Electronic Design

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Power-Delivery Controllers Ease Transition to USB Type-C

Sponsored by Texas Instruments: Highly integrated chips plus performance-validated reference designs help you develop compact USB Type-C solutions for devices ranging from computers and accessories to power tools and e-bikes.

The latest USB Power Delivery (PD) specification, Extended Power Range (EPR) USB PD 3.1, increases the capacity of a USB Type-C cable to 240 W (48 V at 5 A), up from 100 W (20 V at 5 A) for the previous Standard Power Range (SPR) USB PD 3.0 specification.

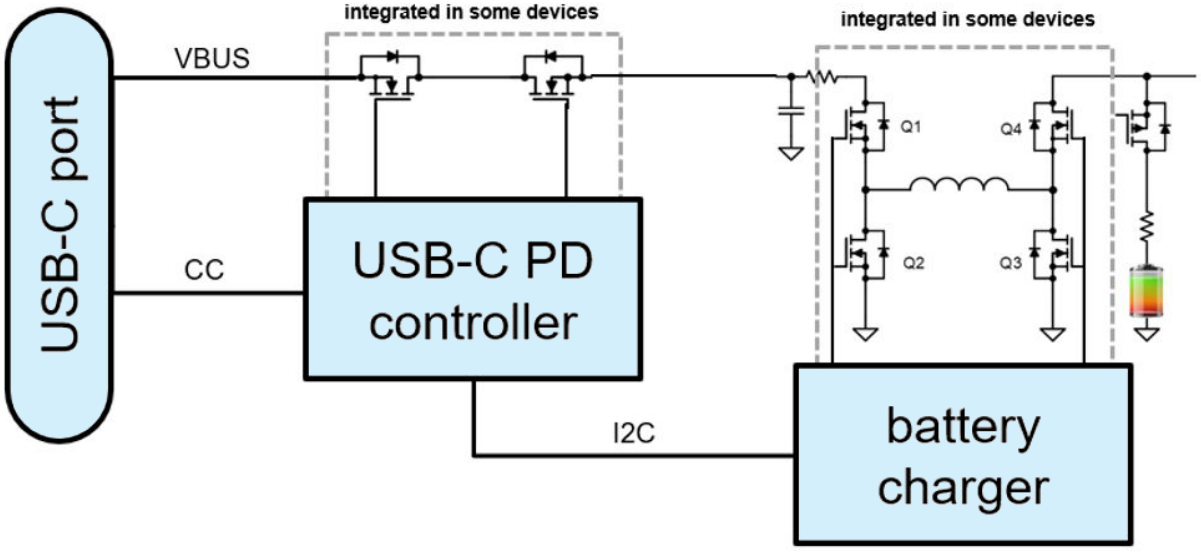
Both EPR and SPR PD offer significant improvements from the original USB Type-C specification's 15-W (5 V at 3 A) power level, allowing for the rapid recharge of battery-powered products ranging from Bluetooth speakers to power tools. In addition, EPR and SPR enable such products to supply power to connected devices using the same USB Type-C port.

SPR and EPR Voltage Ranges

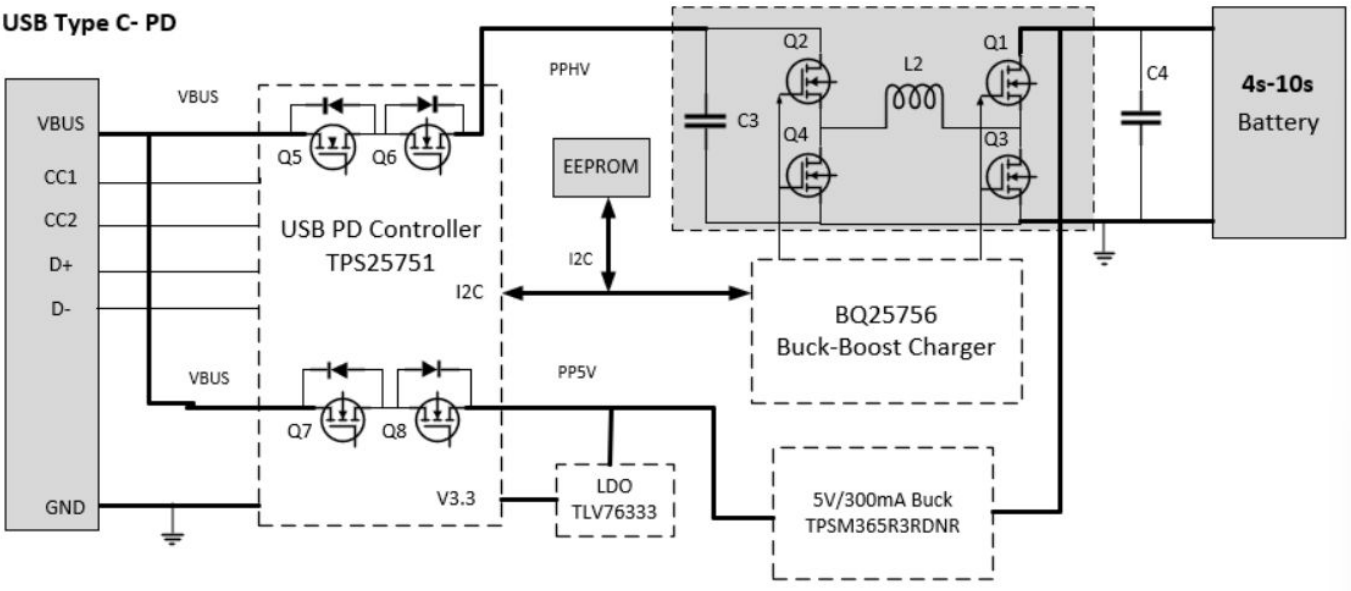
Both SPR and EPR support levels of fixed voltage, current, and power ratings in addition to the maximum. SPR, for example, supports 3 A at 5 V, 9 V, 15 V, and 20 V, as well as the maximum 5 A at 20 V. And EPR offers the following available fixed current and corresponding voltage ranges:

- 3 A at 5 V, 9 V, 15 V, and 20 V.
- 5 A at 20 V, 28 V, and 36 V as well as the maximum 48 V.

For both SPR and EPR, connected USB Type-C devices negotiate an appropriate power, current, and voltage level on power-up. In addition to these fixed ranges, a power supply used for USB PD 3.1 EPR applications must also comply



1. An I2C interface links a USB-C PD controller with a battery-charger chip.



2. The PMP41062 reference design pairs a TPS25751 USB PD controller with a BQ25756 buck-boost battery charger.

with the EPR Adjustable Voltage Supply (AVS) requirement.

AVS calls for the fine-tuning of voltage levels between 15 and 48 V in 100-mV steps—a capability that helps to improve performance and boost thermal efficiency. It provides the flexibility for an EPR device acting as a current sink to receive power from a variety of chargers, minimizing the need for multiple custom adapters.

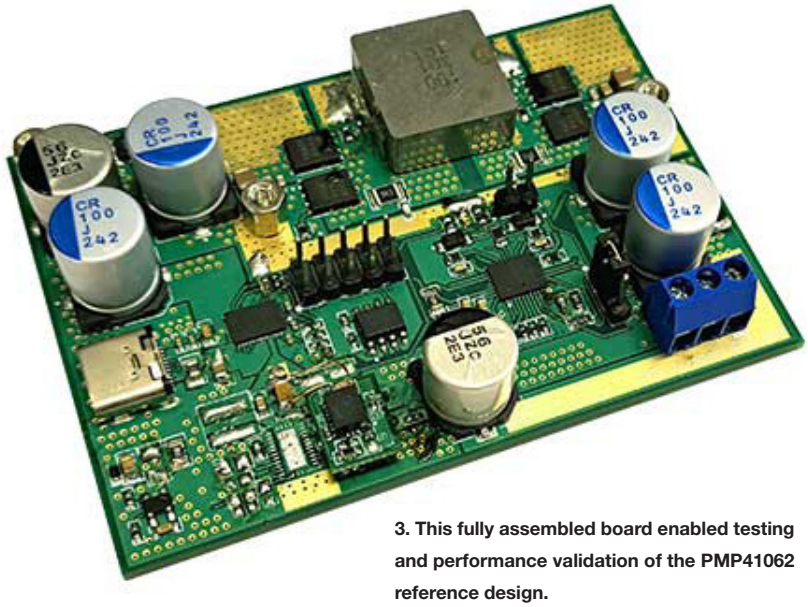
Controller plus Battery Charger

Products that charge their batteries via a USB Type-C port require a USB Type-C PD controller chip along with a battery-charger chip *(Fig. 1)*. The VBUS line carries the negotiated voltage, and the configuration channel (CC), typically consisting of pins labeled CC1 and CC2, helps support cable detection and determine cable orientation and current-carrying capacity.

The battery charger includes an I2C interface, which enables updates of battery-charging parameters based on power negotiations between two USB-connected devices. Many USB Type-C PD controllers, such as the one in *Figure 1*, include an integrated I2C host capability. This allows them to directly control the battery charger without the need for an external microcontroller chip, thereby reducing BOM chip count.

PD Controllers for SPR and EPR

To support USB applications, Texas Instruments offers a variety of USB Type-C and USB PD ICs, including the TPS25751 SPR PD controller and the TPS26750 EPR PD controller. The *table* lists the maximum supported power levels for these devices when paired with a specific battery-charger chip.



3. This fully assembled board enabled testing and performance validation of the PMP41062 reference design.

To help you get started designing with these chips, TI offers a series of reference designs, including the PMP41062 integrated USB Type-C and USB PD charging reference design for solutions incorporating from four-cell to 10-cell batteries.

The design specifies the TPS25751 PD controller and a BQ25756 wide-input-voltage, switched-mode buck-boost battery charger with bidirectional power-flow support. Other components specified in the design include an EEPROM, a low-dropout (LDO) regulator, and a 5-V, 300-mA synchronous buck converter *(Fig. 2)*.

The design supports battery charging at a 100-W level, and it supports a 5-A at 20-V output capability in USB OTG (On the Go) mode—that is, when a USB

device such as a laptop acts as a host and power source for another USB device like a flash drive or other accessory. The reference design offers simplicity and high integration to reduce BOM cost, product size, and time-to-market.

Figure 3 shows an assembled board that enabled test and validation of the PMP41062 reference design. Tests included evaluation of charge-mode and OTG-mode startup waveforms, OTG-mode voltage-transition waveforms, load-transient waveforms, and switching waveforms.

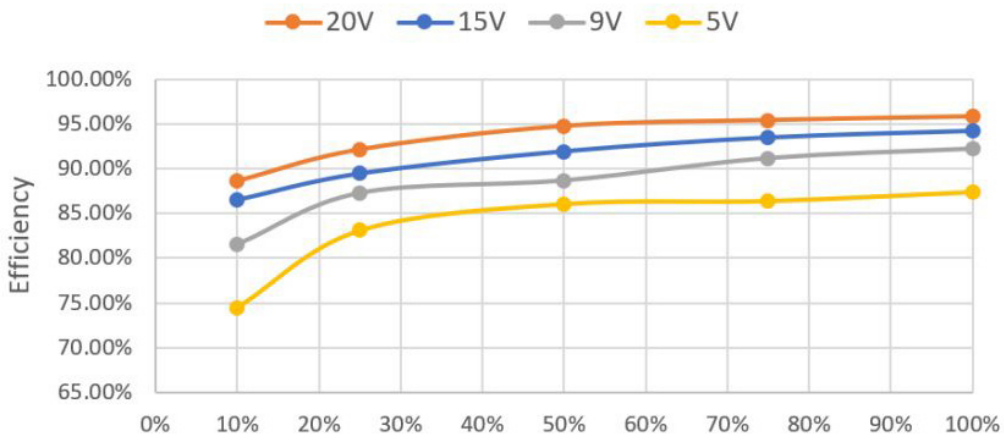
The tests also exercised overcurrent and short-circuit protection features and included thermal imaging and efficiency measurements. *Figure 4*, for example, shows efficiency vs. load at four different voltage levels.

EPR Battery-Charger Demo

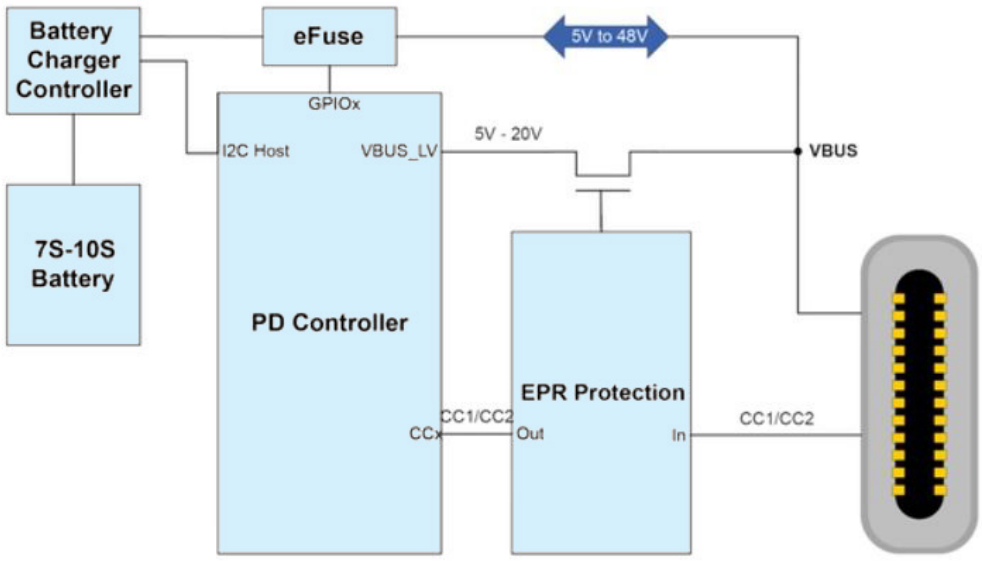
TI offers a video highlighting a USB Type-C PD 3.1 EPR battery-charger demo. The video addresses issues relevant to the design of USB mobile devices and accessories; computers and monitors; and power tools, e-bikes, and home appliances.

The demo covers EPR source and sink current capabilities, overvoltage and overcurrent protection, and for 48-V implementations, protection against shorts from VBUS to the CC lines *(Figure 5)*. It also describes the implementation of an integrated I2C control function without the need for firmware development.

In addition, the demo details a bidirectional buck-boost charge controller that supports lithium-ion and lithium-iron-phosphate batteries up to 70 V with up to 20-A charge currents. It uses a power source to simulate a wall plug and highlights the negotiations required to establish the desired 48-V level. The demo concludes with measurements showing a USB Type-C PD circuit and a battery charger acting as a 258.2-W source and 237.2-W sink, respectively.



4. Testing of the board pictured in Figure 3 resulted in these efficiency curves at four voltage levels.



5. EPR protection circuitry guards against shorts from VBUS to the PD controller's CC1 and CC2 lines.

Conclusion

The USB PD 3.0 SPR and USB PD 3.1 EPR standards offer the opportunity to charge the batteries of products ranging from tablets to power tools over a USB Type-C cable while also enabling those products to power other devices in OTG mode. You can implement high-performance, compact, and cost-effective PD solutions using TI's PD controllers and battery chargers, and the company offers reference designs to get you started quickly.