

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

## Terms and Abbreviations

**Table 2: Terms and Abbreviations as Defined for use in the USB-C Product Matrix<sup>1</sup>**

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"> <li>• Transmits USB 3.2/2.0 data from a Host</li> <li>• PD Alt Mode data as Initiator.</li> <li>• Communication with Active Cable</li> </ul> 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"> <li>• A UFP that is a USB 3.2/2.0 data responder and possibly PD Alt Mode responder</li> <li>• Any number of DFPs that are USB 3.2/2.0 data initiators.</li> </ul>
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"> <li>• Transmits USB 3.2/2.0 data from a Device</li> <li>• Optionally transmits PD Alt Mode data as Responder.</li> </ul> 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**

<b>USB Type-C Cable and Connector Specification</b>
<b>Chapter 1: Introduction</b>
<b>Chapter 1.5: Terms and Abbreviations</b>
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.
<b>Chapter 4: Functional</b>
<b>Chapter 4.5: Configuration Channel (CC)</b>
<b>Chapter 4.5.1: Architectural Overview</b>
<b>Chapter 4.5.1.3: CC Functional Models</b>
<b>Chapter 4.5.1.3.3: DRP CC Functional Model</b>
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.
<b>Chapter 4.5.2: CC Functional and Behavioral Requirements</b>
<b>Chapter 4.5.2.2: Connection State Machine Requirements</b>
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.
<b>Chapter 4.6 Power</b>
<b>Chapter 4.6.2 Vbus Power Provided Over a USB Type-C Cable</b>
<b>Chapter 4.6.2.1 USB Type-C Current</b>
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.

<b>Chapter 4.7: USB Hubs</b>
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.
<b>Chapter 4.8: Chargers</b>
<b>Chapter 4.8.3: Sinking Host</b>
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.
<b>Chapter 4.8.4: Sourcing Device</b>
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.
<b>Chapter 5: Functional Extensions</b>
<b>Chapter 5.1: Alternate Modes</b>
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 <sup>4</sup> or PSD	--	--
	Source	PD Charger	--	--	--
	Sink	--	Charge-through Port <sup>4</sup> 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 <sup>4</sup>	--	PD Device and <sup>1</sup> Alt Mode Only Host <sup>2</sup>
	DRP	--	PD Device or PD Hub (UFP)	PD Device or PD Hub (UFP)	--
DRD	No PD	--	--	--	--
	Source	PD Host and PD Device <sup>3</sup>	--	--	--
	Sink	--	PD Device and PD Host <sup>3</sup>	--	--
	DRP	PD Host and PD Device <sup>3</sup>	PD Device and PD Host <sup>3</sup>	PD Host and <sup>1</sup> 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 <sup>1</sup>
Cable	X	X <sup>2</sup>	X <sup>3</sup>				
Charger			X	X	X	X	X <sup>4</sup>
PSD				X	X		X <sup>7</sup>
PD PSD			X	X	X	X <sup>6</sup>	X <sup>7</sup>
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 <sup>5</sup>	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 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.