

USB-C Product Matrix

USB-IF Compliance Program

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Purpose

The USB-IF has historically relied on the USB 3.2 Product Matrix and USB 2.0 Product Matrix to define mandatory testing requirements for a nearly comprehensive set of USB product categories. The last category, Cables and Connectors, is not included in those documents because it is the only non-port classification. With the introduction of the USB Power Delivery Specification (PD) and USB Type-C Cable and Connector Specification (USB-C) further categorization is required to capture a clear picture of a USB-C product's functionality and ultimately its mandatory testing requirements.

The purpose of this document is to:

1. Categorize a comprehensive USB-C Product Matrix for USB ports and cables which use USB-C connectors.
2. Define the Compliance Test Suites required for each category in the USB-C Product Matrix.

This document is designed so that flipping to the USB-C Product Matrix table or USB-C Test Matrix table may be sufficient to glean an understanding of the USB Compliance requirements. The intermediary document sections are meant to add context and clarification.

Related Documents

Table 1: Test Documents listed in the USB-C Test Matrix (Table 5)

Test Suite	Document Information
USB-C CabCon	USB Type-C Cable and Connector Test Specification https://usb.org/document-library/usb-type-c-connectors-and-cable-assemblies-compliance-document-v12
USB-C EPC	USB-C End Product Cable Test Plan https://usb.org/document-library/usb-type-c-end-product-cable-test-plan
USB PD	USB Power Delivery Test Plan https://usb.org/document-library/usb-pd-30-compliance-plan
USB-C Functional	USB Type-C Functional Test Specification https://usb.org/document-library/usb-type-c-functional-test-specification
USB-C IOP	USB Interoperability Test Specification (see Chapter specific to Type-C) https://usb.org/document-library/xhci-interoperability-test-procedures-peripherals-hubs-and-hosts-version-095
USB-C Source Power	USB-C Source Power Test Specification https://usb.org/document-library/usb-type-c-and-power-delivery-source-power-requirements-test-specification
USB 3.2 and 2.0 Tests	Refer to the USB 3.2 Product Matrix to find further test requirements https://usb.org/document-library/usb-32-product-test-matrix Refer to the USB 2.0 Product Matrix to find further test requirements https://www.usb.org/document-library/usb-20-test-matrix

Terms and Abbreviations

Table 2: Terms and Abbreviations as Defined for use in the USB-C Product Matrix¹

Term	Definition
Alt Mode Only Host	SNKAS in the PoweredAccessory state – A Host that is not capable of USB 3.2/2.0 communication and not capable of Vbus Sourcing and Sinking. In this state the port is a DFP and only supports PD Alt Mode data as the initiator.
Battery Pack	PD Product is a variation of a charger that has a battery and can Source and Sink Vbus and does not have any USB Data Capability or PD Alt Mode Capability. This product may implement data as a DFP to communicate with an active cable.
Charger	Type-C or PD product that can Source Vbus and does not have any USB Data Capability or PD Alt Mode Capability. This product may implement data as a DFP to communicate with an active cable.
Charge-through Port	USB PD or Type-C sink only port that may implement USB 2.0 Billboard device. Its purpose is to power the device and possibly its source ports. A Type-C USB product may include up to 1 (one) charge-through port. When on a product that includes a USB hub, it is the only non-hub USB port allowed on the product and is not logically considered a hub port.

Device (Peripheral)	A product applying this role is a USB 3.2/2.0 data responder and may be a PD Alt Mode responder. If this product is a DRD, it can also operate as a Host. See DRD definition.
DFP	Downstream Facing Port, specifically associated with the flow of data. Supports at least one of the following: <ul style="list-style-type: none"> • Transmits USB 3.2/2.0 data from a Host • PD Alt Mode data as Initiator. • Communication with Active Cable See USB Type-C Cable and Connector Specification.
DRD	Abbreviation for Dual-Role Data – A USB PD Data Capability that includes the ability to act as a UFP and a DFP. DRDs are considered both Host and Device for testing purposes and must test both roles.
DRP	USB Type-C and PD Product that has the capability of acting as either Vbus Source or Sink. USB Type-C role that supports Attached.SRC and Attached.SNK
Host	A product applying this role is a USB 3.2/2.0 data master and/or a PD Alt Mode initiator. If this product is a DRD it can also operate as a Device. See DRD definition.
Hub	This product incorporates multiple USB-C ports: <ul style="list-style-type: none"> • A UFP that is a USB 3.2/2.0 data responder and possibly PD Alt Mode responder • Any number of DFPs that are USB 3.2/2.0 data initiators.
Peripheral (Device)	A product operating as a USB 3.2/2.0 data responder and possibly a PD Alt Mode responder. See Device definition.
PSD	Power Sinking Device – a Sink or DRP that is not capable of acting as a Peripheral Device
Sink	In Table 4 a PD Product that is only capable of acting as a Vbus Sink
SNK	USB Type-C Role that is only capable of acting as a Vbus Sink (i.e. that implements Attached.SNK and not Attached.SRC).
Source	In Table 4 a PD Product that is only capable of acting as a Vbus Source
SRC	USB Type-C Role that is only capable of acting as a Vbus Source (i.e. that implements Attached.SRC and not Attached.SNK)
UFP	Upstream Facing Port, specifically associated with the flow of data <ul style="list-style-type: none"> • Transmits USB 3.2/2.0 data from a Device • Optionally transmits PD Alt Mode data as Responder. See USB Type-C Cable and Connector Specification.

Note 1: There are those who find some terms and definitions inconsistent between USB PD and USB Type-C Specifications. This document follows the USB Type-C, 3.2, and 2.0 Specs (which appear to be consistent with each other) upon any discrepancy.

Method

This section describes how the matrices defined in this document relate to the existing USB Product matrices. The categorization methodology is based on a cross-product of categories available – a set of categories.

The requirements section lists assertions from the USB Type-C and PD Specifications that constrain the product matrix to a few subcategories of the cross-product result.

Categorization

The USB Product classifications defined in the USB 3.2 Product Matrix and USB 2.0 Product Matrix can be represented by the set S , where,

$$S = \{\text{USB 3.2, USB 2.0}\} \times \{\text{Host, Hub, Device}\} \times \{\text{Silicon, End Product}\}$$

The cross product gives us the following listing of Triples for the USB Product classifications set S :

$$\begin{aligned} s_1 &= (\text{USB 3.2, Host, Silicon}), \\ s_2 &= (\text{USB 3.2, Host, End Product}), \\ s_3 &= (\text{USB 3.2, Hub, Silicon}), \\ &\dots \\ s_{12} &= (\text{USB 2.0, Device, End Product}) \end{aligned}$$

Each element $s \in S$ shares a set of mandatory tests (defined in the USB 3.2 and 2.0 Product Matrix documents). Connectors and cables create a final $s \in S$ which requires only CabCon tests.

The new USB-C Product Types can be expressed as set T , where

$$T = S \times \underbrace{\{\text{No PD, Provider, Consumer, DRP}\}}_{\text{PD Power Capability}} \times \underbrace{\{\text{No Data, UFP, DFP, DRP}\}}_{\text{PD Data Capability}} \times \underbrace{\{\text{SRC, SNK, DRP, SNKAS}\}}_{\text{USB Type-C Capability}}$$

It turns out many of the elements within T ($t \in T$) represent illegal USB functionality combinations. For example,

$$t_1 = (\text{USB 3.2, Host, Silicon, No PD, No Data, SNK})$$

The USB-C Product Matrix illustrates the subset of compliant elements within T ($T' \subseteq T$).

The USB-C Product Types (T') is a set that includes standalone cables, each USB-C Product from the Matrix and each USB-C Product from the Matrix with a Captive Cable. USB-C Products may be defined as a union of more than one product type if they have ports with multiple functionalities (Host and Device) or multiple ports with varying functionalities (Hub).

The USB-C Test Matrix describes the mandatory test requirements for each new USB-C Product classification $t \in T'$. The mandatory tests a product is required to run is the union of the tests required for each product type the product implements.

Constraints

The following requirements from the USB Type-C define the constraints on the cross-product of the various product categories defined in the previous section.

Table 3: Requirements used to constrain USB-C Product Matrix

USB Type-C Cable and Connector Specification
Chapter 1: Introduction
Chapter 1.5: Terms and Abbreviations
The DFP is specifically associated with the flow of data in a USB connection. In its initial state, the DFP source Vbus and Vconn, and supports data.
DRD is the acronym used in this specification to refer to a USB port that can operate as either a DFP (Host) or UFP (Device). The role that the port initially takes is determined by the port's power role at attach. A Source port takes on the data role of a DFP and a Sink port takes on the data role of a UFP.
DRP is the acronym used to refer to a USB port that can operate as either a Source or a Sink. Initially when operating as a Source, the port will also take on the data role of a DFP and when operating as a Sink, the port will also take on the data role of a UFP.
A PSD is a sink with draws power but has no other USB or Alternate Mode communication function, e.g. power bank.
A UFP is specifically associated with the flow of data in a USB connection. In its initial state, the UFP sinks Vbus and supports data.
Chapter 4: Functional
Chapter 4.5: Configuration Channel (CC)
Chapter 4.5.1: Architectural Overview
Chapter 4.5.1.3: CC Functional Models
Chapter 4.5.1.3.3: DRP CC Functional Model
The DRP has logic used during initial attach to toggle between Source and Sink operation: Until a specific stable state is established, the DRP alternates between exposing itself as a Source and Sink.
Chapter 4.5.2: CC Functional and Behavioral Requirements
Chapter 4.5.2.2: Connection State Machine Requirements
Entry into any unattached state when "directed from any state" shall not be used to override tDRP toggle.
A DRP or a Sink may consume default power from Vbus in any state where it is not required to provide Vbus.
Chapter 4.6 Power
Chapter 4.6.2 Vbus Power Provided Over a USB Type-C Cable
Chapter 4.6.2.1 USB Type-C Current
A PSD shall fully support USB Type-C Current operation, should support USB PD and may support USB BC 1.2.
A PSD may be a Sink or a DRP operating in Sink mode.
A PSD shall not have a USB or USB Type-C Alternate Mode communications function.

Chapter 4.7: USB Hubs
USB hubs shall have a UFP that may be a Charging Sink.
USB hubs' DFPs shall not have DRD capabilities. They may have DRP capabilities.
Chapter 4.8: Chargers
Chapter 4.8.3: Sinking Host
A Sinking Host is a special sub-class of a DRP that is capable of consuming power, but not capable of acting as a device and does not support DRD. The Sinking Source shall follow the rules for a PD DRP and implement DR_Swap.
Chapter 4.8.4: Sourcing Device
A Sourcing Device is a special sub-class of a DRP that is capable of providing power, but not capable of acting as a host and does not support DRD. The Sourcing Device shall follow the rules for a PD DRP and implement DR_Swap.
Chapter 5: Functional Extensions
Chapter 5.1: Alternate Modes
All hosts and devices (except chargers) using a USB Type-C receptacle shall expose a USB interface.

USB-C Product Matrix

Table 4 indicates product categories defined for the USB Type-C by USB PD product matrix. The table does not include a reference to cable plugs and USB PD Emarkers. Those products are a separate category and enter the USB-C Test Matrix in the next section as "Cable".

Table 4: USB-C Compliant Product Categories

		Type-C Capability			
Data Capability	PD Power Capability	SRC	SNK	DRP	SNKAS
No Data	No PD	Charger	Charge-through Port ⁴ or PSD	--	--
	Source	PD Charger	--	--	--
	Sink	--	Charge-through Port ⁴ or PSD	--	--
	DRP	--	--	PSD (e.g. PD Battery Pack)	--
USB Host	No PD	Host or Hub	--	--	--
	Source	PD Host or PD Hub (DFP)	--	--	--
	Sink	--	--	--	--
	DRP	PD Host or PD Hub (DFP)	--	PD Host or PD Hub (DFP) and PSD	--
USB Device	No PD	--	Device or Hub	--	--
	Source	--	--	--	--
	Sink	--	PD Device or PD Hub (UFP) or Charge-through Port ⁴	--	PD Device and ¹ Alt Mode Only Host ²
	DRP	--	PD Device or PD Hub (UFP)	PD Device or PD Hub (UFP)	--
DRD	No PD	--	--	--	--
	Source	PD Host and PD Device ³	--	--	--
	Sink	--	PD Device and PD Host ³	--	--
	DRP	PD Host and PD Device ³	PD Device and PD Host ³	PD Host and ¹ PD Device	--

Note 1: This product toggles between product type on connect. Its initial functionality depends on the USB Type-C Attached State on connect.

- A DRP that connects to Attached.SRC is initially a Host or Hub DFP
- A DRP that connects to Attached.SNK is initially a Device or Hub UFP
- A SNKAS that connects to PoweredAccessory is an Alt Mode Only Host (see Note 2)
- A SNKAS that connects to Attached.SNK is a Device

Note 2: See definition in Table 2 (Sources Vconn, not Vbus). This product must also be capable of acting as a Device.

Note 3: The product cannot connect into this product type. It can only connect to the first listed role and then perform a data swap to reach this role.

Note 4: A product may have up to 1 (one) charge-through port. This port is a sink-only and may support USB 2.0 signaling as a Billboard Device.

USB-C Test Matrix

Table 5 lists the USB Compliance Test Suites required for each product type defined in the USB-C Product Matrix above.

- If a product in Table 4 is denoted with Note 1, the product must be tested against all required tests for each possible function.
- If the product in Table 4 is denoted with Note 3, the product must be tested against all required tests of its implemented product types.
- If the product incorporates a Captive Cable, the product must be tested against all required cable tests

Table 5: USB-C Test Matrix

Product Type	Testing Required						
	USB-C CabCon	USB-C EPC	USB PD	USB-C Functional	USB-C IOP	USB-C Source Power	USB 3.2 and 2.0 ¹
Cable	X	X ²	X ³	X ³			
Charger			X	X	X	X	X ⁴
PSD				X	X		X ⁷
PD PSD			X	X	X	X ⁶	X ⁷
Host & Hub				X	X	X	X
PD Host & PD Hub			X	X	X	X	X
Alt Mode Only Host			X	X	X		
Device				X	X		X
PD Device			X	X	X	X ⁵	X
OTG	Not compatible with USB Type-C						

Note 1: See USB 3.2 Product Matrix and USB 2.0 Product Matrix to determine required USB 3.2 and 2.0 Compliance tests.

Note 2: USB-C EPC tests are required for USB Type-C plug to Type-C plug cables only. Not applicable for captive cables or legacy cables.

Note 3: USB PD tests and USB-C Functional tests are required if the cable has an Emarker.

Note 4: Requires USB 3.2 Product Matrix and USB 2.0 Product Matrix because USB Battery Charging Test is required on the port.

Note 5: USB Source Power Tests are required for a PD Device on each DRP port.

Note 6: If the port is a DRP (e.g. a Battery Pack) then USB Source Power Tests are required.

Note 7: If the port supports USB BC 1.2, then USB 3.2 Product Matrix and USB 2.0 Product Matrix apply for USB Battery Charging Test.