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USB Type C Connectors and Adaptive Power Delivery White Paper

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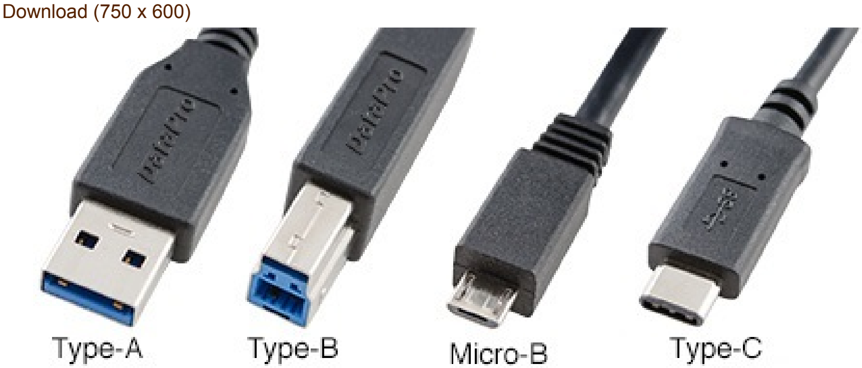

Introduction:

The Universal Serial Bus (USB) has been around for almost 20 years now. Starting with the publication of the USB 1.1 spec in 1998, USB ports have proliferated in computers, entertainment systems and electronic devices of all kinds. Now, a new combination of USB technology promises speed, flexibility, and unprecedented levels of electrical power all via a single, USB Type-C connector.

When the USB Type-C specification was originally published in 2015, it promised to support greater speed, more power, and more convenience than historical USB technologies. A little over a year later, the USB Type-C connection is gaining greater adoption, and it is changing the way manufacturers can utilize the USB connection.

A Brief History of USB:

Literally Billions of USB connectors are shipped each year, and USB provides data connectivity and power input to electronic devices ranging from your computer mouse and keyboard to digital cameras, storage device, phones, and tablets.

Clearly USB has been a very successful technology. Partly this can be attributed to the thoughtful design of the original USB technology and the positive impact of standardization. By standardizing peripheral interconnections across different electronics manufacturers and platforms, USB became ubiquitous. But to a similar degree, the success of USB has been driven by the consistent efforts of developers to improve the specification and enhance the capabilities of the technology. And, although many of these enhancements have addressed only behind the scenes technical issues, the most visible of them have primarily come in two areas: Data Rates, and Power Delivery.

Data Rates… Newer Versions with Higher Speeds:

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Since its original production version, USB 1.1, the spec has evolved through multiple generations, with each successive technology providing more speed, and more throughput. And all the while these USB specifications have carefully included the crucial, additional benefit of being backward compatible with previous versions of USB.

A summary of USB signaling versions to date would include:

- The USB 1.1 spec, published in 1998 defined initial signaling speeds of 1.5 Mb/s (Low Speed) and 12 Mb/s (Full Speed).
- The USB 2.0 spec, published in 2000 added a “Hi-Speed” configuration, which supports signaling rates up to 480 Mb/s.
- The USB 3.0 spec, published in 2008 added a “Super Speed” configuration with a signaling rate of 5 Gb/s and an added ability to transmit data in both directions over the same connection simultaneously.
- The USB 3.1 spec , published in 2013 builds upon the USB 3.0 spec and adds a new configuration called USB Superspeed+, which supports signaling rates of up to 10 Gb/s.

Power Delivery… From Powering Your Mouse to Powering Your Computer:

As USB technology has evolved, it has included an ability to supply increasing amounts of electrical power from one device to another. The earliest USB specification included the ability to supply power to simple peripheral devices like a mouse, keyboard, or small storage drive. Power always flowed from the host side to the device side, and the specification made allowances for powering complex configurations that included multiple cascaded hubs and dozens of peripheral devices.

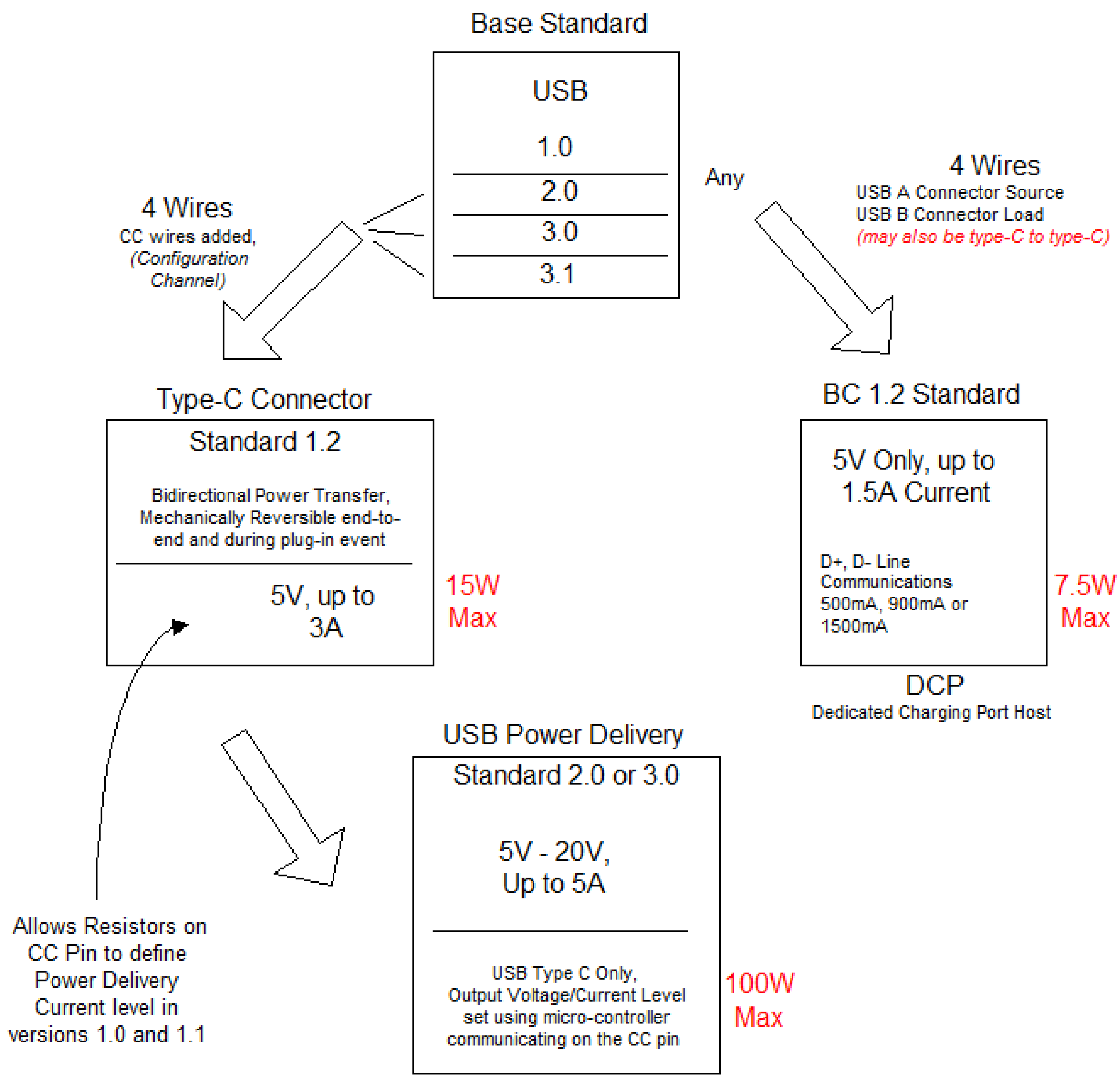
In the early days, this Power Delivery specification was a secondary capability. It supplied only a very limited amount of power and this power was only supplied in conjunction with a data connection. Later USB specs made allowance for higher levels of simple downstream Power Delivery to accommodate power hungry devices and eliminated the need for common peripherals like portable storage devices to provide their own dedicated power sources.

The later specs such as BC1.2 also made allowances for more types of ports including a Dedicated Charging Port configurations that doesn’t include a data connection at all but provides a much higher level of charging power. Charging ports can pull their power from a host device or even from a “dumb” source like a wall charger. This Charging Port configuration has become the familiar USB connection on your Smartphone that acts as both the source of electrical power for charging the device and as the wire-based alternative data connection for transferring data to and from the device.

In its current configuration, the USB 3.1 specification(and it’s derivative specifications, see below Diagram 1) have allowances for a variety of power configurations, ranging from low power, low speed devices that draw under 100 mA to high-power USB Type-C ports that allow power draw of up to 5 Amps @ 20V (100W). And although hardware changes associated with the USB Type-C connector mean that an adapter is necessary to connect an old-style USB mouse to a high power draw port, the USB 3.1 specification requires that these different vintage of electronics are electrically compatible.

Diagram 1:

USB Specifications, focusing on Power Delivery Aspect



Connectors:

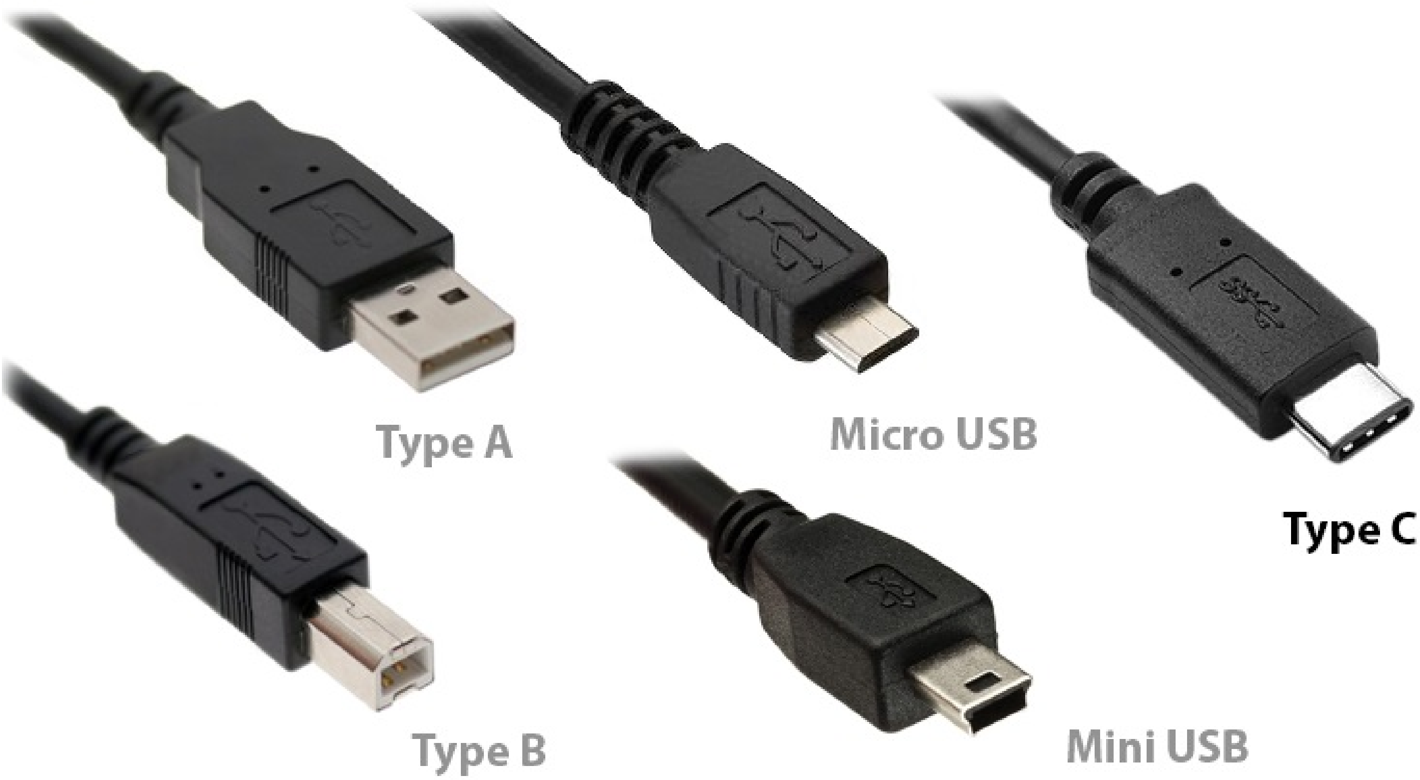
Throughout the history of the USB specifications, the technology has utilized a cabling structure where host systems utilize one type of connector and peripheral devices utilize another. That's why the familiar USB cable traditionally features a boxy, rectangular connector on the host end and one of several standard (or proprietary) smaller connectors on the other end.

A Unidirectional Configuration:

With historical USB connections, you have two distinct connector types. On one end, there is the USB Type A connector, and the other end has a USB Type B connector.

This asymmetrical configuration was designed to force users to implement their USB connections correctly. Early developers feared that unless hardware limitations forced consumers to set up their USB connections correctly, untrained end users would make improper connections. And though much of this was intended to eliminate confusion and avoid negative user experiences, the was a practical safety concern as well. Connecting two USB hosts together could have led to a power overload that fried circuitry or even posed a fire hazard.

USB Types A and B Connectors:



There's historically been only one type of USB Type A connection, and it is present in any legacy USB system. This large rectangular connection is the familiar USB host-end connection that is found in most computer systems and where common peripheral devices such as a USB mouse or keyboard are plugged into their host system. This familiar host connector has been unchanged in its appearance since the first USB products hit the market in the late 1990s. The USB Type A connector has been mated with a variety of differing connectors on the device end.

USB Type B connections are a variety of USB configurations that typically plug into the device you want to connect to your computer. In the lifespan of USB technology, device side, or USB Type B connectors have evolved through several generations. There have been a variety of standard connector types including things like Mini USB and Micro USB, and Apple makes its own custom USB connector for powering iPhones and iPads. Simply put, the USB Type B connection end has been a changing landscape.

USB Type-C Connectors:

The USB Type-C connector specification defines a completely new configuration for USB connectors. Small in size like a Micro USB Type B connector, USB Type-C is also distinct in that both ends of the connector are identical. What's more, each connector is identical on each side, so there's no right and no wrong way to plug it in to the port.

This universal connection will eliminate user frustration and confusion when connecting devices. And since there's only one type of USB Type-C connection and no 'wrong' way to plug in a USB Type-C connector, you'll be able to use any cable to power and provide data to any device with a Type-C connector.

Physically, the very small USC Type-C connector has 24 pins, 2 rows of 12 pins. The extra pins allow for 5 sets of data communications wire pairs, one legacy pair, and 4 super-speed pair. Additionally, there is the addition of the CC pins, for power delivery communication. The CC pin (Configuration Channel), can communicate in primitive fashion using standard specified resistor values to indicate to the maximum available 5V or 3.3V power, up to a 3 amp level. However, larger voltages and power level requirements can be communicated using serial communications on the CC pin/wire, in harmonization with the Power Delivery 2.0/3.0 standard. A certain amount of back and forth handshaking between the two micro-controllers in the power host port and power using port will all occur on the CC wire, before a higher voltage and power level are allowed to be transferred.

Diagram 2:

Downstream Facing Port, Resistor Values to declare Output Current Capability

DFP Current Capability	**Resistor Pull-up to 4.75V - 5.5V**	**Resistor Pull-up to 3.3V ± 5%**
Default USB Power (500mA for USB2.0, 900mA for USB3.0)	56 kΩ ± 20%	36 kΩ ± 20
1.5A @ 5V	22 kΩ ± 5%	12 kΩ ± 5%
3.0A @ 5V	10 kΩ ± 5%	4.7 kΩ ± 5%

USB Type-C connectors are optimized to support the most recent, highest-speed versions of the USB specification, which means USB 3.1 at signaling rates up to 10 Gb/s, using the four super-speed differential wire pairs, and legacy D+/D- pair, often referred to as the non-super-speed differential pair.

Regulating Speeds and Powers.

In the case of the earlier USB technologies, USB retains backward electrical compatibility by adding new components to the connection when adding new capabilities. That way, older technologies simply don't connect to, and are able to ignore the electrical connection of the newer varieties. Data rate regulation was historically managed by smart ports that always included a data connection anyway and enabled chips in the Host and Device.

With the introduction of USB 3.1 and the USB Type-C connector specification, the requirements to regulate and manage bus power are more complex than ever before. And with up to 3 Amps of power coursing through a USB Type-C cable and providing enough power to allow a high-draw machine like an Apple Mac Book to simultaneously operate and charge its batteries, there's clearly enough power there to cause issues with some legacy devices if not managed properly.

Smart Power Regulation:

For users, the move to USB 3.1 and USB Type-C is simple. Just access a compatible port and enjoy the benefits of higher data rates and increased power availability. But the simplicity of the technology for users comes with a tradeoff for developers. Simply put, making it simple for users means that the technology needs to be more robust and fault resistant than earlier connection technologies. And this means a greater burden of reliability and intelligence for USB devices as they are designed, developed and released to the public.

Differentiating USB Type-C:

As a departure from previous standards, the USB-C 1.2 standard is a dedicated connection that provides both power and data connectivity to your devices. Although it has been common since the introduction of the USB standard to have power input to mobile devices via a USB connection, the USB-C connection is envisioned as a more robust and capable power supply, rather than as a primarily data-centric connection that also provided a limited power supply to peripheral devices.

An important thing to remember about USB in all its flavors is that the power supplying structure must be extremely robust in order to function properly in a variety of hubbed and point to point configurations. This means that power supplies must provide adequate power to support a maximum draw situation, while minimizing power consumed from the source to minimize heat, waste, and physical wear.

The USB-C 1.2 standard along with USB Power Delivery 2.0/3.0 standard defines multiple modes of operation to accommodate these diverse power delivery requirements. But devices that are designed to be powered through this source can only access these multiple modes of power operation if the power supply, cabling, and all components meet the new standards.

Certain industry accepted USB standards such as QC2.0 and QC3.0 may also provide a vital role in delivery of 3.3V to 20V adaptive power, with high power levels form dedicated charging ports. These alternate standards although no implicitly defined in the group of USB standards, can provide simple efficient methods to provide voltage level negotiations with the host power source utilizing resistor networks on the D+ and D- pins of the powered USB appliance. Although the QC2.0/3.0 standard is typically delivered using USB type A /type B connector, a type C connector can also be utilized to deliver this power.

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Although typically provided at up to 18W of power, the QC2.0/3.0 standard may be used to provide higher power levels, only limited by the capabilities of the power source.

Use a Trusted Power Supply Source

Globtek designs and manufactures power supplies and battery chargers for diverse needs, from basic consumer applications to advanced medical and scientific applications. Globtek provides power supplies and cables that are designed to provide the USB power to support the highest levels of USB Power and USB Charging without risk of overloading older devices from excessive voltage and power levels.

By optimizing the current, voltage and power supplied to the USB device, an advanced power supply from Globtek ensures that power hungry devices can receive the electrical power they need to operate, while ensuring that legacy systems receive only the lower power they need to operate properly.

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