# USB Type-C™, IEEE CSNV

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  - Specs are available from USB-IF at http://www.usb.org and are subject to change. Usage restrictions are included in the spec.
  - If there are any deviations from spec in this material, the latest spec should be used as reference. User assumes all risk when using this material.

# What is USB-C?

- One plug and one cable for:
  - High speed data transfer (USB2.0 & USB3.1G1 and G2)
  - High power charging (5 to 20V, up to 100W)
  - Display: up to 4 DP lanes
  - Powered dongles (device powers active cables)
  - Docking (combinations of above functions)
  - Debug: debug aux mode
  - and more….
- 24 Pin Reversible, Symmetric Cable
  - Either end can be plugged in either orientation
  - Each end is identical

**Much more than "just USB!"**

# USB Type-C Plug and Socket

**Figure 3-3 USB Full-Featured Type-C Plug Interface Dimensions**

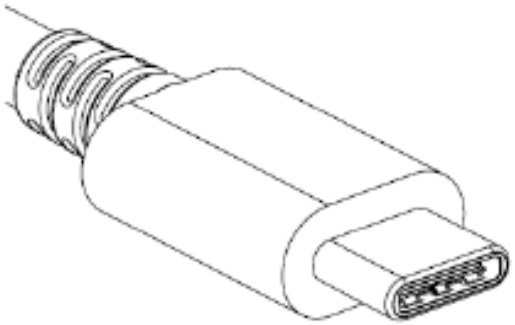
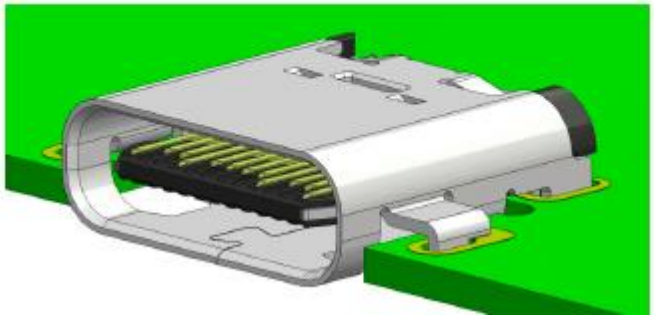
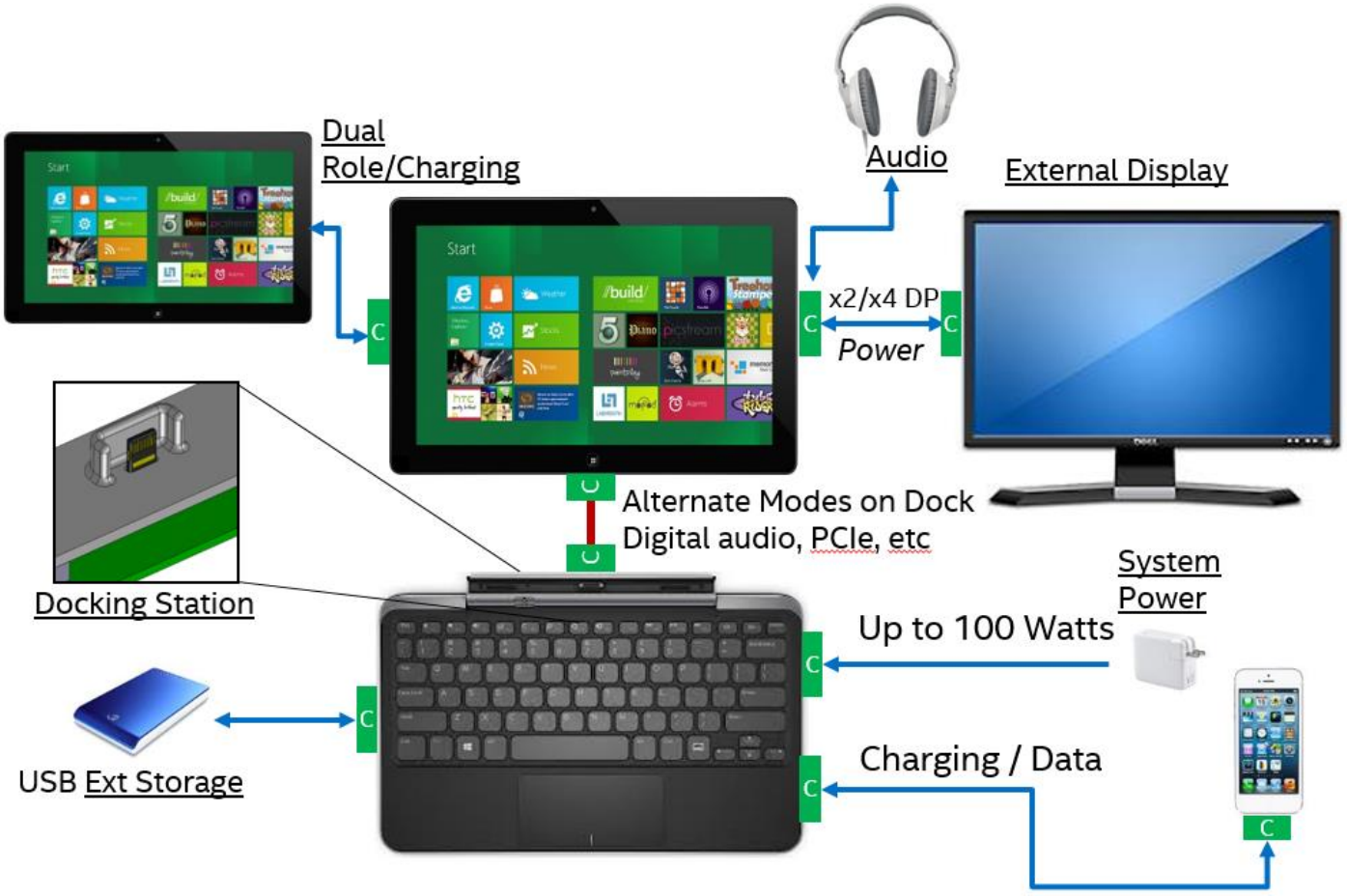


**Figure 3-7 Reference Footprint for a USB Type-C Mid-Mount Dual-Row SMT Receptacle (Informative)**

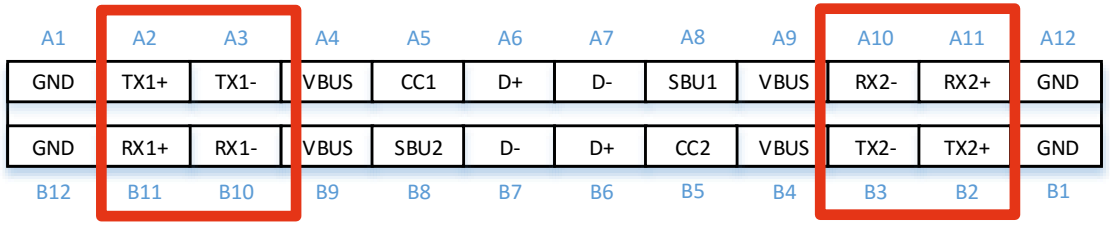


# USB-C Overview

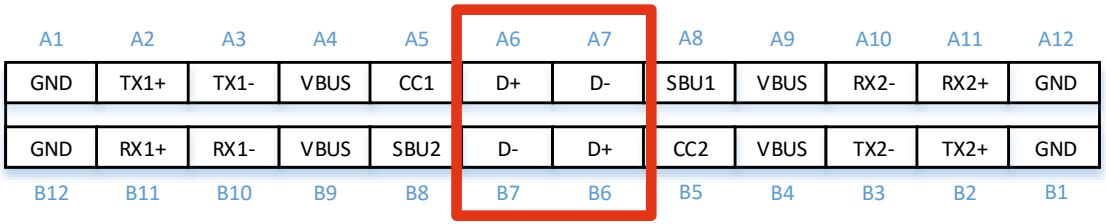


# Roles and Cable Orientation

- USB-C endpoints (port partners) are either a DFP (downward facing port), a UFP (upward facing port) or a DRP (dual role port)
  - DFP = host, also typically the power source
  - UFP = device, also typically the power sink
  - DRP = host or device (think OTG)
- Until roles are determined, ALL signals except CC and Gnd are undriven
- CC lines used to determine roles, to determine cable orientation and to communicate between endpoints
- USB3 (SS) lanes live on one of two possible locations based on cable orientation: mux needed to select correct one
- Alternate modes (e.g., DisplayPort) repurpose SS lanes: mux needed to select different outputs to send to the USB3 socket




| Signal Group | Signal | Description |
|---|---|---|
| **USB 3.1** | **SSTXp1, SSTXn1**<br>**SSRXp1, SSRXn1**<br>SSTXp2, SSTXn2<br>SSRXp2, SSRXn2 | SuperSpeed USB serial data interface: one transmit diff pair and one receive diff pair<br>Two pin sets to enable plug flipping |
| **USB 2.0** | **Dp1, Dn1**<br>Dp2, Dn2 | USB 2.0 serial data interface<br>Two pin sets to enable plug flipping |
| **Configuration** | **CC1, CC2** (receptacle)<br>**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 |



| 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 |

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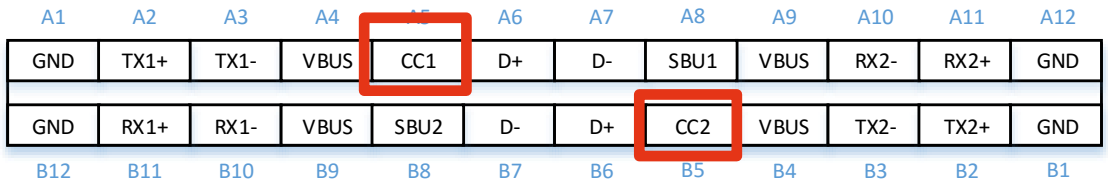


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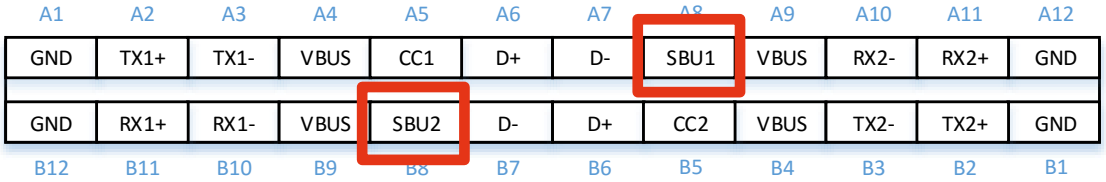


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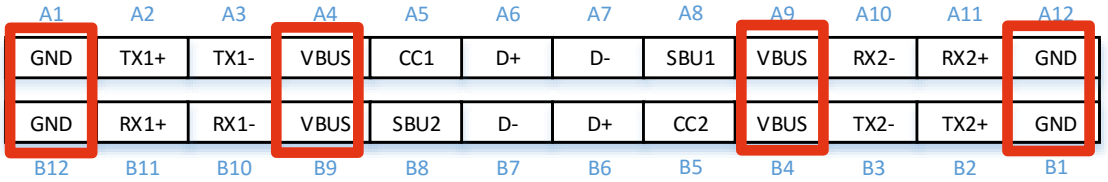


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# How does it work?

- Roles and cable orientation are determined by “CC” lines
  - Only 1 CC line is connected through the cable
  - DFP will provide a resistive pull-up (Rp) on both CC lines
    - Rp varies depending on current sourcing capability of DFP
    - 3 defined values: “default”, 1.5A and 3.0A
  - UFP will provide a resistive pull-down (Rd) on both CC lines
    - Rd is defined and fixed
  - When a DFP is connected to a UFP, each will see one CC line at an intermediate voltage
    - Which CC line tells both the cable orientation
      - Cable orientation could be different at each end
    - DFP then knows to turn on “Vbus” to supply power to the UFP
    - UFP knows the current capabilities of the DFP by the voltage level on CC

- Cable/dongle can put a different resistive pulldown (Ra) on the second CC line
  - DFP needs to distinguish between Rd (CC line that goes through) and Ra (CC line that doesn't go through)
- Ra tells the DFP that the cable/dongle needs power, independent of the Vbus power
  - Power called Vconn, supplied on the Ra CC line
  - DFP needs to provide 5v at up to 200mA for Vconn
    - Alternate modes can provide means for cable/dongle to ask for more than 200mA!
  - Vbus can vary from 5v to 20v, Vconn always remains at 5v
  - Used by an active cable, e.g., to power an integrated retimer
  - Used by a dongle, e.g., to power a DP to HDMI protocol converter

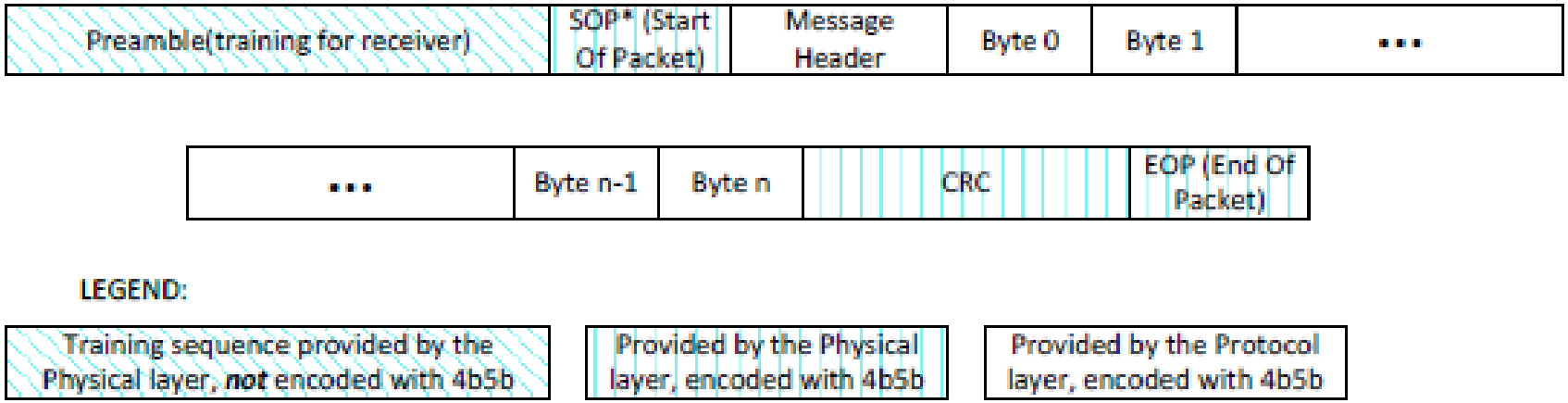
# Dual Role Ports

- Many devices are sometimes DFPs and other times UFPs
  - A laptop is a DFP to a mouse but a UFP to a charger
- When disconnected, DRP devices alternate Rp with Rd on the CC lines
  - 50ms or so switching rate
  - Specified to be inaccurate clocks to prevent synchronized switching between port partners
- Devices can express a preference to be a UFP or a DFP
  - A phone might be a DRP to work with a thumbdrive
  - Always wants to be a power sink when connected with most other DRPs, e.g., laptops

# But wait, there's more

- Once initial roles are established, USB-PD 2.0 can take over
  - USB-PD is optional
  - USB-PD signaled over the connected CC line once roles established
- USB-PD2.0 on Type-C uses Biphase Mark Coding (BMC) over the CC line
- Packets exchanged between port partners

Figure 5-3 USB Power Delivery Packet Format



# Packets…

- SOP, SOP’, SOP’’
  - “Start of Packet”
  - SOP are responded by port partner
  - SOP’ are responded by the near side connector
  - SOP’’ are responded by the far side connector
  - Device can poll cable for capabilities, e.g., current carrying ability
- CRC
  - Packets tested for integrity
  - Receiver must check packet integrity and respond within 1.1ms to avoid retransmit
- Messages and Responses all have SOP*, CRC and EOP

# What Can You Do With PD?

- Get more power!
  - Without PD, power supply limited to 3A@5V
  - With PD, UFP asks for power modes DFP supports
    - DFP responds with up to 7 Power Data Objects (PDOs)
    - These indicate voltage/current capabilities of power supply
      - Must also factor in cable capabilities!
    - Up to 5A@20V
  - The UFP and DFP can then negotiate a new “power contract”
    - UFP selects one of the offered PDOs

# What Else Can You Do With PD?

- UFP and DFP can swap Vbus power roles, Vconn power roles or data roles
  - Why? Devices and docks both are usually DRPs
    - System is a power source (DFP) to a device, e.g., a mouse or a thumb drive
    - System is a power sink (UFP) to a charger
    - System is a power sink (UFP) but a data host (DFP) to a dock
    - System is a power sink (UFP) but a data host (DFP) to a monitor
- UFP and DFP can agree on alternate modes
  - USB3 lanes can be repurposed for other things, e.g., DisplayPort

# And there is still more

- Aux modes are also supported
- Indicated by both CC lines pulled down to “Rd” or both lines pulled down to “Ra”
  - Cable orientation handled by alternate means
- Two are defined:
  - Analog audio aux mode
  - Debug aux mode
- Debug is interesting, analog audio less so

# Implementations

- Something needs to run the state machines
  - Some implementations use a dedicated microcontroller
    - Embedded flash to eliminate external program store
    - Straightforward solution to meeting latencies
  - Other implementations use OS drivers or other CPU code
    - Needs to operate when system is “off”
    - Potentially problematic timing with system load
- Something needs to mux the signals
  - High speed mux for USB3 cable orientation or USB-to-alternate mode function muxing
  - Can use multiple USB3 ports for USB3 cable orientation
- Industry support on the fast track:
  - TI, Cypress, Lattice, Pericom, Rohm, Analogix, DIY, …

# What Could Possibly Go Wrong?

- Tiny power supplies charging large devices
  - The connector fits so why isn't my laptop charging?
- Active cables and alternate modes
  - In the past, connectors defined cable capabilities…
- Asymmetric ports
  - Supporting all features on all ports adds incremental cost
  - One port may (will?) likely be used just for the power brick but
    - If one port is dedicated just for charging, how to you indicate
    - Different users might want to use different ports for charging
  - Similar arguments could be made for display
- User interface needs to help user understand behavior
  - Needs to help user understand USB "it just works" promise

# Questions?