Agilent N5399B HDMI Electrical Performance Validation and Compliance Software for Infiniium Series Oscilloscopes

Data Sheet

Verify and debug your HDMI designs more easily

Agilent Technologies N5399B HDMI electrical performance validation and compliance software for Infiniium 9000, 90000, 90000X-Series oscilloscopes provides you with a fast and easy way to verify and debug your High Definition Multi-media Interface (HDMI) designs for set-top boxes, Digital Video Recorders, DVD players, entertainment systems, and motherboard systems. The HDMI electrical test software is designed for use in HDMI Authorized Test Centers (ATCs) so you can confidently use it to execute HDMI electrical checklist tests as well as employ it as a development tool. It displays the measurement data results in a flexible report format and the report also provides a margin analysis that shows how closely your device passed or failed each test.

To make measurements with the N5399B HDMI electrical test software, you may also need the N1080B HDMI TPA Fixtures for signal access. For testing the new ethernet connectivity and audio channel (HEC and ARC) capability as specified in HDMI 1.4, you may also need additional equipment as listed in table 3c.

The N5399B HDMI electrical test software performs a wide range of tests required to meet the HDMI 1.4 electrical specifications for various home theater components (DVD players, set top boxes, etc), entertainment, and motherboard systems as documented in section 4.2 of the base specification by the HDMI Standards Body1. To introduce an HDMI product to the market, your product must successfully pass compliance testing based on the HDMI specification and it is expected that you have performed the tests included on the checklist before you submit your product for full compliance testing at one of the compliance test labs. The N5399B HDMI electrical test software helps you execute the most difficult physical layer tests on the transmitter (Tx) checklist that can be measured with an oscilloscope. As an HDMI adopter, you must submit your first HDMI product to the HDMI ATC for certification; the N5399B software is targeted to ensure that product has been debugged and well-characterized prior to the certification and to become the sole HDMI test environment for all of your subsequent HDMI transmitter products.

1 High Definition Multi-media Interface Organization (**www.hdmi.org**)

Agilent Technologies

Features

The N5399B HDMI electrical test software offers several features to simplify the validation of HDMI designs:

- Test setup wizard for ease-of-use
- Wide range of electrical tests
- Measurement process configurability
- Automated scope measurement setup
- Test results report generation
- Pass/fail margin analysis

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

N5399B saves you time

N5399B HDMI electrical test software saves you time by setting the stage for automatic execution of HDMI electrical tests. Part of the difficulty of performing electrical tests for HDMI is connecting the oscilloscope to the target device, configuring the instrument for measurement, executing the test procedure, and then analyzing the measured results by comparing them to limits published in the specification. The HDMI electrical test software does almost all of this work for you. Further, new filtering constructs (such as the reference equalizer) adopted in HDMI 1.3 and 1.4 which are extremely difficult to design, are implemented in the software. In addition, if you discover a problem with your device, debug tools are available to aid in root-cause analysis.

The N5399B HDMI electrical test software offers the eight required HDMI Transition Minimized Differential Signaling (TMDS) electrical tests as well as two important tests for cable and receiver tolerance testing. The software automatically configures the oscilloscope for each test, and it provides an informative results report that includes margin analysis indicating how close your product is to passing or failing that specification. Clock recovery of the TMDS clock is accomplished according to the standard by the oscilloscope using proprietary software techniques. See Table 2 for a complete list of the measurements made by the HDMI electrical test software.

Easy test definition

N5399B HDMI electrical test software extends the ease-of-use advantages of Agilent's Infiniium oscilloscopes to testing HDMI designs. The Agilent automated test engine walks you quickly through the steps required to define the tests, set up the test, perform the tests, and view the test results. The user is allowed to pick high level test parameters to suit test process objectives, and then can proceed to select a category of tests all at once, or specify individual tests. The user interface is oriented to minimize your reconnections necessary which saves time as well as minimizes potential for operator error. You can save tests and configurations as project files and recall them later for quick testing and review of previous test results. Straightforward menus let you perform tests with a minimum of mouse clicks.

Test environment setup and test selection

The N5399B now allows the user to select test environment variables to better suite testing goals as well as improving documentation. Three selection areas are offered for Test Setup, Device Under Test, and Probe Offset Calibration: The Test Setup offers channel connection models of 2 or 4 channel connection. The 2 channel connection is the standard user connection model, however, the 4 channel model provides the capability to test all differential parameters with only one test connection. This section also allows entry of the test fixture type used which is important for probe selection and for total compliance test configuration tracking. Also selectable is the HDMI specification version (1.2, or 1.3, or 1.4) and whether you want to hide informative tests. The version for HDMI is now 1.4 however, you may wish to correlate results to HDMI 1.3 and find the option useful. Informative tests are provided for additional characterization capability (such as jitter separation measurement if you have the EZJit Plus analysis package, N5400A).

The Device Under Test section allows selection of device type tested (transmitter, receiver or cable). Though the primary use of this compliance software is for the transmitter, there are use models requiring receiver eye measurement or calibration, cable eye evaluation, and cable equalization where the other options are useful. The Device Identifier targets the type of DUT and will enable only those tests for the device type chosen. The Device Name and Comments allows you to name the device or to identify key configuration details and the Comment field allows further information to be captured. All of these are captured in the final report.

The Probe Offset calibration procedure is provided to make precision measurements when measuring the eye at TP2 (at the receiver). The offset calibration can be zeroed manually and if performed will be used in all measurements for greater accuracy.

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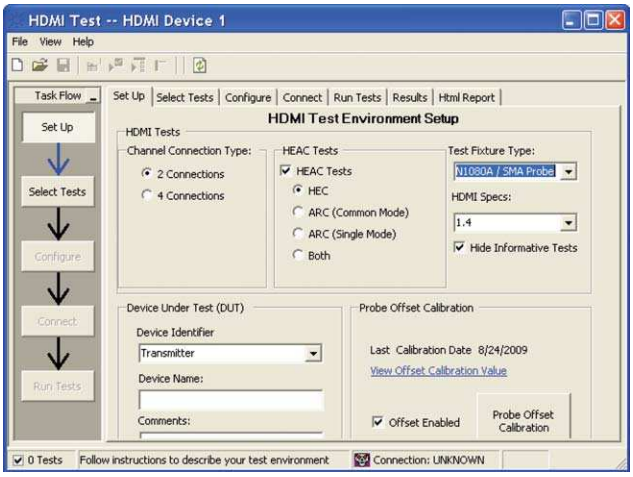

Figure 1. The New Test Setup Screen. Selection for 2 or 4 channel connection model, test fixture selection and device type.

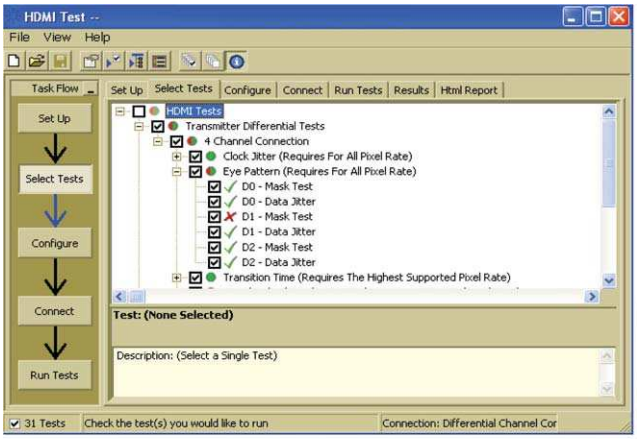

Figure 2. The Agilent automated test engine guides you quickly through selecting tests and configuring tests, setting up the connection, running the tests, and viewing the results. You can easily select individual tests or groups of tests with a mouse-click. Also easily seen is the test status for the device under test

Configurability and guided connections

The N5399B HDMI electrical test software provides flexibility in your test setup. It guides you to make connection changes with hookup diagrams when the tests you select require it. For test parameters such as Bandwidth reduction or data channel selection, the user can select values deemed appropriate; for the more critical parameters, such as rise trigger pattern, default values are tied to the compliance standard and so these can only be altered in the debug screen. Shown in Figure 3 is the selection for the various mask test functions that the N5399B offers. The default for compliance mode is 'Find Passing condition' which will horizontally search for a passing condition of the mask.

After configuring the test according to your needs, the N5399B User Interface will then present you the connection screen which is specific to the configuration data you have selected. Figure 4 illustrates the typical connection guidance provided for a two channel connection model.

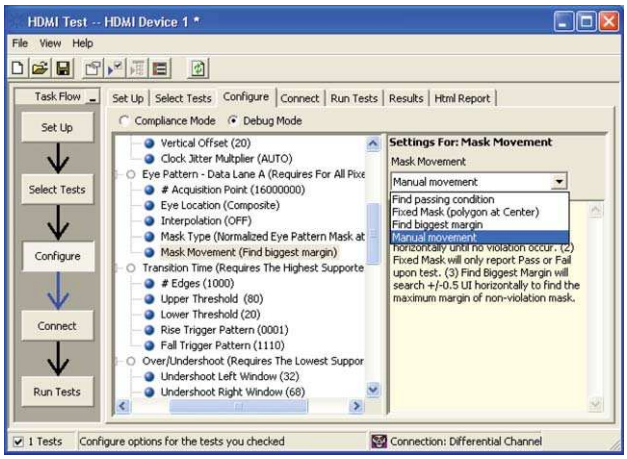

Figure 3. In configuring the tests, you define the device to test, its configuration, and how the oscilloscope is connected. Shown here is the N5399B's Debug Mode selection for Eye analysis.

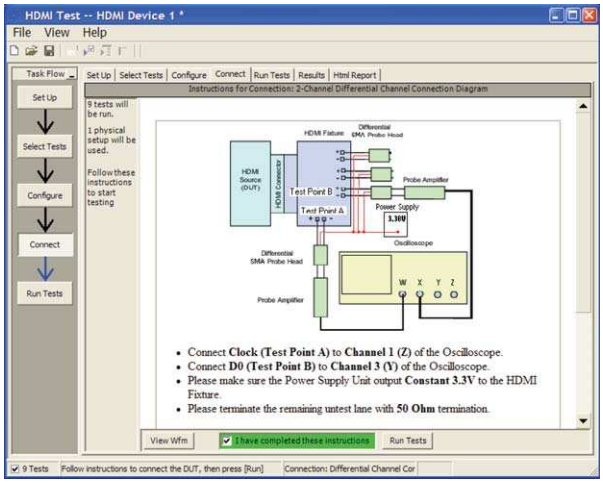

Figure 4. When you make multiple tests where the connections must be changed, the software prompts you with connection diagrams and/or photographs.

N1080 HDMI Test Point Adapters

The N1080B H04 HDMI TPA test fixtures are also available to simplify the measurement process by providing access the electrical measurement points required for the compliance tests. They break out the TMDS (transition minimized differential signaling) lines to SMA connectors for high bandwidth probing with the InfiniiMax SMA differential probes and allows for the single ended measurements required as well. To support the Digital Display Channel where the Electronic Display Identification data is exchanged, the N1080A HO6 can be used. This is shown below in figure 5b. For more information, see publication 5989-5118EN.

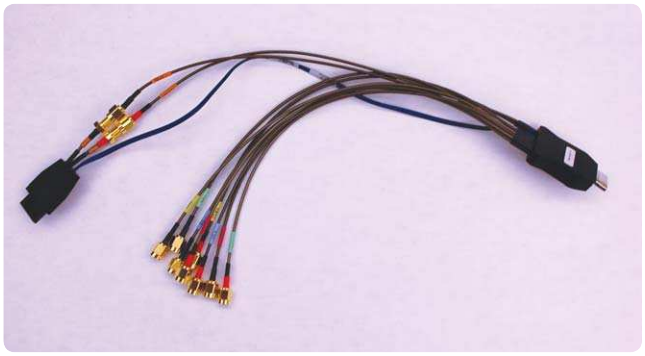

Figure 5a. The Agilent N1080B H04 HDMI Test Point Adapter

Figure 5b. The N1080A H06 test point adapter

Margin analysis

In addition to providing you with measurement results, the N5399B HDMI electrical test software provides a report format that shows you not only where your product passes or fails, but also reports how close you are to the limits specified for a particular test assertion. You select the margin test report parameter, which means you can specify the level at which warnings are issued to alert you to the electrical tests where your product is operating close to the official test limit defined by the HDMI Compliance Test 1.3 Specification for a given test assertion.

Margin is calculated:

Single-sided specification:

$$\text{Margin} = (\text{Value}_{\text{Specification}} - \text{Value}_{\text{actual}})/\text{Value}_{\text{Specification}}$$

Double-sided specification:

$$\text{Margin} = \text{lowest of: } (\text{Value}_{\text{Specification\_High}} - \text{Value}_{\text{actual}})/\text{Range}_{\text{Specification}}$$

$$\text{and } (\text{Value}_{\text{Specification\_Low}} - \text{Value}_{\text{actual}})/\text{Range}_{\text{Specification}}$$

Eye Margin: another method of evaluating the eye is provided by sweeping the eye horizontally with the specified mask and determining the last locations on the left and right portions of the interior eye where there are no violations in the mask. The distance from the center mask location is a measure of design margin and is reported as Eye margin if that eye mask mode is chosen in the configuration screen. configuration screen.

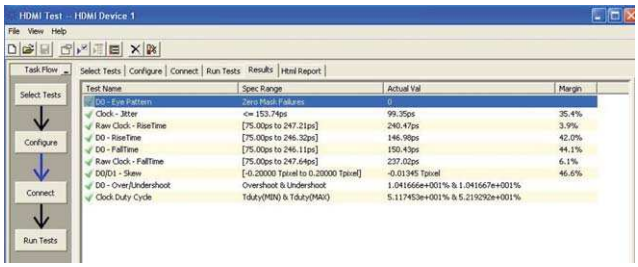

Figure 6. The HDMI electrical test software results report documents your test, indicates the pass/fail status, the test specification range, the measured values, and the margin.

Thorough performance reporting

The N5399B HDMI Compliance and Validation software generates thorough reports that not only capture the performance and status of the device under test, but also the screen shots of the your most significant measurements for your perusal and evaluation. The first page of the report lists equipment and configuration details required in standard quality assurance programs. It also provides a hot-linked results table that will quickly get you to the measurement report section of interest.

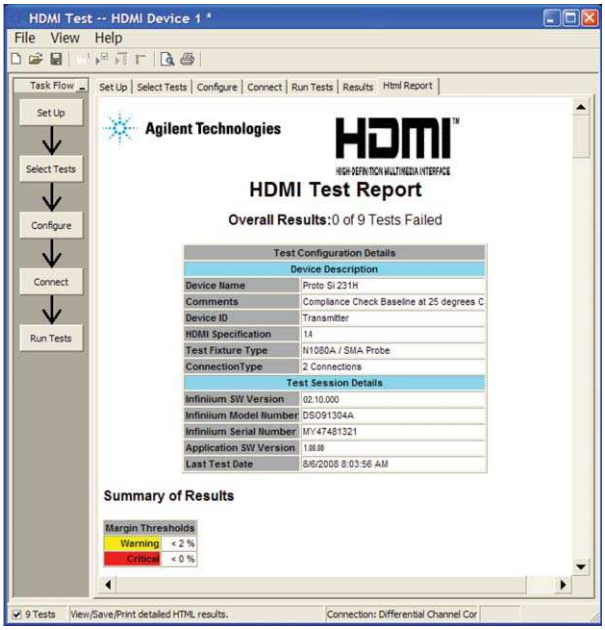

Figure 7a. The N5399B software generates a summary report where you can see the total test results for your device quickly and clearly. This is the title page illustrating the important session information regarding the connection, device and measurement equipment.

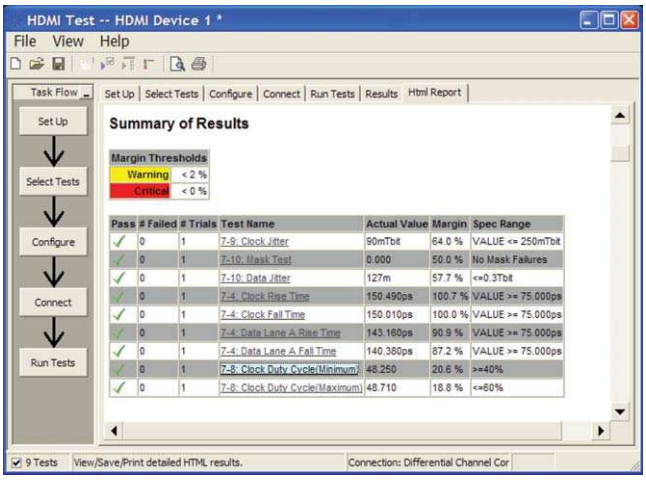

Figure 7b. Additional details are available for each test including the test limits, test description, and test results, including waveforms, if appropriate. In addition, the margin of the result is indicated to provide further insight.

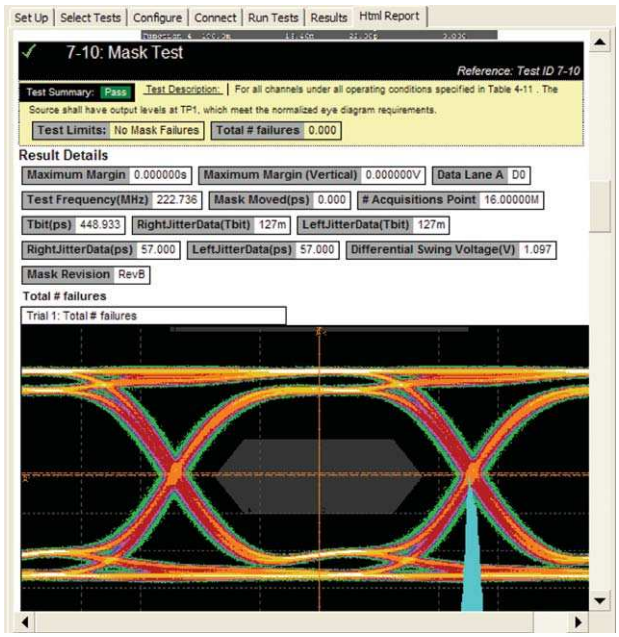

Figure 8. Summary Report Detail: the N5399B software's summary report yields all the screen shots of all the measurements that have been performed. In this figure you can see the Data-Eye. Observe the clear status and description at top and the measurement data just above the eye.

Cable equalization feature

The N5399B software is implemented with the latest features required for HDMI 1.4 CTS compliance. Among the many requirements is the equalization of the cable for receiver eye analysis. This feature can be turned on and off for further insight into cable performance. The figure below illustrates the performance of a non-equalized HDMI cable versus equalization for a 5 meter cable.

A use of this feature is to evaluate receiver design comparing actual or modeled results against the HDMI reference equalizer.

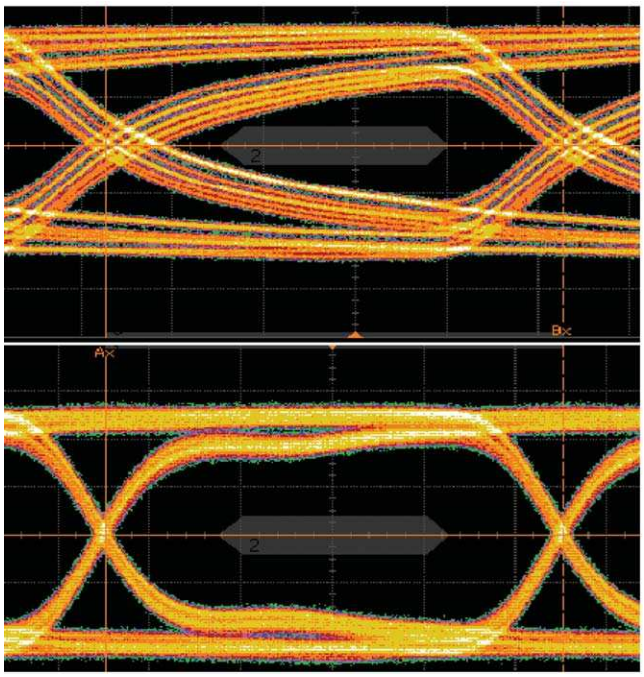

Figure 9. Cable Equalization Model for receiver eye or cable analysis. Top: no equalization. Bottom: 5 meter HDMI equalization model applied.

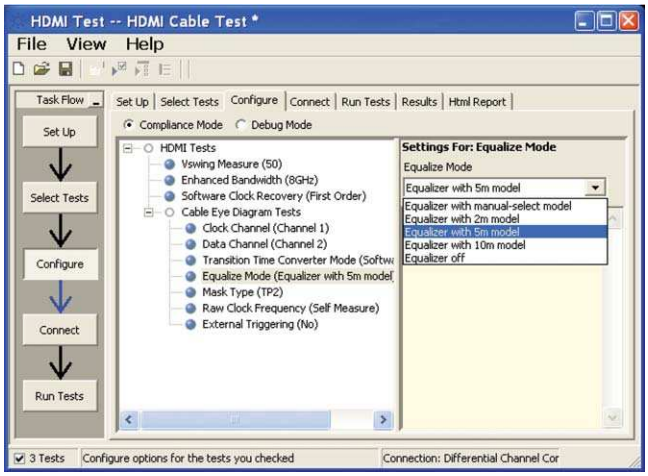

Figure 10. Selecting the Cable length to be equalized in the configuration screen when performing cable end eye measurements.

Extensibility

You may add additional custom tests or steps to your application using the N5467A User Defined Application (UDA) development tool (www.agilent.com/find/uda). Use UDA to develop functional "Add-Ins" that you can plug into your application.

Add-ins may be designed as:

- Complete custom tests (with configuration variables and connection prompts)
- Any custom steps such as pre or post processing scripts, external instrument control and your own device control

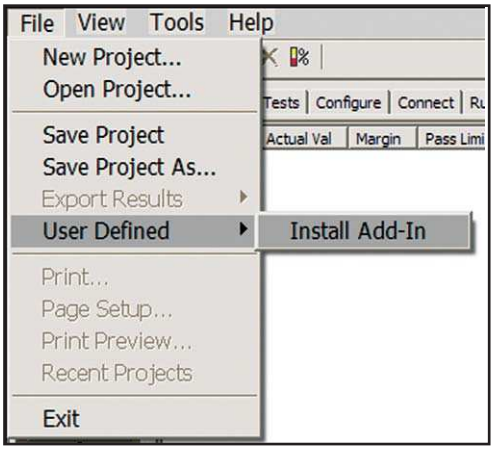

Figure 11. Importing a UDA Add-In into your test application.

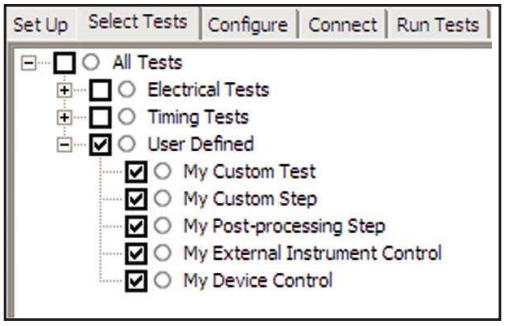

Figure 12. UDA Add-In tests and utilities in your test application.

Automation

You can completely automate execution of your application's tests and Add-Ins from a separate PC using the included N5452A Remote Interface feature (download free toolkit from www.agilent.com/find/scope-apps-sw). You can even create and execute automation scripts right inside the application using a convenient built-in client.

The commands required for each task may be created using a command wizard or from "remote hints" accessible throughout the user interface.

Using automation, you can accelerate complex testing scenarios and even automate manual tasks such as:

- Opening projects, executing tests and saving results
- Executing tests repeatedly while changing configurations
- Sending commands to external instruments
- Executing tests out of order

Combine the power of built-in automation and extensibility to transform your application into a complete test suite executive:

- Interact with your device controller to place it into desired states or test modes before test execution.
- Configure additional instruments used in your test suite such as a pattern generator and probe switch matrix.
- Export data generated by your tests and post-process it using your favorite environment, such as MATLAB, Python, LabVIEW, C, C++, Visual Basic etc.
- Sequence or repeat the tests and "Add-In" custom steps execution in any order for complete test coverage of the test plan.

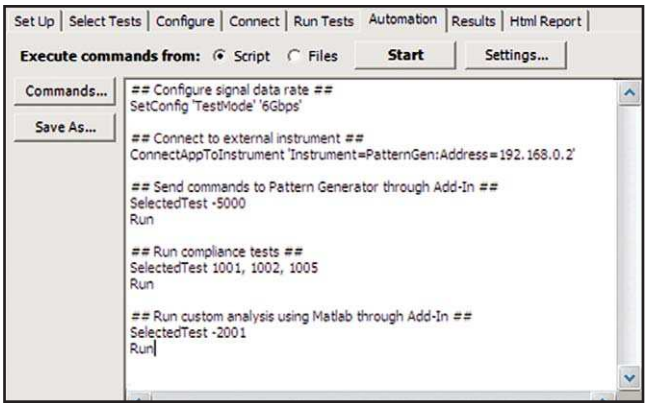

Figure 13. Remote Programming script in the Automation tab.

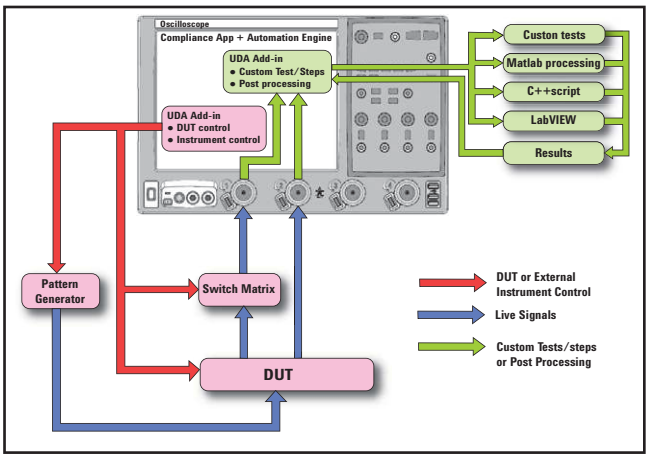

Figure 14. Combine the power of built-in automation and extensibility to transform your application into a complete test suite executive.

Measurement requirements

To use the N5399B HDMI electrical performance validation and compliance software with the Agilent N1080B HDMI TPA Fixture, you will need at least two 7GHz or higher InfiniiMax differential probe amplifiers (1134A, 1168A, or 1169A) with appropriate SMA probe heads (N5380A). If not using the N1080A H04 test point adapter, you will need to select the appropriate probe head to interface with your fixture. For instance, if the TMDS signals are accessible through a terminated 50 ohm transmission line for testing for example, silicon devices, you will need to use the E2678A socketed probe head, or the E2677 or N5381A solder-in differential probe head for high impedance probing.

Test time can be minimized by using four InfiniiMax probes to measure all three differential data lanes (D0, D1, D2) and clock without having to reposition or reconnect probes. This is called the 'Four Probe Connection' and is selectable in the Setup screen.

Oscilloscope compatibility

The N5399B HDMI electrical performance validation and compliance software is compatible with Agilent 54850, 80000 and 90000 Series oscilloscopes with operating software revision A.05.70 or higher (for 54850 or 80000 Series), DSO90000A Series Oscilloscopes with operating software revision A.2.1. 0 or higher and X 90000A Series oscilloscopes with operating software revision 2.5 or higher. For oscilloscopes with earlier software revisions, free upgrade software is available at www.agilent.com/find/infiniium_software.

Date rate	Agilent Oscilloscopes for HDMI 1.4 Compliance Test		Oscilloscope Bandwidth
	Suitable Oscilloscopes	Recommended New Purchase	
Up to 740 Mb/s	DSO9404A/MSO9404A	DSO90404A††	4 GHz
	DSO80404A/B, DSO90404A	DSO90404A††	4 GHz
	DSO80604A/B, DSO90604A	DSO90604A††	6 GHz
	DSO80804A/B, DSO90804A	DSO90804A††	8 GHz†
Up to 3.4 Gb/s	DSO80804A/B, DSO90804A	DSO90804A††	8 GHz
	DSO81004A/B		10 GHz†
	DSO812004A/B, DSO91204A	DSO91204A	12 GHz†
	DSO813004A/B DSO91304A	DSO91304A	13 GHz
		DSOX91604A †††	16 GHz
		DSOX92004A †††	20 GHz
		DSOX92504A †††	25 GHz
		DSOX92804A †††	28 GHz
		DSOX93204A †††	32 GHz

Notes:
† The N5399B software will automatically control the bandwidth setting of the oscilloscope
* The HDMI 1.4 CTS Specification supercedes the previous 1.3c HDMI version.
†† The DSO90000A series of Oscilloscopes are upgradable in bandwidth from 2 to 13 GHz
††† The 90000 X-Series oscilloscopes are upgradable in bandwidth from 16 to 32 GHz

Table 1. Recommended oscilloscopes and bandwidth for HDMI 1.4 specification

Tests performed

The N5399B HDMI electrical performance validation and compliance software performs the following tests as per the HDMI Compliance Test Specifications 1.4 (CTS1.4) as documented in section 4.2 of the base specification.

Assertion No.	Description
Section 7.0	**Transmitter tests**
Test ID 7.2	TMDS VL
Test ID 7.4	TMDS TRise and TFall
Test ID 7.5	TMDS Over/Undershoot*
Test ID 7.6	TMDS Inter Pair Skew
Test ID 7.7	TMDS Intra Pair Skew
Test ID 7.8	TMDS Clock Duty Cycle
Test ID 7.9	TMDS Clock Jitter
Test ID 7.10	TMDS Data Eye Diagram
Sections 5.0 & 8.0	**Cable and Receiver Tests**
Test ID 5.3	Cable Eye Diagram Test
Test ID 8.5	Min/Max Differential Swing Tolerance
Test ID 8.7	TMDS Jitter Tolerance Calibrations
	Supplement 2 of the HDMI 1.4 CTS
	Differential Signal Characteristics
Test ID 5-1	Operating DC Voltage Test
Test ID 5-2	Jitter Max Test
Test ID 5-3	Rise/Fall Time Test
Test ID 5-4	High/Low Center Level Voltage Test
Test ID 5-5	Cycle Time Test
	Common Mode Characteristics
Test ID 5-6	Operating DC Voltage Test
Test ID 5-7	High/Low level Voltage Test
Test ID 5-8	Rise/Fall Time Test
Test ID 5-9	Jitter Max/Clock Frequency Test
	Single Mode Signal Characteristics
Test ID 5-11	Operating DC Voltage Test
Test ID 5-12	Signal Amplitude Test
Test ID 5-13	Rise/ Fall Time Test
Test ID 5-14	Transmit Jitter

* This test omitted in HDMI 1.3 Specification

Table 2. HDMI electrical tests performed by the N5399B software

Note: The N5399B HDMI test software can make measurements for Digital Visual Interface (DVI) 1.0 devices. However, those devices are governed by the DVI specification which calls out different test methodologies and test fixturing. For DVI, Agilent offers the N5394A DVI electrical performance validation and compliance software.

Ordering information

To purchase the N5399B (or -Opt 023) HDMI electrical performance validation and compliance software with a new or existing Infiniium 9000 , 90000, or 90000 X-Series oscilloscope, order the following:

Model number	Description	Quantity
DSO90804A	Oscilloscope (see table 1) 10 MB Memory Standard	1
1168A/1169A	10/12 GHz Probe Amplifiers. 1169A Recommended.	4
N5380A	12 GHZ SMA Probe Heads for differential and single-ended measurements.	5
DSO9404A	Oscilloscope up to 1 Gpt memory	1
1133A or 1134A	7 GHz Probe Amplifiers	4
N5380A or E2695A	12 GHz SMA Probe Heads for differential and single-ended measurements	5
DSOX91604A	Oscilloscope up to 2 Gpts memory	1
N2800A	16 GHz Probe Amplifier	4
N5444A	2.92 SMA Probe Heads	5

Table 3a. HDMI Oscilloscope solution ordering information

For physical connections to an HDMI device to perform tests with the N5399B HDMI compliance test software, order the following:

Model number	Description	Quantity
N1080B H04	HDMI Plug Test Adapter	1
N1080A H06	DDC/CEC Test Adapter board	1
N1080B H05	HDMI Receptacle Test Adapter For cable evaluation or receiver eye tests/analysis	1 (optional)
BIT-HDMI-TDPL-0001	Type D connector Test Point Adapter from Bitifeye GmbH- Plug connector	1 (optional)
BIT-HDMI-TDRE-0001	Type D connector Test Point Adapter from Bitifeye GmbH- Receptacle connector	1 (optional)
BIT-HDMI-TEPL-0001	Type E connector Test Point Adapter from Bitifeye GmbH- Plug connector	1 (optional)
BIT-HDMI-TERE-0001	Type E connector Test Point Adapter from Bitifeye GmbH- Receptacle connector	1 (optional)

Table 3b. HDMI Test Adapter solution ordering information

For HEC and ARC testing using the N5399B HDMI compliance test software, order the following:

Model number	Description	Quantity
N1080B H01	HDMI Plug Test Adapter	1
81150AU-EHD	HEC/ARC Test Fixture	1
E2678A	Differential Socketed probes (used with 81150AU-EHD)	2
1130A	Probe Amplifiers	2 (optional)
E2697A	High Impedance adaptor	2 (optional)
81150A	Arbitrary waveform generator	2 (optional)
N5990A opt 351	HEAC test software option to N5990A Factory automation sw	1 (optional)
BIT-HDMI-HEAC	Stand-alone HEAC receiver physical layer and audio protocol test sw	1 (optional)

Table 3c. HEAC solution ordering information

Measurement and test accessories

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

Model number	Description
11667B	Power splitter, DC to 26.5 GHz, 3.5- mm (f) connectors
11636B	Power divider, DC to 26.5 GHz, 3.5-mm (f) connectors
8493B	Coaxial attenuator (3, 6, 10, 20 or 30 dB), DC to 18-GHz, SMA connector
1250-1158	SMA (f - f) adapter, DC to 18 GHz
1250-1159	SMA (m - m) adapter, DC to 18 GHz
1250-1397	Right-angle adapter, SMA (m - m)
1250-1741	Right-angle adapter, SMA (f - m)
1250-1698	SMA tee adapter (m, f, f), DC to 12.4 GHz
1250-1694	SMA (m) to SMA (f) Adapter
15442A	Cable kit, four 90-cm (36-in) SMA (m - m) cables
15443A	Matched cable pair, two 90-cm (36-in) SMA (m - m) cables, propagation delay within 25 ps
1810-0118	SMA (m) 50Ω termination
33SMA-Q50-0-4	SMA push-on adaptors from S.M. Electronics (or equivalent)
ZX85-12G-S+	Bias Tee from Mini-Circuits Corporation
BIT-HDMI-PPD-7373	Probe Power Distribution Kit from Bitifeye corporation. www.Bitifeye.com
BIT-GEN-SCK-0010	Snap on Connector Kit from Bitifeye corporation. www.Bitifeye.com
BIT-HDMI-HEHD-0001	HEC and ARC Test Accessory Kit

Table 4. Recommended test accessories

Related literature

For copies of this literature, contact your Agilent representative or visit www.agilent.com/find/scope-apps

Publication title	Publication type	Publication number
Infiniium 90000 Series Oscilloscopes	Data Sheet	5989-7819EN
Infiniium 80000 Series Oscilloscopes and 1160 Series Probes	Data Sheet	5989-4604EN
N5394A DVI Electrical Performance Validation and Compliance Software	Data Sheet	5989-1526EN
N1080B HDMI Test Point Access Fixtures	Data Sheet	5989-5118EN
N5990A Automation Software	Data Sheet	5989-5483EN
Infiniium 90000 X-Series oscilloscopes	Data Sheet	5990-5271EN

Product Web site

For the most up-to-date and complete application and product information, please visit our product Web site at:
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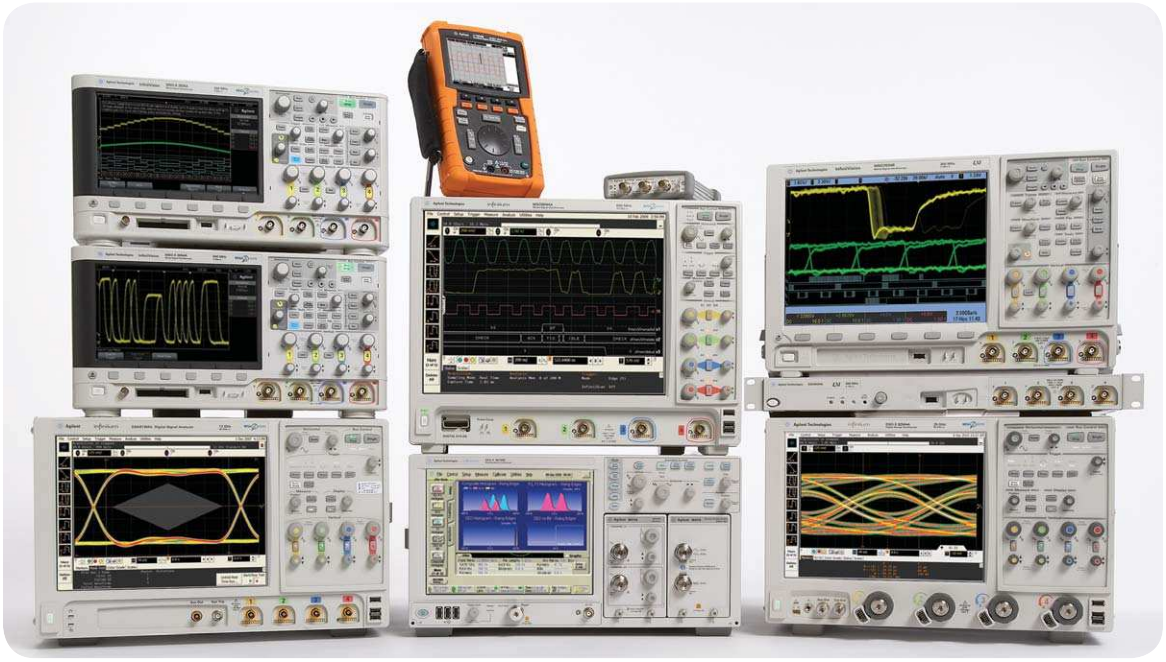

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