



Keysight Technologies

HDMI and DisplayPort Design and Test – A Better Way

Thorough characterization and validation
of your display designs

New Challenges

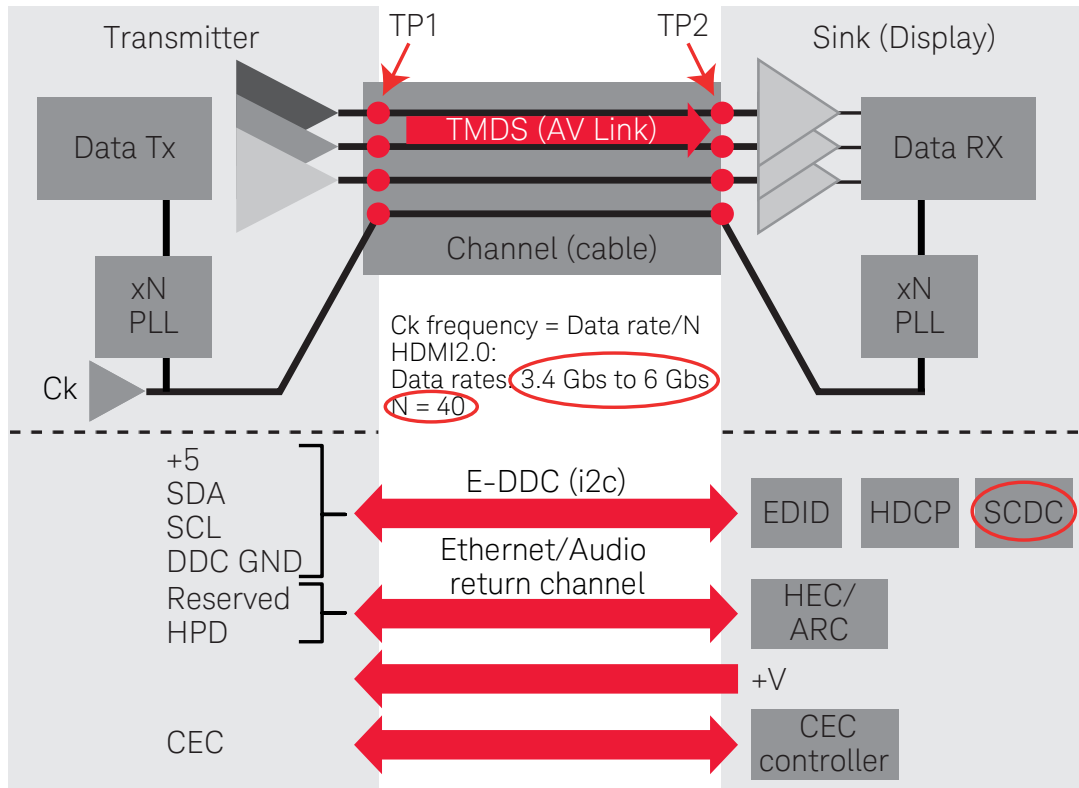


Figure 1 – Test points – source, media, and sink

The High-Definition Multimedia Interface (HDMI) and DisplayPort (DP) interfaces are being implemented broadly in devices from high-definition televisions to personal computers to set-top boxes. The overwhelming concern for developers of these products is interoperability. Interoperability starts with the physical layer where the digital content is driven from one device through media such as a cable to a receiving device. Tools to measure the parameters of these devices are required to understand if the device is in compliance, or how close the device's performance is to the specification.

HDMI Compliance Test Specification (CTS) 1.4a introduced increased functionality that reduced the amount of cabling used in a quality digital video and audio setup.

HDMI 2.0, developed by the HDMI Forum's Technical Working Group, is backward compatible with earlier versions of the HDMI specification and significantly increases transmission bandwidths up to 18 Gbps. Since the transmission rate of HDMI 2.0 is almost double that of HDMI 1.4, interoperability issues due to signal quality distortions introduce new technical requirements for compliance testing of HDMI 2.0 sink and source devices.

Some of the other features include 4K@50/60, which is 4 times the clarity of 1080p/60 video resolution, up to 32 audio channels for a multi-dimensional immersive audio experience, simultaneous delivery of dual video streams to multiple users on the same screen, dynamic synchronization of video and audio streams, CEC extensions providing expanded command, and control of consumer electronics devices through a single control point.

With high speed signals, new functionalities for HDMI, and display technologies being used in devices ranging from computers, to home use, portable electronics, and automotive applications, it is important to have a test solution capable of fully testing all aspects and compliance of these devices to ensure interoperability across all uses and platforms. Keysight offers comprehensive display solutions specific to your needs.

Key tasks

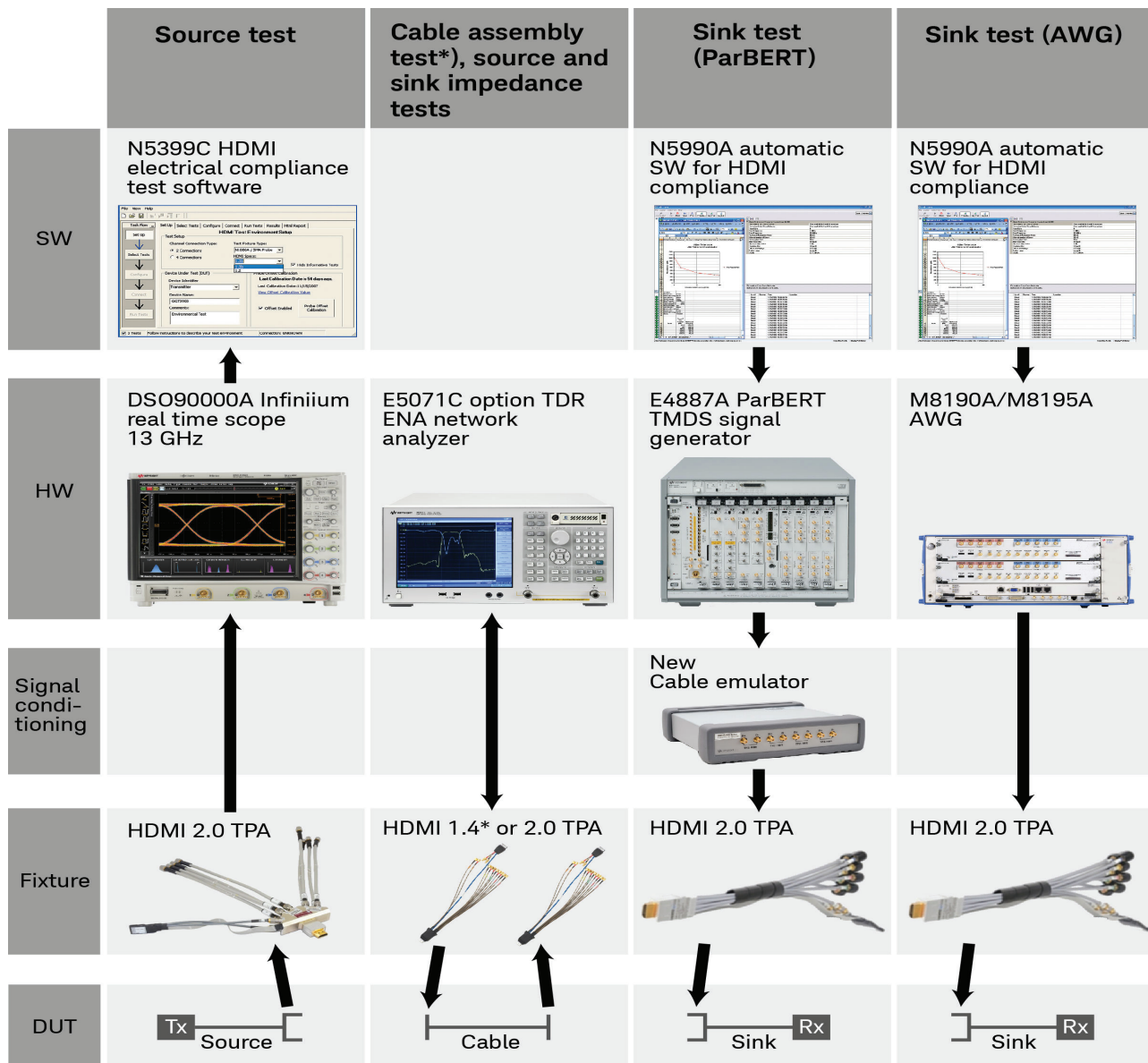
HDMI and DisplayPort characterization can be segmented into multiple areas: source design and test, sink design and test, media physical layer design and evaluation. In each of these areas, the HDMI CTS and VESA for DisplayPort, has recommended procedures, methods, and equipment to perform these tests. In many cases, there are multiple methods, tools or processes to get the job done. The deciding factors on which method to use may be your comfort level with a particular measurement tool, cost, and/or convenience. Keysight offers solutions in each area to meet your needs (see Figure 2).

Applying expertise

When it comes to quality digital measurements and signal integrity, Keysight has decades of experience in RF, microwave and protocol engineering. We understand the reflections, skin effect, insertion and return loss, impedance profiles as well as jitter budget and tolerance, timing margins, compliance and other issues that digital designers and developers have to face in high data rate standards.

With consistent participation in workshops and specification issues and definition, Keysight has a solid background in the physical layer, protocol layer and functional test of HDMI and DisplayPort devices.

Thanks to its premier position as a test company, Keysight also has a long history of collaborative innovation with industry leaders. The expertise of Keysight's Application Engineering team reflects these important experiences. They also put Keysight in a position to develop tools that meet the physical challenges, are customized to the needs of the standard, and are relevant to the way designers and developers need to use them.



Keysight gets involved, you benefit

Keysight's solutions for digital applications are driven and supported by Keysight experts who are involved in various international standard committees. We call it the Keysight Digital Test Standards Program. Our experts are active in the Joint Electronic Devices Engineering Council (JEDEC), PCI-SIG® Video Electronics Standards Association (VESA), Serial ATA International Organization (SATA-IO), Serial Attached SCSI (T10), USB-Implementers Forum (USB-IF), Mobile Industry Processor Interface (MIPI) Alliance, Ethernet standards (IEEE 802.3), Optical Internetworking Forum (OIF), and many others. Our involvement in these standards groups and their related workshops, plugfests, and seminars enable Keysight to bring the right solutions to the market when our customers need them.

Complete, reliable test coverage

What makes Keysights' design and test solutions so compelling is that they are the best tools, in every category, to meet your challenges. We developed these tools to match the application's specific needs – real-time and sampling oscilloscopes to verify signal integrity, pattern/protocol generators to create the necessary stimulus signals,

BERTs to test jitter tolerance of receivers, time-domain reflectometer (TDR) and a vector network analyzer (VNA) to characterize impedance, and automation software to speed

up and simplify the design and measurement processes. That's why most HDMI and DisplayPort Authorized Test Centers (ATC) utilize Keysight solutions.

Because you can rely on the quality of Keysight equipment, it is the key to easier, faster and more confident testing of your designs. That takes strain out of engineering and lowers development costs. Accurate results reduce the number of design cycles to help you get to market faster, and they ensure robust products that uphold your hard-won lead in market.

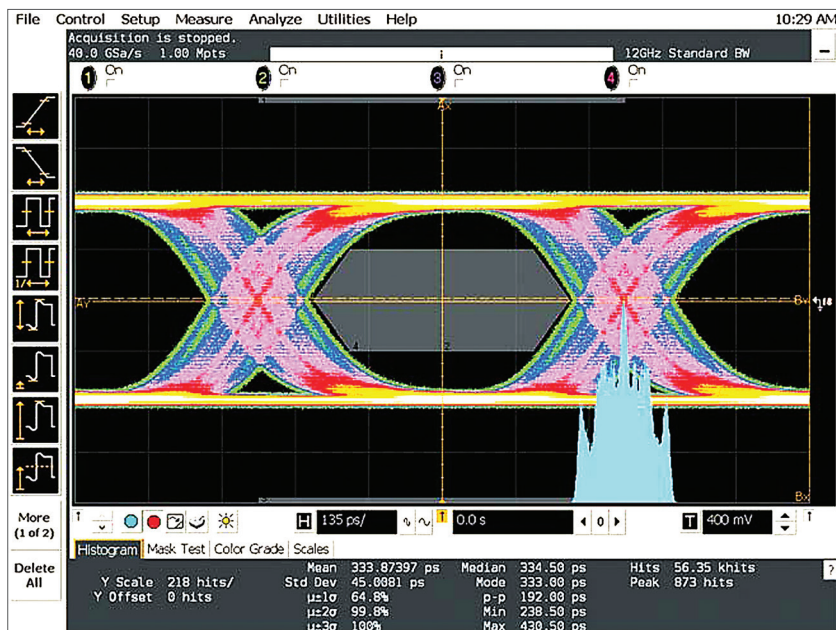


Figure 3. E4887A HDMI TMDS generator has low intrinsic jitter and controlled jitter injection capability for a quality stimulus signal.

Source Test

There are many tests stipulated for Source Test compliance. These include measuring standard waveform parameters such as rise and fall times, but also eye diagrams and jitter analysis where the clock recovery method is stipulated by the standard. Further, new specified filtering algorithms require equalizing the cable and eye and must be performed to correlate receiver performance.

Measure with confidence

Whether troubleshooting, capturing contiguous waveforms, ensuring correct operation, or proving compliance, a real-time oscilloscope with active differential probes and test point access fixtures are critical. Noise floor, jitter noise floor, probe accuracy and test fixture quality all affect measurement

accuracy. For example, the receiver eye tests examine the minimum level for adequate receiver operation. Poor noise performance in the oscilloscope may mislead observations of actual receiver performance.

Keysight's Infiniium 90000A Series Oscilloscopes provide the lowest noise floor, jitter noise floor, and trigger jitter in the industry, enabling more accurate measurements and a better characterization of your device performance. In addition, the InfiniiMax active differential probes provide industry leading noise performance and probe bandwidth and accuracy. Connections to your device are simplified with the N1080B Test Point Access (TPA) fixture for HDMI or the W2641B TPA fixture for DisplayPort to connect directly to HDMI and DisplayPort connectors via the InfiniiMax probes. (See figure 4)

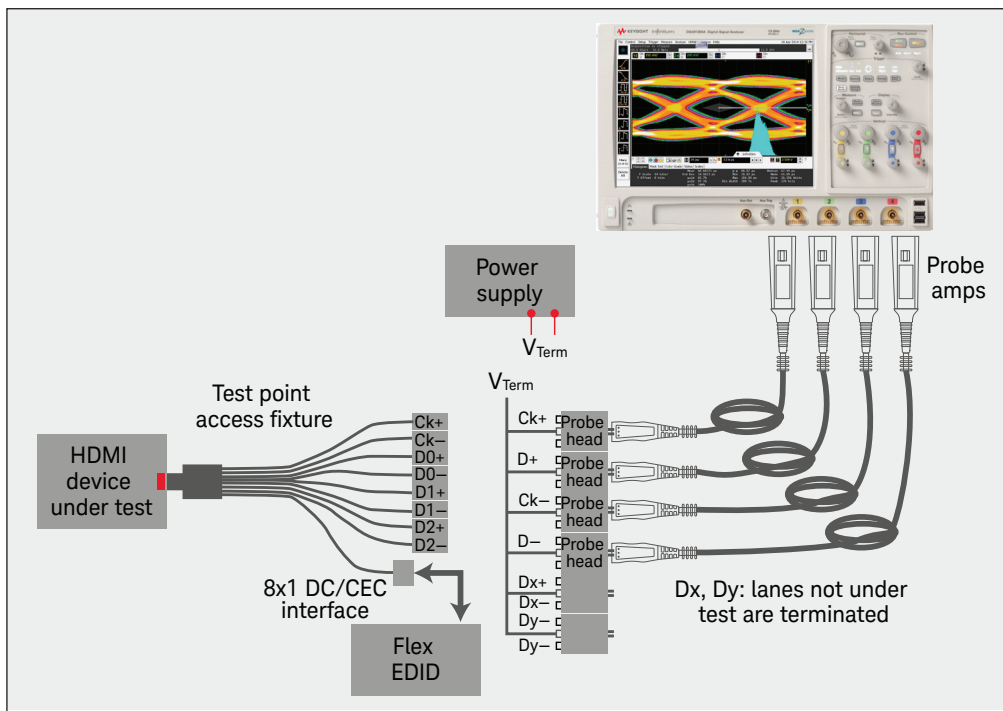


Figure 4. Source Measurement configuration with 90000A Infiniium real-time oscilloscope

Key Feature

Keysight's Infiniium 90000 Series oscilloscopes provide the lowest noise floor, jitter noise floor, and trigger jitter in the industry.

Automate complex tasks

If you plan to perform source, sink, and/or media tests, consider using the Keysight N5990A Test Automation Software Platform. It increases the productivity and efficiency of compliance testing and systematic in-depth characterization. It complements and integrates the N5399C HDMI and U7232B DisplayPort Electrical Compliance Test Software. It controls the associated Keysight instruments from a PC, providing unprecedented test integration, minimum calibration time and maximum test throughput as well as ease-of-use. One button compliance testing, with results displayed on screen, or exported to Excel or other formats allow further data analysis and collection.

The N5399C HDMI and U7232B DisplayPort Compliance and Test Software complement the accuracy of the 90000A Series oscilloscopes by simplifying set-up and performing compliance tests (see Figure 5). The software runs on the oscilloscope itself, and uses a test framework that has proven value to busy engineers who want quick, accurate answers. The software has the most complete set of HDMI and DisplayPort test, whether you work in an Authorized Test Center or if you are evaluating device performance.

The software brings together Keysight's intimate knowledge of the oscilloscope and careful interpretation of the specifications to ensure the best results, high repeatability with minimal effort. The software produces an HTML report, complete with screenshots, which make it easy to share your results, and margin analysis to determine how close you are to the specification (see Figure6).

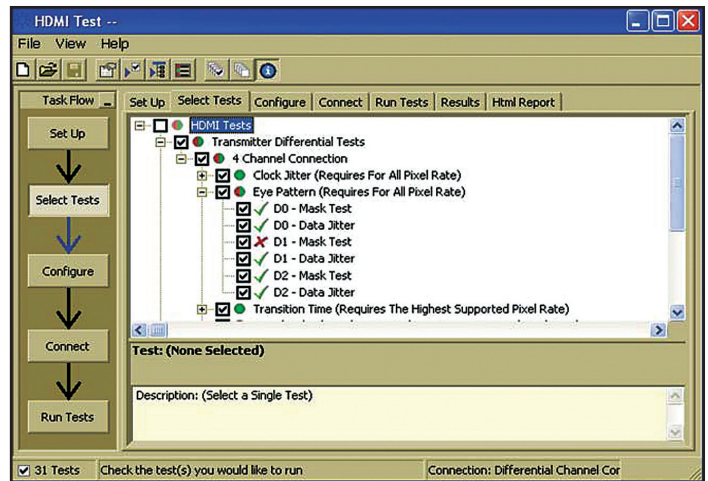


Figure 5. The N5399C and U7232B Compliance and Test software saves you time by selecting tests, configuring tests, setting up the connection, running the tests, and viewing the results.

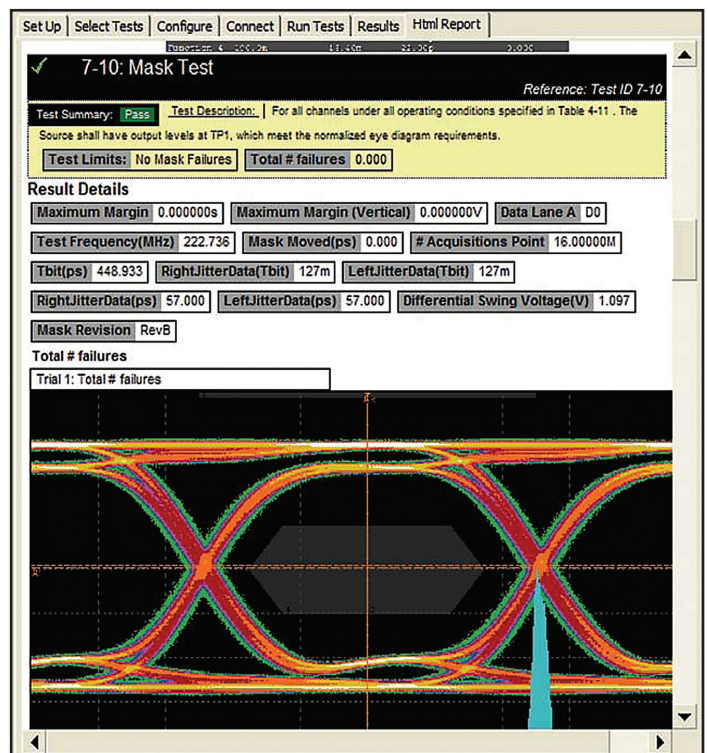


Figure 6. The N5399C and U7232B Compliance and test software generates a summary report for your device quickly, including waveforms and the margin of the result to provide further insight.

Sink Test

Sink testing requires a source capable of generating a wide range of test patterns and the ability to add a precise amount of impairments to the output signal. The major high-speed tests are sensitivity, skew, jitter tolerance, and timing. Since HDMI 2.0 uses an incoherent design with a TMDS clock rate at 1/40 of the bit rate, this results in different jitter behavior on data and clock. Measurement accuracy is determined by the source noise floor (intrinsic jitter), and the ability to control the signal attributes such as injected jitter. The core of the Keysight HDMI sink test solution is the M8190A or M8195A arbitrary waveform generator (AWG) and the N5990A test automation software which guides you through the test procedure with detailed instructions and required system connectivity. This test solution enables independent clock and data jitter injection for accurate sink characterization.

The M8190A or M8195A AWG solution allows flexibility in generating adjustable transition times and ISI emulation. All of the jitter addition and ISI signal emulation can be factored into the waveform on-the-fly with no external equipment required. As a result, it's less expensive and easier to set up.

Based on the capabilities of the sink device under test the N5990A software framework generates a test procedure that includes all required tests in order to meet the requirements set forth in the HDMI 2.0 CTS document. The resulting test protocol may be used to state the compliance with the HDMI 2.0 specification. Furthermore the sink test solution allows for margin testing to discover the design margin of your device under test.

The key features of the M8190A AWG solution include:

- AXIe form factor (2- slot module)
- Sample rate up to 12 GSa/s @ 12 bit resolution
- Deep sample memory, 2G samples per channel (required for generating all of the video signals. This is important because the CTS requires that a valid video signal be generated for each video resolution. Therefore, a large sample memory is required to generate the video frames.)
- Supports data rates up to 6 Gb/s
- Flexible generation of distortions without cable emulators and TTCs
- Approved in Keysight MOI for HDMI 2.0 sink testing

The key features of the new M8195A AWG solution include:

- AXIe form factor (1 slot module)
- Sample rate up to 65 GSa/s @ 8 bit resolution
- Deep sample memory, 16G samples per channel (required for generating all of the video signals. This is important because the CTS requires that a valid video signal be generated for each video resolution. Therefore, a large sample memory is required to generate the video frames.)
- Supports data rates up to 32 Gb/s
- Flexible generation of distortions without cable emulators and TTCs
- Will be included in the Keysight MOI for future HDMI sink testing



Figure 7. Example sink test setup using M8190A AWG

Video Analyzer and Generator.

For DisplayPort, the N4915A-006 ISI generator complements perfectly the Keysight sink test setups as described in detail in the method of implementation (MOI) documents for the Keysight J-BERT N4903B and ParBERT 81250 and can be fully automated using the N5990A test automation software.

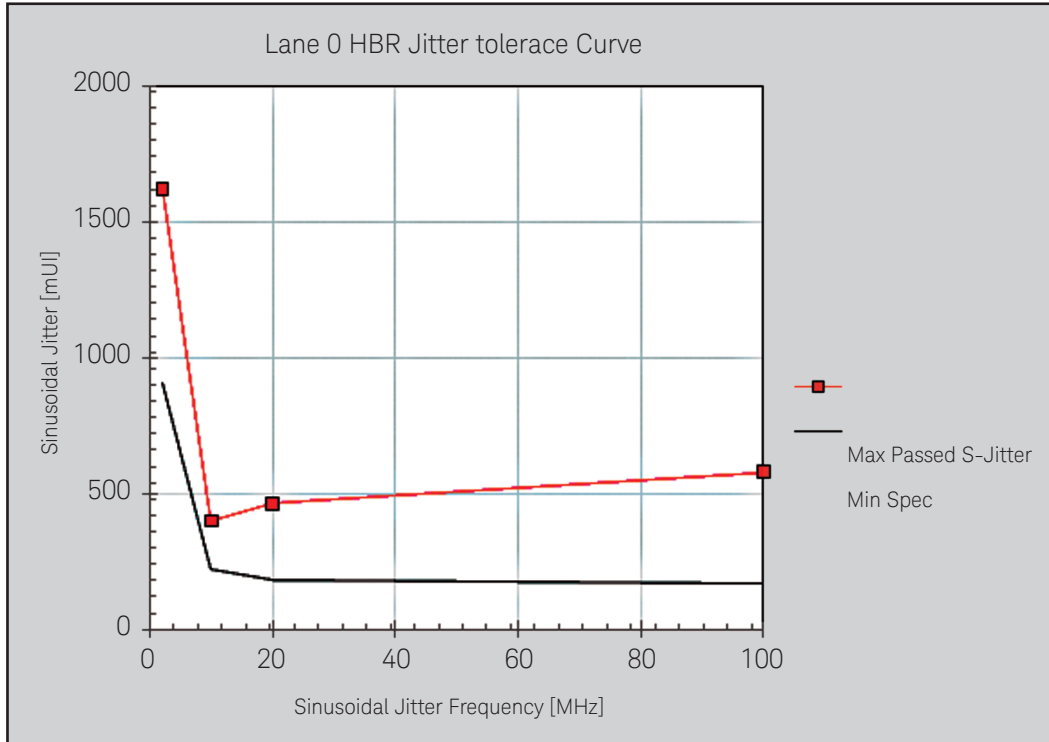


Figure 8. Receiver Jitter Tolerance Test.

Key Feature

Keysight's high performance arbitrary waveform generators use low noise clocks which provide unmatched performance and high quality signal generation to achieve superior fidelity.

An integrated test solution

If you plan to perform source, sink, and/or media tests, consider using the Keysight N5990A Test Automation Software Platform. It increases the productivity and efficiency of HDMI and DisplayPort compliance testing and systematic, in-depth characterization. The N5990A provides unprecedented test integration, minimum calibration time and maximum test throughput as well as ease-of-use for testing.

Media Test

The integrity of the media that connects a source and sink truly determines the display quality. Media tests on cables and printed circuit boards are aimed at preserving video quality through tests like skew, crosstalk, attenuation, and impedance. To assess cable eye diagram measurements or receiver equalization design, a special reference equalization algorithm can be used. Timing tests like skew and eye diagrams are easily accomplished with a real-time or sampling oscilloscope. However, a time-domain reflectometer (TDR) is better suited for intra-pair skew and differential impedance measurements and a vector network analyzer (VNA) for far-end crosstalk and attenuation phase measurements. For these instruments, accurate measurements occur only after performing a calibration sequence to remove the effects of any cables or fixtures that connect the TDR or VNA to the device under test.

Accurate impedance measurements

Keysight offers two excellent solutions for impedance oriented measurements – the Keysight 86100D Infiniium

DCA-X with 54754A Differential TDR/TDT module, or the E5071C ENA RF network analyzer. Connections to the media are made using the N1080B TPA for HDMI or the W2641B TPA for DisplayPort.

The 86100D/54754A TDR utilizes a unique calibration process that can de-embed the effects of cabling, allowing you to see your device and not the test system. By switching to frequency mode, you can also examine the S-parameters for transmission and impedance/reflection performance of channels, cables, connectors, and transceiver. Digital engineers, already familiar with oscilloscopes, can quickly see the relationships between frequency and time effects without having to purchase and learn new pieces of test equipment.

The Keysight E5071C ENA RF network analyzer is based on frequency domain analysis and includes a built-in swept source and a four-port test set for differential measurements from 9 kHz up to 20 GHz. A VNA offers higher accuracy than a TDR due to its higher dynamic range and more complete calibration approach, which is important when measuring low insertion loss or low reflection devices (see Figure 10). All required measurements can be made using the E5071C ENA. Calibration is accomplished quickly using an Keysight N4431B ECal module that eliminates the need to manually connect the multiple calibration standards. In addition, post-measurement analysis of the high speed cable can be easily done in the time and frequency domains utilizing the N1930B Physical Layer Test System (PLTS) software package. Identifying and eliminating crosstalk within the interconnect channel is done by minimizing mode conversion using the PLTS GUI environment.

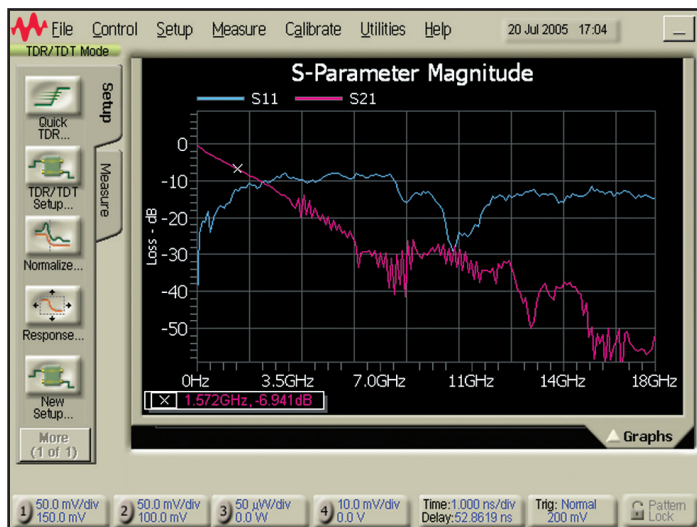


Figure 9. Cable testing using the DCA-J with 54754A.

Key Feature

To improve accuracy, the 86100D TDR utilizes a unique calibration process that removes the effects of cabling, allowing you to isolate your device from the test system.

For the next generation of HDMI and DisplayPort media test, the best solution is the new 5245A PNA-X with 4-port 50GHz test capability. The fifth harmonic of the fundamental frequency of the higher data rates are easily measured with this powerful system. Eye diagrams, intra-pair crosstalk and differential insertion loss are quickly and accurately measured. Also, the new PLTSv5.5 software has the ability to incorporate HDMI and DisplayPort compliance mask testing. See Figure 11 below for an example for this mask tests.

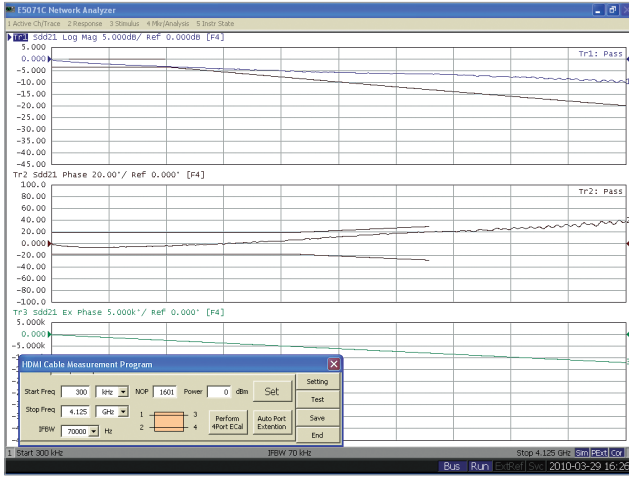


Figure 10. HDMI and DisplayPort cable testing using the E5071C ENA RF network analyzer.

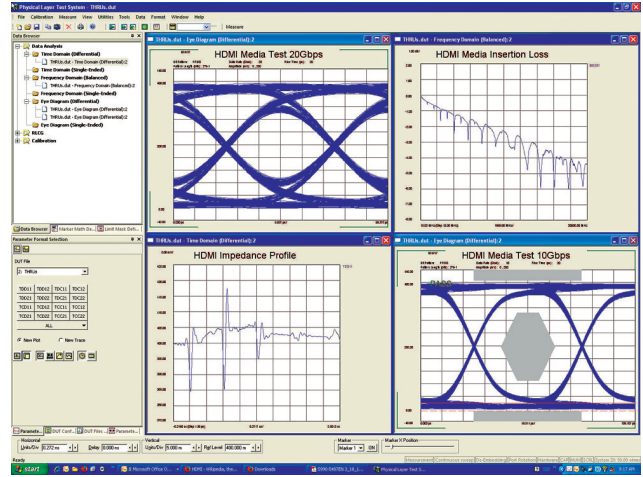
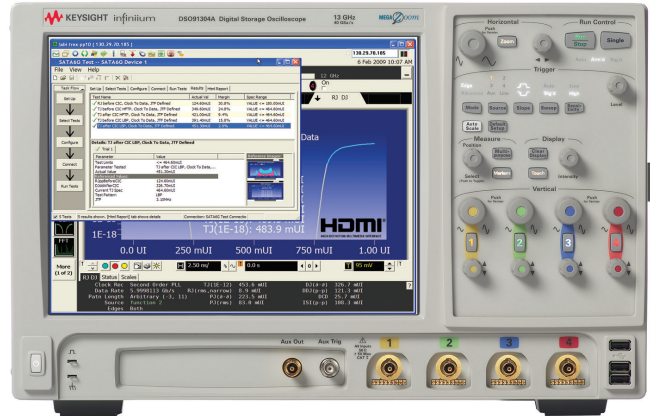


Figure 11. Mask Test example

Keysight HDMI and DisplayPort Solutions

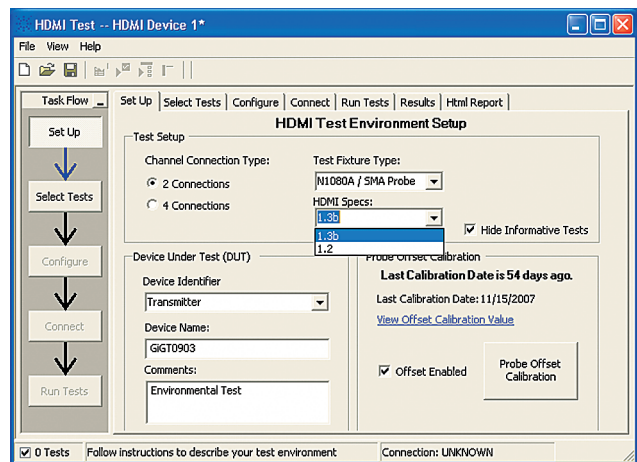
90000A Series Infiniium Real-time Oscilloscope

The Keysight 90000 Series Infiniium oscilloscopes and InfiniiMax probing system deliver the highest performance real-time measurement system available. The Infiniium 90000 Series is engineered for unmatched real-time measurement accuracy and offers the industry’s lowest noise floor, the industry’s deepest memory, and full bandwidth probing, making it the ideal tool for signal integrity and jitter measurements. Models are available from 2.5GHz to 13GHz, and can be upgraded in bandwidth for future needs. InfiniiMax probes are available in differential and single-ended measurements for maximum measurement flexibility.



N5399C HDMI Electrical Compliance Test Software

The Keysight N5399B HDMI electrical performance validation and compliance software for Infiniium 90000 Series oscilloscopes provides a fast and easy way to verify and debug your HDMI designs. The HDMI electrical test software allows you to automatically execute HDMI electrical checklist tests, and displays the results in a flexible report format. In addition to the measurement data, the report provides a margin analysis that shows how closely your device passed or failed each test.



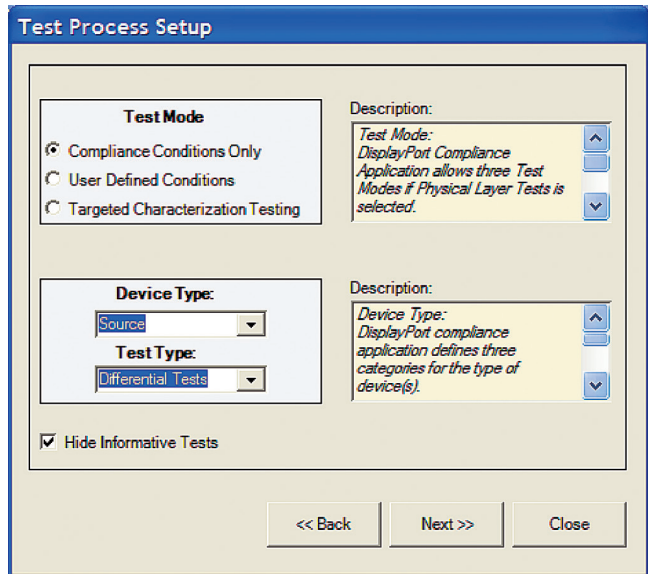
16900 Series Logic Analyzers with FuturePlus FS4430 DisplayPort Analysis Probe

The FuturePlus FS4430 DisplayPort analysis probe, used in conjunction with Keysight 16900 Series logic analyzers, supports X1, X2, and X4 DisplayPort with data acquisition speeds up to 2.7 GT/s. Powerful protocol decode software displays the Main Link and Auxiliary channel activity on the logic analyzer. Probe manager software controls the FS4430 via USB and defines the protocol aware filters for the logic analyzer. The software also allows instant lane reversal and polarity inversion. Quad state LEDs display instant port activity status. Connection to the target system is done via a half-size mid-bus connector, interposer, or flying lead adapter cable.



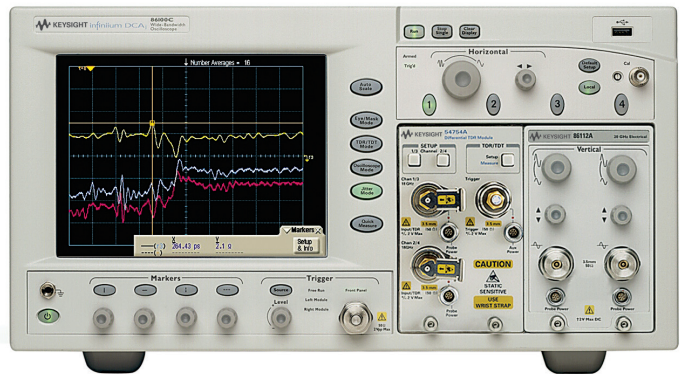
U732B DisplayPort Electrical Compliance Test Software

The Keysight U732B DisplayPort compliance test software sets the benchmark for ease-of-use, and offers complete testing without compromise. The software guides the user sequentially through the tasks ensuring minimal setup error, executes the tests specified by the standard and conveys the test information through a convenient software generated report. The three modes of physical layer test allow for automated measurements based on the customizable configuration of compliance and characterization testing. To make the test signal connection, the Keysight W2641B DisplayPort test point access adaptor completes the DisplayPort source solution..



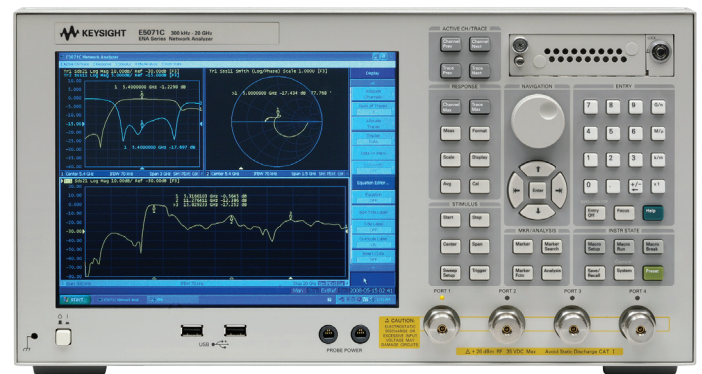
86100D Infiniium DCA-X Wide-Bandwidth Oscilloscope with TDR

The Keysight 86100D Infiniium DCA-X can view optical and electrical waveforms with bandwidths to 80GHz electrical and 65 GHz optical. Jitter analysis is simplified via a one-button approach to review the random and deterministic jitter components. With the 5454A Differential TDR/TDT module, you can characterize impedance and crosstalk in channels and view the results in either time-domain or S-parameters.



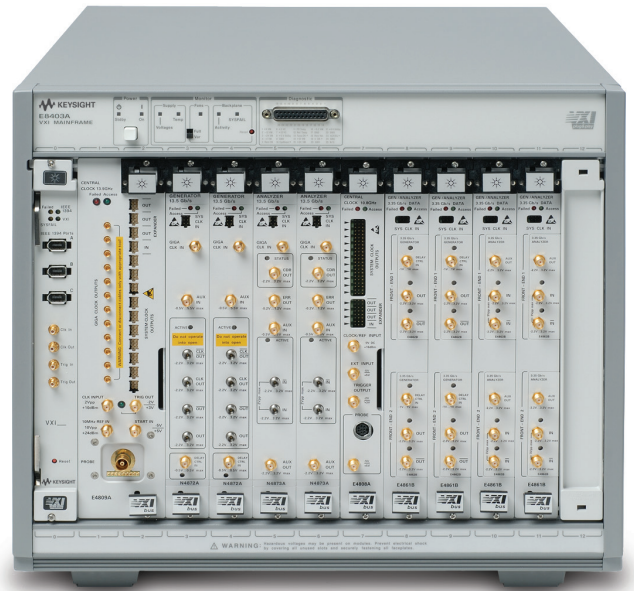
E5071C ENA RF Network Analyzer

The Keysight E5071C ENA RF network analyzer offers the highest RF performance and fastest speed in its class, with a frequency range from 9 kHz up to 20 GHz and versatile functions. Low phase noise and wide dynamic range provide very high accuracy measurements on low level signals. The optional 4-port model or multi-port test set allows differential measurements to be made quickly and easily. When used with the appropriate ECal module, calibration is performed quickly with high accuracy.



E4887A HDMI TMDs Generator

The Keysight E4887A HDMI TMDs Signal Generator provides parallel signals with low intrinsic jitter and fast edges for data rates up to 3.4 Gb/s or 7 Gb/s with 1 or 2 channel jitter capability. The HDMI frame generator software is ideal for manual testing and debugging. It configures the generator with a wide variety of HDMI video frames. The software controls up to two E4438C vector signal generators as well as the TMDs signal generator for defined jittered signals for tolerance testing. When used with the N5998A HDMI protocol generator, complete HDMI source testing is possible.



N4915A-006 DisplayPort ISI Generator

The Keysight N4915A-006 DisplayPort ISI Generator covers ISI requirements for both reduced bit rate and high bit rate. The N4915A-006 integrates perfectly into the Keysight sink test setups as described in detail in the method of implementation documents for the Keysight J-BERT N4903B and Keysight ParBERT 81250. The N4915A-006 is supported by Keysight's N5990A software for full automation.



Arbitrary Waveform Generators (AWG)

Keysight's AWG sources offer greater fidelity, high resolution, and wide bandwidth – simultaneously. This unique combination lets you create signal scenarios that push your design to the limit and bring new insight to your analysis. Get bits and bandwidth – and enhance your reality.

These AWGs are modular instruments packaged in the AXIe form factor. AXIe is a new open standard for high-performance, modular instrumentation, and incorporates the best features of other modular formats including VXIbus, LXI and PXI.

M8190A 12 GSa/s arbitrary waveform generator

The M8190A ensures accuracy and repeatability with 14-bit resolution, up to 8 GSa/s sampling rate and up to 90 dBc SFDR. High dynamic range and excellent vertical resolution give confidence that you are testing your device, not the signal source.



M8195A 65 GSa/s arbitrary waveform generator

The Keysight M8195A high speed AWG offers up to 65 GSa/s sample rate, 20 GHz bandwidth on up to 4 channels per module, output amplitude of up to 2 Vpp(diff.), and adjustable DC offset. Multi-channel operation with up to 16 channels per 5-slot AXIe chassis is supported. Go where you have never been able to test before in speed, in bandwidth and in channel density – explore your possibilities.



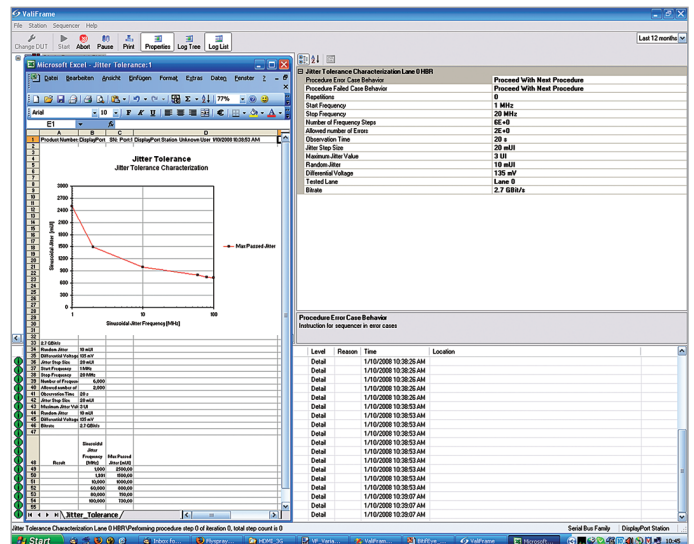
ParBERT 81250 Modular BERT Platform for accurate characterization of multi-port gigabit devices

The Keysight ParBERT 81250 modular BERT platform provides accurate characterization of multi-port gigabit devices. With different module types for clock, data generation, and data analysis for various data ranges, the ParBERT 81250 system can be tailored to meet your needs. Whether you are looking for a multi-port data generator or data analyzer, or a complete BERT system, with ParBERT 81250 you can configure the right solution with up to 64 output and input channels. And because it can be easily extended for future needs, your investments is protected. The 81250 modular BERT platform also provides automated compliance test solutions for standards such as PCI Express, serial ATA or USB 2.0, as well as software that can be customized to fit your individual test needs. Furthermore, a comprehensive measuring suite and delay line input on 13.5/7/3.35 Gb/s data generator modules to inject jitter from an external source, allow in-depth insight into your designs and devices.



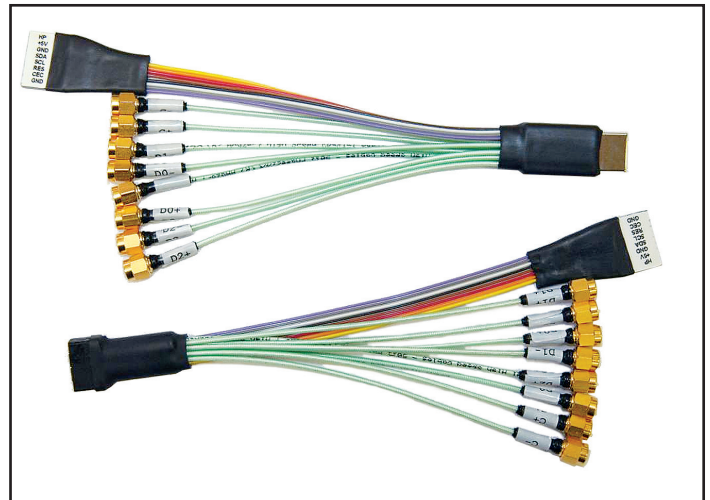
N5990A Test Automation Software Platform

The Keysight N5990A Test Automation Software Platform was designed to automate overall HDMI and DisplayPort compliance testing and for systematic, in-depth device characterization. It complements and integrates the N5399B HDMI and U7232A DisplayPort Electrical Compliance Test Software. It controls the associated Keysight instruments from a PC, providing unprecedented test integration, minimum calibration time and maximum test throughput as well as ease-of-use. One button compliance testing, with results displayed on screen, or exported to Excel or other formats allow further data analysis and collection.



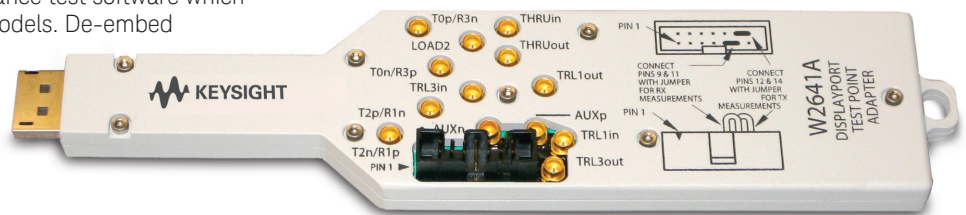
N1080B HDMI Test Point Access Adapters

The Keysight N1080B HDMI test point access adapters are well suited for nearly every test, providing the best rise time, excellent skew and the ability to connect into tight spaces. They are offered in three different configurations: Option H01 is a TPA with a plug and is typically used, in conjunction with the low frequency board, for testing sources and sinks. Option H02 is a TPA with a receptacle, typically used in pairs for testing cables, and with the plug allows TDR calibration. Option H03 is the low frequency board used for various tests on both the sink and source modules. The N1080B version also provides access to the new HEC and ARC signals that are defined in HDMI 1.4a. The N1080B is fully backward compatible with the N1080A.



W2641B DisplayPort Test Point Access Adapters

The Keysight W2641B DisplayPort Test Point Access Adapter breaks out the DisplayPort signals of interest for compliance testing. These signals include the 4 high speed differential lanes that carry the main video content, the auxiliary channel that carries the bidirectional control information, and the Hot Plug Detect and Power lines necessary for standard DisplayPort connection. The fixture is used for both DisplayPort sink and source testing where the device under test connector is a DisplayPort receptacle. The W2641B is used with the U7232B DisplayPort compliance test software which supports 1,2, or 4 lane connection models. De-embed structures provided for removing fixture effects which is important for motherboard and connector transmission analysis.



W2212 Advanced Design System (ADS) bundle

Signal integrity engineers who are hurdling the multi-gigabit/s barrier look to ADS for the correct treatment of high-speed effects like distortion, mismatch, and crosstalk. Uniquely, ADS integrates accurate system, circuit, and EM simulators, so you can not only get the right answers but also get them faster by avoiding error-prone and time-consuming data transfer between a collection of point tools.

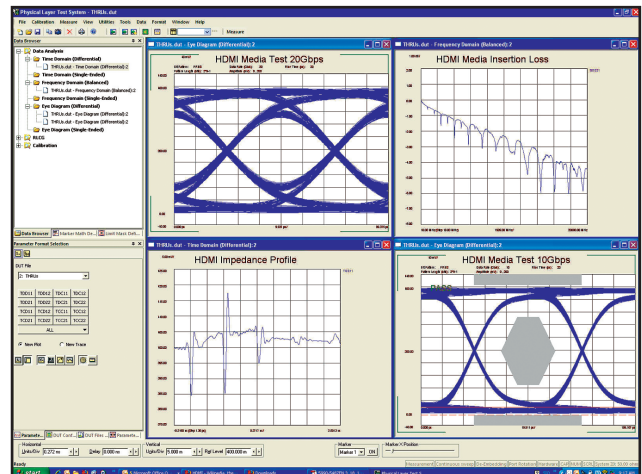


Figure 15. The Physical Layer Test System (PLTS) software allows calibration, measurement and post-measurement analysis of HDMI and DisplayPort Media (Cables, PCBs, connectors, etc). Viewing multiple domains in time, frequency and eye diagram allows compliance mask testing in one easy-manage test suite file.

Related Literature

90000 Series Infiniium Oscilloscope and InfiniiMax Probing System, Data Sheet, Literature Number 5989-7819EN
N5399B HDMI Electrical Characterization and Compliance Software, Data Sheet, Literature Number 5990-5299EN
U7232A DisplayPort Electrical Characterization and Compliance Software, Data Sheet, Literature Number 5989-7198EN
86100C Infiniium DCA-J Wide Bandwidth Oscilloscope with TDR, Brochure, Literature Number 5989-5235EN
J-BERT N4903B High Performance Serial BERT, Data Sheet Literature Number 5990-3217EN
ParBERT 82150, Product Overview, Literature Number 5968-9188E
N5990A Automated Compliance and Device Characterization Test Software, Data Sheet, Literature Number 5989-5483EN
E4887A TMD5 Generator, Data Sheet, Literature Number 5989-5537EN
N4915A-006 DisplayPort ISI Generator, Data Sheet, Literature Number 5989-8688EN
N5998A HDMI Protocol/Audio/Video Analyzer and Generator, Data Sheet, Literature Number 5989-6008EN
W2642A DisplayPort AUX Channel Controller, DataSheet, Literature Number 5989-9973EN
E5071C ENA RF Network Analyzer, Data Sheet, Literature Number 5989-5479EN
N1080 HDMI TPA, Data Sheet, Literature Number 5989-5118EN
W2641A DisplayPort TPA, Data Sheet, Literature Number 5989-7274EN
81150A Pulse Function Arbitrary Noise Generator, Data Sheet, Literature Number 5989-6433EN
W2212 Advanced Design System Core, Transient Convolution, Layout, Momentum G2, FEM, Ptolemy Bundled License
Literature Number 5989-8392EN

myKeysight

myKeysight
www.keysight.com/find/mykeysight
A personalized view into the information most relevant to you.

Keysight Channel Partners
www.keysight.com/find/channelpartners
Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

www.keysight.com/find/hdmi
www.keysight.com/find/displayport

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

Americas

Canada	(877) 894 4414
Brazil	55 11 3351 7010
Mexico	001 800 254 2440
United States	(800) 829 4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 6375 8100

Europe & Middle East

Austria	0800 001122
Belgium	0800 58580
Finland	0800 523252
France	0805 980333
Germany	0800 6270999
Ireland	1800 832700
Israel	1 809 343051
Italy	800 599100
Luxembourg	+32 800 58580
Netherlands	0800 0233200
Russia	8800 5009286
Spain	800 000154
Sweden	0200 882255
Switzerland	0800 805353
	Opt. 1 (DE)
	Opt. 2 (FR)
	Opt. 3 (IT)
United Kingdom	0800 0260637

For other unlisted countries:
www.keysight.com/find/contactus
(BP-09-23-14)