Complete PCI Express® Testing for Electrical Compliance & Cross-layer Debugging

Teledyne LeCroy is the only company that provides PCIe test across the layers – protocol to physical –

while also providing superior instruments with sophisticated jitter, eye diagram, debug and compliance software.

Approved PCIe®, CXL®, and NVMe™ base and compliance test solutions

Simplified PCIe link testing with more visibility of complex PCIe behaviors

Most confidence for PCIe physical layer compliance and interoperability testing

Built-in PCIe test expertise using SDA Expert

teledynelecroy.com/pcie-electrical-test

Simplified PCIe Link Testing with More Visibility of Complex PCIe Behaviors

Seamlessly merge the functions of your protocol analyzer and oscilloscope.

- Validate and debug active PCIe link operation
- Quickly resolve PCIe interoperability issues by capturing the entire PCIe protocol stack
- Analyze PCIe link training with integrated physical layer and protocol views
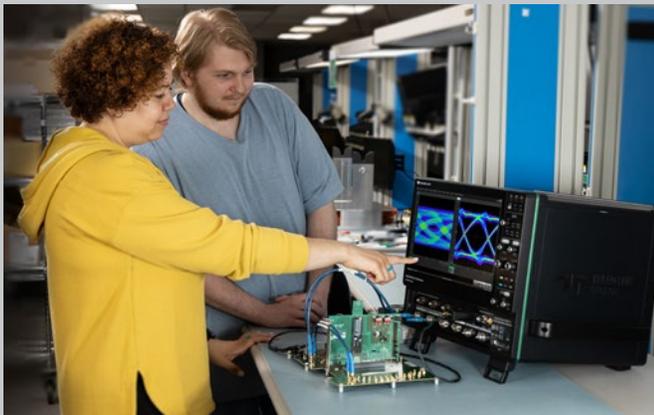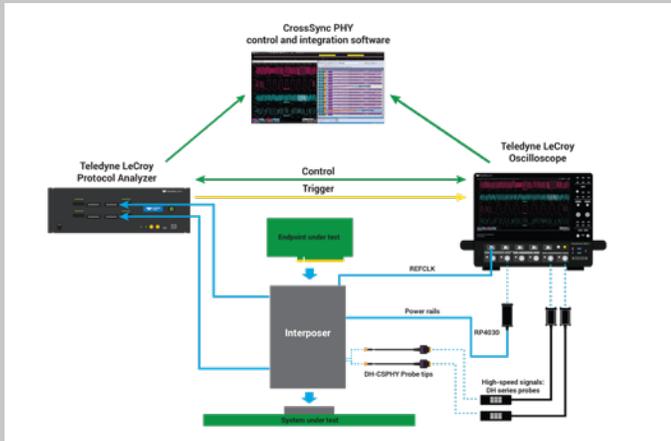
## Most Confidence for PCIe Physical Layer Compliance and Interoperability Testing

Perform PCIe compliance testing with high accuracy.

- Approved solutions for all PCIe compliance tests and CXL compliance tests
- Fully automated Transmitter, Receiver and Link Equalization testing
- Easily transition from PCIe compliance testing to PCIe debug with SDA Expert

Built-in PCIe Test Expertise Using SDA Expert

Contains specialized features for PCIe testing.

- Comprehensive PCIe eye diagrams, jitter and other PCIe measurements
- Simple, powerful PCIe transmitter equalization analysis
- Most complete PCIe SNDR (Signal-to-Noise-and-Distortion Ratio)
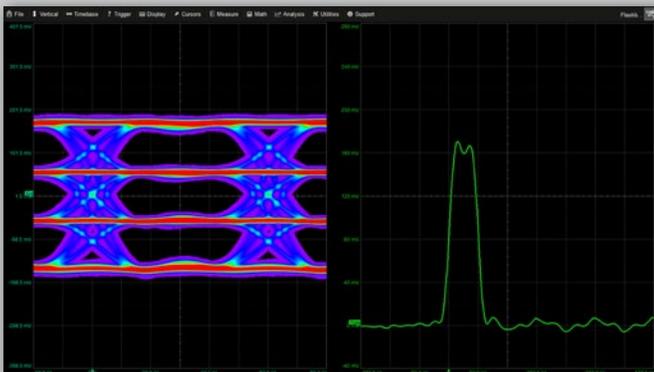
PCIe Test That Crosses the Layers

Teledyne LeCroy's PCI Express electrical and cross-layer test solutions combine superior instruments with sophisticated analysis software.

CROSS-LAYER ANALYSIS AND *Cross*Sync™ PHY

Cross-layer analysis is simultaneous, time-correlated analysis of physical layer and protocol. CrossSync™ PHY is Teledyne LeCroy's name for the technologies that seamlessly merge the functions of your protocol analyzer and oscilloscope.

CrossSync PHY Summary

CrossSync PHY uses a single PCIe interposer and software interface to unify oscilloscope and protocol analyzer views.

- CrossSync PHY PCIe interposers enable observation of both electrical and protocol behavior without disturbing the link

- Sideband signals, reference clock and power rails are all easily accessible to oscilloscope probes

- High-bandwidth oscilloscope probing points are provided for data lanes to allow debug during PCIe link training failures

Click to Watch Video: *teledynelecroy.com/pcie-electrical-test/?wvideo=mac6loase0*

How Are Layers Time Correlated?

Cross triggering is provided between the protocol analyzer and the oscilloscope, and built-in software makes minor timing corrections.

- Trigger protocol analyzer and oscilloscope captures on the same high-level event using the powerful triggering capabilities of the protocol analyzer

- Easily measure timing relationships between protocol and electrical domains.

- Faster root-cause analysis means fewer costly finger-pointing exercises.

How Will This Help with Debug?

CrossSync PHY for PCIe provides one time-correlated view of all protocol traces and oscilloscope waveforms making it easy to gain deep insight into link training.

- Observe electrical-level results of protocol-level commands

- Combined navigation means always knowing which protocol and electrical behaviors happen at the same time

- No single instrument can deliver this level of cross-layer insight into link training

4

CrossSync PHY gives deeper insight and more visibility into the most complex behaviors in a PCI Express link. Link training, retimer operation, power-on operations, and power management transitions all involve interactions between protocol and electrical layers.

CrossSync PHY
control and integration software

Teledyne LeCroy
Oscilloscope

Teledyne LeCroy
Protocol Analyzer

Control

Trigger

Endpoint under test

REFCLK

Power rails

Interposer

RP4030

DH-CSPHY Probe tips

High-speed signals:
DH series probes

System under test
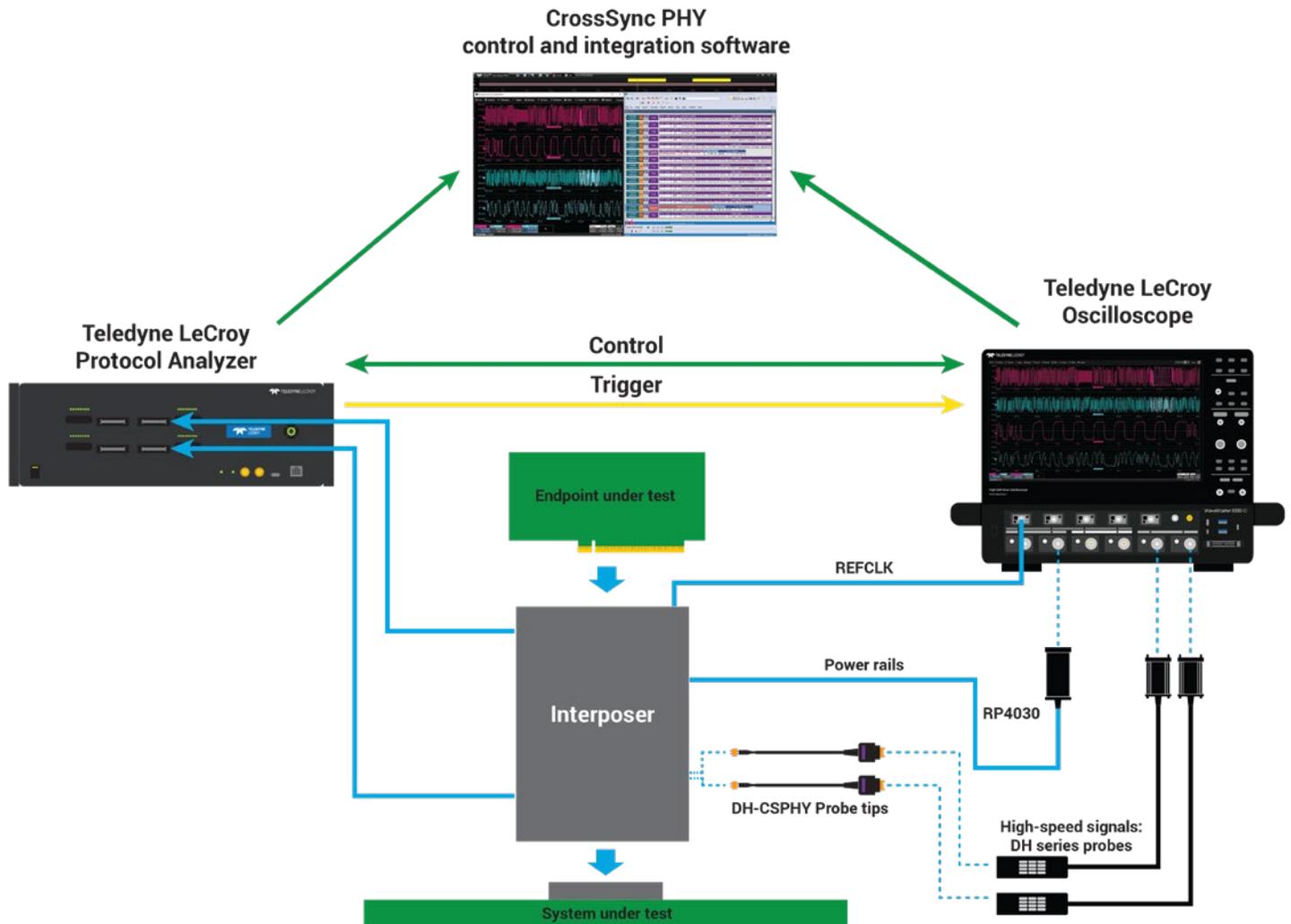
CrossSync PHY Benefits

CrossSync PHY is the first and only capability to seamlessly merge a protocol analyzer and oscilloscope and provide simultaneous and time-correlated views of both protocol and electrical/physical layer waveforms while retaining all of the powerful capabilities of both instruments.

- Validate and debug active link operation

- Debug PCIe retimers and PCIe retimer latency errors

- Quickly resolve interoperability issues by capturing the entire protocol stack

- Analyze PCIe link training with integrated physical and protocol views

Dynamic Link Behavior

Gain further insight into the link behavior while the device negotiates through the various PCIe LTSSM and other training sequences.

- Characterize entire boot sequence with visibility into sideband signals, reference clock, data lanes and power rails

- Observe speed changes in both electrical and protocol domains

- Trigger on problematic link training behaviors and analyze their consequences through the entire protocol stack

Power Management Transitions

Understand the impact of a PCIe power management transition on the PCIe system's electrical behaviors.

- Quick and easy triggering and capture of both protocol and electrical behavior as a device enters or exits low-power states

- Precise timing measurements between protocol commands and electrical behaviors of reference clock and high-speed data lines

- Dynamic power analysis through Power Management transitions including L1 substates

Dynamic Power Characterization

Capture PCIe system's low voltage power rails in conjunction with protocol events to find power integrity problems.

- CrossSync PHY interposers have built-in rail voltage and current measurement points

- Voltage and current waveforms are synchronized and time-correlated to protocol analyzer trace

- Oscilloscope tools enable measurement of dynamic power consumption and power integrity metrics

- Compatible with RP4060 Active Voltage Rail probe

MOST CONFIDENCE FOR PCIE COMPLIANCE TEST

One set of test equipment covers PCIe, CXL and NVMe electrical transmitter and receiver testing and test fixture characterization, including PCIe 6.0 with PAM4 signaling.

Approved Solutions for all PCIe and CXL Compliance Tests

Teledyne LeCroy supports the full PCI Express ecosystem with approved solutions for all PCI-SIG electrical compliance tests.

- PCIe 6.0, 5.0, 4.0, and 3.0 transmitter, receiver and PLL tests
- CXL 3.2, 2.0, 1.0 transmitter tests

Fully Automated Transmitter, Receiver, and Link Equalization Testing

QualiPHY 2 automation software provides high accuracy and repeatability for PCIe and CXL compliance testing.

- Transmitter testing
- Receiver test calibration and execution
- Link equalization testing
- PLL bandwidth testing
- Reference clock testing
- Report generation

Automated PCIe Test Fixture Characterization

The PCIe test fixture characterization automates the entire test fixture characterization process and reduces errors.

- Sets up and controls the Teledyne LeCroy WavePulser 40iX High-speed Interconnect Analyzer during measurements
- Guides the user with a connection diagram at each step of the process
- Automatically makes the measurements and transfers measured data, then makes additional calculations
- Generates a complete report

BUILT-IN PCIE TEST EXPERTISE USING SDA EXPERT

Transmitter characterization is a crucial process to validate the integrity of the transmitter. SDA Expert Serial Data Analysis and the SDAX-PCIE6 or SDAX-PCIE-NRZ options provide the best debug toolset.

Tx Equalization

Unique PCIe transmitter equalization measurements characterize the applied de-emphasis and preshoot.

- Reference and measured pulse response
- Reference and measured step response
- Display preset measurement units in dB or coefficient values
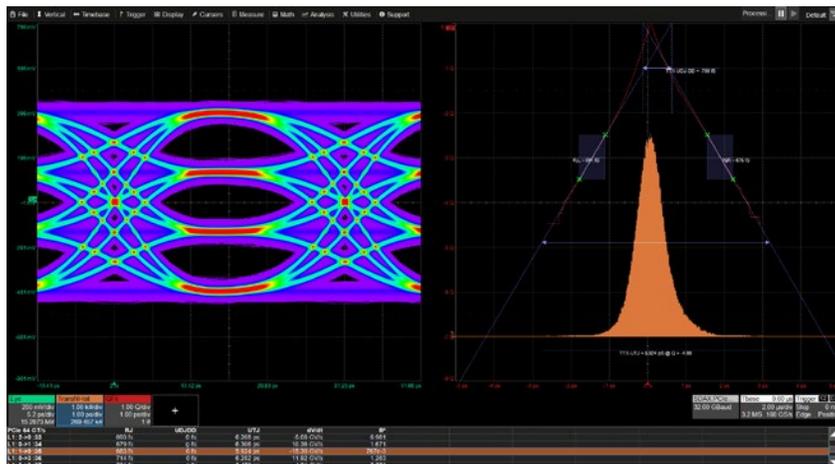
Jitter Measurements

The highest confidence PCIe jitter measurements for NRZ or PAM4 signals with complete measurements for PAM4 transitions.

- Breakdown the jitter measurement composition into the 48 transitions in the 52-UI jitter measurement pattern, 12 voltage level transitions, or a single aggregated set of jitter measurements
- Transition histogram for each of the 48 transitions in the 52-UI jitter measurement pattern
- Each of the 52 measurement table results are locked to its respective transition histogram
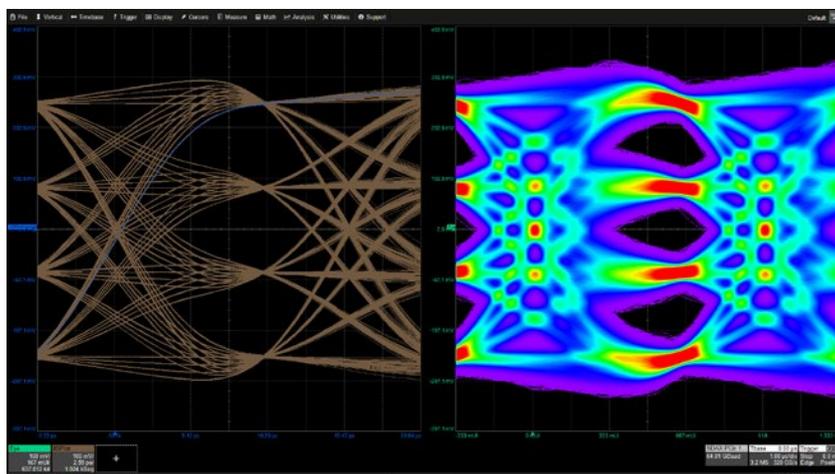
SNDR Measurements

PCIe 6.0 PAM4 signaling increases the impact of the noise at the receiver, requiring low noise measurements for accurate SNDR calculations.

- WaveMaster 8000HD oscilloscopes have 12-bit resolution with low noise - essential for accurate PAM4 measurements
- Highest precision and most accurate noise removal method (using attenuator) – unique to Teledyne LeCroy
- SNDR measurement methodology is current with evolving PCI-SIG requirements

BEST PCIE 7.0 ELECTRICAL TEST TOOLS

PAM4's multiple vertical levels requires higher resolution and lower noise at high bandwidth with additional signal fidelity measurements. Teledyne LeCroy meet these challenges.

**Click to Watch Video:** *teledynelecroy.com/pcie-electrical-test/?wvideo=lgk6bxjh6q*

The PCIe Industry Leader

Teledyne LeCroy is the PCIe industry leader in developing PCIe test tools.

- Proven track record of first-to-market PCIe test solutions

- Continuous engagement with PCI-SIG working groups to closely track PCIe 7.0 base specification

- Complete test coverage from PHY through protocol and in between
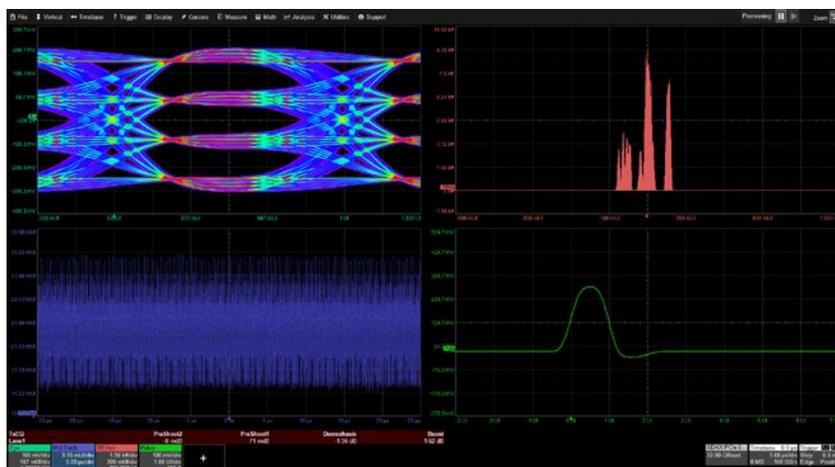
Most Complete Serial Data Toolbox

Simplify first silicon validation with the most complete serial data toolbox.

- 4th generation toolset covers complete needs for NRZ and PAM

- Integrates everything – jitter, noise, crosstalk, equalization, and pulse response

- Unique multi-view support with reference and comparison modes

Most Accurate PAM Signal Characterization

High-resolution acquisitions with the most accurate noise removal method.

- 12-bit resolution at required 65 GHz oscilloscope bandwidth

- Precise amplitude resolution for accurate measurement of PAM4 signal levels

- Highest precision and most accurate noise removal method

ACCELERATE YOUR PCIE 6.0 TESTING

Teledyne LeCroy's PCIe 6.0 electrical and protocol test solutions cover the entire design cycle from first article power on and validation through compliance testing and the most complete interoperability validation and debug.

PCIe 6.0 Compliance Testing in a Fraction of the time

PCI-SIG® approved compliance testing using the QualiPHY® 2 automated compliance test framework.

- Unified Tx/Rx compliance test framework
- Automated PCIe 6.0 test fixture characterization eliminates errors
- Simplified test interface
- Compliance on time from anywhere
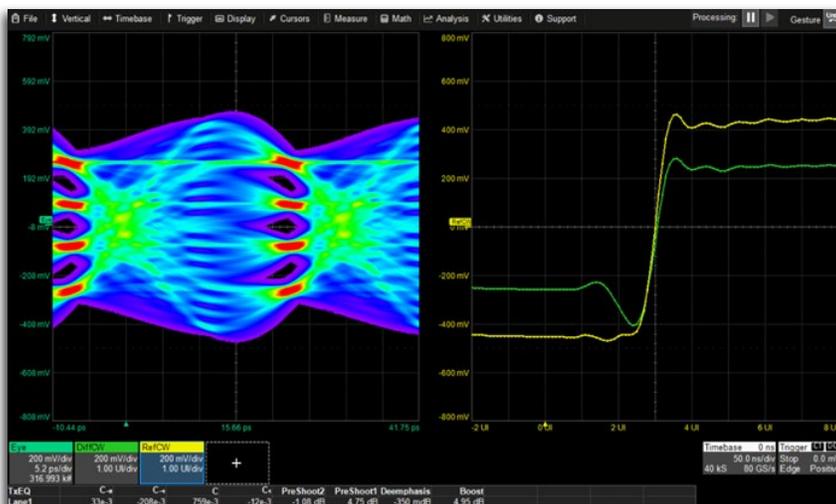
Built-in PCIe 6.0 Test Expertise Using SDA Expert

Specialized PCIe 6.0 measurements for characterizing signals.

- Tx equalization analysis with pulse and step responses
- Specialized PCIe 6.0 specific PAM4 jitter, SNDR and RLM measurements
- Apply user defined patterns to make nonstandard PCIe measurements
- Multiple pattern detection methodologies to increase the measurement accuracy
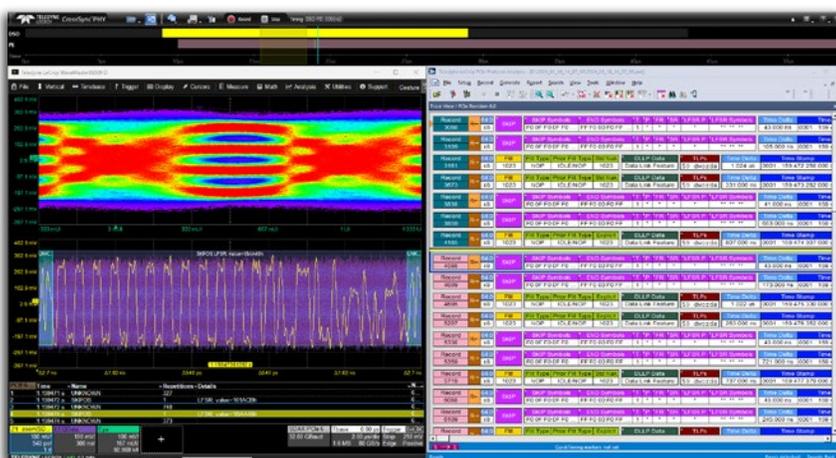
Simplified PCIe 6.0 Link Testing with More Visibility of Complex Behaviors

Seamlessly merge the functions of your protocol analyzer and oscilloscope.

- Validate and debug active PCIe 6.0 link operation
- Quickly resolve PCIe interoperability issues by capturing the entire PCIe protocol stack
- Analyze PCIe link training with integrated physical layer and protocol views

PCIE 5.0 THROUGH 1.0 ELECTRICAL TESTING

Go beyond PCIe compliance test and maximize your PCIe interoperability expertise for all form factors with cross-layer analysis to isolate problems to either physical layer or protocol, from the root complex (systems) to add-in cards.

PCIe Compliance Testing in a Fraction of the time

PCI-SIG approved compliance testing using the QualiPHY 2 automated compliance test framework.

- Unified Tx/Rx compliance test framework

- Automated PCIe 6.0 test fixture characterization eliminates errors

- Simplified test interface

- Compliance on time from anywhere

Support for All PCIe Tests, All Form Factors, All Devices

Comprehensive PCIe embedded test and PCIe debugging.

- Support for CEM, U.2, and M.2 form factors

- Visibility from electrical through transaction layer with decoders and protocol analysis software

- Test the full range of PCIe device types: endpoints, add-in cards, root complex, systems, retimers and switches.

Simplified PCIe Link Testing with More Visibility of Complex Behaviors

Seamlessly merge the functions of your protocol analyzer and oscilloscope.

- Validate and debug active PCIe link operation

- Quickly resolve PCIe interoperability issues by capturing the entire PCIe protocol stack

- Analyze PCIe link training with integrated physical layer and protocol views

EXPERIENCE, LEADERSHIP, SUPPORT

Combining the Teledyne LeCroy WaveMaster 8000HD Oscilloscope, WavePulser 40iX interconnect analyzer and QualiPHY 2 automated compliance test software with the Anritsu SQA-R MP1900A BERT results in the most powerful characterization, compliance and debug solution available.

WaveMaster 8000HD Oscilloscope

WaveMaster 8000HD series oscilloscopes supports all generations of PCIe transmitter and receiver testing at all required bandwidths.

- 65 GHz for PCIe 7.0 (128 GT/s)
- 50 GHz for PCIe 6.0 (64 GT/s) and PCIe 5.0 (32 GT/s)
- 25 GHz for PCIe 4.0 (16 GT/s)
- 13 GHz for PCIe 3.0 (8 GT/s)

WavePulser 40iX Interconnect Analyzer

WavePulser 40iX High-speed Interconnect Analyzer automates the entire PCIe test fixture characterization process, reduces errors and saves time.

- Network analysis from DC to 40 GHz
- Built-in automatic calibration
- Controlled by QualiPHY 2 compliance test software to make all PCIe test fixture characterization measurements and calculations
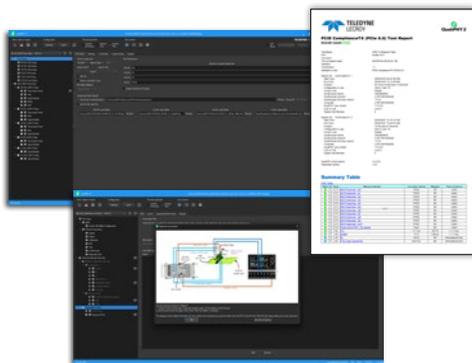
QualiPHY 2 Compliance Software

QualiPHY 2 automated compliance test software fully automates all aspects of PCIe electrical compliance testing

- Transmitter and receiver link equalization testing
- Receiver calibration
- Report generation
- PCIe test fixture characterization

Anritsu SQA-R MP1900A BERT

Anritsu SQA-R MP1900A series BERT supports all-in-one PCIe transmitter equalization validation and PCIe receiver testing.

- Jitter and noise generation for Rx calibration and bit error rate (BER) testing
- High quality waveform PPG with integrated 10-tap emphasis
- LTSSM loopback and Error detector with variable CTLE for PCIe Rx testing

Other Equipment, Technologies and Services Related to PCI Express Deployment

Compute Express Link® (CXL®), and Nonvolatile Memory Express (NVMe™) use PCIe physical layer signaling. Additionally, Teledyne LeCroy provides protocol analyzers and related equipment, training and services, and other electrical test solutions for technologies commonly deployed with PCIe. Use the links below to learn more.

PCIe, NVMe, and CXL Protocol Analyzers and Related Equipment
teledynelecroy.com/protocolanalyzer/solutions-pcie-nvme-cxl

Ethernet and Fibre Channel Protocol Analyzers and Related Equipment
teledynelecroy.com/serialdata/ethernet-testing

PCIe and Other Protocol Layer Testing, Training and Services
teledynelecroy.com/services/austinlabs-training.aspx

50G/100G Electrical Ethernet Serial Data Analysis
teledynelecroy.com/options/productseries.aspx?mseries=774&groupid=130

DDR and LPDDR
teledynelecroy.com/ddr

USB4, USB 3.2, Thunderbolt and USB-C
*teledynelecroy.com/usb-electrical-test*

PCIE SUPPORTED TESTS AND MEASUREMENTS

Test Category	Test/Measurement	2.5 GT/s (PCIe 1.0)	5 GT/s (PCIe 2.0)	8 GT/s (PCIe 3.0)	16 GT/s (PCIe 4.0)	32 GT/s (PCIe 5.0)	64 GT/s (PCIe 6.0)	128 GT/s[1] (PCIe 7.0)
Transmitter Compliance	Signal quality	✓	✓	✓	✓	✓	✓	
	PLL	✓	✓	✓	✓	✓	✓	
	Reference clock	✓	✓	✓	✓	✓	✓	
	Preset			✓	✓	✓	✓	
	UPW-TJ				✓	✓	✓	
	UPW-DJDD					✓	✓	
	UTJ					✓	✓	
	UDJDD					✓	✓	
	SNDR						✓	
	RLM						✓	
Link Equalization Compliance	Rx BER			✓	✓	✓	✓	
	Initial preset			✓	✓	✓	✓	
	Response time			✓	✓	✓	✓	
Transmitter Base	UTJ			✓	✓	✓	✓	✓
	UDJDD			✓	✓	✓	✓	✓
	EIEOS			✓	✓	✓	✓	✓
	UPW-TJ			✓	✓	✓	✓	✓
	UPW-UDJDD			✓	✓	✓	✓	✓
	CH-FS-NO-EQ			✓	✓	✓	✓	✓
	CH-RS-NO-EQ			✓	✓	✓	✓	✓
	DC-CM			✓	✓	✓	✓	✓
	AC-CM-PP			✓	✓	✓	✓	✓
	PS21TX				✓	✓	✓	✓
	DIFF-PP				✓	✓	✓	✓
	CH-UPW-RJ-64G				✓	✓	✓	✓
	CH-UPW-DJ-64G				✓	✓	✓	✓
	RJ				✓	✓	✓	✓
	SNDR						✓	✓
	RLM						✓	✓
Receiver Base	Jitter Tolerance (JTOL)				✓	✓	✓	✓
	Rx BER				✓	✓	✓	✓

1 - PCIe 7.0 Base Specification is still under development and is not finalized. Shown above are the expected measurements to be required at the time this table was published. Consult Teledyne LeCroy for latest information and/or current support.

Most Confidence for PCIe Physical Layer Compliance and Interoperability Testing

Simplified PCIe Link Testing with More Visibility of Complex PCIe Behaviors
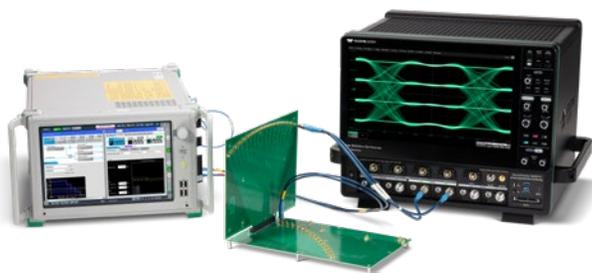
RECOMMENDED TEST EQUIPMENT

Product Description	DUT Type – Test Type		Product Code

2.5 GT/s (PCI Express 1.0)

	Add-In Card / System – Tx Testing	Add-In Card - Tx and PLL Testing	Product Code
Test Instruments	6 GHz oscilloscope	6 GHz oscilloscope	WaveMaster 8060HD
	–	Anritsu Signal Quality Analyzer-R (BERT)	MP1900A
Software Options	Oscilloscope compliance automation software	Oscilloscope compliance automation software	QPHY2-PCIE1-PCIE2-TX
	PCI-SIG Sigtest 3.2.0.3	–	*intel.com/content/www/us/en/collections/technology/high-speed-io-tools.html*
Hardware Accessories	1 x PCIe 5.0 CEM fixture kit rev 4.0	1 x PCIe 5.0 CEM fixture kit rev 4.0	*pcisig.com*
	1 x ATX Power supply	–	
Additional Debug & Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	SDA Expert Technology Framework for PCIe NRZ	SDA Expert Technology Framework for PCIe NRZ	SDAX-PCIE-NRZ
	PCI Express Protocol Link Layer Decode Annotation	PCI Express Protocol Link Layer Decode Annotation	PCIEBUS D
	Decode Annotation and Protocol Analyzer Software Sync Option	Decode Annotation and Protocol Analyzer Software Sync Option	PROTOSYNC

5 GT/s (PCI Express 2.0)

	Add-In Card / System – Tx Testing	Add-In Card - Tx and PLL Testing	Product Code
Test Instruments	13 GHz oscilloscope	13 GHz oscilloscope	WaveMaster 8130HD
	–	Anritsu Signal Quality Analyzer-R (BERT)	MP1900A
Software Options	Oscilloscope compliance automation software	Oscilloscope compliance automation software	QPHY2-PCIE1-PCIE2-TX
	PCI-SIG Sigtest 3.2.0.3	–	*intel.com/content/www/us/en/collections/technology/high-speed-io-tools.html*
Hardware Accessories	1 x PCIe 5.0 CEM fixture kit rev 4.0	1 x PCIe 5.0 CEM fixture kit rev 4.0	*pcisig.com*
	1 x ATX Power supply	1 x ATX Power supply	
	1 x TF-PCIE4-CTRL automation controller	1 x TF-PCIE4-CTRL automation controller	
Additional Debug & Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	SDA Expert Technology Framework for PCIe NRZ	SDA Expert Technology Framework for PCIe NRZ	SDAX-PCIE-NRZ
	PCI Express Protocol Link Layer Decode Annotation	PCI Express Protocol Link Layer Decode Annotation	PCIEBUS D
	Decode Annotation and Protocol Analyzer Software Sync Option	Decode Annotation and Protocol Analyzer Software Sync Option	PROTOSYNC

8 GT/s (PCI Express 3.0)

	Add-In Card / System – Tx Testing	Add-In Card - Tx and PLL Testing	Product Code
Test Instruments	13 GHz oscilloscope	13 GHz oscilloscope	WaveMaster 8130HD
	–	Anritsu Signal Quality Analyzer-R (BERT)	MP1900A
Software Options	Oscilloscope compliance automation software	Oscilloscope compliance automation software	QPHY2-PCIE3-TX-RX
	PCI-SIG Sigtest 3.2.0.3	–	*intel.com/content/www/us/en/collections/technology/high-speed-io-tools.html*
Hardware Accessories	1 x PCIe 5.0 CEM fixture kit rev 4.0	1 x PCIe 5.0 CEM fixture kit rev 4.0	*pcisig.com*
	1 x ATX Power supply	1 x ATX Power supply	
	1 x TF-PCIE4-CTRL automation controller	1 x TF-PCIE4-CTRL automation controller	
	30 x 50 Ohm MMPX terminator	–	
Additional Debug & Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	SDA Expert Technology Framework for PCIe NRZ	SDA Expert Technology Framework for PCIe NRZ	SDAX-PCIE-NRZ
	PCI Express Protocol Link Layer Decode Annotation	PCI Express Protocol Link Layer Decode Annotation	PCIEBUS D
	Decode Annotation and Protocol Analyzer Software Sync Option	Decode Annotation and Protocol Analyzer Software Sync Option	PROTOSYNC

8 GT/s (PCI Express 3.0)

	Add-In Card / System – LEQ Testing	Product Code
Test Instruments	13 GHz oscilloscope	WaveMaster 8130HD
	Anritsu Signal Quality Analyzer-R (BERT)	MP1900A
Software Options	Oscilloscope compliance automation software	QPHY2-PCIE3-TX-RX
	PCI-SIG Sigtest 3.2.0.3	*intel.com/content/www/us/en/collections/technology/high-speed-io-tools.html*
Hardware Accessories	1 x PCIe 3.0 Compliance Base Board 3 and Compliance Load Board 3 (CLB3/CBB3)	*pcisig.com*
	1 x ATX Power supply	
	1 x Anritsu Clock Buffer Z2029A (for system tests)	
	2 Pairs x Phase match 1ft 2.92mm (male) to 2.92mm (male) cables	
	5 Pairs x Phase match 3m 2.92mm (male) to 2.92mm (male) cables	
	2 x 1m 2.92mm (male) to BNC cable (male)	
	6 x 2.92mm (female) to SMP (female) adapters	
	2 x 40 GHz DC blocks	
	4 x 50/50 Power splitters	
Additional Debug & Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	SDA Expert Technology Framework for PCIe NRZ	SDAX-PCIE-NRZ
	PCI Express Protocol Link Layer Decode Annotation	PCIEBUS D
	Decode Annotation and Protocol Analyzer Software Sync Option	PROTOSYNC

Product Description	DUT Type – Test Type		Product Code

16 GT/s (PCI Express 4.0)

	Add-In Card / System – Tx Testing	Add-In Card - Tx and PLL Testing	
Test Instruments	25 GHz oscilloscope	25 GHz oscilloscope	WaveMaster 8250HD
	–	Anritsu Signal Quality Analyzer-R (BERT)	MP1900A
Software Options	Oscilloscope compliance automation software	Oscilloscope compliance automation software	QPHY2-PCIE4-TX-RX
	PCI-SIG Sigtest 4.0.52	–	*intel.com/content/www/us/ en/collections/technology/ high-speed-io-tools.html*
Hardware Accessories	1 x PCIe 5.0 CEM fixture kit rev 4.0	1 x PCIe 5.0 CEM fixture kit rev 4.0	*pcisig.com*
	1 x ATX Power supply	1 x ATX Power supply	
	1 x TF-PCIE4-CTRL automation controller	1 x TF-PCIE4-CTRL automation controller	
	30 x 50 Ohm MMPX terminators	–	
Additional Debug & Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	SDA Expert Technology Framework for PCIe NRZ	SDA Expert Technology Framework for PCIe NRZ	SDAX-PCIE-NRZ
	PCI Express Protocol Link Layer Decode Annotation	PCI Express Protocol Link Layer Decode Annotation	PCIEBUS D
	Decode Annotation and Protocol Analyzer Software Sync Option	Decode Annotation and Protocol Analyzer Software Sync Option	PROTOSYNC

16 GT/s (PCI Express 4.0)

	Add-In Card / System – LEQ Testing	Product Code
Test Instruments	25 GHz oscilloscope	WaveMaster 8250HD
	Anritsu Signal Quality Analyzer-R (BERT)	MP1900A
Software Options	Oscilloscope compliance automation software	QPHY2-PCIE4-TX-RX
	PCI-SIG Sigtest 4.0.52	*intel.com/content/www/us/ en/collections/technology/ high-speed-io-tools.html*
Hardware Accessories	1 x PCIe 4.0 CEM electrical test fixture kit	*pcisig.com*
	1 x ATX Power supply	
	1 x TF-PCIE4-CTRL automation controller	
	1 x Anritsu Clock Buffer Z2029A (for system tests)	
	2 Pairs x Phase match 1ft 2.92mm (male) to 2.92mm (male) cables	
	5 Pairs x Phase match 1m 2.92mm (male) to 2.92mm (male) cables	
	2 x 1m 2.92mm (male) to BNC cable (male)	
	6 x 2.92mm (female) to SMP (female) adapters	
	2 x 40 GHz DC blocks	
	4 x 50/50 Power splitters	
	1 x 50 Ohm SMP terminator	
Additional Debug & Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	SDA Expert Technology Framework for PCIe NRZ	SDAX-PCIE-NRZ
	PCI Express Protocol Link Layer Decode Annotation	PCIEBUS D
	Decode Annotation and Protocol Analyzer Software Sync Option	PROTOSYNC

16 GT/s (PCI Express 4.0)

	M.2 – CrossSync PHY	Product Code
Test Instruments	25 GHz oscilloscope	WaveMaster 8250HD
	Anritsu Signal Quality Analyzer-R (BERT)	MP1900A
	Protocol analyzer	Summit T416
Software Options	PCIe CrossSync PHY protocol analyzer synchronization	CROSSSYNC-PHY-PCIE
Hardware Accessories	PCIe 5.0 M.2 M-Key Interposer with oscilloscope probe lane 0, 1, 2, 3	PE222UIA-4PHY, PE222UIA-2PHY, PE222UIA-1PHY
	PCIe 5.0 M.2 M-Key Interposer CrossSync PHY upgrade	PE222UIA-X
	Y-Cable for connecting Summit T416 to PE222UIA-X	PE021UCA-X
	25 GHz differential probe with ProAxial interface	DH25-PX
	4 GHz Power/Voltage Rail Probe	RP4030
Additional Debug & Characterization Tools	Oscilloscope compliance automation software	QPHY2-PCIE4-TX-RX
	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	SDA Expert Technology Framework for PCIe NRZ	SDAX-PCIE-NRZ
	PCI Express Protocol Link Layer Decode Annotation	PCIEBUS D
	Decode Annotation and Protocol Analyzer Software Sync Option	PROTOSYNC
	Clock Expert Jitter Analysis Framework with SSC, Phase Noise and Accumulated Jitter Analysis	CLOCK-X-PRO
	PCI-SIG Sigtest 4.0.52	*intel.com/content/www/us/ en/collections/technology/ high-speed-io-tools.html*

Product Description	DUT Type – Test Type		Product Code
32 GT/s (PCI Express 5.0)			
	Add-In Card / System – Tx Testing	*Add-In Card – PLL Testing*	
Test Instruments	33 GHz oscilloscope	33 GHz oscilloscope	WaveMaster 8330HD
	–	Anritsu Signal Quality Analyzer-R (BERT)	MP1900A
Software Options	Oscilloscope compliance automation software	Oscilloscope compliance automation software	QPHY2-PCIE5-TX-RX
	PCI-SIG Sigtest Phoenix 5.1.08	–	*intel.com/content/www/us/ en/collections/technology/ high-speed-io-tools.html*
Hardware Accessories	1 x PCIe 5.0 CEM fixture kit rev 4.0	1 x PCIe 5.0 CEM fixture kit rev 4.0	*pcisig.com*
	1 x ATX Power supply	1 x ATX Power supply	
	1 x TF-PCIE4-CTRL automation controller	1 x TF-PCIE4-CTRL automation controller	
Additional Debug & Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	SDA Expert Technology Framework for PCIe NRZ	SDA Expert Technology Framework for PCIe NRZ	SDAX-PCIE-NRZ
	PCI Express Protocol Link Layer Decode Annotation	PCI Express Protocol Link Layer Decode Annotation	PCIEBUS D
	Decode Annotation and Protocol Analyzer Software Sync Option	Decode Annotation and Protocol Analyzer Software Sync Option	PROTOSYNC

Product Description	DUT Type – Test Type	Product Code
32 GT/s (PCI Express 5.0)		
	Add-In Card / System – LEQ Testing	
Test Instruments	50 GHz oscilloscope	WaveMaster 8500HD
	Anritsu Signal Quality Analyzer-R (BERT)	MP1900A
Software Options	Oscilloscope compliance automation software	QPHY2-PCIE5-TX-RX
	PCI-SIG Sigtest Phoenix 5.1.08	*intel.com/content/www/us/ en/collections/technology/ high-speed-io-tools.html*
Hardware Accessories	1 x PCIe 5.0 CEM fixture kit rev 4.0	*pcisig.com*
	1 x ATX Power supply	
	1 x TF-PCIE4-CTRL automation controller	
	1 x Anritsu Clock Buffer Z2029A (for system tests)	
	2 Pairs x Phase match 1ft 2.92mm (male) to 2.92mm (male) cables	
	5 Pairs x Phase match 3m 2.92mm (male) to 2.92mm (male) cables	
	2 x 3ft 2.92mm (male) to BNC cable (male)	
	6 x 2.92mm (female) to MMPX (male) adapters	
	2 x 40 GHz DC blocks	
	4 x 50/50 Power splitters	
	1 x 50 Ohm MMPX terminator	
Additional Debug & Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	SDA Expert Technology Framework for PCIe NRZ	SDAX-PCIE-NRZ
	PCI Express Protocol Link Layer Decode Annotation	PCIEBUS D
	Decode Annotation and Protocol Analyzer Software Sync Option	PROTOSYNC

Product Description	DUT Type – Test Type	Product Code
32 GT/s (PCI Express 5.0)		
	CEM – CrossSync PHY	
Test Instruments	33 GHz oscilloscope	WaveMaster 8330HD
	Protocol analyzer	Summit T516
Software Options	PCIe CrossSync PHY protocol analyzer synchronization	CROSSSYNC-PHY-PCIE
Hardware Accessories	PCIe 5.0 CEM x16 interposer	PE230UIA-X
	PCIe 5.0 CEM x16 interposer CrossSync PHY upgrade	PE120ACA-X
	Y-Cable for connecting Summit T516 to PE120ACA-X	PE028UCA-X
	30 GHz differential probe with ProAxial interface	DH30-PX
	Probe tip to connect DH series oscilloscope probe to PE120ACA-X	DH-CSPHY-PCIE5-CEMx16
	4 GHz Power/Voltage Rail Probe	RP4030
Additional Debug & Characterization Tools	Oscilloscope compliance automation software	QPHY2-PCIE5-TX-RX
	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	SDA Expert Technology Framework for PCIe NRZ	SDAX-PCIE-NRZ
	PCI Express Protocol Link Layer Decode Annotation	PCIEBUS D
	Decode Annotation and Protocol Analyzer Software Sync Option	PROTOSYNC
	Clock Expert Jitter Analysis Framework with SSC, Phase Noise and Accumulated Jitter Analysis	CLOCK-X-PRO
	PCI-SIG Sigtest Phoenix 5.1.08	*intel.com/content/www/us/ en/collections/technology/ high-speed-io-tools.html*

RECOMMENDED TEST EQUIPMENT

Product Description	DUT Type – Test Type	Product Code

32 GT/s (PCI Express 5.0)

Product Description	M.2 – CrossSync PHY	Product Code
Test Instruments	33 GHz oscilloscope	WaveMaster 8330HD
	Protocol analyzer	Summit T516
Software Options	PCIe CrossSync PHY protocol analyzer synchronization	CROSSSYNC-PHY-PCIE
Hardware Accessories	PCIe 5.0 M.2 M-Key Interposer with oscilloscope probe lane 0, 1, 2, 3	PE222UIA-4PHY, PE222UIA-2PHY, PE222UIA-1PHY
	PCIe 5.0 M.2 M-Key Interposer CrossSync PHY upgrade	PE222UIA-X
	Y-Cable for connecting Summit T516 to PE222UIA-X	PE028UCA-X
	30 GHz differential probe with ProAxial interface	DH30-PX
	4 GHz Power/Voltage Rail Probe	RP4030
Additional Debug & Characterization Tools	Oscilloscope compliance automation software	QPHY2-PCIE5-TX-RX
	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	SDA Expert Technology Framework for PCIe NRZ	SDAX-PCIE-NRZ
	PCI Express Protocol Link Layer Decode Annotation	PCIEBUS D
	Decode Annotation and Protocol Analyzer Software Sync Option	PROTOSYNC
	Clock Expert Jitter Analysis Framework with SSC, Phase Noise and Accumulated Jitter Analysis	CLOCK-X-PRO

32 GT/s (PCI Express 5.0)

Product Description	U.2/U.3 – CrossSync PHY	Product Code
Test Instruments	33 GHz oscilloscope	WaveMaster 8330HD
	Protocol analyzer	Summit T516
Software Options	PCIe CrossSync PHY protocol analyzer synchronization	CROSSSYNC-PHY-PCIE
Hardware Accessories	PCIe 5.0 U.2/U.3 12 inch Interposer	PE221UIA-X
	PCIe 5.0 U.2/U.3 12 inch Interposer CrossSync PHY upgrade	PE130ACA-X
	Y-Cable for connecting Summit T516 to PE130ACA-X	PE028UCA-X
	30 GHz differential probe with ProAxial interface	DH30-PX
	Probe tip to connect DH series oscilloscope probe to PE130ACA-X	DH-CSPHY-PCIE5-U2U3
	4 GHz Power/Voltage Rail Probe	RP4030
Additional Debug & Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	SDA Expert Technology Framework for PCIe NRZ	SDAX-PCIE-NRZ
	PCI Express Protocol Link Layer Decode Annotation	PCIEBUS D
	Decode Annotation and Protocol Analyzer Software Sync Option	PROTOSYNC
	Clock Expert Jitter Analysis Framework with SSC, Phase Noise and Accumulated Jitter Analysis	CLOCK-X-PRO
	PCI-SIG Sigtest Phoenix 5.1.08	*intel.com/content/www/us/ en/collections/technology/ high-speed-io-tools.html*

32 GT/s (PCI Express 5.0)

Product Description	EDSFF – CrossSync PHY	Product Code
Test Instruments	33 GHz oscilloscope	WaveMaster 8330HD
	Protocol analyzer	Summit T516
Software Options	PCIe CrossSync PHY protocol analyzer synchronization	CROSSSYNC-PHY-PCIE
Hardware Accessories	PCIe 5.0 x4 EDSFF E1.S Interposer or PCIe 5.0 x8 EDSFF E1.L Interposer or PCIe 5.0 x16 EDSFF E3.x Interposer	PE243UIA-X or PE241UIA-X or PE135ACA-X
	PCIe 5.0 x4 EDSFF E1.S, x8 EDSFF E1.L, and x16 EDSFF E3.x Interposers CrossSync PHY upgrade	PE135ACA-X
	Y-Cable for connecting Summit T516 to PE135ACA-X	PE028UCA-X
	30 GHz differential probe with ProAxial interface	DH30-PX
	Probe tip to connect DH series oscilloscope probe to PE135ACA-X	DH-CSPHY-PCIE5-EDSFF
	4 GHz Power/Voltage Rail Probe	RP4030
Additional Debug & Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	SDA Expert Technology Framework for PCIe NRZ	SDAX-PCIE-NRZ
	PCI Express Protocol Link Layer Decode Annotation ()	PCIEBUS D
	Decode Annotation and Protocol Analyzer Software Sync Option	PROTOSYNC
	Clock Expert Jitter Analysis Framework with SSC, Phase Noise and Accumulated Jitter Analysis	CLOCK-X-PRO
	PCI-SIG Sigtest Phoenix 5.1.08	*intel.com/content/www/us/ en/collections/technology/ high-speed-io-tools.html*

2.5 to 64 GT/s (PCI Express 6.0 to 1.0)

Product Description	System – Reference Clock Testing	Product Code
Test Instruments	5 GHz or higher oscilloscope	WavePro 604HD or any WaveMaster 8000HD
Software Options	Oscilloscope compliance automation software	Any QPHY2-PCIEx software option
	PCI-SIG clock jitter tool software	*intel.com/content/www/us/ en/collections/technology/ high-speed-io-tools.html*
Hardware Accessories	1 x PCIe 6.0 CEM fixture kit	*pcisig.com*
Additional Debug & Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	Clock Expert Jitter Analysis Framework with SSC, Phase Noise and Accumulated Jitter Analysis	CLOCK-X-PRO

RECOMMENDED TEST EQUIPMENT

Product Description	DUT Type – Test Type		Product Code

64 GT/s (PCI Express 6.0)

	Add-In Card / System – Tx Testing	Add-In Card – PLL Testing	Product Code
Test Instruments	50 GHz oscilloscope	50 GHz oscilloscope	WaveMaster 8500HD
	–	Anritsu Signal Quality Analyzer-R (BERT)	MP1900A
Software Options	Oscilloscope compliance automation software	Oscilloscope compliance automation software	QPHY2-PCIE6-TX-RX
	PCI-SIG Sigtest Phoenix 6.x.xx	–	intel.com/content/www/us/en/collections/technology/high-speed-io-tools.html
Hardware Accessories	1 x PCIe 6.0 CEM fixture kit (2.92mm kit)	1 x PCIe 6.0 CEM fixture kit (2.92mm kit)	pcisig.com
	1 x ATX Power supply	1 x ATX Power supply	
	1 x TF-PCIE4-CTRL automation controller	1 x TF-PCIE4-CTRL automation controller	
Additional Debug & Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	PAM Serial Data Expert Analysis Framework, Eye,Jitter and Noise Measurements	PAM Serial Data Expert Analysis Framework, Eye,Jitter and Noise Measurements	SDAX-PAM
	SDA Expert Technology Framework for PCIe 6.0	SDA Expert Technology Framework for PCIe 6.0	SDAX-PCIE6
	PCI Express 6.0 to 1.0 Protocol Link Layer Decode Annotation	–	PCIE6BUS D

64 GT/s (PCI Express 6.0)

	Add-In Card / System – LEQ Testing	Product Code
Test Instruments	50 GHz oscilloscope	WaveMaster 8500HD
	Anritsu Signal Quality Analyzer-R (BERT)	MP1900A
Software Options	Oscilloscope compliance automation software	QPHY2-PCIE6-TX-RX
	PCI-SIG Sigtest Phoenix 6.x.xx	intel.com/content/www/us/en/collections/technology/high-speed-io-tools.html
	Seasim 2.0.103f	pcisig.com
Hardware Accessories	1 x PCIe 6.0 CEM fixture kit (2.92mm kit)	pcisig.com
	1 x ATX Power supply	
	1 x TF-PCIE4-CTRL automation controller	
	1 x Anritsu Clock Buffer Z2029A (for system tests)	
	2 Pairs x Phase match 1ft 2.92mm (male) to 2.92mm (male) cables	
	4 Pairs x Phase match 1m 2.92mm (male) to 2.92mm (male) cables	
	2 x 1m 2.92mm (male) to BNC cable (male)	
	4 x 2.92mm (female) to MMPX (male) adapters	
	2 x 40 GHz DC blocks	
	2 x 50/50 Power splitters	
	1 x 50 Ohm SMP terminator	
Additional Debug & Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	PAM Serial Data Expert Analysis Framework, Eye,Jitter and Noise Measurements	SDAX-PAM
	SDA Expert Technology Framework for PCIe 6.0	SDAX-PCIE6
	PCI Express 6.0 to 1.0 Protocol Link Layer Decode Annotation	PCIE6BUS D

64 GT/s (PCI Express 6.0)

	CEM – CrossSync PHY	Product Code
Test Instruments	50 GHz oscilloscope	WaveMaster 8500HD
	Protocol analyzer	Summit M616
Software Options	PCIe CrossSync PHY protocol analyzer synchronization	CROSSSYNC-PHY-PCIE
Hardware Accessories	PCIe 6.0 CEM x16 interposer	PE6117UIA-X
	PCIe 6.0 CEM x16 interposer CrossSync PHY upgrade	PE6817ACA-X
	Y-Cable for connecting Summit M616 to PE6817ACA-X	PE028UCA-X
	30 GHz differential probe with ProAxial interface	DH30-PX
	Probe tip to connect DH series oscilloscope probe to PE6817ACA-X	DH-CSPHY-PCIE6
	4 GHz Power/Voltage Rail Probe	RP4030
Additional Debug & Characterization Tools	Oscilloscope compliance automation software	QPHY2-PCIE6-TX-RX
	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	PAM Serial Data Expert Analysis Framework, Eye,Jitter and Noise Measurements	SDAX-PAM
	SDA Expert Technology Framework for PCIe 6.0	SDAX-PCIE6
	PCI Express 6.0 to 1.0 Protocol Link Layer Decode Annotation	PCIE6BUS D
	Clock Expert Jitter Analysis Framework with SSC, Phase Noise and Accumulated Jitter Analysis	CLOCK-X-PRO
	PCI-SIG Sigtest 6.1.11	intel.com/content/www/us/en/collections/technology/high-speed-io-tools.html

128 GT/s (PCI Express 7.0)

	Add-In Card / System – Tx Testing	Add-In Card – PLL Testing	Product Code
Test Instruments	65 GHz oscilloscope	65 GHz oscilloscope	WaveMaster 8650HD
	–	Anritsu Signal Quality Analyzer-R (BERT)	MP1900A
Characterization Tools	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	Bundle - Multi-Lane SDA Expert Framework, incl. Eye, Jitter, Noise, Crosstalk Measurements and VirtualProbe	SDAX-COMPLETE
	PAM Serial Data Expert Analysis Framework, Eye,Jitter and Noise Measurements	PAM Serial Data Expert Analysis Framework, Eye,Jitter and Noise Measurements	SDAX-PAM