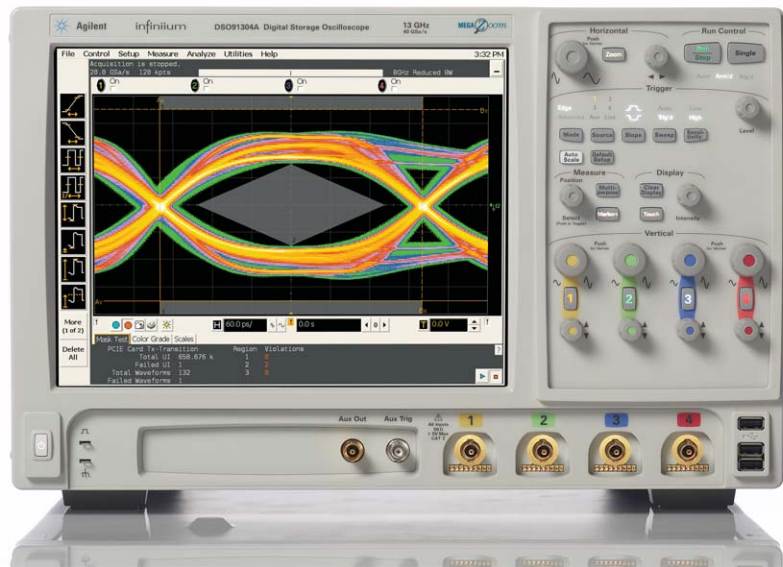Agilent Technologies

N5393B PCI Express® 2.0 (Gen2) Electrical Performance Validation and Compliance Software for Infiniium Oscilloscopes

Data Sheet

Table of Contents

Agilent Technologies

Verify and debug your PCI Express® designs more easily

Agilent Technologies N5393B PCI Express electrical performance validation and compliance software provides you with a fast and easy way to verify and debug your PCI Express 2.0 and 1.1/1.0a designs for add-in cards and motherboard systems.

The PCI Express electrical test software allows you to automatically execute PCI Express electrical tests, and it displays the results in a flexible report format. In addition to the measurement data, the report provides a margin analysis that shows how closely your device passed or failed each test.

The N5393B PCI Express electrical test software utilizes the prescribed test methods and algorithms as required by the PCI Express Card Electromechanical (CEM) specifications for all current PCI Express Standards. This produces results that are not only consistent with the PCI-SIG's own SigTest utility, but also provides you with a fast and easy means of executing complex two-port motherboard tests and single port add-in card test with total automation.

The PCI Express electrical performance validation and compliance software performs a wide range of electrical tests as per the PCI Express 2.0, 1.0a and 1.1 electrical specifications for add-in cards and motherboard systems as documented in Section 4 of the base specification and Section 4 of the card electromechanical specification.

Tests for PCI Express 2.0 (based on section 4.7.2., Table 4-8) are also included to help you test your products against for the next generation of this powerful I/O technology

In addition to full swing (800 mV) testing, the N5393B also supports testing for low-power, half-swing devices (400 mV) as per the PCI Express Architecture Mobile Graphics Low-Power Addendum to the PCI Express Base Specification Revision 1.0.

1   Peripheral Component Interconnect Special
    Interest Group

Features

The N5393B PCI Express electrical test software offers several features to simplify the validation of PCI Express designs:

- Automated 1M Unit Interval (or greater) testing for highest accuracy

- Results consistent with PCI-SIG SigTest software utility

- Test setup wizard for ease-of-use

- Wide range of electrical tests

- PCI-SIG SigTest clock recovery algorithm

- Automated scope measurement setup

- Test results report generation

- Pass/fail margin analysis

- Reference clock phase jitter analysis (1.1)

- Two-port (explicit clock and data) supported for motherboard signal quality testing

- Support for both full-swing and low-power, half-swing devices.

With the PCI Express electrical test software, you can use the same oscilloscope you use for everyday debugging to perform automated testing and margin analysis based on the PCI-SIG-specified tests.

PCI Express compliance testing
To pass signal quality testing at a PCI-SIG-sponsored compliance workshop, your product must successfully pass "Gold Suite" testing, based on the PCI-SIG SigTest application. The SigTest application tests your device against the minimum signal-quality performance requirements for PCI. If you are developing receivers and transmitters for add-in boards and system motherboards, the N5393B PCI Express electrical test software helps you execute all the SigTest tests and additional oscilloscope already completed tests. See the list of tests in Table 3 on page 15 (for 1.1 test coverage).

While SigTest tests provide a good overview of PCI Express electrical signal quality, they address only a small subset of the electrical compliance measurements specified in the PCI-SIG specification. The SigTest application also provides minimal reporting capability with pass/fail indication and measurement values, and has limited debugging capabilities to decipher eye mask violations or excessive jitter.

For PCI Express 2.0 measurements, the N5393B software automatically calculates deterministic jitter and total jitter at 10^{-12} BER. Random jitter is also reported for completeness and a voltage margin "eye" diagram is included in the final HTML report. DJ and TJ values are specified in the PCIe 2.0 specification and are required for compliance verification.

PCI Express 2.0 supports data rates up to 5.0 GT/s as shown above (-3.5 dB de-empasis)

Benefits

N5393B benefits
The N5393B PCI Express electrical test software saves you time by setting the stage for automatic execution of PCI Express electrical tests. Part of the difficulty of performing electrical tests for PCI Express is hooking up the oscilloscope, loading the proper setup files, and then analyzing the measured results by comparing them to limits published in the specification. The PCI Express electrical test software does much of this work for you. In addition, if you discover a problem with your device, robust debug tools are available to aid in root-cause analysis. These debug tools are provided by the Agilent E2688A high-speed serial data analysis software, which you must install on your oscilloscope to use the PCI Express electrical test software.

The N5393B PCI Express electrical test software offers many more electrical tests than the SigTest application. Unlike the SigTest application, the N5393B PCI Express electrical test software automatically configures the oscilloscope for each test, and it provides an informative results report that includes margin analysis indicating how close your product is to passing or failing a particular test assertion. Table 1 shows a side-by-side comparison of the capabilities of the SigTest application and the Agilent N5393B PCI Express electrical test software. A list of the measurements made by the PCI Express electrical test software can be found in Table 3, (Table 3 contains comparison of SigTest vs. Agilent).
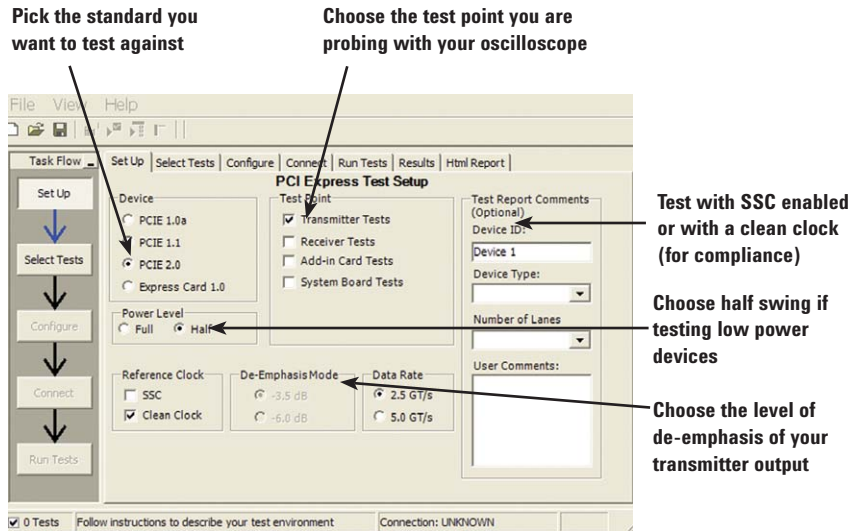
Capability	Agilent N5393B	PCI-SIG SigTest
Number of measurement assertions	16+	4
Support for PCIe 1.0a, 1.1, 2.0	Yes	Yes
Reference clock tests	10 (1.1)	0*
Automated oscilloscope setup for each measurement	Yes, guided	No, single setup
Measurement results	Pass/fail with margin analysis	Pass/fail with measured value
CEM based measurments methodology	Yes	Yes
Clock recovery method	PCI-SIG SigTest or 1st/2nd order PLL	PCI-SIG SigTest
Brick wall filter (2.0 testing)	Yes	Yes
Custom HTML report generation	Yes	No
Support for low power device	Yes	No
Selectable number of tests performed	Yes	No
Multi-trial run support	Yes	No
Debug mode for "what if" analysis	Yes	No
Compliance test boards supported	CBB1, CBB2, CLB1, CLB2	CBB1, CBB2, CLB1, CLB2

*   PCI-Sig offers a separate utility (Clock_Jitter) for analyzing reference clock phase jitter.
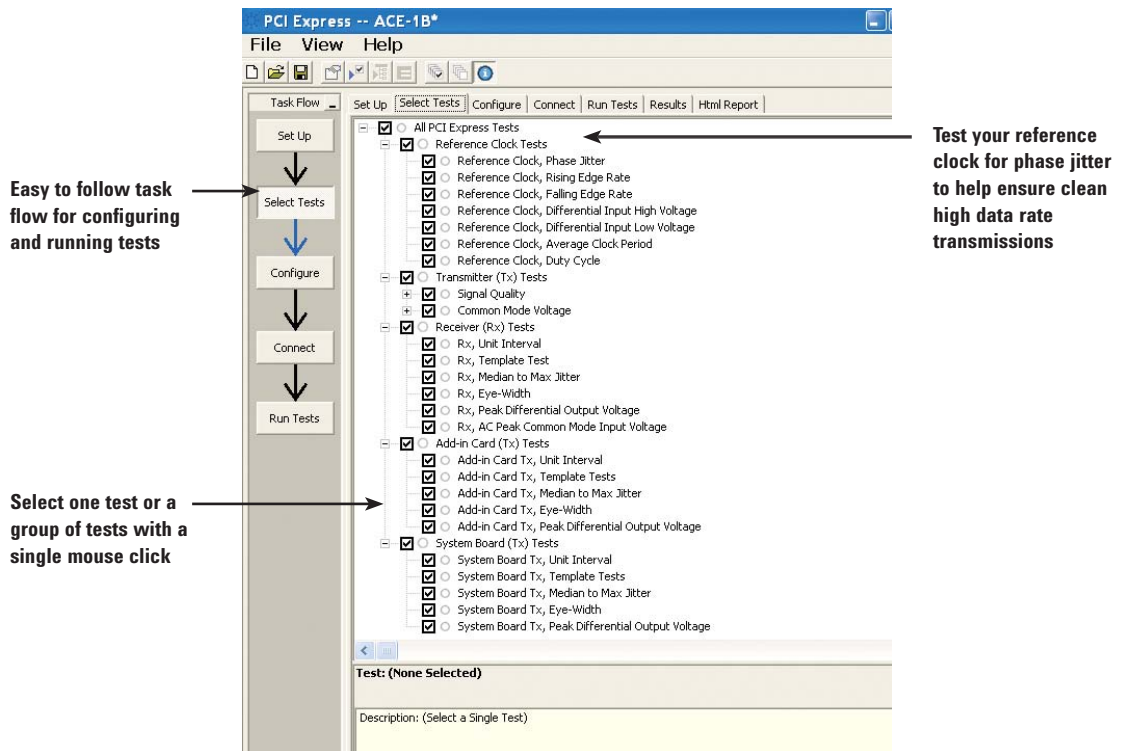
Table 1. Comparison of capabilities of the Agilent PCI Express electrical test software and the PCI-SIG SigTest application.

Easy Test Definition

The N5393B PCI Express electrical test software extends the ease-of-use advantages of Agilent's Infiniium 54855A or 80000 Series oscilloscopes to testing PCI Express designs. The Agilent automated test engine walks you quickly through the steps required to define the tests, set up the tests, perform the tests, and view the test results. You can select a category of tests all at once, or specify individual tests. You can save tests and configurations as project files and recall them later for quick testing and review of previous test results. Straightforward menus let you perform tests with a minimum of mouse clicks.

Pick the standard you want to test against

Choose the test point you are probing with your oscilloscope

Test with SSC enabled or with a clean clock (for compliance)

Choose half swing if testing low power devices

Choose the level of de-emphasis of your transmitter output

Figure 1. The Agilent N5393B allows you to easily specify the test standard you want to use to test the compliance of your device. This makes test setup easy as only the appropriate tests for the test point you pick are shown on later test selection pages.

Easy to follow task flow for configuring and running tests

Test your reference clock for phase jitter to help ensure clean high data rate transmissions

Select one test or a group of tests with a single mouse click

Figure 2. The Agilent automated test engine guides you quickly through selecting tests, configuring tests, setting up the connection, running the tests, and viewing the results. Individual tests or groups of tests are easily selected with a mouse click.

Configurability and Guided Connections

The N5393B PCI Express electrical test software provides flexibility in your test setup. It guides you to make connection changes with hookup diagrams when the tests you select require it. All PCI Express electrical compliance tests you perform are based on the official PCI-SIG approved set of test fixtures. The compliance fixtures include the Compliance Base Board (CBB2) for add-in card testing, and the Compliance Load Board (CLB2) for motherboard or system testing. Connection to the compliance test fixtures is selectable between SMA/SMP cables or Agilent InfiniiMax active differential probes.
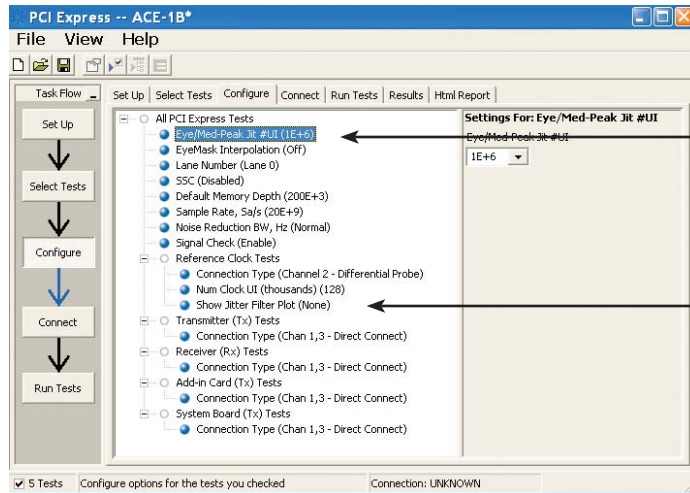
Specify 1 million UI (or more) for your jitter measurements

Show the spectral response of your reference clock in the critical 1.5 - 22-MHz region

Figure 3. In configuring the tests, you specify the device to test, its configuration, and how the oscilloscope is connected.

If more than one test setup connection is required, you will be notified here

You are prompted to make the appropriate connections for the set of tests

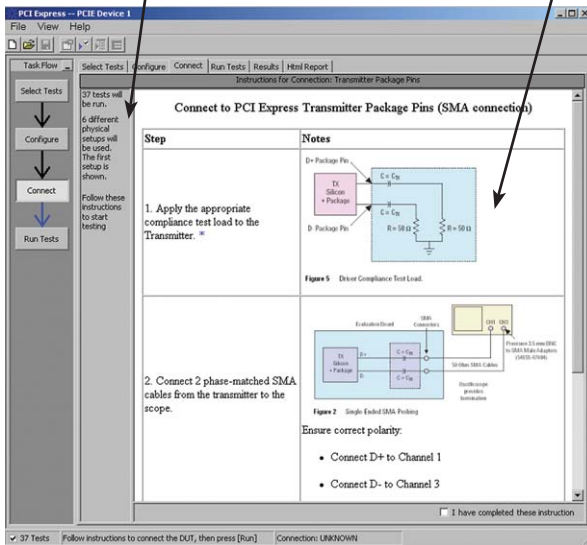**Toggle circuit to switch between Gen1 (2.5 GBit/s) and Gen2 (50 GBit/s)**

Figure 4. When you make multiple tests where the connections must be changed, you are prompted with connection diagrams and/or photographs.
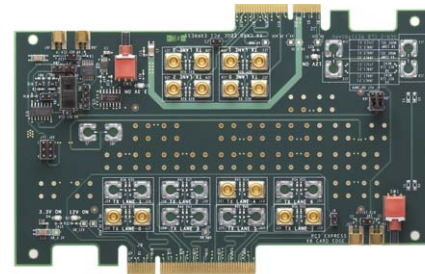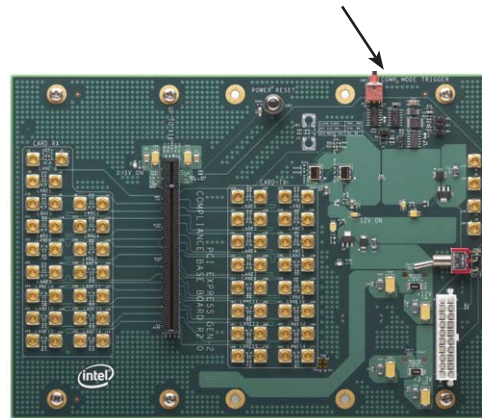

Figure 5. The PCI-SIG Compliance Base Board (CBB2) for Gen2 add-in card testing, and the Compliance Load Board (CLB2) for Gen2 motherboard or host system testing.

Reports with Margin Analysis

In addition to providing you with measurement results, the N5393B PCI Express electrical test software provides a report format that shows you not only where your product passes or fails, but also reports how close you are to the limits specified for a particular test assertion. You can select the margin test report parameter, which means you can specify the level at which warnings are issued to alert you to electrical tests where your product is operating close to the official test limit defined by the PCI Express 2.0, 1.0a or 1.1 specifications.
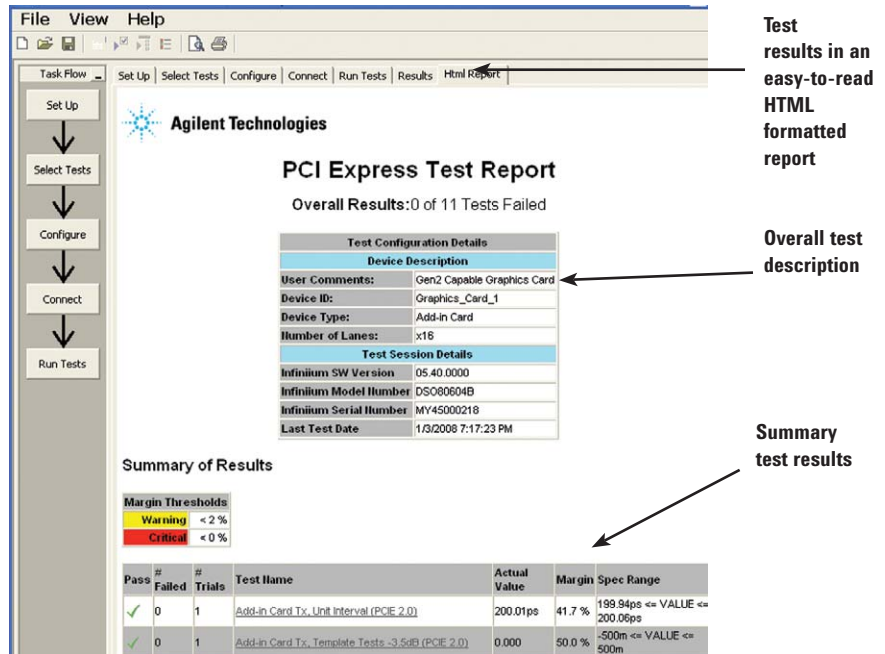
Figure 6. The PCI Express electrical test software results report documents your test, indicates the pass/fail status, the test specification range, the measured values, and shows how much margin you have.
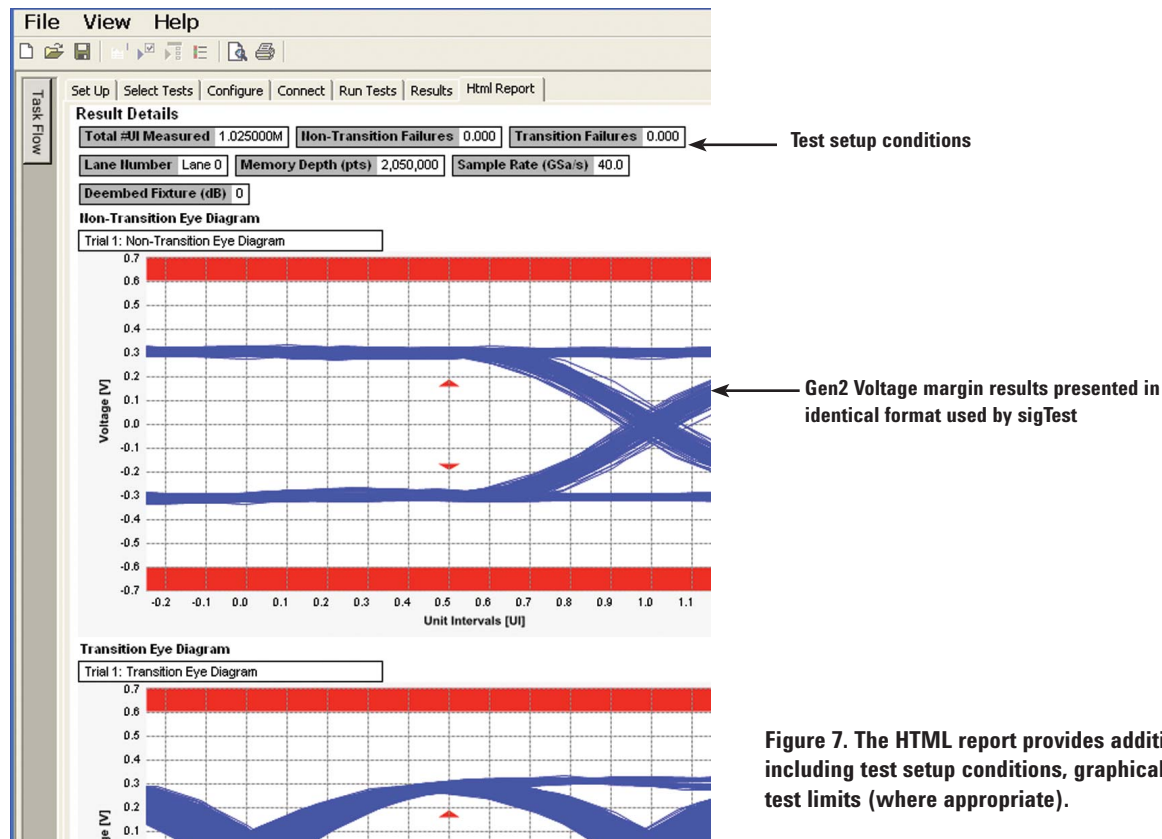

Figure 7. The HTML report provides additional details including test setup conditions, graphical results, and test limits (where appropriate).

Reports with Margin Analysis (continued)

User set margin thresholds for warning and failure indicators

Margin values indicate when the results are approaching test limits. Warnings and failures are highlighted.

Figure 8. How close you are to passing or failing a test is indicated as a % in the margin field. A result highlighted in yellow or red indicates that the margin threshold level for a warning or failure was detected.

Reference Clock Measurements

The PCI Express 1.0a specification failed to specify the input bandwidth the reference clock receiver or phase jitter of the reference clock itself. This is important because jitter that lies within the loop bandwidth the receiver PLL for the reference clock will transfer onto the high speed data lines. This hole in the PCI Express specification was corrected in the 1.1 update.

The N5393B includes powerful reference clock evaluation tools including phase jitter. The specification calls for a very specific phase jitter filter that focuses the measurement on the jitter that lies between 1.5 and 22-MHz. The filter also amplifies the jitter 3dB (peaking) within this region. The Agilent N5393B includes proprietary filtering software (patent pending) that exactly implements the filter specified in the 1.1 PCI Express specification.

Utilizing Agilent's InfiniiMax 1169A high performance differential probes, you can measure your reference clock using the PCI-SIG's Compliance Load Board (CLB1).
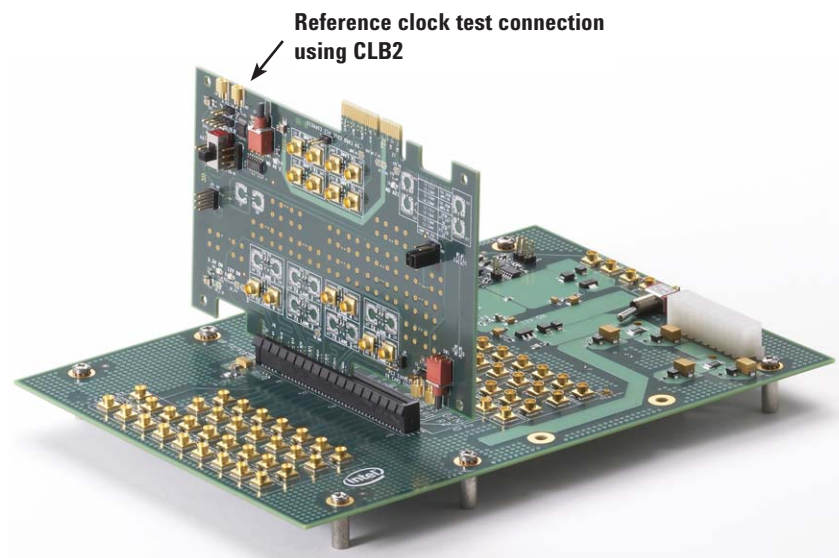
Reference clock tests

• Phase jitter

• Rising edge rate

• Falling edge rate

• Differential input high voltage

• Differential input low voltage

• Average clock period

• Duty cycle
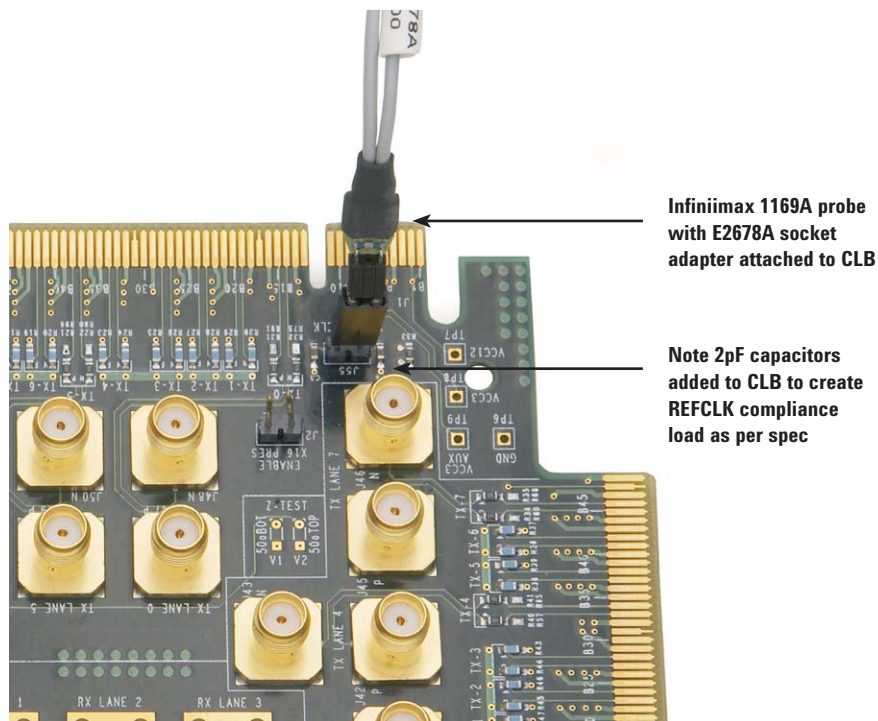
Infiniimax 1169A probe with E2678A socket adapter attached to CLB

Note 2pF capacitors added to CLB to create REFCLK compliance load as per spec

Figure 9. The N5939A software includes important tests for the reference clock of your PCI Express system. This signal can be probed using the Agilent InfiniiMax 1169A probes in conjunction with the PCI-SIG's compliance load board.

Reference clock test connection using CLB2

Figure 10. This shows the CLB2 inserted into the CBB2 test fixture, representing the setup required to test add-in cards

Powerful Debugging Aids

If your device fails a test, you need to determine how it failed. To use N5393B PCI Express electrical test software, you must install Agilent E2688A high-speed serial data analysis software, which provides you with several powerful debugging tools. The 8b/10b decoding feature lets you identify data-dependent errors that result in eye mask violations caused by inter-symbol interference (ISI). You can perform 8b/10b decoding to capture and display serial data synchronized with the analog view of a serial data stream.

Make sure your compliance pattern has the proper disparity (K28.5-, D21.5, K28.5+, D10.2)

Use the 10-bit code display to validate your compliance pattern conforms to the PCI Express standard

Figure 11. The 8b/10b decoded symbol information is shown below the appropriate portion of a PCI Express signal using the E2688A software.
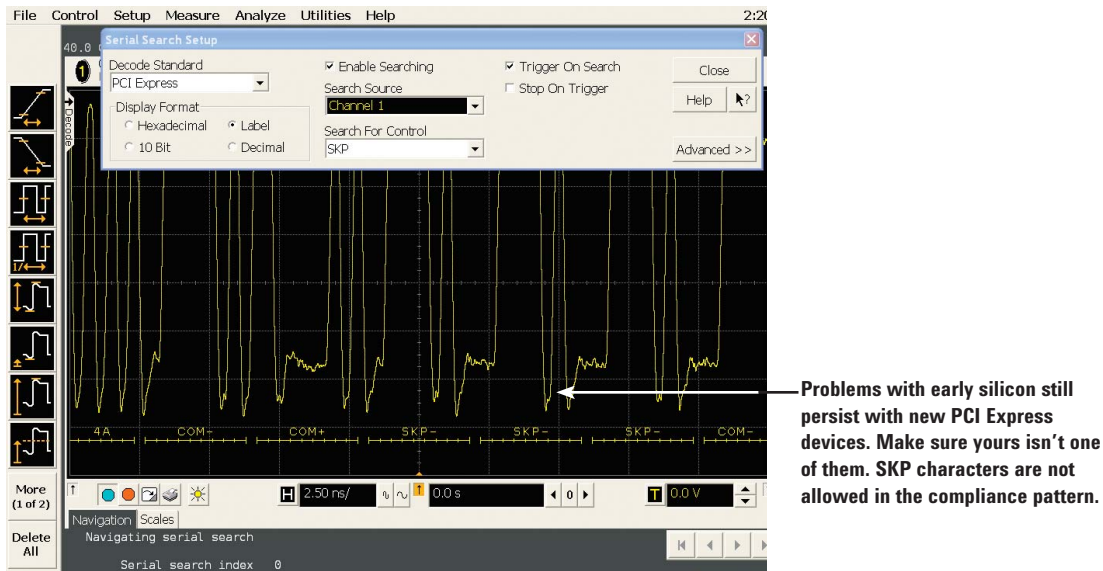
Powerful Debugging Aids (continued)

Using the E2688A Serial Data Analysis tool you can test for illegal characters in your compliance pattern. You can also use the mask test feature to identify the specific digital patterns that caused a specific failure in the eye diagram when testing under the 1.1 specification (using a first order PLL).

For 2.0 testing you can use a first or second order PLL for clock recovery and apply a TIE brick wall filter (included with the E2688A Series Data Analysis package) to achieve a proper clock filtering.

Problems with early silicon still persist with new PCI Express devices. Make sure yours isn't one of them. SKP characters are not allowed in the compliance pattern.

Figure 12. Check for illegal characters in the compliance pattern (such as SKP's) using the E2688A Serial Data Analysis tool.
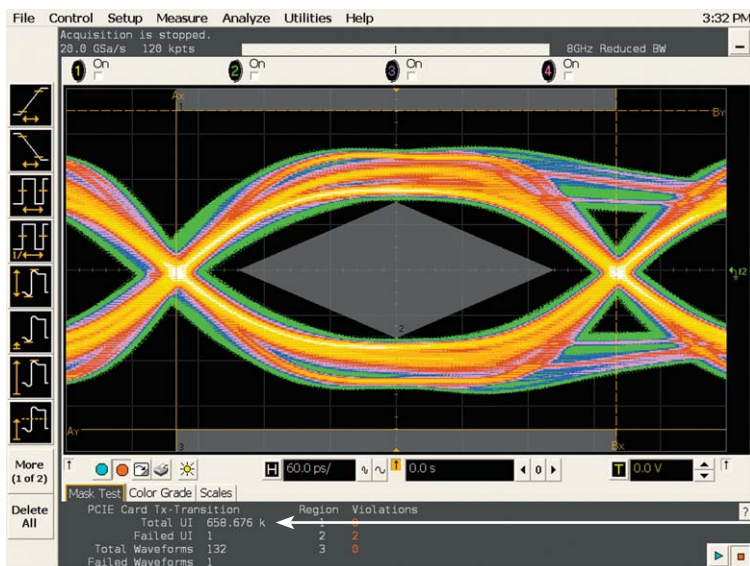
Powerful Debugging Aids (continued)

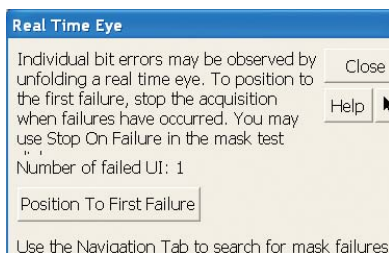**This eye fails after 658K UIs are analyzed**

Figure 13.

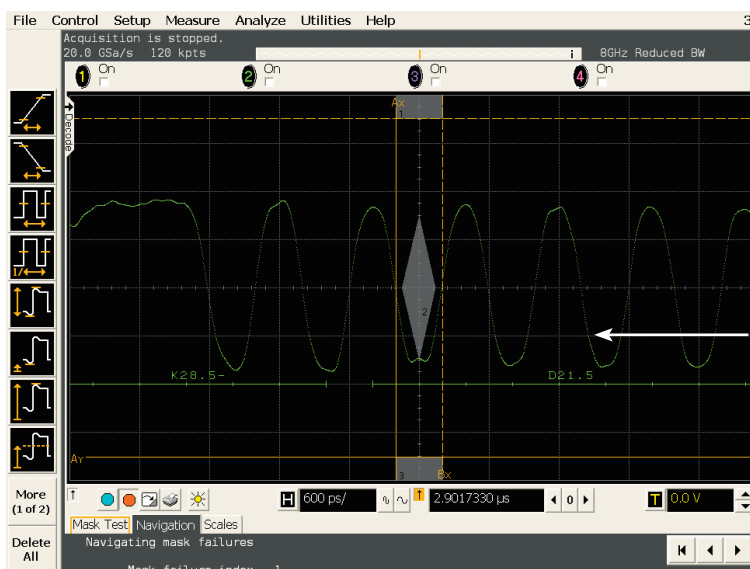**Here you see the specific waveform (and 10-bit code) that caused the eye failure**

Figure 14. The E2688A allows you to show the specific waveform that caused an eye diagram failure.

Measurement Requirements

The N5393B PCI Express electrical performance validation and compliance software requires the E2688A high-speed serial data analysis software, one of the PCI-SIG approved compliance test fixtures (CBB or CLB), and at least two SMA cables or InfiniiMax active differential probes. Some of the measurements cannot be made with the PCI-SIG compliance test fixtures and may require you to build or acquire a custom test board, assembly, or other test fixture.

To purchase the PCI Express compliance test fixtures, consult the PCI-SIG Web site and select the PCI-SIG specification order form link at: **www.pcisig.com/ specifications/ordering_information**

Compliance test fixture	Description
CBB	PCI Express Compliance Base Board for testing PCI Express add-in cards
CLB	PCI Express Compliance Load Board for testing PCI Express platforms
CBB2	Gen 2 PCI Express Compliance Base Board for testing PCI Express add-in cards
CLB2	Gen2 PCI Express Compliance Load Board for testing PCI Express platforms

Recommended Test Accessories

To complete your test setup, Agilent provides a wide range of cables, adapters, terminations, etc.

Note:
While the PCI-SIG does supply Gen2 test fixtures for motherboard and add-in card testing, you will need to obtain SMP cables, adapters and terminators from a vendor of your choice as the SIG does not supply them.

Add-in card testing

Model number	Description
	PCI-SIG Compliance Base Board (order from **www.pcisig.com/specifications/ordering_information**)
15442A	Two SMA cables
	One PC power supply
	One power supply load for regulation
1810-0118	Six 50 Ω terminators

System motherboard testing

Model number	Description
	PCI-SIG Compliance Base Board (order from **www.pcisig.com/specifications/ordering_information**)
15442A	Two SMA cables
1134A or 1169A	InfiniiMax probe with socketed (E2678A) probe adapter
1250-1741	Two right angle SMA adapters (f - m)
1810-0118	Six 50 Ω terminators

Semiconductor device testing

Model number	Description
	Customer supplied custom test fixtures with SMAs
15442A	Two SMA cables
1169A	One InfiniiMax probe with differential solder connection (E2677A)

Optional (for all types of testing)

Model number	Description
11667B	Power splitter, DC to 26.5 GHz, 3.5 mm (f) connectors
11636B	Power divider, DC to 26.5 GHz, 3.5 mm (f) connectors
1250-1159	Three SMA (m - m) adapters
8493B	Coaxial attenuator (3, 6, 10, 20 or 30 dB), DC to 18 GHz, SMA connector
	Matched cable pair, two 90cm (36 inch) SMA (m - m) cables propagation delay within 25 ps
1810-0118	SMA (m) 50 Ω termination

Table 2. Recommended test accessories

Oscilloscope Compatibility

The N5393B PCI Express electrical performance validation and compliance software is compatible with Agilent DSO/DSA 90000 Series oscilloscopes with operating system software revision A.01.10 or higher. The Agilent N5393B tool is also compatible with Agilent 80000 Series oscilloscopes with operating software revision A.05.40 or higher. To use it, you must also install Agilent E2688A high-speed serial data analysis software. For oscilloscopes with earlier software revisions, free upgrade software is available at **www.agilent.com/find/infiniium_software**

Data rate	Recommended oscilloscope	Bandwidth of recommended oscilloscope
2.5 Gb/s	DSO91304A	13 GHz
	DSO91204A	12 GHz
	DSO90804A	8 GHz
	DSO90604A	6 GHz
	DSO81304B	13 GHz
	DSO81204B	12 GHz
	DSO81004B	10 GHz
	DSO80804B	8 GHz
	54855A	6 GHz
5.0 Gb/s	DSO91304A*	13 GHz
	DSO91204A	12 GHz
	DSO81304B	13 GHz
	DSO81204B	12 GHz

*DSA model equivalents are also compatible

Tests Performed

The N5393B PCI Express electrical performance validation and compliance software performs the following tests as per the PCI Express 1.0a and 1.1 electrical specifications for add-in cards and motherboard systems as documented in Section 4 of the base specification ("PHY") and Section 4 of the card electromechanical specification ("EM"). For reference, the tests performed by the SigTest application are also noted.

For Gen2 testing coverage, the PCI-SIG decided not to create checklist, as was done for Gen1. For test coverage refer to section 4.7.2. Table 4-8 of the PCI Express 2.0 Card Electromechanical Specification.

Assertion no.	Description	N5393B	SigTest
Transmitter tests			
PHY.3.1#26	DC common mode voltage	Y	N
PHY.3.2#1	De-emphasis on multiple bits same polarity in succession	Y	N
PHY.3.2#2	Transition bit voltage	Y	N
PHY.3.3#1	Transmitter eye diagram	Y	N
PHY.3.3#2	Unit interval without SSC variations	Y	N
PHY.3.3#3	Minimum D+/D- output rise/fall time	Y	N
PHY.3.3#4	Jitter median to max deviation	Y	N
PHY.3.3#5	Maximum RMS AC common mode voltage	Y	N
PHY.3.3#9	Minimum eye width	Y	N
Receiver tests			
PHY.3.4#1	Minimum receiver eye diagram	Y*	N
PHY.3.4#2	AC peak common mode input voltage	Y*	N
PHY.3.4#6	Jitter median to max deviation input	Y*	N
System board (connector) tests			
EM.4#4	Minimum jitter	Y	Y
EM.4#20	Transmitter path eye diagram	Y	Y
Reference clock (connector) tests			
PHY.3.3#2	Phase jitter	Y	N/A*
PHY.3.3#1	Rising edge rate	Y	N/A
PHY.3.3#1	Falling edge rate	Y	N/A
PHY.3.3#4	Differential input high voltage	Y	N/A
PHY.3.3#4	Differential input low voltage	Y	N/A
PHY.3.3#9	Average clock period	Y	N/A
PHY.3.2#2	Duty cycle	Y	N/A
Add-in card (connector) tests			
EM.4#13	Minimum jitter	Y	Y
EM.4#19	Transmitter path eye diagram	Y	Y

* Note: Receiver tests provided by the N5393A do not validate the receiver's tolerance or ability to correctly receive data. They validate the signal at the receiver against specified tolerances.

Table 3. PCI Express Electrical tests performed by the N5393B software.

Ordering Information

To purchase a new license for the PCI Express Electrical performance validation and compliance software with an Infiniium Series oscilloscope, please order the following:

| Model number	Description
N5393B Opt 002	PCI Express Electrical Test software for Infiniium 90000 Series, 80000 Series or 54844A oscilloscopes
Option 003	High Speed serial Data Analysis Software for Infiniium 90000 Series, 80000 Series, or 548551 Oscilloscope

To add the PCI Express Electrical Performance Validation and Compliance software to an existing Infiniium Series oscilloscope, please order the following:

Model number	Description
N5393B Opt 002	PCI Express Electrical Test Software for Infiniium 90000 Series, 80000 Series, or 548551 Oscilloscope
E2688A	High Speed SDA Software for Infiniium 90000 Series, 80000 Series, or 548551 Oscilloscope

Upgrade to N5393B
To upgrade your existing version of the N5393A to the N5393B, order the following:

Model number	Description
N5393B Opt 001	Upgrade to N5393B from N5393A PCI Express Electrical test software for Infiniium 90000 Series, 80000 Series, or 548551 Oscilloscopes

Related literature

Publication title	Publication type	Publication number
Infiniium 90000 Series Oscilloscopes and InfiniiMax II Series Probes	Data Sheet	5989-7819EN
E2688A, N5384A High-Speed Serial Data Analysis with Clock Recovery Software for Infiniium Oscilloscopes	Data Sheet	5989-0108EN
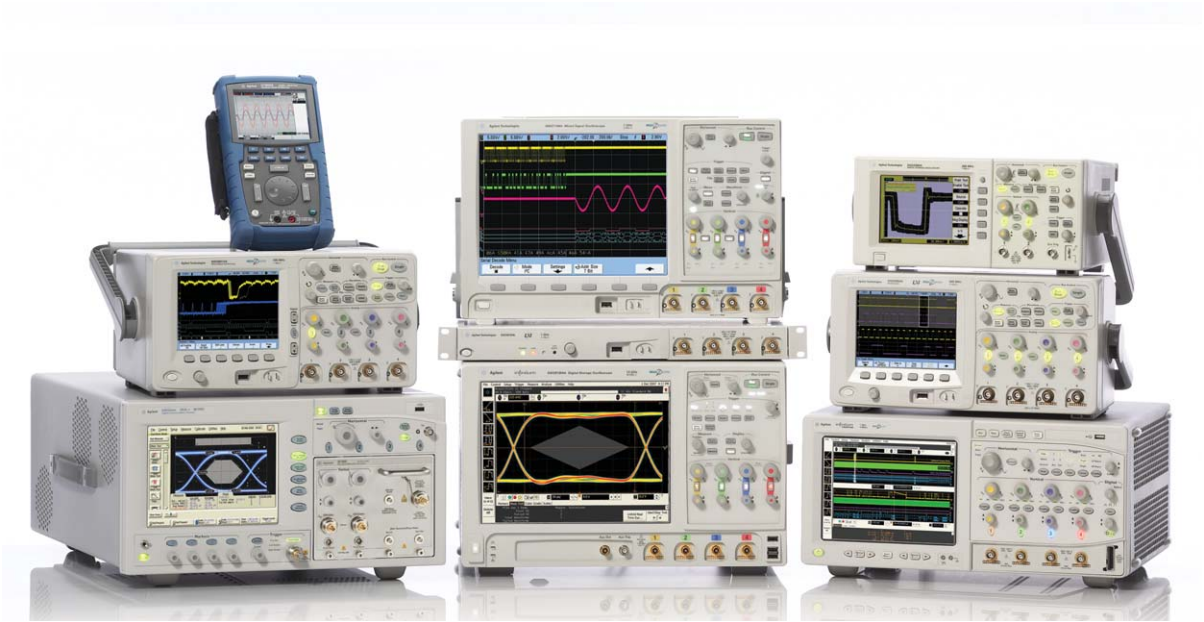
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manufacture electronic products. Agilent
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of system-ready instruments, open industry
software, PC-standard I/O and global
support, which are combined to more
easily integrate test system development.

LXI

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