USB Type-C™ Overview

Developer Days 2016

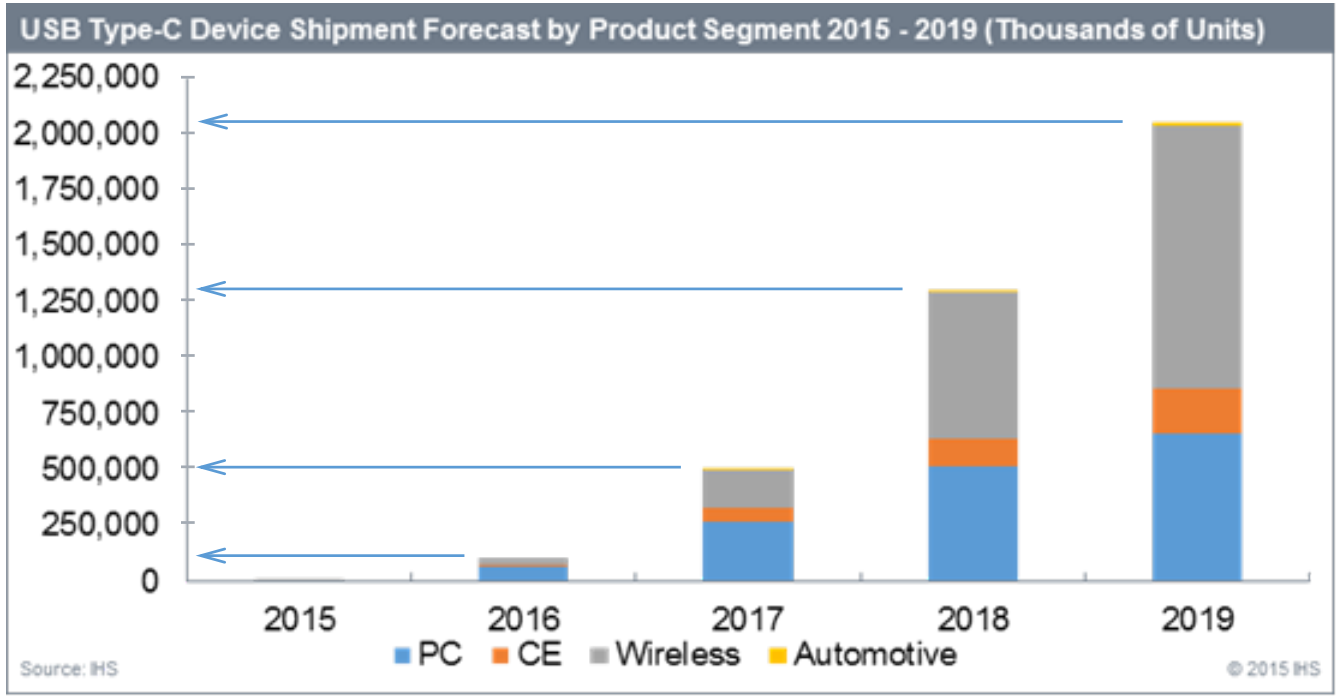
Hong Kong

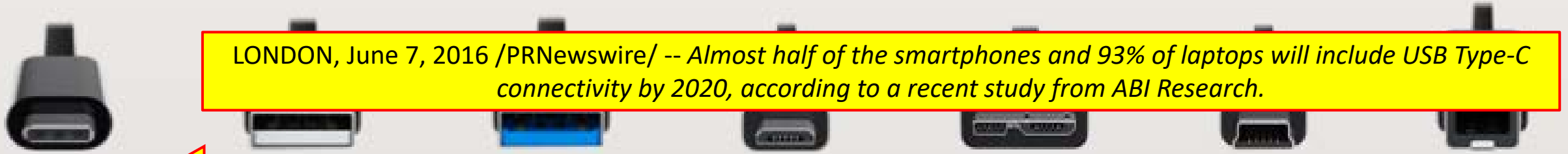
October 19 – 20, 2016

USB Type-C – The Connector of the Future

It's happening now …

- IHS (Brian O'Rourke) report completed December 2015
- Over 2 billion USB Type-C based units expected to ship in 2019
  - 40% of USB TAM

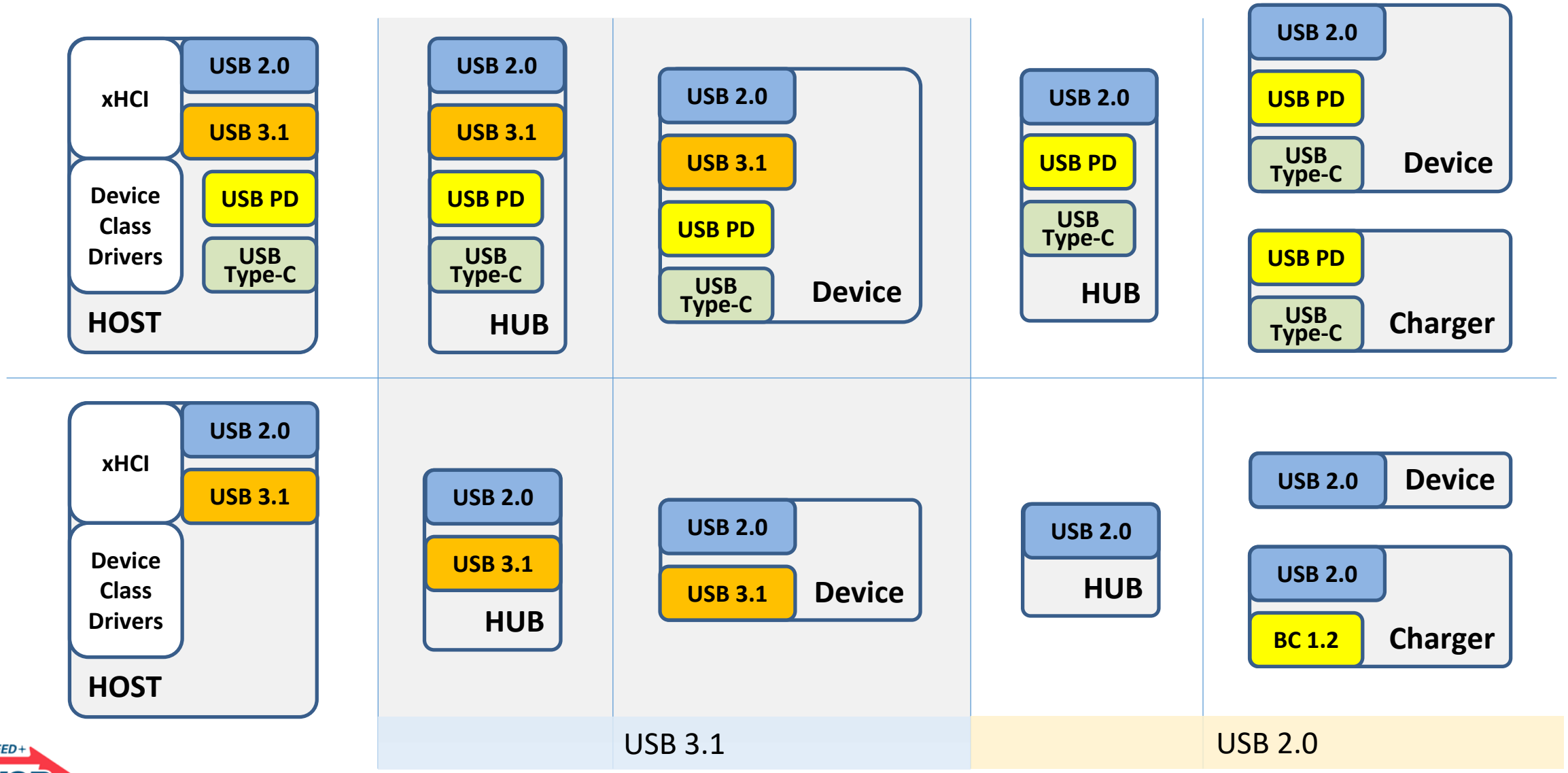




LONDON, June 7, 2016 /PRNewswire/ -- *Almost half of the smartphones and 93% of laptops will include USB Type-C connectivity by 2020, according to a recent study from ABI Research.*

USB Type-C | **USB 2.0 Standard-A** | **USB 3.1 Standard-A** | **USB 2.0 Micro-B** | **USB 3.0 Micro-B** | **USB 2.0 Mini-B** | **USB 2.0 Standard-B**

System Perspective



USB Type-C Specification Structure

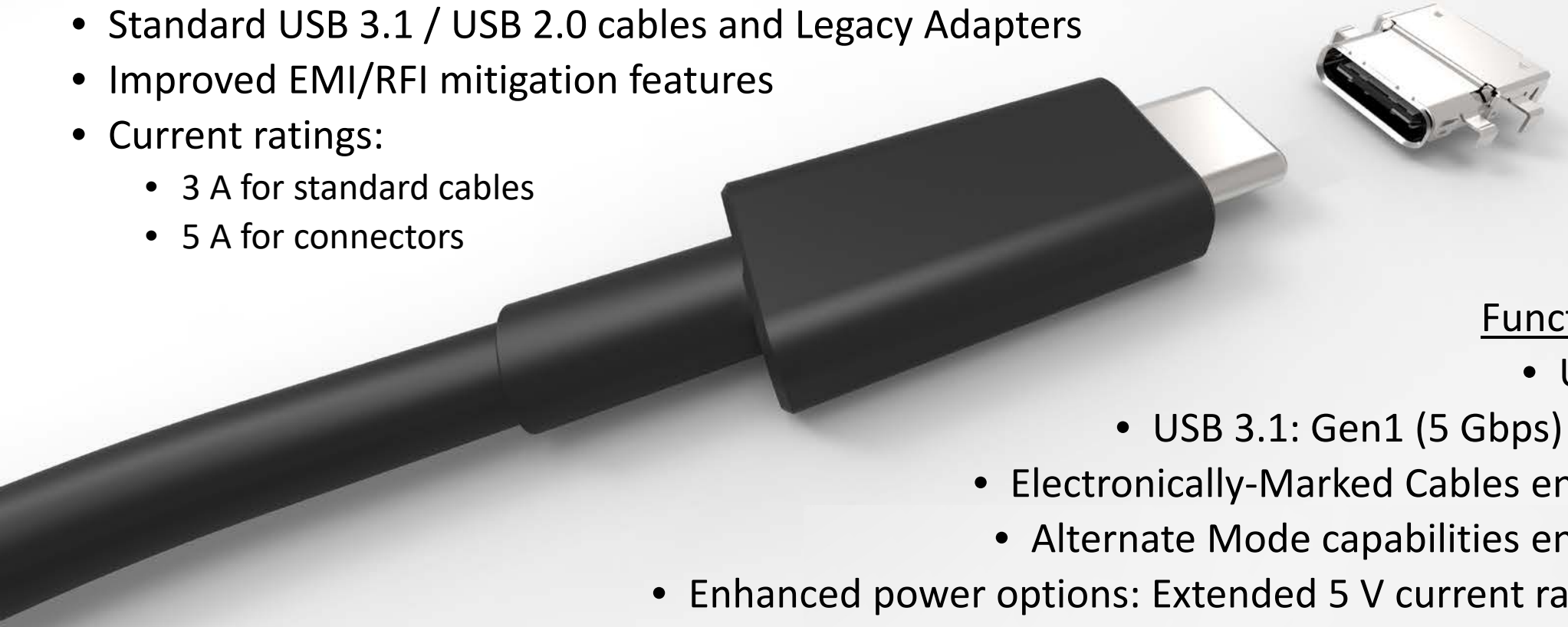
1. Normative References
   - USB 2.0 Specification
   - USB 3.1 Specification
   - USB Power Delivery Specification, Revision 2.0 (3.0)
   - USB Billboard Device Class Specification, Revision 1.2
   - USB Battery Charging Specification, Revision 1.2
2. Overview
   - Informative functional overview
3. Mechanical Requirements
   - Connector and cable definitions
   - Includes electro-mechanical performance requirements
4. Functional Requirements
   - Pin and signal requirements
   - Configuration channel requirements
   - Power requirements
5. Functional Extensions
   - Alternate Modes
   - Managed Active Cables

These specs are the foundation on which USB Type-C is defined

USB Type-C – Summary Characteristics

<u>Mechanical specifications</u>

- 24-pin receptacle – ~8.3 mm x ~2.5 mm – 10,000 cycle durability
- Flip-able, reversible plugs/cables
- Standard USB 3.1 / USB 2.0 cables and Legacy Adapters
- Improved EMI/RFI mitigation features
- Current ratings:
  - 3 A for standard cables
  - 5 A for connectors



<u>Functional capabilities</u>

- USB 2.0: LS/FS/HS
- USB 3.1: Gen1 (5 Gbps) / Gen2 (10 Gbps)
- Electronically-Marked Cables enabled via USB PD
- Alternate Mode capabilities enabled via USB PD
- Enhanced power options: Extended 5 V current ranges plus USB PD

Rendering courtesy of Foxconn

USB Type-C Functional Highlights

- Flipping and swapping
  - Both plug and cable orientation no longer keyed
  - Hosts and devices require logic to resolve their roles for proper USB bus operation
  - “Dual-role” products capable of host and device roles supported
- Lots of new pins
  - Required to enable plug orientation flipping
  - Offers path to higher performance and extensibility
- Two power sources
  - V_{BUS} – definition expanded with USB Type-C Current
  - V_{CONN} – a dedicated source for powering cable electronics
- Functional Extensions
  - A USB-defined method for enabling innovation in the form of Alternate Modes and Accessory Modes
  - Functional support for identifying and managing passive and active cables

Some Words of Caution …

- ***Only design to official released versions of USB specifications***
  - Developer presentations are intended to help familiarize you with the general characteristics of these specifications and provide design guidance
  - These presentations are not technically complete and should not be used as the sole basis for product designs

- USB technology has evolved into highly complex and challenging designs
  - When possible, make use of certified product suppliers – silicon, connectors, etc.
  - Proper materials and manufacturing processes are increasingly more critical to making successful certified products
  - *Submit your products for USB certification*

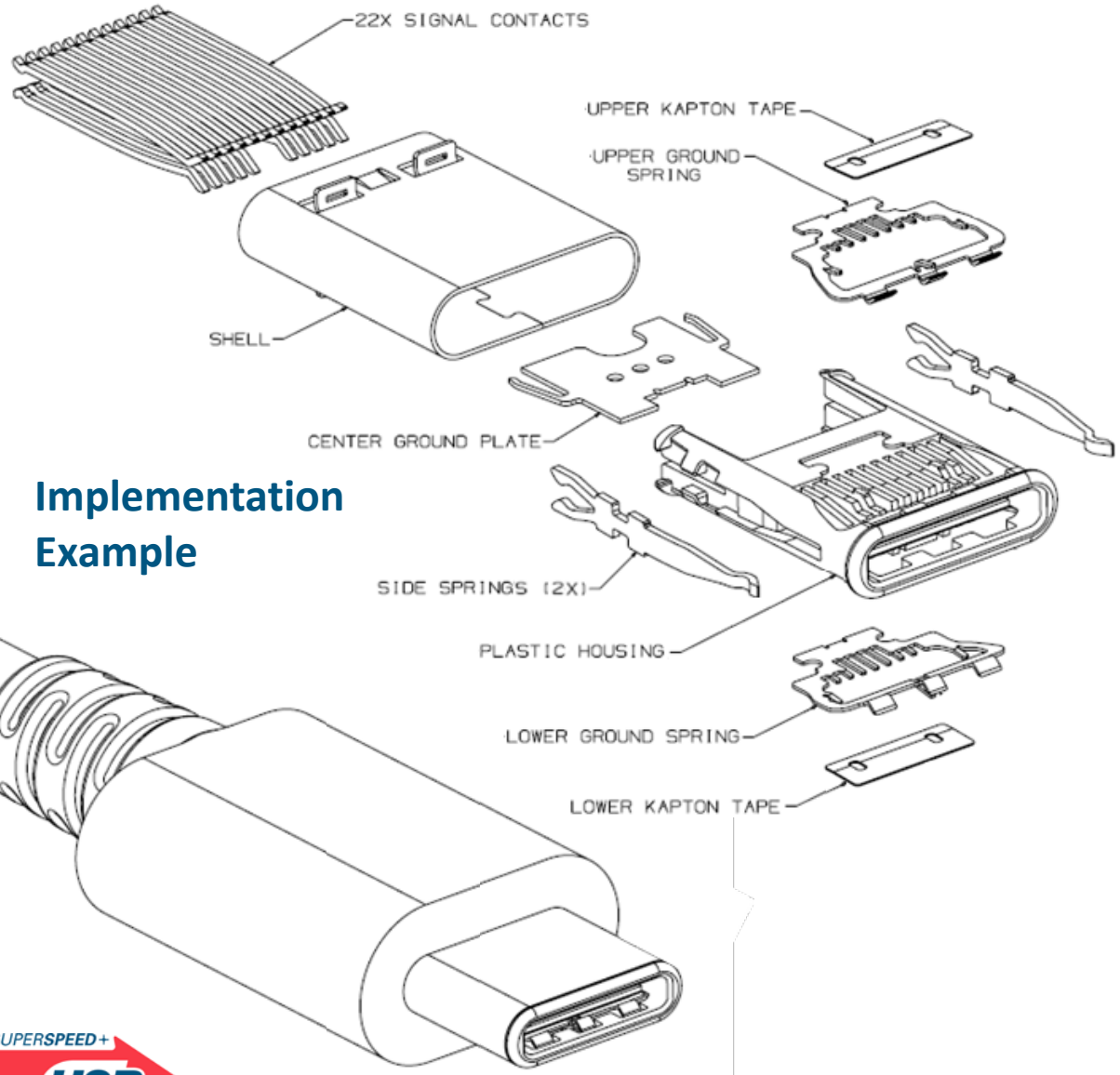
Topic Agenda

- Technical Solutions and Requirements
- Implementation Model
- USB Type-C Enabled Solutions

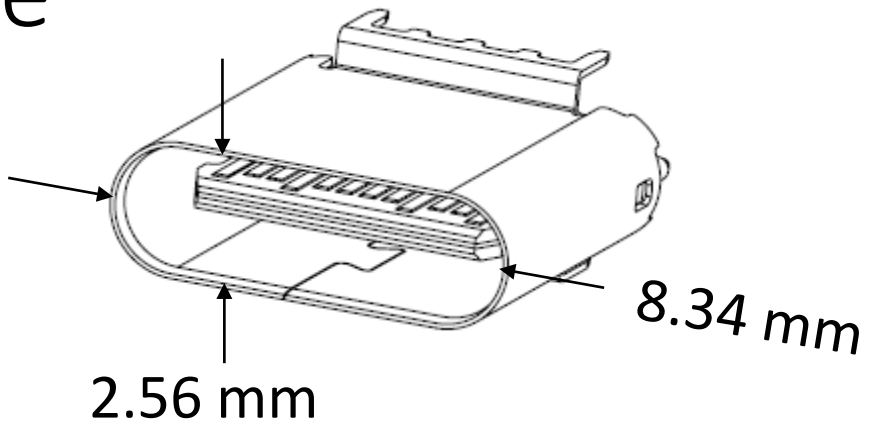
Technical Solution and Requirements

- Electro-Mechanical
- Signals and Pin-out
- Discovery and configuration
- Power
- Electronically Marked Cables
- Functional Extensions

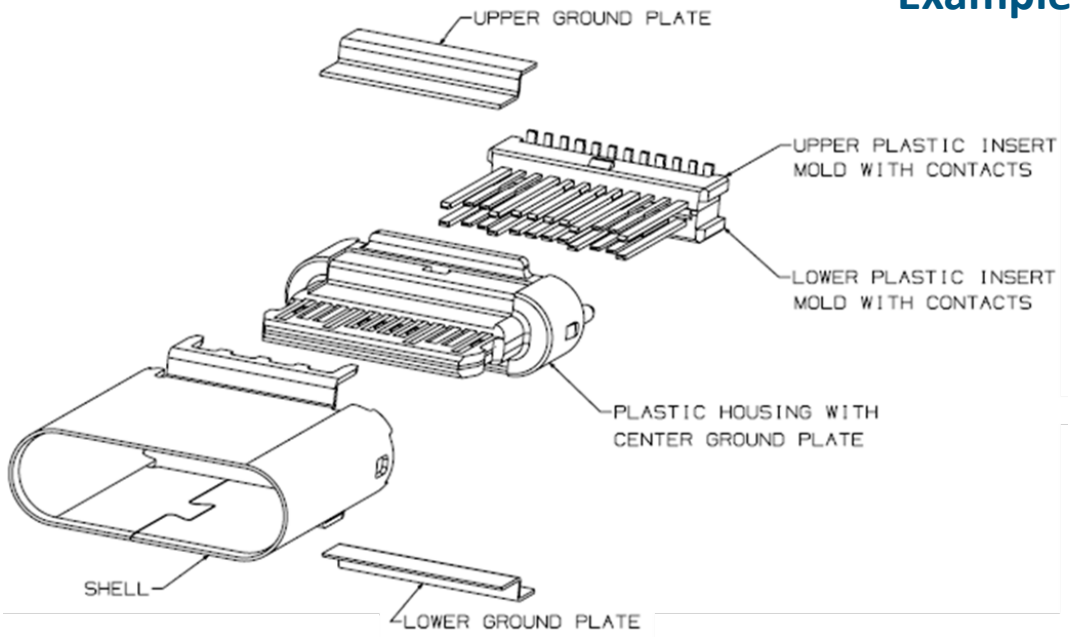
USB Type-C Plug and Receptacle



Implementation Example

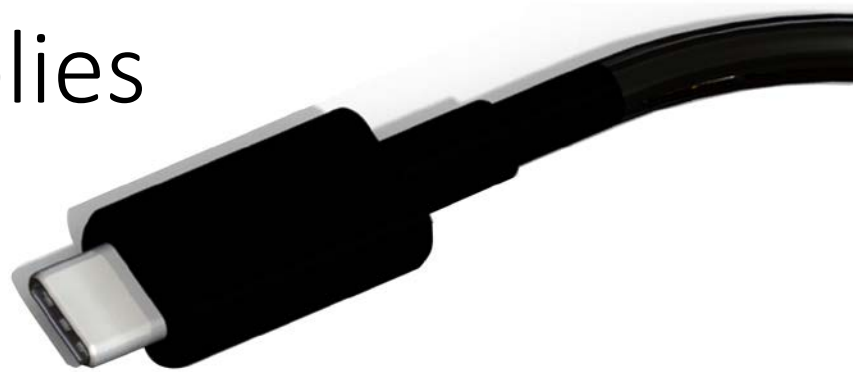


Implementation Example

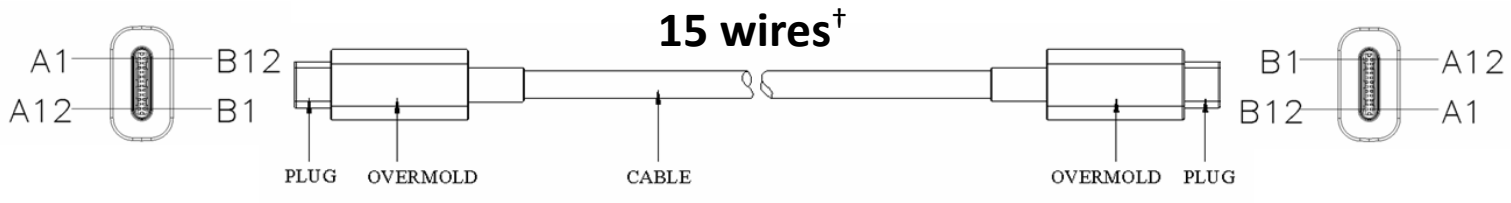


USB Type-C Standard Cable Assemblies

- Two USB Type-C to Type-C cables defined

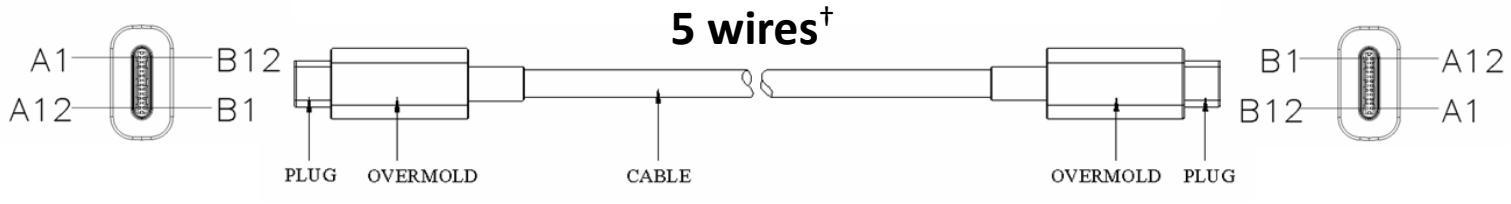


USB 3.1 Type-C to Type-C Cable Assembly



or

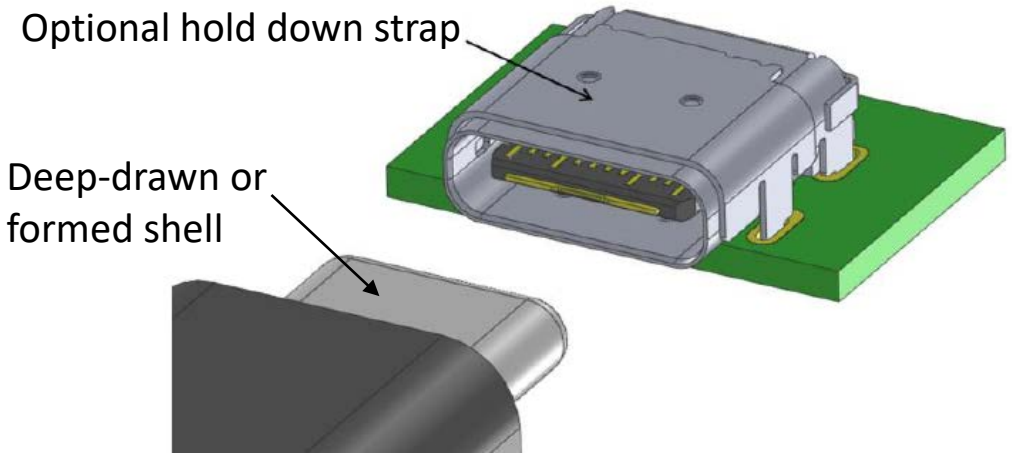
USB 2.0 Type-C to Type-C Cable Assembly

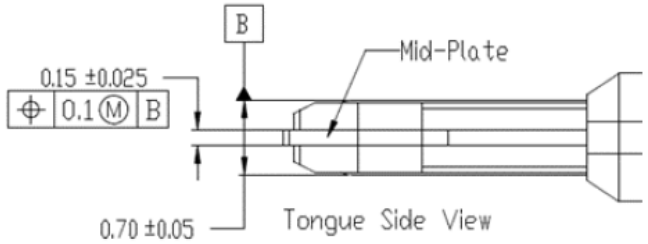


Artist rendering courtesy of Foxconn

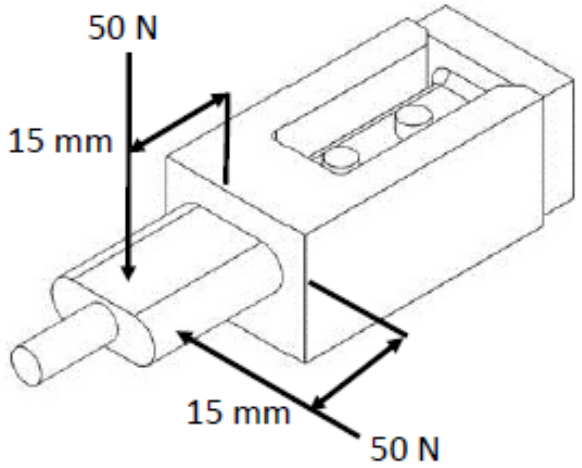
†Minimum number, count may differ depending on power/ground/shielding approach

Mechanical Robustness





Metal re-enforced tongue and tight tolerance/fit between plug and receptacle shells

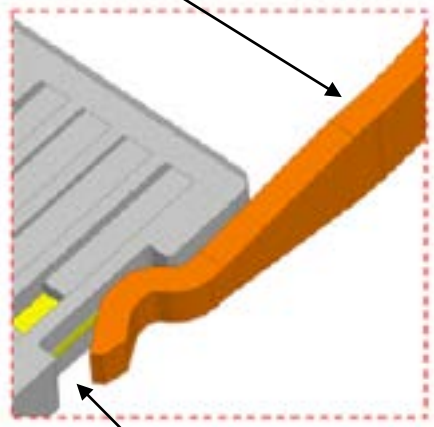


Wrenching test (2 of 4 axis shown)

Plug wrenching strength testing is mandatory

- Durability cycle: 10,000 min
- Mating force: 5 N to 20 N
- Un-mating force: 8 N to 20 N

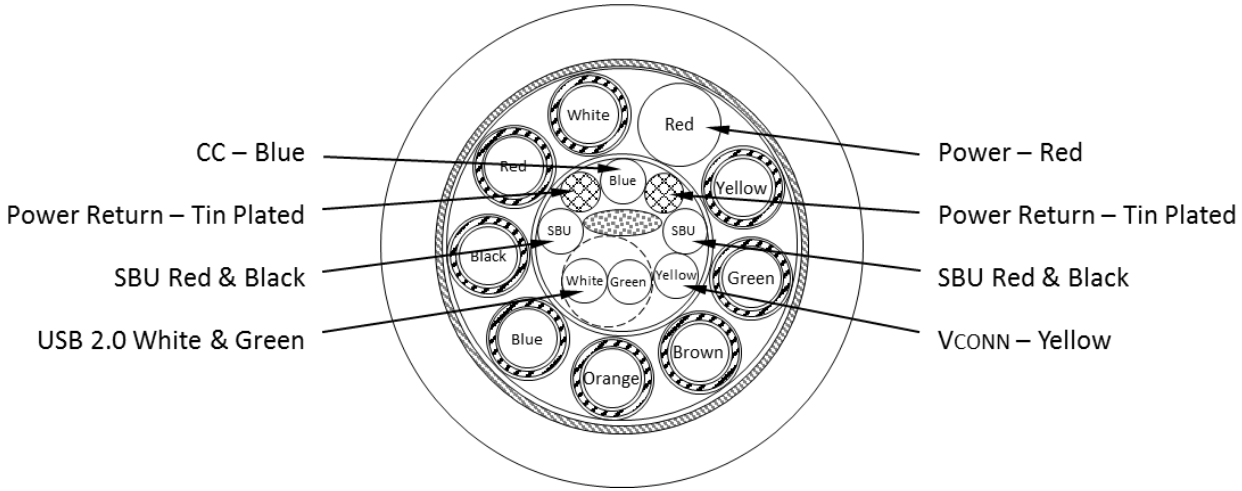
Side (Retention) Latch in plug



Recess on receptacle tongue

Cable Assembly Insertion Loss Requirements

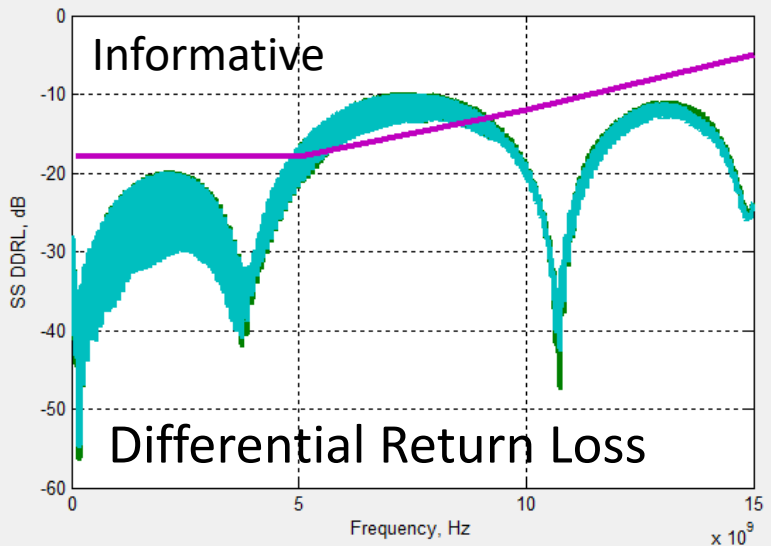
- USB 3.1 Gen 2 Type-C to Type-C cable assembly is allocated with −5.8 dB loss at 5 GHz, supporting a cable about 1-meter long
  - Control the loss at 10 GHz (20 GHz) to be ≤ −11 dB for future scalability
- USB 3.1 Gen 1 Type-C to Type-C cable assembly is allocated with −7 dB loss at 2.5 GHz, supporting a cable about 2-meter long

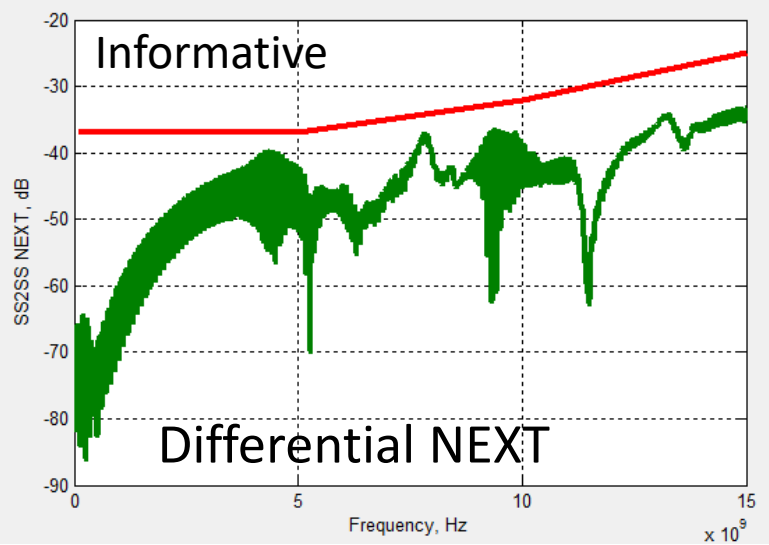


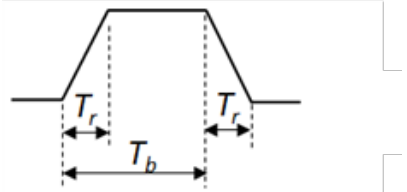
Raw cable may be coax or twisted pairs

Other High Speed Requirements

- All SuperSpeed TDR impedance and S-parameters specs are *informative, except for Differential-to-Common-Mode Conversion*
- The normative spec is the integrated S-parameters meet certain thresholds







T_b=Unit interval=100 ps
T_r=0 to 100% rise time = 0.4T_b

$$|V_{in}(f)| = \left| \frac{\sin(\pi f T_r)}{\pi f T_r} \cdot \frac{\sin(\pi f T_b)}{\pi f T_b} \right|$$

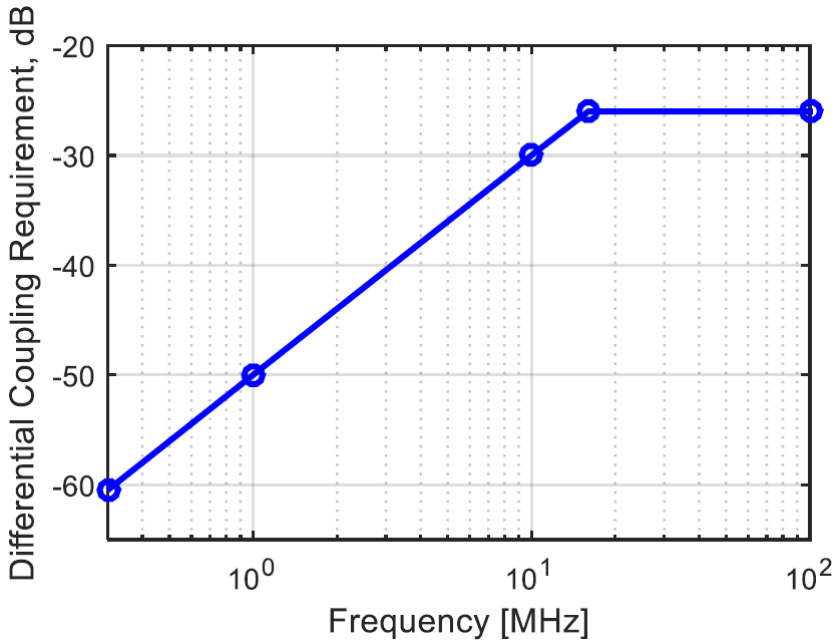
$$INEXT = dB\left(\sqrt{\frac{\int_0^{f_{max}} |Vin(f)|^2 (|NEXT(f)|^2 + 0.125^2 \cdot |C2D(f)|^2) df + |Vdd(f)|^2 \, |NEXTd(f)|^2 df}{\int_0^{f_{max}} |Vin(f)|^2 df}} \right)$$

Low Speed Signal Requirements

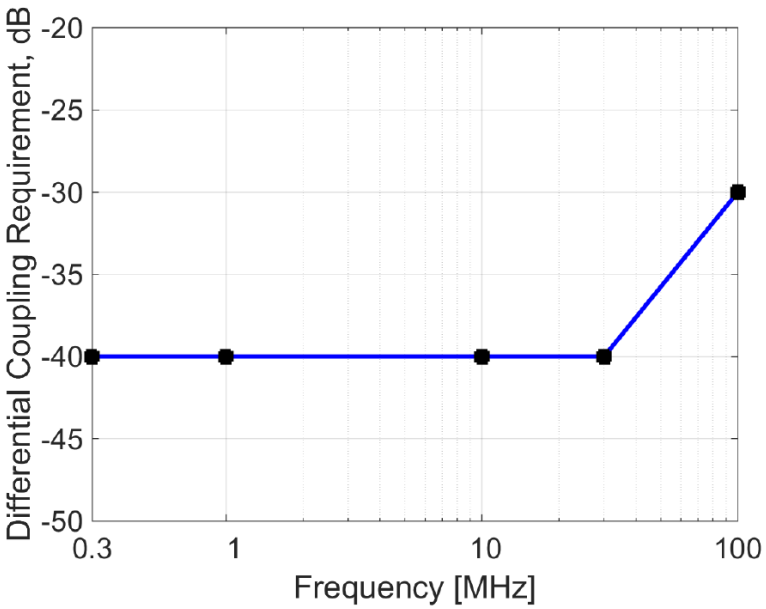
Pay attention to cable wire bundle design!

- Low speed signals include CC, SBU and VBUS
- Impedance for CC is from 32 – 93 ohms, SBU is from 32 – 53 ohms
- The VBUS line loop inductance is 900 nH max to manage load release
- Couplings between low speed signals are specified

Requirement for Differential Coupling between CC and D+/D–

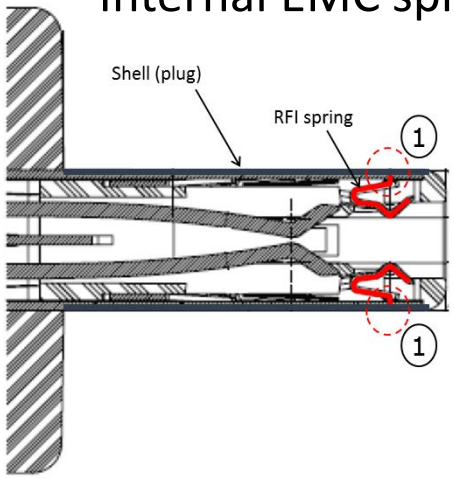


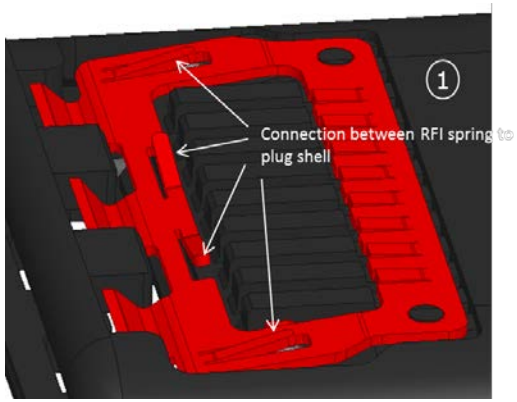
Requirement for Differential Coupling between VBUS and D+/D–

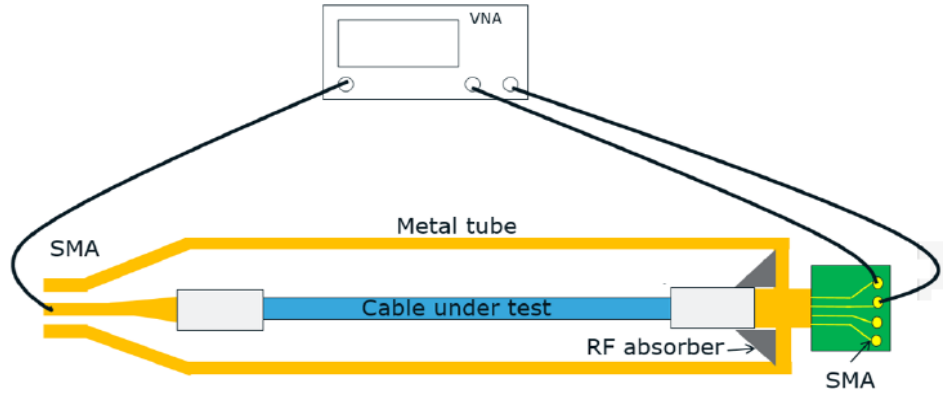


EMC Shielding Solutions and Requirements

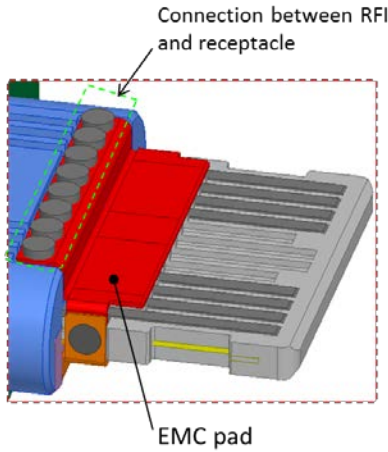
Internal EMC springs in plug



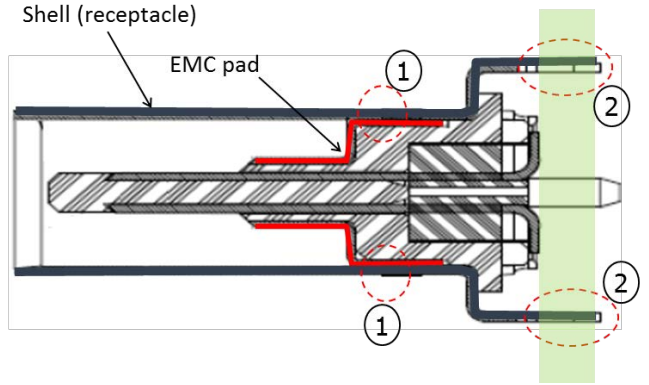


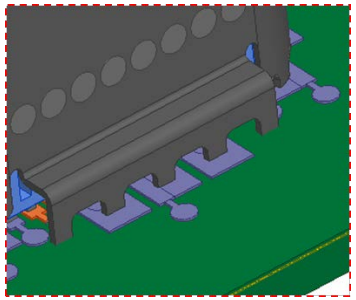


Normative shielding effectiveness test over frequency ranges of interests



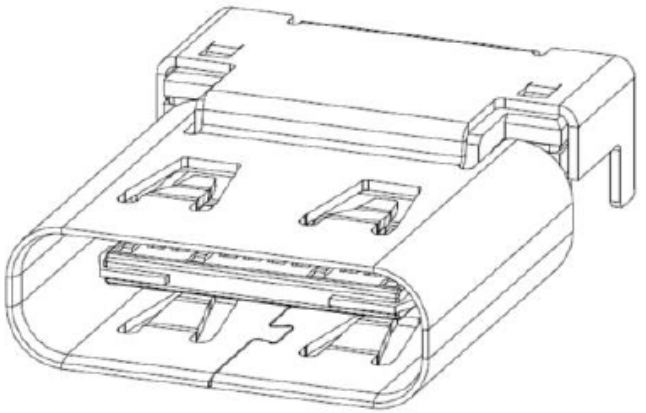
EMC pad in receptacle





Footprint shielding

Optional external EMC springs



USB Type-C Revision 1.2 – Notable Updates

- Chapter 3 – Mechanical
  - Wrenching test updated to allow testing a plug before overmold is applied so cable makers can buy certified connectors prior to assembling the cable
  - Added a new staggered pin dimension for non-conductive receptacle shell implementations
  - Redefined the current rating test specifically for USB Type-C connectors
    - Provides a worst case measurement so that most implementations will provide less temperature rise than seen during the product certification process
  - 4-axis continuity test updated to provide a consistent force at the connector interface rather than variations as a function of the strain relief size
  - Clarified legacy cable adapter resistor requirements

Legacy Cable Assemblies and Adapters

- CC termination represents legacy port capabilities – not a cable rating

The most common cables:

Plug 1	Plug 2	USB Version	Current Rating	CC (A5) Termination	
A	C	USB 2.0	3 A	Rp (56 kΩ ± 5%)	New devices with legacy host
A	C	USB 3.1			
C	Micro-B	USB 2.0	3 A	Rd (5.1 kΩ ± 20%)	Legacy peripherals with new host
C	Micro-B	USB 3.1			

The only defined adapters:

Plug	Receptacle	USB Version	Current Rating	CC (A5) Termination	
C	Micro-B	USB 2.0	3 A	Rp (56 kΩ ± 5%)	Legacy Micro-B chargers with new devices
C	A	USB 3.1	3 A	Rd (5.1 kΩ ± 20%)	Legacy "thumb drives" with new hosts

USB Type-C Revision 1.2 – Latest ECNs

- Chapter 3 – Mechanical
  - USB 2.0-only receptacle defined
  - Over-mold length dimension reclassified as a reference dimension
  - Defined maximum DC Resistance for USB 2.0 D+/D–

USB Type-C Signal Summary

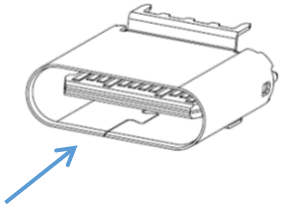
Signal Group	Signal	Description
USB 3.1	**SSTXp1, SSTXn1** **SSRXp1, SSRXn1** SSTXp2, SSTXn2 SSRXp2, SSRXn2	SuperSpeed USB serial data interface: one transmit diff pair and one receive diff pair Two pin sets to enable plug flipping
USB 2.0	**Dp1, Dn1** Dp2, Dn2	USB 2.0 serial data interface Two pin sets to enable plug flipping
Configuration	**CC1, CC2** (receptacle) **CC** (plug)	CC channel in the plug used for connection detect, interface configuration and VCONN
Auxiliary signals	**SBU1, SBU2**	Sideband Use
Power	**VBUS**	USB cable bus power
	VCONN (plug)	USB plug power
	GND	USB cable return current path

USB Type-C Configuration Channel (CC)

- ✓ Detect attach of USB ports
- ✓ Establish “source” and “sink” roles between two attached ports
  - *Initially synonymous with “host” and “device” roles*
- ✓ Discover and configure VBUS
- ✓ Discover and configure VCONN
- ✓ Resolve cable orientation and twist connections to establish USB data bus routing
- ✓ Discover and configure optional Alternate and Accessory modes

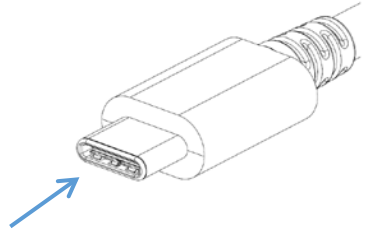
USB Type-C – Functional Model

- USB 3.1 data bus
  - Two sets of TX/RX pin pairs, only one set active during SuperSpeed USB operation
- USB 2.0 data bus
  - Two pin sets on host, one set on device – strapped together within the host and device
- Two power buses
  - VBUS and VCONN
- Two sideband pins (SBU1/SBU2)
- CC – Configuration Channel
  - Two CC pins in connector
  - One CC wire in cable



Looking into the product receptacle:

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
GND	TX1+	TX1−	VBUS	CC1	D+	D−	SBU1	VBUS	RX2−	RX2+	GND
GND	RX1+	RX1−	VBUS	SBU2	D−	D+	CC2	VBUS	TX2−	TX2+	GND
B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1

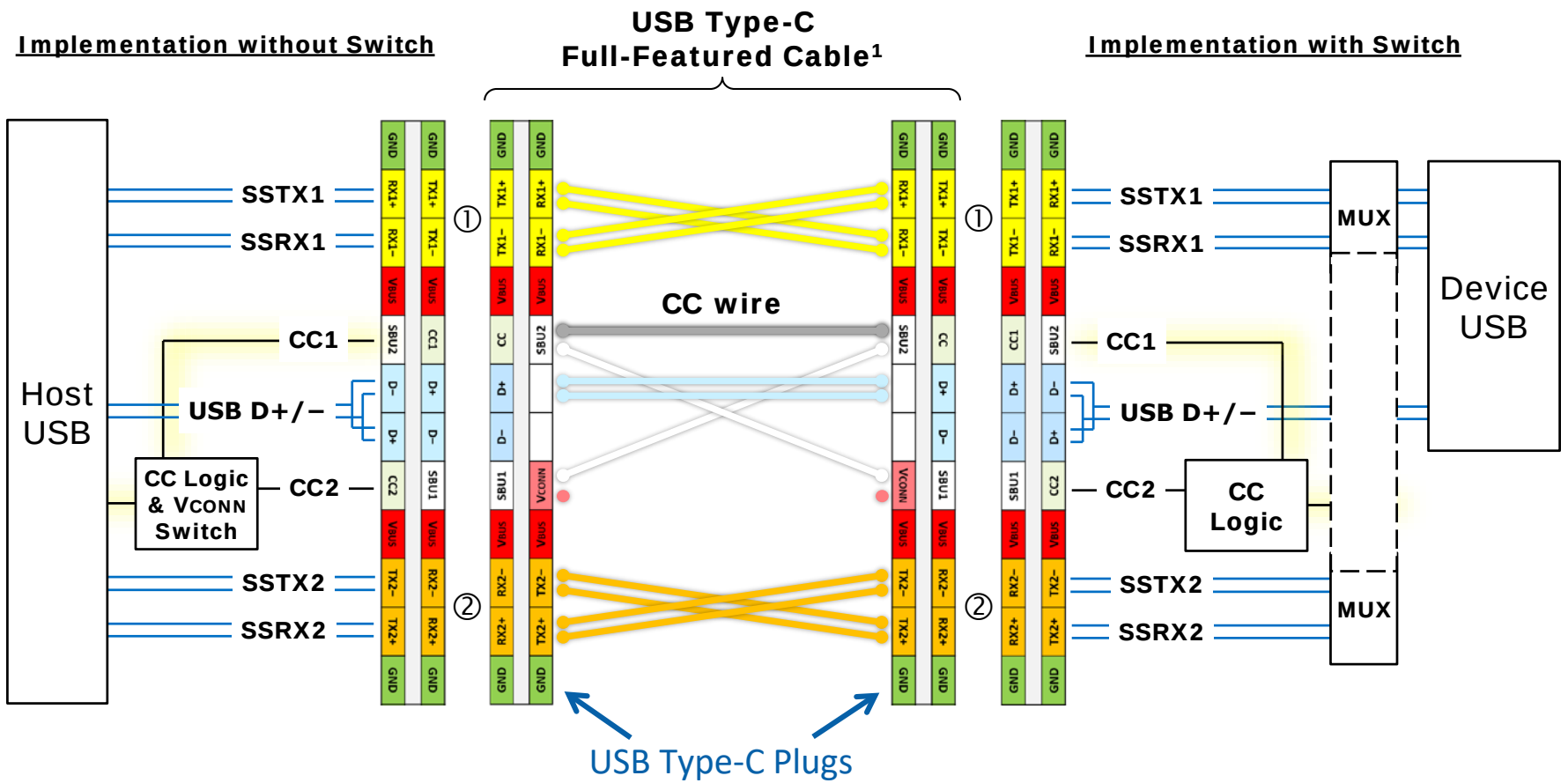


Looking into the cable or product plug:

A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1
GND	RX2+	RX2−	VBUS	SBU1	D−	D+	CC	VBUS	TX1−	TX1+	GND
GND	TX2+	TX2−	VBUS	VCONN			SBU2	VBUS	RX1−	RX1+	GND
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12

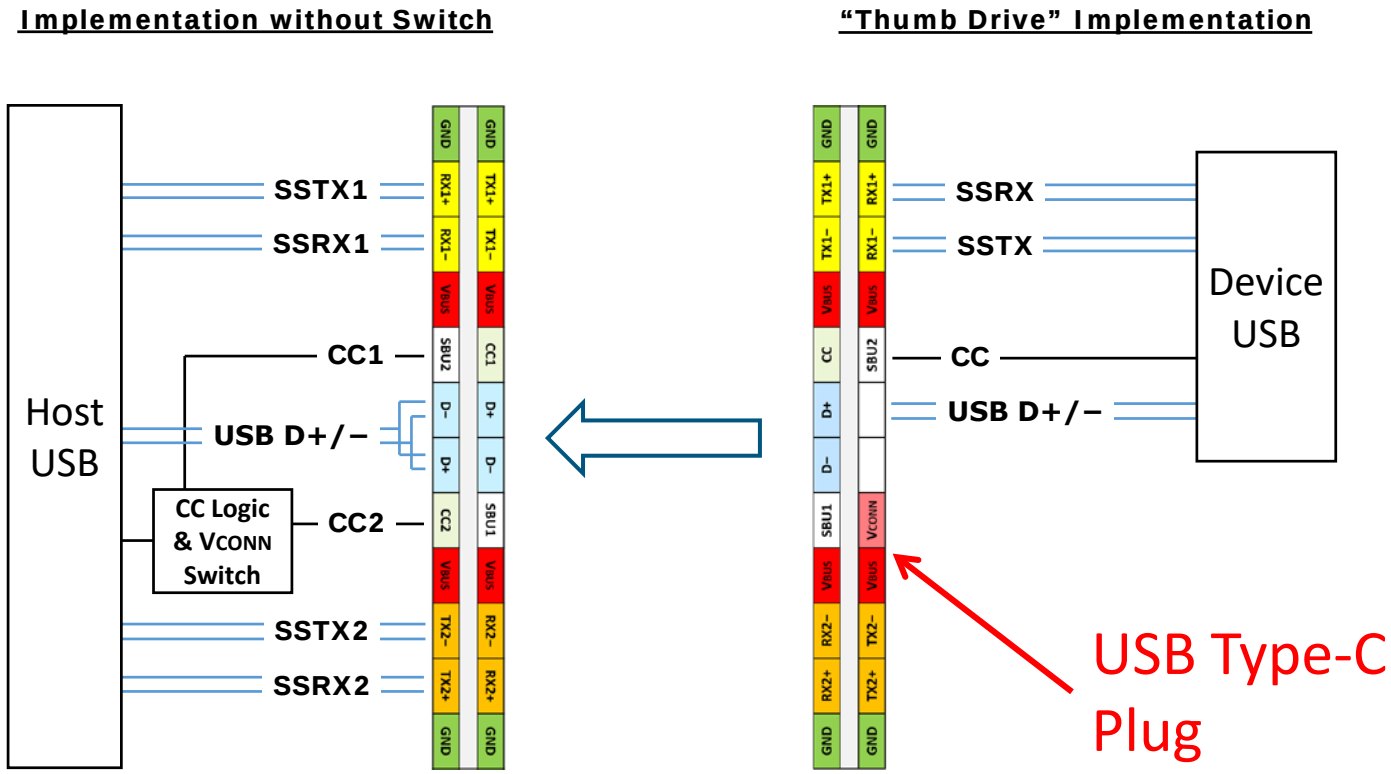
USB Type-C – Functional Model

- USB Type-C Full-Featured Cable supports all USB operating modes



Note: 1. Required VBUS and Ground wires not shown in this illustration

Direct Connect Functional Model

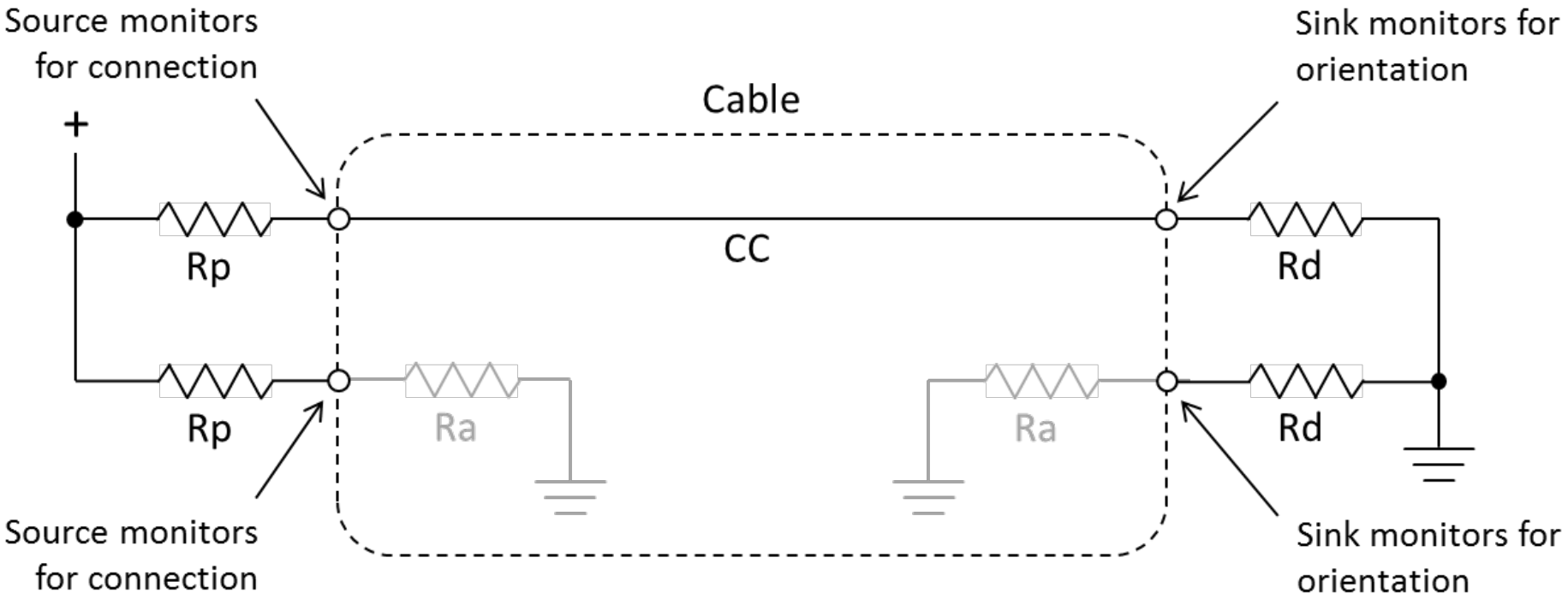


- Platform implementation impact varies based on capabilities chosen and level of integration

Understanding USB Type-C port behaviors

- Power roles:
  - Source – typical of Standard-A host or hub ports
  - Sink – typical of Standard-B or Micro-B device ports
  - Dual-Role Power – can be either a Source or a Sink
- Data roles:
  - DFP-mode only – typical of Standard-A host or hub ports
  - UFP-mode only – typical of Standard-B or Micro-B device ports
  - Dual-Role Data – typical of “on-the-go” ports
- Roles can be dynamically swapped using USB PD
  - Power role swap, data role swap

USB Type-C – Pull-Up/Pull-Down CC Model



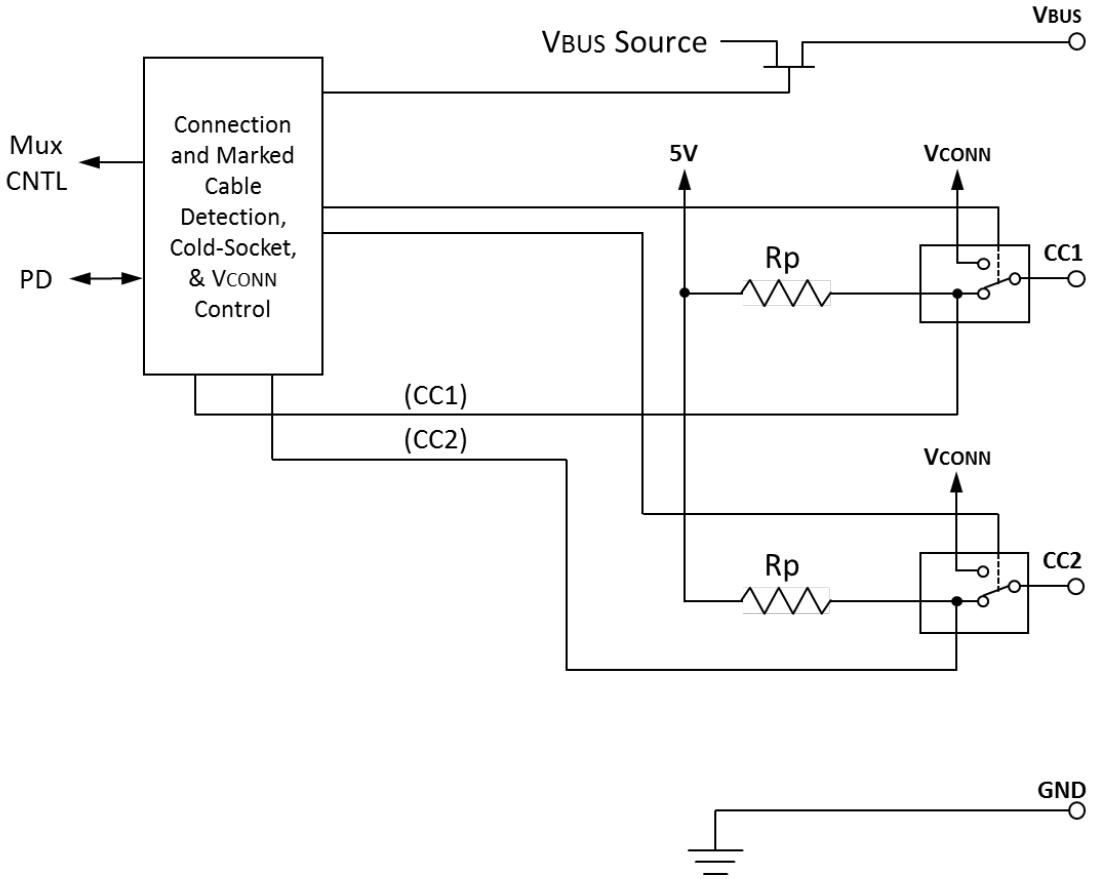
- Host side can substitute current sources for Rp
- Powered cables and accessories introduce Ra at the “unwired” CC pins which are used to indicate the need for V_{CONN}

USB Type-C – Source (Host) Detected Connection States

	CC1	CC2	State	Position	
No device attached	Open	Open	Nothing attached	N/A	
Device attached	Rd	Open	Sink attached	①	Most common states
	Open	Rd		②	
	Open	Ra	Powered cable without Sink attached	①	
	Ra	Open		②	
	Rd	Ra	Powered cable with Sink or VCONN-powered Accessory attached	①	← Not flipped
	Ra	Rd		②	← Flipped
	Rd	Rd	Debug Accessory Mode attached (Appendix B)	N/A	
	Ra	Ra	Audio Adapter Accessory Mode attached (Appendix A)	N/A	

The CC pins *magic decoder ring* from the Source perspective

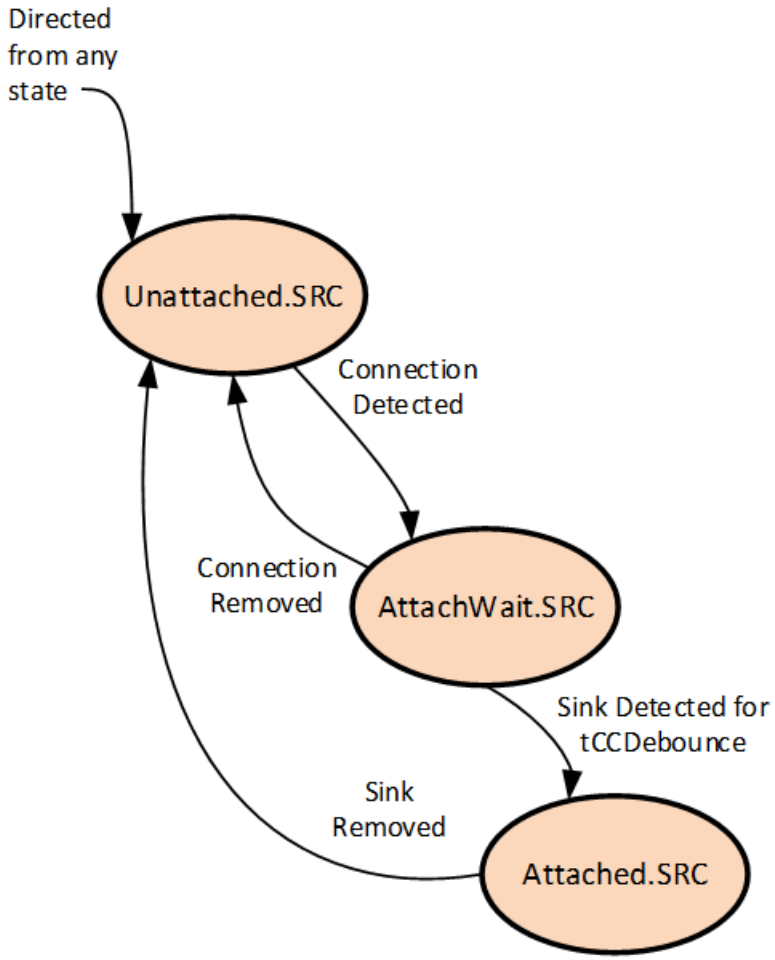
Source-Only Functional Model for CC1/CC2



- Defaults to being a power Source and USB Host
  - No support for USB PD power or data role swaps
- Rp used to sense Sink attach and advertise USB Type-C Current

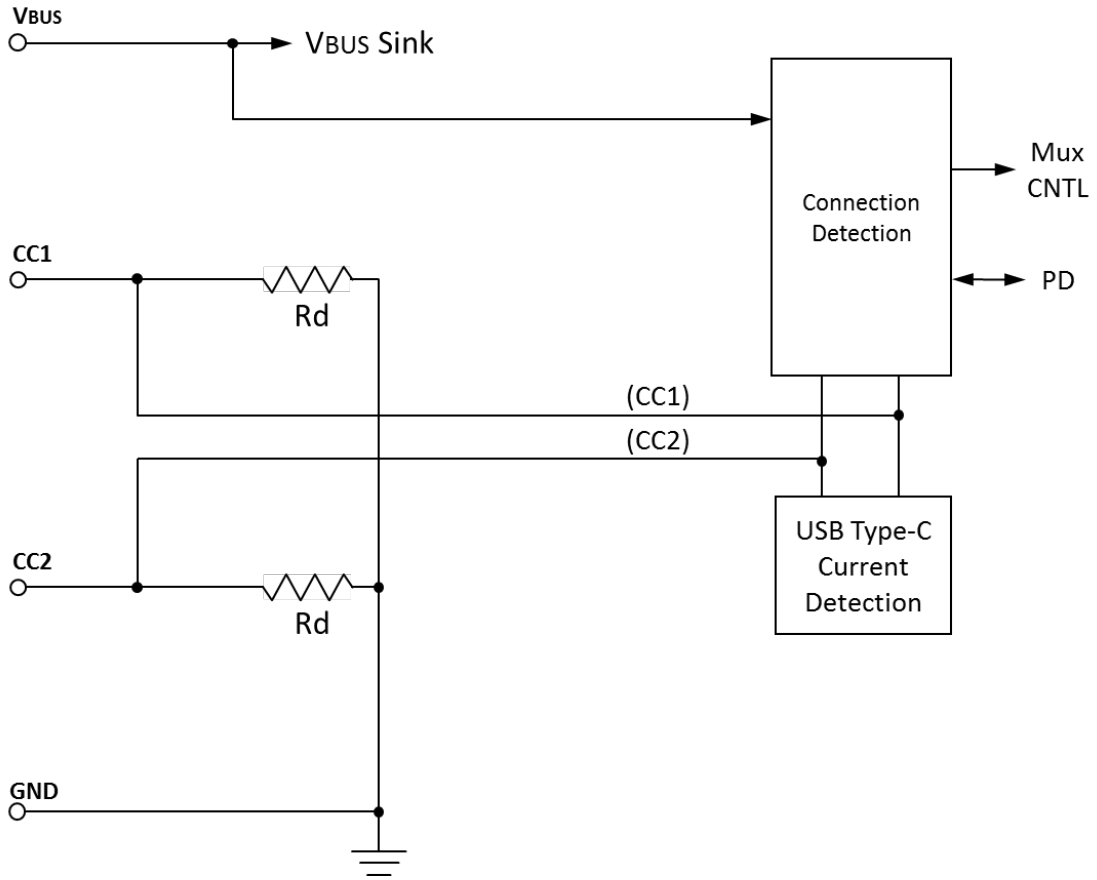
Source-Only Connection State Diagram

- Mandatory states:
  - Unattached.SRC
  - AttachWait.SRC
  - Attached.SRC
- Optional states (not shown):
  - Disabled
  - ErrorRecovery
  - Accessory states
  - Debug states



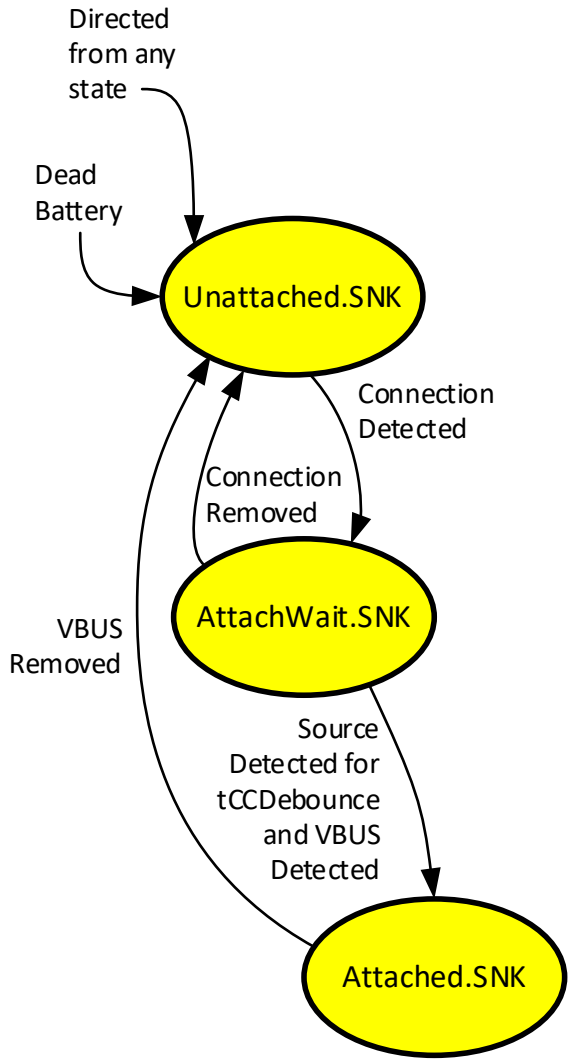
Sink-Only Functional Model for CC1/CC2

- Defaults to being a power Sink and USB Device
  - No support for USB PD power or data role swaps
- Rd allows Source to sense Sink attach and advertise USB Type-C Current

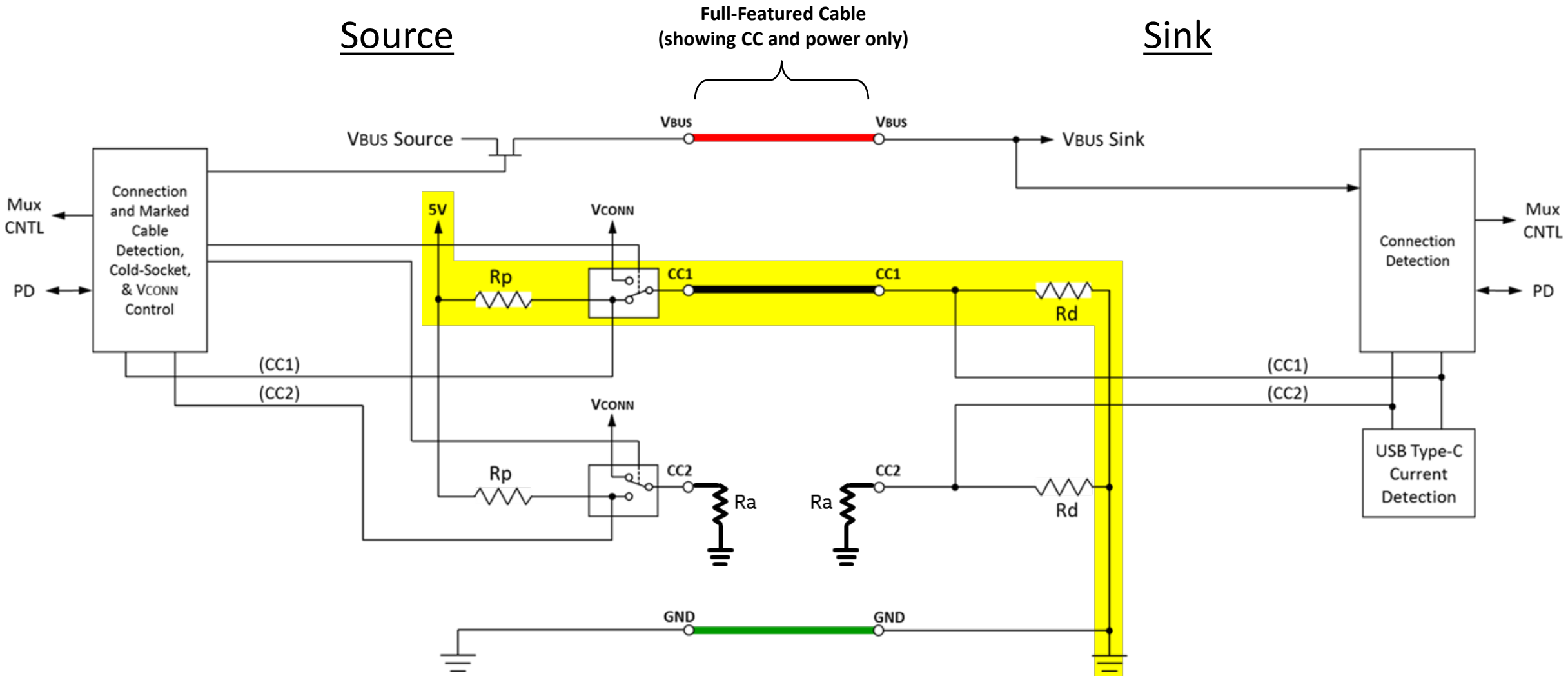


Sink-Only Connection State Diagram

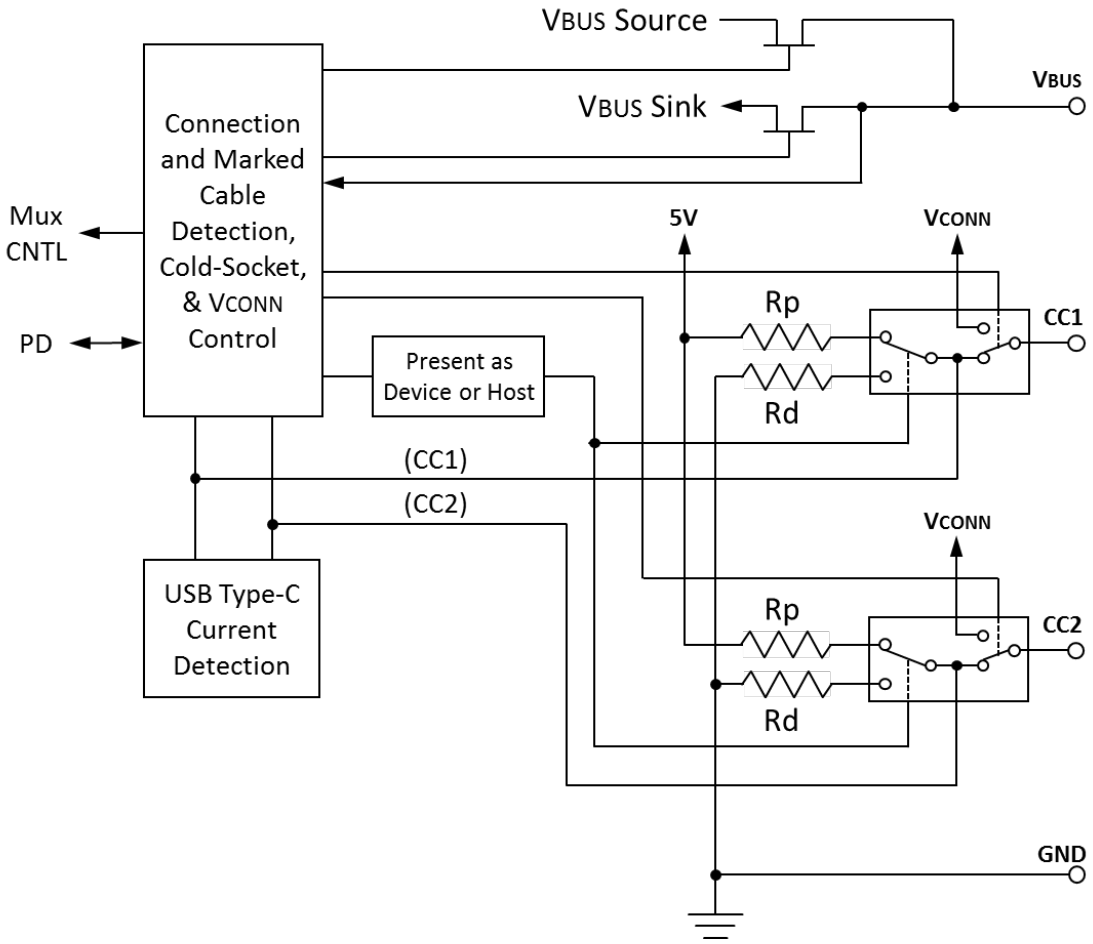
- Mandatory states:
  - Unattached.SNK
  - AttachWait.SNK
  - Attached.SNK
- Optional states (not shown):
  - Disabled
  - ErrorRecovery
  - Accessory states
  - Debug states



Source-Only Meets Sink-Only



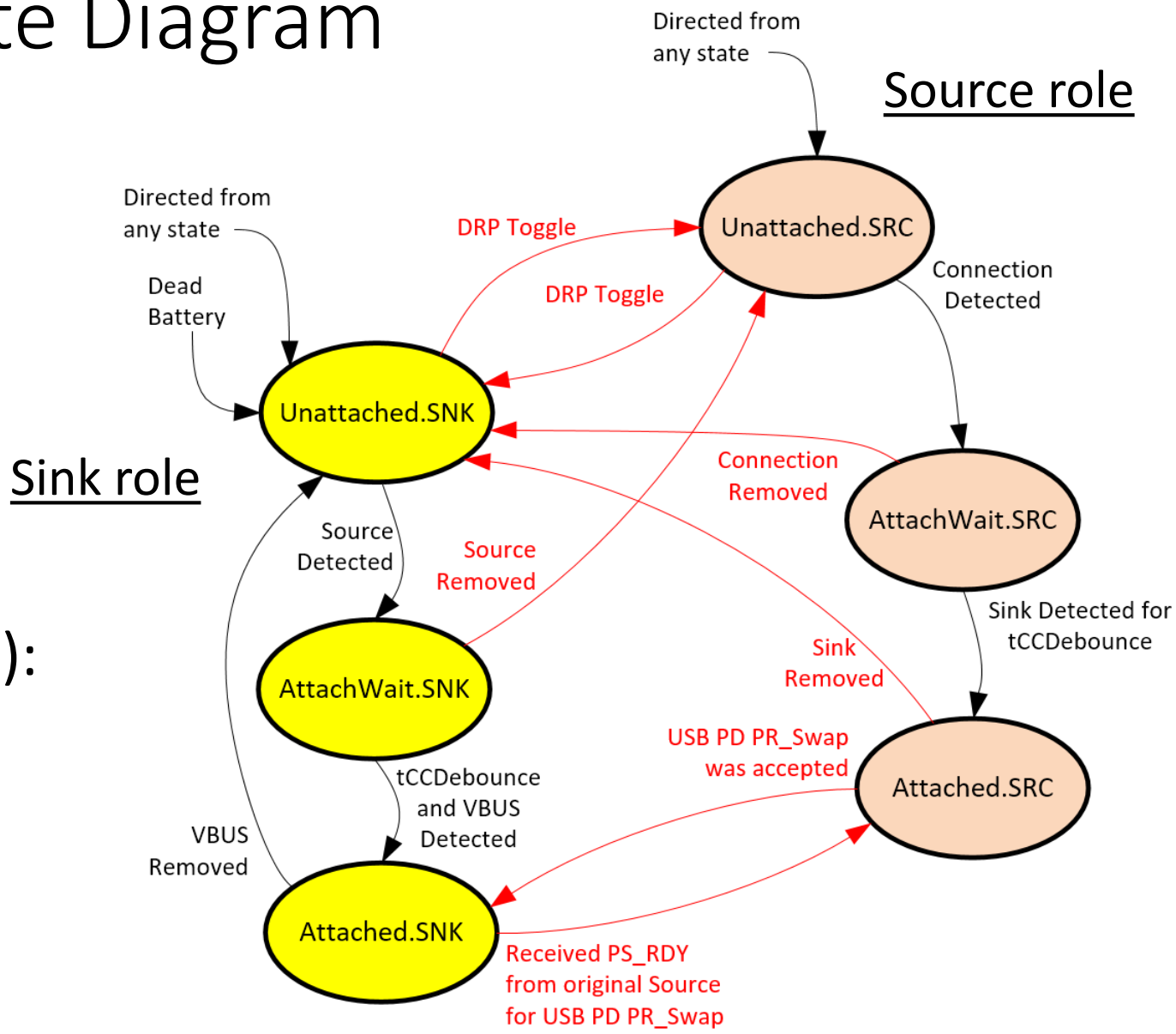
DRP Functional Model for CC1/CC2



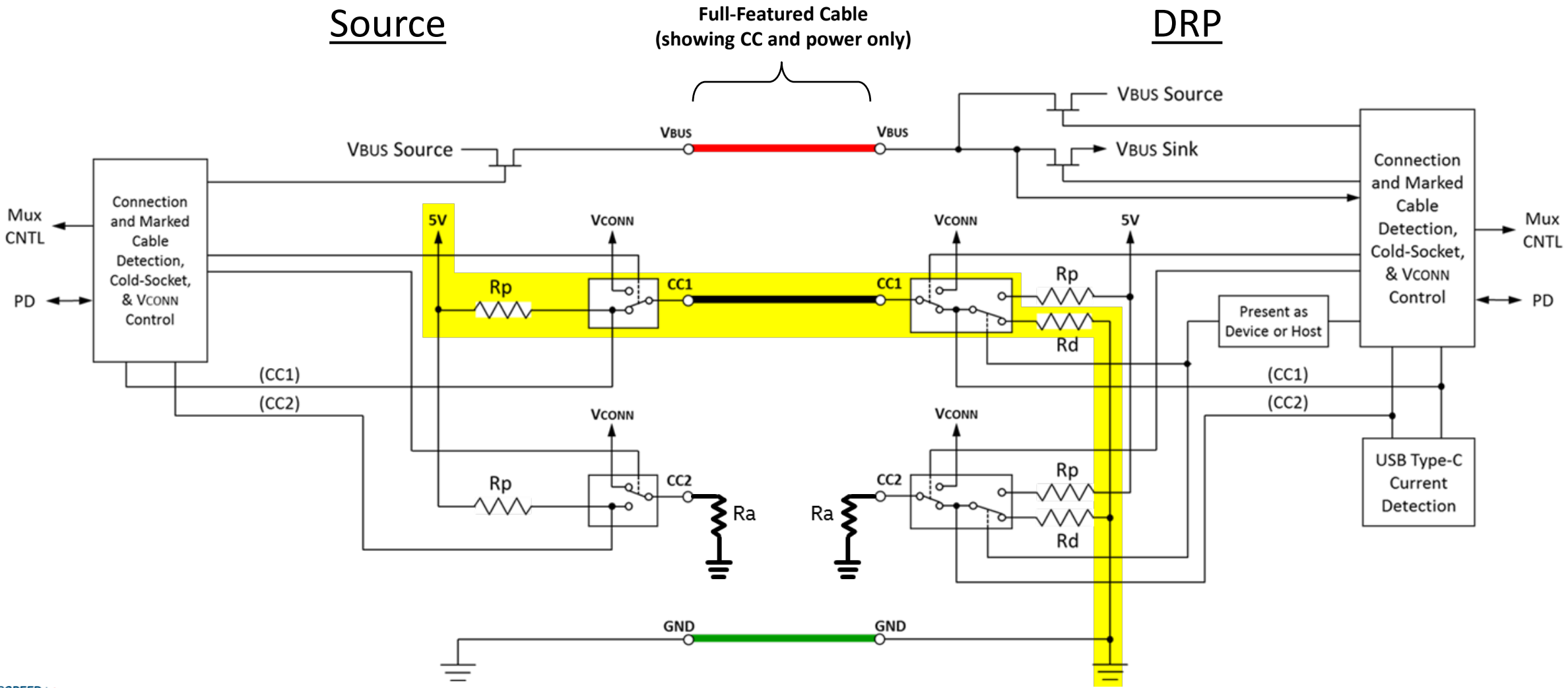
- DRP = Source + Sink
  - Aligns to correct role based on whatever gets attached
- For discovery, toggles between presenting as a Source or Sink
  - Cycles 10 – 20 times per second

DRP Connection State Diagram

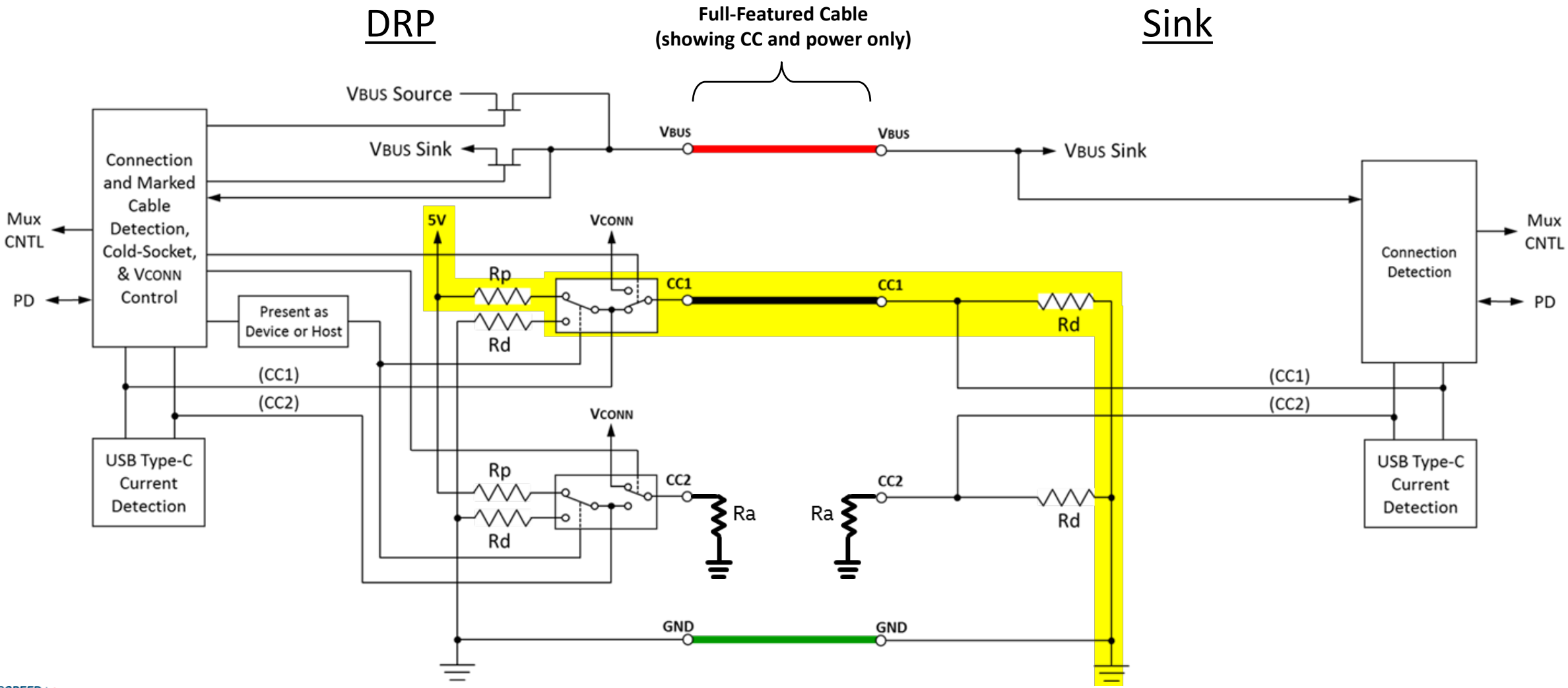
- Mandatory states:
  - Unattached.SNK
  - AttachWait.SNK
  - Attached.SNK
  - Unattached.SRC
  - AttachWait.SRC
  - Attached.SRC
- Optional states (not shown):
  - Disabled
  - ErrorRecovery
  - Accessory States
  - Try States



Source-Only meets DRP → DRP resolves to Sink

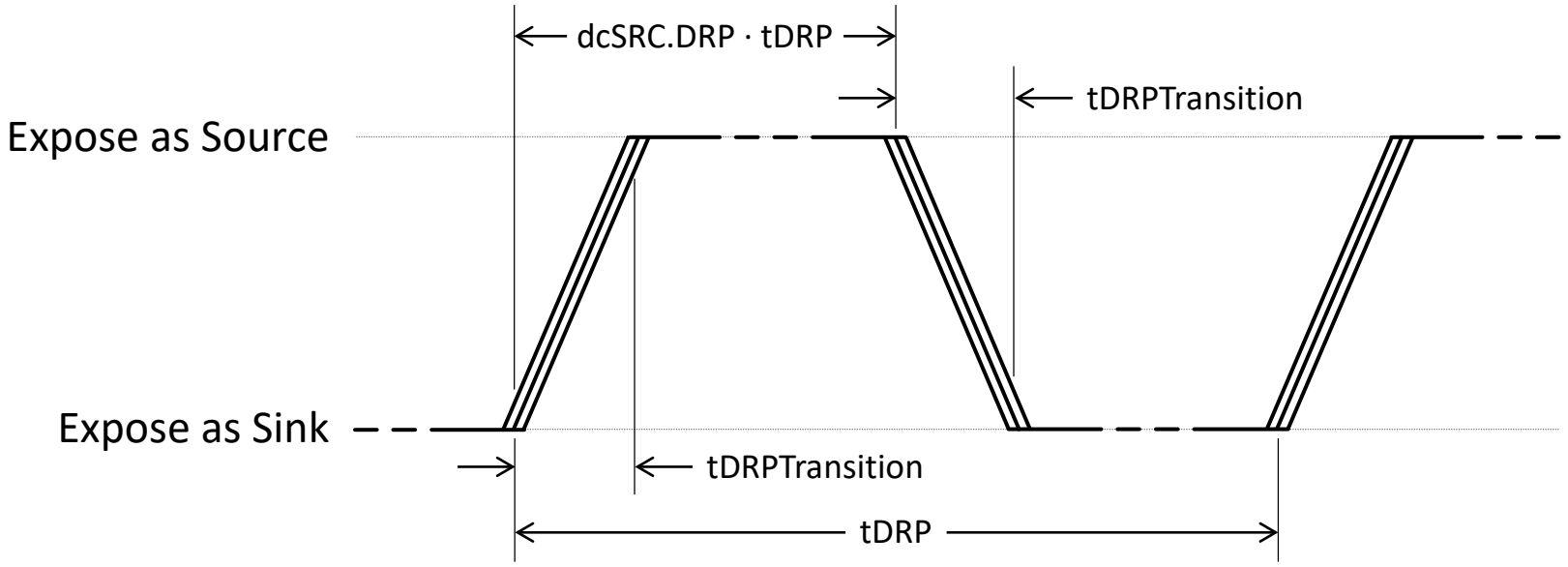


DRP meets Sink-Only → DRP resolves to Source

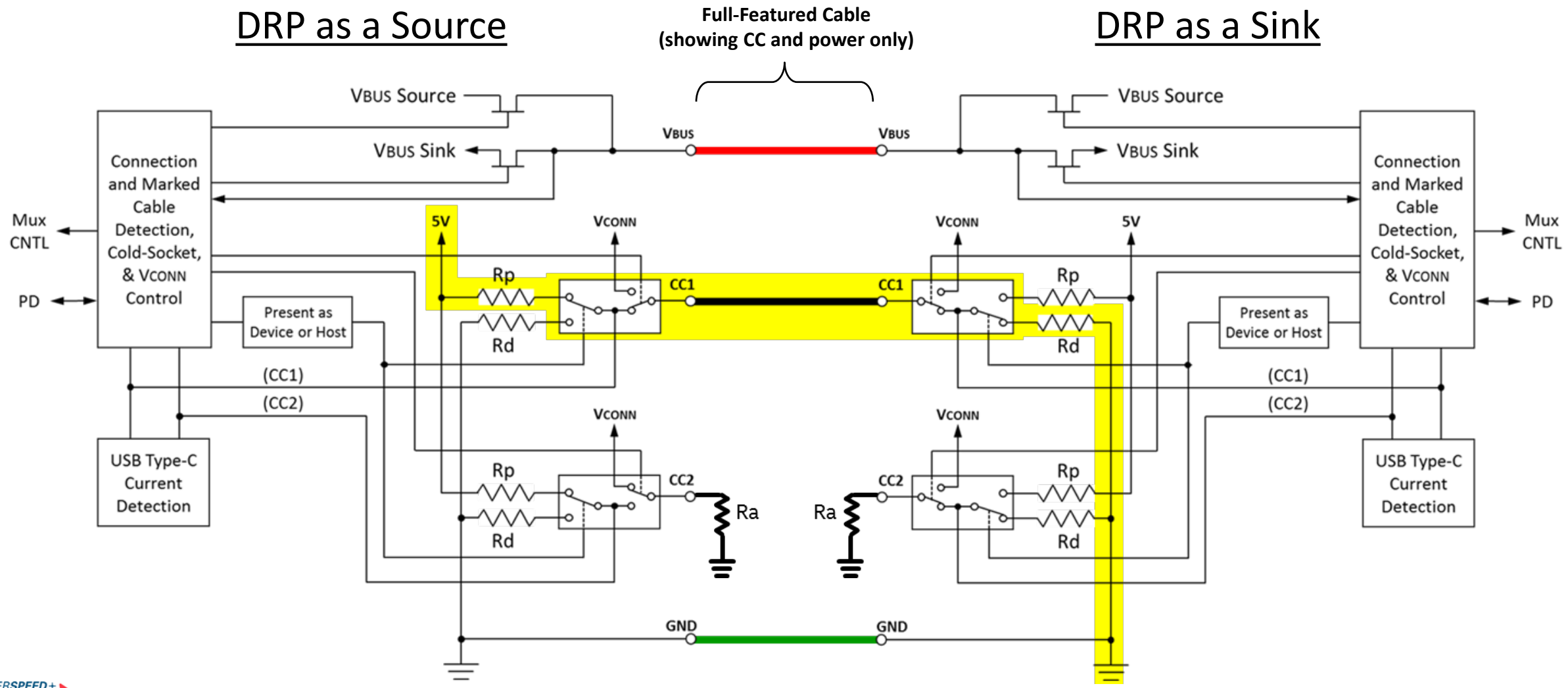


DRP meets DRP

- *Interesting situation* ☺
- The final result depends on multiple factors:
  - Randomness within the toggle protocol
  - Product configuration
  - User preferences



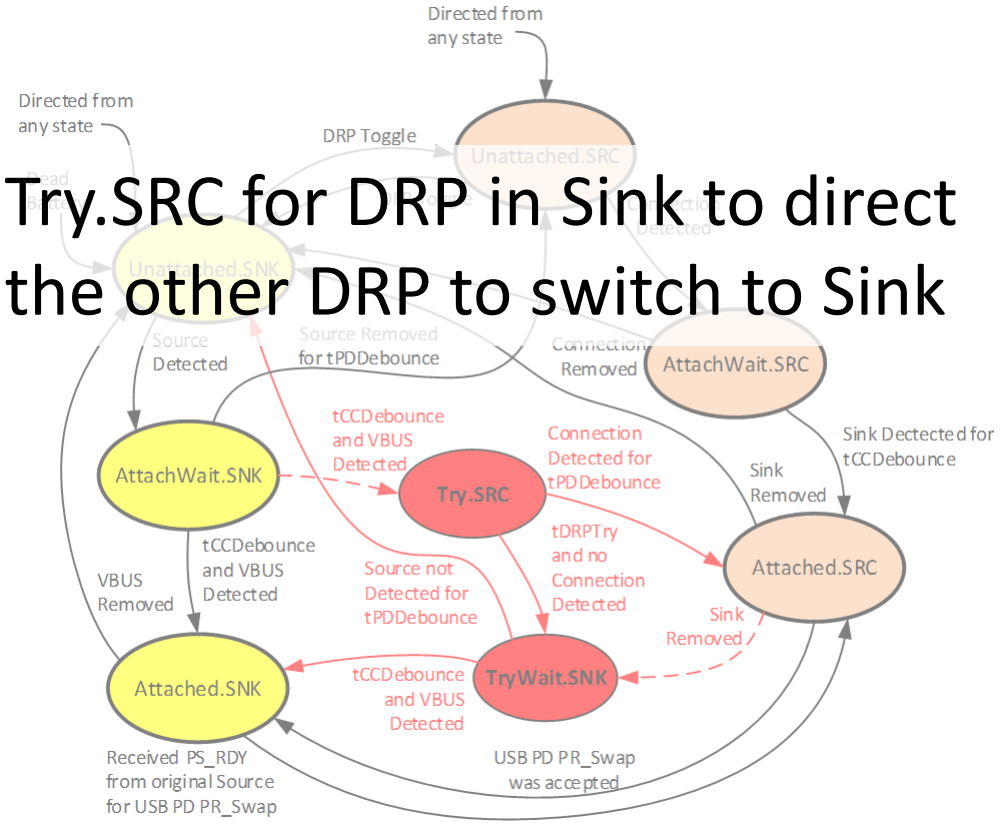
DRP meets DRP → DRPs resolving to opposites



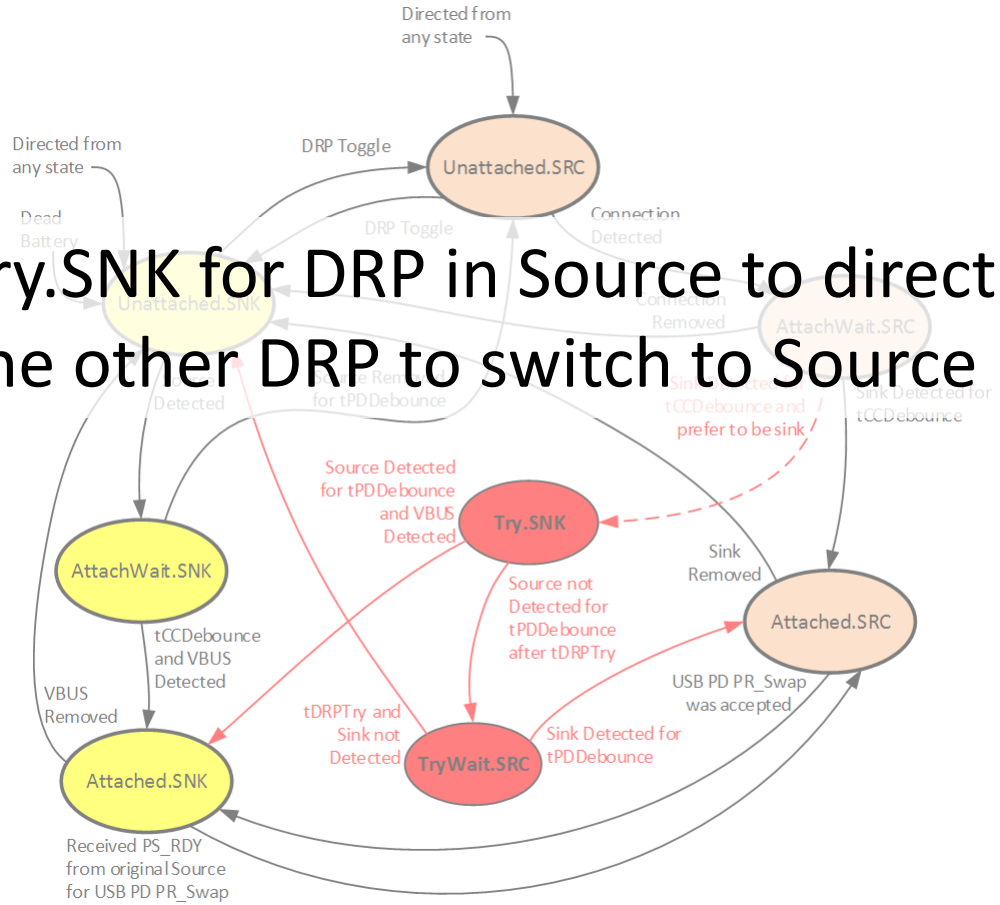
But what if DRP #2 would prefer being a Source?

- Upon initial connection, DRPs have one time *option* to forces a role swap via the state machine

Try.SRC for DRP in Sink to direct the other DRP to switch to Sink



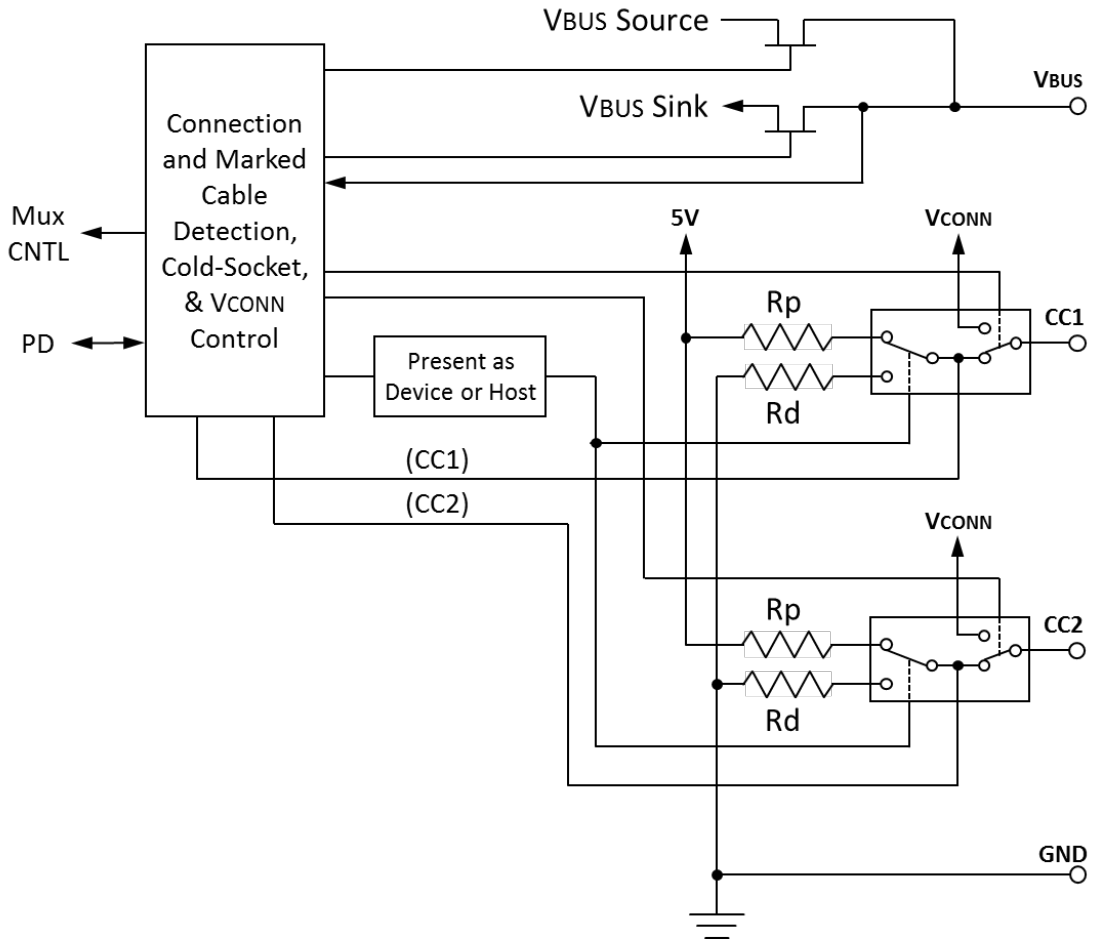
Try.SNK for DRP in Source to direct the other DRP to switch to Source



USB Type-C Swaps

- Initial USB Type-C connect
  - Rp → VBUS and VCONN Source and Downstream Facing Port (USB Host)
  - Rd → VBUS Sink and Upstream Facing Port (USB Device)
- Try.SRC and Try.SNK role swaps
  - Available even when USB PD is not present
  - Enable simple devices to exchange Rp and Rd at connect only
- USB PD enabled role swaps
  - Power Role Swap
  - Data Role Swap
  - VCONN Source Swap

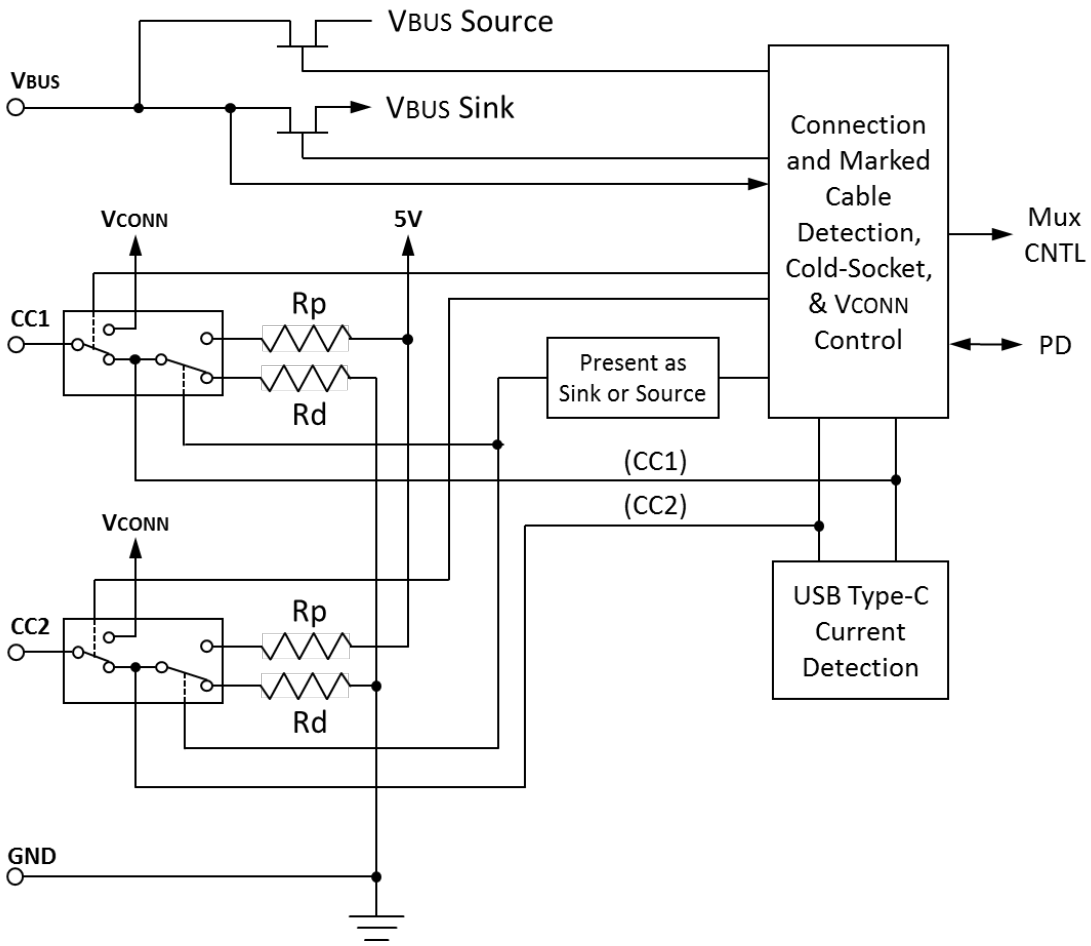
USB Host Supporting USB PD Source/Sink



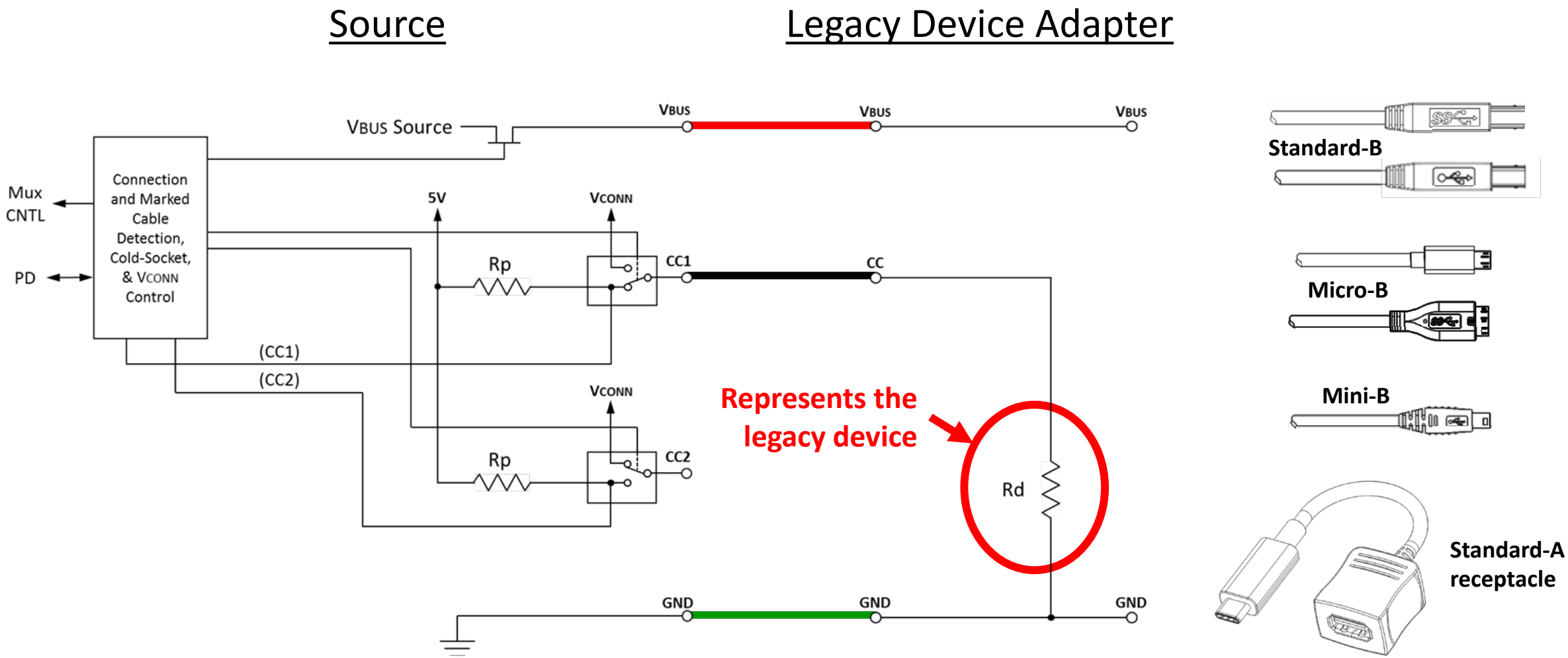
- Supports USB PD data and power role swaps
- Normally Rp is presented
  - If the USB Host requires power to operate (e.g. dead battery case), present Rd and subsequently use USB PD to swap data roles

USB Device Supporting USB PD Sink/Source

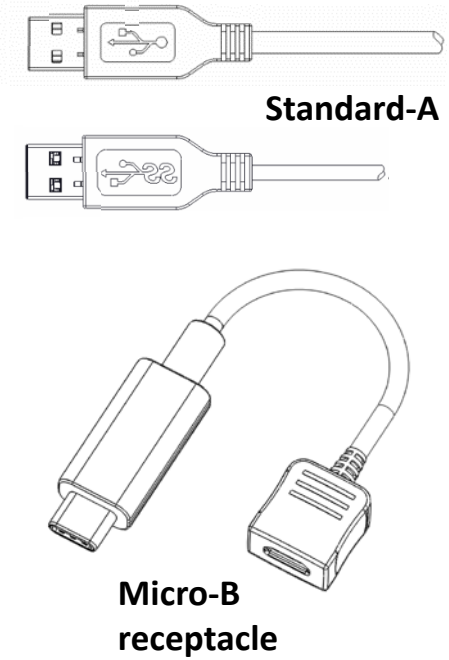
- Supports USB PD data and power role swaps
- Normally Rd is presented
  - If the USB Device is able to charge a Host with dead battery, it periodically presents Rp



Adapting for Legacy Devices

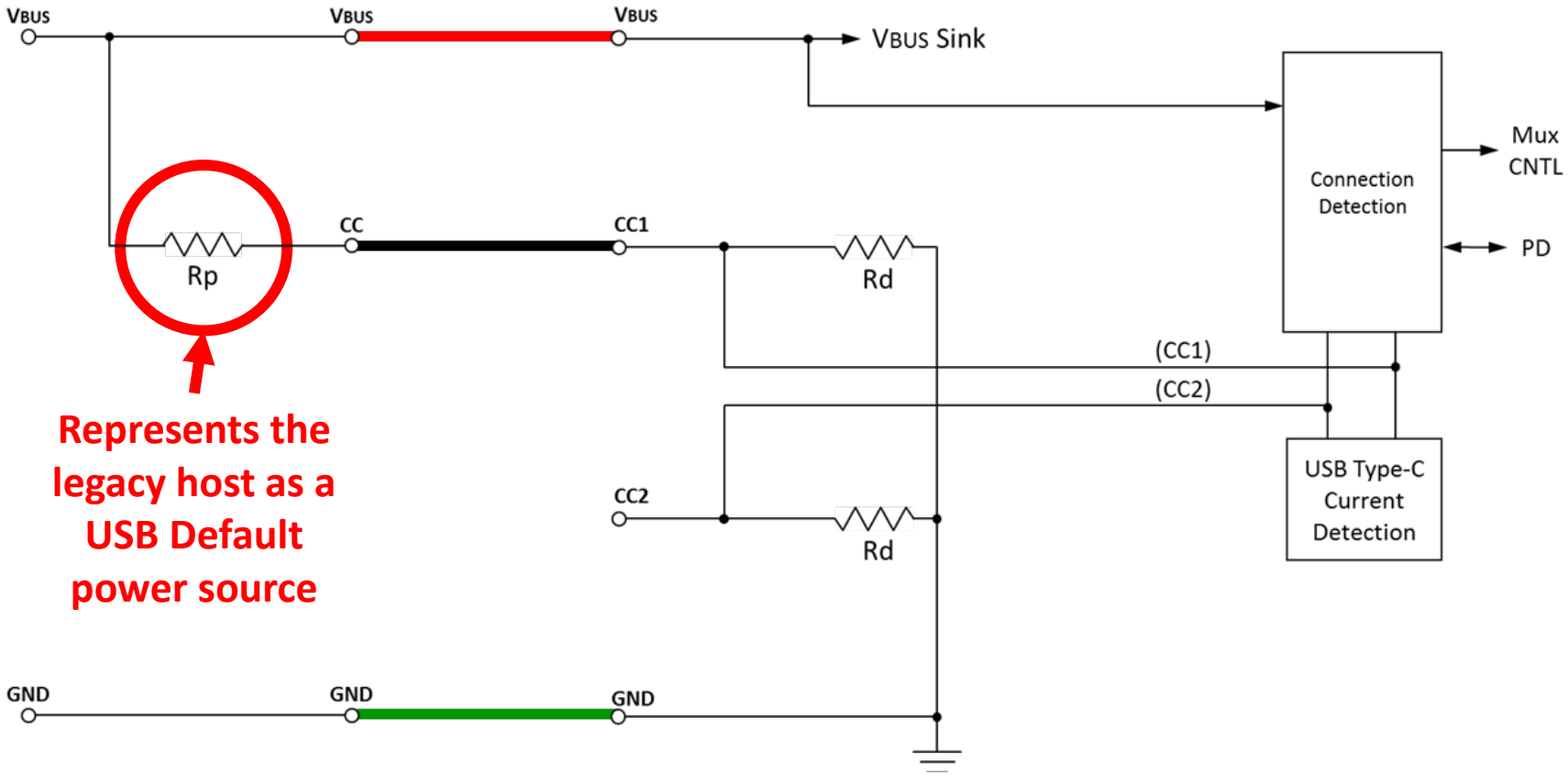


Adapting for Legacy Hosts/Chargers



Legacy Host Adapter

Sink



Represents the legacy host as a USB Default power source

USB Type-C Power

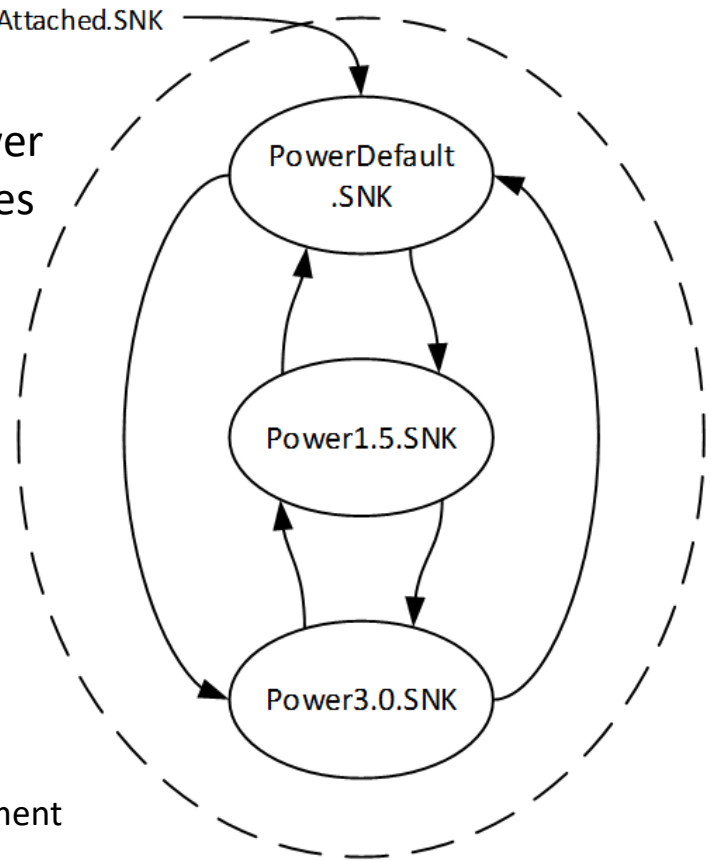
- All solutions required to support Default USB Power appropriate to product – as defined by USB 2.0 and USB 3.1

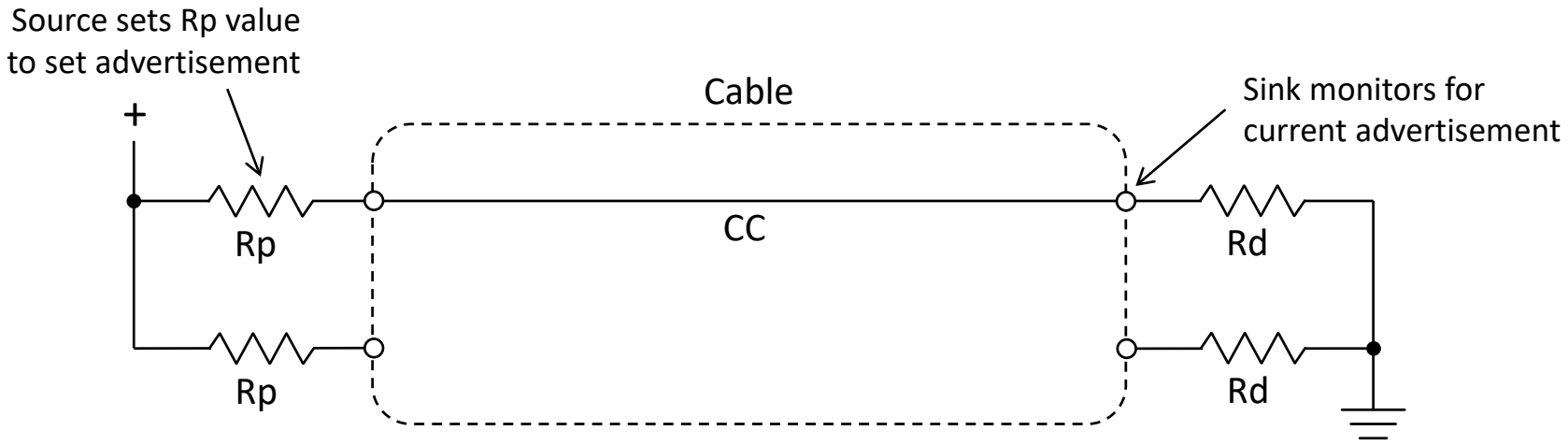
Precedence	Mode of Operation		Nominal Voltage	Maximum Current
Highest	USB PD		Configurable	5 A
	USB Type-C Current @ 3.0 A		5 V	3.0 A
↓	USB Type-C Current @ 1.5 A		5 V	1.5 A
	USB BC 1.2		5 V	Up to 1.5 A
	Default USB Power	USB 3.1	5 V	900 mA
Lowest		USB 2.0	5 V	500 mA

- USB Type-C Current @ 1.5 A and 3.0 A – preferred alternative to using BC 1.2 for mobile devices

USB Type-C Current

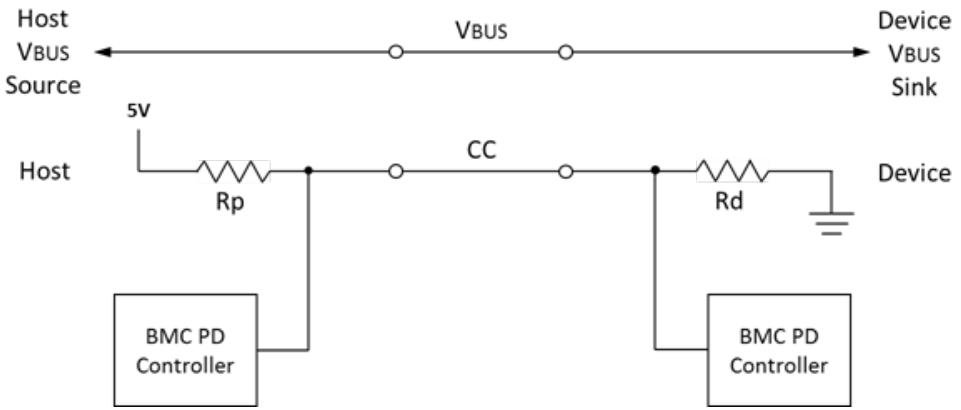
- Source advertises level of USB Type-C Current available
  - Sink may optionally draw higher current at 5V when available and shall return to lower draw levels when Source advertises less

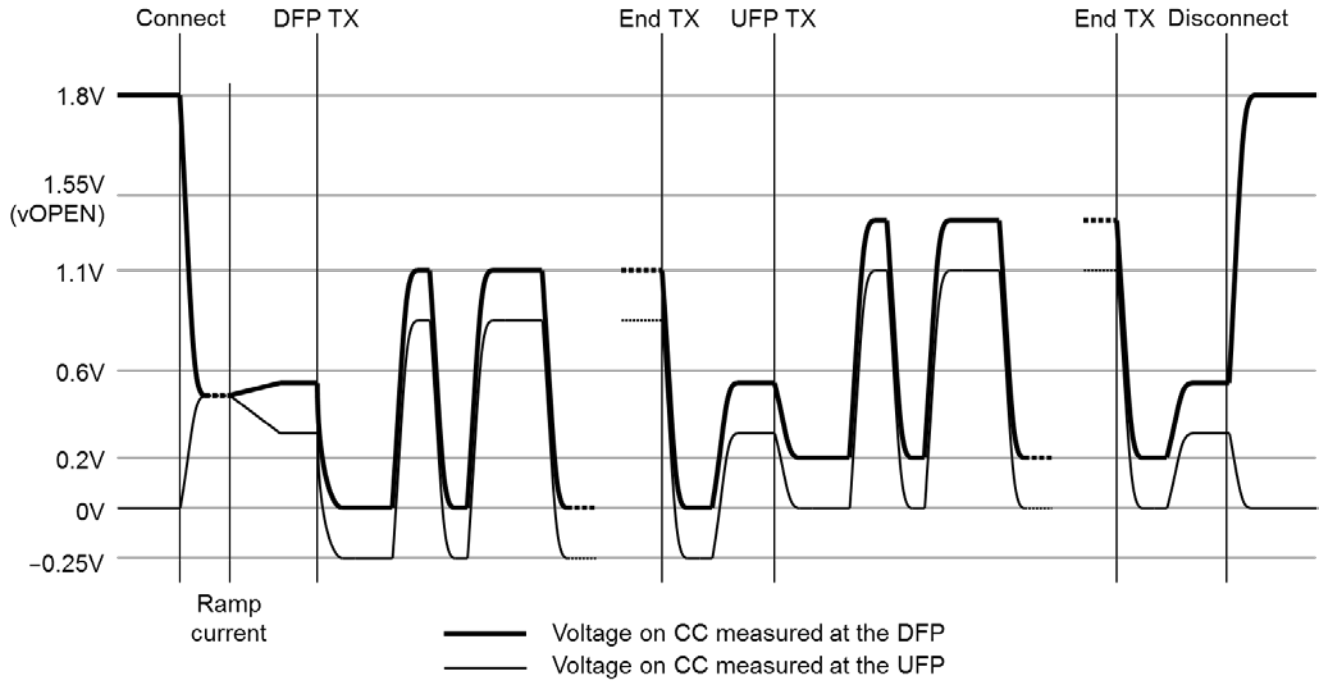




USB Power Delivery (PD) on USB Type-C

- USB PD 2.0 specifies DC-coupled Biphase Mark Coding (BMC) signal encoding for use over CC





Rp, Rd and Ra Termination Requirements

- Value and interpretations ranges were impacted by USB Type-C Current and USB PD operating over CC

Source CC Termination (Rp) Requirements:

Source Advertisement	Current Source to 1.7 – 5.5 V	Resistor pull-up to 4.75 – 5.5 V	Resistor pull-up to 3.3 V ± 5%	
Default USB Power	80 µA ± 20%	56 kΩ ± 20%	36 kΩ ± 20%	Rp-USB
1.5 A @ 5 V	180 µA ± 8%	22 kΩ ± 5%	12 kΩ ± 5%	Rp-1.5
3.0 A @ 5 V	330 µA ± 8%	10 kΩ ± 5%	4.7 kΩ ± 5%	Rp-3.0

Sink CC Termination (Rd) Requirements:

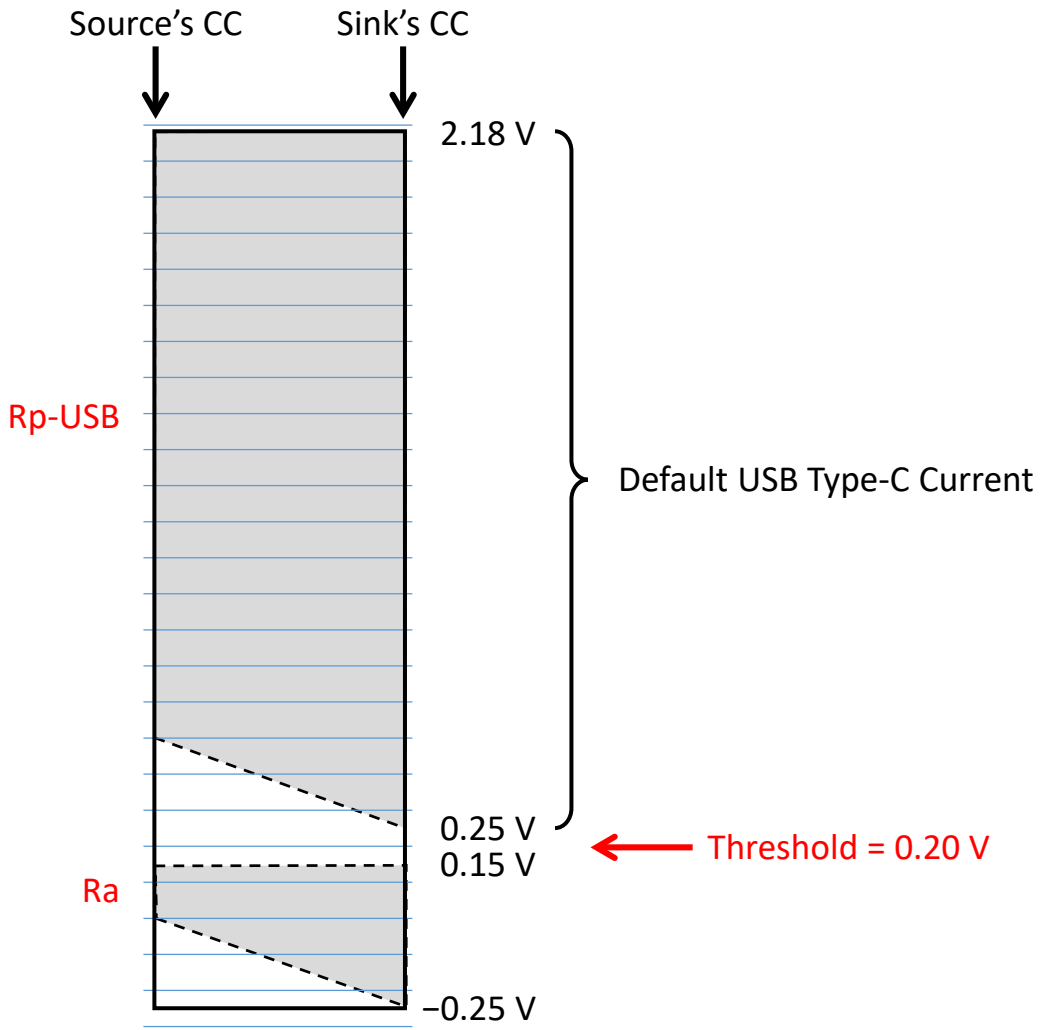
Rd Implementation	Nominal value	Can detect power capability?	Max voltage on pin
± 20% voltage clamp[1]	1.1 V	No	1.32 V
± 20% resistor to GND	5.1 kΩ	No	2.18 V
± 10% resistor to GND	5.1 kΩ	Yes	2.04 V

Powered Cable Termination (Ra) Requirements:

	Minimum Impedance	Maximum Impedance
Ra	800 Ω[1]	1.2 kΩ

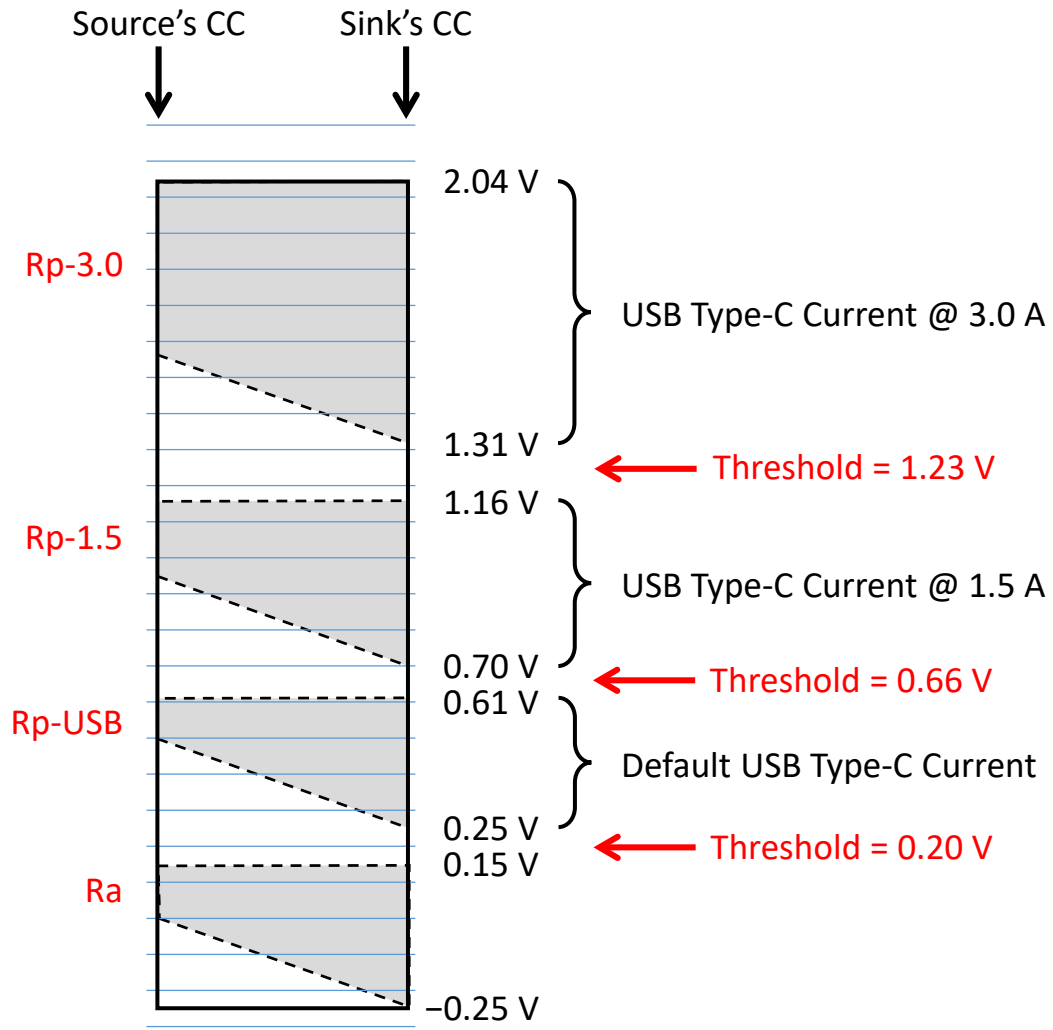
Sink Interpretation of CC Voltages

- For a traditional Sink (Default USB Type-C Current only):
  - A single connect threshold differentiates the CC to the Source from a powered cable termination
- Due to potential for up to 250 mV DC loss in the cable ground, CC voltage may drop to −0.25 V



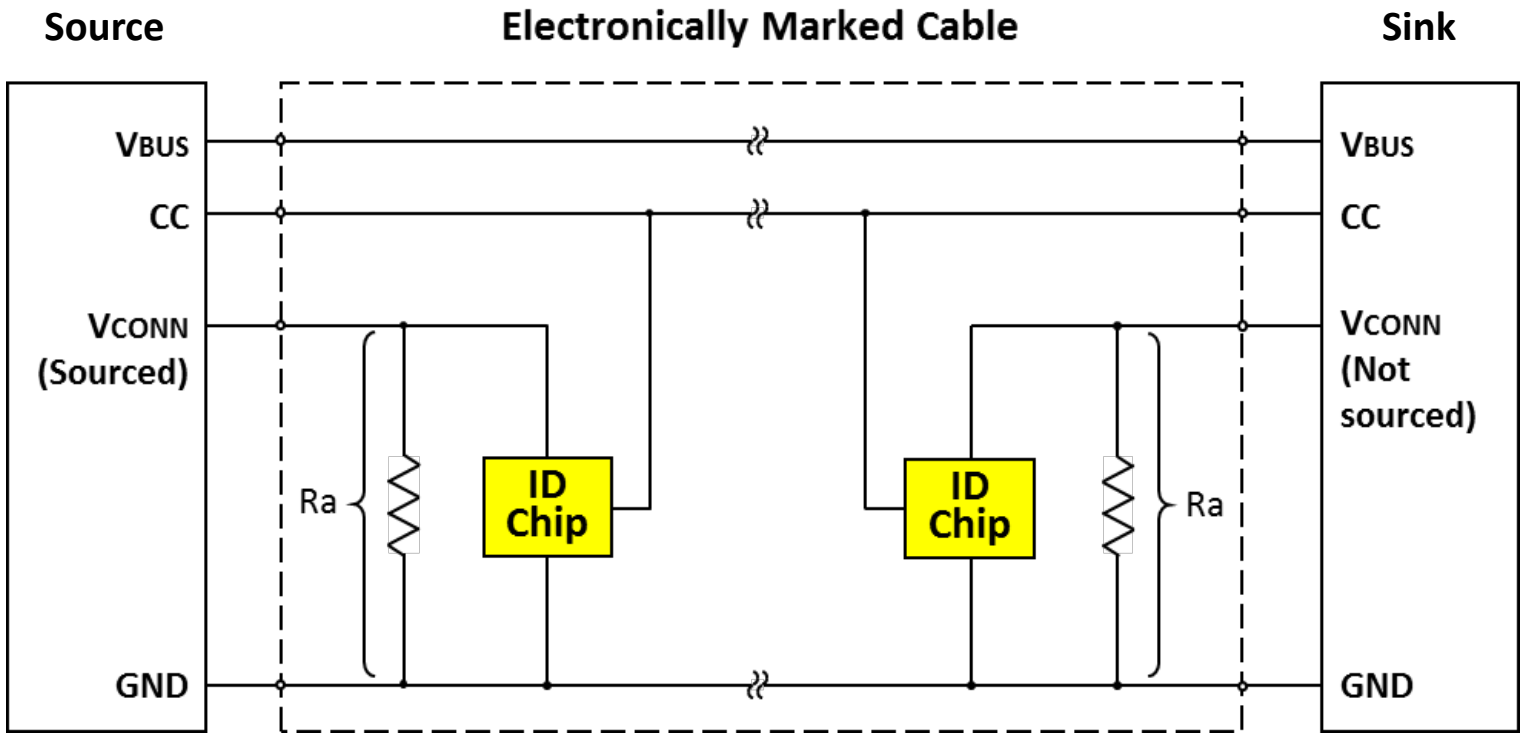
Sink Interpretation of CC Voltages

- For a Sink that supports multiple USB Type-C Current ranges:
  - A single connect threshold differentiates the CC to the Source from a powered cable termination
  - Additional connect thresholds differentiate current levels



Electronically Marked Cables

- All USB 3.1 Type-C cables require electronic marking
  - Also required for USB 2.0 Type-C cables with a current rating over 3 A



- Electronic marking mechanism defined in USB PD 2.0
- Electronically marked cable limited to drawing 70 mW from VCONN

Active Cables

- An active cable is defined as an electronically marked cable with *data bus signal conditioning circuits – Typically used for implementing longer cables*
- Communicating with managed active cables defined in USB PD 2.0
- Limited to drawing 1 W from V_{CONN}

Attend Tuesday afternoon session on
USB 3.1 System Design to learn more about Re-timers

USB Type-C Revision 1.2 – Notable Updates

- Chapter 4 – Functional
  - Terminology clarifications to better align with USB Power Delivery
    - Replaced ‘DFP’ with ‘Source’ or ‘host’, as appropriate
    - Replaced ‘UFP’ with ‘Sink’ or ‘device’, as appropriate
  - Clarified V_{BUS} and V_{CONN} source requirements
  - Added Try.SNK – enable non-PD dual-role devices to prefer being sink/device
    - Also added clarification for power roles and swapping mechanisms
  - Clarified V_{BUS} voltage thresholds for Exiting from Attached.SNK
  - Updates to state machine behaviors to improve robustness
    - Added AttachWait States to provide settling time to assure connections
  - Updates to state machines to incorporate Debug Accessory Mode
  - Removed USB PD BFSK support from USB Type-C
  - Clarified cable power voltage drop as a function of load

USB Type-C Revision 1.2 – Latest ECNs

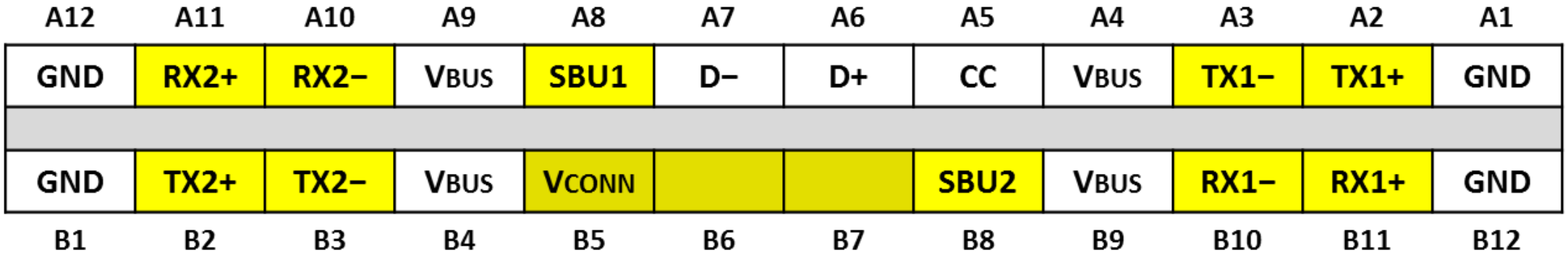
- Chapter 4 – Functional
  - Add new state to Source Connection State Diagram to cover VCONN discharge wait period
    - Also re-specified VCONN Source Bulk Capacitance to be similar to how VBUS is specified in USB base specifications
  - Revised VCONN requirements
    - VCONN Sources now range from 3.0 to 5.5 V
    - Some new requirements for Electronically Marked cables to align with new VCONN range and address Ra characteristics/behaviors
  - Fixed a potential Try.SRC infinite loop issue

USB Type-C Functional Extensions

Optional Feature

- Alternate Modes – *enabling OEM product differentiation*
  - Use of USB PD Structured Vendor Defined Messages (VDMs) to extend the functionality a device exposes
  - Only a subset of the pins can be re-purposed depending on product type

Looking into the cable or product plug:



All USB Type-C ports are required to function as compliant USB ports when not operating in a recognized Alternate Mode

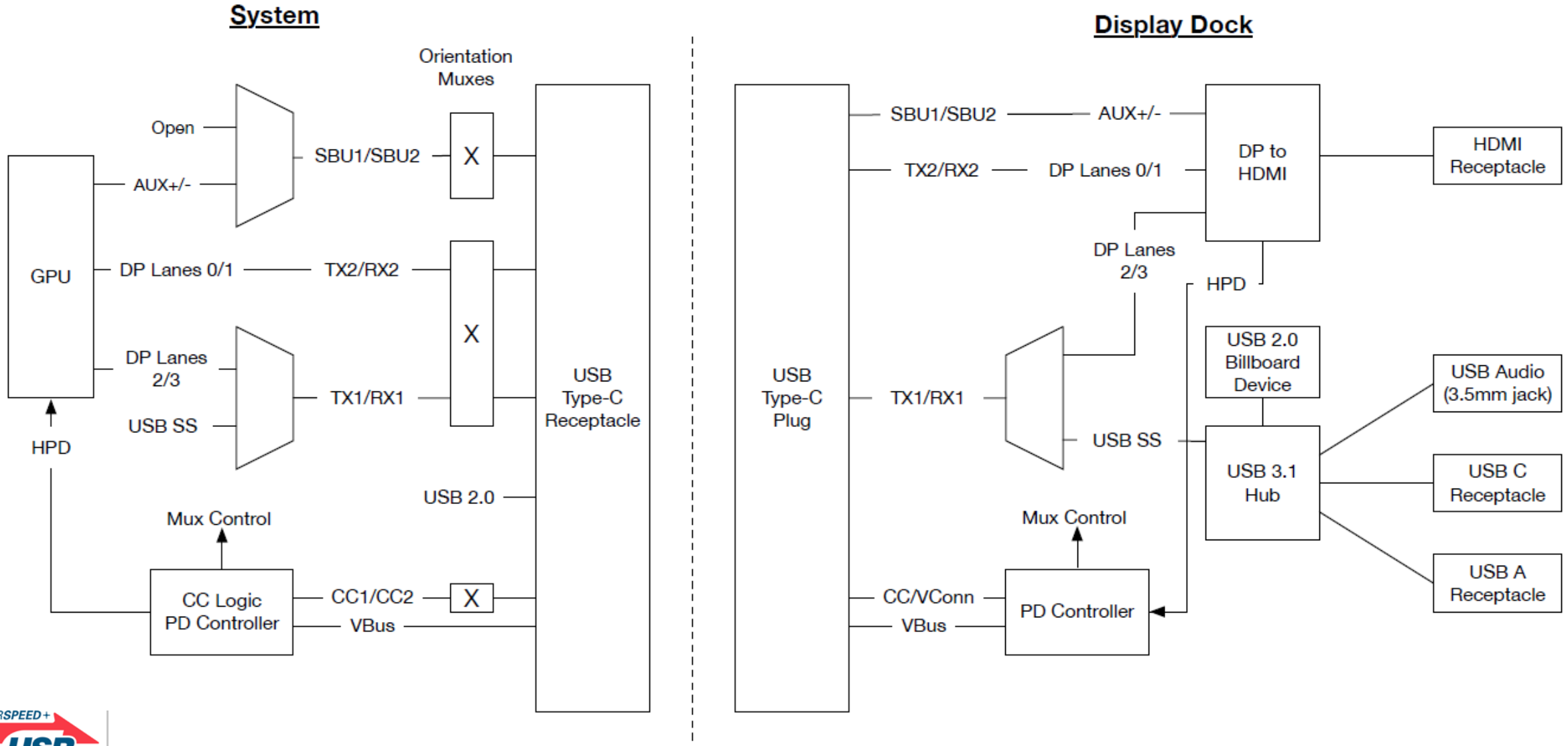
Vendor-Specific and Standard Alternate Modes

- Vendor-Specific Alternate Modes are specific to a Vendor ID (VID)
  - Intended for docking and other vendor proprietary designs
- Standard Alternate Modes are specific to a Standard ID (SID)
  - Intended for industry standards that have agreements to use USB Type-C
  - Three user-visible modes exist today:
    - DisplayPort Alt Mode on USB Type-C ← spec by VESA
    - MHL Alt Mode on USB Type-C ← spec by MHL Consortium
    - HDMI 1.4 Alt Mode on USB Type-C ← spec by HDMI Founders

Look for presentations regarding these on tomorrow's agenda

- USB Billboard Device Class
  - Used to identify incompatible connections made by users
  - This interface will appear on the device's USB 2.0 bus when Alternate Modes are unable to be negotiated between the host and device

Alternate Mode Example



USB Billboard Device

- New USB 2.0 device class
- Provides the OS with information to display to the user:
  - Details of the Alternate Modes supported
  - User readable strings with product description and sources of further information (URL)
- Alternate Mode device configuration failure is one potential use of the USB Billboard Device
  - Presented when failure does not fall back to an ‘equivalent USB function’

USB Type-C Revision 1.2 – Notable Updates

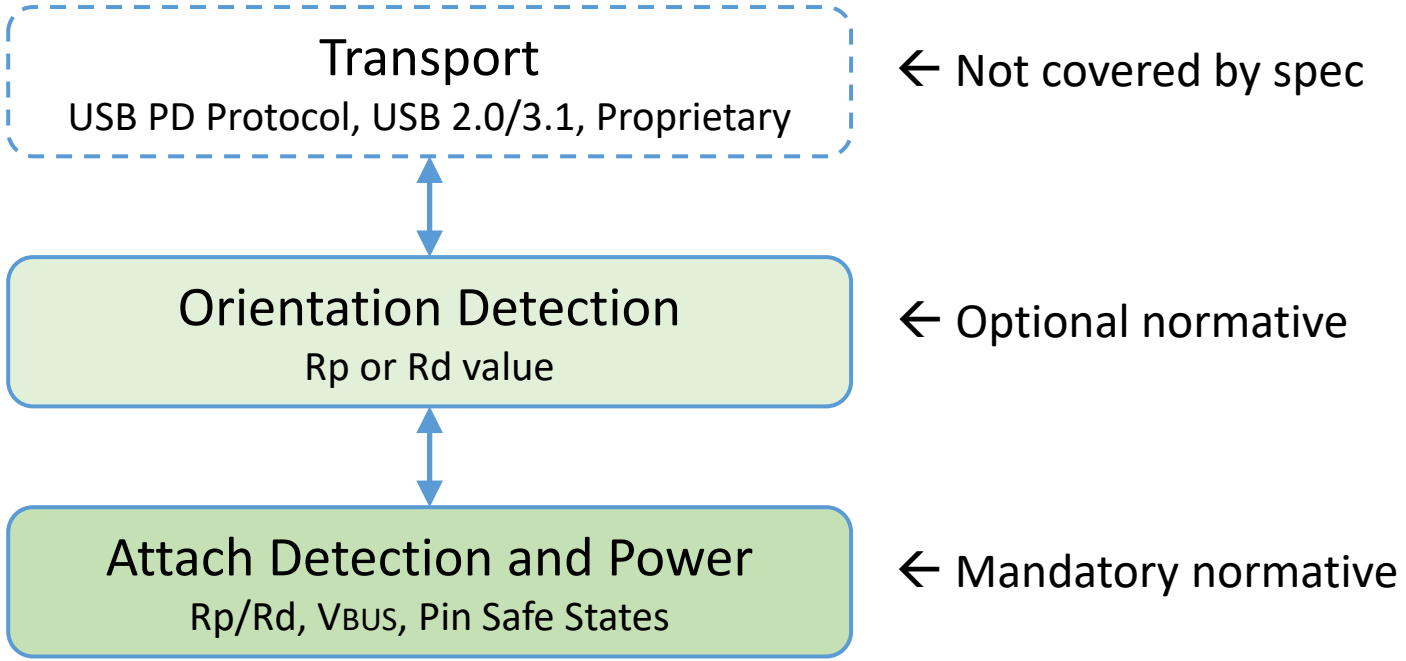
- Chapter 5 – Functional Extensions
  - Clarified Alternate Mode electrical requirements with regard to AC coupling of TX and RX signals
  - Replaced the USB/PCI Express dock example with a USB/DisplayPort dock example

- Appendix B – Debug Accessory Mode ← new

USB Type-C – Debug Accessory Mode

New Capability

- Enables proprietary use of the USB Type-C port to debug closed-chassis, form-factor devices
  - Debug covers many areas ranging from detailed JTAG test access in a lab to high-level debug of software applications in production
- Debug Test System (DTS) must use captive cable or direct attach
- Security/Privacy Requirements
  - Vendors are required to protect against unintended use



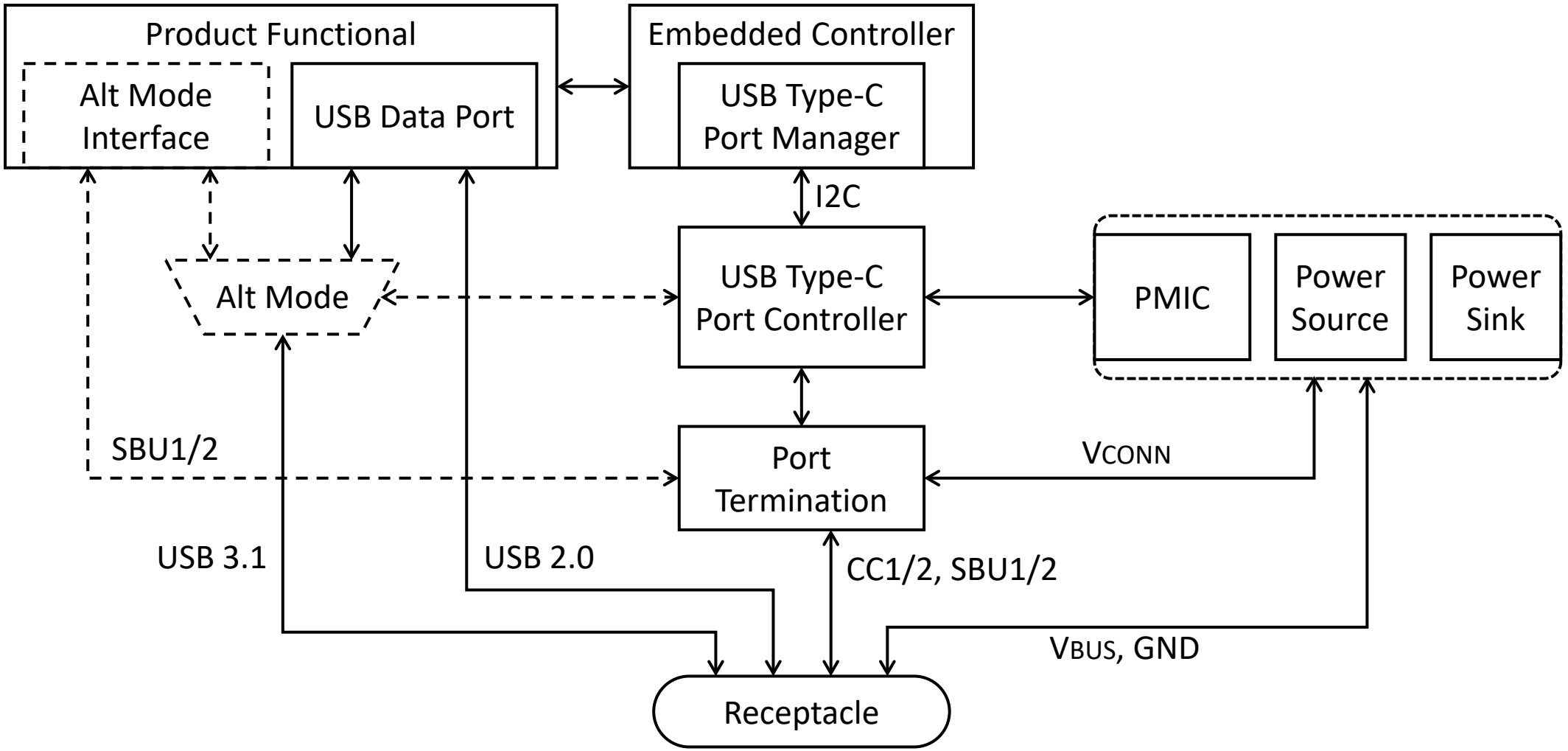
Topic Agenda

- Technical Solutions and Requirements
- Implementation Model
- USB Type-C Enabled Solutions

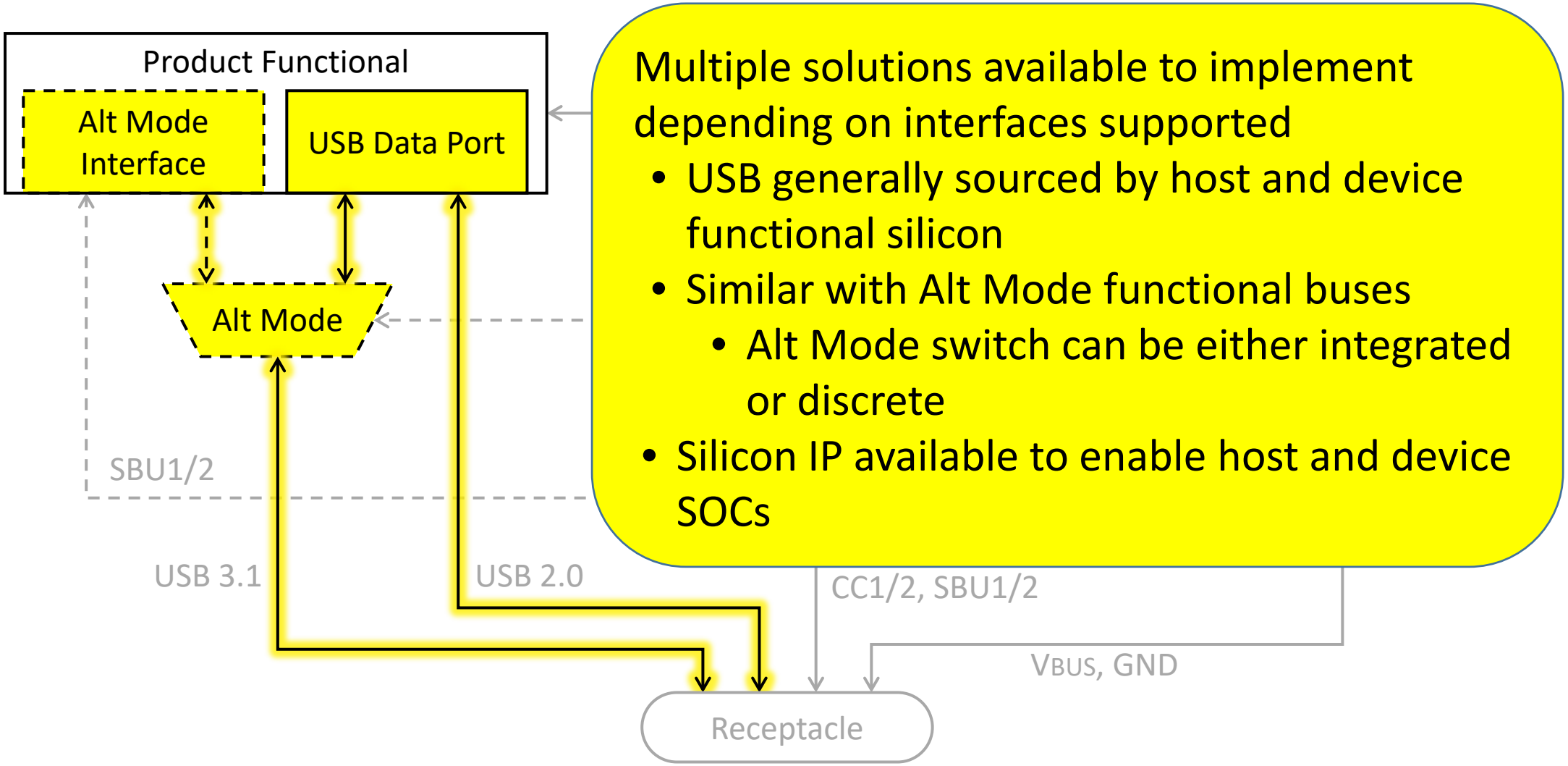
Implementation Model

- USB Data Bus Interface
- USB Type-C Port Controller
- USB Power Delivery
- USB Type-C Chargers

Basic Implementation Model



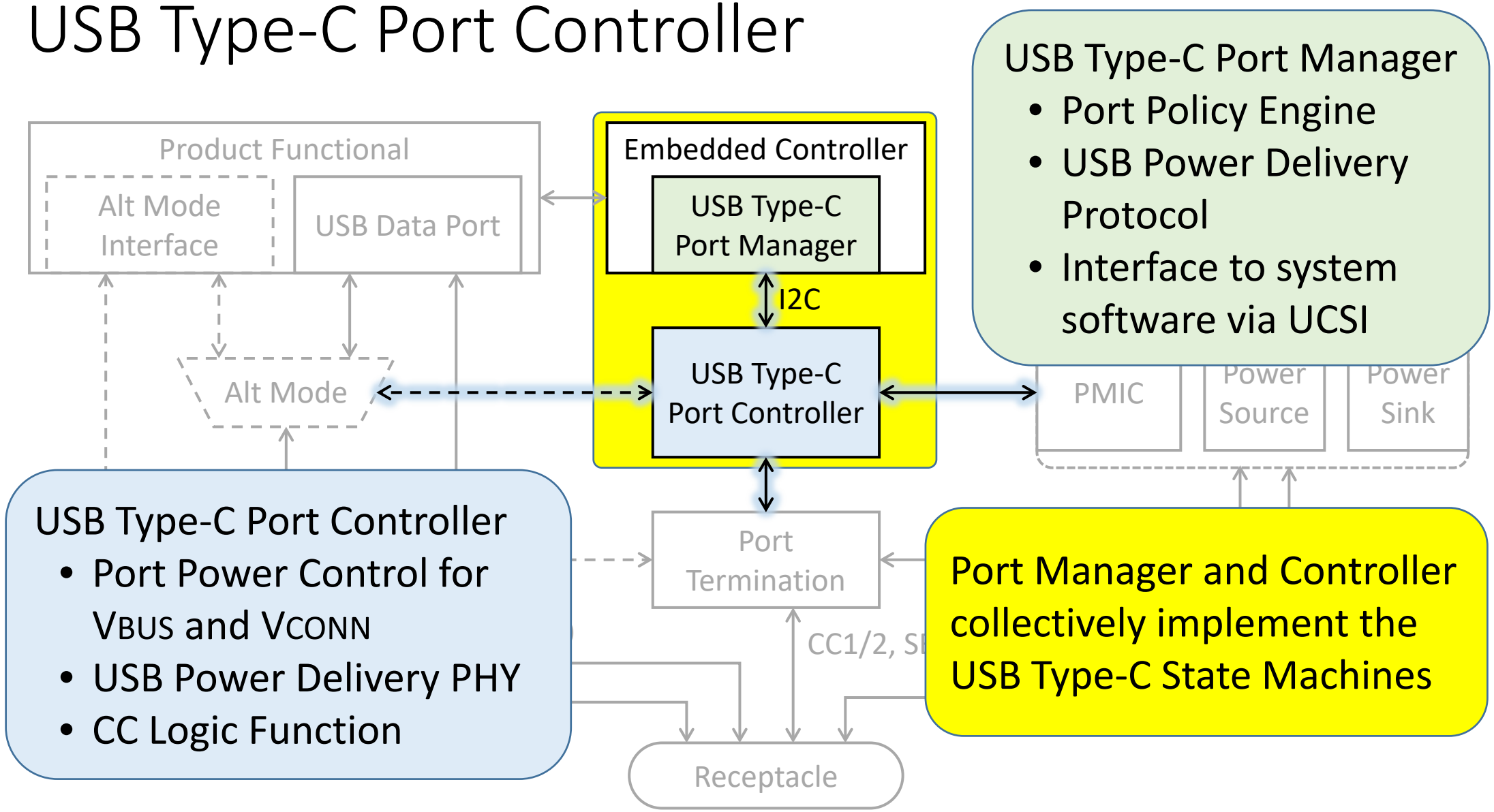
Data Bus Interface Implementation



Multiple solutions available to implement depending on interfaces supported

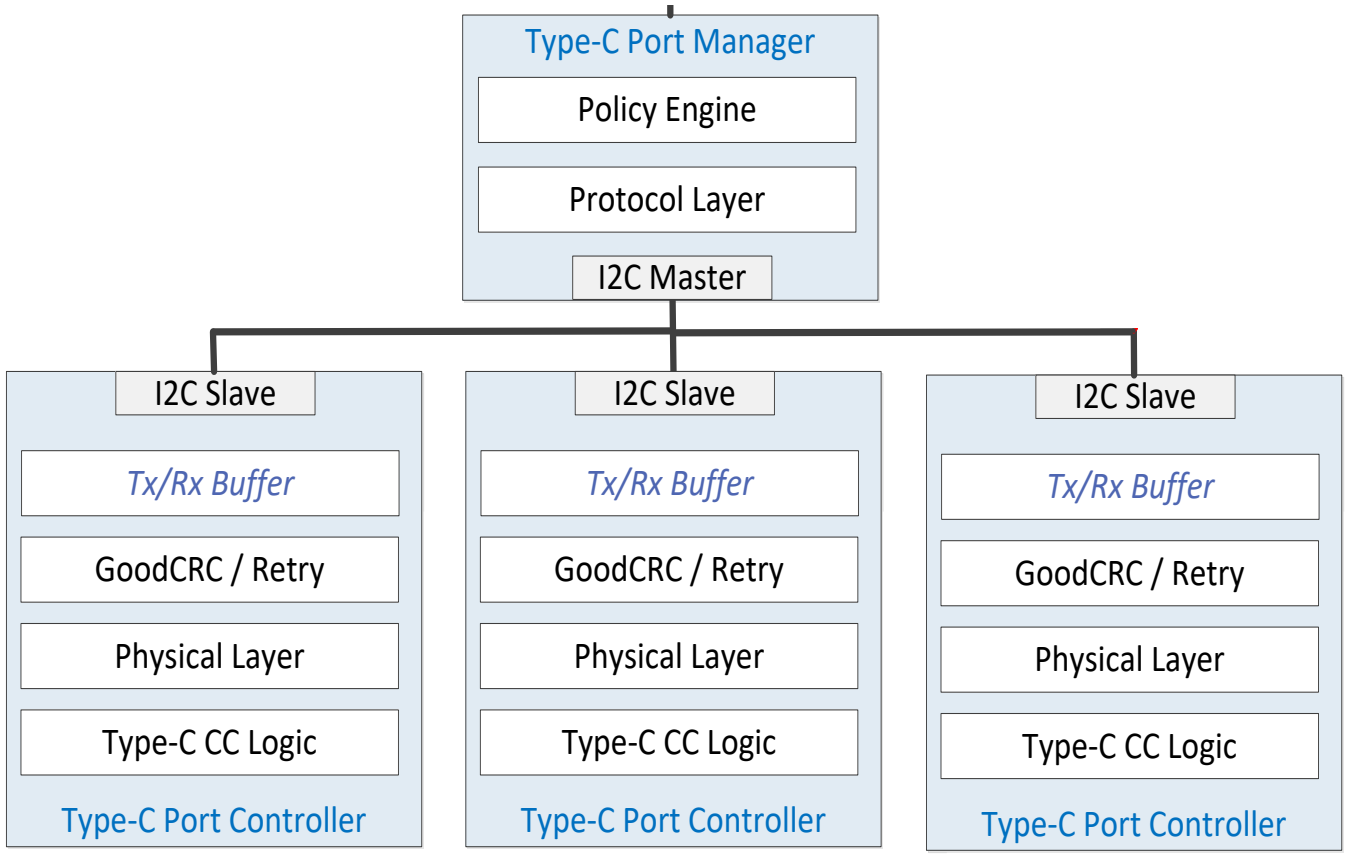
- USB generally sourced by host and device functional silicon
- Similar with Alt Mode functional buses
  - Alt Mode switch can be either integrated or discrete
- Silicon IP available to enable host and device SOCs

USB Type-C Port Controller



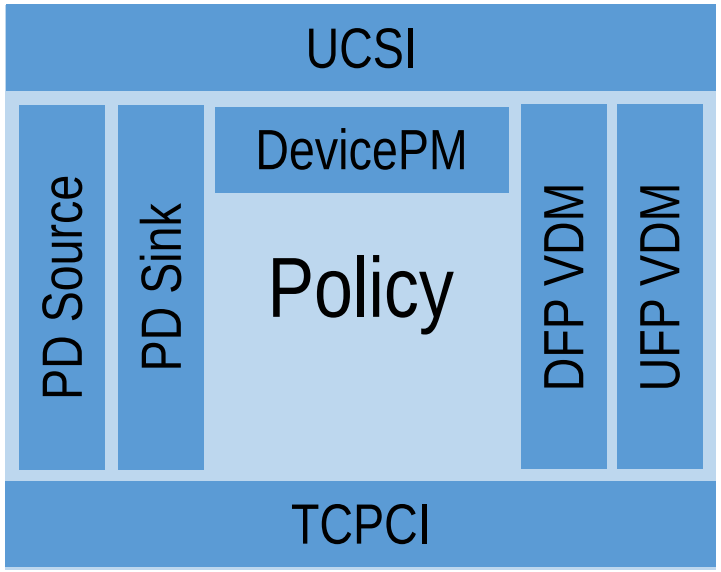
USB Type-C Port Controller Interface (TCPCI)

- Interface between the USB Type-C Port Manager and one or more USB Type-C Port Controllers
- A comprehensive set of TCPC registers defined
  - Device capabilities
  - Control and configuration for TCPC, CC roles, Power and Faults
  - Status for CC roles, Power and Faults

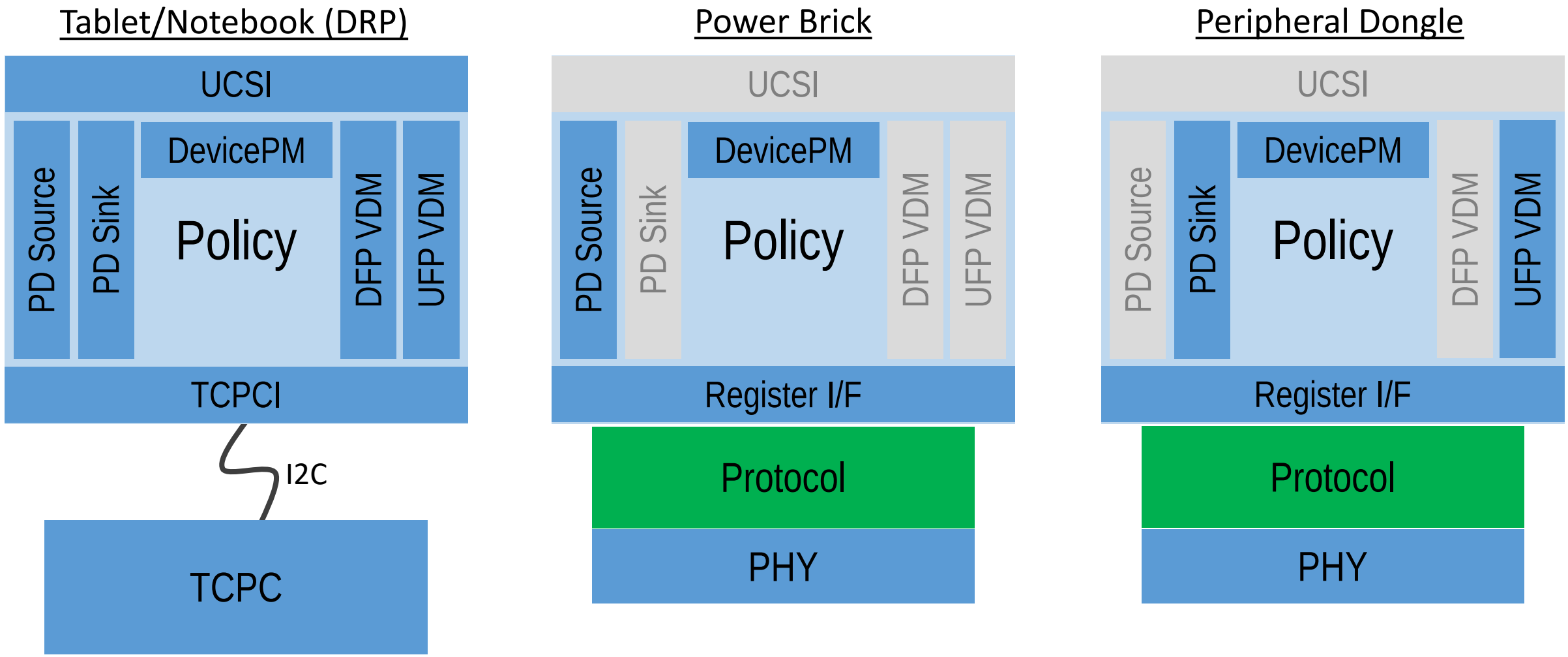


Example Architecture of a USB PD Port Manager

- USB Type-C Software Interface (UCSI) to the system
- Device Level Policy Manager
  - Modules to manage power as a Source and a Sink
  - Modules to manage behavior/configuration as an Alternate Mode device
- USB Type-C Port Controller Interface (TCPCI)



Example Architectures for Tablet & Peripherals

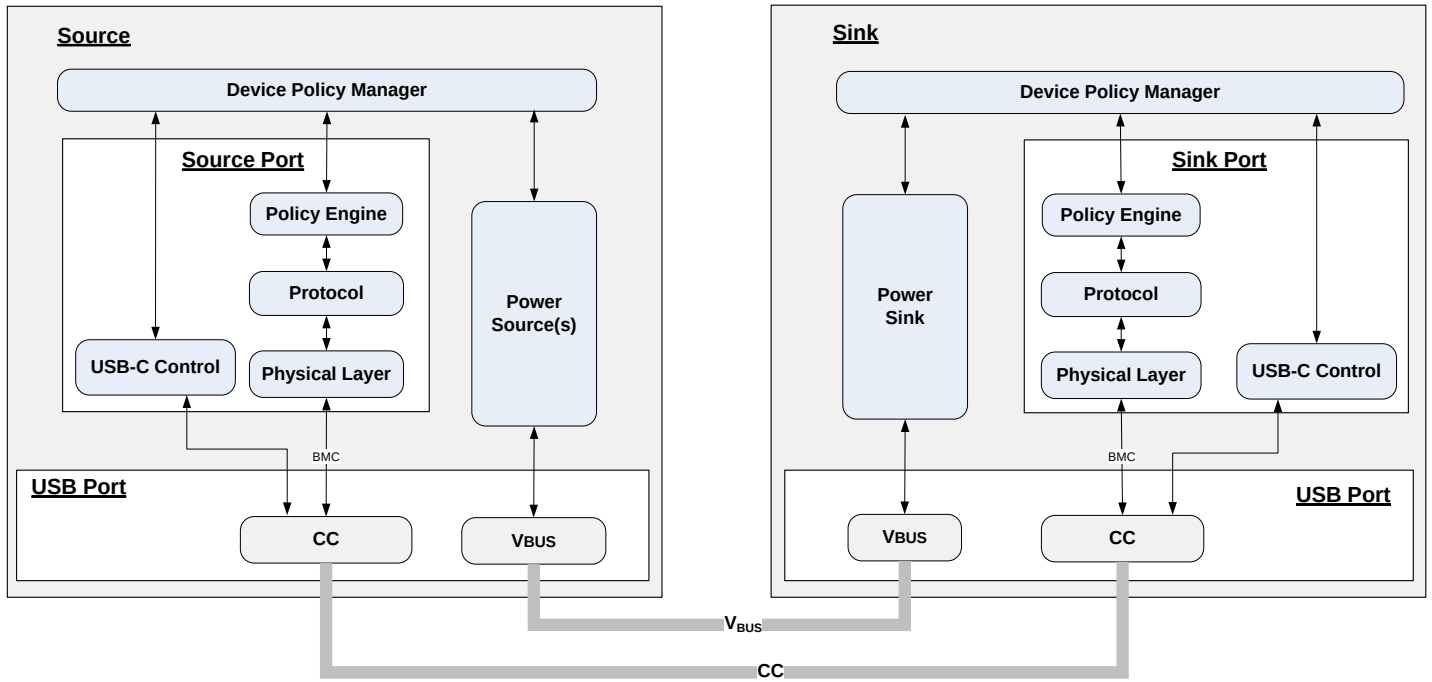


USB Power Delivery for USB Type-C

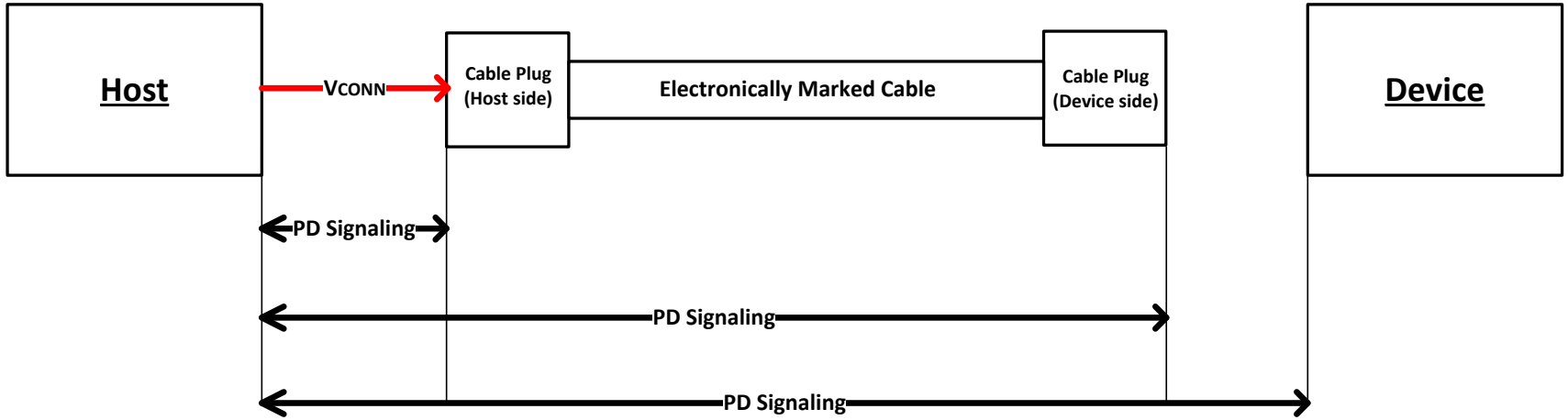
- USB PD signaling over USB Type-C CC wire
  - Separate from power line
  - No inductor or modem components as needed by BFSK
- VDM concept
  - Unstructured VDM
  - Structured VDMs to support USB Type-C Alternate Modes and Electronically Marked cables
- Multi-drop capability
  - Support USB Type-C Electronically Marked and active cables
- Swapping data roles and port sourcing V_{CONN}
- And continues to Manage Power
  - Enables voltage and current values to be negotiated
  - Enables higher voltage and current in order to deliver power up to almost 100W
    - Limits to match cable capabilities
    - Upper limit bound by international safety requirements
  - Switchable source of power delivery without changing cable direction
  - Coexists with USB Battery Charging 1.2 and USB Type-C Current

USB Power Delivery (PD) Overview

- Communication is port to port
  - No dependence on USB communications
  - Over CC wire
- V/I/direction negotiated
- Cable Capability Detection
  - Electronically marked cables
- Connectors
  - USB Type-C connectors rated for 5A
  - USB Type-C cables rated for 3A or 5A



Multi-drop for Communicating with Cables



- Original port-to-port architecture expanded
  - Cable managed by the Host
  - Electronically Marked Cables
  - Manage active cables
  - Individually address each end of the cable

Electronically Marked Cable Information

- SVID
- XID
- Hardware/Firmware Version
- Passive/Active
- V_{CONN} required
- RX/TX Directionality
- V_{BUS} current capability
- USB Signalling (2.0, Gen1, Gen 2)
- Latency

USB Type-C Chargers

Starting with USB Type-C, a new focus underway toward enabling worldwide interoperable charger standards

1. *USB Type-C and USB Power Delivery standards*
   - *As needed, extending these to enable emerging charging techniques*
2. *International recognition of USB standards*
   - *USB-IF working with IEC on publishing and recommending USB specs*
3. *USB charger compliance program and charger-specific certification logo*
   - *USB-IF to administer and promote worldwide recognition of the program*

Charging by USB Connector Type

USB Legacy Connectors

- Applicable connector types:
  - USB Standard-A receptacles
  - USB Micro-B receptacles/plugs
- Recommended power methods:
  - VBUS per USB 2.0 and USB 3.1
  - USB Battery Charging 1.2
- Additional methods:
  - Non-USB/proprietary charging methods

Assure interoperability

Increase 5V current

Increase power safely

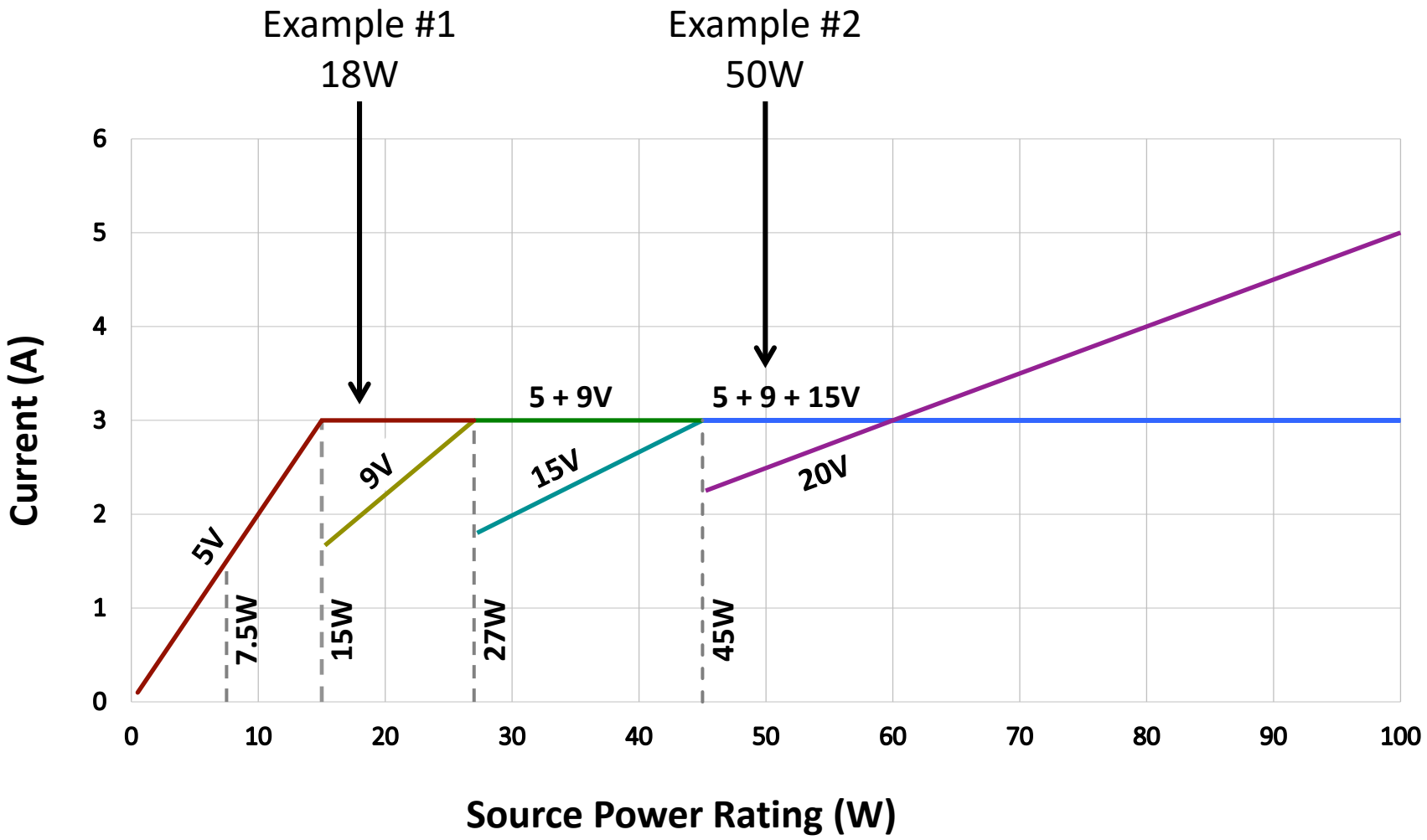
USB Type-C Connectors

- Applicable connector types:
  - USB Type-C receptacles/plugs
- Recommended power methods:
  - VBUS per USB 2.0 and USB 3.1
  - USB Type-C 1.5A/3.0A Current
  - USB Power Delivery (PD)
- Additional methods:
  - USB Battery Charging 1.2

USB Type-C Power Rules

- Defined in the USB PD specification

- Examples:
  1. 18W power rating = 5V up to 3A + 9V up to 2A
  2. 50W power rating = 5V up to 3A + 9V up to 3A + 15V up to 3A + 20V up to 2.5A



USB-IF / IEC Relationship

- USB-IF and IEC have been working together since 2013
  - Agreement for publication of USB specs as IEC standards to support global goals for interoperable device data delivery and charging applications for environmental e-waste reduction
  - Cooperation supports global recognition and adoption of USB technologies in international and regional standards (IEC, ITU-T [ITU L.1002 : Universal charger for laptops], regional SDOs, etc.) and regulatory policies
- IEC 62680 series
  - USB 2.0, USB Micro-B, and USB BC 1.2
  - USB 3.1, USB Type-C™, and USB PD
- IEC 63002
  - Mobile charging interoperability approach based on USB Type-C and USB PD
- IEC 62684
  - Mobile phone interoperability with legacy USB technologies (developed by CENELEC to support EU standardization mandate)

MEDIA RELEASE

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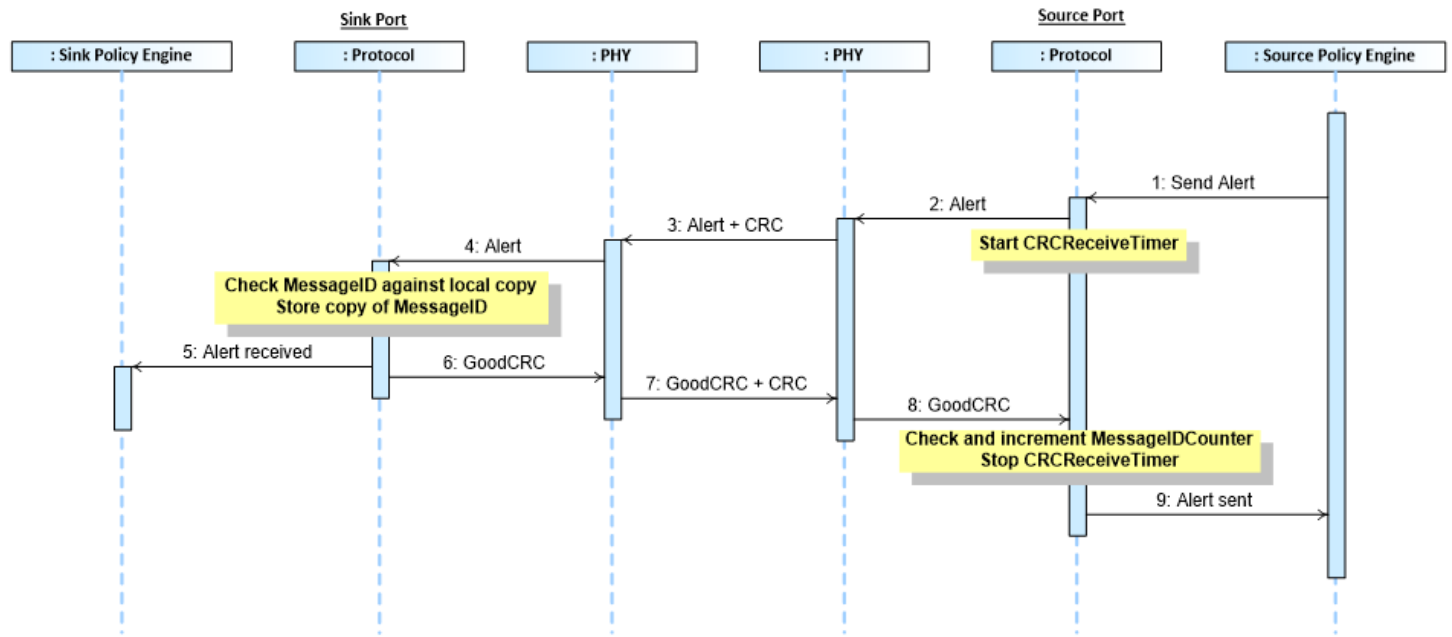
IEC and USB-IF Expand Cooperation to Support Next-Generation High-Speed Data Delivery and Device Charging Applications

GENEVA, Switzerland and BEAVERTON, Ore., U.S. – December 8, 2014 – The IEC (International Electrotechnical Commission) and the USB Implementers Forum (USB-IF) today announced that they have expanded international standards cooperation to include the latest USB-IF specifications for high-speed data delivery and enhanced usages for device charging. In particular, the USB-IF has submitted to the IEC the USB Power Delivery (Rev. 2.0, v1.0), USB 3.1 (SuperSpeed USB 10 Gbps), and USB Type-C Cable and Connector specifications.

International Charger Standardization Alignment

- IEC PT 63002 WG requested some extensions to USB PD
  - Updated existing and added new capabilities reported by the power source
  - Expecting national bodies to mandate some level of compliance for chargers sold in their country based on this standard
- Uses Extended Data messages
  - Extended Source Capabilities
  - Source Status
  - Source Alert
    - Change in source input / battery system
    - OCP / OTP / OVP events

Figure 8-20 Source Alert to Sink



USB Type-C Charger Certification

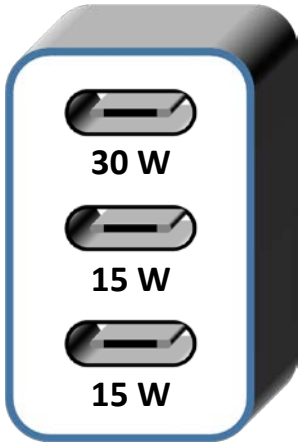
- Based on charger power capabilities and behaviors defined by the USB Type-C and USB PD specifications
- USB-IF has just announced the Certified USB Type-C Charger Logo program
  - Use of certification logo and USB PD icons require both passing product certification and executing a trademark license agreement
  - Product labeling requirements and guidelines defined
- Displayed rating represents nominal capability, independent of the regulatory product labeling requirements

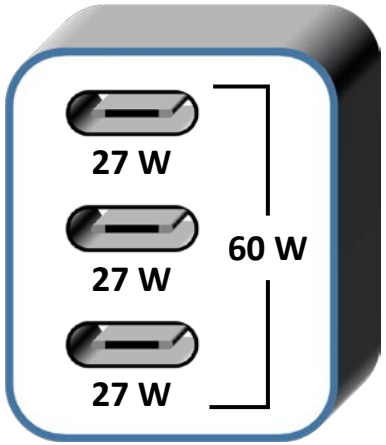
Example:

USB Type-C Multi-Port Chargers

- Two categories of charger ports
  - Assured Capacity Ports
    - Each port is able to deliver its rated/labeled power capacity independent of all other ports
  - Shared Capacity Ports
    - Each port is able to deliver up to its rated/labeled power capacity depending on the remaining available capacity that is shared by a group of multiple ports
    - The total available power capacity of the group of ports is indicated to the user and all ports in the group are capable of delivering to the same power rating

Example of an Assured Capacity Charger that has a total capability of 60 W and a USB Charger certification of 30 W





Example of a Shared Capacity Charger that has a total capability of 60 W and a USB Charger certification of 27 W

USB-IF Charging Recommendations

- For legacy USB Standard-A and Micro-B, recommend:
  - For interoperability, specify use of V_{BUS} per USB 2.0/USB 3.1 and the Battery Charging 1.2 specifications
  - For non-USB proprietary methods, products need to assure safe fallback to interoperability mode when such methods fail to be detected between the charger and device

No USB logo certification program available

- For USB Type-C™ connectors, recommend:
  - For interoperability, specify use of V_{BUS} per USB 2.0/USB 3.1 specs
  - For higher current 5V charging, specify 1.5A/3.0A modes of USB Type-C specification
    - Supporting USB BC 1.2 specification optional for legacy compatibility
  - For higher power needs, specify use of USB Power Delivery specification

USB Type-C Charger logo certification program

Topic Agenda

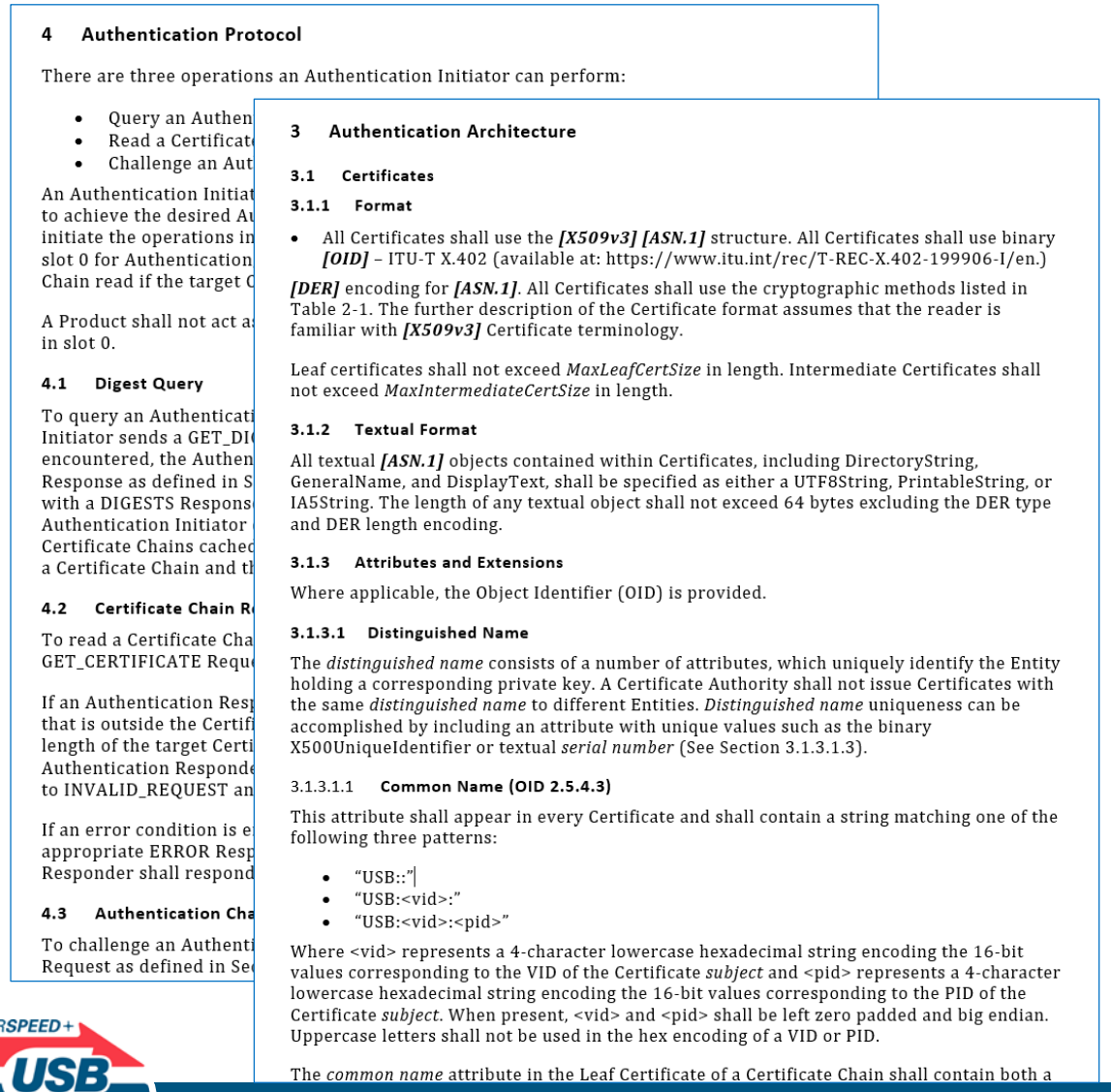
- Technical Solutions and Requirements
- Implementation Model
- USB Type-C Enabled Solutions

USB Type-C Enabled Solutions

- USB Type-C Authentication
- USB Type-C Digital Audio
- USB PD Firmware Update
- USB Display Class

USB Type-C Authentication Specification

New Capability



4 Authentication Protocol

There are three operations an Authentication Initiator can perform:

- Query an Authen
- Read a Certificat
- Challenge an Aut

An Authentication Initiat
to achieve the desired Au
initiate the operations in
slot 0 for Authentication
Chain read if the target C

A Product shall not act a
in slot 0.

4.1 Digest Query

To query an Authenticati
Initiator sends a GET_DI
encountered, the Authen
Response as defined in S
with a DIGESTS Respons
Authentication Initiator
Certificate Chains cache
a Certificate Chain and t

4.2 Certificate Chain R

To read a Certificate Cha
GET_CERTIFICATE Requ

If an Authentication Resp
that is outside the Certifi
length of the target Certi
Authentication Responde
to INVALID_REQUEST an

If an error condition is e
appropriate ERROR Resp
Responder shall respond

4.3 Authentication Cha

To challenge an Authenti
Request as defined in Se

3 Authentication Architecture

3.1 Certificates

3.1.1 Format

- All Certificates shall use the ***[X509v3] [ASN.1]*** structure. All Certificates shall use binary ***[OID]*** – ITU-T X.402 (available at: https://www.itu.int/rec/T-REC-X.402-199906-I/en.)

[DER] encoding for ***[ASN.1]***. All Certificates shall use the cryptographic methods listed in Table 2-1. The further description of the Certificate format assumes that the reader is familiar with ***[X509v3]*** Certificate terminology.

Leaf certificates shall not exceed *MaxLeafCertSize* in length. Intermediate Certificates shall not exceed *MaxIntermediateCertSize* in length.

3.1.2 Textual Format

All textual ***[ASN.1]*** objects contained within Certificates, including DirectoryString, GeneralName, and DisplayText, shall be specified as either a UTF8String, PrintableString, or IA5String. The length of any textual object shall not exceed 64 bytes excluding the DER type and DER length encoding.

3.1.3 Attributes and Extensions

Where applicable, the Object Identifier (OID) is provided.

3.1.3.1 Distinguished Name

The *distinguished name* consists of a number of attributes, which uniquely identify the Entity holding a corresponding private key. A Certificate Authority shall not issue Certificates with the same *distinguished name* to different Entities. *Distinguished name* uniqueness can be accomplished by including an attribute with unique values such as the binary X500UniqueIdentifier or textual *serial number* (See Section 3.1.3.1.3).

3.1.3.1.1 Common Name (OID 2.5.4.3)

This attribute shall appear in every Certificate and shall contain a string matching one of the following three patterns:

- "USB::"
- "USB:<vid>:"
- "USB:<vid>:<pid>"

Where <vid> represents a 4-character lowercase hexadecimal string encoding the 16-bit values corresponding to the VID of the Certificate *subject* and <pid> represents a 4-character lowercase hexadecimal string encoding the 16-bit values corresponding to the PID of the Certificate *subject*. When present, <vid> and <pid> shall be left zero padded and big endian. Uppercase letters shall not be used in the hex encoding of a VID or PID.

The *common name* attribute in the Leaf Certificate of a Certificate Chain shall contain both a

- Protocol for authenticating USB hosts, devices, cables and power sources
- Implementation supported over:
  - Legacy or USB Type-C* connectors for authentication via USB data bus
  - USB Type-C connectors for authentication via USB Power Delivery over CC
- Products retains responsibility for the security policies that are implemented and enforced
- Released April 2016

USB Type-C Digital Audio

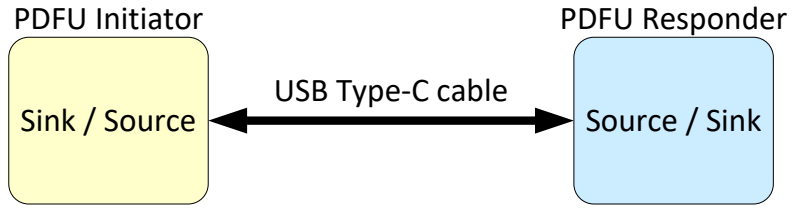
New Capability

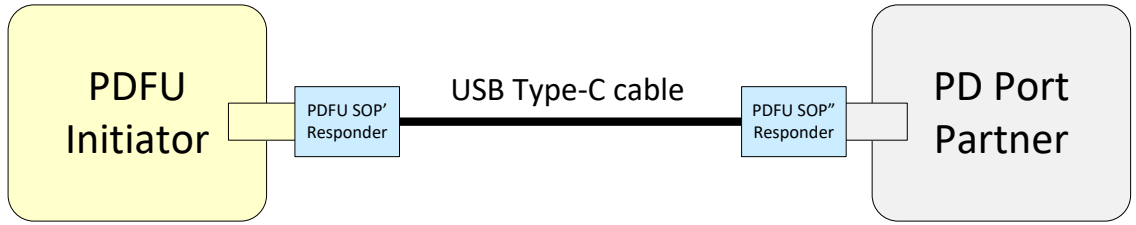
- Enable the move from analog to digital
  - Volume & shrinking transistors reduce cost over time
  - Users see and value improved digital headset features
- USB Audio Device Class 3.0 specifications
  - Updated Audio Core, Formats and Terminal Types with expanded definitions to include more recent audio specs and features
  - Introduced the concept of Power Domains for improved and more granular internal power management
  - Added Basic Audio Device Definition (BADD) for simplified discovery and configuration to enable simpler hosts
  - Backwards USB Audio compatibility supported by the use of a other configurations
    - The first configuration is either Audio 1.0 or 2.0 compliant
- Specification targeting release later this quarter

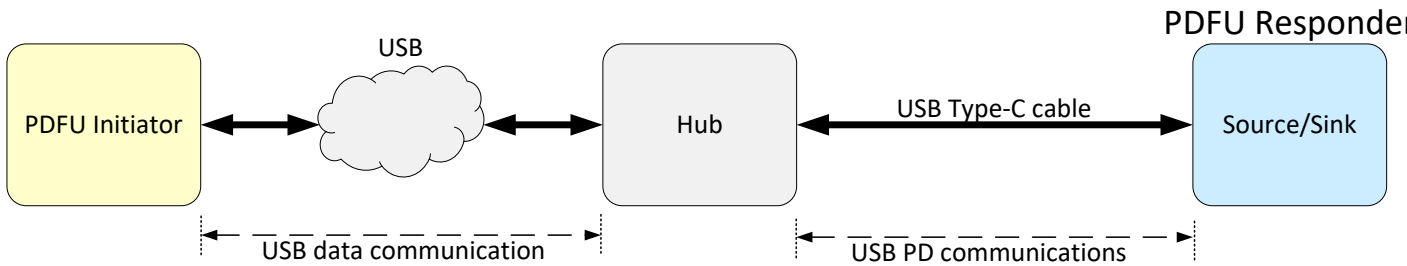
USB PD Firmware Update

New Capability

- Defines a common method to update the firmware in a USB PD-capable device
  - Examples: USB Type-C Charger, USB Type-C Alt Mode device
- Secure method designed to thwart installation of compromised firmware
- Complements existing USB DFU Class implementations



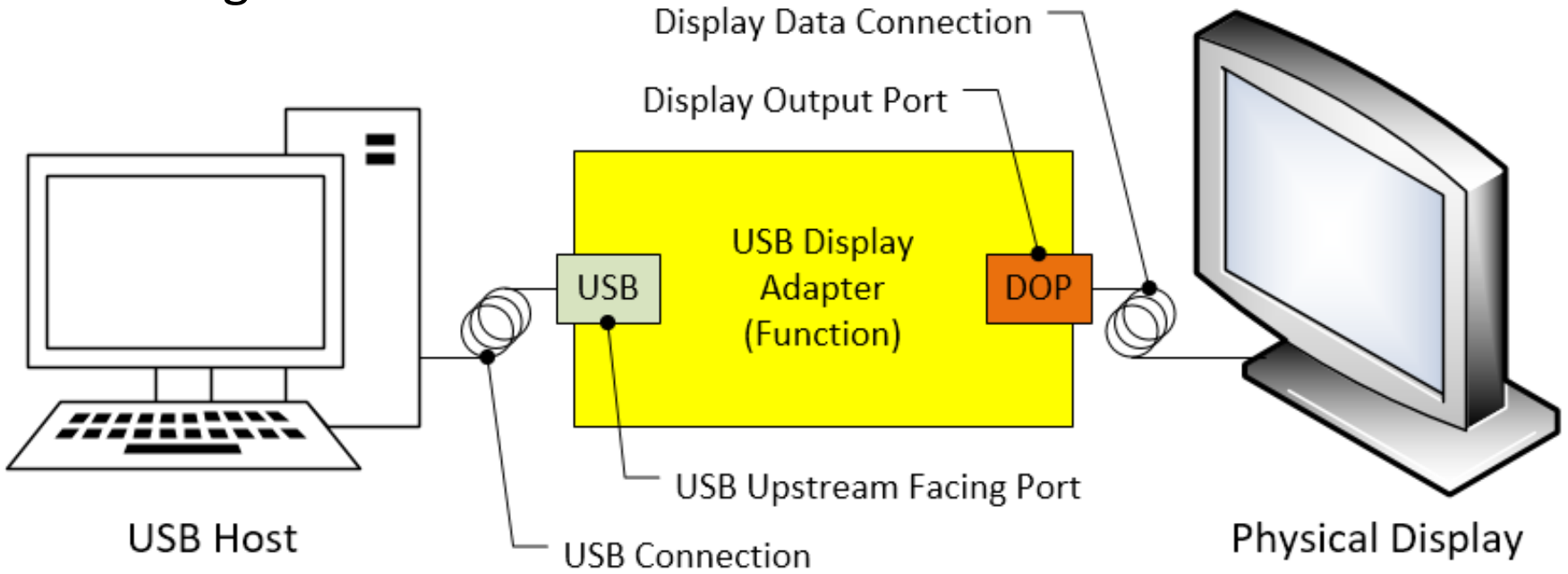




USB Display Class ← *new USB-IF WG activity*

In Development

- Enable USB-based displays and display adapters
  - USB displays are for output only applications
  - Supporting multiple monitors, boot usages, scalable resolutions/frame rate
  - Capable of displaying protected content
  - Full operation through USB hubs



Q&A