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STM32 MCU solutions for USB Type-C™ technology

STM32

Introduction to USB Type-C™ technology

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Visit our Wiki page on USB Type-C™

Find all the information you need for beginners and advanced users

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Wiki by

https://wiki.st.com/stm32mcu/wiki/USB_Power_Delivery_overview

Main reasons to use USB Type-C™ in embedded devices

More Versatile

- **Reversible, thinner and robust** newest USB Type-C™ connector
- **More interoperability**: sink, source or dual role, while being host or device

More Power

- 15W @ 5V with Type-C only
- **Up to 100W with USB Power Delivery** (USB PD) 3.0 protocol
- **Extend Power Range up to 240W** @ 48V with USB PD 3.1 NEW
- Universal **fast charging capability** with PPS (Programming Power Supply)

More Protocols & Speeds

- **Separate channels** for USB 2.0 (LS/FS/HS) and USB 3.x (SuperSpeed)
- **Proprietary protocols are supported** (DP, HDMI, Ethernet, Thunderbolt…)

More Secure

- **Device/source Authentication** via USB PD (Vendor Define Messages)
- Firmware Update or **Secure Firmware Install** (SFI)

More use-cases

- **Power swap** capability (from sink to source or vise-versa)
- USB **data swap** capability (from device to host or vise versa as for OTG)

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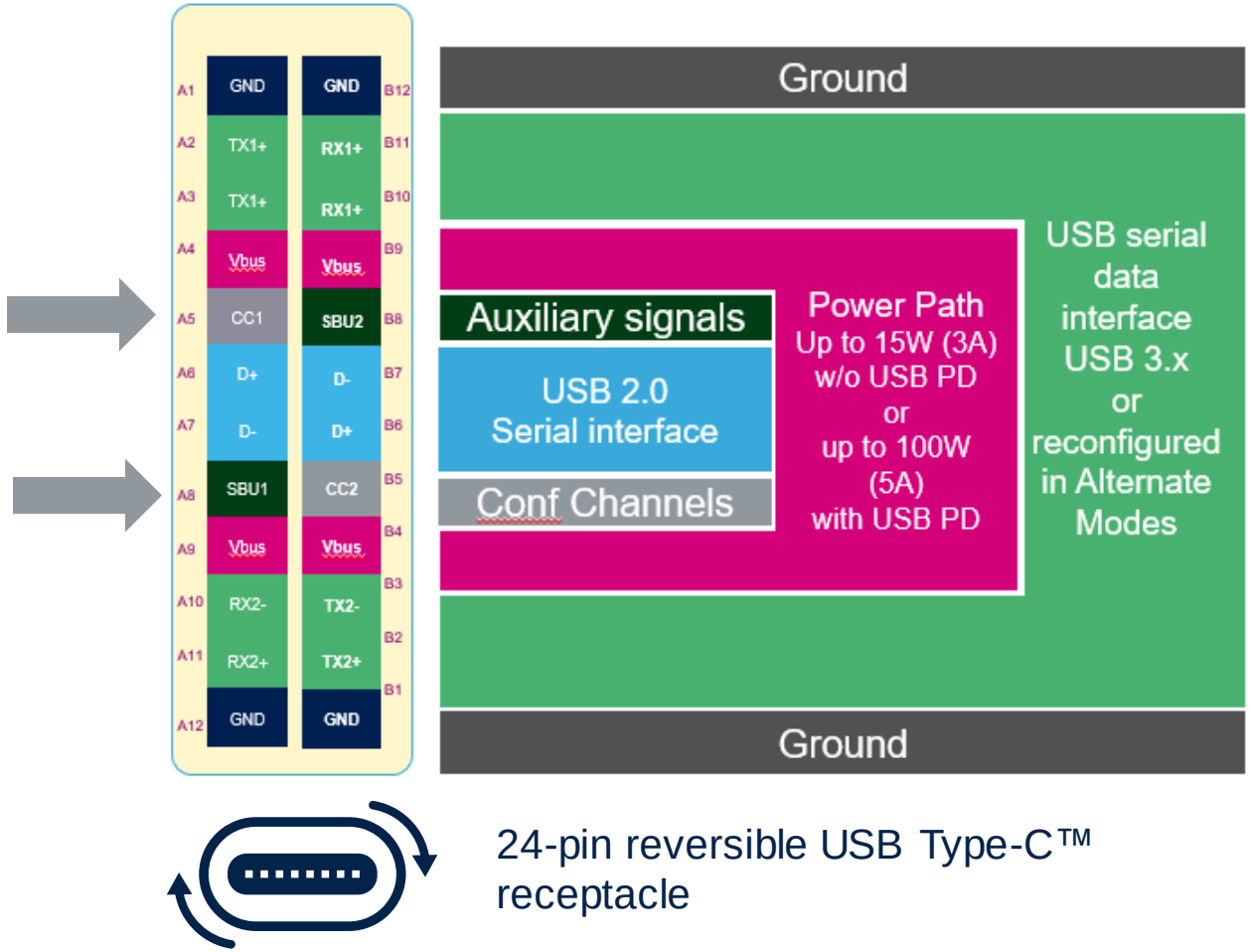
USB Type-C™ pin outs functions

Purpose of the CC Channels:
(Configuration & Communication channels):

➔ **Manage the attachment of the USB Type-C™ connector:**

- Attach/detach and role management (Sink, Source, Dual Role Power) between two devices
- Discover and configure VBUS, VCONN
- Resolve cable orientation and twist connections to establish USB data bus routing

➔ **Handle USB Power Delivery protocol**



24-pin reversible USB Type-C™ receptacle

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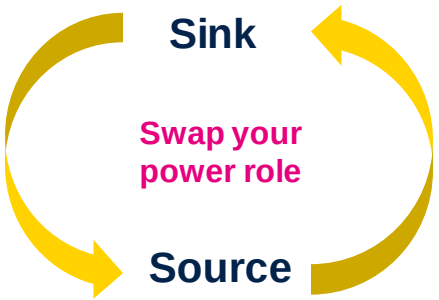
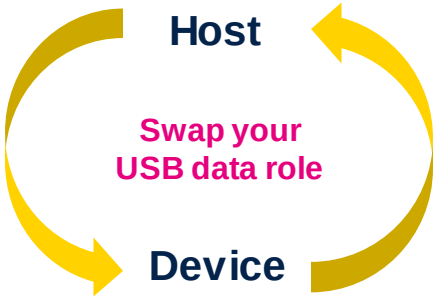
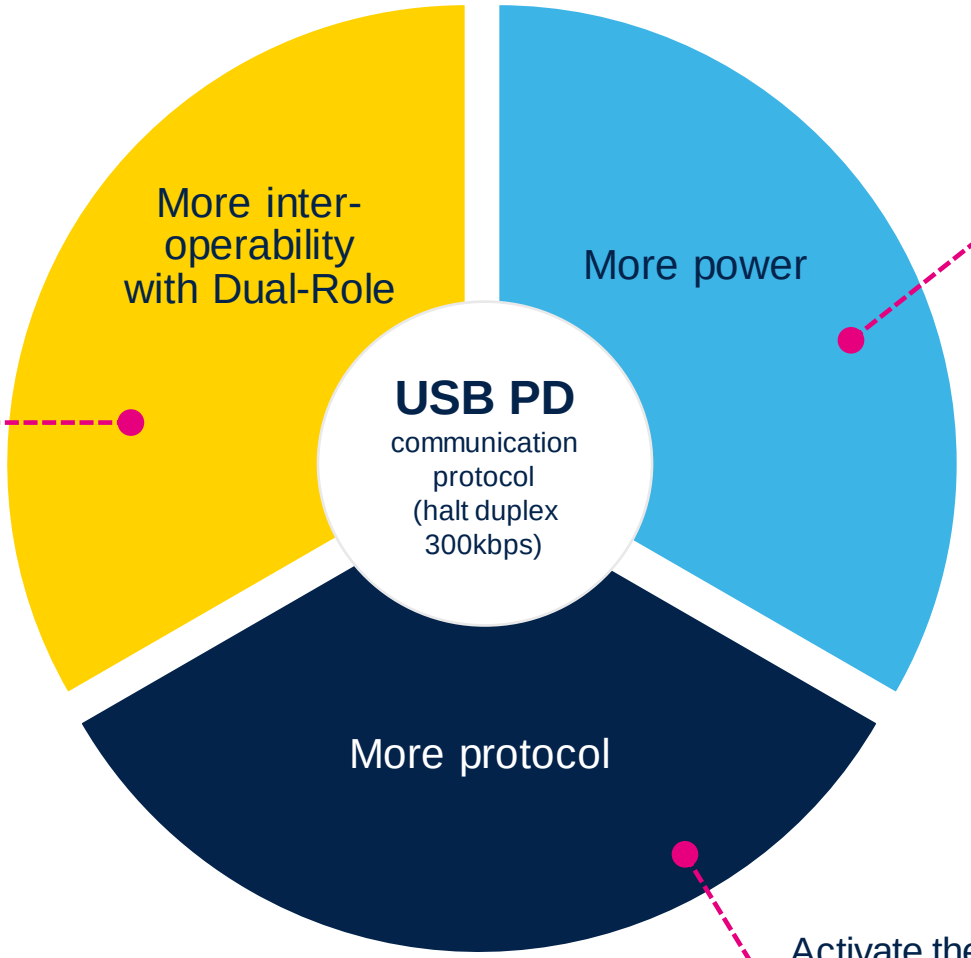
USB Power Delivery







Source or sink power **up to 240 W** with 5 V to 48 V on V_{bus} (5 A max)

From 7.5W

Up to **240 W**

Activate the alternate mode to enable Display Port, HDMI, Ethernet, Thunderbolt protocols

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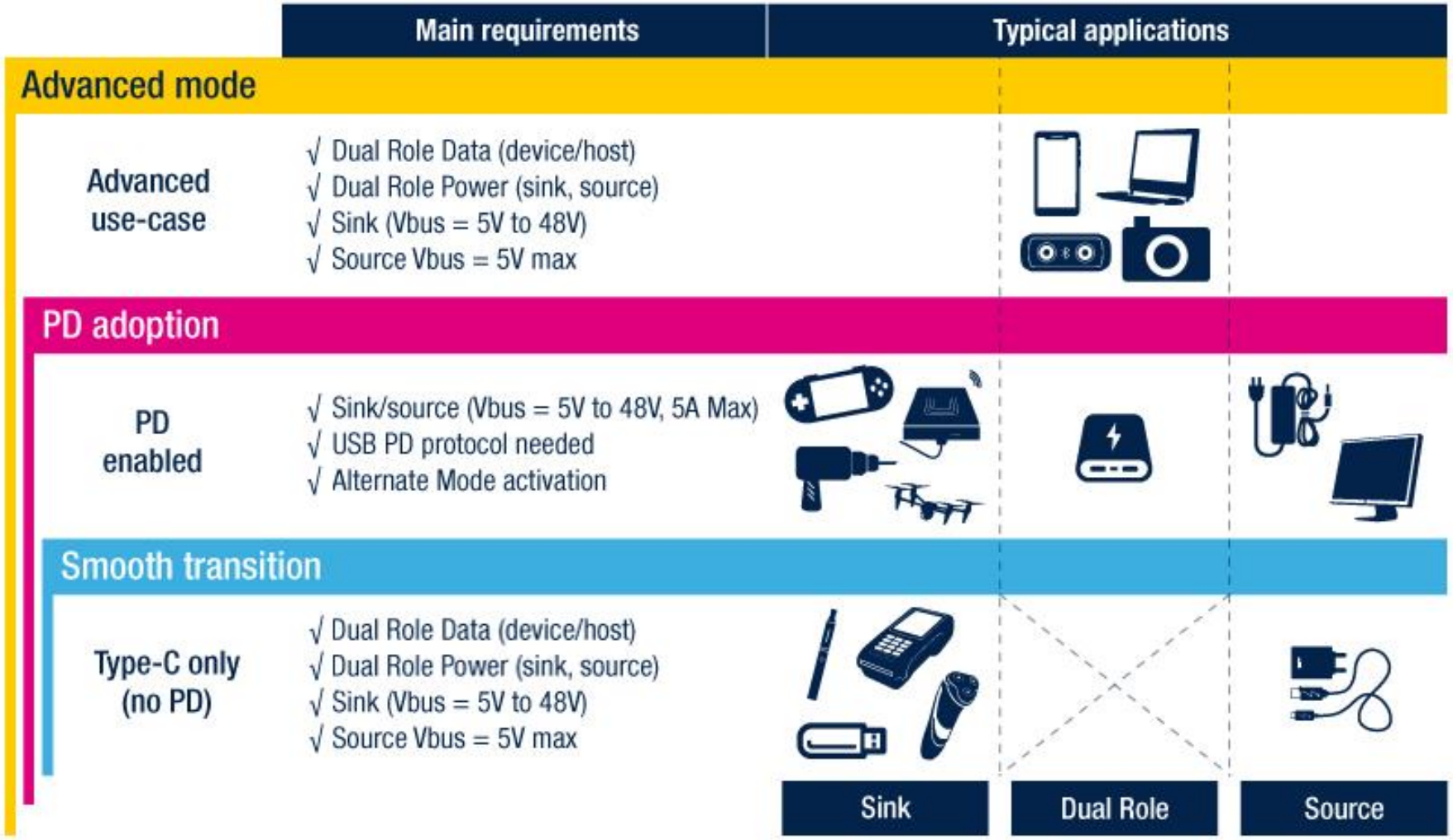
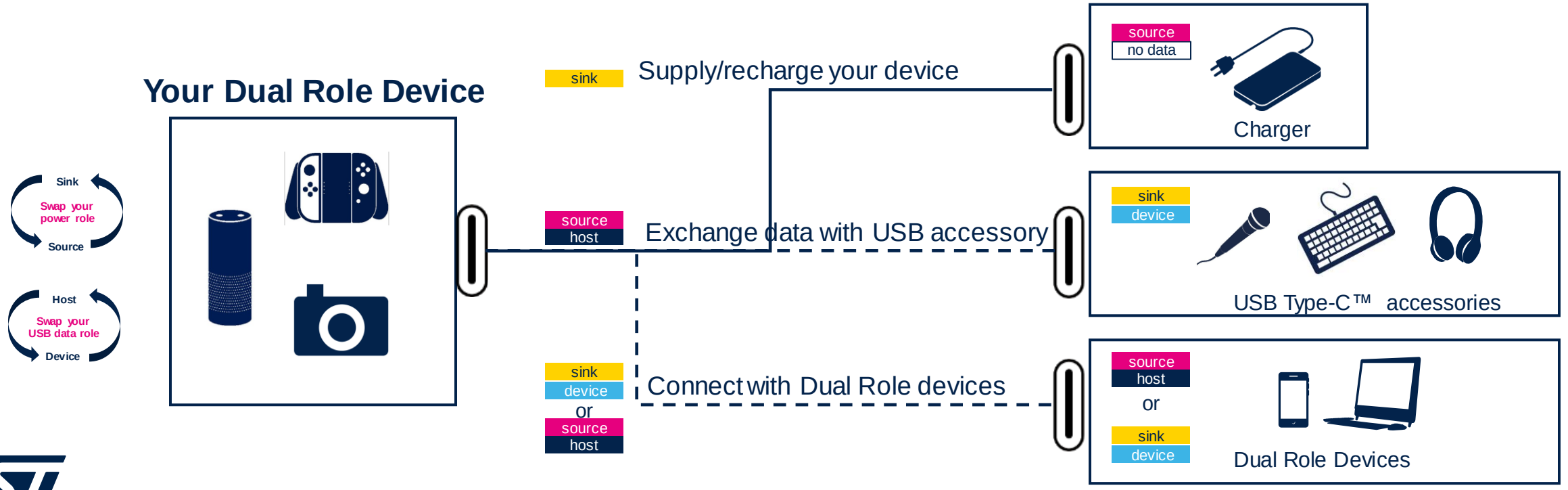
Main use-cases



Dual Role Device (DRD)

- DRD is a category of devices such as smartphones and notebooks that can act as source or sink while being host or device for USB data communication purpose.
- It allows to extend interoperability by supporting advanced use-cases.
- Swap between power and data roles are done independently by using USB PD swap commands.
- DRD replaces and enhances “On-The-Go” becoming obsolete



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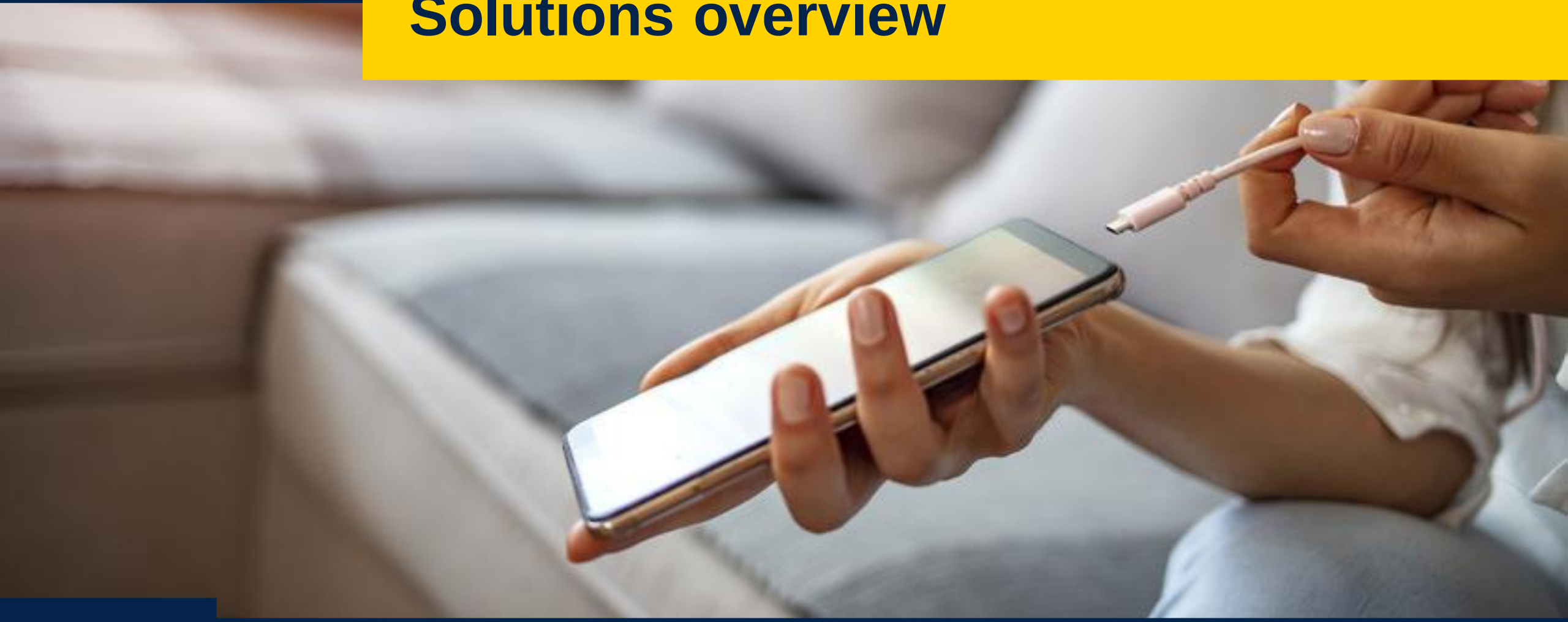
STM32 USB Type-C™ Solutions overview



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USB Type-C™ + PD3.1 Two solutions

1 STM32 MCU with integrated UCPD controller

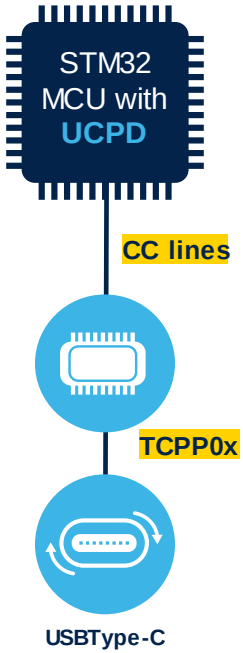
UCPD stands for USB Type-C™ and Power Delivery controller

STM32 UCPD MCUs
- Application tasks
- Policy Manager
- Policy Engine
- Protocol Layer

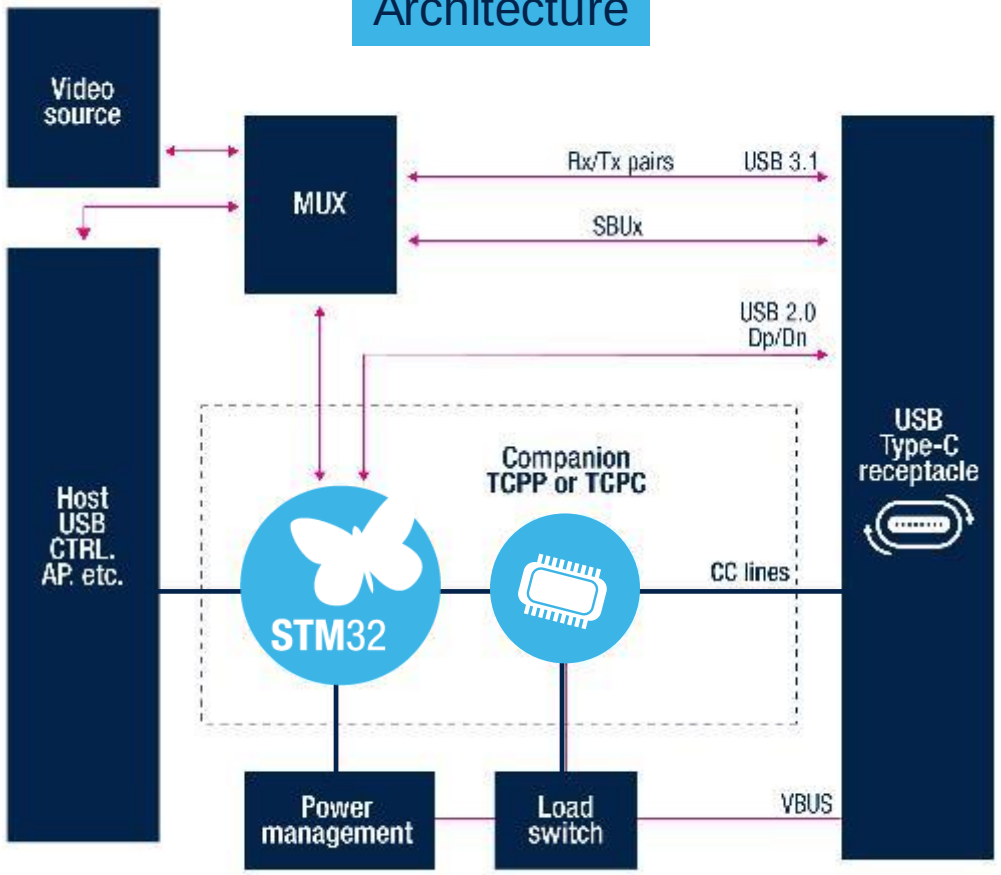
UCPD controller
- CC logic/USB PD PHY

TCPP0x port protection
- Dead battery
- ESD/OVP protection
- N-Gate driver
- OCP*
- Bus Discharge*

*w hen required



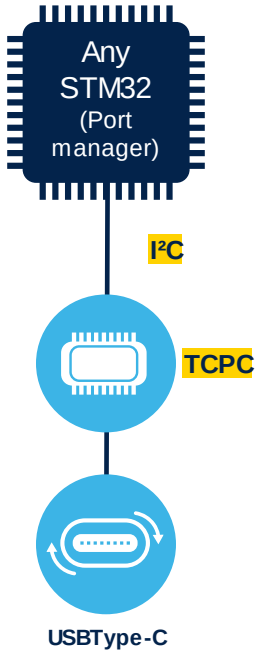
Architecture



2 Any STM32 as Type-C Port Manager

By any STM32
- Application tasks
- X-CUBE-USB-PD

3rd party TCPC port controller
- CC logic/USB PD PHY
- Dead battery
- Gate driver



Sink / Source / DRP, 5 V / 20 V – 240 W
Attachment + protection + power negotiation + alternate modes + PPS + C-Auth

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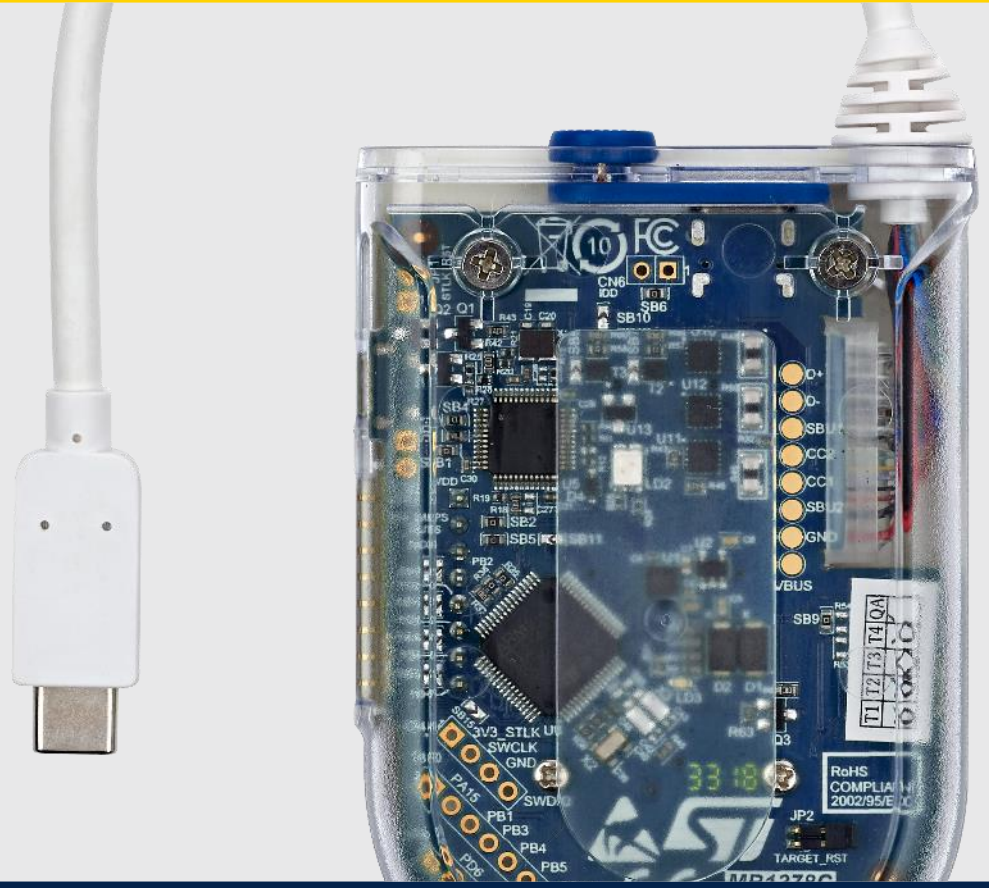
Solution N°1: using STM32 MCU with integrated UCPD* controller



* USB Type-C™ Power Delivery

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STM32, World 1st MCU with built-in UCPD controller

Available on STM32G0, STM32G4, STM32L5 and STM32U5 series

* UCPD stands for USB Type-C and Power Delivery Interface

Harness Type-C & USB PD protocol with a standard MCU

No need for an external PD controller

UCPD controller supports connector management and USB PD r3.1 protocol

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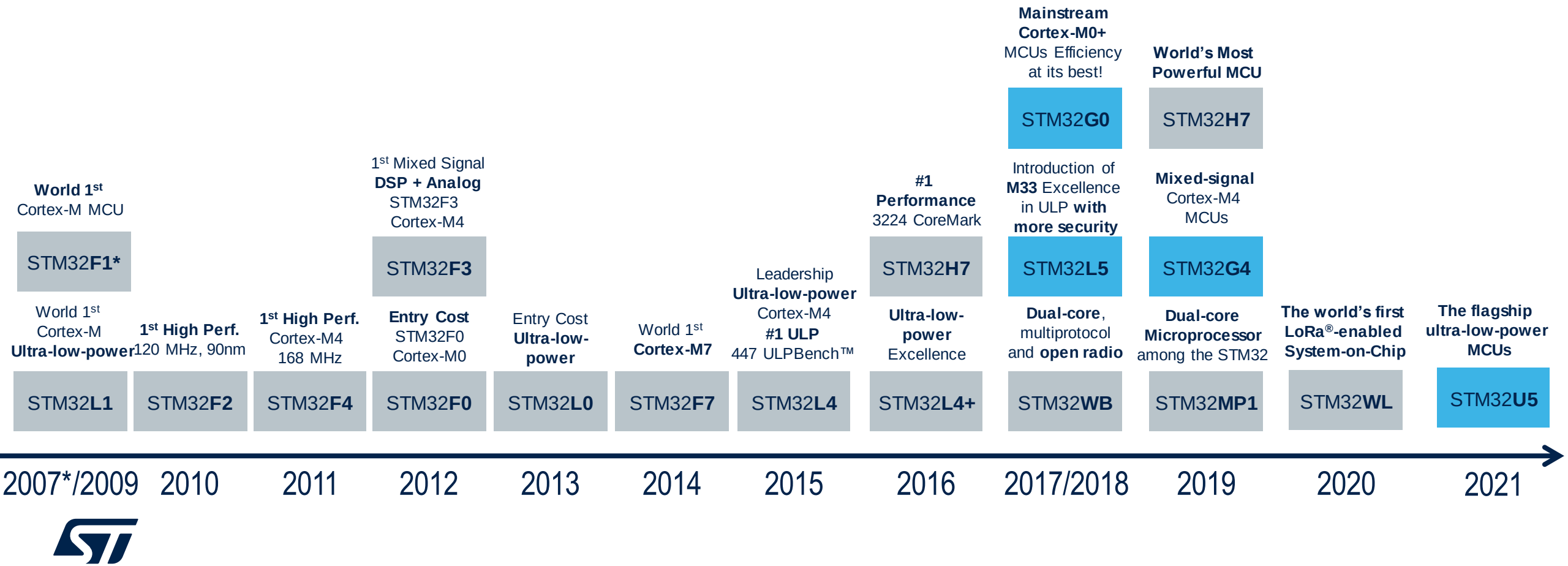
Wide Range of STM32 UCPD MCUs

More than 411 Part Numbers propose UCPD among STM32G0, STM32G4, STM32L5, STM32U5 series



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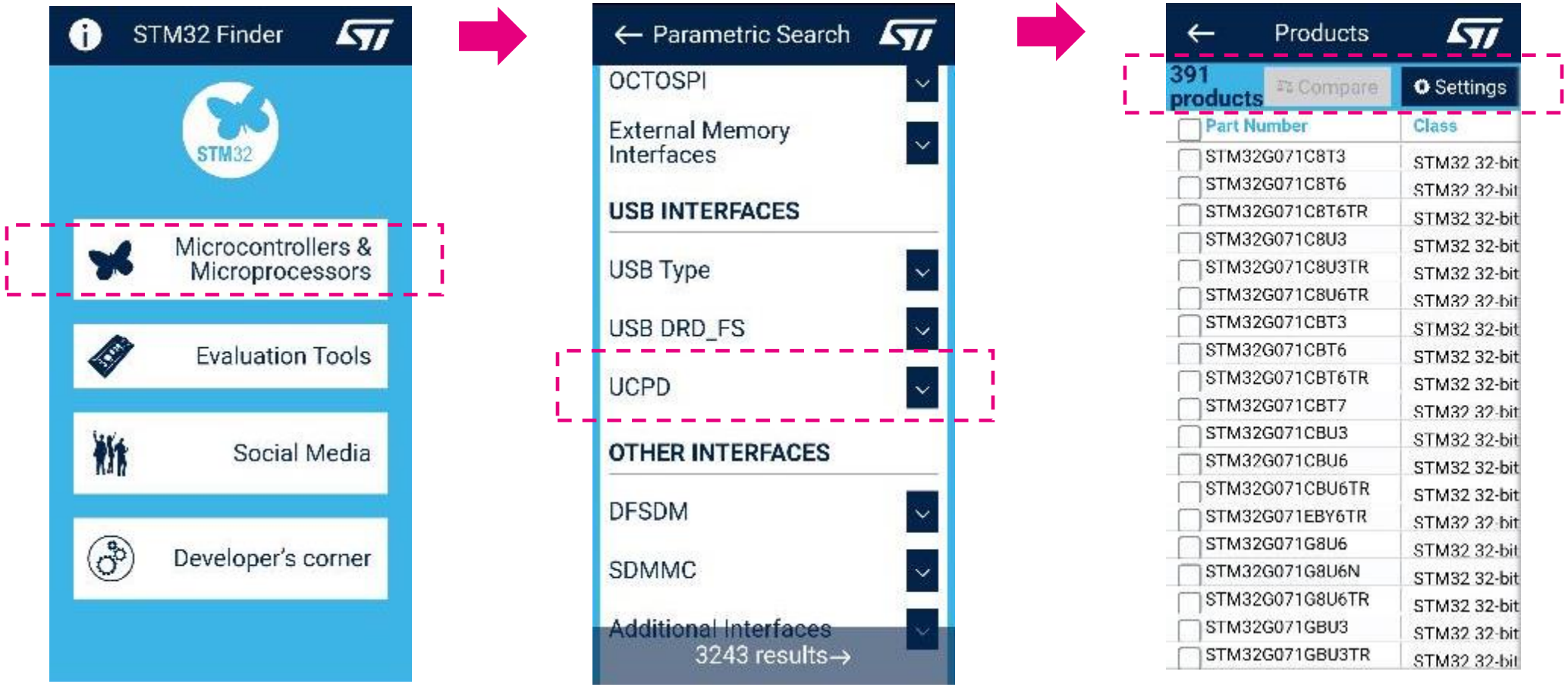
Find UCPD ready STM32 easily with STM32Finder app

Our Smartphone application **STM32Finder** allows to identify STM32 with UCPD" controller



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UCPD highlights

Example in STM32G0x1 access line

x 2

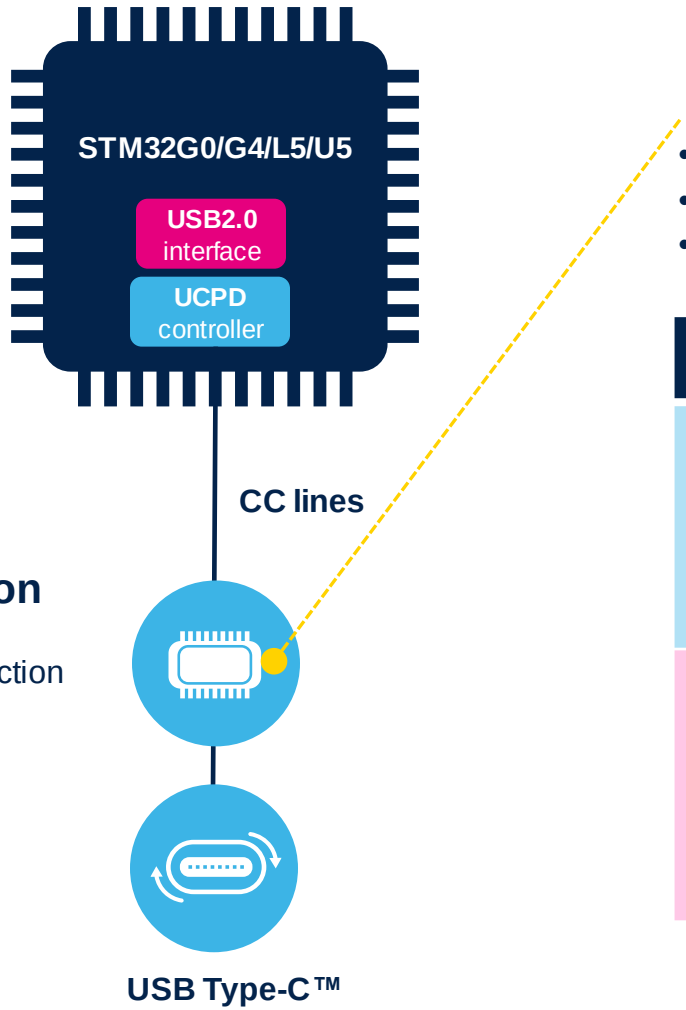
UCPD main features

- Dual port certified solution (TID 227)
- Support sink, source and Dual Role
- CC logic control and voltage monitoring
- Built-in Rp/Rd and dead battery resistors
- USB PD transceiver PHY
- Digital BMC / CRC encoding/decoding
- Support Programming Power Supply (PPS)
- Enable Fast Role Swap signaling (FRS)

USB2.0 Dual Role Data interface

- USB2.0 data interface (FS, HS)
- Dual-Role mode supported (Device/Host)
- Crystal-less

Cost effective partitioning with USB Type-C™ Port Protection devices



TCPP0x
Port protection

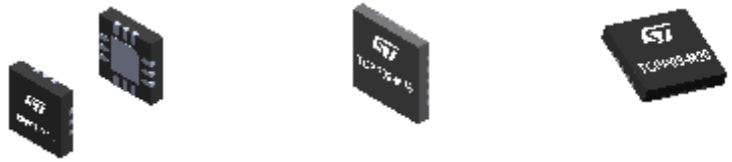
- Dead battery
- ESD/OVP protection
- N-Gate driver
- OCP*
- Bus Discharge*

**When required*

Protect your device with our companion TCPP0x high-voltage Port Protection ICs

- TCPP1-M12 for sink/device
- TCPP02-M18 for source/host
- TCPP03-M20 for dual-Role (DRP/DRD)

		SINK TCPP01-M12	SOURCE TCPP02-M18	DRP TCPP03-M20
CC	ESD ±8kV, OVP	✓	✓	✓
	Dead batteries	✓		✓
	V_{conn} switch, Over Current Protection, discharge		✓	✓
V_{BUS}	Gate driver	Sink	Source	Sink / Source
	Over Voltage Protection	✓		✓
	Over Current Protection, current sense		✓	Bi-directional
	Discharge		✓	✓
	Low pin count Package	QFN-12L (3x3)	QFN-18L (3.5x3.5)	QFN-20L (4x4)



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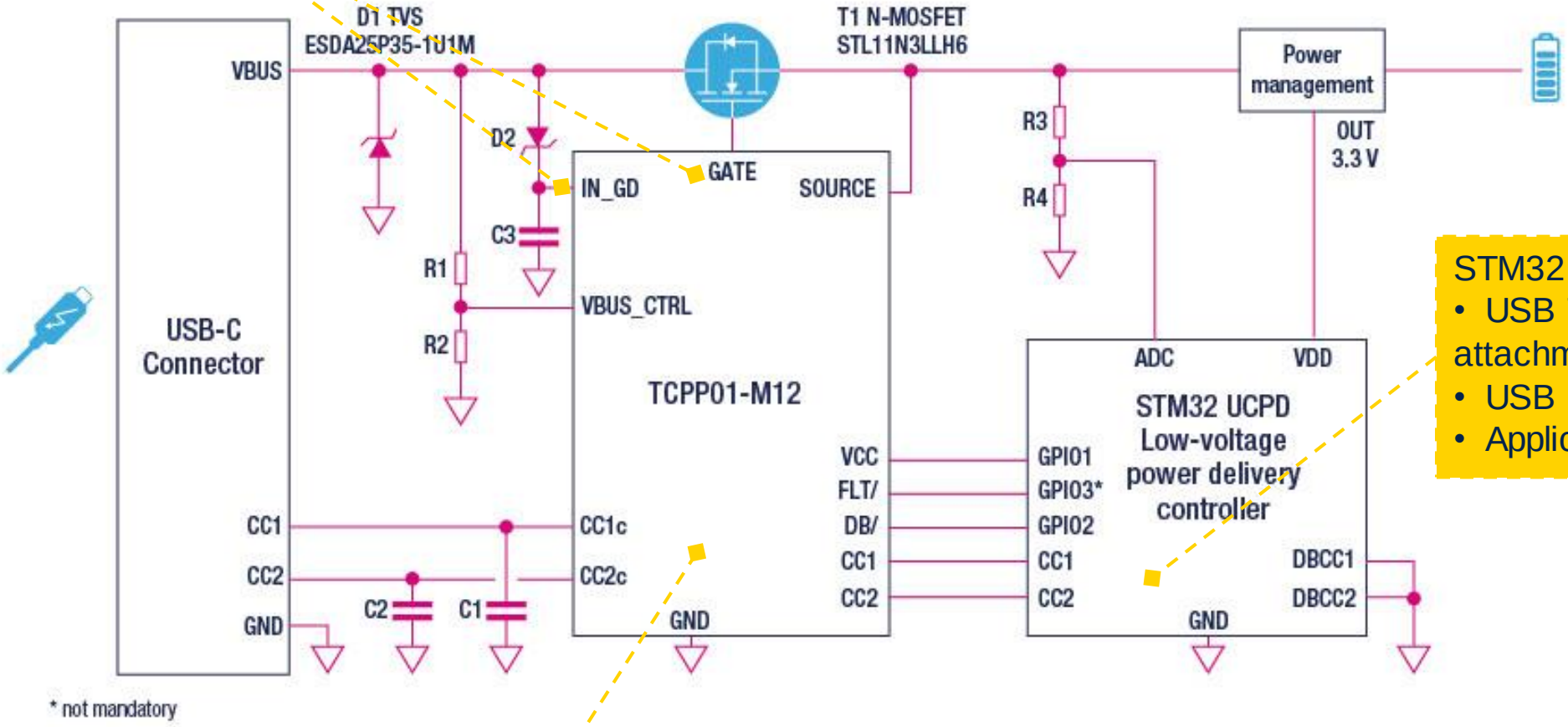
Sink with TCPP01-M12

- VBUS monitoring and Protection (OVP)
- Drive VBUS with integrated gate driver



STM32 UCPD
- USB Type-C™ attachment
- USB PD stack
- Application tasks

- CC lines OVP (6V) against short-to-VBUS
- ESD protection
- Dead battery

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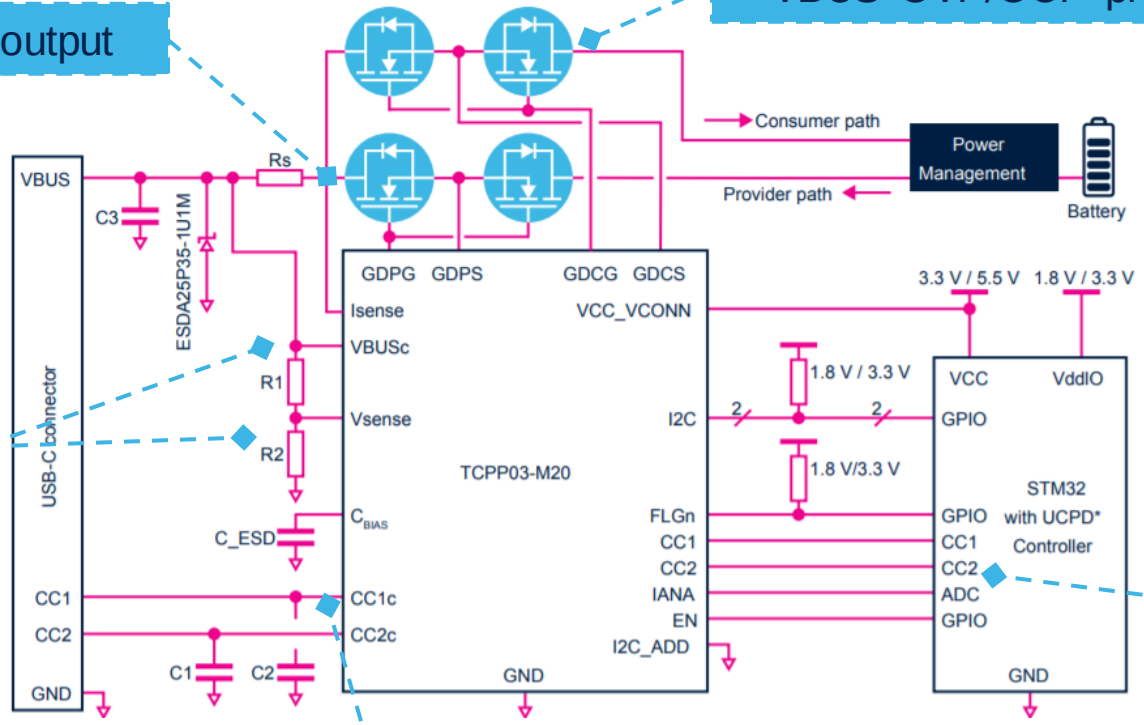
Dual Role with TCPP03-M20

- Current Sensing with digital output

- VBUS OVP/OCP protections and gate drivers

- VBUS/VCONN discharge
- VBUS/IBUS monitoring



STM32 UCPD
- USB Type-C™ attachment
- USB PD stack
- Application tasks

- CC lines OVP (6V) against short-to-VBUS
- 24V ESD protection on CC lines
- VCONN OCP (100mW) and OVP(6V)
- Dead battery

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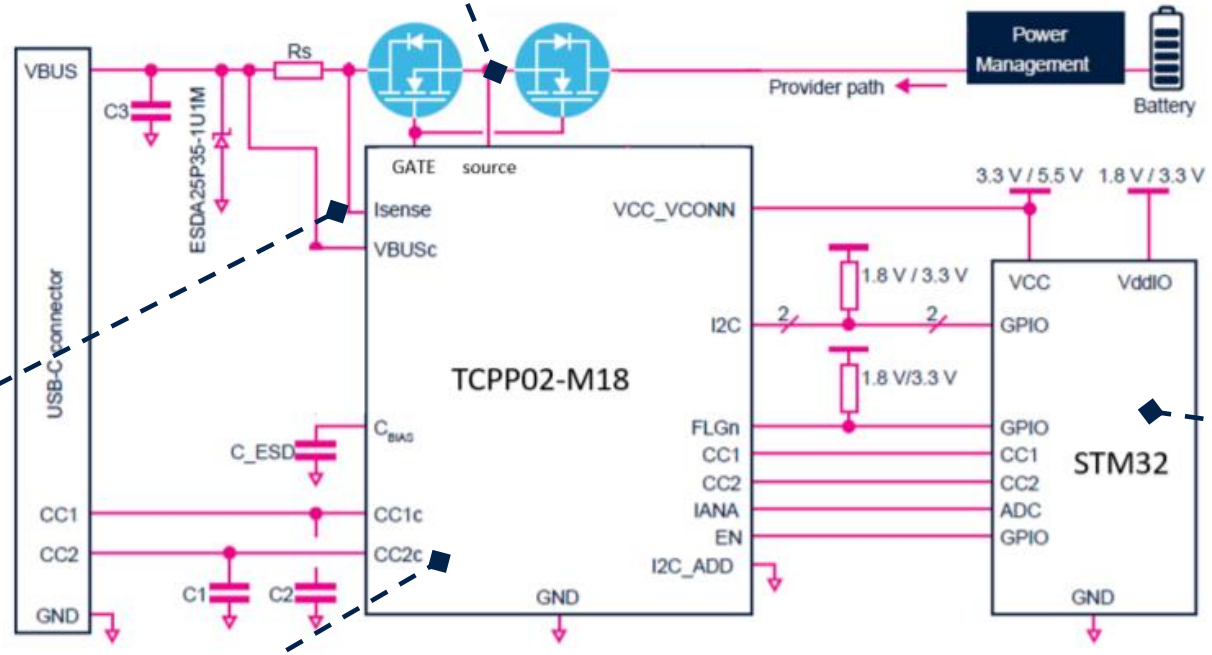
Source with TCPP02-M18

- VBUS monitoring, OVP/OCP protections
- Integrated gate driver
- Integrated discharge for VBUS and VCONN



- Current sensing

- CC lines OVP (6V) against short-to-VBUS
- ESD protection
- Dead battery

STM32 UCPD
- USB Type-C™ attachment
- USB PD stack
- Application tasks

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Quick evaluation with STM32 Nucleo USB Type-C™ expansion boards

+

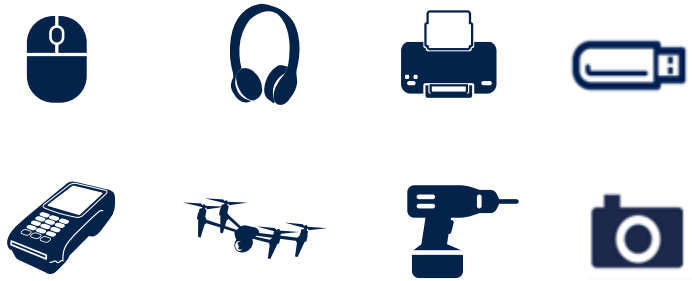
X-CUBE-TCPP

Ready to run
firmware examples projects
for STM32 Nucleo 64pin

For SINK/Device

X-NUCLEO-SNK1M1

based on TCPP01-M12



For DRP/DRD

X-NUCLEO-DRP1M1

based on TCPP03-M20

For SOURCE/Host

X-NUCLEO-SRC1M1

based on TCPP02-M18

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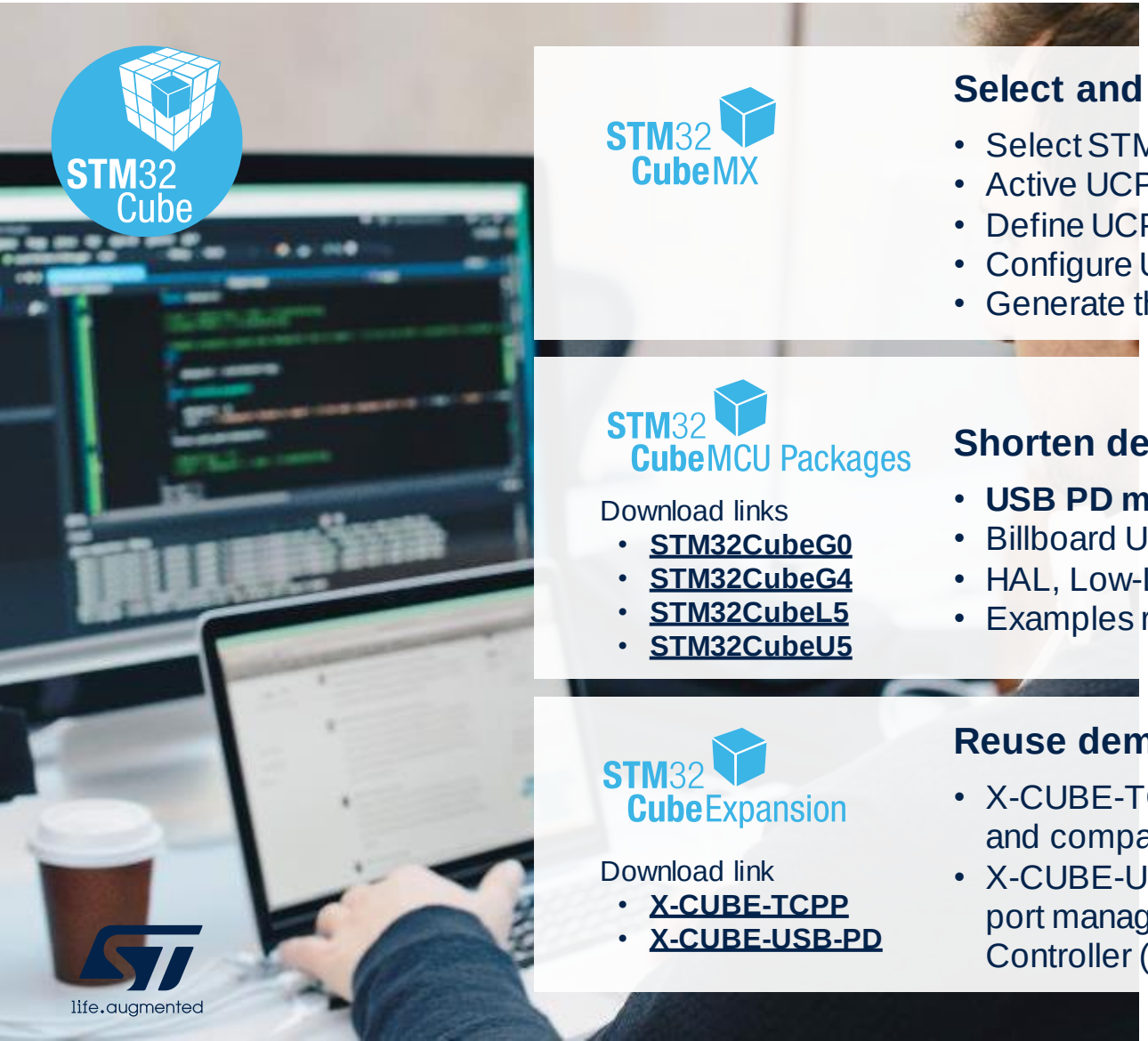
Fast development with STM32Cube USB Type-C™ ecosystem

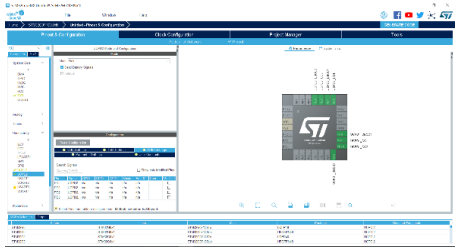


STM32 Cube

STM32 CubeMX

Select and configure your STM32 UCPD controller

- Select STM32 resources and peripherals
- Active UCPD peripherals and define USB-C role
- Define UCPD middleware settings
- Configure USB data peripherals and drivers
- Generate the code



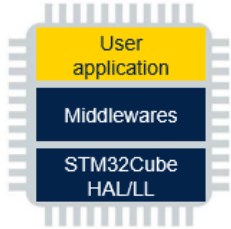
STM32 CubeMCU Packages

Download links

- **STM32CubeG0**
- **STM32CubeG4**
- **STM32CubeL5**
- **STM32CubeU5**

Shorten development with STM32CubeMCU packages

- **USB PD middleware library**
- Billboard USB drivers, FreeRTOS, AzureRTOS ThreadX
- HAL, Low-Layer APIs CMSIS
- Examples running on ST boards



STM32 CubeExpansion

Download link

- **X-CUBE-TCPP**
- **X-CUBE-USB-PD**

Reuse demonstration firmware

- X-CUBE-TCPP to implement sink, source or dual role with STM32 UCPD MCU and companion **TCPP**
- X-CUBE-USB-PD is our legacy solution for multi-port to implement a Type-C port manager (TCPM) on any STM32 MCU and to control Type-C Port Controller (**TCPC**) chip from 3rd parties.

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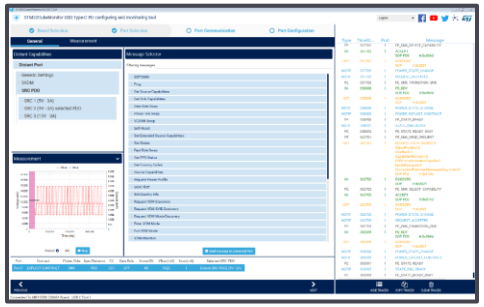
Monitor your design with STM32 USB Type-C™ tools

STM32 CubeMonitor-UCPD



STM32CubeMonUCPD, a free software monitoring and configuring tools for USB Type-C™ applications

- Support of USB Type-C™ 1.2 and USB PD r3.1
- Port configuration pane for PD setting, VDM, SOP, Source and Sink Capabilities
- Port communication pane for VBUS and IBUS monitoring, distant port capabilities, message selector, and real-time traces

STM32G071B-DISCO is a USB Type-C™ and PD sniffer

- Discover, display USB Type-C™ power and feature capabilities of any host.
- Sniff USB PD data packets and display Vbus voltage, Ibus current
- Debug, configure and inject USB PD3.1 packet using STM32CubeMonitor UCPD

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Hardware tools & reference designs

SOLUTIONS	STM32F0	STM32G0	STM32G4	STM32L5	STM32U5
USB Type-C™ to DisplayPort™ adapter	**STEVAL-USBC2DP**				
TCPM/TCPC	**ON-FUSB3-STM32** (with 3rd party TCPC)				
AC/DC USB PD Power Adapter	**STEVAL-USBPD45C** (45W)	**STEVAL-USBPD27S** (27W / PPS ready) **STEVAL-2STPD01** (2x 60W)			
USB Type-C™ Discovery kits		**STM32G071B-DISCO** (USB-C Sniffer/Analyzer)	**B-G474E-DPOW1** 1 port DRP	**STM32L562E-DK** 1 port SNK	**B-U585I-IOT02A** 1 port DRP
Evaluation boards		**STM32G0C1E-EV** 1 port 45W DRP 1 port Sink	**STM32G474E-EVAL** featuring 1 port DRP	**STM32L552E-EVAL** 1 port SNK	**STM32U575I-EV** 1 port DRP
Nucleo board Nucleo shield	**P-NUCLEO-USB002** 1 port DRP with STM32F072RBT6 + STUSB1602	**X-NUCLEO-SNK1M1** **X-NUCLEO-DRP1M1** **X-NUCLEO-SRC1M1**	**X-NUCLEO-SNK1M1** **X-NUCLEO-DRP1M1** **X-NUCLEO-SRC1M1**	**NUCLEO-L552ZE-Q** 1 port SNK	**NUCLEO-U575ZI-Q** 1 port SNK

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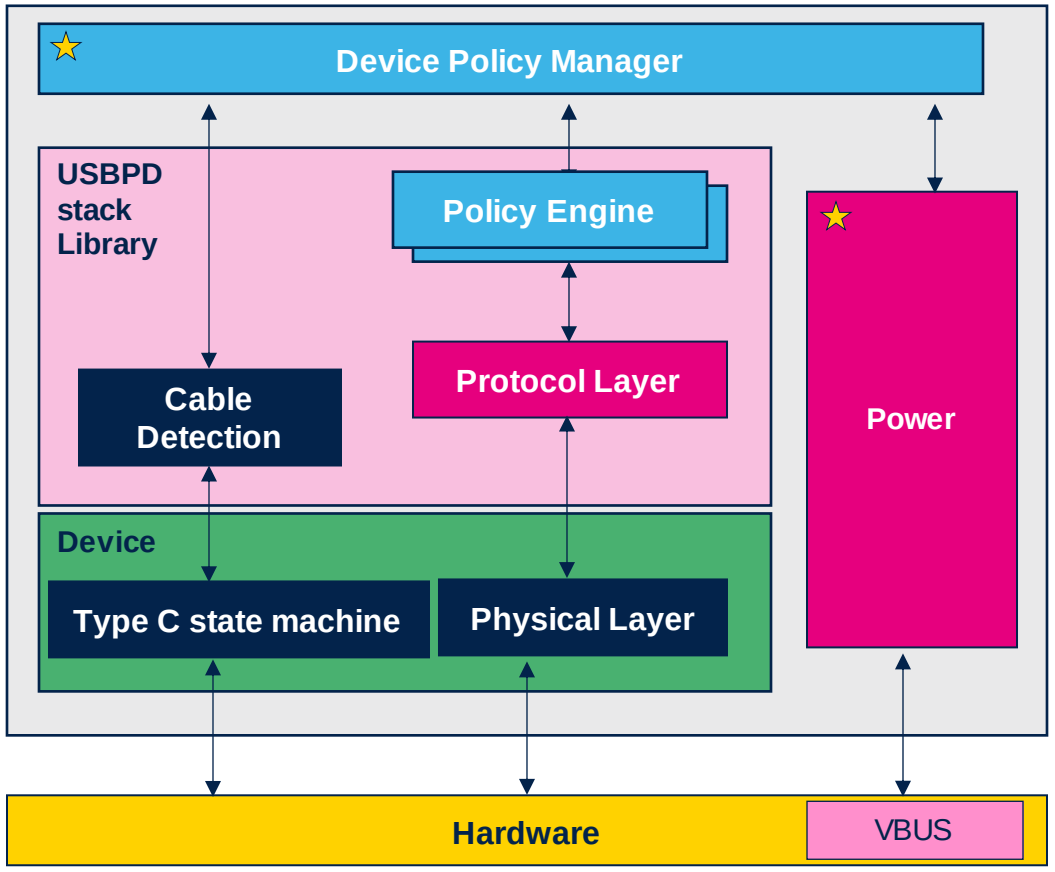
High level of customization with ST USBPD Middleware



☆ Parts to be customised by customer

- Available in STM32CubeMCU packages
- Compliant with USB Type-C™ 1.2 and USB PD r3.1
- Embeds the Policy Engine, Protocol Layer, Physical Layer, USB-C port Control
- Applies for STM32 UCPD or TCPM/TCPC implementation
- Policy engine includes 3 state machines (SRC, SNK, cable).
- User application customization is done in the Device Policy manager
- A set of API (get VBUS, set VBUS) and utilities (tracer, low power manager, power monitor) are available for maximum of usability

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USB PD power adapter

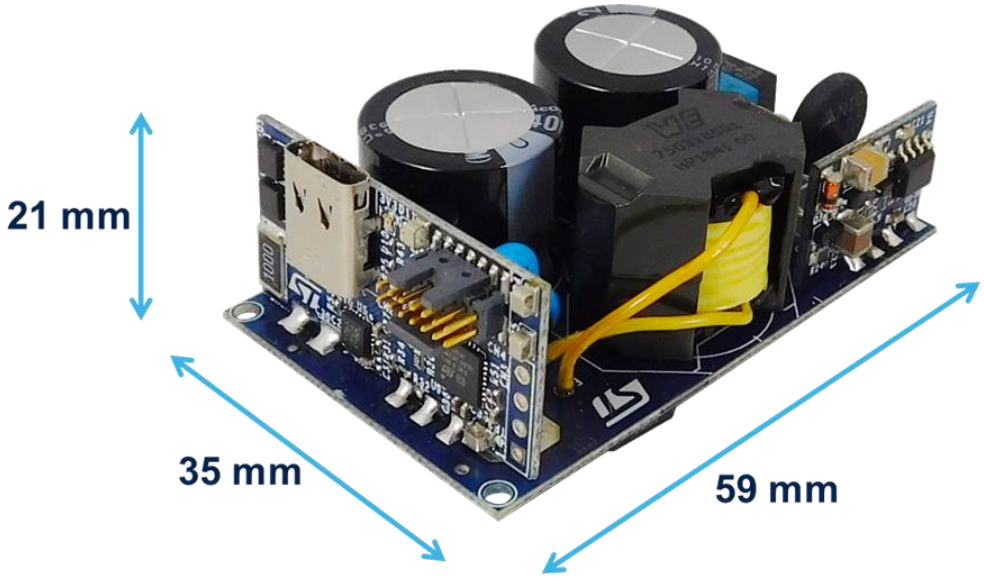
27 W PD3.0/PPS Power adapter with STM32G0

Key Features

- Universal input mains voltage range
- Two fixed PDOs: 5V @ 5A, 9V @ 3A
- Two APDOs for PPS
- Adaptive synchronous rectification, MCU-driven
- Energy efficiency compliant with CoC Tier 2 and DoE Level VI
  - Full Load Efficiency 89,4% at 230V_{AC} input
  - < 40 mW no-load standby power

Key Products

- Primary Side Controller: STCH03
- USB PD and SR Controller: STM32G0
- Primary MOSFET: STD7N65M6, Load Switch: STL11N3LLH6
- ESD and CC Lines protections + Gate Driver: TCPP01-M12
- High performance LDO: LDK320



Board ref: **STEVAL-USBPD27S**

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Step by Step tutorial

Wiki by

Create a USB-PD Sink Device in 45min

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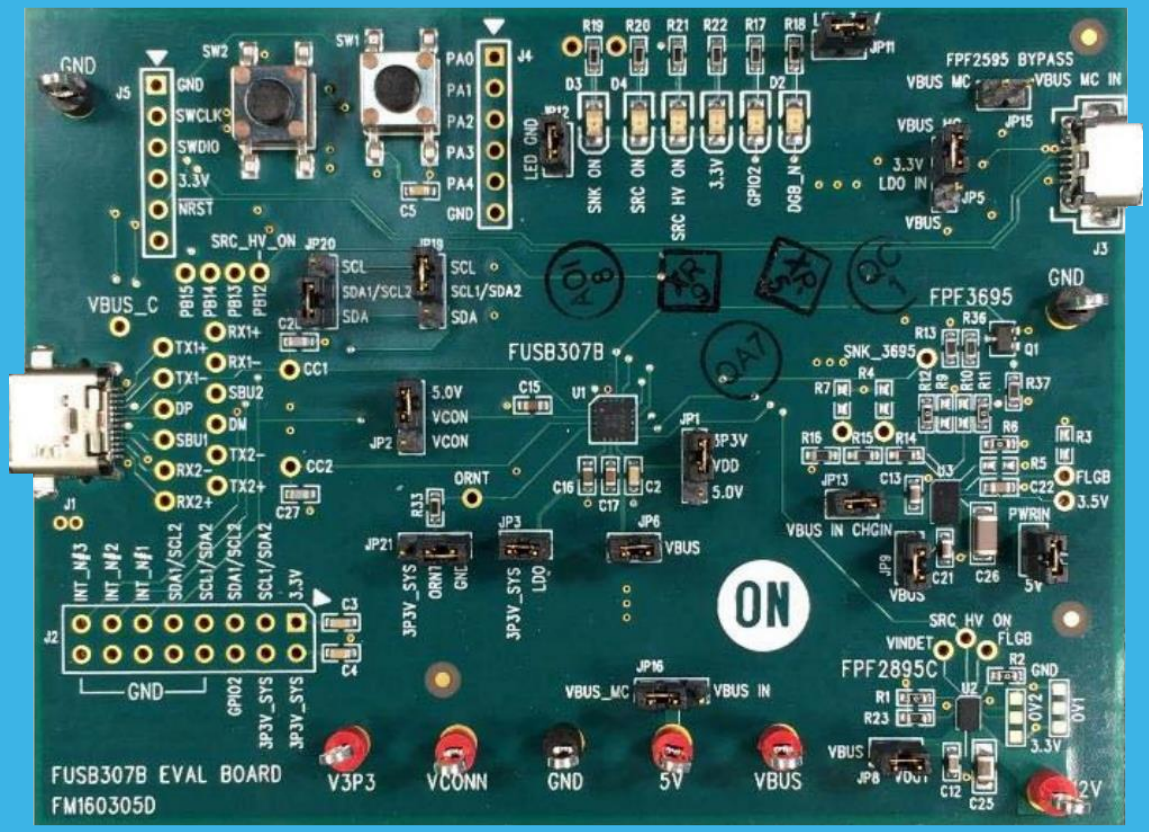
Solution N°2
STM32 as Type-C Port Manager



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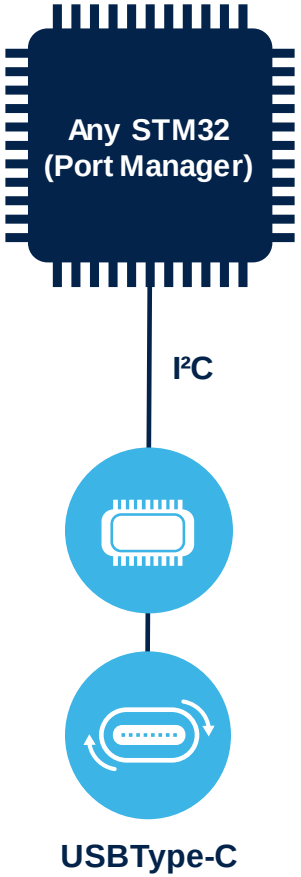
X-CUBE-USB-PD for Type-C Port Manager on any STM32

By any STM32
- Application tasks
- X-CUBE-USB-PD

3rd party TCPC port controller
- CC logic / USB PD PHY
- Dead battery
- Gate driver



- Certified Port Manager (TCPM) stack eases migration to USB-PD 3.0 Power Delivery on any STM32
- X-CUBE-USB-PD complies with:
  - USB-C 1.3 and **USB PD 3.0** specifications
  - Type-C Port Controller Interface specification (TCPCi)
- Single- or multi-port supported (Sink, Source, and Dual Role Power)
- Hardware architecture supported
  - Any STM32 as **TCPM** with standardized **TCPC** from 3rd parties
    - Note: Solution tested with ON Semiconductor® FUSB307B, a USB-PD 3.0 v1.1-certified TCPC
  - Or STM32F0 with STUSB1602 Type-C interface
- Running X-CUBE-USP-PD on UCPD certified STM32 allows multi-port solutions

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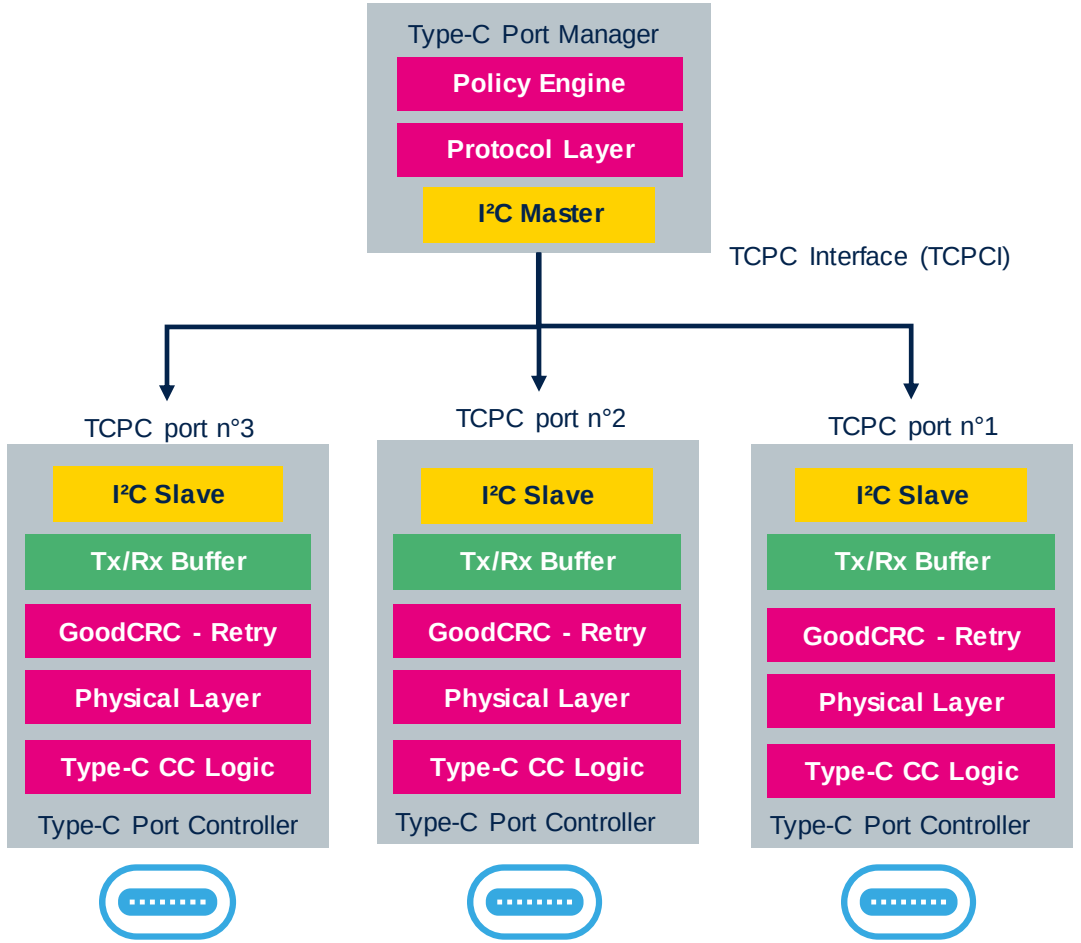
Benefits of TCPM / TCPC split

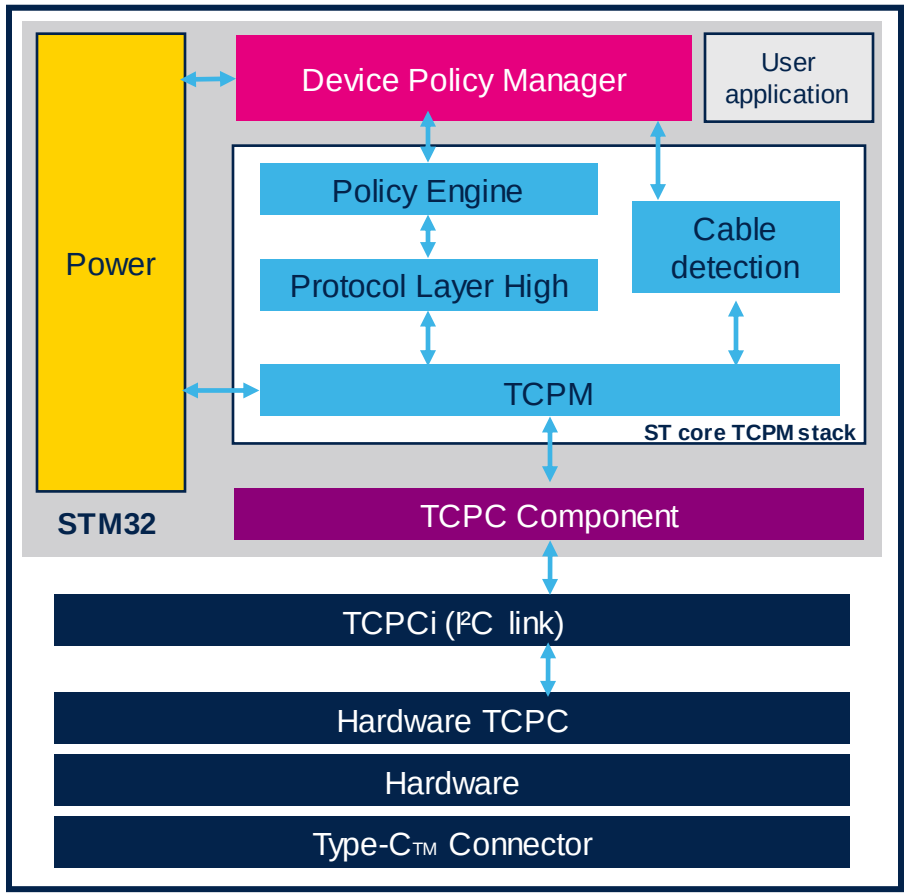
Optimized HW/SW partitioning for single- or multi-port

- The STM32 provides a high customization and flexibility to manage power policy, application layers.
- TCPCI interface provides a low pin count interconnect using Fast-Mode Plus I²C (1 MHz) bus, plus one alert line, and a comprehensive set of TCPC registers making stack porting across STM32 platform easier.
- TCPC provides the “Power Path” and integrate components with fast latency requirements as well as USB-C/PD PHY, V_{conn}, dead battery and protection.



Features and memory footprint

Compliant with USB Type-C™1.3 and USB PD 3.0 specifications



X-CUBE-USB-PD Expansion Software package includes

- USB PD "core" library for Cortex™-M0/M4 based devices (STM32F0/F4/L4/F3)
- Open-source drivers to support TCPC devices
- Firmware examples (Provider, Consumer, Dual Role Power) for MDK-Arm®, IAR-EWARM and SW4STM32 IDEs

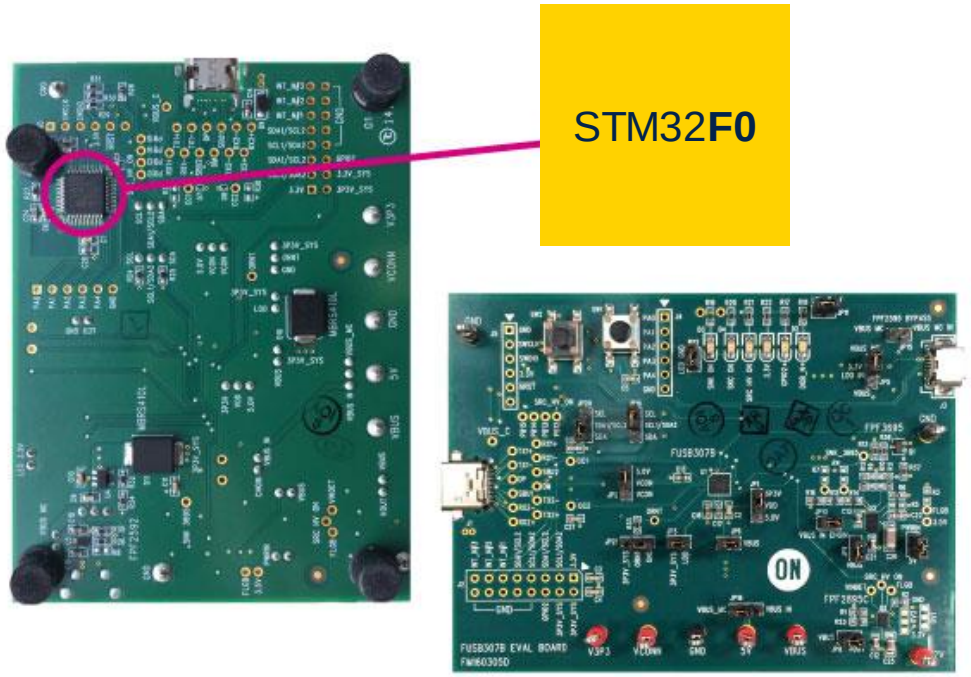
Key features

- Device Policy Manager, Policy Engine and Protocol Layer
- Cable detection and orientation
- Supports Vendor-Defined Messages (Alternate Modes)
- Billboard driver
- SOP' and SOP'' for communication with cables

Typical TCPM Memory Footprint (no VDM, no Vconn)	Source or Sink only	Dual Role Power
1 port (w/o RTOS)	32 Kbytes in Flash 3.6 Kbytes in RAM	40 Kbytes in Flash 3.6 Kbytes in RAM
2 port (w/RTOS)	32 Kbytes in Flash 7.8 Kbytes in RAM	43 Kbytes in Flash 8.1 Kbytes in RAM

STM32F072 Type-C port manager evaluation board

TCPM/TCPC evaluation board



Board ref: **ON-FUSB3-STM32**

Key features

- 1 USB Type-C™ port
- Sink, Source, and DRP capability
- STM32F072CBT6, 32-bit Arm® Cortex®-M0 MCU as TCPM
- ON Semiconductor® FUSB307B Type-C port controller
- On-board power management and dedicated power connector to interface with an external power supply
- Order one kit (149$ range): Click here

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USB-PD Community

STM32 solutions for USB Type-C and PD

wiki.st.com/USBPD

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In less than 10 minutes

TCPP product page

Our technology starts with You

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