Keysight Technologies

N5990A Test Automation Software Platform

Multi-Bus Stimulus/Response Test Software
Ideal for Digital High-Speed Interface Buses
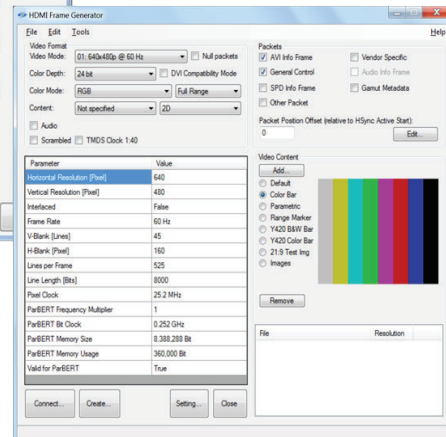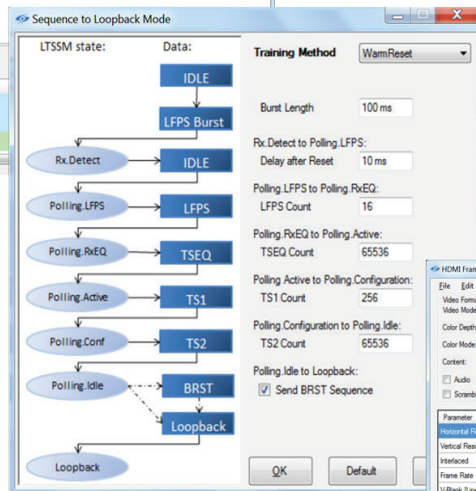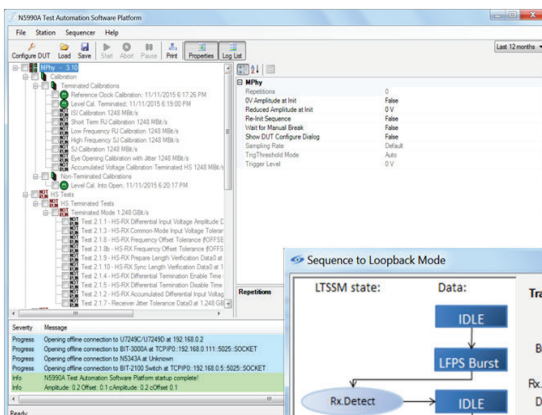
Data Sheet

KEYSIGHT
TECHNOLOGIES

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Introduction

N5990A takes test automation to the next level of performance and convenience

- Universal bus test solution, supports, MIPI® M-PHY®, HDMI, MHL, DisplayPort, PCI Express®, SATA, SAS, USB®, SD UHS–II and Thunderbolt. Other standards are under development. Support for MIPI® C-PHY SM and D-PHY SM is available as M8085A.
- Single and multi-lane device testing
- Complements and enhances Infiniium 90000A DSO/DSA-Series, 90000 X-Series, V-Series and Z-Series series oscilloscope bus test software applications
- Fast system calibration
- One button compliance tests
- Characterization mode for in-depth testing
- Supports real-time parameter changes of amplitude levels etc.
- HTML and / or Microsoft Excel reports for easy post-processing
- Optional interfaces to web and database servers
- Optional user programming for legacy code integration (e.g. LabView,
- VEE, C++) and custom test procedures
- Complementary services
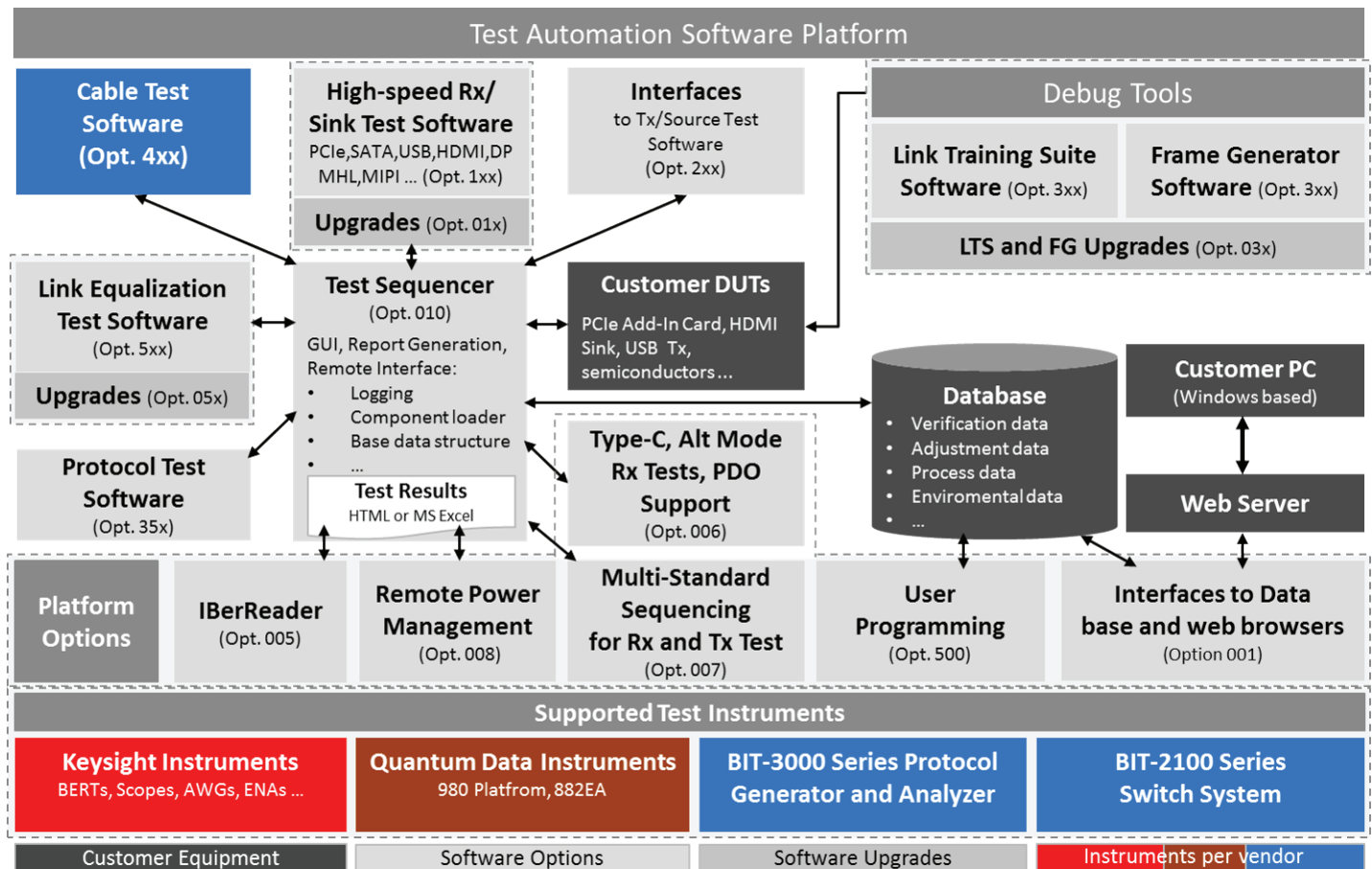
Features and Benefits

Figure 1. Software platform block diagram

Turn your test instruments into a solution

An efficient test strategy is a proven competitive advantage. The Keysight Technologies, Inc. N5990A test automation software platform is a key element of winning strategies.

By combining the performance of your instruments with the convenience of your PC, the N5990A provides unprecedented test integration, high throughput and ease-of-use for a wide range of stimulus and response systems. It is this level of control that turns a collection of instruments into a generic test solution.

Fast and reliable testing

The comprehensive N5990A software platform increases testing speed, reduces test costs and ensures greater thoroughness than manual electrical testing. Using PCI Express as an example, it is suitable for testing devices such as transmitters, receivers and bridges, network adapters, DSP, TV and data acquisition cards, whether you are evaluating production ready prototypes or development boards or chipsets.

Proven reference solution

The N5990A has proven its compliance testing abilities at many interoperability workshops ("plug fests") since its introduction in January 2006. As a result, the N5990A is recommended e.g. in the HDMI CTS and the USB MOI. From the beginning, the N5990A delivered what competitive products are just starting to explore.

Receiver tests

The N5990A's receiver test options provide dedicated receiver and sink compliance tests for popular and emerging digital buses. The libraries ideally complement Keysight's portfolio of transmitter and source test software applications for computer buses such as PCI Express or video buses like HDMI. Apart from the fast reassurance of the compliance mode, the characterization mode offers in-depth analysis.

Features and Benefits *(continued)*

Integrated, generic solution

The N5990A supports a broad portfolio of Keysight instruments, such as the M8020A high performance BERT, Arbitrary Waveform Generators such as the M8195A or M8190A and Infiniium oscilloscopes (see Figure 2). It also allows efficient control of jitter sources like function, or high-quality signal generators.

You can select the hardware performance you need to test your specific DUT, single or multi-lane. The N5990A's software layers seamlessly complement the instrument software, providing a common, generic test environment.

Standardize your tests

The automation platform makes it simple to test multiple buses. The same user interface applies to buses as different as HDMI, PCI Express, MIPI M-PHY or SD-UHS-II. This translates to significant productivity gains. More time is gained by the common HTML or Excel format for reporting results (see Figure 3), and common data structures for advanced data management using data bases.

Maximum throughput

The N5990A's software architecture is based on C# code in the Microsoft .NET framework. In conjunction with on-the-fly amplitude and jitter control supported by many Keysight instruments, this ensures fast interaction, calibration and test execution for best throughput. As an example, for USB Rx Test arbitrarily specified jitter tolerance curves can be measured in a fraction of the time needed with competitive solutions.

Figure 2. Test platform elements for digital stimulus/response test, example MIPI M-PHY.

Features and Benefits *(continued)*

User programming

The test platform is flexible and open. This means you can integrate your own C# code or program your own test sequences with the user programming option. You can also easily integrate software dynamic link libraries (dlls) implemented in graphical environments such as LabView or VEE (contact Keysight). Strong partnership for flexibility and support

The N5990A test software platform is developed by BitifEye Digital Test Solutions. This partner company complements the Keysight instruments with software, accessories incl. switching and services. Keysight guarantees worldwide service and support of the test platform. To meet specific needs, BitifEye offers customization services (see www.bitifeye.com).

Test selection

The test automation software platform lets you select tests from an intuitive tree structure with multiple levels of detail. A key element of the platform is the test sequencer. This lets you select the tests which you want to run, for example for in depth product characterization and the number of repetitions (loops).

Test results

The test automation software platform provides test results in HTML or Microsoft Excel format. When you measure parameter curves, it delivers both the curves (see Figure 4) and a data table. The N5990A displays and updates all the results on-line. After stopping or pausing the sequencer, you can access any result for analysis at your convenience.

Compliance and characterization modes

In compliance mode, you run individual tests as specified by the applicable standards. In characterization mode, experienced users have access to test properties such as frequency range, frequency step width and limits (see Figure 5). This makes it easy to perform margin tests.
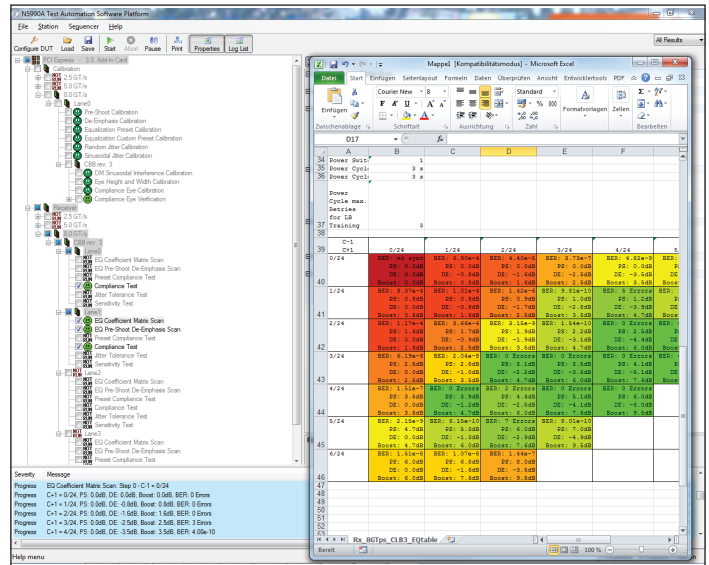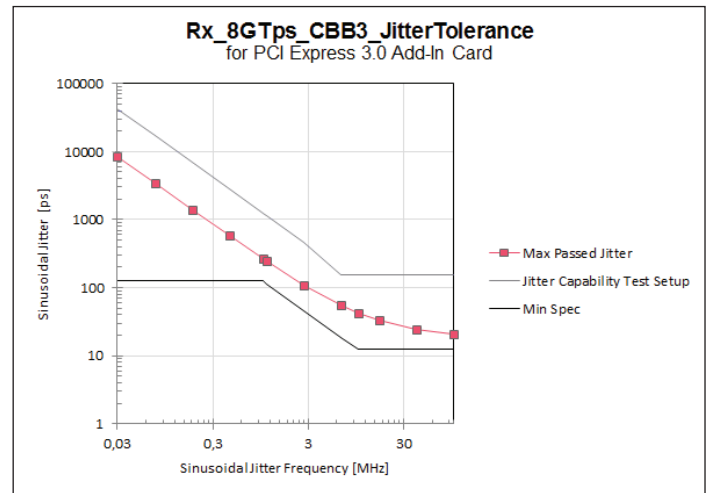

Figure 3. User interface and results display

Figure 4. Jitter tolerance test results

Computer Bus Applications - PCI Express

Compliance test and characterization

Options 101 and 201 simplify PCI Express receiver and transmitter characterization as well as compliance testing. The PCI Express receiver tests (N5990A Option 101)
fully support Keysight's M8020A J–BERT. PCI Express 3.0 and 4.0 can be tested with the build in LTSSM for convenient Link Training. For the test coverage see Table 1.

Receiver jitter tolerance tests complement transmitter tests

Option 101 provides the important jitter tolerance test. In the test station setup shown in Figure 6, J–BERT's built-in jitter generator is used to insert the jitter components which are required by the compliance tests. Transmitter test are conducted with a suitable Infiniium oscilloscope and application N5393F. The oscilloscope is also used for the calibration of the test setup. The N5393F software is integrated into the N5990A test automation and enhanced with Option 201. This lets you select test parameters conveniently on the PC controller. A consolidated test report is provided, comprising receiver and transmitter test results. The controller PC can be used to display and analyze oscilloscope data too, so that productivity is further increased.

Link training suite

The PCI Express Link Training Suite (N5990A Option 301) offers an easy and quick set up of the PCI Express loopback training sequences as well as the signal parameters. It is ideal for debugging and troubleshooting. The generated sequences can be imported in the test automation.

Link equalization tests

The PCI Express Link Equalization Tests (N5990A Option 501) with the J–BERT M8020A use interactive link training. The tests verify the proper transmitter and receiver link equalization negotiation capabilities of an add-in card or a host system.

U.2 receiver tests

The add-on Option 111 provides receiver test coverage for PCIe Gen3 / 8G U.2 storage devices for CC, SRIS and SRNS.

Multi lane testing

Multi-lane Transmitter and receiver testing can be conducted with the BIT-2100 Series switch system from BitifEye.

Table 1. PCI Express test coverage

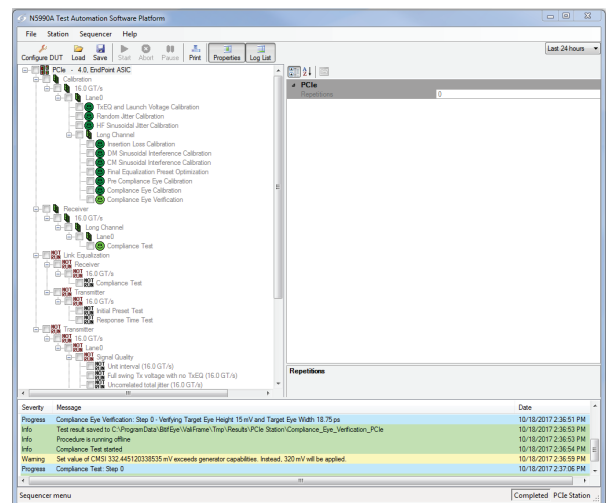| Test name |
| --- |
| Add-In Card Transmitter Signal Quality |
| Add-In Card Transmitter Preset Test for 8.0GT/s |
| Add-In Card Transmitter Initial TX EQ Test for 8.0GT/s |
| Add-In Card Transmitter Link Equalization Response Test for 8.0GT/s |
| System Board Transmitter Signal Quality |
| System Board Transmitter Preset Test for 8.0GT/s |
| System Board Transmitter Link Equalization Response Test for 8.0GT/s |
| Add-In Card Receiver Jitter Tolerance Test |
| System Receiver Jitter Tolerance Test |
| Add-In Card Receiver Link Equalization Test for 8.0GT/s |
| System Receiver Link Equalization Test for 8.0GT/s |
| 4.0 EndPoint / Root Complex ASIC 16.0 GT/s Long Channel Receiver Test |
| 4.0 EndPoint / Root ComplexASIC 16.0 GT/s Lane0 Receiver Test |
| 4.0 EndPoint / Root Complex ASIC 16.0 GT/s Compliance Test |
| 4.0 EndPoint ASIC 16.0 GT/s Long Channel Link Equalization Receiver Test |
| 4.0 EndPoint ASIC 16.0 GT/s Lane0 Link Equalisation Receiver Test |
| 4.0 EndPoint / Root Complex ASIC 16.0 GT/s Link Equalization Receiver Compliance Test |
| 4.0 EndPoint ASIC 16.0 GT/s Link Equalisation Transmitter Initial Preset Test |
| 4.0 EndPoint ASIC 16.0 GT/s Link Equalisation Transmitter Initial Response Test |
| 4.0 Root Complex ASIC 16.0 GT/s Link Equalisation Transmitter Response Time Test |

Figure 5. Test selection details (characterization mode)
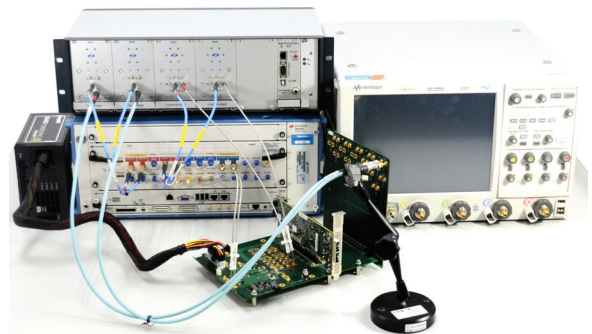
Figure 6. PCI Express test station

Computer Bus Applications - SATA

Test the standard with the standard

Over the years, serial ATA (serial advanced technology attachment or SATA) became the de-facto standard for connecting hard drives into computer systems. By design, SATA is less susceptible to crosstalk and EMI than the preceding parallel implementation. Testing it to the standard defined by the SATA-IO (www.serialata.org) to guarantee compatibility and interoperability however is still mandatory and actually vital to vendors.

Convenient, automated RX tests

The N5990A test automation software platform provides rapid testing and fully controls the test setup, covering all of the RSG compliance tests (Figure 9).

The coverage of the receiver tests N5990A Option 103 is given in Table 2. The crucial receiver jitter tests are provided for devices and hosts in both the pure compliance and the advanced expert mode. For device characterization, complementary tests are available in expert mode.

Interface to oscilloscope transmitter tests

The full range of the Keysight N5411B oscilloscope SATA electrical performance measurements, such as general specifications and transmitted signal requirements, is available for PC-controlled test through the interface Option N5990A-203. See the N5411B data sheet for the long list of supported measurements.

System calibration

This initial step is mandatory for reliable measurements. It used to be slow and inconvenient in the past. N5990A's automated calibration provides a new user experience. Stress your device with precisely calibrated jitter! The oscilloscope is used for the calibration of the receiver test subsystem.

Link training suite

The default loopback training sequences can be adjusted to a particular DUT's needs with the SATA Link Training Suite N5990A Opt. 303. The sequences which it generates can be sent directly to the J-BERT for quick, manual testing and they can be imported in the N5990A test automation, too.
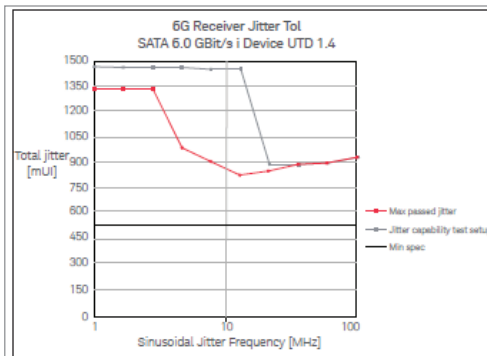
Figure 7. Excel results
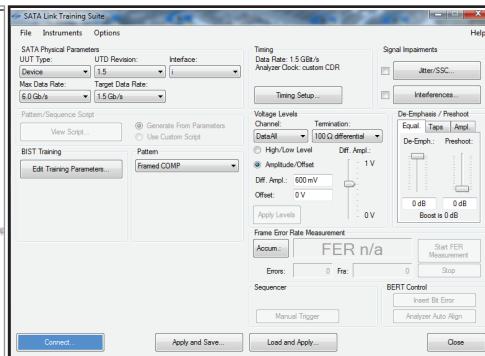
Figure 8. SATA Link Training Suite
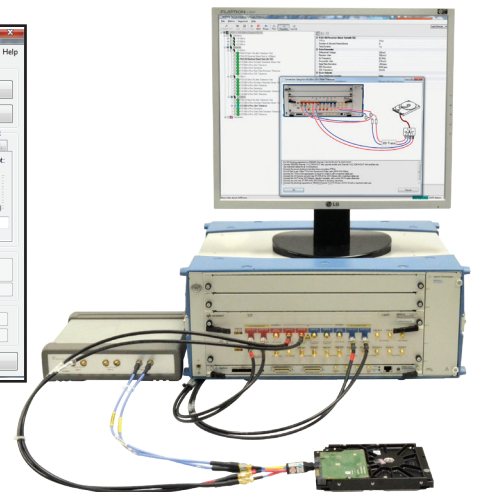
Figure 9. Automated SATA test station

Table 2. SATA receiver test coverage (host and device DUTs)

Test requirement	Test name	Compliance mode	Expert mode
RSG-01	Gen1 (1.5 Gb/s) receiver jitter tolerance test	•	•
RSG-02	Gen2 (3 Gb/s) receiver jitter tolerance test	•	•
RSG-03	Gen3 (6 Gb/s) receiver jitter tolerance test		•
RSG-05	Asynchronous receiver stress test		•
RSG-06	Asynchronous receiver stress test with SSC		•
	Receiver differential sensitivity		•
	Receiver jitter tolerance		•
	Receiver constant parameter stress test		•

Computer Bus Applications - USB

SuperSpeed USB 3.1 Gen2 and "Type-C" are gaining ground

With USB 2.0, the Universal Serial Bus interface became indispensable in PC peripherals such as printers, mice or webcams and consumer electronic products such as digital cameras. USB 2.0 operated at 480 MBit/s. With USB 3.0, also known as SuperSpeed USB and USB 3.1 Gen 2, data rates are increased up to 10 Gb/s! This tremendous increase enables new applications such as the fast data transfer from external computer hard drives. A reliable implementation however requires thorough testing.

USB 3.0/3.1 Gen 1, Gen 2 and Type-C test coverage from the start

The proven N5990A test automation software provided USB 3.0 and USB 3.1 test coverage from the beginning. This was achieved by actively cooperating with key technology drivers and supporting industry events such as interoperability tests. N5990A comprises receiver tests for USB 2.0 devices and USB 3.0/3.1 hosts and devices. The crucial jitter tolerance test is supported as well as other critical tests, see Table 3.

Complementing USB transmitter tests

The N5990A Option 102 receiver tests are complemented by the Infiniium oscilloscope transmitter compliance test software applications N5416A (USB 2.0) and U7243B (USB 3.1). The transmitter test software is fully integrated into the test software automation platform by N5990A Option 202.

USB receiver tests

A test station is shown exemplarily in Figure 10. It comprises a J-BERT M8020A, the USB test fixtures and the test software. For error counting, the J-BERT SER/FER analysis capability removes the SKP OS filler symbols from the data stream. For debugging purposes, the USB Link Training Suite (Opt. 302) allows to modify the loopback training sequences and to change test signal parameters on the fly. For USB 3.0 and 3.1 LTSSM Link Training is also supported in Option 102.

Type-C and PDO Support available

Full Type-C functionality with an integration of Power delivery tests are available by adding N5990A Opt. 006 to your test environment.

Multi-Standard Sequencing for Receiver and Transmitter Test

Can be achieved with N5990A option 007. Freely combine TX and RX test of USB, Thunderbolt and / or DisplayPort. For more information please check page 14.

Figure 10. USB SuperSpeed test station

Cable tests

USB 3.1 and Type-C cable tests can be conducted with a Keysight E5071C ENA with opt. TDR. Cable test automation software is available from BitifEye. It provides fully automated testing of all lanes of a USB cable, using a remotely controlled BitifEye 2100 Series switch system (see Figure 11).
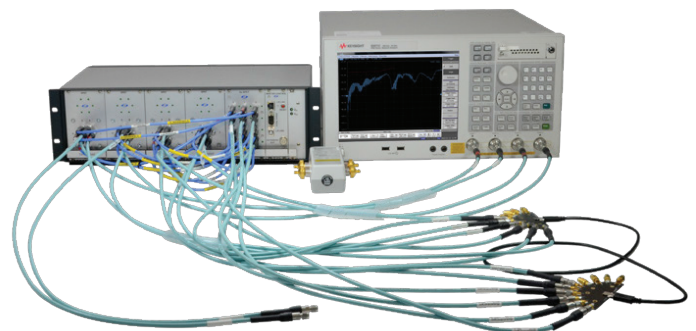
Figure 11. USB 3.1 Type C cable test station with E5071C ENA/TDR and BitifEye 2100 Switch System.

Table 3. USB receiver test coverage (host and device DUTs)

Standard version	Test requirement	Test name	Compliance mode	Expert mode
USB 2.0	EL_11	Receiver data rate	●	●
	EL_13	Receiver jitter tolerance	●	●
	EL_15	Receiver common mode voltage	●	●
	EL_16	Receiver squelch detection	●	●
	EL_17	Receiver squelch suppression	●	●
	EL_18	Receiver min. sync field	●	●
USB 3.1	TD_1.2	LFPS receiver test	●	●
	TD_1.8	Receiver jitter tolerance at 5GT/s	●	●
	TD_1.9	Receiver jitter tolerance at 5GT/s (Type-C)		●
	TD_1.10	Receiver jitter tolerance at 10 GT/s		●
		Receiver constant parameter stress test		●
		Receiver jitter tolerance characterization		●
		Receiver sensitivity test		●

Computer Bus Applications – "Type-C"

Go beyond just one standard

With the continued success of the USB interface, there exists a need to adapt USB technology to serve newer computing platforms and devices as they trend toward smaller, thinner and lighter form-factors. On top of that the USB Type-C has been opened to include other standards, such as Thunderbolt, DisplayPort, HDMI and MHL and is also able to provide power up to 20v/5A. This positions the Type-C connector to become the most used interface in new applications.

Unique solution to address the test challenges

The benefit of the customer presents the challenge to the manufacturer and with this new test cases. Keysight is addressing this challenge with a test system build up, which comprises Power Delivery, USB 3.1, Thunderbolt and DisplayPort with it´s M8000 J-BERT platform, high-end Oscilloscopes, the N7018A Type-C Test Controller and with the N5990A Test Automation Software.

Type-C, Alt Mode Receiver Tests and PDO Support made simple
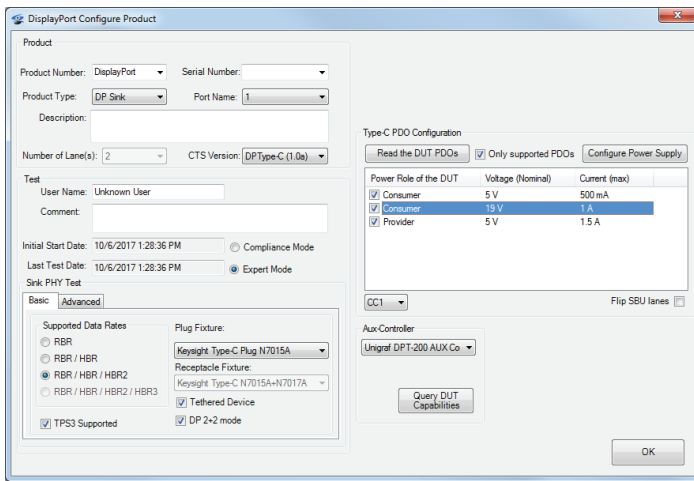
N5990A Option 006 provides full control of the USB Type-C interface which is core to the RX and TX compliance testing in USB3.1, Thunderbolt and DisplayPort in their own ALT-Modes as well power contracts (consuming or providing) can be made up to 100 Watts. Test results are available as HTML or Excel workbook.

Multi-Standard Sequencing for Receiver and Transmitter Test
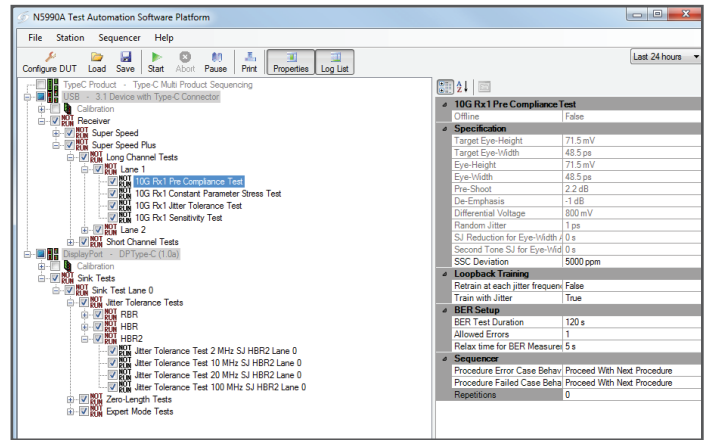
While within every N5990A - receiver test standard the - transmitter application can be included with separate options, the Type-C test requirements do also have a need to do this across standards. Option 007 allows to combine freely any of the Type-C test requirements, regardless if it is TX or RX across all involved standards and instruments. It requires at a minimum N5990A Opt. 010 (Test Sequencer), N5990A Opt. 006 (Type-C , Alt Mode Receiver Tests and PDO Support) and any of the following options: N5990A Opt. 102 (USB), 104 (Thunderbolt) and 155 (DisplayPort) combined with a TX Scope app from either of these standards and the N5990A Opt.: 2xx interface. Usually a BIT-2100 Switch System is involved, so option 004 "Switch System and DSGA Platform Support" must be combined to this.
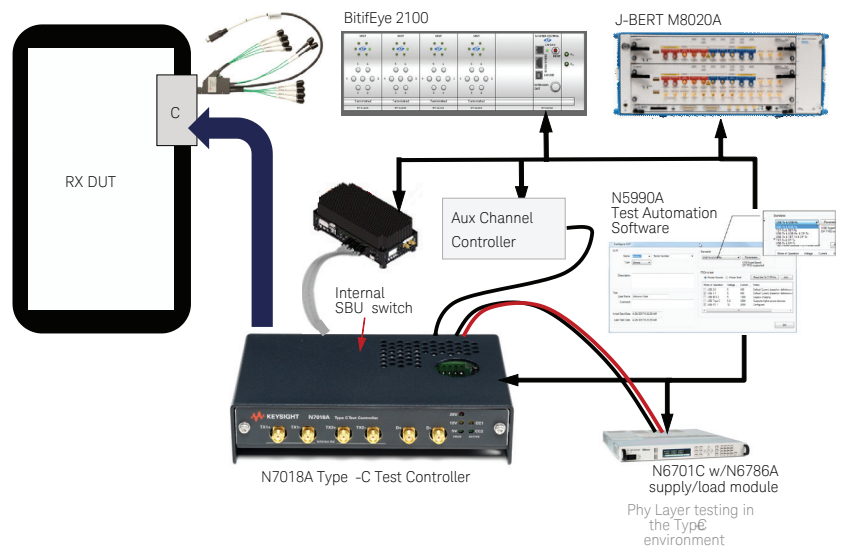
Computer Bus Applications - Thunderbolt

The USB-C that does it all

Thunderbolt™ 3 brings Thunderbolt to the USB Type-C (commonly known as USB-C) connector at speeds up to 40 Gbps, creating one compact port that does it all – delivering the fastest, most versatile connection to any dock, display, or data device. For the first time, one computer port connects to Thunderbolt™ devices, every display, and all USB devices. It's intended for new uses, such as 4K video, single-cable docks with charging, external graphics, and built-in 10 GbE networking.

Receiver testing in its most convenient form

As with all other computer bus applications the N5990A option 104 works with the M8020A J-BERT with the same look and feel. This boosts productivity. The test automation software covers all the tests given in Table 4 for pure compliance tests. For device characterization, complementary tests are available in expert mode. Test results can be saved either in HTML or Excel format.

Interface to oscilloscope transmitter tests

The full range of the Keysight N6470A Thunderbolt 3 Transmitter Compliance Test Software for Infiniium Oscilloscopes is available for PC-controlled test through the interface option N5990A-204.

Type-C and PDO Support available

Full Type-C functionality with an integration of Power delivery tests are available by adding N5990A Opt. 006 to your test environment.

Multi-Standard Sequencing for Receiver and Transmitter Test

Can be achieved with N5990A option 007. Freely combine TX and RX test of USB, Thunderbolt and / or DisplayPort.

Table 4. Thunderbolt Test Coverage

Test Description	Ports		Lanes		Test points		Data rates		SJ frequencies				
	A	B	0	1	TP2	TP3EQ	10.3125 Gbps	20.625 Gbps	1 MHz	2 MHz	10 MHz	50 MHz	100 MHz
Receiver Test for 10.3125 Gb/s at TP2	X	X	X	X	X	X	X	X	X	X	X	X	X
Receiver Test for 10.3125 Gb/s at TP3EQ	X	X	X	X	X	X	X	X	X	X	X	X	X
Receiver Test for 20.625 Gb/s at TP2	X	X	X	X	X	X	X	X	X	X	X	X	X
Receiver Test for 20.625 Gb/s at TP3EQ	X	X	X	X	X	X	X	X	X	X	X	X	X
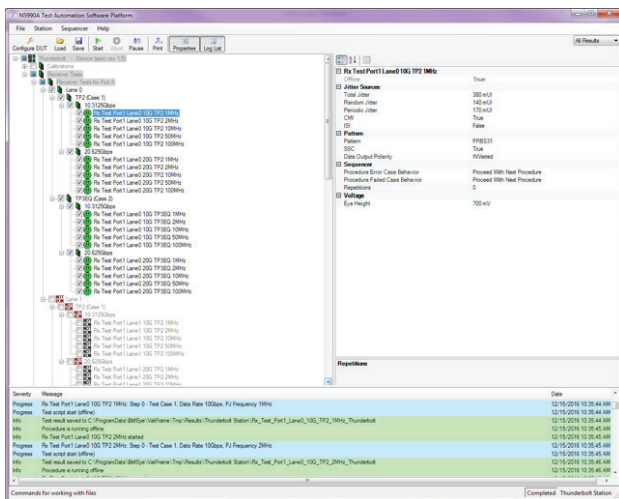
Figure 12. N5990A Thunderbolt Test Tree

Figure 13. Thunderbolt Test Station

Computer Bus Applications – SAS

SAS – PCIe Storage for the Enterprise

The SCSI Trade Association (STA) was established in 1996 to provide a focal point for members to communicate the benefits of SCSI to the industry. STA promotes the understanding and use of Serial Attached SCSI (SAS) technology and influences the evolution of SCSI standards to meet future industry needs. SAS has been shipping dual-port drives since its inception. A benefit of SAS-based storage subsystems is the native dual-port capability of each SAS drive, providing a redundant path to each drive in the event of a controller-level failover. In addition, multi-initiator capability can be achieved with a SAS Fabric implementation through SAS expanders. This can be further enhanced with simultaneous access and dual-active port support, in addition to the inherent redundant paths to the SAS drives.

SAS Gen4

In a step towards satisfying the need for tremendous bandwidth as well as increasing IOPS requirements for big data analytics and scale-out storage in the datacenter, the SCSI Trade Association (STA) has developed the 24G Serial Attached SCSI (SAS) specification. 24G SAS end-user products are anticipated mid-2019 to early 2020. Comprised of SAS-4 and SPL-4, the 24G SAS specification is backward compatible with 12Gb/s and 6Gb/s SAS but will use a different encoding scheme than previous versions.

Enhance your M8020A capabilities

Based on the well-known structure of the N5990A Test Automation Software, option 105 provides rapid testing and fully controls the test setup, covering all receiver tests for SAS Gen3 and Gen4.

System calibration

This initial step is mandatory for reliable measurements. It used to be slow and inconvenient in the past. N5990A's automated calibration provides a new user experience. Stress your device with precisely calibrated jitter! The oscilloscope is used for the calibration of the receiver test subsystem.

Link training suite

The default link training sequences can be adjusted to a particular DUT's needs with the SAS Link Training Suite N5990A Opt. 305. The sequences which it generates can be sent directly to the J-BERT for quick, manual testing and they can be imported in the N5990A test automation, too.
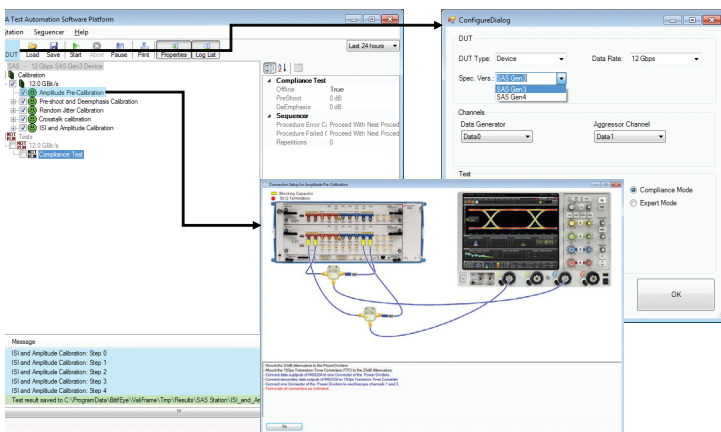
Figure 14. N5990A SAS Configuration example
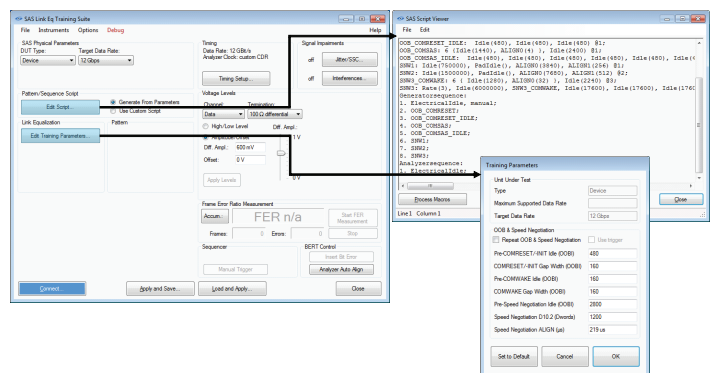
Figure 15. N5990A SAS Link Training Suite options

Video Test Applications - HDMI

Go beyond the instruments

By combining the performance of Keysight instruments with the flexibility of a PC, N5990A provides unprecedented test integration, minimum calibration time and maximum test throughput as well as ease-of-use for HDMI test. It is this level of control and performance which leapfrogs competitive solutions.

Fast and reliable HDMI testing

The comprehensive N5990A automation software platform increases testing speed, reduces test cost and ensures greater thoroughness than manual HDMI compliance testing and characterization. Competitive, stand-alone software applications are often outperformed.

Cable tests

HDMI cable tests can be conducted with a Keysight E5071C ENA with opt. TDR. HDMI cable test automation software is available from BitifEye. It provides fully automated testing of all lanes of a HDMI cable, using a remotely controlled BitifEye 2100 Series switch system.

Integrated sink and source TMDS and protocol, EDID, CEC and HDCP and HEAC tests

The N5990A Test Automation Software for HDMI tests provides the industry's broadest test coverage. The consolidated test report boosts productivity tremendously. For the sink test setups with M8190A or M8195A Arbitrary Waveform Generators (AWG) select opt. 151, N5990A option 250 provides the interface to source test with Infiniium oscilloscopes. Option 350 enables protocol, EDID, CEC and HDCP test with the Quantum Data 980 Advanced Test Platforms and 882EA Video Test Instrument. HEAC tests with the 81150A generator are supported by opt. 351.

For the sink test setups with M8190A or M8195A Arbitrary Waveform Generators (AWG) select opt. 151, N5990A option 250 provides the interface to source test with Infiniium oscilloscopes. Option 350 enables protocol, EDID, CEC and HDCP test with the Quantum Data 980 Advanced Test Platforms and 882EA Video Test Instrument. HEAC tests with the 81150A generator are supported by opt. 351.
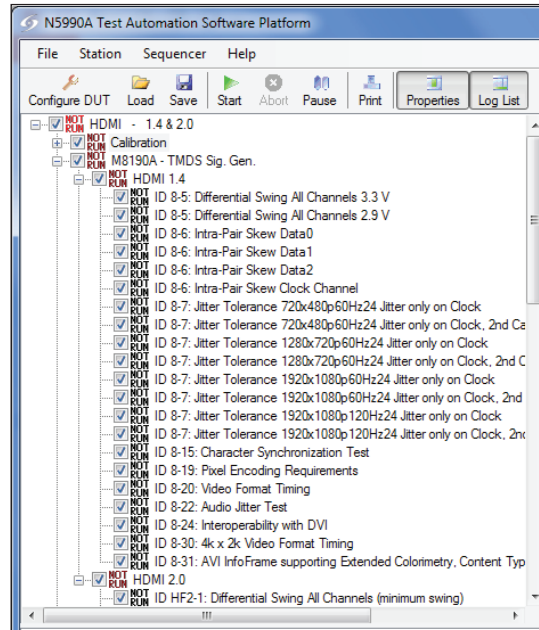
Figure 16. TMDS, protocol, EDID, CEC and HDCP tests
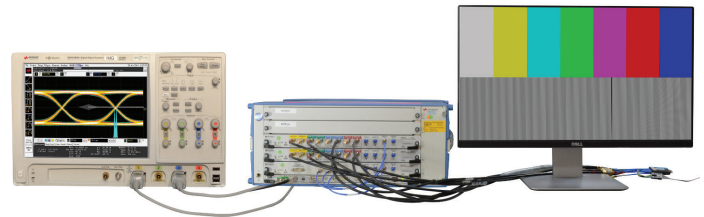
Figure 17. M8195A Sink and Source test set up

Table 5. HDMI sink test coverage with M8190A or M8195A

CTS 1.4b Test ID	Test name	CTS 2.0 Test ID	Test name
8-5	TMDS min. differential sensitivity	HF2-1	Min/Max differential swing tolerance
8-6	TMDS intra-pair skew	HF2-2	Intra-pair skew
8-7	TMDS jitter tolerance	HF2-3	Jitter tolerance
8-15	Character synchronization	HF2-6	Video timing 2160p 24-bit
8-16	Acceptance of all valid packet types 1	HF2-7	Video timing 2160p deep color
8-19	Pixel encoding	HF2-8	Video timing 2160p 3D
8-20	Video format timing	HF2-23	Pixel decoding YCbCr 4:2:0
8-21	Audio Clock Regeneration 2	HF2-24	Pixel decoding YCbCr 4:2:0 deep color
8-22	Audio Sample packet jitter	HF2-25	Video timing 21:9 (64:27)
8-23	Audio Formats 2	HF2-36	Video timing non-2160p 24-bit
8-24	Interoperability with DVI	HF2-37	Video timing non-2160p 24-bit deep color
8-25	Deep color 3	HF2-38	Video timing non-2160p 24-bit 3D
8-29	3D video format timing 1		
8-30	4K x 2K video format timing		
8-31	AVI info frame extended colorimetry		

Video Test Applications – HDMI *(continued)*

eARC

Enhanced Audio Return Channel (eARC) supports the most advanced audio formats such as object-based audio, and enables advanced audio signal control capabilities including device auto-detect. eARC is introduced with HDMI 2.1.

eARC increases bandwidth from originally 384 Kbps to approximately 1 Mbps to 38 Mbps ARC (8 channels, 192 kHz, 24 bits). This covers everything requiring a high bit rate including e.g. uncompressed Dolby True HD, Dolby Atmos, DTS:X and DTS HD Master Audio. It does present the opportunity to keep AV and eARC paths separate within the HDMI transmissions. With this it addresses current user behavior to e.g. simultaneously streaming video contents from the internet, while playing a video game.

Test Automation

For the first time N5990A will also be required for TX / Source Tests as well as RX / Sink Tests. Option 351 comprises HDMI eARC and HEAC Receiver and Transmitter Tests, customers with the need for source tests only can use Option 352 HDMI eARC and HEAC Transmitter Tests.

Instrumentation

HEAC tests are supported by the 81150A Pulse Function Arbitrary Noise Generator. By using two 81150A generators audio and Ethernet signals can be gener¬ated simultaneously. With the extension to eARC an additional bi-directional test were implemented. For the execution of these test an additional analyzer is needed, such as the BIT-3000 Series DSGA from BitfEye, which is also controlled by the eARC Frame Generator software and 81160A Pulse Function Arbitrary Noise Generator. To include the HEAC tests, use the two-channel option with the 81160A Pulse Function Arbitrary Noise Generator.

HDMI eARC Frame Generator

All eARC, HEC and ARC PHY test requirements are covered in the HDMI eARC Frame Generator. This supplementary test software to N5990A for semiautomatic debugging and trouble-shooting (Figure 18) is avail¬able from BitifEye as BIT-2010-0004-1.
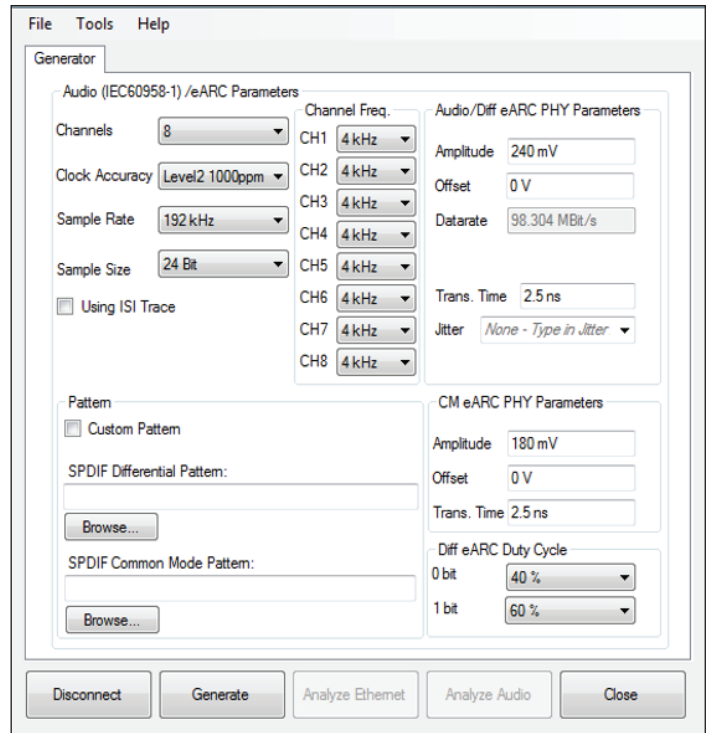
Figure 18. Complementary BitifEye HEACphy test software
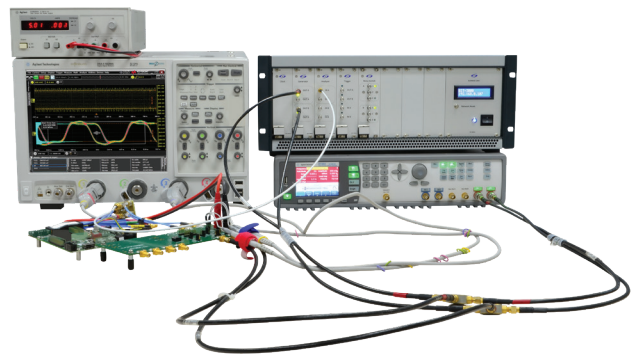
Table 6. eARC

Test number	Test name
HFR5-61	eARC RX Termination Supply Voltage Tolerance at TP2 (VEH_eARC)
HFR5-62	eARC RX Differential Mode Swing Tolerance at TP2 (VeARC_SWING_DM2)
HFR5-64	eARC RX Differential Bit Rate Tolerance at TP1 (ReARC_BIT_AUDIO)
HFR5-65	eARC RX Differential Mode Eye Diagram Tolerance at TP1
HFR5-66	eARC RX Differential Mode Duty Cycle Tolerance at TP1 (DeARC_DM1)
HFR5-67	eARC RX Common Mode Input Swing Tolerance at TP1 (UeARC_MASTER_SWING_CM1)
HFR5-68	eARC RX Common Mode Output Swing at TP1 (UeARC_SLAVE_SWING_CM1)
HFR5-70	eARC RX Common Mode Output Rise/Fall Time (10% - 90%) at TP1 (TeARC_RISE_FALL_CM)

Video Test Applications – HDMI *(continued)*

This solution also facilitates thorough product verification and margin analysis where repetitive measurements are required for parameters such as timing and voltage. Some HDMI 1.4b protocol tests are also supported by the N5998A protocol generator and analyser and the Quantum Data 882EA. For details contact Keysight.

Table 7. N5990A opt. 351 HEAC test coverage

5-10	Sink	IEC 60958-1 Stream Verification Test
5-15	Source	IEC 60958-1 Stream Verification Test
5-16	Sink and Source	Differential Signal Receiver Performance Test
5-17	Source	Common Mode Signal Receiver Performance Test
5-18	Source	Single Mode Signal Receiver Performance Test
5-19	Source	Common Mode Operating DC Voltage Test
5-20	Source	Single Mode Operating DC Voltage

Table 8. N5990A opt. 351 HEAC test coverage

HDMI 1.4b Tests covered by Quantum Data 980	
Sink - EDID / E-DDC	8-1,8-2,8-3
Sink Protocol	8-16
Sink Video	8-17, 8-18, 8-19, 8-20
Sink Audio	8-21, 8-23
Sink Advanced Features	8-25, 8-31
Source Protocol	7-16, 7-17, 7-18, 7-19
Source Video	7-21, 7-22, 7-23, 7-24, 7-25, 7-26, 7-27
Source Audio	7-28, 7-29, 7-30, 7-31, 7-32
Source Interoperability with DVI	7-33, 7-33a
Source Advanced Features	7-34, 7-35, 7-36, 7-37, 7-38, 7-39, 7-40
DDC	DDC1-1, DDC1-2
HDMI 2.0 Tests covered by Quantum Data 980	
Sink TMDS Protocol	HF2-9, HF2-5
Sink Pixel Decoding	HF2-23, HF2-24
Sink Video Timing	HF2-6, HF2-7, HF2-8, HF2-25
Sink EDID	HF2-10, HF2-31, HF2-32, HF2-35, HF2-26, HF2-39, HF2-41, HF2-53
Sink E-DDC Protocol	HF2-12, HF2-16, HF2-34, HF2-44, HF2-50
Sink Audio Decoding and Rendering Tests	HF2-30
High Dynamic Range (HDR)	HF2,54
Source TMDS Protocol 6G and Scrambling	HF1-10, HF1-11, HF1-12, HF1-13, HF1-21, HF1-22
Source Video Timing – 6G	HF1-14, HF1-15, HF1-16, HF1-24, HF1-25, HF1-26, HF1-33, HF1-34, HF1-35
Source AVI InfoFrame and GCP	HF1-18, HF1-28, HF1-51, HF1-52
Source Audio Encoding High Bit Rate (HBR) Audio Test	HF1-43
HF1-43Source HDR InfoFrame Test	HF1-53
HDMI 1.4b Tests covered by Quantum Data 882EA	
HDCP Sink	2C-01, 2C-02, 2C-03, 2C-04
HDCP Source	1A-01, 1A-02, 1A-03, 1A-04, 1A-05, 1A-06, 1A-07, 1A-08, 1A-09, 1B-01, 1B-02, 1B-03, 1B-04, 1B-05, 1B-06

Video Test Applications – Mobile High Definition Link (MHL)

Mobile High-Definition Link

The Mobile High-Definition Link (MHL) interface addresses the emerging use model of streaming HDMI content from a mobile device to displays. MHL specifies a HD video and digital audio interface designed for connecting mobile phones and portable devices to HDTVs and other home entertainment products. MHL uses the established Micro USB and HDMI connectors and features a single cable with a 5-pin interface. It supports 1080p HD video and digital audio and simultaneously provides power to the mobile device. MHL also supports remote control.

MHL test requirements

The 3 differential data lanes used for the HDMI colors are multiplexed onto the single differential MHL TMDS data lane. The clock is added as a common mode signal to the data lane signal. The receiver then needs to have both, differential and common mode detection circuits. In addition, MHL uses a single-wire Control.

Bus (eCBUS) for configuration and status exchange between the source and the sink. The eCBUS provides high-level control functions between all of the various audiovisual products in a user's environment. Finally, MHL comprises a dedicated VBUS for power distribution.

MHL test solution

The Keysight N6460B MHL source compliance test software performs the full physical layer compliance suite for MHL data transmitters with a suitable Infiniium Series Oscilloscope. Full, automated physical layer compliance testing for MHL receivers and dongles is provided by N5990A Option 153 for the M8190A 12 GSa/s or M8195A Arbitrary Waveform Generator (Figure 19).

New customers: contact Keysight for more information.

The complementary MHL Frame Generator software BIT-2070-0000-0 is available from BitifEye. This software is optimized for debugging and trouble-shooting.

The receiver test coverage is given in Table 9.
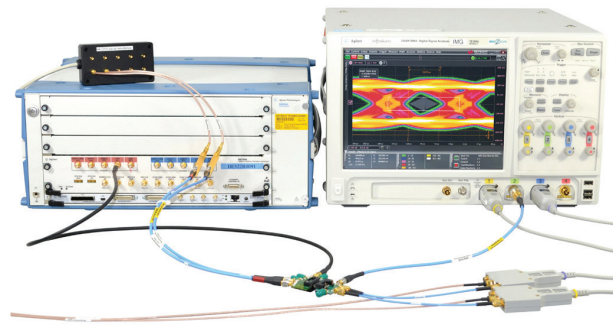
Figure 19. MHL RX Test set up with M8190A

Table 9. MHL Receiver test coverage

Legacy MHL		
CTS test ID no	**DUT type**	**Test name**
4.1.1.1	Sink	Input Signal DC Voltage Level Tolerance
5.1.1.1	Dongle	Input Signal Single-Ended Voltage Level Tolerance
4.1.1.2 / 5.1.1.2	Sink / Dongle	Input Min&Max Swing Voltages Tolerance
4.1.1.3 / 5.1.1.3	Sink / Dongle	Intra-Pair Skew Tolerance
4.1.1.4 / 5.1.1.4	Sink / Dongle	Jitter Tolerance in Normal Mode
4.1.1.8 / 5.1.1.9	Sink / Dongle	Jitter Tolerance in PackedPixel Mode
7.2.1.16	Cable	Minimum Clock Swing Test
7.2.1.17	Cable	Cable Eye Diagram Test
MHL 3		
CTS test ID no	**DUT type**	**Test name**
3.7.2.32	Source	Input DC Voltage Tolerance of eCBUS-S BWD Data
3.7.2.33	Source	Single-Ended Input Swing Tolerance of eCBUS-S BWD Data
3.7.2.36	Source	Jitter Tolerance of eCBUS-S BWD Data
4.7.2.1	Sink	Input DC Voltage Tolerance of Differential TMDS Data
4.7.2.3 / 5.7.2.5	Sink / Dongle	Differential Input Swing Tolerance of Differential TMDS Data
4.7.2.5	Sink	Input DC Voltage Tolerance of Single-Ended MHL Clk and eCBUS-S FWD Data
4.7.2.6 / 5.7.2.9	Sink / Dongle	Single-Ended Input Swing Voltage Tolerance of Single-Ended MHL Clk and eCBUS-S FWD Data
4.7.2.7 / 5.7.2.10	Sink / Dongle	Differential Intra-Pair Skew Tolerance of Differential TMDS Data
4.7.2.10 / 5.7.2.13	Sink / Dongle	Jitter Tolerance of Single-Ended MHL Clk, eCBUS-S FWD Data and Differential TMDS Data
5.7.2.1	Dongle	Single-Ended High Level Input Voltage Tolerance of Differential TMDS Data
5.7.2.2	Dongle	Single-Ended Low Level Input Voltage Tolerance of Differential TMDS Data
5.7.2.7	Dongle	Single-Ended High Level Input Voltage Tolerance of Single-Ended MHL Clk and eCBUS-S FWD Data
5.7.2.8	Dongle	Single-Ended Low Level Input Voltage Tolerance of Single-Ended MHL Clk and eCBUS-S FWD Data

Video Test Applications - DisplayPort

DisplayPort, one connection, infinite ways to connect

DisplayPort defines a high-bandwidth interface for connecting laptop or personal computers with display monitors or high-definition consumer electronic devices. VESA, an organization comprised of leading companies in the high-definition digital display industry drives the development of this interface.

Meet the test requirements

As part of its standards compliance, VESA has established a comprehensive compliance test program for DisplayPort that includes product certification at independent third-party test houses, for physical layer and link layer compliance testing. Physical layer test is comprised of source, sink and cable (media) tests detailed in the DisplayPort CTS (compliance test specification). The Keysight test products and methodologies are approved as MOI (method of implementation) by VESA.
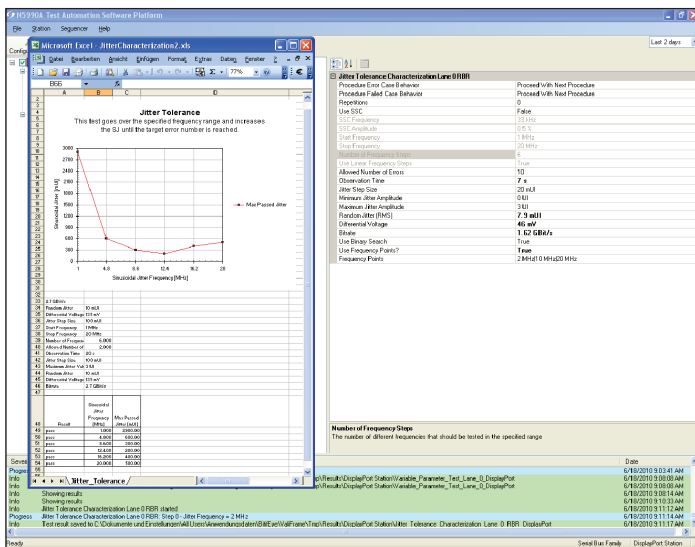
Figure 20. N5990A DisplayPort receiver jitter tolerance test
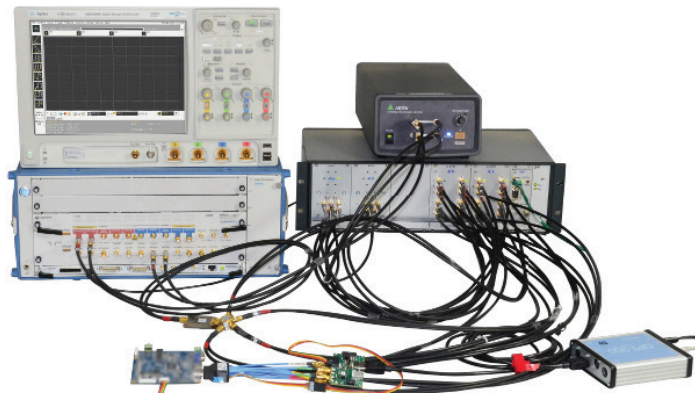
Figure 21. Receiver test station

Automated tests

As with all other supported computer bus or video standard tests, the N5990A software platform provides fast, calibrated, automated receiver testing.

The receiver tests N5990A Option 155 (Figure 20) require DUT register access. They complement the Infiniium oscilloscope transmitter compliance test software U7232D. This software is fully integrated into the N5990A with Option 255. The CTS 1.2 test coverage is given in Table 10.

Table 10. DisplayPort receiver test coverage

Receiver test name
RBR, HBR and HBR2 jitter tolerance tests
HBR and HBR2 zero-length jitter tolerance tests
Jitter tolerance characterization
Datarate deviation tests
Sensitivity tests
Intra-pair skew tests
Variable parameter test (user-selectable swing, SJ and RJ)

Supported hardware

The standard DisplayPort receiver test setup is given in Figure 21. It is based on the J-BERT M8020A, test fixtures, a DisplayPort AUX channel controller and an ISI generator (these accessories are available from BitifEye) and an external PC running N5990A. A suitable Infiniium oscilloscope is used for the transmitter tests and the calibration of the receiver test subsystem. All DisplayPort data lanes can be tested one after the other without the need of user interaction in combination with an optional BitifEye 2100 Series switch.

Add-on option eDP - Be Ready for the future

The embedded DisplayPort (eDP receiver tests) are available as opt. 156 for tablets, notebooks and "All-in-one"- PCs. This option requires opt. 155.

Type-C and PDO Support available

Full Type-C functionality with an integration of Power delivery tests are available by adding N5990A Opt. 006 to your test environment.

Multi-Standard Sequencing for Receiver and Transmitter Test

Can be achieved with N5990A option 007. Freely combine - transmitter and - receiver test of USB, Thunderbolt and / or DisplayPort.

Mobile Device Interface Test Applications – MIPI M-PHY

MIPI, the mobile standard

The Mobile Industry Processor Interface (MIPI) Alliance is an open membership organization that includes leading companies in the mobile industry that share the objective of defining and promoting open specifications for interfaces in mobile terminals. MIPI specifications establish standards for hardware and software interfaces between the processors and peripherals typically found in mobile terminal systems such as cell phones. MIPI D-PHY currently operates at up to 4.5 Gb/s per lane, while with MIPI C-PHY 3 Gb/s per lane can be accomplished. The data rate may increase in the future.
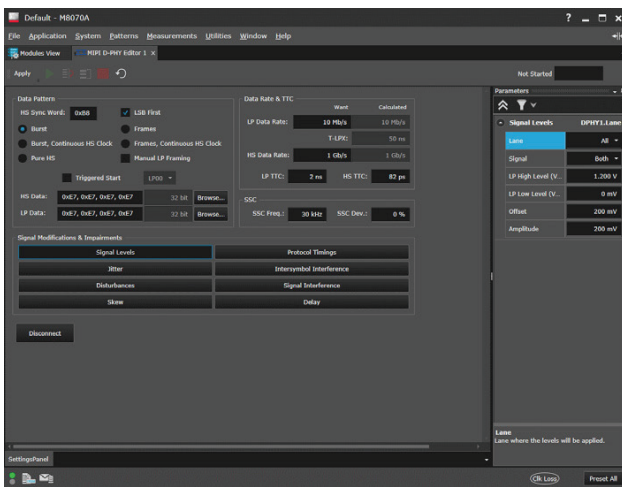
Figure 22. MIPI D-PHY Editor

Meet the test requirements

As part of its standards compliance, the MIPI Alliance has established a comprehensive compliance test program for both MIPI C-PHY and MIPI D-PHY that includes product certification at independent third-party test houses for physical layer and link layer compliance testing. Physical layer test is comprised of receiver and transmitter tests. The M8085A Calibration, Conformance and Characterization Procedures software plug-in creates the standard conformant test signals.

Automated tests

Like for all other supported interface bus standard tests, the N5990A test sequencer (option 010) in conjunction with the M8085A software plug-ins provides fast, calibrated, automated testing by using the M8190A or M8195A hardware. The test reports are available as either HTML or MS Excel reports. The list of C-PHY and D-PHY receiver tests is given in M8085A MIPI Receiver Test Solutions data sheet (5992-1106EN).

The test automation software provides compliance tests and device

MIPI D-PHY and C-PHY Editors

The MIPI frame generator (Figure 22) allows conducting semi-automatic tests, e.g. for debugging. It supports calibrations provided by the M8085A CTS software plug-in and control of the receiver test hardware, including real-time parameter changes.

Supported hardware

The standard MIPI receiver test setup is shown in Figure 23 for the M8190A configuration. In a MIPI D-PHY test environment it is recommended to use the BitifEye´s Dynamic Sequencing Generator and Analyzer (DSGA) for creation of low power signals. Contact BitifEye for details.

The source tests are conducted with a suitable Infiniium oscilloscope. This is used for the calibration of the receiver test subsystem, too.
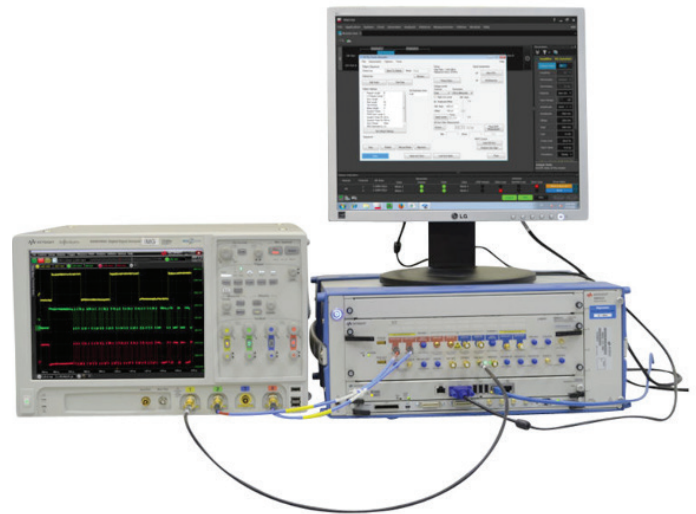
Figure 23. Receiver test station

Table 11. MIPI C-PHY and MIPI D-PHY Test Coverage

List of tests C-PHY provided by options CTA and CNA	
GROUP 1: LP-RX VOLTAGE AND TIMING REQUIREMENTS	
Test 2.1.1	LP-RX Logic 1 Input Voltage (VIH)
Test 2.1.2	LP-RX Logic 0 Input Voltage, Non-ULP State (VIL)
Test 2.1.3	LP-RX Input Hysteresis (VHYST)
Test 2.1.4	LP-RX Minimum Pulse Width Response (TMIN-RX)
Test 2.1.5	LP-RX Input Pulse Rejection (eSPIKE)
GROUP 2: LP-RX BEHAVIORAL REQUIREMENTS	
Test 2.2.1	LP-RX Initialization period (TINIT)
Test 2.2.2	ULPS Exit: LP-RX TWAKEUP Timer Value
Test 2.2.3	LP-RX Invalid/Aborted Escape Mode Entry
Test 2.2.4	LP-RX Invalid/Aborted Escape Mode Command
Test 2.2.5	LP-RX Escape Mode, Ignoring of Post-Trigger-Command Extra Bits
Test 2.2.6	LP-RX Escape Mode Unsupported/Unassigned Commands
GROUP 3: HS-RX VOLTAGE AND JIT TER TOLERANCE REQUIREMENTS	
Test 2.3.1	HS-RX Amplitude Tolerance (VCPRX(DC), VIHHS, VILHS)
Test 2.3.2	HS-RX Differential Input High/Low Thresholds (VIDTH, VIDTL)
Test 2.3.3	HS-RX Jitter Tolerance
GROUP 4: HS-RX TIMER REQUIREMENTS	
Test 2.4.1	HS-RX T3-TERM-EN Duration
Test 2.4.2	HS-RX T3-PREPARE Tolerance
Test 2.4.3	HS-RX T3-PREBEGIN Tolerance
Test 2.4.4	HS-RX T3-PROGSEQ Tolerance
Test 2.4.5	HS-RX T3-POST Tolerance

Table 11. MIPI C-PHY and MIPI D-PHY Test Coverage *(continued)*

List of tests D-PHY options DTA and DNA	
GROUP 1: LP-RX VOLTAGE AND TIMING REQUIREMENTS	
Test 2.1.1	LP-RX Logic 1 Input Voltage (VIH)
Test 2.1.2	LP-RX Logic 0 Input Voltage, Non-ULP State (VIL)
Test 2.1.3	LP-RX Logic 0 Input Voltage, ULP State (VIL-ULPS)
Test 2.1.4	LP-RX Input Hysteresis (VHYST)
Test 2.1.5	LP-RX Minimum Pulse Width Response (TMIN-RX)
Test 2.1.6	LP-RX Input Pulse Rejection (eSPIKE)
Test 2.1.7	LP-RX Interference Tolerance (VINT and fINT)
GROUP 2: LP-RX BEHAVIORAL REQUIREMENTS	
Test 2.2.1	LP-RX Initialization period (TINIT)
Test 2.2.2	ULPS Exit: LP-RX TWAKEUP Timer Value
Test 2.2.3	Clock Lane LP-RX Invalid/Aborted ULPS Entry
Test 2.2.4	Data Lane LP-RX Invalid/Aborted Escape Mode Entry
Test 2.2.5	Data Lane LP-RX Invalid/Aborted Escape Mode Command
Test 2.2.7	Data Lane LP-RX Escape Mode, Ignoring of Post-Trigger-Command Extra Bits
Test 2.2.8	Data Lane LP-RX Escape Mode Unsupported/Unassigned Commands
GROUP 3: HS-RX VOLTAGE AND SETUP/HOLD REQUIREMENTS	
Test 2.3.1	HS-RX Common Mode Voltage Tolerance (VCMRX(DC))
Test 2.3.2	HS-RX Differential Input High Threshold (VIDTH)
Test 2.3.3	HS-RX Differential Input Low Threshold (VIDTL)
Test 2.3.4	HS-RX Single-Ended Input High Voltage (VIHHS)
Test 2.3.5	HS-RX Single-Ended Input Low Voltage (VILHS)
Test 2.3.6	HS-RX Common-Mode Interference 50MHz - 450MHz (ΔVCMRX(LF))
Test 2.3.7	HS-RX Common-Mode Interference Beyond 450MHz (ΔVCMRX(HF))
Test 2.3.8	HS-RX Setup/Hold and Jitter Tolerance
GROUP 4: HS-RX TIMER REQUIREMENTS	
Test 2.4.1	Data Lane HS-RX TD-TERM-EN Value
Test 2.4.2	Data Lane HS-RX THS-PREPARE + THS-ZERO Tolerance
Test 2.4.3	Data Lane HS-RX THS-SETTLE Value
Test 2.4.4	Data Lane HS-RX THS-TRAIL Tolerance
Test 2.4.5	Data Lane HS-RX THS-SKIP Value
Test 2.4.6	Clock Lane HS-RX TCLK-TERM-EN Value
Test 2.4.7	Clock Lane HS-RX TCLK-PREPARE + TCLK-ZERO Tolerance
Test 2.4.8	Clock Lane HS-RX TCLK-SETTLE Value
Test 2.4.9	Clock Lane HS-RX TCLK-TRAIL Tolerance
Test 2.4.11	Clock Lane HS-RX TCLK-PRE and TCLK-POST Tolerance

Mobile Device Interface Test Applications – MIPI M-PHY

The All-Rounder PHY

The MIPI Alliance is focused on mobile devices, ranging from smartphones to wireless-enabled tablets and netbooks. The distinctive requirements of mobile terminals are driving the development of MIPI Specifications, and hence the numbers of mobile terminals are growing rapidly. The increased functionality in each of these devices leads to an exponential growth of the data rates between peripherals. The wide-scale adoption of modern telecommunication standards such as LTE and upcoming 5G standard continues to increase the data rates in mobile devices significantly. High-resolution cameras in mobile devices, even with 3D technology, match displays with increased resolution and bigger size. MIPI M-PHY is an asynchronous system with the clock embedded in the data stream. Compared to D-PHY, it saves power and cost.

MIPI M-PHY test requirements and supported hardware

M-PHY data rates are defined up to 6 Gbps for future applications. The MIPI M-PHY receiver test requirements, especially the error detection, depend on the protocol, which is implemented on the physical layer. Supported protocols are Dig RF v4, Unipro, LLI and SSIC. CSI-3, DSI-2 and UFS can be implemented on top of Unipro. Depending on the specific protocol, bit errors can be detected by either a protocol analyzer, by internal loopback to a BERT analyzer, or by accessing internal error registers. For details, contact Keysight.
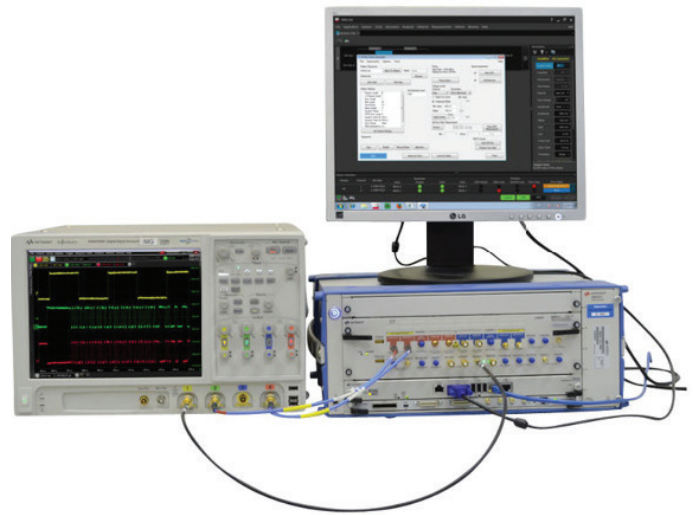
Figure 24. Receiver test station

Table 12. MIPI M-PHY Receiver test coverage

HS Tests	
Test 2.1.1	HS-RX Differential Input Voltage Amplitude
Test 2.1.2	HS-RX Accumulated Differential Input Voltage Tolerance
Test 2.1.3	HS-RX Common-Mode Input Voltage Tolerance
Test 2.1.4	HS-RX Differential Termination Enable Time (T TERM-ON-HS-RX)
Test 2.1.5	HS-RX Differential Termination Disable Time (T TERM-ON-HS-RX)
Test 2.1.6	HS-RX Lane-to-Lane Skew
Test 2.1.7	Receiver Jitter Tolerance
Test 2.1.8a	HS-RX Frequency Offset Tolerance (fOFFSET-RX) during HS-Burst
Test 2.1.8b	HS-RX Frequency Offset Tolerance (fOFFSET-RX) during HS-Continuous Mode
Test 2.1.9	HS-RX Prepare Length Verification
Test 2.1.10	HS-RX Sync Length Verification
	Jitter Sensitivity
	Low Frequency Jitter Sensitivity
SYS Burst Tests	
Test 2.3.1	SYS-RX Differential Input Voltage Amplitudes
Test 2.3.3	SYS-RX Common Mode Input Voltage Tolerance
Test 2.3.4	SYS-RX Differential Termination Enable Time (T TERM-ON-SYS-RX)
Test 2.3.5	SYS-RX Differential Termination Disable Time (T TERM-OFF-SYS-RX)
Squelch Tests	
Test 2.4.3	SQ-RX Squelch Exit Voltage
Test 2.4.4	SQ-RX Squelch Exit Time (T_SQ)
Test 2.4.5	SQ-RX Squelch Noise Pulse Width (T_PULSE-SQ)
Test 2.4.6	SQ-RX Squelch Noise Pulse Spacing (T_SPACE-SQ)
PWM Tests	
Test 2.2.1	PWM-RX Differential DC Input Voltage Amplitude
Test 2.2.3	PWM-RX Common-Mode Input Voltage Tolerance
Test 2.2.4	PWM-RX Differential Termination Enable Time (T TERM-ON-PWM-RX)
Test 2.2.5	PWM-RX Differential Termination Disable Time (T TERM-ON-PWM-RX)
Test 2.2.6	PWM-RX Lane-to-Lane Skew
Test 2.2.7a	PWM-RX Receive Bit Duration Tolerance (TOLPWM-RX)
Test 2.2.7b	PWM-RX Receive Bit Duration Tolerance, During LINE-READ (TOLPWM−G1-RX)
Test 2.2.8	PWM-RX Receive Ratio, PWM-G1 and Above (kPWM-RX)
Interference Tests	
Test 2.4.7	SQ-RX Squelch RF Interference Tolerance (V_INT-SQ, f_INT-SQ)
Common Mode Interference	

Mobile Device Interface Test Applications – MIPI M-PHY UFS Compliance and Macro Options

UFS / UniPro compliance test matrix

The UniPro protocol provides a transport layer for applications using the M-PHY interface. Currently it is primarily used by UFS storage devices within the mobile phones or tablets. For the emerging Universal Flash Storage (UFS) standard the UFS / UniPro Compliance Test Matrix (CTM) opt. 167 allows to perform the required receiver tests to obtain the UFS logo.

Test Set Up

M-PHY supports two types of low speed modes. Type 1 systems use the PWM signaling with embedded clock. Type 2 systems use the clock synchronous SYS signaling. Data rates in the PWM mode depend on the gears supported. UFS devices are Type 1 so they use PWM. Only Gear 1 is mandatory. For generation and decoding of PWM signals the use of BitifEye's Dynamic Sequencing Generaand Analyzer (DSGA) is recommended the M8020A (see Figure 26). This combination provides a unique testing capability. For details, contact BitifEye.

Figure 25. UniPro Test Tree example with one Gear

Debugging capabilities

The complementary MIPI M-PHY Frame Generator software runs with all supported configurations. It is available as opt. 366. This Software is optimized for debugging and troubleshooting.

The new Unipro Error Counter and Test Script Wizard (N5990A-367) is an add-on to the MIPI M-PHY Frame Generator. It provides the ability to receive and decode the DUT responses either with a M8020A ED or a BitifEye DSGA. It also contains the new "Test Sequence Generator" and an additional test to verify that the Frame and Error Counters are working.

Protocol-specific macros

A macro is a single statement which, when passed to the Frame Generator (FG), has the FG execute multiple commands sequentially. The macros thus offer customer convenience by increasing effectiveness and avoiding errors. Protocol-specific macros are currently available for Unipro, LLI, SSIC and DigRF v4 Apart from the protocol-specific macros, generic macros are available. They offer basic, protocol-independent functionality, e.g. the HSStart macro. Option 368 contains protocol-specific macros for LLI, SSIC and DigRF v4.
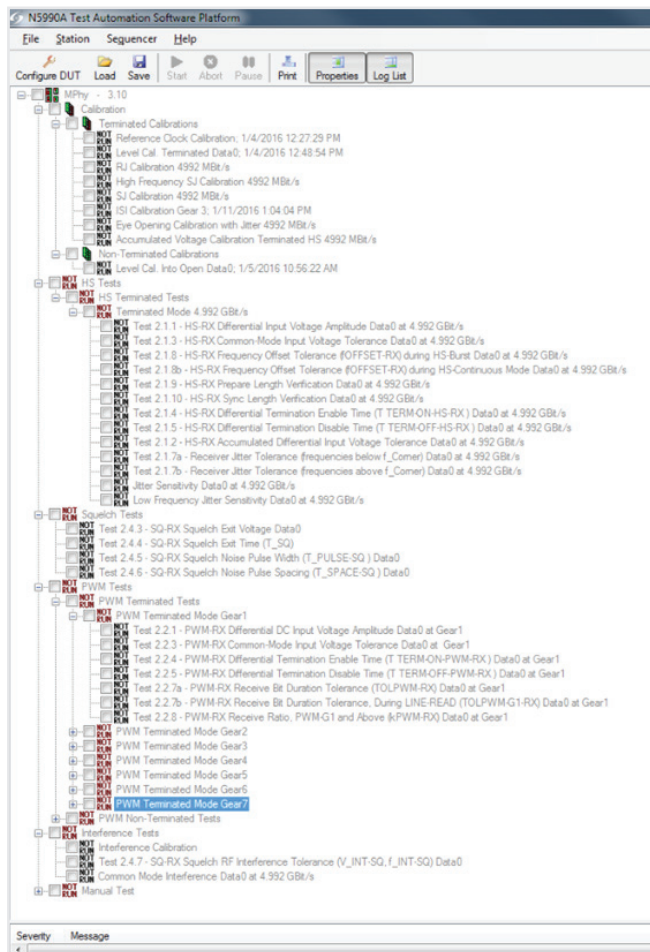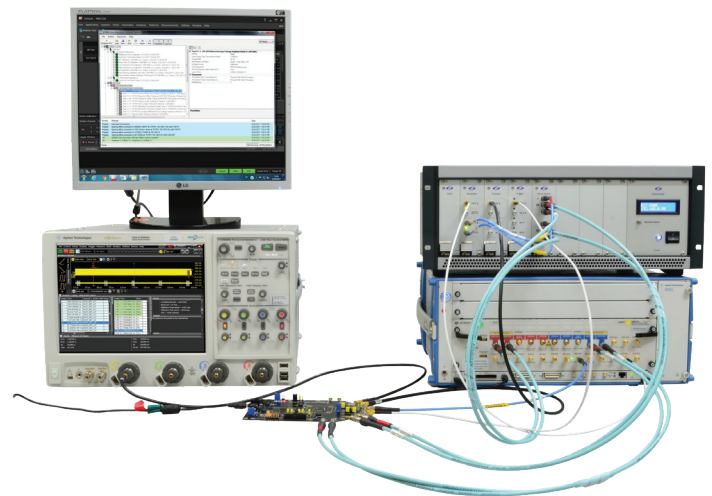

Figure 26. Receiver test station

Consumer Electronics and Memory Applications – SD Ultra High Speed (UHS)

SD, the most common memory card

Secure Digital (SD) is a memory card used extensively in portable devices, such as mobile phones, digital cameras, GPS navigation devices, handheld consoles, and tablet computers. It is a family of solid-state storage media.

The Secure Digital standard is maintained by the SD Association (SDA). The Secure Digital format includes four card families available in three different form factors. The four families are the original Standard-Capacity (SDSC), the High-Capacity (SDHC), the eXtended-Capacity (SDXC), and the SDIO, which combines input/output functions with data storage. The three form factors are the original size, the mini size, and the micro size. Electrically passive adapters allow a smaller card to fit and function in a device built for a larger card.

User selection and DUT configuration

In the configuration dialog the user selects between compliance and expert mode. The latter provides access to all relevant test parameters for advanced tasks such as debugging, validation, characterization and margin test.

Supported hardware

The SD UHS-II receiver tests (N5990A Opt. 120) enables full automated SD UHS-II receiver tests including compliance test, product characterization and debugging for bus speeds up to 312MB/s for the Keysight J-BERT M8020A. The SD UHS-II transmitter tests can be conducted stand-alone with a suitable Keysight Infiniium oscilloscope with the N6461A (UHS-II) software and a Keysight N6461A SD UHS-II card compliance test application, with the test software automaplatform BIT-2081-0220-0 from BitifEye. Differential SMA Probe Head for InfiniiMax probes are required with opt. 220. The oscilloscope is also needed for the SD UHS-II receiver test for calibration of the SD UHS Signal Generator prior to the receiver tests.
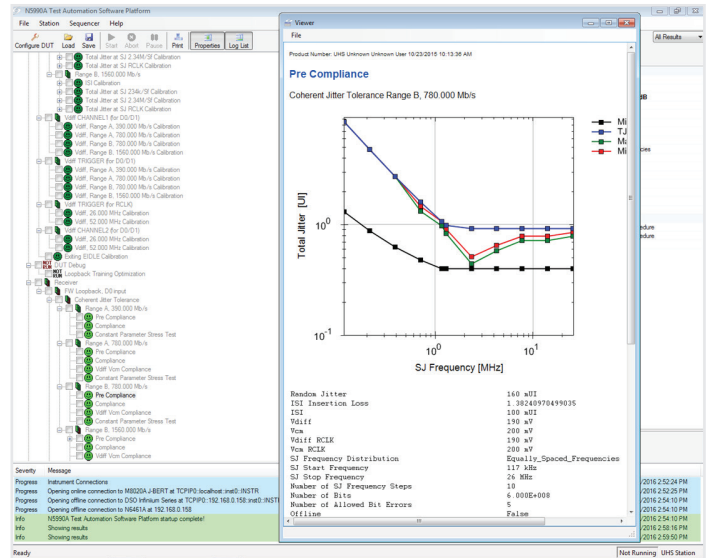
Figure 27. Rc Precompliance Test

Table 13. UHS-II receiver test coverage (host and device DUTs)

Test Name	Compliance Mode	Expert Mode
D0/D1 Differential voltage and common mode voltage	X	X
D0/D1 Jitter tolerance vs. Jitter frequency pre compliance	X	X
D0/D1 Jitter tolerance vs. Jitter frequency compliance	X	X
RCLK TJ tolerance	X	X
Shall exit EIDL for device	X	X
Shall not exit EIDL for device	X	X
Constant parameter stress test		X

Instrument Compatibility

The following instruments are supported for the applications indicated.

Table 14. Instrument Compatibility

Recommended instrument	Remark	PCI Express	SATA	USB	HDMI		MHL	Display Port	MIPI C-PHY	MIPI D-PHY	MIPI M-PHY	SD UHS-II	Thunderbolt
					TMDS Signal Generator	HEAC Arbitrary Waveform Generator							
Generator (Contact Keysight for configuration)													
J-BERT M8020A	M8041A, 8.5 or 16 Gb/s, integrated jitter generation and de-emphasis	x	x	x				x			x	x	x
M8190A Arbitrary Waveform Generator	12 GSa/s, two channels				x		x		x	x			
M8195A Arbitrary Waveform Generator	16 GSa/s, two channels				x		x		x	x			
81150A	120 MHz pulse/ pattern generation with variable rise/ fall time					x							
Error detector / Error counter													
J-BERT M8020A	M8041A, 8.5 or 16 Gb/s, BER, SER and FER measure- ment, filler symbol filtering, CTLE	x	x	x								x	x

Transmitter / Source Tests		N5393D	N5411B	U7243B	N5399C	N6460B	U7232D	U7250A	U7238C	U7249C	N6461A	N6470A
Oscilloscope2,3,4	Standard	PCIe	SATA	USB	HDMI	MHL	DP	C-PHY	D-PHY	M-PHY	SD UHS-II	Thunderbolt
Infiniium Z-Series	required min bandwith in Gb/s	8.12	8.12	13.16	13	8.13	13	6	6.12	6,12,20	6	25
Infiniium V-Series	required min bandwith in Gb/s	8.12	8.12	13.16	13	13	6	6.12	25			
Infiniium 90000 X-series	required min bandwith in Gb/s	8.12	8.12	13.16	13	8	13	6	6.12	6,12,20	6	

1. Oscilloscope required for the calibration of the receiver test system, for other oscilloscope models, contact Keysight
2. N5990A supports Keysight Infiniium oscilloscopes through the electrical performance specification applications, transmitter tests and compliance software applications shown to the right with 4 channels. Additional oscilloscope options may be required.
3. Oscilloscope FW version 5.70 or higher required

System Requirements

Minimum system requirements for the Keysight N5990A

Software requirements

– Windows 7, English version
– Microsoft .NET Framework version 2.0
– Keysight IO Libraries Suite 16.2 or higher
– Recommended: Microsoft Office Excel 2003 or higher, English version

PC hardware requirements and recommendations

– 4GB RAM or higher recommended
– Super VGA (800 x 600) display or higher resolution monitor with 256 colors or more
– PC keyboard and 2-button mouse with spinning wheel
– Required connectivity options for instrumentation, depending on configuration:
– LAN
– GPIB or Keysight 82357B USB/GPIB interface

Note: Microsoft Excel is not included in the N5990A. It must be furnished by the customer, e.g., as part of MS Office.

Software option requirements for Keysight Infiniium Z–Series, Infiniium V–Series and Infiniium 90000 oscilloscopes

Keysight DSA 90K oscilloscopes recommended: EZJIT Plus, and Serial Data Analysis already included in DSA package

Table 15. Oscilloscope Software Option Requirements

ValiFrame Test Station	EZJIT Plus N5400A	Serial Data Analysis E2688A	Infiniium Serial Data EqualizationN5461B	Infiniisim N5465B	Oscilloscope Transmitter Test Application
PCI-Express		required			N5393D - for transmitter tests
SATA	required	required		required for uHost	N5411B - for transmitter tests
USB	required	required			N5416B - for USB 2.0 transmitter tests
Thunderbolt					U7243B - for USB 3.0/3.1 transmitter tests
HDMI		required			N5399D - always required
HEAC					N5399D - always required
MHL		required			N6460B - always required
DisplayPort	required	required	required		U7232D - for transmitter tests
MIPI C-PHY					U7250A - for transmitter tests
MIPI D-PHY	required	required			U7238C - for transmitter tests
MIPI M-PHY	required	required			U7249C - for transmitter tests
SD UHS-II	required	required			N6461A - for transmitter tests

Measurement Requirements

Computer bus test

PCI Express

To run the N5990A PCI Express receiver tests (Option 101), the DUT must support loopback mode. A CBB or CLB might be required to connect to the DUT.
www.keysight.com/find/pci-express

SATA

The N5990A RSG/Rcvr tests require the far end retimed loopback mode (BIST-L). For the full equipment list, refer to the latest Keysight "method of implementation" (MOI) www.sata-io.org or www.keysight.com/find/sata

USB 3.0/3.1

For BER measurements, the DUT shall support loopback. For automated testing the test automation software fully integrates the N4903B and M8020A J-BERT's SER/FER analysis. For debugging purposes, reading out a DUT's internal error is supported, too.
www.keysight.com/find/USB

Thunderbolt

To run the N5990A Thunderbolt receiver tests (Option 120) completely it is required to also purchase TenLira and TCL scripts. For the full equipment list, refer to the latest Keysight "method of implementation" (MOI) on www.keysight.com

Video Bus Test

HDMI, MHL

Depending on the test (sink or source) and configuration (E4887A or AWG), accessories such as cable emulators, TPAs (test point access assemblies), transition time converters or bias tee kits are required. For details, contact Keysight.
www.keysight.com/find/HDMI

For HEAC tests the HEAC test board 81150AU-EHD is required.

DisplayPort

A W2641B test point access adaptor is required. For automated receiver jitter tolerance testing a suitable DisplayPort AUX channel controller is mandatory,and the DUT must support the register access indicated in CTS 1.2b, chapter 4. For the calibration of the receiver test setup, a receptacle fixture is needed: (1) BIT-1050-0000-0; receptacle test fixture kit (for Rx tests) or 1 x BIT-1050-0001-0 cable test kit, see
www.bitifeye.com
For the full list of accessories, contact Keysight.
keysight.com/find/DisplayPort

Memory Bus Test

SD UHS-II

An elegant way to put the DUT into TX test mode, is to use the J-BERT to activate the"Build In Self Test (BIST)". Contact Keysight for more details.

C-PHY and D-PHY

For fully automated receiver testing and frame error rate counting, access to the receiver registers is required. The N5990A supports both the PPI (PHY protocol interface) as well as an interface to customized register access tools.

For fully automated receiver testing and frame error rate counting, access to the receiver registers is required. Both plug ins, the M8085CC1A and the M8085DC1A support the PPI (PHY protocol interface) as well as an interface to customized register access tools.

MIPI M-PHY

For fully automated receiver testing and error rate counting, access to the receiver registers is required. For details and for the full list of accessories, contact Keysight.
www.keysight.com/find/MIPI

UniPro and UFS

To test MIPI M-PHY in the UniPro Mode, a PWM signal is required to set the DUT into Testmode. To be able to acquire the full test automation set up, the J-BERT and the Scope require a DSGA and a Switch System.
www.bitifeye.com/products/hardware/dsga/

How To Get Updates

Each new receiver test option (N5990A Opt.1xy) comes with a Software Maintenance for the first year and six month free upgrade window. During the lifetime of CTS there are ongoing modifications to add additional features, improve user handling and also allow access of the latest hardware features. To make sure you keep yourself updated with these developments, you can add the software maintenance extension to your purchase. These are available for every standard and include the receiver test options, as well as the Link Training Suites and Frame Generators as well.

Table 16. N5990A Example Configuration of PCI Express Testing

Option number	Description
N5990A Opt.601	N5990A/ValiFrame One Year Software Maintenance Extension PCIe Lic. Sheet
N5990A Opt.602	N5990A/ValiFrame One Year Software Maintenance Extension USB Lic. Sheet
N5990A Opt.603	N5990A/ValiFrame One Year Software Maintenance Extension SATA Lic. Sheet
N5990A Opt.604	N5990A/ValiFrame One Year Software Maintenance Extension TBT Lic. Sheet
N5990A Opt.605	N5990A/ValiFrame One Year Software Maintenance Extension SAS Lic. Sheet
N5990A Opt.620	N5990A/ValiFrame One Year Software Maintenance Extension SD UHS-II Lic. Sheet
N5990A Opt.650	N5990A/ValiFrame One Year Software Maintenance Extension HDMI Lic. Sheet
N5990A Opt.652	N5990A/ValiFrame One Year Software Maintenance Extension MHL Lic. Sheet
N5990A Opt.655	N5990A/ValiFrame One Year Software Maintenance Extension DP Lic. Sheet
N5990A Opt.665	N5990A/ValiFrame One Year Software Maintenance Extension MIPI M-PHY Lic. Sheet

Upgrade options help to reduce your costs and reward customer loyalty. They also apply per application, but are needed, once there is a new major specification change and therefore also a CTS change needed. Ideally both options are combined with each other (Figure 16).

To meet your requirements, please select the models and options for your application from the following table.

Model number	Description
Upgrades	
N5990A-011	Upgrade to current PCI Express test specification standard and Test Instrument Support
N5990A-012	Upgrade to current USB compliance test specification standard and Test Instrument Support
N5990A-013	Upgrade to current SATA Unified Test Document standard and Test Instrument Support
N5990A-014	Upgrade to current HDMI compliance test specification standard and Test Instrument Support
N5990A-015	Upgrade to current DisplayPort compliance test specification standard and Test Instrument Support
N5990A-017	Upgrade to current MHL Compliance Test Suite standard and Test Instrument Support
N5990A-019	Upgrade to current SD UHS-II Test Specification Standard and Test Instrument Support
N5990A-020	Upgrade to current Thunderbolt Test Specification Standard and Test Instrument Support
N5990A-031	Upgrade to PCI Express Link Training Suite
N5990A-032	Upgrade to USB Link Training Suite
N5990A-036	Upgrade to MIPI M-PHY Frame Generator Software

Ordering Information

To meet your requirements, please select the models and options for your application from the following table.

Table 17. Ordering information

Model number	Description
N5990A-010	Test Automation Software, GUI, Report Generation, Remote Interface, 1 yr S/W Maintenance
N5990A-001	Data Base and Web Browser Interface
N5990A-004	Switch System and DSGA Platform Support
N5990A-005	Integrated BER Counter Interface Support
N5990A-006	Type-C, Alt Mode Receiver Tests and PDO Support
N5990A-007	Multi-Standard Sequencing for Receiver and Transmitter Test
N5990A-008	Remote Power Management Support
N5990A-003	Multi-lane (> 2) Support
High-speed receiver/sink test libraries (Software Maintenance extensions are available as N5990A-6XX option for every 1xx option)	
N5990A-101	PCI Express Receiver Tests
N5990A-102	USB Receiver Tests
N5990A-103	Serial ATA RSG Tests
N5990A-104	Thunderbolt Receiver Tests
N5990A-105	SAS Receiver Tests
N5990A-111	PCI Express u.2 Receiver Test Add-On
N5990A-120	SD UHS-II Receiver Tests
N5990A-151	HDMI Sink Tests
N5990A-153	MHL Receiver Tests
N5990A-155	DisplayPort Receiver Tests
N5990A-156	eDP Receiver Tests Add-On
N5990A-165	MIPI M-PHY Receiver Tests
Interfaces to high-speed transmitter/source tests (on Infiniium oscilloscopes)	
N5990A-201	Interface to PCI Express Tx Test Software
N5990A-202	Interface to Oscilloscope USB Tx Text Software
N5990A-203	Interface to Oscilloscope Serial ATA Tx Test Software
N5990A-204	Interface to TBT Transmitter Test
N5990A-250	Interface to HDMI Source Test Software
N5990A-252	Interface to MHL Source Compliance Test Software
N5990A-255	Interface to DisplayPort Tx Test Software
N5990A-265	Interface to MIPI M-PHY Tx Test Software
Link training, low speed electrical and protocol tests	
N5590A-301	PCI Express 3.0 Link Training Suite
N5990A-302	USB 3.0/3.1 Link Training Suite
N5990A-303	SATA Link Training Suite
N5990A-305	SAS Link Training Suite
N5990A-350	HDMI EDID, CEC, HDCP and P/ A/ V/ Tests
N5990A-351	HDMI HEAC tests
N5990A-366	MIPI M-PHY Frame Generator
N5990A-500	User Programming (API Including C-Sharp Templates), Additional Developer License
N5990A-501	PCIe® Link Equalization Tests

Related Literature

Title	Type	Publication Number
Hardware		
M8195A 65 GSa/s Arbitrary Waveform Generator and M8197A Multi-Channel Synchronization Module	Data Sheet	5992-0014EN
Keysight M8190A Arbitrary Waveform Generator	Data Sheet	5990-7516EN
J-BERT M8020A High-performance BERT	Data Sheet	5991-3647EN
M8062A 32 Gb/s Front-End for J-BERT M8020A High-Performance BERT	Data Sheet	5992-0987EN
81150A Pulse Function Arbitrary Noise Generator	Data Sheet	5989-6433EN
81160A Pulse Function Arbitrary Noise Generator	Data Sheet	5989-6433EN
N5990A General Documents		
N5990A Test Automation Software Platform	Installation Guide	N5990-91010
N5990A Test Automation Software Platform	User guide	N5990-91010
PCI Express		
N5990A Test Automation Software Platform for PCIe	User guide	N5990-91040
N5393D, PCI Express® 3.0 (Gen3) Software for Infiniium Oscilloscopes	Data Sheet	5991-4756EN
N5990A-301 PCI Express Link Training Suite	User guide	N5990-91100
N5990A PCIe Link Training Suite	Language Guide	N5990-91110
Accurate Calibration of PCIe 3.0 Receiver Stress Signals	Application Note	5990-6599EN
Accurate Calibration of Receiver Stress Test Signals for PCI Express	Application Note	5990-6599EN
How to Pass Receiver Test According to PCI Express 3.0 CEM Specification	Application Note	5990-9208EN
PCI Express Revision 2.0 Receiver Testing with J-BERT and 81150A	Application Note	5990-3233EN
PCI Express Transmitter Electrical Validation and Compliance Testing with Keysight Infiniium Oscilloscopes	Application Note	5989-1275EN
SATA		
N5990A Test Automation Software Platform for SATA	User guide	N5990-91050
N5411B, Serial ATA 6 Gb/s Compliance Test Software	Data Sheet	5990-3594EN
N5990A SATA Link Training Suite	User guide	N5990-91090
N5990A SATA Link Training Suite	Language Guide	N5990-91130
USB		
N5990A Test Automation Software Platform for USB	User guide	N5990-91030
U7243B, USB 3.1 — 5 Gbps and 10 Gbps Transmitter Compliance Software	Data Sheet	5992-0154EN
N5990A USB Link Training Suite	User guide	N5990-91080
N5990A USB Link Training Suite	Language Guide	N5990-91120
Thunderbolt		
N6470A Thunderbolt 3 Transmitter Compliance Test Software for Infiniium Oscilloscopes	Data Sheet	5992-1654EN
HDMI		
HDMI Module Option 150 and 151	User guide	N5990-91180
N5399C, N5399D HDMI Electrical Performance Validation and Compliance Software	Data Sheet	5990-5299EN
N5990A HDMI Option 350 Procedure Descriptions	User guide	N5990-91190
HDMI Sink and Source Compliance Test and characterization	Data Sheet	5989-4959EN

Related Literature *(continued)*

Title	Type	Publication Number
MHL		
MHL Receiver Test	User guide	N5990-91170
N6460B MHL Source Compliance Test Software For Infiniium Oscilloscopes	Data Sheet	5992-0011EN
DisplayPort		
N5990A DisplayPort	User guide	N5990-91070
U7232B/U7232C DisplayPort Electrical Performance Validation and Compliance software	Data Sheet	5990-7697EN
MIPI M-PHY		
N5990A Test Automation Software Platform for MIPI M-PHY	User guide	N5990-91150
U7249A MIPI M-PHY Compliance Test Software	Data Sheet	5990-8933EN
N5990A MIPI M-PHY Frame Generator Software	User guide	N5990-91060
MIPI M-PHY Frame Generator	Language Guide	N5990-91260
How to test a MIPI M-PHY High-speed Receiver	Application Note	5991-2848EN
MIPI C-PHY / D-PHY		
M8085A MIPI Receiver Test Solutions	Data Sheet	5992-1106EN
M8085A MIPI C-PHY Receiver Test Software	User guide	M8085-91030
U7250A MIPI C-PHY Compliance Test Software for Infiniium Oscilloscopes	Data Sheet	5992-1362EN
MIPI C-PHY Editor for M819xA AWG	User guide	M8085-91010
M8085A MIPI D-PHY Receiver Test Software	User guide	M8085-91020
U7238C and U7238D MIPI D-PHY Conformance Test Software	Data Sheet	5991-2400EN
U7238A MIPI D-PHY Compliance Test Software for Infiniium Oscilloscopes	Data Sheet	5989-9337EN
M8085A MIPI D-PHY Editor Plug-in	User guide	M8085-91040
How to characterize the Physical Layer of Mobile Industry Processor Interface (MIPI D-Phy)	Application Note	5989-7184EN
SD UHS-II		
Valiframe UHS Test	User guide	N5990-91250
N6461A SD UHS-II Compliance Test Application for Infiniium 90000 Series Oscilloscope	Data Sheet	5990-9553EN

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