Trevor Smith
Pico Technology

Physical layer validation of high-performance backplanes, connectors, cables and high speed serial data systems using a sampling oscilloscope

Agenda

- Introduction
- Oscilloscope types, applications and costs
- Sampling oscilloscopes
- Signal Integrity Measurements
  - Frequency / Bit Rate / Jitter / Noise / Eye Analysis
- TDR / TDT Introduction
- Optical
- Questions

Introduction

Critical Signal Integrity (SI) considerations for high speed digital designs

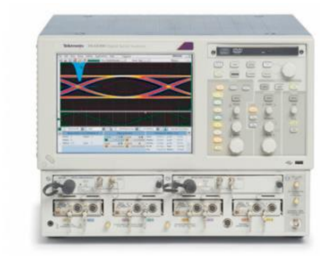
- PCB layout
- Backplane design
- Connectors
- External interfaces
- Component performance
- Compliance and interoperability with industry standards

High Bandwidth Oscilloscopes

Real-time Oscilloscopes

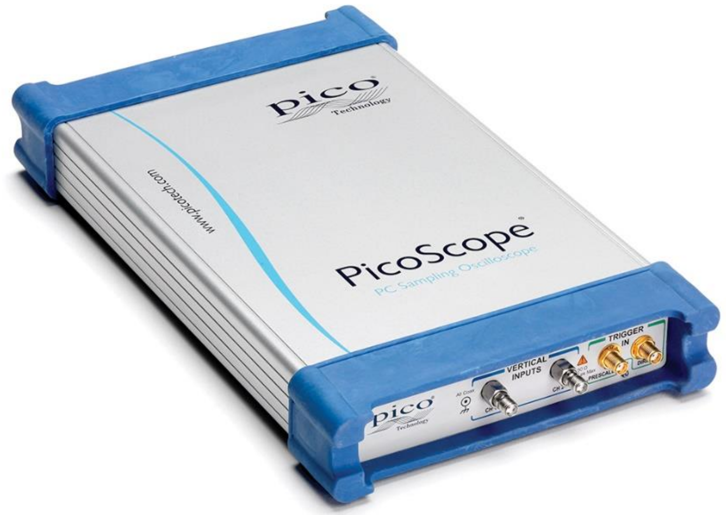
- Can capture single instantaneous or repetitive events
- 8-bit ADC resolution, but lower effective bits at high frequencies
- Deep buffer memory
- Advanced triggers & display modes to capture intermittent events
- Serial bus decoding
- Ideal for general use and fault diagnosis
- Real-time GS/s sampling is ***expensive***: ~ $200K for 20 GHz

Sampling Oscilloscopes



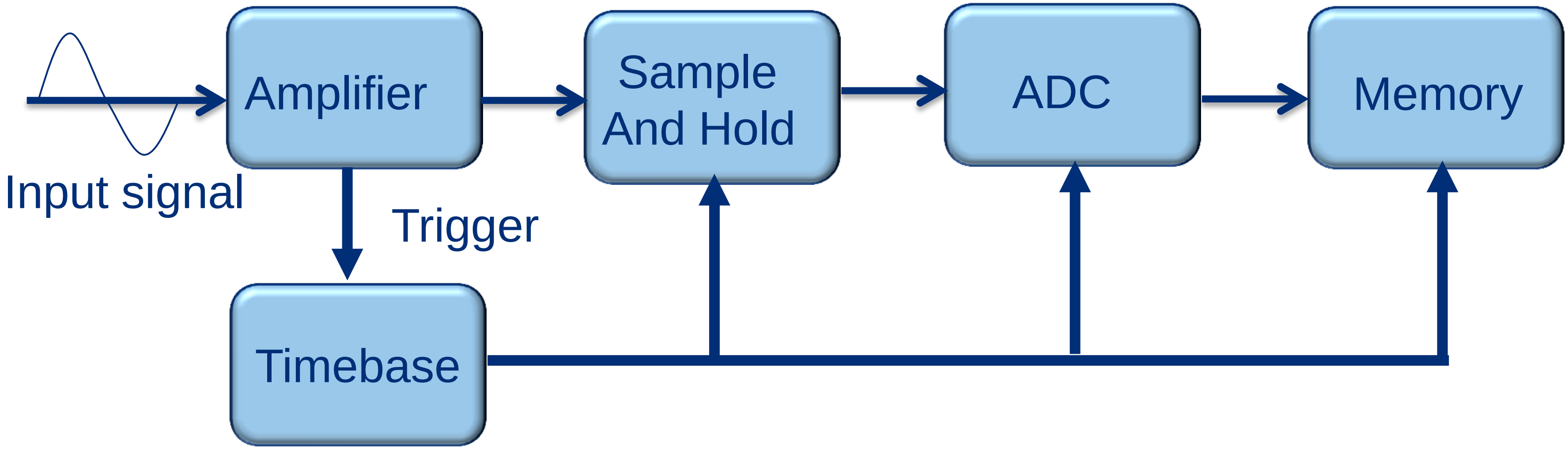
- Can capture cyclic signals & repeating patterns at steady data rate
- Short buffer memory
- Low sample rate
- Lower intrinsic jitter and noise
- Eye diagrams and mask testing
- Best choice for TDR/TDT
- Lower, but still significant cost: ~ $50K for 20 GHz

PicoScope PC-based instruments

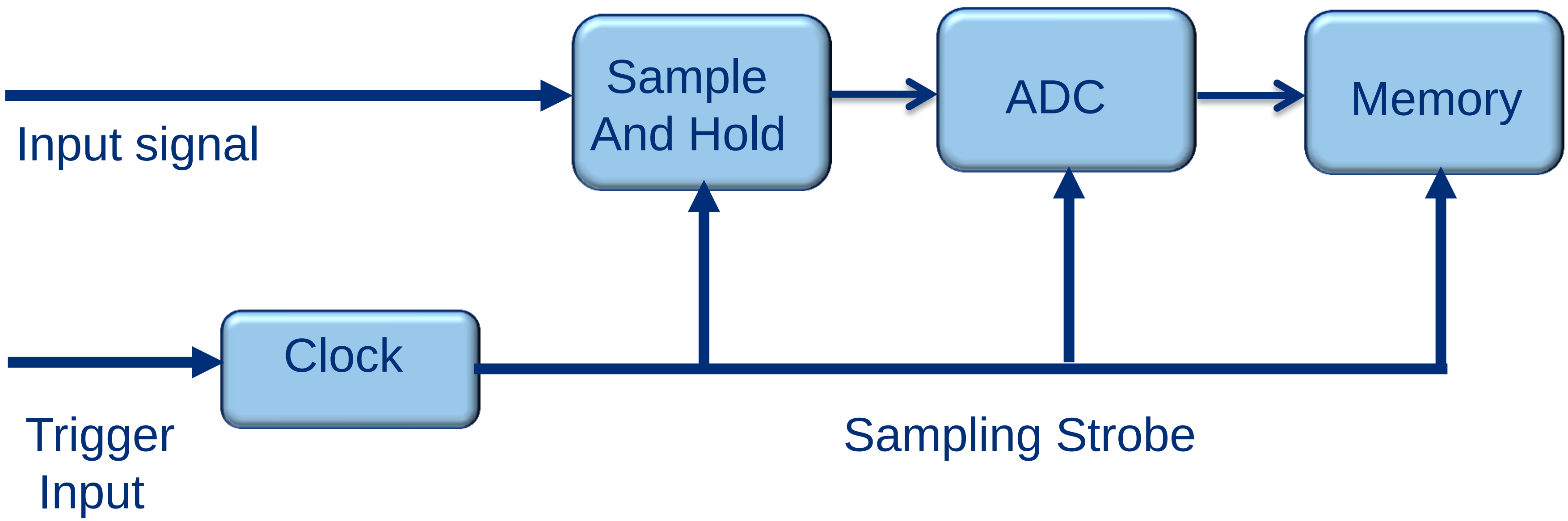


PicoScope 9300

- 20 GHz bandwidth
- 2 channels
- Built-in pattern generator
- Automated measurement tools and analysis of clock, data and eye diagrams mask testing
- Models with:
    - Clock recovery to 11.3 Gb/s
    - Differential TDR/TDT with 40 ps edge
    - Optical
- Low cost: 20 GHz for $15K

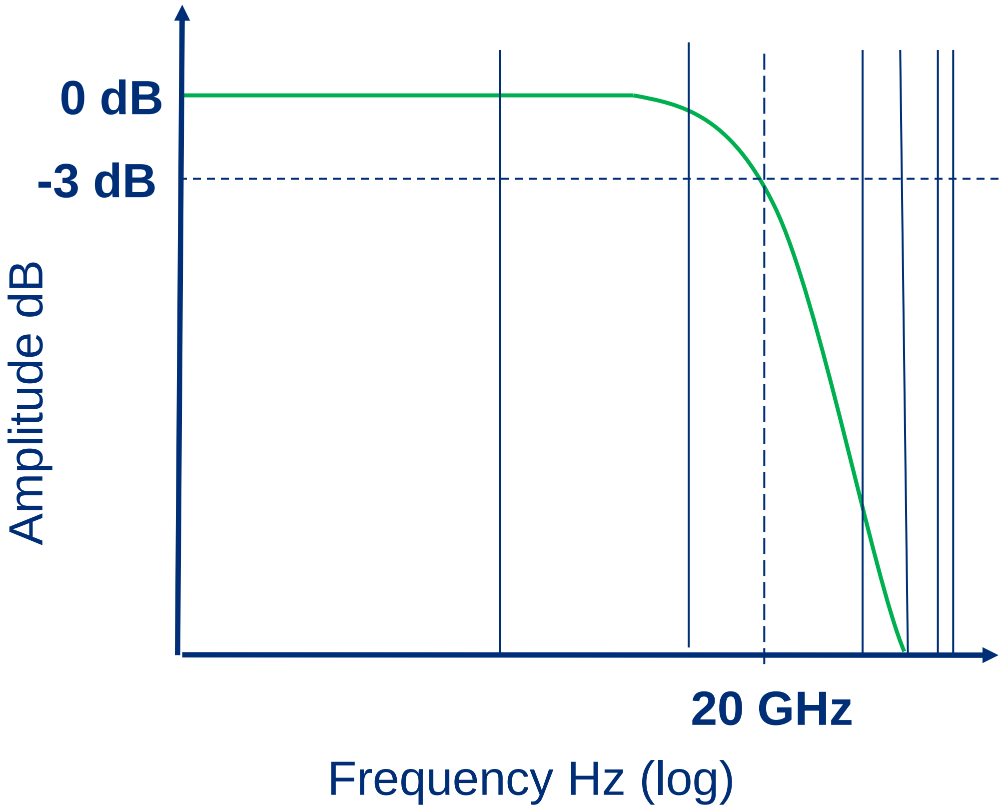


Real-time Digital Oscilloscope



Sampling Oscilloscope

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



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

Bandwidth and Data Rate

Calculating bandwidth from data rate:

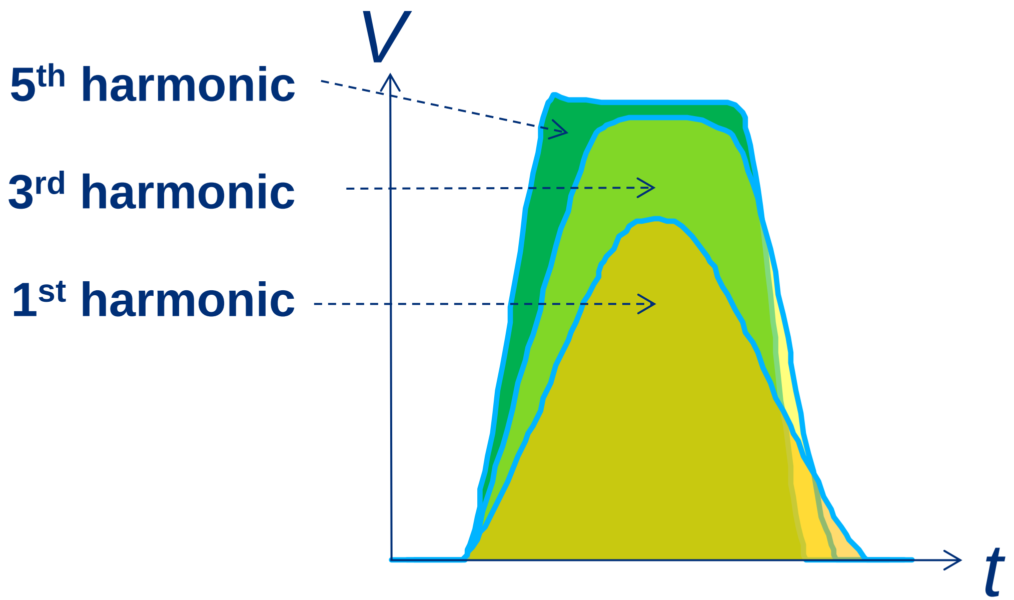
$$3^{rd}\text{ Harmonic} = 3 \times \frac{\text{Bit rate}}{2}$$

$$5^{th}\text{ Harmonic} = 5 \times \frac{\text{Bit rate}}{2}$$

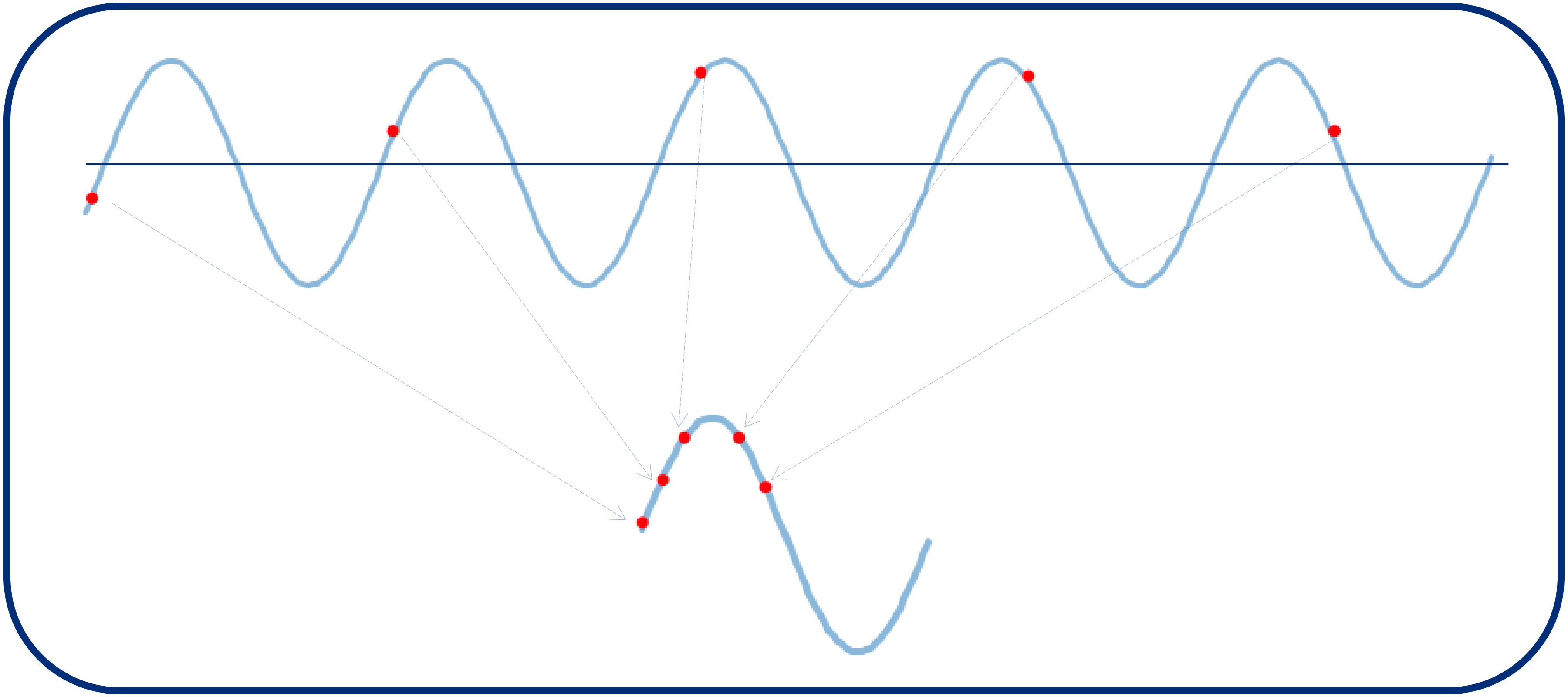
Application example

PCIe R1.0a has a data rate of 2.5 Gbps (1.25 GHz frequency)

Bandwidth required to see 5 harmonics is 1.25 GHz x 5 = **6.25 GHz**



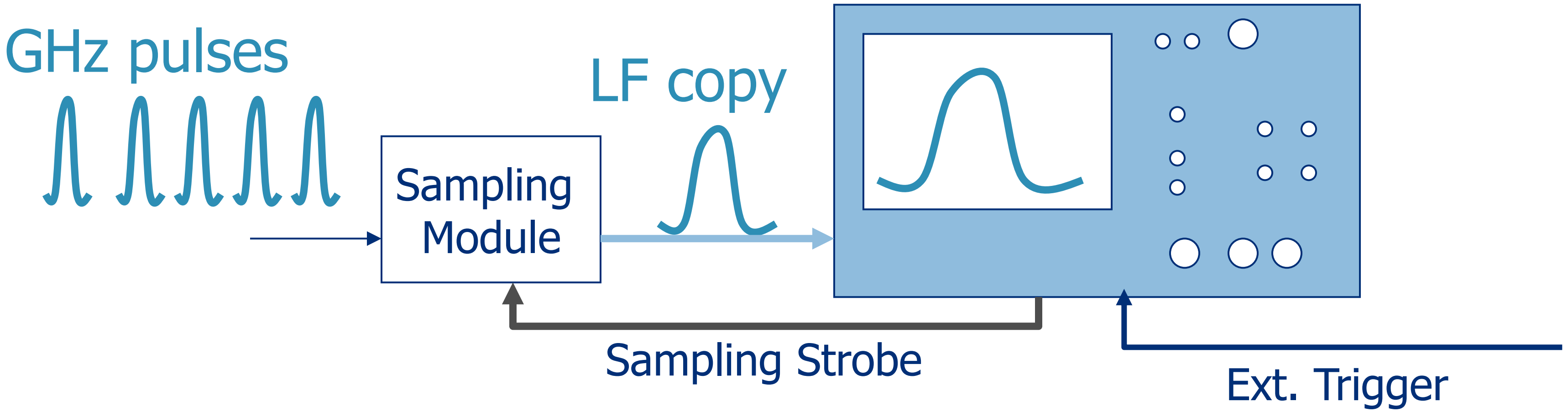
Sequential Sampling



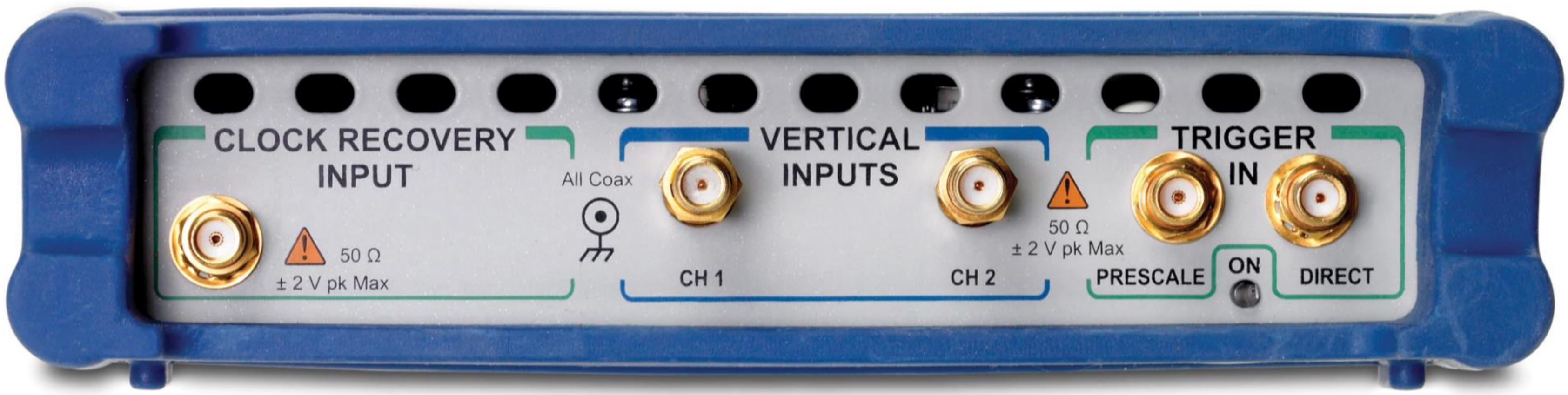
- Data points are acquired sequentially from many cycles to build one screen image
  - PicoScope 9300 sample rate is 1 MS/s, bandwidth is 20 GHz

Sampling Oscilloscope

- Convert high-speed signal (GHz) to a low-frequency copy (kHz)

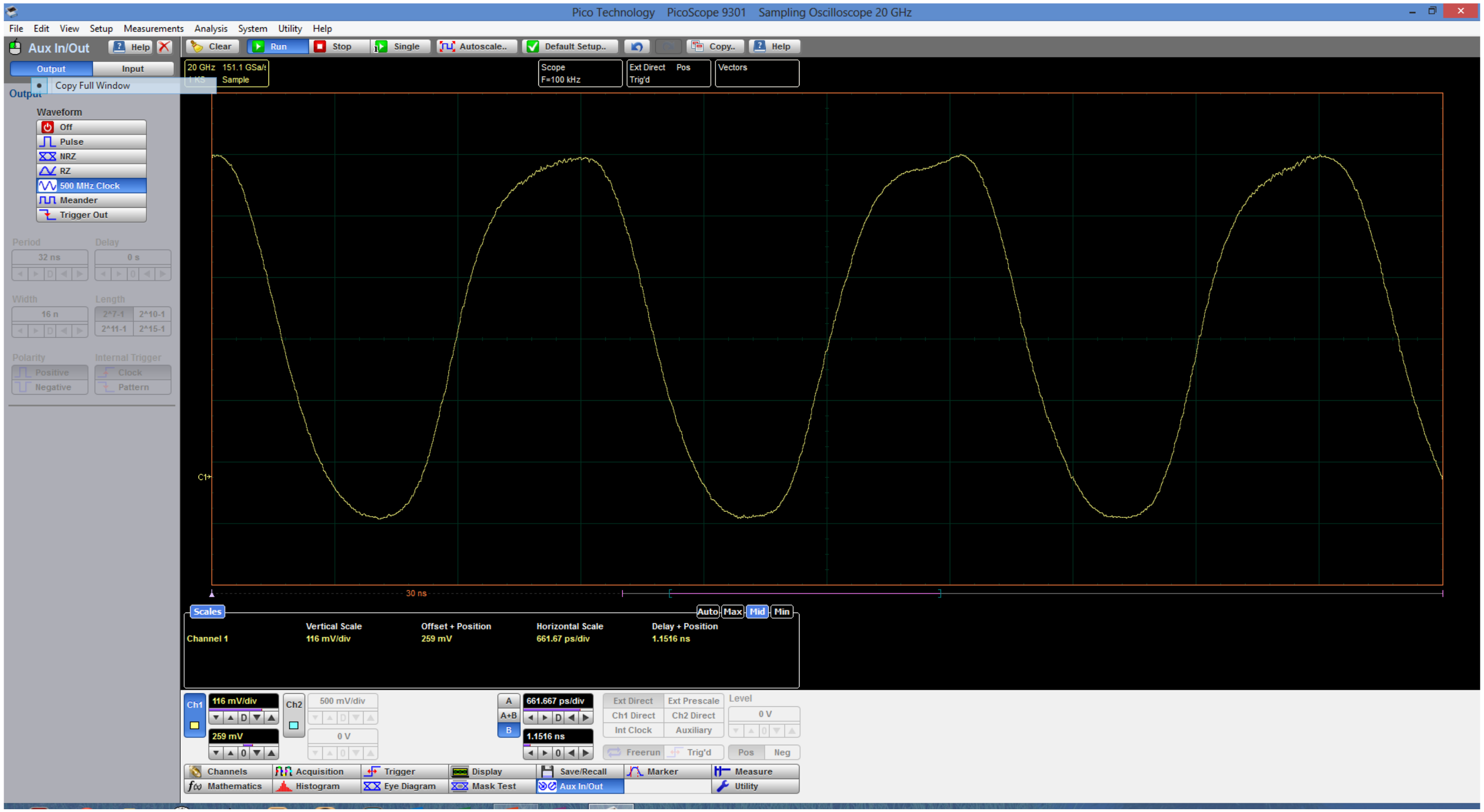


PicoScope 9300 Front Panel



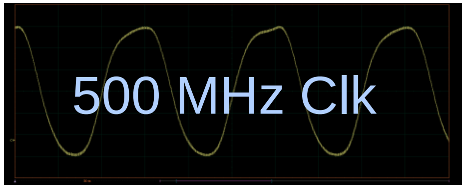
- 20 GHz
- 2 channels
- Clock Data Recovery: 11.3 Gb/s
- Differential TDR: 40 ps, 200 mV step (6 V, 65 ps step)
- USB & LAN interfaces
- PicoSample™ 3 software

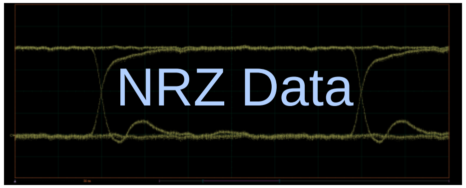
Making Basic Measurements

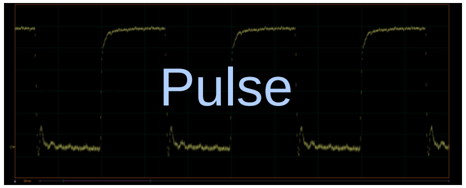


Revealed Menu

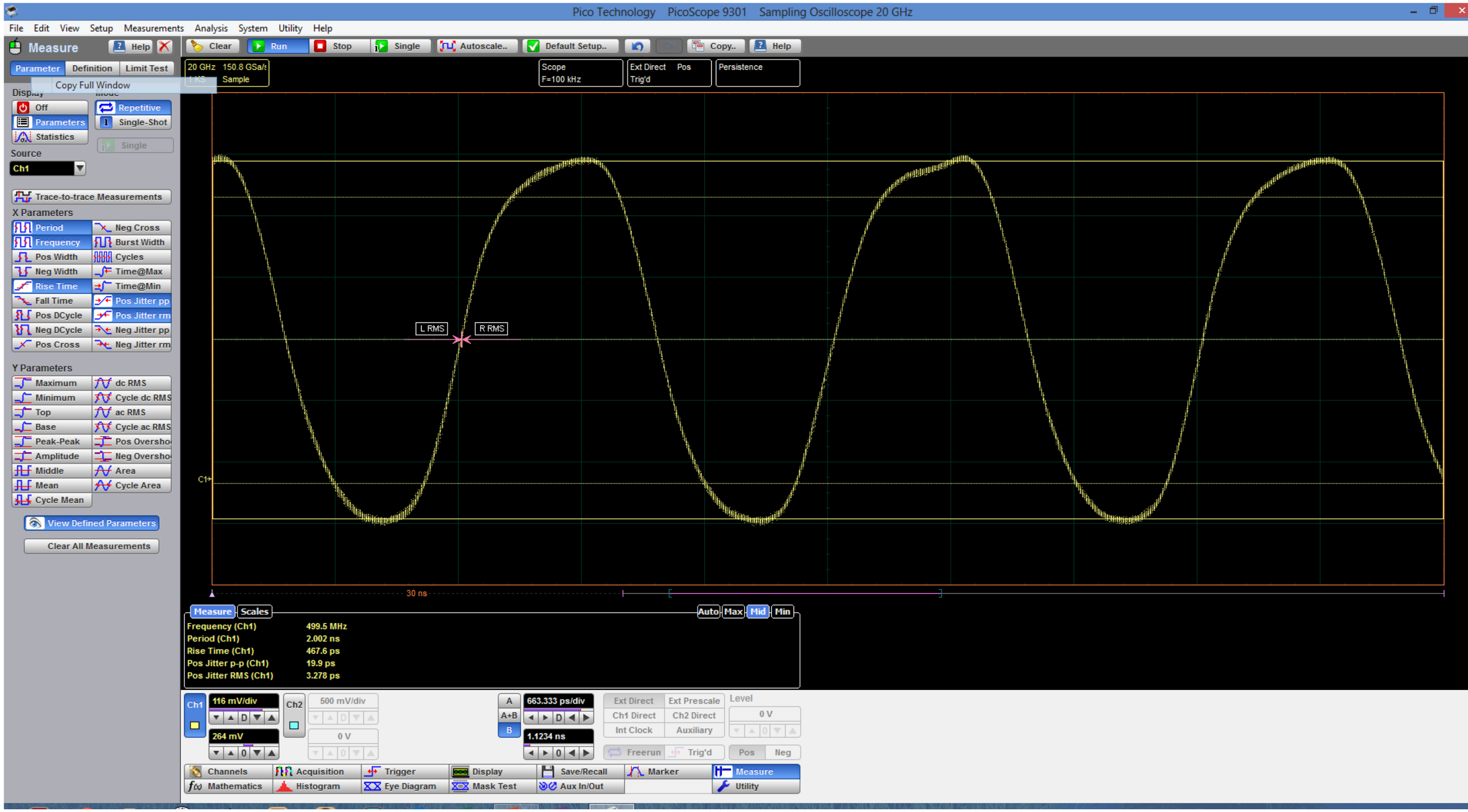
Menu bar and basic controls above







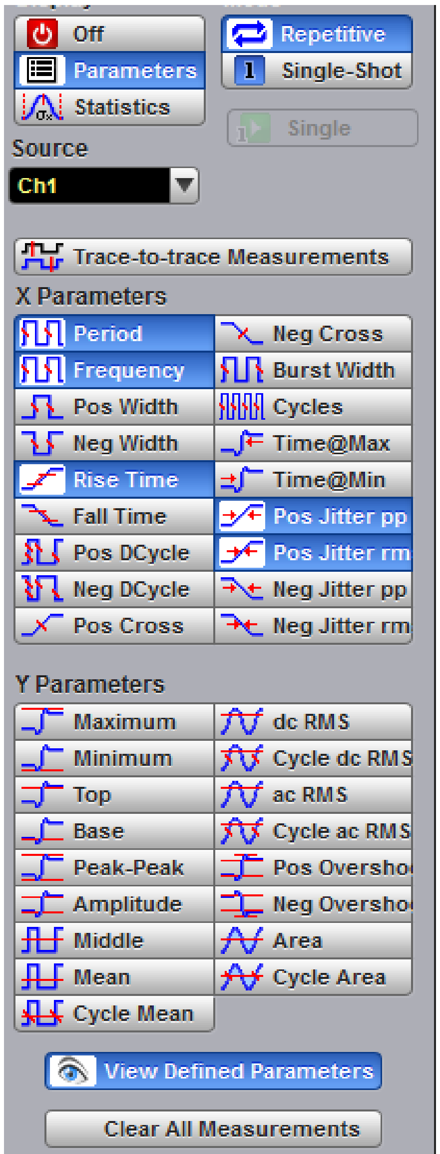
Comprehensive Measurements

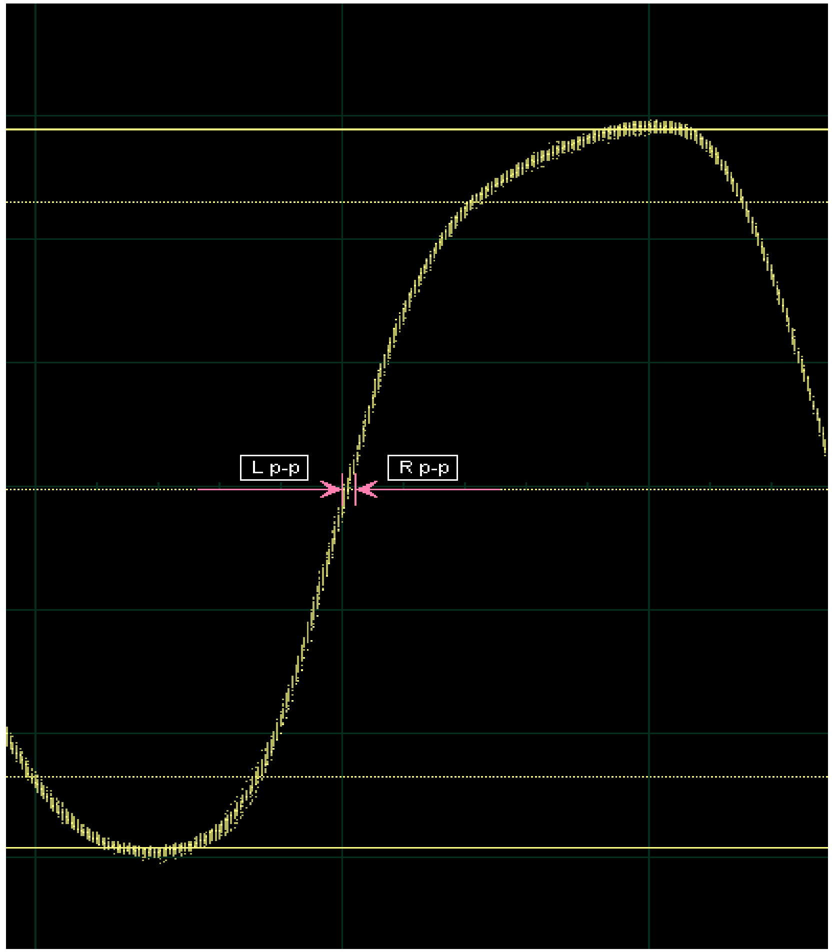


Measure | Scales | Auto | Max | Mid | Min

	Current	Total Wfms	Minimum	Maximum	Mean	Std Deviation
Frequency (Ch1)	500 MHz	36905	498.3 MHz	501.3 MHz	499.9 MHz	367.6 kHz
Period (Ch1)	2 ns	36905	1.995 ns	2.007 ns	2 ns	1.471 ps
Rise Time (Ch1)	477.2 ps	36905	453.6 ps	484.7 ps	469.5 ps	4.347 ps
Pos Jitter p-p (Ch1)	26.53 ps	36856	6.633 ps	26.53 ps	21.27 ps	2.888 ps

Comprehensive Measurements ….





Auto Measurements
18 X (time) parameters
17 Y parameters
13 Channel to Channel
with or without statistics
15 NRZ Time
27 NRZ Y Params
with or without statistics
17 RZ Time
26 RZ Y Params
with or without statistics
5 FFT Parameters
138 Total Measurements

Measure | Scales | Auto | Max | Mid | Min

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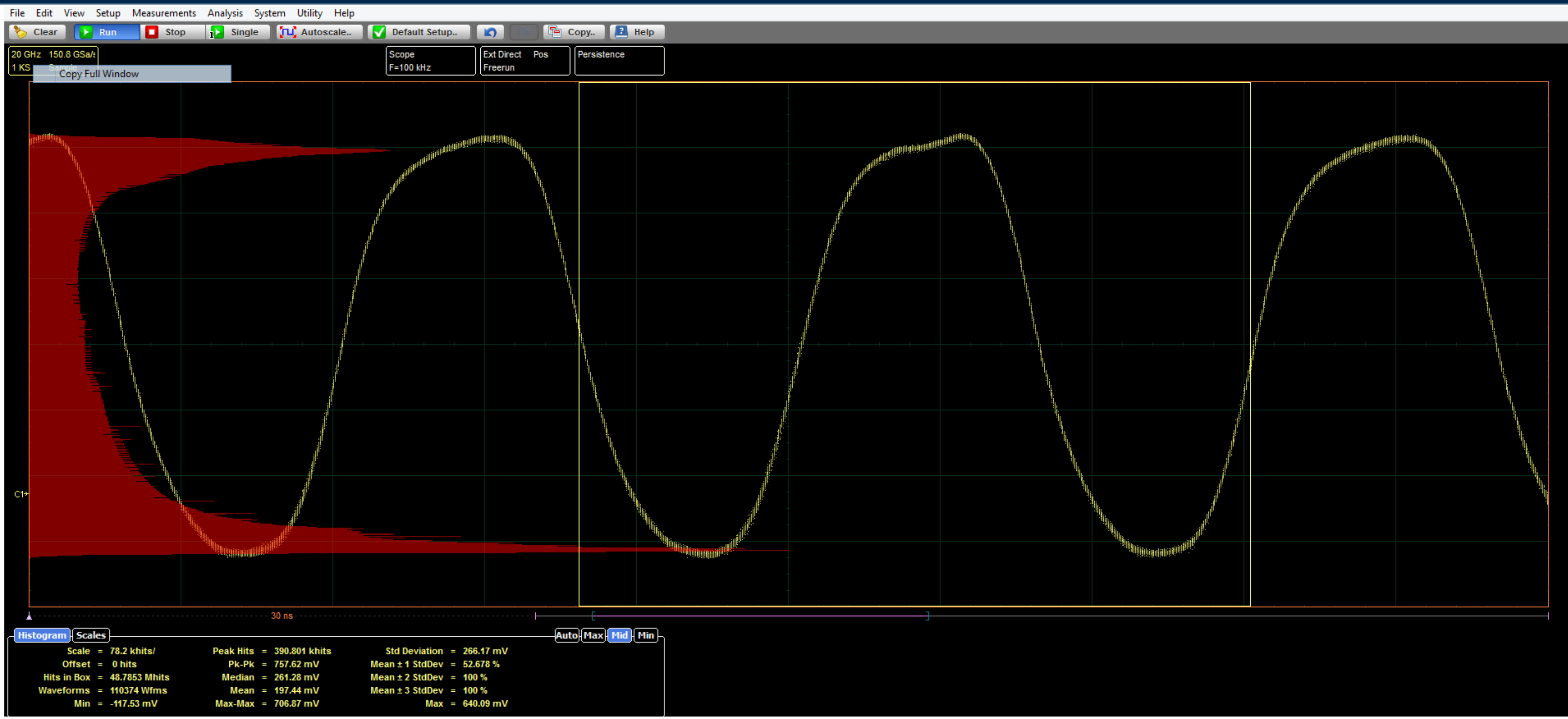
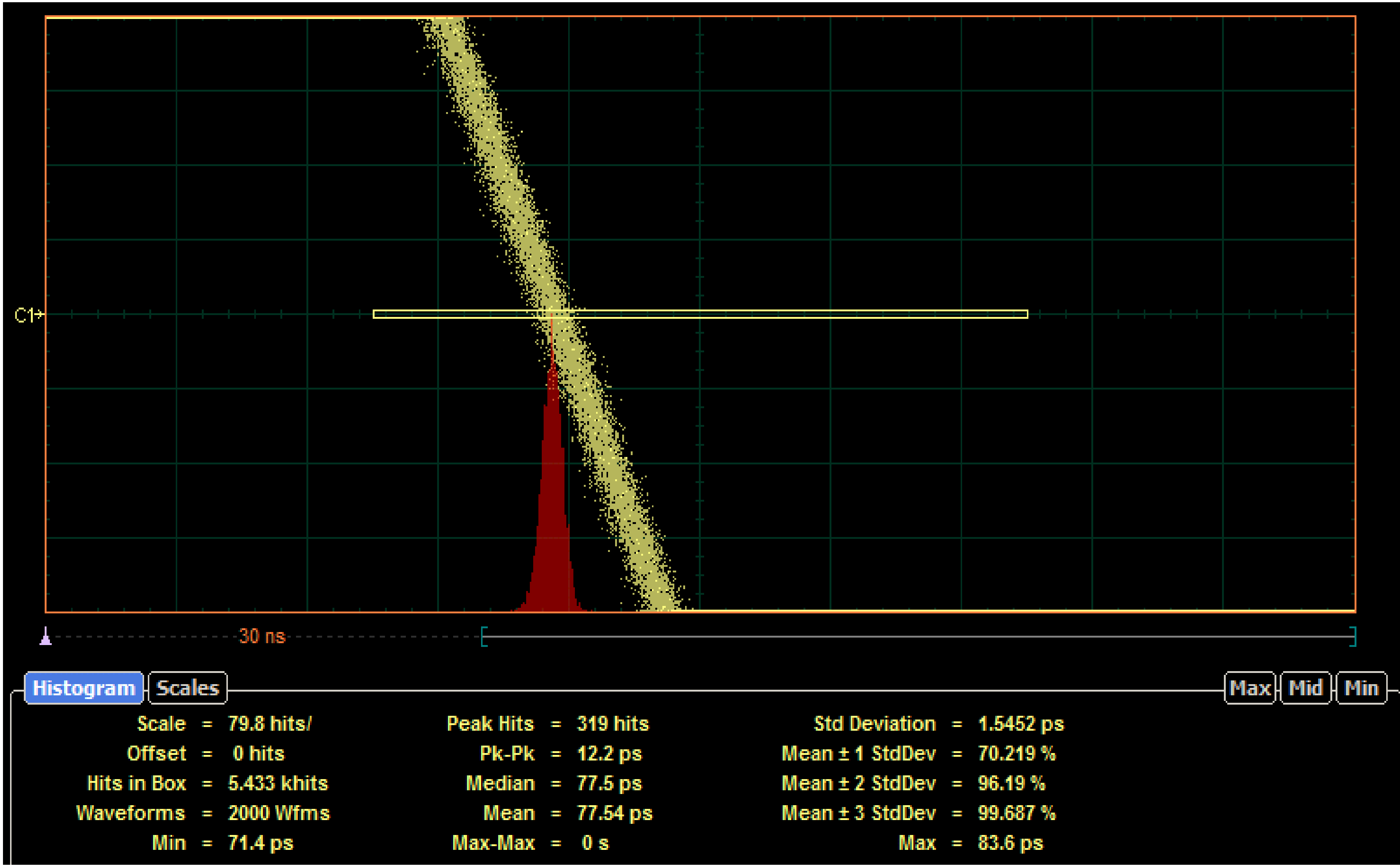
Vertical Histogram



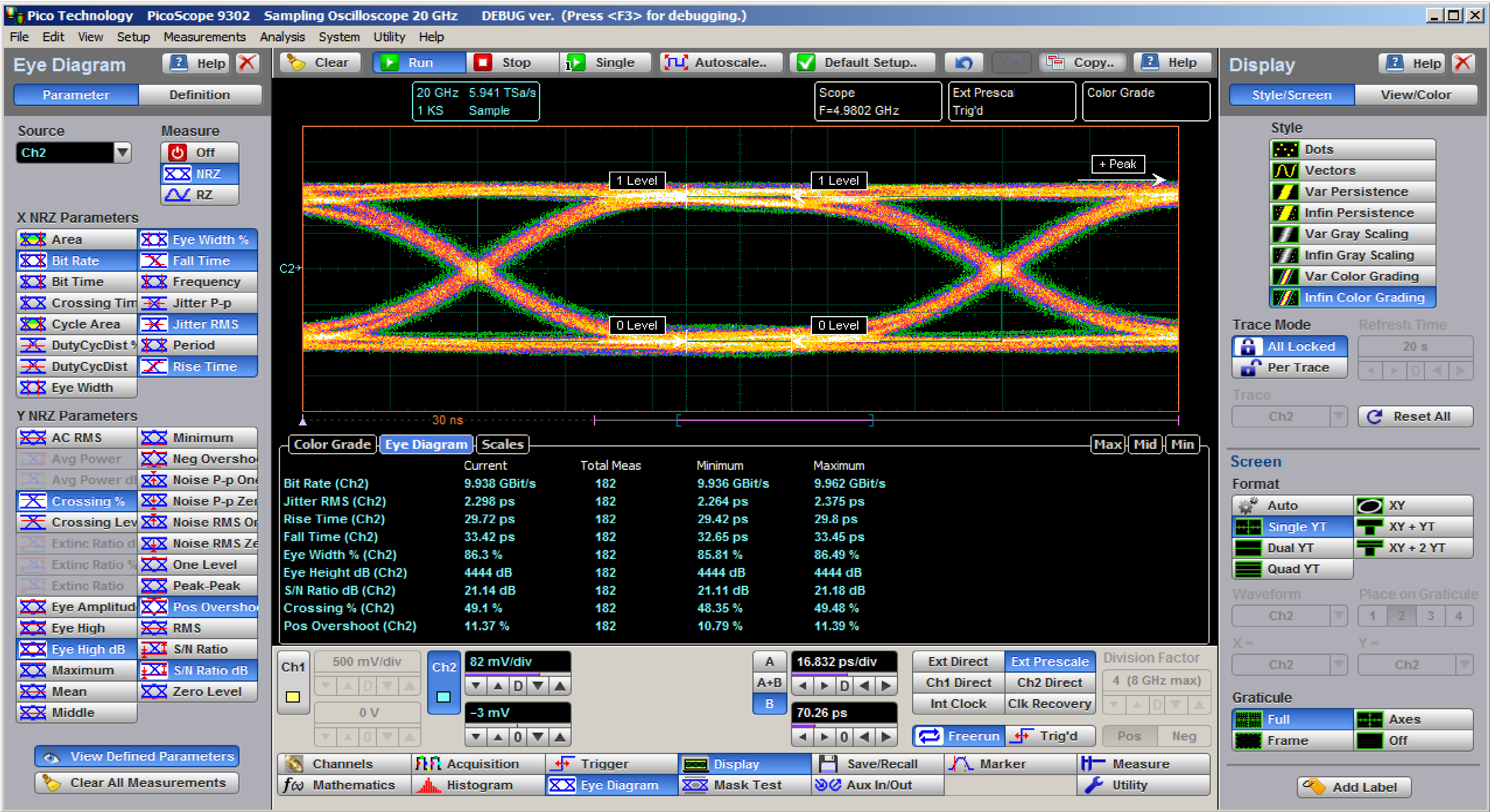
Histogram | Scales | Auto | Max | Mid | Min

Scale = 78.2 khits/	Peak Hits = 390.801 khits	Std Deviation = 266.17 mV
Offset = 0 hits	Pk-Pk = 757.62 mV	Mean ± 1 StdDev = 52.678 %
Hits in Box = 48.7853 Mhits	Median = 261.28 mV	Mean ± 2 StdDev = 100 %
Waveforms = 110374 Wfms	Mean = 197.44 mV	Mean ± 3 StdDev = 100 %
Min = -117.53 mV	Max-Max = 706.87 mV	Max = 640.09 mV

Horizontal Histogram

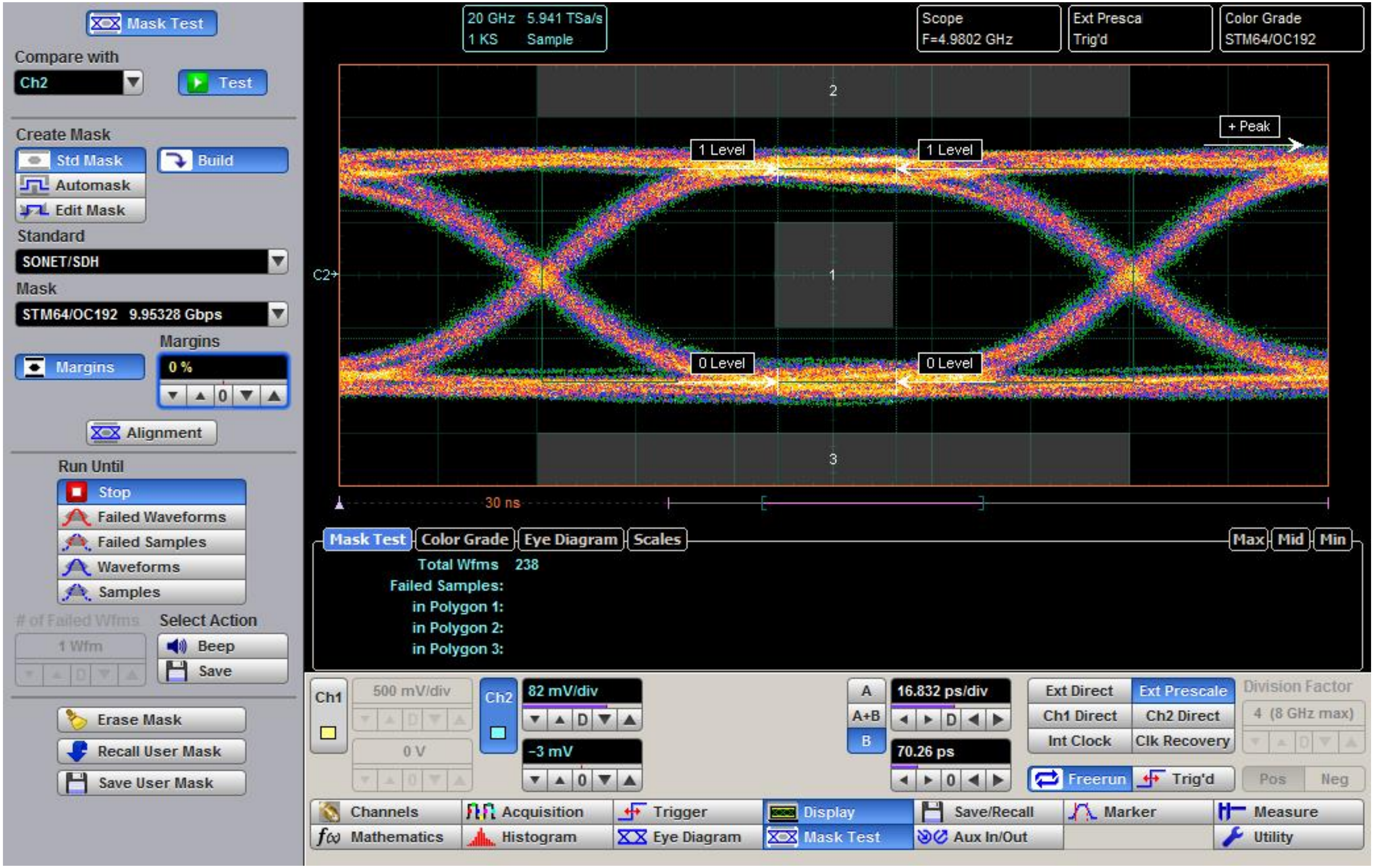


Look into My Eyes!

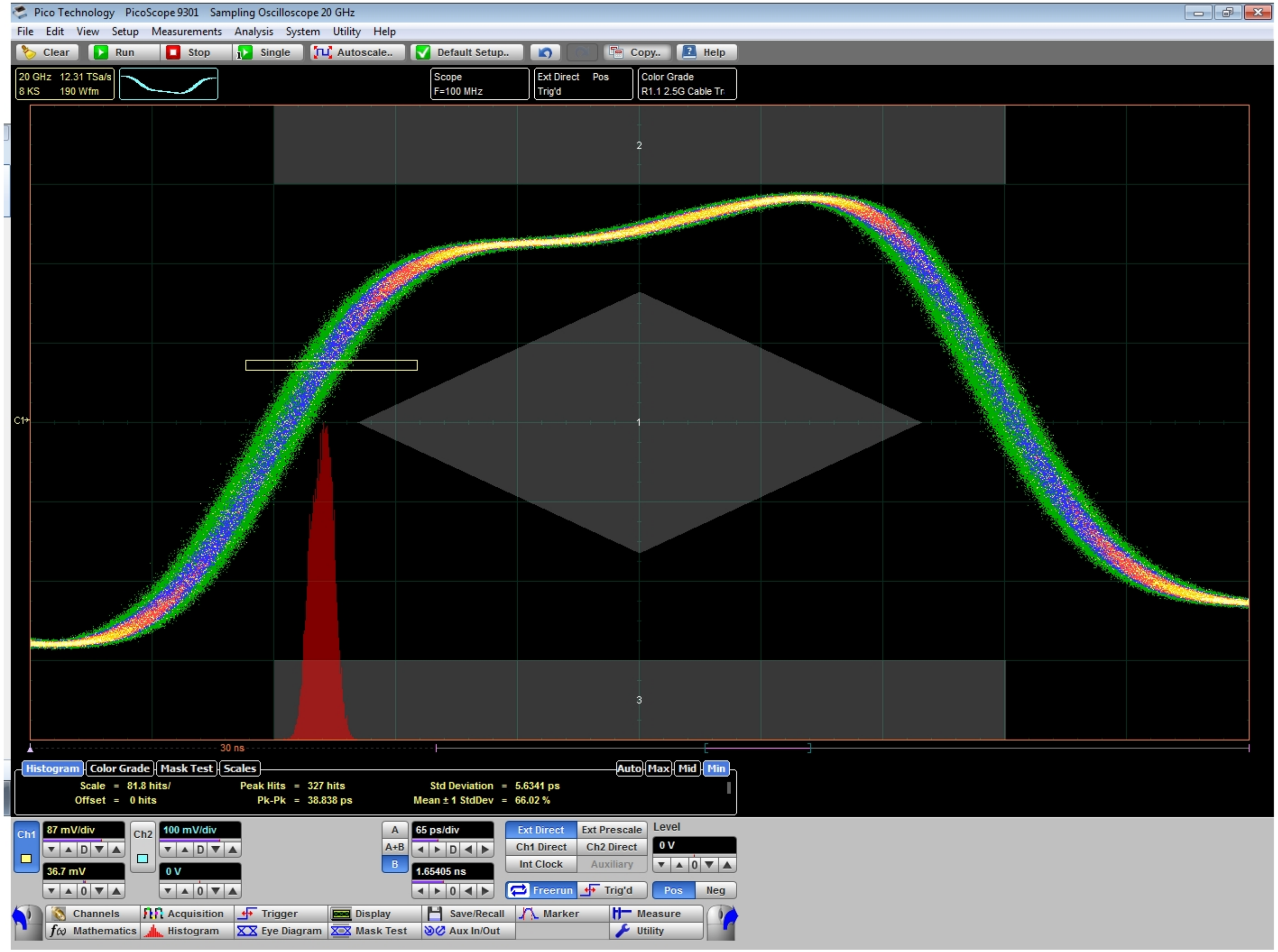


Automatic eye measurements and data

9.95 Gb/s with 10 Gb/s Mask

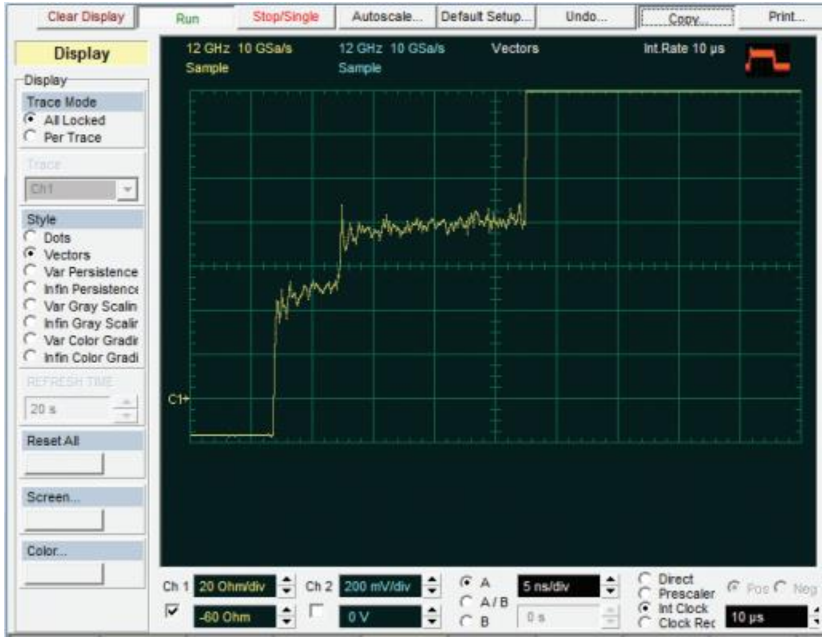


Eye-line Triggering

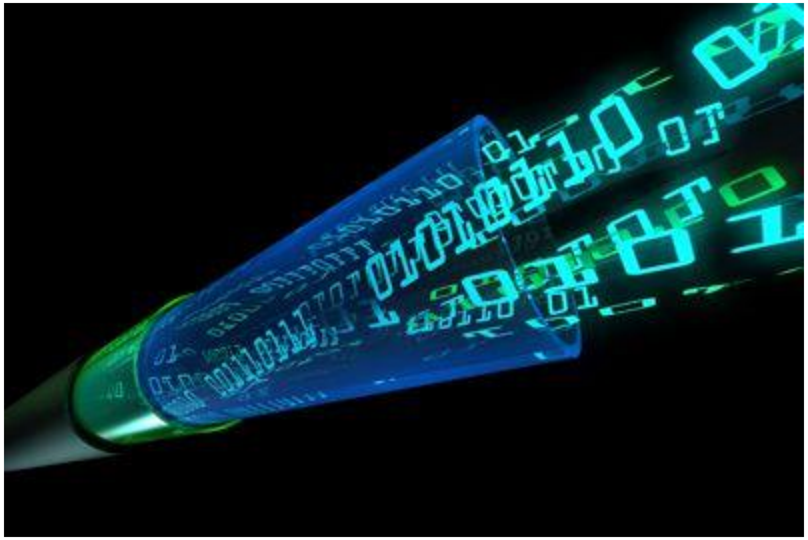


TDR/TDT

- Differential TDR
- 65 ps, 6 V step generator built in
- 40 ps, 200 mV external generator
- Plot voltage, impedance or reflection coefficient against time or distance



Optical



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

PicoScope 9300 Applications

SIGNAL ANALYSIS

- Electrical standards compliance testing
- Eye-diagram analysis

HIGH-SPEED DIGITAL COMMUNICATIONS

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

RF COMPONENT TESTING

- RF components
- Cables and connectors
- Pulsed RF switches

SEMICONDUCTOR TESTING

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

R & D

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

MANUFACTURING

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

Summary

9300 Sampling Oscilloscopes

- Economical 20 GHz solution
- Broad range of SI measurements
- Eye diagram analysis
- Mask testing for production
- Support for popular industry standards
  - PCIe, SATA, SONET/SDH, Ethernet, RapidIO, InfiniBand . . . plus user-defined
- TDR/TDT for validation of cables, connectors, interconnects etc.
- Optical
- Signal & timing analysis, testing and design of high-speed digital communication systems, network analysis, & semiconductor testing