

# D9040DPPC DisplayPort Electrical Performance Validation and Compliance Software

Keysight Technologies, Inc. DisplayPort Electrical Performance Validation and Compliance software for Infiniium Series oscilloscopes provides you with a fast and easy way to verify and debug your DisplayPort interface designs for sink and source ICs, motherboard systems, computers and graphics cards and now supports the DisplayPort 1.4a specification.



The DisplayPort electrical test software is designed for use in DisplayPort authorized compliance test centers. This allows users to execute DisplayPort electrical checklist tests as well as employ the software as a characterization tool.

## Features

The DisplayPort Electrical Performance Validation and Compliance software is a full-featured package to simplify the validation process of DisplayPort designs:

- Full physical layer testing high speed lanes
- Full physical layer testing of AUX channels
- USB Type-C interface control with N7018A Type-C Test Controller
- Offline testing capability with waveform files for completeness of simulation to validation workflow
- Selectable capture and analysis modes
- Automation control through AUX Channel Controller
- Optional switch control for unattended automation

## Comprehensive Test Coverage

The DisplayPort Electrical Performance Validation and Compliance software saves you time by setting the stage for automatic execution of DisplayPort electrical tests. Part of the difficulty of performing electrical tests for DisplayPort is connecting the oscilloscope to the target device, configuring the instrument for measurements, executing the test procedures, defining the capabilities of the device under test, and then analyzing the measured results by comparing them to limits published in the specification. The DisplayPort electrical test software does almost all of this work for you. In addition, if you discover a problem with your device, debug tools are available to aid in root cause analysis.

The DisplayPort software offers the electrical tests for the source as well as important tests for cable and calibration for receiver tolerance testing. The software automatically configures the oscilloscope for each test, and it provides an informative results report that includes margin analysis indicating how close your product is to passing or failing that specification. Clock recovery of each lane is accomplished according to the standard by the oscilloscope using proprietary software techniques. See Table 1 for a complete list of the measurements made by the DisplayPort electrical test software.

## Easy Test Definition

The DisplayPort Electrical Performance Validation and Compliance software extends the ease-of-use advantages of Keysight's Infiniium Series oscilloscopes to testing DisplayPort designs. The Keysight automated test engine walks you quickly through the steps required to define the device under test, to select the tests, set up the tests, perform the tests, and view the test results. You can pick high-level test parameters to suit your test process objectives, and you can then proceed to select a category of tests all at once, or specify individual tests.

The user interface is oriented to minimize reconnections, which saves you time and minimizes potential for operator error. You can save tests and configurations as project files and recall them later for quick testing and review of previous test results. Straightforward menus let you perform tests with a minimum of mouse clicks. Further test process control is also provided through the automation tab of graphical user interface. This tab allows the user to tailor scripts to control external equipment such as power supplies and temperature control units, or to provide a different test flow.

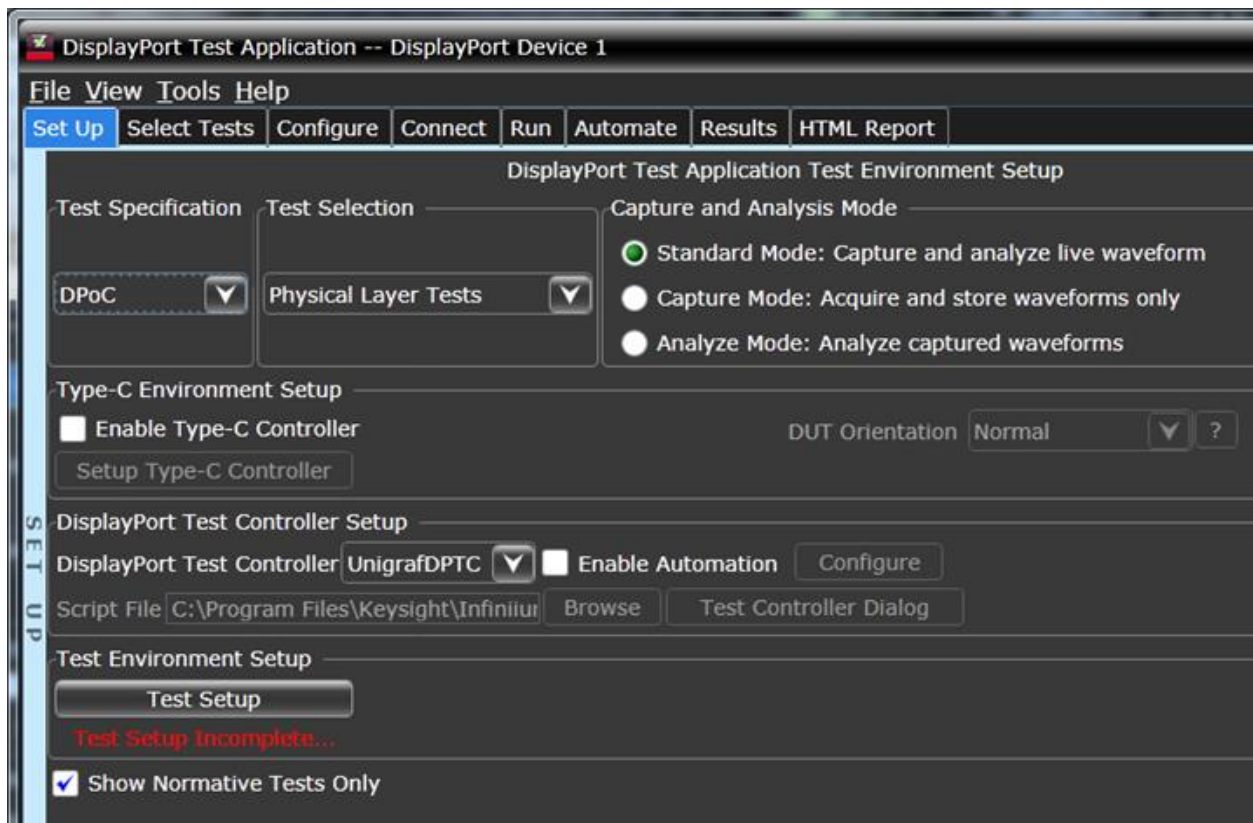


Figure 1. DisplayPort compliance software Setup Screen

## Test Environment Setup and Test Selection

The DisplayPort Electrical Performance Validation and Compliance software now allows you to define the DUT capability and select test environment variables to better suit your testing goals for speed and cost. The setup process begins with the Setup entry screen (shown in Figure 1). This screen enables selection of the DisplayPort Compliance test specification, for instance, DPoC (DisplayPort over Type-C) as shown in Figure 1 and test suite groupings for various DP validation tasks. These are: High speed lane Physical Layer Tests (shown), AUX channel and Inrush testing, and characterizations such as CTLE sweep found in Test Tools.

A radio button at the bottom allows the user to choose between exposing just normative (mandatory) tests or all tests: normative and informative. The screen will dynamically change based on user selections. For instance Figure 1 depicts selection of DisplayPort alt mode (DPoC) and when this is done, a Type-C environment setup section is enabled as shown in the figure. Enabling a Type C controller will activate the Type-C setup, selection of the controller, power supply, remote control of the power supply, and enable query of the DUT for its power delivery objects and alt mode capabilities. Other sections expand similarly. The other two sections are DisplayPort Test Controller Setup and Test Environment Setup.

The DisplayPort Test Controller Setup is for full automated testing using DisplayPort test mode (which is specified as optional, however, strongly recommended for compliance testing) as well as Link Training Mode which controls the DUT through the normal link training state machine. The primary means for automated control is the AUX channel controller from Unigraf, the DPR-100 which is already integrated into the compliance software. Enabling automation will configure the DPR-100 and a convenient GUI can be launched to verify you have control of your device independent of specific testing. The GUI window for DP device control verification is shown in Figure 2.

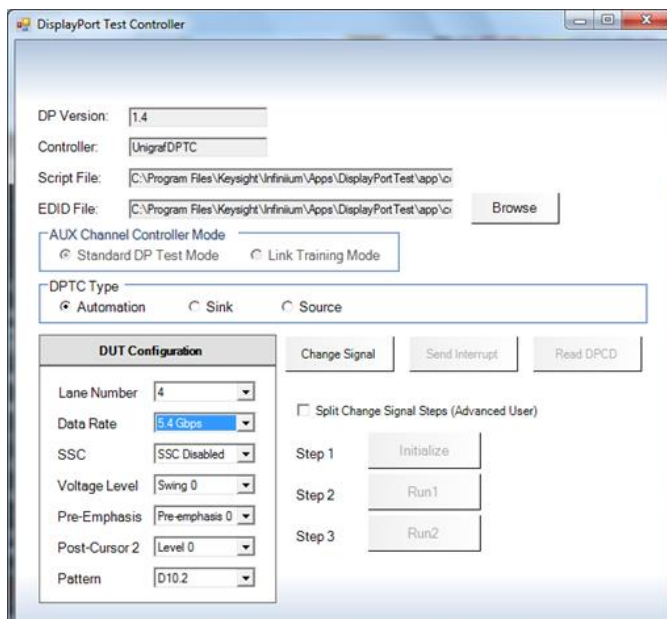


Figure 2. AUX Channel Controller GUI for verification of control DUT

The Test Environment Setup section addresses user input of the Device Under Test capabilities (bit rate, levels preemphasis settings etc) which is needed to drive the test plan, and it also provides for defining the connection to the oscilloscope. The information for these are entered by selection of the Test Setup (shown in Figure 1) and Connection Setup (not shown) buttons. In all cases where information is not defined, the User is alerted to the fact by red text. When parameters are NOT defined then testing cannot proceed. Selecting Test Setup yields the following screen:

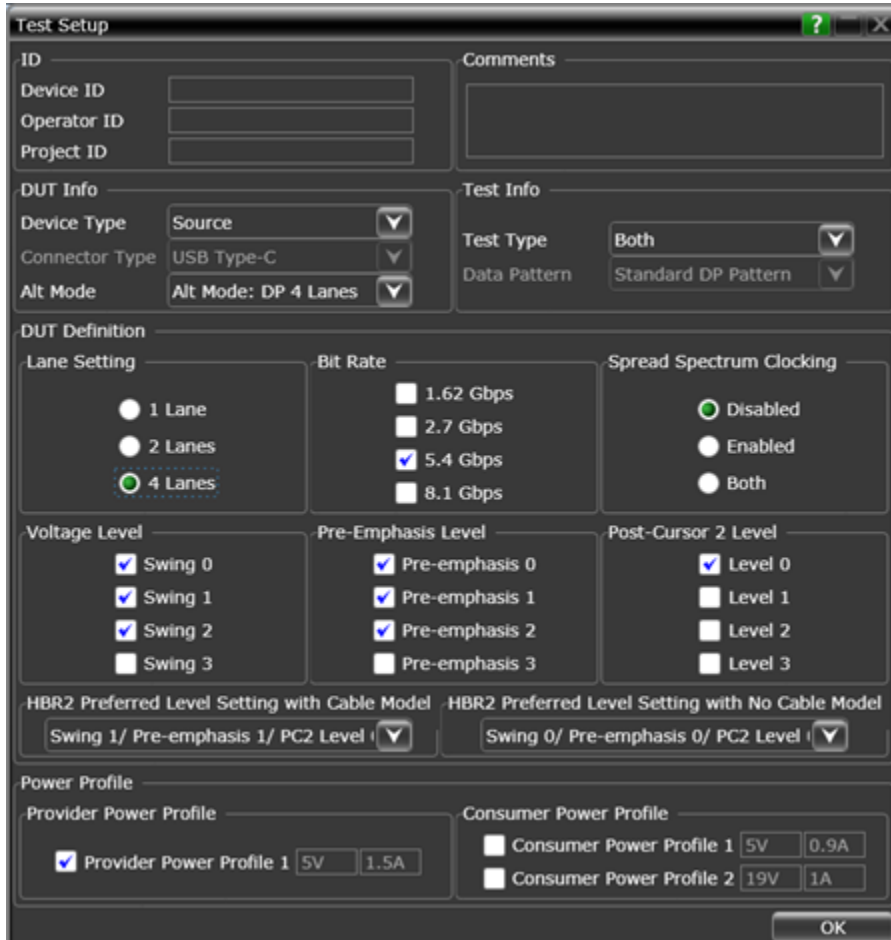


Figure 3. Test Setup screen for setting up the DUT capabilities.

The Test Setup screen presents one screen for all key device related information. It is worth noting a few key attributes.

Firstly, test session information such as device number, operator of tests and conditions of test are captured in the top two sections. The DUT Info section enables selection of the device type and shows connector type (determined by the test suite chosen in figure 1), and the alt mode (in this case DP 4 lane). The Test Info area is used to select the connection type required: if both single ended and differential tests are desired then the test type = Both and the connection to the scope must be single ended. If Differential tests are selected the connection model is chosen in the Test Connection screen.

## Device Definition

The DUT definition section allows entry of key device capabilities which is used to create the test plan (test sequencing) which is defined by the DisplayPort CTS and session specifics. The intention of the test plan is to run only those tests required by the CTS. This leads to the most efficient testing because some tests are to be run for a limited subset of device states. While this is efficient for the final compliance test run, it is also the case that much of what validation engineers do is troubleshoot and running all the tests every session procedure can be too time intensive. In this case, the DUT definition can be purposely limited to target key tests or conditions. Note for example that Figure 3 has data rate at 5.4Gbs (HBR2) only.

A device that can do 5.4Gbs MUST be able to operate at 1.62 and 2.7Gbs as well but these are excluded in this test session defined. Also note in this section that there are preferred settings for HBR2 and HBR3 (only HBR2 is shown because the device is defined to only have 5.4Gbs capability. These settings are declarations by the validation engineers of the settings where the particular device is most likely to pass. There are two selections: one with a cable model applied, and one without a cable model applied. This mean it is unlikely that the same level and preemphasis combination is optimal for both.

The bottom section exists to enable characterization of DisplayPort alt mode devices, and in particular if the validation engineer wants to sweep the Power Delivery Objects (PDOs) that are valid for the device under test. Such a procedure might be to run jitter tests vs each PDO supported.

## Test connection Setup

Lastly, the user must define the connection to the oscilloscope by clicking on the Connection Setup button. Upon so doing, the following screen (Figure 4) will be seen:

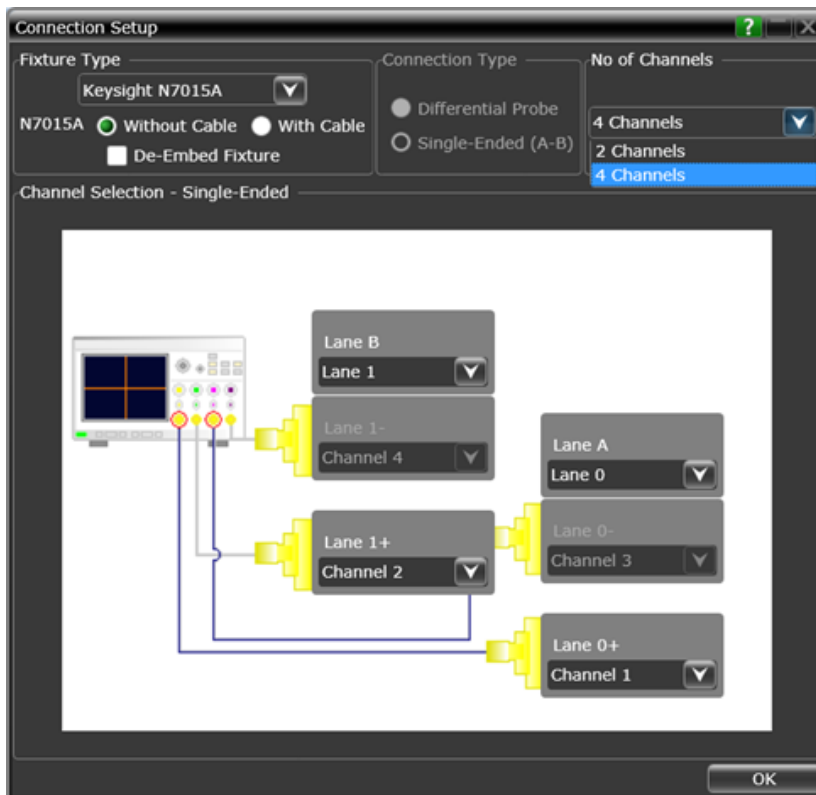


Figure 4. Connection Setup

This screen defines the assignment of oscilloscope channels to the DUT as well defines details about the test point adapter (TPA) to be used. The DisplayPort Electrical Performance and Validation software supports multiple TPAs in the Fixture Type drop down and, if the vendor provides the s-parameters for their product, we will allow a de-embedding of these fixtures. With the Keysight N7015A Type-C fixture, Keysight has de-embed files for the TPA itself as well as with cables that extend reach. If a proprietary fixture is desired to be used, it can be handled as 'Other' and a de-embed file can be added to the scope for de-embedding it.

The connection type is either single ended or differential. If a user selects 'BOTH' in the Test setup screen then this will be single ended and cannot be changed. If the user selects 'Differential' in that screen then a selection on connection type is made here. Differential probes enable full testing with no further reconnections, however, probes always hve slightly more noise than going straight into the oscilloscope channel so users have decision or further characterizations to make. Finally, the number of channels is a field that will either be 1, 2, or 4. 1 is only possible in differential mode with one lane. Two lanes may be one lane single ended or two lanes differential, four channels will be two lanes single ended or 4 lanes with differential connection.

## Test Selection

After defining the test environment through the test setup loop, you are presented with only those tests that are appropriate for the environment chosen. For instance, if spread spectrum clocking (SSC) is not enabled, then no SSC tests will appear. This is the case for the optional settings of pre-emphasis and levels as well. If your device definition is one lane only, or your defined device connection is one lane (one differential probe or two single-ended connections) then no inter-pair skew tests will appear in the test suite. This dynamic filtering simplifies your job by ensuring you attempt to test only what is possible for the DUT and the connection model you have chosen.

The DP 1.4 test suite is shown in the Test Selection screen is shown in Figure 5. It is partitioned in groups of tests as a function of the pattern that is required to test. HBR (2.7 Gb/s) and RBR (1.62 Gb/s) bit rates require PRBS7 and D10.2 patterns while HBR2 (5.4 Gb/s) require special patterns such as the HBR2 compliance test pattern that has a repetition length of 2520 bits (referred to as 'CP2520' or 'HBR2CPAT'). Tests may be selected independently and any number of tests may be selected for a given run.

If more than one lane is possible to run (as determined by the selections in Setup) then test selection by lane is also possible. If different connections or conditions of test are required from one test to another, a splash screen is presented to the user indicating the required change. When automation mode is used with the AUX Channel Controller, the device is changed automatically and there is no need for the splash screens. As an example, if 2 data rates (RBR and HBR) are defined for the device, and one test is selected that test will run twice, once for RBR and once for HBR.

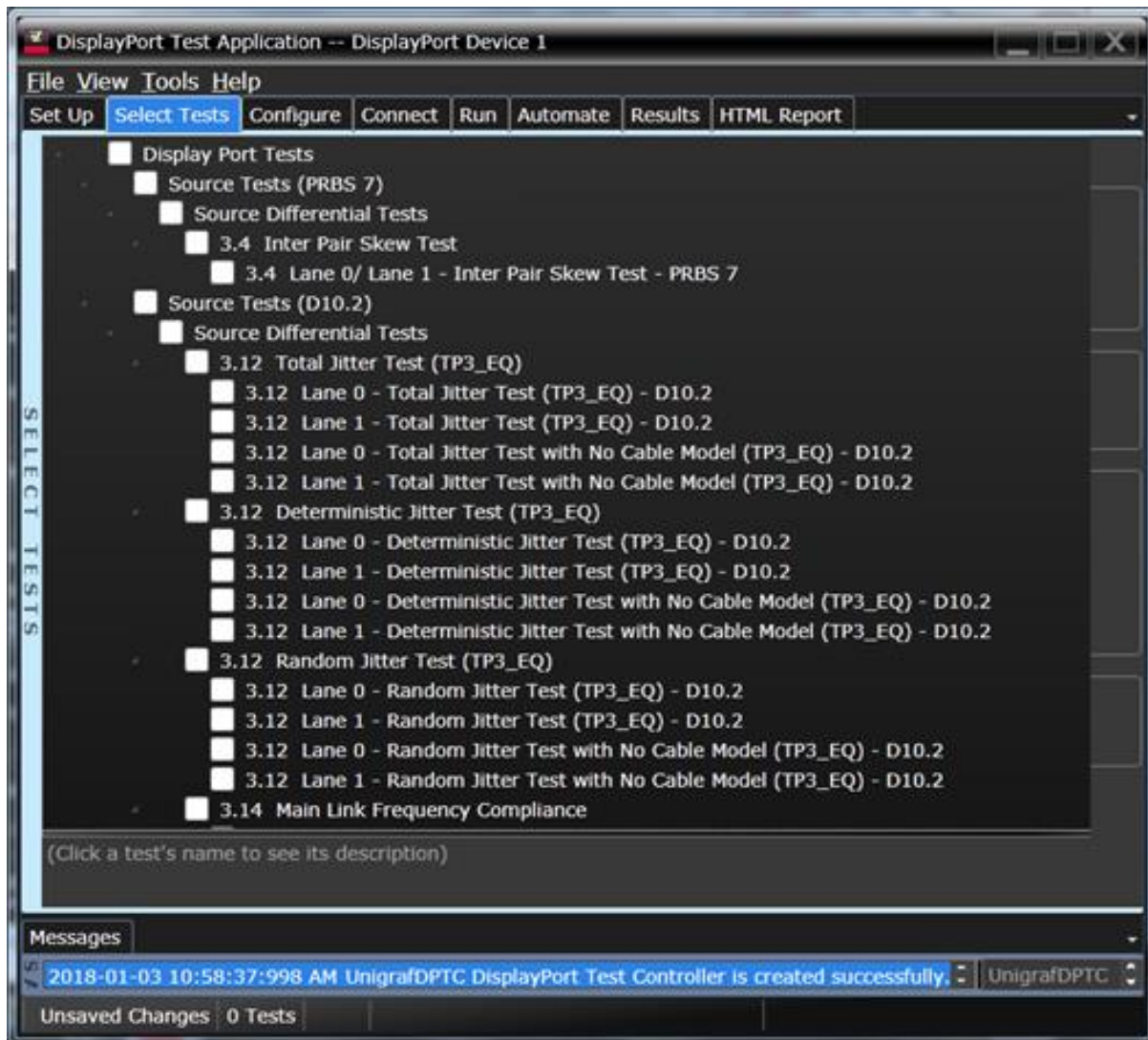


Figure 5: Test Selection by pattern required

## Configurability and Guided Connection

The DisplayPort Electrical Performance Validation and Compliance software provides flexibility in your test setup. It guides you to make connection changes with hookup diagrams when the tests you select require it. For test parameters such as bandwidth, you can select appropriate values. For more critical parameters, such as mask scaling option or number of edges for analysis, default values are tied to the compliance standard; these values can only be altered in the debug screen. In Figure 6 you can see the selection for equalization. The application has default values it uses, however, different use models require exploration and resetting the various measurement parameters.

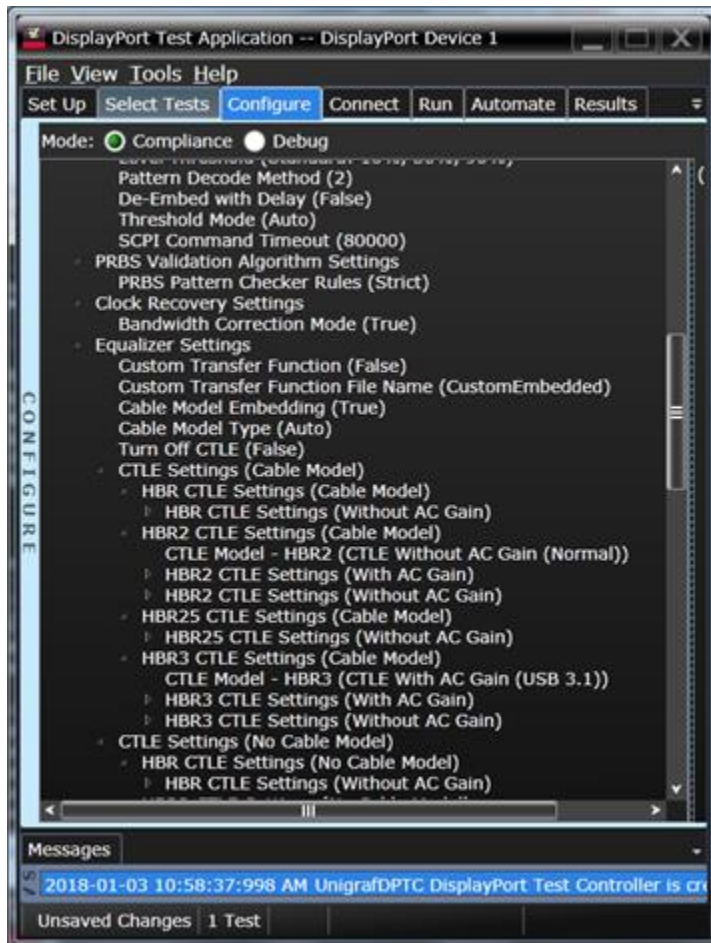


Figure 6: The Configure Tab enables many possibilities for parameters for each test that you can change or optimize your testing or for characterization or troubleshooting.

## Thorough Performance Reporting

The DisplayPort 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 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.



## USB Type-C Control

The DisplayPort Electrical Performance Validation and Compliance software fully controls devices that incorporate the USB Type-C™ connector using the new Keysight N7018A Type-C Test Controller. The test controller is required to establish power delivery contracts (known as PDOs: Power Delivery Objects) as well as to place the Device Under Test into the proper alternate mode for DisplayPort. The Type-C Test Controller and power supply setup is initiated by selection of the Type-C automation control setup shown Figure 1.

**Power Delivery Contracts:** the thorough testing of devices using the USB Type-C interface will require verification at all the possible power delivery settings and the DisplayPort EPV&C software handles this with ease. In the setup of the Type-C environment, the device is queried for its possible contracts and these are reflected in a PDO selection window and integrated into the test plan using the Keysight N6701C power supply which can handle both the provision and consumption of power. One or many PDOs may be selected; if more than one is selected, the test plan will repeat for each PDO.

**Alternate mode:** to obtain DisplayPort functionality from a Type-C device, it must be put into a DisplayPort alternate mode and two of these are defined: there is 'DP 2+2' mode which has 2 lanes of DP with 2 lanes dedicated to USB3, or, 'DP 4 Lane' operation which is standard full bandwidth DisplayPort operation. Alternate mode setting is chosen in the setup of the DisplayPort device. Figure 7 below shows a sequence of Type C windows that walk the user through enabling USB Type C controller, automating power supply, PDO availability and alt mode selection, before setting the software on a measurement task.

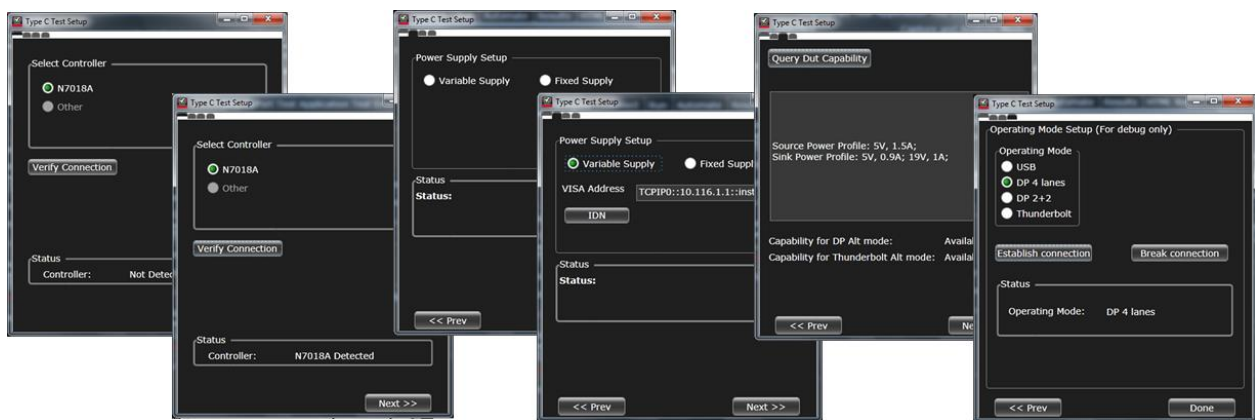


Figure 7: Enabling USB Type-C: Interactive setup connection of Type C controller, power supply connection, and DUT query for PDOs and alt modes while in the Setup screen.

## 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](http://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.

## 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](http://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 it using your favorite environment, such as MATLAB, Python, LabVIEW, C, C++, Visual Basic etc.
- Sequence or repeat the tests and "Add-In" custom steps execution in any order for complete test coverage of the test plan.

## 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.
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More information of the switching solution and configuration, visit [www.keysight.com/find/switching](http://www.keysight.com/find/switching) and the Keysight application note with the publication number 5991-2375EN.

## DisplayPort Test Point Adapters

DisplayPort has added other connector form factors in addition to the original standard connector. These include the Mini-DP connector (mDP) and the USB Type-C connector. The DisplayPort Electrical Performance Validation and Compliance software allows you to choose the test point adapter you want and if the file is available from the vendor, it allows you to de-embed it as well.

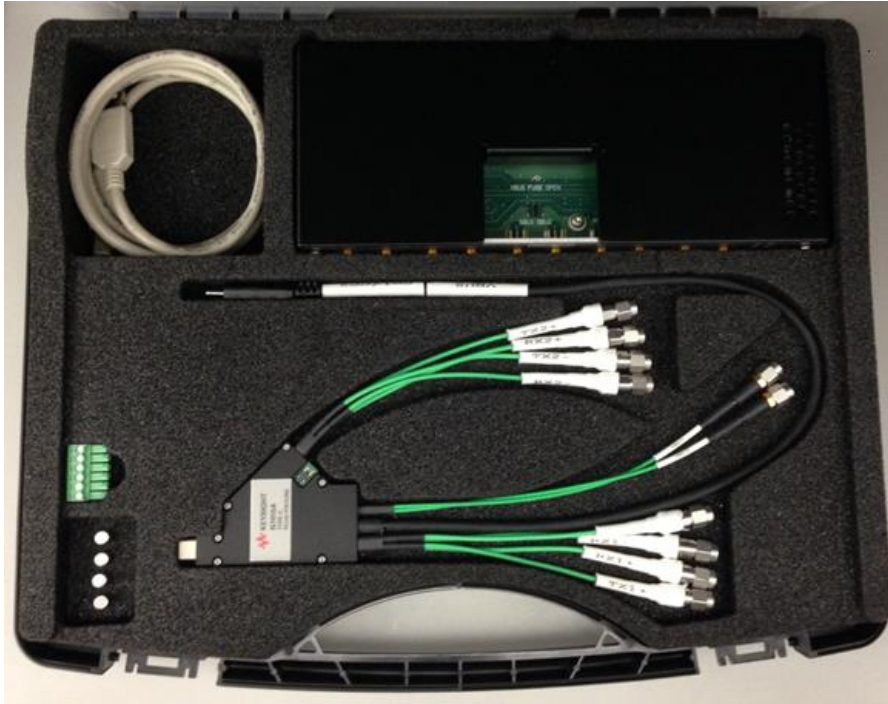


Figure 8: N7015A USB Type-C Test point adapter

## DisplayPort AUX Channel control

The DisplayPort specification allows for automated device control through manipulation of the DPCD (DisplayPort Configuration Data) registers. Those registers are most conveniently controlled by an AUX channel controller. The recommended choice of AUX channel controllers is the Unigraf DPR100 and more details are given in the ordering information section.

## Tests Performed

The DisplayPort Electrical Performance Validation and Compliance software performs all the anticipated required tests for the DisplayPort Compliance Test Specification 1.4 (CTS 1.4) and DPoC (DisplayPort over Type-C) CTS.

Table 1. DisplayPort electrical tests performed by the DisplayPort software.

Assertion No.	Test Description	Compliance Status	Included with DP EPVC software
Test ID 3.1	Data Eye Diagram	Normative	Yes
Test ID 3.2	Non Pre-Emphasis Level Verification	Normative	Yes
Test ID 3.3	Pre-Emphasis Level Verification	Normative	Yes
Test ID 3.4	Inter-Pair Skew	Normative	Yes
Test ID 3.5	Intra-Pair Skew	Informative	Yes
Test ID 3.10	AC Common Mode Noise	Informative	Yes
Test ID 3.11	Non-ISI Jitter Measurements	Normative	Yes
Test ID 3.12	Total Jitter Measurements	Normative	Yes
Test ID 3.14	Main Link Frequency Compliance	Normative	Yes
Test ID 3.15	Spread Spectrum Modulation Frequency	Normative	Yes
Test ID 3.16	Spread Spectrum Modulation Deviation	Normative	Yes
Test ID 3.17	Spread Spectrum dF/dt	Informative	No
Test ID 3.18	Dual Mode: TMDS Clock	Normative	Yes
Test ID 3.19	Dual Mode: TMDS Eye Diagram Testing	Normative	Yes
<b>Section 8</b>	<b>Common Tests</b>		
Test ID 8.1	AUX Manchester Channel Eye	Normative	Yes
Test ID 8.2	AUX Manchester Channel SensitivityTest	Normative	Yes
Test ID 8.3	Aux Channel DC Test: Aux - Termination	Normative	No
Test ID 8.4	Aux Channel DC Test: Aux + Termination	Normative	No
Test ID 8.5	Inrush/Outrush Tests	Normative	Yes
Test ID 8.6	DP_PWR DC Levels	Normative	No
Test ID 8.7	DP_PWR Current	Normative	No

Note: Tests 8.3 and 8.4 are easily accomplished on a source device with use of an AUX signal breakout device such as the Wilder TPA-DP-A with external resistors, a 3.3 volt power supply and a voltmeter

## Data Analytics

The KS6810A data analytics web service software provides an interface that allows the user to export the test result directly to the data repository server via a URL. The user can retrieve the aggregated measurement to be viewed using the visualization tool included in the KS6810A software. The visualization tool provides graphical plots in histogram or line mode that describes the measurement in different test conditions or properties.

## Ordering Information

### Recommended oscilloscope

The DisplayPort Electrical Performance Validation and Compliance software is compatible with the following Infiniium series oscilloscopes:

Data rate	Recommended Bandwidth	Oscilloscope
Up to HBR2 (5.4 Gbs)	13GHz minimum	Infiniium V, Z and UXR series
Up to HBR3 (8.1Gbs)	16GHz recommended	Infiniium V, Z and UXR series

### Software

Model number	Description	Note
D9040DPPC	DisplayPort Transmitter Compliance Test Software	Required
D9020ASIA	Advanced Signal Integrity Software (EQ, InfiniiSim Advanced)	Required
D9020JITA	Jitter, Vertical and Phase Noise Analysis Software	Recommended
D9010DMBA	Precision Cable Calibration	Optional
D9020SCNA	InfiniiScan Event Identification Software	Optional
KS6810A	Data Analytics software (1 license)	Optional

### Test Point Access Adapters

For physical connection to a DisplayPort device to perform test with the DisplayPort Electrical Performance Validation and Compliance software, order one or more of the following Test Point Adapters (TPAs) in the table below:

Model Number	Description	
N7015A	USB Type-C Test Point Adapter	Keysight TPA with BW of 20GHz and de-embeddable to 30GHz
BIT-1000-0000-0	Type-C Alt mode plug TPA	Bitifeye Corporation, recommended integrator for Keysight solutions.
BIT-1050-0040-0	Standard DisplayPort Plug and AUX TPA	

## Unattended Testing with Probes or Switch Matrix

For one connection testing with full automation in DisplayPort either each lane is connected to a differential probe amplifier and SMA probe head, or, a switch matrix under control of the DisplayPort Electrical Performance Validation and Compliance software is used. For accuracy, direct connection to oscilloscope as always preferred, however, Keysight enables test automation through these two methods to support validation productivity.

One Connection Solution	Description	Vendor and details
Four channel Differential Connection	Amplifiers: 1169A, N280xA or N700xA Probe heads: N5480B, N5444A	Keysight probe solutions supported by the D9040DPPC
Switch Matrix	BIT-2100B: BIT-4000-2114-1 modules, qty=2 (4-to-1 switches) Mainframe BIT-4000-2100-1	Bitifeye Corporation, recommended integrator for Keysight solutions. Switch Matrix supported by the D9040DPPC

## Recommended Type-C Accessories

For testing USB Type-C™ devices, the following solution elements are recommended for the purposes identified:

Model number	Description	Quantity	Purpose
N7018A	Type-C Test Controller	1	Control Power Delivery contracts, alternate mode and orientation
N7015A	Type-C Plug Test point adapter	1	Access of all Type-C signals
N6701C	Power Supply Chassis	1	Power Supply/Active Load for arbitrary Power Delivery settings
N6786A	Power Supply & Active Load	1 minimum / 2 optional	Power Supply/Active Load for arbitrary Power Delivery settings
N9398C	DC Blocking Capacitors	2 minimum / 4 recommended	The RX lanes of Type-C devices do not have blocking capacitors. When testing DP, at least on of these lanes is tested
5061-5311	3.5mm f-f adapter	4 minimum / 8 recommended	Connect matched cables to break out coaxial connector of N7015A
N2823A	1 m matched cable set	2 minimum	Connect scope to N7015A break outs
N5448B	0.25 m matched cable set	2 minimum	Connect scope to N7015A break outs

## AUX Channel Controller

To purchase AUX channel controller for automated control of a DisplayPort TX device under test using the Keysight DisplayPort Electrical Performance Validation and Compliance software, order:

Model Number	Description	Quantity
Unigraf DPR-100	AUX channel controller requires hardware and software license from Unigraf Oy. <a href="http://www.unigraf.fi">www.unigraf.fi</a>	1

## Flexible Software Licensing and KeysightCare Software Support Subscriptions

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 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.

**KeysightCare Software Support Subscription provides peace of mind amid evolving technologies.**

- Ensure your software is always current with the latest enhancements and measurement standards.
- Gain additional insight into your problems with live access to our team of technical experts.
- Stay on schedule with fast turnaround times and priority escalations when you need support.

### Selecting your license:

- Step 1.** Choose your software product (eg. 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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