VESA

DISPLAYPORT™ TECHNOLOGY UPDATE

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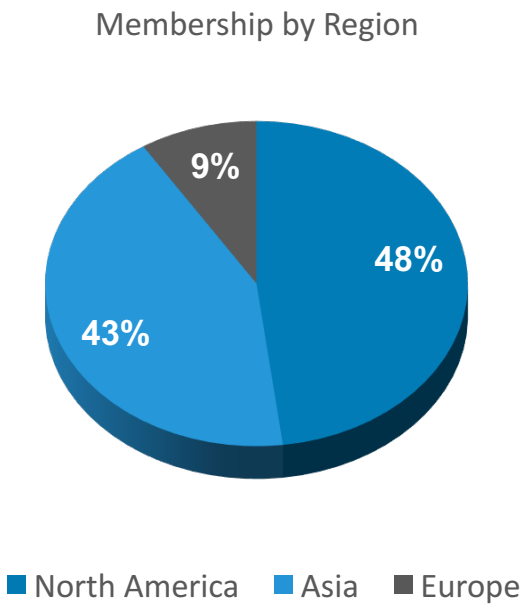
June 15, 2017

Agenda

- VESA Overview
- DisplayPort™1.4 Early Certification
- DisplayPort over USB-CTM Certification
- Summary

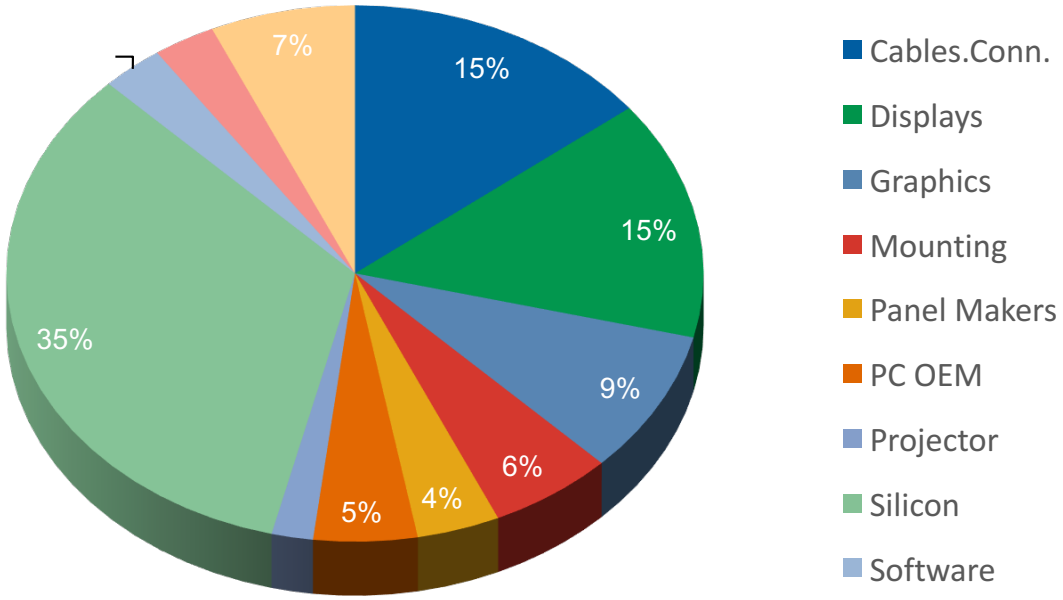
VESA OVERVIEW

About VESA

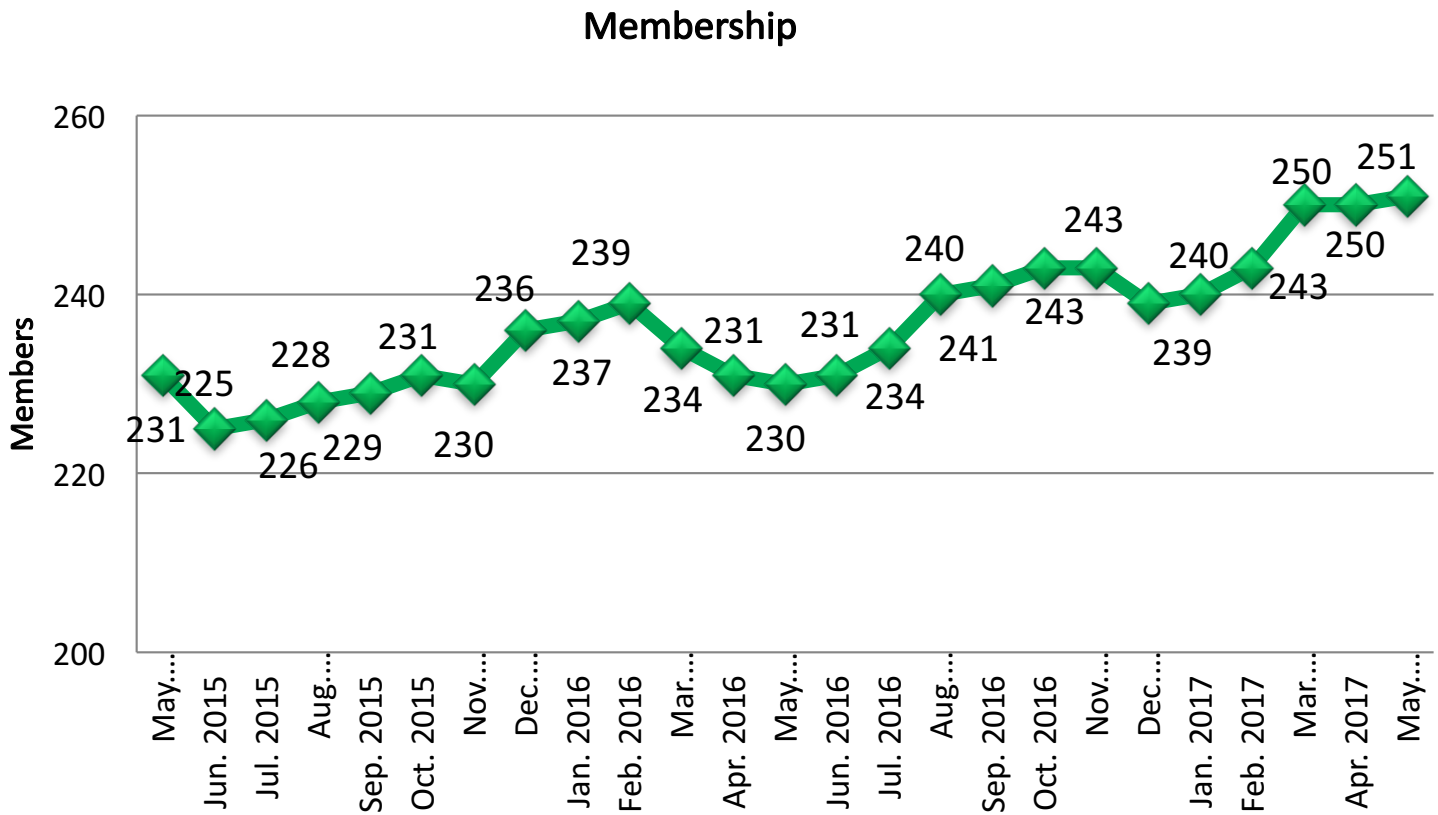


- Global industry alliance with more than 250 member companies
- Mission to develop, promote and support ecosystem of vendors and certified interoperable products for the electronics industry
- Facilitate DisplayPort standards development, publication and compliance testing, as well as promotion and marketing

VESA Membership is Diverse



VESA Membership Continues to Grow



Overview of Base DisplayPort Standard

- Starting 2005, major suppliers in the personal computer industry set off to define the next generation display interface
  - PC, Display, Semiconductor and Connectivity OEMs drove development
- Overall objectives
  - Open standard, contribution open to all companies
  - Future proof in both performance and features
  - Applicable over a wide range of applications
- Development was done within the Video Electronics Standards Association
  - None-disclosure and IP policies protect contributing companies when presenting new technology and provide a productive work environment

Mobile Computing Shipment Forecast

STRATEGY ANALYTICS
Research, Experts, and Analytics

Mobile Computing Device Enabling Technologies Shipment Forecast 2012-2021

Total Mobile Computing Device Shipments (Millions of Units)

	2012	2013	2014	2015	2016	2021	CAGR 2016-2021
Global	**1980.7**	**2119.7**	**2256.2**	**2274.8**	**2222.4**	**2519.7**	**2%**

DisplayPort Mobile Computing Device Shipments (Millions of Units)

	2012	2013	2014	2015	2016	2021	CAGR 2016-2021
Global	**80.4**	**90.1**	**115.4**	**101.3**	**116.4**	**733.8**	**36%**
Penetration Rate	*4%*	*4%*	*5%*	*4%*	*5%*	*29%*	

Type-C USB Mobile Computing Device Shipments (Millions of Units)

	2012	2013	2014	2015	2016	2021	CAGR 2016-2021
Global	**0.0**	**0.0**	**0.0**	**6.7**	**153.8**	**1924.1**	**52%**
Penetration Rate	*0%*	*0%*	*0%*	*0%*	*7%*	*76%*	

Date: June 2017

STRATEGY ANALYTICS
Research, Experts, and Analytics

Mobile Computing Device Enabling Technologies Shipment Forecast 2012-2021

Total Handset Shipments (Millions of Units)

	2012	2013	2014	2015	2016	2021	CAGR 2016-2021
Global	**1580.9**	**1685.0**	**1812.7**	**1870.6**	**1849.9**	**2111.9**	**2%**

DisplayPort Handset Shipments (Millions of Units)

	2012	2013	2014	2015	2016	2021	CAGR 2016-2021
Global	**0.7**	**6.4**	**21.0**	**15.3**	**12.0**	**412.6**	**80%**
Penetration Rate	*0%*	*0%*	*1%*	*1%*	*1%*	*20%*	

Type-C USB Handset Shipments (Millions of Units)

	2012	2013	2014	2015	2016	2021	CAGR 2016-2021
Global	**0.0**	**0.0**	**0.0**	**5.7**	**104.8**	**1567.6**	**57%**
Penetration Rate	*0%*	*0%*	*0%*	*0%*	*6%*	*74%*	

Date: June 2017

"Strategy Analytics estimates that 5% of laptops, tablets, and handsets shipped in 2016 are DisplayPort capable (including DisplayPort AltMode), with the figure rising to 29% by 2021…"

Date: June 2017

Factors driving increased DisplayPort adoption rates are:

- Demand for high-quality video (4K UHD and higher)
- VR/AR
- Increased adoption of USB-C and Thunderbolt 3
- Mobile device docking solutions

DISPLAYPORT™ 1.4

DisplayPort 1.4 Summary

- The VESA DisplayPort Standard, Version 1.4, was released on February 23, 2015
- Added new features and capabilities such as Display Stream Compression (DSC), Forward Error Correction (FEC) and enhanced Multi-Stream Transport (MST) feature
- Backward compatible, offers new optional features
- New Silicon supporting HBR3 is shipping and new features are under development
- Compliance testing began in second half of 2016

DP Link Rate Increase

DP Version Introduction	Link Rate Name	Bit Rate	Max Resolution Support (24bpp, 60Hz Refresh, 4:4:4 format	Max Resolution Support (24bpp, 60Hz Refresh, 4:2:0 format
DP 1.0	RBR HBR	1.62 Gbps 2.7 Gbps	1920x1080 2560x1600	Not supported Not supported
DP 1.2	HBR2	5.4 Gbps	4K x 2K	Not supported
DP 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 Type-C connector, using the DisplayPort Alt Mode
  - VESA DockPort Standard
  - VESA Mobility DisplayPort Standard (MyDP)
  - VESA Embedded DisplayPort Standard (eDP)
  - ThunderBolt
  - Virtual and Augmented Reality Technologies

VESA Forms Special Interest Group Focused on Emergent Virtual and Augmented Reality Markets

Posted on May 8th, 2017

Rapid growth and fragmentation in AR/VR market highlight need for standardization to enhance and optimize system usability and user experience SAN JOSE, Calif. – May 8, 2017 – The Video Electronics [...]

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
- **Royalty free standard** available to VESA members

Expected DisplayPort 1.4 Deployment

- HBR3 (32.4 Gbit/s) still remains the highest available mode and is shipping today. Early certification of HBR3 Silicon/end products started 2H'2016
- DP 1.4 is expected to be enabled in both native DP devices and devices using the USB Type-C interface with the DisplayPort Alternate Mode
- DP 1.4 CTS development is underway
  - Tests under development cover HBR3, DSC, FEC and HPD/IRQ_HPD response testing
  - Updates to Link Layer CTS and PHY Layer CTS documents are in progress and expected to be published in 2H'2017

VESA PlugTest Events

- PlugTests have significant value to member companies. Particularly as new capabilities and products are deployed.
- Demonstrate and improve Traditional Interoperability
- Test DP 1.4 and DP Alt Mode over USB Type-CTM products
  - HBR3 and other new capabilities
  - Verify Test Equipment Correlation
- VESA hosted three successful PlugTests in 2016
- VESA plans to host three PlugTests in 2017
  - March 2017 Burlingame CA, USA: **Completed**
  - June 26th Taipei Taiwan: Scheduled
  - Oct/Nov PlugTest TBD

Top DP Compliance Test Issues

- Reduced Lane Fallback Requirements
  - DP 1.4 clarified reduced lane count fallback requirements
  - GRL and Allion have been performing informative tests for a year
  - QD and Unifgraf have implemented tests
  - Will be require as certification test in 2H'2017
- Sink Bit Error Count Registers not implemented correctly
  - These are important so that DP Sources can detect marginal or failing link and take corrective action (re-initiate link training)
  - Will be required and tested in 2H'2017

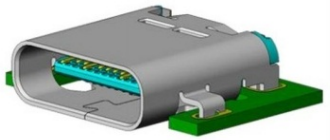
Top DP Compliance Test Issues

- HBR3 Compliance Testing
  - Test tools and CTS are being updated to support HBR3 products with final correlation testing during June Taiwan PlugTest event
  - “Early Product Certification Plan” is being used for early adopters. Several reference chipsets have been certified.
    - AMD, Nvidia: HBR3 DP Sources
    - Realtek, Mstar: HBR3 DP Sinks

DISPLAYPORT OVER USB-C™ OVERVIEW

DisplayPort Over USB-C Summary

- The *VESA DisplayPort Alt Mode Standard, Version 1*, was released on Sept 22, 2014
- Enables the use of the USB Type-C interface for DisplayPort



- Alternate Mode functional extension of the USB Type-C interface
- Developed in liaison with the USB 3.0 Promoter Group

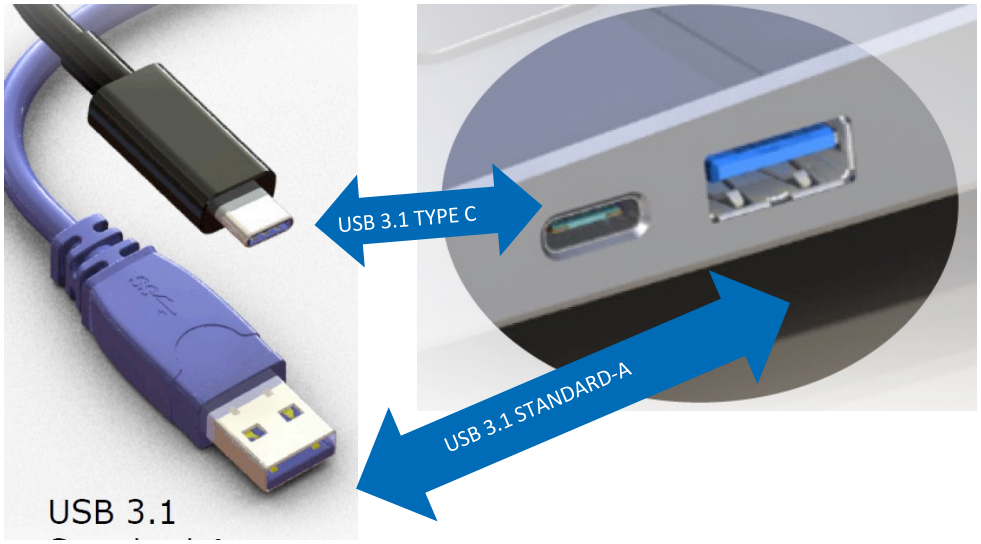
Introduction of USB Type-C

- New generation of USB connector developed to serve the market for next 20 years
- Thin profile suitable for both ultra portable devices and larger devices
- Reversible plug orientation & cable direction
  - USB 3.1 Gen 2 (10Gbps)
  - USB Power delivery, up to 100 watts
  - Supports DisplayPort Alternate Mode

USB Type-C information is provided as an informative overview only.
Please refer to the USB Type-C Cable and Connector Specification available at www.usb.org for more information

Introduction of USB Type-C

- USB Type-C will be the only interface you will need
  - High speed, secure data
  - Display connection
  - System Power



USB Type-C information is provided as an informative overview only.
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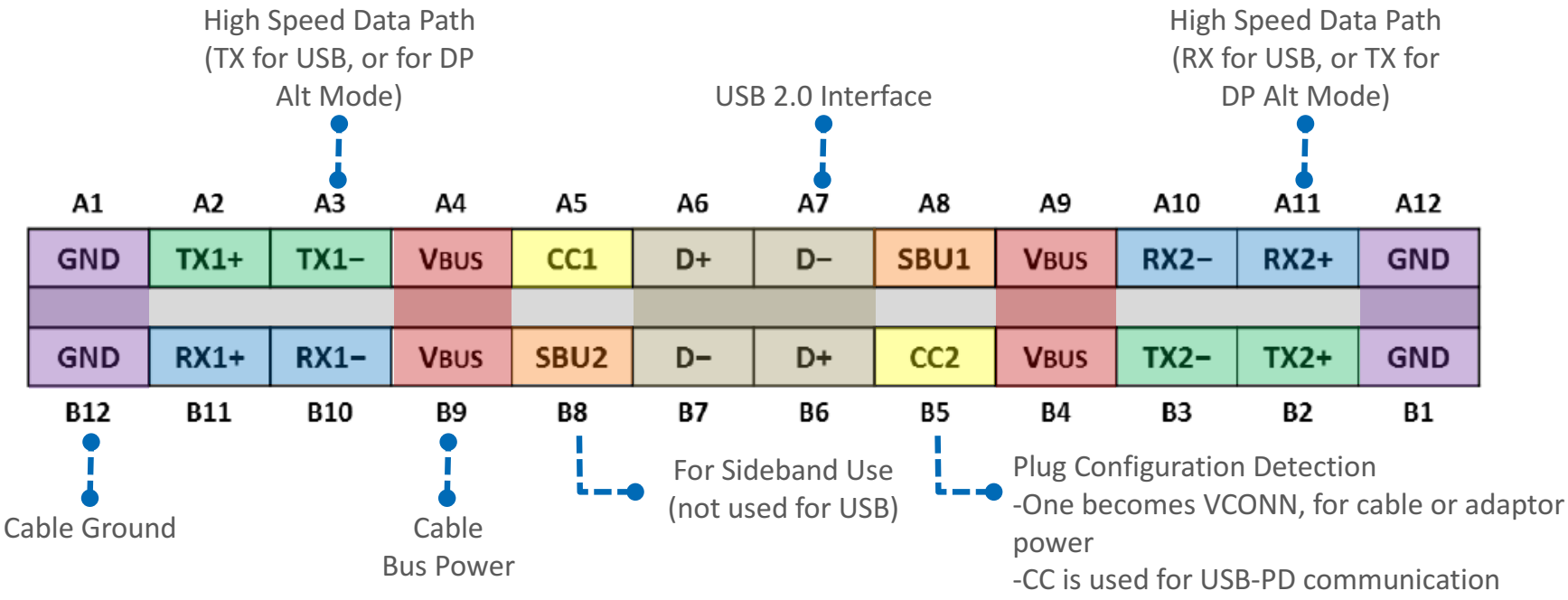
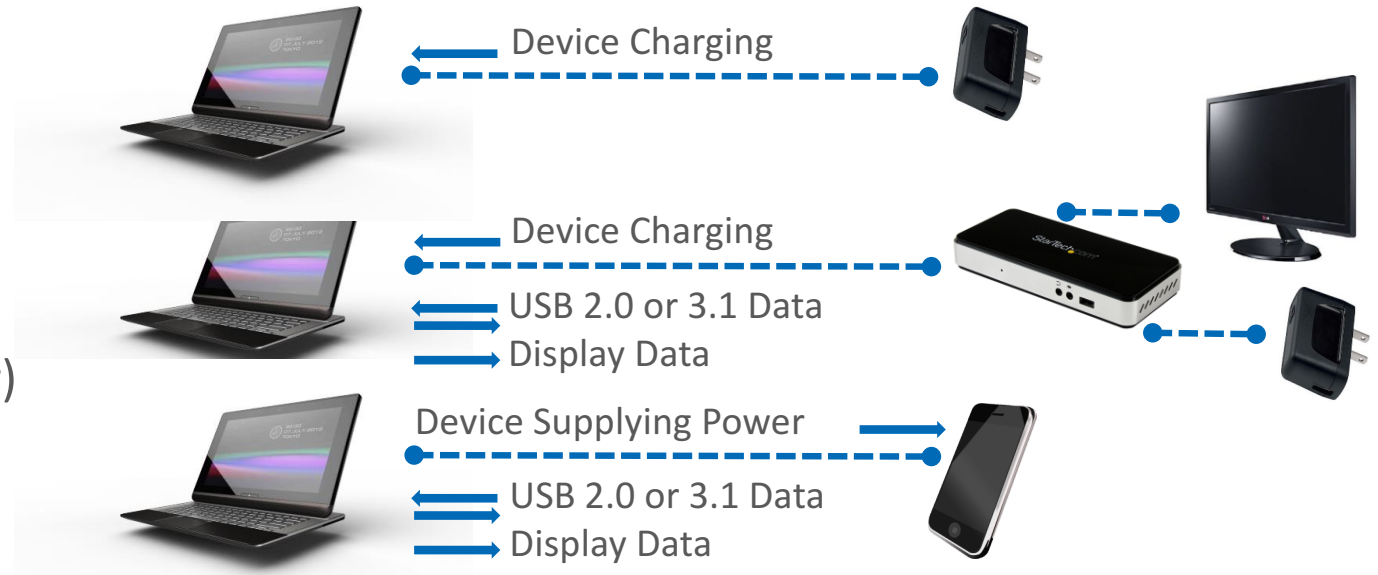
USB Type-C Receptacle Pins

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



Example USB Type-C Configurations

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



Example USB Type-C Configurations

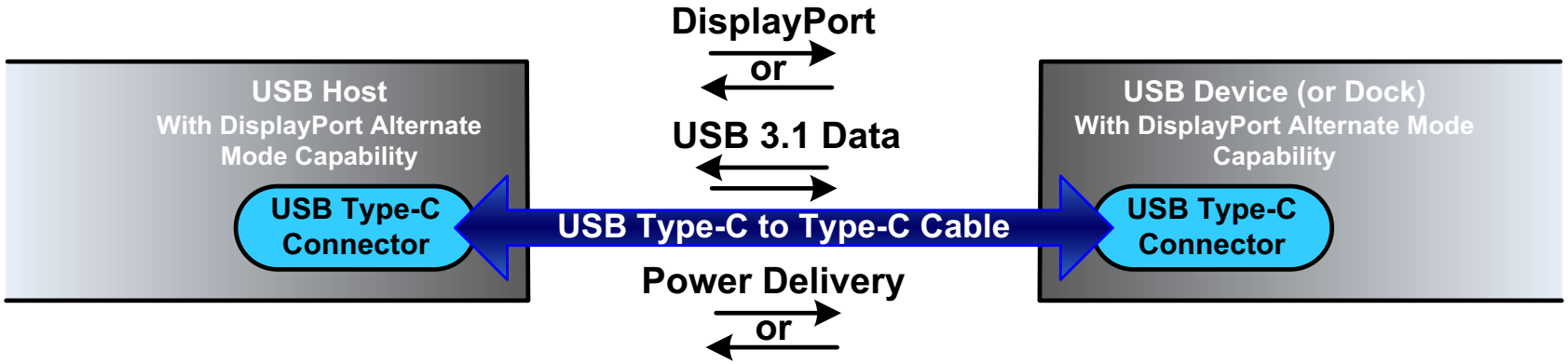
Samsung 8 uses USB-C for charging

or

Samsung 8 Phone + DEX dock acts as USB2 Host, USB-PD Power Consumer, and DisplayPort Video Source

USB Type-C Connector Function Extension DisplayPort Alternate Mode

- DisplayPort can be combined with USB 2.0 and/or USB 3.1 operation over the same USB Type-C cable. With 2 lanes of DP 1.4 HBR3 can drive 4K60hz display.
  - Implemented with two high speed pairs for DP (using two lane DP operation), and two high speed pairs for USB (USB 3.1 only uses two high speed lanes for normal operation)
  - Useful for docking stations or hubs, or for adding docking station functionality to a display

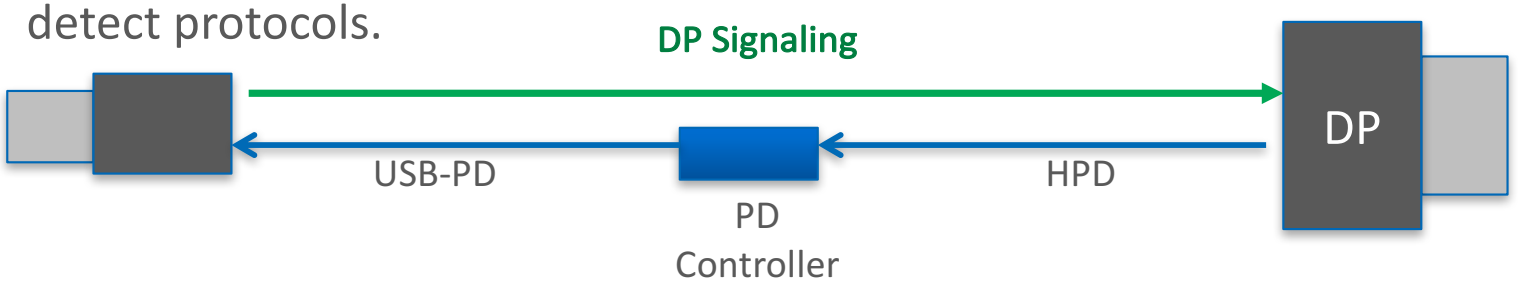


Supported Cable Types

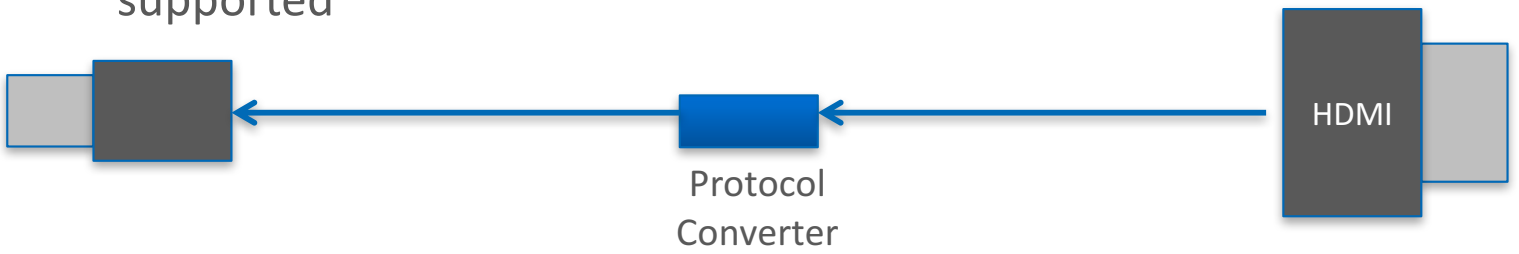
- USB-C to USB-C
- USB-C to DP
- USB-C to Protocol converter
- USB-C to Docking station or embedded hub solution

Supported Cable Types

- USB-C to DP Plug cables must include logic to support USB PD and DP connection detect protocols.



- Protocol converters must support some optional features in DP 1.4 specification
  - Protocol converters translate source DP signals to the respective protocol supported



Wide Range of Adapters Shipping Today

USB-C™ to USB A Plug

USB-C™ to USB A Receptacle

USB-C™ to DP

USB-C™ to USB-C™

USB-C™ to HDMI

DISPLAYPORT OVER USB-C™ CERTIFICATION

DisplayPort Alternate Mode - Compliance Test Plan

- VESA developed the DP Alternate Mode compliance test in coordination with the USB-IF to ensure interoperability of products across supported standards
- VESA DisplayPort over USB Type-C Compliance Test Specification (CTS) v1.0 was released January 2017
- Certification of DisplayPort Alternate Mode products is still increasing with dozens of products certified over the last year

DP over USB-C Product Example Certification Test

USB Type-C Docks shall perform the following tests:

Test Item	Test Name	Description	Requirement	Pass/Fail	Comments
6.3 #1	DP PHY TX	DP PHY TX tests up to maximum supported data rate on all DP DFPs	Pass DP TX tests		
6.3 #2	USB 3.1 Tests	USB 3.1 Electrical, Crosstalk, Functional, Link and Interop	Pass if supported		
6.3 #3	PD/USB Power	USB PD Power test requirements	All PDOs		
6.3 #4	Sink Tests	RX JTOL tests for four lanes up to Max supported rate	Pass JTOL tests in section 3.2 of DP Alt Mode CTS		Normal orientation
6.3 #5	USB-PD Protocol	Verify compliance with USB-PD protocol test requirements	Pass USB PD Protocol Testing		Normal orientation
6.3 #6	USB-PD PHY	Verify compliance to USB-PD PHY specification requirements	Pass USB PD PHY Testing		CC1 and CC2
6.3 #7	Display Interop	Using a reference DP Alt Mode source (supporting 4xHBR2) verify that a all external display connection display functions correctly at the required resolutions	Pass interoperabilty testing		Normal and Inverted orientation
6.3 #8	Vconn and Vbus	Dock tests for proper implementation of Vconn and Vbus rules	Pass Vbus and Vconn tests		Normal and Inverted orientation
6.3 #9	USB Billboard	Test compliance of USB Billboard functionality and PHY testing	Pass USB Billboard tests		Normal orientation
6.3 #10	Aux and HPD tests	USB Type-C Dock must perform all AUX and HPD tests in section 9, upstream and downstream facing ports.	Pass AUX and HPD tests		Normal orientation

Table 6-4: USB Type-C Dock test requirements

DP over USB-C Product USB Certification Test

- USB compliance tests are conducted to achieve certification of DP Alt Mode products to ensure that functionally the USB features of those products provides a good user experience.
- Devices that support USB functionality shall conduct the USB tests included in the compliance test summary tables for each product category.
- Completing USB-IF certification testing and receiving USB-IF TID will be sufficient to show that those tests have been completed and pass.

Top DP Alt Mode Compliance Test Issues

- Pin Assignment Testing
  - Issues with proper implementation pin assignment E support and source device selection have been uncovered
  - New tests have been implemented by test equipment to verify correct implementation of pin assignments
- DP Alt Mode CTS pin assignment test updates V4 SCR is under General Member Review (GMR) ending July 10, 2017
- USB PD Protocol failures
    - Use certified USB PD controllers and passing fw

DP Alt Mode CTS pin assignment test updates

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Example: DisplayPort Alt Mode Tests for DFPs

Table 10-1: DFP_D connected to receptacle

Line no.	Tester Presents Receptacle Indication	Tester Presents UFP_D Pin Assignments presented	Tester Presents Multi-Function Preferred bit	UUT pin assignment selection (in DP Configure message) shall be:
1	Receptacle	C, D, E	No	C or D
2	Receptacle	C, D, E	Yes	C or D
3	Receptacle	C, E	No	C

When DP Alt Mode Source is connected to Receptacle based Sink it must ***never*** *select pin assignment E!*

Top DP Alt Mode Compliance Test Issues

- 2xDP/2xUSB 3.1 configuration testing
  - Cross talk between USB 3.1 lines and DP lines can degrade the link
- USB Type-C to DP Plug adapter reversibility
  - USB Type-C to DP plug adapters must work connected in both directions

DP Alt Mode Certification Policies

- USB Type-C to HDMI protocol converters
  - DP Alt Mode spec states they must support HDMI 2.0 among other requirements
  - These requirements can be waived until 2018 for certification
  - VESA has certified two OEM products that meet all specification requirements

Summary

- DP 1.4 provides over 50% increase in performance among other improvements
  - Enables 4K120Hz, 8K@30Hz and 2 lane 4K60Hz for DP Alt Mode
- DisplayPort over USB-C is a game changer for small form factor and portable products
- DP Alt Mode CTS published in January of 2017
- Testing and certification of DP Alt Mode products is comprehensive and underway
- Next VESA PlugTest event scheduled week of June 26th in Taipei Taiwan

Questions?

Demo Station Overview

THANK YOU

displayport.org

vesa.org