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Accelerate Your USB Power Delivery Battery Charger Designs

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Advanced features like 5G and 4K displays in portable devices are driving up power consumption—a lot more than 15 W in many cases in devices operated by high capacity 2S batteries. For these power-hungry gadgets, USB power delivery (PD) is a boon as it enables fast charging that gets these products back in operation with little downtime (Figure 1). Also, many applications that previously used AC-to-DC barrel adapters are migrating to USB PD for convenience and standardization. For designers, however, compliance with the USB PD standard typically requires complex firmware development and additional hardware components. With the short distance and high voltage (20 V) between pins on the Type-C port, there are certainly opportunities for damage if the connector is inserted or disconnected at an angle. Indeed, both USB Type-C and USB PD specifications require hardware and software design expertise as well as advanced knowledge of the USB specification.

Consumer devices like cameras, AR/VR systems, and wireless speakers are leading the charge to USB Type-C and USB PD. Ironically, these are the very products that can ill afford an extensive development cycle, given the time-to-market pressures. On the horizon, applications in areas like industrial and medical are on the cusp of greater adoption, as the same consumers are demanding the same level of convenience in their professional environments. We're also seeing the USB Type-C standard used in things like point-of-sale (POS) devices, industrial scanners, and breast pumps. In this article, we'll share some tips to streamline the design effort for USB PD designs.

Figure 1. USB Type-C and USB PD are bringing the conveniences of fast data transfer and charging to portable devices.

Design Challenges of USB-C Charging Systems

USB Type-C and USB PD enable designers to realize the promise of a universal connector, providing the specifications for a reversible 24-pin connector for data transfer and power delivery. USB-C specifies 5 V up to 3 A (15 W), while USB PD 3.0 specifies 5 V to 20 V up to 5 A (100 W). To design a charging system for USB-C, you'll need to:

- Address signal integrity and speed issues
- Connect to a variety of legacy interfaces
- Make sure that your design can handle a wide range of voltages and currents, including starting up with a cold socket (0 V until end-to-end detection is complete)[1]
- Ensure that the charger and the port controller will be able to talk to each other when the USB-C charging source is plugged in
- Meet the shrinking size demands of products like consumer devices
- Maintain thermal efficiency to minimize temperature rise

Meeting these challenges typically requires complex host-side software development for USB-C negotiation or additional parts such as external FETs and external microcontrollers. However, there are charging system solutions available that help minimize these challenges. One key feature is compliance with the protocols, as this will simplify the design implementation. Some solutions are also designed with event-based action scripts that make the customization process easier. Highly integrated ICs will eliminate the need for too many discrete components. Also, be sure to consider features that will help maintain reliable operation in harsh environments (varying temperatures or moist conditions, for instance).

Another consideration arises with the use of higher capacity batteries, which the power-hungry end devices need in order to support longer runtimes. Migrating from a 1S to a 2S battery increases the capacity without increasing the charging current. Since USB-C supports input voltages between 5 V and 20 V and 2S or 3S battery voltages fall somewhere in between, a buck-boost converter can help bridge the gap. See Figure 2 for a block diagram of a 2S battery-based application.

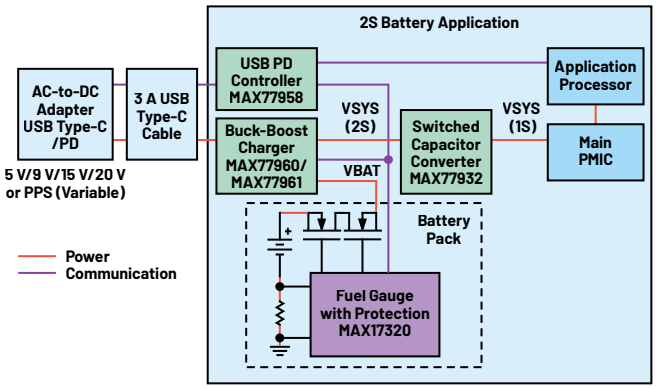

Figure 2. A block diagram of a 2S battery-based application.

Out-of-the-Box USB-C Compliance

Analog Devices has several USB-C charging system solutions that provide out-of-the-box compliance with the USB PD 3.0 specification, eliminating firmware development and reducing development time by up to three months. Their compact footprint also reduces the solution size by half compared to competitive solutions. The MAX77958 USB Type-C and USB PD charge controller is responsible for doing away with the firmware step, thanks to its GUI-driven customization script, BC1.2 support, and configuration settings related to Fast Role Swap (FRS), dual-role port (DRP), and Try.SNK mode. The standalone device eliminates an external microcontroller, provides out-of-the-box USB PD 3.0 compliance, and enables you to customize operation for the end application without firmware development. The device is also designed to withstand harsh environments via features including a 28 V rating, V_{BUS} short protection to CC pins, an integrated analog-to-digital converter (ADC), and moisture detection/corrosion prevention.

The MAX77958 can autonomously control a companion charger through its master I^2C interface. The MAX77961 is a 6 A buck-boost charger with integrated FETs for fast charging of high capacity 2S and 3S Li-Ion batteries. It provides a wide input voltage range (3.5 V to 25 V) for USB PD charging, requires no discrete FETs, and can be configured with or without an application processor. Peak efficiency is 97% at 9 V_{IN}, 7.4 V_{OUT}, 1.5 A_{OUT}.

You can evaluate both parts with the MAX77958EVKIT-2S6# (configured for 2S batteries) or the MAX77958EVKIT-3S6# (configured for 3S batteries), which demonstrate the MAX77958 autonomously controlling the MAX77961 charger with its I^2C master feature. You can also consider the MAXREFDES179# that allows easy evaluation of the USB-C PD controller, buck-boost charger, fuel gauge with integrated protection, and 2S-to-1S switched-capacitor converter that allows using a 2S battery for 1S-equivalent downstream power management.

These devices are part of a broader portfolio of USB Type-C and USB PD devices that includes power-efficient chargers and converters, autonomous and robust controllers, and power path and protection ICs.

References

[1]Perry Tsao. "Simplifying Mobile USB-C Designs." Analog Devices, Inc., 2014.

About the Authors

Bakul Damle is responsible for Analog Devices' battery and power management product lines including fuel gauges, battery safety, protection, and authentication as well as wireless and USB Type-C/power delivery battery chargers. An industry veteran, Bakul joined ADI in 2005 after leading a team of engineers at National Instruments. He holds an M.Sc. degree in electrical engineering from California Institute of Technology and a bachelor of technology in engineering physics from the Indian Institute of Technology. Bakul has several patents in the area of test and measurement.

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