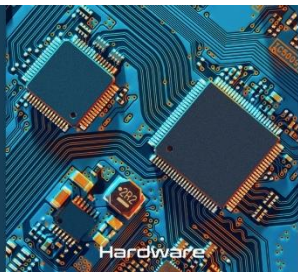




USB-C PD Applications within the Industrial Market

Venkata Appanabhotla

D&E
EVENT



Het ontwerpen van
innovatieve elektronica

Woensdag 19 april 2023
1931 Congrescentrum 's-Hertogenbosch

Introduction

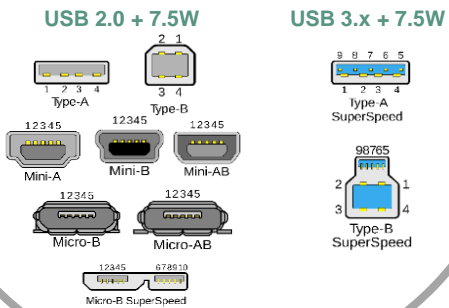
- Venkata is a Field Application Engineer based out of Munich. He is responsible for USB and USB Type-C PD applications for Automotive, Industrial and Consumer segments for the EMEA region.
- EBV is the distributor of semiconductors, one of their key manufacturer is Infineon Technologies.
- Besides distribution, dedicated technical support is one of their strong competencies.



USB Type-C: Single connector for all battery powered devices?

Charger and adapter barrel connectors (only power transfer)

Legacy USB connector types (Power & Data transfer)

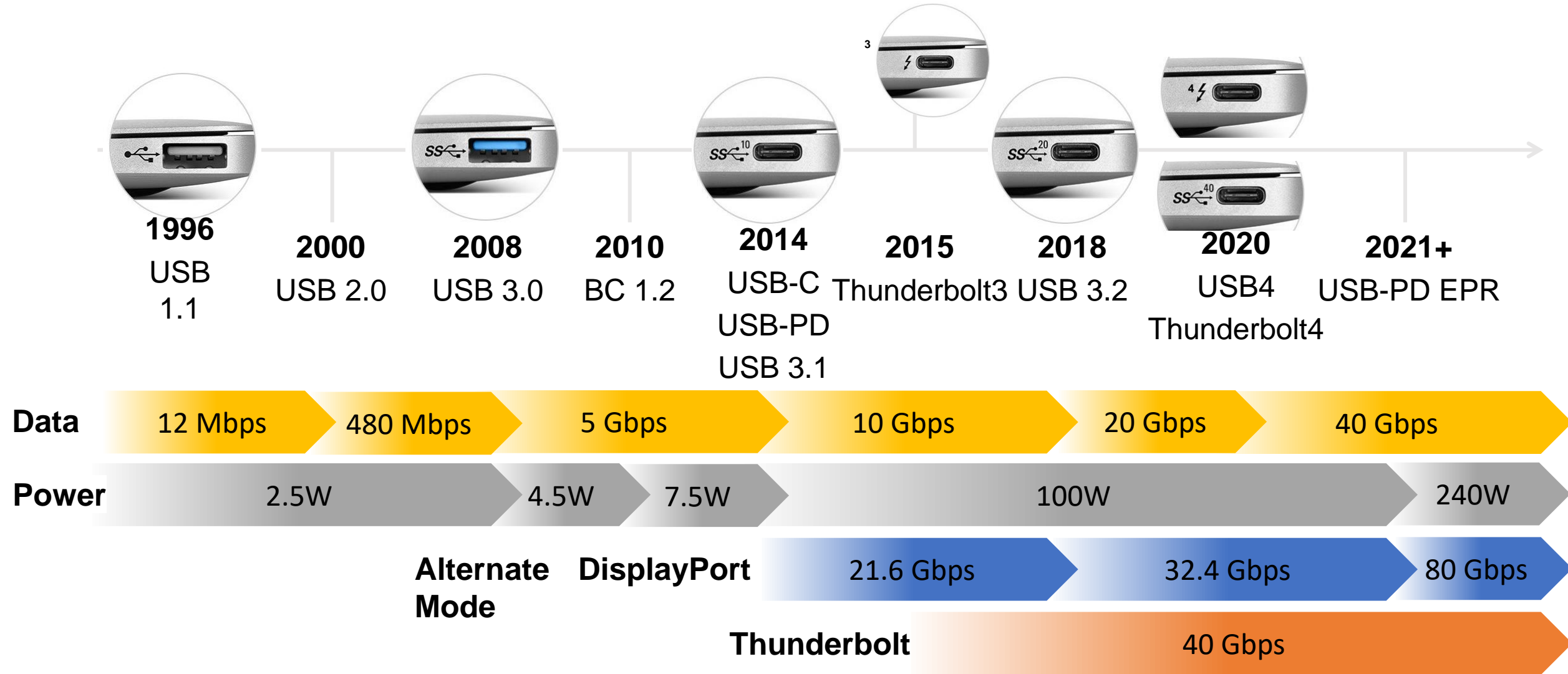


USB Type-C PD Terms

- **USB Implementers Forum**: USB-IF is the governing body of all USB Standards including USB Type-C PD spec, EPR spec and USB Data Specs.
- **USB Type-C**: USB Type-C is a new reversible USB connector specification that can support a number of new standards including USB 3.1 (Gen 1 and Gen 2), Display Port, and USB PD.
- **USB Power Delivery**: USB-Power Delivery (USB PD) is a specification standard that supports power delivery up to 100 W(20V, 5A) while transmitting data over the same cable at same time.
- **Extended Power Range (EPR)**: EPR is an update to the existing USB PD spec. This spec supports power delivery up to 240W (48V, 5A).
- **Display port**: Display port (DP) is a digital display interface that is used to connect a video source to a display device. For example, connecting a laptop (video source) to a display monitor (device).
- **Downstream Facing Port (DFP)/Source Port**: The Source Port is the power provider port, which supplies power over VBUS. It is, by default, a USB port on the Host or Hub.
- **Upstream Facing Port (UFP)/Sink Port**: The Sink Port is the USB power consumer port, which consumes power over VBUS. It is, by default, a USB port on a device.
- **Dual Role Port**: Dual Role Port (DRP) is a USB Type-C port that can operate as a DFP or UFP.



The Evolution of Universal Serial Bus (USB) and USB-C/PD



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USB-C: Past, present, and future

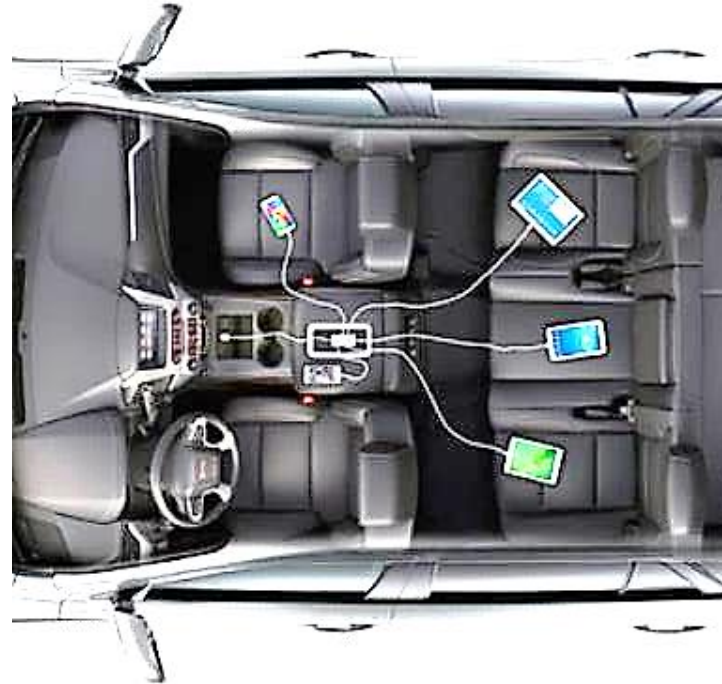
2015 to Today



Data, video, power over USB-C

USB-C enables one-cable docking to ultra-sleek, ultra-mobile notebook and smart phones

Next 2 Years



USB-C in every car

Abundance of USB-C ports in a car to fast-charge everyone's smart phone, tablet or notebook PC

Next 3 Years



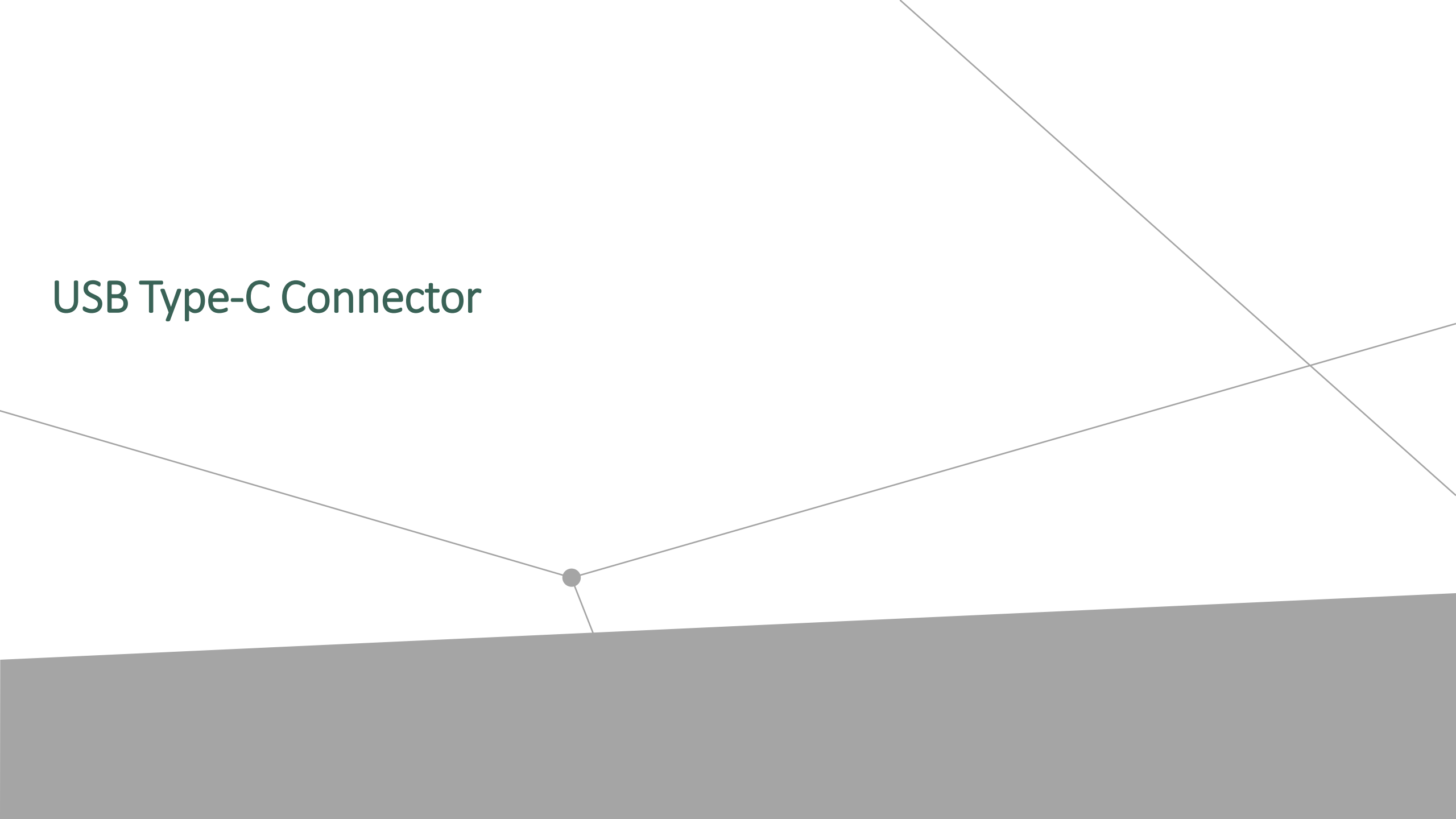
USB-C powers everything

USB-C chargers and power outlets replace all conventional power adapters



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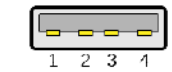
USB Type-C Connector



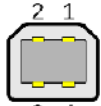
From USB-to-USB Type-C

USB 2.0 + 7.5W

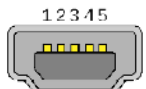
USB 3.x + 7.5W



Type-A



Type-B



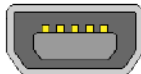
Mini-A

12345



Mini-B

12345



Mini-AB

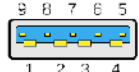


Micro-B

12345



Micro-AB



Type A SuperSpeed

98765



Type B SuperSpeed

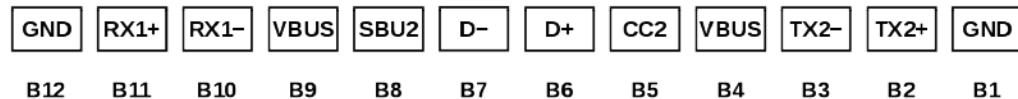
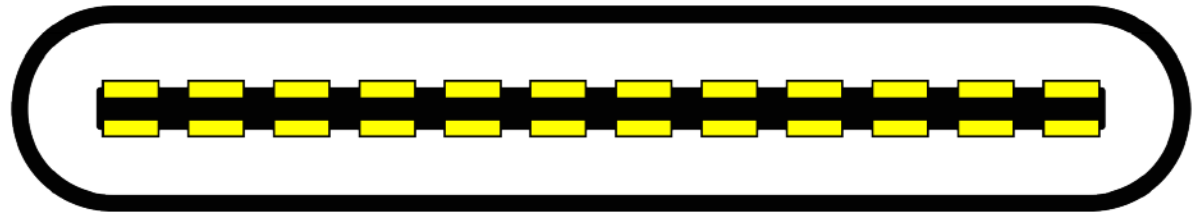
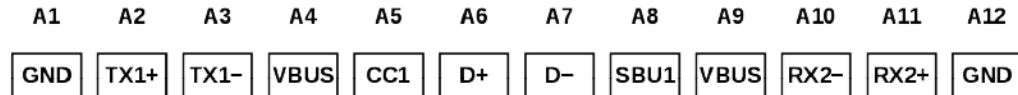
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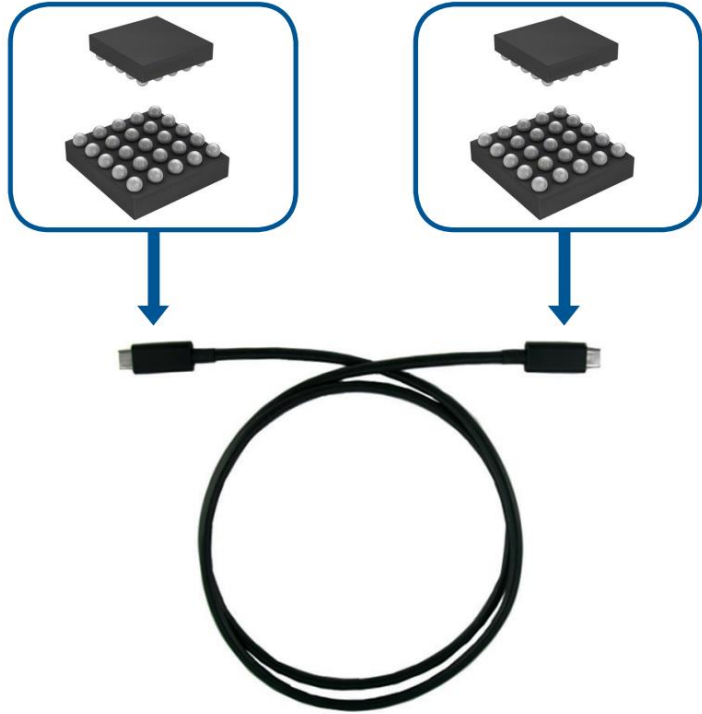
Micro-B SuperSpeed

USB-C

- ✓ USB 2.0/3.x/4
- ✓ Only 8.25 mm x 2.40 mm in connector size
- ✓ Plug orientation agnostic
- ✓ Directional agnostic
- ✓ Multi-protocol – USB, DisplayPort, Thunderbolt, HDMI
- ✓ **100W, up to 240W with EPR, bi-directional**

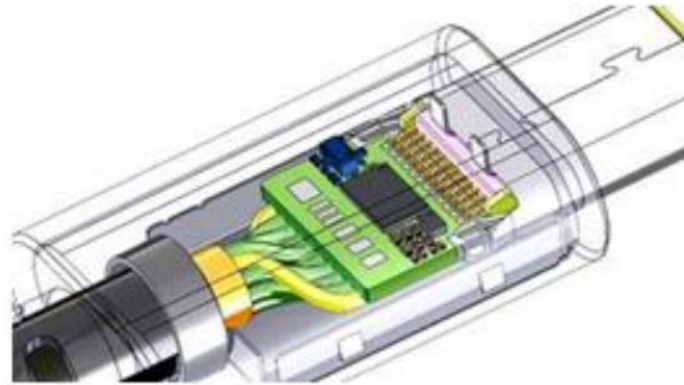


What is the USB Type-C Connector/Cable/Plug?



EMCA¹ Type-C Cable

A Type-C Cable with a controller on both ends of the cable inside the plug



USB Type-C Plug Housing



USB Type-C Receptacle

A Receptacle is the connector on the host or device



USB Type-C Plug

A Plug is the connector attached to the cable



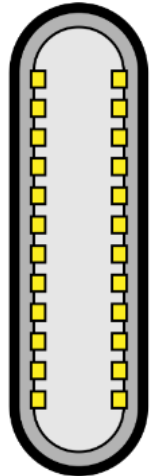
¹ Electronically Marked Cable Assembly: A USB Cable with an IC that reports cable characteristics (e.g., current rating) to the Type-C Ports

USB Type-C (USB 3.2+)

- **Low speed lines**
 - D+/ D- „legacy“ USB 2.0 signal lines
 - CC – Configuration channel used in the discovery, configuration and management of connections across a USB Type-C cable
 - SBU – sideband use pins, used in in *Alternate Modes* and *Accessory Modes* (Audio Adapter, ...)
 - V_{bus} – supply lines, with up to 22-24V voltage and up to 5A current capability
 - Risk of high voltage DC event on data lines due to malfunction
 - Overvoltage protection can be a requirement

- **SuperSpeed lines**

- RX# +/- / TX# +/-

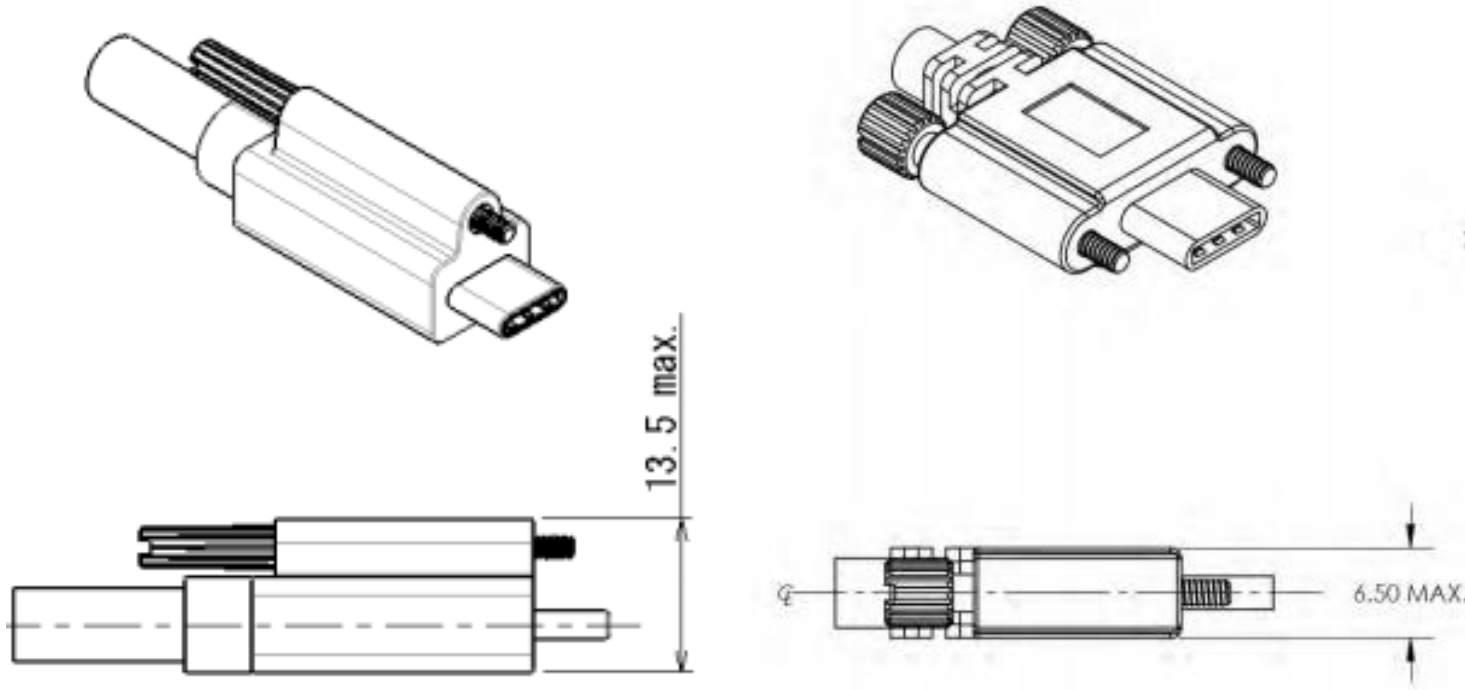


A12	GND	GND	B1	
A11	RX2+	TX2+	B2	SuperSpeed
A10	RX2-	TX2-	B3	
A9	Vbus	Vbus	B4	Supply
A8	SBU1	CC2	B5	Low speed
A7	D-	D+	B6	
A6	D+	D-	B7	
A5	CC1	SBU2	B8	
A4	Vbus	Vbus	B9	Supply
A3	TX1-	RX1-	B10	SuperSpeed
A2	TX1+	RX1+	B11	
A1	GND	GND	B12	

	Signaling
SuperSpeed (Rx, Tx)	USB 3.2 and beyond > 5 Gbps
Low Speed (D+, D-, CC, SBU)	USB 2.0: < 480 Mbps,
Supply (Vbus)	5.5V typical up to 22V for fast charging/power delivery

USB-C Connectors for Industrial Applications

Secure connection with USB Type-C Locking Connector Specification¹



Reliable for *Industrial Environment*



Also, as IP67 versions



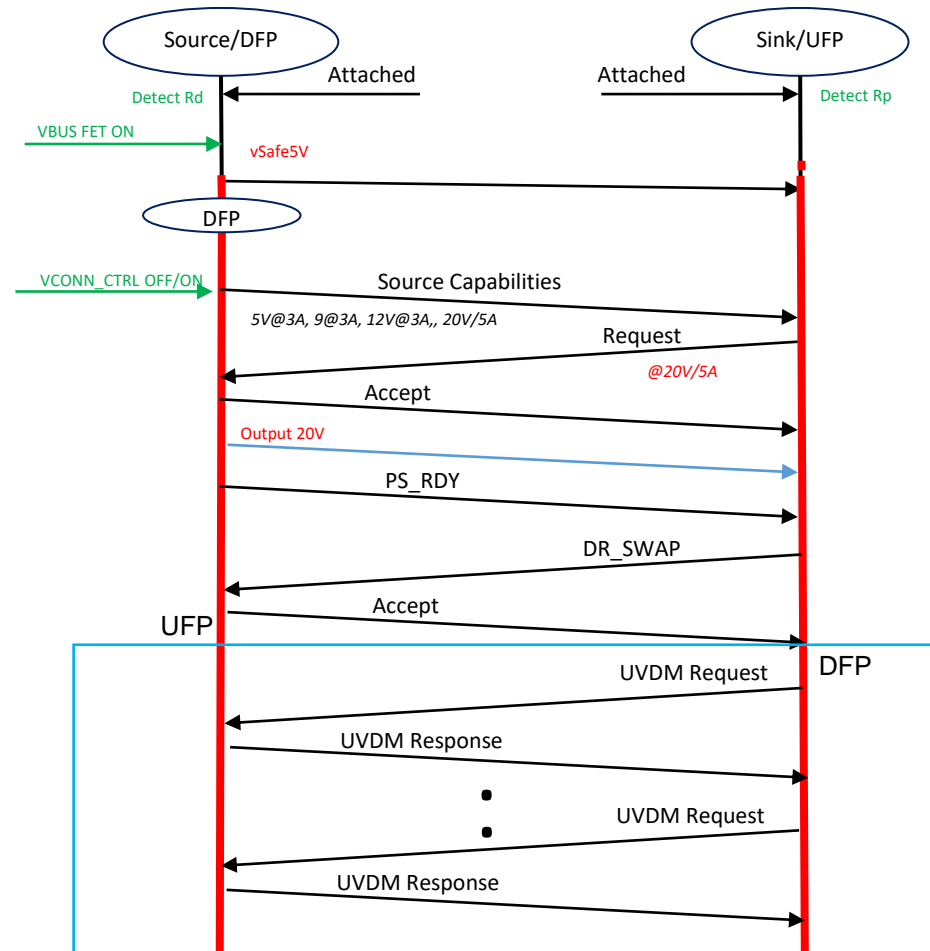
infineon

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PD3.0 Contract Negotiation and User Vendor Defined Messages (UVDM)



Do the data transaction from CC lines (UVDM)

USB Type-C PD Standards



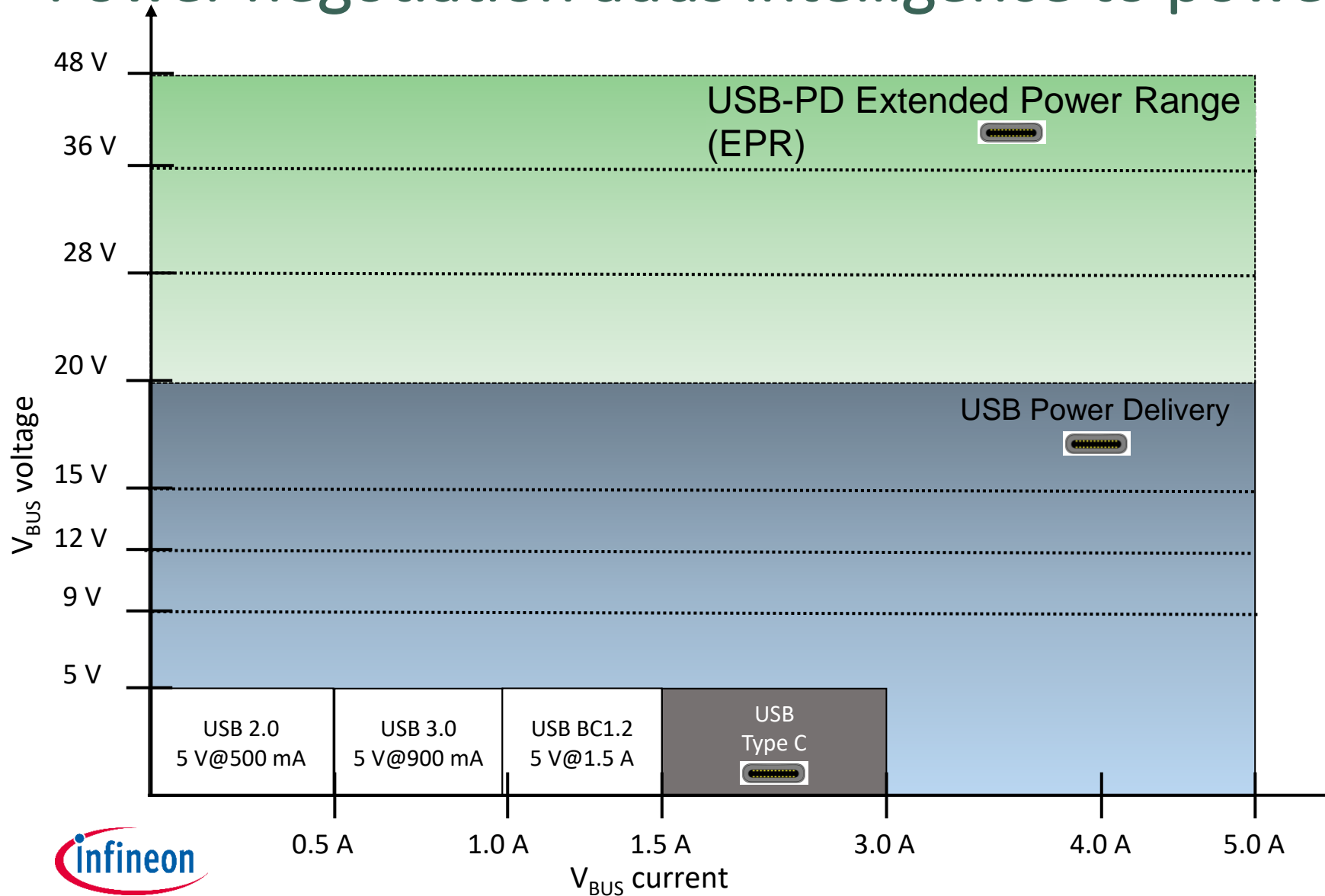
USB Type-C PD Standards

Spec	Release Date	Connector Type	Voltage	Current	Max. Power	Features
USB BC 1.2	2010	Type-A	5	1.5	7.5W	
USB PD 1.0	2012	Type-A, Type-B	5 / 12 / 20	1 / 2 / 3 / 5	100W	BFSK, fixed
USB Type-C	2014	Type-C	5	3	15W	Fixed
USB PD 2.0	2014	Type-C	5 / 9 / 12 / 15 / 20	3 / 5	100W	BMC
USB PD 3.0	2015	Type-C	5 / 9 / 12 / 15 / 20	3 / 5	100W	Auth/Feedback
USB PD 3.0 PPS	2017	Type-C	5 / 9 / 12 / 15 / 20	3 / 5	100W	PPS, Renegotiate
USB PD 3.1	2021	Type-C	5 / 9 / 12 / 15 / 20 / 28 / 36 / 48	3 / 5	240W	EPR

- › BMC: Bi-phase Mark Code
- › BFSK: Binary Frequency Shift Keying



Power negotiation adds intelligence to power delivery

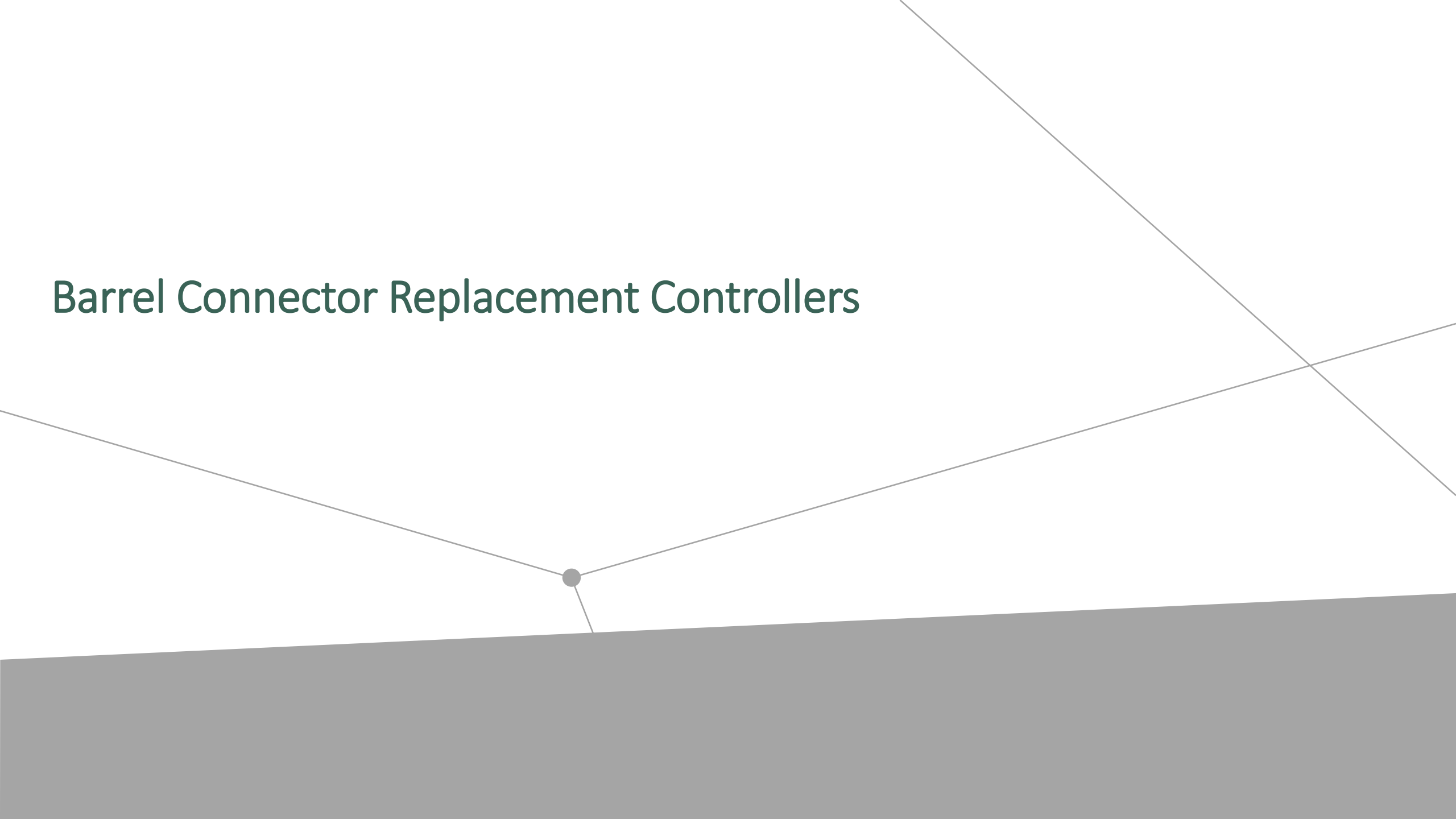


- › In the world before USB-PD voltage fixed \rightarrow 5 V; power limited to **7.5W**
- › USB-C connector introduced but still fixed voltage \rightarrow 5 V power up to **15W**
- › USB-C connector kept
- › Power Delivery (PD) protocol comprises flexible power supply concept
- › Hand shake between source & sink
- › Higher level of intelligence required
- › USB-C connector kept
- › Extended power/voltage range added while keeping the intelligence of power negotiation

Future Trends - USB PD EPR



Barrel Connector Replacement Controllers



USB-C Standardizes Power Adapters to a Common Connector

Disposal of chargers estimated causing about **11,000 tons** per year electronic waste in the EU



Universal Charger



European Union recognized the potential of USB power delivery

- › European Parliament and Commission reached agreement on 12 applications to have only USB-C connector for charging
- › With USB-C connector in box charger can be removed from those products
- › The new requirement will apply in Q4 2024



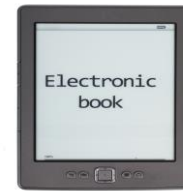
Tablets



Mobile phones



Digital cameras



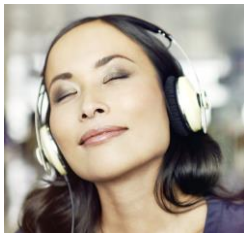
E-readers



Keyboards & mice



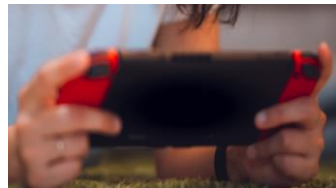
Portable speakers



Headphones & headsets



Earbuds



Videogame consoles



Portable navigation systems



USB-C: The New Universal Power Connector

Conventional Power Adapters

- ✗ Incompatible Connectors
- ✗ Fixed Voltage & Current
- ✗ Not made for sharing or re-use



USB-C Power Adapters

- ✓ Universal Connector
- ✓ Negotiable Voltage & Current up to 100W
- ✓ Standardized for sharing and re-use



Converting barrel connector to USB-C

Power provider



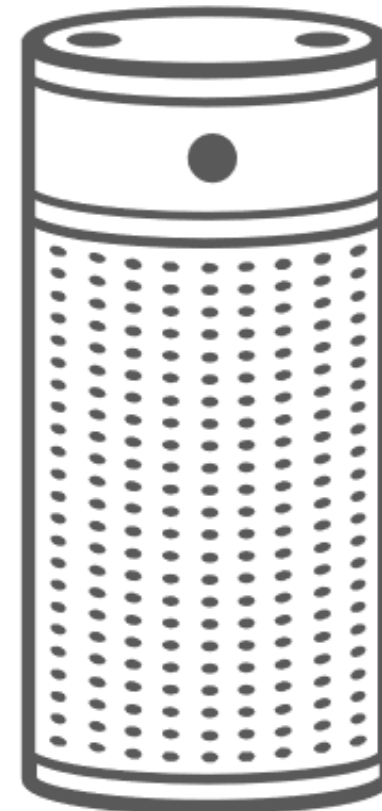
USB-C power provider



Power consumer



USB-C power consumer



EZ-PD™ BCR adds USB-C power-consumer to any system



No firmware development needed



Market proven, widely deployed, and it just works!

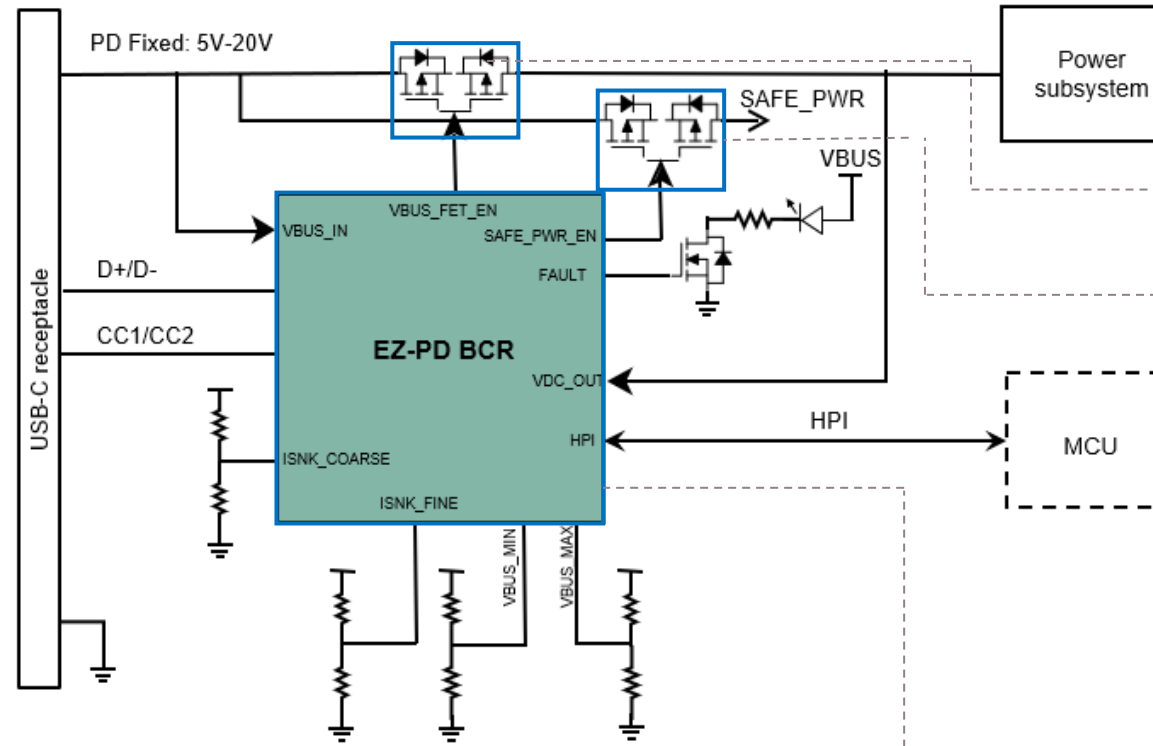


No expert knowledge of USB-C, USB-PD required



The easiest USB-C power consumer solution in the market because it works autonomously

System block diagram:



MOSFETs

V_{BUS} switch

> Back-to-back MOSFET

SAFE Power switch

> Back-to-back MOSFET

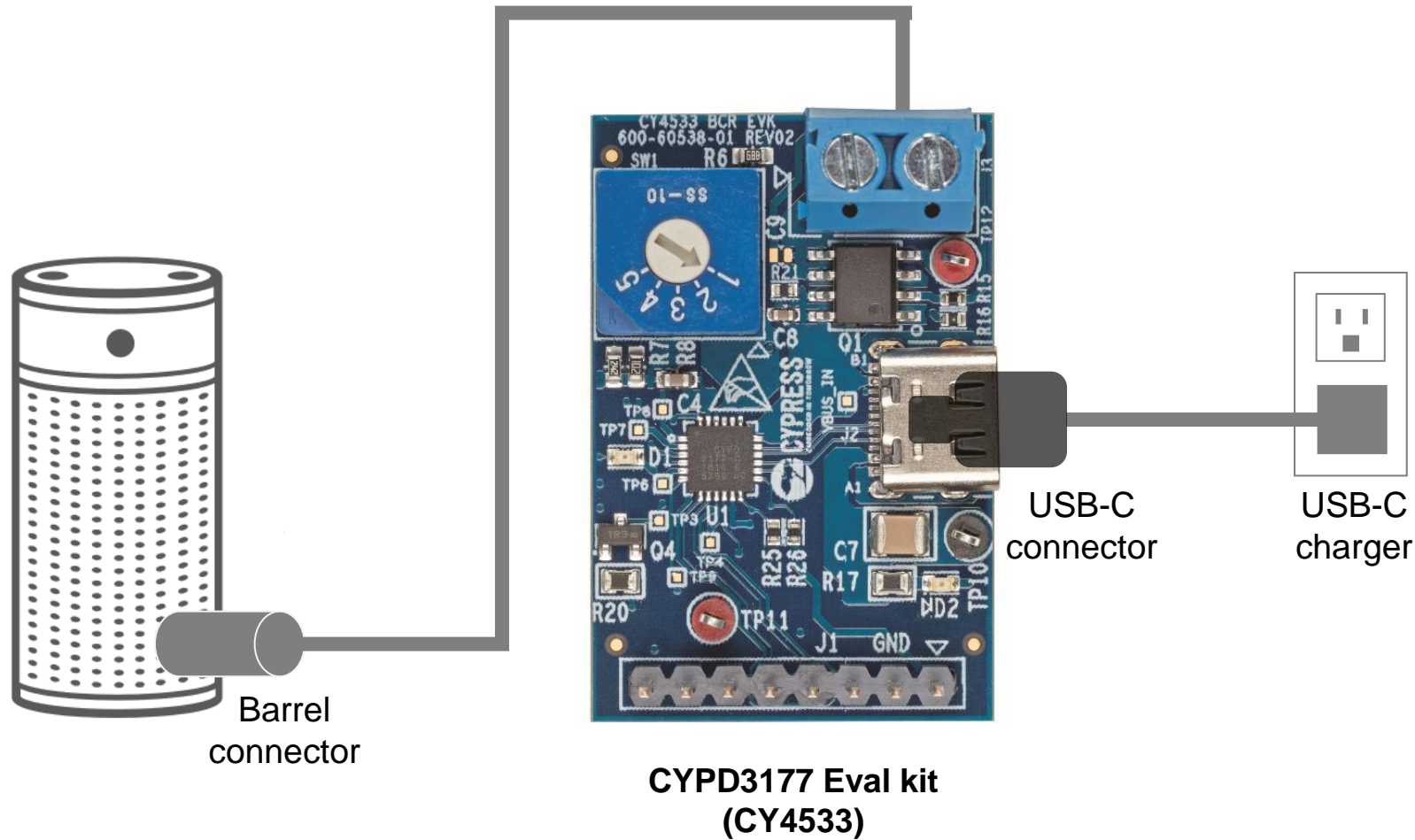
Controllers

USB-C & PD controllers

> CYPD3176 / 3177 / 3178



Prototype a USB-C power consumer with EZ-PD™ BCR kit



CYPD3176 Eval kit (CY4534)



CYPD3178 Eval kit (CY4535)



Infineon Developer Community

The screenshot shows the Infineon Developer Community website. On the left is a navigation menu with categories: Home, Product (Microcontrollers, USB), Software (Wireless Connectivity, Power), Applications (Sensors, Memories, Other Technologies), Blogs, Trainings (Security & Smart Card, Radio Frequency (RF)), General, Member Contributions & Content, and Community Sitemap. The main header features the Infineon logo, a search bar for 'All Community', and a 'Sign In' button. A green banner below the header reads 'Welcome to the Infineon Developer Community' and displays statistics: 66857 Discussions, 39059 Members, and 38087 Solutions. The 'Recent discussions' section is sorted by 'Most recent activity' and includes filters for 'Recent', 'Unanswered', 'Unsolved', and 'Solved'. Three discussion threads are visible: 1) 'Why USB time out error has been occurred?' by Ektars, dated Oct 9, 2022, with 8 views and 0 replies. 2) 'USB low-full-high speed peripherals FX2 thermal problem!' by not_A_quitter, dated Sep 30, 2022, with 67 views and 3 replies. 3) 'PSoC4 AD value not correct' by Li_Qiang, dated Oct 8, 2022, with 47 views and 4 replies, marked as 'Solved'. On the right side, there are two promotional cards: one for 'OktoberTech™ Asia Pacific, 13 Oct 2022' with the tagline 'Driving decarbonization and digitalization. Together.', and another for 'Community update: Application forums & training page launch' with a 'Read more' button. Below the update card is a 'Top Solution Authors' section.

<https://community.infineon.com/>

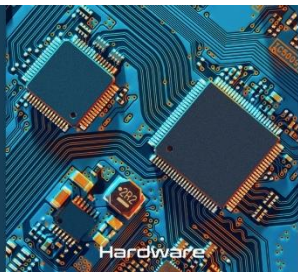
See you at EBV's booth



- Where you can find us today
 - Booth 7, D&E Event

- Where you can find us tomorrow
 - EBV Elektronik Utrecht
 - Ph No. 0346-583010
 - www.ebv.com
 - www.infineon.com

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