

D902xHDMC HDMI Tx Electrical Performance Validation and Compliance Software

For Infiniium Series Oscilloscopes



Complete Physical Layer Testing for HDMI 1.4, HDMI 2.1, and HDMI 2.2

Keysight's HDMI Tx electrical performance validation and compliance software, D9021HDMC for HDMI 1.4 and HDMI 2.1, along with D9022HDMC for HDMI 2.2, offers a complete test execution environment for validating and troubleshooting the electrical performance of HDMI source devices. The D902xHDMC PHY compliance test software, which uses a new licensing model, operates on the Keysight industry-performance-leading Infiniium oscilloscope hardware, and 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 the product is a DVD player, computer, graphics card, or any of the many other 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 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 HDMI specifications (HDMI 1.4b, HDMI 2.1, and HDMI 2.2). Using the HDMI Electrical Performance Validation and Compliance (EPVC) software during the development and pre-compliance stages will give you confidence in achieving a successful test outcome at the HDMI ATC. Upon completion, you may become an HDMI self-certifier, utilizing the same documented test processes and equipment.

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Features

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

- Specification selections (HDMI 1.4b, HDMI 2.1 TMDS, HDMI 2.1 Fixed Rate Link, HDMI 2.2 Fixed Rate Link).
- Complete test suites for HDMI: HDMI 1.4, HDMI 2.1 TMDS test, HDMI 2.1 Fixed Rate Link, HDMI 2.2 Fixed Rate link devices. HEAC (Ethernet/Audio return channel) and eARC (available through N5991A 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.

Easy-to-Use HDMI EPVC Software

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.

Time-Saving HDMI EPVC Software

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 and HDMI 2.2, 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: Key Differences from HDMI 1.4 and HDMI 2.0

High Definition Multimedia Interface (HDMI)

Figure 1 shows the 19-pin interface of HDMI, 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 the audio return channel.

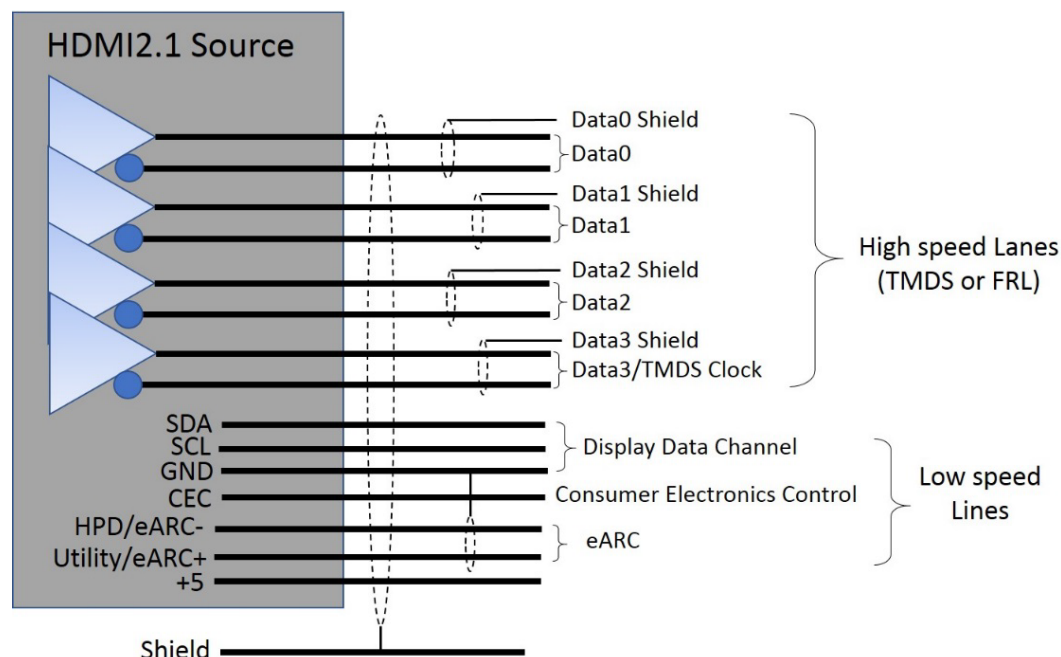


Figure 1. HDMI 2.1 source

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 ANSI 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 HDMI 2.1 specification, released in the year 2017, 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.

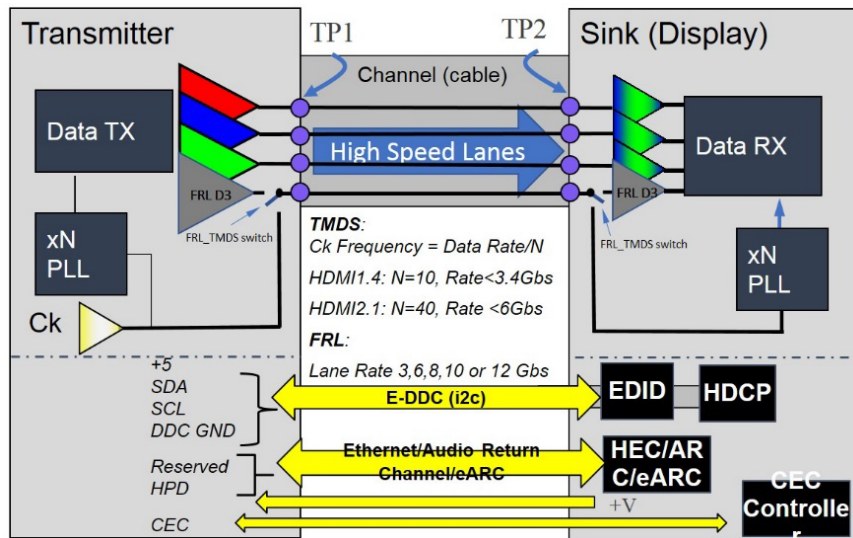


Figure 2. HDMI system

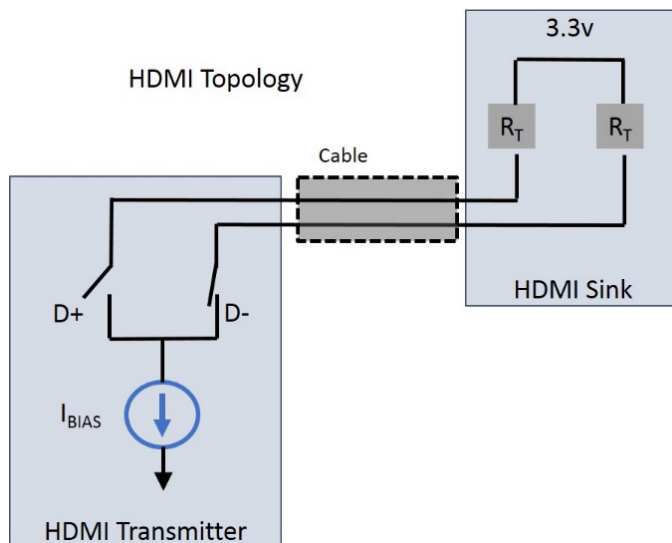


Figure 3. HDMI TMDS lane topology

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 uses 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 on page 26 identifies the TPAs to use with the Keysight HDMI compliance software (see Figure 12 for an illustration). A simplified illustration of how HDMI signals are accessed by the measurement system is shown below 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.

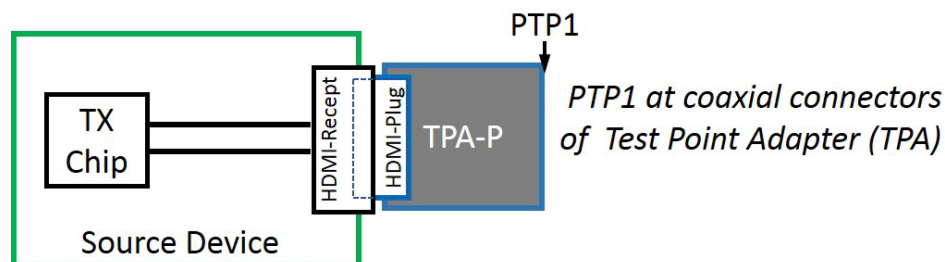


Figure 4. Updated TPA: illustrating acquisition at Practical Test Point 1 (PTP1)

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 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 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.

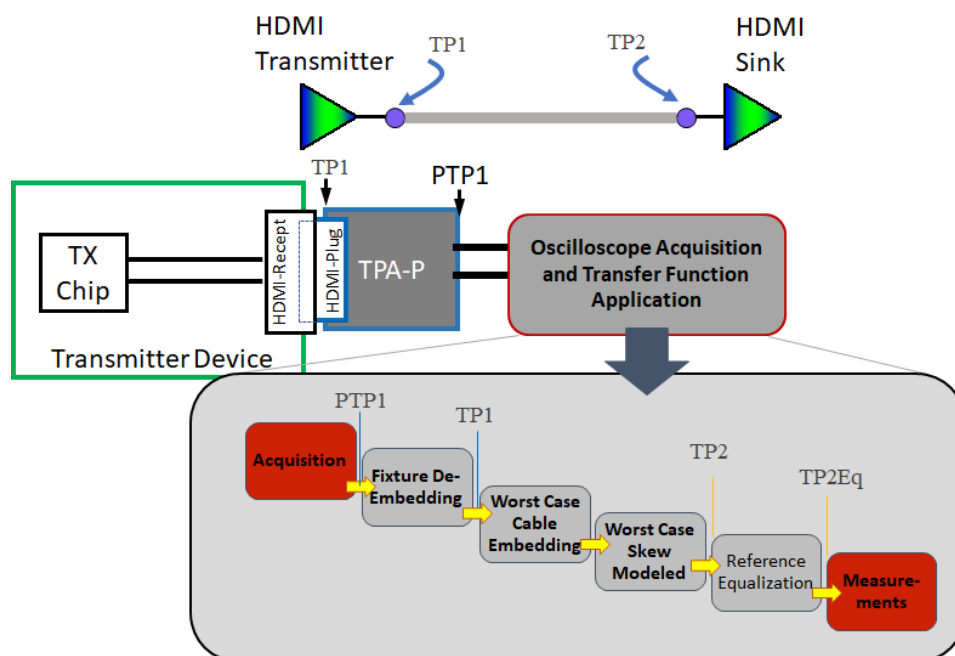


Figure 5. Test points and signal processing in HDMI

To validate a transmitter, 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 the following:

- 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 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.

In Brief: HDMI 2.2 – Key Differences from HDMI 2.1

HDMI 2.2, with its specification release in 2025, is an evolution of HDMI 2.1 FRL. The per lane rate has increased from 3, 6, 8, 10, or 12 Gbps to 16, 20, or 24 Gbps, while maintaining NRZ modulation. The four lanes, at 24 Gbps per lane, allow for a 96 Gbps data channel, making HDMI 2.2 synonymous with the term Ultra96 HDMI®.

Physical layer testing for HDMI 2.1 and 2.2 remains largely similar, albeit with increased data rates, with notable exceptions in the form of minor modifications to the methods of testing the data eye diagram and transmitter feed-forward equalization (TxFFE).

The HDMI EPVC Software

Getting Started

Launching the HDMI EPVC software is the same regardless of whichever or all D902xHDMC licenses are installed. To launch the HDMI EPVC software from the Infiniium interface, go to **Analyze > Automated Test Apps > D9021HDMC HDMI Test App**.

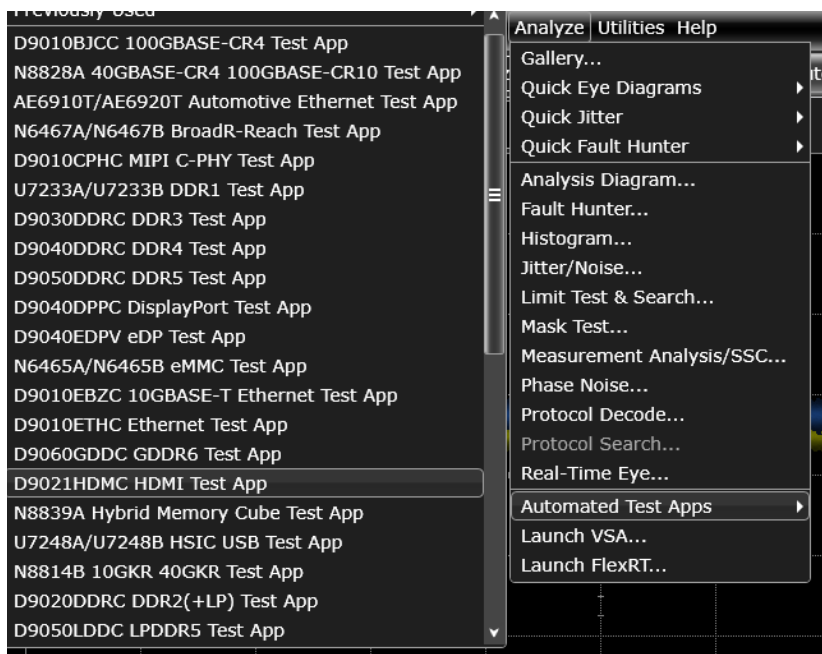


Figure 6. Launching the HDMI EPVC software

If a valid version of the **D9021HDMC** license is installed, you will see the following options on the **HDMI Test Type** drop down menu:

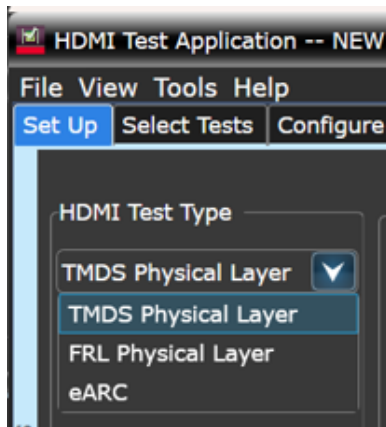


Figure 7. Drop down menu with valid D9021HDMC license installed

If a valid version of the **D9022HDMC** license is installed, you will see the following option on the **HDMI Test Type** drop down menu:

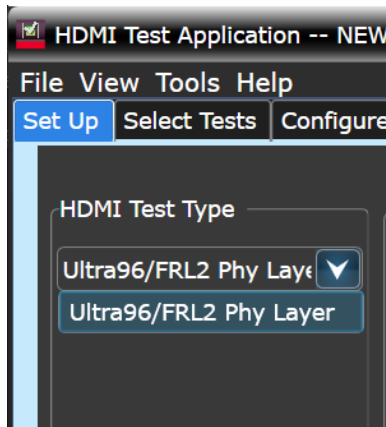


Figure 8. Drop down menu with valid D9022HDMC license installed

If a valid version of both the **D9021HDMC** and **D9022HDMC** licenses are installed, you will see the following options on the **HDMI Test Type** drop down menu:

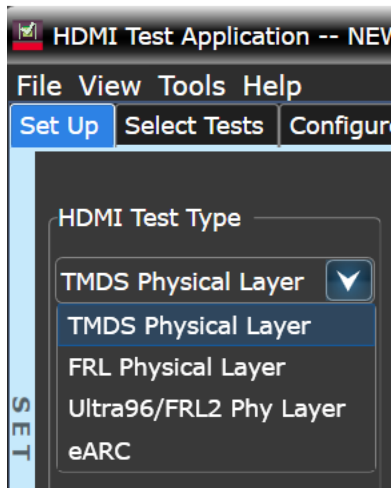


Figure 9. Drop down menu with valid D9021HDMC and D9022HDMC licenses installed

Using the HDMI EPVC Software

The HDMI software logically guides the user through the test process. As shown in Figure 10 below, the graphical user interface is designed to glean test process and device under test information from the user to efficiently carry out the testing. The user will know the device type (which determines the test suite) and which specification applies (HDMI 1.4b, HDMI 2.1 TMDS, HDMI 2.1 FRL, or HDMI 2.2 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 shown in Figure 13.

Select **HDMI 2.1 FRL** to view HDMI 2.1 FRL tests and **HDMI 2.2/Ultra96** to view HDMI 2.2 FRL tests.

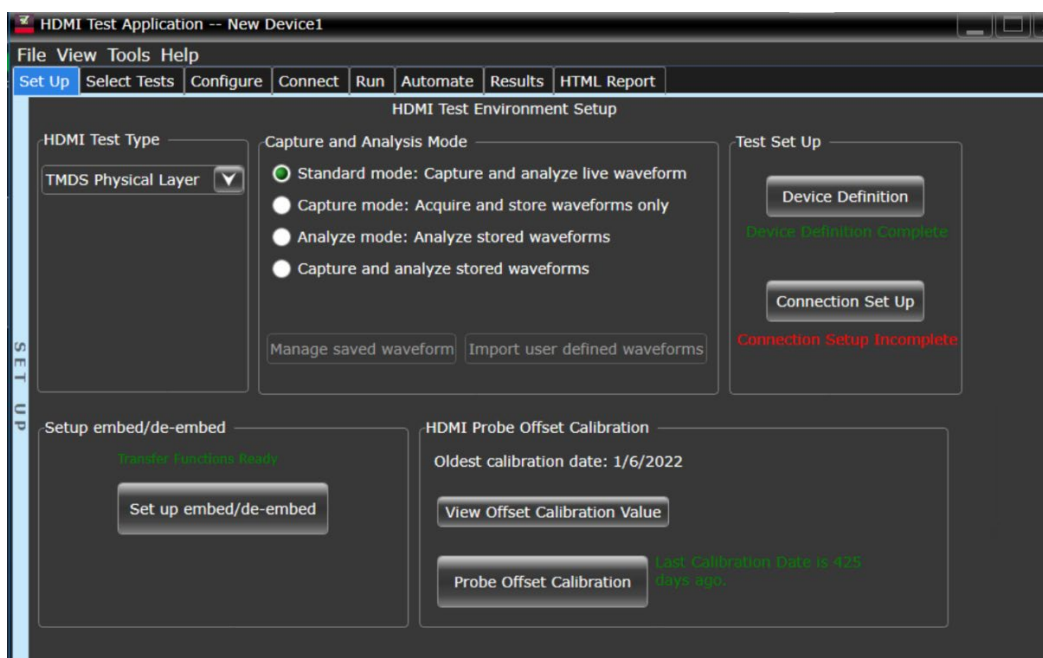


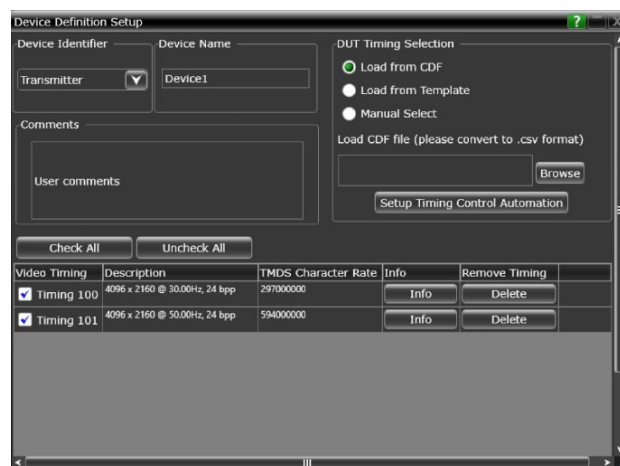
Figure 10. HDMI software application entry screen

The Keysight HDMI validation software now offers device definition and connection setup tabs on the setup screen, as seen in Figure 10. These tabs are labeled with a colored status: red indicates that the user must complete some actions before proceeding, while 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

The information entered in the device definition screen is used to create a test plan for the device. 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 several formats entered in TMDS have the same bit rate, only one format is tested at that bit rate. Furthermore, some tests are only run on the lowest bit rates whilst other tests are run at the highest bit rate.



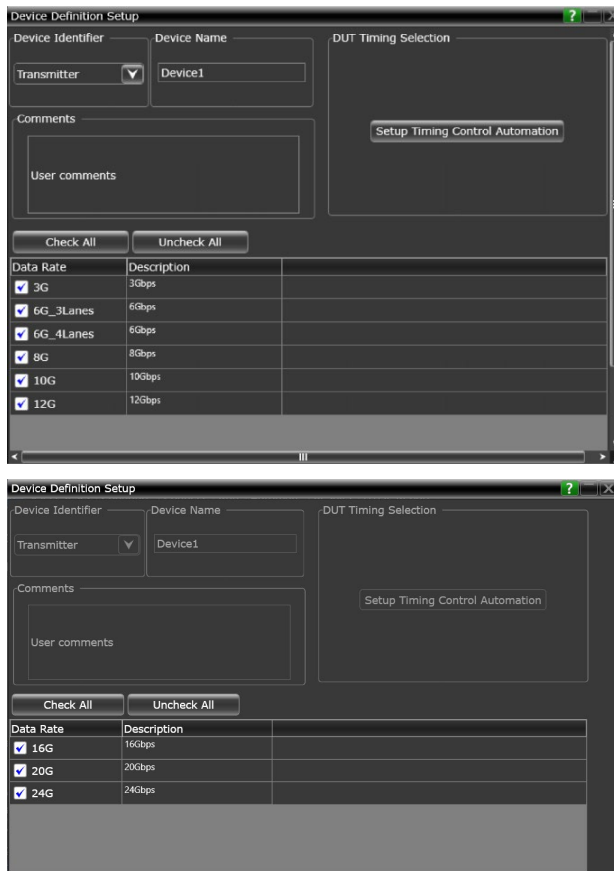


Figure 11. HDMI software application definition screens for HDMI 2.1 TMDS, HDMI 2.1 FRL, and HDMI 2.2 FRL

The device definition screen supports standard DUT identification and test comments. You can now also define the timings/resolutions for each test by:

- Using the capability declaration form (CDF).
- Using a previously stored template.
- Using the default setup (which you can define).
- Adding your own custom timing.
- 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.

User Connection Setup

Test Fixture Type
Wilder HDMI2.1 TPA-P

Test Fixture

Probe Type
N5444A/N700XA

Probe Type

Probe Connection
☒ 2 Probes
☐ 4 Probes

Channel Selection

Lane Connection
☐ 1 Data Lane
☒ 3 Data Lanes

Switch Matrix
Status: Not Connected
If using the BIT 2100 switchbox please enter the module number assignments:
D+ Module (SP4T): 3
D- Module (SP4T): 5

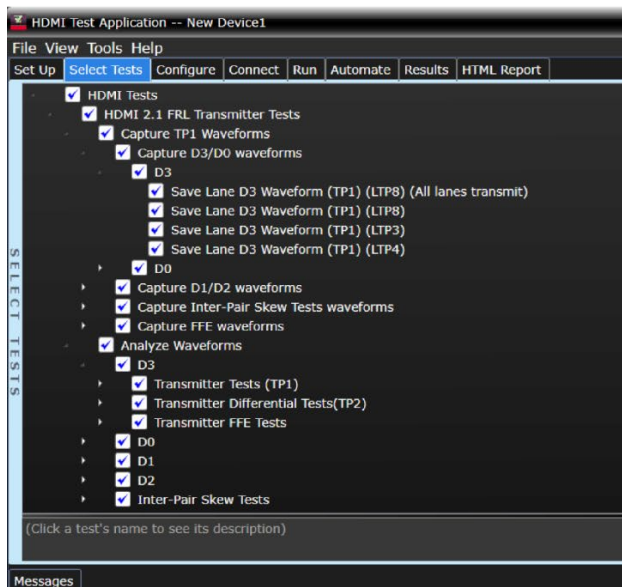
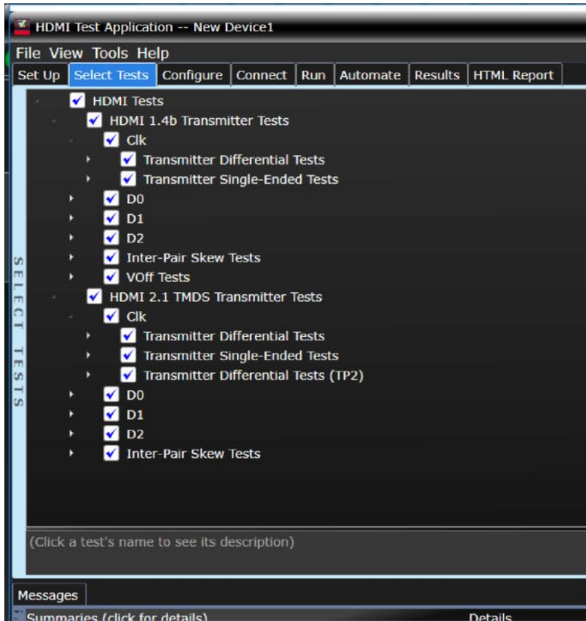
Switch Matrix

Figure 12. HDMI software application test connection screen

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.

Test Selection

After completing the DUT definition and test connection, you are ready to make test selections. Click on the **Select Tests** tab to select the tests you wish to run.



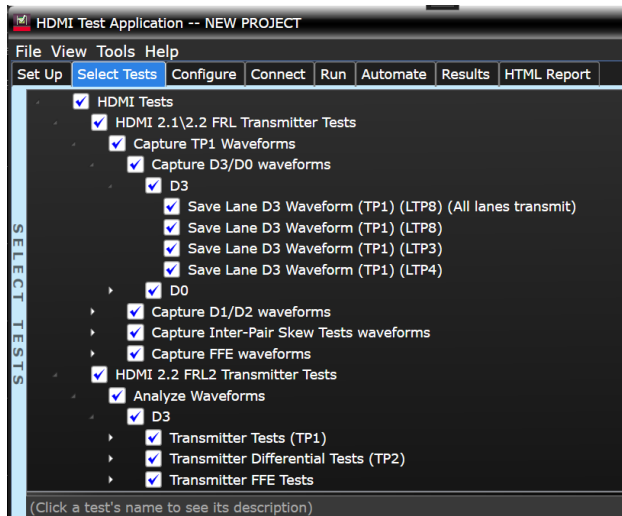


Figure 13. HDMI software application test selection screen

Figure 13 shows three test suites for transmitter tests: HDMI 1.4b, HDMI 2.1, and HDMI 2.2. Information filled in during the device definition stage will determine the test lists that appear. For procedures with multiple resolutions, the test plan rules of the software will govern which tests are executed. Test procedures 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, proceed to the connect tab, which gives detailed information and a pictorial view of how you should connect your device. Figure 14 illustrates the connection diagram for the recommended 4-channel single-ended connection.

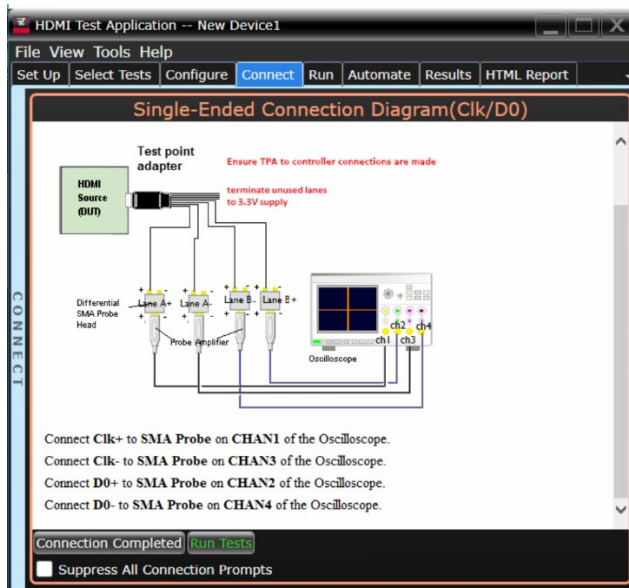


Figure 14. HDMI software application test connection screen

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 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.

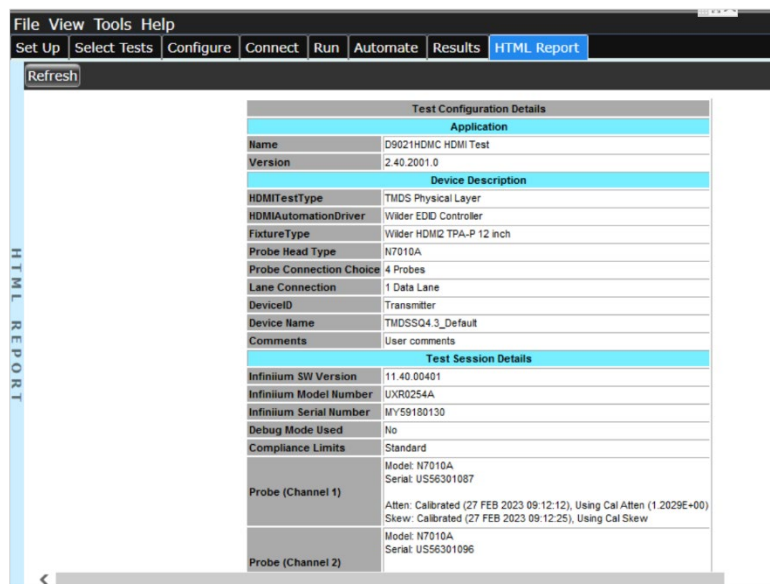


Figure 15. The HDMI software generates a summary report where you can see the total test results for your device quickly and clearly. This is the title page illustrating the important session information regarding the connection, device, and measurement equipment.

Summary of Results	
Test Statistics	
Failed	0
Passed	84
Total	90
Margin Thresholds	
Warning	< 10 %
Critical	< 0 %

✓	0	1	HF1-8: Clock Only Cycle/Maximum	58.102	16.6 %	<=80%
✓	0	1	HF1-8: Clock Rate	148.499745000 MHz	2.3 %	85.000000000 MHz <= VALUE <= 150.000000000 MHz
✓	0	1	HF1-1: V _A Clock +	2.801 V	37.4 %	2.300 V <= VALUE <= 3.100 V
✓	0	1	HF1-1: Clock + V _{Swing}	404 mV	49.0 %	200 mV <= VALUE <= 600 mV
✓	0	1	HF1-1: V _A Clock -	2.802 V	37.3 %	2.300 V <= VALUE <= 3.100 V
✓	0	1	HF1-1: Clock - V _{Swing}	401 mV	49.8 %	200 mV <= VALUE <= 600 mV
✓	0	1	HF1-4: Intra-Pair Skew - Clock	55 mTbit	31.3 %	-150 mTbit <= VALUE <= 150 mTbit
✓	0	1	HF1-7: Differential Clock Voltage Swing - V _A (TP1)	801 mV	49.0 %	400 mV <= VALUE <= 1,200 V
✓	0	1	HF1-7: Clock After (TP2: EQ with Worst Case Positive Skew)	95 mTbit	70.0 %	VALUE <= 300 mTbit
✓	0	1	HF1-7: Clock After (TP2: EQ with Worst Case Negative Skew)	159 mTbit	66.7 %	VALUE <= 300 mTbit
✓	0	1	HF1-8: DQ Minimum Differential Voltage	479 m	39.4 %	VALUE <= 750 m
✓	0	1	HF1-8: DQ Minimum Differential Voltage	-477 m	38.5 %	VALUE <= -750 m
✓	0	1	HF1-8: DQ Rise Time	33.696 ps	99.9 %	VALUE <= 42,500 ps
✓	0	1	HF1-8: DQ Fall Time	37.030 ps	104.8 %	VALUE <= 42,500 ps
✓	0	1	HF1-1: V _A DQ	2.823 V	12.6 %	2.300 V <= VALUE <= 2.900 V
✗	1	1	HF1-1: DQ - V _{Swing}	358 mV	31.6 %	400 mV <= VALUE <= 600 mV
✓	0	1	HF1-1: V _A DQ	2.823 V	12.6 %	2.300 V <= VALUE <= 2.900 V
✗	1	1	HF1-1: DQ - V _{Swing}	357 mV	31.6 %	400 mV <= VALUE <= 600 mV
✓	0	1	HF1-4: Intra-Pair Skew - Data Lane 3	27 mTbit	41.0 %	-150 mTbit <= VALUE <= 150 mTbit
✓	0	1	HF1-8: DQ Mask Test (TP2: EQ with Worst Case Positive Skew)	0.000	50.0 %	No Mask Failures

Figure 16. 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).

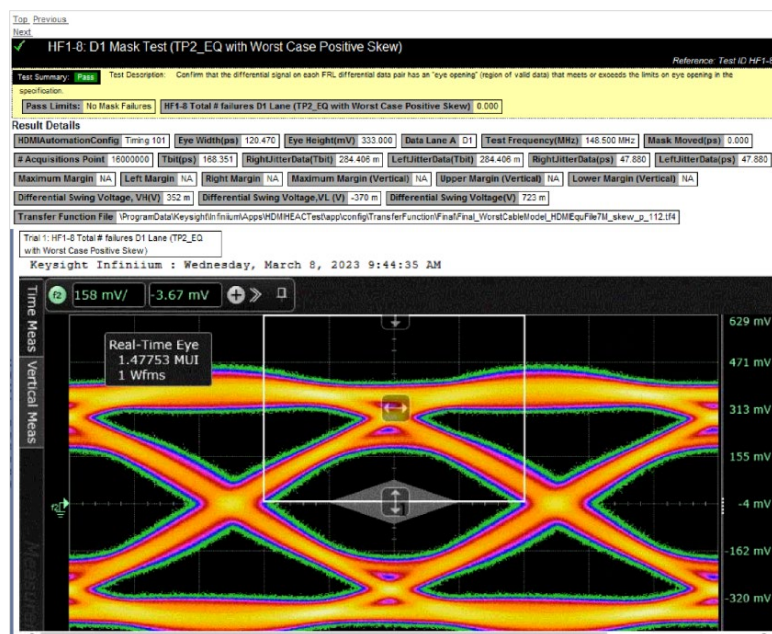


Figure 17. Summary report detail: The HDMI summary report yields all the screen shots of all the measurements that have been performed. In this figure you can see the data eye. Observe the clear status and description at top and the measurement data just above the eye.

Margin Analysis

In addition to measurement results, the HDMI test software also 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 as follows:

Single-sided specification

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

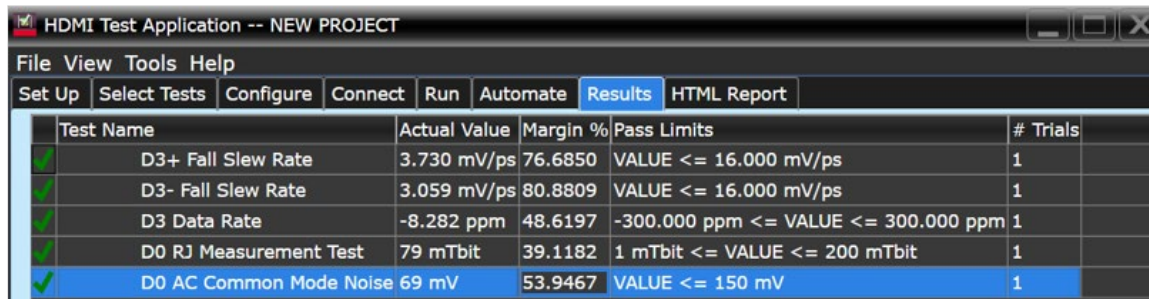
Double-sided specification

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

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.



Test Name	Actual Value	Margin %	Pass Limits	# Trials
D3+ Fall Slew Rate	3.730 mV/ps	76.6850	VALUE <= 16.000 mV/ps	1
D3- Fall Slew Rate	3.059 mV/ps	80.8809	VALUE <= 16.000 mV/ps	1
D3 Data Rate	-8.282 ppm	48.6197	-300.000 ppm <= VALUE <= 300.000 ppm	1
D0 RJ Measurement Test	79 mTbit	39.1182	1 mTbit <= VALUE <= 200 mTbit	1
D0 AC Common Mode Noise	69 mV	53.9467	VALUE <= 150 mV	1

Figure 18. The HDMI software results report documents the 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.

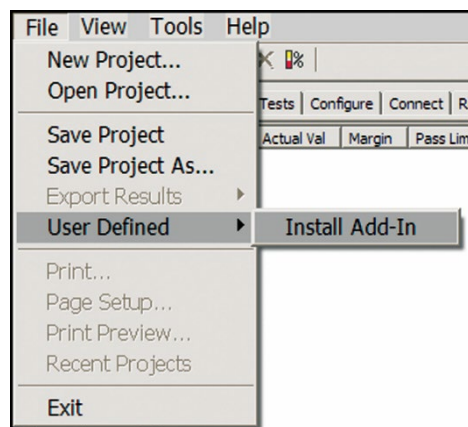


Figure 19. Importing a UDA Add-In into your test application

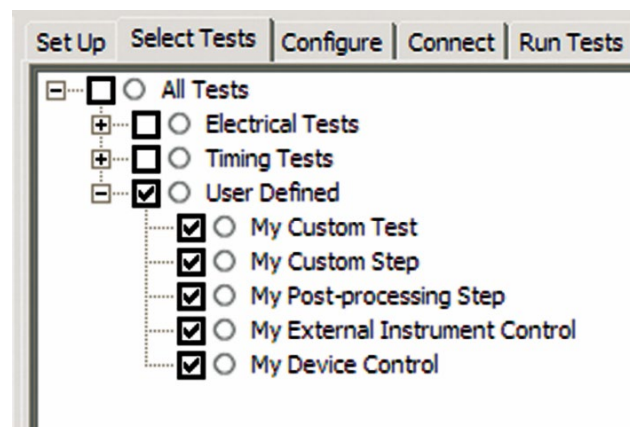


Figure 20. UDA Add-In tests and utilities in your test application

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 the 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.

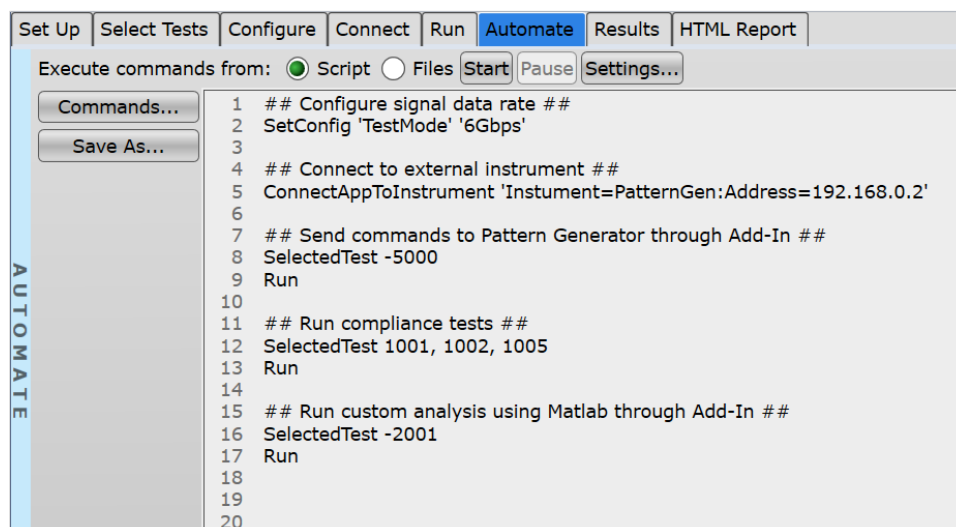


Figure 21. Remote Programming script in the Automation tab

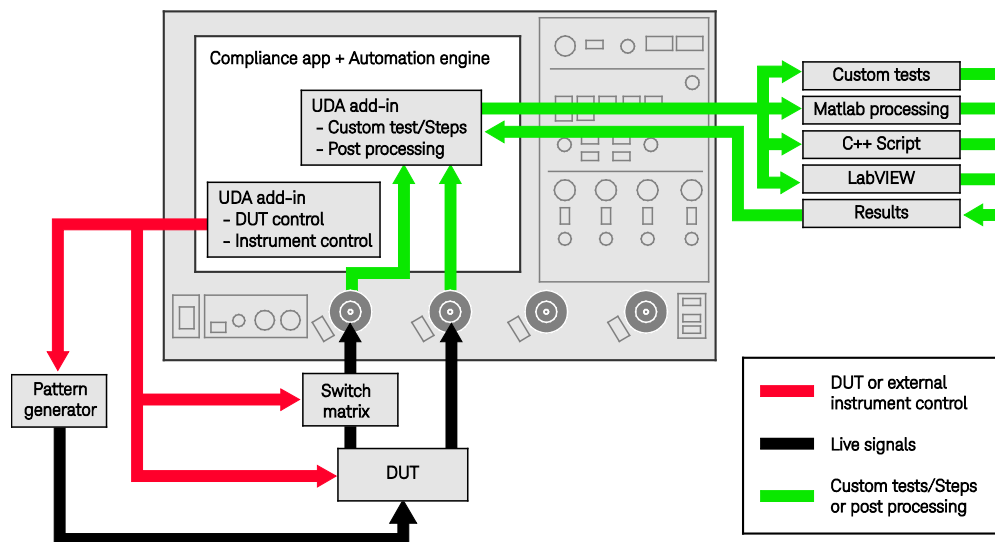


Figure 22. Combine the power of built-in automation and extensibility to transform your application into a complete test suite executive.

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.

Keysight's recommended switch for HDMI compliance test usage is BitifEye's BIT2100 series switch. Navigate to **Home > Products > Switching Solutions** and click on the **HDMI Source/Cable** tab for more information on the BitifEye webpage.

For proper setup and usage, refer to the [BIT2100 Switch with D9021HDMC HDMI Compliance App User's Guide](#).

Alternatively, you may contact your local Keysight representative for more information.

Tests Performed

The HDMI electrical performance validation and compliance software performs the following tests per the HDMI Compliance Test Specifications (CTS 1.4, 2.1, and 2.2).

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.	HDMI 2.2 FRL Ultra96 Assertion No.
GCTS1.4b Section 7.0	GCTS2.1 Sources Section 7.1.1	GCTS2.1 Sources Section 8.1.1	TBD
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 HFB 1.3
Test ID 7.6	Test ID HF 1.3	Test ID HFR1.4	Test ID HFB 1.4
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 HFB 1.7
—	—	Test ID HFR1.1	Test ID HFB1.1
—	—	Test ID HFR1.2	Test ID HFB1.2
—	—	Test ID HFR1.5	Test ID HFB1.5
—	—	Test ID HFR1.6	Test ID HFB1.6
—	—	Test ID HFR1.8	Test ID HFB1.8
—	—	Test ID HFR1.9	Test ID HFB1.9

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 processes.

Measurement Requirements

To use the HDMI electrical performance validation and compliance software, you will need a suitable 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 that you 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, and convenient single ended connections at a low cost, where you can evaluate two FRL lanes at a time or one TMDS data lane at a time (assuming the required TMDS clock connection is made for the eye diagram). No manual reconnections are required when using a switch box to route the signals.

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, the 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
HDMI 2.2 FRL	25 GHz	4	Infiniium UXR Series
HDMI 2.1 FRL	20 GHz	4	Infiniium V, Z, UXR Series
HDMI 2.1 TMDS and HDMI 1.4b	13 GHz	4	Infiniium V, Z, UXR Series
HDMI 1.4b	8 GHz	2	Infiniium S-Series, V-Series, Z series

Required for Oscilloscope for HDMI 2.1 TMDS

200 MPt memory	Fixed	Factory installed	DSOV000-200/DSOZ000-200
		User installed	N2810A -50M, -100, -200 (based on initial scope acquisition memory)
500 MPt memory recommended		User installed	N2810A-500 is highly recommended to reduce test time for some newer TMDS tests

Probes and Probe Amplifiers

Recommended probes per Infiniium scope family:

Probe Component	Infiniium V, Z, UXR-Series	Infiniium S-Series
Probe amplifiers (qty 4) ¹	N280xA, N7001/2/3A ² , MX002xA ³ or 1169B with N5442A adapters, or N7010A Active Termination Adapters ⁴	1169B
Differential SMA probe heads (qty 4)	N5444A (with N280xA or N700XA), MX0105A ⁵ (with MX002xA) or N5380B ⁶ (only with 1169B)	N5380B

- Quantity 2 for HDMI 1.4b testing is allowed.
- For HDMI 2.1 FRL: N7003A or N7010A or N2803A is required.
- MX002xA where MX0021A/22A can be used for TMDS, MX0024A/25A can be used for FRL and TMDS. MX0023A is not recommended.
- N7010A Active Termination Adapters require no differential probe head. The N7010A is the only available choice for HDMI 2.2.
- For MX0105A with MX0021/22/24/25A probes, ensure you use an internal oscilloscope 3.3 V termination source. Conversely, when used with the MX0023A, use an external 3.3 V termination source.
- The N5380B probe heads have entered discontinuance. It is highly recommended to migrate to newer probe and probe head combinations. The 1169B + MX0105A combination is not approved for HDMI MOIs and is not recognized as a suitable replacement.

Software

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

Model Number	Description	Note
D9022HDMC	HDMI Electrical Performance Validation and Compliance Test Software	Required for HDMI 2.2
D9021HDMC	HDMI Electrical Performance Validation and Compliance Test Software	Required for HDMI 1.4, HDMI 2.1
D9020JITA	Jitter, Vertical and Phase Noise Analysis Software	Required
D9020ASIA	Advanced Signal Integrity Software (EQ, InfiniiSim Advanced)	Required
D9010DMBA	De-embedding Software	Required if BitfEye BIT2100 switch is used Optional if no switch is used
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
HDMI 2.2 Type A connector plug TPA	Select one:		
	▪ TBA	1	Available from Wilder Technologies
	▪ BIT-1010-0520-0	1	Available from BitifEye GmbH
HDMI 2.1 Type A connector plug TPA	Select one:		
	▪ HDMI-A-TPA-P	1	Available from Wilder Technologies
	▪ SP0612A	1	Available from Keysight
	▪ BIT-1010-0420-0	1	Available from BitifEye GmbH
	▪ BIT-1010-0400-0	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-1016-0010-1		Available from BitifEye GmbH
Power supply	Keysight E3630A or 3640A power supply	1	Or a suitable alternative
Power distribution	BitifEye BIT-1003-0001-0	1	GP Power Distribution Kit, 10 SMB Ports
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
	▪ BIT-1010-0007-0	1	HDMI lanes should be terminated to 3.3 V through 50 Ω resistors when not being tested

NOTE: BitifEye GmbH is a preferred Keysight integrator.

HEAC, ARC, and eARC Solutions

Please refer to the Keysight N5991HE1A HDMI eARC Compliance Test Software page.

HDMI Rx Solutions

Please refer to the Keysight N5991HP1A HDMI 2.1 Receiver Compliance Test Software page.

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 Website

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

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Keysight offers a variety of flexible licensing options to fit your needs and budget. Choose your license term, license type, and KeysightCare software support subscription.

License Terms

Perpetual – Perpetual licenses can be used indefinitely.

Time-based – Time-based licenses can be used through the term of the license only (6, 12, 24, or 36 months).

License Types

Node-locked – License can be used on one specified instrument/computer.

Transportable – License can be used on one instrument/computer at a time but may be transferred to another using Keysight Software Manager (Internet connection required).

USB Portable – License can be used on one instrument/computer at a time but may be transferred to another using a certified USB dongle (available for additional purchase with Keysight part number E8900-D10).

Floating (single site) – Networked instruments/computers can access a license from a server one at a time. Multiple licenses can be purchased for concurrent usage.

KeysightCare Software Support Subscription Provides Peace of Mind Amid Evolving Technologies

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KeysightCare Software Support Subscriptions

Perpetual licenses are sold with a 12 (default), 24, 36, or 60-month software support subscription. Support subscriptions can be renewed for a fee after that.

Time-based licenses include a software support subscription through the term of the license.

Selecting Your License:

Step 1. Choose your software product (e.g. S1234567A).

Step 2. Choose your license term: perpetual or time-based.

Step 3. Choose your license type: node-locked, transportable, USB portable, or floating.

Step 4. Depending on the license term, choose your support subscription duration.

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