USB 3.1 Type-C and USB PD connectors
Presentation

• Introduction
  USB Type-C connectors
  • Supplement to the USB 3.1 and Power Delivery specification

• Purpose
  Define USB 3.1 Type-C receptacle, plug and cable assembly

• Overview
  Adaptation of USB Power Delivery to the Type-C connection model

• Type-C cable and connector supports:
  ▪ USB performance at SuperSpeed, (SS) Gen 1 = 5Gbps
  ▪ USB performance at SuperSpeed Plus (SSP) Gen 2 = 10Gbps
  ▪ USB Power Delivery up to 100W

• USB Power Delivery 2.0 update
  ▪ Manage power delivered across VBUS between USB products
    with control over power delivery direction, voltage up to 20V and current up to 5A.
The Single Connector Platform Model
Use Cases for USB 3.1

Support attach of much higher performance peripherals
- A/V Display beyond 1080p (uncompressed) and multi-displays
- SSD, RAID HDD, or Hybrid HDD

Blazing fast data sync

Enable multi-function, single port connections
- SuperSpeed Hubs with fatter system pipe supporting multiple SuperSpeed downstream devices
- Display Dock enabling mix of SuperSpeed-based A/V, webcam, storage, etc. over a single connection
Comparison of USB connectors

The USB Type-C connector and cable specification defines a new receptacle, plug, cable and detection mechanisms that are compatible with existing USB interface electrical and functional specifications.

USB Type-C Receptacle

USB Type-C is low profile, narrower, more aesthetically pleasing, and more robust.
USB 3.1 Type-C Connector
Product Offering

- USB 3.1 Type-C Standard Compliant Connectors
  - USB 3.1 Full-Featured Type-C receptacle
  - USB 3.1 Full-Featured Type-C plug
  - USB 2.0 Type-C plug

- USB 3.1 Type-C Alternate Connectors
  - USB Type-C Top Mount Dual Row SMT receptacle
  - USB Type-C Top Mount Hybrid receptacle
  - USB Type-C Mid-Mount Dual Row SMT receptacle
  - USB Type-C Mid-Mount Hybrid receptacle
  - USB Type-C Vertical Mount SMT receptacle
USB Type-C

Targeting new thinner and high performance platforms and devices
- USB Type-C to legacy adaptation cables defined to support gradual transition

Top-Mount Receptacle
Top-Mount Rec Hybrid
Top-Mount Rec Dual-Row SMT
Mid-Mount Receptacle
Mid-Mount Rec Hybrid
Mid-Mount Rec Dual-Row SMT

Power-Only Plug & Captive Cable
USB 2.0 Plug & Cable
Full Feature Plug & Cable

Artist renderings courtesy of Foxconn®
Key features of the USB Type-C connector

- Entirely new design
  - Tailored for emerging product designs
  - Robust enough for laptops and tablets; slim enough for mobile phones
  - Similar to size of USB 2.0 Micro-B
- Usability enhancements
  - Both plug and cable orientation no longer keyed
  - Hosts and devices require logic to resolve their roles for proper USB bus operation
- Supports scalable power charging
- Future scalability
  - Designed to support future USB performance needs
- Two Power Sources
  - VBUS – definition expanded with USB Type-C Current
  - VCONN – a dedicated source for powering cable electronics, +5V pin powers circuits in the plug needed to implement Electronically Marked Cables. Vconn is independent of VBUS.
USB Type-C Functional Pin-Out

<table>
<thead>
<tr>
<th></th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
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<td>TX1+</td>
<td>TX1-</td>
<td>VBUS</td>
<td>CC1</td>
<td>D+</td>
<td>D-</td>
<td>SBU1</td>
<td>VBUS</td>
<td>RX2-</td>
<td>RX2+</td>
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<tr>
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<td>D-</td>
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<td>VBUS</td>
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<td>RX2-</td>
<td>VBUS</td>
<td>SBU1</td>
<td>D-</td>
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<table>
<thead>
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<th>TX2+</th>
<th>TX2-</th>
<th>VBUS</th>
<th>Vconn</th>
<th>SBU2</th>
<th>VBUS</th>
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# USB Type-C Signal Summary

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

Implementation without Switch

This version of the model illustrates a traditional host to device

Implementation with Switch

USB Type-C Receptacles

Platform implementation impact varies based on capabilities chosen and level of integration
USB Type-C Functional Model

Implementation without Switch

Implementation with Switch

Full-Featured Cable

Host USB

CC Logic & VCONN Switch

SSTX1
SSRX1

USB D+/-

CC1

CC2

SSTX2
SSRX2

Device USB

USB D+/-

Full-Featured Cable

CC1

CC Logic

MUX

USB Type-C Plugs

CC wire determines orientation through the cable
USB Type-C Functional Model

Implementation without Switch

Full-Featured Cable

Implementation with Switch

⇒ Un-flipped straight through – Position ① ⇔ Position ①
USB Type-C Functional Model

⇒ Un-flipped twisted through – Position ① ↔ Position ②
USB Type-C Functional Model

- Implementation without Switch
- Full-Featured Cable
- Implementation with Switch

⇒ Flipped straight through – Position ② ⇔ Position ②
USB Type-C Functional Model

Implementation without Switch

Full-Featured Cable

Implementation with Switch

⇒ Flipped twisted through – Position ② ⇔ Position ①
USB Type-C Connector Mechanical Features

- Type-C connector

- Receptacle Mechanical Features
  - Receptacle opening: ~ 8.3mm X ~ 2.5mm
  - Durability: 10,000 cycles
  - Improved EMC and RFI mitigation features
  - No exposed voltage pins

- Key Components
  - Shell
  - EMC Shield
  - Alignment
  - Tongue with mid-plate-
    - Signal contacts
    - Ground plane
    - Latching detents
    - Robustness

- Retention of the cable assembly in the receptacle is achieved by the side-latches in the plug and features on the sides of the receptacle tongue.
Type-C Electrical Performance

- **Electrical Ratings**
  - Supports 3A for standard cables
  - Supports 5A for connectors
  - Supports voltages as high as +20V

- **Contact Ratings**
  - Contact resistance: 40 mΩ
  - Connector contact current rating of 5A for ganged VBUS pins
  - Contact construction requires new method for measuring temperature rise

- **Impedance**
  - Connector differential impedance: 85 +/- 9 Ohms
    - along interconnect path, determined by geometry, dielectric materials, stamped and formed contacts to match impedance
  - Raw cable differential impedance: 90 +/- 5 Ohms
    - Chosen for lower loses
## USB Type-C Power Options

<table>
<thead>
<tr>
<th>Mode of Operation</th>
<th>Nominal Voltage</th>
<th>Maximum Current</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB 2.0</td>
<td>5V</td>
<td>500mA</td>
<td>Default USB Power</td>
</tr>
<tr>
<td>USB 3.1</td>
<td>5V</td>
<td>900mA</td>
<td>Default USB Power</td>
</tr>
<tr>
<td>USB BC 1.2</td>
<td>5V</td>
<td>Up to 1.5A</td>
<td>Legacy charging</td>
</tr>
<tr>
<td>USB Type-C Current @ 1.5A</td>
<td>5V</td>
<td>1.5A</td>
<td>Supports higher power devices</td>
</tr>
<tr>
<td>USB Type-C Current @ 3.0A</td>
<td>5V</td>
<td>3A</td>
<td>Supports higher power devices</td>
</tr>
<tr>
<td>USB PD</td>
<td>Configurable up to 20V</td>
<td>Configurable up to 5A</td>
<td>Directional control and power level management</td>
</tr>
</tbody>
</table>
Full Feature and USB 2.0 Only Plugs

USB 2.0 only version  Full Feature version
USB 3.1 Type-C Plug to Type-C Plug Cable Assembly
USB Type-C Plug Mechanical Features

• Type-C connector

  • Plug Mechanical Features
    • Receptacle opening: ~ 8.3mm X ~ 2.5mm
    • Durability: 10,000 cycles min
    • Mating force: 5 N to 20 N
    • Un-Mating force: 8 N to 20 N
    • Improved EMC and RFI mitigation features

  • Key Components-Full-Feature and USB 2.0 only versions
    • Shell
    • Signal contact springs
    • Cable Electronic Marking (as required)
    • Latching springs
      ▪ Provides positive feel for full insertion
      ▪ Maintains mated condition
      ▪ Eliminates holes in the shell, providing EMC reduction
      ▪ Provides an additional GROUND return path
    • EMC springs
      ▪ Full-Feature version has six springs while USB 2.0 version has four
      ▪ EMC springs are critical to design to ensure the springs don’t short Vbus to GND
Type-C EMC Improvements

• Goal - Target radiation 15-20 dB lower than legacy USB 3.0 Standard-A

• Type-C plug
  ▪ no holes/cutouts in plug shell
  ▪ has ground contacts in front of shell to connect with ground bar in the back of receptacle
  ▪ Side latches-have electrical connection to receptacle mid-plate
  ▪ Low ESL bypass caps are required for VBUS lines on host and inside cable plug
  ▪ Sufficient connection points between the internal RFI spring and plug shell
  ▪ Cable external braid is physically connected to the plug metal shell as close to 360° as possible to control EMC

• Type-C receptacle
  ▪ Sufficient connection points between the internal EMC pad and the receptacle shell
  ▪ Receptacle mid-plate is directly connected to system PCB GND via solder tails
  ▪ External spring on receptacle shell is optional- internal EMC pad is not required if external springs are formed on the receptacle shell. May provide additional shielding
  ▪ Back-shield is critical- one of the main sources of leakages
Wire / Raw Cable

• No hard requirement on wire type. Expect both micro-coax and shielded twisted pairs to be used.
• Raw cable impedance for SuperSpeed pairs is recommended to be 90+/− 5 ohms
  − 85 ohm cable would be better in matching impedance with the connector, but it will have more loss.
• Managing intra-pair skew is important to meet the mode conversion spec, particularly for micro-coax.
• Pay attention to wire bundle design to achieve impedance and crosstalk targets for the low speed (CC, SBU, Vbus, and USB 2.0).
USB Type-C Configuration Channel (CC)

- Detect attach of USB ports
- Resolve cable orientation and twist connections to establish USB data bus routing
- Establish “host” and “device” roles between two attached ports
- Discover and configure VBUS
- Configure VCONN
- Discover and configure optional Alternate and Accessory modes
USB 3.1 Type-C Cable Assemblies
Product Offering

- USB 3.1 Type-C Standard Cable Assemblies
  - USB 3.1 Type-C to Type-C plug on each end, Gen 1, ≤ 2M length.
  - USB 3.1 Full-Featured Type-C plug on each end, Gen 2, ≤ 1M length.
  - USB 2.0 Power only, Type-C plug on each end, ≤ 4M length.
  - USB 3.1 Type-C plug to Micro B receptacle, USB version 2.0, ≤ 0.15M
  - USB 3.1 Type-C plug to Type-A receptacle, USB 3.1, Gen 1, ≤ 0.15M

- USB 3.1 Type-C to Legacy Adapter Assemblies
  - USB Type-C plug to Micro B receptacle, USB version 2.0
  - USB Type-C plug to Type A receptacle, USB 3.1, Gen 1 (5Gbps)
USB Type-C Legacy Cable Assemblies

USB Type-C to USB 3.1 Cable Assemblies:
- Standard-A
- Micro-B
- Standard-B

USB Type-C to USB 2.0 Cable Assemblies:
- Standard-A
- Standard-B
- Micro-B
- Mini-B

8 wires*
4 wires*

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

Artist renderings courtesy of Luxshare-ICT
# USB Type-C Cable Assemblies

## Power Capability

<table>
<thead>
<tr>
<th>Cable Ref</th>
<th>Plug 1</th>
<th>Plug 2</th>
<th>USB Version</th>
<th>Cable Length</th>
<th>Current Rating</th>
<th>USB Power Delivery</th>
<th>USB Type-C Electronically Marked</th>
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</thead>
<tbody>
<tr>
<td>CC2-3</td>
<td>C</td>
<td>C</td>
<td>USB 2.0</td>
<td>≤ 4 m</td>
<td>3A</td>
<td>Supported</td>
<td>Optional</td>
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<td>CC2-5</td>
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<td>C</td>
<td>USB 2.0</td>
<td>≤ 4 m</td>
<td>5A</td>
<td>Supported</td>
<td>Required</td>
</tr>
<tr>
<td>CC3G1-3</td>
<td>C</td>
<td>C</td>
<td>USB 3.1 Gen 1</td>
<td>≤ 2 m</td>
<td>3A</td>
<td>Supported</td>
<td>Required</td>
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<tr>
<td>CC3G1-5</td>
<td>C</td>
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<td>USB 3.1 Gen 1</td>
<td>≤ 2 m</td>
<td>5A</td>
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<td>CC3G2-3</td>
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<td>USB 3.1 Gen 2</td>
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<td>5A</td>
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<td>Required</td>
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</tbody>
</table>
Electronically Marked Cables

All USB Type-C Full-Featured cables and cables rated over 3 A require electronic marking
  • Also required for USB Type-C to legacy cables implementing USB 3.1 Gen2
Electronic marking mechanism (SOP’) defined in USB PD 2.0
Electronically marked cable limited to drawing 70 mW from Vconn
## USB Type-C Legacy Cable Assemblies

<table>
<thead>
<tr>
<th>Cable Ref</th>
<th>Plug 1</th>
<th>Plug 2</th>
<th>USB Version</th>
<th>Cable Length</th>
<th>Current Rating</th>
<th>USB Power Delivery (BFSK)</th>
<th>USB Type-C Electronically Marked</th>
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<td>AC2-1.5</td>
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<td>C</td>
<td>USB 2.0</td>
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<td>1.5 A</td>
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<tr>
<td>AC2-5</td>
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<td>5 A</td>
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<td>Optional</td>
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<td>CµB2-3</td>
<td>C</td>
<td>Micro-B</td>
<td>USB 2.0</td>
<td>≤ 2 m</td>
<td>3 A</td>
<td>Supported</td>
<td>Optional</td>
</tr>
<tr>
<td>CµB3G2-1.5</td>
<td>C</td>
<td>Micro-B</td>
<td>3.1 Gen 2</td>
<td>≤ 1 m</td>
<td>1.5 A</td>
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<tr>
<td>CµB3G2-3</td>
<td>C</td>
<td>Micro-B</td>
<td>3.1 Gen 2</td>
<td>≤ 1 m</td>
<td>3 A</td>
<td>Supported</td>
<td>Required</td>
</tr>
</tbody>
</table>
USB Type-C Legacy Adapters

Only two USB Type-C to legacy adapters are defined and allowed

USB Type-C to USB Standard-A Receptacle Adapter

- Superspeed Certified USB
- 8 wires*

Intended for legacy “thumb drive” use with new host platforms

USB Type-C to USB 2.0 Micro-B Receptacle Adaptor

- Hi-Speed Certified USB
- 4 wires*

Intended for adapting existing Micro-B chargers to new devices
USB Type-C Functional Extensions

Audio Adapter Accessory Mode – alternative for a 3.5 mm audio jack
• Enabling the single-connector phone or tablet

• Platforms supporting this extension will require accessory mode circuits that include special consideration for both digital and analog grounding
USB Type-C Compliance Testing

• Signal integrity compliance testing is for USB Type-C to Type-C cable assembly
  ▪ There will be no signal integrity and EMC component-level compliance test for receptacles
  ▪ The receptacle is considered part of the host or device, and host/device makers are responsible for managing the receptacle performance

• There will be system level tests
  ▪ includes system Tx and Rx tests and RFI tests
  ▪ Host/device makers may request mated connector simulation or measure data from connector suppliers to verify the receptacle performance

• Test Fixtures for Compliance Testing
  ▪ USB Type-C workgroup is defining a common fixture design for Type-C cable assembly
  ▪ Can choose to fabricate your own, or buy from a fixture vendor
  ▪ The compliance spec is targeted to finish by the end of 2014
Thank You

Note: Selected artist renderings courtesy of USB Implementers Forum 2014, Foxconn, and Luxshare-ICT