WHITE PAPER

USB-C®: A True Reality in Pro AV Integration

1st edition

Atlona® | 2025

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USB-C: A True Reality in Pro AV Integration

1st edition

Introduction

Without a doubt, USB-C® is a very hot topic in the professional AV industry. It's the most significant AV interface since the dramatic rise of HDMI® two decades ago. The persistent growth of the HDMI interface ultimately led to the displacement of analog video in our industry.

Today, USB-C in computers and mobile devices is fast approaching ubiquity as a unified interface for USB data, video and audio, power, and other applications. As a result, for AV system design USB-C is an essential connectivity option alongside HDMI. And in fact, for many laptops today you'll find USB-C ports but no HDMI interface (the MacBook Air® and Microsoft® Surface Laptop are great examples).

USB-C is also very important in pro AV because of the widespread usage of USB data communications, which are now just as vital as video presentation in applications such as video conferencing and hybrid meetings.

What is USB-C, anyway?

USB-C, formally known as **USB type C**, is an industry-standard **connector** for USB-equipped devices. It's the latest in a long line of USB connectors that include USB type A and USB type B, among others.

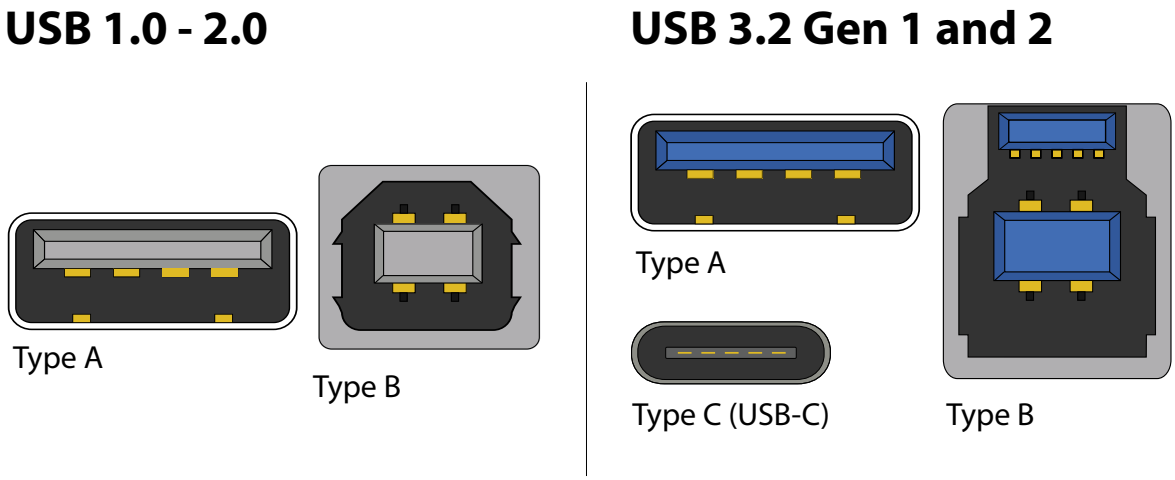


Figure 1 – USB port types commonly encountered in pro AV products.

Here are the important attributes and advantages of USB-C:

- Compared to USB type A and USB type B, USB-C has a slimmer, more compact profile designed for the low-profile devices commonly seen today.
- The USB-C connector is reversible, so that orientation does not matter when connecting into a port.
- It is designed for high density and high bandwidth data transfer, and as a result has been adopted for Thunderbolt™ as well as USB.
- USB-C includes a **DisplayPort™ Alternate Mode** for carrying video, which is prevalent in pro AV products.
- Up to 240 watts of power is possible for charging laptops through the **USB Power Delivery** standard.

USB-C has replaced the USB type A connector in many peripherals such as keyboards, microphones, and webcams, as well as in chargers and automobiles. On some desktop monitors and USB hubs, you'll find that it has replaced the USB type B host interface for connecting to a computer.

Ultimately, USB-C is expected to supersede all other USB connectors. Nonetheless, it is expected that multiple USB interfaces will co-exist into the future. You will commonly encounter USB-C, USB type A, and USB type B ports in pro AV products.

USB-C and USB standards

USB-C has frequently been associated with the USB 3.x standards. However, it is important to emphasize that USB-C is a connector, not USB as the technology standard, which specifies the interface, data transfer protocol, and power delivery between hosts (usually computers), peripheral devices, and hubs.

Table 1 lists all of the USB standards defined to date by the USB Implementers Forum (USB-IF). USB-C is associated with all of them except USB 1.0 and 1.1. In the pro AV industry, USB 2.0 and USB 3.2 Gen 1 are the most relevant standards. USB 2.0 is overwhelmingly the standard most frequently in use, while specialized applications are beginning to emerge for USB 3.2 Gen 1. Also perhaps worth noting is that USB in general has been part of AV system integration for over a decade.

USB-C: A True Reality in Pro AV Integration

1st edition

Standard	Year introduced	Alternate names	Supported data rate*	USB connector(s)	Cable length**
USB 1.0 **USB 1.1**	1996 1998	Low-Speed USB Full-Speed USB *Also known as Basic-Speed USB*	1.5 Mbps 12 Mbps	USB type A USB type B	5 meters (16 feet)
USB 2.0	2000	Hi-Speed USB	480 Mbps	USB type A USB type B USB Micro A USB Micro B USB Mini A USB Mini B USB-C	5 meters (16 feet)
USB 3.2 Gen 1	2008 (as USB 3.0) 2013 (as USB 3.1)	USB 5Gbps USB 3.2 Gen 1×1 *Previously known as: SuperSpeed USB, USB 3.0, USB 3.1 Gen 1*	5 Gbps	USB type A USB type B USB Micro B USB-C	3 meters (9 feet)
USB 3.2 Gen 2	2013 (as USB 3.1)	USB 10Gbps USB 3.2 Gen 2×1 *Previously known as: SuperSpeed+ USB, SuperSpeed USB 10Gbps, USB 3.1, USB 3.1 Gen 2*	10 Gbps	USB type A USB type B USB Micro B USB-C	3 meters (9 feet)
USB 3.2 Gen 1x2	2017	USB 10Gbps	10 Gbps	USB-C	3 meters (9 feet)
USB 3.2 Gen 2x2	2017 (as USB 3.2)	USB 20Gbps *Previously known as: SuperSpeed USB 20Gbps, USB 3.2*	20 Gbps	USB-C	3 meters (9 feet)
USB4 Version 1.0	2019	USB 20Gbps USB 40Gbps USB4 Gen 2x2 USB4 Gen 3x2	20 Gbps 40 Gbps (optional)	USB-C	0.8 meter (2.6 feet)
USB4 Version 2.0	2022	USB 80 Gbps USB Gen 4	80 Gbps 120 / 40 Gbps	USB-C	0.8 meter (2.6 feet)

* USB 1.0 / 1.1 and USB 2.0 data rates are for half-duplex operating mode. Full-duplex operating mode applies to all successive USB standards.

** Nominal lengths for passive cables. Longer lengths are possible with active cables, or active optical cables.

Table 1 – Summary of USB standards from USB 1.0 to USB4 Version 2.0.

Confusion in standards naming

If you look again at Table 1, you will notice that USB standards have a primary name, together with alternative names, including some that are deprecated. For example, what is known today as USB 3.2 Gen 1 was widely known as USB 3.0 and SuperSpeed USB, both which are now officially retired along with USB 3.1 Gen 1. (The USB-IF has discontinued all instances of the SuperSpeed branding.)

Yes, this is confusing because all these names mean the same thing. USB 3.2 Gen 1 is the latest and correct name to use. However, you will find USB 3.0 and SuperSpeed USB continue to be referenced in product descriptions, specifications, and logos, as well as legacy USB 3.0 products and cables. You may also see arbitrary variations of these names. The USB 5Gbps branding is more recent, likely to be found on packaging for USB cables certified by the USB-IF.

How USB-C is used in pro AV

As an AV input

USB-C commonly serves as an AV input into a switcher or matrix switcher alongside HDMI. It can also be part of a multi-input HDBaseT transmitter or AV over IP encoder. For many of these products, the USB-C port serves only as an AV input, with no support for USB data. The video over USB-C is DisplayPort, or to be more exact to the USB-C specification, DisplayPort Alternate Mode (or simply DisplayPort Alt Mode).

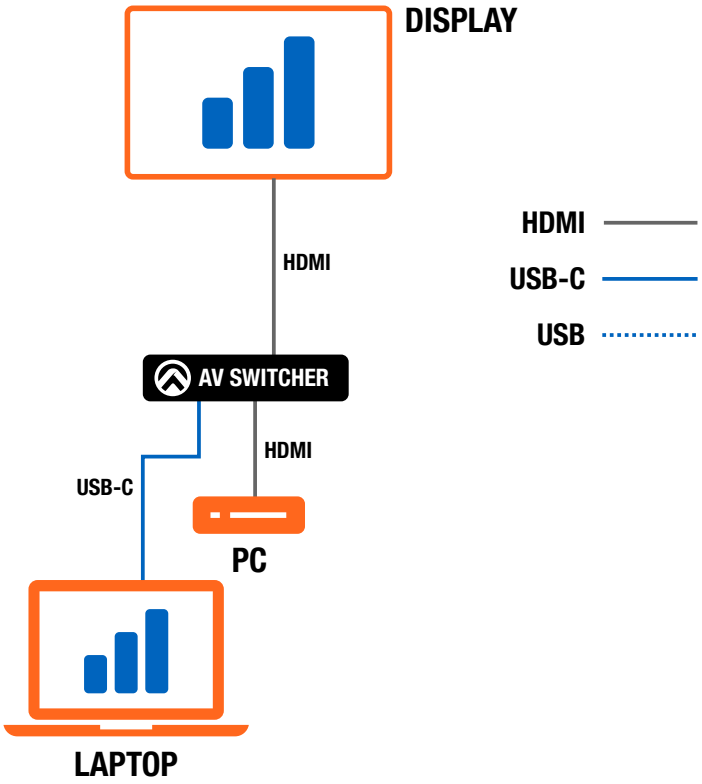


Figure 2 – AV switcher with USB-C and HDMI inputs for AV.

For DisplayPort Alt Mode, the high-resolution video capability is much like HDMI, up to 4K/60 4:4:4, with support for HDR formats at 4K or 1080p resolution. Pro AV products generally support DisplayPort 1.2, 1.3, or 1.4 over USB-C.

AV input and USB data communications

Some products with USB-C for AV input also have a built-in USB hub. In this case, the USB-C also supports USB data communications between a host PC connected to it, and any peripherals connected to the hub. This is happening alongside the AV delivered from the PC via DisplayPort Alt Mode. Additionally, the USB-C interface may also support Ethernet pass-through.

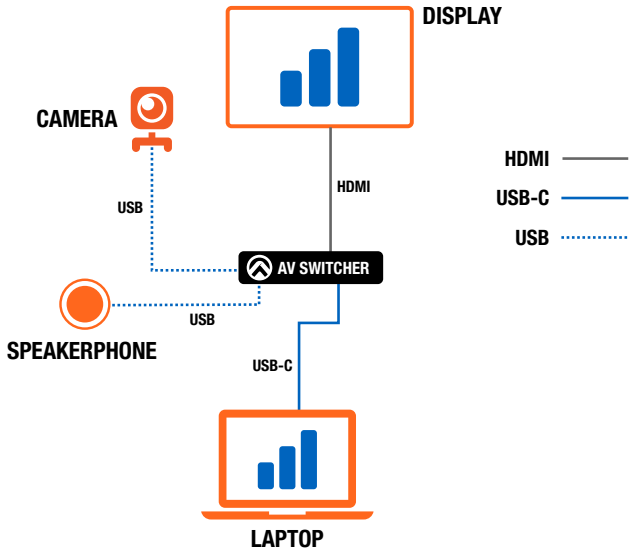


Figure 3 – AV switcher with USB-C input and a built-in USB hub.

In addition to a built-in USB hub, some AV switchers also provide for switching between two or more USB hosts. They may include a USB-C AV input, and a USB type B host port assigned to an HDMI input. The host selected has access to the USB hub. This is a beneficial feature in meeting applications to allow sharing the camera, soundbar, interactive display or other device between two or more participants.

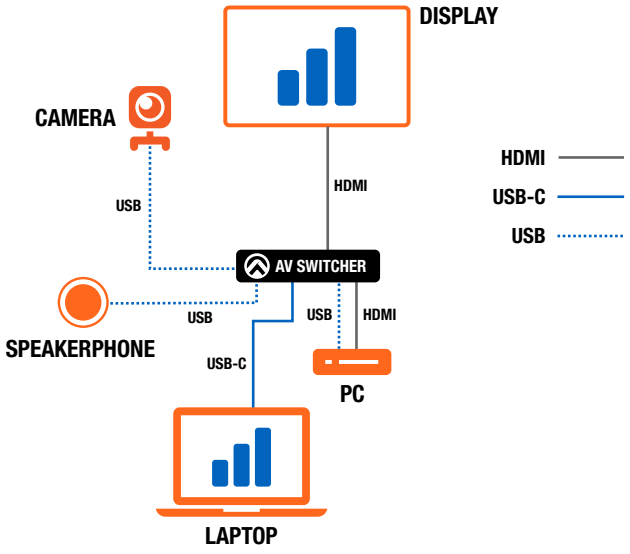


Figure 4 – AV switcher with the ability to switch between two USB hosts.

Extending USB signals

USB-C can be found in some HDBaseT extenders for USB data, and network interfaces for extending or distributing USB data over Ethernet, up to a maximum distance of 100 meters or 330 feet with Category network cable. For some AV switchers with USB-C input and USB integration, including the Atlona **Omega™ Series**, USB data can be extended over HDBaseT, together with video and audio to a receiver, making a long-distance connection to its own USB hub.

A major benefit of an extender for both AV and USB is that just a single Category twisted pair cable allows a laptop at a meeting table or lectern to interface with a display, plus a USB camera or conferencing bar at another end of the room. It's the reason why this type of extender is so extensively used in meeting rooms and classrooms.

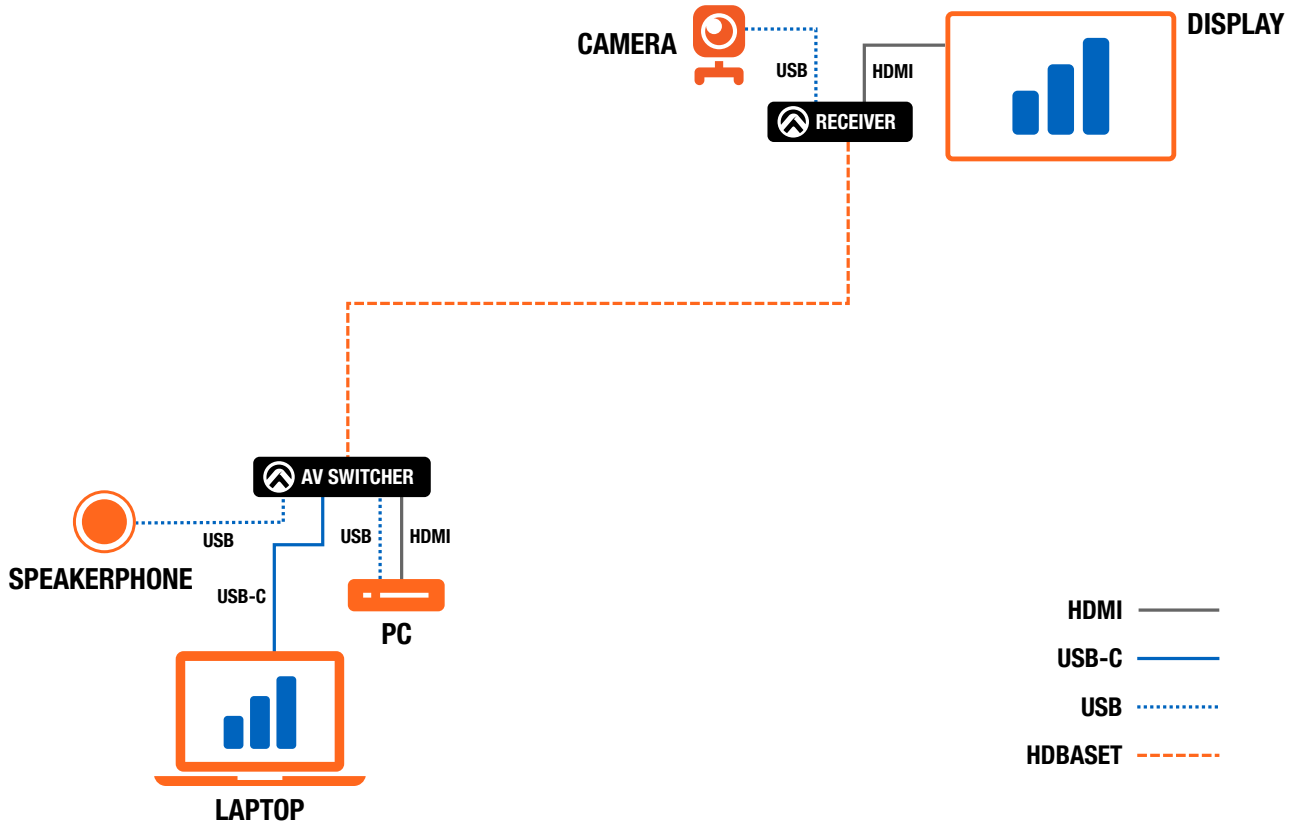


Figure 5 – AV switcher with HDBaseT extension of AV and USB to a display.

Powering and charging mobile devices

Many AV products with USB-C can supply power to a laptop or mobile device connected to the port. They support the USB Power Delivery standard and typically provide at least 60 watts for battery charging.

A single-cable convenience

Taken together, a single USB-C cable can carry video and audio, USB data, and power between a laptop and a USB-equipped AV system. This is most useful for BYOM (bring your own meeting) applications when the AV system is connected to video conferencing USB peripherals including a camera, microphone, speakerphone or conferencing bar. A meeting participant can simply connect a USB-C cable to the laptop to host a webinar or conduct a hybrid meeting.

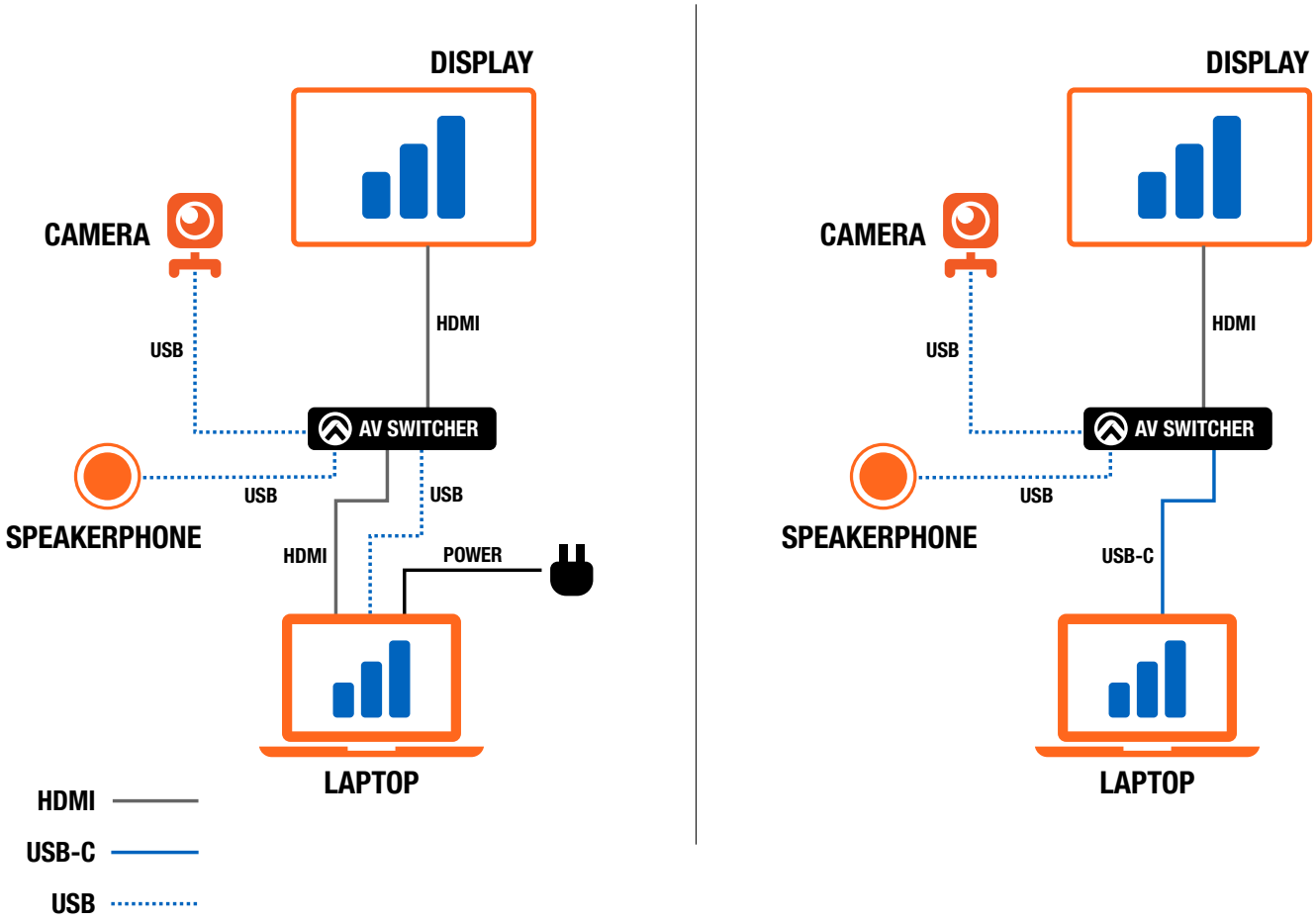


Figure 6 – USB-C simplifies AV, USB, and power to a single cable connection.

It is perhaps worth mentioning that for pro AV products, it is not common to find USB-C as an AV output. For displays and projectors, HDMI remains the predominant video input. However, you will find USB-C in desktop monitors for video, along with USB data, power, and in higher-end models, Thunderbolt.

The history of Atlona and USB-C (plus USB)

Atlona was among the first in the industry to offer a product for AV and USB integration with the AT-UHD-HDVS-300-KIT in 2016. This product included USB extension over HDBaseT, and an industry first: combined AV and USB host switching. We made the decision to incorporate USB into AV products, in response to the rise of video conferencing with software codecs that utilized USB webcams and speakerphones.

AT-UHD-HDVS-300-KIT
Soft Codec Conferencing System

It was in the mid-2010s that the first computers emerged with a USB-C port, notably the MacBook, shortly after the introduction of USB-C in 2014. With the ability to support USB data, AV, and charging over the same interface, we immediately saw the potential for USB-C in the pro AV industry, and developed what would become the AT-UHD-SW-510W in 2017 – the industry's first product with USB-C as an AV input (plus 60 watts power for a laptop).

Since then, Atlona has developed numerous pro AV solutions with USB and USB-C interfacing. Today, the Omega™ Series is the industry's most comprehensive lineup of USB-C equipped products for AV systems.

OMEGA™

Pro AV considerations for USB-C and USB

A major challenge in successfully integrating USB into AV systems, including USB-C, is the consideration of many different factors relevant to the complex nature of USB. To say that USB is technically complicated is quite an understatement.

Here, we aim to provide a series of high-level overviews to help facilitate a basic understanding of USB in relation to pro AV integration. They can then serve as a starting point for further research and education.

USB-C capabilities and product features

Let's begin with selecting the right USB-C equipped product for your needs. Are you looking to just deliver AV from a laptop's USB-C port? Or do you also need to interface with USB peripherals for video conferencing?

And, do you think users will want to be able to charge their laptops while plugged into an AV system?

You'll want to look closely at the information provided for an AV product, and check whether the USB-C interface is identified for video and audio input but no USB data, or if both AV and USB data are mentioned.

If device charging is important, then you'll also want to look for at least 60 watts of power delivered over USB-C.

For example, for the Atlona **AT-OME-SW32** product page, you will find this feature bullet clarifying that the USB-C input is only for AV:

- USB-C input for AV (does not support USB data or device charging)

On the other hand, the Atlona **AT-OME-MS42-HDBT** page indicates that the USB-C interface is fully featured for AV, data, and power.

- USB-C input for AV, USB data, and device charging (up to 60 watts)

Note that some USB-C equipped AV products will require purchase of an optional power supply to charge a laptop. If so, this should be clearly indicated in the product information.

Beware that not all USB-C ports are created equal. For example, you may encounter ports only intended for firmware management, or to connect a power supply. Or, a USB-C port may be specifically for a keyboard or mouse which operates at low data rates (up to 12 Mbps). Such a port may be labeled as "KVM," "HID," or similar.

Always check the port labeling and product specifications to confirm the functionality of a particular USB-C interface.

USB specifications and limitations

As previously mentioned, the USB specifications most relevant to the pro AV industry are USB 2.0 and USB 3.2 Gen 1. The USB-C interface supports both standards simultaneously.

USB 2.0 defines data rate capability up to 480 Mbps. USB 2.0 hubs, including those built into AV products theoretically support up to 480 Mbps.

USB 3.2 Gen 1, with theoretical data rate capability up to 5 Gbps, is emerging in the form of cameras, USB hubs built into AV switchers, and point-to-point extenders. (It should be noted that for USB 2.0 and USB 3.2 Gen 1, real-world data rates will always be somewhat lower.)

The foreseeable use case for USB 3.2 Gen 1 is capture and extension of 4K camera content (USB 2.0 is limited to HD resolutions). Other potential applications include multiple camera feeds, and camera video capture with metadata for motion or audio-based subject tracking.

Note that products supporting USB 3.2 Gen 1 can also support USB 2.0 at the same time.

It bears repeating that USB 3.2 Gen 1 is also known by several other names: USB 5Gbps, USB 3.2 Gen 1×1, SuperSpeed USB, USB 3.0, and USB 3.1 Gen 1, and arbitrary variations of them. Despite this reality, and the fact that several of them are officially deprecated (refer to Table 1 for more details), you will continue to encounter them in product information, specifications, and logos. Just keep in mind that they all generally mean the same thing as you're researching USB features and capabilities.

Extending USB and USB-C

To make USB and USB-C connections between equipment, standard (passive) USB cables are available in lengths up to 5 meters or 16 feet (see Table 1 for more information). When longer lengths are needed, active cables can go up to 10 meters or 33 feet.

However, far greater distances are frequently required for pro AV integration, to transmit AV and USB signals within walls, over ceilings, under floors, and sometimes well beyond. A variety of signal extenders are available for USB transmission, with a theoretical maximum distance up to 100 meters (330 meters) over Category network cable.

USB signal extension is available in products with AV switching and distribution, such as the Omega Series, as well as point-to-point extender kits and network interface products.

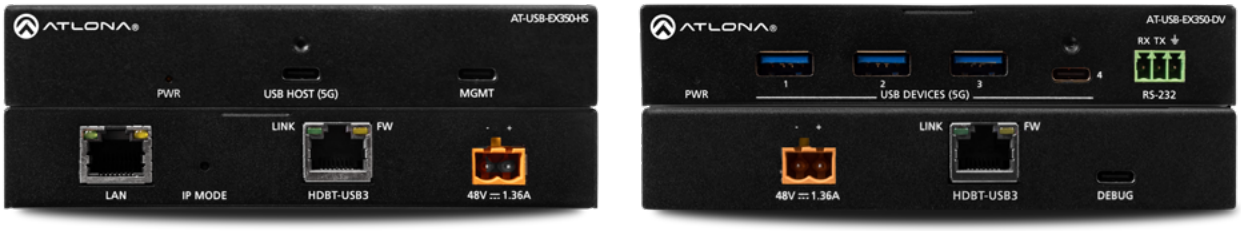
The Omega Series features USB 2.0 extension utilizing HDBaseT 2.0 technology. USB data capacity over HDBaseT 2.0 is 190 Mbps rather than 480 Mbps, due to specific bandwidth limitations inherent to the extension technology.

However, Atlona further specifies a maximum data rate of 120 Mbps of USB 2.0 over HDBaseT. This is to account for overhead considerations for other data signals over the HDBaseT link (such as AV control).

This means that while the local USB 2.0 hub in a Omega product can support up to 480 Mbps, the maximum data rate over HDBaseT will be 120 Mbps.

(It should be noted that there are competing AV products available that incorporate HDBaseT 3.0 technology, which increases USB 2.0 data capacity from 190 Mbps to 320 Mbps.)

USB point-to-point extender kits feature a transmitter for the host device, and a receiver for connecting USB peripherals. USB 2.0 extenders are available for data rates from about 300 Mbps to 480 Mbps. There are also extenders for USB 3.2 Gen 1 (up to 5 Gbps), such as the Atlona **AT-USB-EX350-KIT**. They can also support USB 2.0 at the same time (up to 480 Mbps).



AT-USB-EX350-KIT
USB 3.2 Gen 1 Data Extender Kit

In addition to USB point-to-point extender kits, USB can be extended with network interface products such as the Atlona **AT-OMNI-311** and **AT-OMNI-324**, which support up to 480 Mbps. USB network interfacing is also available in AV over IP encoders and decoders. For USB network interface products, an encoder (for the USB host) can be paired with multiple decoders (for USB peripherals) on the network, or used simply for point-to-point extension.

It should be noted that dedicated USB extender products are only for USB data. Those with a USB-C host interface will not work with DisplayPort Alt Mode for AV, and usually will not supply USB PD over USB-C for charging a laptop. This is in contrast to the Omega Series and other AV switching products with multi-functional USB-C ports for AV input, USB data, and device charging.

USB-C cable selection

When it comes to selecting cables for USB-C equipped products, there are separate considerations for USB 2.0 and USB 3.2 Gen 1. Let's begin with USB 2.0 since the criteria is simpler for cable specification.

There are very inexpensive USB-C cables and USB type A to USB-C cables intended only for charging devices. Many actually are included accessories. There is a good chance that they will not support USB 2.0. When selecting cables, the best recommendation is to look for explicit mention of USB 2.0 in the cable's product information, and then verify successful interfacing through a simple connection test.

When it comes to USB 3.2 Gen 1, the requirements are more specific. To ensure you're able to get all of the data, AV and power capabilities over USB-C, the general recommendation is to make sure the cable's product description or features include the following:

- Support for USB 3.2 Gen 1 or 5 Gbps data rate
- The ability to carry 60 watts power over the cable
- Video specification of 4K @ 60 Hz (or support for DisplayPort Alt Mode)

Some cables include what's known as an E-Marker chip that electronically certifies safe passage of 5 amps or at least 60 watts of power, and the ability to carry data rates for USB 3.2 Gen 1 or better. A so-called "Full Featured" USB-C cable meets all of the requirements above and has the E-Marker chip.

There are a few other measures you can take to help ensure the right cable selection:

- Look for an USB-IF certified cable with at least 5 Gbps and 60 watts on the USB product logo
- Reference this extensive database of USB-C cable test results from MET at Grafisch Lyceum Rotterdam
- Use a Thunderbolt 3 or Thunderbolt 4 cable – Thunderbolt specifications exceed USB-C and USB 3.2 Gen 1

Testing cables is always important to ensure they can deliver power, connect reliably to USB peripherals, and pass AV signals. Many cables may have the necessary device charging and USB data rate specs, but fail to work with DisplayPort Alt Mode.

Atlona switchers with USB-C AV input include a two-meter USB-C cable that meets data rate, power, and video specifications of the product. The nominal cable length is 3 meters per the official USB 3.2 Gen 1 specification; longer lengths are possible with specialized active cables and active optical cables, typically up to 5 meters and 10 meters, respectively. Atlona offers the **AT-LC-UC2UC-5M** 5-meter USB-C active cable – which actually supports USB 3.2 Gen 2 up to 10 Gbps.

AT-LC-UC2UC-5M
LinkConnect USB-C Active Cable – 5 Meters

USB system topology

One of the most important integration considerations for USB is the topology of the system, that is, the number of devices that will be chained, or cascaded from the host computer to the peripherals. In a typical desktop PC setup, the scenario is usually straightforward, with the PC connected directly to devices, or interfaced through them with a hub in between.

For an AV system with a USB connection, things can get considerably complicated when there is the potential for multiple hubs, including those built into AV switchers and devices such as PCs and interactive displays, plus whatever dock or hub a user may choose to bring into the system.

The more hubs cascaded between the host PC and terminal devices, the more potential for latency, which will affect USB handshake and communication reliability. Ultimately, a USB peripheral may fail to enumerate if there are too many hubs interconnected in the signal chain.

To help ensure reliability, the USB standard specifies a maximum number of seven tiers in a USB system cascade, as illustrated in this diagram of a USB device tree.

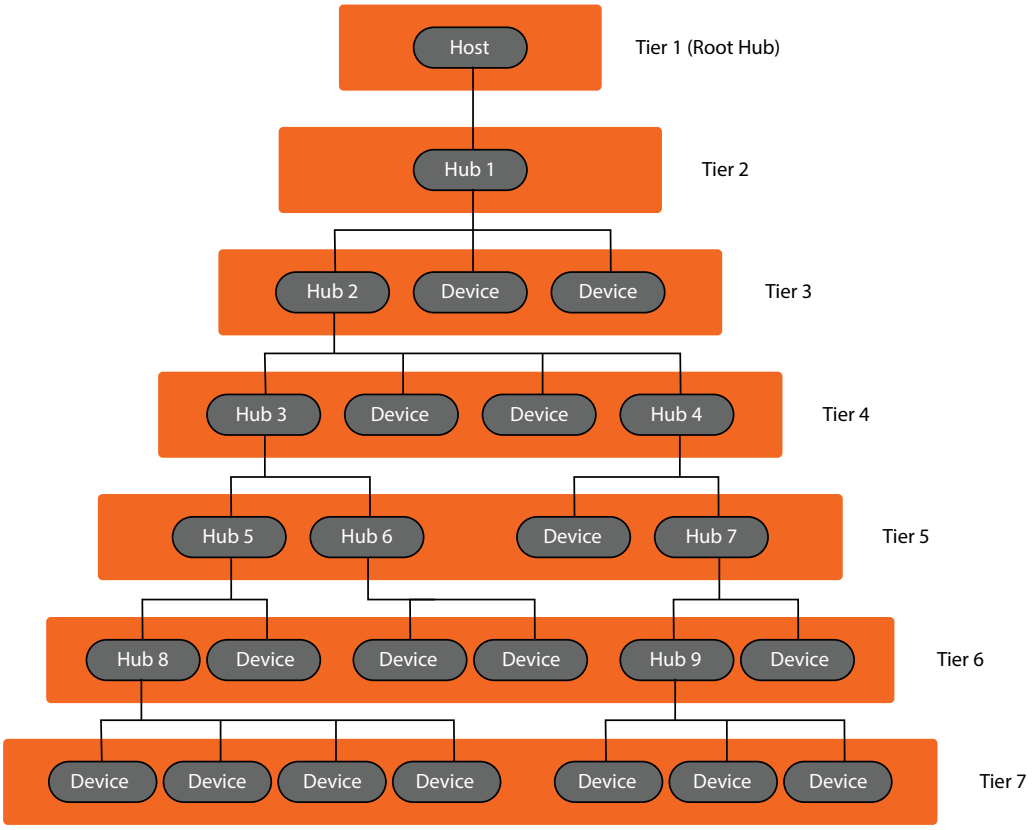


Figure 7 – USB device tree illustrating a maximum of seven allowable tiers.

A detailed explanation of USB system topology and analysis is beyond of the scope of this article, but will be covered in future Atlona webinars, training sessions, blog posts, and more.

Nonetheless, as an overview, here is a summary of the important points to understand for any setup with a host computer, hubs, and devices. See below for a simple example.

- Tier 1 is generally the USB root hub for the host computer. The host initiates and drives USB communication through the cascade.
- Tier 7, or the last tier in any USB system, is usually a device.
- A host PC has a USB root hub, but usually at least one additional hub. That hub would be cascaded as Tier 2.
- USB hubs with more than four ports, or hubs with Ethernet adapters and other functions are two hubs cascaded internally, and consume two tiers.
- Do not exceed seven tiers in your USB system!
- A total of 127 USB connections (addresses) are allowed in the system, including the USB root hub.
- You will often find multiple USB root hubs in a computer. That could mean multiple USB device trees!

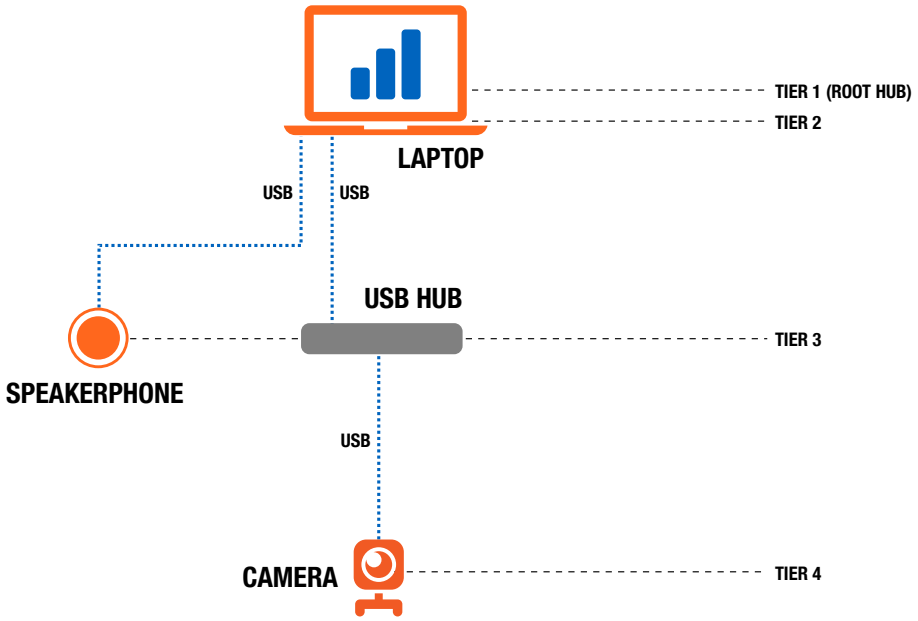


Figure 8 – A USB system setup with four tiers.

The best way to get a visual assessment of the USB system is using **USB Device Tree Viewer** software on a Windows PC. For a Mac, an internal USB device tree viewer is available. You will likely notice separate device trees for USB 2.0 and USB 3.2 Gen 1 (or Gen 2).

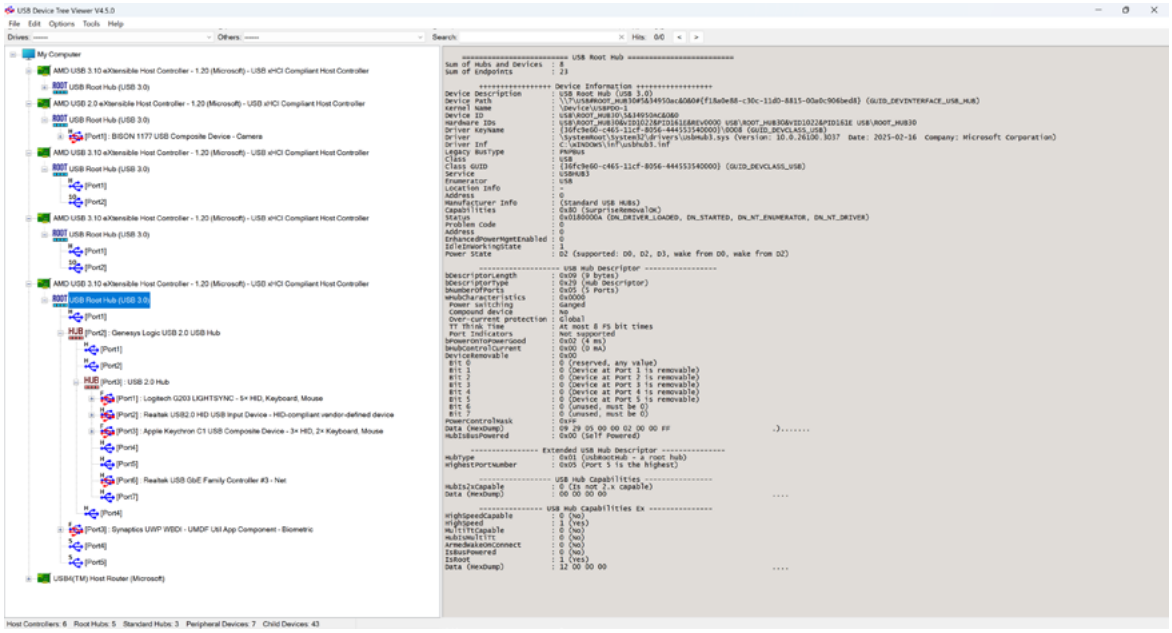


Figure 9 – USB Device Tree Viewer software.

For USB-equipped pro AV products, switchers, DSPs, extenders, and other devices with built-in USB hubs will have one or two internal tiers. Some interactive displays may have as many as three internally cascaded USB hubs, and some active cables may consume at least one tier.

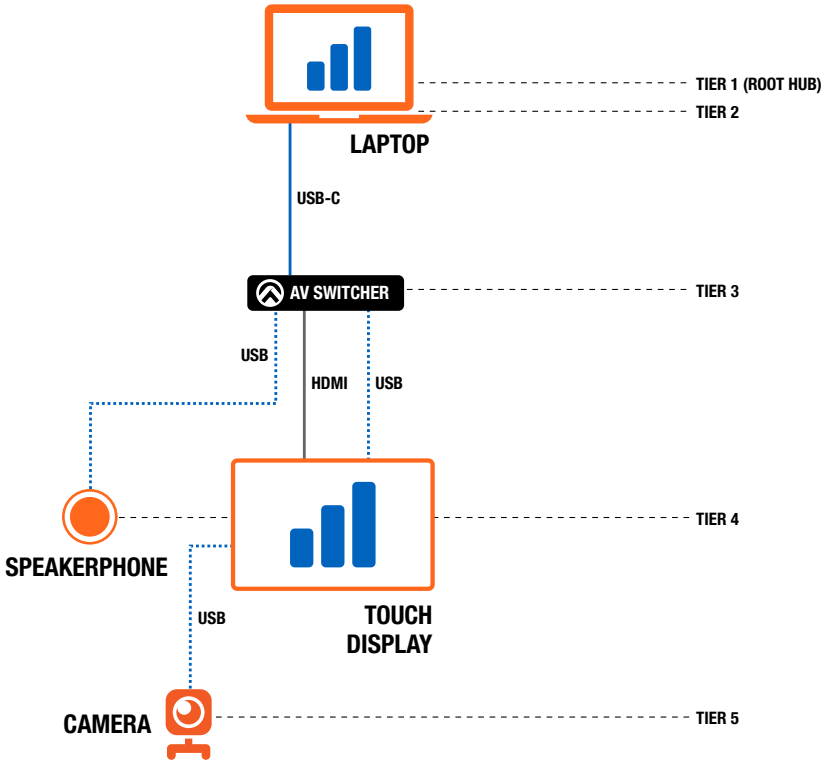


Figure 10 – AV system with a switcher, peripherals, and touch display that takes up five tiers.

Atlona publishes information on the number of internal USB hubs in product specifications. This includes any cascaded hubs and the number of tiers.

The AT-USB-EX350-KIT, a USB 3.2 Gen 1 point-to-point extender, consumes two tiers from transmitter to receiver. The AT-OMNI-311 and AT-OMNI-324, for USB 2.0 network-based distribution and extension, each consume one tier.

Specific USB topology rules apply to the Omega Series, which utilizes USB 2.0 point-to-point extension with HDBaseT technology.

- The HDBaseT extension consumes a single tier from transmitter to receiver.
- When analyzed with the USB Device Tree Viewer software in the host PC, this tier is visible to the host PC as a seven-port USB 2.0 hub.
- This hub is actually a “virtual” USB root hub with its own device tree. For the Omega Series, the tree allows a maximum of the following:
    - Five USB tiers
    - Six USB hubs
    - Seven device (peripheral) connections
- When analyzed with the USB Device Tree Viewer software, peripheral connections to the seven-port hub will be visible, but downstream tiers (USB hubs) will not be shown.
- Therefore, it is important to account for USB hub connections downstream from the HDBaseT extension, which includes the internal USB hub built into the receiver.

Similar USB topology rules apply to the AT-USB-EX350-KIT in USB 2.0 mode, except that the maximum allowable USB hubs is nine instead of six.

Summary

USB-C, and USB in general are absolutely integral to the pro AV industry. USB-C is a critical aspect of simplifying the AV connectivity experience for presenters, with a simple cable connection essential to getting started for a virtual meeting or standard video presentation.

USB 2.0 and USB 3.2 Gen 1 are currently the predominant USB standards in the AV industry. However, USB-C is inherently future-proof, with the ability to support very high-bandwidth data rates up to 120 Gbps (USB4 and Thunderbolt 5), along with the potential for 8K video. Whatever happens now or into the future, a fundamental understanding of USB will always be a critical aspect of successful USB system design and integration.