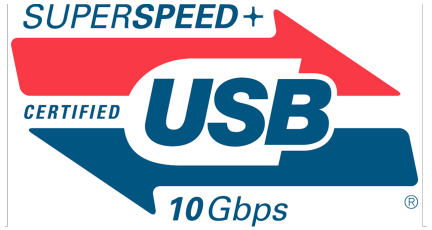

VESA – DisplayPort™ Alternate Mode on USB-C™ - Technical Overview

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VESA Compliance Program Manager

Hong Kong

October 19 – 20, 2016

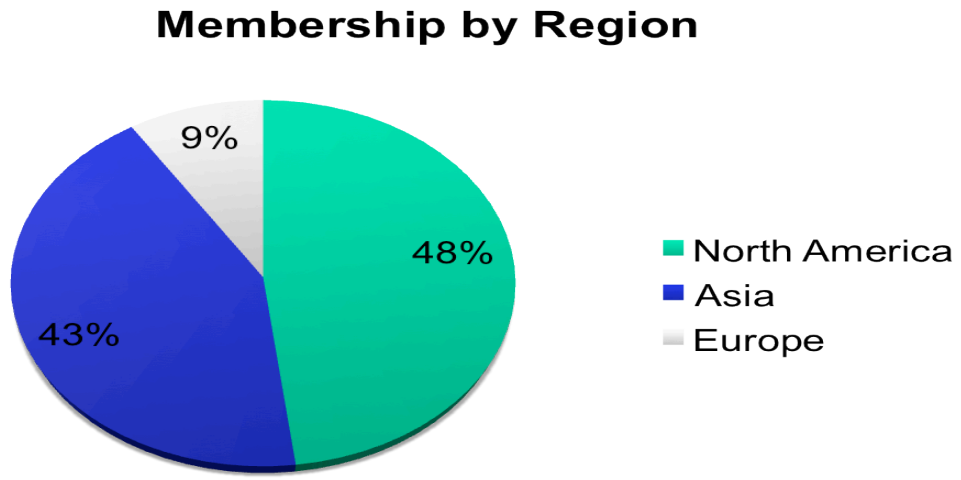
Agenda

- Introduction
- DisplayPort Technology Roadmap
- DisplayPort Alternate Mode on USB-C Technical Overview
- Compliance
- Demo
- Summary

About VESA

VESA is the **Video Electronics Standards Association**

Global industry alliance with **more than 230 member companies**



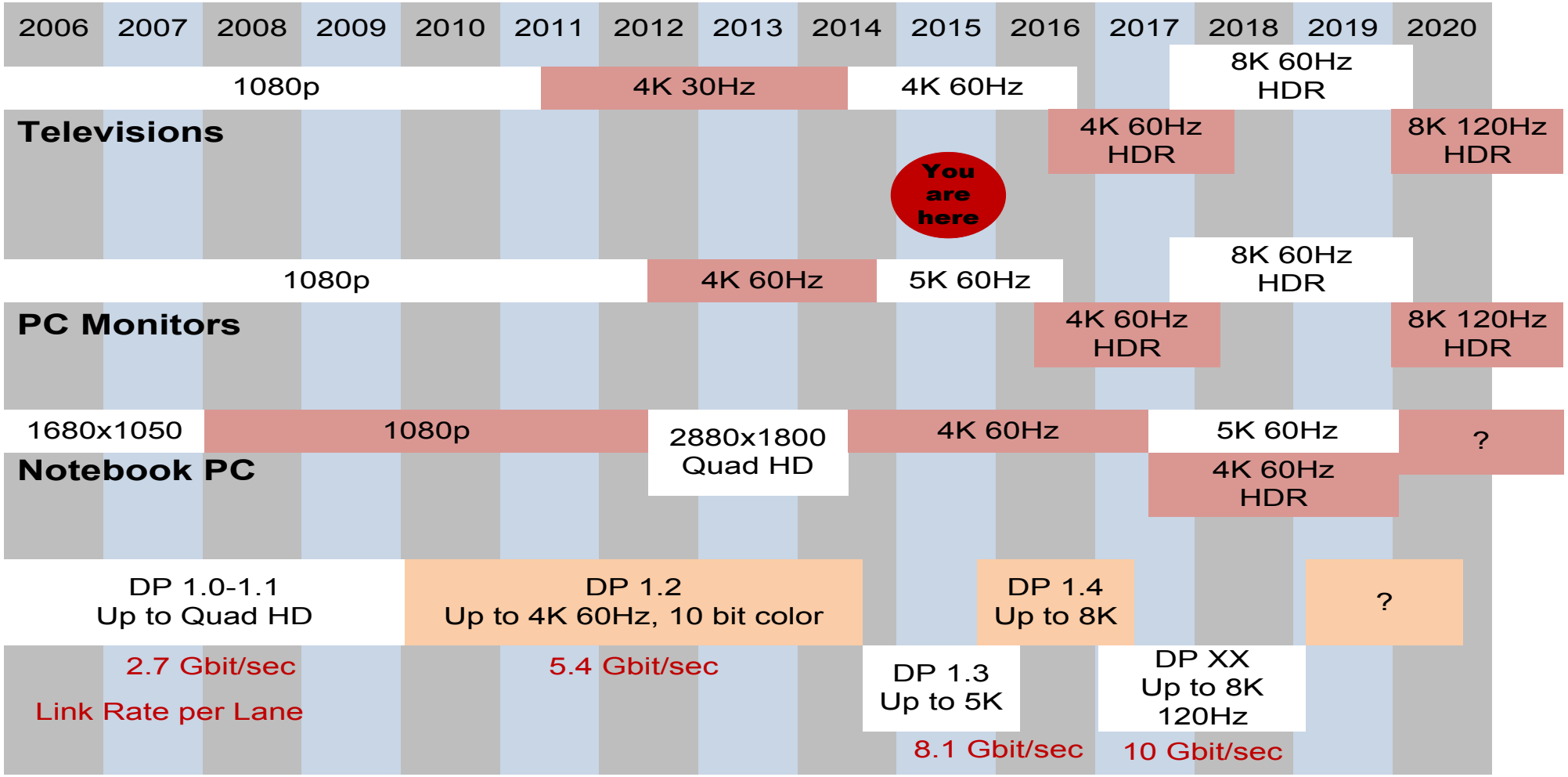
Mission is to develop, promote and support an ecosystem of vendors and certified interoperable products for the electronics industry

Facilitates display related standards development, publication and compliance testing, as well as promotion and marketing

Develops Open standards, contribution is open to all companies at all stages of development

Example of VESA Members

Display Trends and DisplayPort Roadmap



DisplayPort Specification Summary

- The VESA DisplayPort Standard, Version 1.4, was released on March 1, 2016
  - Replaces DisplayPort Version 1.2a/DP1.3 for new designs
- Backward compatible, offers new optional features
- New Silicon supporting HBR3 is under deployment and certification testing has started
- DisplayPort 1.4 New Features
  - Forward Error Correction
  - Adds DSC, Audio extensions, improved MST functionality, Adaptive Sync
  - 30 bit color; 8K 4:4:4, 7680X4320 @60Hz – Single Cable

DP 1.4 Link Rate Increase

DP Version Introduction	Link Rate Name	Bit rate	Max Resolution Support (24 bpp, 60Hz Refresh, 4:4:4 format)	Max Resolution Support (24 bpp, 60Hz Refresh, 4:2:0 format)
DP 1.0	RBR	1.62 Gbps	1920x1080	Not supported
	HBR	2.7 Gbps	2560x1600	Not supported
DP 1.2	HBR2	5.4 Gbps	4K x 2K	Not supported
DP 1.3/1.4	HBR3	8.1 Gbps	5K x 3K	8K x 4K

Total useable data transfer rate for DP 1.4 = 25.92 Gbps

8.1 Gbps link rate, per lane
x 0.8 to account for 8b/10b transport coding overhead
x 4 maximum number of available lanes
25.92 Gbps total usable data transfer rate

Optimization for Shared Interface Use

- Numerous specification enhancements to simplify the use of DisplayPort as an ingredient in the following interface examples:
  - The USB-C connector, using the DisplayPort Alt Mode
  - VESA DockPort Standard
  - VESA Mobility DisplayPort Standard (MyDP)
  - VESA Embedded DisplayPort Standard (eDP)
  - ThunderBolt 3.0
  - Wireless interfaces

DisplayPort 1.4 Continues to Support Other Features that are Unique to DisplayPort

- Multiple monitors using Multi-Stream
- High-definition audio formats
- Adaptive Sync
- Protocol converters to VGA, DVI, or HDMI
- Low voltage, AC coupled interface compatible with sub-micron process geometry, simplifying integration
- Data scrambling and fixed link rates simplify EMI and RFI mitigation

Progression of Display Experience with DisplayPort

DP 1.0/1.1 (4/2007) – HBR1
- A setup driven by 6 Mini-DP connectors at 2560x1600@60Hz on single graphics card

DP 1.2 (12/2009) – HBR2
- UHD – 4K
- 30 bit color; 3840x2160@60Hz
- Tiled Display: 4Kx2K single cable
- Tiled Display: 5Kx3K Dual Cable
- AdaptiveSync

DP 1.3 (9/20014) – HBR3
- HDR, PQ Gamma, BT 2020
- HDCP 2.2, 420
- Tiled Display: 8K 444 Dual Cable
- 5Kx3K@60 and 4k@120Hz Single Cable
- Single cable for DP A/V, power and data using DP Alt Mode on USB-C

DP 1.4 (3/20016) – HBR3 & DSC
- UHD – 8K
- 30b color; 8K 444 (7680x4320) @60Hz – Single Cable
- VR – 4K + 120Hz + USB3.1 + Pwr
- Multi Display Docking with DP Alt Mode on USB-C
- Dynamic HDR Meta

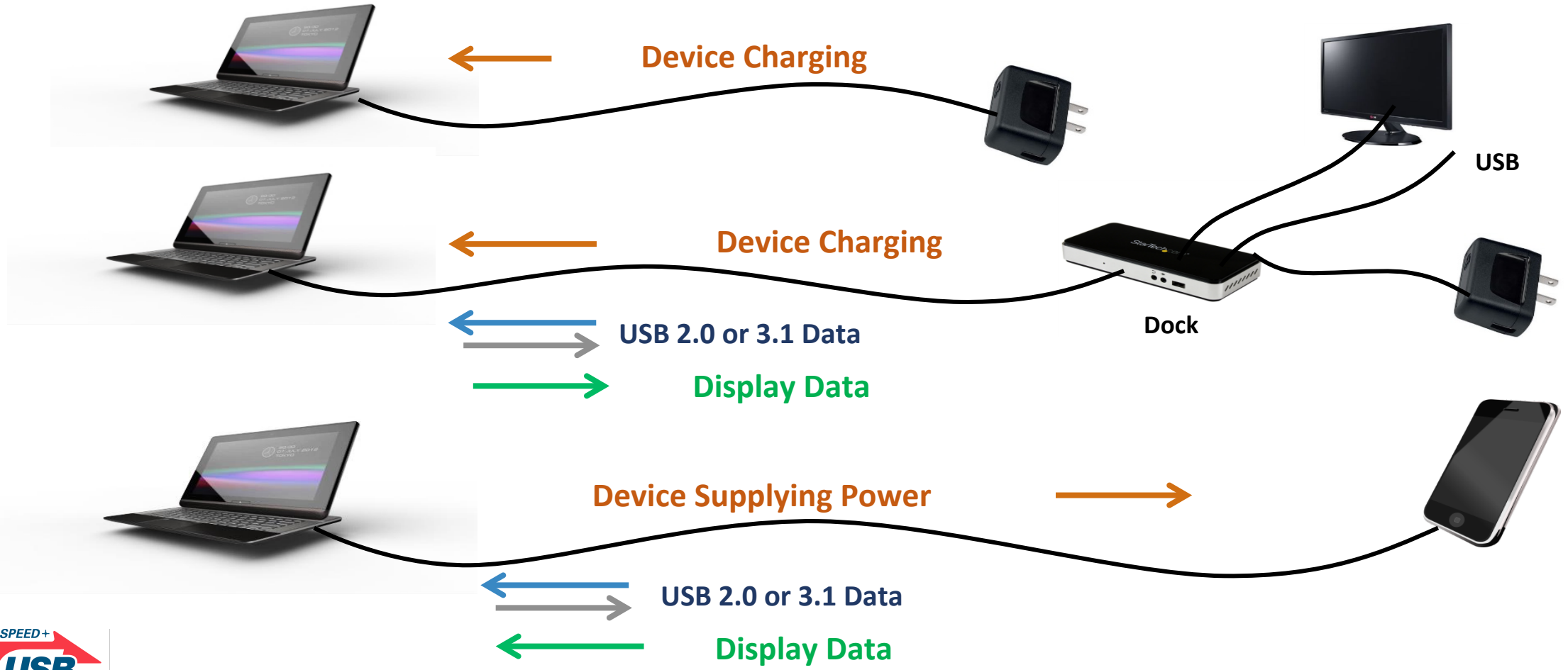
DisplayPort Alternate Mode on USB-C Overview and Certification

VESA DisplayPort Alternate Mode on USB-C Summary

- The VESA DisplayPort Alt Mode Standard, Version 1.0a , was released on Aug 10, 2015
- Enables the use of the USB-C interface for DisplayPort
- DisplayPort Alternate Mode is a functional extension of the USB-C interface
- Developed in liaison with the USB 3.0 Promoter Group
- The DisplayPort Alternate Mode over USB-C Compliance Test Specification draft is under General Member Review with expected release next quarter

Example USB Type-C Configurations

Either end can serve as USB Host, USB-PD Power Consumer, and DisplayPort Video Source (these services are independent of each other



USB-C with DP Alt Mode Ecosystem Deployment Underway

DP Alt Mode Products

Apple MacBook

HP Pro Tablet 608 G1

Dell XPS 13/15

LG 27UD88 4K display

StarTech 4 in 1 Adapter

Google Chromebook Pixel

Microsoft Lumia 950 and 950XL Smartphones

Many different adapters available

- C to DP adapters, Multifunction docks
- Type C protocol converters (HDMI, VGA, DVI) using DP Alt Mode

More are expected soon

- Major PC continue to launch new products with DP Alt Mode over USB-C
- Thunderbolt includes USB 3.1 + DP Alt Mode as standard compatibility modes

Wide Range of Cables/DP Alt Mode Adapters Shipping Today

Standard USB-C to USB-C Cable

USB-C to VGA

USB-C to DP

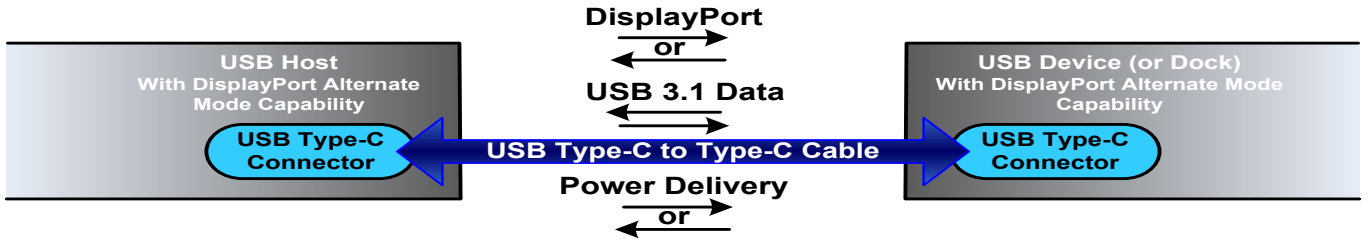
USB-C to DVI

USB-C to HDMI Plug

USB-C to HDMI Receptacle

These adapters enable the use of the vast install base of legacy displays for the increasing numbers of systems that support DisplayPort Alternate Mode over USB-C.

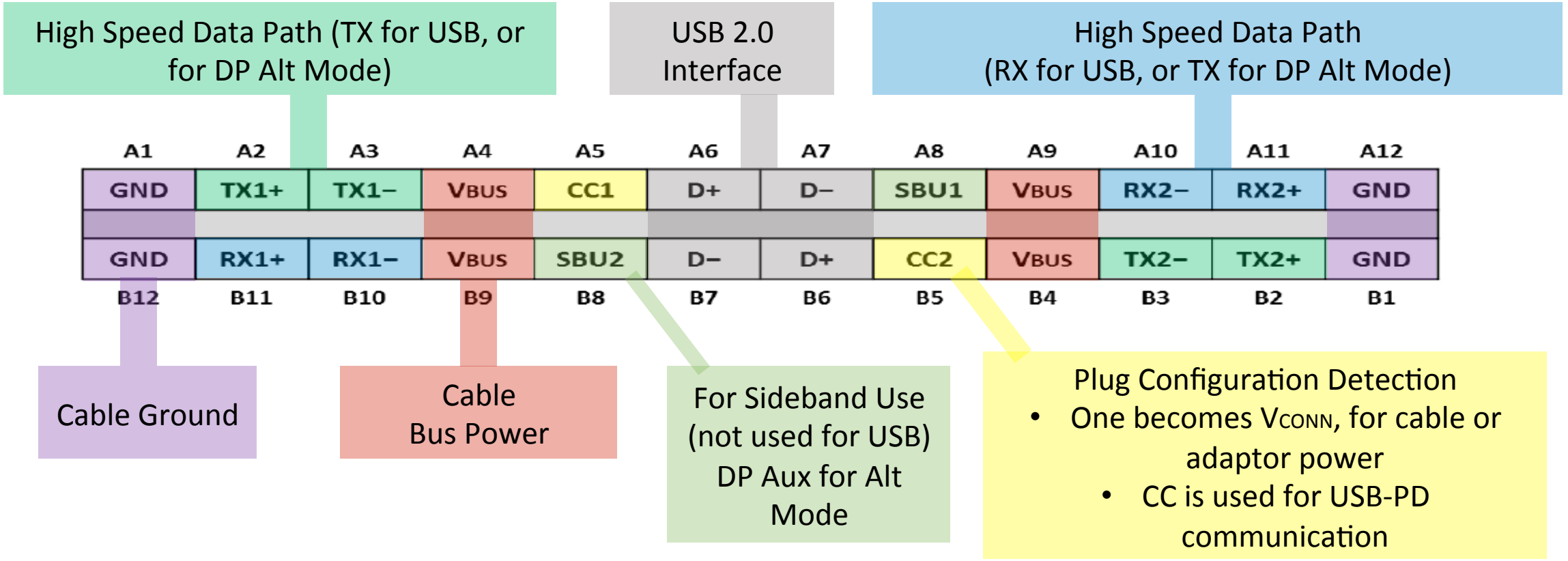
USB-C Connector Functional Extension DisplayPort Alternate Mode



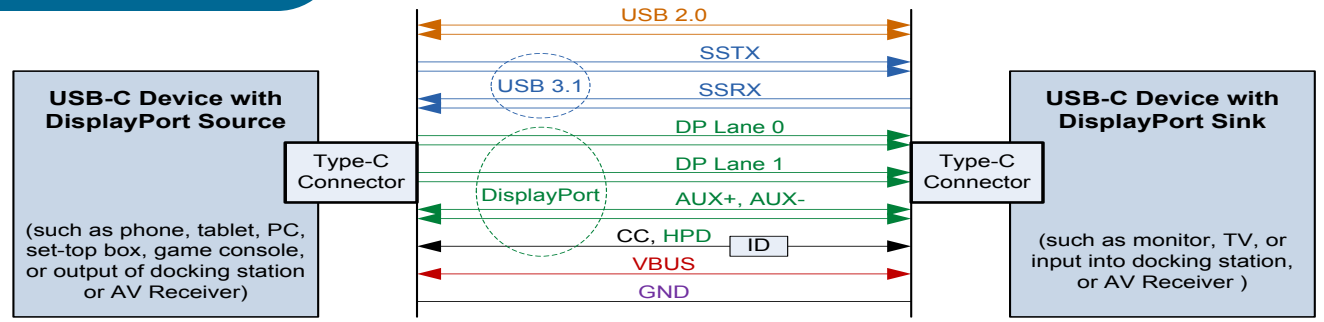
- A passive Full Feature USB Type-C to Type-C cable can carry up to four DisplayPort lanes
  - Same performance and features as a standard DisplayPort connection
  - Allows DisplayPort data rates to increase in the future, since the USB Type-C connector has very high data rate capability
- DisplayPort can be combined with USB 3.1 operation over the same USB Type-C cable
- USB 2.0 and USB Power Delivery is available in all configurations

USB Type-C Receptacle Pins

- Below is a diagram of the pins defined for system or device receptacle



DisplayPort and USB 3.1 over a Standard USB-C Cable

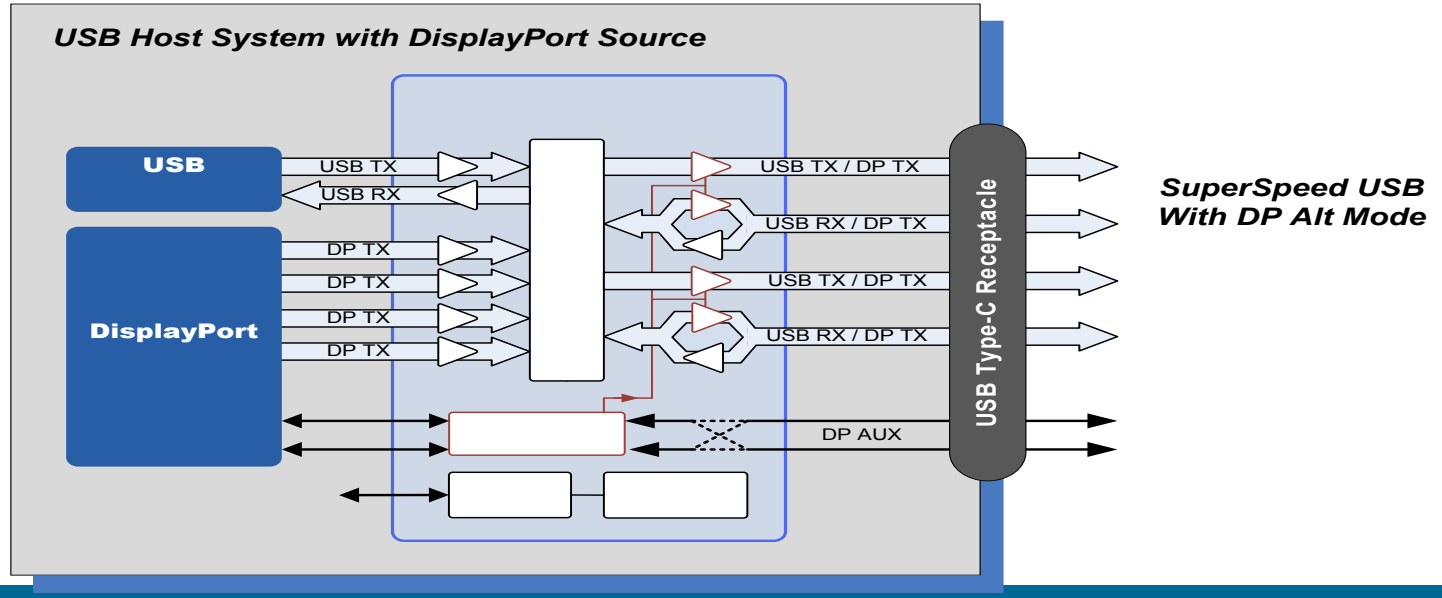


- Uses a standard “Full Feature” USB-C to USB-C cable which is designed to include DisplayPort
- The above configuration uses two high-speed lanes each for DisplayPort and USB 3.1
  - Ideal for docking stations, or for displays or TVs that include USB 3.0 functions
- DisplayPort performance provided by two lanes
  - DP v1.2 (existing Source devices): Two 1080p displays, or one 4k@30Hz
  - DP v1.4 (HBR3 Source devices): 4K@60, or HDR 4K@60 using 4:2:0 and 12bpp
- 4 Lanes of DisplayPort available if only USB 2.0 implemented in Sink
  - Support for 4K@60, or two 2560x1600, or four 1080p

Example USB-C PHY Port Configuration Switch for Systems with DisplayPort Source

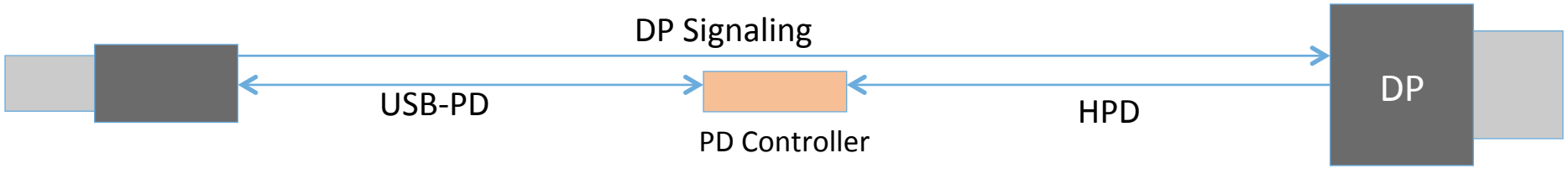
- Equalization and re-drivers for the SS USB and DisplayPort signals increase margins
- Compensates for loss in PCB traces and switch, increases system design flexibly and compliance margin
- Routes signals according to plug orientation and use of SS USB and/or DP
- Similar switch needed

at source side

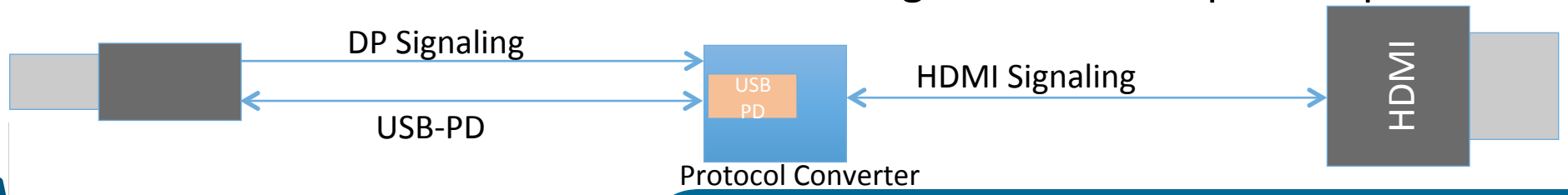


Supported cable types

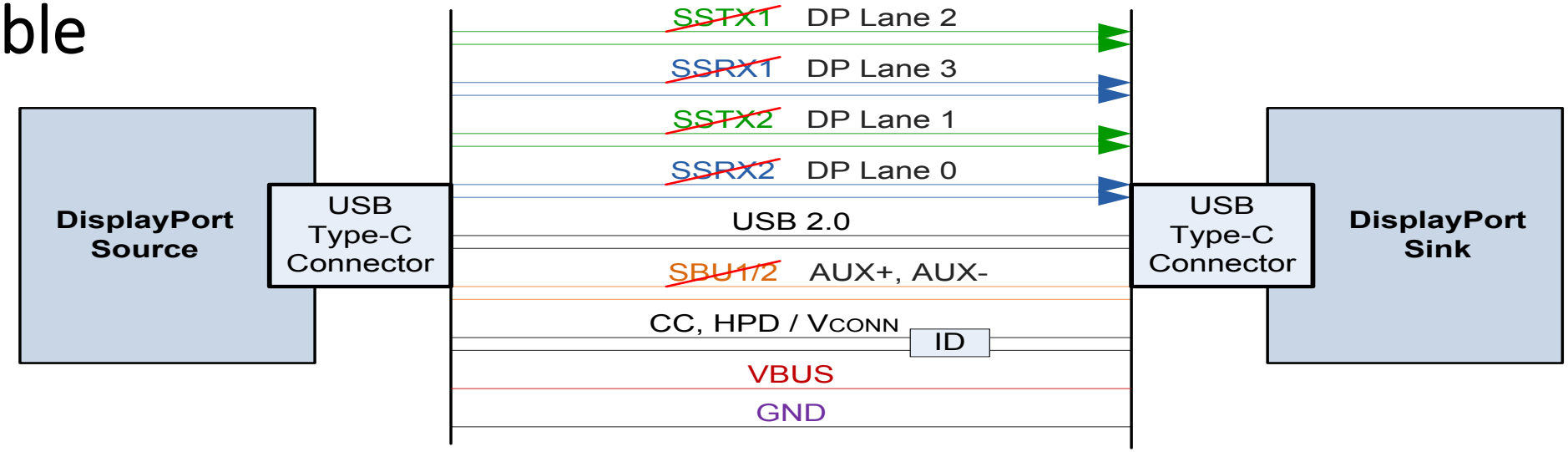
- USB-C to USB-C
- USB-C to DP
- USB-C to Protocol converter
- USB-C to Docking station or embedded hub solution
- USB-C to DP cables must include logic to support USB PD and DP connection detect protocols.



- Protocol converters must support some optional features in DP 1.3 specification
  - Protocol converters translate source DP signals to the respective protocol supported

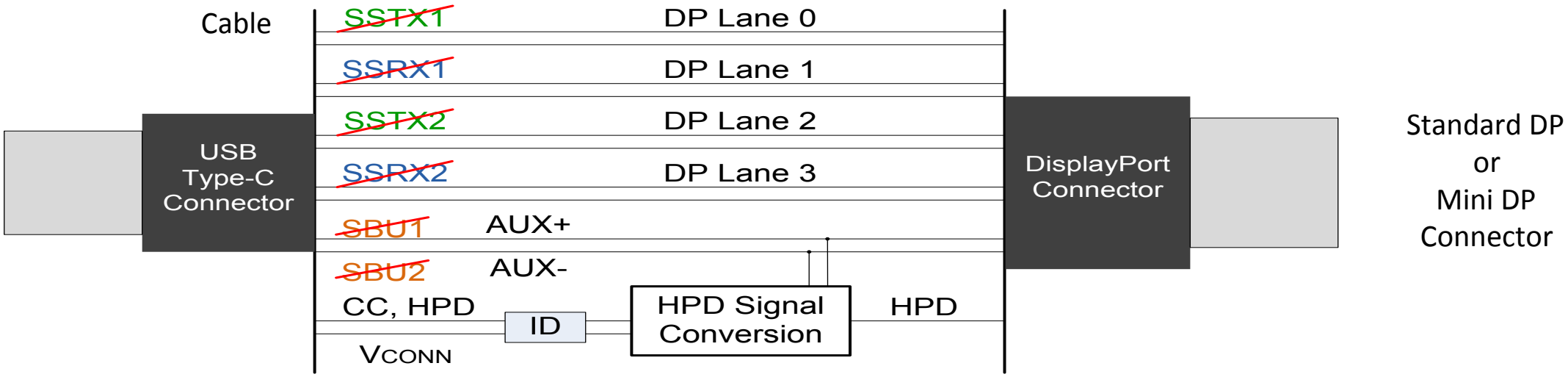


DisplayPort Over a USB Type-C to USB Type-C Full Feature Passive Cable



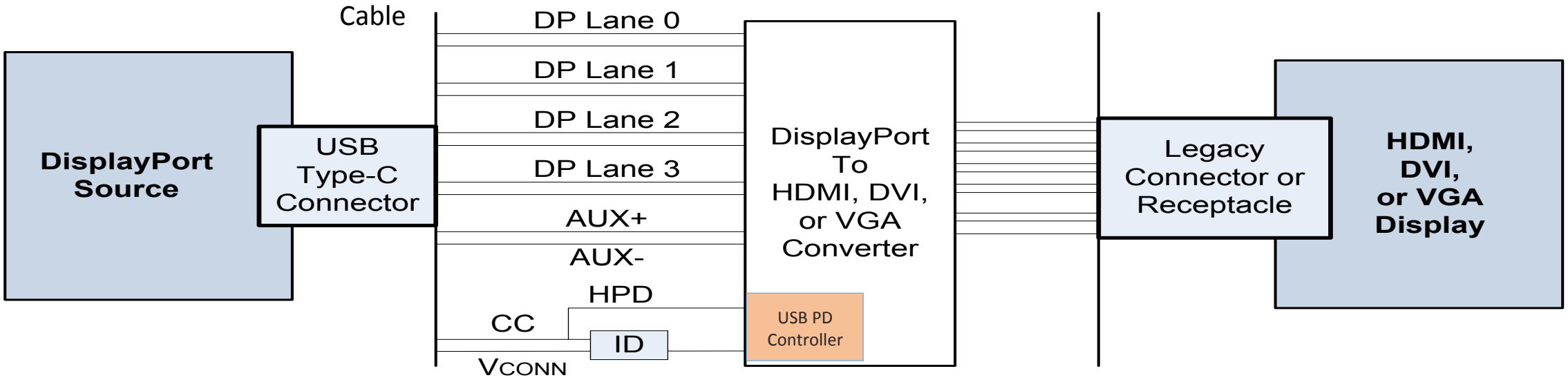
- Utilizes optional DisplayPort Alt Mode capability of USB Type-C connector
- DisplayPort can use all four high speed lanes to deliver full DisplayPort performance
- The DisplayPort AUX Channel uses the SBU pins
- The DisplayPort HPD / IRQ is transmitted over the CC pin using the USB-PC protocol
- USB 2.0 and USB Power Delivery always available

USB Type-C to DisplayPort Adapter Cable



- Uses DisplayPort Alt Mode capability of USB Type-C connector
- Cable must be reversible, works in either direction; four lanes of DisplayPort
- Supports legacy DisplayPort Source and Sink Devices
- Detected by USB Type-C enabled device that supports DP Alt Mode
- No support for USB (other than USB Billboard) or other alt modes
  - These features are not supported by legacy DisplayPort devices

USB Type-C to HDMI, DVI and VGA Adapter Cables / Cable Adapters

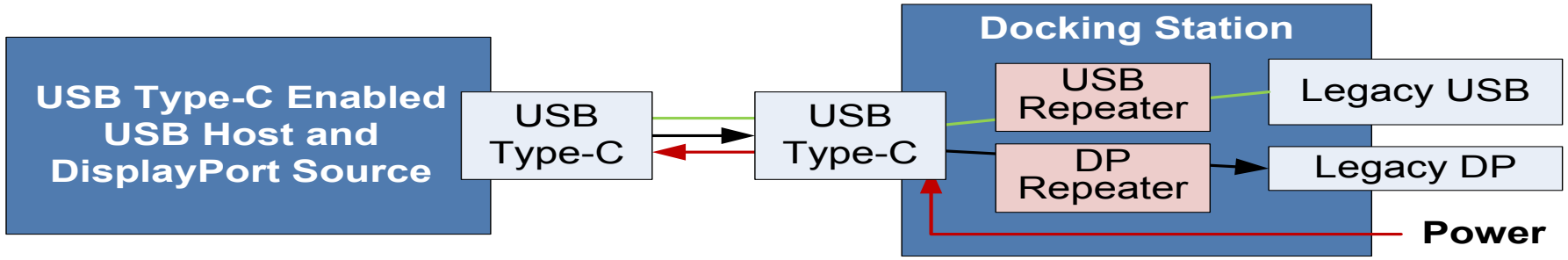


- Uses DisplayPort Alt Mode capability of USB Type-C connector
- Adapter Cable: USB Type-C plug on one end, legacy **plug** on other end
- Adapter: USB Type-C plug on one end, legacy **receptacle** on other end
- USB Type-C will NOT support DisplayPort Dual Mode (DP++)
- USB Type-C to HDMI Converters support up to HDMI 2.0 and CEC

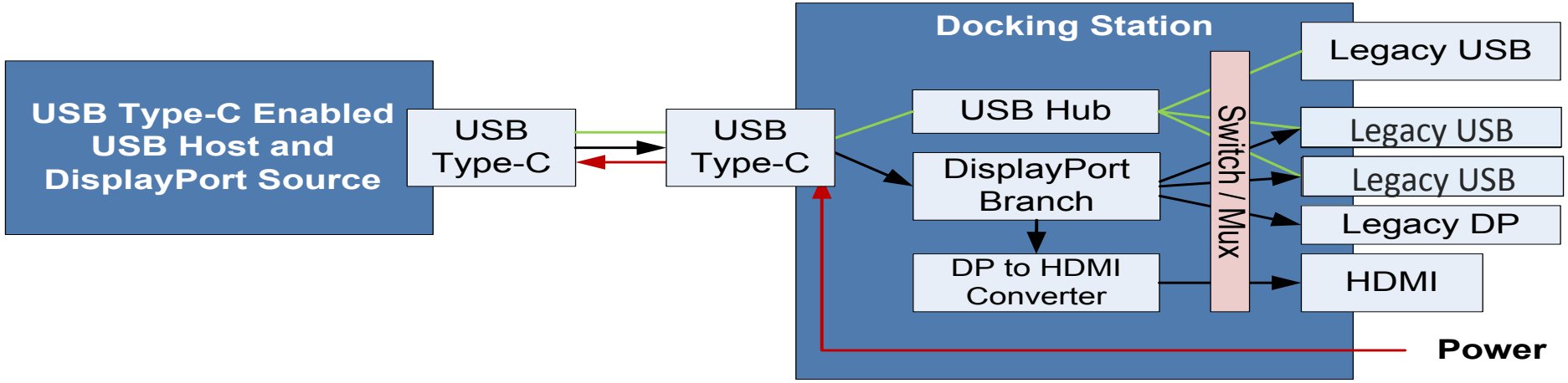
Both styles are available

Example Docking Configurations using the USB Type-C DisplayPort Alternate Mode

Simple Docking Configuration



More Complex Docking Configuration



DisplayPort Alternate Mode Compliance Test Plan

- VESA is developing the DP Alternate Mode compliance test in coordination with the USB-IF
- Compliance test specification (CTS) is under under general membership review
  - Draft 1.0 expected to release next quarter
- The objective is to enable compliance testing for USB Type-C, and the DP Alt Mode for USB Type-C, at the same ATCs enabling the use of a single test station
- Certification of many DisplayPort Alternate Mode enabled products is in progress at GRL and Allion ATCs

Certification Test Coverage

Test plan and CTS covers all features and supported pin assignments.

- USB PD Compliance Testing
  - Demonstration of proper functionality/behavior for DP Alt Modes
  - A device must pass DisplayPort Alt Mode USB-PD certification tests to receive DP certification
- Electrical testing of all supported modes with PHY test fixtures
  - USB PHY electricals
    - USB 3.1 Gen1 5G
    - USB 3.1 Gen2 10G (if supported)
    - USB 2.0 480Mb/s
  - DP PHY electricals (DP 1.2b CTS)
    - RBR
    - HBR
    - HBR2 (HBR3 compliance requirements under development)
    - Aux Channel

Certification Test Coverage (continued)

- USB 3.1 Interop testing (functional)
- USB 3.1 Link testing
- Full DP certification testing using reference Adapters
  - Interoperabilty testing
    - Interop testing with a required matrix of products and adapters that are available.
    - Testing with reference USB-C to DP adapters is required.
    - Testing with reference DP Alt Mode over USB-C reference sources and sinks is required.
  - Link layer testing
  - EDID testing
  - MST testing if supported
- Certification testing of USB 3.1 functionality not duplicated if product vendor provides VESA USB-IF Compliance Test ID

Cable & Adapter testing

- Certification testing of cables/adapters
- USB-C to USB-C cables certified via USB-IF
- USB Type C to DP cable
  - Electrical testing
  - Interoperability testing
  - Link Layer testing
- Protocol converters (all protocol converters are DP sinks)
  - Receiver testing
  - USB PD testing
  - Link Layer Sink tests
  - Interoperability tests

VESA Synchronization with USB-IF Compliance Test Program

- Coordinate certification plans, test coverage and timing for early products
- Avoid scheduling conflicts
- Participate in USB-IF certification and interoperability events
- VESA will continue to participate in USB-IOP events and workshops

VESA PlugTest Events in 2016

- PlugTests have significant value to member companies. Particularly as new capabilities and products are deployed.
- VESA planned to host three PlugTests in 2016. The third event this year is in Taiwan.
- November Taiwan event introduced workshop pre-cert testing

- Objectives of 2016 Plugtests
  - Demonstrate and improve interoperability
    - Particularly important for new product capabilities
  - Test DP 1.4 and DP Alt Mode over USB Type-C
  - Verify Test Equipment Correlation
- Dates/Locations:
  - Done: March 23-26th 2015, Milpitas CA
  - Done: September 14th-17th 2015, Embassy Suites Burlingame CA
  - Planned: Taiwan December 12-16th, Westin Taipei

Logo Useage Guidlines

- No change to existing DP product logo guidelines
- For DP over USB-Type C products
  - DP certification includes subset of testing requirements of USB-IF
  - Requirement to use new fixtures and DP over USB Type-C adapters
- Refer to VESA DisplayPort logo useage guidelines for further information
- Refer to the USB-IF Trademark License Agreement for further information
- VESA is working with the USB-IF to create additional logo guidelines as well as common product description terminology

SuperSpeed USB Trident Logo
+ DisplayPort Logo

SuperSpeed USB Power Delivery Trident Logo
+ DisplayPort Logo

SuperSpeed USB 10 Gbps Power Delivery Trident Logo
+ DisplayPort Logo

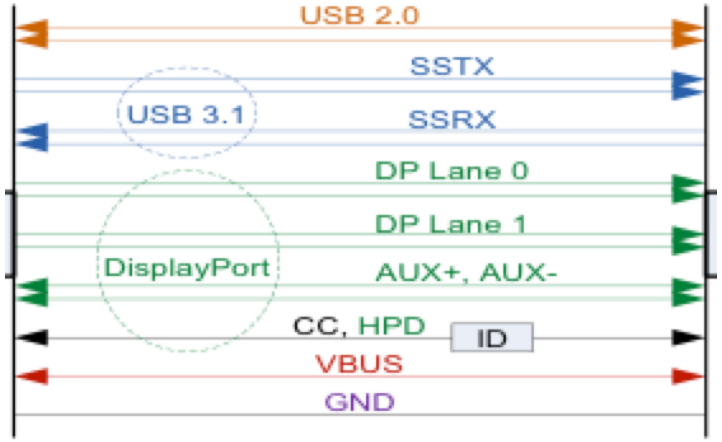
Compliance Test Issues

Common compliance testing problems encountered

- DP Alt Mode PHY Compliance
  - OS specific toolset are often required to properly get into test modes
  - Some products/chipsets do not support Test Automated over Aux
  - This is being addressed in new methodology under developer, the Link Training Test Automation Mode.
- USB-PD testing issues
  - Specification has been changing
  - New tests added to draft CTS have uncovered implementation issues
  - DP Alt Mode CTS USB-PD Test 10.1.2 Status update Command Test failures. The test fails if the Status field is invalid
  - A number of other issues have been identified at recent USB-IOP events and VESA PlugTest events. Tests will be added to verify product compliance.

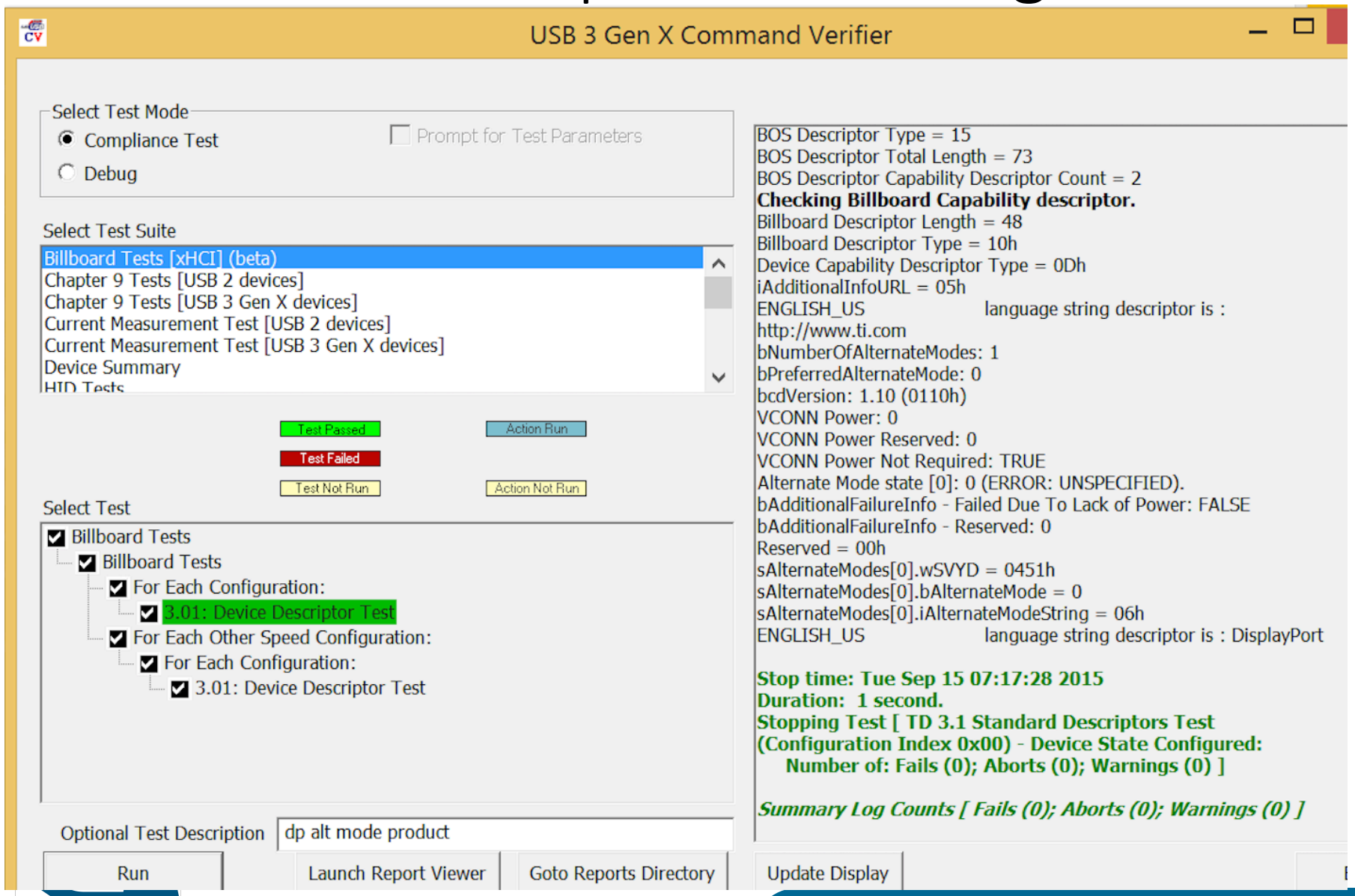
Compliance Test Issues

- 1 or 2 lane configuration compatibility issues



- Source and sink chipset issues uncovered during interoperability testing of DP Alt Mode products using USB-C docks.
  - Issue occurs when Dock is configured in 2 lane mode to support 2 lanes of DP and 2 lanes for USB 3.1
- Sources fail if they don't implement fallback rules in DP 1.4 specification
- Sinks fail if they don't support reduced lane operation or if they don't correctly report CR and/or Link EQ/Alignment failures on unconnected lanes
- Billboard implementations: many products have not updated to Billboard latest requirements
- Compliance tests are under development to address these issues

Billboard Compliance Testing



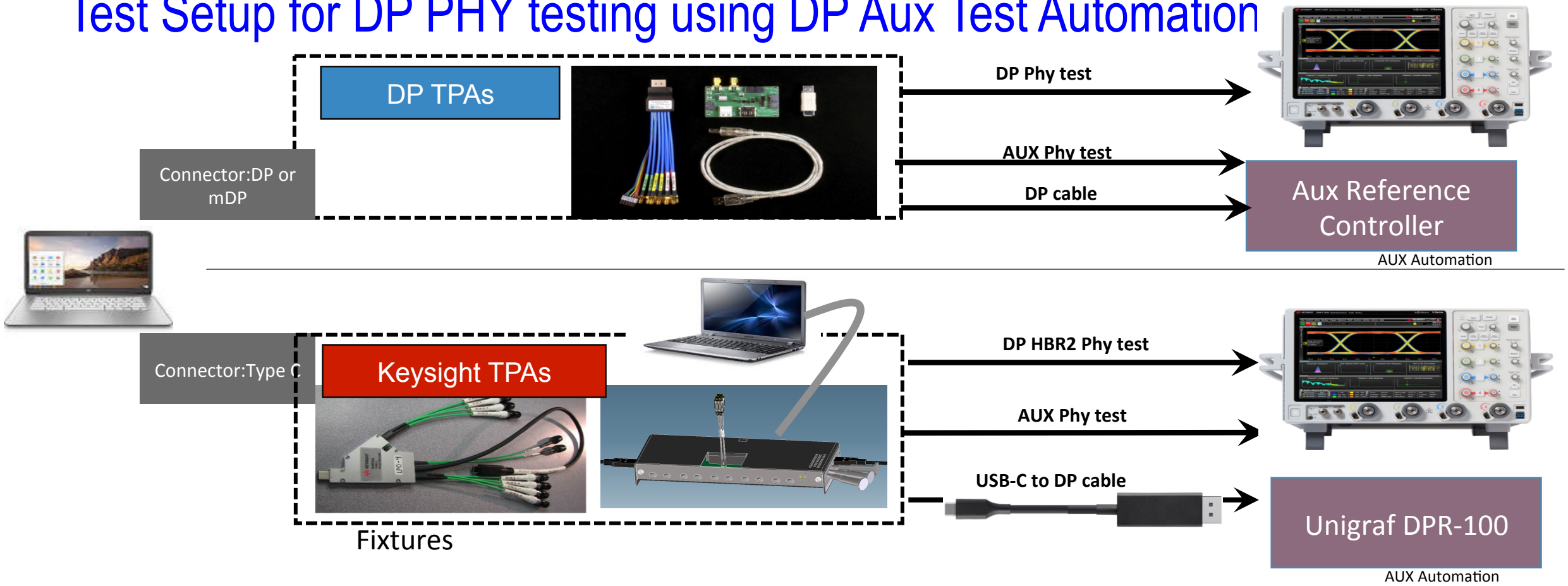
- Download USB3CV from USBIF developers page
- X32 or X64
- Install on system with xHCI

(no Alt Mode Support)

- Select Billboard tests and run

DP Alt Mode PHY Testing

Test Setup for DP PHY testing using DP Aux Test Automation



Test Setup for DP PHY testing using Link Training Test Automation

Summary of DP Alt Mode over USB-C supported features

Feature	DisplayPort Alt Mode
Supports HDMI 1.4b displays	✓
Supports 4K 30 Hz displays	✓
No adapter required for connection from USB Type-C to standard HDMI TV	✓
Supports HDMI 2.0 displays	✓
Supports 4K 60 Hz displays	✓
Supports High Dynamic Range	✓
Supports multiple video streams	✓
Connects to USB-C enabled displays that are shipping now (DisplayPort Alt Mode enabled)	✓
Supports USB SuperSpeed concurrent with video display	✓
Supports simple adapter for connection to existing HDMI cables	✓
Avoids rewiring of pre-installed HDMi cables	✓
Supports HDR	✓
Supports 4K 60 Hz full color (4:4:4)	✓
Supports 4K 60Hz deep color	✓
Supports multiple 4K videos	✓

Feature	DisplayPort Alt Mode
Supports High Dynamic Range	✓
Supports 4K high refresh rate (120Hz)	✓
Supports 8K video (with HBR3 plus DSC)	✓
Low latency interactive VR experience with 90+ 4K+ with DP + USB 3.0	✓
Supports USB Type-C on TV	✓
Runs on USB Type-C to USB Type-C cables	✓
Connects to wide range of already deployed USB-C devices	✓
Use Cases	
Multi 4k display productivity with single cable docking	✓
Low latency Interactive VR experience with dual 4k>90Hz + Power + USB 3.1 (HBR3+DSC)	✓
Smooth low latency gaming with AdaptiveSync	✓
8k HDR workstation productivity with DP + DSC	✓

DisplayPort 1.4 along with DP Alt Mode over USB-C & DSC can do today what you want your products to do tomorrow.

Demos

Demo 1: DP Alt Mode over USB-C 4K UHD HDMI 2.0 demo

LG 43UH610 HDMI 2.0 Smart LED TV

- 4K UHD 43” TV

Lenovo Yoga 900

- Connected to USB-C port via DP Alt Mode

Cable Creations CD0042

- USB- C to HDMI 2.0 cable (plug)

Summary

- DP 1.4 introduced many new capabilities and products are under development and in the certification process for these new features
- Many Certified USB-C devices with DP Alt Mode are shipping with many more in development
- DP Alt Mode CTS is under General Member Review and will be published by VESA in Q4'2016.
- DP Alt Mode device certification is available from certified ATCs since 2015, allowing use of DP logo
- Final 2016 VESA PlugTest event is in Taiwan December 12-16th 2016

Questions?


DisplayPort over USB-C
The most advanced display connection now uses the most versatile connector.
Learn More
Go to www.displayport.org