

Thunderbolt 3

Training

Let MindShare Bring Thunderbolt 3 to Life for You

Thunderbolt 3 is an Intel hardware interface standard that provides a method for delivering multiplexed PCI Express and Display Port data as well as up to 100W of dc power—all using a single cable between attached devices, a host computer and dock, etc. Thunderbolt 3 employs the same USB-C (USB Type-C) interconnect already migrating into devices ranging from cell phones and tablets up to large workstations and servers. Present at each Thunderbolt 3 port is an Intel *Alpine Ridge* controller. Depending on the capabilities of attached devices and cables, the actual IO protocol used on a specific port may be Thunderbolt 3, USB 2.0/3.1, or another supported USB-C alternate mode. The fact that multiple IO protocols are possible adds complexity to the scenarios a user may encounter when making device connections. This complexity is compounded by power delivery and the many variants of active and passive USB-C and Thunderbolt 3 cables—all of which are similar in appearance, but have different protocol, speed, and power capabilities.

The goal of this course is to describe the scope and basic elements of Thunderbolt 3. Where appropriate, demonstrations are used to shed light on the capabilities and key hardware/software features.

You Will Learn:

- Thunderbolt features
- Thunderbolt applications
- Intel Thunderbolt Controller (Alpine Ridge) architecture
- Thunderbolt port (USB Type-C) architecture
- Thunderbolt port initialization
- Power Delivery messaging
- Thunderbolt 3 Electronically Marked Cable Assembly (EMCA)

Course Length: 2 Days

Course Outline:

- Background
 - Problem addressed by the original Thunderbolt
 - Thunderbolt 2 enhancements
 - Thunderbolt 3 motivations and key features
 - Important Thunderbolt 3 applications
 - 4K (and higher resolution) video monitors
 - External graphics
 - Docking (single cable)
 - Networking
 - Mass storage
 - Key specifications
 - Thunderbolt 3 Specification (Intel proprietary)
 - USB-C Cable and Connector Specification (usb.org)
 - USB Power Delivery Specification (usb.org)
 - Display Port 1.2 (vesa.org)
 - USB Type-C Authentication Specification

- The Thunderbolt 3 USB-C Port
 - 24 pins, small form factor
 - Reversible cable and plugs
 - Port and cable signal groups
 - Signal repurposing in alternate modes
- Thunderbolt 3 Controller (Alpine Ridge)
 - Supported port protocols
 - Alpine Ridge controller logic and PCI functions
 - Alpine Ridge controller host and device modes
 - **Demo: Arbor scan of Thunderbolt 3 controllers and attached devices**
- If Port Operates in Thunderbolt 3 USB-C Alternate Mode
 - Alpine Ridge controller at both host and device ends of the link
 - Power delivery message negotiation required to enter Thunderbolt 3 USB-C alternate mode
 - 20 Gb/s or 40 Gb/s bus bandwidth
 - Multiplexed PCI Express (PCIe) and Display Port (DP) Data
 - Bandwidth sharing, traffic prioritization, performance considerations
 - PCIe Gen3 protocol basics
 - Display Port 1.2 protocol basics
 - **Demo: Arbor scan of Alpine Ridge controllers and attached devices**
- If Port Operates in USB 2.0/3.1 Mode
 - Support for all five USB protocols/speeds (10 Gb/s maximum speed)
 - Integrated xHCI USB host controller per Alpine Ridge controller
 - Two xHC root hub ports are available if USB device attached at either Alpine Ridge port receptacle
 - xHC appears to software as an integrated PCIe function
 - Overview of xHC operational model
 - **Demo: Arbor scan of Alpine Ridge xHCI host controller**
- If Port Operates in Display Port 1.2 USB-C Alternate Mode
 - Thunderbolt 3 to Display Port Adapter (captive cable)
 - Power delivery message negotiation required to enter Display Port USB-C alternate mode
- Thunderbolt 3 Electronically Marked Cable Assembly (EMCA).
 - Power Delivery (PD) message software interface
 - Cable characteristics and options
 - **Demo: Analyzer capture of PD messages between host and cable electronics**
- Thunderbolt 3 Port Initialization
 - Attachment/removal and cable/plug orientation
 - Default port roles and VBUS source/sink and current offering
 - Initial power delivery contract negotiation
- USB Power Delivery (PD) Sideband Messaging
 - Standard and vendor-defined messages (VDMs)
 - Negotiated VBUS power contract (up to 100 W)
 - Discovery of host, cable, and device capabilities
 - Authentication
 - PD message USB-C alternate mode entry/exit (e.g. Thunderbolt 3)
 - **Demo: Analyzer captures: PD message power contract negotiation, alternate mode entry**

Recommended Prerequisites: none.

Course Materials:

Students will be provided with an electronic (PDF) version of the presentation