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Connect to USB Type-C™ with STM32 MCUs

STM32

Presentation agenda

USB-C和电源传输技术概述

ST提供了两种解决方案，以帮助开发人员为其应用找到最佳解决方案：

- STM32 UCPD控制器和开发生态系统
- 适用于任何STM32的X-CUBE-USB-PD扩展软件包

为什么要使用USB-C™和Power Delivery技术？

USB Type-C™连接器可改善用户体验

•这是24针微型可逆连接器。 两侧的USB-C插头相同
· 某些引脚可以改用于支持专有协议（备用模式）
· 无需USB PD协议即可本地传输15W功率

使用各种协议更快地交换更多数据

- 2 separate USB data paths are available simultaneously: USB 2.0 + USB 3.1 (up to 10 Gbit/s)
- Display Port, HDMI, MHL, Thunderbolt are supported to carry video/audio signals
- Conventional I²C/SPI/UART/Ethernet interfaces can be “bridge” to USB-C

通过全面而强大的协议获得更多功能

- **USB Power Delivery** protocol enables power negotiation (up to 100 W)
- Able to discover power capabilities and needs between two USB-C™ connected devices
- Enables advanced voltage and current negotiation to support fast charging
- USB PD is used to activate Alternate Modes or to carry Authentication messages

保护您的应用程序并扩展其功能

- Identify genuine chargers or accessories using USB PD authentication messages
- USB PD Alternate Modes and Vendor Defined Messages enable product differentiation.
- Secure firmware upgrade capability

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USB T peJC™引脚分配功能

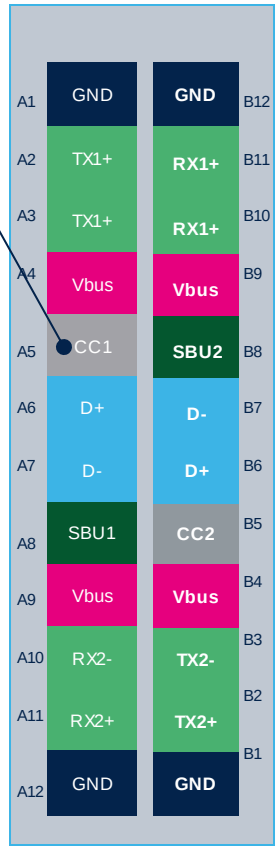
CC1 / CC2电线的用途
（配置和通讯渠道）

C型连接器接口：

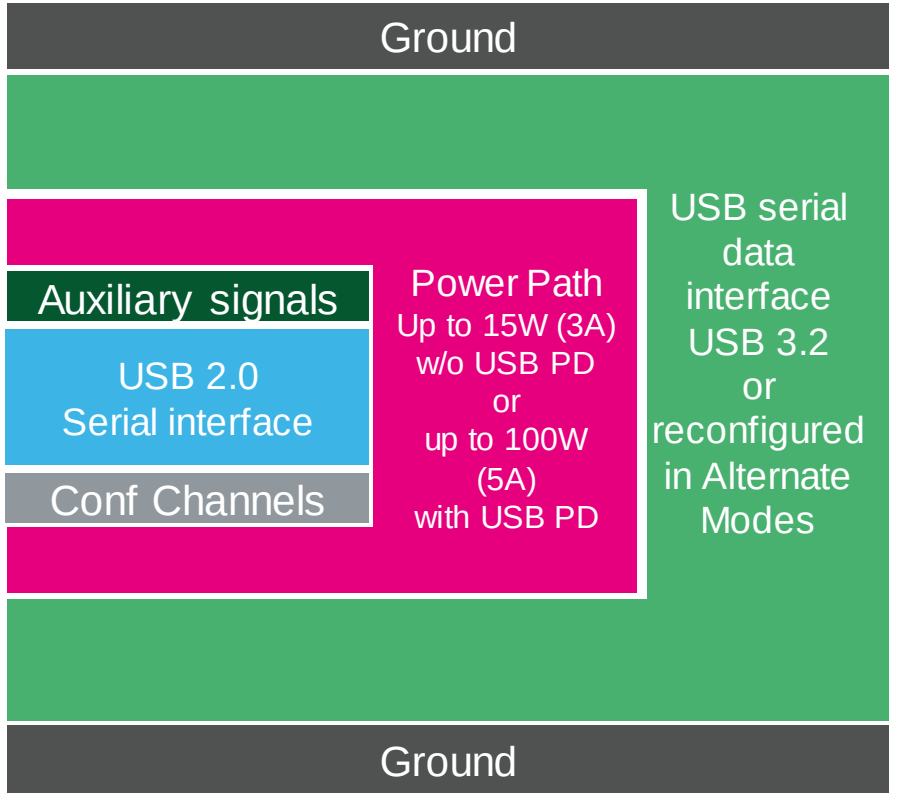
- 两台设备之间的连接/分离和角色管理（SNK，SRC和DRP）
  - 发现并配置VBUS和VCONN
  - 解决扭曲和电缆方向以建立USB数据总线路由

供电协议管理：

- 发现远方端口的电源功能
  - 协商功率合同最高可达到100 W
  - 交换电源方向
  - 交换USB数据角色
  - 处理备用模式（AM）
  - 验证设备或充电器



24-pin
USB-C receptacle



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USB Power Delivery is a protocol!

通过创新安全地增强用户体验

以强大而安全的方式获得更多动力!

•支持高级和更高的电压和电流协商（高达100 W）

· Source和Sink建立符合其电力能力和需求的电力合同（例如：使用的电池技术，电力预算分配，端口数量等）

· 电源电压（Vbus）是固定的（5V，9V，15V或20V）或可配置的（编程电源）

· 双角色电源设备可以交换电源方向

（例如：使用平板电脑为笔记本电脑充电！）

Mode of operation		Nominal voltage	Maximum current	Maximum power
USB PD		可配置的	**5 A**	**100 W**
USB Type-C Current @ 3.0 A		5 V	3.0 A	15 W
USB Type-C Current @ 1.5 A		5 V	1.5 A	7.5 W
USB BC 1.2		5 V	Up to 1.5 A	7.5 W
Default USB Power	USB 3.2	5 V	900 mA (x1) 1,500 mA (x2)	4.5 W 7.5 W
	USB 2.0	5 V	500 mA	2.5 W

扩展设备功能并创造独特的差异!

- 使用USB PD结构化的供应商定义消息（VDM）扩展功能（视频输出，身份验证等）

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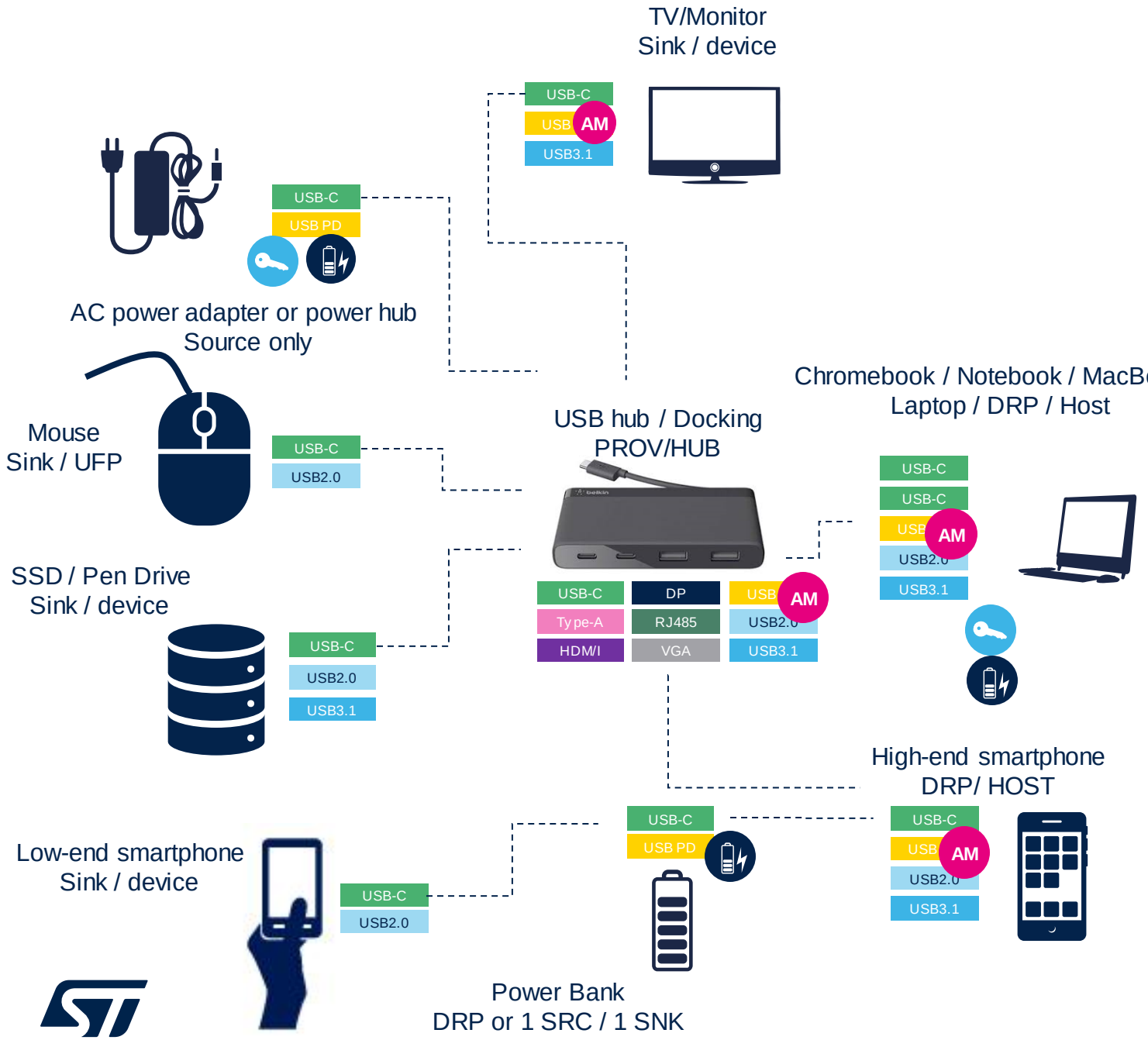
许多组合



Terminology

Power roles

- Source/Provider: Provide Power
- Sink/Consumer: Consume power
- DRP**: Dual Role Power** (can be either Sink or Source)

Data roles

- DFP: Downstream Facing Port (usually a Host / HUB ports)
- UFP: Upstream Facing Port (usually a device)
- DRD: **Dual-Role Data** - typical of “on-the-go” ports

Power role and Data role can swap !

Roles can be dynamically swapped using USB PD

AM — Alternate Mode capabilities enabled via USB PD

Authentication

Fast charging using PPS

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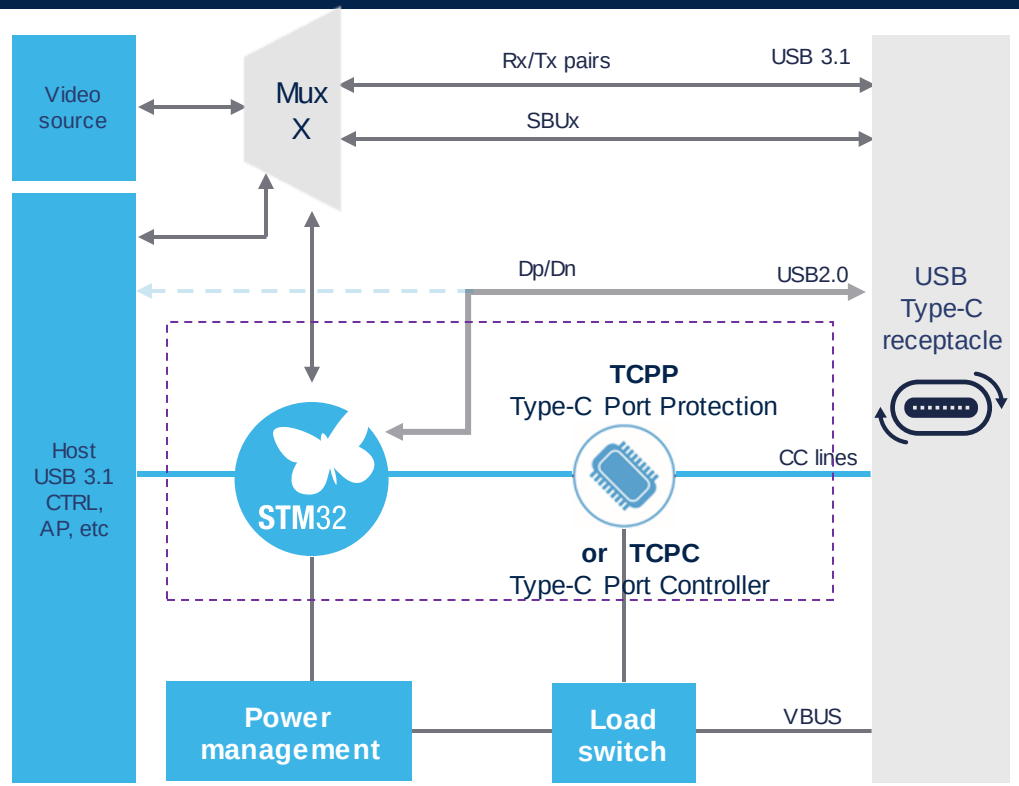
使用STM32的两种解决方案

Flexible solutions for existing or new designs



1

通过使用STM32G0，STM32G4和STM32L5微控制器中提供的UCPD（*）接口。

（*）UCPD = USB-C型和供电接口USB C型伴侣端口保护设备（TCPP01-M12）可用于保护USB-C连接器。

2

通过使用任何STM32作为运行我们的X-CUBE-USB-PD软件包的Type-C端口管理器（TCPM），来控制第三方Type-C端口控制器（TCPC）或STUSB1602。

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Partitioning

1

解决方案
带有内置USB PD接口（UCPD）的STM32

SW : USB PD Middleware in STM32Cube
- Device Policy Manager
- Policy Engine
- Protocol Layer

HW : UCPD Hardware
- GoodCRC / retry
- Physical Layer
- Type-C Logic
- Dead Battery

TCPP
- Dead Battery
- ESD protection
- 22V CC lines protection
- V_{bus} gate Driver

STM32L5
STM32G0
STM32G4

CC lines

Type-C Port Protection TCPP (TCPP01-M12)

USB Type-C

2

Solution
X-CUBE-USB-PD
Software Pack running on any STM32

X-CUBE-USB-PD
- Device Policy Manager
- Policy Engine
- Protocol Layer

TCPM (Type-C Port Manager)

I²C

TCPC
- GoodCRC / retry
- Physical Layer
- Type-C Logic
- Dead Battery
- Protection
- V_{bus} gate driver

Type-C Port Controller TCPC

USB Type-C

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STM32 with built-in USB PD interface (UCPD)

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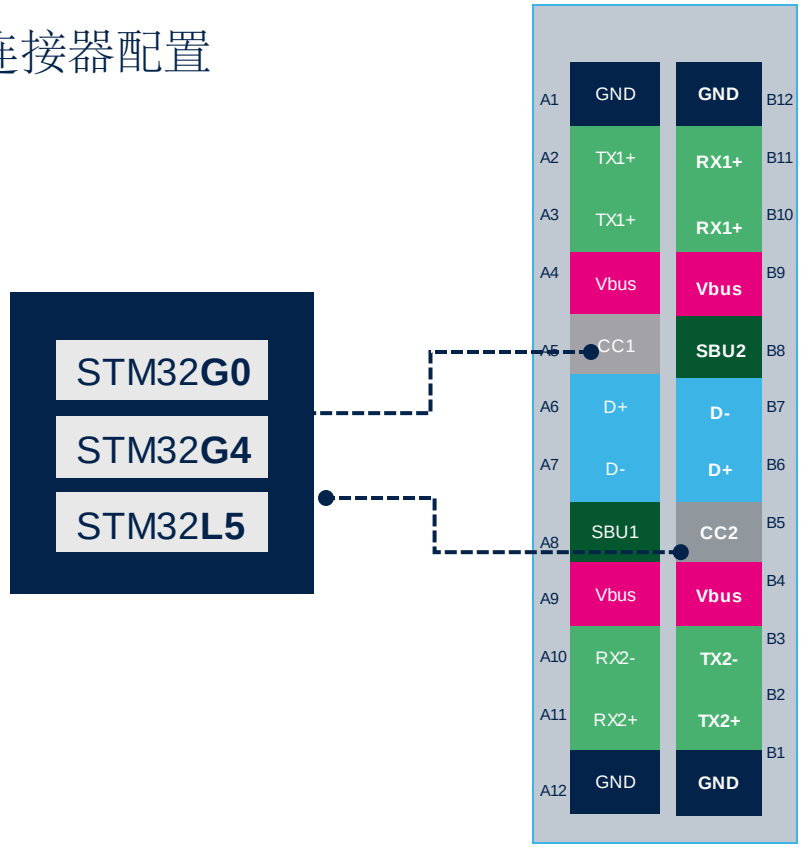
Direct connection to USB Type-C

这个新的UCPD接口管理Type-C连接器配置和通信通道
（CC行）用于：

1. Type-C™ Control
2. USB PD communication



24-pin
USB-C™ receptacle

UCPD built-in features

C型控制

- \+ Built-in Rp/Rd resistors
- \+ CC logic control (CC PHY)
- \+ CC lines voltage monitoring
- \+ Dead battery resistors
- \+ Fast Role Swap signaling

Enabling

15W max
(5V/3A)

- ✓ Attach/detach and role management (SNK, SRC, and DRP)
- ✓ Resolve cable orientation and twist connections to establish USB 2.0 /USB 3.x data bus routing
- ✓ Discover and configure VBUS or VCONN

USB PD通讯

- \+ PD transceiver PHY
- \+ Digital BMC
- \+ CRC encoding/decoding

Enabling

100W max
+
Alternate Mode

- ✓ Power contract negotiation (up to 100 W)
- ✓ Power or USB data Role swap
- ✓ Alternate mode through Vendor Define Messages
- ✓ PPS, Firmware upgrade, and Authentication messages

UCPD is compliant with USB PD r3.0 specification

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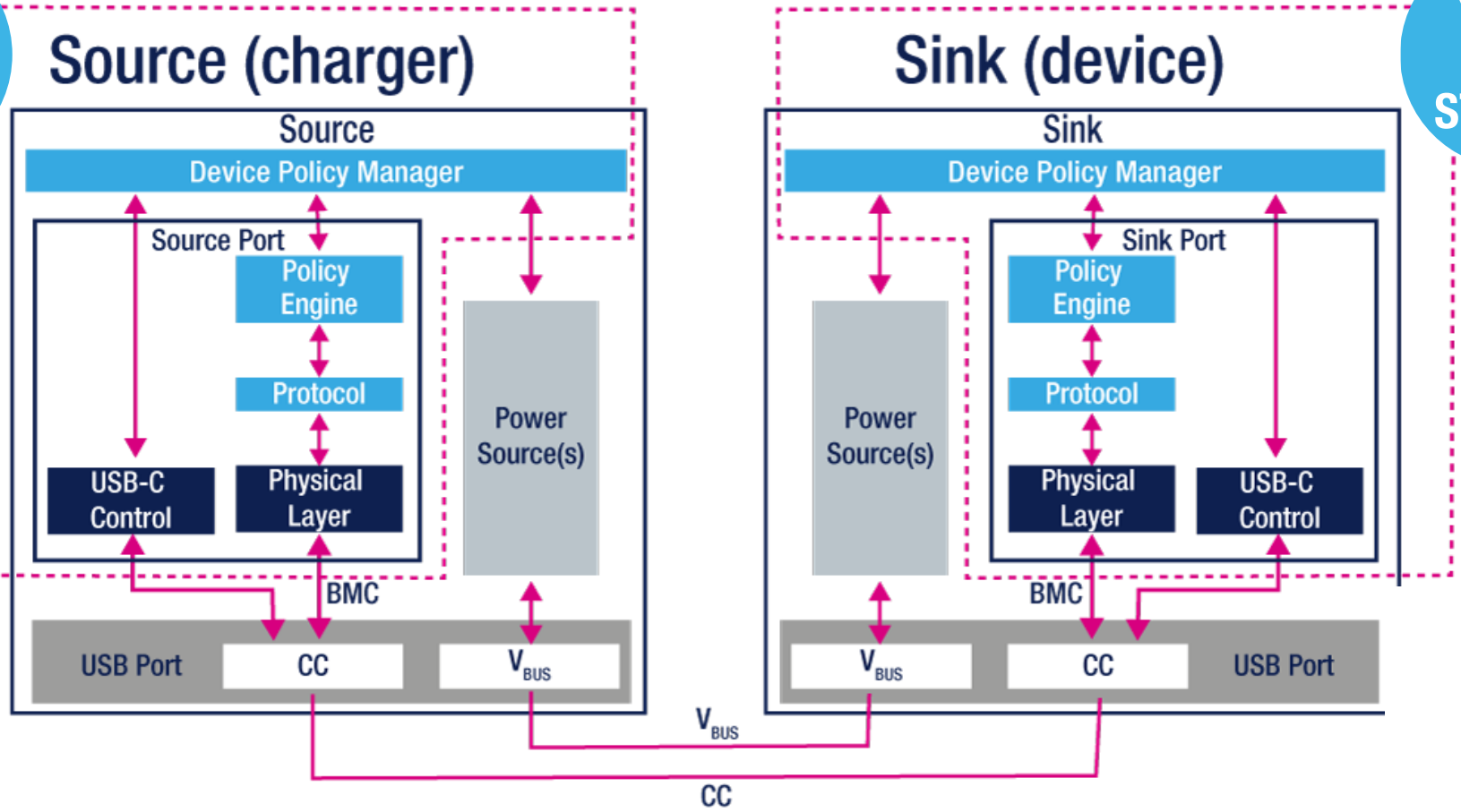
Optimized SW/HW architecture

STM32**L5**

STM32**G0**

STM32**G4**

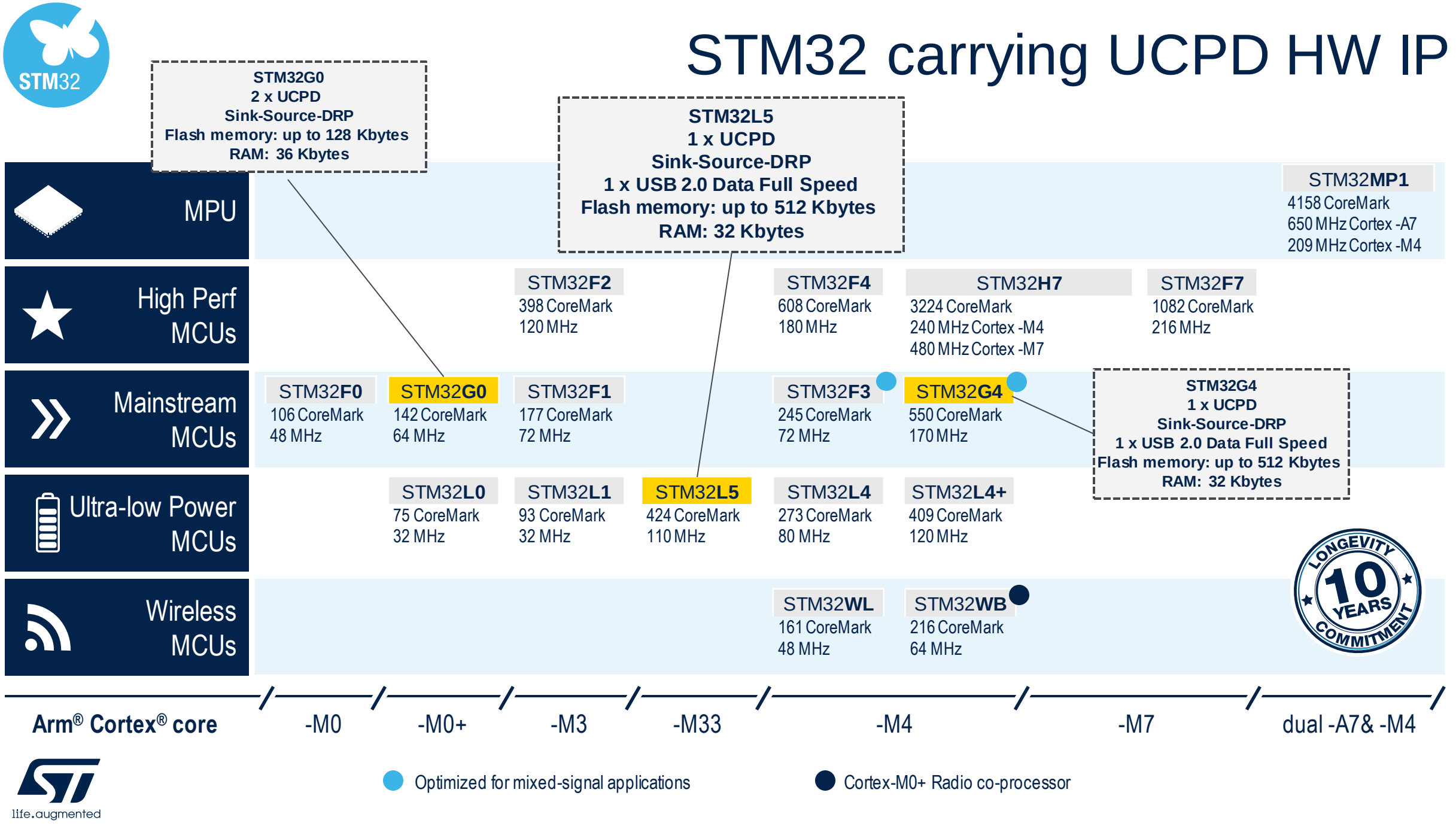


STM32**L5**

STM32**G0**

STM32**G4**

STM32 carrying UCPD HW IP



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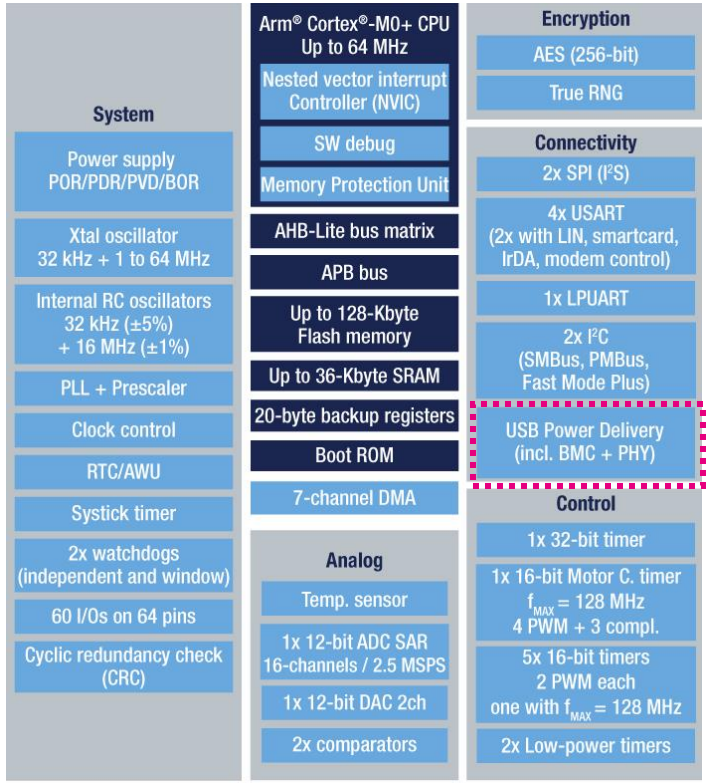
More on: www.st.com/STM32G0

STM32G0 MCUs
Efficient, robust, simple

New series of STM32 MCUs kick-starts advanced innovations for smaller, more capable, and power-efficient smart objects



STM32G081 block diagram

- Cortex®-M0+ STM32 platform
- Up to 2 built-in UCPD interfaces
- 128 Kbytes of Flash – 36 Kbytes of SRAM
- Versatile analog and digital peripherals
- Security features
- 28, 32, 48, and 64-pin packages available

(*): USB-IF TID 227

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More on: www.st.com/STM32G4

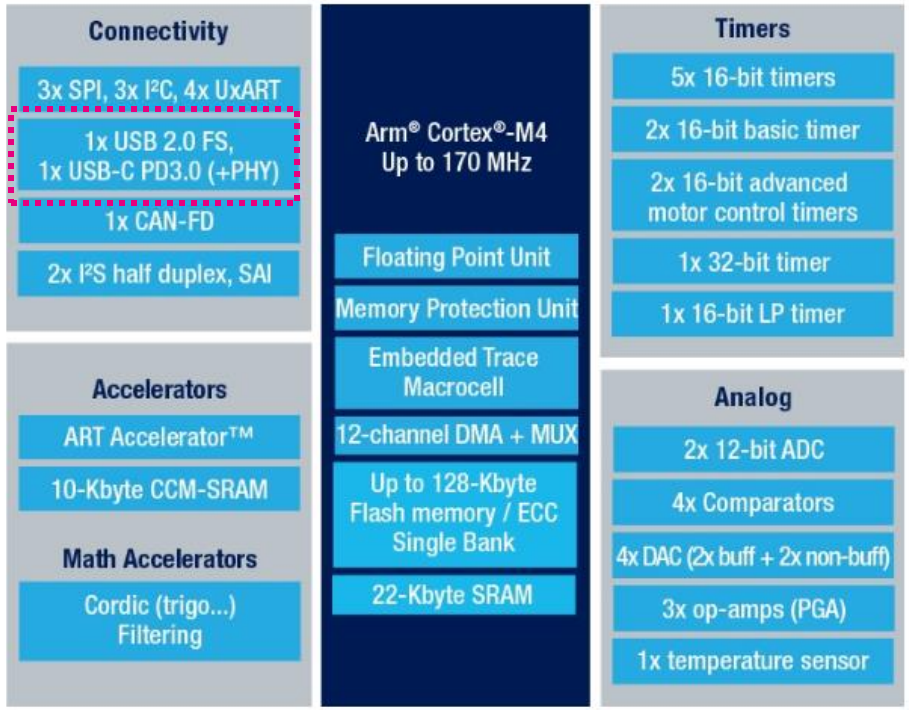
STM32G4 MCUs Mixed-signal

Ideal for applications requiring MCU with advanced and rich analog peripherals

- Cortex®-M4 STM32 platform
- Up to 512 Kbytes of Flash memory
- 32 Kbytes of SRAM
- 1 UCPD interface
- 1 USB2.0 FS data Interface
- Advanced and rich analog peripherals
- 28, 32, 48, and 64-pin packages available

USB-C

STM32**G0**



STM32G431 block diagram

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More on: www.st.com/STM32L5

STM32L5 MCUs
ULP excellence with more security

First STM32 MCU based on Arm® Cortex®-M33 and TrustZone®

- A full set of security features
- Extended battery lifetime
- High integration & innovation
- 1 UCPD interface
- 1 USB2.0 FS Interface

- ART Accelerator™
- USART, SPI, I²C
- Octo-SPI
- 16 and 32-bit timers
- SAI + audio PLL
- SHA, TRNG
- 2x 12-bit DAC
- Temperature sensor
- Low voltage 1.71V to 3.6V
- Vbat Mode
- Unique ID
- Capacitive Touch sensing

Product line	FLASH (KB)	RAM (KB)	Memory I/F	2 x Op-Amp	2 x Comp	4ch / 2x Sigma Delta Interface	12- bit ADC 5 Msps 16 bit HW oversampling	USB2.0 Device XTAL-less USB Type-C and Power Delivery	CAN-FD	AES, PKA, OTFDEC 128/256-bit
STM32L552 USB Device & CAN-FD	512 to 256	256	SDIO FSMC Octo SPI	•	•	•	2	•	•	
STM32L562 USB Device & CAN-FD & AES	512	256	SDIO FSMC Octo SPI	•	•	•	2	•	•	•

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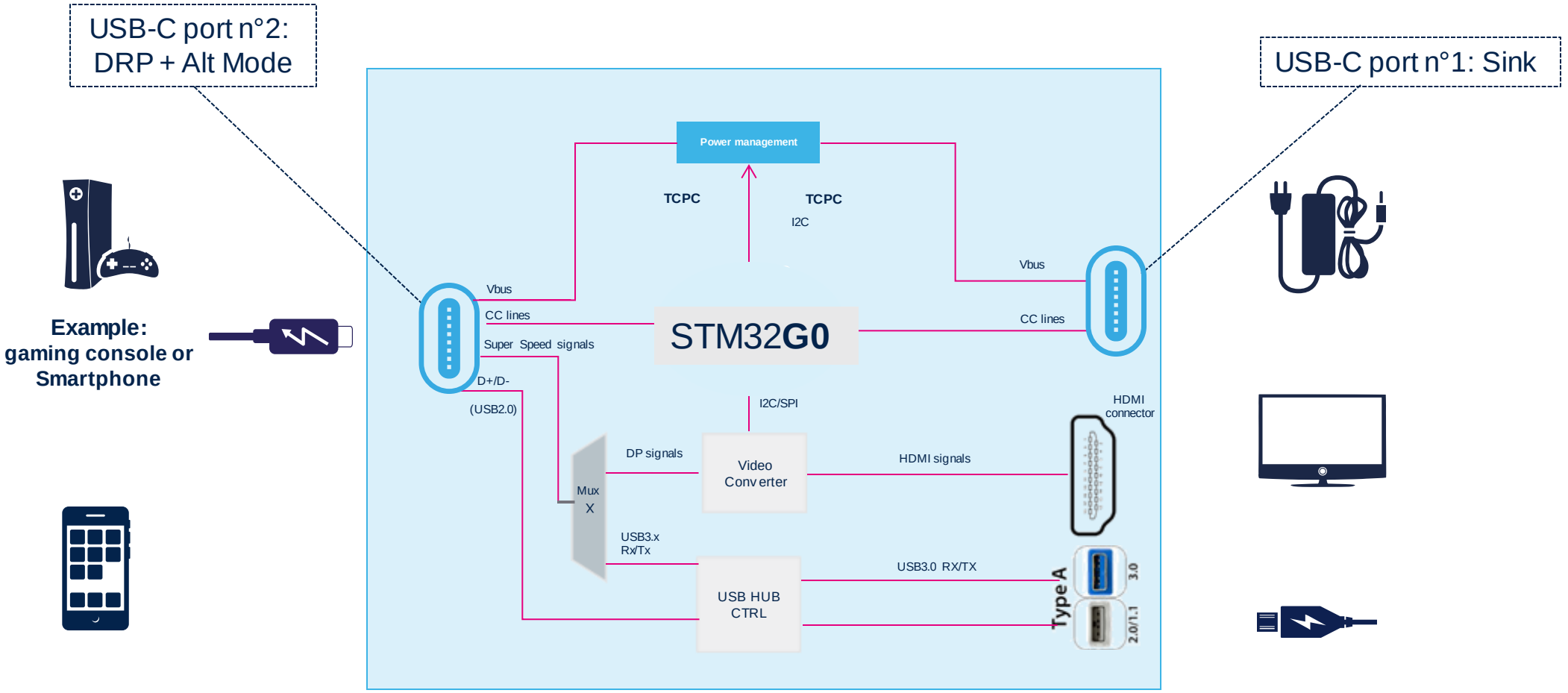
Typical block diagram
Example: multi-port docking station



- Port 1 negotiates power contracts with external USB-C power adapter.
- Port 2 supplies plugged accessory and handle HDMI signals request when TV detected, or USB devices inserted into legacy USB connectors.

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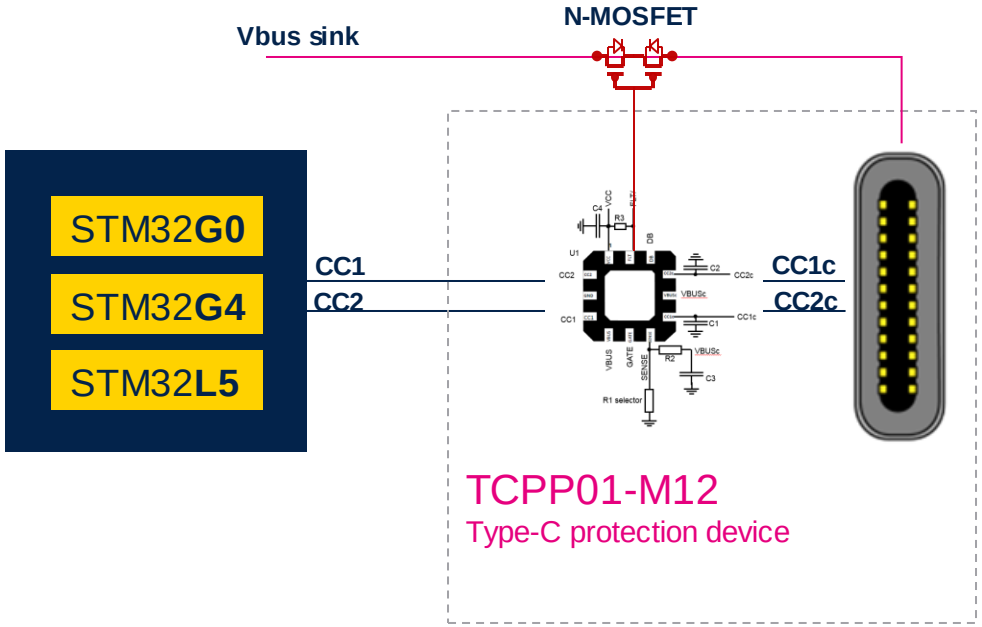
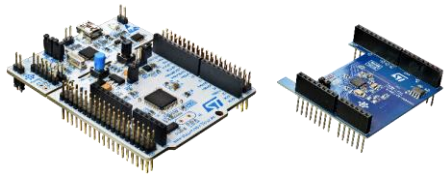
Type-c port protection IC TCPP01-M12

Protects USB Type-C applications against ESD and overvoltage on V_{BUS} and CC lines



STM32 Nucleo

X-NUCLEO-USBPDM1 shield
(availability Q4'2020)



- ±8kV ESD protection on V_{BUS} and CC lines
- Overvoltage protection on V_{BUS} line
- 24V OVP against CC lines short-to-V_{BUS}
- Integrated V_{BUS} gate driver of external NMOS
- Integrated Dead Battery resistors
- Zero power consumption when no cable attached
- 12-pin QFN package (3 x 3 mm, pitch 0.5 mm)

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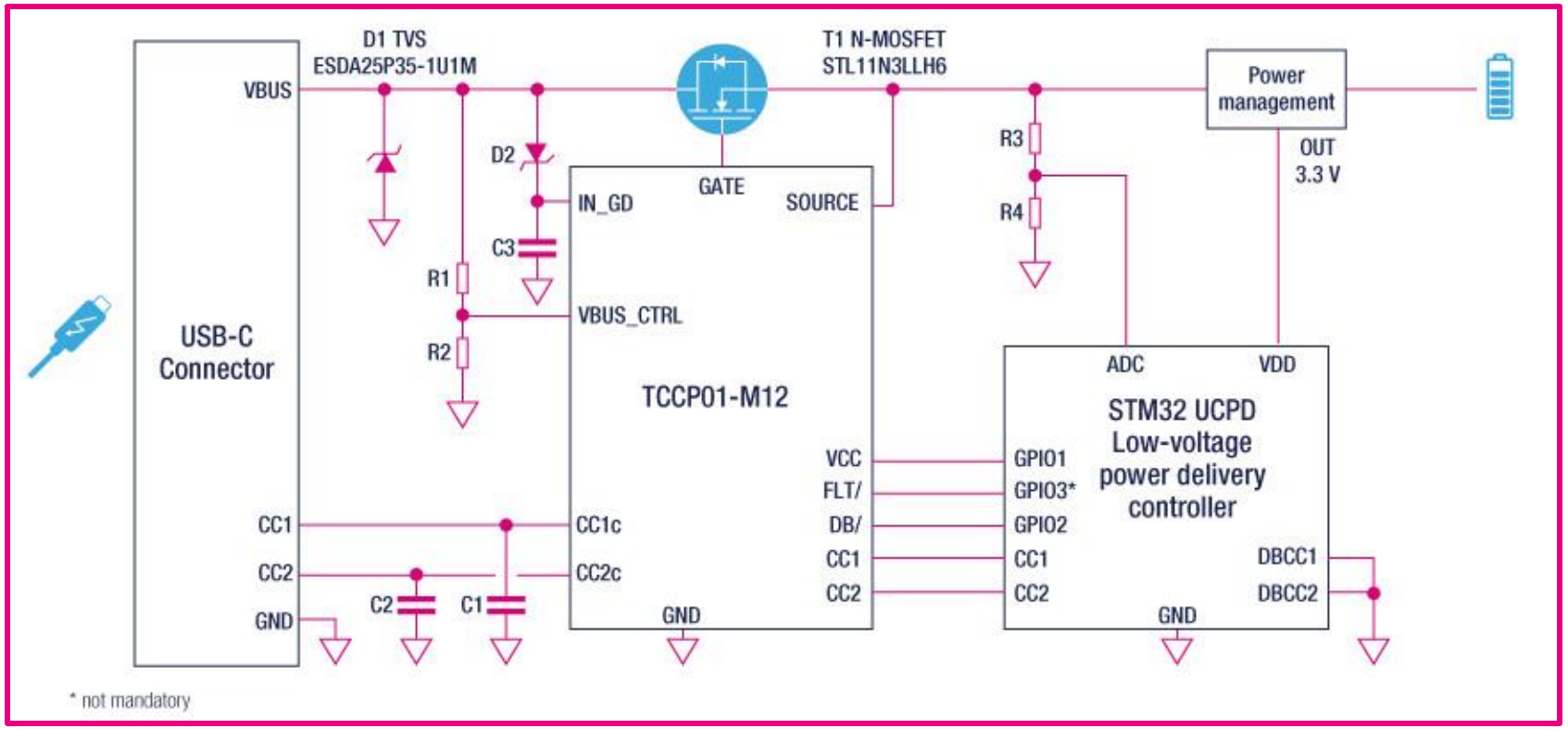
典型的应用示例



STM32

STM32**G0**

STM32**G4**

STM32**L5**

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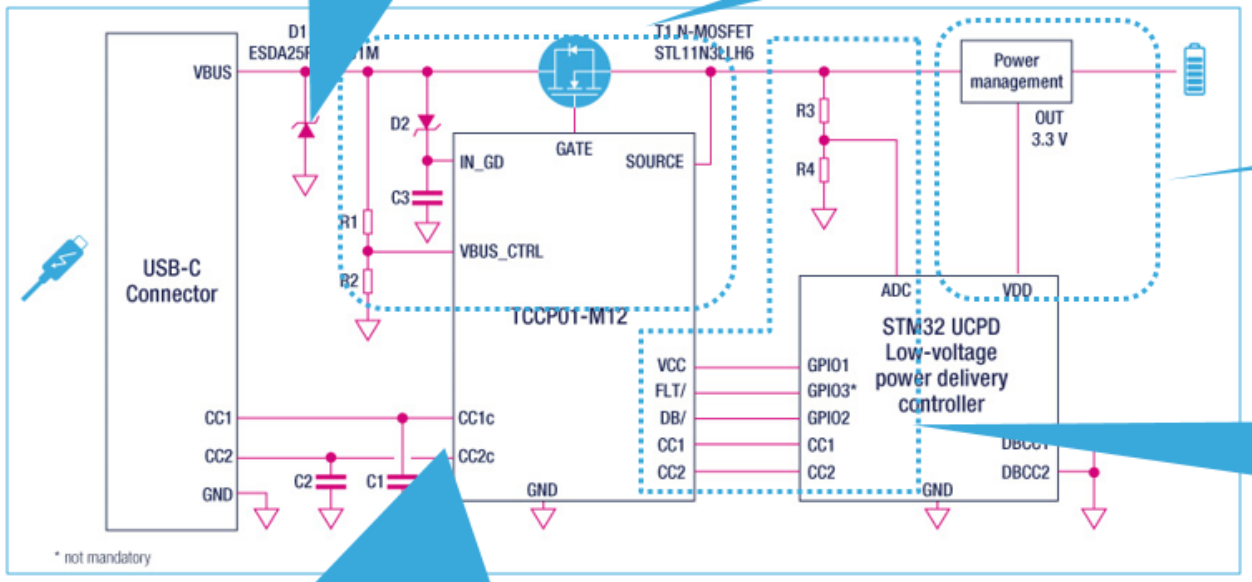
Typical sink application example

3. SOURCE applies 5V on Vbus
10. SOURCE applies 20V on Vbus

4. TCPP01-M12 check the voltage
5. TCPP01-M12 turn-on N-MOS



6. Power management system turn-on
7. STM32 wake-up

8. STM32 UCPD start :
Attached detection
TCPP01-M12 powered
TCP001-M12 dead battery clamps removal
9. USB PD 20V contact negotiation
11. STM32 UCPD voltage acknowledge

1. TCPP01-M12 presents dead battery clamps on CC lines
2. When SOURCE is plugged voltage change appears on one CC line

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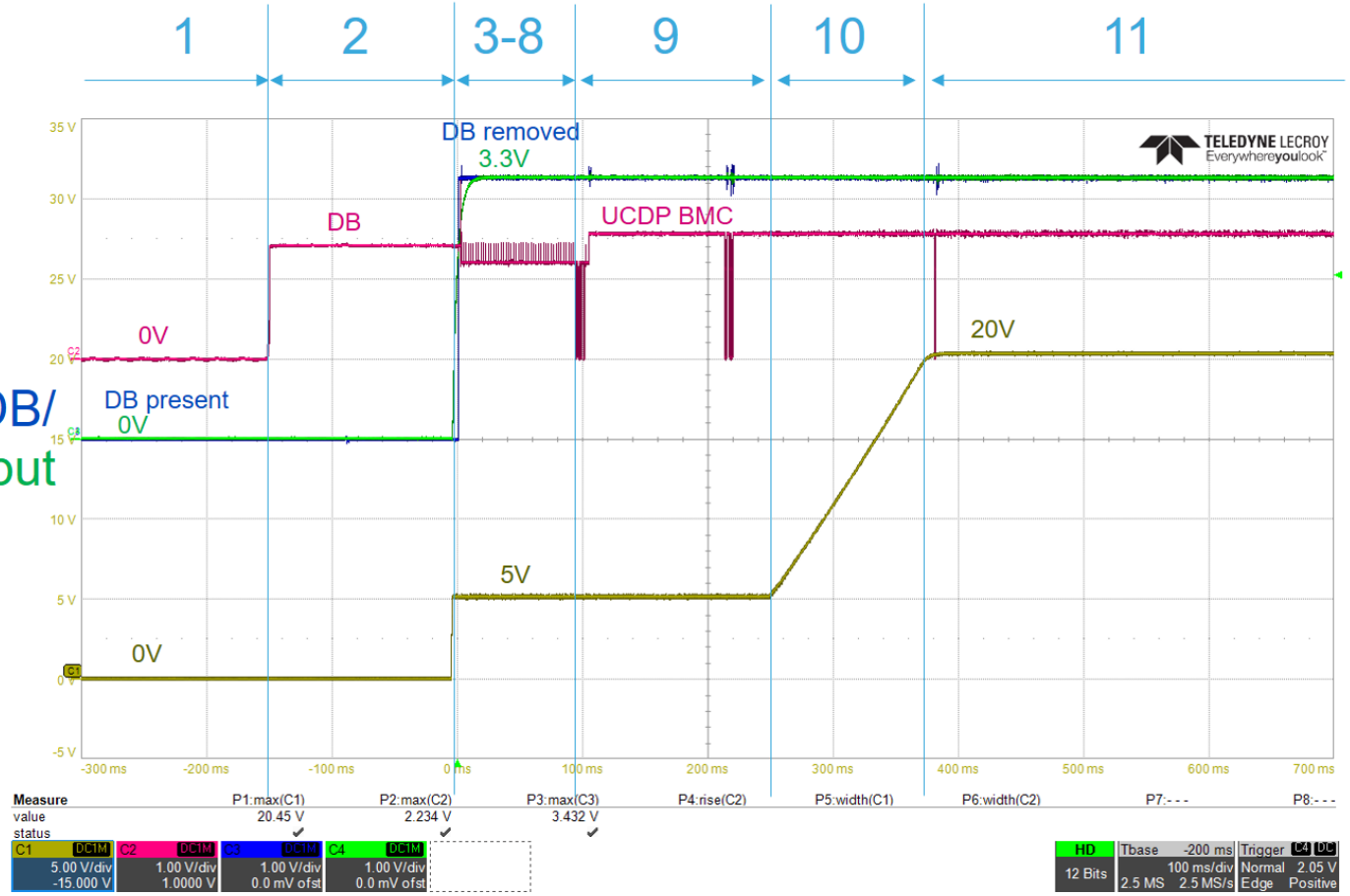
Typical sink application example

CC

TPCPP01-M12 DB/
LDO output

Vbus



20V negotiation example screenshot

Complete USB-C ecosystem for short time-to-market

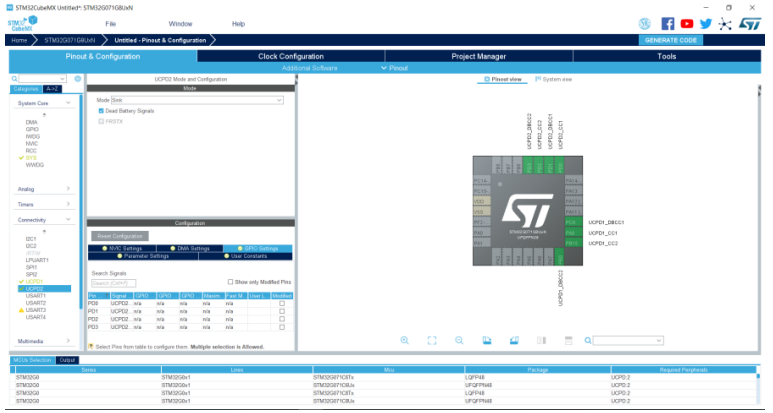
STM32G071B-DISCO
- USB-C analyzer (Sink)

STM32**G0**

STM32G081B-EVAL
- 1 Port DRP (45W)
- 1 port Sink (AM)

STM32CubeMonitor

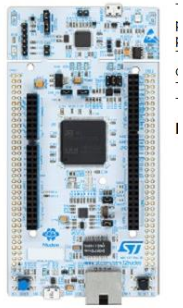
UCPD configuration



B-G474E-DPOW1
- 1 port Sink + USB data

STM32**G4**

STM32G474E-EVAL
- 1 Port DRP (15W) + USB data



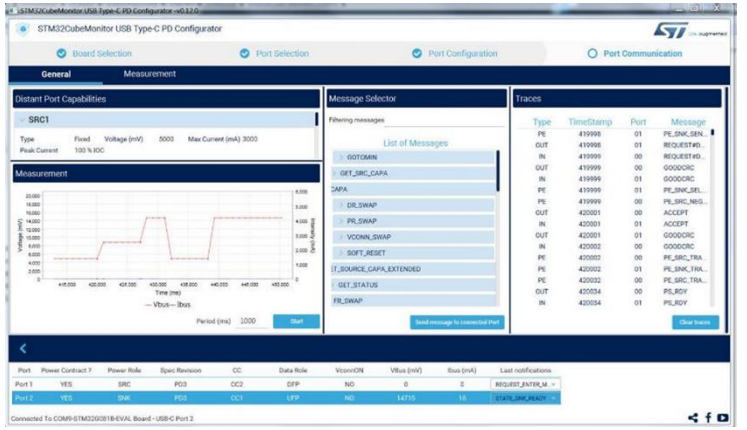
NUCLEO-L552ZE-Q
- 1 Port Sink + USB data

STM32**L5**

STM32L552E-EVAL
- 1 Port Sink + USB data

STM32CubeMonitor-UCPD

Debug tool



USB-C sniffer

STM32G071B-DISCO

- Discover and display USB-C™ power and feature capabilities of any host.
- Analyze and sniff USB PD data packets and display V_{BUS} voltage and I_{BUS} current values
- Debug, configure and inject USB PD3.0 packets using STM32CubeMonitor UCPD.

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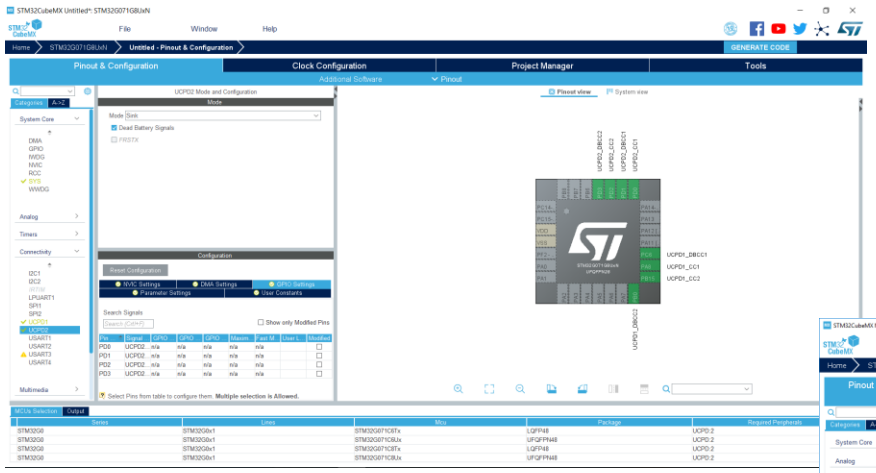
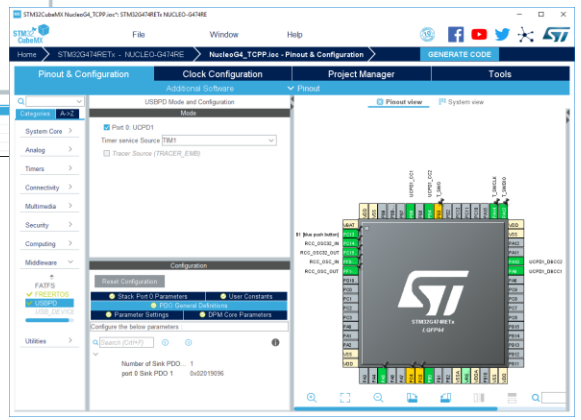
Easy configuration

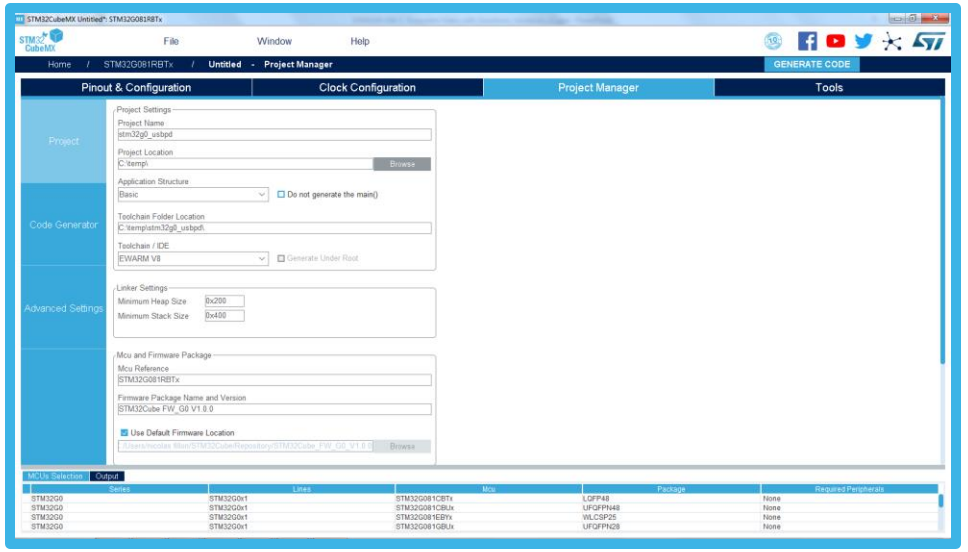


Device selection
and peripherals configuration
(port 1 or 2 and role of each port: SNK, SRC, DRP)



USB-PD middleware
parameters settings

STM32CubeMX



Code generation

[Visit STM32Cube Ecosystem webpage]

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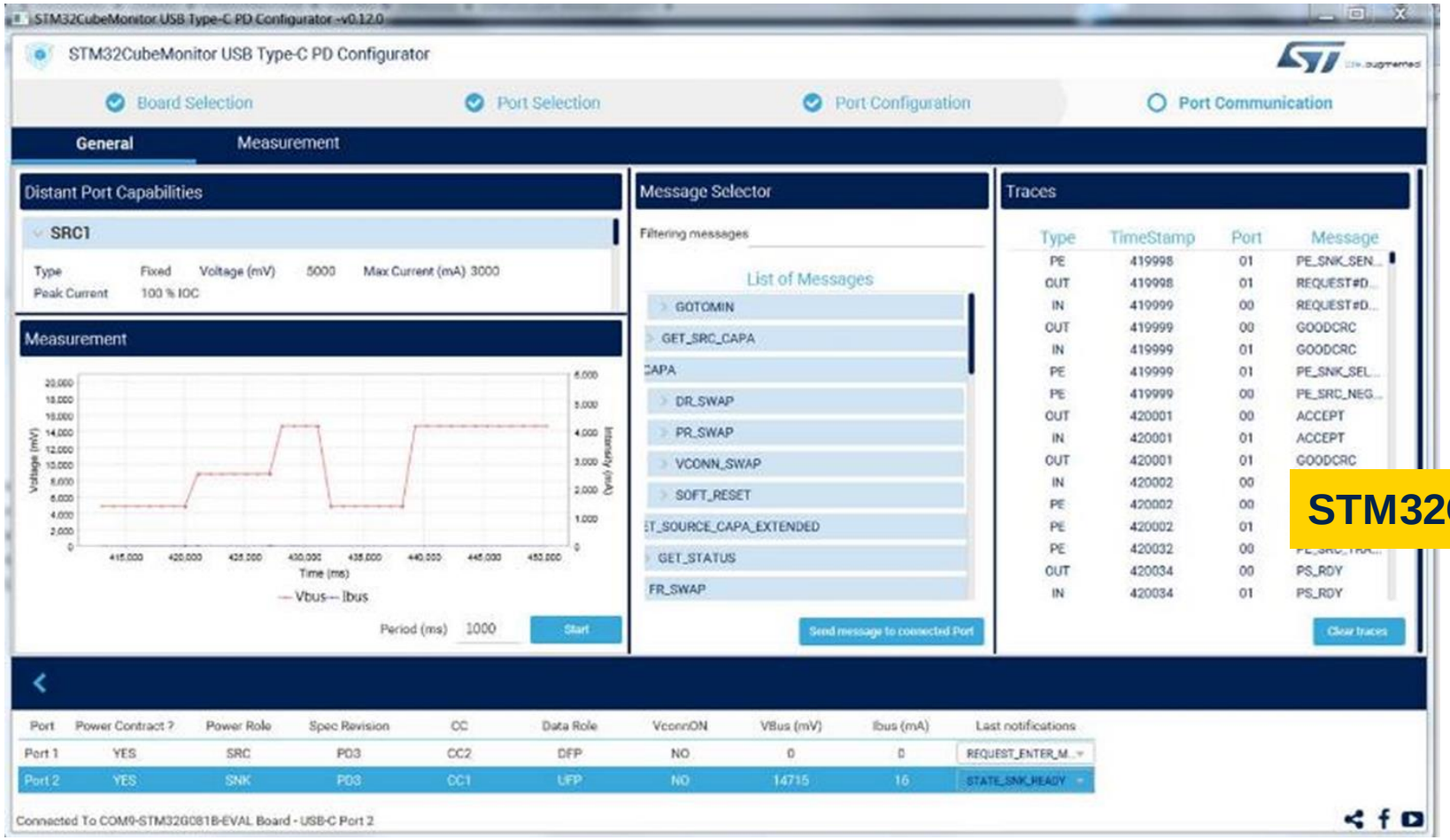
Easy debug with stm32cubemonucpd

PC Software GUI to display and configure parameters of USB PD Middleware

FREE TOOL!

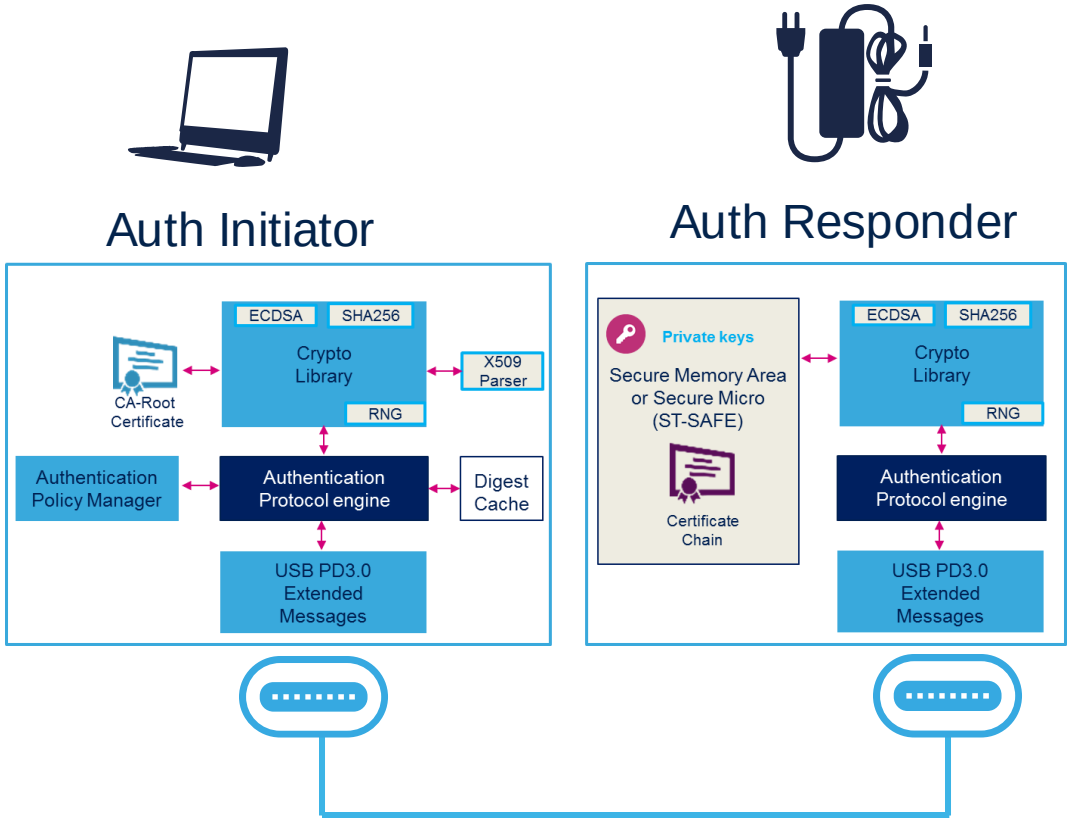


STM32CubeMonitor-UCPD

https://www.st.com/STM32CubeMonUCPD

USB-C authentication ready

Verify that the device is genuine & embeds the expected profile



- Security messages carry via USB PD3.0
- Compliant solution with timing constraints

- Flexible authentication library.
- Initiator and Responder mode supported

- Secret keys storage in securable memory area or external secure-micro (ST-SAFE)

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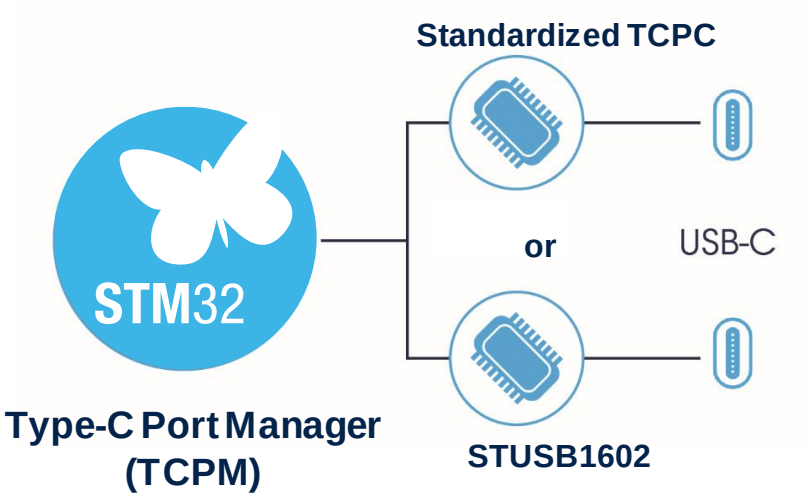
Certified software pack eases migration to USB-PD 3.0 Power Delivery

X-CUBE-USB-PD software pack

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 (TCPCi)
- 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, and Dual Role Power)
- Optional features such as Programming Power Supply (PPS), Authentication messages and Fast Role Swap (FRS) are supported

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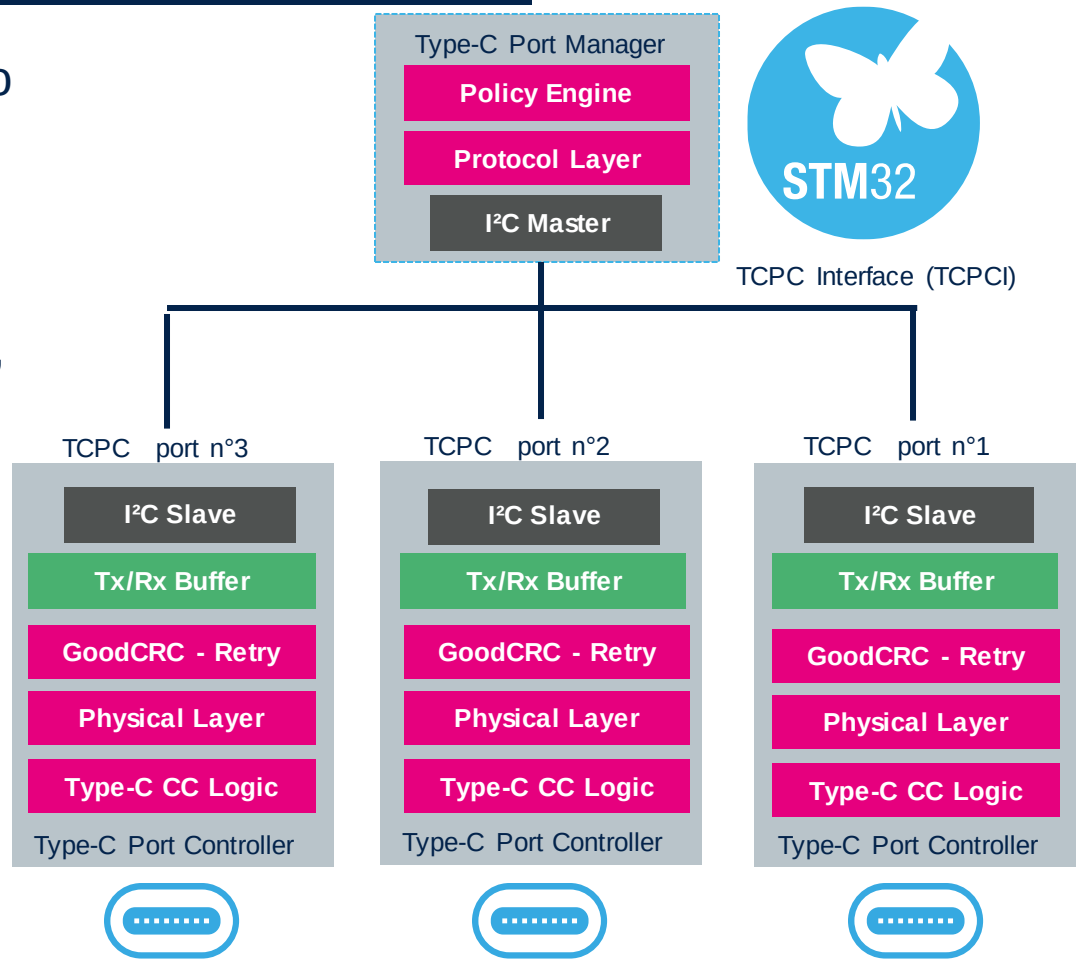
Benefits of TCPM / TCPC split

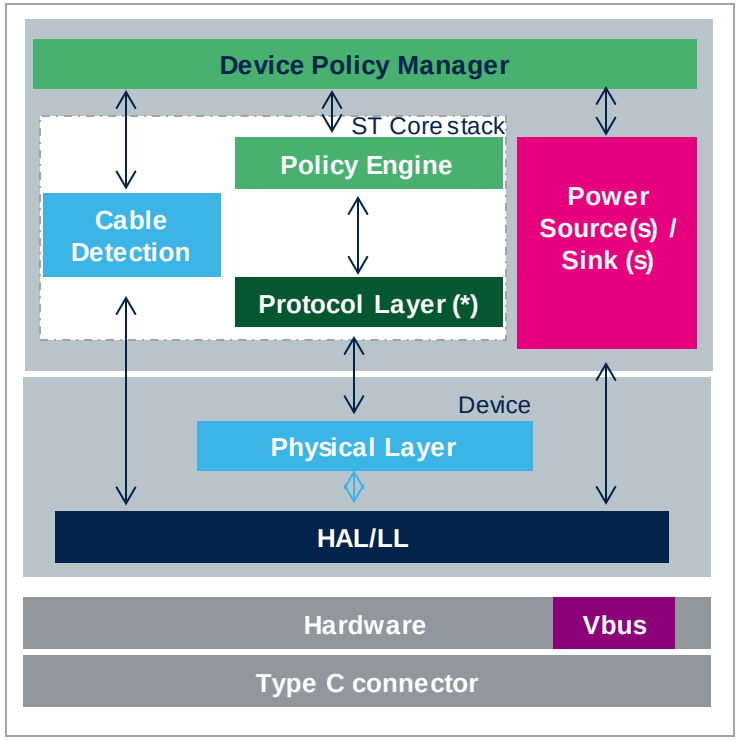
Optimized HW/SW partitioning for single- or multi-port

- The STM32 provides a high customization and flexibility to manage power policy, application layers, and to support evolution of the standard faster.
- 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 and STUSB1602
  - 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

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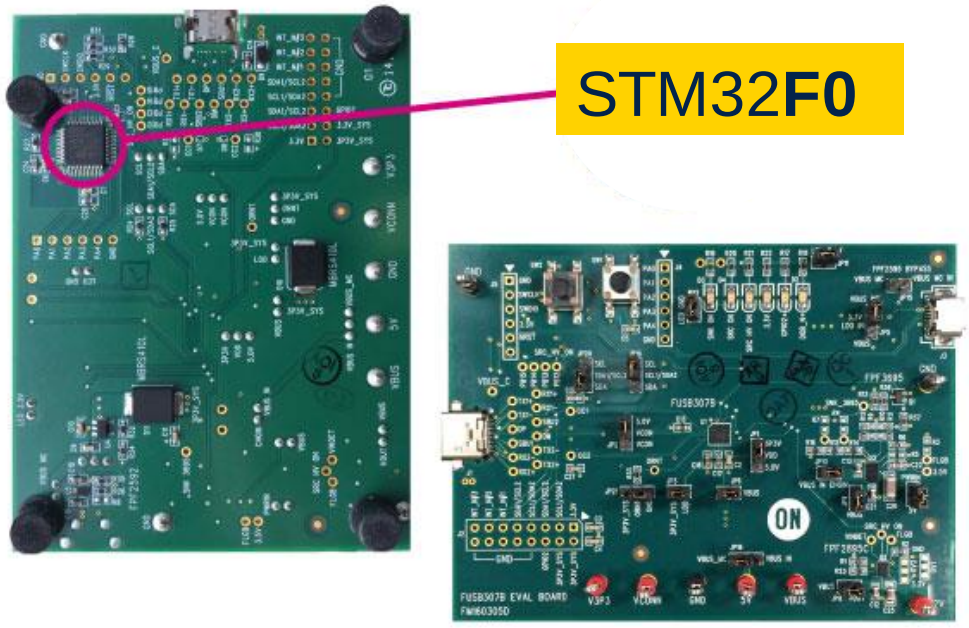
ON-FUSB3-STM32
STM32F072 type-c port manager evaluation board

TCPM/TCPC evaluation board



Main 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
- Link to order one kit (149$ range)

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Documentation

- Getting started video with USB type-C and STM32G0 ecosystem: [YouTube]
- STM32G0 Entry-level Arm® Cortex®-M0+ MCUs webpage: link
- STM32G0 Discovery kit for USB Type-C™ and Power Delivery (STM32G071B-DISCO) Databrief: [PDF]
- STM32CubeMonUCPD Monitoring and configuration software tool for STM32 USB-C and Power Delivery 3.0 applications webpage: link
- STM32G0 Online Training: link and a specific training on STM32G0 UCPD interface here
- Application note AN5225: USB Type-C™ Power Delivery using STM32xx Series MCUs and STM32xxx Series MPUs: [PDF]
- USB Power Delivery on STM32 expansion software for STM32Cube (X-CUBE-USB-PD) webpage: link
- Single-chip USB type-C port protection IC (TCPP01-M12) webpage: link

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