



**EUROPEAN
MICROWAVE WEEK**

**NCC NUREMBERG, GERMANY
6-11 OCTOBER 2013**

**EXHIBITION HOURS:
TUE 9.30-17.30 WED 9.30-17.30 THU 9.30-16.30**



Trevor Smith Pico Technology



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

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

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

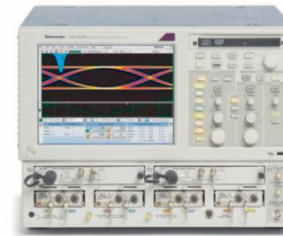


Real-time Oscilloscopes

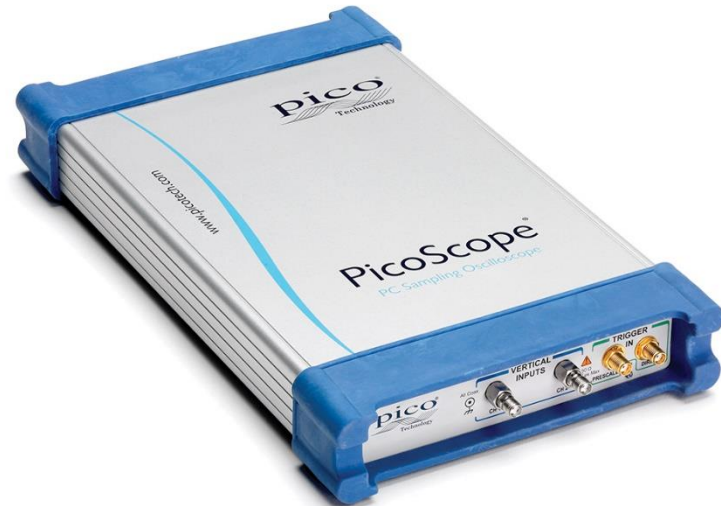


- Can capture single instantaneous or repetitive events
- 8-bit ADC resolution, but lower effective bits at high frequencies
- Deep buffer memory
- Advanced triggers & display modes to capture intermittent events
- Serial bus decoding
- Ideal for general use and fault diagnosis
- Real-time GS/s sampling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

Sampling Oscilloscopes



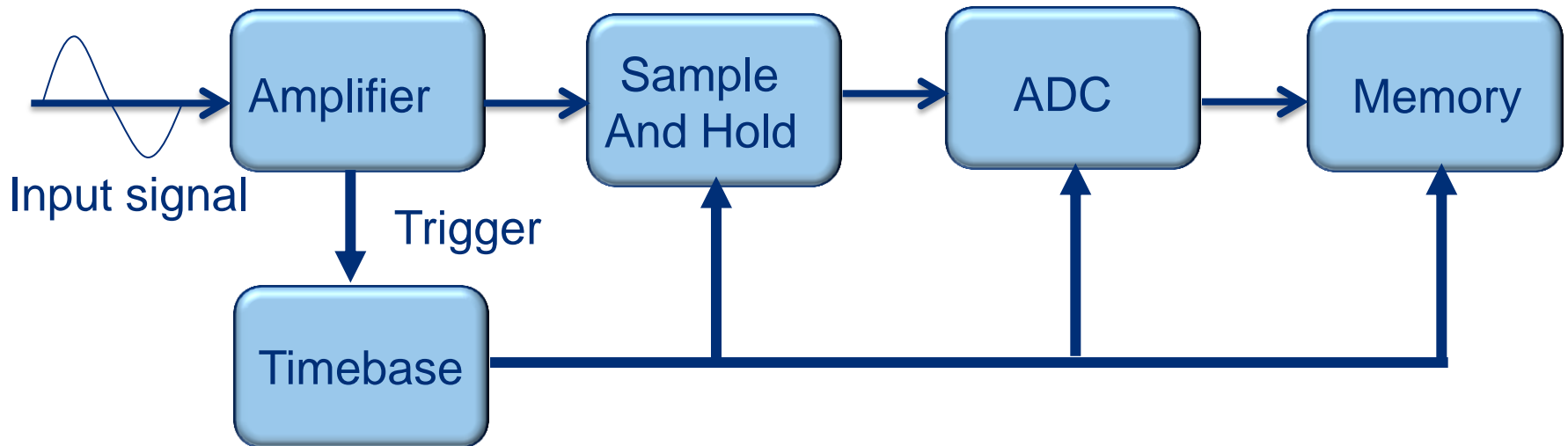
- Can capture cyclic signals & repeating patterns at steady data rate
- Short buffer memory
- Low sample rate
- Lower intrinsic jitter and noise
- Eye diagrams and mask testing
- Best choice for TDR/TDT
- Lower, but still significant cost: ~ \$50K for 20 GHz



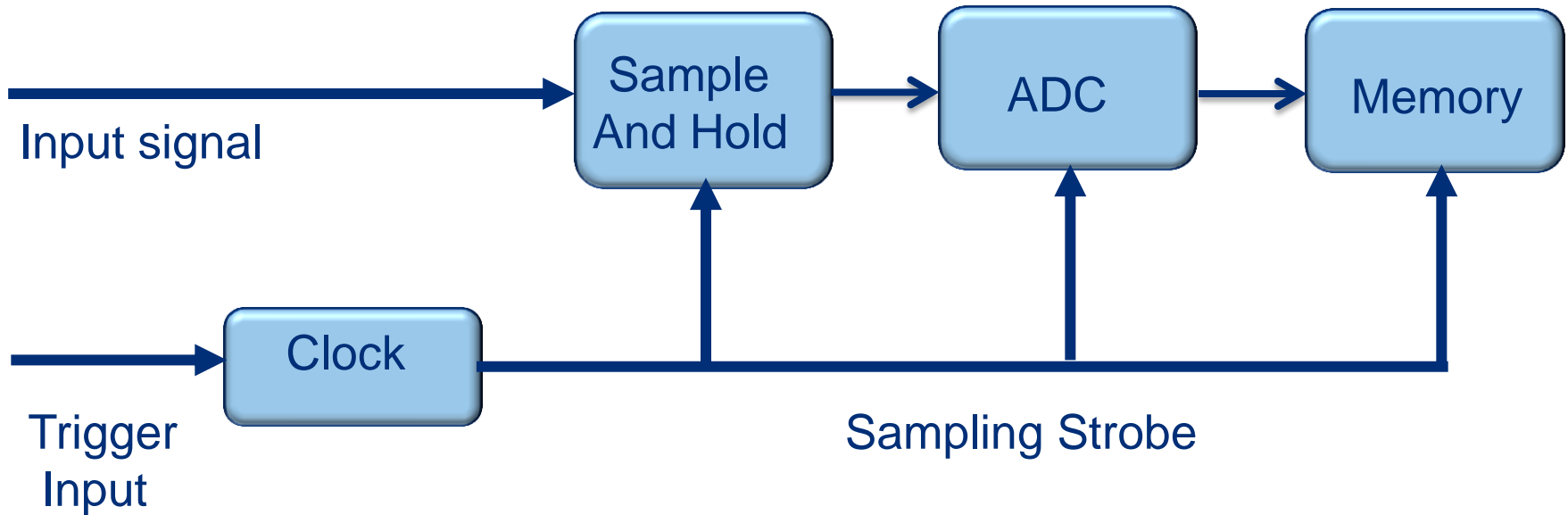
PicoScope 9300

- 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



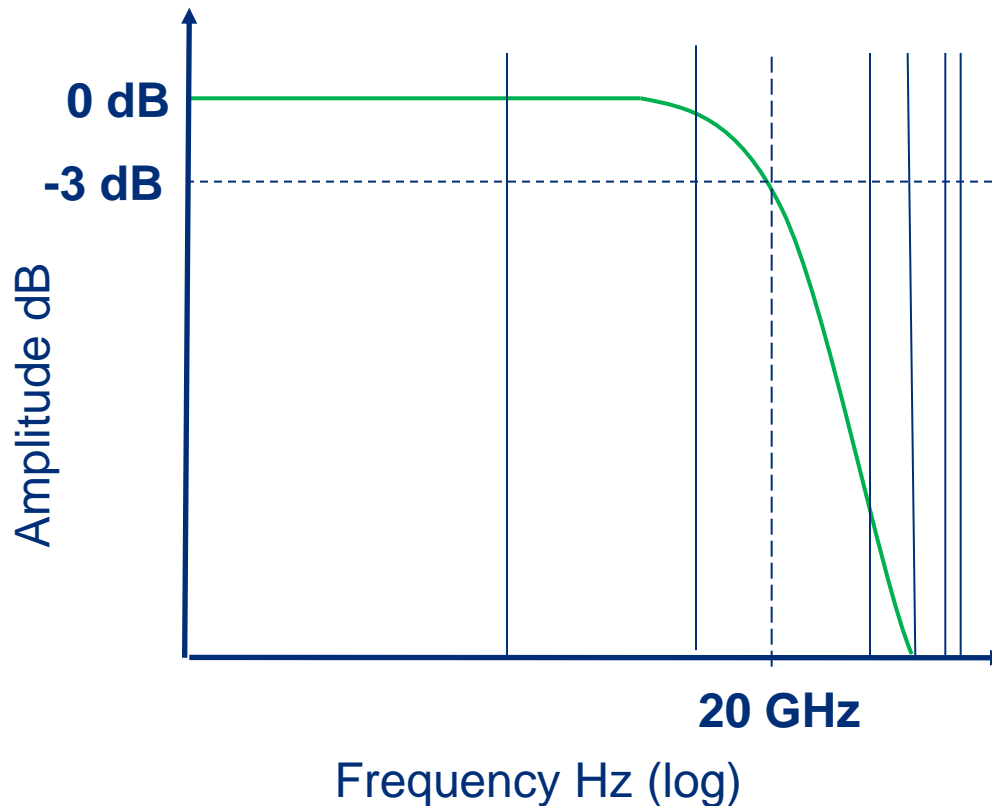


Real-time Digital Oscilloscope



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

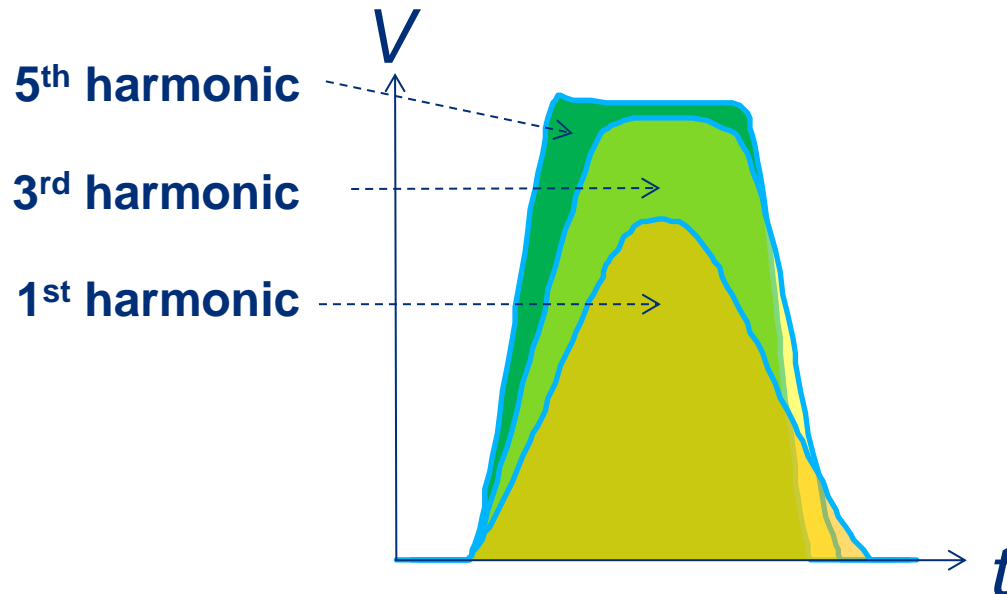
Calculating bandwidth from data rate:

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

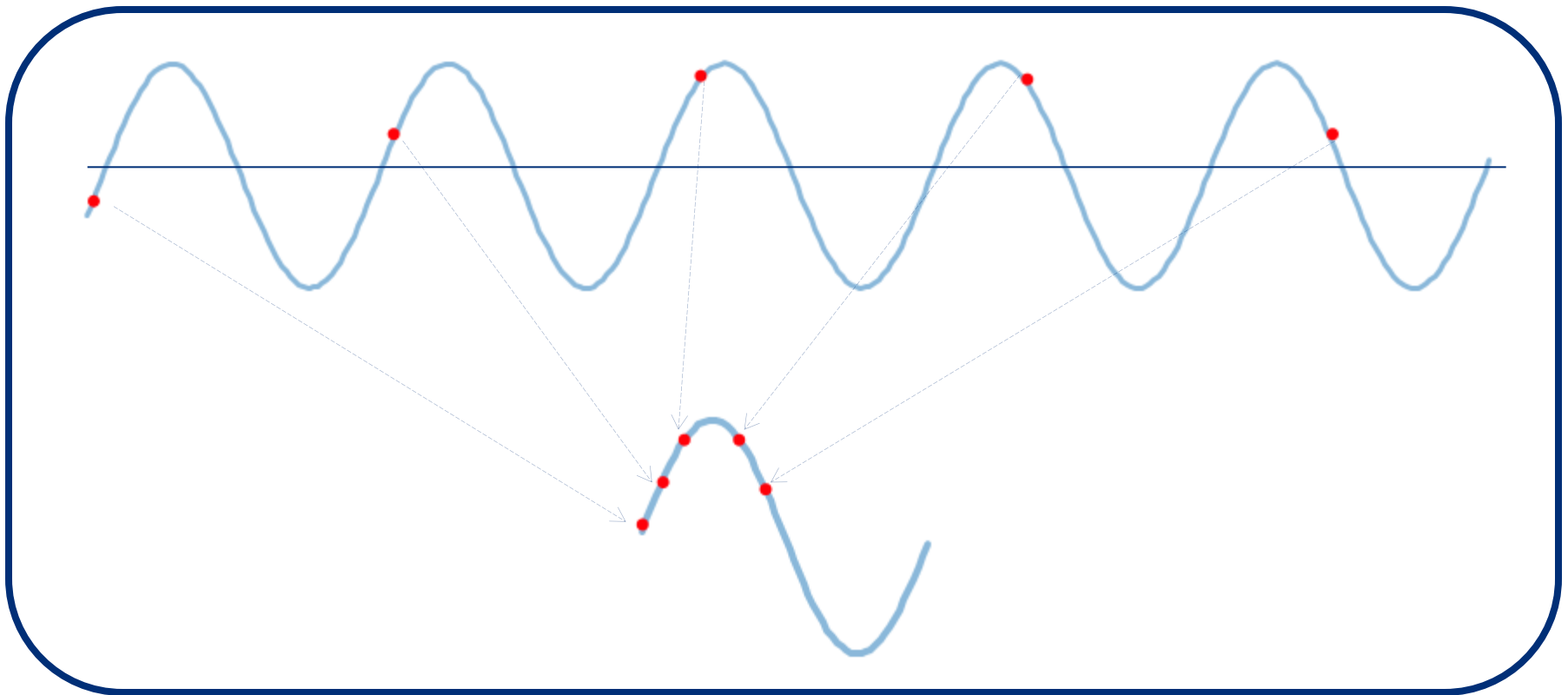
$$5^{\text{th}} \text{ Harmonic} = 5 \times \frac{\text{Bit rate}}{2}$$

Application example

PCIe R1.0a has a data rate of 2.5 Gbps (1.25 GHz frequency)
Bandwidth required to see 5 harmonics is $1.25 \text{ GHz} \times 5 = \underline{\underline{6.25 \text{ GHz}}}$



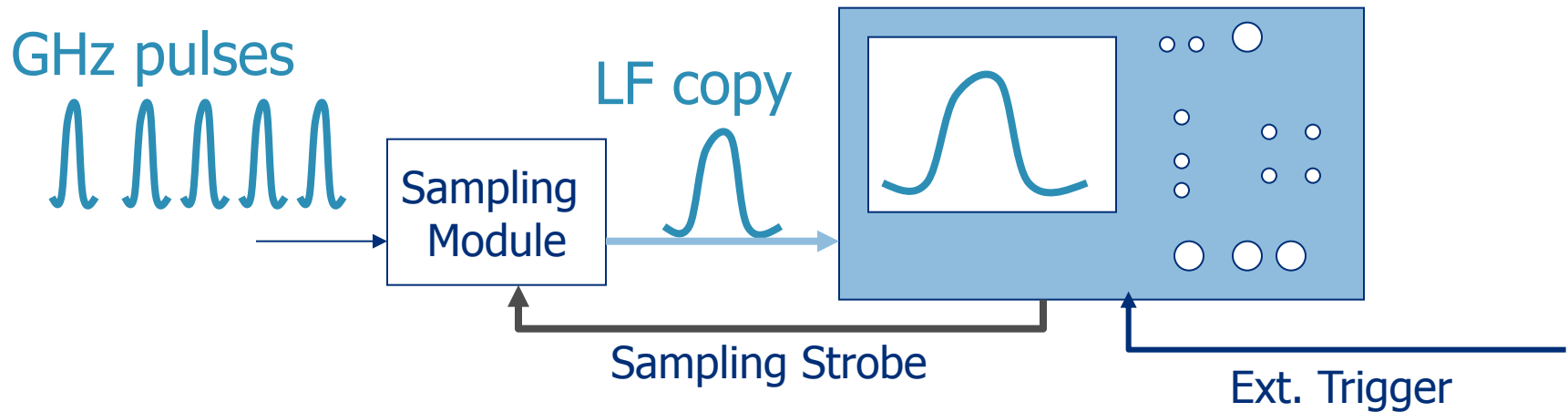
Sequential Sampling



- 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

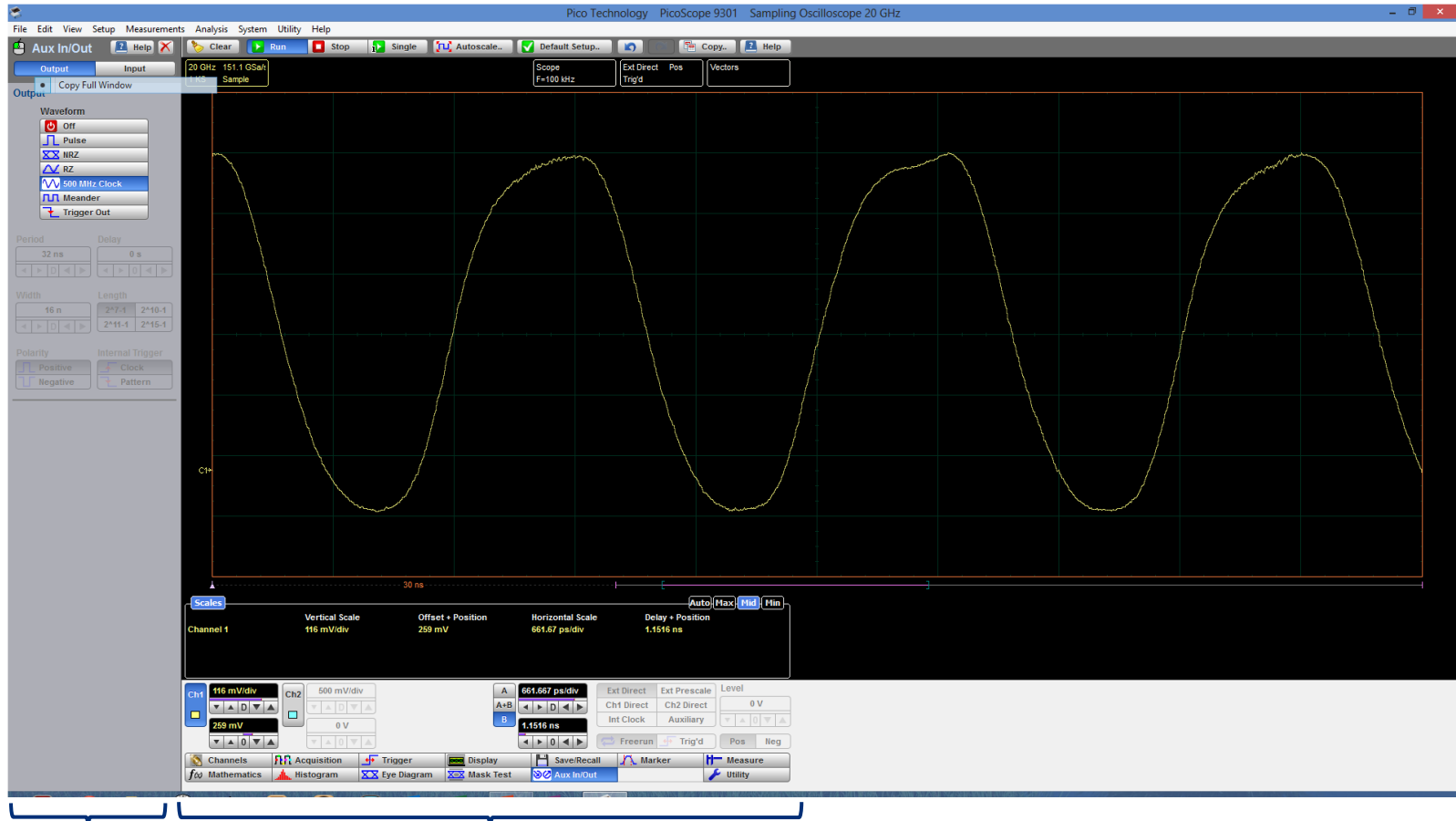
Clock Data Recovery: 11.3 Gb/s

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



500 MHz Clk



RZ Data

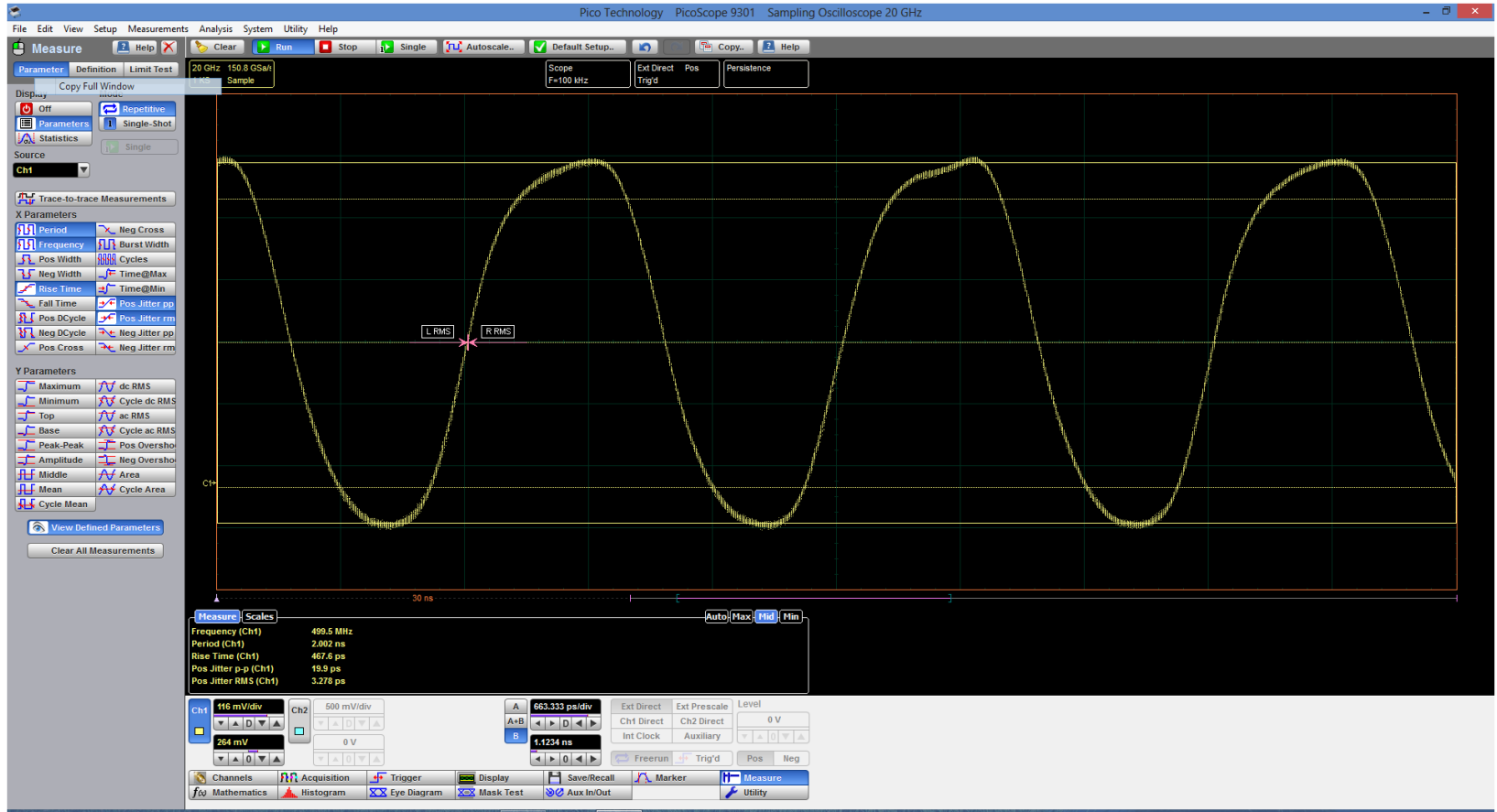


NRZ Data



Pulse

Comprehensive Measurements



	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



Source
Ch1

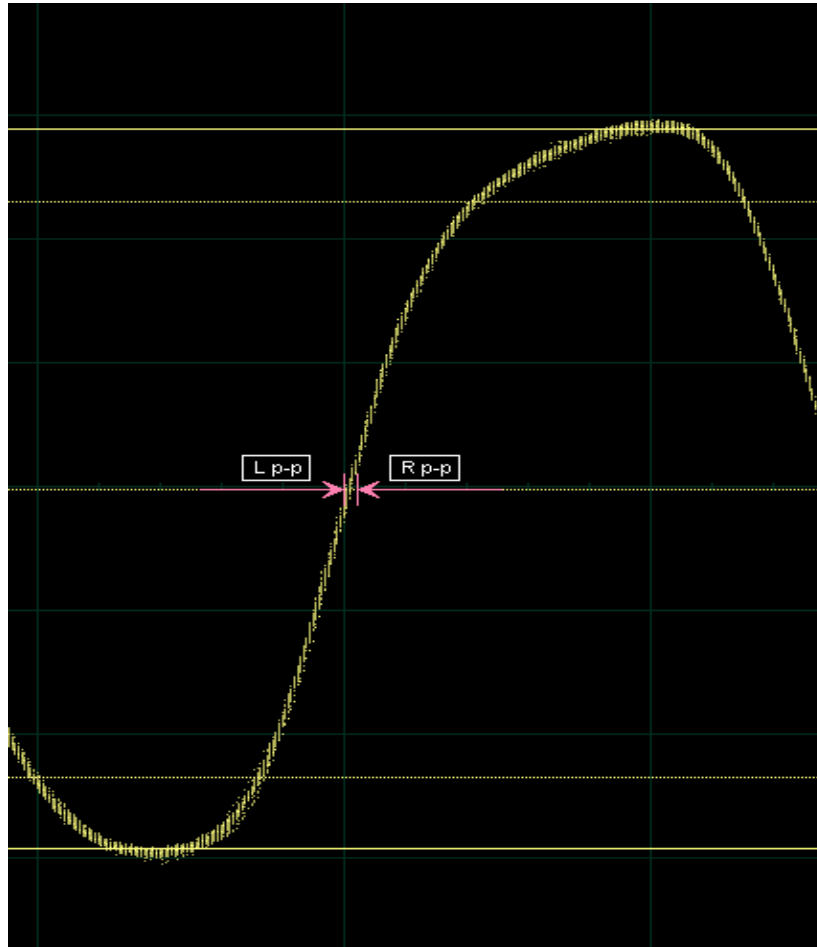
Trace-to-trace Measurements

X Parameters

<input type="checkbox"/> Period	<input type="checkbox"/> Neg Cross
<input type="checkbox"/> Frequency	<input type="checkbox"/> Burst Width
<input type="checkbox"/> Pos Width	<input type="checkbox"/> Cycles
<input type="checkbox"/> Neg Width	<input type="checkbox"/> Time@Max
<input type="checkbox"/> Rise Time	<input type="checkbox"/> Time@Min
<input type="checkbox"/> Fall Time	<input type="checkbox"/> Pos Jitter pp
<input type="checkbox"/> Pos DCycle	<input type="checkbox"/> Pos Jitter rm
<input type="checkbox"/> Neg DCycle	<input type="checkbox"/> Neg Jitter pp
<input type="checkbox"/> Pos Cross	<input type="checkbox"/> Neg Jitter rm

Y Parameters

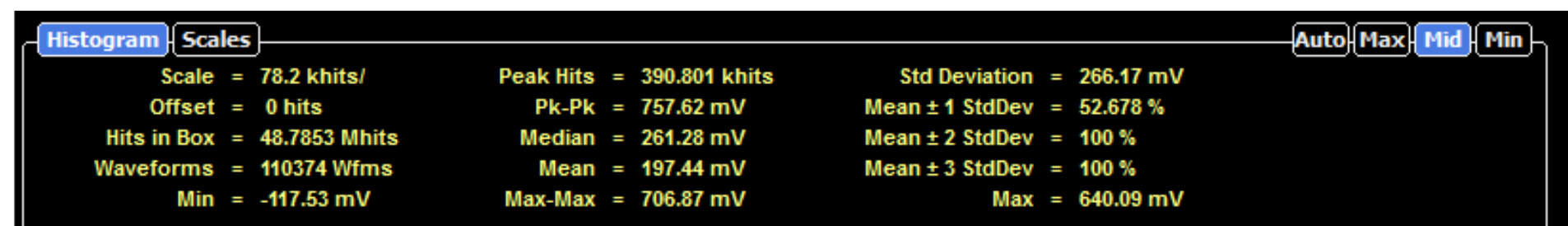
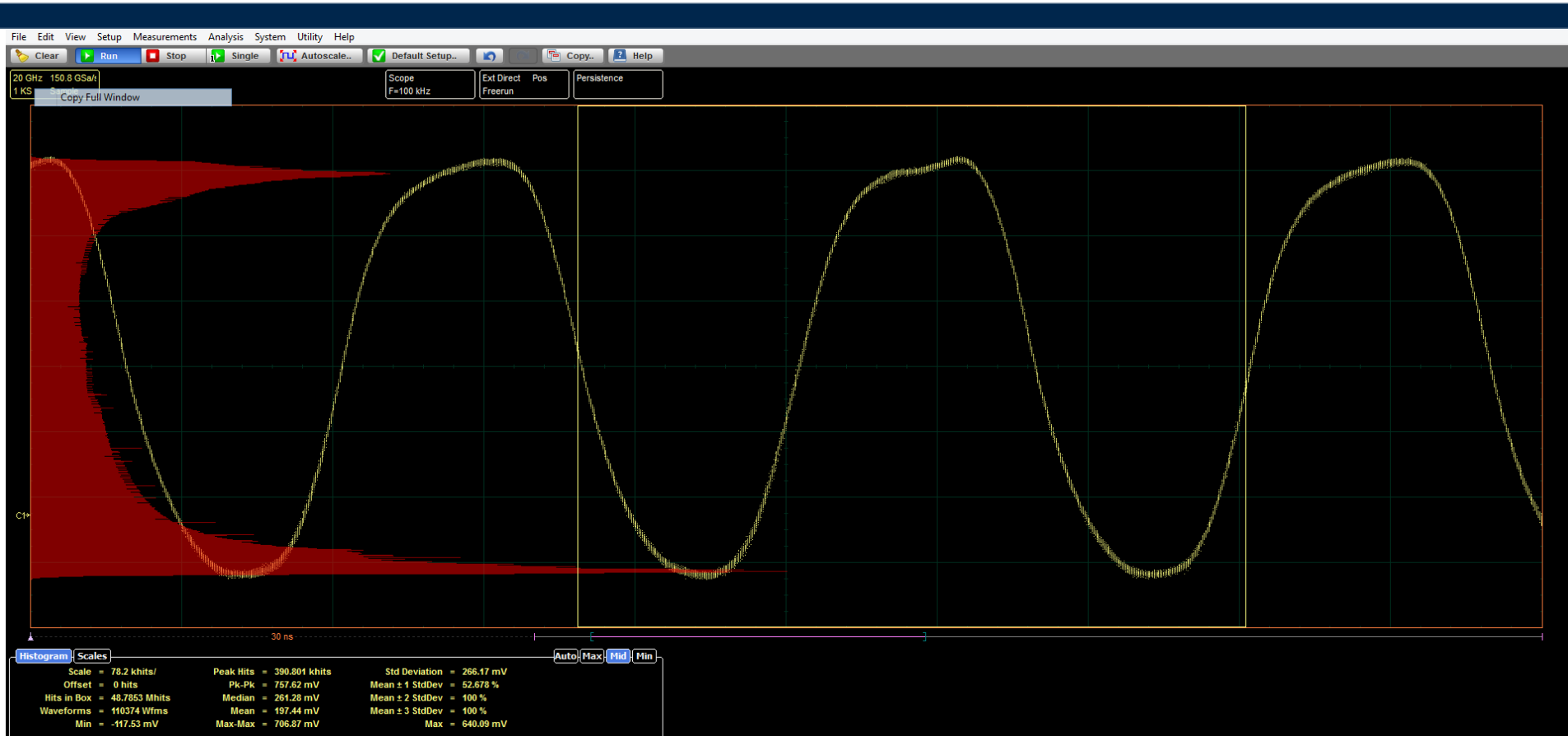
<input type="checkbox"/> Maximum	<input type="checkbox"/> dc RMS
<input type="checkbox"/> Minimum	<input type="checkbox"/> Cycle dc RMS
<input type="checkbox"/> Top	<input type="checkbox"/> ac RMS
<input type="checkbox"/> Base	<input type="checkbox"/> Cycle ac RMS
<input type="checkbox"/> Peak-Peak	<input type="checkbox"/> Pos Oversho
<input type="checkbox"/> Amplitude	<input type="checkbox"/> Neg Oversho
<input type="checkbox"/> Middle	<input type="checkbox"/> Area
<input type="checkbox"/> Mean	<input type="checkbox"/> Cycle Area
<input type="checkbox"/> Cycle Mean	



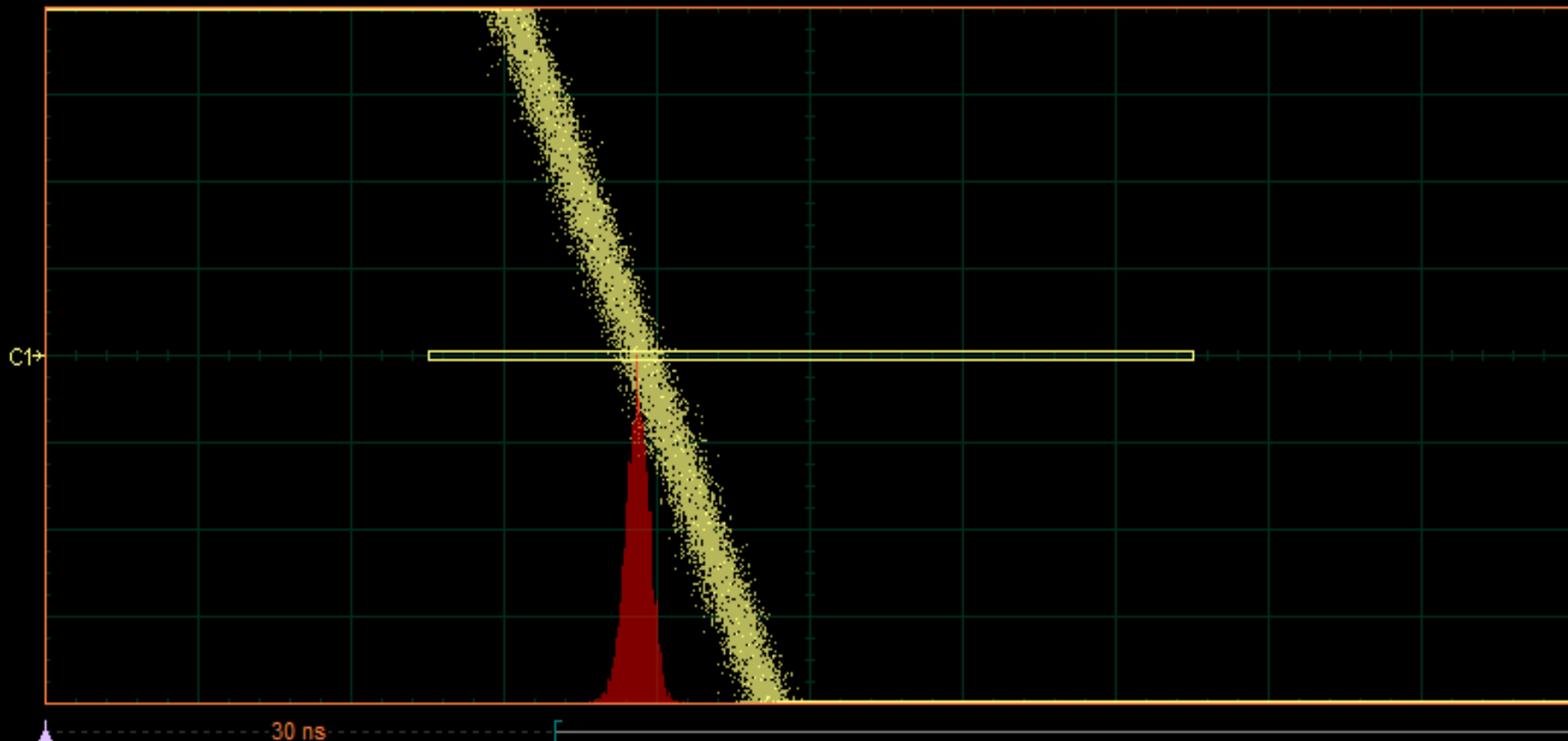
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Auto Measurements	
18	X (time) parameters
17	Y parameters
13	Channel to Channel
<i>with or without statistics</i>	
15	NRZ Time
27	NRZ Y Params
<i>with or without statistics</i>	
17	RZ Time
26	RZ Y Params
<i>with or without statistics</i>	
5	FFT Parameters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

Vertical Histogram



Horizontal Histogram



Histogram Scales

Max Mid Min

Scale = 79.8 hits/	Peak Hits = 319 hits	Std Deviation = 1.5452 ps
Offset = 0 hits	Pk-Pk = 12.2 ps	Mean \pm 1 StdDev = 70.219 %
Hits in Box = 5.433 khits	Median = 77.5 ps	Mean \pm 2 StdDev = 96.19 %
Waveforms = 2000 Wfms	Mean = 77.54 ps	Mean \pm 3 StdDev = 99.687 %
Min = 71.4 ps	Max-Max = 0 s	Max = 83.6 ps

Look into My Eyes!



Pico Technology PicoScope 9302 Sampling Oscilloscope 20 GHz DEBUG ver. (Press <F3> for debugging.)

File Edit View Setup Measurements Analysis System Utility Help

Eye Diagram ? Help X

Parameter Definition

Source: Ch2 Measure: Off, NRZ, RZ

X NRZ Parameters: Area, Eye Width %, Bit Rate, Fall Time, Bit Time, Frequency, Crossing Tim, Jitter P-p, Cycle Area, Jitter RMS, DutyCycDist %, Period, DutyCycDist, Rise Time, Eye Width

Y NRZ Parameters: AC RMS, Minimum, Avg Power, Neg Oversho, Avg Power d, Noise P-p On, Crossing %, Noise P-p Zer, Crossing Lev, Noise RMS Zer, Extinc Ratio d, Noise RMS Ze, Extinc Ratio %, One Level, Extinc Ratio, Peak-Peak, Eye Amplitud, Pos Oversho, Eye High, RMS, Eye High dB, S/N Ratio, Maximum, S/I Ratio dB, Mean, Zero Level, Middle

View Defined Parameters Clear All Measurements

Clear Run Stop Single Autoscale.. Default Setup.. Copy.. Help

20 GHz 5.941 TSa/s 1 KS Sample Scope F=4.9802 GHz Ext Presca Trig'd Color Grade

Trace Mode: All Locked, Refresh Time: 20 s, Per Trace

Trace: Ch2, Reset All

Screen Format: Auto, XY, Single YT, XY + YT, Dual YT, XY + 2 YT, Quad YT

Waveform: Ch2, Place on Graticule: 1, 2, 3, 4

X = Ch2, Y = Ch2

Graticule: Full, Axes, Frame, Off

Add Label

	Current	Total Meas	Minimum	Maximum
Bit Rate (Ch2)	9.938 GBit/s	182	9.936 GBit/s	9.962 GBit/s
Jitter RMS (Ch2)	2.298 ps	182	2.264 ps	2.375 ps
Rise Time (Ch2)	29.72 ps	182	29.42 ps	29.8 ps
Fall Time (Ch2)	33.42 ps	182	32.65 ps	33.45 ps
Eye Width % (Ch2)	86.3 %	182	85.81 %	86.49 %
Eye Height dB (Ch2)	4444 dB	182	4444 dB	4444 dB
S/I Ratio dB (Ch2)	21.14 dB	182	21.11 dB	21.18 dB
Crossing % (Ch2)	49.1 %	182	48.35 %	49.48 %
Pos Overshoot (Ch2)	11.37 %	182	10.79 %	11.39 %

Ch1: 500 mV/div, Ch2: 82 mV/div, A: 16.832 ps/div, A+B: 70.26 ps, B: 70.26 ps

Ext Direct, Ext Prescale, Ch1 Direct, Ch2 Direct, Int Clock, Clk Recovery, Division Factor: 4 (8 GHz max)

Freerun, Trig'd, Pos, Neg

Channels, Acquisition, Trigger, Display, Save/Recall, Marker, Measure, Mathematics, Histogram, Eye Diagram, Mask Test, Aux In/Out, Utility

Automatic eye measurements and data

9.95 Gb/s with 10 Gb/s Mask



Mask Test

Compare with: Ch2 **Test**

Create Mask: Std Mask Automask Edit Mask Build

Standard: SONET/SDH

Mask: STM64/OC192 9.95328 Gbps

Margins: Margins 0%

Alignment

Run Until: Stop Failed Waveforms Failed Samples Waveforms Samples

of Failed Wfms: 1 Wfm Select Action: Beep Save

Erase Mask Recall User Mask Save User Mask

20 GHz 5.941 Tsa/s 1 KS Sample

Scope F=4.9802 GHz Ext Presca Trig'd Color Grade STM64/OC192

Mask Test Color Grade Eye Diagram Scales Max Mid Min

Total Wfms 238
Failed Samples:
in Polygon 1:
in Polygon 2:
in Polygon 3:

Ch1 500 mV/div Ch2 82 mV/div

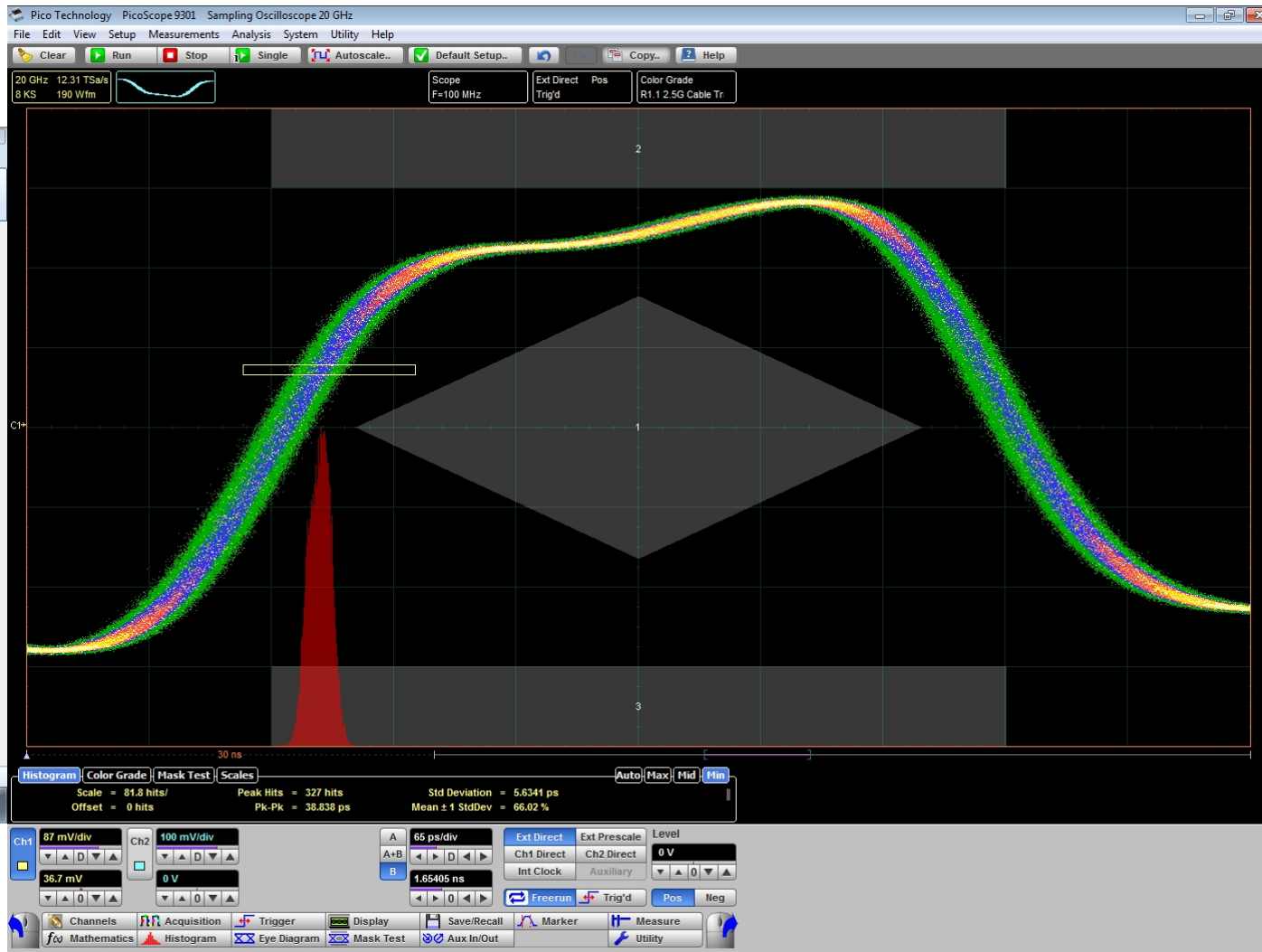
A 16.832 ps/div
A+B
B 70.26 ps

Ext Direct Ext Prescale Division Factor 4 (8 GHz max)
Ch1 Direct Ch2 Direct
Int Clock Clk Recovery

Freerun Trig'd Pos Neg

Channels Acquisition Trigger Display Save/Recall Marker Measure
Mathematics Histogram Eye Diagram Mask Test Aux In/Out Utility

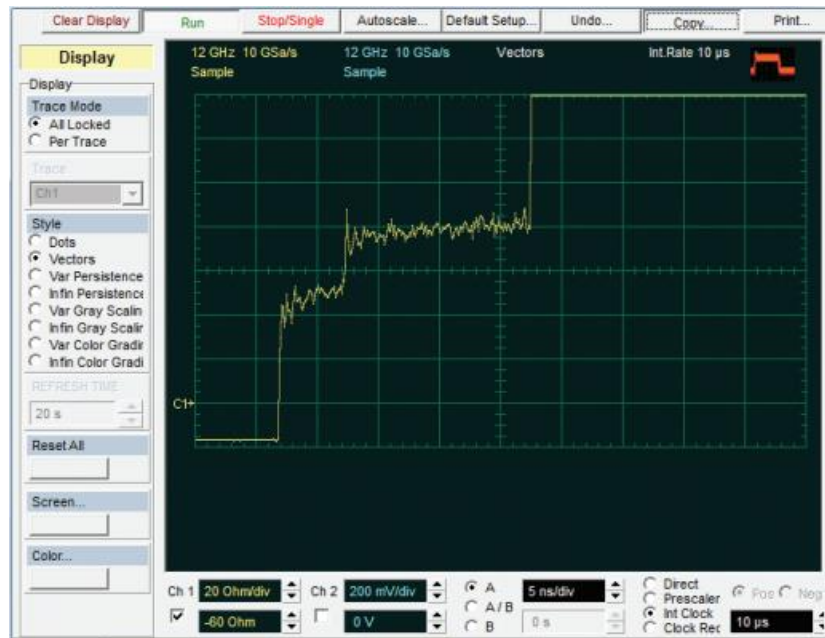
Eye-line Triggering

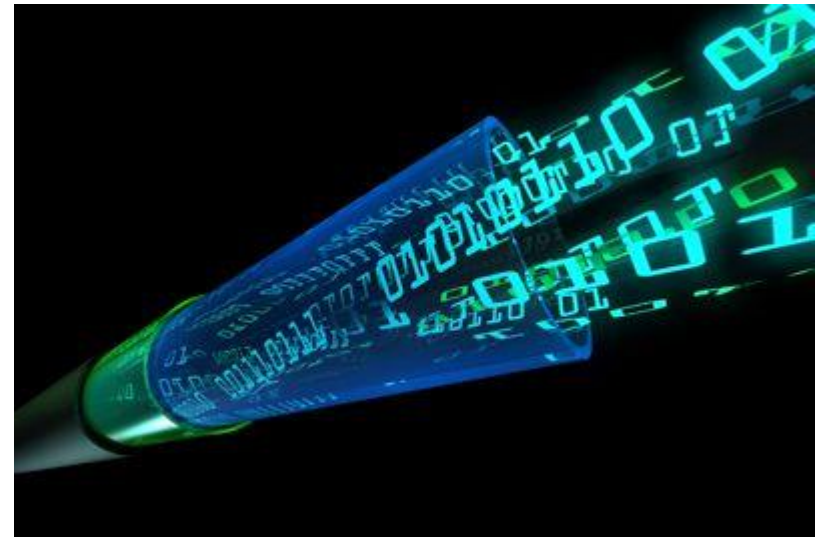


TDR/TDT



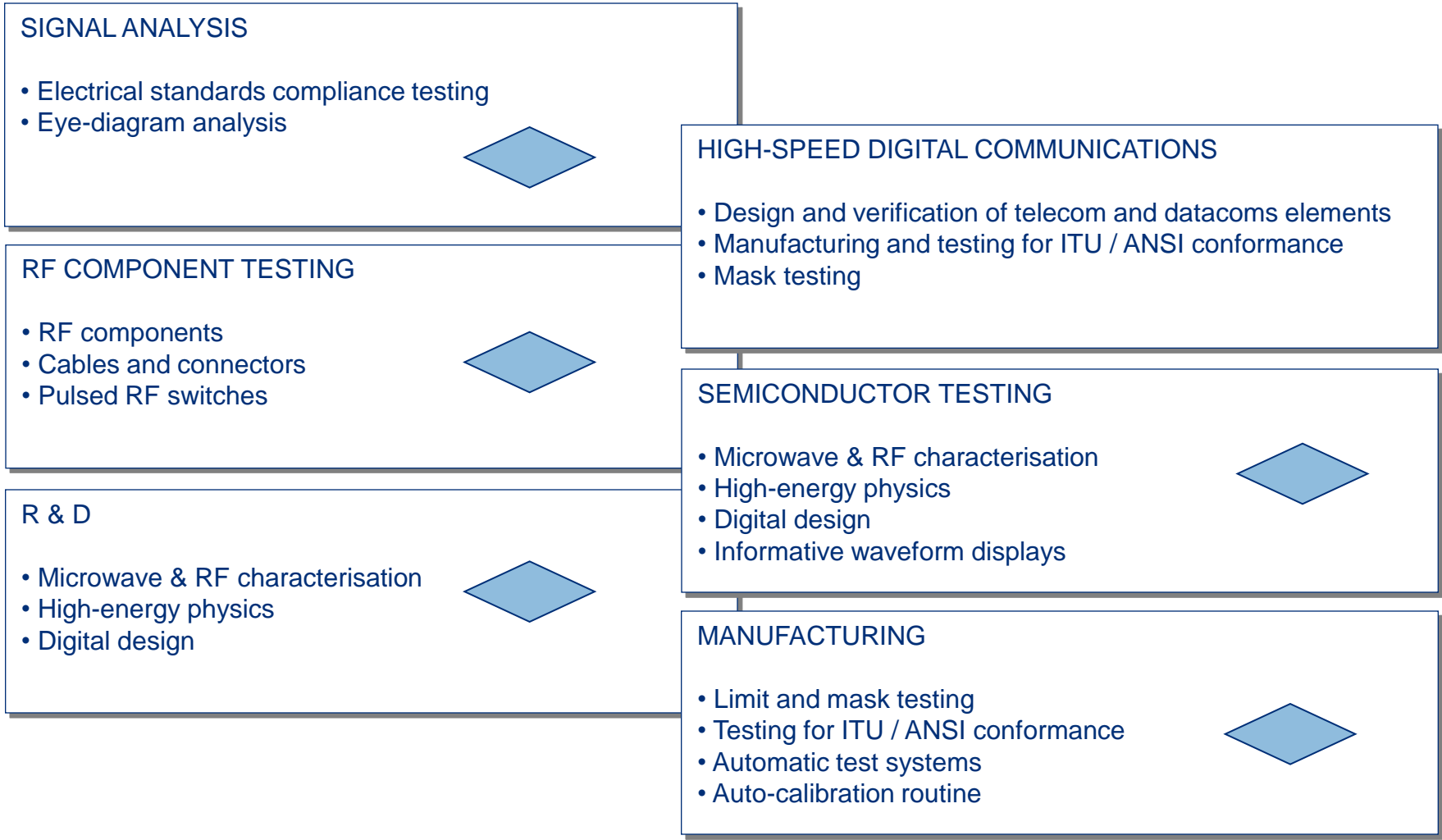
- Differential TDR
- 65 ps, 6 V step generator built in
- 40 ps, 200 mV external generator
- Plot voltage, impedance or reflection coefficient against time or distance





- 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



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