USB Type C, DisplayPort and HDMI

Next Generation Mobile and Desktop Connectivity

“Everything is connected... no one thing can change by itself.” - Paul Hawken

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Mobile and Desktop A/V Connector Ecosystem

It’s helpful to envision physical layer A/V connectivity as “wheels inside wheels” with each successive layer encompassing more categories and bridging longer distances.
“The Past is to be respected and acknowledged, but not to be worshiped. It is our future in which we will find our greatness.” – Pierre Trudeau
## An Overview of Universal Serial Bus Technology

<table>
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<tr>
<th>Version</th>
<th>Year</th>
<th>Low Speed</th>
<th>Full Speed</th>
<th>High Speed</th>
<th>Super Speed</th>
<th>Super Speed +</th>
<th>Power Limit</th>
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<td>■</td>
<td></td>
<td></td>
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<td>2007</td>
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<td>■</td>
<td>You Won’t Believe Me!</td>
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USB “Pyramid” Topology

Host

Tier 2
Tier 3
Tier 4
Tier 5
Tier 6

Tier 7 - Functions

Host is tier 1 (inside the computer)

Tier 2 hub (typically inside computer)

Tier 3 may be a passive hub

Tier 4 may be a passive hub

Active Hub required here

Tier 6 may be a passive hub

This level is for the device, aka “function”
USB 1.1 & 2.0 and Time

• USB 2.0 is a half-duplex system that operates within rigid time constraints where hubs and functions must respond to the host within a tightly defined time frame.

• 5 Meter USB length limitation is derived from this time constraint.

• Velocity of propagation - the speed of transmission through a physical medium such as a cable or fiber.
Comparison of USB Connectors

USB 2.0 “A” and “B”

USB Type A and Micro B

USB 3.0 “A” and “B”
USB 3.0 – Dual Link and Eye Pattern
Power In The USB Environment

- USB specifies 5 V (+/-5%)
- Power is delivered in quanta of unit loads
- A single unit load is 100mA for USB 1.1
  - 150mA for USB 3.0 devices
- Low-power devices draw 1 unit load
- High-power devices may draw up to the maximum number of unit loads permitted (5) after negotiation
USB Battery Charging

Broad international adoption of USB Battery Charging standard for mobile devices

- China, Europe drove standardization as a means to increase charger reuse and reduce electronic waste

Agreement reached on Micro-USB connector and the standard for the common mobile charger

CENELEC and the USB Implementers Forum reach agreement on memorandum of understanding

BRUSSELS – March 1, 2011 – A Memorandum of Understanding (MoU) was signed today between the USB-IF and CENELEC, the European Committee for Electrotechnical Standardization.
Interactive Flat Panels Demand Power

- Most interactive flat panel displays require a full 5 unit loads of power at USB 2.0 speed for proper operation
- Bus powered (passive) USB extension solutions may result in unpredictable outcomes
Human Interface

• USB HID class describes devices used with nearly every installation
  – HID protocol is used unmodified in Bluetooth human interface devices
  – USB HID class is in Device Class Definition for HID 1.11
  – Many predefined functions exist in the USB HID class allowing for a “plug and play” experience

• HID devices almost never demand bandwidth beyond USB 2.0
USB 1.1 and 2.0 Connectivity

- Pin 1 Vbus
- Pin 2 D-
- Pin 3 D+
- Pin 4 Ground

- Pin 1 Ground
- Pin 2 USB OTG Address Bus
- Pin 3 D+
- Pin 4 D-
- Pin 5 Vbus

Type “A” Connector

Type “Micro B” Connector
USB On One End, HDMI On The Other

- Current installed base of more than 1.4 billion devices
- Established in 2010
MHL In The Market

• Leverages HDMI form factor
• Runs efficiently – uses less battery life than wireless connectivity
  – May even charge mobile devices during operation, design dependent
• Most displays and advanced switching/control solutions deploy MHL compliant HDMI ports
Series and Parallel
Understanding DisplayPort Topology

- **Power Return**
- **Aux**
- **Lane 0**
- **Lane 1**
- **Lane 2**
- **Lane 3**

- +3.3V @ 500mA
- **Hot Plug**
- **Config**
Understanding HDMI Connector Topology
Transition Minimized Differential Signaling

- TMDS adds a 9th bit to the digital word to “minimize” the transitions from digital ones to digital zeros
  - This decreases high frequency content making the signal more robust and easier to transport
- The algorithm then adds a 10th bit to provide for DC balancing
  - DC balancing inverts the digital word so the signal has an equal number of zeros and ones
  - Provides a stable, predictable signal to the differential amplifiers
DisplayPort 1.2 “Speaks” HDMI

- Native MST for extended desktop and multi-display installations
- Up to 8.1 Gbit/s per lane
  - Dual lane allocation supports UltraHD resolutions
- Supports RGB And YPrPb Color Space
  - W/ up to 8-channels embedded audio
- *DisplayPort 1.1, not 1.2, is embedded in new USB Type-C*
Interface Using Dual-mode adapter

PC System

Notebook PC Motherboard or Video Subsystem

Video / Graphics Processing Unit (GPU)

Dual-mode DisplayPort Source Function

DisplayPort Interface

TMDS Data

TMDS Clock

DDC

HPD

Adapter Detect

CEC

Power

3.3 V @ 500mA

DisplayPort Plug with or without short cable

Dual-mode DisplayPort Video Adapter

Voltage Shifter

DVI or HDMI Receptacle

DDC Buffer w/ HDMI Det

3V to 5V Converter

Standard DisplayPort or Mini DisplayPort Receptacle
“The cloning of humans is on most of the lists of things to worry about from science, along with behavior control, genetic engineering, transplanted heads, computer poetry and the unrestrained growth of plastic flowers.”

– Lewis Thomas
The A/V “Unicorn”

“USB Type-C is the physical “form factor” and more..."

“This next generation of USB technology opens the door for the invention of an entirely new, super thin class of devices that consumers haven’t even seen yet”

- Designed for 10,000 plug/unplug cycles
- Robust enough for laptops and tablets; slim enough for mobile phones
Apple, Google, Microsoft...
USB Type-C Pin Out

High Speed Data Path (TX for USB, or for DP Alt Mode)

<table>
<thead>
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<th>A1</th>
<th>A2</th>
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</table>

USB 2.0 Interface

Cable Ground

Cable Bus Power

For Sideband Use (not used for USB)

Plug Configuration Detection
- One becomes $V_{CONN}$, for cable or adaptor power
- CC is used for USB-PD communication
Alternate Mode

USB Host or Device with DisplayPort Alternate Mode Capability.

USB 3.1 Data
USB Power Delivery
DisplayPort A/V

USB Type-C to Type-C Cable.
What Can Alternate Mode Do?

“Any sufficiently advanced technology is indistinguishable from magic.”

– Arthur C. Clarke
MHL Via USB Alternate Mode
MHL & superMHL Connections
USB Type-C to Legacy Mode Adapter Cables / Cable Adapters

- Utilizes DisplayPort Alt Mode capability of Type-C connector
- Adapter Cable: Type-C plug on one end, legacy plug on other end
- Cable Adapter: Type-C plug on one end, legacy receptacle on other end
- HDMI Adapter Cable takes advantage of new HDMI “direct connect Source” provision
- USB Type-C will NOT support DisplayPort Dual Mode (DP++)
- All certified Type-C to HDMI Converters will support HDMI 2.0
USB Type C Adapter Cables

- Type-C to Type-B
- Type-C to DisplayPort
- Type-C to Micro-B
- Type-C to Type-A
USB Battery Charging Is Now USB Power Delivery

Extend ease of use, reduce clutter, reduce even more waste
USB Power Delivery Profiles

**PROFILE 0**
Reserved

**PROFILE 1**
5V @ 2A
10W
Default start-up profile

**PROFILE 2**
5V @ 2A, 12V @ 1.5A
18W

**PROFILE 3**
5V @ 2A, 12V @ 3A
36W

**PROFILE 4**
5V @ 2A, 12V, 20V @ 3A
60W
Limit for Micro-B/AB connector

**PROFILE 5**
5V @ 2A, 12V, 20V @ 5A
100W
Limit for Standard A/B connector

Requires new detectable Cables for > 1.5A or > 5V
Marker and Billboard Chips

- Interconnects and devices will use embedded marker and billboard chips to ensure all devices can handle proposed power levels.
Alternate Reality...

• Pop up menu shows potential USB Type-C connection choices and modes
• Includes support for external MIDI devices like keyboards.
  - Builds on some of the audio features Google introduced in Lollipop, including a reduction in latency, multichannel audio stream mixing, and support for USB microphones, amplifiers, speakers, and other accessories.
• USB Type-C can support analog ear buds and a microphone (TRRS) for hands-free operation. It will do this through the Alternate Mode channel.
A Final Thought To Take With You...

“If it works, it’s obsolete” – Marshall McLuhan