DEVELOPED BY YOU
IDF15 INTEL DEVELOPER FORUM
Thunderbolt™ 3 Technology and USB-C

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HSTS004
Agenda

• USB-C Introduction

• Thunderbolt™ 3 Technology Overview

• Key User Experiences

• Thunderbolt Device Development

• USB-C Alternate Mode and Power Delivery

• Summary
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• **USB-C Introduction**

• *Thunderbolt™ 3 Technology Overview*

• **Key User Experiences**

• *Thunderbolt Device Development*

• **USB-C Alternate Mode and Power Delivery**

• **Summary**
USB-C Cables and Connectors

- Symmetric and Flip-able/Reversible
- Power delivery up to 100W of power - 20V at 5A
- Supports Alternate Modes – DisplayPort*, Thunderbolt™, Audio etc.

Thunderbolt 3 is bringing Thunderbolt to USB-C
More Speed

• **40Gbps** Thunderbolt™ 3
  - Bi-directional, PCI Express® and DisplayPort*
  - Four lanes of PCI Express Gen 3
  - Eight lanes of DisplayPort 1.2

• Native **USB 3.1** (10Gbps)

• Native **DisplayPort 1.2**
Thunderbolt™ 3 Brings Thunderbolt to USB-C

The USB-C that does it all.

- More Speed: 40 Gbps – fastest connection
- More Protocols: THUNDERBOLT, USB, DisplayPort, PCI EXPRESS
- More Pixels: Dual 4K displays 60hz
- More Power: 100W charging, 15W device
Not all USB-C Computer Ports Will be Equal

<table>
<thead>
<tr>
<th>USB 2.0</th>
<th>USB 3.1</th>
<th>USB 3.1</th>
<th>DisplayPort* Multi-Function 5 (or) 10 Gb/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>480 Mb/s</td>
<td>5 Gb/s</td>
<td>10 Gb/s</td>
<td>5 (or) 10 Gb/s</td>
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<tr>
<td>PD Enabled</td>
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More Protocols

More protocols than any other I/O controller

Connect any dock, device or display, including billions of USB devices
Thunderbolt™ 3 - Host Mode

- Connected through PCI Express® (PCIe) switch to Host PCIe bus
- Always functions as a Host USB controller
  - Appears in host Device Manager even if located in a dock or device
Thunderbolt™ 3 – USB 3.1 Host Mode
Thunderbolt™ 3 – Thunderbolt/USB 3.1 Host Mode

Each Thunderbolt port is configured independently.
Thunderbolt™ 3 DisplayPort* Host Mode

Thunderbolt Switch

PCI Express® (PCIe) Switch

xHCI Controller

Host DMA

Link Controller

Thunderbolt Phy

DisplayPort* 1.2

2x DP 1.2 In (x4)

PCIe x4 Gen 3

DP In Phy

DP In

DP In Phy

DP In

Active Path

Inactive Path

Active Block

Inactive Block
More Pixels

Large displays with amazing detail

- Twice the video bandwidth of any other cable
- Single-cable connection for two 4K 60Hz or a 5K 60Hz display
- 2 streams (eight lanes) of DisplayPort\* 1.2
More Power

100W System Charging
For single-cable docking

15W to bus-powered devices
- Higher speed and capacity storage
- Portable displays
- High-performance adapters
Thunderbolt™ Daisy-Chain

Daisy-chain up to six Thunderbolt devices

Open Thunderbolt port operates the same as computer port and supports Thunderbolt, USB, or DisplayPort* devices
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4K Video

External Graphics

Single-cable Docking

Thunderbolt™ Networking
Thunderbolt™ 3 Delivers Best Docking over USB-C

Single-Cable Docking
• 40Gbps Data + 4K Video + 100W PC Charging
• Only way to get 4K + data from one USB-C connection
• Two uncompressed 4K displays
Thunderbolt™ 3 External Graphics

External graphics solution that supports hot plug & surprise removal of cable on dedicated PC-device

• External graphics can connect to external monitor, or be routed back to notebook screen

Graphics Dock

USB 3.0, GbE, Discrete Graphics with HDMI*, VGA

Standalone Graphics

150-200W discrete graphics card for premium gaming

All information related to future Intel products and plans is preliminary and subject to change at any time, without notice.
Thunderbolt™ Networking with Thunderbolt 3

- Peer-to-Peer communication between computers
- Bridging or routing between multiple computers
- Behaves as if systems were connected with Ethernet
  - Uses existing OS network and sharing infrastructure
    - File, print, share internet connection, etc...
- Connect Mac*/PC/Linux* to Mac/PC/Linux

Only PC I/O to offer 20Gbps network data transfer speed
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Thunderbolt™ 3 Peripheral Device Targets

Device Categories

- **Docks**
- **Displays**
- **Storage**
- **Cables**
  - Thunderbolt™ 20Gbps and 40Gbps
  - USB-C to USB Type-B, Type-A and Micro-B, DisplayPort®, mDP, HDMI®
- **Adapters**
  - Thunderbolt 3 to legacy Thunderbolt (based on mDP)
  - Dual video and more
- **Audio/Video**
- **NAS**
Thunderbolt™ 3 Dock – Connect to PC with One Cable

Showing max bandwidth for each protocol listed - many other protocols are possible depending on dock configuration (eSATA*, card slots, Firewire*, HDMI*, WiGig*)

Source of performance measurement: Intel testing in Intel lab. Other developers may receive different results. Diagrams for marketing purposes only, see IBL for specific details. All products, designs, computer systems, dates and figures specified are preliminary based on current expectations, and are subject to change without notice.
**Full x4 PCI Express® Gen 3 Bandwidth to Device**

- **Intel SSD 730 Series SATA**: ~450MB/s
- **Thunderbolt™ 3**: ~2400MB/s
- **Thunderbolt 2**: ~1200MB/s
- **USB 3.0**: ~700MB/s
- **Thunderbolt 3 External Storage Device using Intel® SSD 750 Series (NVM Express™)**

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*Thunderbolt™ Technology*
Thunderbolt™ 3 Base Design for Devices

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Thunderbolt™ Cables

• **Passive lower cost cables will support Thunderbolt™ at 20Gb/s**
  - Low cost cables will be adequate for many Thunderbolt devices
  - Lengths up to 2.0m

• **Thunderbolt active cables will support Thunderbolt at 40Gb/s**
  - Needed for high-performance docking with 4K displays and storage, and enthusiast-level external graphics
  - Lengths up to 2.0m

• **Optical Cables will support Thunderbolt at 40Gb/s**
  - Targeted for 2016 with lengths up to 60m
How to Become a Thunderbolt™ Developer

• Visit
  thunderbolttechnology.net

• Submit Application Form
  thunderbolttechnology.net/developers
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TPS65982 Handles HV Charging
System Concerns – Charging from VBUS

- System power must meet the positive voltage transition spec
  - Dip is allow at the beginning of the transition
    - Must not drop vSrcValid (min) USB 2.0/3.1
  - Must be monotonic when transitioning

- System power must meet the negative voltage transition spec
  - Dip is allow at the end of the transition
    - Must not drop vSrcValid (min) USB 2.0/3.1
  - Must be monotonic when transitioning

- Pull down circuit may be implemented for negative slew rate
USB Power Delivery Contract Example

Scope Capture w/ TPS65982 Firmware
(One DFP as a Dock & One UFP as a Notebook)

- DFP & UFP establish a PD power contract
- DFP send source capabilities and UFP will send back sink capabilities
- PD contract established VBUS changes to 20V
- DFP enters Discovery Mode
### Features

- Supports all USB-C High Current Modes
  - Integrated Port Power Switches up to 20V @ 3A
  - Supports bi-directional external power NMOS FETs
- Fully compliant USB PD Baseband modem per USB PD2.x
  - BMC encoder/decoder
  - Physical Layer with CRC
  - Policy and Policy Engine
- Performs all CC pin functions
  - Cable Detection and Cable Orientation
- Integrated HS Mux
  - CC/2, SBU1/2, USB TP/TN, USBBP/BN
  - Support for Guest Port Protocols
    - DisplayPort™, Thunderbolt™
- Flexible system interfaces
  - I2C Slave/Master, SPI, Simple connection to HD3SS460 SS Mux for Display Port/USB3.0
- Easy to use 6 x 6 mm uBGA ZQZ 96pin, 0.5mm pitch

### Applications

- Notebook / Desktop Computers
- Dock / Camera / Storage / Tablet / TV / Monitor
- Power Management System

### Benefits

- Fully Integrated USB-C and PD Solution
  - No additional discrete components needed for full CC Function
  - No additional components needed for Power Paths up to 20V @ 3A
- Compliant to the USB-C 1.x and USB PD 2.x Specifications
- Configurable as either a Downward Facing Port, Upward Facing Port or Dual Role Port
- Integrated USB Endpoint
- Industry’s smallest solution size

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**TPS65982** | **USB-C Port Power Switch with USB-PD Controller & HS Mux**

**Available Now**

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**TPS65982**

**Host Interface**

**High Speed Mux**

**Alternate Mode Mux Ctrl**

**USB PD Controller**

**Type-C Cable Detection**

**CC1/2**

**VBUS**

**D+/D−, VBUS**

**SBU1/2**

**USB, UART, & Side-Band Data**

**SuperSpeed Mux**

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**Texas Instruments**
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Summary

• Thunderbolt™ 3 is a premium I/O controller that supports 3rd Gen Thunderbolt, USB 3.1 and DisplayPort® 1.2

• Thunderbolt 3 will adopt the USB-C connector as the Thunderbolt connector for future generation designs
  - Small form factor, standard, and high volume
  - One connector for charging, power delivery, USB, video, and Thunderbolt

• Key user experiences are 4K video, single wire docking, Thunderbolt networking and external graphics

• Texas Instruments provides a complete power delivery solution
**Additional Sources of Information**

- A PDF of this presentation is available from our Technical Session Catalog: [www.intel.com/idfsessionsSF](http://www.intel.com/idfsessionsSF). This URL is also printed on the top of Session Agenda Pages in the Pocket Guide.

- Come and see our demos in the Intel Computing Innovation Exhibit located on the 2nd floor concourse

- Additional info in the Thunderbolt™ Community – Booth #’s 931-942

- More web based info: [www.thunderbolttechnology.net](http://www.thunderbolttechnology.net)

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Intel® Compute Stick (20)

**Day 2 Prize**
Microsoft* Surface* 3 (6)

**Day 3 Prize**
Dell Venue 10 7000 Series (4)

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Rev. 4/14/15
Backup
# New Thunderbolt™ 3 Branding

<table>
<thead>
<tr>
<th>Name</th>
<th>Logo</th>
<th>Icon</th>
<th>Port Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thunderbolt™ 3</td>
<td><img src="image" alt="THUNDERBOLT™ Logo" /></td>
<td><img src="image" alt="Icon" /></td>
<td><img src="image" alt="Port Placement" /></td>
</tr>
<tr>
<td>Generation Rev</td>
<td></td>
<td>No change</td>
<td></td>
</tr>
</tbody>
</table>
USB-C & Thunderbolt™ Lane Bonding

- **USB-C connectors provide 4 high-speed differential signal paths clockable up to 20 Gbps each**
- **Thunderbolt™ 3 controllers bond two lanes in each direction at 10 Gbps or 20 Gbps to create either two 20 Gbps or 40 Gbps links, enabling high-speed data transfers in each direction simultaneously**