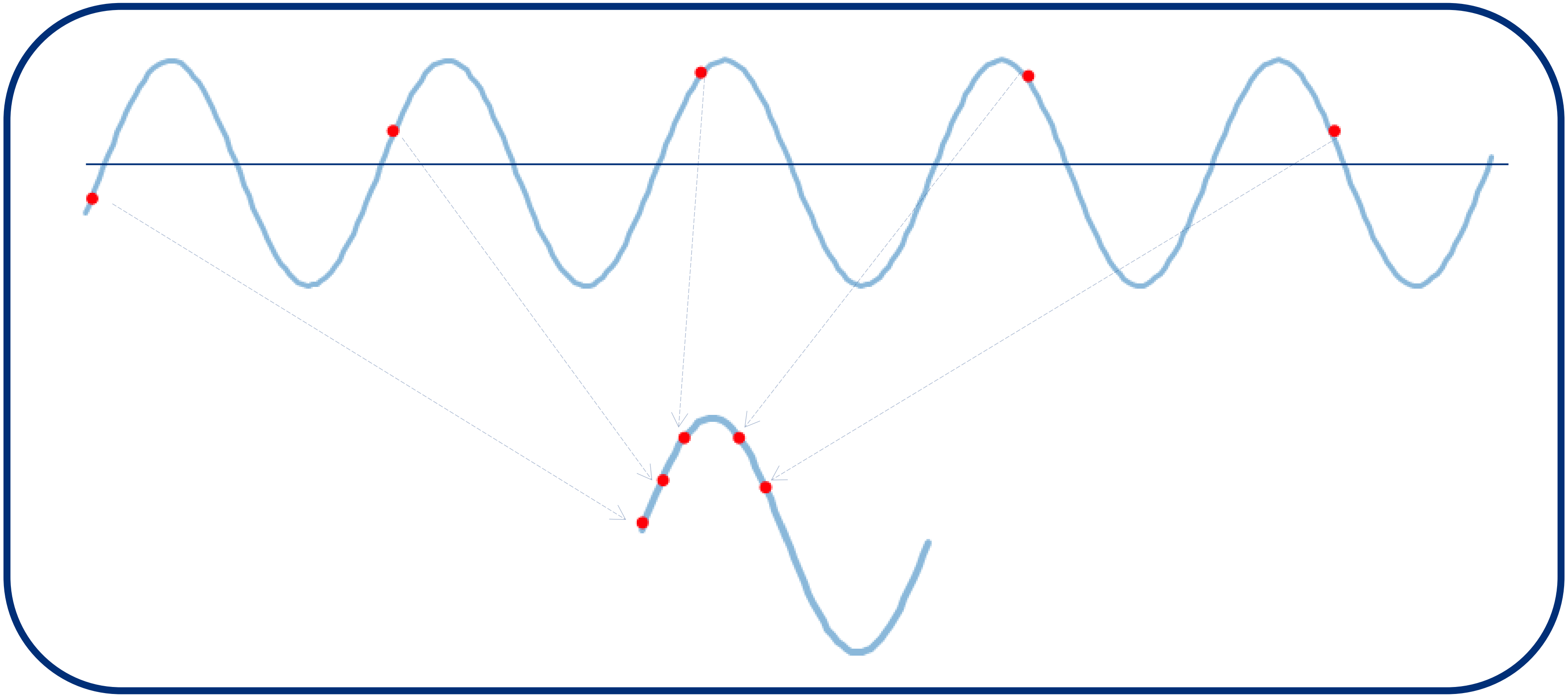
Rule of thumb…

$$BW = \frac{0.35}{t_{rise}}$$

$$t_{rise} = \frac{0.35}{BW}$$

Sampling methods – Equivalent time 1

Sequential Sampling – as used with PicoScope 9000



- Data points are acquired sequentially from many cycles to build one screen image
- PicoScope 9000 sample rate is 200 kS/s, bandwidth is 12 GHz

PicoScope 9000 Applications

SIGNAL ANALYSIS

- Electrical standards compliance testing
- Eye-diagram analysis
- Spectrum analysis
- Statistical analysis

TIMING ANALYSIS

- Automatic parametric measurements
- Pulsed RF switches
- Compliance testing

R & D

- Microwave & RF characterisation
- High-energy physics
- Digital design
- PCB and connector transmission line testing

HIGH-SPEED DIGITAL COMMUNICATIONS

- Design and verification of telecom and datacoms elements
- Manufacturing and testing for ITU / ANSI conformance
- Crosstalk analysi
- TDR/TDT

SEMICONDUCTOR TESTING

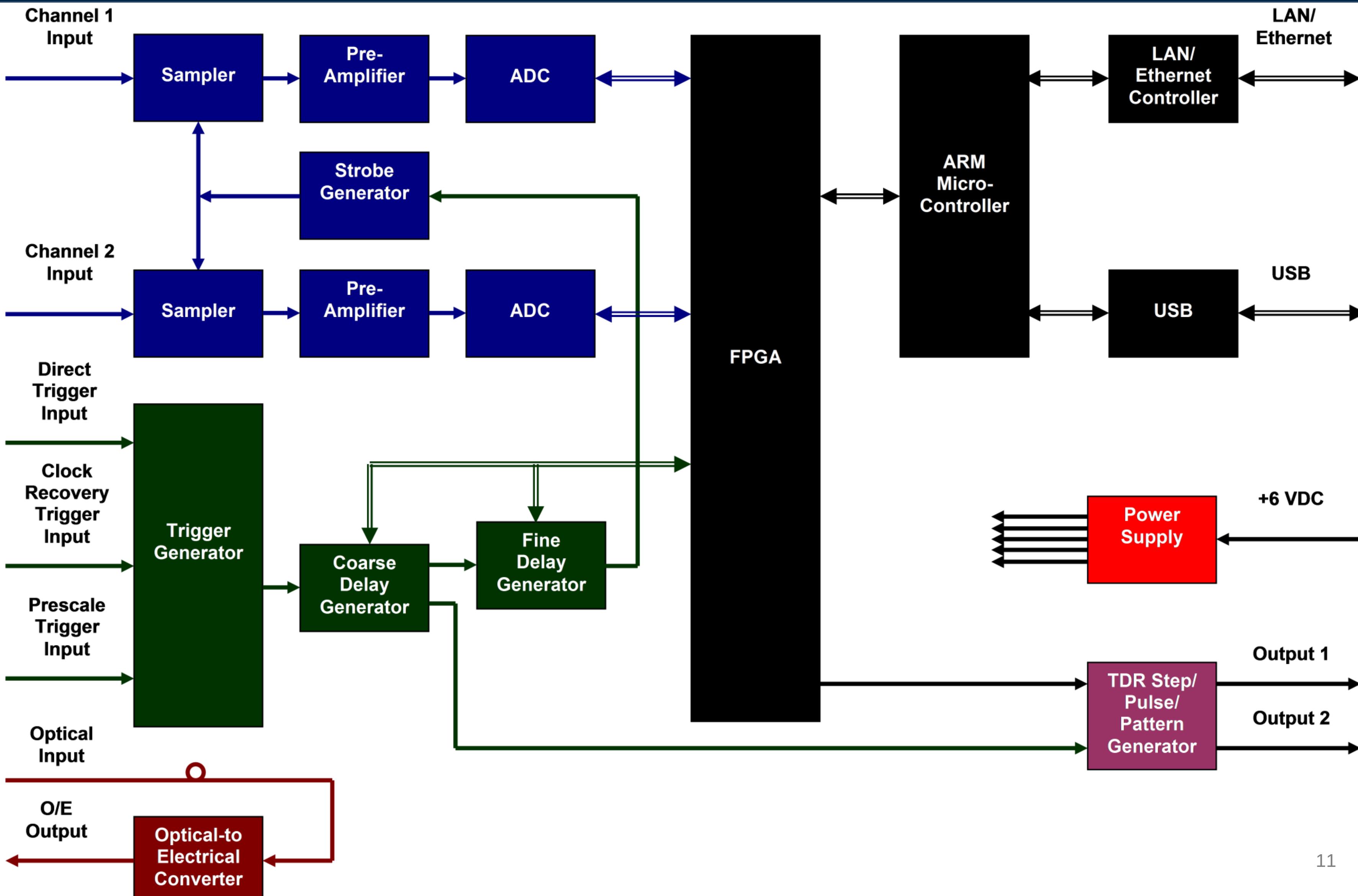
- Microwave & RF characterisation
- High-energy physics
- Digital design
- Informative waveform displays

MANUFACTURING

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

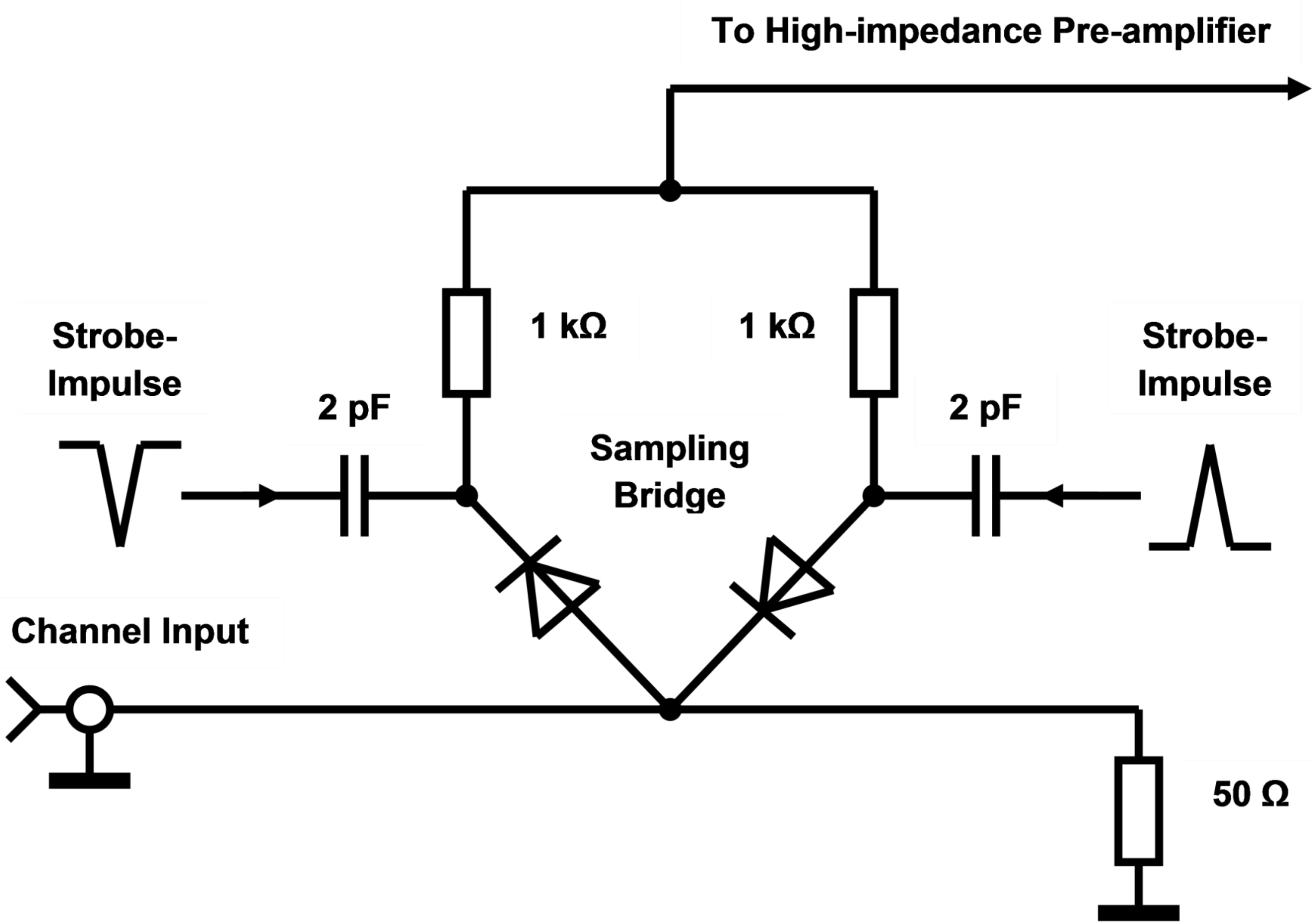
PicoScope 9000

PicoScope 9000 Block diagram

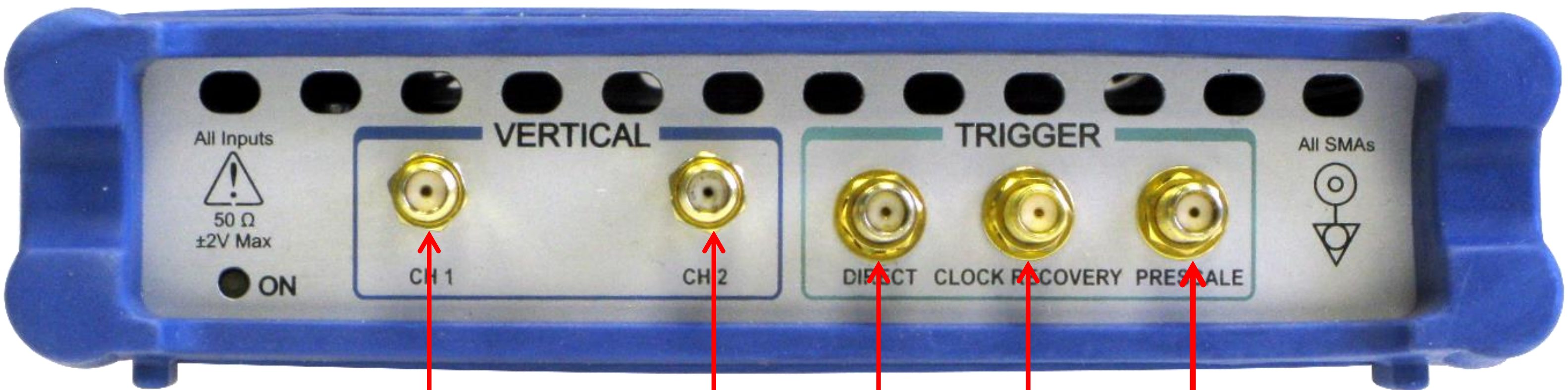


Block Diagram of the PicoScope 9000.

Sampling Diodes



PicoScope 9211A front panel



Electrical inputs

Prescaled trigger

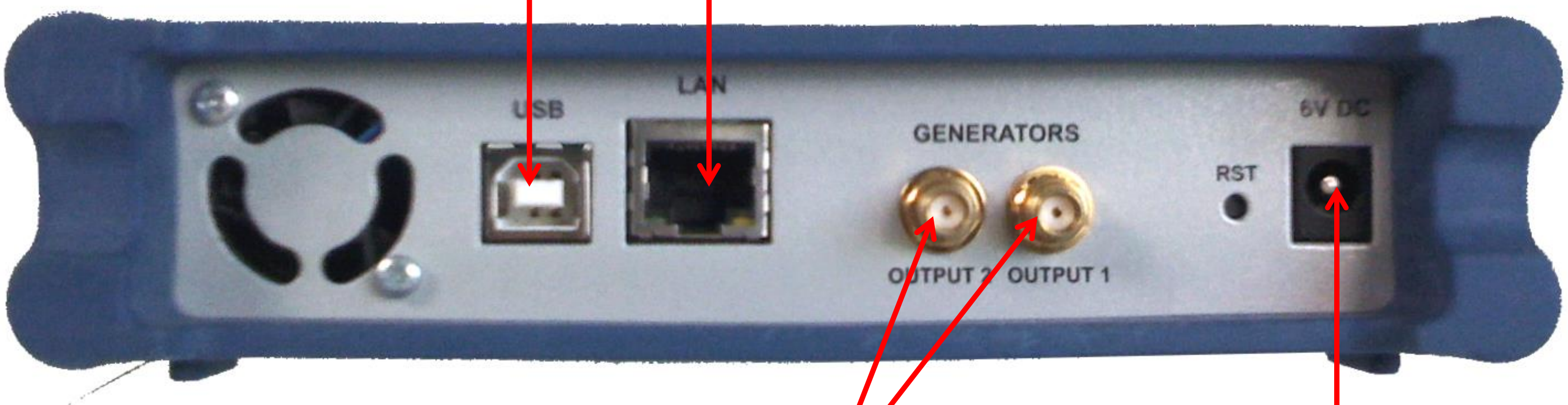
Clock recovery trigger

Direct trigger

PicoScope 9211A rear panel

USB Connection

Ethernet Connection



Multifunction signal generators

DC Power input

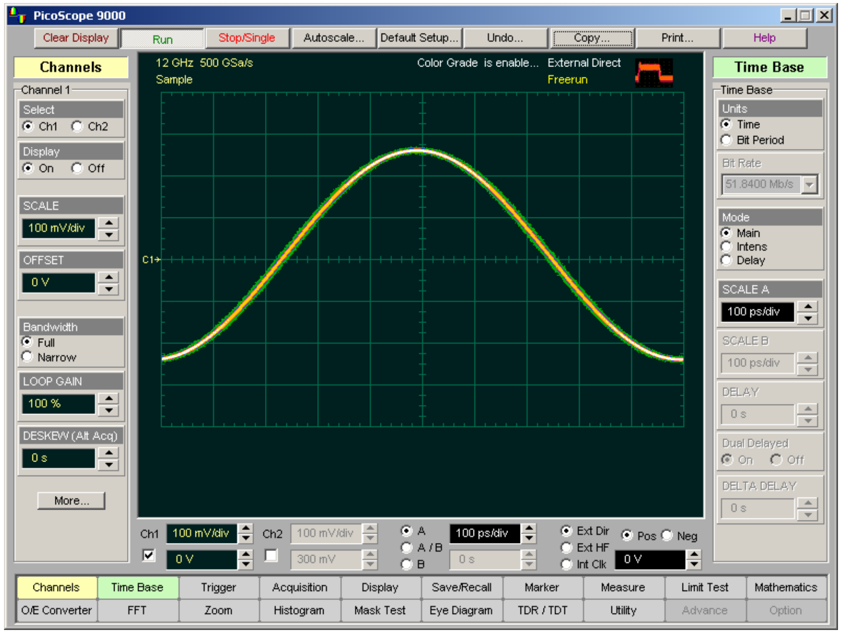
Direct Trigger

Equipment connections for Direct Trigger Test

The power of wide-bandwidth sampling oscilloscopes is largely useless without fast, low-jitter triggering.

Key specifications of Direct Trigger:

- DC to 1 GHz trigger bandwidth
- 100 mV p-p DC to 100 MHz, 400 mV p-p at 1 GHz sensitivity
- <3.5 ps max RMS jitter

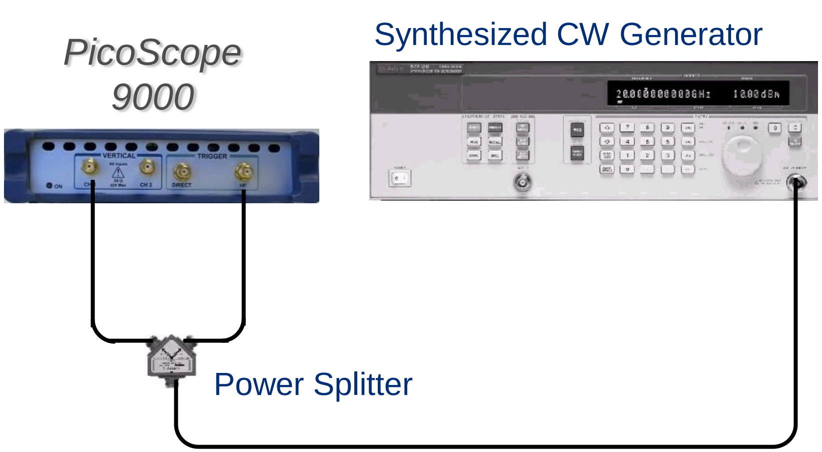


Typical picture of a 1 GHz signal using Direct Trigger

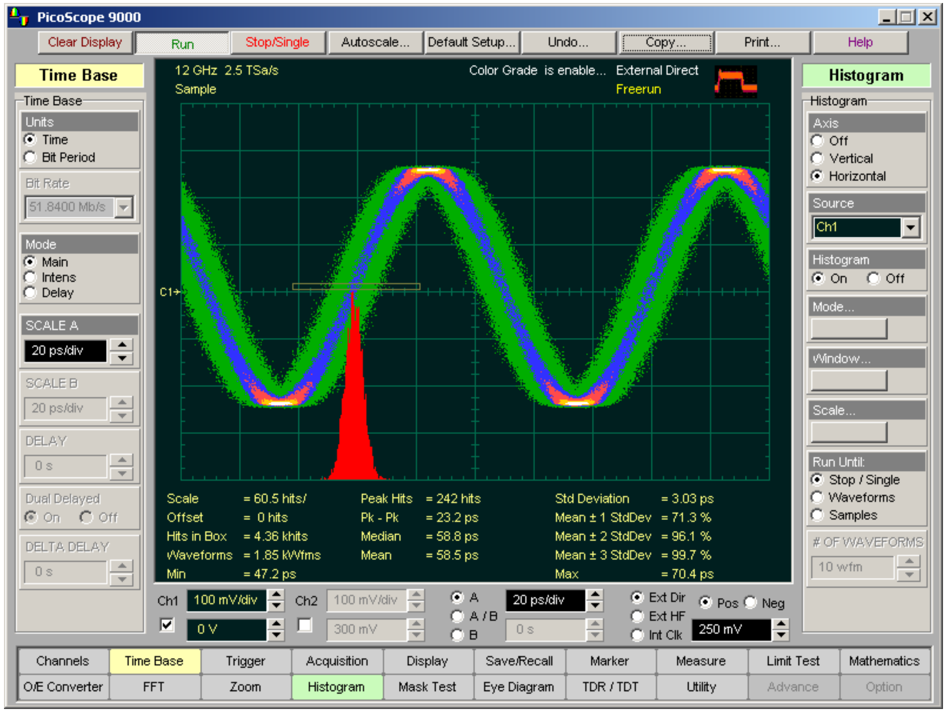
HF Prescaled Trigger

The PicoScope 9000 HF (prescaled) trigger is an AC-coupled 10-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 <3.5 ps typ. is possible.



Equipment connections for prescaled trigger test

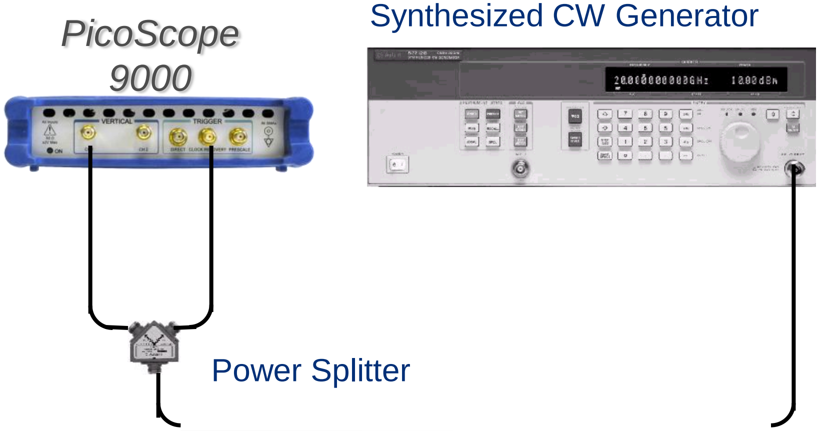


A 10 GHz sine-wave signal with prescaled trigger

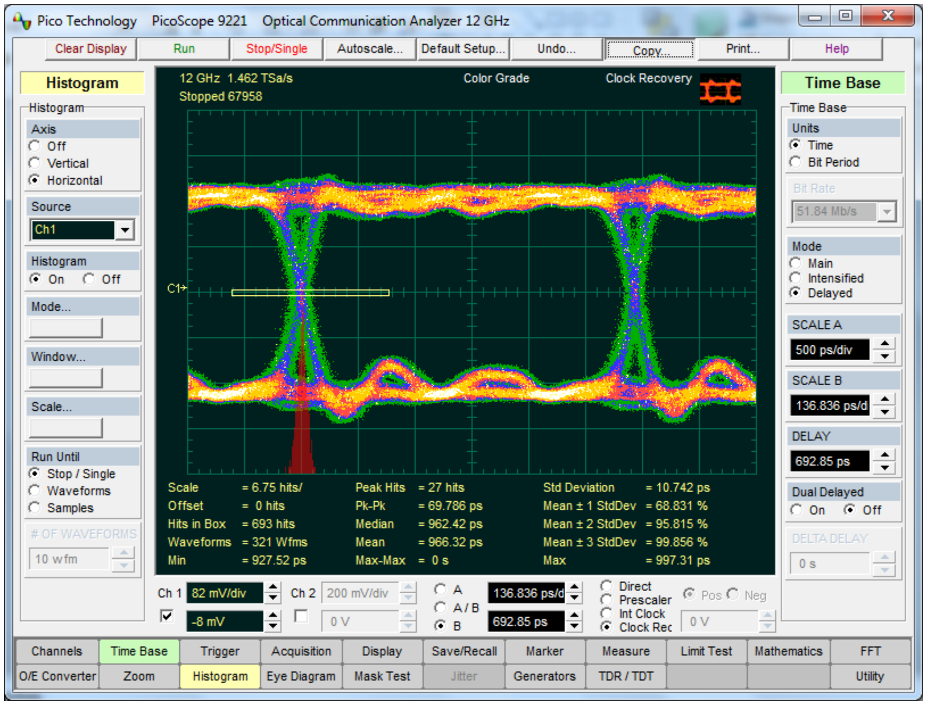
Clock recovery trigger

Use when the trigger source is an NRZ signal (without a dedicated trigger input) input with a data rate between 12.3 Mb/s and 2.3 Gb/s

Recovered Clock RMS Trigger Jitter, maximum: *1 ps + 1.0% of Unit Interval*



Equipment connections for clock recovery trigger test



A 1.25 GB/s pattern using clock recovery trigger

Pattern sync trigger

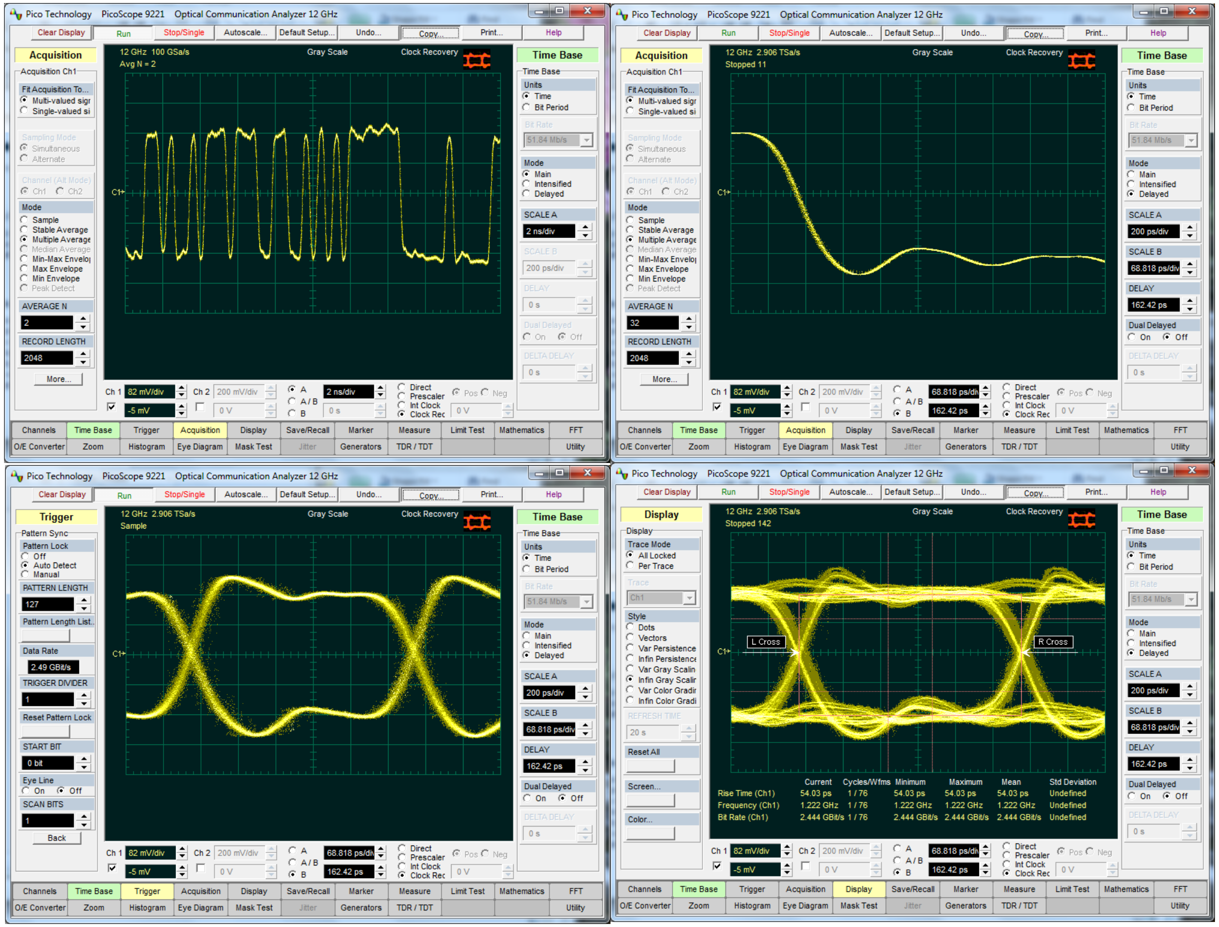
Use pattern sync menu to provide pattern lock trigger, and generate an eye line.

Pattern Lock Trigger:

…is the ability of the PicoScope 9000A to internally generate and lock onto a pattern trigger.

Eye line:

…is used to average eye diagrams and to view specific bit trajectories. The **Eye Line** mode uses the pattern lock feature to establish a pattern sync trigger and then to use that trigger to walk through each bit of the data pattern

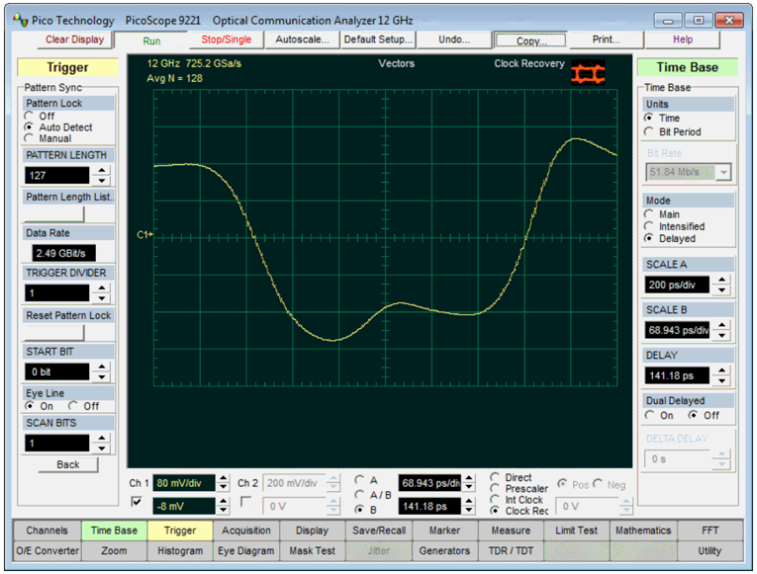


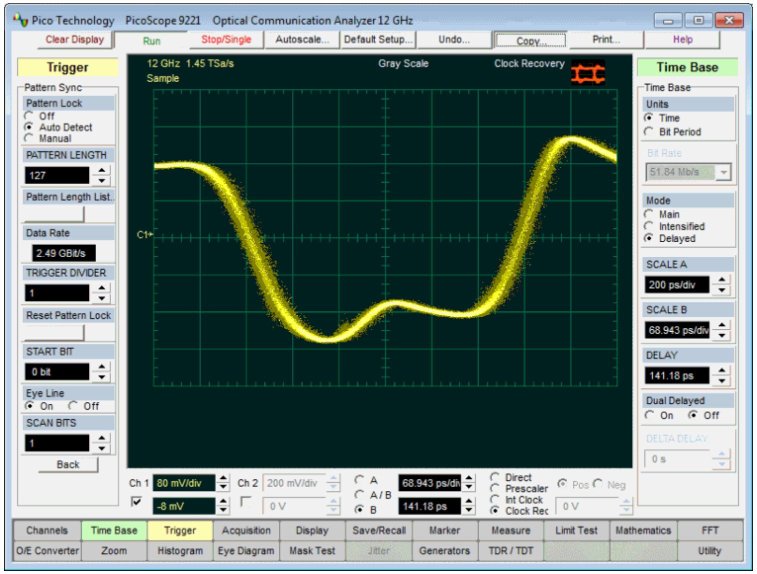
Building an eye diagram

The eye diagram is valuable for giving a comprehensive view of all signal integrity faults (except clock jitter):

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

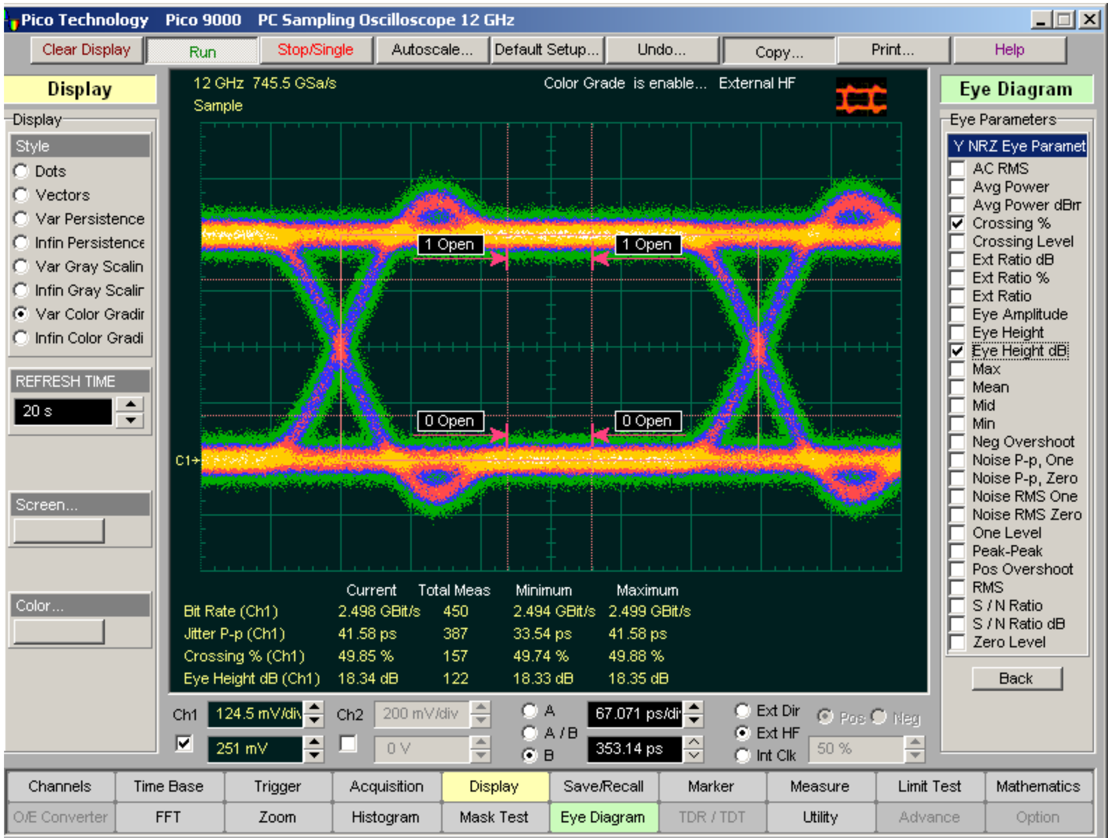
The process of building an eye diagram includes serial acquisitions of the waveform database





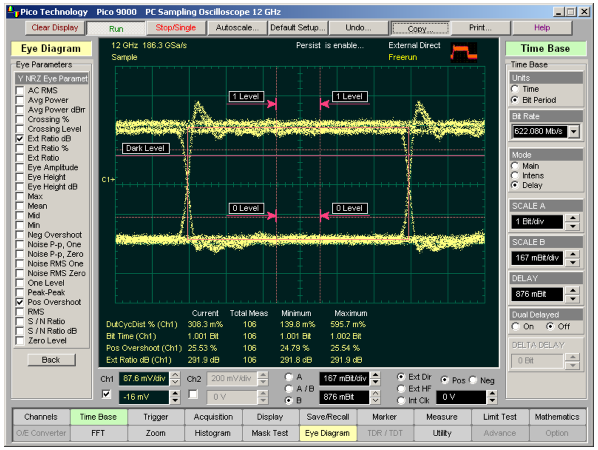
NRZ Eye Diagram Measurements

The PicoScope 9000 quickly measures 42 fundamental parameters used to characterise non-return-to-zero (NRZ) signals. Up to four parameters can be measured simultaneously.



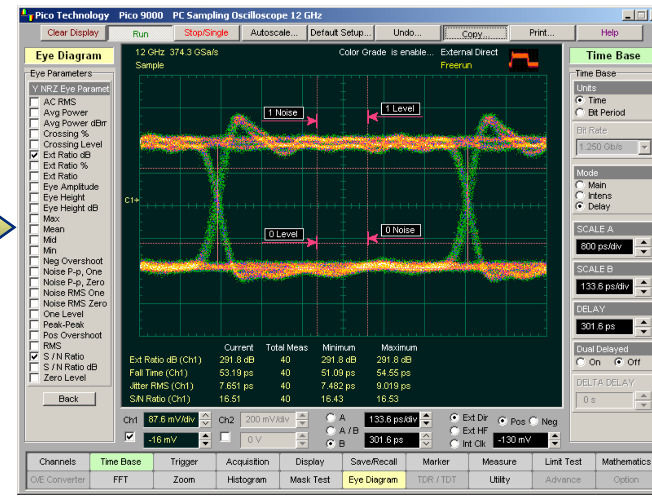
The PicoScope 9000 displaying 4 automatic measurements on a 2.5-Gbit NRZ eye diagram

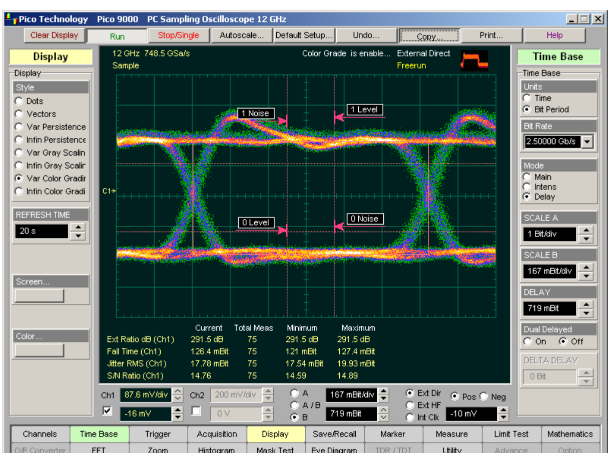
Examples of NRZ Measurements



Measurement of 622-Mbit eye diagram

Measurement of 1.25-Gbit eye diagram

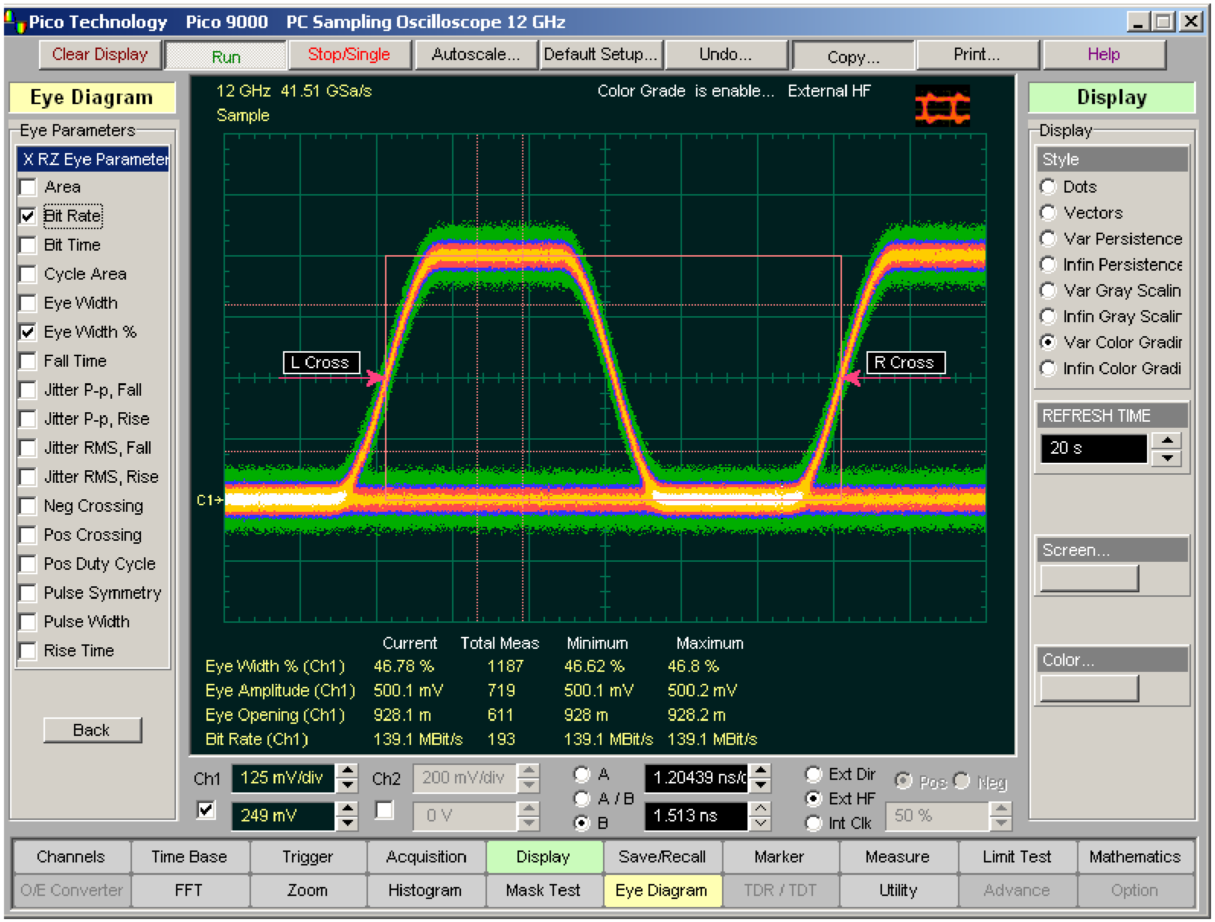




Measurement of 2.5-Gbit eye diagram

RZ Eye Diagram Analysis

The PicoScope 9000 quickly measures 43 fundamental parameters used to characterise return-to-zero (RZ) signals. Up to four parameters can be measured simultaneously.



The PicoScope 9000 measuring a 139-Mbit RZ eye diagram

Mask Test

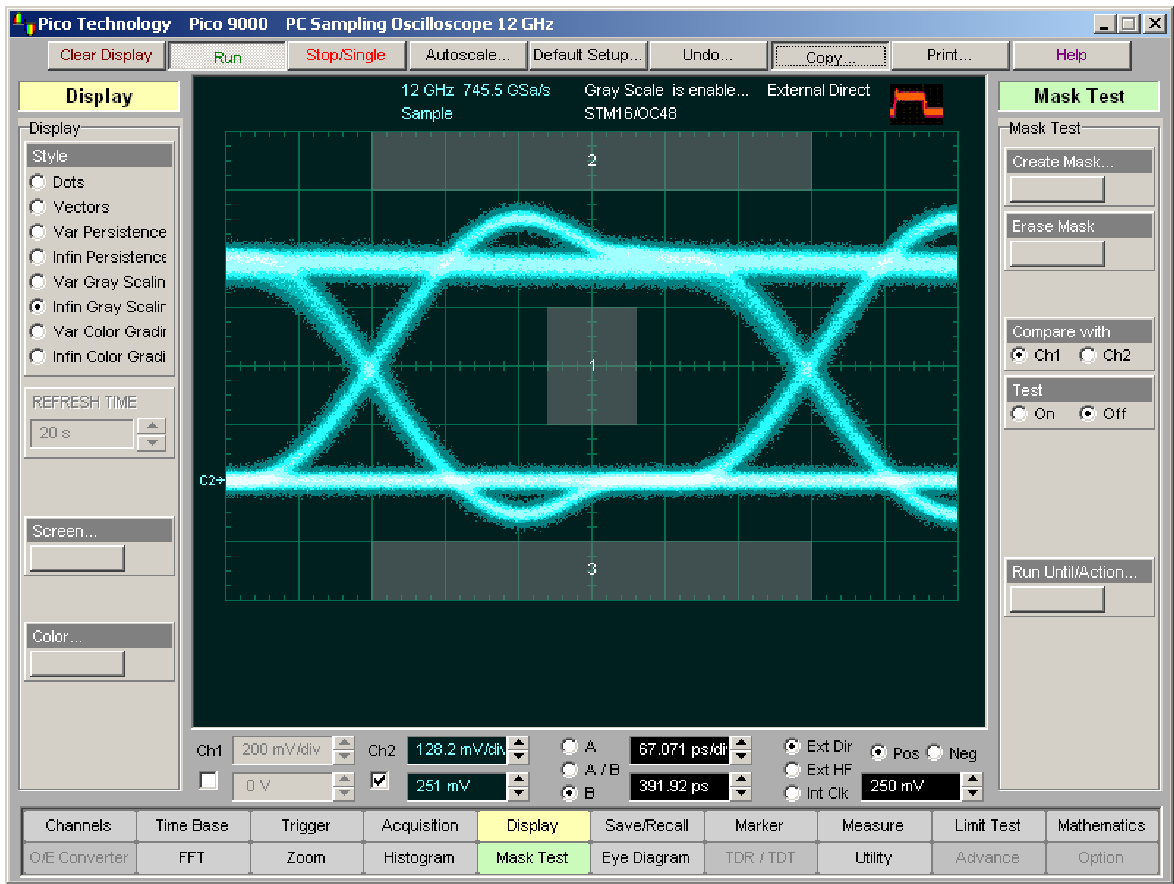
For eye-diagram masks, such as those specified by the SONET and SDH standards, the PicoScope 9000 supports on-board mask drawing for visual comparison. The display can create grey-scaled or colour-graded displays to aid in analysing noise and jitter in eye-diagrams.

Mask test quickly characterises:

- Noise
- Jitter
- Aberrations
- Rise time
- Fall time

The on-board mask drawing capability allows simple, operator-independent visual comparison of signal with standard mask.

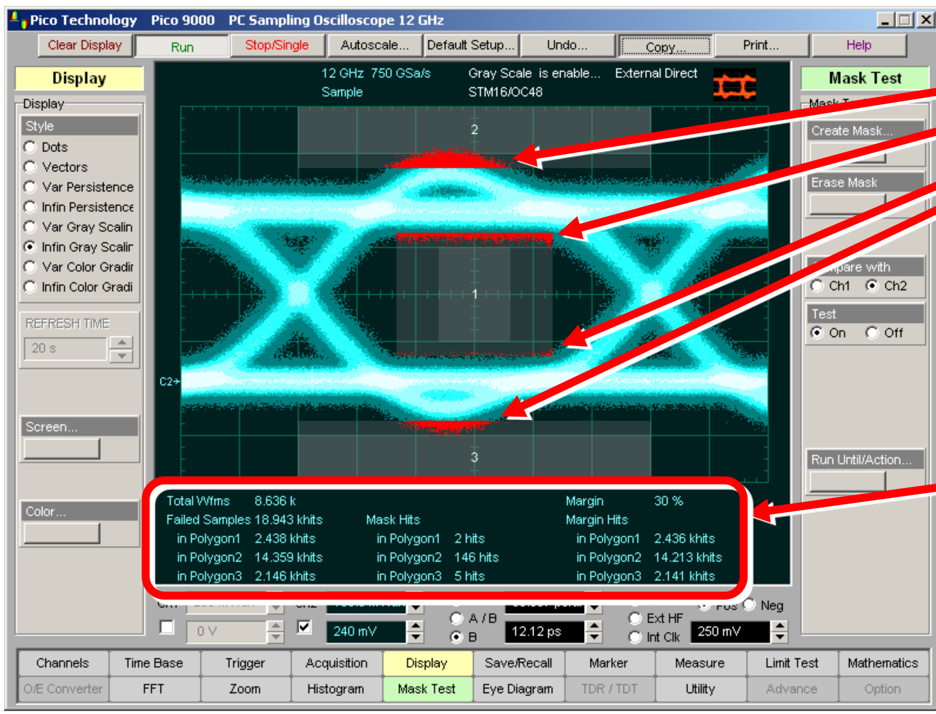
SONET/SDH (OC64/STM16) signal compared with the standard mask, showing a compliant waveform



Mask Margins

Mask margins are used to determine the margin of compliance for a standard or scaled mask.

The PicoScope 9000 goes beyond basic testing with mask margin analysis for process monitoring.



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

Mask hits/failures are easily viewed with red pixels

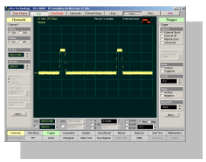
Mask test results show:

- Total waveforms
- Failed samples
- Mask hits
- Mask margin value
- Margin hits
- Margin hits in polygon

Measurements and Tests

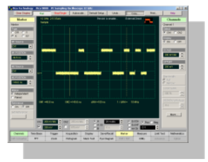
Types of Measurements

Graticule Measurements



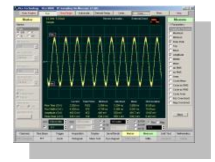
10 by 8 display graticule with Grid, Axes, Frame and Off options

Marker Measurements



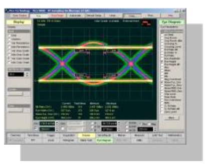
Two X, Y, or XY markers provide absolute, delta or ratiometric measurements

Pulse Measurements



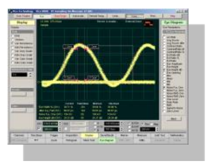
19 Amplitude, 29 Timing and 5 FFT measurements can be performed automatically

NRZ Eye Measurements



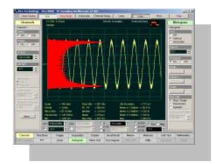
Measurement list includes 42 NRZ eye parameters

RZ Eye Measurements



43 automatic measurements are built for characterisation of RZ signals

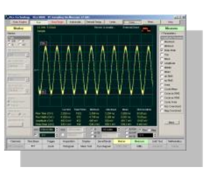
Histogram Measurements



Up to 15 statistical measurements of vertical and horizontal histograms

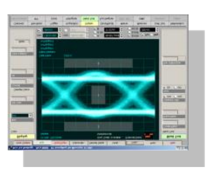
Types of Measurement Test

Limit Test



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

Mask Test

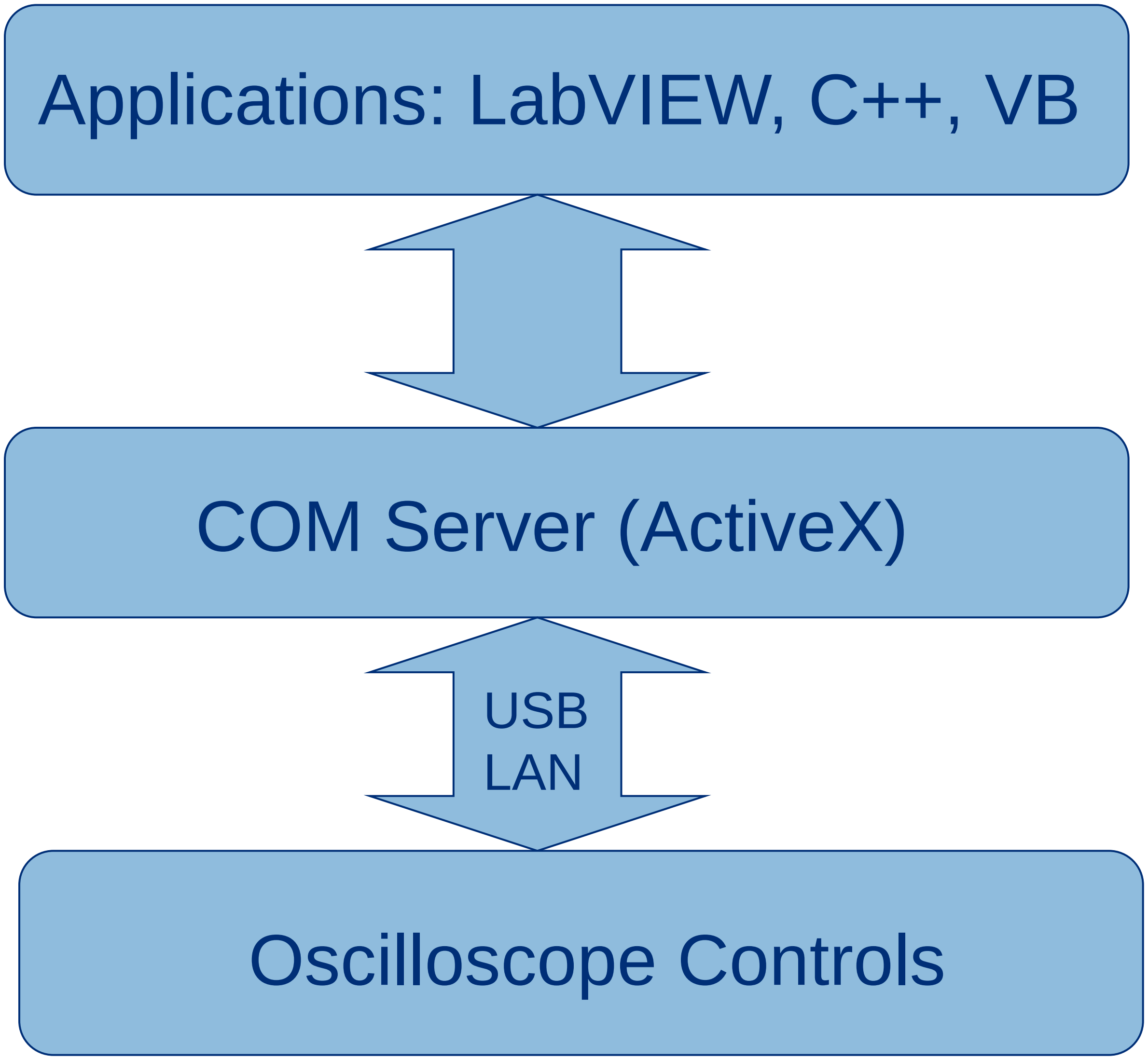


Standard, auto or custom masks can be used for mask test

Mask Margin Test

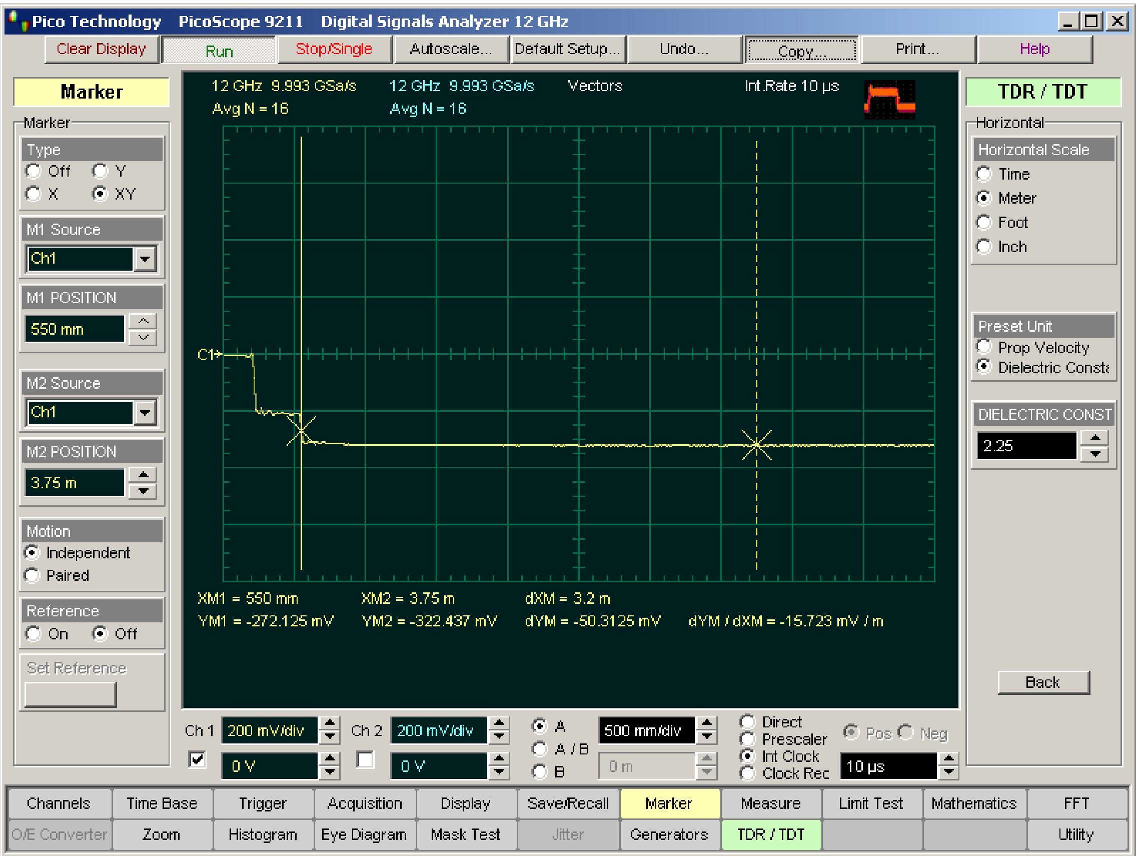
Test is used to determine the margin of compliance for a standard or scaled mask

Programming the scope



TDR/TDT 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.



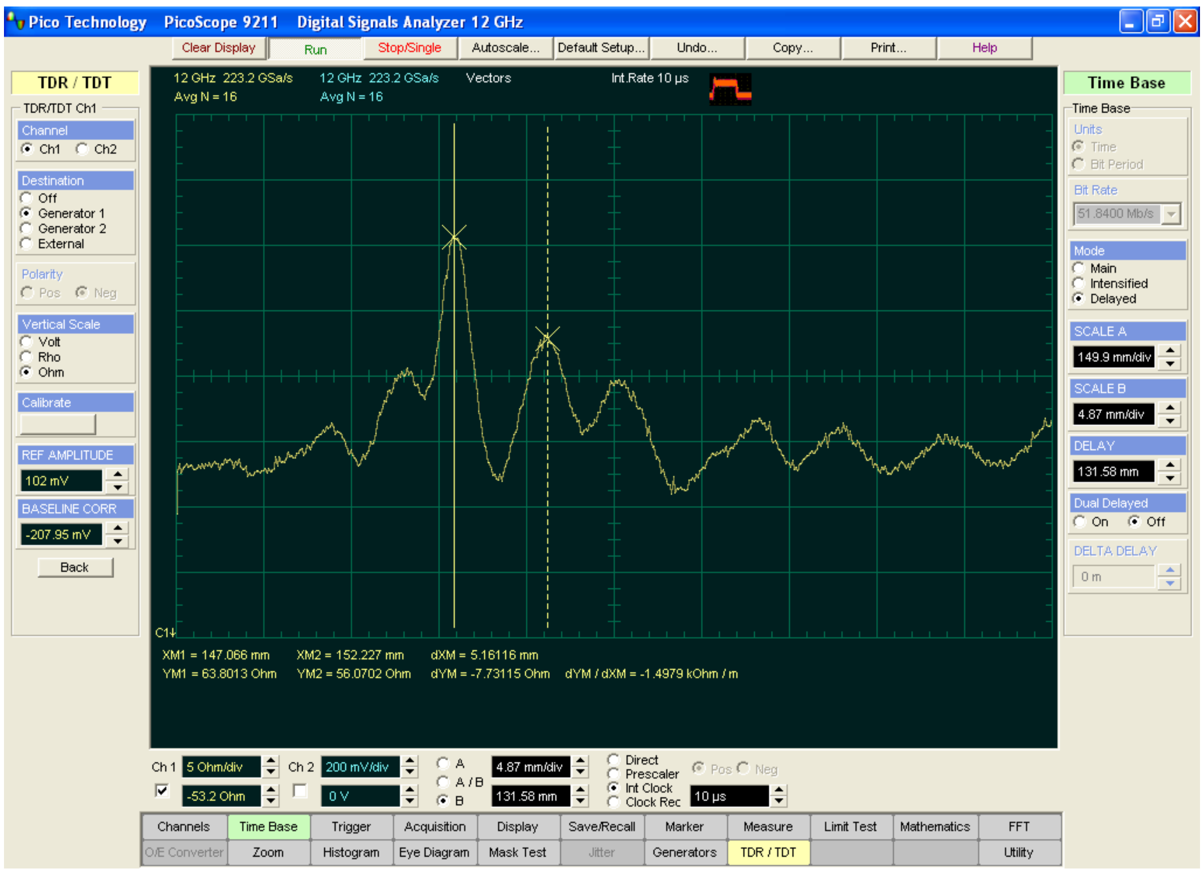
An example of Z-profile of transmission line. Both markers provide distance and Ohm measurements

A TDR step can also be used to make Time Domain Transmission (TDT) measurements. TDT is a technique that allows you to measure the response of a system by sending steps through a device and monitoring the output of the device.

The measurements are made on signals transmitted through the device, rather than reflections from the device (as in TDR).

TDR/TDT applications

TDR response from analyzing a PCB, showing three vias 5mm apart



PicoScope 9000 Specifications

VERTICAL
- DC to 12 GHz bandwidth
- 29.2 ps rise time
- Two channels
- ±2 % vertical gain accuracy
- 16-bit vertical resolution
- <2.0 mV RMS noise
- ±1 V input range

HORIZONTAL
- Dual timebase 10 ps/div to 50 ms/div
- ±0.2% ±15 ps time interval accuracy
- <200 fs sampling interval
- Up to 4 k-point/channel buffer size

TRIGGER
- DC to 1 GHz full direct trigger
- 10 GHz prescaled trigger
- <3.5 ps RMS jitter
- 2.7 GHz Clock recovery
- Pattern sync trigger

OPERATIONAL
- Power consumption: 15 W max
- Weight: 1 kg
- Size: W170 x H40 x D255 mm

TDR/TDT
- Two channels
- Vertical scales: Volts, Rho (2mrho/div to 2 rho/div), Ohm (1 ohm/div to 100 ohm/div)
- Horizontal scale: Time or distance (Meter, Foot, inch)
- TDR stimulus from internal or external generators

Signal Generators (9211A)
- Modes: Step, Coarse timebase, Pulse, NRZ and RZ
- 100 ps risetime (typ) for Step (TDR)

MEASUREMENTS and ANALYSIS
- High-resolution cursors, automatic waveform measurements, statistics and pass / fail limit tests
- Waveform processing including FFT with five FFT windows

UTILITY
- Autoscale
- Automatic calibration
- Windows XP, Vista and Windows 7
- Built-in information system using Windows Help

Question and answers