

Keysight N5990A Test Automation Software Platform

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

Data Sheet

The screenshot displays the Keysight N5990A Test Automation Software Platform interface. The main window shows a test sequence configuration for PCI Express 2.0. The sequence includes calibration steps for 2.5 Gbit/s and 5 Gbit/s Random Jitter and Differential Voltage, followed by receiver and transmitter tests for 2.5 Gbit/s and 5 Gbit/s. The results pane on the right shows the configuration for the 5 Gbit/s Receiver Jitter Tolerance test.

Parameter	Value
Random Jitter	5.4 ps
HF Sinusoidal Jitter	27 ps
HF Sinusoidal Jitter Frequency	150 MHz
SSC Residual	0 s
Differential Voltage	300 mV
Jitter Step Size	2 ps
Start Frequency	1.5 MHz
Stop Frequency	100 MHz
Number of Frequency Steps	10
Confidence Level	95 %
Target BER	1E-9

Sequencer

Procedure Error Case Behavior	Proceed With Next Procedure
Procedure Failed Case Behavior	Proceed With Next Procedure
Repetitions	0

Number of Frequency Steps
The number of jitter frequency points. The frequency points are spaced logarithmically between start and stop frequency.

Message Log:

Severity	Message
Info	Test result saved to C:\Dokumente und Einstellungen\All Users\Anwendung...
Info	5 Gbit/s - 6.0dB Maximum Deterministic Jitter (without crosstalk) started
Progress	5 Gbit/s - 6.0dB Maximum Deterministic Jitter (without crosstalk) Step 0
Info	Test result saved to C:\Dokumente und Einstellungen\All Users\Anwendung...
Info	5 Gbit/s - 6.0dB Total Jitter at BER-12 (without crosstalk) started
Progress	5 Gbit/s - 6.0dB Total Jitter at BER-12 (without crosstalk) Step 0
Info	Test result saved to C:\Dokumente und Einstellungen\All Users\Anwendung...



Overview

- Universal bus test solution, supports MIPI D-PHY, MIPI M-PHY, HDMI, MHL, DisplayPort, PCI Express®, SATA and USB, other standards are under development
 - Single and multi-lane device testing
 - Complements and enhances Infiniium 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.
 - 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
- N5990A takes test automation to the next level of performance and convenience

Features and Benefits

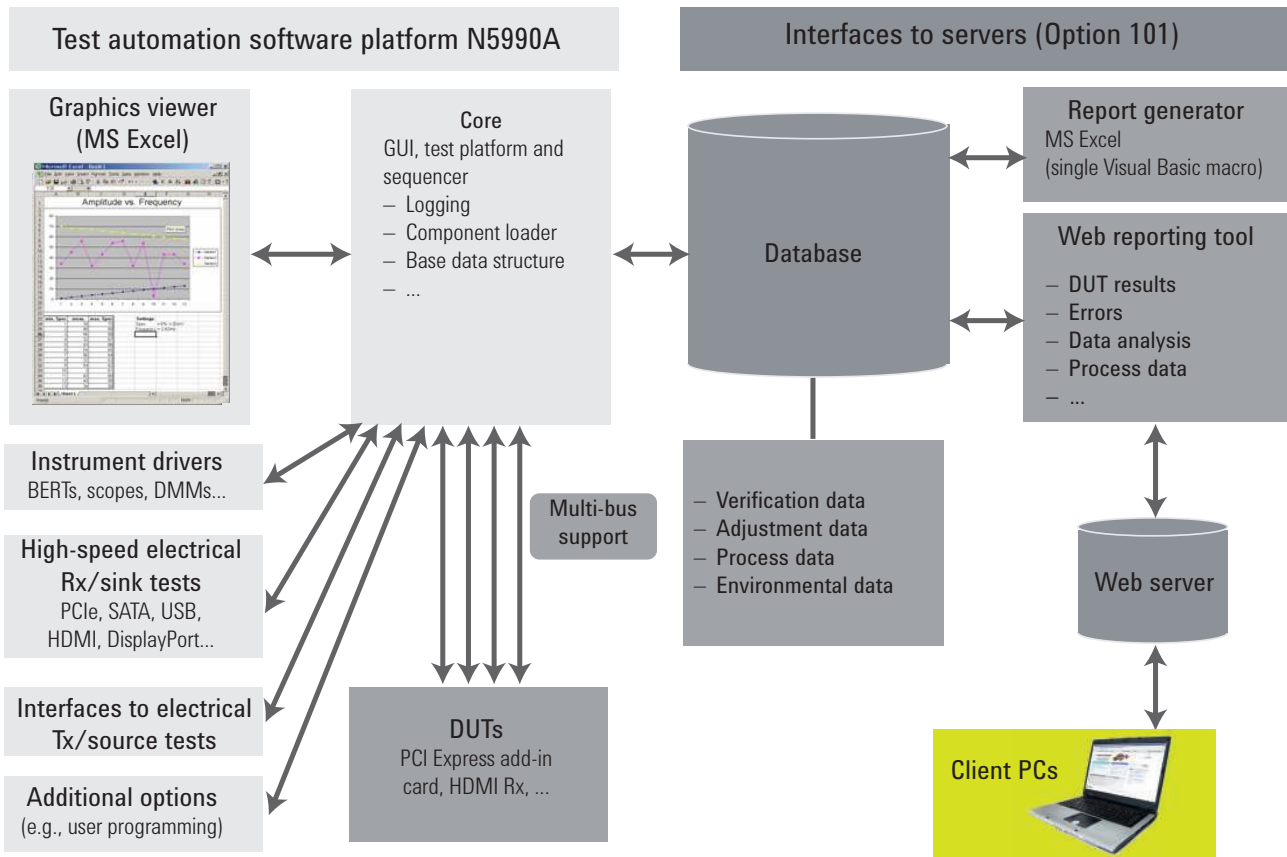


Figure 1. Software platform block diagram

Turn your test instruments into a solution

An efficient test strategy is a proven competitive advantage. Keysight Technologies' 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,

N5990A is recommended e.g. in the HDMI CTS and the SATA RSG MOI. From the beginning, 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 (N5393C) or video buses like HDMI (N5399B). Apart from the fast reassurance of the compliance mode, the characterization mode offers in-depth analysis.

Features and Benefits

Integrated, generic solution

The N5990A supports a broad portfolio of Keysight instruments, such as serial bit error ratio testers (BERTs), the multi-channel ParBERT platform, and Infiniium oscilloscopes (see Figure 2). It also allows efficient control of jitter sources like function, arbitrary waveform 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 or MIPI Express. This translates to significant productivity gains. More time is gained by the common 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 SATA arbitrarily specified jitter tolerance curves can be measured in a fraction of the time needed with competitive solutions.

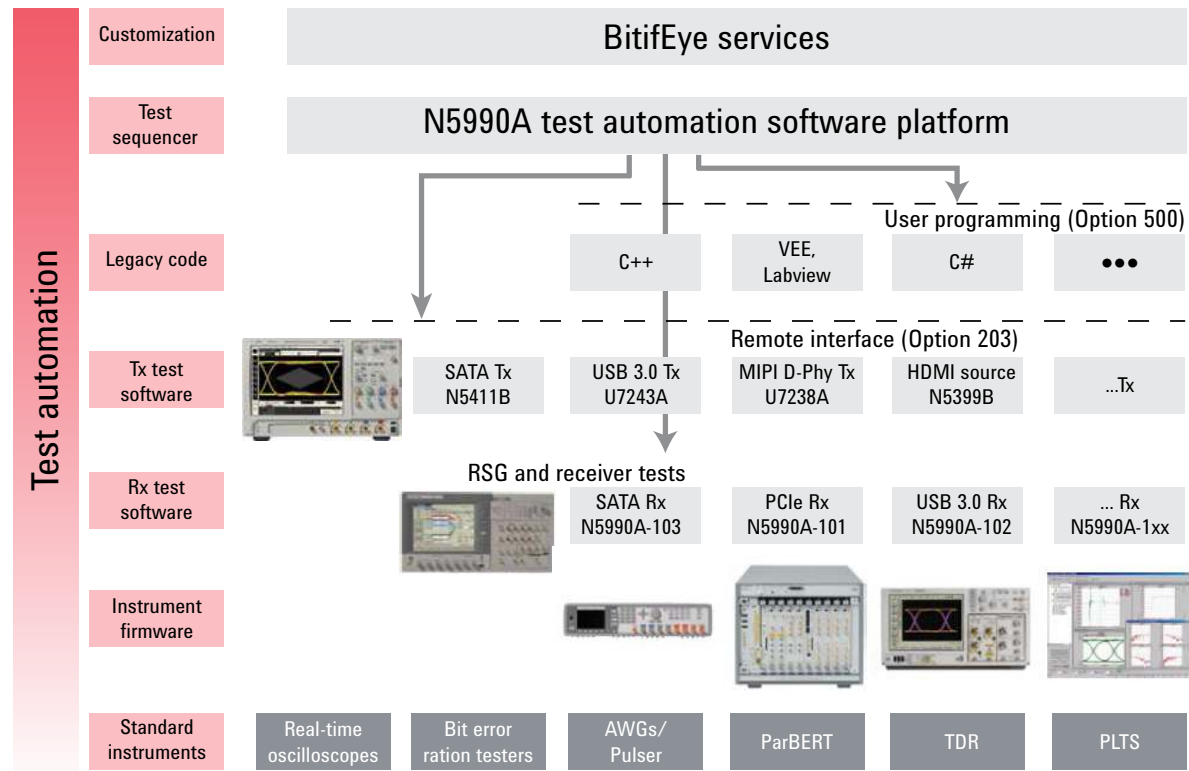


Figure 2. Test platform elements for digital stimulus/response test, example SATA

Features and Benefits

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

Based on a Keysight manufacturing test program, the test software and services provider BitifEye Digital Test Solutions developed the N5990A software platform. Keysight guarantees worldwide service and support. 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 define which tests are to run, for example, and the number of repetitions (loops).

Test results

The test automation software platform provides test results in 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.

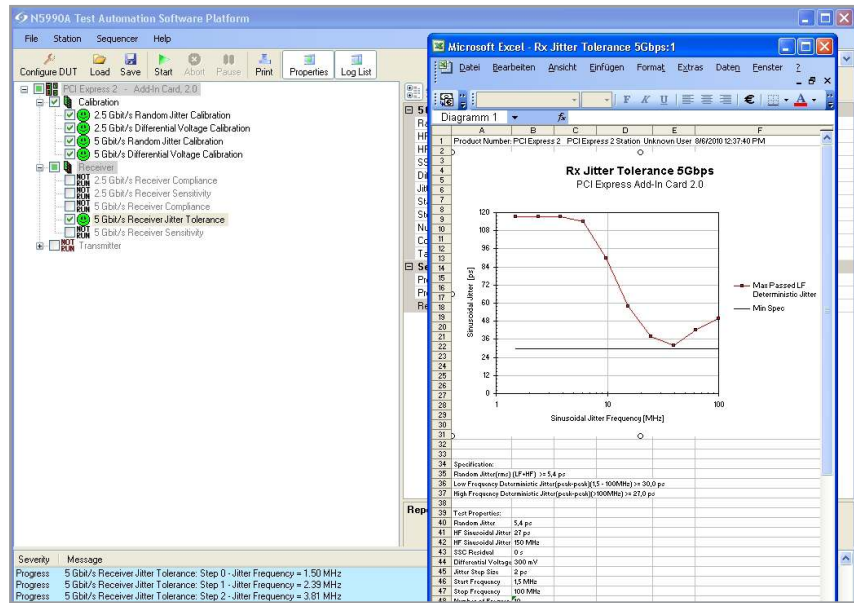


Figure 3. User interface and results display

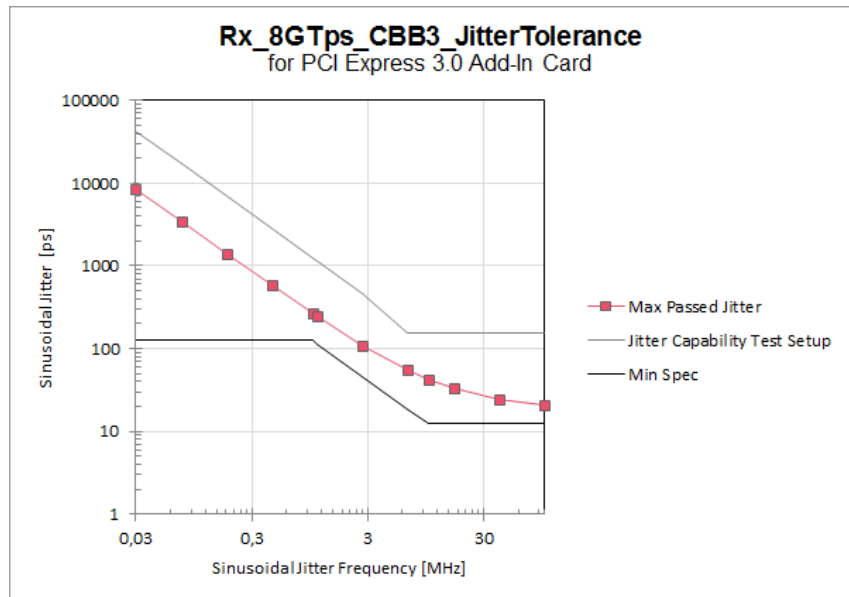


Figure 4. Jitter tolerance test results

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 N4903B J-BERT high-performance serial BERT. This ensures you can test PCI Express 1.1, 2.0, and 3.0 receivers efficiently. 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 required jitter components compliance tests conducted with an Infiniium oscilloscope (N5393C).

The N5393B 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 analyse oscilloscope data too, so that productivity is further increased.

CBB and CLB support

The DUT shown in Figure 6 is a PCI Express 2.0 add-in card. A graphics card is used as an example. The DUT is plugged into a Compliance Base Board (CBB) available from the PCI-SIG®.

The CBB needs to be modified slightly for use with the N5990A. Details are available from Keysight. Keysight can also provide details for system board tests using a Compliance Load Board (CLB, also available from the PCI-SIG).

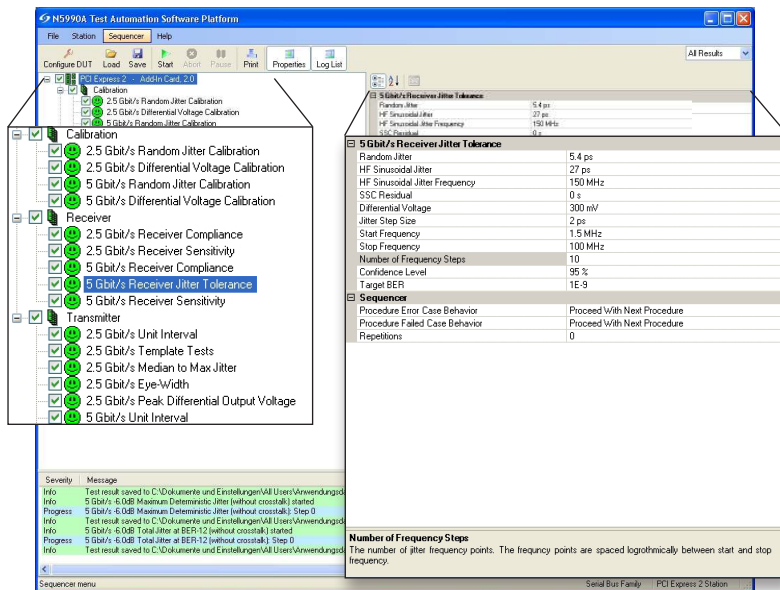


Figure 5. Test selection details (characterization mode)

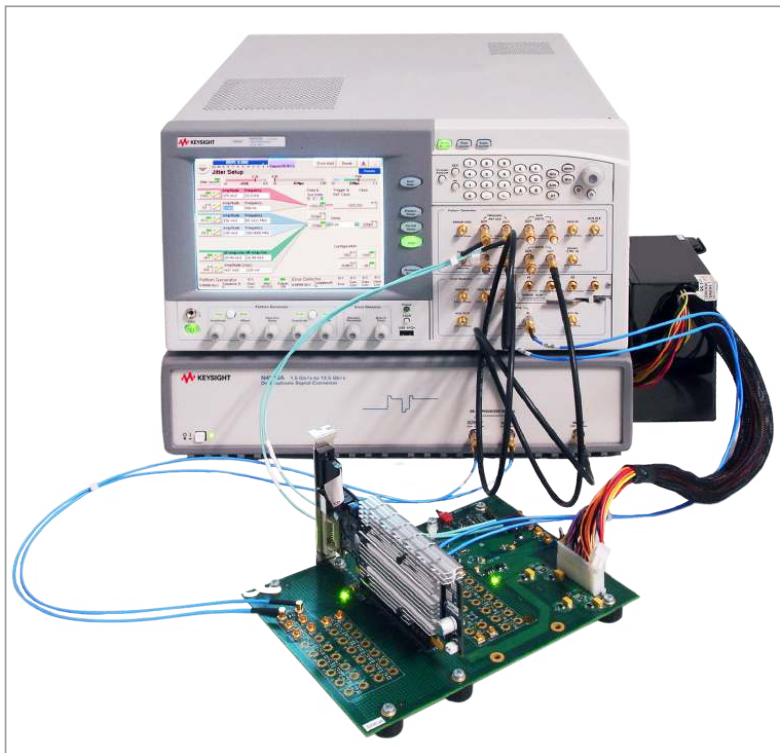


Figure 6. PCI Express test station

Table 1. PCI Express test coverage

Test number	Test name
2.8	Add-in Card Receiver Jitter Tolerance Test
2.9	System Receive Jitter Tolerance Test
2.10	Add-in Card Receiver Link Equalization Test for 8.0 GT/s
2.11	System Receiver Link Equalization Test for 8.0 GT/s

Computer Bus Applications - SATA

Test the standard with the standard

In the past 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 8).

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 5989-3662EN 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.

Test results

The SATA test data is available in the common, ready-to-use N5990A Microsoft Excel format graphs and data tables (Figure 7). This enables quick and easy post-processing.

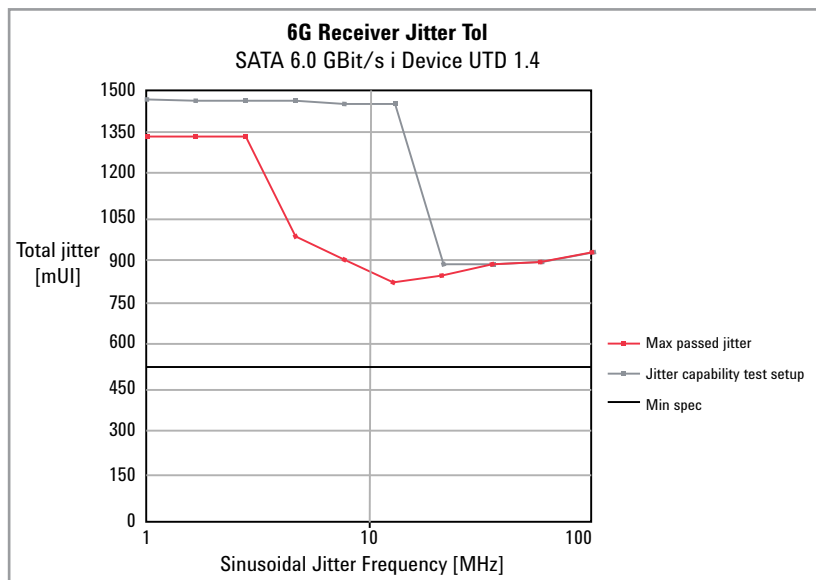


Figure 7. Excel results



Figure 8. 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	Gen 3 (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 is gaining ground

With USB 2.0, the Universal Serial Bus interface became indispensable in PC peripherals such as printers, mice or web-cams 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, data rates are increased by an order of magnitude to 5 Gbit/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 test coverage from the start

The proven N5990A test automation software provided USB 3.0 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 hosts and devices. The crucial jitter tolerance test is supported as well as other critical tests, see Table 3.



Figure 9. USB 3.0 test station

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 U7243A (USB 3.0). The transmitter test software is fully integrated into the test software automation platform by N5990A Option 202.

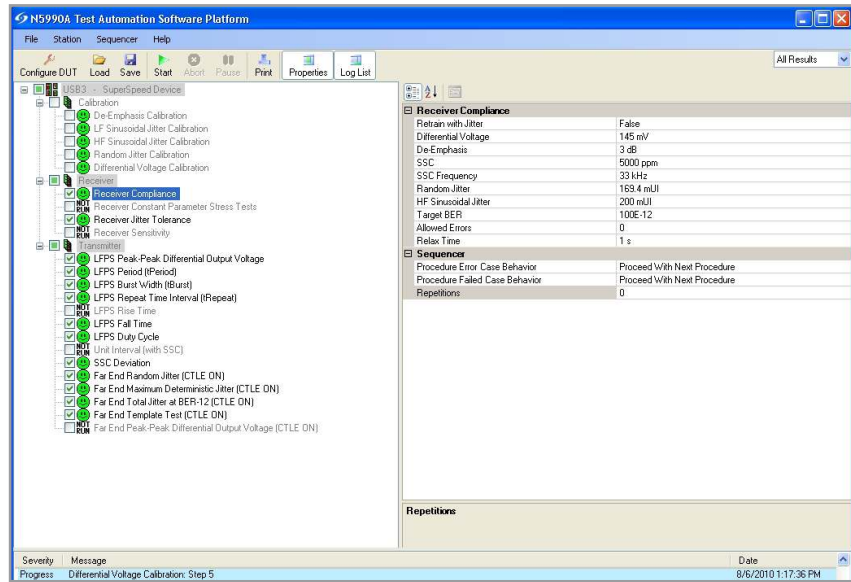


Figure 10. N5990A USB 3.0 test selection

USB test station

A USB 3.0 device test station is shown exemplarily in Fig. 9. It comprises a N4903B J-BERT with N4916A de-emphasis signal converter, USB 3.0 fixture and the test software. For error counting, both the N4903B-A02 J-BERT SER/FER analysis and the Ellisys USB Explorer 280 are supported. For debugging purposes, automated readout of a DUT's internal error counter is supported, too.

Receiver tests

As an example, the jitter tolerance characterization results of a device passing the test are shown in Figure 11.

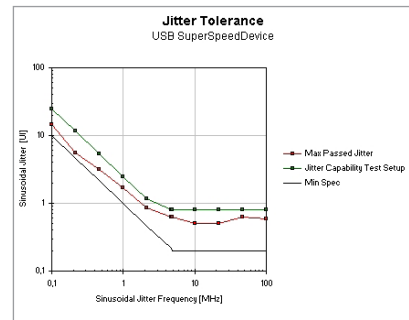


Figure 11. USB 3.0 jitter tolerance curve

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_12	Receiver differential voltage	●	●
	EL_13	Receiver jitter tolerance	●	●
	EL_15	Receiver common mode voltage	●	●
	EL_16	Receiver squelch detection	●	●
	EL_18	Receiver min. sync field	●	●
USB 3.0	TD_1.5	Receiver Jitter tolerance	●	●
		Receiver LFPS test	●	●
		Receiver constant parameter stress test		●

Consumer Electronics and Video Test Applications - HDMI

Go beyond the instruments

By combining the performance of Keysight instruments with the flexibility of a PC (see Figure 12), 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.

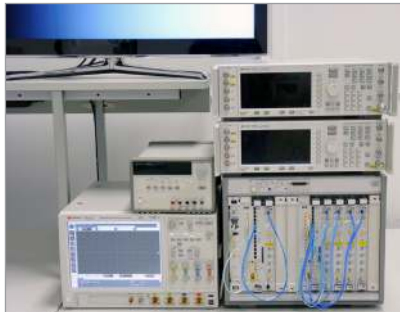


Figure 12. E4887A HDMI test station

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

The N5990A Test Automation Software supports the E4887A HDMI TMDs Signal Generator Platform, the DSO80000 and 90000 Series real-time oscilloscopes, the N5998A HDMI Protocol Analyzer and Generator, the Quantum Data 882EA and the 81150A HEAC generator through options 150, 250, 350 and 351 (see Figures 12 and 13). This provides the industry's broadest test coverage (Table 4). The consolidated test report boosts productivity tremendously.

As an alternative to the E4887A, a setup of two M8190A 12-GSa/s Arbitrary Waveform Generators (AWG) can be used for the TMD receiver tests. Test automation for the AWG setup is provided by N5990A, Option 151.

Full support for independent clock and data jitter insertion

N5990A enables and fully supports the unique independent clock and data jitter insertion capability of the Keysight TMDs signal generator E4887A Option 007.

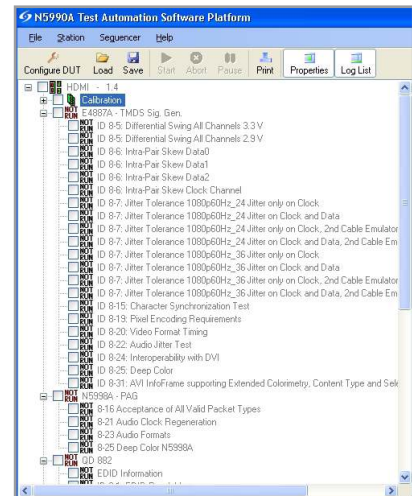


Figure 13. TMDs, protocol, EDID, CEC, HDCP and HEAC tests

Table 4. HDMI test coverage by CTS 1.4 test ID and name

N5399A & N5990A Option 250	Source test name	N5990A Option 150	Sink and cable test name	N5990A Option 350	Test name
7-2	TMDS VL	5-3	TMDS data eye diagram	8-1	EDID readable
7-4	TMDS rise & fall times	8-5	TMDS min. differential sensitivity	8-2	EDID VESA structure
7-5	TMDS over/undershoot	8-6	TMDS intra-pair skew	8-3	CEA timing extension structure
7-6	TMDS inter-pair skew	8-7	TMDS jitter tolerance	8-17	861B format support
7-7	TMDS intra-pair skew	8-15	Character synchronization	8-18	HDMI format support
7-8	TMDS clock duty cycle	8-19	Pixel encoding	8-19	Pixel encoding
7-9	TMDS clock jitter	8-20	Video format timing	8-20	Video format timing
7-10	TMDS data eye diagram	8-22	Audio sample packet jitter	2C-01 to 2C-04	HDCP tests
		8-24	Interoperability with DVI	CECT 7 to 11	CEC tests
		8-25	Deep color ¹		
		8-30	4K x 2K Video Format Timing		
		8-31	AVI Info Frame Extended Colorimetry		

1. See E4887A data sheet for supported video formats

Consumer Electronics and Video Test Applications - HDMI, HEC and ARC

The HDMI Ethernet Channel (HEC) and Audio Return Channel (ARC) are new, optional features, introduced with HDMI 1.4. Two lines of the HDMI connector are used to establish a Full-Duplex 100Base-Tx Ethernet connection as well as a digital IEC60958-1 compliant audio return channel from a sink to a source device. HEC and ARC are also known as HEAC.

HEAC tests are supported by the 81150A Pulse Function Arbitrary Noise Generator. With the use of two 81150A generators audio and Ethernet signals can be generated simultaneously. The HEAC tests are supported by the N5990A software with opt. 351. A test setup example is shown in Figure 14, the coverage is given in Table 5. The complementary „HEACphy“ test software for semi-automatic debugging and trouble-shooting (Figure 15) is available from BitfEye as BIT-HDMI-HEAC.

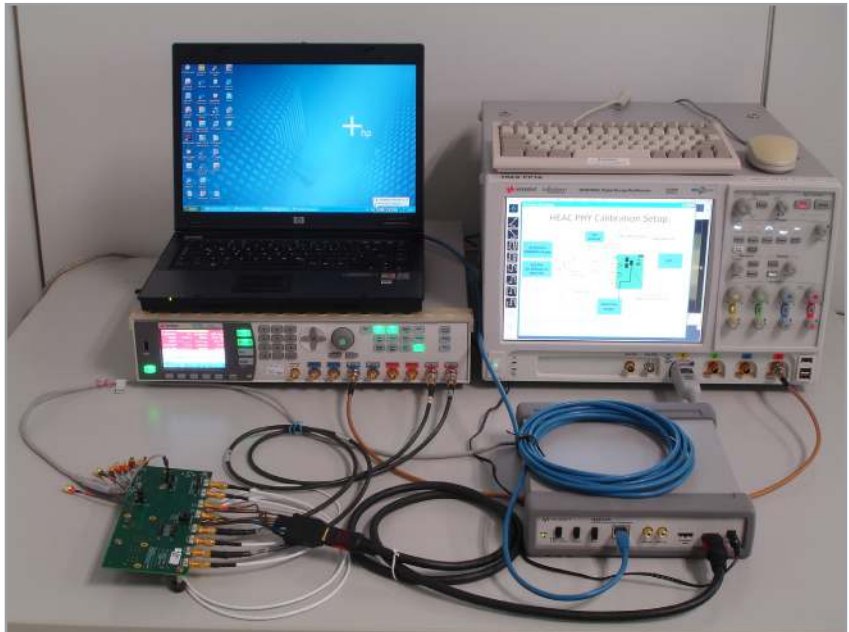


Figure 14: HEC and ARC test setup

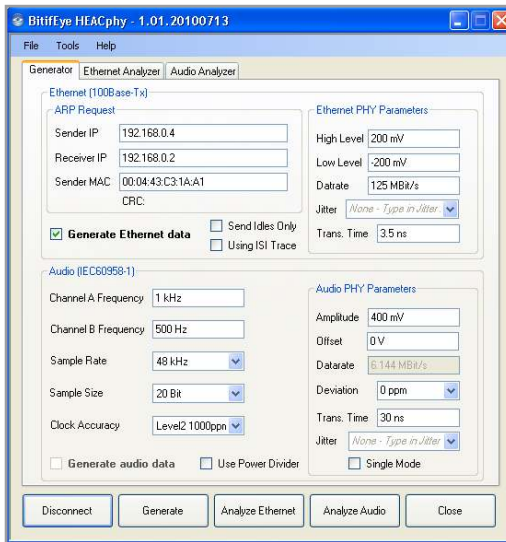


Figure 15: Complementary BitfEye HEACphy test software

Table 5: N5990A opt. 351 HEAC test coverage

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

Consumer Electronics and 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. The MHL specification is an 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 (CBUS) for configuration and status exchange between the source and the sink. The CBUS provides high-level control functions between all of the various audio-visual products in a user's environment. Finally, MHL comprises a dedicated VBUS for power distribution.

MHL Test Solution

The Keysight N6460A MHL source compliance test software performs the full physical layer compliance suite for MHL data transmitters with Infiniium 90000A Series Oscilloscopes. Full, automated physical layer compliance testing for MHL receivers and dongles is provided by N5990A Option 152 for the popular Keysight E4887A HDMI TMDS Signal Generator Option 007 (Figure 16).

With N5990A Option 153 the MHL receiver compliance testing can be performed with the M8190A 12 GSa/s Arbitrary Waveform Generator.

Table 6: MHL Receiver Test Coverage

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 Signal 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



Figure 16. MHL Rx test setup

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 6.

Consumer Electronics and Video Test Applications - DisplayPort

DisplayPort, an emerging standard

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 new digital 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.

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 17) require DUT register access. They complement the Infiniium oscilloscope transmitter compliance test software U7232A. U7232A is fully integrated into the N5990A with Option 255. The CTS 1.1 test coverage is given in Table 7. For CTS 1.2b testing, contact Keysight.

Table 7. DisplayPort 1.1 test coverage

Receiver test name
RBR and HBR sensitivity tests
RBR and HBR jitter tolerance tests
RBR and HBR intra-pair skew test
Variable parameter test (user-selectable swing, SJ and RJ)

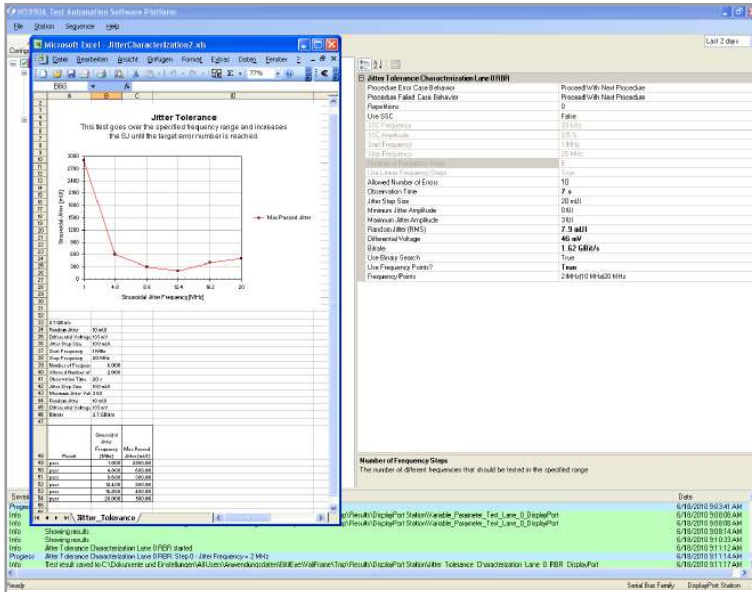


Figure 17. N5990A DisplayPort receiver jitter tolerance test

Compliance and characterization

In the configuration dialog (Figure 18) 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.

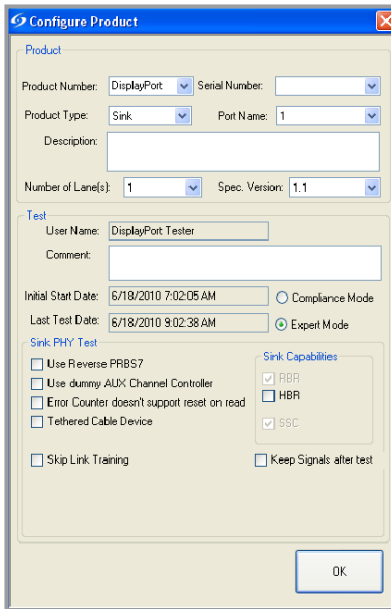


Figure 18. Configuration screen

Supported hardware

The standard DisplayPort receiver test setup is given in Figure 19. It is based on the J-BERT N4903B, the W2641A test fixture, the W2642A DisplayPort test controller, the N4915A-006 ISI generator and an external PC running N5990A. A DS090000 Series oscilloscope is used for the transmitter tests and the calibration of the receiver test subsystem.

For investment protection of HDMI customers, the TMDS signal generator E4887A-007 is supported alternatively. Note that in this setup an additional 81150A jitter source is needed.

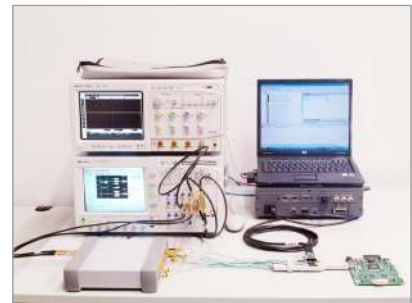


Figure 19. Receiver test station

Mobile Device Interface Test Applications – MIPI D-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 1.5 Gb/s per lane. The data rate may increase in the future.

Meet the test requirements

As part of its standards compliance, the MIPI Alliance has established a comprehensive compliance test program for 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 detailed in the MIPI D-PHY compliance test suite. The Keysight test products and methodologies are approved as MOI (method of implementation) by the MIPI Alliance.

Automated tests

Like for all other supported computer bus or video standard tests, the N5990A software platform provides fast, calibrated,

automated testing. The coverage of the receiver tests, N5990A Option 160 is shown in Table 8. They complement the Infiniium oscilloscope transmitter compliance test software U7238A. U7238A is fully integrated into N5990A with Option 260. The test automation software provides compliance tests and device characterization, incl. margin test.

MIPI D-PHY frame generator

The MIPI frame generator (Figure 20) allows conducting semi-automatic tests, e.g. for debugging. It provides full calibration and control of the receiver test hardware, including real-time parameter changes. It is available from BitifEye as BIT-2060-0000-0.

Supported hardware

The standard MIPI receiver test setup is shown in Figure 21. It is based on a ParBERT 81250A with external clock, jitter and noise sources, a logic analyzer, an oscilloscope and an external PC running the N5990A software.

For investment protection of HDMI and DisplayPort customers, the MIPI receiver test configurations are available as extensions of the TMD5 signal generators, E4887A.

The source tests are conducted with DSO90000A Series oscilloscopes. The oscilloscope is used for the calibration of the receiver test subsystem, too.

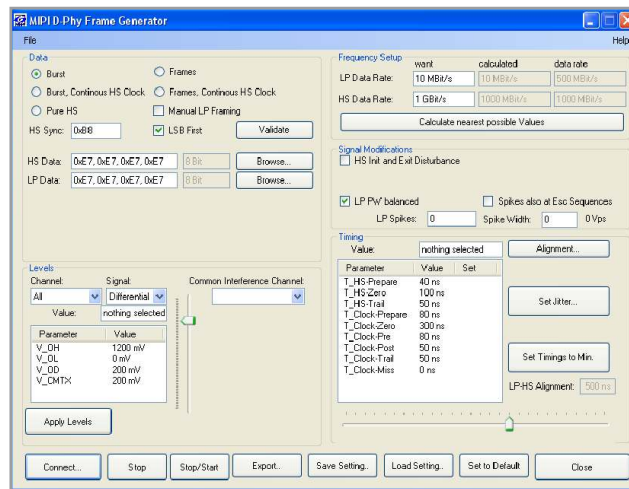


Figure 20. Complementary MIPI frame generator

Table 8. MIPI D-PHY 1.1 test coverage

Receiver Test Name	
Group 1: LP-Rx Voltage and Timing Requirements	Test IDs: 2.1.1, 2.1.2, 2.1.3 2.1.4, 2.1.5, 2.1.6, 2.1.7, 2.1.8
Group 2: LP-Rx Behavioral Requirements	Test IDs: 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.2.5, 2.2.6, 2.2.7, 2.2.8
Group 3: HS-Rx Voltage and Setup/Hold Requirements	Test IDs: 2.3.1, 2.3.2, 2.3.3, 2.3.4, 2.3.5, 2.3.6, 2.3.7, 2.3.8
Group 4: HS-Rx Timer Requirements	Test IDs: 2.4.1, 2.4.2, 2.4.3, 2.4.4, 2.4.5, 2.4.6, 2.4.7, 2.4.8, 2.4.9, 2.4.10, 2.4.11

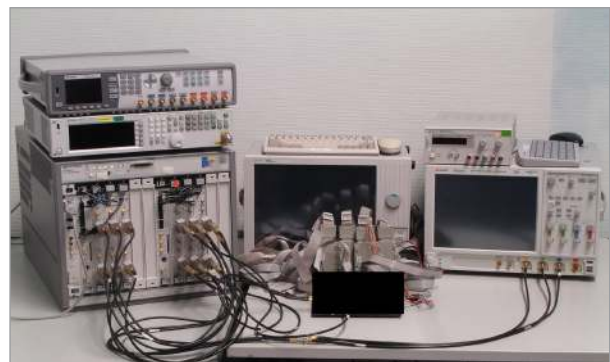


Figure 21. Receiver test station

Mobile Device Interface Test Applications – MIPI M-PHY

Multi Industry Processor Interface (MIPI) M-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 3G, LTE and upcoming 4G standards 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

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 loop-back to a BERT analyzer, or by accessing internal error registers. For details, contact Keysight.

M-PHY supports two types of low speed modes. Type 1 systems use the PWM mode with embedded clock. Type 2 systems use the clock synchronous SYS mode. Data rates in the PWM mode depend on the gears supported. The default mandatory gear is G1 with rates from 3 Mbps to 9 Mbps.

MIPI M-PHY Test Solution

The Keysight U7249A MIPI M-PHY source compliance test software performs the physical layer compliance suite for M-PHY transmitters with Infiniium 90000A series oscilloscopes.

Automated physical layer compliance testing for M-PHY receivers is provided by N5990A opt. 165 for a range of Keysight 81250A and J-BERT N4903B configurations.

Note that presently the receiver test section of the M-PHY CTS (Conformance Test Suite) is not fully defined yet. The current receiver test coverage is given in Table 9.

Table 9: MIPI M-PHY Receiver Test Coverage

Receiver Test Name	
SECTION 2: RX TIMERS AND ELECTRICAL TOLERANCES	
GROUP 1: HS-RX REQUIREMENTS	
Test 2.1.1	HS-RX Differential DC Input Voltage Amplitude Tolerance (V DIF-DC-HS-RX)
Test 2.1.2	HS-RX Accumulated Differential Input Voltage Tolerance (V DIF-ACC-HS-RX)
Test 2.1.3	HS-RX Common-Mode Input Voltage Tolerance (V CM-RX)
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-OFF-HS-RX)
Test 2.1.6	HS-RX Lane-to-Lane Skew (T L2L-SKEW-HS-RX)
Test 2.1.7	HS-RX Receiver Jitter Tolerance (TJ RX , DJ RX , RJ RX , STTJ RX , STDJ RX)
GROUP 2: PWM-RX REQUIREMENTS	
Test 2.2.1	PWM-RX Differential DC Input Voltage Amplitude Tolerance (V DIF-DC-PWM-RX)
Test 2.2.3	PWM-RX Common-Mode Input Voltage Tolerance (V CM-RX)
Test 2.2.7	PWM-RX Receive Bit Duration Tolerance (T PWM-RX)
Test 2.2.8	PWM-RX Receive Bit Duration Tolerance, During LINE-READ (TOL PWM-G1-RX)
Test 2.2.9	PWM-RX Receive Ratio, PWM-G1 and Above (k PWM-RX)
GROUP 3: SYS-RX REQUIREMENTS	
Test 2.3.1	SYS-RX Differential Input Voltage Amplitude Tolerance (V DIF-DC-SYS-RX)
Test 2.3.3	SYS-RX Common-Mode Input Voltage Tolerance (V CM-DC-SYS-RX)
GROUP 4: SQ-RX REQUIREMENTS	
Test 2.4.3	SQ-RX Squelch Exit Voltage (V SQ)
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)
Test 2.4.7	SQ-RX Squelch RF Interference Tolerance (V INT-SQ , f INT-SQ)

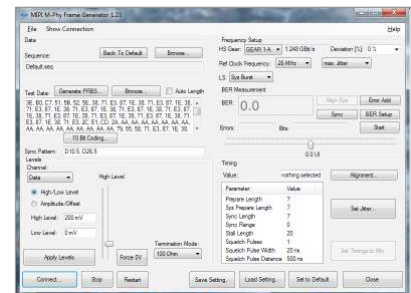


Figure 22. Complementary MIPI M-PHY Frame Generator

The complementary MIPI M-PHY Frame Generator software BIT-2060-0001-0 is available from BitifEye. This software is optimized for debugging and troubleshooting.

Instrument Compatibility

The following instruments are supported for the applications indicated.

Table 10. Instrument compatibility (Keysight instruments if no vendor mentioned)

Recommended instrument	Remark	PCI Express	SATA	USB 3.0	HDMI		MHL	DisplayPort		MIPI D-PHY	MIPI M-PHY
					TMSD Signal Generator	HEAC Arbitrary Waveform Generator		ParBERT	J-BERT		
Generator											
81250 ParBERT	3.3 Gb/s, 7 Gb/s or 13.5 Gb/s; external jitter sources required, contact Keysight					x ¹		x	x ^{1,2}	x	x
N4903B J-BERT	7 Gb/s or 12.5 Gb/s, integrated PJ, SJ, RJ and SSC generation	x ³	x	x						x	x
M8190A-002 Arbitrary Waveform Generator	12 GSa/s, 5 GHz analog bandwidth				x		x				
81150A-002	120 MHz pulse/pattern generation with variable rise/fall time					x					
Error detector / Error counter											
N4903B-C07 or N4903B-C13		x	x	x						x ⁵	
N4903B-A02			x	x							
SerialTek BusXpert			x ⁴								
Ellisys USB Explorer				x							

Oscilloscope5, 6		N5393B	U5411B	U7243A	N5399B	N6460A	U7232A	U7238A		
DSO-X		x	x	x	x	x	x	x	x	x
DSA91304A	13 GHz	x	x	x	x	x	x	x	x	x
DSA91204A	12 GHz	x	x	x	x	x	x	x	x	x
DSA90804A	8 GHz	x		x	x	x	x	x	x	x
DSA90604A	6 GHz	x		x	x	x	x	x	x	x
DSO9404A	4 GHz					x				

1. Configurations and specifications: see E4887A data sheet (5989-5537EN)
2. E4887A-003 not supported
3. Additional 81150A required for Gen3 ASIC tests
4. Additional error detectors supported for SATA 1.5 Gb/s and 3 Gb/s, contact Keysight
5. Oscilloscope required for the calibration of the receiver test system
6. N5990A supports Keysight Infiniium oscilloscopes through the electrical performance specification applications, transmitter tests and compliance software applications shown to the right. Additional oscilloscope options may be required. Refer to Table 11.

System Requirements

Minimum system requirements for the Keysight N5990A

Software requirements

- Windows XP with Service Pack 2 or higher, or Windows 7, English version
- Microsoft .NET Framework version 2.0
- Keysight IO Libraries Suite 16.2 or higher
- Microsoft Office Excel 2003 or higher, English version

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

PC hardware requirements and recommendations

- 1.6 GHz CPU x86
- 512 MB RAM or higher recommended
- 100 MB free hard disk space
- CD-ROM drive (if installing from CD)
- Super VGA (800 x 600) display or higher resolution monitor with 256 colors or more
- PC keyboard and 2-button mouse
- Required connectivity options for instrumentation, depending on configuration:
 - IEEE 1394 (Firewire)
 - LAN
 - GPIB or Keysight 82357A USB/GPIB interface

Software Option Requirements for Keysight Infiniium 90000 Series Oscilloscopes

Keysight DSA 90K oscilloscopes recommended: EZJIT Plus, SDA, Noise Reduction and Bandwidth Control already included in DSA package

Table 11. Oscilloscope Software Option Requirements

ValiFrame test station	EZJIT Plus (N5400A or Option 004)	Serial Data Analysis (E2688A or Option 003)	Noise Reduction and Bandwidth Control (N5403A or Option 005)	Oscilloscope Transmitter Test Application	Infiniiscan (N5414A or Option 009)
PCI-Express		Required		N5393C - for transmitter tests	
SATA	Required	Required	Required	N5411B - for transmitter tests	
USB	Required	Required		N5416A - for USB 2.0 transmitter tests U7243A - for USB 3.0 transmitter tests	
HDMI		Required		N5399B - always required	
HEAC		Required		N5399B - always required	
MHL		Required		N6460A - always required	
DisplayPort	Required	Required	Required	U7232A - for transmitter tests	
MIPI D-PHY	Required	Required	Required	U7238A - for transmitter tests	For transmitter tests
MIPI M-PHY	Required	Required	Required	U7249A - 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.

SATA

The N5990A RSG/Rcvr tests require the far end retimed loopback mode (BIST-L). Control software is available for example from ULINK Technology.
www.ulinktech.com

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 2.0

See the “Recommended Test Equipment” sections in the N5416A data sheet (5989-4044EN). Note that N5990A currently only supports the 81134A pulse pattern generator. In case you need support for your 81130A, contact Keysight.

USB 3.0

For BER measurements, the DUT shall support loopback. For automated testing the test automation software fully integrates the N4903B-A02 J-BERT SER/FER analysis as well as the Ellisys USB Explorer 280. For debugging purposes, reading out a DUT’s internal error is supported, too.
www.keysight.com/find/USB

Consumer electronics and video 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 W2641A test point access adaptor is required. For automated receiver jitter tolerance testing a DisplayPort test controller (DPTC) W2642A is mandatory, and the DUT must support the register access indicated in CTS 1.1, chapter 4. For the calibration of the receiver test setup, a receptacle fixture is needed:

(1) BIT-DP-RTF-0001; receptacle test fixture kit (for Rx tests) or
1 x BIT-DPCBL-0001 cable test kit, see
www.bitifye.com.

For the full list of accessories, contact Keysight.

MIPI 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.

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

Configuration Example

Table 12. N5990A example configuration for HDMI testing - configurations for other applications in correspondence to this example

	Application	Mandatory	Recommended
HDMI	Sink test, cable test	N5990A-010 N5990A-150 (for E4887A) or N5990A-151 (for M8190A) N5399B (refer to table 9)	N5990A-001
	Source test	N5990A-250 N5399B	
	EDID, CEC, video and HDCP test with Quantum Data 882EA and Keysight N5998A PAG	N5990A-350	
	HEAC tests with 81150A	N5990A-351	
Legacy Code Integration, User Programming	Communication and interaction with e.g. C, C++, C#, Visual Basic, VEE or LabView code	Configure as above for the individual bus, N5990A-500	
	User programming	Templates for custom calibration and test procedures and for instrument drivers N5990A-500	

Ordering Information

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

Table 13. Ordering information

Model number	Description
N5990A-010	Test Automation Software Platform Including Remote Interface, Multi-Bus-Support, required for all other options
N5990A-001	Data Base and Web Browser Interface
N5990A-003	Multi-lane (> 2) Support
N5990A-500	User Programming (API including templates), Additional Developer License
High-Speed Receiver / Sink Test Libraries	
N5990A-101	PCI Express 1.1, 2.0, and 3.0 Receiver Tests with J-BERT
N5990A-102	USB 3.0 Receiver Tests with J-BERT
N5990A-103	Serial ATA Revision 3.0 RSG Tests with J-BERT (with 81134A up to 3 Gbit/s)
N5990A-150	HDMI 1.4 Electrical High-Speed Sink Tests with E4887A platform
N5990A-151	HDMI 1.4 Electrical High-Speed Sink Test with two M8190A
N5990A-152	MHL 2.0 Receiver Tests with ParBERT 7 Gbps
N5990A-153	MHL 2.0 Receiver Tests with Arbitrary Waveform Generator M8190A
N5990A-155	DisplayPort 1.1 Receiver Tests with J-BERT
N5990A-160	MIPI D-PHY Receiver Tests with ParBERT, including MIPI PPI Interface Control
N5990A-165	MIPI M-PHY Receiver Tests with J-BERT or ParBERT 7 Gbps
Interfaces To High-Speed Transmitter / Source Tests (On Infiniium Oscilloscopes)	
N5990A-201	Interface to N5393C PCI Express Tx Test Software (N5393C not included)
N5990A-202	Interface to U7243A Oscilloscope USB 3.0 Tx Test Software (U7243A not included)
N5990A-203	Interface to N5411B Oscilloscope Serial ATA Tx Test Software (N5411B not included)
N5990A-250	Interface to N5399B HDMI Source Test Software (N5399B not included)
N5990A-252	Interface to N6460A MHL Source Compliance Test Software (N6460A not included)
N5990A-255	Interface to U7232B DisplayPort Tx Test Software (U7232B not included)
N5990A-260	Interface to U7238A MIPI Tx Test Software (U7238A not included)
N5990A-265	Interface to U7249A MIPI M-PHY Compliance Test Software (U7249A not included)
Link Training, Low Speed Electrical And Protocol Tests	
N5590A-301	PCI-Express Link Training Suite
N5990A-350	HDMI EDID, CEC and HDCP Tests for Quantum Data 882EA, P/ A/ V/ Sink Tests with N5998A
N5990A-351	HDMI HEAC tests with Pulse Function Arbitrary Noise Generator 81150A
Upgrades	
N5990A-011	Upgrade to current PCIeExpress test specification standard
N5990A-012	Upgrade to current USB compliance test specification standard
N5990A-013	Upgrade to current SATA Unified Test Document standard
N5990A-014	Upgrade to current HDMI compliance test specification standard
N5990A-015	Upgrade to current DisplayPort compliance test specification standard

Related literature

Table 14. Related literature

	Publication number
<i>How to Pass Receiver Test According to PCI Express 3.0 CEM Specification - Application Note</i>	5990-9208EN
<i>Accurate Calibration of Receiver Stress Test Signals for PCI Express - Application Note</i>	5990-6599EN
<i>PCI Express Revision 2.0 Receiver Testing with J-BERT and 81150A - Application Note</i>	5990-3233EN
<i>PCI Express Transmitter Electrical Validation and Compliance Testing with Keysight Infiniium Oscilloscopes - Application Note</i>	5989-1275EN
<i>How to characterize the Physical Layer of Mobile Industry Processor Interface (MIPI D-Phy) - Application Note</i>	5989-7184EN
<i>ParBERT 81250A Product Overview - Application Note</i>	5968-9188E
<i>J-BERT N4903B High-Performanc Serial BERT - Data Sheet</i>	5990-3217EN
<i>Keysight M8190A Arbitrary Waveform Generator - Data Sheet</i>	5990-7516EN
<i>81150A Pulse Function Arbitrary Noise Generator - Data Sheet</i>	5989-6433EN
<i>81160A Pulse Function Arbitrary Noise Generator - Data Sheet</i>	5989-6433EN
<i>HDMI Sink and Source Compliance Test and characterization - Data Sheet</i>	5989-4959EN
<i>N5393C PCI EXPRESS® Electrical Performance Validation and Compliance Software - Data Sheet</i>	5989-1240EN
<i>N5399B HDMI Electrical Performance Validation and Compliance Software - Data Sheet</i>	5990-5299EN
<i>U7243A USB 3.0 Compliance Software - Data Sheet</i>	5990-4115EN
<i>N5411B Serial ATA 6 Gb/s Compliance Test Software - Data Sheet</i>	5990-3594EN
<i>U7232B DisplayPort 1.2 Compliance and Validation Test Software - Data Sheet</i>	5990-7697EN
<i>U7238A MIPI D-PHY Compliance Test Software for Infiniium Oscilloscopes - Data Sheet</i>	5989-9337EN
<i>U7249A MIPI M-PHY Compliance Test Software - Data Sheet</i>	5990-8933EN
<i>N6460A MHL Source Compliance Test Software - Data Sheet</i>	5990-9323EN

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