

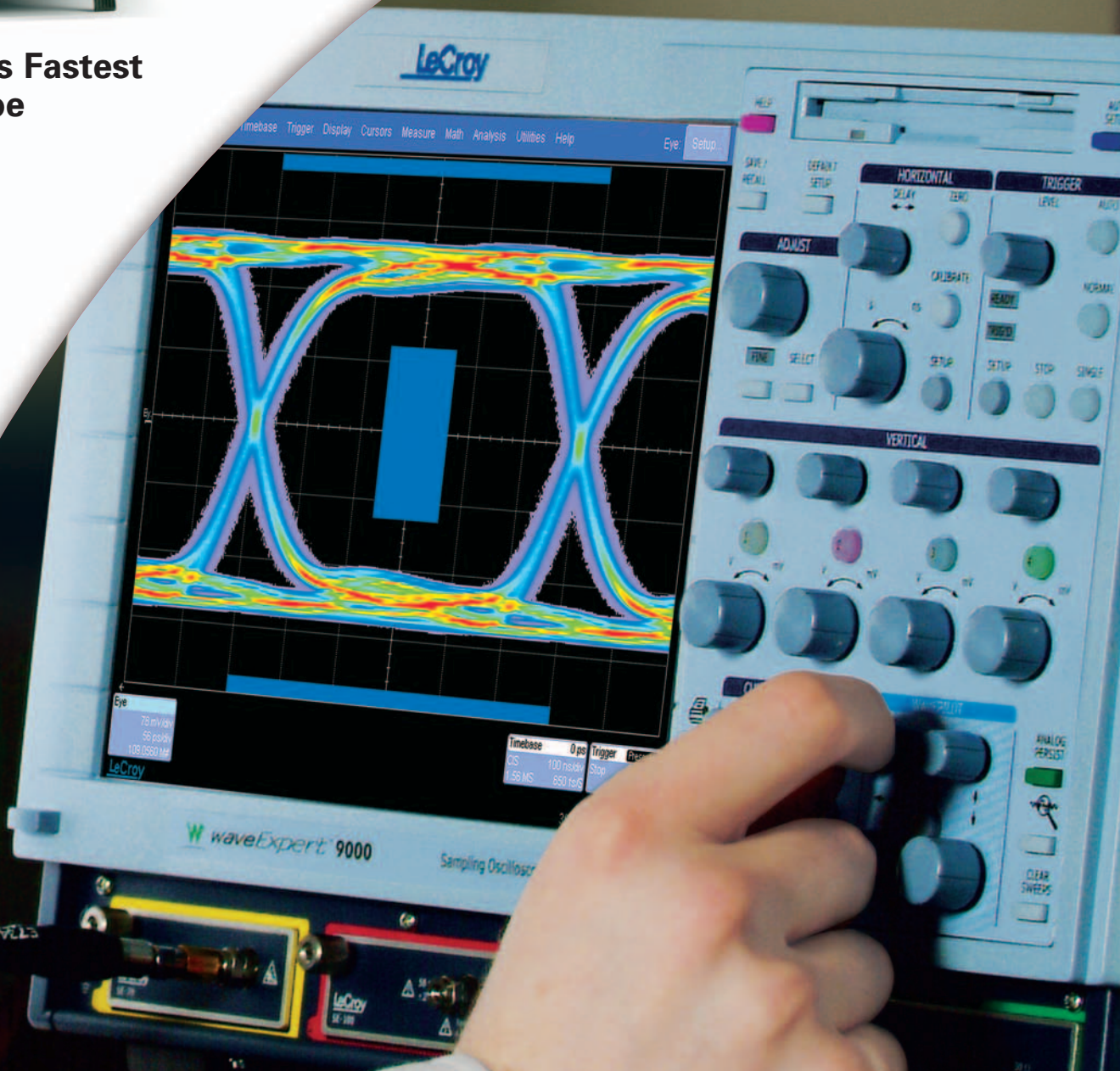
# LeCroy

## WAVEEXPERT™ SERIES OSCILLOSCOPES

WE 9000  
NRO 9000  
SDA 100G



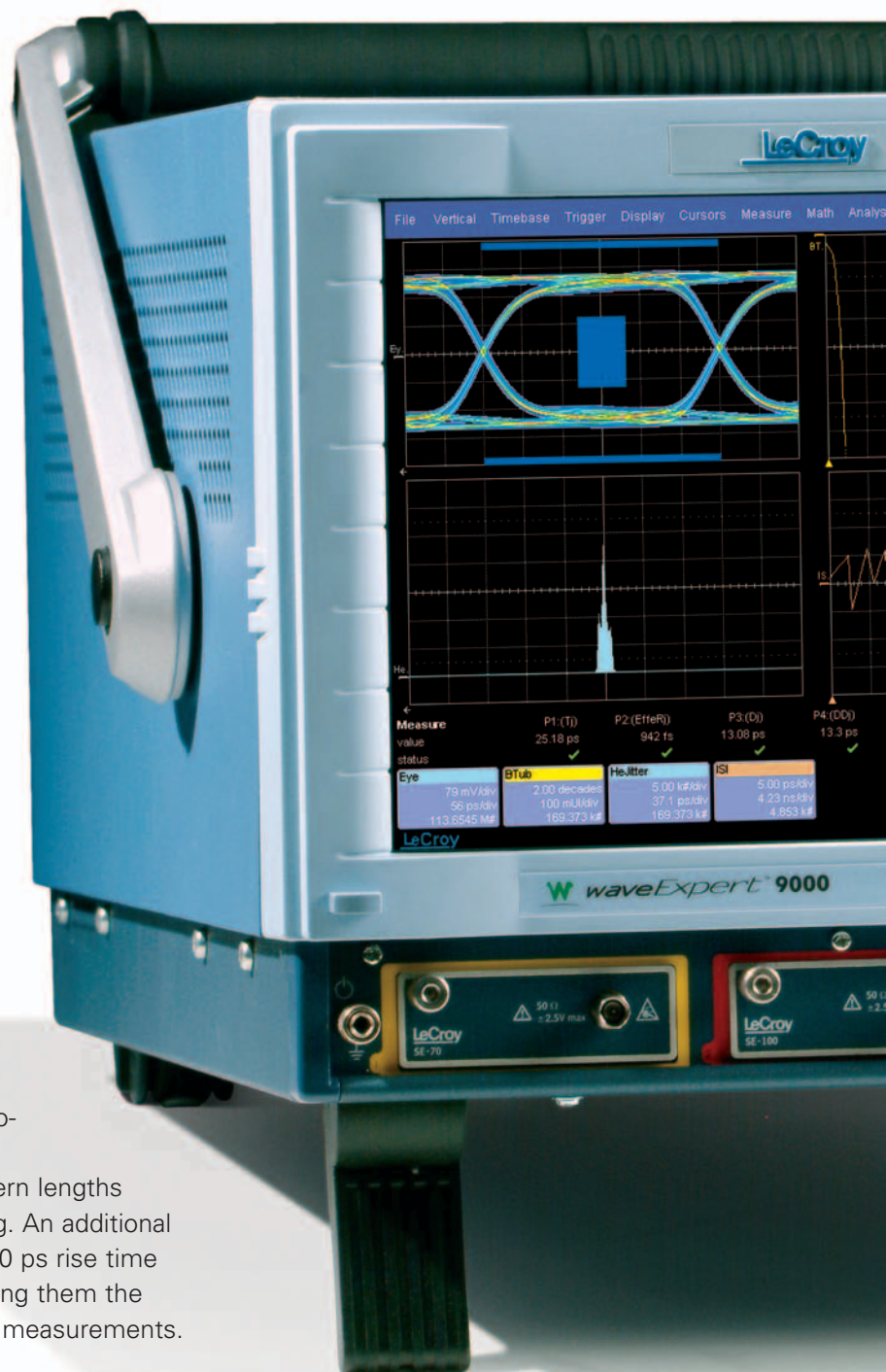
The World's Fastest  
Oscilloscope



# The Fastest Oscilloscope in the Marketplace

The WaveExpert and SDA 100G are the first instruments to combine the high bandwidth and accuracy of a sampling oscilloscope with the speed and flexibility of a real time instrument. These are the first products in the new instrument class called Near Real Time Oscilloscopes (NRO) which eliminate most of the constraints of traditional sampling scopes. The WaveExpert family features high acquisition speed, a responsive GUI and a powerful suite of analysis tools. Enabled by another new LeCroy technology—Accelerated Throughput Architecture (ATA), WaveExpert comes to market with up to 100 GHz bandwidth, signal acquisition speeds 100 times faster, and memory depths 125,000 times deeper than conventional sampling scopes. In addition to much higher throughput, LeCroy ATA allows for signal analysis algorithms that rival capabilities found in only real-time oscilloscopes.

Underlying the ATA technology is a LeCroy exclusive Coherent Interleaved Sampling mode. The CIS timebase, (Patent Pending) permits the capture and display of very long serial data waveforms without the need for an external pattern trigger. The WaveExpert and SDA 100G have an acquisition rate of up to 10 MS/s, which is a 100 times improvement over existing instruments in this class. The WaveExpert and SDA 100G are modular based instruments that can accommodate up to (4) acquisition modules. Additionally, the oscilloscopes have an optional source module. The source generates PRBS sequences in commonly used pattern lengths and bit rates that can be used for component testing. An additional acquisition module can output a TDR pulse with < 20 ps rise time which is 30% faster than existing instruments, making them the tools of choice for time domain reflectometry (TDR) measurements.





# 100 GHz Bandwidth is Here!



## Leading Features

- 100 GHz bandwidth
- 10 MS/s acquisition rate
- 512 Mpts waveform memory
- < 600 fs rms timebase jitter
- Jitter and eye pattern measurement software
- Real-time oscilloscope interface including a full set of math functions and parameters
- < 20 ps TDR rise time
- Integrated 12.5 Gb/s serial pattern generator

## Jitter Analysis Software

The Jitter Analysis software, available on the WaveExpert NRO 9000 and SDA 100G, measures the total jitter as well as the breakdown of random and deterministic sources. A summary display is provided that shows the eye pattern along with several views of the jitter.

# The First Sampling Scope with a Real-time Interface

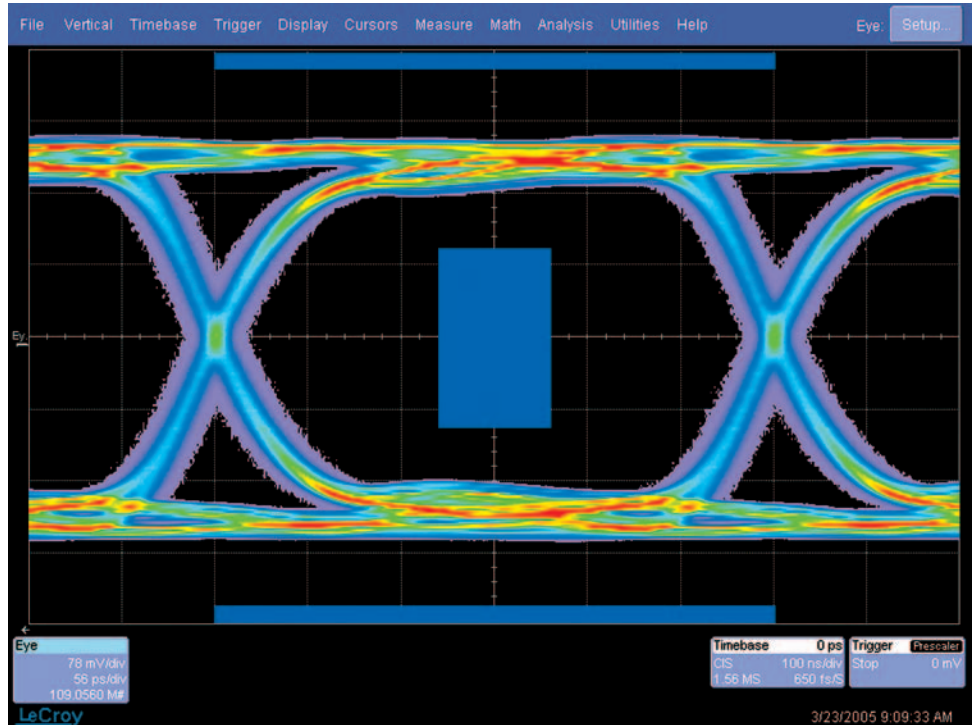
## The Most Convenient Sampling Oscilloscope

The WaveExpert uses LeCroy's award-winning user interface pioneered in the WaveMaster® Series of real-time oscilloscopes. This interface provides access to dozens 50 measurements and math functions that can be combined to give an unparalleled level of analysis. More in-depth analysis is possible using custom functions that can be created using MATLAB, Mathcad, Excel, or any other Windows-compatible programming language.

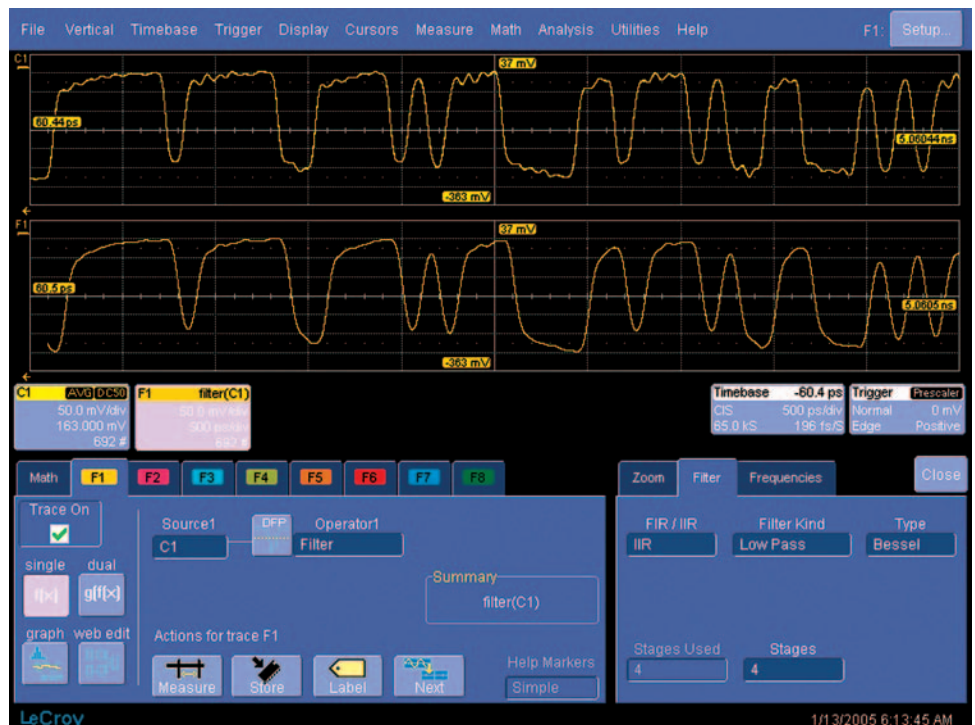
The automatic pattern-lock capability in the coherent interleaved time-base, makes it possible to capture voltage vs. time waveforms without a pattern trigger. With the optional clock recovery module, an external clock is not required, making the WaveExpert ideal for analyzing high-speed serial data signals.

## Coherent Interleaved Sampling

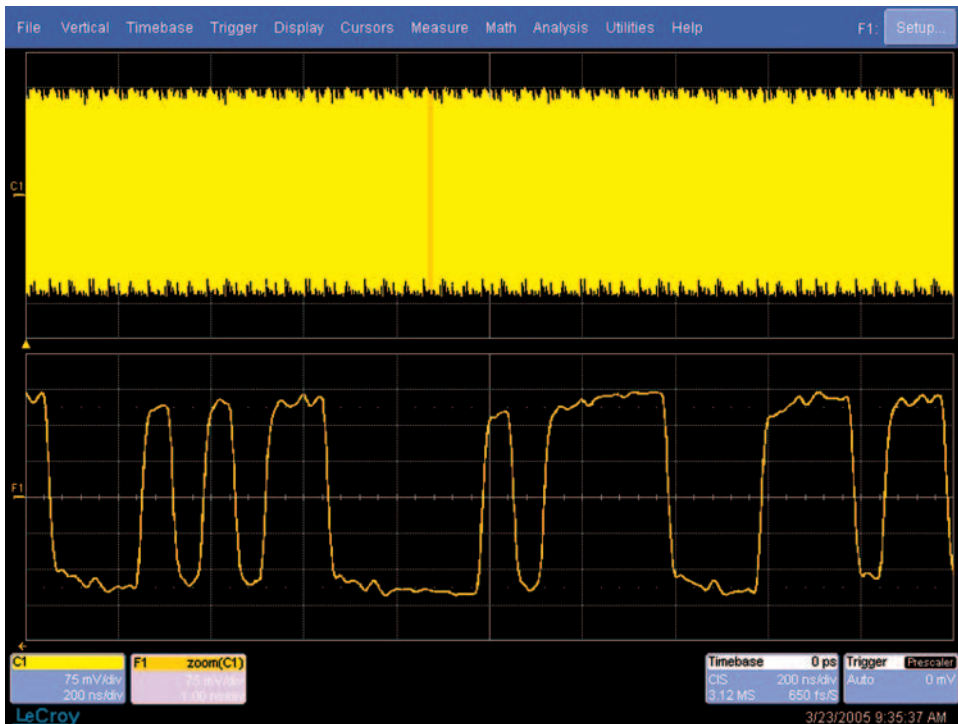
The unique and powerful analysis capabilities of the WaveExpert are due to the development of an entirely new method of sampling known as coherent sampling (CIS). This sampling method employs a phase-locked sampling strobe that is referenced to a user-supplied or recovered clock. The sampling clock is locked to the bit clock of the signal under test, so trigger jitter is eliminated.



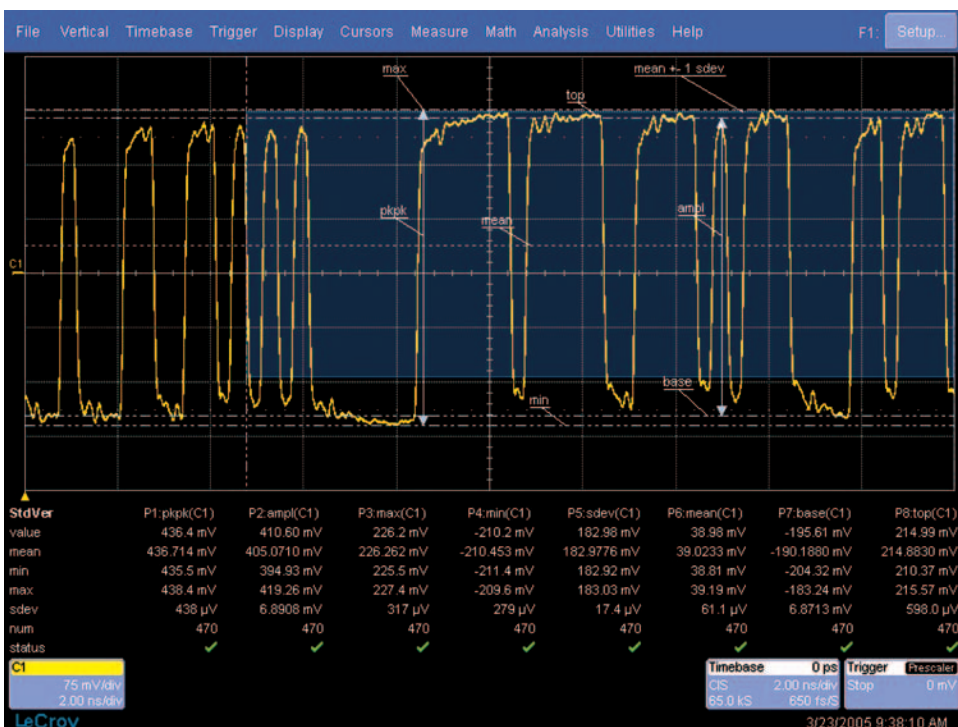
Eye patterns measured using the optional CIS timebase and Jitter Analysis software accumulate up to 3.3 MS/s.



Filtering functions are available that offer custom FIR, IIR filters as well as built-in LPF, BPF, HPF and Notch types.



The WaveExpert can capture over 125,000 times more waveform samples than any other sampling oscilloscope, opening up a vast array of measurement and analysis capabilities.



The user interface includes a full complement of math and measurement functions. The operation of the instrument is essentially the same as LeCroy's real-time oscilloscopes, making it easy to quickly move among different scopes.

For the case when the signal under test consists of a repeating data pattern, the CIS timebase can be set to pattern lock on the signal, resulting in a voltage vs. time waveform. The voltage vs. time can be processed in many ways, similar to a waveform from a real-time oscilloscope. Processing includes convolution, FFT, and filtering.

### Jitter-free Clock Recovery

A common limitation of electrical clock recovery circuits used to supply trigger signals to sampling scopes is that they add to the trigger jitter, thus increasing the overall measurement inaccuracy. The CIS timebase, with its phase-locked loop, maintains the same jitter performance whether clock recovery is used or not.

### Integrated Data Source

The analysis capability of the WaveExpert is further enhanced by the first-ever available internal data generator. This serial data generator operates at bit rates up to 12.5 Gb/s and features a < 30 ps rise time and support for  $2^7$ ,  $2^{10}$ ,  $2^{15}$ ,  $2^{23}$ , and  $2^{31}$  PRBS patterns. The unit plugs into any available module slot in the main frame and includes differential data outputs, a clock output, and clock input. The generator's internal clock provides bit rates of 2.45 to 2.87, 4.9 to 5.75, and 9.8 to 11.5 Gb/s. An external clock input is available to allow other data rates.

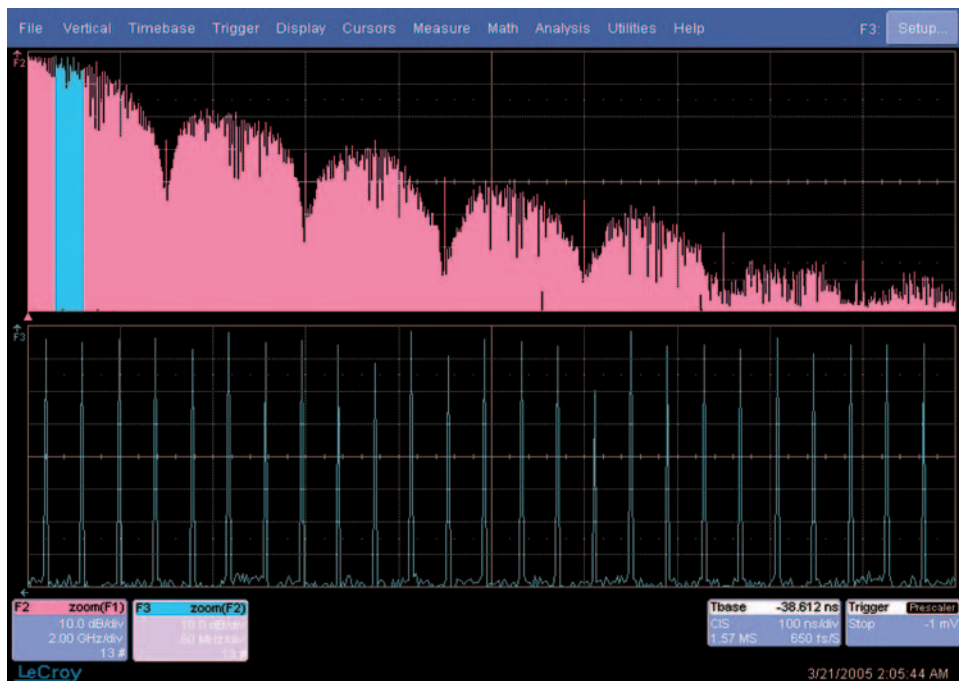


The data generator is ideal for testing backplanes, circuit boards, amplifiers, and other modules that require a PRBS signal input.

### Clock Recovery

Both optical and electrical clock recovery modules are available for cases when a symbol clock is not available. The electrical clock recovery module plugs into any available main frame slot and supports both differential and single-ended signal types. An internal passive power divider allows the signal under test to be looped through the clock recovery module so that external power dividers are unnecessary. The module recovers clock signals of data streams from 622 MHz through 13.5 GHz.

Optical clock recovery is available using an external module for data rates from 12.5 MHz to 2.7 GHz and 9.95 through 12.5 Gb/s. The optical signal loops through the clock recovery, and the recovered clock is electrically coupled to the instrument's trigger input. The form factor of this clock recovery module allows for an overall smaller system height, minimizing space requirements in rack mount configurations.



Detailed frequency domain analysis is provided by the standard Fourier transform function. This functionality is unavailable in other sampling oscilloscopes.

### Eye Pattern Analysis—Fast and Accurate

The traditional eye pattern view of serial data signals continues to be the most widely used measurement of signal integrity. The WaveExpert eye pattern mode uses a standard persistence display with the acquisition triggered by an external or recovered clock. The optional coherent timebase and Jitter

Analysis software (standard in the SDA 100G) measures a complete voltage vs. time waveform which is then “folded” to create the eye pattern. This dramatically improves measurement throughput and enables the display of specific symbols within the data pattern that are causing mask violations. Compliance masks are included for most common standards, and additional masks can be easily created for new and emerging standards.



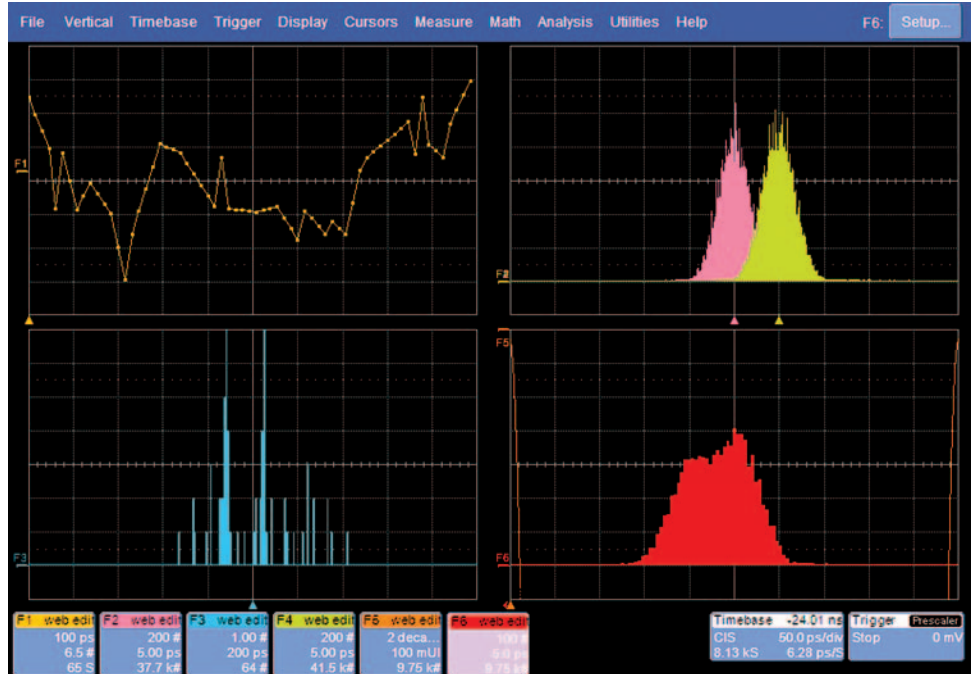
LeCroy's Optical and Electrical Sampling Heads

## Complete Jitter Analysis

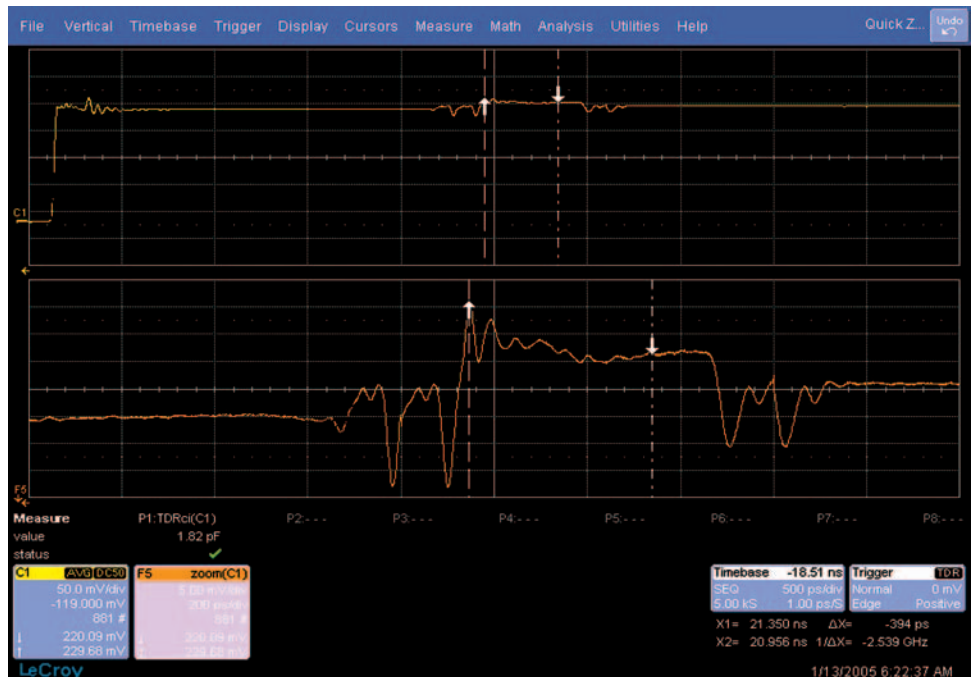
Jitter measurement has become a critical component of serial data analysis for systems and components. Traditionally, sampling oscilloscopes have measured jitter by determining the peak-to-peak and rms values of histograms on eye diagrams. This method was simple and reliable. However, current serial data standards require more detailed jitter analysis, that includes the total jitter at a specific bit error rate, as well as the random and deterministic components.

## Fastest TDR Step

The WaveExpert contains the fastest TDR step available in any instrument. The 20 ps rise time allows the measurement of even the smallest feature sizes. TDR traces can be scaled in volts, reflectance, or ohms. The capacitive or inductive reactance of specific portions of the trace can also be displayed by placing markers around the section of the trace of interest. The instrument supports both single-ended and differential TDR as well as TDT measurements.



The optional jitter analysis package (standard in the SDA 100G) measures total jitter at a selectable bit error rate, as well as the deterministic jitter and its components. Data dependent jitter, random + periodic jitter histograms for positive and negative-going edges, and the jitter bathtub curves are displayed.



TDR measurements are enhanced by the fastest step in the industry. Traces can be scaled in impedance, reflectance, or volts. The capacitive or inductive reactance of specific features can also be displayed.

# Specifications

## Timebase

### Trigger Input

Input Channels	1
Input Connector	2.92 mm
Frequency Range	DC to 5 GHz
Input Impedance	50 $\Omega$ nominal
Input Amplitude	$\pm 1$ V
Max. Input Voltage	$\pm 2.5$ V
Coupling	DC only
Threshold Range	$\pm 1$ V
Threshold Resolution	2 mV

### Prescaler Input

Input Channels	1
Input Connector	2.92 mm
Frequency Range	125 MHz* to 14 GHz
Input Impedance	50 $\Omega$ nominal
Input Amplitude	0.0 dBm $\pm 6$ dBm
Max. Input Voltage	$\pm 2.5$ V
Coupling	AC coupled

### Sequential Timebase

Minimum Time Per Division	1 ps
Time Resolution	100 fs
Timebase Delay Time Range	25 ns to 13 ms
Time Interval Accuracy	1 ppm * Reading
Long Term Sample Rate and Delay Time Accuracy	$\pm 1$ ppm
Maximum Record Length	16k samples – Std., 100K L option
Sample Rate	1 MS/s
Jitter	1.8 ps rms (typical) $\pm 1$ ppm * delay

### CIS Timebase

Frequency Ranges	62.5 MHz to 100 GHz
Frequency Stability	Determined by the stability of the trigger prescaler signal
Jitter	600 fs rms (typical)
Timebase Range	1 ps/div to 500 ns/div (4M memory)
Timebase Delay Time Range	$\pm 1$ pattern
Time Interval Accuracy	Determined by trigger/prescaler signal
Sample Rate	10 MS/s
Maximum Record Length	4M Std., 64M - L, 128M - VL, 256M - XL, 512M - XXL

## Electrical Sampling Modules

### 20 GHz/TDR

Connector Type	2.92 mm
Rise Time	18 ps
Bandwidth	20 GHz
Input Voltage Range	2 $V_{pk-pk}$
DC Vertical Voltage Accuracy (worst case)	$\pm 1\%$ (800 mV <sub>p-p</sub> signal)
Aberrations	First 40 ps: $\pm 10\%$ , 40 ps to 200 ps: $\pm 5\%$ , 200 ps – 10 ns $\pm 2\%$
Rms Noise	700 $\mu$ V max. (500 $\mu$ V typical)
TDR Step Voltage	250 mV
Incident Rise Time	20 ps (typical)
Offset Range	$\pm 1$ V
TDR Pulse Rate	1 MHz
Offset Range	$\pm 1$ V

\*1 ns maximum rise time

## Electrical Sampling Modules (continued)

### 30 GHz

Connector Type	2.92 mm
Rise Time	12 ps
Bandwidth	30 GHz
Input Voltage Range	2 $V_{pk-pk}$
DC Vertical Voltage Accuracy	$\pm 1\%$ (800 mV <sub>p-p</sub> signal)
Aberrations	First 40 ps: $\pm 10\%$ , 40 ps to 200 ps: $\pm 5\%$ , 200 ps – 10 ns $\pm 2\%$
Rms Noise	1 mV (typical)
Offset Range	$\pm 1$ V

### 50 GHz

Connector Type	2.92 mm
Rise Time	8 ps
Bandwidth	50 GHz
Input Voltage Range	2 $V_{pk-pk}$
Aberrations	First 40 ps: $\pm 10\%$ , 40 ps to 200 ps: $\pm 5\%$ , 200 ps – 10 ns $\pm 2\%$
Rms Noise	2 mV (typical)
Offset Range	$\pm 1$ V

### 70 GHz

Connector Type	1.85 mm
Rise Time	5 ps
Bandwidth	70 GHz
Input Voltage Range	2 $V_{pk-pk}$
Aberrations	First 40 ps: $\pm 10\%$ , 40 ps to 200 ps: $\pm 5\%$ , 200 ps – 10 ns $\pm 2\%$
Rms Noise	3m V (typical)
Offset Range	$\pm 1$ V

### 100 GHz

Connector Type	1 mm
Rise Time	4 ps
Bandwidth	100 GHz
Input Voltage Range	2 $V_{pk-pk}$
Aberrations	First 40 ps: $\pm 10\%$ , 40 ps to 200 ps: $\pm 5\%$ , 200 ps – 10 ns $\pm 2\%$
Rms Noise	3 mV (typical)
Offset Range	$\pm 1$ V

## Optical Sampling Modules

### SO 50

Optical Bandwidth	50 GHz
FWHM (50%)	8.5 ps (typical), 8.8 ps (max.)
Wavelength Range	1280 to 1620 nm
Responsivity	17 V/W (typical) 15 V/W (min.) @ 1564 nm, 11 V/W (typical) 9 V/W (min.) @ 1310 nm
Maximum Peak Optical Input	50 mW (+17 dBm)
Maximum Average Optical Input	20 mW (+13 dBm)
Noise Equivalent Power	83 $\mu$ W (-11 dBm) @ 50 GHz bandwidth with 150 MHz IF bandwidth
Optical Power Monitor	-30 dBm to +10 dBm $\pm 5\%$
Optical Return Loss	> 25 dB @ 1550 nm



# Specifications

## SO 25

Optical Bandwidth	28 GHz
FWHM (50%)	15 ps
Wavelength Range	1280 to 1620 nm
Responsivity	17 V/W (typical) 15 V/W (min.) @ 1564 nm, 11 V/W (typical) 9 V/W (min.) @ 1310 nm
Maximum Peak Optical Input	50 mW (+17 dBm)
Maximum Average Optical Input	20 mW (+13 dBm)
Noise Equivalent Power	47 $\mu$ W (-13.2 dBm) @ 28 GHz bandwidth with 150 MHz IF bandwidth
Optical Power Monitor	-30 dBm to +10 dBm $\pm$ 5%
Optical Return Loss	> 25 dB @ 1550 nm

## SO 10

Optical Bandwidth	9 GHz (min.) 10 GHz (typical)
FWHM (50%)	40 ps (max.) 35 ps (typical)
Wavelength Range	750 to 1650 nm
Responsivity	
Maximum Peak Optical Input	631 $\mu$ W (-2 dBm)
Optical Return Loss	-22 dB (SM), -14 dB (MM)
Noise Equivalent Power	2.5 $\mu$ W rms 1550 SM and 1310 MM, 2.1 $\mu$ W rms 1310 SM, 3.7 $\mu$ W 850 MM
Sensitivity	-15 dBm 10.7 Gb/s 1550 SM, -14 dBm 12.5 Gb/s 1550 SM

## Optical Reference Receiver Filters for SO 10 Module

### Individual Filters

155 Mb/s	REF-00155
622 Mb/s	REF-00622
1.063 Gb/s	REF-01063
1.250 Gb/s	REF-01250
2.125 Gb/s	REF-02125
2.48832 Gb/s	REF-02488
2.5 Gb/s	REF-02500
3.125 Gb/s	REF-03125
3.188 Gb/s	REF-03188
3.320 Gb/s	REF-03320
4.250 Gb/s	REF-04250
9.953 Gb/s	REF-09950
10.31 Gb/s	REF-10310
10.52 Gb/s	REF-10520
10.66 Gb/s	REF-10660
10.71 Gb/s	REF-10710
11.1 Gb/s	REF-11100

### Filter Kits

SONET/SDH Kit. Includes: REF00155, REF00622, REF-2488, REF-09950, REF-10660, REF-10710	RefKit-Telco
Serial Bus Kit. Includes: REF01063, REF-01250, REF-02125, REF-02500, REF-03125, REF-03188, REF-03320, REF-04250, REF-09950, REF-10310, REF-11100	RefKit-Sbus

## Clock Recovery and Source Optical/Electrical Modules

### Clock Recovery Modules

#### CDR-E135

Configuration	Electrical differential data input/output (passive loop-through) with single-ended clock output
Frequency Range	622 Mb/s to 8 Gb/s (13.5 Gb/s with option 001)
Input Sensitivity	100 mV to 2 $V_{p-p}$
Input Return Loss	> -10 dB
Max. Input Level	2 $V_{p-p}$
Clock Out Level	> .5 $V_{p-p}$
Output Clock Rise/Fall Time	30 ps
Output Clock Jitter	< 800 fs rms
PLL Loop Bandwidth	6 MHz

#### CDR-O125

Configuration	External optical clock recovery with multi mode optical input/output and single-ended electrical clock output
Frequency Range	155 Mb/s to 2.7 Gb/s, 9.95 Gb/s to 12.5 Gb/s
Wavelength Range	750 nm to 1650 nm
Phase-Locked Loop Bandwidth	300 kHz and 4 MHz, user selectable
Clock Outputs	350 mV <sub>p-p</sub> (9.95 to 12.5 Gb/s), 500 mV <sub>p-p</sub> (155 Mb/s to 2.7 Gb/s)
Recovered Clock Jitter	.007 UI rms max.
Optical Signal Level Range	-10 dBm to +5 dBm
Optical Connector	Diamond MAS series 62.5 $\mu$ m fiber with FC-PC
Input Return Loss	-15 dB
Input insertion loss	-3 dB

### Pulse Pattern Generator

#### PPG-E125

Configuration	Differential data output, single-ended clock output with external clock input
Frequency Range	2.45 to 2.875 Gb/s, 4.9 to 5.75 Gb/s, 9.8 to 11.5 Gb/s
Data Patterns	PRBS 7, 10, 15, 23, 31
Mark Density	0.5, 0.25, 0.125
Data Output Voltage	500 mV <sub>p-p</sub>
Data Output Jitter	< 1 ps rms
Data Output Rise/Fall Time (20–80%)	30 ps
Clock Out Level	> 0 dBm
Clock Input Level	> 0 dBm
Frequency Accuracy	$\pm$ 3 ppm

# Ordering Information

Product Description	Product Code
<b>WaveExpert 9000 Mainframe</b>	
Standard 4-slot Mainframe	WE 9000
100K/Channel Memory	WE9K-L
Gated Trigger	WE9K-GT

Product Description	Product Code
<b>WaveExpert NRO Mainframe</b>	
NRO 4-slot Mainframe (includes CIS timebase)	NRO 9000
Serial Data Package (Jitter and Hi-Throughput Eye-Pattern Analysis)	NRO-SDA
64M (1 Ch), 32M (2 Ch), 16M (4 Ch) Waveform Memory	NRO-L
128M (1 Ch), 64M (2 Ch), 32M (4 Ch) Waveform Memory	NRO-VL
256M (1 Ch), 128M (2 Ch), 64M (4 Ch) Waveform Memory	NRO-XL
512M (1 Ch), 256M (2Ch), 128M (4 Ch) Waveform Memory	NRO-XXL
Gated Trigger	NRO-GT

Product Description	Product Code
<b>WaveExpert SDA Mainframe</b>	
SDA 4-slot Mainframe (includes CIS timebase, Serial Data Analysis Package)	SDA 100G
64M (1 Ch), 32M (2 Ch), 16 M (4 Ch) Waveform Memory	SDA 100G-L
128M (1 Ch), 64M (2 Ch), 32M (4 Ch) Waveform Memory	SDA 100G-VL
256 M (1 Ch), 128M (2 Ch), 64M (4 Ch) Waveform Memory	SDA 100G-XL
512M (1 Ch), 256M (2 Ch), 128M (4 Ch) Waveform Memory	SDA 100G-XXL
Gated Trigger	SDA 100G-GT

Product Description	Product Code
<b>Software Options</b>	
Digital Filter Software Package	WE9K-DFP2
Advanced Customization Software Package	WE9K-XDEV
Advanced Math Software Software Package	WE9K-XMATH

Product Description	Product Code
<b>Electrical Sampling Heads</b>	
100 GHz Electrical Sampling Head	SE-100
70 GHz Electrical Sampling Head	SE-70
50 GHz Electrical Sampling Head	SE-50
30 GHz Electrical Sampling Head	SE-30
20 GHz Electrical Sampling Head with TDR	ST-20

Product Description	Product Code
<b>Optical Sampling Heads</b>	
High Sensitivity 10 GHz Optical Sampling Head with Plug-in Reference Receivers	SO-10
28 GHz Optical Sampling Head	SO-25
50 GHz Optical Sampling Head	SO-50
Optical Reference Receiver Kit – Serial Bus	REFKIT-SBUS
Optical Reference Receiver Kit – SONET/SDH	REFKIT-TELCO
155 Mb/s Reference Receiver Filter for SO-10	REF-00155
622 Mb/s Reference Receiver Filter for SO-10	REF-00622
1.063 Gb/s Reference Receiver Filter for SO-10	REF-01063
1.250 Gb/s Reference Receiver Filter for SO-10	REF-01250
2.125 Gb/s Reference Receiver Filter for SO-10	REF-02125

Product Description	Product Code
<b>Optical Sampling Heads (continued)</b>	
2.488 Gb/s Reference Receiver Filter for SO-10	REF-02488
2.5 Gb/s Reference Receiver Filter for SO-10	REF-02500
3.125 Gb/s Reference Receiver Filter for SO-10	REF-03125
3.188 Gb/s Reference Receiver Filter for SO-10	REF-03188
3.32 Gb/s Reference Receiver Filter for SO-10	REF-03320
4.25 Gb/s Reference Receiver Filter for SO-10	REF-04250
9.950 Gb/s Reference Receiver Filter for SO-10	REF-09950
10.31 Gb/s Reference Receiver Filter for SO-10	REF-10310
10.52 Gb/s Reference Receiver Filter for SO-10	REF-10520
10.66 Gb/s Reference Receiver Filter for SO-10	REF-10660
10.71 Gb/s Reference Receiver Filter for SO-10	REF-10710
11.1 Gb/s Reference Receiver Filter for SO-10	REF-11100

Product Description	Product Code
<b>Hardware Options and Accessories</b>	
1.5 meter Module Extender Cable	ME-15
IEEE-488 GPIB Remote Control Interface	GPIB-1
Keyboard, USB	KYBD-1
Oscilloscope Cart with Extra Shelf and Drawer	OC1024
Oscilloscope Cart	OC1021
Rackmount Adapter with 25" slide	RMA-25
Rackmount Adapter with 30" slide	RMA-30
Removable Hard Drive Package	WE9K-RHD
Additional Removable Hard Drive	WE9K-RHD-02
2.92 mm F-F Adapter	ADAPT-292
2.92 – SMA F-F Adapter	ADAPT-292-SMA
1.85 mm F-F Adapter	ADAPT-185
1 mm F-F Adapter	ADAPT-100
1 mm – 1.85 mm F-F Adapter	ADAPT-100-185
4 in.-lb. Torque Wrench	TW-4
8 in.-lb. Torque Wrench	TW-8

Product Description	Product Code
<b>Optical Clock Recovery Modules</b>	
Optical Clock Recovery Module (12.5 MHz to 2.5 Gb/s, 9.95 Gb/s to 12.5 Gb/s)	CDR-O125
Electrical Clock Recovery (622 MHz to 8 GHz)	CDR-E135
Extend Frequency Range of CDR-E135 to 13.5 Gb/s	CDR-E035-001

Product Description	Product Code
<b>Pulse Pattern Generator</b>	
PRBS Source 10 Gb/s, 5 Gb/s, 2.5 Gb/s	PPG-E125

**Customer Service**  
LeCroy scopes are designed, built, and tested to ensure high reliability. In the unlikely event you experience difficulties, our digital oscilloscopes are fully warranted for three years.

This warranty includes:

- Calibration after repairs
- No charge for return shipping
- Long term 7-year support
- Upgrade to latest software at no charge



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To find the most convenient one visit [www.lecroy.com](http://www.lecroy.com)