

USB Type-C™ and USB PD Demystified

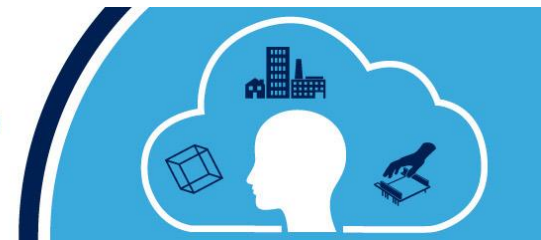
Gregory Gosciniak
Application engineer

STMicroelectronics



**ST Developers
Conference**

September 12th, 2019
Santa Clara Convention Center - Mission City Ballroom
Santa Clara, CA



Agenda 2

USB Type-C and USB Power Delivery Benefits

USB Type-C Technical Details

ST Offer

Evaluation Tools



The Re-evolution of USB

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USB has evolved from a data interface capable of supplying limited power to a primary provider of power with a data interface



USB
Type-C



Power
Delivery



USB
Data



Alternate
Mode

A smart and green technology

- More **flexibility** with a new reversible & thinner connector, more robust
- More **power** with USB Power Delivery (up to 100W)
- More **speed** with USB 3.1 (5/10Gbps) or USB 3.2 (20Gbps)
- More **protocols** (Display Port, HDMI, Thunderbolt 3, ...)



Power, Data & Display: All-in-One interface

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Power management



High Speed Data
USB 2.0
USB 3.x



Display Connection
Video + Audio
(DisplayPort™ or HDMI™)



USB Type-C™
USB-C™

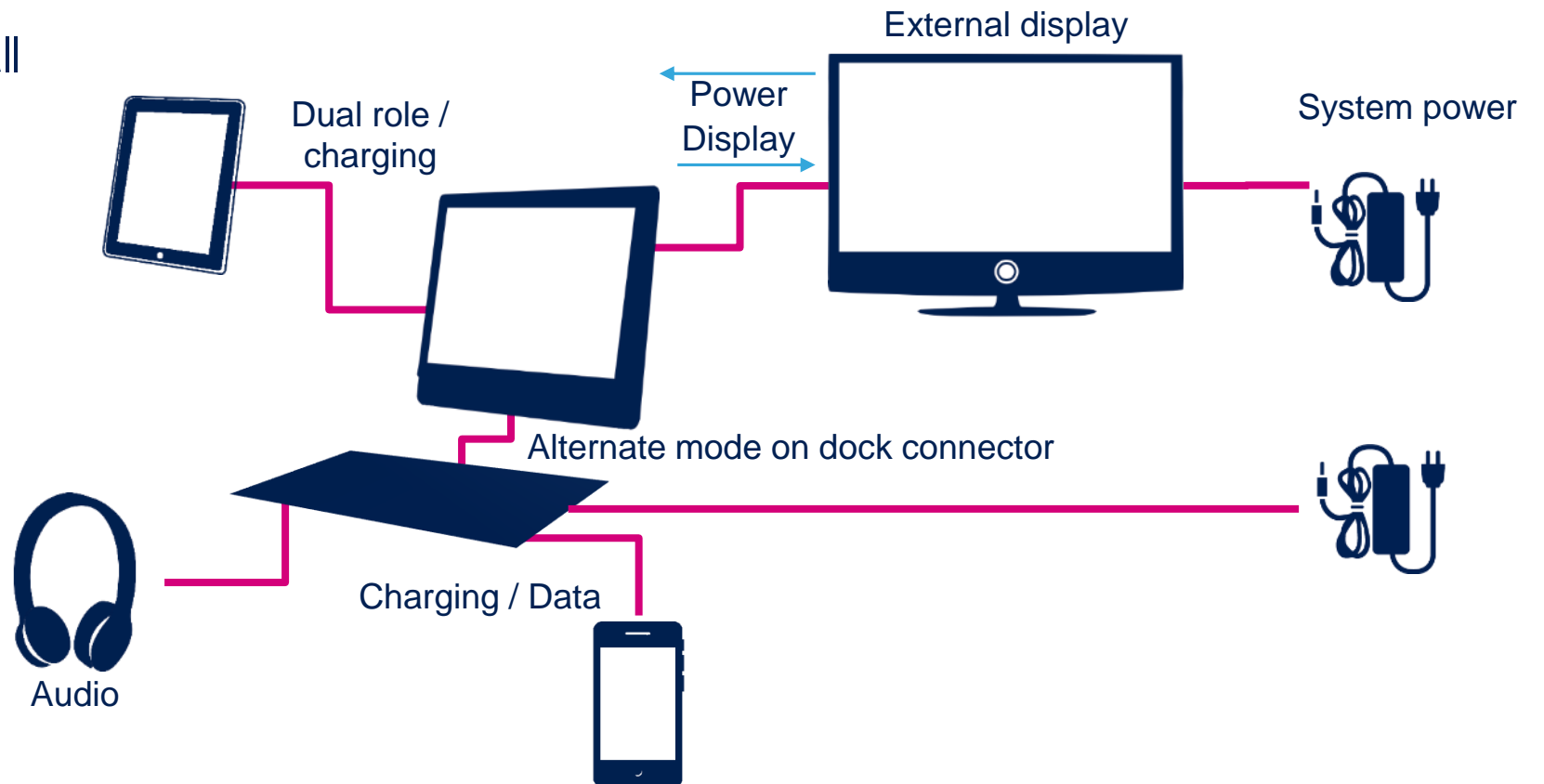


USB Type-C and USB Power Delivery

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Modifying the ecosystem.....enabling new scenarios!

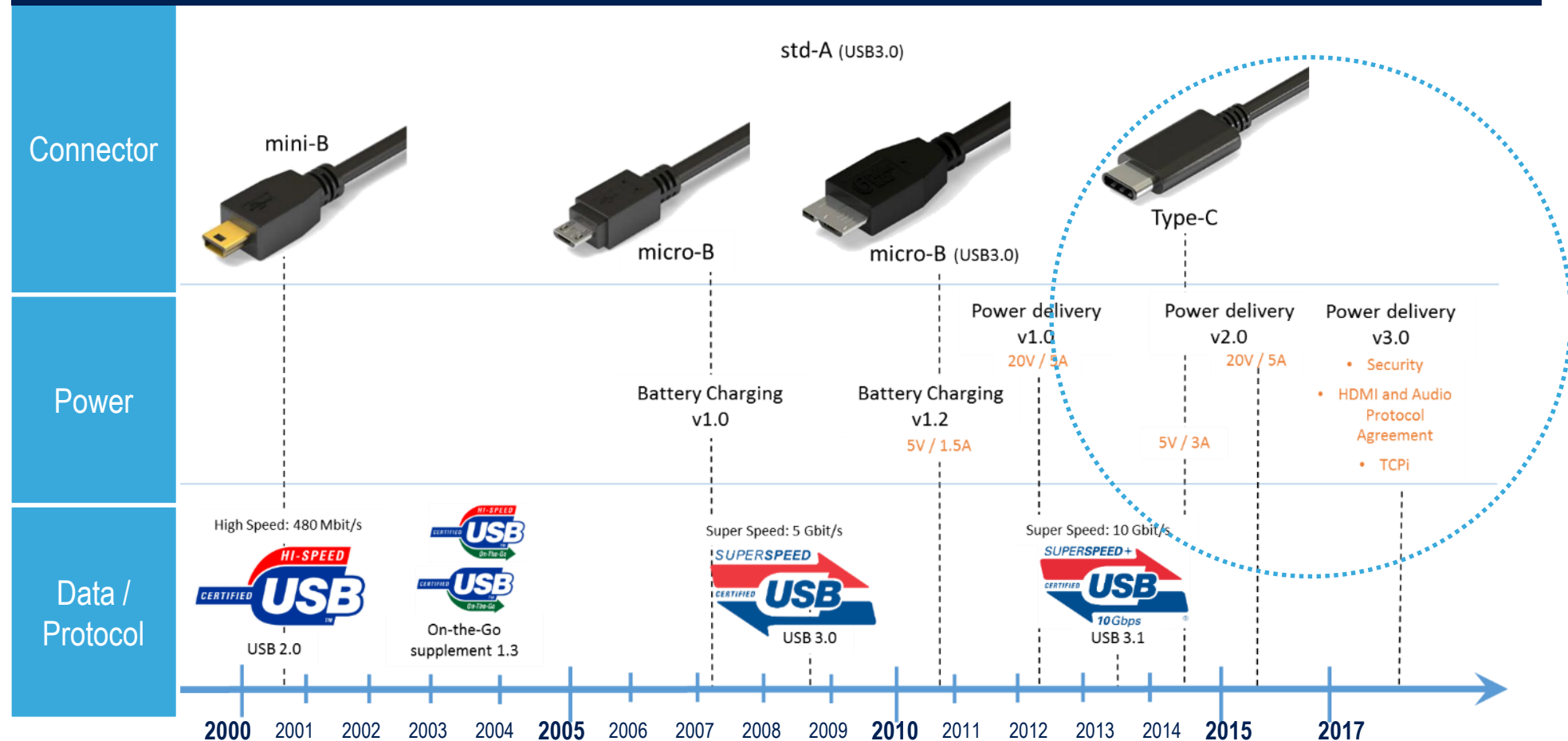
USB Type-C:
One port to rule them all



USB Global Evolution

6

STMicroelectronics is a board member of USB-IF and USB 2.0 & USB 3.0 promoter



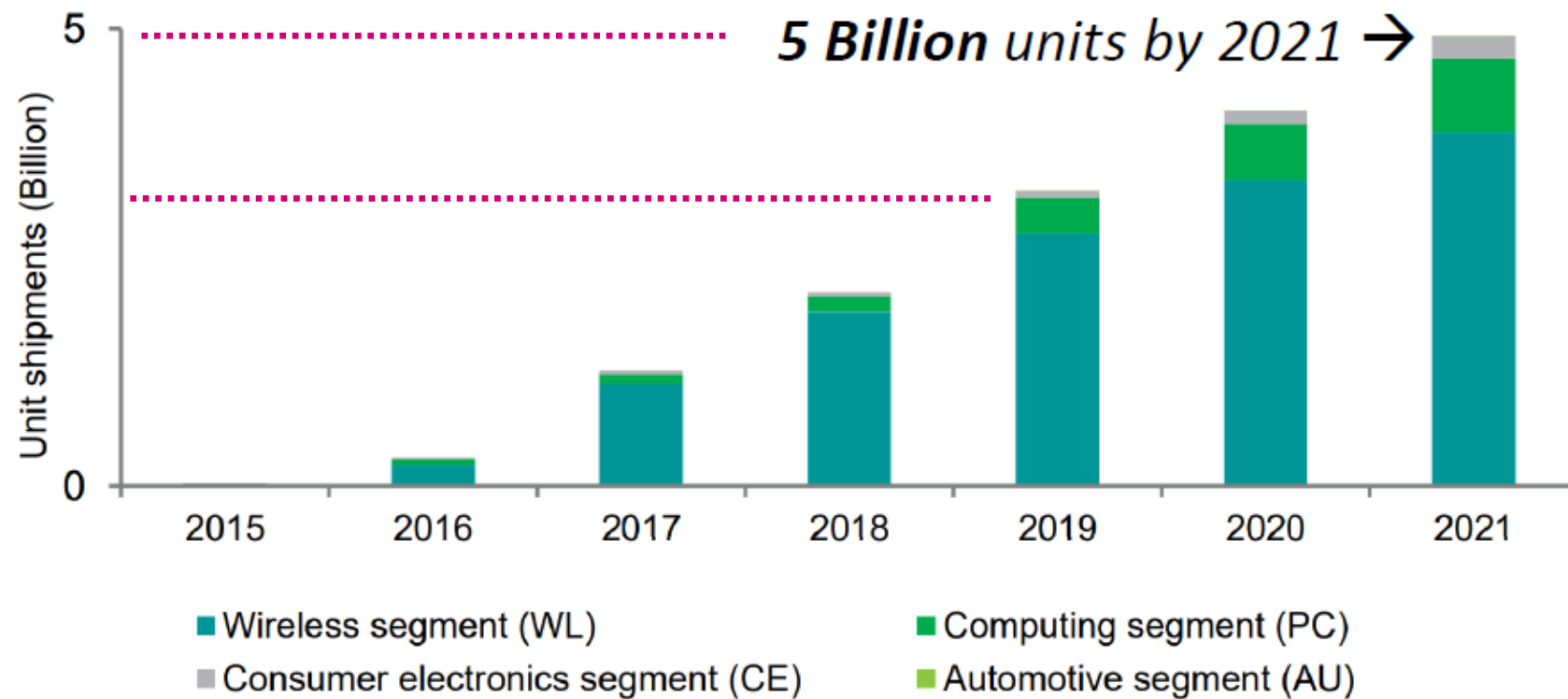
What to Expect?

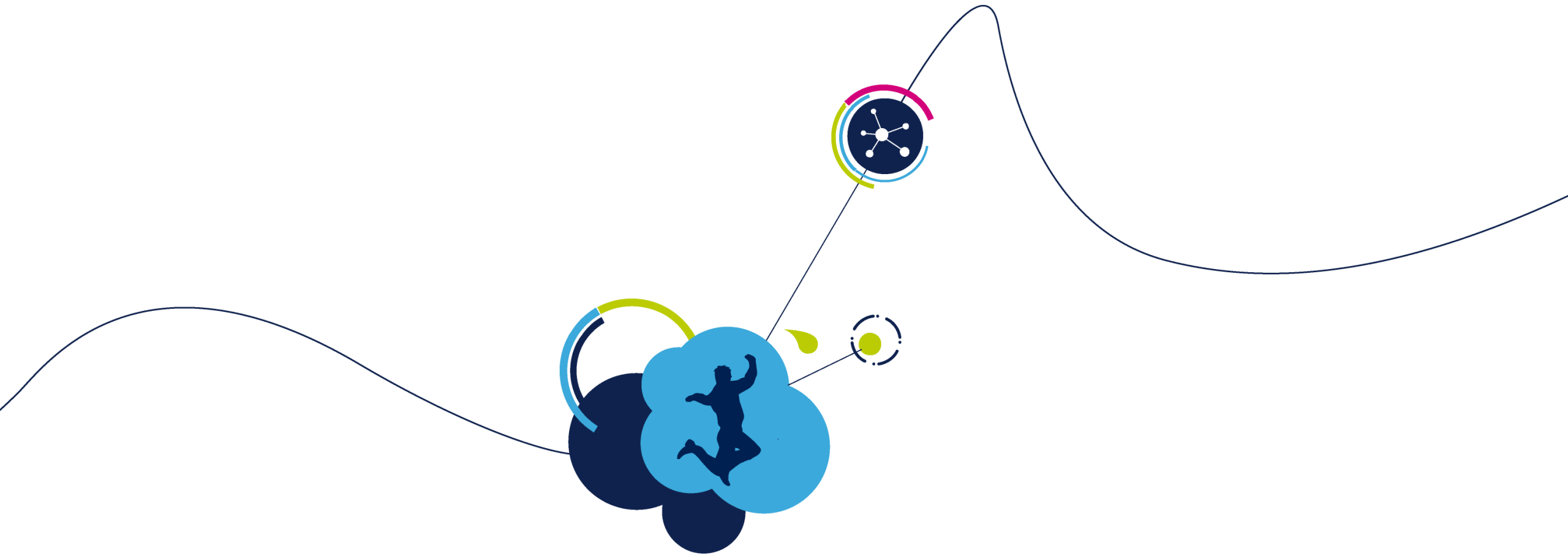
7

USB-C

A huge market...

Global adoption of USB Type-C across product segment : 2016 - 2021





USB Type-C Technical Details

USB Type-C Pinout Functions 9

Enhance ease of use

Receptacle



A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
GND	TX1+	TX1-	V _{BUS}	CC1	D+	D-	SBU1	V _{BUS}	RX2-	RX2+	GND
B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1
GND	RX1+	RX1-	V _{BUS}	SBU2	D-	D+	CC2	V _{BUS}	TX2-	TX2+	GND

Two pins on the USB Type-C receptacle, CC1 and CC2, are used in the discovery, configuration and management of connections across the USB Type-C cable

Plug



A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1
GND	RX2+	RX2-	V _{BUS}	SBU1	D-	D+	CC	V _{BUS}	TX1-	TX1+	GND
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12
GND	TX2+	TX2-	V _{BUS}	V _{CONN}			SBU2	V _{BUS}	RX1-	RX1+	GND

On a standard USB Type-C cable, only a single CC wire within each plug is connected through the cable to establish signal orientation. The other CC pin is repurposed as V_{CONN} for powering electronics
Also, only one set of USB 2.0 D+/D- wires are implemented

High Speed Data Path
(RX for USB 3.1, or
reconfigured in Alternate Mode)

High Speed Data Path
(TX for USB 3.1, or
reconfigured in Alternate Mode)

USB 2.0
Interface

Cable Bus Power
(from 5V up to 20V)

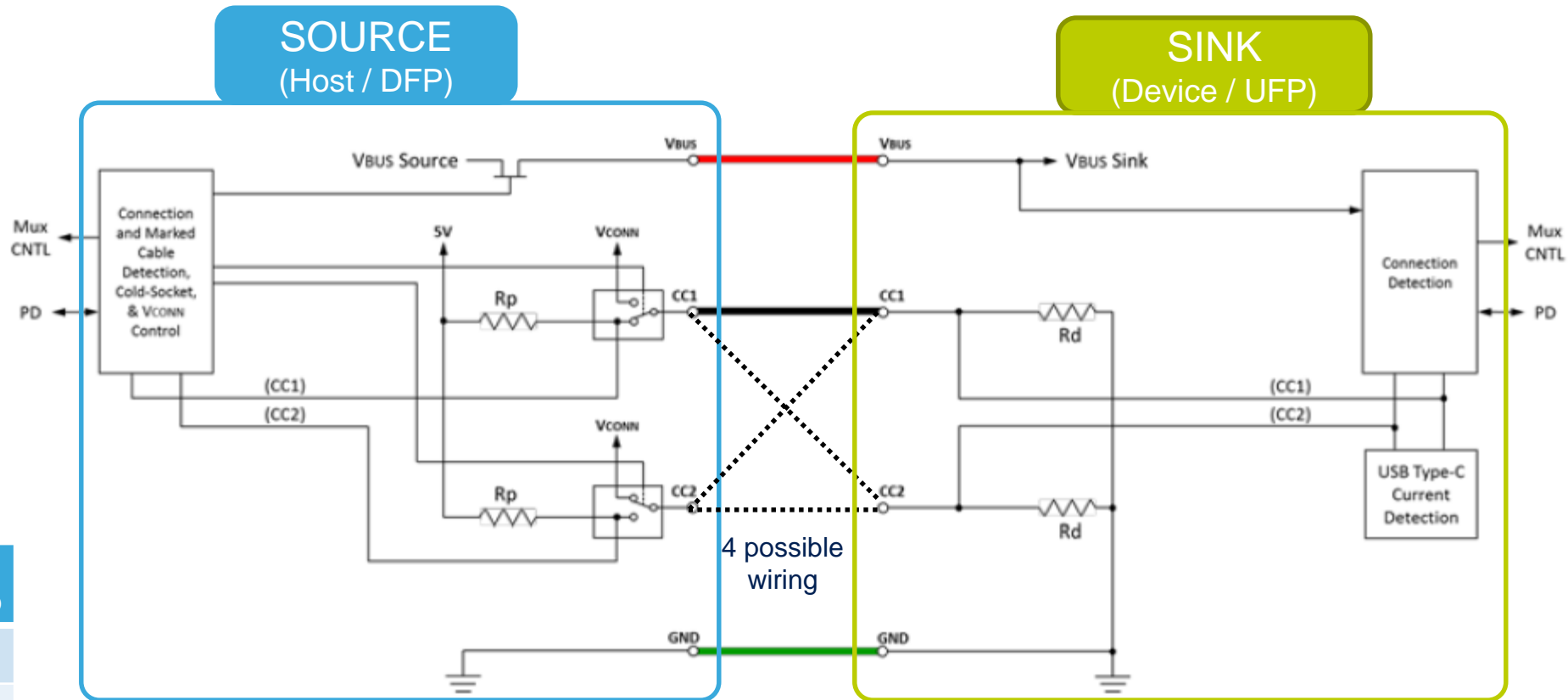
Sideband
use

Cable
Ground

Configuration
Channel

USB-C: Host-to-device Connection

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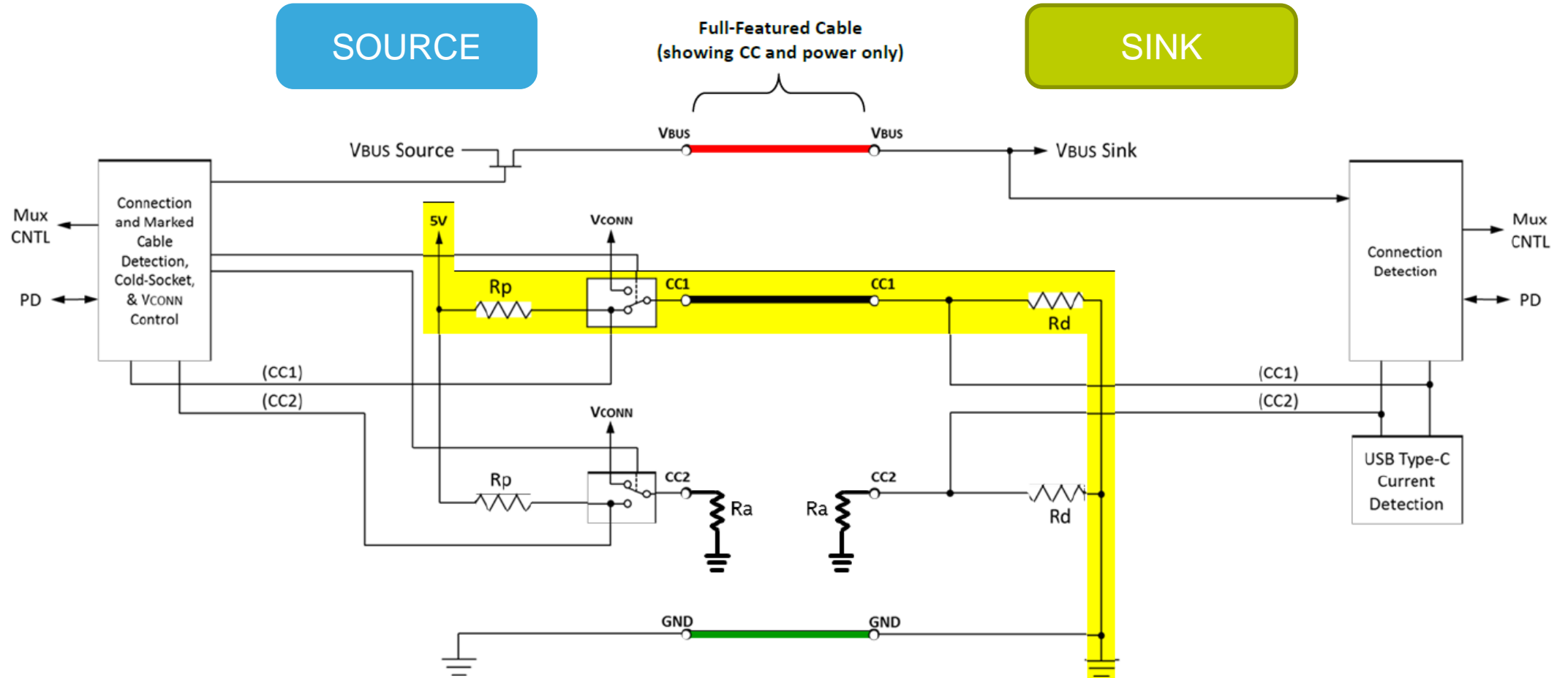
Source Power	Rp pull-up
Legacy current	56 kΩ
1.5A @ 5V	22 kΩ
3A @ 5V	10 kΩ

1. By default: **VBUS is not powered** (cold socket)
2. At insertion detect, the Configuration Channel (**CC pin**) is used to solve plug orientation (**CC1 or CC2**)
 - HOST identified by Pull-up resistor / current source on its CC pin
 - Device identified by Pull-Down resistor on CC pin
3. After correct Host to Device connection, VBUS is supplied as well as Vconn on the unconnected CC pin
4. Optionally, USB PD, Alternate or Accessory Mode can be supported

USB-C principle

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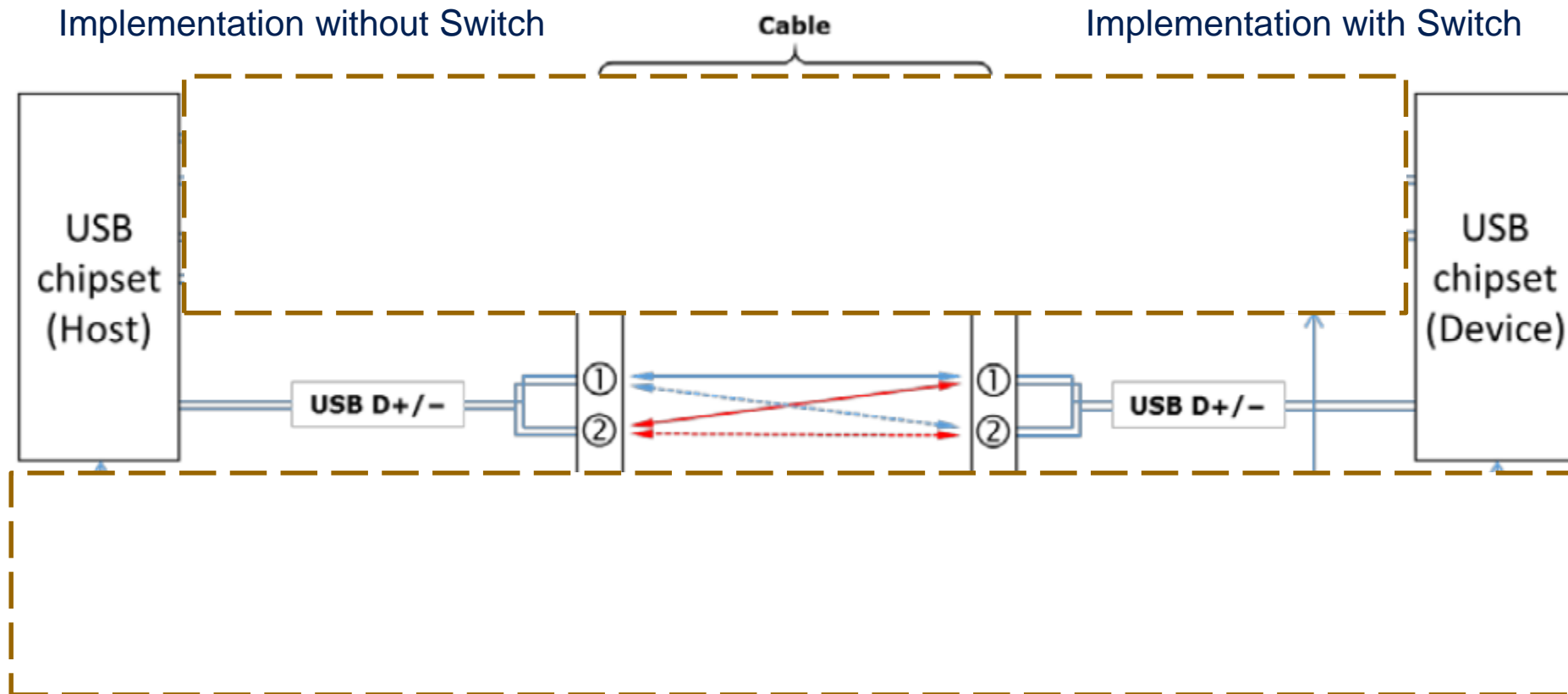
- Source-Only meets Sink-Only



Host-to-device Connection

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- Logical Model for Data Bus Routing

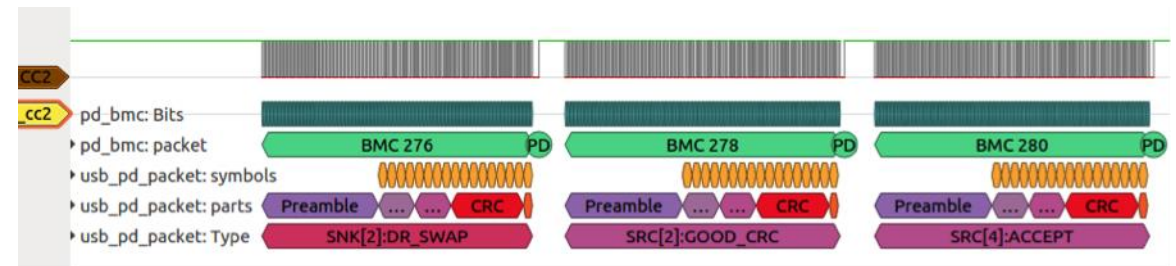


USB Power Delivery (USB PD)

Key Characteristics

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- Voltage and Current values are **negotiated** (via CC pin)
 - Higher voltage and current: power up to 100W (20V / 5A)
- **Swapping** of power direction, data direction and source of VCONN
- Communication with USB Type-C Electronically Marked Cables (**EMC**)
- Support for **Alternate Modes** of operation (DP, MHL, Thunderbolt)
- Signaling :
 - 1-wire communication, bidirectional
 - Half duplex system
 - Biphase Mark Coding (BMC)
 - Bit rate : 300kbps
 - CRC-32 used to detect data corruption

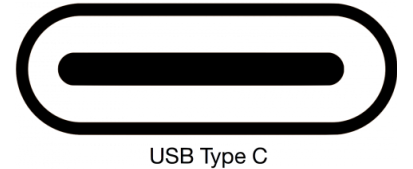


USB Type-C [vs] USB PD

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- USB-C

- Power: **15W** max
 - 5V/3A, 5V/1.5A, 5V/LegacyCurrent
 - Legacy USB2.0 power: 5V/500mA (after USB enumeration), 5V/100mA (no enumeration)
- Power Role: Source, Sink, or Dual Role Power (DRP)



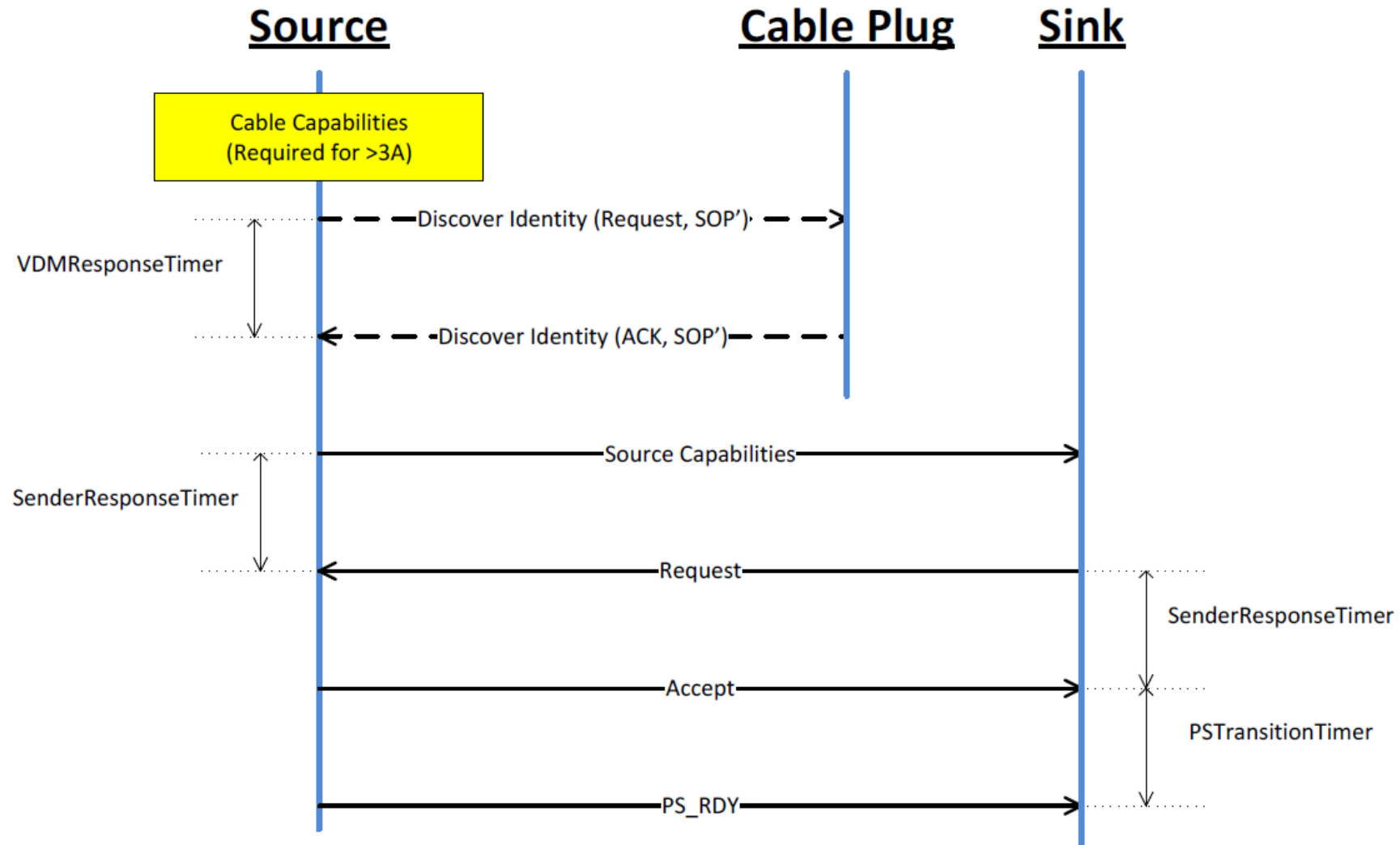
- USB-C Power Delivery

- PD communication occurs on CC line
- Power: **100W** max (20V@5A)
 - VBUS min= 5V ; max= 20V
 - Several power profiles possible (PDO). e.g.: [5V, 9V, 15V, 20V]
- PD mode always starts after USB-C attachment is done (i.e. 5V is available on VBUS at this point)
- Additional optional features:
 - Swap of Power Role, Swap of Data Role
 - Communicate with EMC cables, VDM, authentication, Alternate modes, Firmware update over CC, ...



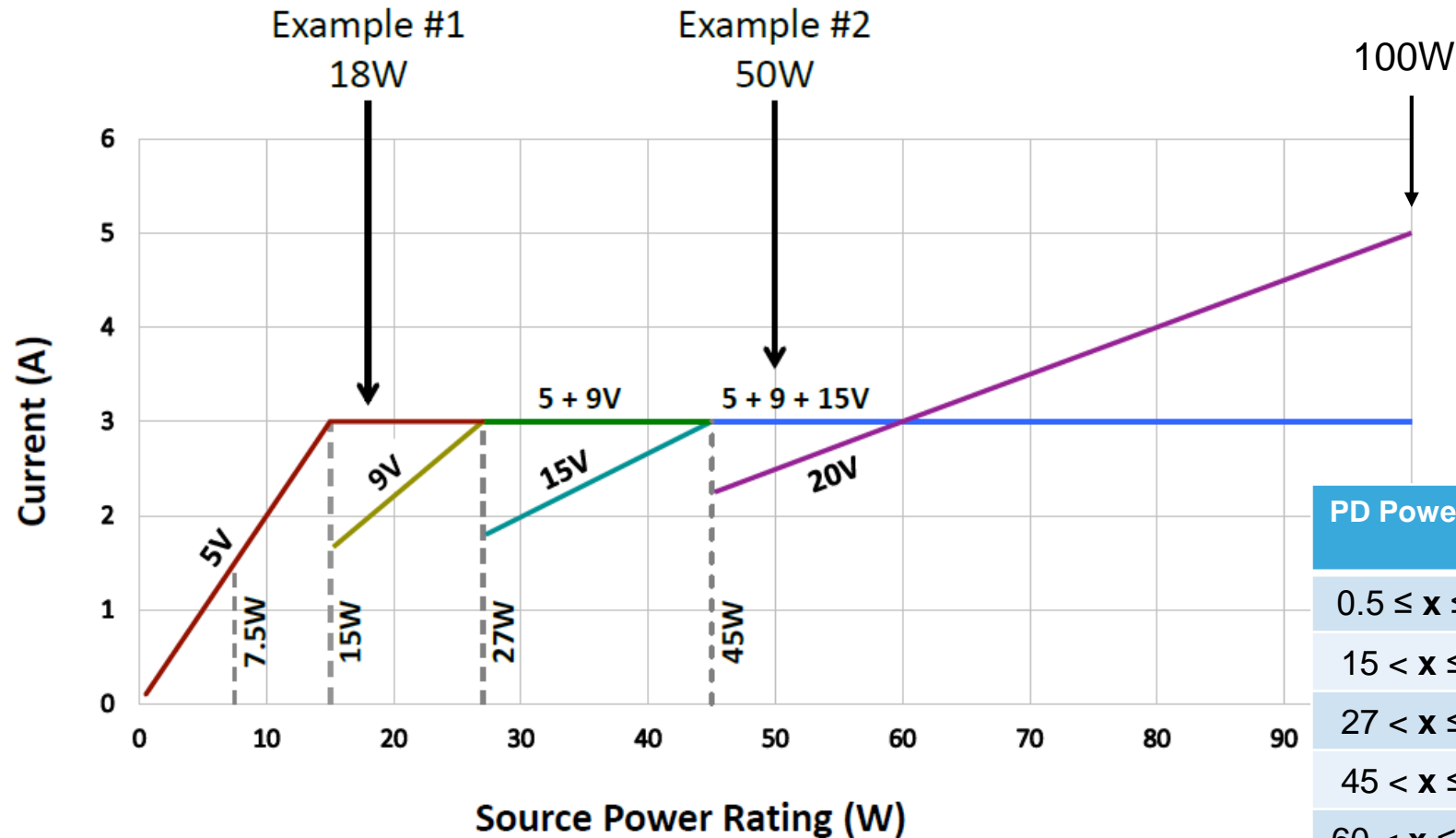
USB-PD: Power Negotiation Sequence

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USB-PD 2.0 & 3.0 Power Rules

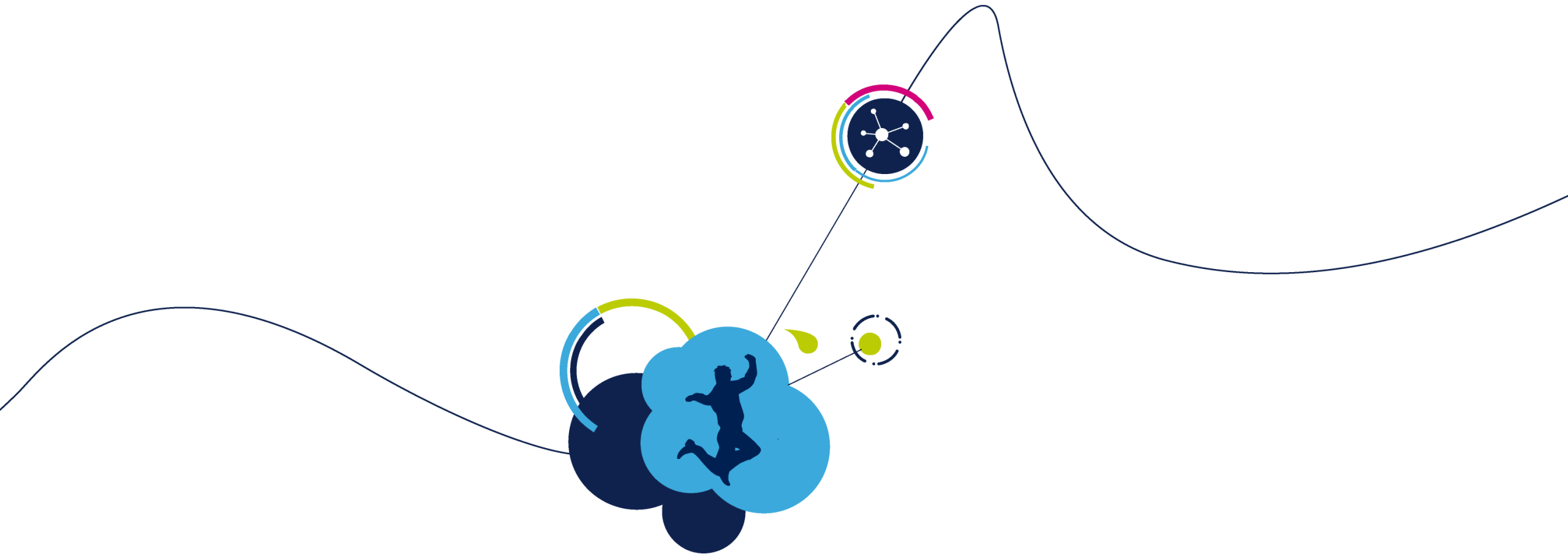
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PDO : Power Data Object
(Voltage, Current)

PD Power (W)	Current (A) at 5V	Current (A) at 9V	Current (A) at 15V	Current (A) at 20V
$0.5 \leq x \leq 15$	$x \div 5$			
$15 < x \leq 27$	3	$x \div 9$		
$27 < x \leq 45$	3	3	$x \div 15$	
$45 < x \leq 60$	3	3	3	$x \div 20$
$60 < x \leq 100$	3	3	3	$x \div 20$ (*)

(*) Requires a 5A cable

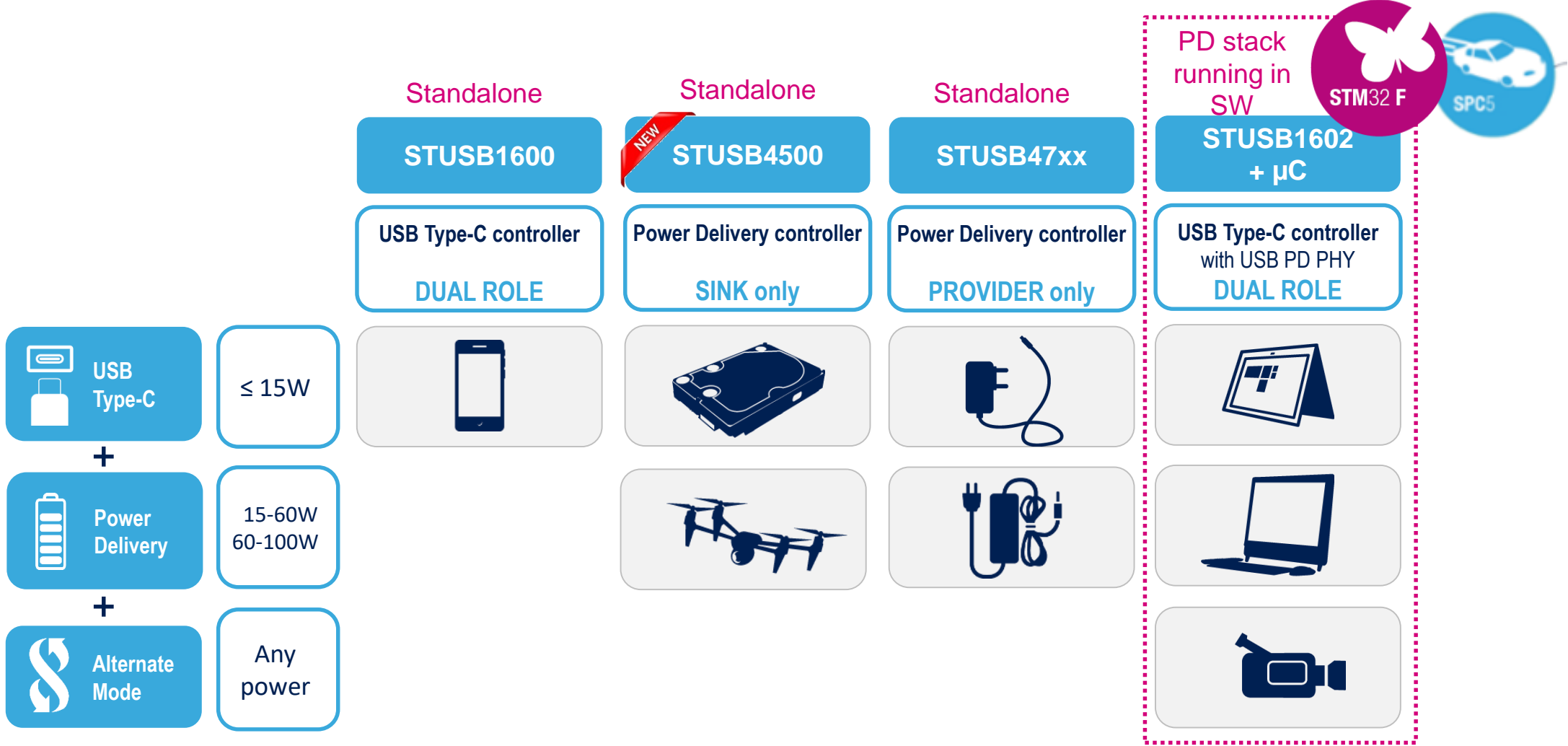


ST Offer



Hard Coded Type-C™ and USB PD Controllers

Covering all use cases from Type-C to full-feature Power Delivery





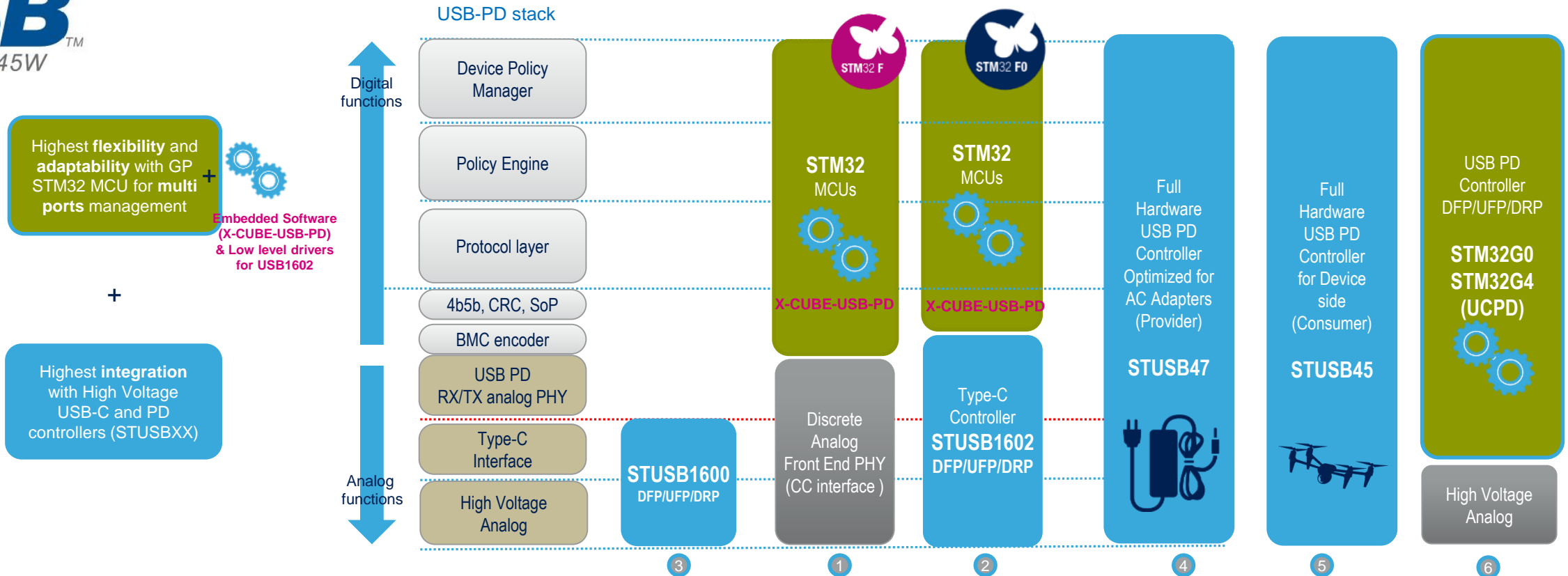
Type-C & USB PD Controllers

Certified Solutions

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Offer to designers the flexibility to enable the needed optimization of stack partitioning and BOM



1. Market proven FW solution on STM32F0 with discrete Analog Front End to control two DRP Type-C
2. More integration with STUSB1602 Type-C PD Controller including PD PHY and BMC line driver
3. Full HW solution with STUSB47 PD controller optimized for AC adapters (1 Port Provider)
4. Standalone Type-C interface STUSB1600 up to 15W



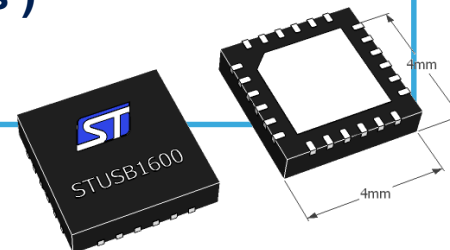
STUSB1600

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USB Type-C controller – Source / Sink / DRP

Features

- **Transition any USB Type-A/Micro-B to USB Type-C**
- Performs USB Type-C detection including port attach & cable orientation
- Supports legacy, 1.5A & 3A USB Type-C charging profiles
- Embeds
 - VCONN power switch (OVP,OCP,OTP)
 - Vbus Monitoring & Discharge Path
 - Dead Battery Support
 - PMOS Gate drivers
 - **High Voltage Protections (CC pins & Vbus)**





STUSB47xx - SOURCE

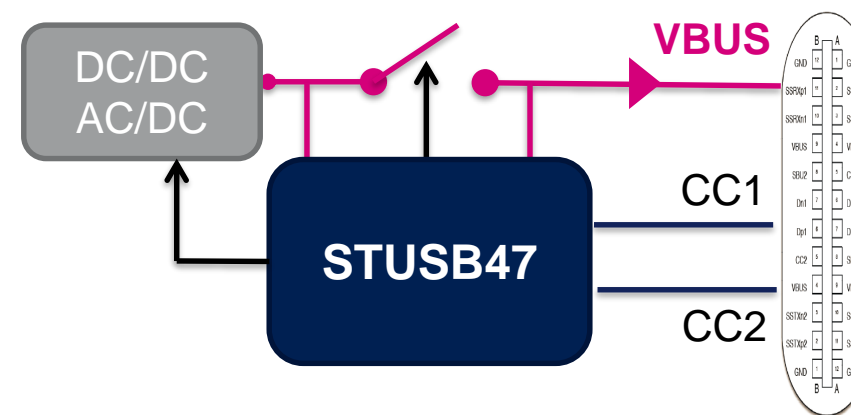
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Standalone USB Power Delivery Controller - SOURCE

Provider

- all USB PD profiles supported up to 100W
- Suitable for AC/DC and DC/DC

- Auto-run / Plug & Play
- Dead Battery Support
- Up to 5 PDO profiles
- Short to VBUS Protections
- Power sharing capable thru MCU



Certified





STUSB4710

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Autonomous Type-C & USB PD controller

Features

- **Full HW USB-PD stack** for safe USB PD r2.0 negotiation
- Single Role, **Provider Only** (Source)
- Performs USB Type-C detection including port attach & cable orientation
- Establish Safe & valid Host to Device Connection
- Offers up to 5 programmable PDOs
- Offers very low power consumption
- Embeds
 - Vbus Monitoring & Discharge Path
 - PMOS Gate drivers
 - **High Voltage Protections (CC pins & Vbus)**



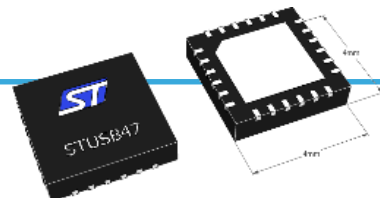
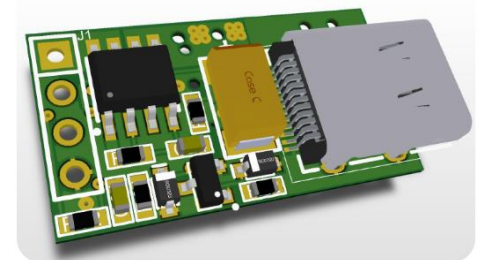
SO-16



QFN-24
4x4 mm²



QFN-16
3x3 mm²





STUSB4500 - SINK

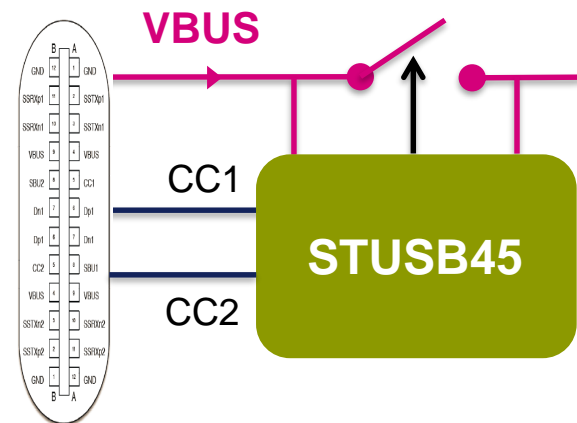
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Standalone USB Power Delivery Controller - SINK

Consumer

- all USB PD profiles supported up to 100W
- Fast migration to USB PD

- Auto-run / Plug & Play
- Dead Battery Support
- Up to 3 SINK PDO profiles
- Short to VBUS Protections
- PCB area saving



To battery charger
or system DC/DC

Certified



STUSB4500 Footprint

DEMO BOARD – USB Type-C/PD SINK

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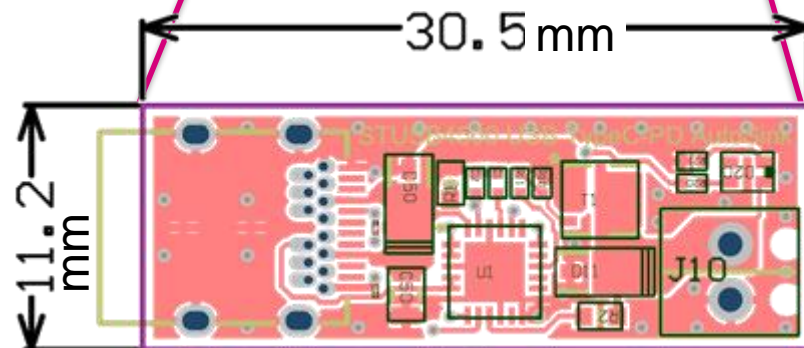
Passive components
supplied by
Würth Elektronik:



Power any 100W (or less)
device with USB PD!

It's:

- Tiny,
- Safe,
- Certified,
- Plug-Play
- Customizable

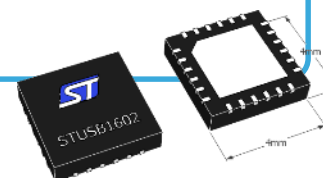
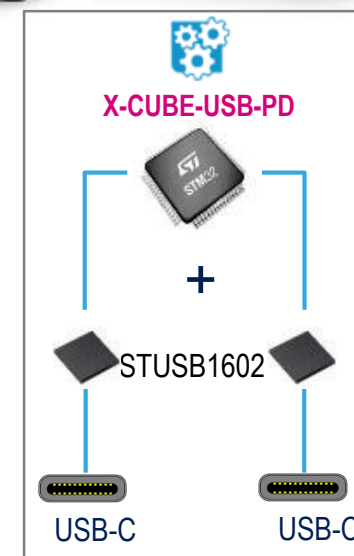


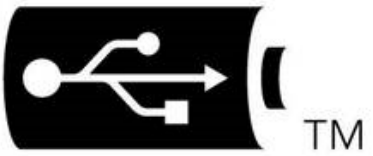


Type-C & USB PD controller – DRP/Source/sink

Features

- Analog Front End
- **Integrates the USB PD r2.0 PHY + BMC encoding**
- **Compatible with USB PD r3.0**
- Perfect companion chip to EC to manage USB Type-C port
- Performs USB Type-C detection including port attach & cable orientation
- Embeds
 - VCONN power switch (OVP,OCP,OTP)
 - Vbus Monitoring & Discharge Path
 - Dead Battery Support
 - PMOS Gate drivers
 - High Voltage Protections (CC pins & Vbus)
- Solves **Security & safety** concerns

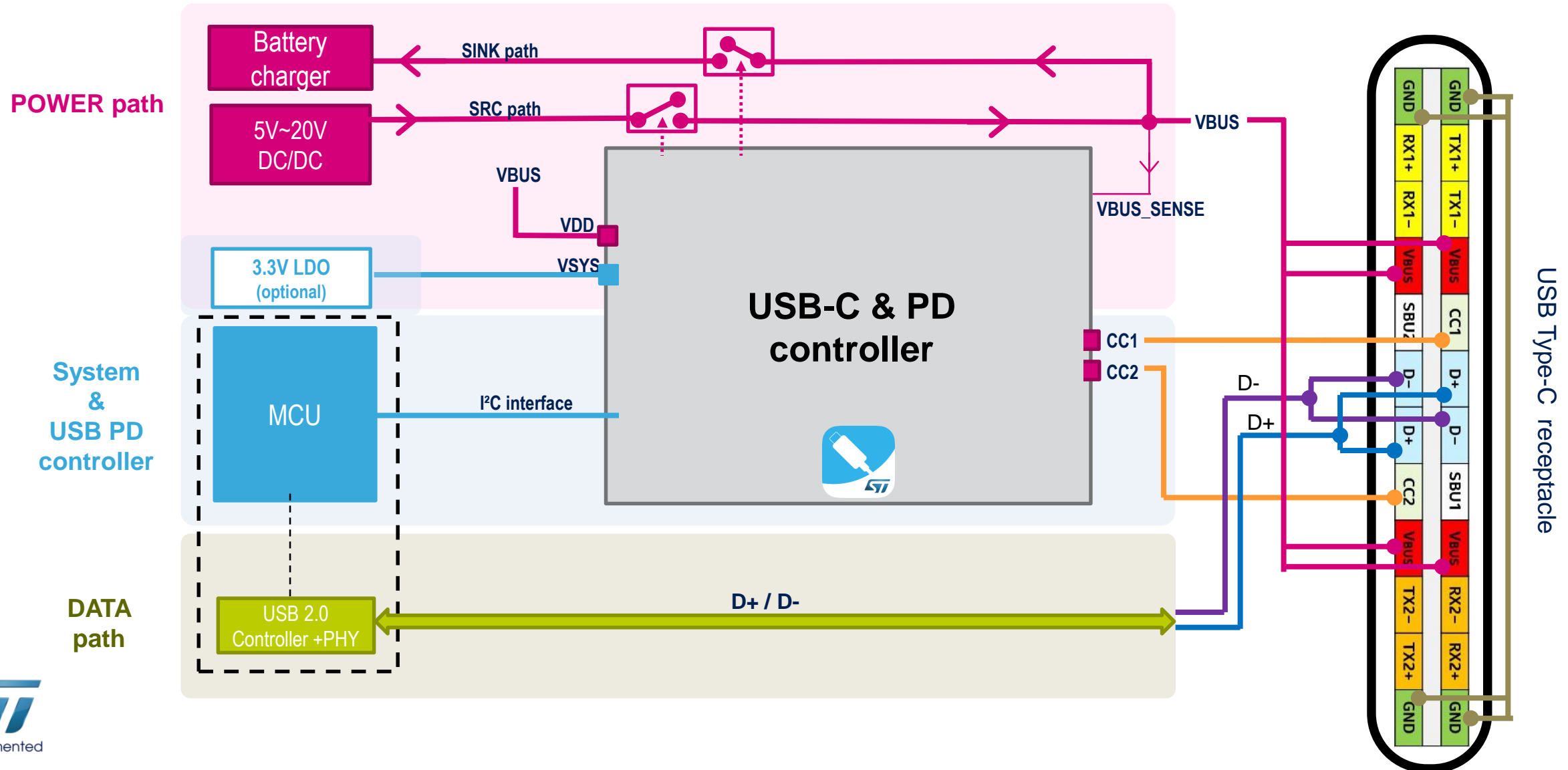




USB Type-C + USB 2.0

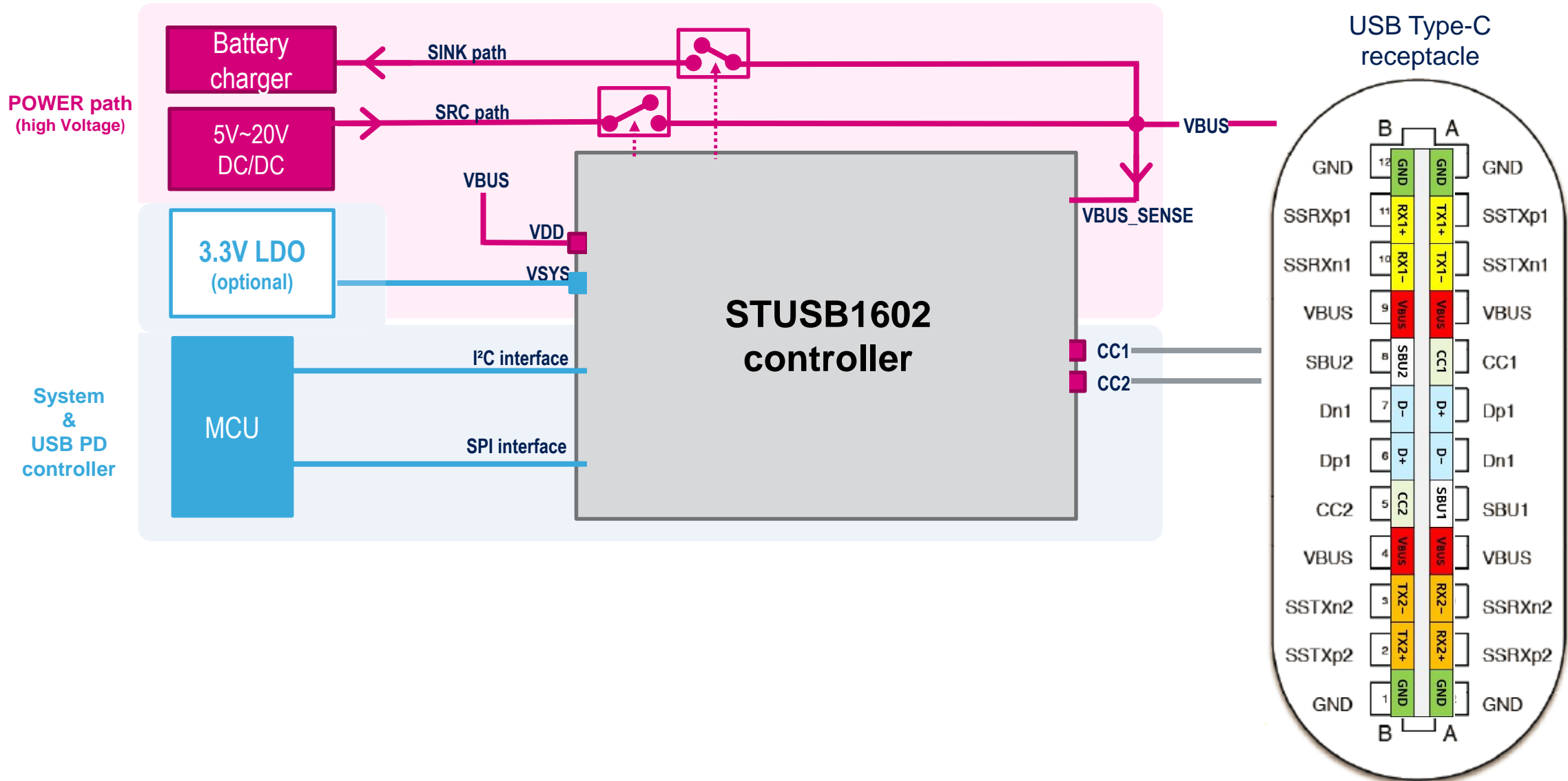
HW implementation in DRP mode

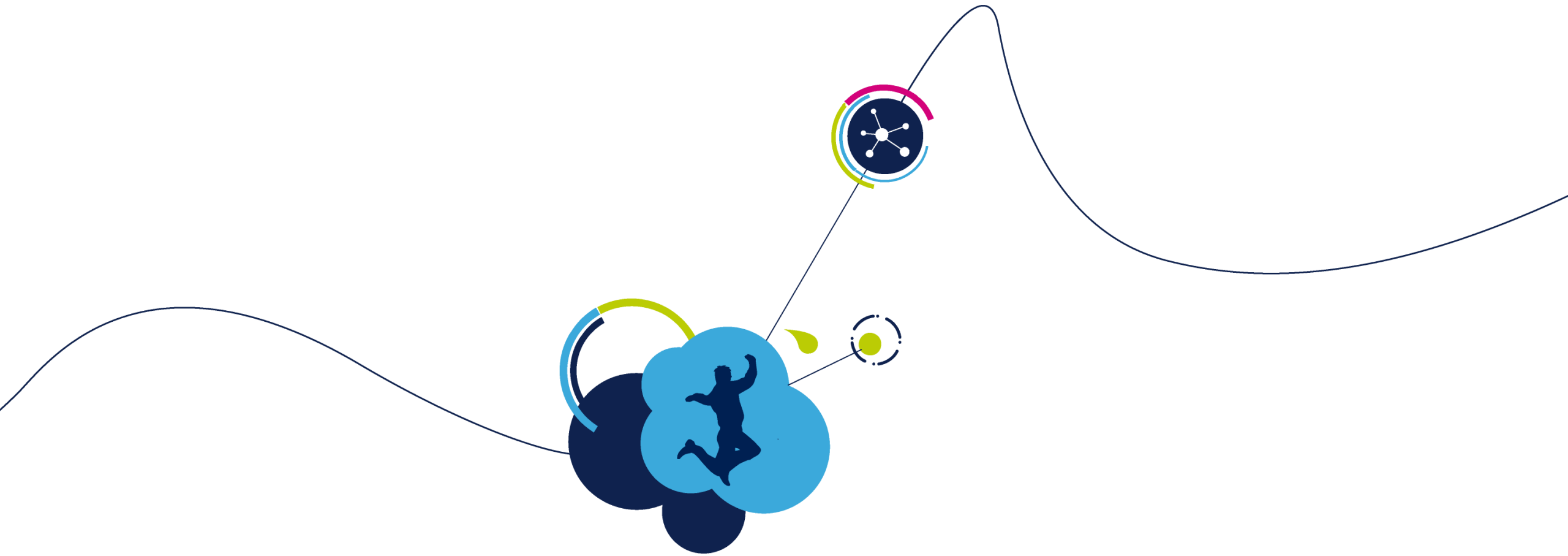
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STUSB1602 Dual-Role Power (DRP) Implementation example

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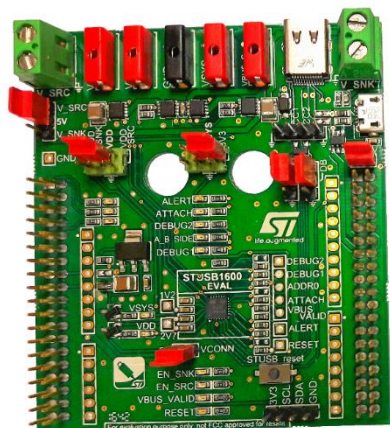
Evaluation Tools



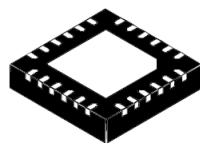
STUSB1600A - DRP

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Standalone USB Type-C Controller



STEVAL_CCC002V1



QFN-24 - EP
4x4 mm²

- Dual Role, provider, consumer
- Fast migration to Type-C <15W

- Configurable start-up profiles
- Dead battery support
- Short to VBUS Protections



Ideal solution for <15W
charging (1.5A @5V / 3A@5V)
with or without
USB DATA

CERTIFICATION

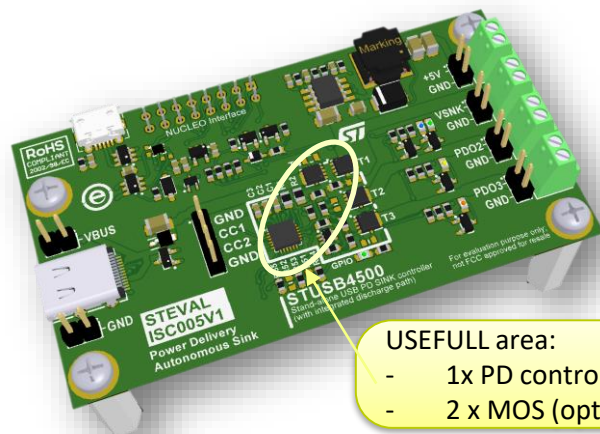
- Certified according to:
 - USB type-C™ (rev1.2 + ECN)
 - TID: 1000100



STUSB4500 - SINK

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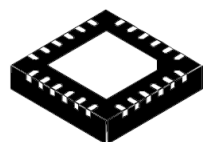
Standalone USB PD Controller - SINK



USEFULL area:

- 1x PD controller
- 2 x MOS (optional)

STEVAL_ISC005V1



QFN-24 - EP
4x4 mm²

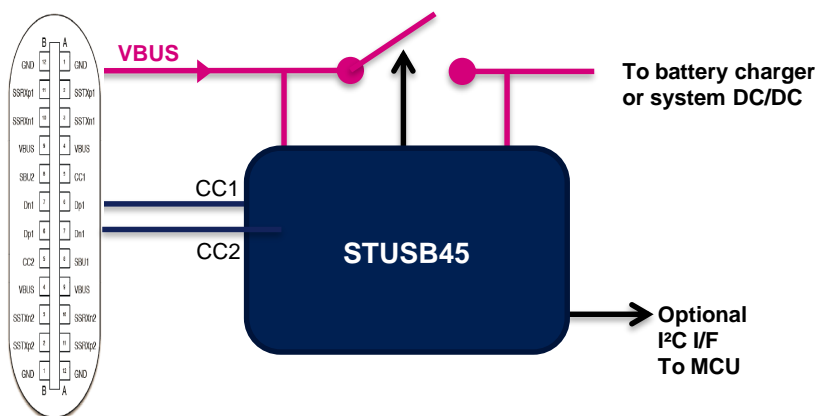


WLCSP-25
(2.6x2.6x0.5)

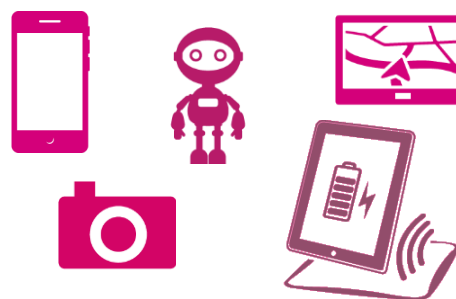
Consumer

- all USB PD profiles supported up to 100W
- Fast migration to USB PD

- Auto-run / Plug & Play
- Dead Battery Support
- Up to 3 SINK PDO profiles
- Short to VBUS Protections
- PCB area saving



USB devices



CERTIFICATION

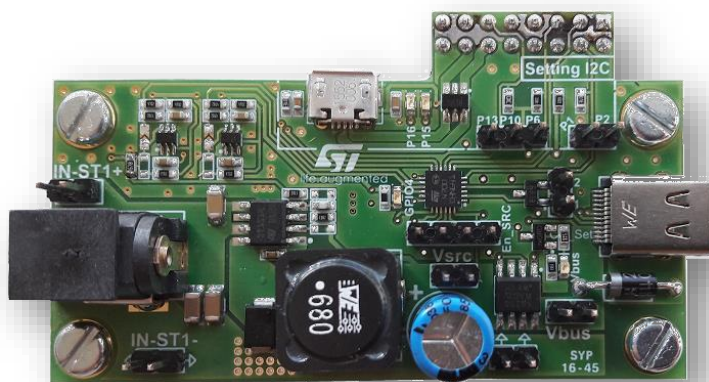
- Certified according to:
 - USB type-C™ (rev1.2)
 - USB PD (rev2.0)
 - TID: 1000133
- Compliant with USB PD (rev3.0)



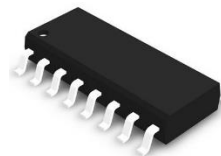
STUSB47xx - SOURCE

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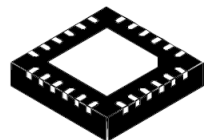
Standalone USB PD Controller - SOURCE



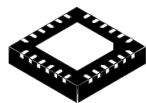
STEVAL_ISC004V1



SO-16



QFN-24
4x4 mm²



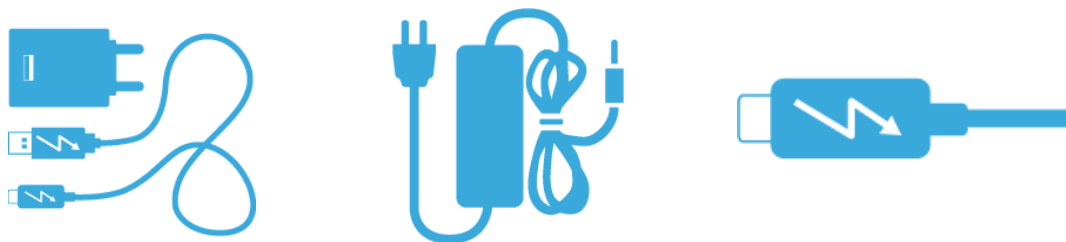
QFN-16
3x3 mm²

Provider

- all USB PD profiles supported up to 100W
- Suitable for AC/DC and DC/DC

- Auto-run / Plug & Play
- Dead Battery Support
- Up to 5 PDO profiles
- Short to VBUS Protections
- Power sharing capable thru MCU

AC adapters & Power supplies



CERTIFICATION

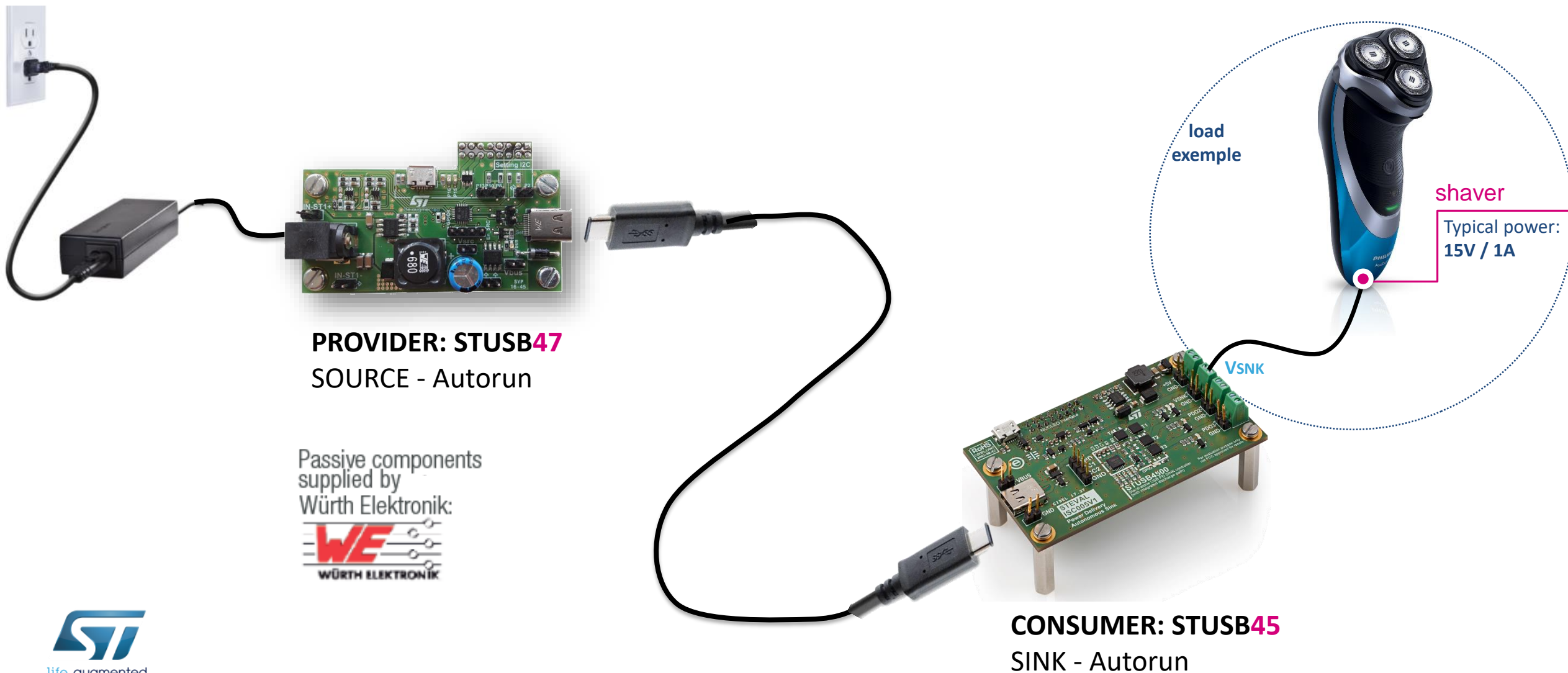
- Certified according to:
 - USB type-C™ (rev1.2)
 - USB PD (rev2.0)
 - TID: 1000125 / 1030023
- Compliant with USB PD (rev3.0)

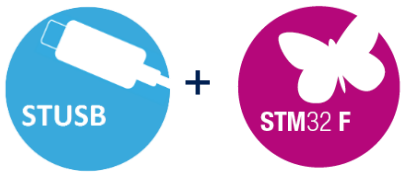


STUSB47 meets STUSB45

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Stand-alone controllers for SOURCE and SINK applications

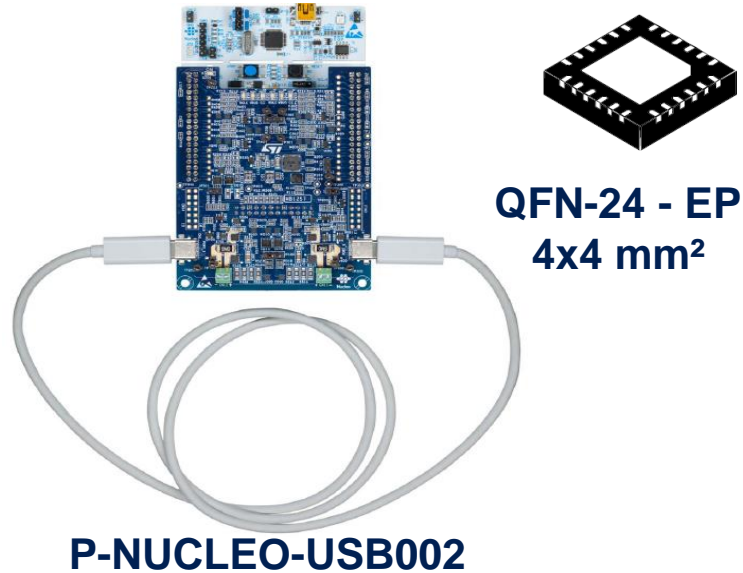
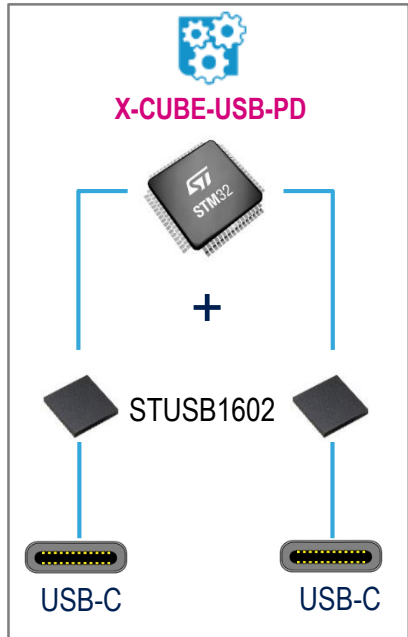




STUSB1602 - DRP

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USB Type-C controller with PD PHY



- Dual Role: DFP/UFP/DRP
USB PD PHY + BMC (PD support)

- Interconnects with STM32
- Development tool available (P-NUCLEO-USB00X)



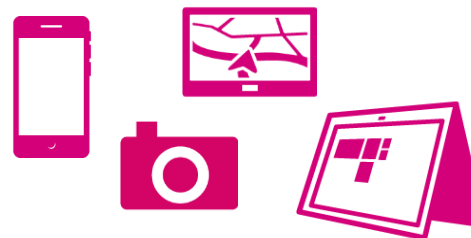
Dual port USB devices



Universal chargers (source)



Multi cell USB devices



CERTIFICATION

- Certified according to:
 - USB type-C™ (rev1.2)
 - USB PD (rev2.0)
- TID: DRP 1000117 / Source 1000118 / Sink 1000119
- Compliant with USB PD (rev3.0)

STM32G0 USB-C Discovery

Promotional kit and tool to learn and discover USB-C port capabilities. It offers 3 operating modes :

1. **“Standalone” mode**: Discover and display power / data / Alternate Mode capability of any USB-C host (source/DRP).
2. **“Sniffer + USB PD meter” mode**: Display current direction, power information (V_{bus} voltage, I_{bus} current) between two USB-C enabled devices.
3. **“Advanced User” mode**: Debug, configure, inject USB PD3.0 packet using “STM32CubeMonUCPD”.

Ordering info :

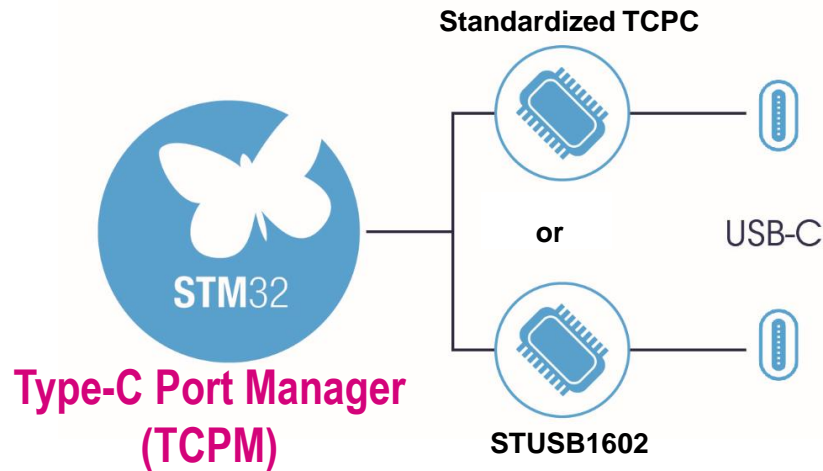
RPN :STM32G071B-DISCO

POS/RRP : 65\$



X-CUBE-USB-PD Software Pack 37

Enables any STM32 to handle USB-C and Power Delivery



TCPM stands for Type-C Port Manager
TCPC stands for Type-C Port Controller

- X-CUBE-USB-PD complies with :
 - ✓ USB-C 1.3 and **USB PD 3.0** specifications
 - ✓ Type-C Port Controller Interface specification (TCPC¹)
- Hardware architecture supported
 - Any STM32 as **TCPM** with standardized **TCPC** from 3rd parties
(Our stack has been tested with ON Semiconductor® FUSB307B, a USB-PD 3.0 v1.1-certified TCPC)
 - Or STM32F0 with STUSB1602 Type-C interface
- Single-or multi-port supported (Sink, Source, Dual Role Power)
- Optional features such as Programmable Power Supply (PPS), Authentication messages and Fast Role Swap (FRS) are supported

STEVAL-USBC2DP: USB Type-C to DisplayPort adapter

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Key Features:

- The USB Type-C to DisplayPort Adapter expands a USB Type-C laptop screen onto a monitor or projector equipped with DisplayPort
- Based on the Alternate Mode Functional Extension of the USB Type-C & Power Delivery to enables the DisplayPort interface

Advantages

- Type-C Alternate Mode demo in a compact PCB design (5.5 x 2.3 mm)
- Full ST BOM for a cost-effective solution based on Discrete AFE approach
- Including the DFU feature



 **DisplayPort**

Key Products

STM32F072: the high-performance ARM® Cortex®-M0 32-bit RISC core operating at up to 48 MHz frequency, high-speed embedded memories and with USB 2.0 data interface.

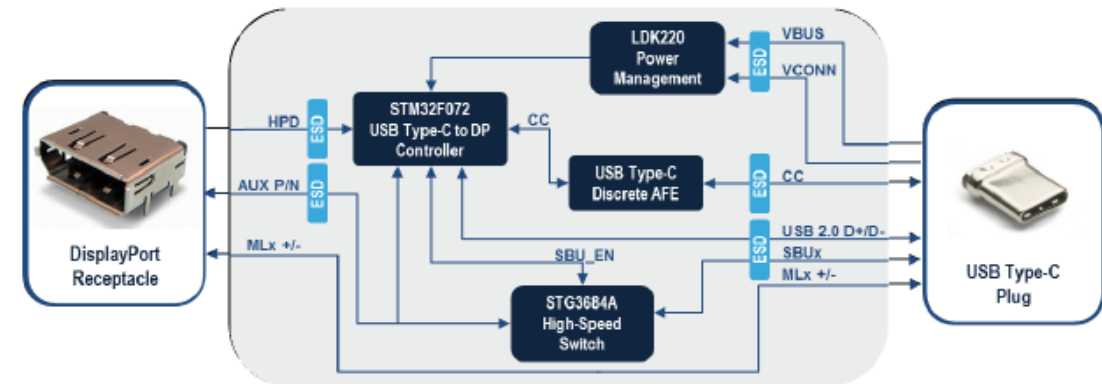
LDK220: 200 mA low quiescent current and low noise LDO.

STG3684A: Low Voltage 0.5 Ohm Max Dual SPDT Switch with Break-Before-Make

ESDALC5-1BF4: Low clamping and low capacitance bidirectional single line ESD protection

STPS0520Z: Power Schottky rectifier

X-CUBE-USB-PD: STM32 USB-PD package consisting of libraries and application examples for STM32F0 devices acting as USB-PD controllers





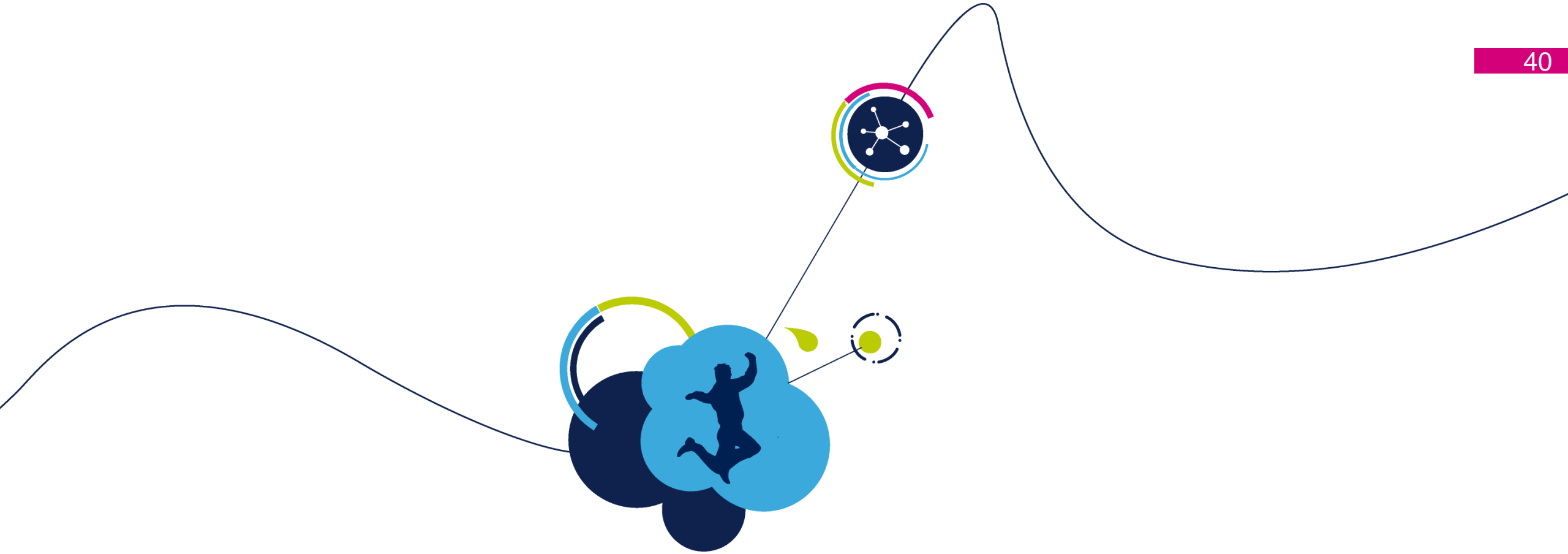
Summary

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- USB Docs: www.usb.org/documents
- ST is strongly involved in USB Type-C & PD controllers
 - Member of the USB-IF consortium / Member of USB PD working groups
- Certified Solutions available
 - Type-C only for an **easy & Safe transition from Std-A to Type-C** using the [STUSB1600](#)
 - USB PD & Type-C **Autonomous full HW** controller for Provider Only application using the [STUSB4700](#), or Consumer only with [STUSB4500](#)
 - USB PD & Type-C controller for DRP/DFP/UFP application as the perfect companion to Embedded Controller using the [STUSB1602](#) supporting USB PD rev3.0.
- Automotive
 - Using [STUSB1700Y](#), [STUSB4700Y](#), [STUSB1702Y](#) for **Automotive grade** devices





Thank you