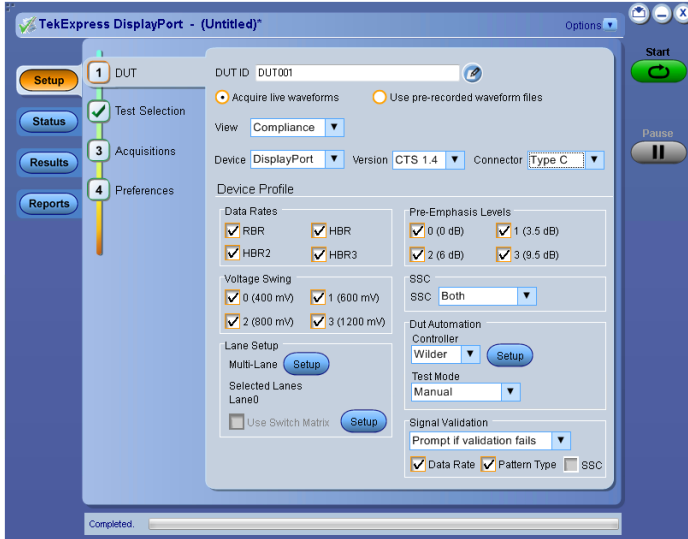# DisplayPort 1.4 and Type-C Compliance/Debug Solution

TekExpress DisplayPort DUT Panel

Tektronix provides DisplayPort 1.4 and Type-C compliance/debug solutions and DisplayPort 1.2 receiver solutions.

DisplayPort 1.4 and Type-C Compliance/Debug solution key features

- Complete automated compliance testing in less than 7 hours for data rates up to HBR2 and less than 11 hours for data rates up to HBR3

- Intelligent pattern recognition before test execution

- Fixture de-embed feature → Use the default filter file for de-embedding fixture effect or create a custom filter file using SDLA software to leverage the channel modeling and receiver equalization functionality

- Easy option to support repeatability of measurements

- Customization of reports according to Tests, Lanes, Data Rates or Pass/Fail results

- Timer pop-ups for **zero** user interaction during entire DisplayPort testing

- Enhanced TekExpress report with new measurement plots

- Single application for Standard and Type-C DisplayPort testing

- 100% DisplayPort High Speed transmitter test coverage

- Complete DUT automation for hands free testing

- Simplistic User Experience with single UI for DUT configuration

- Optimized algorithms execute tests with improved accuracy

- Optional signal validation helps to detect anomalies quickly in the signal

- Reports available in mht, pdf and csv formats for advanced data analysis

- Compliance (TekExpress) and Characterization (DPOJET) test support

- Support for DUT automation over SCPI based Programmatic Interface (PI)

- Automation support and scripting interface with Iron Python which supports socket based programming remote interface

- Supports Manual and Automated test modes for Type-C and Standard DP testing

- Stand-alone utility support for DPR-100 aux controller

- Capture and save DUT waveforms for offline analysis

DisplayPort 1.2 Receiver solution key features

- Automated DisplayPort Sink electrical calibration and compliance testing consistent with the VESA DP 1.2b Sink MOI (Method of Implementation)

- 100% coverage of Sink Jitter Tolerance Tests per DisplayPort PHY 1.2b CTS

- Automated DDJ (ISI) calibration & Jitter Margin testing at user-defined Jitter Frequency Steps

- Support for multiple Variable ISI Hardware Solutions

- Simple Setup, Test Execution, and Reporting in HTML and .csv formats

- Fully integrated with Unigraf DPT-200 DisplayPort AUX Channel Reference Source

- Automates checking of DisplayPort Configuration Data (DPCD) registers for Bit Error Rate (BER) validation

Applications

Tektronix provides the most comprehensive solutions to serve the needs of engineers designing DisplayPort silicon for computer systems and embedded systems, as well as those validating the physical-layer compliance of DisplayPort devices to the DisplayPort 1.4 Compliance Test Specification.

The Tektronix Option DP14 application is compatible with Tektronix DPO/MSO/DPS 70000 C/D/DX/SX series oscilloscopes that are designed to meet the challenges of the next generation of Display standards such as HDMI and DisplayPort.

DisplayPort 1.4 and Type-C compliance/ debug solution

Solution overview

One of the biggest challenges for DisplayPort compliance testing has been long test times and need for complete DUT automation. Most of the time, engineers need to spend a great deal of their time in front of the test setup monitoring the execution in progress. What makes this even more challenging is the integration of DisplayPort and USB Type-C and this challenge is reaching a wider audience.

Tektronix DisplayPort Transmitter test solution solves this challenge by introducing a test application with an integrated Type-C and HBR3 data rate test support. The Tektronix DP12 software, combined with a DisplayPort Aux controller automates DisplayPort physical layer source compliance testing for Standard and Type-C Compliance needs. The TekExpress solution integrates with Unigraf DPR-100 reference sink and eliminates the need for user interaction during testing. Engineers can simply select the desired tests to run and work on other tasks while the tests are being executed.

The new option DP14 supports Transmitter compliance testing up to 8.1 Gbps (HBR3) as per the DisplayPort 1.4 spec. The application also includes support for debugging the setup using a new utility developed for controlling the DPR-100 controller.

Simple setup and test execution

Test setup and test execution is very simple with the DP1.4 automated software. The schematic corresponding to each test provides the details of the connections. The TekExpress software provides a Graphical User Interface (GUI) and an intuitive workflow through setup and testing. When setting up a test, nothing can be simpler than hooking up the test system by looking at a schematic. View the schematic of the selected test with a click of a button.
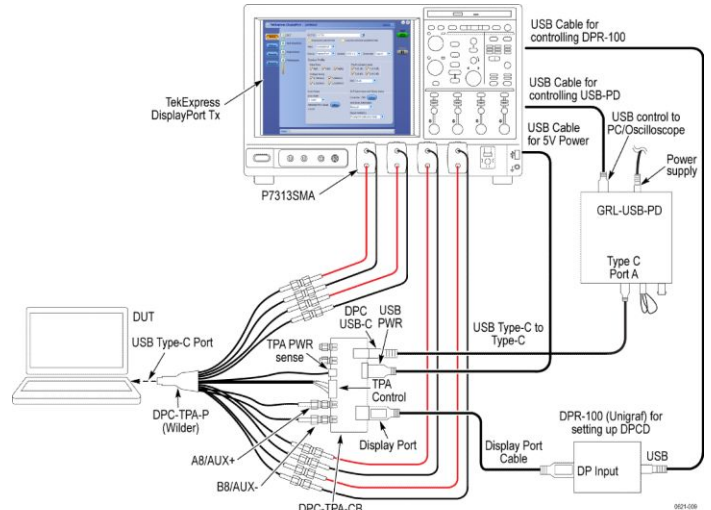
DisplayPort Type-C Setup Overview

With the introduction of Type-C, DisplayPort broadens its reach and functionality by operating as one of the alternate modes of the USB over Type-C technology. This gives a great advantage to end user adopting Type-C who can integrate display, data and power needs into single physical connector. The test challenge here is the user now needs to test the same physical layer for three different standards for complete Type-C compliance.

For DisplayPort, there are some functional differences between a Standard and Type-C DUT and the procedure involved to make these DUTs transmit a signal. The HPD (Hot Plug Detect) signal needed for a source DUT to start transmitting a signal is changed from Interrupt based to Message based in Type-C.

This is achieved by putting the Type-C DUT from default mode (USB) to DisplayPort mode by exchanging series of PD messages over CC (Configuration Channel) lines as per the Power Delivery spec. This requires a presence of a USB PD controller in the setup. Once this controller negotiates the messages and DUT goes into DisplayPort mode, it can be controlled using a second controller (test mode controller) to change the DUT configuration (control data rates, patterns, amplitude, pre-emphasis etc.).
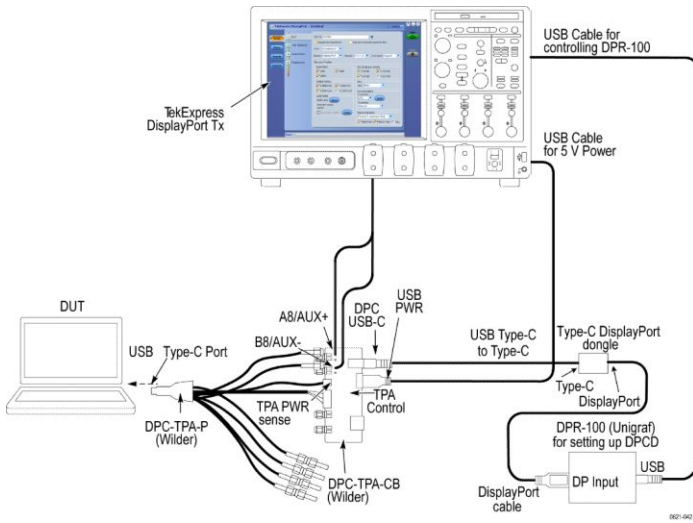
The Tektronix Type-C setup below automates both the controllers using TekExpress framework and integrates the Type-C fixture to achieve complete 4-lane DUT automation using P7313SMA differential probes.

DisplayPort Type-C Setup

For testing ML0 and ML3 signals(i.e Pins A10-A11, B10-B11), connect recommended DC blocks at the output of the test fixture.
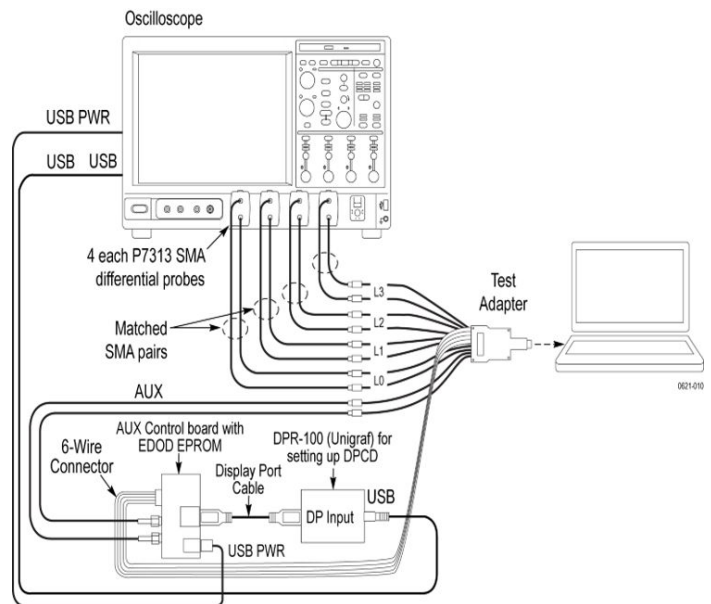
DisplayPort Type-C setup with dongle

DisplayPort Transmitter Test Overview

DisplayPort sources (transmitters) have state control requirements in order to transmit the data patterns and signal properties required to demonstrate conformance to the Compliance Test Specification. The following properties and patterns need to be transmitted for full measurement coverage:

- Bit rates: RBR, HBR, HBR2, and HBR3

- Data patterns: D10.2, PRBS7, COMPEYE, PLTPAT

- FFE (pre-emphasis): 0 dB, 3.5 dB, 6 dB, 9.5 dB

- Output levels: 400 mV, 600 mV, 800 mV, 1200 mV

- SSC (spread spectrum): On/Off

TekExpress Compliance Solution Overview

TekExpress provides automated test support for Standard and Type-C DisplayPort Compliance Testing. The new and advanced TekExpress DisplayPort application leverages the features of the latest TekExpress 4.0 framework and optimizes the overall testing by nearly three times.

Detailed report with summary table

Bathtub and Histogram plot for HBR2 datarate at TP3_EQ

CSV reporting for data analysis

Transmitter Eye Diagram Measurement:

The screen shots below show how an adaptive mask is used in a DP Eye diagram measurement.
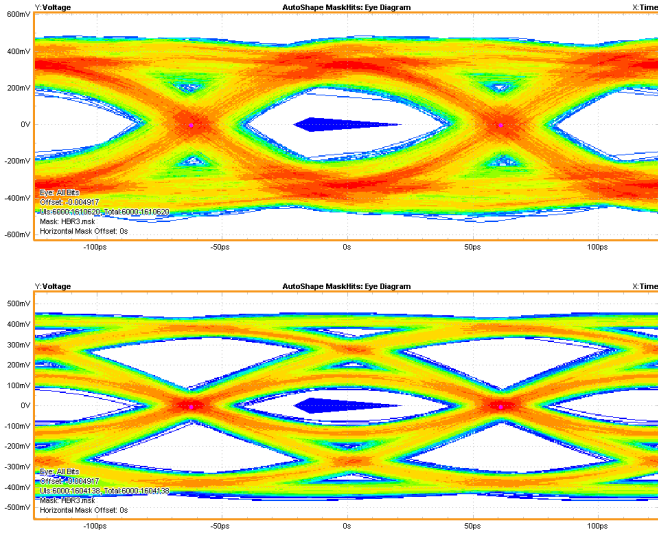
Eye-diagram with dynamic mask generation capability

According to the spec, the eye diagram needs to follow the mask limits:

- Eye diagram width is established at any passing location along 0mV.
- Eye diagram height (symmetric around 0mV) is established at any passing location between 0.375 to 0.625UI.

The measured eye must be equal to or larger than the appropriate eye mask.

The TekExpress application leverages the DPOJET analysis engine to generate a dynamic mask appropriate to the acquired signal and auto adjusts the position of the mask based on eye opening along the horizontal axis. The vertical coordinates are placed at the eye mask location corresponding to the max amplitude level.

Compliance to Characterization Support

Along with TekExpress solution, Tektronix offers DisplayPort DPOJET essentials package which comes bundled with TekExpress and can be used to characterize a DUT and analyzing its finer behavior. It serves as an analysis tool when the DUT fails any portion of the compliance tests or user wants to take a deeper look into the failures. All the compliance tests which are supported in TekExpress and require a single acquisition are supported in this package. The user can build automation scripts around these measurements to setup a custom test environment.
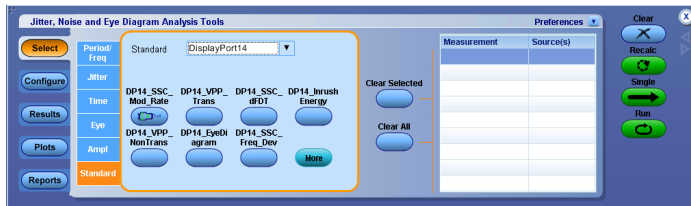
DisplayPort DPOJET Essentials package

You can enable this package by running 'DisplayPort 1.4 essentials' from the Scope → Analyze menu. The DisplayPort DPOJET measurement library helps in characterizing the silicon. Other advantages of this library is the ability to debug the measurement in case of failures. If any of the tests fail during compliance testing, users can tap into the DPOJET DisplayPort measurement library for a dive deeper into the failures such as Eye diagram mask hit failures and look at relation between Pre-emphasis level vs Voltage swing tests to perform root cause analysis. The solution also gives users the flexibility to configure measurements at different settings, make configuration changes in existing measurements on the fly and run tests in single-shot or free-run repetitive modes.

Introducing DPR-100 utility

This new utility helps verify setup connections and DUT behavior before running compliance tests and comes bundled with TekExpress DP 1.4 installer. The utility controls DPR-100 Aux controller to change the DUT settings like data rates, patterns and levels. The utility also helps control PD controller as part of DisplayPort Type-C setup.
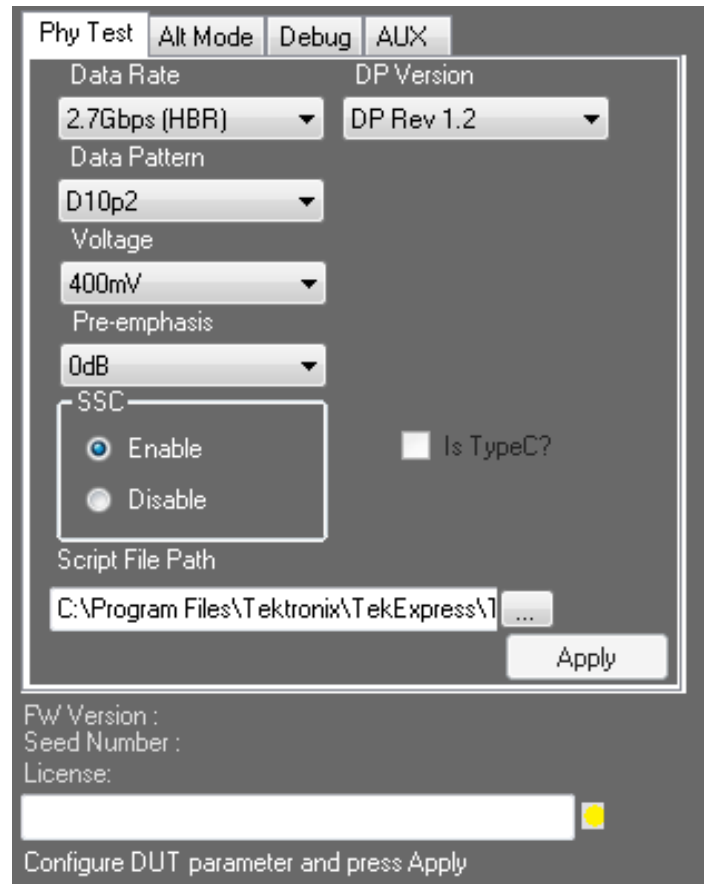
DPR-100 utility

SDLA Features

SDLA enables user to probe and visualize data at the required location (de-embed / embed) using virtual probing through test points. It can remove (de-embed) the effects of the cables, probes and fixtures to get more accurate measurement results. It can embed user defined channel models to simulate the signal at the end of the link. It can also be used to open a closed eye using receiver equalization, Continuous Time Linear Equalizer (CTLE), Decision Feedback (DFE), or Feed Forward Equalization (FFE) . SDLA also has advanced analysis and modeling capabilities. One can view and measure multiple test points using DPOJET Jitter and Eye analysis comprehensive frequency and time domain plots, enable quick verification of S-parameters and test point transfer functions.

Switch Matrix support

Switch Matrix for DisplayPort (SWX-DP) is a software solution integrated with TekExpress DisplayPort application which simplifies the user experience to configure and setup automated multi-lane testing using RF switch.

The user can perform both differential and single ended tests as per DP 1.2/1.4 spec, without a need to make change connections. which significantly cuts down the test times.
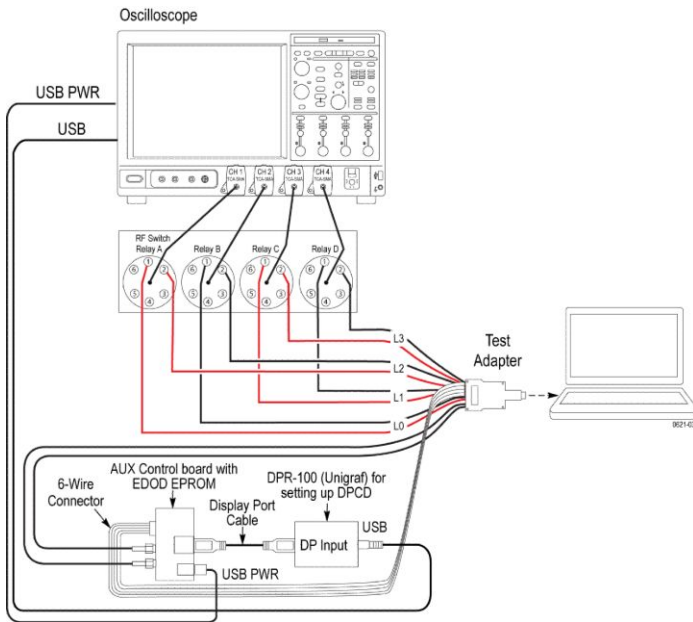
Key features of SWX-DP include:

- Auto Detects the Keithley switch on the GPIB/LAN interface.
- De-embed using filter files – with multiple de-embed options (per relay, per input, etc.).
- Operates with TekExpress and DPOJET (Debug Mode).
- Save/recall switch configurations.
- Graphical view with print option to support hardware wiring.
- Graphical view integration with TekExpress report.
- Built-in error handling to support easy and error-free configuration.
- Support for custom input labels such as Lane, Port, etc. via XML file edits.
- Programmatic interface to support scripting and easy integration into user's automation environment.

DisplayPort 1.2 Receiver solution

DisplayPort Sink Test automation software overview

The DisplayPort Sink Test Automation Software for the Tektronix BERTScope (TEK-GRL-DP-SINKSW) provides an automated, simple, and efficient way to test DisplayPort Sink (Receiver) devices per the Jitter Tolerance requirements of the DisplayPort Physical Layer Compliance Test Specification (CTS) version 1.2.

The GRL-DP-SINK application automates single and multi-lane measurements at all DisplayPort data rates 1.62, 2.7, and 5.4 Gb/s (RBR, HBR, and HBR2), and runs on a 70K series Windows 7 OS-based Oscilloscope.

The test automation software eliminates the need for user interaction during testing. It enables automated calibration between the BERTScope and real-time scope to generate stressed-signal conditions for DisplayPort 1.2b PHY CTS Sink Compliance testing.

The unique DDJ (ISI) calibration feature incorporated into the software eliminates the need for fixed ISI boards, and supports multiple test cases without change in setup (such as Long Channel, Short Channel, No Channel) The software supports multiple Variable ISI Hardware Solutions, including the Tektronix BERTScope DPP125C + LE320 Variable ISI, and Artek CLE1000-A1 Low Frequency Variable ISI.

The combination of test automation software and an AUX Channel Controller (Unigraf DPT-200 Reference Source with AUX Control) automates Link Training and BER validation. The Margin Test feature stresses the Receiver to failure at user-defined Jitter Frequency Steps, revealing the true capabilities of your Receiver design.
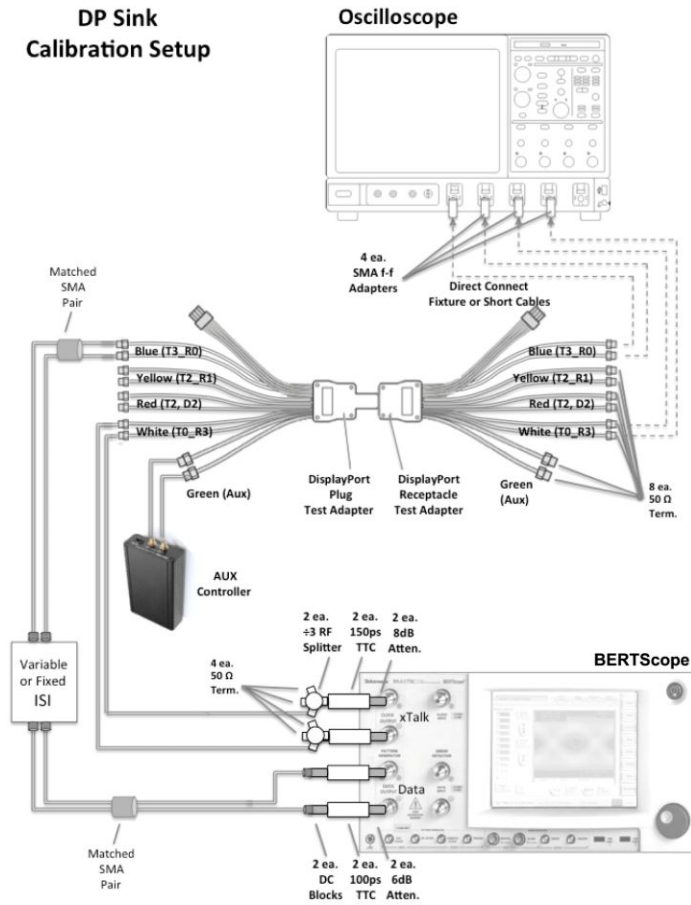
Calibration and compliance testing

Refer to VESA DisplayPort PHY CTS Rev. 1.2b and Tektronix Method of Implementation (MOI) for specific details.

The receiver testing comprises of a two-step operation. Calibration and Compliance testing.

Calibration

Refer to the following figure for the calibration setup:


Calibration setup

The following DUT parameters are calibrated in the first step of calibration:

- ISI calibration:
  - The software sets up DPOJET to measure the ISI (DDJ) of the Channel that is connected as per the specification. This measurement is at TP3 for RBR and TP3_Eq for HBR and HBR2. If the measured DDJ is within the target value of the spec, the software reports a pass.
  - A variable ISI channel can be used to more easily adjust the channel to be within the specification. The test automation software supports automated control of the Tektronix BSAITS or ARTEK CLE1000-A2 variable ISI generator.

- Random jitter:
  - This step calibrates RJ on the BERTScope. The pattern changes from CP_2520 (or PRBS-7 for HBR, RBR) to 1100 for RJ calibration.

- SJ Fixed:
  - (This is for HBR2 only). 1100 pattern is used for SJ_Fixed Calibration.

- SJ Sweep:
  - All SJ Frequencies are calibrated as part of this step. 1100 is the pattern used.

- Crosstalk:
  - This step calibrates the xTalk amplitude on the BERTScope. The signal amplitude being calibrated on Ch3-Ch4 with ¼ Rate Clock from the Clock outputs of the BERTScope.

- Eye-Height:
  - This step calibrates the Eye Height on the BERTScope. The pattern for Eye Height is changed back to the Compliance Pattern (CP_2520 for HBR2, PRBS-7 for RBR and HBR).

Testing the DUT for CTS Compliance

Refer to the following figure fro the test setup:
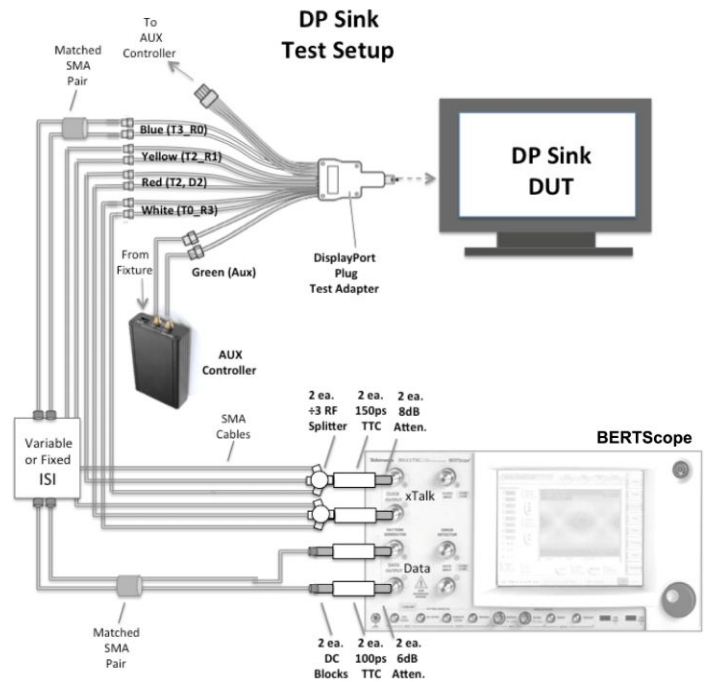
Test setup

The BERTScope outputs stressed pattern as defined in specification with RJ, SJ, and ISI jitter injected. The error counter is initially cleared. The sink compliance tests are run for a specified time. If the Sink DUT supports aux communication, then after the specified test time, the error counter is read through by reading sink DPCD register.

The software test application supports automated testing of a sink device if the sink device supports standard DPCD through the AUX channel. Unigraf DPT-200 Aux controller is required for this test. The test software performs link training and then performs jitter tolerance at selected frequencies. Test matrix for BER measurement are defined in the specification. Refer to table 4-1 of DisplayPort 1.2 spec. After all test conditions are complete, a compliance report is generated.

For Compliance, it is sufficient to perform the compliance tests on each test condition. However, it is often useful to understand how much margin your design has. The test software provides ability to margin test the DUT by considering Minimum bits to be tested, Maximum errors, Jitter step size and Minimum step size. There is alos a provision to generate Calibration and Margin test plots.

Specifications

List of Measurements Supported as per DP 1.4 Standard/Type-C CTS

- 3.1 Eye-diagram Testing
- 3.2 Non Pre-Emphasis Level Verification Testing
- 3.3 Pre-Emphasis Level Verification Testing
- 3.3 HBR2HBR3 Level and Equalization Verification Testing
- 3.4 Inter Pair Skew Test
- 3.5 Intra-Pair Skew Test
- 3.10 AC Common Mode Noise
- 3.11 Non ISI Jitter Measurements
- 3.12.1 Total Jitter (TJ) and Deterministic (DJ) Measurements
- 3.12.2 Random Jitter (RJ) Measurements
- 3.14 Main Link Frequency Compliance
- 3.15 Spread Spectrum Modulation Frequency
- 3.16 Spread Spectrum Modulation Deviation
- 3.17 dF/dt Spread Spectrum Deviation HF Variation
- 3.18 Dual mode TMDS Clock
- 3.19 Dual-mode EYE Diagram Testing
- 8.1 AUX Manchester Channel Eye Test
- 8.2 AUX Manchester Channel Sensitivity Test
- 8.5 AUX Inrush Test
- 9.2 AUX Slew Rate

Physical characteristics	Configuration	Description
	Oscilloscope	DPO/MSO71604C or above including latest SX series oscilloscopes with Option DJA, 5XL and SDLA64 • 4 GHz and above is recommended for RBR • 8 GHz and above is recommended for HBR • 12.5 GHz and above is recommended for HBR2 • 16 GHz and above is recommended for HBR3
	Probe	P7313SMA x 4 (for multilane testing) P7713-P77C292MM or P7716-P77C292MM or P7720-P77C292MM or P7313SMA x 4 (for multilane testing)

Ordering information

Software Ordering Information

DP1.4 software can be ordered separately as an upgrade option for a Tektronix oscilloscope or ordered along with a new oscilloscope. Please refer to http://www.tektronix.com/displayport for detailed product configuration on Source and Sink testing.

Option	Description
DP14	TekExpress DP 1.4 Conformance Automation Solution: Instrument License
DPOFL-DP14	TekExpress DP 1.4 Conformance Automation Solution: Floating License
DPO-UP DP14	TekExpress DP 1.4 Conformance Automation Solution: Software Upgrade
DP12/DPOFL-DP12/DPOFT-DP12	TekExpress DP 1.2 Conformance Automation Solution for backward compatibility testing
SWX-DP/DPOFL-SWX-DP/DPOFT-SWX-DP	Switch Matrix option for DisplayPort testing
SDLA64	Serial Data Link Analysis for Win10 (64 bit) along with Win7 Oscilloscopes

Recommended Fixture and Accessories for DisplayPort Testing

Option	Description
TF-DP-TPA-P	Standard DisplayPort Plug fixture
DP-TPA-A	DisplayPort Aux Control Adapter from Wilder Tech
DPR-100	DisplayPort Reference Sink Aux Controller from Unigraf
DPR-100 FW	DisplayPort Aux Refsink Controller DisplayPort Aux Refsink Controller upgrade for HBR3
GRL-USB-PD-C1	Type-C Power Delivery Controller from Granite River Labs
Type-C to Display Port Dongle	Dongle acts as a Alt mode controller
TBTCAMT-TPA-P	Tektronix pre-compliance Type-C fixture
PSPL5501A (or equivalent DC Block) (4 n.o)	Recommended DC Block for DP Type-C testing

Prerequisite Host System Software Requirements for DisplayPort Testing

Operating System	Windows 10 and 7, 64 bit
Software	• Microsoft Internet Explorer 7.0 SP1 or later • Adobe Reader 7.0 or equivalent software for viewing Portable Document Format (PDF) file • Microsoft Excel 2007 or equivalent software for viewing Comma-separated Value (CSV) file

For more information about DisplayPort testing, visit our website http://www.tek.com/displayport-0

Recommended software and equipment for DisplayPort Sink Test Automation

Recommended equipment and software

Equipment / software	Description
Stressed signal generator	BERTScope BSX125
Oscilloscope	DPO/MSO 71254C/DX (or above) with DPOJET option DJA and SDLA64 for creating CTLE filters
Automation software	Option TEK-GRL-DP-SINKSW

Recommended accessories

Accessories	Description
Aux controller	Unigraf DPR-200 (for DUT automation)
Matched pair cables	5 pairs, Tektronix part number: 174-4944-xx
ISI Generator	Artek CLE1000-A2
Fixture	F-DP-TPA-PR, plug and receptacle fixture
DC blocks	2 each; 20 GHz DC Block
Divide by 3 splitter	2 each; JFW 50PD-292 or equivalent
150 ps TTC filters	2 each

For Further Information. Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit www.tek.com.

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