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Webinar

USB-C®: Global mandates and the new USB Power Delivery 3.1 Extended Power Range

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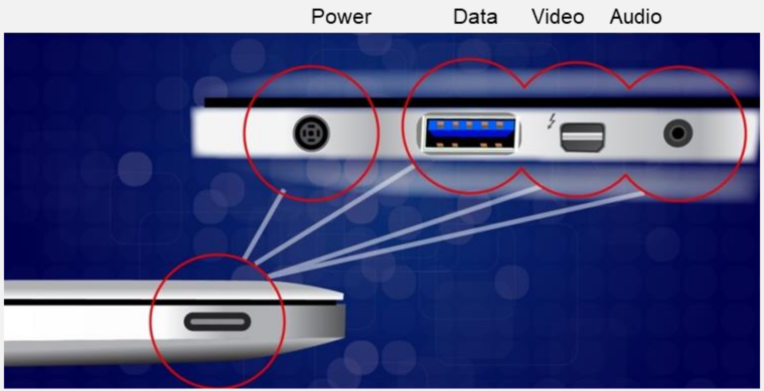
- **Adam McGaffin, Product Marketing Engineer**
  - With TI and UCB-C since 2018
    - Applications engineer - 2018-21
    - Product marketing engineer - 2021-present

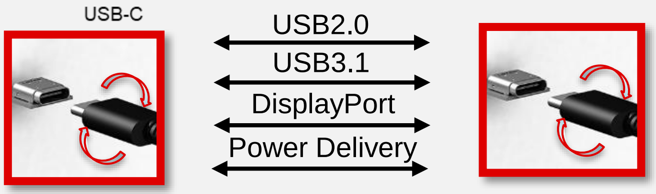
Agenda

- Introduction and overview of the new USB Power Delivery 3.1 (USB PD3.1) Extended Power Range (EPR)
- What was added in USB Power Delivery 3.2 (USB PD3.2)?
- Overview of USB-C mandates (European Union)
- Value of adding USB-C to battery powered applications, and the solutions TI has to offer

USB Type-C overview and new PD3.1 and PD3.2 specifications

What is USB Type-C?





The universal connector of the future

power, data, and video on a single port

capable of supporting up to 240W (48V/5A) of power

capable of transferring up to 80Gbps (USB4) data and 8K video

TI USB Type-C at a glance

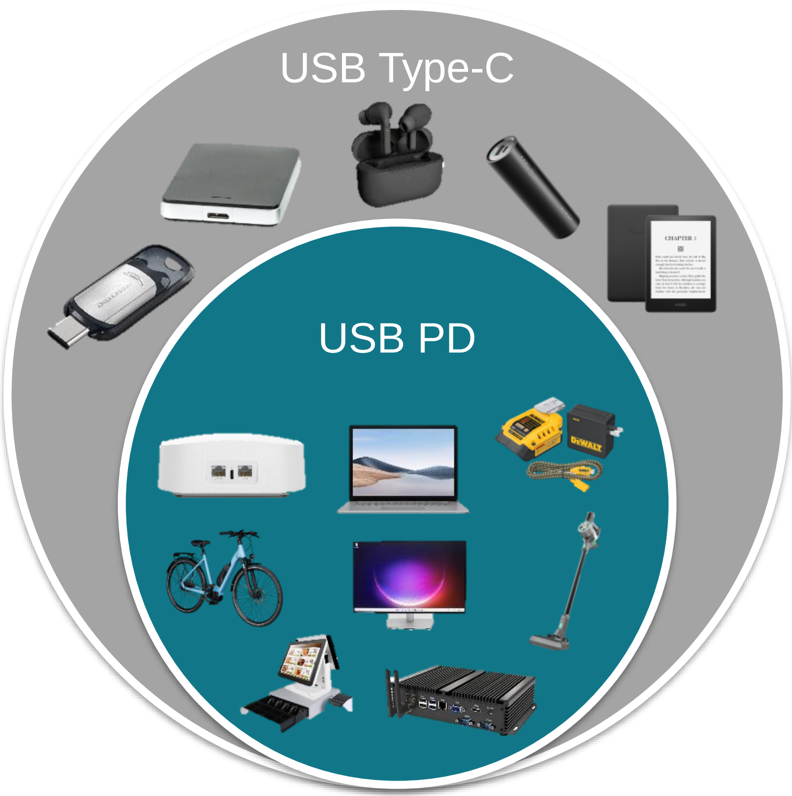
- Global market leader in USB-PD
- 1 Billion+ USB-PD Ports shipped

- Global support infrastructure
- Resources in Dallas, India, Taiwan, and Shenzhen

Are all USB Type-C ports the same?

Not all USB Type-C Ports are the same

- While they implement the same connector, there are two categories for USB Type-C:
  - USB Type-C
  - USB Power Delivery
- Not all USB Type-C systems are USB PD capable, but all USB PD systems are support USB Type-C



When do you need a USB PD controller?

Power

> 5V

- If you want to implement voltages > 5V, you need a USB PD controller
- For example, even if a customer wants only 5V and 9V, there must be a USB PD controller on both ends to negotiate a 9V power contract

Video

- Alternate modes such as DisplayPort and Thunderbolt require a USB PD controller

Power role ≠ Data role

- If you want to have the data and power roles be different, you need a USB PD controller (Source/UFP)
- Good example is a docking station. Will act as a power source for a laptop to charge, but a data UFP to receive video

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- **If any or all of the above criteria match your customer use case, you need a USB PD controller**
- **If none of these criteria match, then you can use a standard USB Type-C port controller**

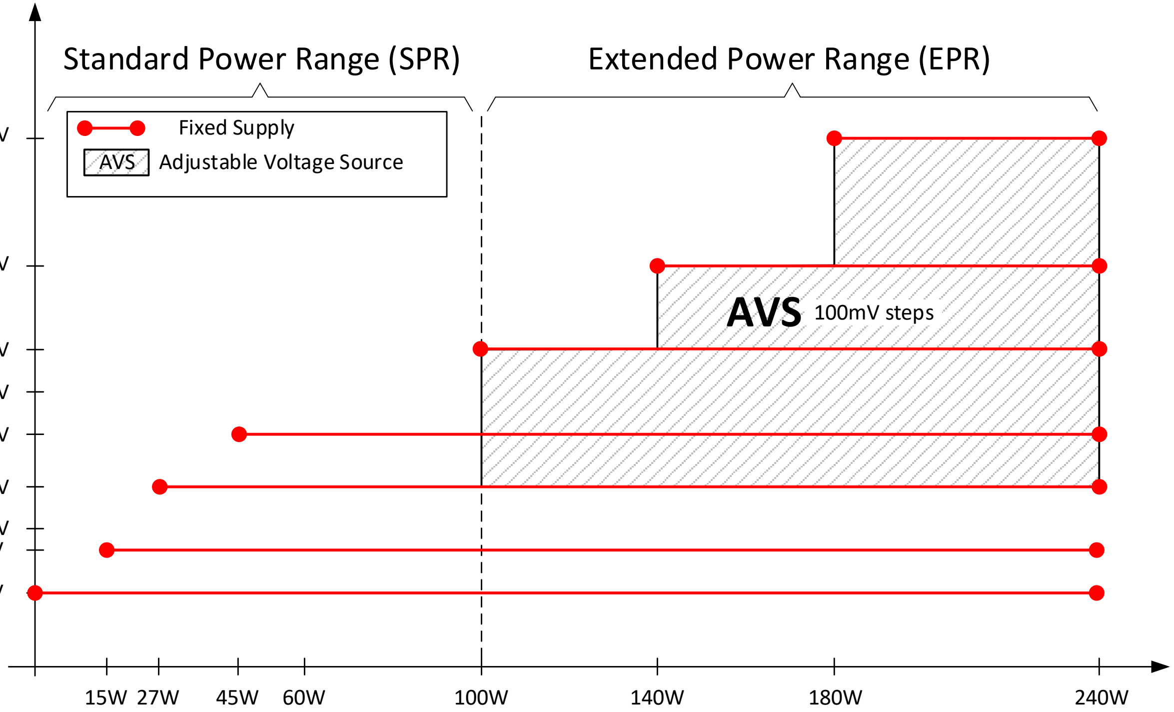
USB power supply options

USB protocol	Nominal voltage	Maximum current	Power
USB Type-C	5V	3A	15W
USB PD 3.0	Configurable up to 20V	5A	Up to 100W
USB PD 3.1	Configurable up to 48V	5A	Up to 240W

Summary of USB PD power rules (R3.1)

- Chart shows which voltages a source with a given power rating must be capable to provide
  - For <100W there were at most 4 voltages required
  - PPS is optional and not shown
  - Cable may limit to ≤ 20V
- Required current
  - ~PDP Rating ÷ Voltage
  - ≤ 5A
  - Cable may limit to ≤ 3A

Voltages required for the source



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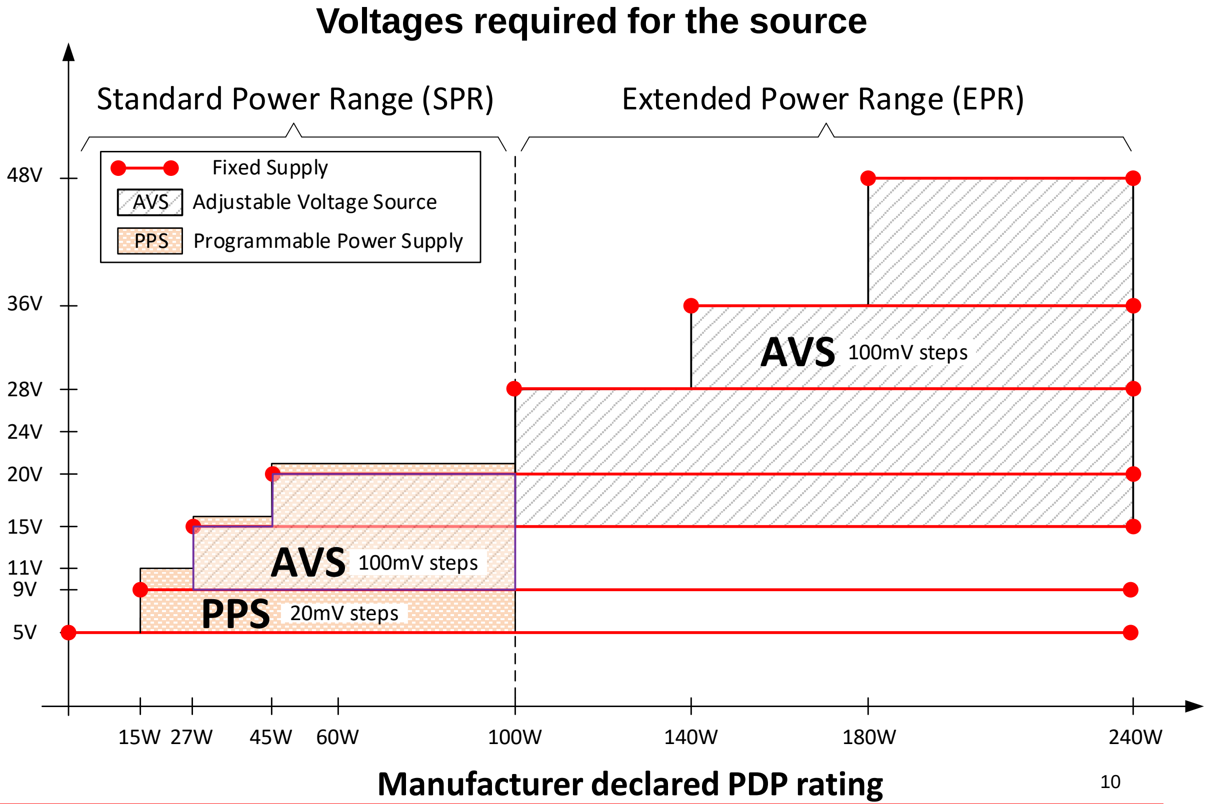
Summary of USB-PD power rules
(R3.2 as of October 2023)

- Required current same as R3.1
- AVS now required for SPR
  - 27W < PDP ≤ 45W: 9V-15V
  - 45W < PDP ≤ 100W: 9V-20V
- Options allowed
  - Extra current
  - Extra voltages <9V only,
  - Additional restrictions for EPR
    - No extra voltages at all
    - No Variable supply while in EPR mode
  - PPS (with 5V minimum)
    - Increased from 3.3V



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AVS ≠ PPS

PPS = Programmable power supply

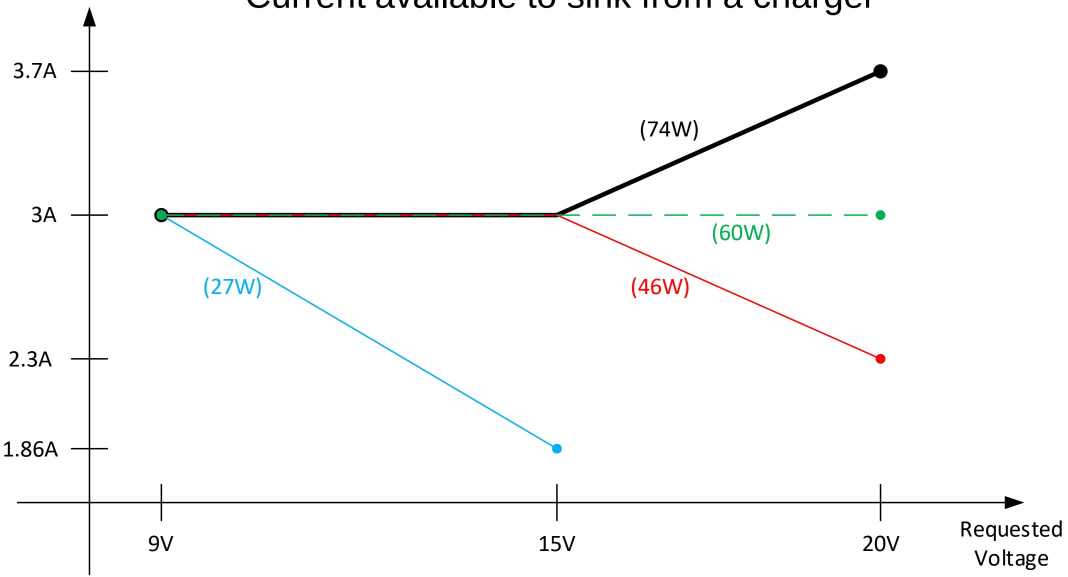
AVS = Adjustable voltage supply

- AVS and PPS both have programmable voltages (different step sizes)
- Only PPS requires a current limit (50mA steps, +/-5%)
  - Relaxed from -25mA/+100mA to larger of (±150mA or ±5%)
- A USB-IF certified charger may or may not include PPS
  - USB-IF certifies “fast charger” with PPS
  - USB-IF certifies “charger” without PPS
- A “fast charger” implements PPS & can “easily” add AVS
- AVS is a big change for “charger” implementations
  - Because they don’t already implement PPS
- Some sinking products will charge faster if PPS is available; it is a cost trade-off for the source

Expanding AVS below 100W

- Why add AVS?
  - Avoid one-off chargers with a specific/unique voltage
    → achieve universal behavior
  - A sink can be designed for a specific voltage since USB PD 3.2 chargers provide that voltage
    - Sinks should still be designed to function when connected to an older adaptor
  - Ex. Sinks can improve charging efficiency by selecting an input voltage closer to the battery voltage when connected to PD 3.2 charger

Current available to sink from a charger



Voltage range available with 100mV step size

(Manufacturer declared PDP rating)

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Ensuring safety through EPR mode entry process

1. Negotiate an explicit power contract in the standard power range
   - During this step, EPR-capable sources and sinks will declare their EPR capabilities through PDO and RDO exchanges
   - This requires an EPR sink to understand new bit fields that a legacy sink would not process

1

2. An EPR Sink, having discovered an EPR source, can request EPR mode entry
   - This is a new message a legacy sink would not know how to formulate

2

3. The EPR source, upon receiving an EPR mode entry request from the EPR sink, will:
   - Send an ACK message to acknowledge the request
   - Verify the sink has declared itself EPR capable
     - This requires the sink to properly set certain new bit fields differently from legacy sinks
   - Confirm the cable is EPR capable
     - This requires the cable to properly set certain new bit fields differently from legacy cables
   - Send a message that EPR mode is entered successfully
     - This requires the sink to understand a new message that a legacy sink would not process

3

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5 checks to ensure EPR mode is not entered “accidentally”

4. While in EPR Mode
   - The EPR source sends EPR capabilities (fixed PDOs and an AVS APDO) to the EPR sink which requires the sink to evaluate and respond as appropriate to adjust the explicit power contract
   - The EPR Sink maintains a regular cadence of communications with the EPR source to allow EPR mode to continue
   - If the source doesn’t see any message for 1 second, it is treated as a fault condition

EPR PD log example

Item	Direction	Payload	Status	Time
SOP' Discover Identity › Ack (Type-C to Type-C 5A)	OUT	4 bytes (01 A0 00 FF)	OK	9.538 675 990
SOP' Discover Identity	OUT	4 bytes (01 A0 00 FF)	OK	9.538 675 990
SOP' Discover Identity packet	OUT	4 bytes (01 A0 00 FF)	OK	9.538 675 990
SOP' GoodCrc packet	IN	0 bytes	OK	9.539 348 458
SOP' Discover Identity Ack (Type-C to Type-C 5A)	IN	20 bytes (41 A0 00 FF C2 …	OK	9.539 910 059
SOP' Discover Identity Ack packet (Type-C to Type-C 5A)	IN	20 bytes (41 A0 00 FF C2 …	OK	9.539 910 059
SOP' GoodCrc packet	OUT	0 bytes	OK	9.541 245 105

1

Passive Cable VDO	
Cable Hardware Version	4
Cable Firmware Version	6
Cable VDO Version	Version 1.0
Type-C to Captive	Type-C
EPR Mode Capable	Yes
Cable Latency	<10ns (~1m)
Cable Termination Type	VCONN not required
Max VBUS Voltage	50V
VBUS Current Handling C…	5A
USB Highest Speed	USB4 Gen3

Item	Direction	Payload	Status	Time
Source Capabilities (1=Fixed 5V 3A, 2=Fixed 9V 3A, 3=Fixed 15V 3A, 4=Fixed 20V 5A)	OUT	16 bytes (2C 91 81 0A 2C …	OK	9.461 645 963
Request (1=Fixed 5V 3A, Requested 3A, Max 3A, EPR Capable) › Accepted	IN	4 bytes (2C B1 C4 13)	OK	9.467 415 963
Request (1=Fixed 5V 3A, Requested 3A, Max 3A, EPR Capable)	IN	4 bytes (2C B1 C4 13)	OK	9.467 415 963
Request packet (1=Fixed 5V 3A, Requested 3A, Max 3A, EPR Capable)	IN	4 bytes (2C B1 C4 13)	OK	9.467 415 963
GoodCrc packet	OUT	0 bytes	OK	9.468 151 349
Accept	OUT	0 bytes	OK	9.471 844 604
PsRdy	OUT	0 bytes	OK	9.553 642 209
EPR Mode Enter (65W) › Ack	IN	4 bytes (00 00 41 01)	OK	9.559 877 877
EPR Mode Enter (65W)	IN	4 bytes (00 00 41 01)	OK	9.559 877 877
EPR Mode Enter (Ack)	OUT	4 bytes (00 00 00 02)	OK	9.564 170 824
EPR Mode Enter (Succeeded)	OUT	4 bytes (00 00 00 03)	OK	9.569 339 795
EPR Mode Enter packet (Succeeded)	OUT	4 bytes (00 00 00 03)	OK	9.569 339 795
GoodCrc packet	IN	0 bytes	OK	9.570 027 772
EPR Source Capabilities (1=Fixed 5V 3A, 2=Fixed 9V 3A, 3=Fixed 15V 3A, 4=Fixed 20V 5A, 5=Fixed 0V 0A, 6=Fixed 0V 0A, 7=Fixed 0V 0A, 8=Fixed 28V 5A, 9=Fixed 36V 5A, 10=EPR Adj 18…	OUT	40 bytes (2C 91 81 0A 2C …	OK	9.575 164 880
EPR Request (9=Fixed 36V 5A, Requested 3.25A, Max 3.25A, EPR Capable) › Accepted	IN	8 bytes (45 15 C5 93 F4 4…	OK	9.592 178 051
PsRdy	OUT	0 bytes	OK	10.103 952 257
EPR Keep-Alive	IN	2 bytes (03 00)	OK	10.110 107 953
Data-Role Swap › Accepted	IN	0 bytes	OK	10.120 190 010
Discover Identity › Not Supported	OUT	4 bytes (01 A8 00 FF)	OK	10.131 454 632
EPR Keep-Alive (x 63)	OUT	2 bytes (03 00)	OK	10.546 052 476
EPR Keep-Alive	OUT	2 bytes (03 00)	OK	10.546 052 476

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keep alive

USB-C global mandates

European Union USB-C Mandate

What is it?	- In 2022, the EU pass the Radio Equipment Directive (directive (EU) 2022/2380)
	- Mandates the use of USB-C as a universal charger using a standard USB-C to USB-C cable for:
	  - Mobile phones, tablets and e-readers
	  - Digital cameras and video game consoles
	  - Headphones, earbuds and portable loudspeakers
	  - Wireless mice and keyboards
	  - Portable navigation systems
	  - Laptops (from spring 2026)
	- Starting end of 2024, these products must comply with the requirements of the EN/IEC 62680 standard

Why was it passed?	- Simpler for consumers - Universal charger supports all consumer devices - Reduce E-waste

Impact	- Products mentioned above must provide relevant certification when entering customs for EU countries
	- Below are the relevant IEC # these products must conform to
	  - IEC 62680-1-2
	  - IEC 62680-1-3

IEC / USB-IF correlation and testing

IEC #	USB-IF specification
IEC 62680-1-2	USB-IF USB Power Delivery specification revision 3.1, version 1.1
IEC 62680-1-3	USB-IF USB Type-C cable and connector specification revision 2.0

USB test specification	External power supply	USB Type-C cables	Portable battery powered device	USB Type-C connectors
USB Type-C functional test specification	X	X	X	
USB Power Delivery compliance CTS	X	X	X	
USB source power test specification	X			
End-product cable test plan		X		
USB Type-C cable and connector compliance test specification		X		X

Minimal required tests for conformity to this program as summarized by USB-IF

Getting conformity to IEC 62680 standards

- USB-IF has launched new programs to help OEMs and ODMs demonstrate conformity to IEC 62680
- Can have their USB Type-C products formally tested by USB-IF authorized independent test labs (ITLs)
- Upon successful completion of testing, OEMs/ODMs will receive conformity documentation
- Links for additional details provided

USB
Enabling Connections™

+

IEC

EU mandate: Moving forward

Going Further

- Now with the ability to charge up to 240W on a USB-C cable, EU council is discussing whether the list of mandated products should be expanded
- Discussions on this topic are being done at the moment, but no clear date on when a final decision will be made
- An expansion in the mandated products will likely occur at some level, given the mission of the original mandate

What could be included?

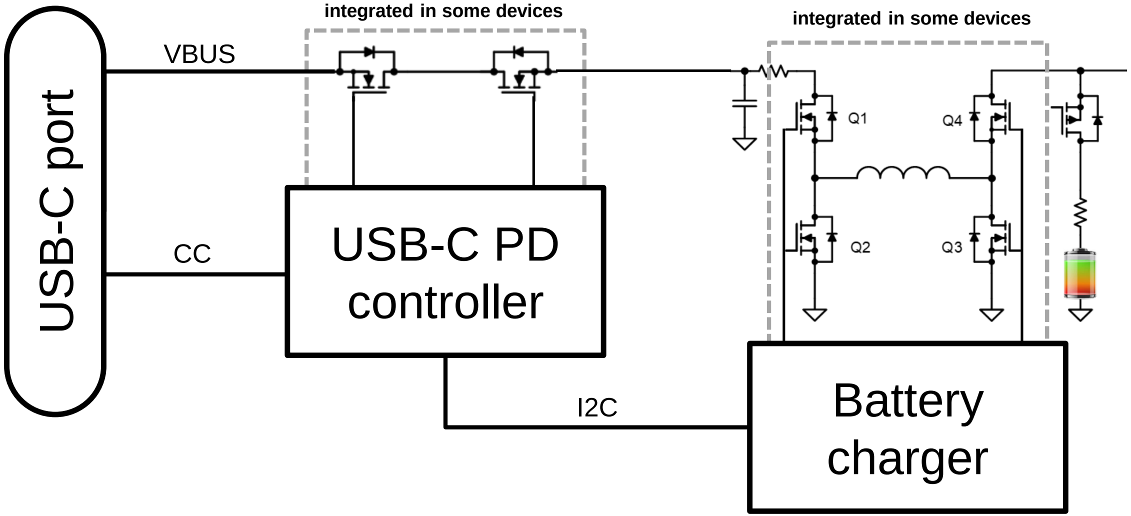
- Any chargeable device that takes in power less than 240W:
  - Ex. Power tools, portable appliances such as vacuums, garden tools
- Any non-chargeable device that is currently powered by DC supply less than 240W
  - Ex. Smart speakers, Wi-Fi router, monitors

What this means

- Like current mandate, would require new mandated products to move to USB-C
- USB-C will become the dominant power connector and will more than likely be adopted for all PSU inputs

USB-C and USB PD solutions for battery powered systems

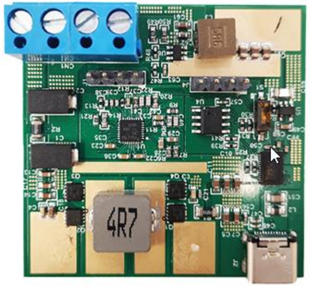
Overview of USB PD system with buck-boost charger



- Wide input voltage 5V ~ 48V to charge multi-cell battery 1S ~ 16S
- Support up to 240W USB-C power delivery
- With a step up/down buck-boost charger, the V_{IN} and V_{OUT} combination can be very flexible
- Support both power source and sink capabilities from a single port

USB PD + battery charger support

≤100W Sink <45W Source 1 – 4 Cell	≤100W Sink ≤100W Source 1 – 5 Cell	≤100W Sink ≤100W Source 1 – 16 Cell	240W Sink 240W Source 1 – 16 Cell
Products • TPS25751D/S • BQ25798	**Products** • TPS25751D/S • BQ25731	**Products** • TPS25751 • BQ25756	**Products** • TPS26750 • BQ25756



Find & learn more at www.ti.com/usb-c

USB PD + battery charger support

≤100W Sink
<45W Source
1 – 4 Cell

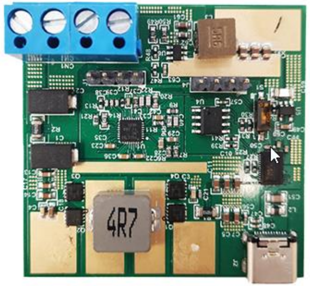
Products

- TPS25751D/S
- BQ25798

≤100W Sink
≤100W Source
1 – 5 Cell

Products

- TPS25751D/S
- BQ25731



≤100W Sink
≤100W Source
1 – 16 Cell

Products

- TPS25751
- BQ25756

240W Sink
240W Source
1 – 16 Cell

Products

- TPS26750
- BQ25756

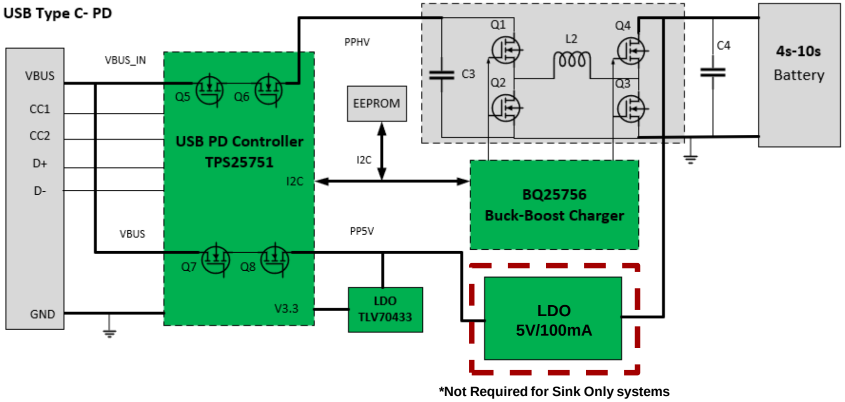
Find & Learn more at www.ti.com/usb-c

PMP41062 100-W, integrated USB Type-C bi-directional charger design for 4s~10s batteries

Features

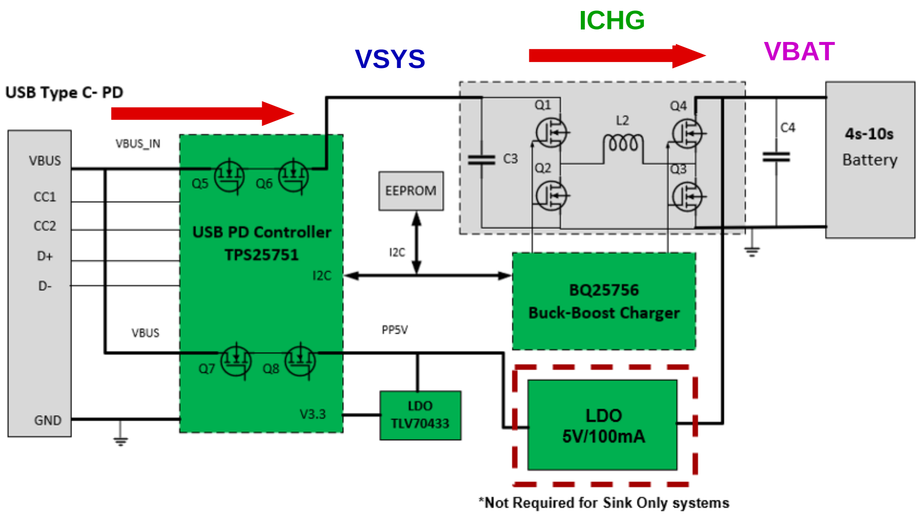
- Options for 100W, 60W, 45W, 27W, & 15W source and sink settings
- USB OTG output fully compatible with USB PD 3.0
- 97%>full load efficiency
- X-Y-Z mm in PCB size
- Buck boost charger for 4s-10s battery with Seamless transition among buck, buck-boost and boost modes
- Comprehensive integrated power path management & protection
- Configured using a simple web-based GUI tool w/o MCU coding
- TPS25751, BQ25756, LM61440, TLV70433

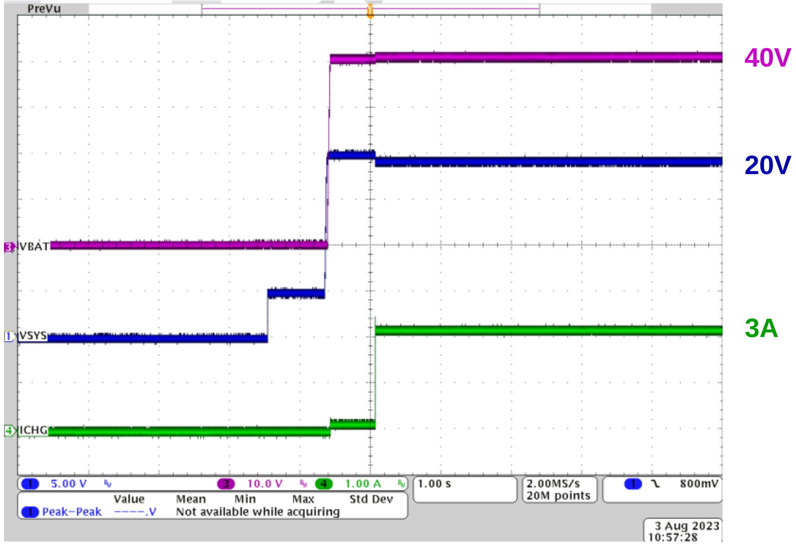
Parameter	Specification
Input voltage	5V/9V/15V/20V Type-C
Output voltage	14.4V-42V battery
Output power	100W max



For test report, design files, and more: https://www.ti.com/tool/PMP41062

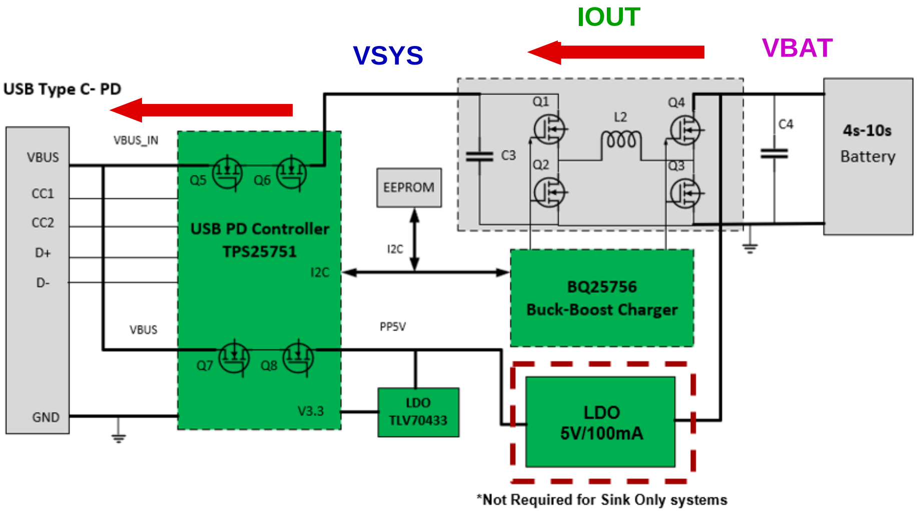
TPS25751 + BQ25756 (no microcontroller) power sink

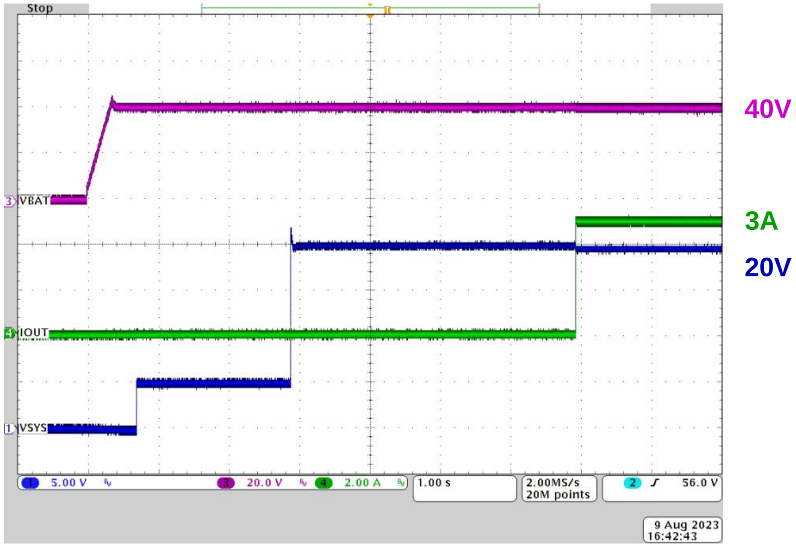




- TPS25751 controls BQ25756 to charge 10S battery from 20-V adapter
- TPS25751 negotiates a 20V USB-C PD contract
- TPS25751 sends I2C commands to BQ25756
- BQ25756 boosts 20V input to 40V 10S battery voltage

TPS25751 + BQ25756 (no microcontroller) power source





- TPS25751 controls BQ25756 to enter OTG mode and supply 20V contract
- TPS25751 negotiates first a 5V and then 20V USB-C PD contract
- TPS25751 sends I2C commands to BQ25756 to change output voltage from battery charger
- BQ25756 bucks 40V input from 10S battery to 5V and 20V output

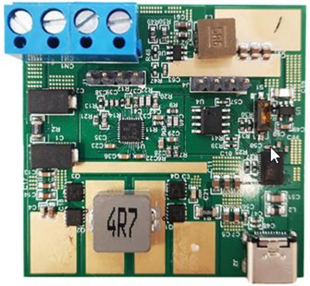
USB PD + battery charger support

≤100W Sink
<45W Source
1 – 4 Cell

Products
- TPS25751D/S
- BQ25798

≤100W Sink
≤100W Source
1 – 5 Cell

Products
- TPS25751D/S
- BQ25731



≤100W Sink
≤100W Source
1 – 16 Cell

Products
- TPS25751
- BQ25756

240W Sink
240W Source
1 – 16 Cell

Products
- TPS26750
- TPD4S480
- BQ25756

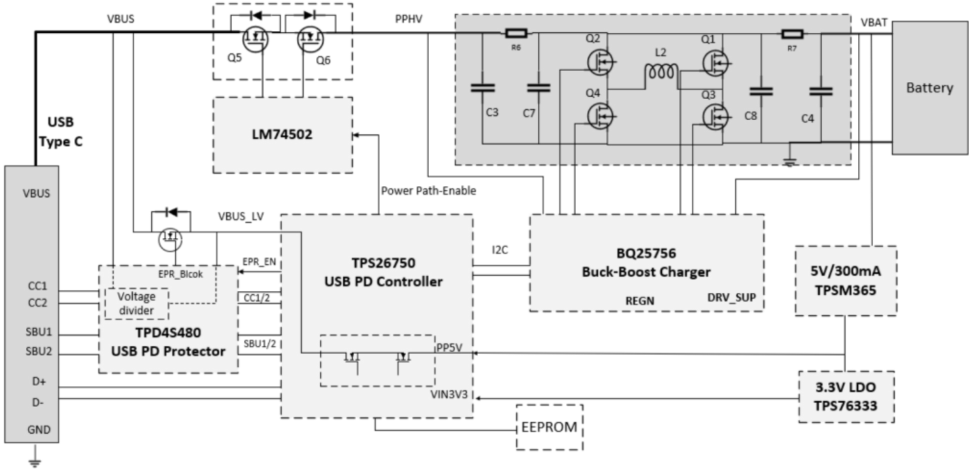
Find & Learn more at www.ti.com/usb-c

PMP41115 240W USB Type-C PD3.1 EPR battery charger reference design

Features

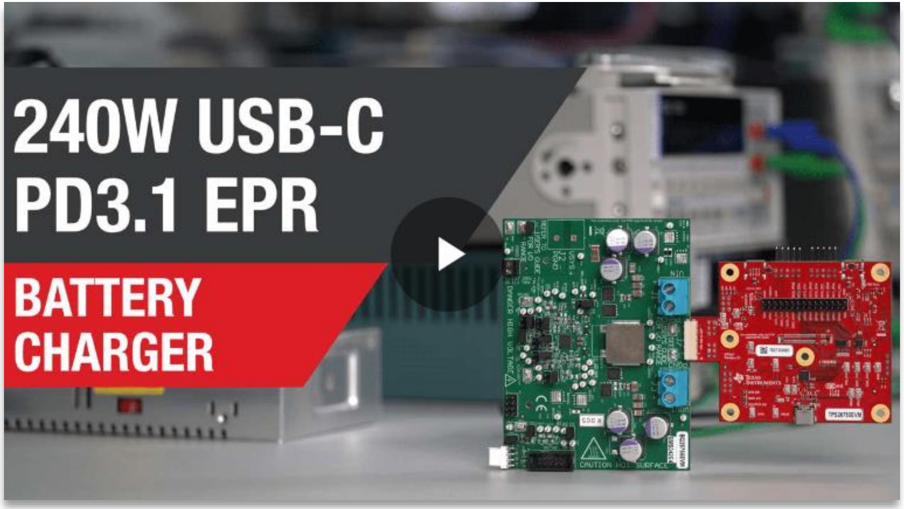
- Fully compatible with USB PD 3.1 EPR input source
- Support 7S-14S high cell battery charger
- Peak Efficiency>98%
- 43mm x 94mm x 14mm PCB board size
- Bi-directional power flow
- 4 switch buck boost charger Seamless transition among buck, buck-boost and boost modes
- Comprehensive integrated power path management & protection
- Provide moisture detection function for harsh environment

Parameter	Specification
Input source	5V/3A, 9V/3A, 15V/5A, 20V/5A, 28V/5A, 36V/5A, 48V/5A
Output voltage	21V-58V
Max charge current	5A



For test report, design files, and more: https://www.ti.com/tool/PMP41115

EPR Demo and Technical Article



Technical Article

USB Type-C® and USB Power Delivery: Designing for both Extended Power Range and battery-powered systems

TEXAS INSTRUMENTS

Adam McGaffin

With applications in personal electronics, automotive, industrial and enterprise systems, USB Type-C® (USB-C®) is an industry-standard connector that enables the transmission of both data and power on a single interface. USB Power Delivery (PD) is a standard using the USB-C connector that increases the capabilities and features of a USB-C interface. Until recently, the USB PD 3.0 specification allowed for up to 100W (20V, 5A) of power, now called Standard Power Range (SPR), to flow in both directions. The latest USB PD 3.1 specification increases the power range to 240W (48V, 5A), now called Extended Power Range (EPR), through a USB-C cable.

Table 1 shows how EPR compares to SPR.

Table 1. SPR and EPR fixed voltage ranges

Power range	Available current and voltages	Power delivery profile range	Notes
SPR	3A: 5V, 9V, 15V, 20V 5A 1: 20V	15W-60W >60W-100W	
EPR	5A 2: 28V, 36V, 48V	>100W-240W	Requires entry into EPR mode

1. Requires 5A cable.
2. Requires EPR cable.

EPR allows support for up to 240W of power (28V, 36V and 48V at 5A). EPR mode has the same requirement for sinks to evaluate and respond to new source capabilities messages as in a typical USB PD contract negotiation. After entering EPR mode, a port starts to negotiate a power delivery object (PDO) as high as 240W (48V, 5A). The 48V limit represents a practical limit when considering design safety margins.

On top of the fixed voltage-level extension in EPR mode, the supply must also follow the specifications for an adjustable voltage supply (AVS). Within EPR mode, AVS enables the sink to fine-tune the voltage between 15V and 48V in steps of 100mV for improved performance and thermal efficiency. AVS also allows flexibility for the sink to receive voltages from any charger, which enables you to avoid custom adapters and create a consistent user experience within your electronic ecosystem.

References

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