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APPLICATION NOTE 6918

SIMPLIFYING MOBILE USB-C DESIGNS

By: Perry Tsao, Executive Director, Mobile Solutions Business Unit

Abstract: An increasing number of laptops, phones, and PCs these days is built with USB-C, the small, versatile connector for bi-directional data transmission and power delivery. With USB-C (also known as USB Type-C), consumers are freed from having to carry around multiple cords to charge their devices, transfer data, or connect to a display or other peripheral. The standard provides more than enough power to fully charge an array of portable electronic devices, from power banks to personal computers and monitors. However, designing the charging circuits for USB-C is a unique skillset, especially compared to the effort involved in designing for legacy USB variants. This white paper will discuss how a buck charger can simplify the USB-C charging system design process.

Introduction

From wearables to building automation systems, medical devices, and beyond, more compact, lithium-ion battery-powered electronics are joining the USB-C party. In fact, the growing usage of lithium-ion batteries in various consumer devices is contributing to USB-C adoption, since all of these devices need power conversion. According to IHS Markit, devices with at least one USB-C port are anticipated to number almost five billion in 2021, up from 300 million in 2016. Among the biggest adopters during this period are mobile phones, mobile PCs, flash drives, media tablets, and docking stations[1]. So, even though adoption has been slower than some industry experts have anticipated, the market opportunities are certainly there.

USB-C is positioned as a universal standard because it replaces a tangle of different cables, streamlining the process for fast charging, content streaming, and data transferring. Double-sided and reversible, a USB-C connector has 24 pins and is slightly larger than a micro-B connector (the miniaturized version of the Universal Serial Bus interface). USB 3.1, whose Gen 2 specifies data rates at 10Gbps (twice as fast as USB 3.0), is the default protocol with the USB-C connector. For even faster speeds, there's the Thunderbolt 3 protocol, which USB-C supports. Thunderbolt 3 brings the bandwidth to 40Gbps, with less power consumption and the ability to move as much as 100W of power. A device with a USB-C port with Thunderbolt 3 requires only a single cable to power and transfer a large amount of data to and from a device as complex as a computer[2].

From a design standpoint, one attractive benefit of USB-C for mobile devices is that it allows smaller and thinner designs. But while the standard simplifies things for end users, it is challenging to design the charging circuits for USB-C.

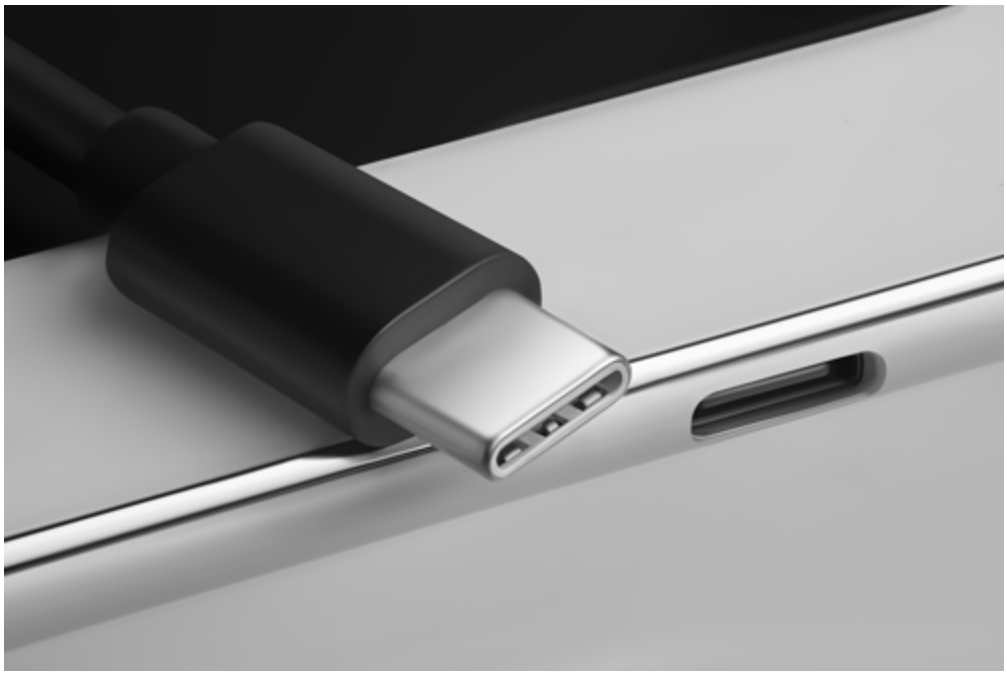

Figure 1. A USB-C cable connector and smartphone input.

What Makes Designing for USB-C a Challenge?

The USB communications protocol is fairly complex, so it can be challenging and time-consuming to implement. A USB microcontroller with custom USB firmware or a fixed-function communication bridge (the easier route for those with less USB expertise) provide a couple of options for integrating USB communications into a design. Designing for the latest USB standard, USB-C, comes with its own unique challenges: the need to address signal integrity and speed issues in an embedded design, to accommodate 100W of power flowing in either direction, and to connect it to a host of legacy interfaces (including USB 1.1/2.0/3.0, HDMI, Ethernet, DisplayPort, and power and audio connections)[3].

In addition, chargers available today lack built-in USB-C port control functions. As a result, when a USB-C charging source plugs in, the charging won't start automatically until the port recognizes the adapter. So, you've got to make sure that the charger and the port controller can talk to each other. Ensuring that analog and digital signals are detected, read, and processed between the charger and controller requires complex host-side software development. For example, you'll want to ensure that your design will be able to handle a wide range of USB-C and legacy USB power adapters. You'll also need to properly manage the charger input current limit based on the source capability detected by the port controller IC. (Setting the charger's input current limit allows the charger to charge the battery at the source's full capability, which results in faster charging.) This requires software development in the host applications processor or microcontroller.

USB-C on its own supports up to 5V at 3A, and is sufficient for the many applications which require less

than 15W of power. However, for the source adapter to supply 5V on V_{BUS}, the USB-C port controller must establish end-to-end port detection; otherwise, V_{BUS} is a cold socket at 0V (which is a big difference from legacy USB). USB-C with USB Power Delivery, the specification that supports power delivery up to 100W, enables the ecosystem to support multiple power levels up to 20V at 5A maximum, but this requires a more complex USB-C Power Delivery microcontroller and many applications do not need that level of power.

Solution size is yet another important design consideration. USB-C connectors are much smaller than their legacy counterparts; however, battery-powered consumer devices are continuing to shrink (thanks in part to USB-C, which necessitates fewer ports on the device). So, the USB-C charging system should meet increasingly small form-factor demands, too.

Simplify Your Design with an Integrated USB-C Buck Charger

For applications requiring less than 15W of power, Maxim has introduced a USB-C buck charger that eliminates the need for a separate port controller IC, reduces host software development, and reduces bill of materials (BOM) costs. The MAX77860 is a USB-C 3A switch mode charger that integrates a USB-C port controller and charger IC for 15W applications. It is also the market's first integrated USB-C buck charger with integrated channel configuration (CC) detection, providing a simplified and more flexible USB-C charging system design in a 30% smaller solution size versus the closest competitor. The device's CC pin detection feature allows it to automatically complete USB port connection detection, which is required for the USB-C source to deliver power on V_{BUS}. (The CC pins also detect cable attachment and removal and receptacle/plug orientation. In addition, the pins can be used for the communications needed by USB Power Delivery and Alternate Mode, which supports third-party protocols like DisplayPort and HDMI.)

Charging starts automatically without host intervention. While its 3A charging current capability charges batteries quickly, the high efficiency of the MAX77860 also keeps the end device cool during charging. Available in a 3.9mm x 4.0mm package, the charger uses a relatively small inductor and capacitor due to its high switching frequency (2MHz/4MHz).

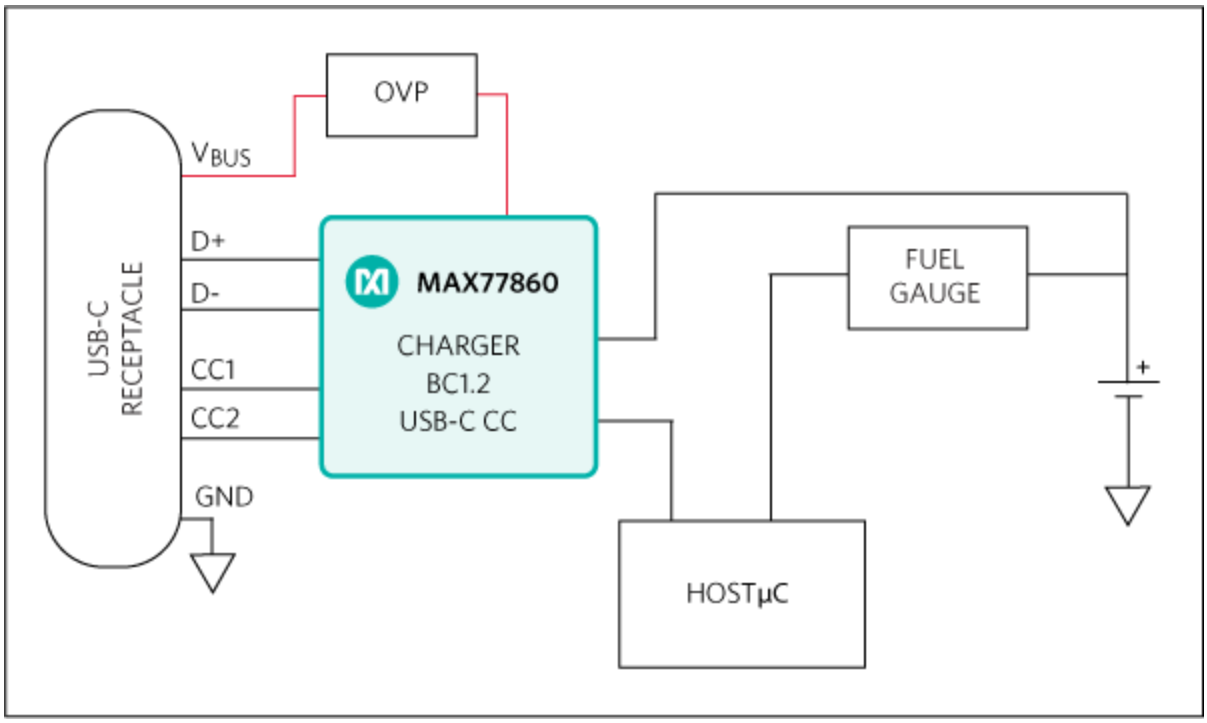

Figure 2. Sub-system block diagram showing how MAX77860 can be integrated into a USB-C charging system.

The MAX77860 features a high-efficiency buck that reduces heat dissipation. The device also supports backwards compatibility with legacy USB BC1.2 adapters. An integrated 6-channel analog-to-digital converter (ADC) provides accurate voltage and current measurements, while freeing up resources in the host application processor or microcontroller. The port controller on the device provides plug detection, cable orientation detection, power and data role detection, and V_{BUS} current capability discovery. 5.1V/1.5A reverse boost OTG powers auxiliary devices in USB On-The-Go (OTG) mode.

Summary

Because they provide a compact, versatile cable for bi-directional power delivery and data transfer, it's no wonder USB-C connectors are a welcome sight for consumer electronic devices. For designers accustomed to developing solutions for legacy communication protocols, however, designing for USB-C does come with its own set of complexities in terms of voltage management, efficiency, and solution size. A USB-C buck charger optimized to address these challenges can help simplify the process for bringing the convenience of this standard to a variety of portable products.

Resources

1. USB Type-C Adoption Keeps Growing Across Industry Segments.
2. What Is USB-C? An Explainer.
3. USB Type-C is Coming: 3 Things You've Just Gotta Know.

Related Parts		
MAX77860	USB Type-C, 3A Switch-Mode Buck Charger with Integrated CC Detection, Reverse Boost, and ADC	Free Samples

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