N5399E, N5399F HDMI Electrical Performance Validation and Compliance Software

For Infiniium Series Oscilloscopes

Complete Physical Layer Testing for HDMI 1.4 and HDMI 2.1

Keysight's D9021HDMC HDMI electrical performance validation and compliance software offers a complete test execution environment for validating and troubleshooting the electrical performance of HDMI 1.4 and HDMI 2.1 source devices. The software, which uses a new licensing model, operates on the Keysight industry-performance-leading Infiniium oscilloscope hardware with. The D9021HDMC is functionally identical to the N5399E HDMI compliance test software, which is well-established through the world's HDMI Authorized Test Centers (ATCs).

The primary application for the HDMI EPVC software is physical layer compliance testing for HDMI sources that are performed at HDMI ATCs worldwide. The software package is also designed to flexibly handle development tasks such as characterization and troubleshooting to complement the required compliance testing.

Whether your product is a DVD player, computer, graphics card, or any of the other many product types that use the successful HDMI interface, you must submit your first article HDMI product to an HDMI ATC for certification. Requirements for compliance testing are documented in the HDMI 2.1 Generic Compliance Test Specification (GCTS) for HDMI sources. The GCTS defines the tests that must be run on one or more of the four high-speed TMDS (transition minimized differential signaling) and FRL (fixed rate link) lanes at each of the various resolution settings for both specifications (HDMI 1.4b and HDMI 2.1). Using the HDMI Electrical Performance Validation and Compliance (EPVC) software in the development and pre-compliance steps will give you confidence in successful outcome for the test process at the HDMI ATC. Upon completion, you may become an HDMI self-certifier using your same documented test process and test equipment.

Features

The HDMI EPVC software offers a comprehensive range of features to simplify the validation of HDMI designs. It includes:

- Specification selections (HDMI 1.4b, HDMI 2.1 TMDS, HDMI 2.1 Fixed Rate Link)
- Complete test suites for HDMI: HDMI 1.4, HDMI 2.1 TMDS test, HDMI 2.1 Fixed Rate Link, Direct Attach devices. HEAC (Ethernet/Audio return channel) and eARC (available through N5990A eARC software only).
- Device capability entry using resolution and timing descriptors, video identifier codes (VIC) as well as FRL features
- Automated test sequencing for given test connection
- Full device automation using optional switch network
- Guided connection and instructions throughout the test process
- Test report including system, connection details, summary table, with hotlinks to ancillary test result data, and screen shots of the test measurements
- Tabular final results page with statistical analysis
- Pass/fail margin analysis
- Transfer function generation for the complex test requirements for HDMI 2.1 and for extended analysis
- Scripting for complex testing or cycling requirements
- Remote user interface
- Test algorithm control through configurable parameters
- Test selection to support one test, many tests, or all tests
- Test plan flow control

HDMI EPVC software is easy to use

The HDMI EPVC software extends the ease-of-use advantages of Keysight's Infiniium oscilloscopes to the testing of HDMI designs. The Keysight automated test engine takes you quickly and intuitively through the steps to define device capability, test selections, and test connection as well as enables you to easily perform tests and view test results. You can simply select a category of tests or specify individual tests by flexibly choosing high level test parameters (e.g. specification or test suite) that suit various test process objectives.

A prompt screen conveniently guides users to make any required connection or bit rate change during the sequencing of tests in an overall test plan. In automation modes, the testing continues without having to wait for operator input. When the requested test procedure is complete, an HTML report is generated that allows the user to view all key information. In addition, a tabular view (reports tab) is available for immediate viewing of measurement results and statistics. The project file can be saved for continued testing on the same device later. The resume testing mode allows the user to continue the test procedure where it left off.

HDMI EPVC software saves you time

The HDMI software guides you through the whole process – from setup to analysis of results. The intuitive graphical user interface for this process allows you to select the specifics of test such as the test suite and test system connection, as well as to declare product capability that will govern the product's required test plan. The test algorithms have been certified through HDMI Forum sponsored test event qualification and are officially approved by the HDMI Forum. The need for proprietary software development is eliminated. In HDMI 2.1, filtering constructs, such as addition of skew on either signal line of a differential pair, embedding a cable model, impressing an equalization function, de-embedding a fixture, and even compensating for a lossy intervening switch network, are all handled automatically.

HDMI 2.1: What is Different from HDMI 1.4 and HDMI 2.0?

High definition multimedia interface

HDMI is a 19-pin interface (see Figure 1), which is the preferred interface in the industry for transmission of digital video to high resolution displays. Twelve of these pins are dedicated to four highspeed differential lanes and shielding. Three pins are dedicated to i2c interface for reading EDID or SCDC channels (SCL, SDA, and GND). The CEC (Consumer Electronics Control) line is used to control connected equipment. +5 pin supplies power to devices and HPD is the Hot plug detect pin used to determine connectivity between sources and displays. The HPD and Utility line are also used as the eARC (ARC) interface for audio return channel.
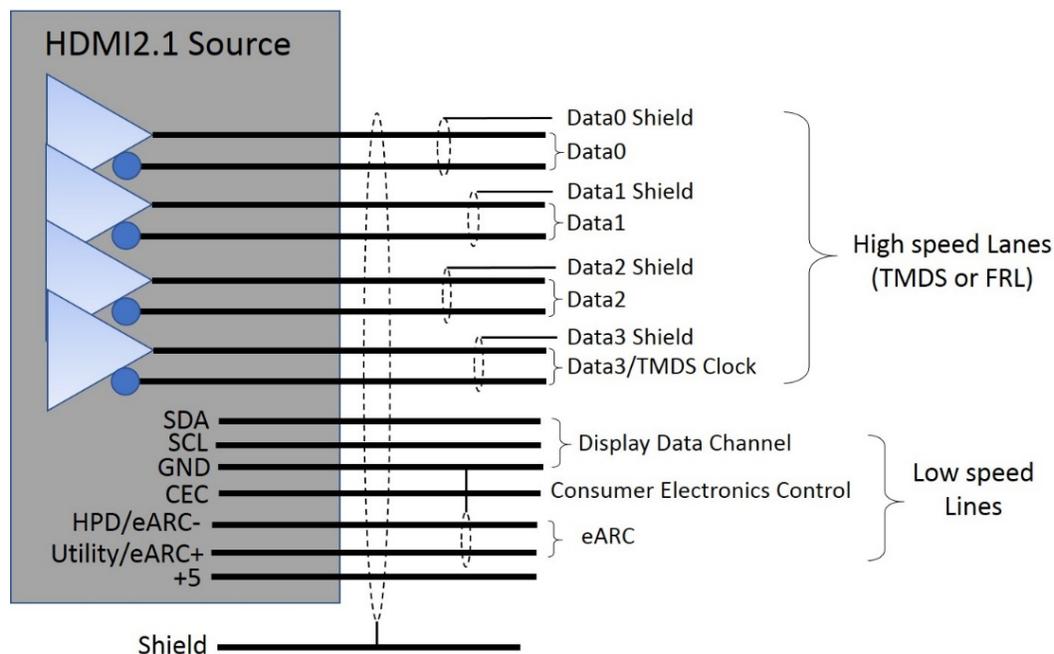

Figure 1. HDMI 2.1 source

For HDMI 1.4 and HDMI 2.0 (now referred to as 'HDMI 2.1 TMDS'), the four high speed lanes consist of an explicit clock (Ck) and three lanes for payload data (D0, D1, D2). These four lanes are referred to as the TMDS link (transition minimized differential signaling) and the data lanes are encoded with an 8b/10b overlay that minimizes the transitions. TMDS 8b/10b is different from ANSII 8b/10b, which seeks to maximize transitions in the data stream. The TMDS system makes use of a divided forwarded clock, which is referred to as the 'TMDS clock.' For HDMI 2.1 TMDS, the divisor is 40, and for HDMI 1.4b the divisor is 10. For HDMI 1.4b, the maximum composite bit rate is 10.2 Gbs (three data lanes at 3.4 Gbs maximum per lane); with HDMI 2.1 TMDS, the maximum composite bit rate is increased to ~18 Gbs (three data lanes at maximum of 5.94 Gbs per lane).

The new HDMI2.1 specification includes a dramatically different transport system called 'Fixed Rate Link' (FRL). FRL uses the four high speed lanes for data transport using 16b/18b encoding and increases the maximum data rate to 12 Gbs per lane, which nearly triples the video payload. Although HDMI products may use FRL or TMDS, FRL must be used if more than ~18 Gbs is needed for a given format.
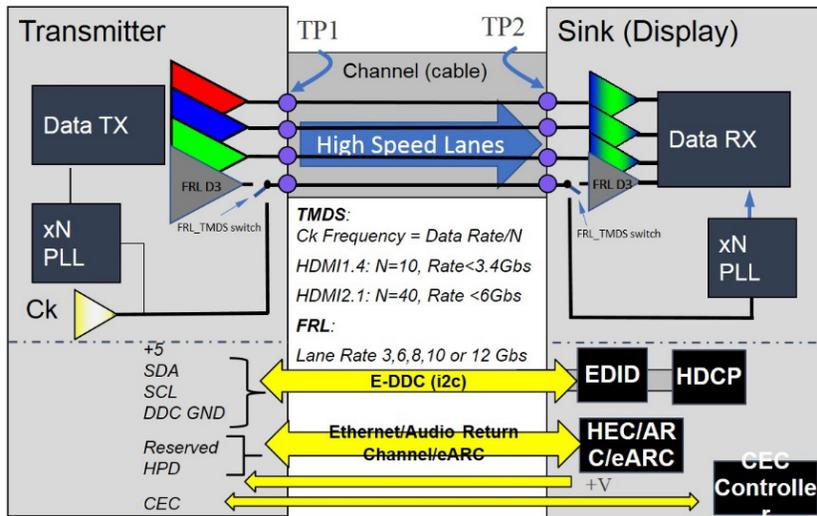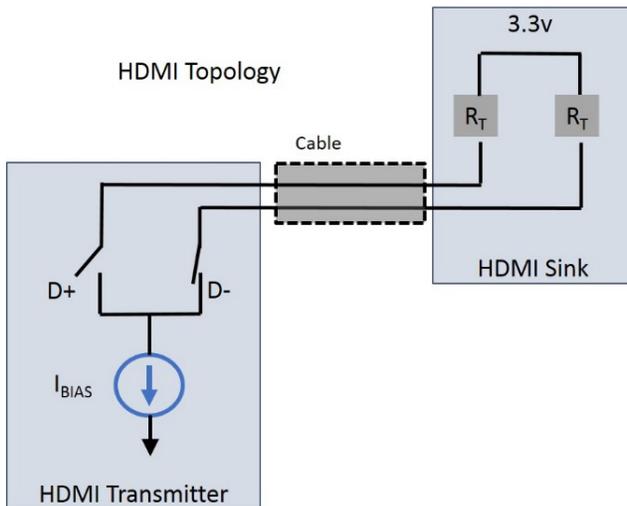

Figure 2. HDMI system

Figure 3. HDMI TMDS lane topology

Testing HDMI transmitters

To test a digital transmitter of any sort, the test equipment must be connected to an interface. Since physical layer test equipment use coaxial connectors, a test point access adapter (TPA) that breaks out the test signals from the device under test with HDMI connector to the test equipment must employ a coaxial connector. The connection accessories table (below) identifies the TPAs to use with the Keysight HDMI compliance software (see Figure 8 for an illustration). A simplified illustration of how HDMI signals are accessed by the measurement system is shown in Figure 4. When not all HDMI highspeed signals can be connected to the measurement system at the same time, the software will guide the user through the test process to establish a re-connection of signals when necessary. In these cases, untested lanes should be terminated properly, illustrated in Figure 3, at the sink where R_T=50 ohms.
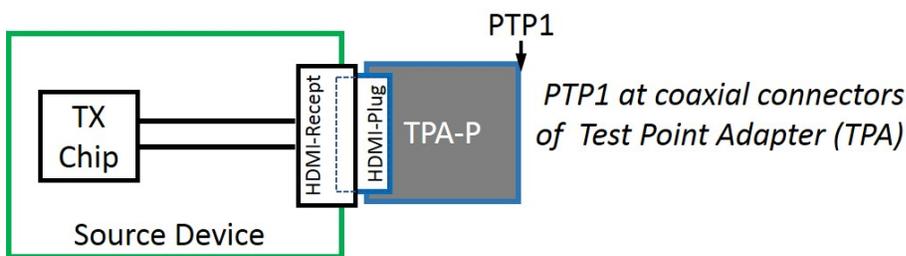

Figure 4. Updated TPA: illustrating acquisition at Practical Test Point 1 (PTP1)

In HDMI, there are tests that measure single-ended parameters as well as differential parameters. When single-ended parameters are measured, the waveform for a single line of the differential lane is analyzed. If a single line (e.g. D0+) is compared with another line (e.g. D0-, as in intra-pair skew testing), the D0- signal will be routed to one oscilloscope channel and the D0+ will be routed to another.

For tests that require differential analysis there are two cases:

- The first case is for PTP1 (output of transmitter) measurements where a differential probe may be used directly, or two single-ended measurements may be subtracted (performing a Math function for instance).
- The second case is when a TP2 (end of cable) measurement is being made, in these cases a single-ended acquisition at PTP1 must be used to properly manifest the effects of the cable mathematically.

In either case, the resultant waveform is analyzed for the parameter of interest (level, rise time, etc.). There are times when two differential signals (two TMDS lanes) are required (data eye test being the most significant case). When performing such tests, the HDMI EPVC software can use single-ended acquisitions or can acquire the information from differentially probed lines. In all cases, the connecting network, shown in Figure 4, and the oscilloscope connection must behave according to the topology requirements shown in Figure 3 for the HDMI sink connection.

New HDMI Transmitter Test Requirements for HDMI 2.1

While many of the tests remain similar for HDMI 2.1 as performed in HDMI 1.4, there are many complex mathematical processes that are now required for the test processing on the oscilloscope for the data rates above 3.4 Gbs. These processes amount to filtering acquired data using transfer functions to obtain the required view. Examples of such functions are finite impulse response filters (FIRs) that can be convolved with acquisitions to accomplish de-embedding the fixture and embedding a standard-prescribed worst-case cable. In the figure below, we have an idealized HDMI link with HDMI transmitter, sink and cable between them. The use of decision feedback equalization (DFE) in the TP2Eq processing is another example of the extended requirement for HDMI 2.1 FRL products with 12 Gbs capability.
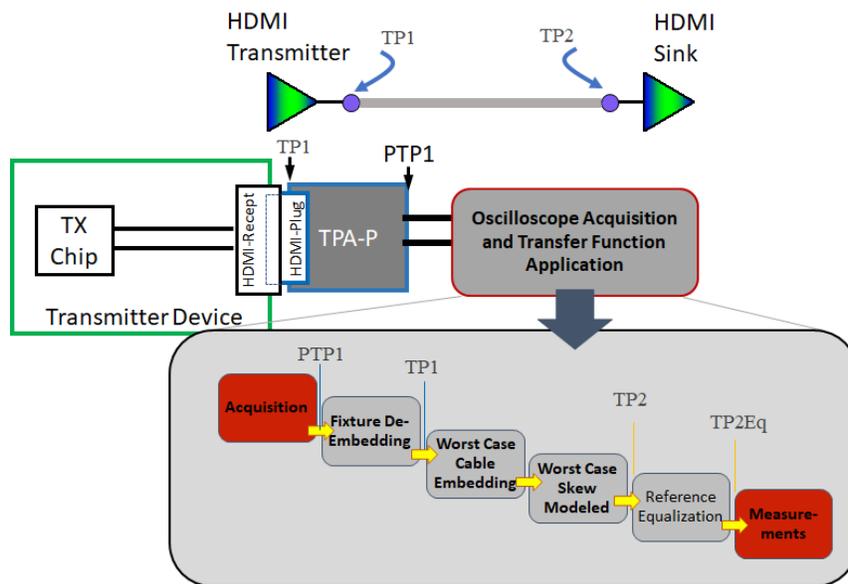

Figure 5. Test points and signal processing in HDMI

To validate a transmitter, we must access the signals of the transmitter with a test point adapter and analyze it with an oscilloscope. The HDMI 2.1 required processing functions are depicted below the oscilloscope block. These functions include:

- fixture de-embedding for removing the effects of the fixture, impressing a cable model that is considered a worst-case acceptable cable in an HDMI system (the cable model includes loss vs. frequency, crosstalk and mode conversions)
- adding worst-case skew to either side of the differential pair (one signal at a time)
- modeling the minimum equalization an HDMI receiver will have (the HDMI reference equalizer).

The HDMI EPVC software generates all of these transfer functions and enables any combination of them. It is also possible to create other transfer functions using different fixtures, cable models and equalizers.

Using the HDMI EPVC Software

The HDMI software logically guides the user through the test process. The graphical user interface is designed to glean test process and device under test information from the user to efficiently carry out the testing. (Refer to Figure 6.) The user will know the device type (which determines the test suite) and which specification applies (HDMI 1.4b, HDMI 2.1 TMDS or HDMI 2.1 FRL). Though the specifications for HDMI 2.1 TMDS and HDMI 1.4b are different, the selection of HDMI 2.1 TMDS will reveal both 1.4b and 2.1 TMDS tests, as seen in Figure 9. HDMI 2.1 FRL tests are only shown when HDMI 2.1 FRL is selected.
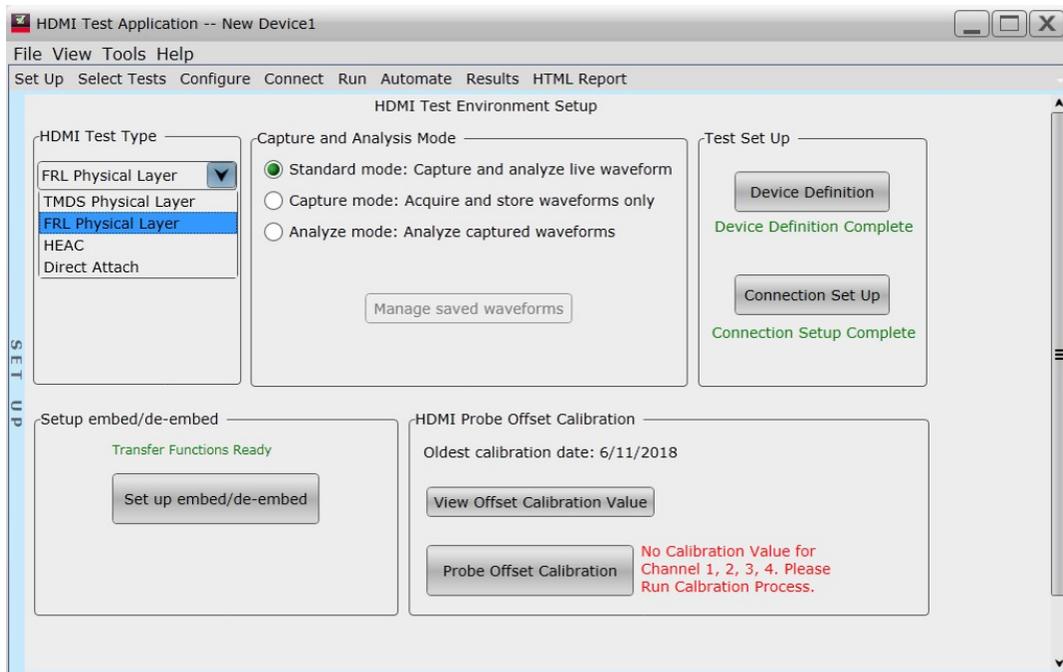

Figure 6. HDMI software application entry screen

The Keysight HDMI validation software now offers device definition and connection setup tabs in the setup screen as can be seen in Figure 6. These tabs are labeled with a colored status. The color red indicates that the user has to complete some actions before proceeding, while the color green indicates valid state and ready to test.

The setup screen also includes transfer function generation and probe offset calibration. The probe offset calibration is not new and should be run periodically to make precision measurements, particularly when measuring the eye at TP2. The offset calibration is for HDMI measurements only. If run after standard probe calibration and de-skew, it will result in the elimination of offsets in the differential measurements made by the software. The transfer function generation feature allows the user to create new filters that may be needed when performing characterizations with different cable models, different fixtures, equalization and skew. Generally, required filters, or transfer functions, are provided as part of the software package as defaults, which means the user does not have to create any.

Device Definition

To create a test plan for a device, the information entered in the device definition screen is used. The device definition may be limited (for example, one format given) or it may be fully defined (listing many possible formats. Logic in the software creates the minimum test procedure required. For instance, if a number of formats are entered in TMDS that have the same bit rate, only one format is tested at that bit rate. Further, some tests are only run on the lowest bit rates whilst other tests are run at the highest bit rate.
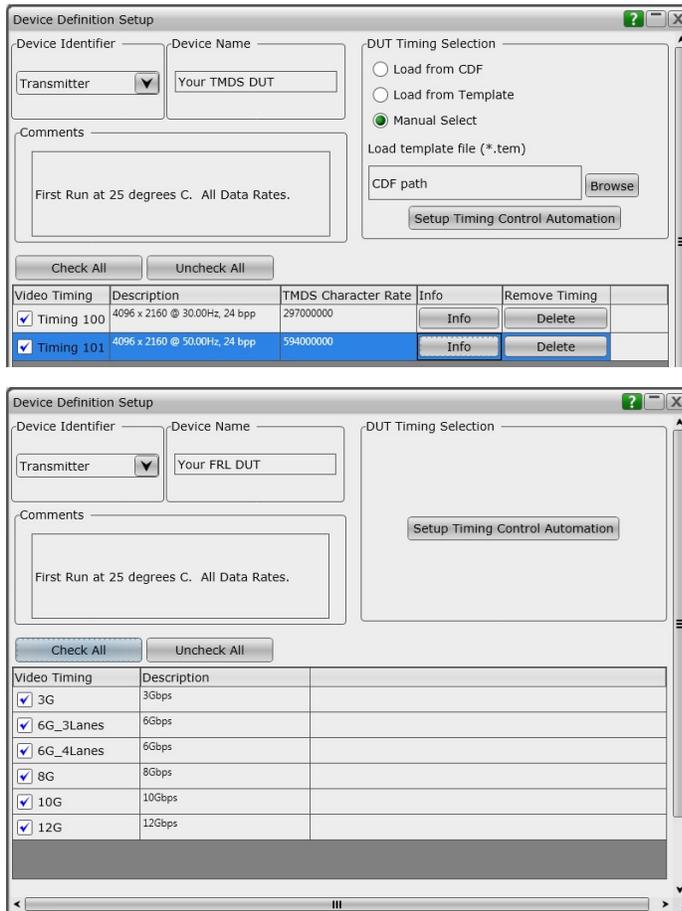

Figure 7. HDMI software application definition screens for HDMI 2.1 TMDS and HDMI 2.1 FRL

The device definition screen supports standard DUT identification and test comments. Users can now also define the timings/resolutions at which to test. You can enter these resolutions by:

1. Using the capability declaration form (CDF)
2. Using a previously stored template
3. Using the default setup (which you can define)
4. Adding your own custom timing
5. Independently editing any of these using the check boxes in the pixel clock tabs at the top of the bottom section

Once the resolution/timing table is defined, it can be stored as a template or as a default state. If defined as default, it will show up on all future application start-ups.

Connection Setup

The connection setup screen lets you enter the details of connection from the device under test to the oscilloscope. The connection elements include the test fixture (or test point adapter, or TPA), the probe heads that connect to the high speed TMDS (or FRL) lanes, and an optional switch matrix for automated testing. The application allows different connections, including a choice of using two or four probes that are single-ended or differential. While the recommended use model is four probes with single-ended connection (one data lane), other use models are possible to reduce capital outlay in test solutions or to facilitate specific testing in the device characterization stage.
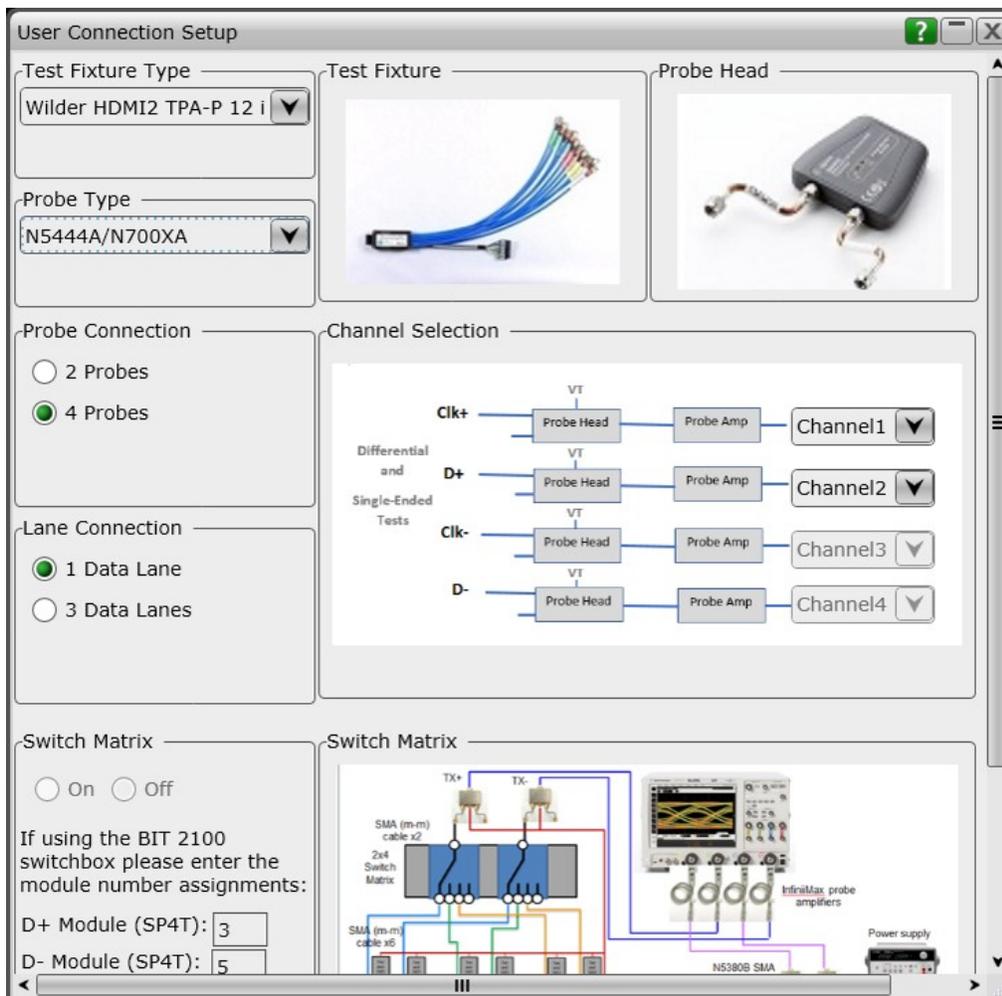

Figure 8. HDMI software application test connection screen

Test Selection

After completing the DUT definition and test connection, you are ready to make test selections. By clicking on the 'Select Tests' tab, you can proceed to select the tests you wish to run.
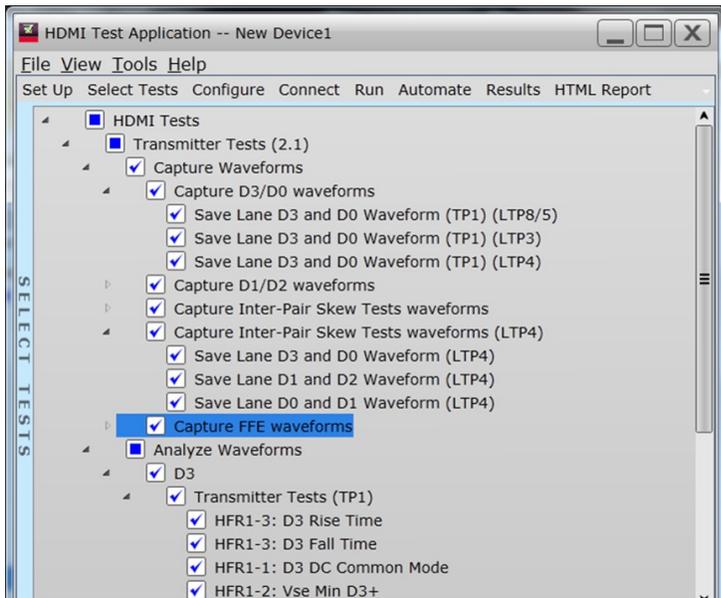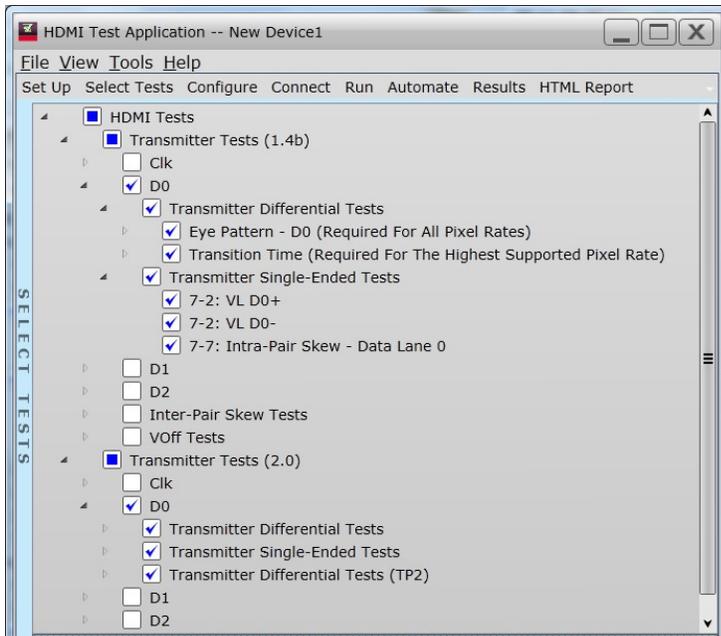

Figure 9. HDMI software application test selection screen

Figure 9 shows two test suites for transmitter tests: HDMI 1.4b and HDMI 2.1. For a device that can perform HDMI 2.1 data rates as well as HDMI 1.4b, the HDMI 2.1 test suite will be shown. If the device is limited to the lower data rates (< 3.4 Gbs), only the HDMI 1.4b tests will be available. For procedures with multiple resolutions, the test plan rules of the software will govern the tests that are run. Test procedures that are performed with only one resolution or timing format will run all tests selected.

Connection Diagram and Instructions

After configuring the tests according to your objectives, you then proceed to the connect tab, which gives detailed information and a pictorial view of how you should connect your device. Figure 10 illustrates the connection diagram for the recommended 4-channel single-ended connection.
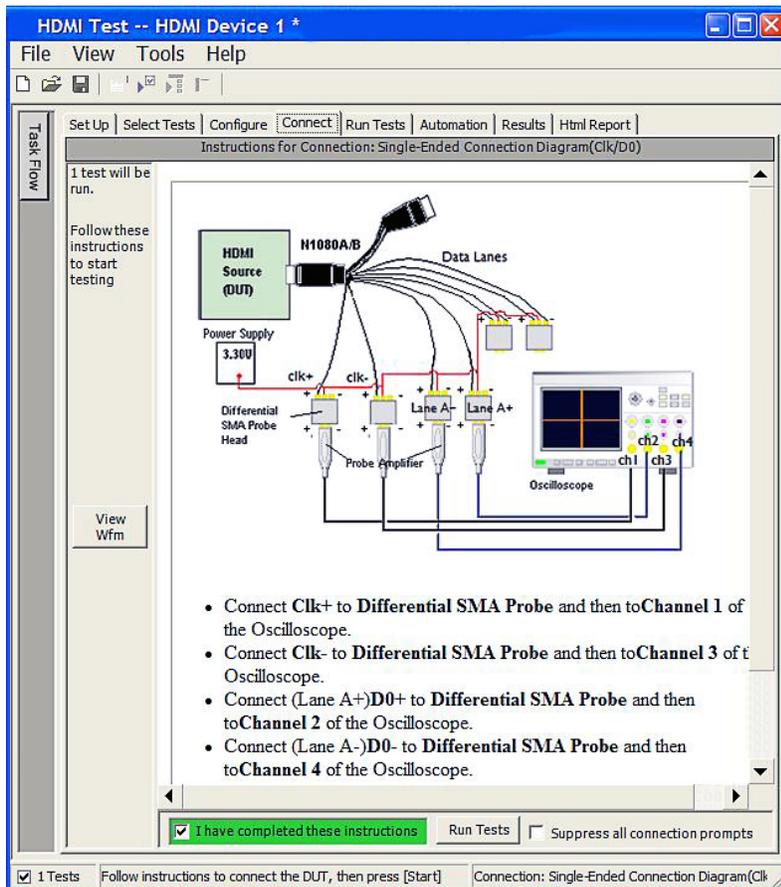

Figure 10. HDMI software application test connection screen

Thorough Performance Reporting

The HDMI electrical performance validation and compliance 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 11a. The HDMI 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 11b. View of the test results summary table. Additional details are available for each test including the test limits, test description and test results (including waveform captures).
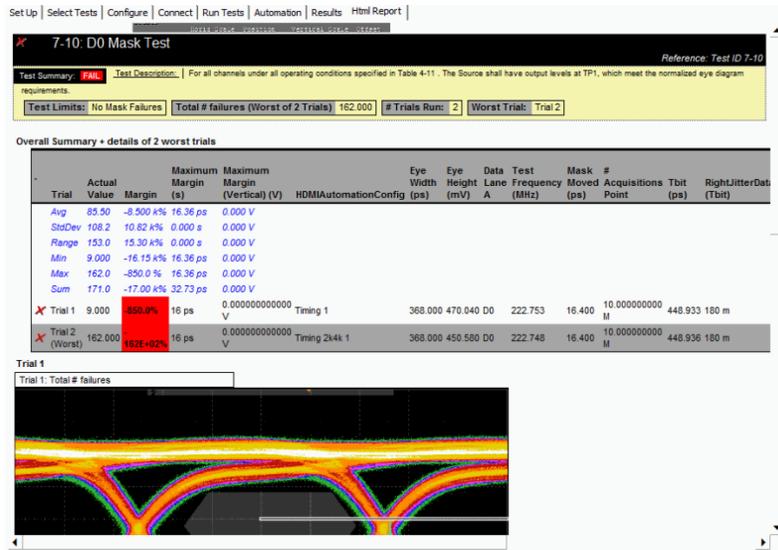
Figure 12. Summary report detail: The HDMI summary report yields all the screen shots of all the measurements that have been performed. In this figure you can see the data-eye. Observe the clear status and description at top and the measurement data just above the eye.

Margin Analysis

In addition to providing you with measurement results, the HDMI 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 specification for a given test assertion.

Margin is calculated:

Single-sided specification:

Margin = (Value$_{Specification}$ − Value$_{actual}$)/Value$_{Specification}$

Double-sided specification:

Margin = lowest of: (Value$_{Specification\_}$High − Value$_{actual}$)/Range$_{Specification}$

and

(Value$_{Specification\_Low}$ − Value$_{actual}$)/Range$_{Specification}$

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.

Figure 13. The HDMI software results report documents your test, indicates the pass/fail status, the test specification range, the measured values, and the margin.

Extensibility

You may add additional custom tests or steps to your application using the user-defined application (UDA) development tool (www.keysight.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
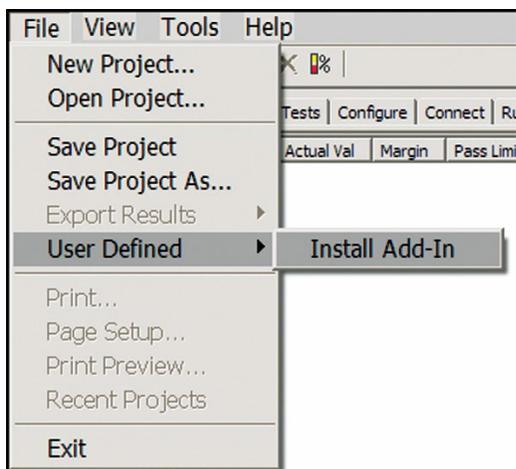
Figure 14. Importing a UDA Add-In into your test application.
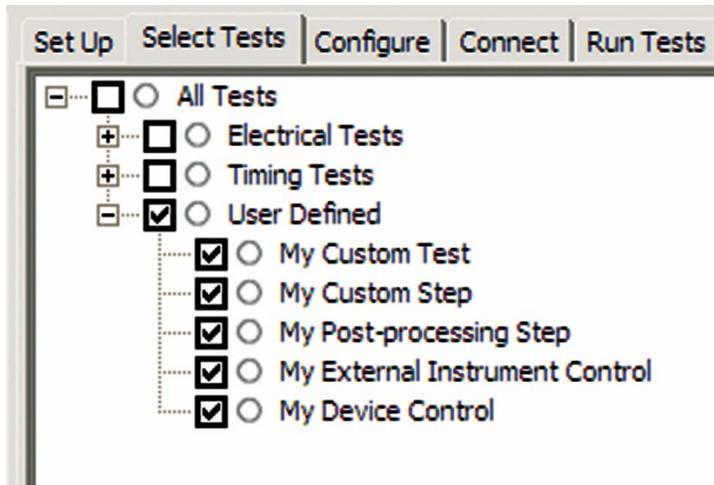
Figure 15. UDA Add-In tests and utilities in your test application.

Automation

You can completely automate execution of your application's tests and Add-Ins from a separate PC using the included remote interface feature (download free toolkit from www.keysight.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 the data 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.
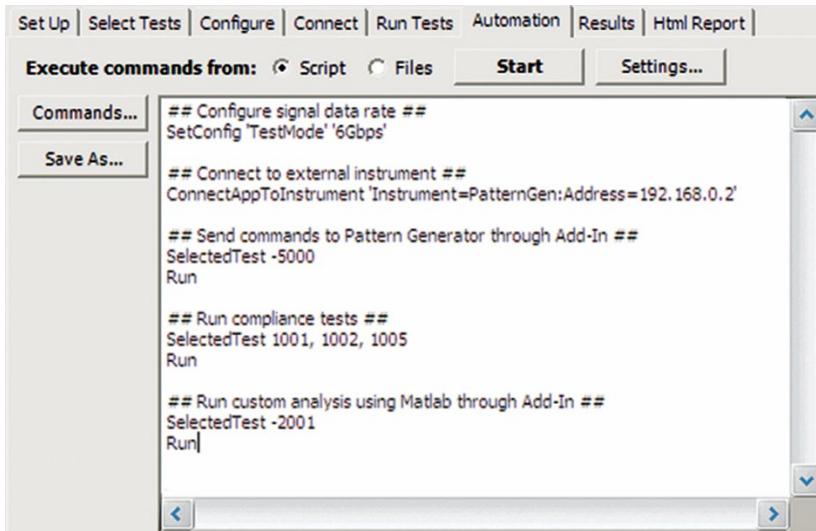
Figure 16. Remote Programming script in the Automation tab.
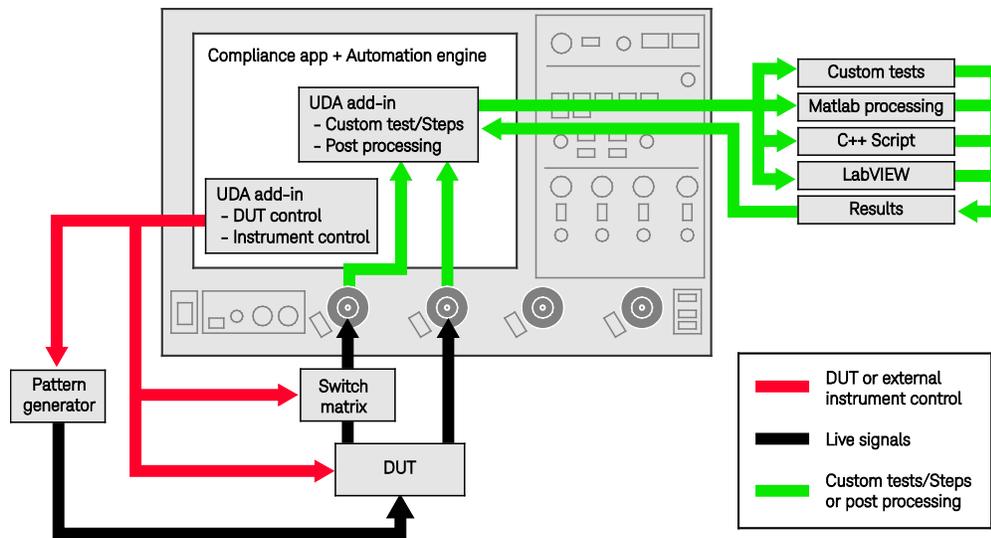
Figure 17. Combine the power of built-in automation and extensibility to transform your application into a complete test suite executive.

Switch Matrix

The Keysight switch matrix software option for the compliance application, used together with switch matrix hardware, enables fully automated testing for multi-lane digital bus interfaces. The benefits of this automated switching solution include:

- Eliminate reconnections, which saves time and reduces errors through automating test setup for each lane of a multi-lane bus.
- Maintain accuracy with the use of unique PrecisionProbe or InfiniiSim features to compensate for switch path losses and skew.
- Customize testing by using remote programming interface and the User-Defined Application tool for device control, instrument control and test customization.

For more information about the switching solution and configuration, visit www.keysight.com/find/switching and the Keysight application note with the publication number 5991-2375EN.

Figure 17. Automated testing for multi-lane digital bus interface through switching solution.

Tests Performed

The HDMI electrical performance validation and compliance software performs the following tests per the HDMI Compliance Test Specifications (CTS 1.4 and 2.1).

HDMI electrical transmitter tests performed by the HDMI EPVC software.

HDMI 1.4b assertion no.	HDMI 2.1 TMDS assertion no.	HDMI 2.1 FRL assertion no.
GCTS1.4b Section 7.0	GCTS2.1 Sources Section 7.1.1	GCTS2.1 Sources Section 8.1.1
Test ID 7.2	Test ID HF 1.1	
Test ID 7.3	—	--
Test ID 7.4	Test ID HF 1.2	Test ID HFR1-3
Test ID 7.6	Test ID HF 1.3	Test ID HFR1-4
Test ID 7.7	Test ID HF 1.4	--
—	Test ID HF 1.5	
Test ID 7.8	Test ID HF 1.6	--
Test ID 7.9	Test ID HF 1.7	--
Test ID 7.10	Test ID HF 1.8	Test ID HFR1.7
--	--	Test ID HFR1.1
--	--	Test ID HFR1.2
--	--	Test ID HFR1.5
--	--	Test ID HFR1.6
--	--	Test ID HFR1.8
--	--	Test ID HFR1.9

Note: The 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 process.

Measurement Requirements

To use the HDMI electrical performance validation and compliance software, you will need an HDMI TPA fixture and at least two InfiniiMax differential probe amplifiers with appropriate SMA probe heads. If you choose to probe HDMI signals not using an HDMI TPA fixture, you will need to select the appropriate probe head for a solder-in or browsed connection. For instance, if the high-speed signals are accessible for testing on board silicon devices, you will need to use a solder-in differential probe head for low loading probing.

Keysight offers different probe connections and the user can choose to minimize cost or to minimize reconnection time. For example, the use of N7010A Active Termination Adapters will give high signal fidelity, low noise, convenient single ended connections at a low cost, where you can evaluate 2 FRL lanes at a time or 1 TMDS data lane at a time (assuming the required TMDS clock connection is made for the eye diagram). Using a switch box to route the signals, no manual reconnections would be required.

Ordering Information
Oscilloscopes

The HDMI electrical performance validation and compliance software is compatible with Keysight Infiniium Series oscilloscopes with operating software revision 6.30 or higher. For oscilloscopes with earlier revisions, free upgrade software is available here: www.keysight.com/find/scope-apps-sw.

Recommended oscilloscope series and bandwidth

HDMI Specification	Minimum Bandwidth	Number of Channels	Compatible Oscilloscopes
HDMI2.1 FRL	20 GHz	4	Infiniium V, Z, and UXR Series
HDMI2.1 TMDS & HDMI1.4b	13 GHz	4	Infiniium V, , Z, and UXR Series
HDMI 1.4b	8 GHz	2	Infiniium S-Series, V-Series, Z series

Required for oscilloscope for HDMI2.1 TMDS

200 MPt memory	Fixed	Factory Installed	DSOV000-200/DSOZ000-200
		User Installed	N2810A -50M, -100, -200 (based on initial scope acquisition memory)

Probes and Probe Amplifiers

Recommended Probes per Infiniium scope family

Probe Component	Infiniium X, V, Z, UXR-Series	Infiniium 90000A Series	Infiniium S-Series
Probe amplifiers (qty 4) [1]	N280xA, N7001/2/3A[2] or 1169B with N5442A adapters, or N7010A Active Termination Adapters [4]	1169B	1169B
Differential SMA probe heads (qty 4) [3]	N5444A (with N280xA or N700XA) or N5380B (only with 1169B)	N5380B	N5380B

1. Quantity 2 for HDMI 1.4b testing is allowed.
2. For HDMI2.1 FRL: N7003A or N7010A or N2803A required
3. N5380B probe heads may be used as terminations as well.
4. N7010A Active Termination Adapters require no differential probe head.

Software

To purchase the HDMI software with a new or existing Infiniium Series oscilloscope, choose from the following options.

Model number	Description	Note
D9021HDMC	HDMI Electrical Performance, Validation and Compliance Test Software	Required
D9020JITA	Jitter, Vertical and Phase Noise Analysis Software	Required for HDMI 2.1 FRL
D9020ASIA	Advanced Signal Integrity Software (EQ, InfiniiSim Advanced)	Required for HDMI 2.1 FRL
D9010DMBA	De-embedding Bundle	Optional for switch path calibrations
D9020SCNA	InfiniiScan Event Identification Software	Optional
KS6810A	Data Analytics software (1 license)	Optional

Connection accessories

HDMI test adapter and termination ordering information

Description	Model Number	Quantity	Comments
Type A connector plug TPA	Select one:		
	HDMIA-TPA-P	1	Available from Wilder Technologies
	BIT-1010-0200-0	1	Available from BitifEye GmbH
Low frequency DDC/CEC/EDID test adapter fixture	Select one:		
	AJSC-1 EDID / SCDC Controller		Allion (**https://www.allion.com/test-fixture/hdmi-scdc-edid-controller/**) – recommended
	BIT-1010-0004-0		Available from BitifEye GmbH
Type D connector plug TPA	BIT-1010-0100-0	1	Order from BitifEye GmbH
Type E connector plug TPA	BIT-1010-0150-0	1	Order from BitifEye GmbH
Power supply	Keysight E3630A or 3640A power supply	1	Or suitable alternative
Power distribution	BitifEye BIT-1003-0000-0	1	Unit supplies DC power to 5 components
Termination	Select one:		
	Wilder HDMI TPA-T	1	HDMI lanes should be terminated to 3.3 V through 50 Ω resistors when not being tested
	Keysight N5380B	1, 2, or 3	
	MiniCircuits ZX85-12G-S+	1 to 6	

Note: BitifEye GmbH is a preferred Keysight integrator.

HEAC, ARC, eARC solutions

HEAC solution ordering information.

Model Number	Description	Quantity
N1080B H04	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 software	1 (Optional)
BIT-HDMI-HEAC	Stand-alone HEAC receiver physical layer and audio protocol test software	1 (Optional)

For HDMI2.1 eARC testing using Keysight test software, order the following:

Name	Product Number	Supplier	Comments
DSGA Dynamic Sequencing Generator and Analyzer	BIT-3000	BitifEye	
Arbitrary Function Generator	81160A	Keysight	
Test Sequencer	N5990A-010	Keysight	
Switch Platform	N5990A-004	Keysight	
RX and TX Test suites	BIT-2011-0351-1	BitifEye	
RX test suite	BIT-2011-0352-0	BitifEye	
HDMI Ethernet Physical Layer Test Board	81150AU-EHD	Keysight	
Power divider	11636B	Keysight	
SMA male 50 Ohm termination	1250-2153	Keysight	
Socketed Probe head	E2678A/B	Keysight	
1134A InfiniiMax 7 GHz Probe	1134A	Keysight	
Precision BNC adapter	N5442A	Keysight	
DSGA Dynamic Sequencing Generator and Analyzer	BIT-3000	BitifEye	
Arbitrary Function Generator	81160A	Keysight	
Test Sequencer	N5990A-010	Keysight	
Switch Platform	N5990A-004	Keysight	

Test Accessories

Recommended general purpose test accessories.

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)
5061-5311	3.5 mm (f - f) connector adapter
1250-1694	SMA (m) to SMA (f) Adapter
N1021-60003	2.92 mm (m) to 2.92 mm (m) phase matched cable pair, 1 m, < 5 ps
1810-0118	SMA (m) 50 Ω 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 GmbH. www.bitifeye.com
BIT-GEN-SCK-0010	Snap on connector kit from BitifEye GmbH. www.bitifeye.com
BIT-HDMI-HEHD-0001	HEC and ARC test accessory kit

Product Web Site

For the most up-to-date and complete application and product information, please visit our product Web site at: www.keysight.com/find/scope-app

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