Universal Serial Bus
Upstream Facing Port Powered Hub
White Paper Document

Revision 0.8

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Revision History

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1. Introduction

1.1 Background

The USB 2.0 compliance program allowed the certification of bus powered hubs. The USB 3.2 compliance program has not allowed certification of bus powered hubs because of power limitations.

1.2 Objective

This document establishes definitions and guidelines that allow expansion of the Bus Powered Hub certification program to include USB 2.0 and USB 3.2 hubs that receive at least 3A of USB Type-C Current on the Upstream Facing Port.

1.3 Scope of the Document

This document is for the developers of hubs that can be powered from sinking V_{BUS} on its upstream facing port and/or from some other source. The original definitions of bus-powered and self-powered mapped those power characteristics directly to specific bus/self-powered fields in the Configuration and Capability Descriptors defined in the USB 2.0 and USB 3.2 specifications [USB 2.0, USB 3.2]. This description is no longer sufficient for defining compliance testing for hubs using USB Type-C and USB Power Delivery.

This document should be used in combination with other compliance documents applicable to the Devices USB product type. To determine which other compliance documents are applicable please use the test matrixes linked in Section 1.5 Related Documents.

Table 1-1 Summary of power type combinations addressed in this document

		UFP Power				
		None	Legacy Bus Power	USB Type-C Current	USB Power Delivery	BC 1.2
External Power	None	Invalid Configuration	USB 2.0 Testing / USB 3.2 Not Allowed	This Document	This Document	This Document
	USB PSD Port	USB 2.0/ USB 3.2 Testing	USB 2.0/ USB 3.2 Testing	This Document	This Document	This Document
	Other (Barrel Jack, etc)	USB 2.0/ USB 3.2 Testing	USB 2.0/ USB 3.2 Testing	This Document	This Document	This Document

1.4 UFP Powered Definitions

The term 'UFP Powered' is used to describe any peripheral that is capable of sinking power from V_{BUS} on its upstream port. A bus-powered peripheral is a specific subset of a UFP Powered peripheral.

A peripheral is considered a 'UFP Powered Device' if it has the capability of sinking UFP Power. Similarly, a peripheral is considered an 'Externally Powered Device' if it has the capability of sinking power from any source other than the UFP. A peripheral can be both a UFP Powered Device and an Externally Powered Device.

1.5 Related Documents

[USB 2.0] – Universal Serial Bus Base Specification, Revision 2.0, 27 April 2000.
https://www.usb.org/document-library/usb-20-specification

[USB 3.2] – Universal Serial Bus Base Specification, Revision 3.2, 22 September 2017.
https://www.usb.org/document-library/usb-32-specification-released-september-22-2017-and-ecns

[USB Type-C] – Universal Serial Bus Type-C Cable and Connector Specification, Revision 2.0, August 2019.
https://www.usb.org/document-library/usb-type-cr-cable-and-connector-specification-revision-20

[USB PD] – Universal Serial Bus Power Delivery Specification, Revision 3.0, Version 2.0, 07 February 2020.
https://www.usb.org/document-library/usb-power-delivery

[USB BC 1.2] – Universal Serial Bus Battery Charging Specification, Revision 1.2, 15 March 2012.
https://www.usb.org/document-library/battery-charging-v12-spec-and-adopters-agreement

[USB 2.0 Matrix] – Universal Serial Bus 2.0 Product Matrix, 1 March 2019.
https://usb.org/document-library/usb-20-test-matrix

[USB 3.2 Matrix] – Universal Serial Bus 3.2 Product Matrix, 19 November 2018.
https://usb.org/document-library/usb-32-product-test-matrix

[USB Type-C Matrix] – Universal Serial Bus Type-C Product Matrix, Revision 0.95, 1 March 2019.
https://usb.org/document-library/usb-type-c-product-test-matrix-0
[USB BB] – Universal Serial Bus Device Class Definition for Billboard Devices, Revision 1.21, 8 September 2016.

https://www.usb.org/document-library/billboard-device-class-spec-revision-121-and-adopters-agreement

[USB Interop] – Universal Serial Bus xHCI Interoperability Test Procedures For Peripherals, Hubs and Hosts, Revision 1.0, July 2020.
https://usb.org/document-library/xhci-interoperability-test-procedures-peripherals-hubs-and-hosts-version

[USB Legacy CabCon] – Universal Serial Bus USB 3.1 Legacy Cable and Connector Revision 1.0, Revision 0.97, September 2020.
https://usb.org/document-library/usb-31-legacy-cable-and-connector-revision-10

1.6 Terms and Abbreviations

Term	Definition
Assured Capacity	A multi-port device where the sum of the maximum capabilities of all of the exposed ports, as indicated to the user, is equal to the total power delivery capacity of the charger. [USB Type-C]
Billboard Device	Either a standalone USB device that adheres to this class specification or a Device Container that exposes other USB functionality but includes the Billboard Descriptors as part of its complete BOS descriptor. [USB BB]
Compound Device	A physical package implementing multiple functions and an embedded hub with a single USB cable, appears to the host as a hub with one or more non-removable USB devices. [USB 2.0]
Downstream Facing Port (DFP)	Indicates the Port's position in the USB topology which typically corresponds to a USB Host Root Port or Hub Downstream Port, at connection the Port defaults to operation as a USB Host (when USB Communication is supported) and Source. [USB Type-C]
Dual-Role-Data (DRD)	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. [USB Type-C]
Dual-Role-Power (DRP)	A USB port that can operate as either a Source or a Sink. The role that the port offers may be fixed to either a Source or Sink or may alternate between the two port states. 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. [USB Type-C]
External Power	Power drawn from an external source via a non-UFP Port (e.g. USB Type-C PSD, barrel jack, etc.).

Legacy Connector	USB Type-A and USB Type-B Connectors [USB Legacy CabCon].
Port Partner	Refers to the port (device or host) a port is attached to. [USB Type-C]
Power Sinking Device (PSD)	Sink which draws power but has no other USB or Alternate Mode communication function.
Shared Capacity	A multi-port device where the sum of the maximum capabilities of all of the exposed ports, as indicated to the user, is less than the total power delivery capacity of the charger [USB Type-C].
Sinking Host	A special sub-class of a DRP that is capable of consuming power, but is not capable of acting as a USB device [USB Type-C].
Upstream Facing Port (UFP)	Indicates the Port's position in the USB topology typically a Port on a device, at connection the port defaults to operation as a USB Device (when USB Communication is supported) and Sink [USB Type-C].
Upstream Facing Port (UFP) Power	Power drawn from the UFP which may be one or more of the following: USB 2.0 or 3.2 Power, USB Type-C Current, USB PD Contract or USB BC 1.2.
USB 2.0 Unit Load	A USB 2.0 Unit Load is defined to be 100 mA [USB 2.0].
USB 3.2 Unit Load	A USB 3.2 Unit Load is defined to be 150 mA [USB3.2].
USB 2.0 Low Power Port	A port supplying 1 USB 2.0 Unit Load – 100 mA. [USB 2.0]
USB 3.2 Low Power Port	A port supplying 1 USB 3.2 Unit Load – 150 mA. [USB 3.2]
USB 2.0 High Power Port	A port supplying at least 5 USB 2.0 Unit Loads – 500 mA. [USB 2.0]
USB 3.2 Single-Lane Port	A port supplying at least 6 USB 3.2 Unit Loads – 900 mA. [USB 3.2]
USB Type-C 1.5A Port	A port supplying at least 1.5A of USB Type-C Current. [USB Type-C]
USB Type-C 3.0A Port	A port supplying at least 3A of USB Type-C Current. [USB Type-C]
USB Type-A	A general reference to all versions of USB "A" plugs and receptacles.
USB Type-B	A general reference to all versions of USB "B" plugs and receptacles.
USB Type-C	A general reference to all versions of USB "C" plugs and receptacles.

2. Configuration, Functional and Power Guidelines

2.1 Configuration and Capability Descriptors

A UFP Powered Port will set its Configuration and Capability descriptors based on the below table [USB 2.0, USB3.2, USB Type-C, USB PD].

Table 2-1 clarifies which hubs are described as UFP Powered

UFP Power	Configuration Descriptor bmAttributes D6	Configuration Descriptor bMaxPower	USB PD Capability Descriptor bmAttributes	USB PD Consumer Port Capability Descriptor bmCapabilites	USB PD Consumer Port Capability Descriptor dwMaxOperatingPower
Legacy Connectors	0 or 1	USB 2.0 0 < x ≤ 500mA	descriptor not present	descriptor not present	descriptor not present
USB Type-C Default	0 or 1	USB 2.0 0 < x ≤ 500mA	bit 6 set to 0 bit 14 set to 1	bit 2 set to 0	500 mA – max 2.5 W
		USB 3.2 0 < x ≤ 900mA			900 mA – max 4.5 W
USB Type-C (1.5A or 3.0A)	1	0	bit 6 set to 1 bit 14 set to 1	bit 2 set to 1	1.5 A – max 7.5 W
					3.0 A – max 15 W
USB PD	1	0	bit 2 set to 1 bit 4 set to 1 bit 14 set to 1	bit 1 set to 1	max 100 W
BC 1.2	1	0	bit 1 set to 1 bit 14 set to 1	bit 0 set to 1	max 7.5 W

These descriptors are based on current guidance; however, they are in the process of being updated by USB working groups and will likely be changed in the coming months.

2.2 UFP Powered Hub Configuration

The following describes the configuration guidelines of a UFP Powered Hub.
- A UFP Powered Hub may only sink power from one USB Type-C data capable port at a time (i.e. a UFP Powered Hub may sink power from the UFP or one of its DFPs).
- If operating from UFP Power, a DFP may disable its Battery Charging 1.2 capability.
- Power drawn by the product (including indicator lights) should be reported in the PD descriptors.
- A UFP Powered Hub's power draw may not exceed the power contract negotiated with the source regardless of what occurs on the DFPs.

2.3 Hub Upstream Facing Port

The following is defined for UFP Powered Hubs Upstream Facing Ports:
- A UFP Powered Hub should have one UFP that is properly labeled, and its role is clearly communicated to the end user [USB Type-C].
- The UFP of a USB 3.2 UFP Powered Hub must be a USB Type-C port.

This document assumes that the UFP on a UFP Powered Hub is acting as a power sink.

2.4 Hub Downstream Facing Ports

The following is defined for UFP Powered Hubs Downstream Facing Ports:
- A UFP Powered Hub must provide multiple exposed DFPs.
- The USB Type-A and USB Type-C DFPs will be implemented as independent groups, any load change on a USB Type-A port should not result in a voltage change on any of the USB Type-C ports and vice-versa [USB Type-C].
- It is encouraged that each DFP have its own power limiting and overcurrent protection.

Additional non-USB ports and other functionality will add additional power requirements.

2.4.1 USB Type-C DFPs

The following is defined for any USB Type-C DFPs:
- USB Type-C DFPs should support at least USB 3.2 Single-Lane Power as a source [USB Type-C].
- All USB Type-C DFPs should support the same functionality or shall be clearly marked as to the functionality supported [USB Type-C].
- A UFP Powered Hub's USB Type-C DFPs may not have Dual-Role-Data (DRD) capabilities.
- A UFP Powered Hub's USB Type-C DFPs may have Dual-Role-Power (DRP) capabilities.
    - Note – This includes Sinking Host ports. [USB Type-C]
- A UFP Powered Hub with multiple USB Type-C DFPs will act as an Assured Capacity USB Type-C Multi-Port Charger [USB Type-C].
    - Note – This will be reviewed and updated upon the availability of the "USB-IF USB Type-C Shared Capacity charging program".

2.4.2 USB Type-A DFPs

The following is defined for any USB Type-A DFPs:
- USB Type-A DFPs should support at least USB 2.0 High Power as a source [USB 2.0].
- USB Type-A DFPs that are USB 3.2 capable may disable USB 3.2 SuperSpeed functionality and drop down to USB 2.0 speeds and power when there is insufficient power received by the UFP. [USB 3.2, USB 2.0].

2.5 Power Sinking Device (PSD) Port

This document currently does not cover the use case of a Power Sinking Device port on a UFP Powered Hub. Until guidelines are solidified, Power Sinking Device ports are not encouraged.

2.6 Compound Device

A UFP Powered Hub may be implemented as a Compound Device, in which case it should meet all testing conditions for a UFP Powered Hub, except that a Compound Device's DFPs are not required to be exposed and may be internal to the device.

2.7 USB Billboard Device

A UFP Powered Hub should present a Billboard Device in any situation in which the source does not provide enough power for the hub to provide full functionality [USB BB]. If insufficient power to present a Billboard Device is provided to the hub (less than 4.5W), the hub should not enumerate.

3. Testing Procedures

3.1 General Testing Requirements

A UFP Powered Hub will be tested against all applicable tests in the "USB 3.2 Product Test Matrix" [USB 3.2 Matrix] and the "USB Type-C Product Matrix" [USB Type-C Matrix].

If the product is to be shipped with a USB charger/cable, the charger/cable must be certified.

3.1.1 Externally and UFP Powered Hubs

A hub capable of sinking power from both the UFP and External Power will be tested with its External Power connected and disconnected as defined in the "USB Interoperability Test Procedures" specification [USB Interop].

3.1.2 UFP Powered Hubs (No External Power Capability)

A UFP Powered Hub with no external power capabilities should provide some hub functionality if drawing more than or equal to 15W from its UFP. Hub functionality is defined as the ability to provide power and data capabilities to two or more DFPs (USB or Non-USB).

Note – Presenting a USB Billboard Device is not defined as providing some hub functionality in this context.

3.2 Hub Depth Tests

The following provides a brief description of the depth testing conditions for a UFP Powered Hub. A full description of test steps will be provided in the *Bus-Powered Hub Interoperability Test Steps* in the "USB Interoperability Test Procedures" specification [USB Interop]:
- Test fully populated DFPs at 1 hub depth. All DFPs will be populated with peripherals of different transfer types.
- Follow standard interoperability hub testing procedure, using Externally Powered Hubs for hubs not under test.
- UFP Powered Hubs that do not support External Power do not need to be tested against the *Self-Powered Hub Interoperability Test Steps* described in the "USB Interoperability Test Procedures" specification [USB Interop].

3.3 Upstream Port Partner Testing Conditions

UFP Powered Hubs will be tested using the following sources:
- USB Type-C Host operating as a 15W source
    - Expected to provide some hub functionality if no external power capabilities.
    - Expected to provide USB Billboard Device if full functionality not provided.
- USB Type-C Host operating as a 7.5W source
    - Expected to provide USB Billboard Device if full functionality not provided.
- USB Type-C Host operating as a 4.5W source
    - Expected to provide USB Billboard Device if full functionality not provided.
- USB Type-C Host that can source the required power for the hub to operate at full functionality (Only tested if hub cannot provide full functionality at 15W).

4. Example Implementations

The following tables provide several examples for potential UFP Powered Hubs, they are for reference only and are only four of many possible UFP Powered Hub implementations eligible for certification. They are meant to provide a base for what the power consumption and management may look like in USB 3.2 UFP Powered Hubs.

These hub examples include some 'non-USB ports', the port current and power associated with these ports are for reference only. Non-USB ports may have Interoperability requirements defined in the "USB Interoperability Test Procedures" specification [USB Interop].

The examples below factor in the minimum source voltage of 4.75V and maximum USB Type-C cable drop of 750mV. Therefore, as shown below a UFP Powered Hub should be designed to operate while only receiving 12W of power on its UFP.

Table 4-1 Example UFP Powered Hub – 1 USB Type-C Source, 1 USB Type-A Source, 1 Non-USB

Source Power	Max Cable Power Loss	UFP Power Received	DFPs	Port Current (As Source)	Port Power (As Source)	Power Available for Hub Circuitry
14.25 W	2.25 W	12 W	USB Type-C (Source)	1.5 A (USB Type-C Power)	7.5 W	1.75 W
			USB Type-A (Source)	500 mA (USB 2.0 High Power)	2.5 W	
			Non-USB	50 mA	0.25 W	

1. Assumed 14.25W (4.75V/3A) of UFP Power as only power source (no External Power).
2. 1.75W of power available to the hub circuitry.

Table 4-2 Example UFP Powered Hub – 1 USB Type-C DRP, 2 USB Type-A Sources

Source Power	Max Cable Power Loss	UFP Power Received	DFPs	Port Current (As Source)	Port Power (As Source)	Power Available for Hub Circuitry
14.25 W	2.25 W	12 W	USB Type-C (DRP)	900 mA (USB Type-C Default; USB 3.2 Single-Lane)	4.5 W	2.5 W
			USB Type-A (Source)	500 mA (USB 2.0 High Power)	2.5 W	
			USB Type-A (Source)	500 mA (USB 2.0 High Power)	2.5 W	

1. Assumed 14.25W (4.75V/3A) of UFP Power as only power source (no External Power).
2. 2.5W of power available to the hub circuitry.

Table 4-3 Example UFP Powered Hub – 1 USB Type-C Source, 1 USB Type-A Source, Non-USB

Source Power	Max Cable Power Loss	UFP Power Received	DFPs	Port Current (As Source)	Port Power (As Source)	Power Available for Hub Circuitry
14.25 W	2.25 W	12 W	USB Type-C (Source)	900 mA (USB Type-C Default; USB 3.2 Single-Lane)	4.5 W	4.75 W
			USB Type-A (Source)	500 mA (USB 2.0 High Power)	2.5 W	
			Non-USB	50 mA	0.25 W	

1. Assumed 14.25W (4.75V/3A) of UFP Power as only power source (no External Power).
2. 4.75W of power available to the hub circuitry.

Table 4-4 Example UFP Powered Hub – 2 USB Type-C DRPs

Source Power	Max Cable Power Loss	UFP Power Received	DFPs	Port Current (As Source)	Port Power (As Source)	Power Available for Hub Circuitry
14.25 W	2.25 W	12 W	USB Type-C (DRP)	900 mA (USB Type-C Default; USB 3.2 Single-Lane)	4.5 W	3 W
			USB Type-C (DRP)	900 mA (USB Type-C Default; USB 3.2 Single-Lane)	4.5 W	

1. Assumed 14.25W (4.75V/3A) of UFP Power as only power source (no External Power).
2. 3W of power available to the hub circuitry.

5. Summary of Guidelines

The following section summarizes the conditions that will be considered in the USB-IF certifying a UFP Powered Hub in addition to the testing the product undergoes.

5.1 UFP Powered Hub Checklist

1. Set Configuration Descriptors correctly based on the UFP Power provided?

2. Set Capability Descriptors set correctly based on the UFP Power provided?

3. Does the UFP Powered Hub expose 1 clearly identifiable USB Type-C UFP?

4. Does the UFP Powered Hub expose 2 USB DFPs (may be internal for Compound Device)?

5. Are the USB Type-C and USB Type-A DFPs implemented as independent groups?

6. Do all exposed USB Type-A DFPs provide a minimum of USB 2.0 High Power?

7. Do all exposed USB Type-C DFPs provide a minimum of USB 3.2 Single-Lane Power?

8. Do all USB Type-C DFPs act as Assured Capacity Chargers with the same capabilities?

9. Does the UFP Powered Hub provide some hub functionality at 15W of UFP Power?

10. If UFP Powered Hub cannot provide full functionality at the received UFP Power does it present a billboard device indicating insufficient power?