USB Type-C™ and USB PD Demystified

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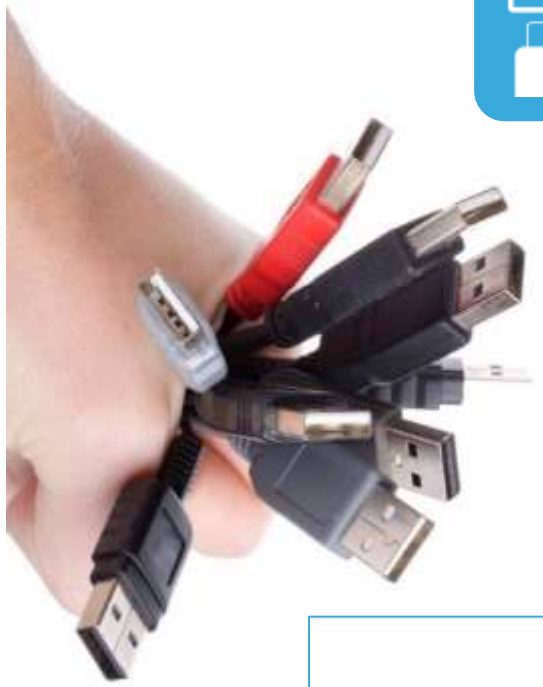
Technology Tour 2017

Content

The Re-evolution of USB

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

Alternate Mode

USB IF

A smart and green technology

- More **flexibility** with a new reversible & thinner connector
- More **power** with USB Power Delivery (100W)
- More **protocols** (Display Port, HDMI, VGA, Ethernet…)
- More **speed** with USB 3.1 gen 2 (10 Gbps)

Click on the video

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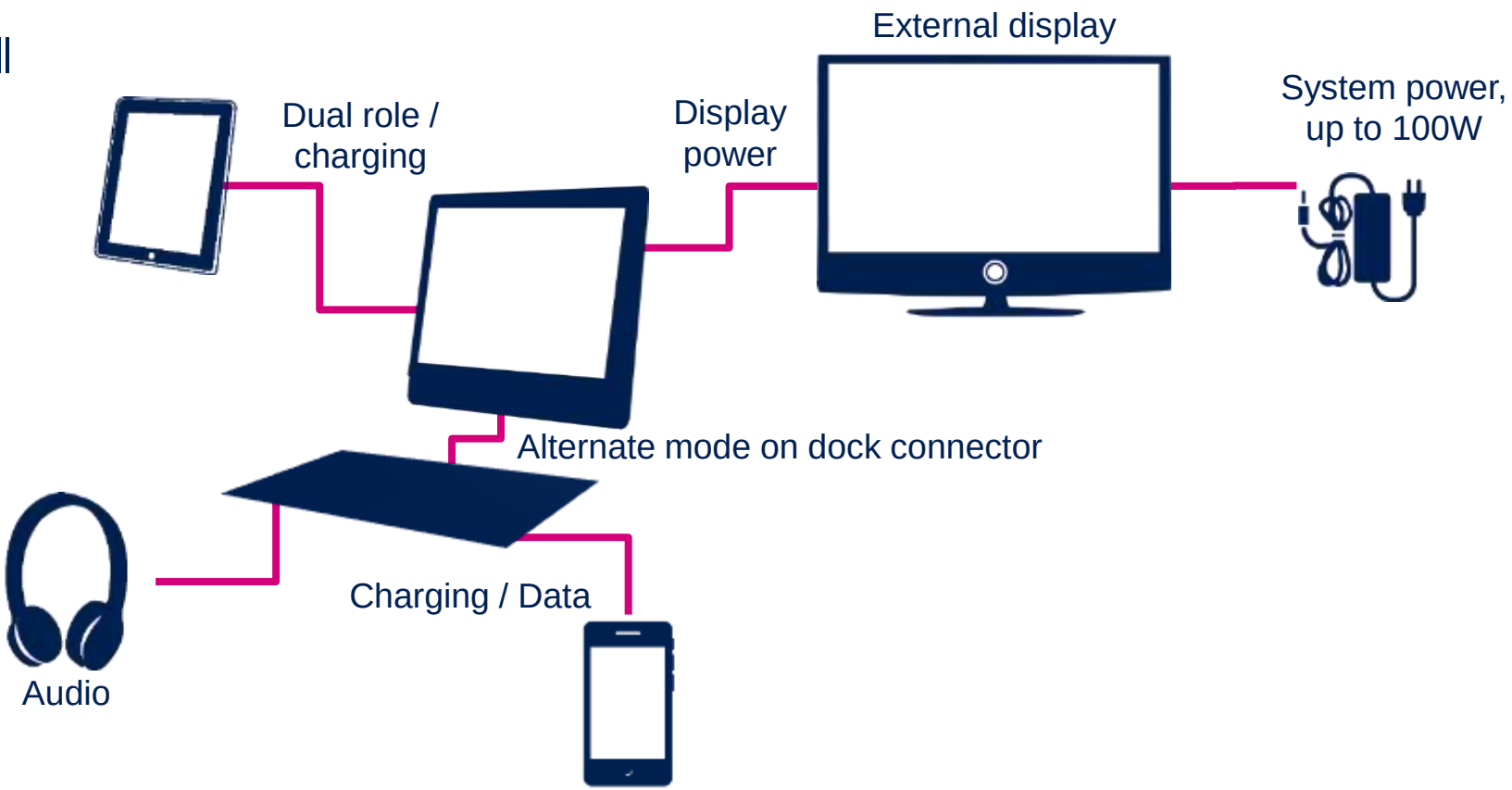
USB Type-C
and USB Power Delivery

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

USB Type-C:
One port to rule them all



USB Type-C Overview

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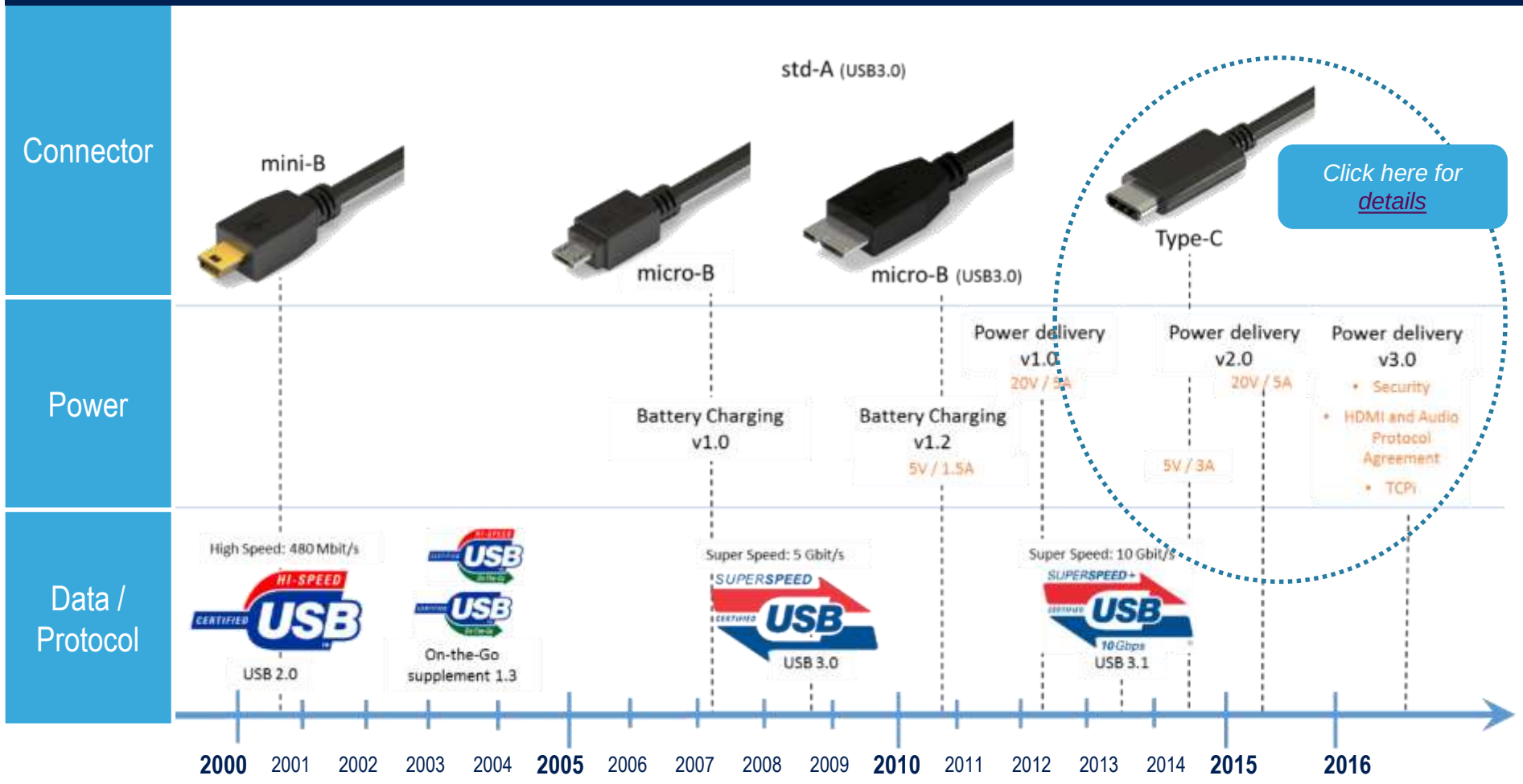
USB Global Evolution

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



http://www.usb.org/developers/powerdelivery/

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USB Type-C Pin-Out Functions

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
GND	RX1+	RX1-	V_{BUS}	SBU2	D-	D+	CC2	V_{BUS}	TX2-	TX2+	GND
B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1

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
GND	TX2+	TX2-	V_{BUS}	V_{CONN}			SBU2	V_{BUS}	RX1-	RX1+	GND
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12

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

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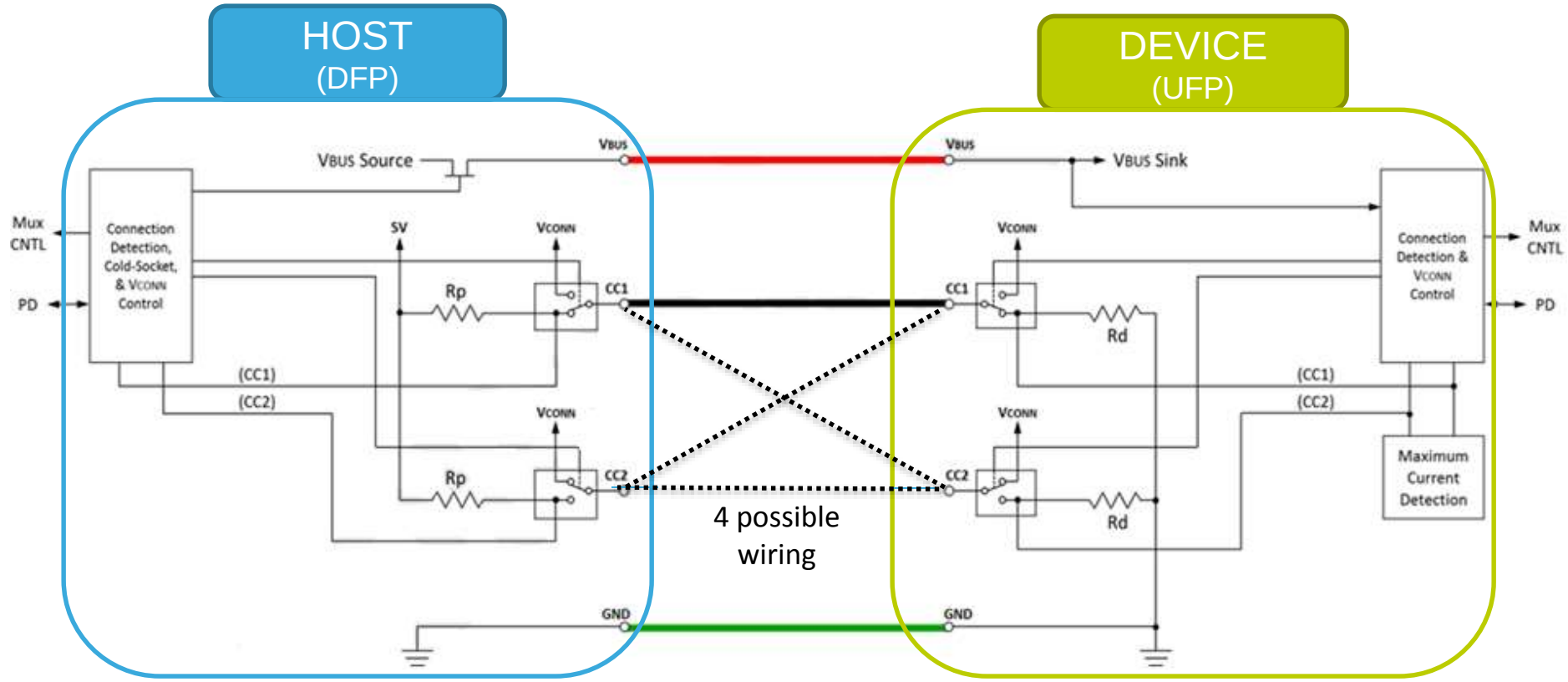
Host to Device Connection



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

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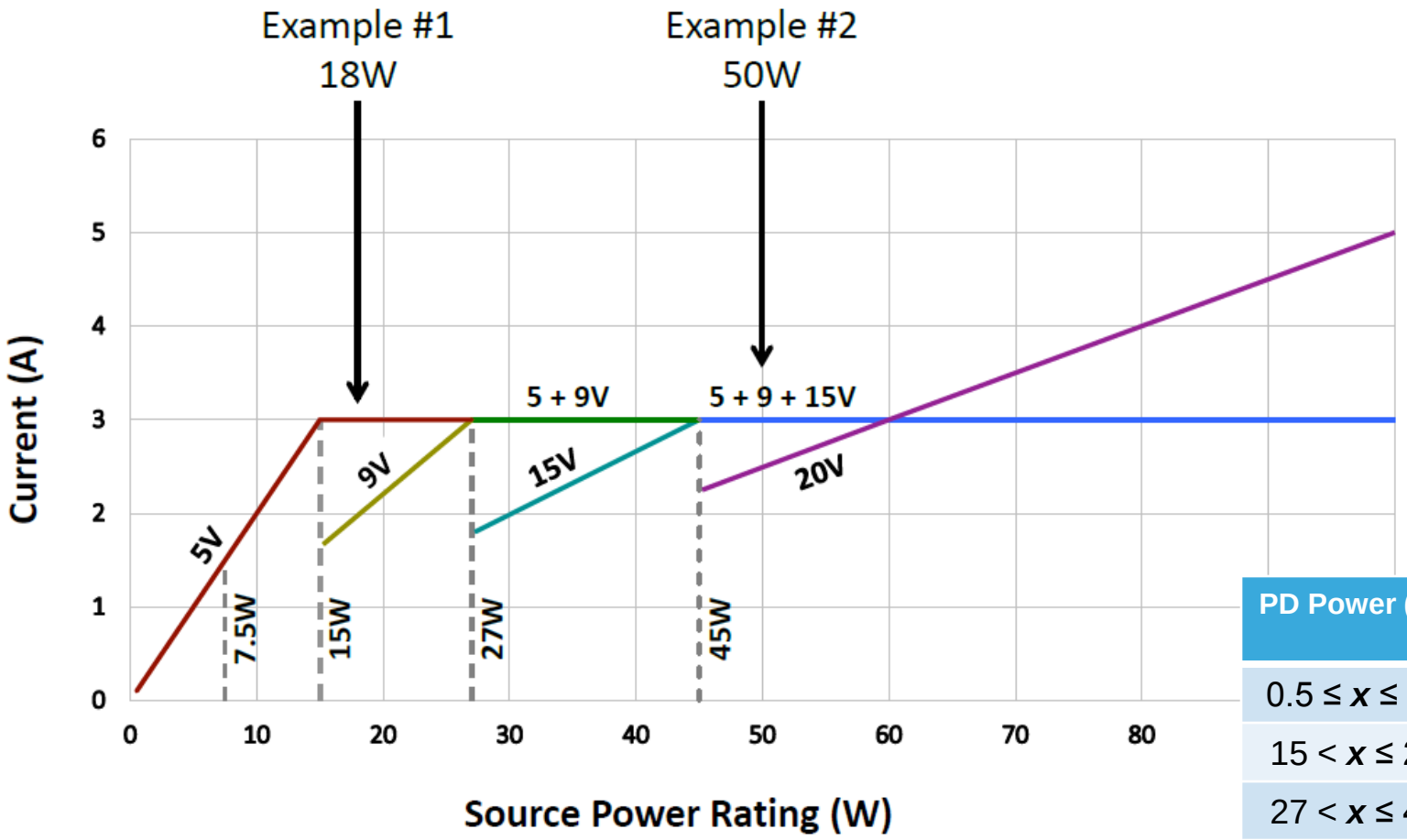
USB-PD 2.0(v1.2) & 3.0 Power Rules



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 ≤ ***x*** ≤ 15	***x*** ÷ 5			
15 < ***x*** ≤ 27	3	***x*** ÷ 9		
27 < ***x*** ≤ 45	3	3	***x*** ÷ 15	
45 < ***x*** ≤ 60	3	3	3	***x*** ÷ 20
60 < ***x*** ≤ 100	3	3	3	***x*** ÷ 20 (*)

(*) Requires a 5A cable

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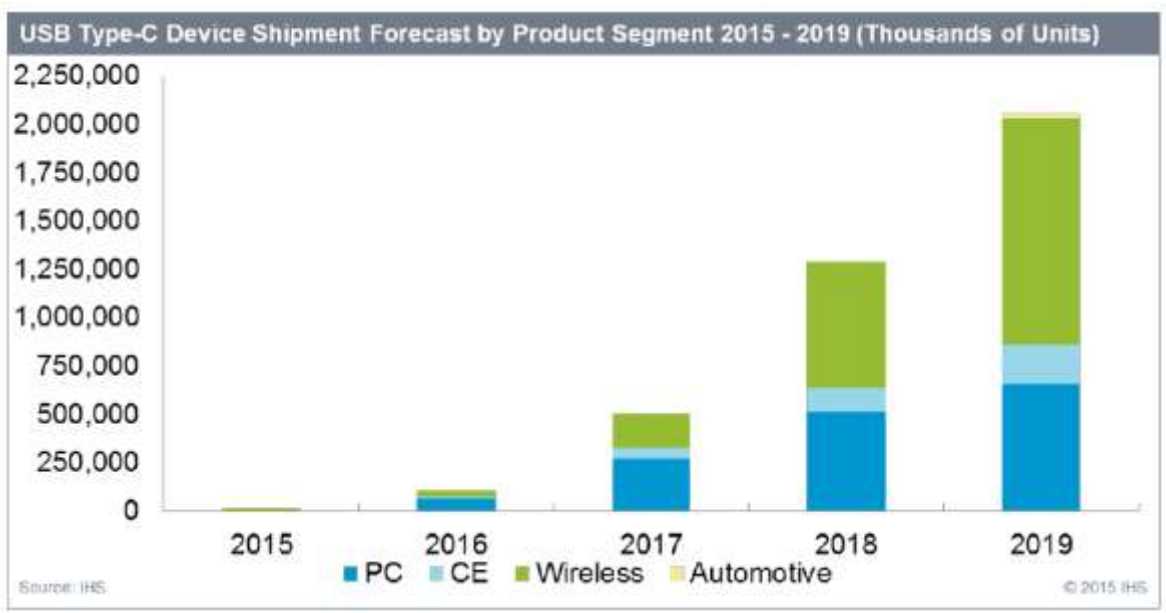
What to expect?

USB-C

A huge market…



- 2 billion+ units FORECAST to ship in 2019
  - 40% of Total Units
- Source: IHS (B. O'Rourke) as of Dec. 2015

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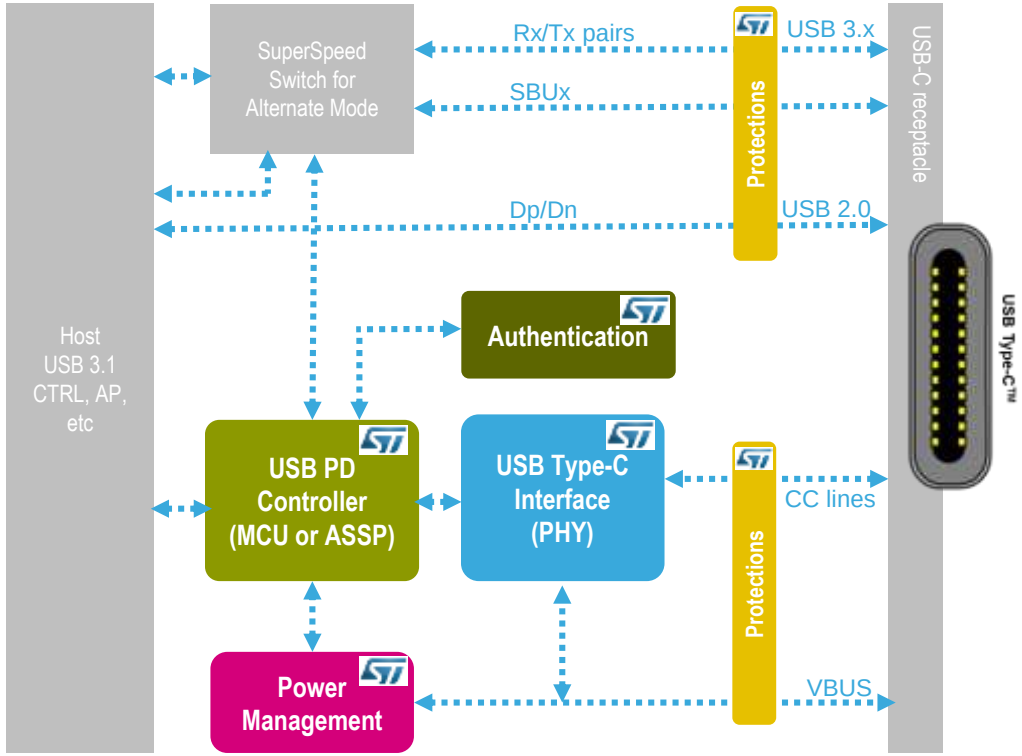
USB Type-C
and USB Power Delivery-enabled subsystems

ST Chipset: A flexible offer in the USB Type-C PD ecosystem



Scalable offer for USB-PD controller and USB Type-C interface: from STM32 general purpose MCU to hard-coded solution to fit different use cases and power ratings

Large product portfolio for protection and filtering covering all the application needs

Highly secure solution using STSAFE secure element family for strong authentication needs

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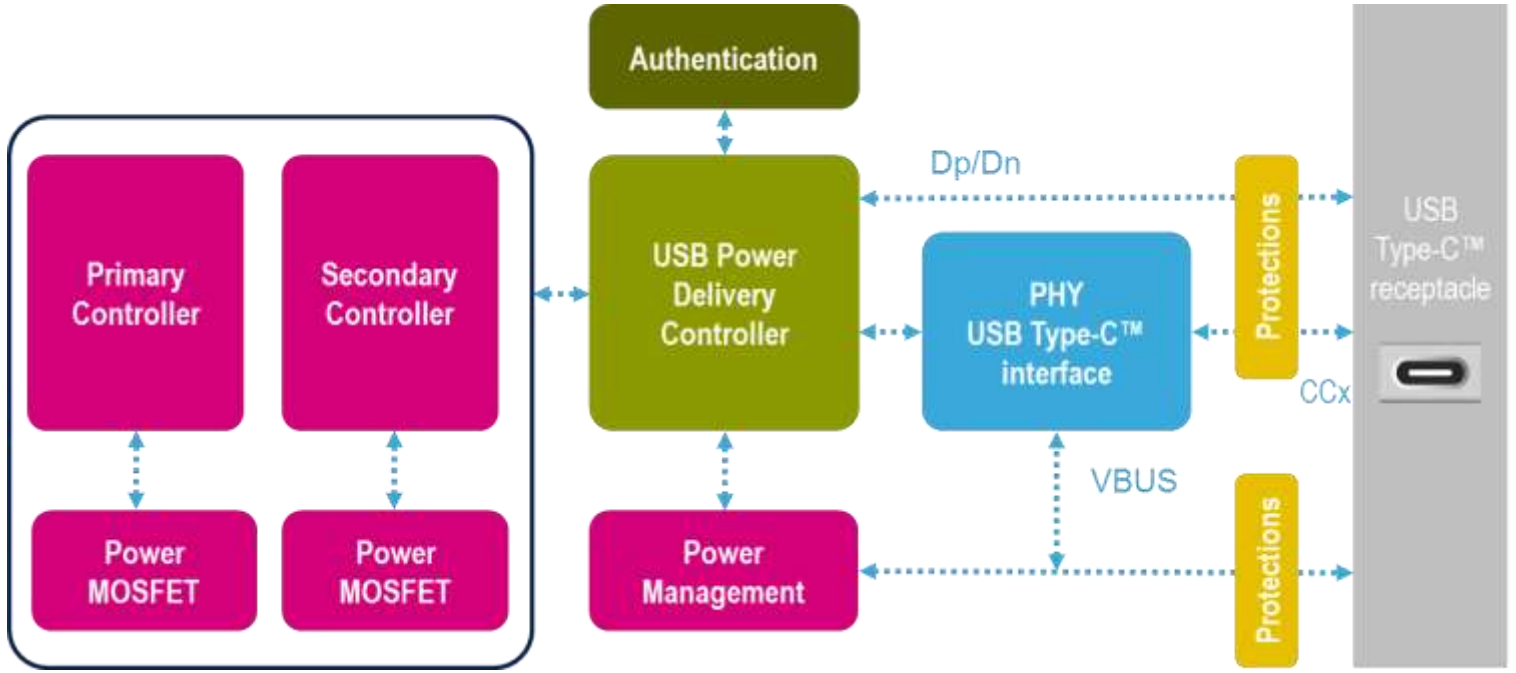
USB Type-C and USB Power Delivery

AC / DC converters

ST Chipset: ultra-low standby and compact power supplies



Power Supplies

Power Hubs

High efficient and fully integrated AC-DC controllers enabling high efficiency and low EMI design AC-DC controllers

Wide Power MOSFETs product range with reduced switching losses, easy driving features and lower design complexity

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ST Offer

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Hard-Coded USB Type-C and USB PD Controllers

STUSB Family: from USB Type-C Interface to 100% HW Power Delivery Controllers

		STUSB1600	STUSB1602	STUSB47xx
		USB Type-C interface	**USB Type-C controller** with PD PHY and BMC driver	**Power Delivery controller** Provider only
USB Type-C	Less than 15W			
+ **Power Delivery**	15W to 100W			
+ **Alternate Mode**	5W to 100W			

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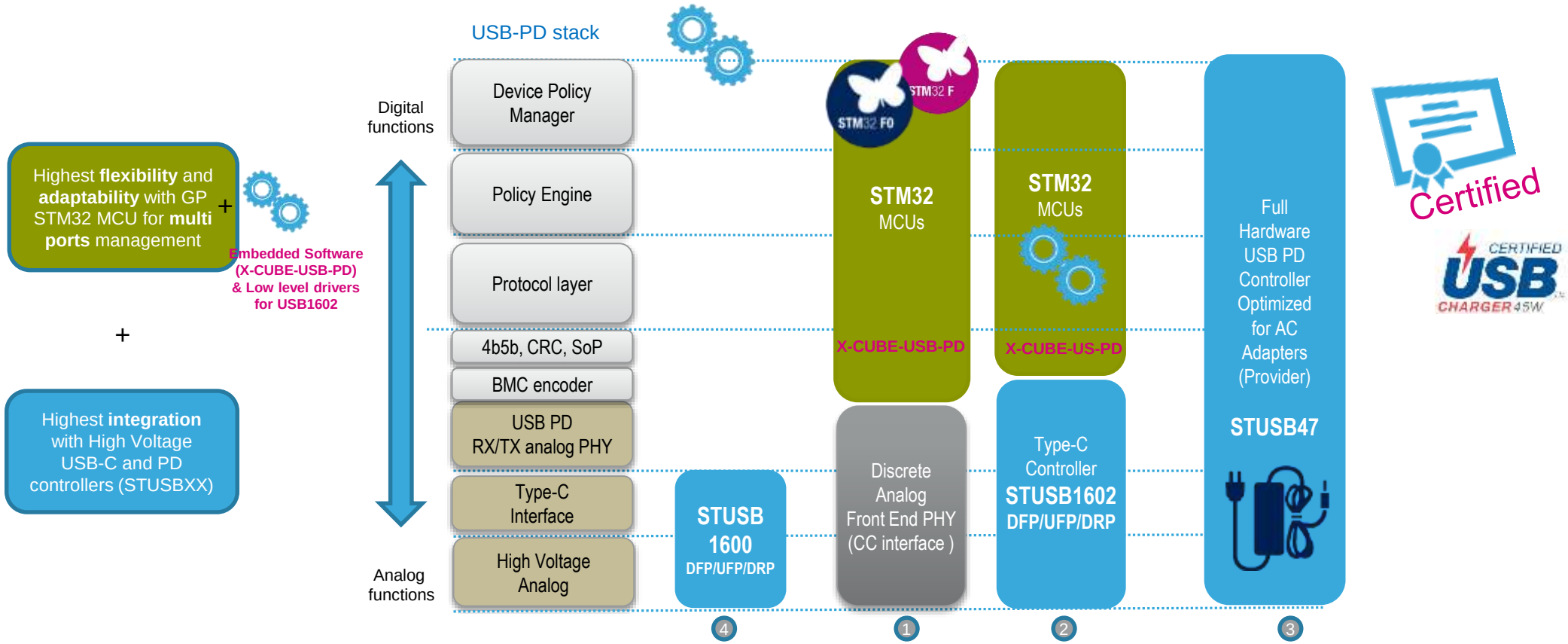
Type-C & USB PD Controllers
Certified Solutions

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

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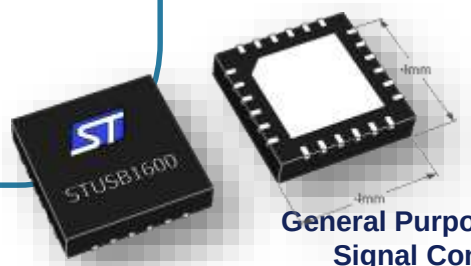
STUSB1600

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)**

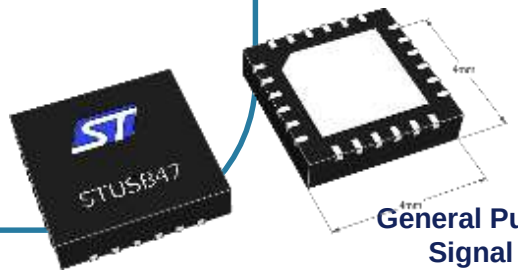


STUSB4700

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)**



STUSB4700 key differentiators

FEATURE	BENEFIT
• USB IF Certified silicon	• Proven solution
• Hard-wired	• **NO NEED FOR MCU,** Robust / Predictive
• Low Power consumption	• Contribution to Energy-saving Standards
• CC Short to Vbus protection • CC pins protected up to 22V	• Safe for users & devices
• Wide Supply Voltage range [3V; 22V]	• **No external LDO required** – Low BOM cost
• High BOM Integration	• Contribution to Power Density
• Internal NVM	• Easy customisation – Plug & PLAY • NO Software know-how required

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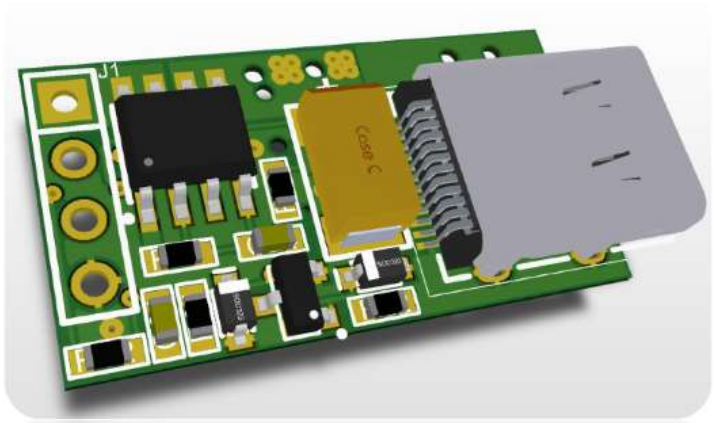
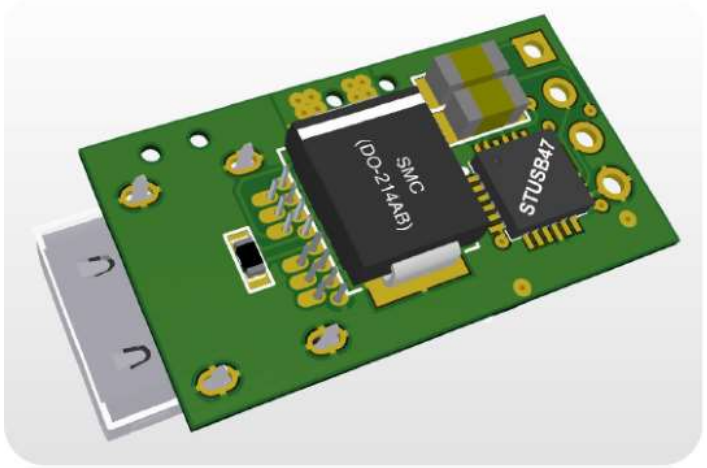
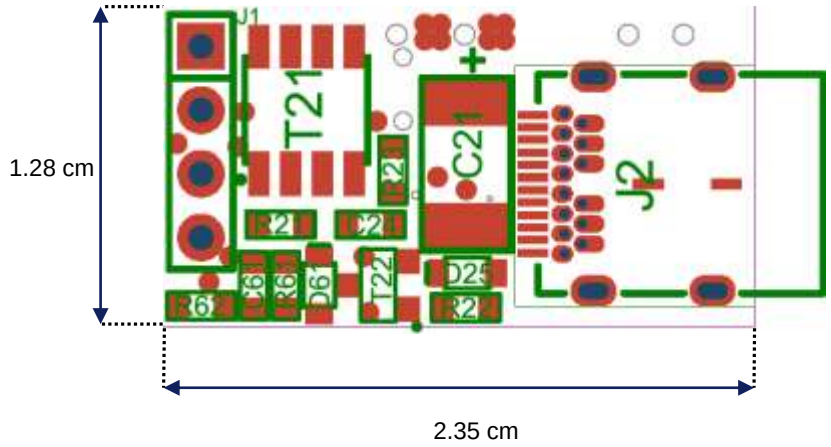
STUSB4700 Layout
High Integration/PCB Area Saving







USB PD - Fly Back Secondary side

- class 5 PCB
- clearance and track width : 150 µm / 5.905 mils
- Size could be reduced with further optimization

STUSB4700 **vs** MCU-Based Solutions in Power Supply

Using MCU-Based Solution

- Need dedicated DC-DC to get a 5V input
  - STUSB47 is powered directly on VBUS (4 - 22V)
- Power consumption is much higher to run MCU ~7.5mA (Critical in low load conditions)
  - STUSB47 is fully autonomous with 0.80mA Power consumption (0.05mA with No Load)
- Need external HV protections
  - STUSB47 has 22V AMR protection on CC pins
  - STUSB47 has 28V AMR for other HV pins
- Need external MOS for Discharge Path
  - STUSB47 has integrated Discharge Path
- Need external Gate Drivers
  - STUSB47 has integrated Gate drivers
- Potentially need External Vconn
  - STUSB47 has integrated Vconn

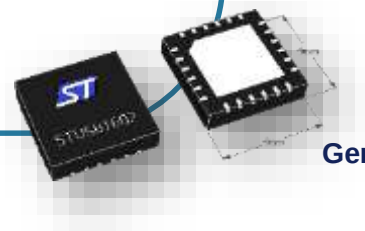
MCU-based solutions are NOT effective for First Default protection

STUSB1602

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

Features

- **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



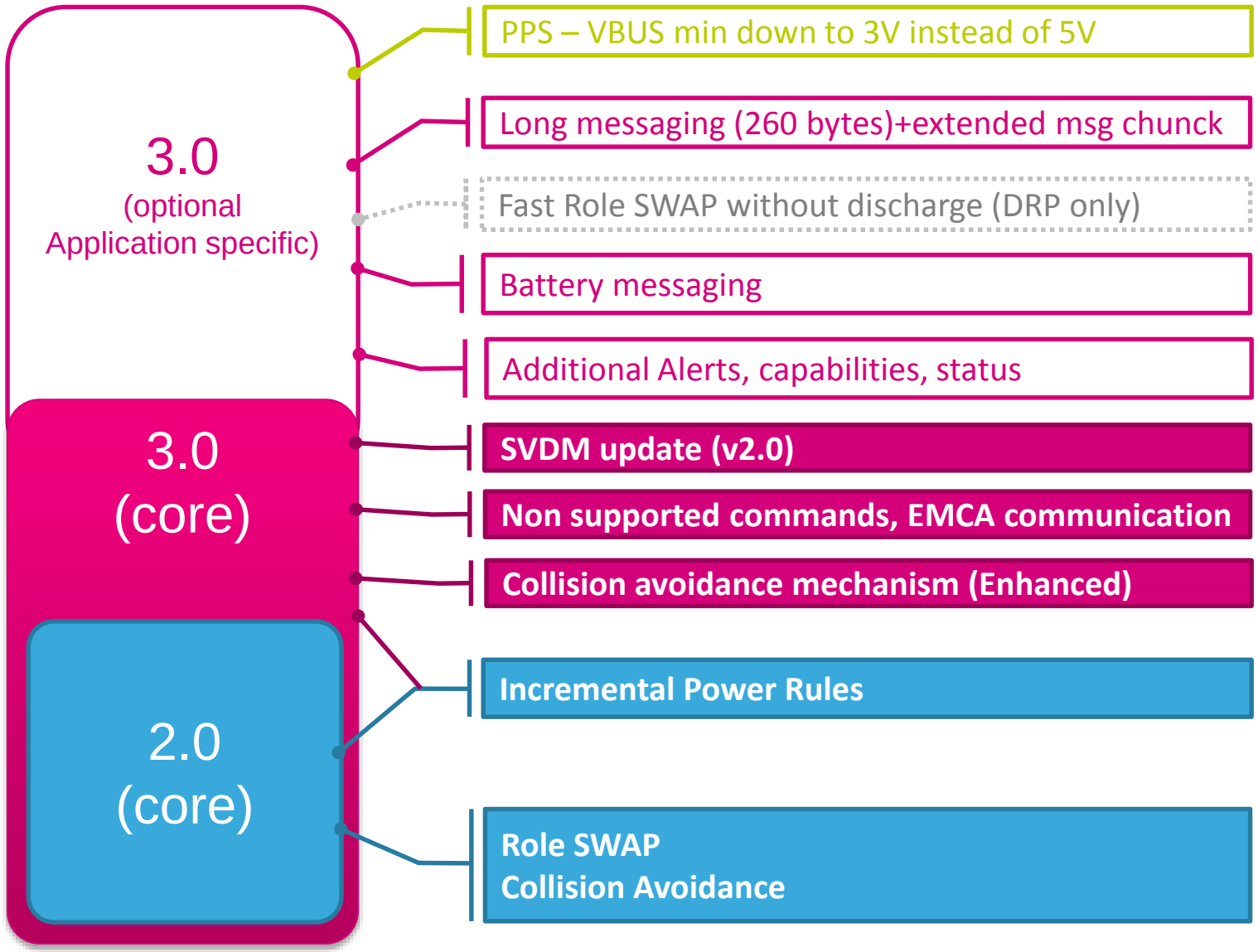
supported

NOT SUPPORTED

UNDER EVALUATION

STUSB1602 vs USB PD r3.0

IC compatibility versus standard



Smartphone Chargers

Authentication / Firmware Update applications

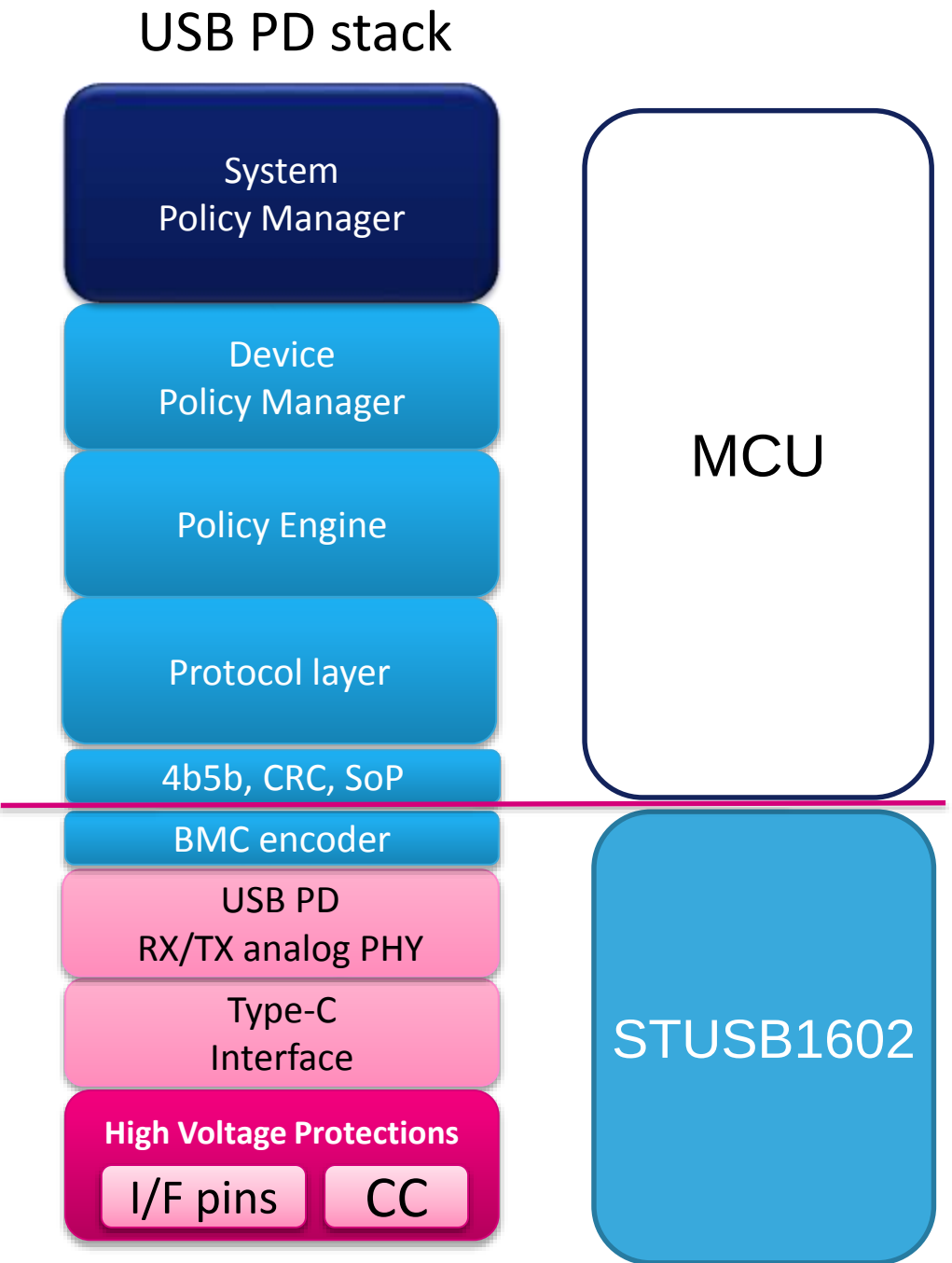
Docking Stations, Computer

Required for battery operated systems

Support for IEC 63002 power supply standards

STUSB1602 is compliant with PDr3.0 core features

USB PD HW/SW partitioning with STUSB1602



USB PD features

- Packets **signal conditioning** for both RX / TX
- Packets **encoding /decoding** (BMC)

Type-C features

- **Manage** USB Type-C port connection
- **Handle** Dead Battery connection & system start-up
- **Manage** cable orientation
- **Supply** VCONN (programmable limit)

System/application features

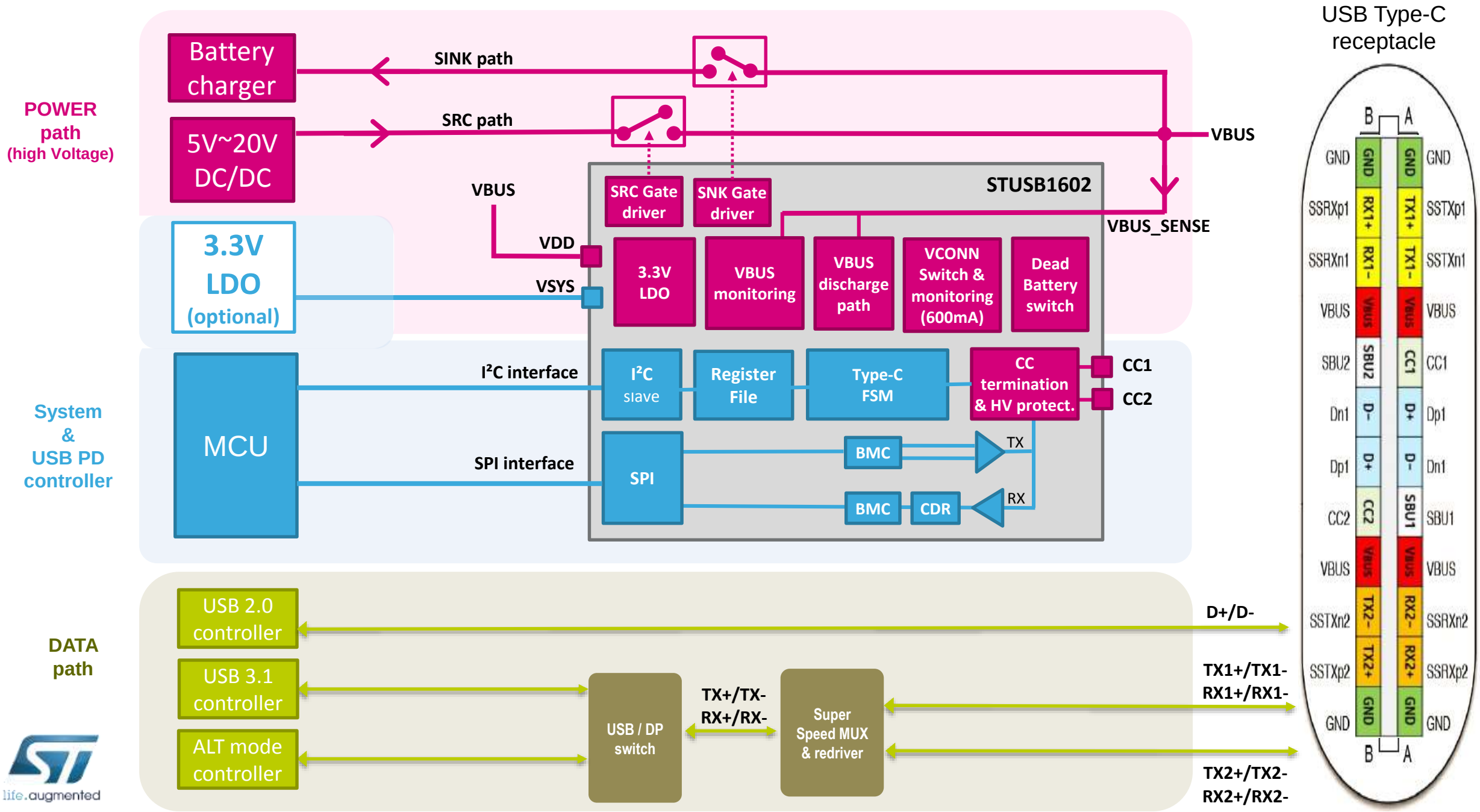
- **Enable** the power path ➔ VBUS Gate drivers (PMOS)
- **Manage** voltage transitions ➔ VBUS discharge path
- **Monitor** the power path ➔ VBUS Monitoring
- **Protects** from High Voltage ➔ Short-to-VBUS protections (up to 28V)
- **Protects** Vconn ➔ OVP, OCP, OTP

STUSB1602 Suitable Applications
in either PD r2.0 or r3.0

- **All SINK applications:**
  - including authentication (PDr3.0 option) and long messaging (PDr3.0)

- **SOURCE:**
  - Conventional chargers and AC/DC adapters
  - PPS fast charger (under evaluation)
  - DC/DC

- **DUAL ROLE**
  - All single port-supplied applications (smartphone, tablet)
  - Multi-port applications which do not require Fast Role SWAP
    - Set-top-box
    - TVs


POWER path (high Voltage)
Battery charger
5V~20V DC/DC
3.3V LDO (optional)
SINK path
SRC path
VBUS
VBUS
VDD
VSYS
STUSB1602
SRC Gate driver
SNK Gate driver
3.3V LDO
VBUS monitoring
VBUS discharge path
VCONN Switch & monitoring (600mA)
Dead Battery switch
VBUS_SENSE
System & USB PD controller
MCU
I²C interface
SPI interface
I²C slave
Register File
Type-C FSM
CC termination & HV protect.
CC1
CC2
SPI
BMC
TX
BMC
CDR
RX
DATA path
USB 2.0 controller
USB 3.1 controller
ALT mode controller
USB / DP switch
TX+/TX-
RX+/RX-
Super Speed MUX & redriver
D+/D-
TX1+/TX1-
RX1+/RX1-
TX2+/TX2-
RX2+/RX2-
USB Type-C receptacle
B A
GND GND GND GND
SSRXp1 RX1+ TX1+ SSTXp1
SSRXn1 RX1- TX1- SSTXn1
VBUS VBUS VBUS VBUS
SBU2 SBU2 CC1 CC1
Dn1 D- D+ Dp1
Dp1 D+ D- Dn1
CC2 CC2 SBU1 SBU1
VBUS VBUS VBUS VBUS
SSTXn2 TX2- RX2- SSRXn2
SSTXp2 TX2+ RX2+ SSRXp2
GND GND GND GND
B A
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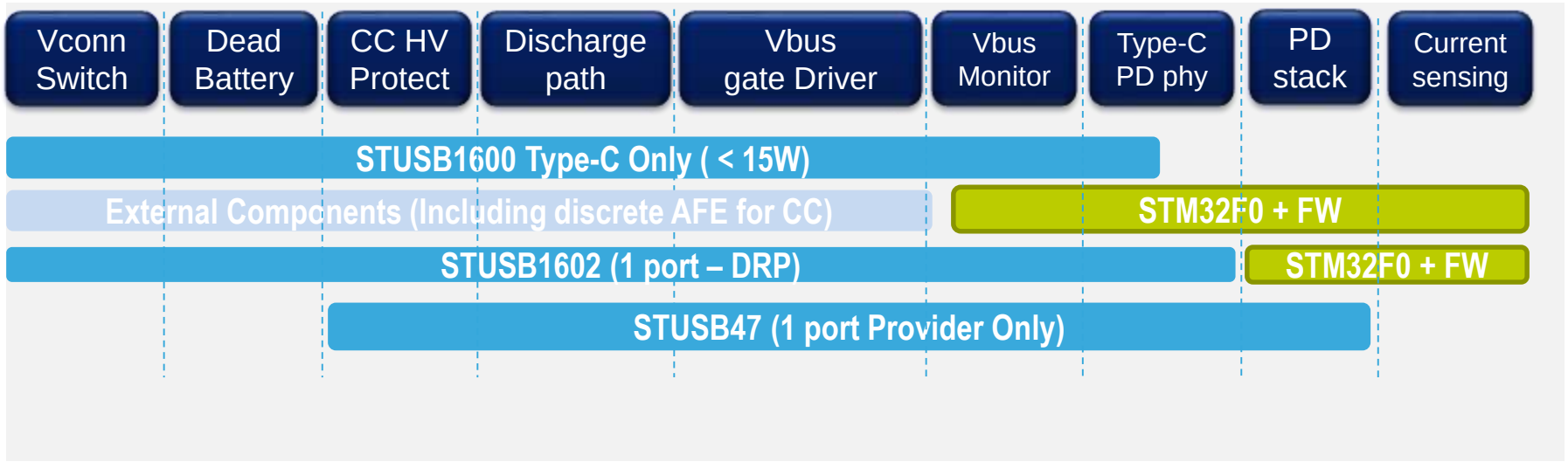
Integration Comparison



Features	Benefits of STUSB16xx
Vconn switch	Support Active cable & mandatory for USB3.1 & >60W charging Application
Dead Battery	Mandatory for Battery powered consumer devices or Vbus powered devices
CC HV protection	Overvoltage protections on CC pins (up to 24V)
Vbus Discharge Path	High voltage discharge switch
Vbus Switch Driver	High voltage (up to 24V) switch
Vbus monitoring	Fast overvoltage detection, under voltage Lock out
Type-C PD phy	BMC & Rx Tx drivers[1] , Configurable Start-up profiles, Wide Supply voltage range (3 to 5.5V)

Evaluation Tools

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STUSB4700

DEMO - **36W** Fly-back

STATUS

ORDER CODE: -
AVAILABILITY: On Request (limited quantities)

Target Applications

- Universal or OEM Power Supplies and
- AC adapters for Computer, Tablets, STB etc…

Key ST products

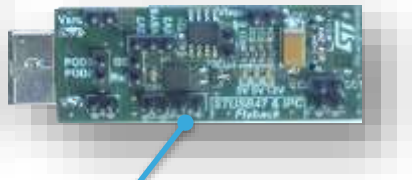
- IPC : PWM controller (STCH02)
- IPC : CV controller (TLVH431)
- GPA : PD controller (STUSB4700)
- IPAD: ESD protection (ESDA25L- SMM4F24A)

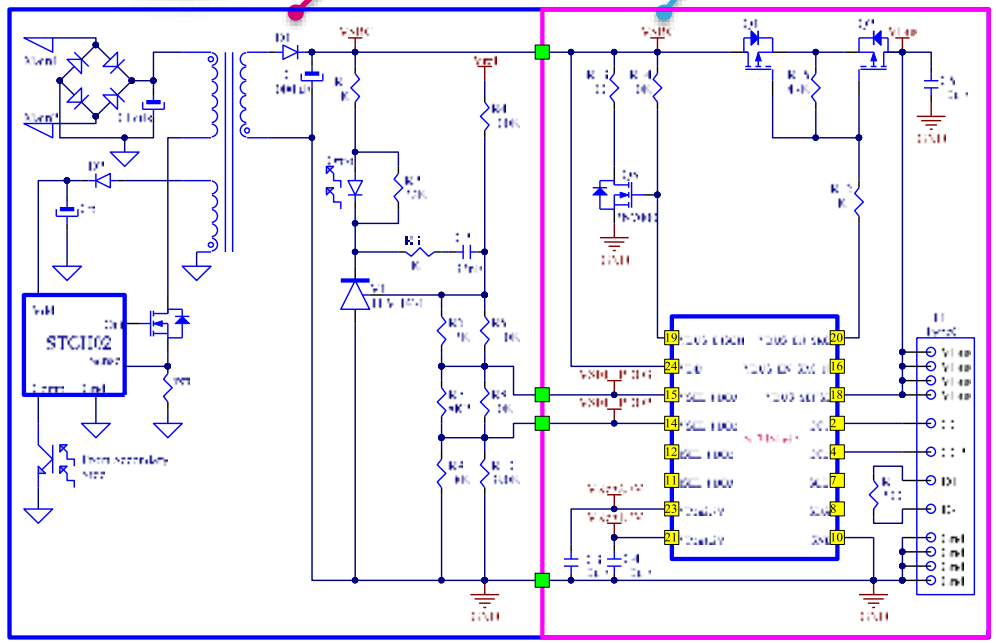
Description

- AC/DC 36W Fly-back topology with CV
- Number of PDO: #3
- Voltage Select: Digital Output (Vsel_PDO)
- Fixed current

STEVAL STCH02 36W
(EVAL-CHG-36W)
Flyback – Primary side

STUSB47 Dongle 36W
Fly-back – Secondary side





STUSB4700

DEMO - **45W** Fly-back

STATUS

AVAILABILITY: On Request (limited quantities)

Target Applications

- Universal or OEM Power Supplies and
- AC adapters for Computer, Tablets, STB etc…

Key ST products

- **USB PD controller (STUSB4700)**

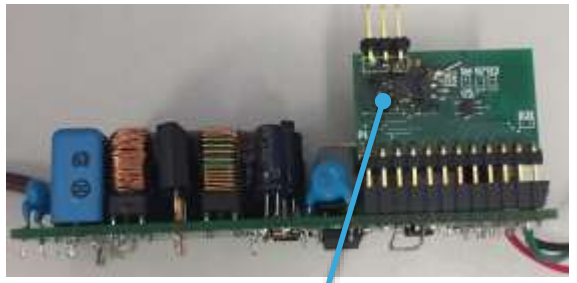
- PWM controller (STCH02)
- CV controller (TLVH431AICT)
- ESD protection (ESDA25L- SMM4F24A)

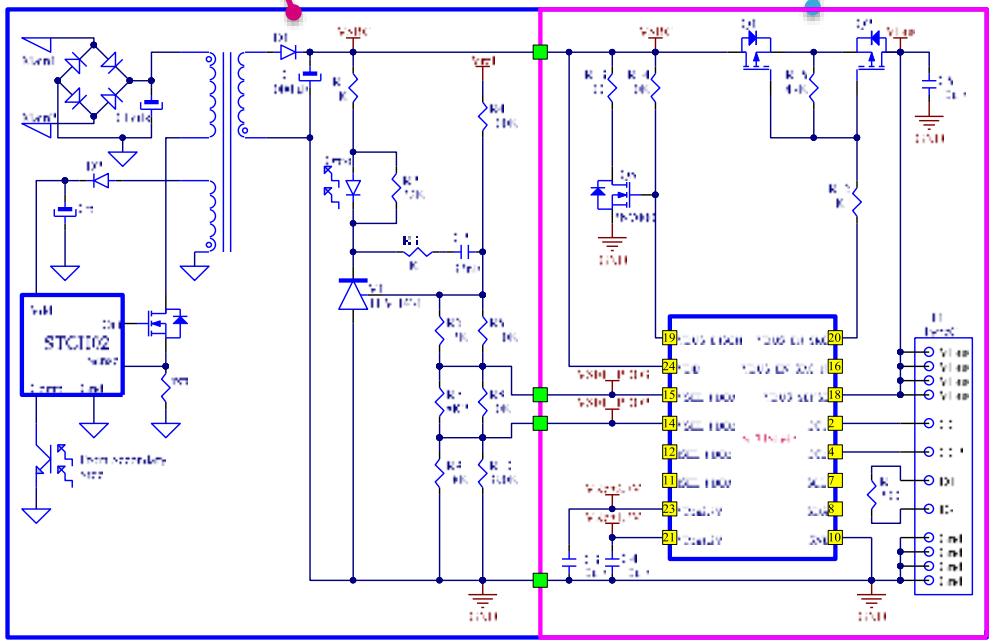
Description

- AC/DC 45W Fly-back topology with CV
- Number of PDO: #3
- Voltage Select: Digital Output (Vsel_PDO)
- Fixed current

Top view

Side view





STUSB4700

EVALUATION - **60W** Buck DC/DC converter

STATUS

ORDER CODE: STEVAL-4710-BUCK
AVAILABILITY: yes (tbc)

Target Applications

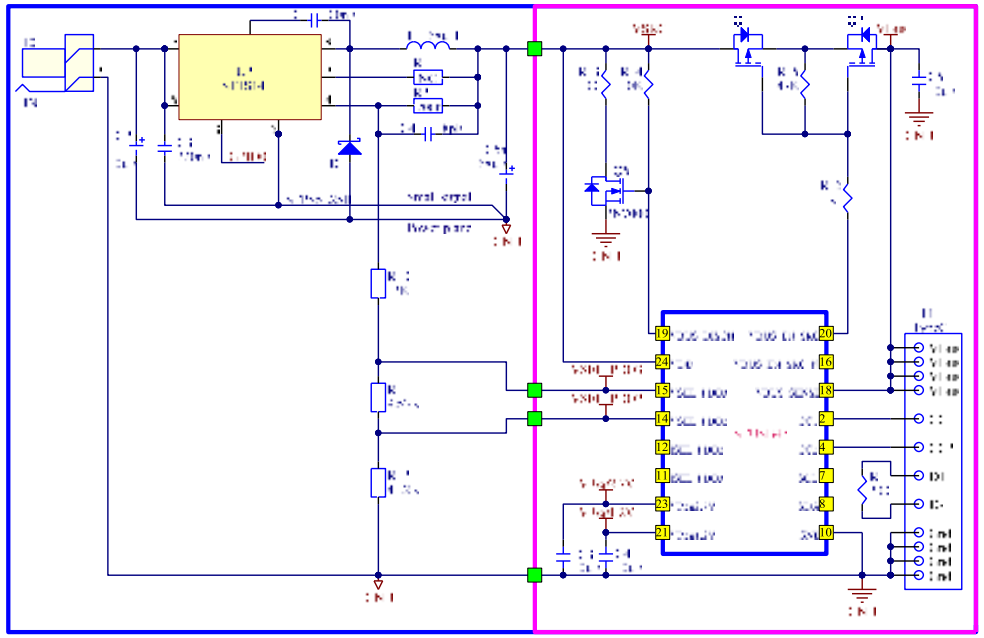
- Computer, Power Hub, Accessories,
- TV, Display, Set Top Box, Gaming, Industrial

Key ST products

- IPC : DC/DC (ST1S14)
- GPA : PD controller (STUSB4700)
- IPAD: ESD protection (ESDA25L- SMM4F24A)

Description

- DC/DC 60W Buck Topology
- Number of PDO: #5
- Voltage Select: Analog Output (VVAR)
- Current regulation: ST1S14



EVALUATION – Single Port Xpansion board

STATUS

ORDER CODE: X-NUCLEO-1600
AVAILABILITY: yes (tbc)

Target Applications

- Computer, Power Hub, Accessories,
- TV, Display, Set Top Box, Gaming, Industrial

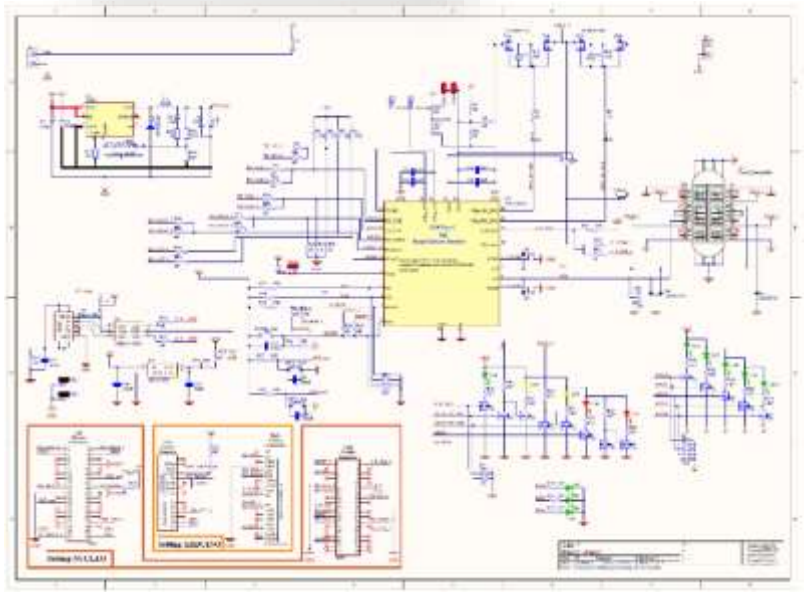
Key ST products

- GPA : Type-C controller (STUSB1600)
- IPAD: ESD protection (ESDA25L- SMM4F24A)

Optional NUCLEO board:
- MCD: MCU (STM32F072 - NUCLEO)

Description

- STUSB1600 evaluation environment
- Suitable for SINK, SOURCE, DRP
- Dead Battery Support
- Vconn, Vsys, VDD
- Can run without Nucleo board (only required to access STUSB1600 I²C interface from the GUI)



DEVELOPMENT – Dual Port STM32 Nucleo Pack

STATUS

ORDER CODE: P-NUCLEO-USB002
AVAILABILITY: yes (tbc)

Target Applications

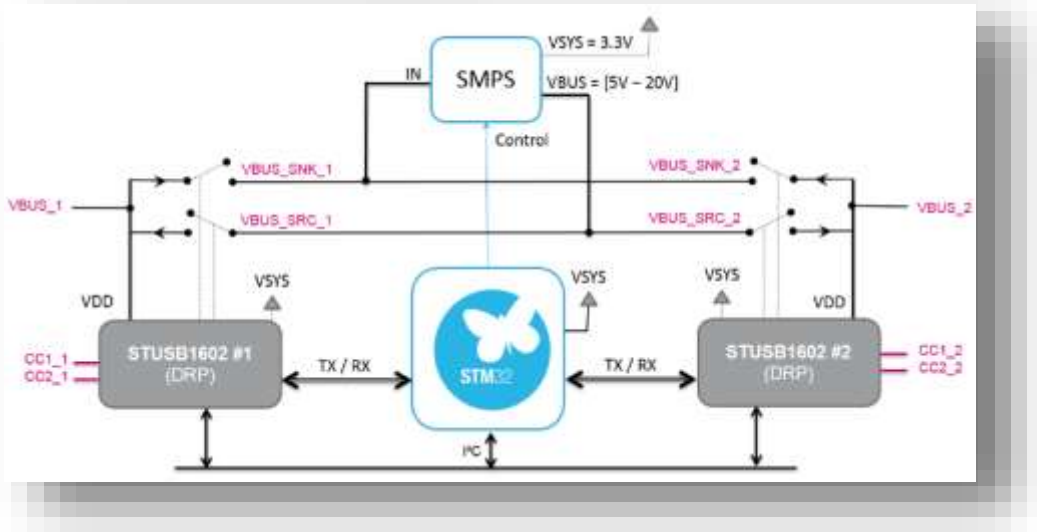
- Computer, Power Hub, Accessories,
- TV, Display, Set Top Box, Gaming, Industrial

Key ST products

- GPA : PD controller (2 x STUSB1602)
- IPAD: ESD protection (ESDA25L- SMM4F24A)
- MCD: MCU (STM32F072 - NUCLEO)
- SMD : Authentication IC (STSAFE)

Description

- STM32 + STUSB1602 evaluation environment
- Type-C cable included
- Dual Port DRP system
- Dead Battery Support
- Vconn, Vsys, VDD support
- Requires dedicated SW environment



Key messages

- 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
  - USB PD & Type-C controller for DRP/DFP/UFP application as the perfect companion to Embedded Controller using the STUSB1602 supporting USB PD r3.0.
- Towards more features …
  - Using a Gen2 USB PD & Type-C **Autonomous full HW** controller supporting USB PD r3.0
  - Using a Gen2 **TCPC controller** including HV analog Front end
  - Using a new family of **Power switches** for Type-C & PD application.
  - Using STUSB1600Y, STUSB4700Y, STUSB1602Y for **Automotive grade** devices