

USB4™ Thunderbolt3™ Compatibility Requirements Specification

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1 Introduction

This document defines the requirements that a USB4 Product must fulfill in order to claim, “Compatible with Thunderbolt™”.

1.1 Related Documents

USB4™ Specification, Revision 1.0 (USB4 Specification)

USB Type-C® Cable and Connector Specification, Release 2.0 (USB Type-C Specification)

Universal Serial Bus Power Delivery Specification, Release 3.0, Version 2.0, August 2019 (USB PD Specification)

USB4™ Device ROM Specification Revision 1.0 (DROM Specification)

1.2 Terms and Abbreviation

This section lists and defines the terms and abbreviations used throughout this specification. Note that terms and abbreviations not defined here, use their generally accepted or dictionary meaning.

Term/Abbreviation	Description
BPD	Bus powered device. A USB4 Device that draws power from VBUS.
DPD	Dual power (SPD and BPD) device. A USB4 Device that draws power either from an external power or from VBUS.
SPD	Self-powered device. A USB4 Device that draws power from an external power source.
TBT2	Thunderbolt™ 2
TBT3	Thunderbolt™ 3

2 USB4 Requirements

A USB4 Product shall implement Chapter 13 of the USB4 Specification.

3 USB Type-C Requirements

A USB4 Product shall perform Thunderbolt Compatibility Discovery and Entry as described in Appendix F of the USB Type-C Specification.

4 USB Power Delivery Requirements

A USB4 Product shall provide power as described in the USB PD Specification and shall follow the additional Thunderbolt-specific power requirements defined in this section.

The requirements in this section apply to a USB4 Product when one or more of its USB4 Ports are operating with a Link that uses Thunderbolt Alternate Mode. Thunderbolt Alternate Mode entry occurs after a USB PD Explicit Power Contract is established.

4.1 Host Source Power Provisioning

A USB4 Host shall support Host Power provisioning as defined in the USB PD Specification. If a USB4 Host has one USB4 Port, it shall provide at least 15W of power after Thunderbolt Alternate Mode is entered. If a USB4 Host has more than one USB4 Port, it is recommended that the Host provides at least 15W of power for every two USB4 Ports after Thunderbolt Alternate Mode is entered. A USB4 Host may optionally provide 15W or more power on a USB4 Port via explicit PD contract.

Note: A USB4 Host may offer default, 1.5A or 3.0A on its USB Type-C port as implicit current prior to establishing a USB PD contract.

Note: A USB4 Port that does not provide at least 15W of power may not function correctly with most Thunderbolt Bus Powered Devices (BPDs).

When a USB4 Host provides at least 15W of power on VBUS, it shall meet the VBUS Source requirements defined in Table 4-2.

When a USB4 Host is not capable of providing at least 15W of power to each of its USB4 Ports, it shall allocate power among its USB4 Ports as described in Table 4-1. Table 4-1 gives the minimum power allocation and a USB4 Host may optionally provide more power (but not less).

A USB4 Host shall provide 1.5W VCONN on each USB4 Port as described in Table 4-3.

Implementation Note:

A USB4 Host should implement a source policy manager to dynamically allocate power across its USB Type-C ports. The source policy manager allocates power from an available power pool based on the power contracts in place. The power pool is sized as described in Table 4-1 as a minimum. The source policy manager changes the advertisement of power on each port with each USB Type-C connection. For example, if the first connection is a 15W device, the source policy manager may reduce the power advertisement on the second port to 7.5W. If the first connection is a 7.5W device, the source policy manager must advertise 15W on the second port.

Table 4-1. Thunderbolt Host VBUS Provisioning in Explicit USB PD Contract

Power Standard	Voltage/Current	Number of USB4 Ports in Host							
		1	2	3	4	5	6	7	8
		Generic Power Provider (First-Come, First-Serve)							
15W Full Power VBUS	5V/3A ^{1,3}	1	1	1	1	2	2	2	2
7.5W min Power VBUS	5V/1.5A ^{2,3,4}	NA	1	2	3	3	4	5	6
		14" or Smaller without Keyboard							
VBUS Power	5V/1.5A ⁴	1	2	3	4	--	--	--	--
<p>Notes:</p> <ol style="list-style-type: none"> 1. 5V/3A is required for one of every four ports. It is recommended that 5V/3A be provided per every two ports if possible. The power rules defined in USB PD shall be followed if power greater than 15W is provided. 2. 5V/1.5A minimum is required for the second, third, and fourth ports. 3. Power should be allocated on a first-come first-serve basis between the ports. If the first port only consumes 5V/1.5A, then second port shall make 5V/3A available. If the first and second ports only consume 5V/1.5A each, the third port shall make 5V/3A available. If the first, second, and third ports only consume 5V/1.5A each, the fourth port shall make 5V/3A available. 4. Most Thunderbolt Bus Powered Devices have no functionality with 7.5W minimum power. 									

4.2 Device Source Power Provisioning

4.2.1 Self-Powered Device

A Self-Powered Device (SPDs) that is a USB4 Hub or USB4 Dock shall provide at least 15W on VBUS to each USB4 Port to enable support for upstream (charging) and downstream BPDs.

An SPD that is a USB4 Peripheral Device shall provide at least 4.5 W VBUS on the upstream facing port. This is to support a legacy (TBT2-to-TBT3) Thunderbolt adapter.

An SPD shall meet the VCONN requirements defined in Table 4-3.

An SPDs may optionally provide up to the maximum power allowed by the USB PD Specification. An SPD shall follow the power rules defined in the USB PD Specification when providing power greater than 15W.

4.2.2 Bus Powered Device

A Bus-Powered Device (BPD) shall connect as a Sink presenting Rd on both CC1 and CC2. A BPD is not required to provide VCONN.

Note: A BPD does not need to be functional when connected via an active optical cable.

4.2.3 Dual Powered Device

A Dual Powered Device (DPD), shall meet the VBUS requirements in Table 4-2. A DPD shall meet the VCONN requirements defined in Table 4-3.

A DPD shall not have more than one USB Type-C port.

A DPD may optionally provide up to the maximum power allowed by the USB PD Specification. A DPD shall follow the power rules defined in the USB PD Specification when providing power greater than 15W.

4.3 Source VBUS Requirements

4.3.1 Electrical

Table 4-2 defines the Host Source requirements for a USB4 Host. The voltages defined in Table 4-2 shall be met while the maximum load current is applied by the Sink. All other requirements defined in the USB PD Specification and the USB Type-C Specification for Sources (such as ramp rates, overshoot, capacitive loading, etc.) shall be met.

Table 4-2. Thunderbolt VBUS Source Electrical Parameters

Parameter	Description	Min	Typical	Max	Units	Notes
iVBUS_OCP	Over Current Protection	IPDO		2*IPDO	A	IPDO is the negotiated PDO current. Short applied to the port.
iSrc5Full	TBT full power current	3			A	TBT Full power current.
vSrc5Full ¹	TBT Full Power voltage	4.75	5	5.5	V	Same as the USB Type-C Specification. All load conditions.
pSrcSleep ²	TBT Sleep Power	3.0			W	
Notes: 1. Required 5V VBUS range for TBT Full Power mode. Other voltages may be provided in addition to 5V. The Source Power Rules defined in USB PD shall apply. 2. A USB4 Host shall provide a minimum of 3W per port even when the Host is in Sleep mode. A Self-Powered device shall continue to provide 15W of power to its downstream facing ports even in Sleep mode.						

4.4 Output Over Current Protection

A Source shall implement output over current protection to prevent damage from output current that exceeds the current handling capability of the Source. The definition of current handling capability is left to the discretion of the Source implementation and shall take into consideration the current handling capability of the connector contacts.

4.5 Source VCONN Electrical Requirements

Table 4-3 defines the VCONN Source requirement for a USB4 Port that acts as a Source. All other requirements defined in the USB PD Specification and the USB Type-C Specification for Sources (such as ramp rates, overshoot, capacitive loading, etc.) shall be met.. A Source may disable VCONN if connected via a passive cable (as indicated by the cable eMarker) and no further communication is needed.

The OCP (overcurrent) threshold for VCONN in a VCONN source shall be set at least 5% higher than the minimum operating current that it supports, $iVCONN_min$, calculated as $iVCONN_min = 1.5W/VCONN_min$ where $VCONN_min$ is the lowest voltage at which the VCONN source will supply VCONN. The VCONN source OCP shall not trip before 1ms on excursions greater than $iVCONN_min + 5\%$ of $iVconn_min$.

Table 4-3. Thunderbolt Vconn Source Electrical Requirements

Parameter	Description	Min	Max	Units	Note
iVconn_OCP	OCP Circuit Current	iVCONN_min + 5% of iVCONN_min	900	mA	Short applied to the port. See Note 1,2.
vVCONNsrc_Active ¹	Minimum voltage provided to port in S0	4.25	5.5	V	All load conditions.
pVCONNsrc_Sleep	Minimum power provided to port in sleep	100		mW	See Note 3.
vVconnSrc_Sleep	Minimum voltage provided to port in sleep	4.25	5.5	V	100mW load. See Note 3.

Notes:

1. The Vconn source OCP should not trip before 1ms on excursions greater than iVconn_min +5% of iVconn_min.
2. iVconn_min, calculated as iVconn_min = 1.5W/Vconn_min where Vconn_min is the lowest voltage at which the Vconn source will supply Vconn.
3. Minimum power in USB suspend or TBT Sleep.

4.6 Device Sink Power Consumption

Table 4-4 and Table 4-5 defines the power requirements for non-captive and captive USB4 Bus Powered Devices that acts as a Sink. USB4 Non-Captive Bus-Powered Devices shall meet the power requirements defined in Table 4-4. USB4 Captive Bus-Powered Devices shall meet the power requirements defined in Table 4-5. All other requirements defined in the USB PD Specification and the USB Type-C Specification for Sinks shall be met.

Table 4-4. Non-Captive Bus Powered Device Sink VBUS Electrical Parameters

Parameter	Description	Min	Max	Units	Note
pSnk_BPD5f	Full Power Class		12	W	4.0V to 5.5V May not function with all Legacy Hosts
pSnkSleep	TBT Sleep Power		2.8	W	Without loads on IO ports

Table 4-5. Captive Bus Powered Device Sink VBUS Electrical Parameters

Parameter	Description	Min	Max	Units	Note
pSnk_CBPd5f	Full Power Class		14.25	W	4.75V to 5.5V May not function with all Legacy Hosts
pSnkSleep	TBT Sleep Power		3.0	W	Without loads on IO ports

5 USB4 Re-Driver (with TBT3) Cable

Cable requirements

A USB4 Re-Driver (with TBT3) cable shall reply to SOP' as follows:

1. For a Discover Identity Command:
 - a. ID Header VDO B29..27 Product Type (Cable Plug) is set to 011b (Passive Cable).
 - b. ID Header VDO Modal Operation Supported B26 is set to 1b Support Model Operation (ALT MODE).
 - c. Passive Cable VDO B2..0 USB Highest Speed is set to 010b ([USB 3.2]/[USB4] Gen2).
2. During Thunderbolt Compatibility Discovery (as described in Appendix F of the USB Type-C Specification)
 - a. Discover SVID: set to 0x8087 (TBT3 SVID).
 - b. TBT3 Cable Discover Mode VDO Responses:
 - i. Active_Passive B25: is set to 1b (Active cable).
 - ii. Re-timer B22: is set to 0b (Not-Re-timer).
 - iii. Cable Speed B18..16 is set to 011b (10 Gbps and 20 Gbps (TBT 3rd Gen active cables and 20 Gbps passive cables)).

USB4 DFP requirements

When a USB4 Product is connected via a USB4 Re-Driver (with TBT3) cable, it shall do the following:

- Per Figure 5-1 of the USB Type-C specification, when the cable responds as a Passive Cable with USB 3.2 Gen2 as its highest supported speed, check the cable for TBT3 support.
- When an LRD cable responds to TBT3 discovery Mode with bit B25 in the VDO set as Active Cable, proceed as follows:
 - Use a TBT3 Cable Enter Mode Command (as described in Appendix F of the USB Type-C Specification).
 - If operating in TBT3 mode, use a TBT3 Device Enter Mode Command with B25 set to 1b.
 - If operating as USB4, use an Enter_USB Message with an Enter_USB Data Object that has B20..19 (Cable Type) set to 10b (Active Re-driver).

Table 5-1. Summary of Differences between USB and TBT3 Cables

Cable	Function					SOP' Configuration					
						ID Header VDO	Discover Mode (8087)				
	USB2	USB3	TBT3	USB4	DP	Passive /Active B29..27	Re-Timer B22	Passive /Active B25	Uni/Bi-Directional B23	Rounded /None B20..19	Optical /None B21
Passive	Yes	Yes	Yes	Yes	Yes	011b	0b	0b	N/A(0b)	N/A(0b)	0b
USB4 Re-Driver (no TBT3)	Yes	Yes	No	Yes	Optional	100b	N/A	N/A	N/A	N/A	N/A
USB4 Re-Driver (with TBT3)	Yes	Yes	Yes	Yes	Optional	011b ¹	0b	1b	1	01	0b

Notes:

1. This cable is an active cable, however, to support backward compatibility with TBT3 legacy devices B29..27 should be set to 011b.

6 Thunderbolt VID

All Thunderbolt compatible solutions except a platform integrated Host Router shall have a Thunderbolt VID (refer Section 8.4 of DROM Specification). A Vendor (implementing a Thunderbolt compatible solution) who does not have a Thunderbolt VID assigned can obtain a Thunderbolt VID by following the below defined process:

1. Vendor requests Intel Thunderbolt VID (directly from thunderboltadmin@intel.com)
2. Vendor signs Thunderbolt Trademark & Brand agreement and send to Intel
3. Upon signing Intel provides Thunderbolt VID to Vendor
4. Vendor goes through USB4 with Thunderbolt compatibility certification in USB-IF

7 Prohibited Product IDs

A Device Router shall not contain any of the following values in the Product ID field in Router Configuration Space:

- 0x1500-0x15FF
- 0x0B26