USB Type-C™ & Power Delivery firmware solution based on STM32F0

X-CUBE-USB-PD

life.augmented

STM32 F0

The Re-Evolution of USB

From a data interface to a primary provider of power with a data interface

USB Type-C™
One port to rule them all

Type-C

Power Delivery

Alternate Mode

USB IF
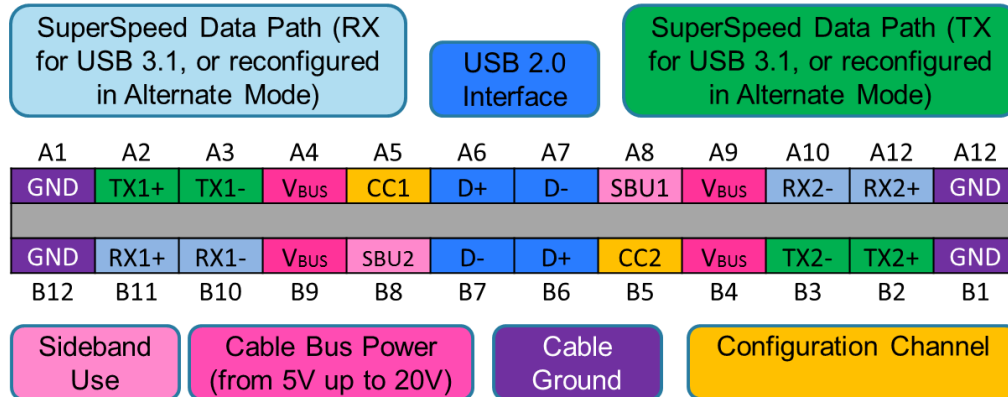
A smart and green technology

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

life.augmented

Type-C pinout functions

Receptacle

		SuperSpeed Data Path (RX for USB 3.1, or reconfigured in Alternate Mode)			USB 2.0 Interface		SuperSpeed Data Path (TX for USB 3.1, or reconfigured in Alternate Mode)				
A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A12	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

- Sideband Use
- Cable Bus Power (from 5V up to 20V)
- Cable Ground
- Configuration Channel
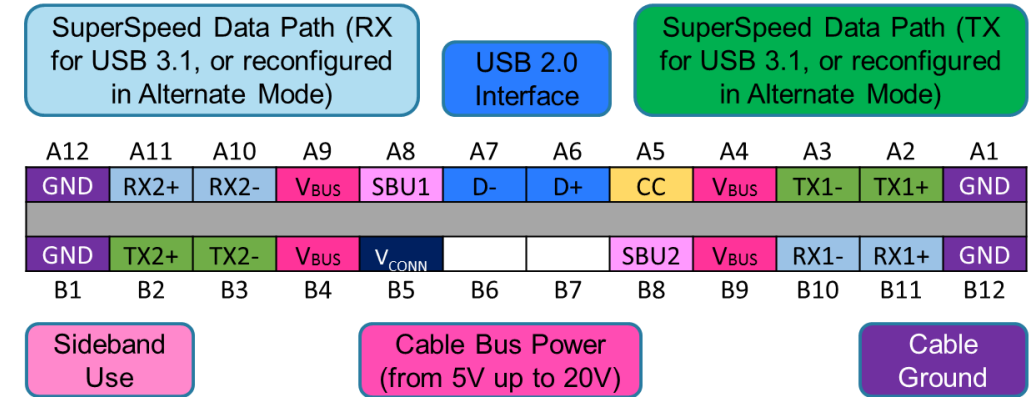
Two pins on the USB Type-C receptacle, CC1 and CC2 are used in the discovery, configuration and management of connections across USB type-C cable.

Plug

		SuperSpeed Data Path (RX for USB 3.1, or reconfigured in Alternate Mode)			USB 2.0 Interface		SuperSpeed Data Path (TX for USB 3.1, or reconfigured in Alternate Mode)				
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

- Sideband Use
- Cable Bus Power (from 5V up to 20V)
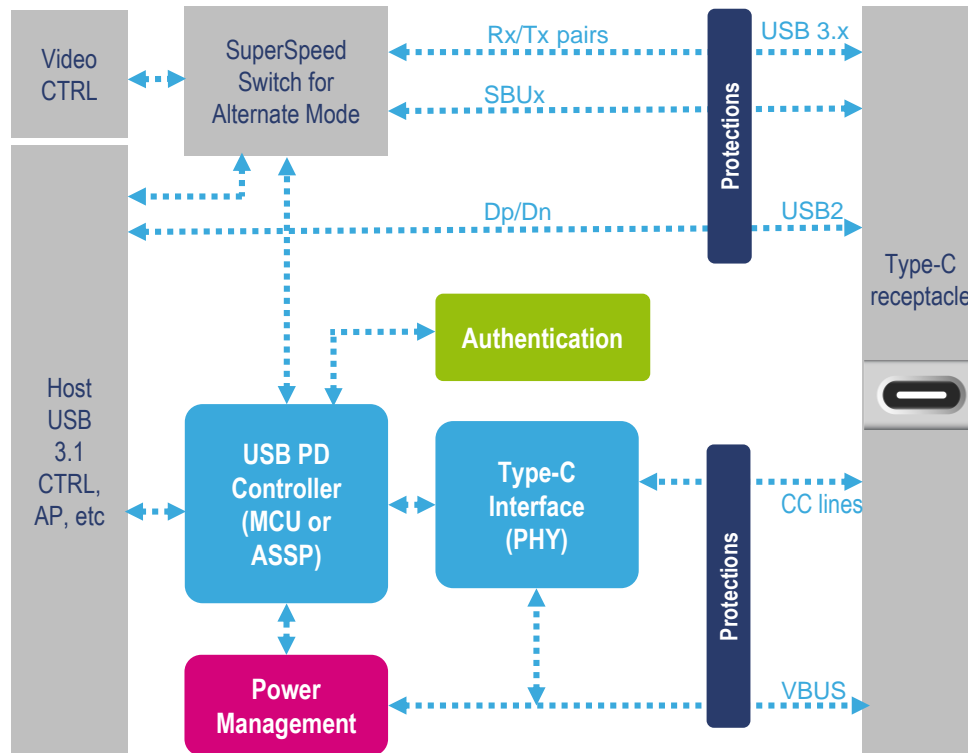- Cable Ground

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

life.augmented

ST chipset & system architecture

A complete offer to "lean in" USB Type-C PD ecosystem

Video CTRL

SuperSpeed Switch for Alternate Mode

Rx/Tx pairs — USB 3.x

SBUx

Protections

Dp/Dn — USB2

Type-C receptacle

Authentication

Host USB 3.1 CTRL, AP, etc

USB PD Controller (MCU or ASSP)

Type-C Interface (PHY)

CC lines

Protections

Power Management

VBUS

Scalable offer for USB-PD controller and Type-C interface: from STM32 general-purpose MCU to hard-coded solution

STM32 F0

Large product portfolio for protection and filtering covering all application needs

Historical best-in-class technologies for high-performance power conversion solutions

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

life.augmented

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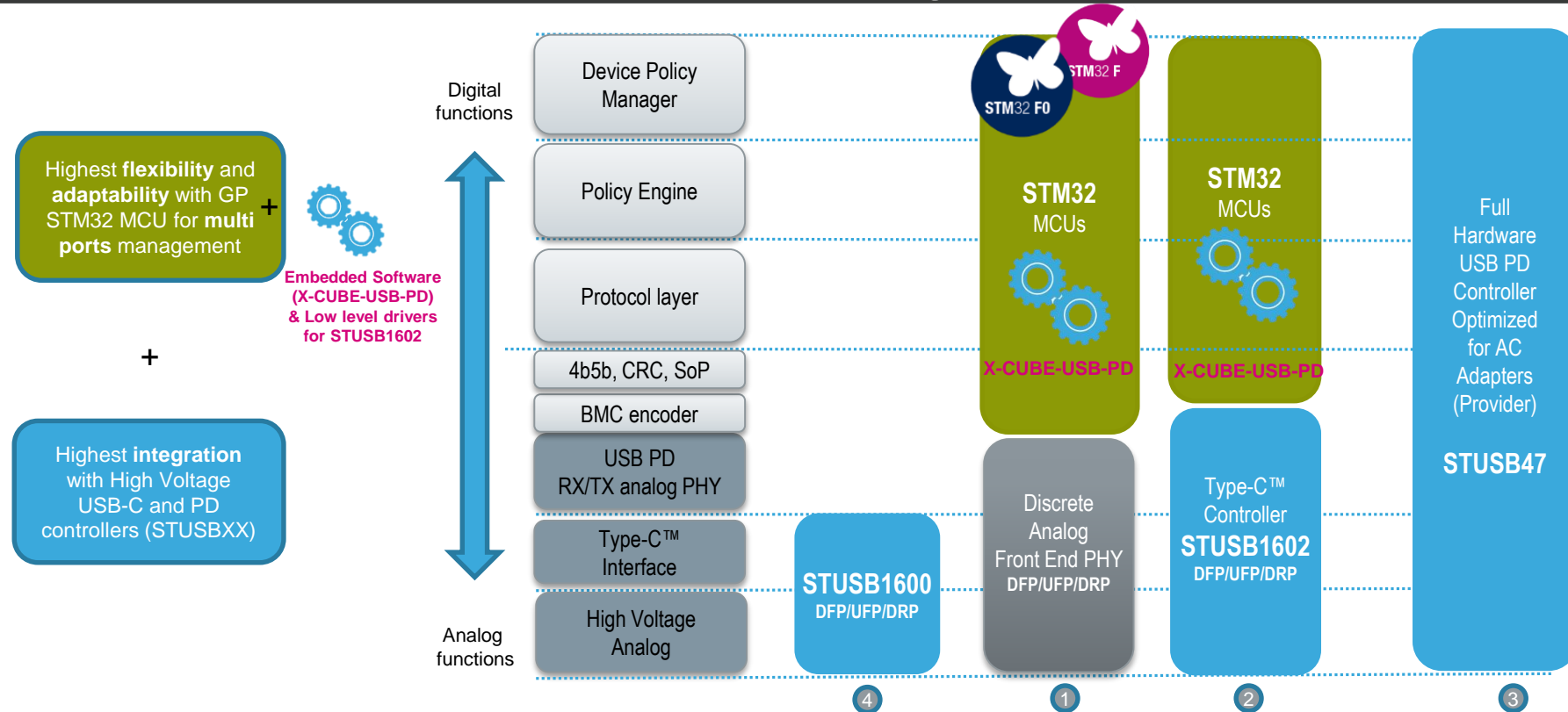
1. Market proven Certified FW solution on STM32F0 with discrete Analog Front End to control two DRP Type-C
2. More integration with STUSB1602 Type-C PD Controller including PD PHY and BMC line driver
3. Full HW solution with STUSB47 PD controller optimized for AC adapters (1 Port Provider)
4. Standalone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

Using an STM32 MCU as USB PD controller

USB-C

MegaChips
**DisplayPort to HDMI
protocol converter**

HDMI

USB Type-C

USB Power Delivery

Alternate Mode
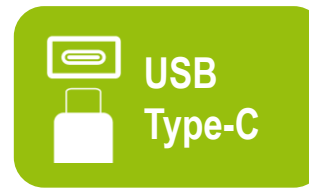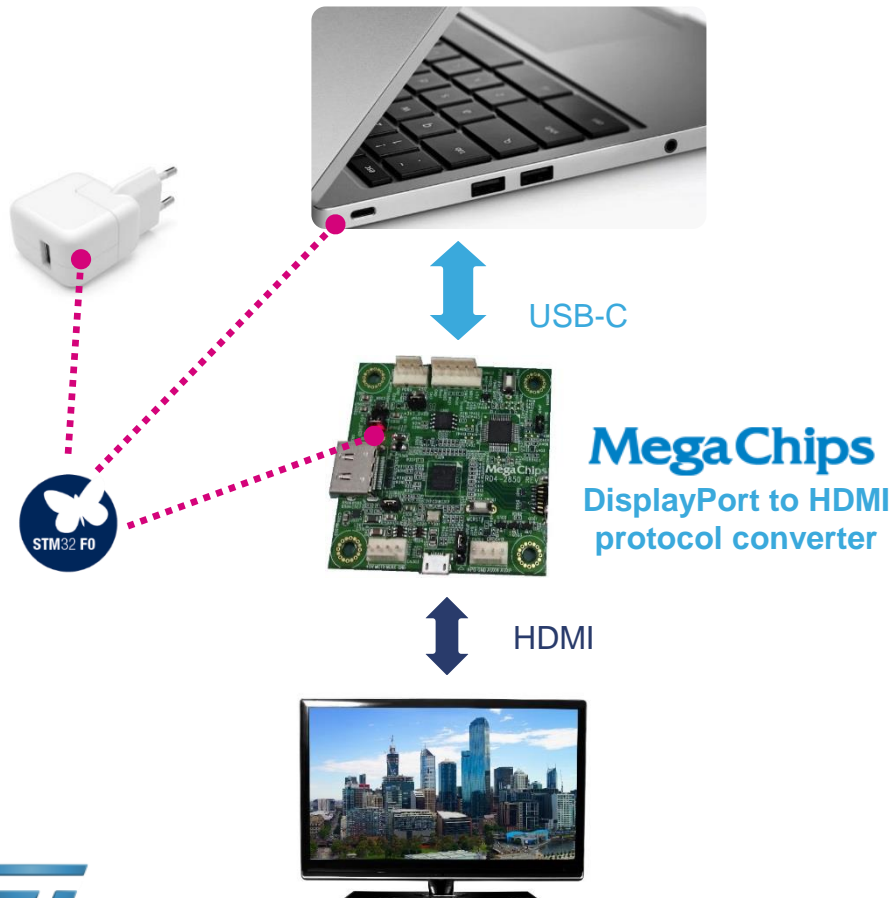
- Market-proven and flexible combo solutions using **STM32** MCU platform to design Provider, Consumer, Dual-Role devices or accessories.

- Reference designs with open-source firmware libraries for USB-C AC chargers, multi-functions protocol converters using Alternate Mode commands.

X-CUBE-USB-PD

Certified embedded software solution

Market-proven solutions using STM32 to design Provider, Consumer, Dual Role devices

STM32F0

↕ GPI/Os

Disc. AFE or STUSB16xx

CC1/CC2   CC1/CC2
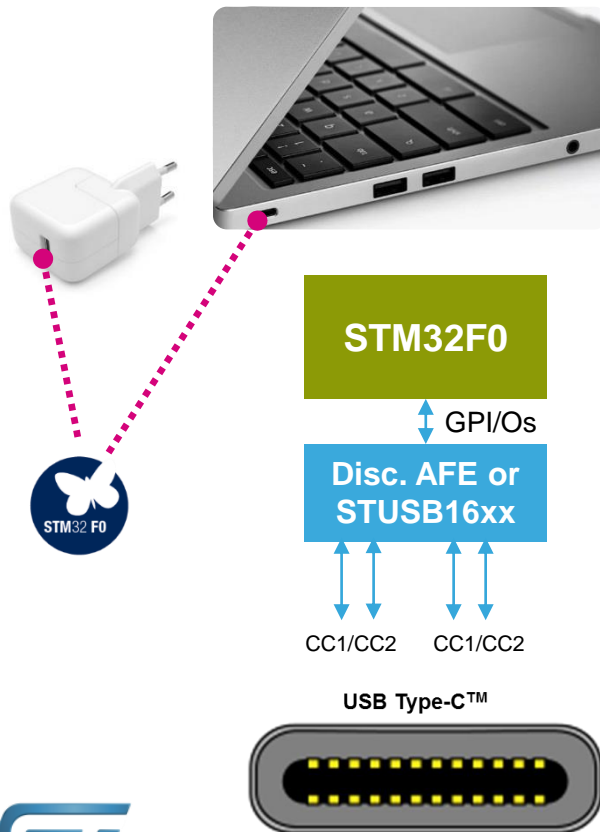
USB Type-C™

- Firmware implementation of USB Type-C™ 1.2 and USB PD 2.0 specifications – Certified by USB.org

- Based on entry-level STM32F0 Cortex-M0 MCU

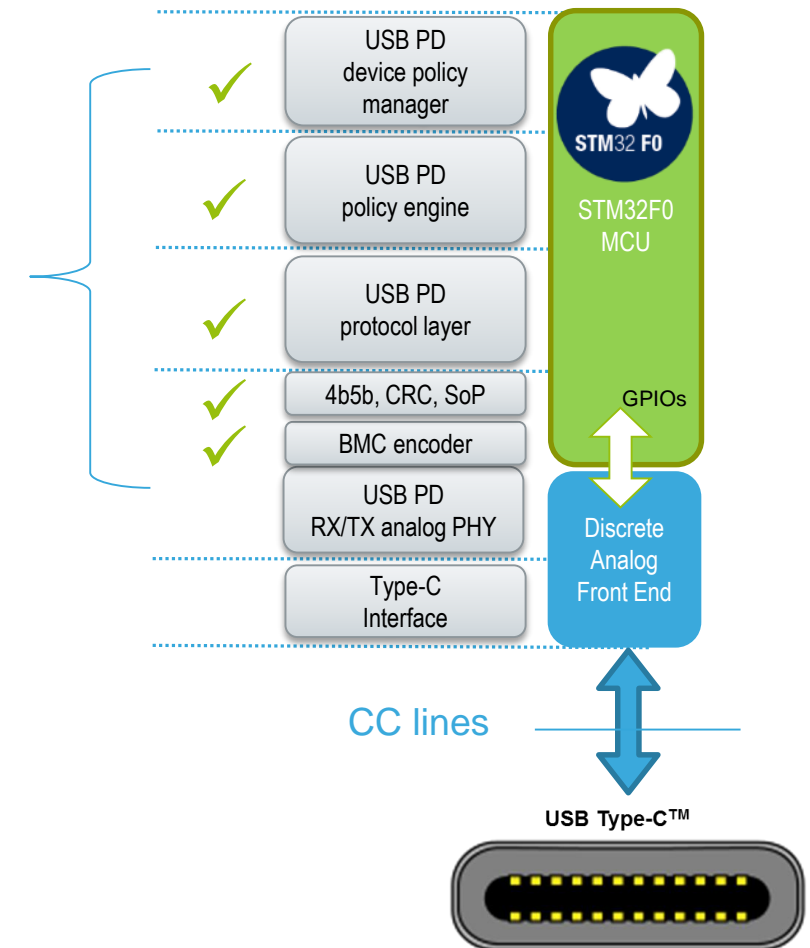| 1 port • Provider • Consumer • Dual Role	STM32F051 + Discrete Analog Front End
	SMT32F031 + STUSB1602
2 Ports • Provider • Consumer • Dual Role	STM32F072 (with USB 2.0 FS interface as peripheral in one port) + Discrete Analog Front End
	STM32xxxx + STUSB1602

- Discovery and development tool STM32 NUCLEO Pack available for $49.90 (P-NUCLEO-USB001)

What does embedded software do ?

- Configure and monitor the CC lines to establish provider and consumer roles between two port partners
  - Detect attach/detach sequences between port partners
  - Resolve plug orientation and twist connections for USB data bus routing
  - Establish power relationship between two ports
  - Detect port partner current capability
  - Drive V_{CONN} switch and SuperSpeed switches for flippable connector or AM

- Communicate with Port Partner using PD protocol
  - Establish power contract negotiation between two attached ports
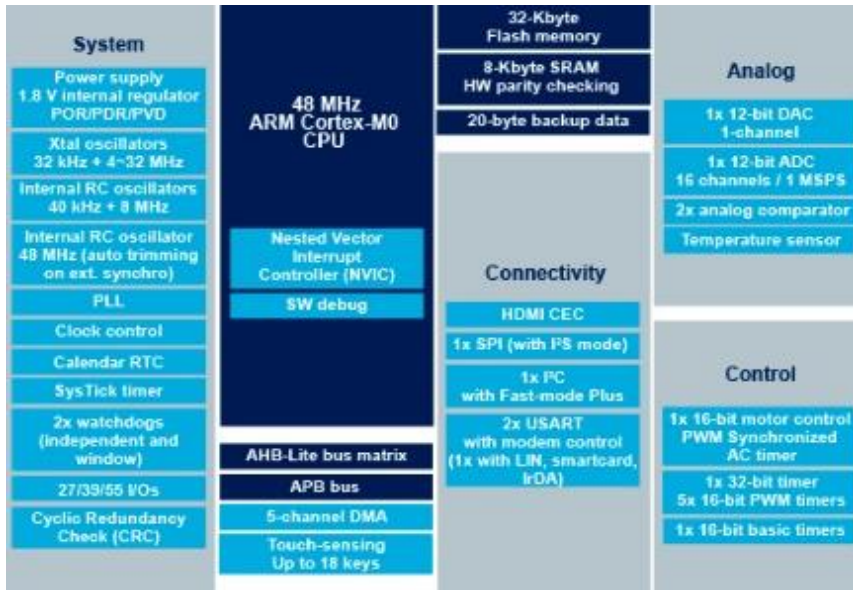 - Handle vendor-defined messages and Alternate Mode commands

X-CUBE-USB-PD main functions

✓	USB PD device policy manager
✓	USB PD policy engine
✓	USB PD protocol layer
✓	4b5b, CRC, SoP
✓	BMC encoder
	USB PD RX/TX analog PHY
	Type-C Interface

STM32 F0

STM32F0 MCU

GPIOs

Discrete Analog Front End

CC lines

USB Type-C™

- TX/RX BMC$^{(*)}$ transceiver uses: 1 embedded **comparator, timers, SPI, GPIO and DMA peripherals**

- Embedded **ADC** for device detection and power measurements

- **CRC** to evaluate message's checksum

- Standard GPIOs to control V_{CONN}, load switch, V_{BUS} discharge switch, V_{OUT} selection or to control other specific application tasks

(*) USB PD uses half-duplex, 300 Kbit/s, 4b5b + bi-phase mark coded signaling over CC wire
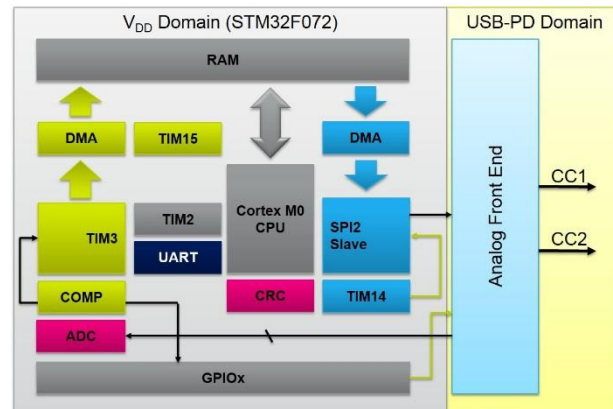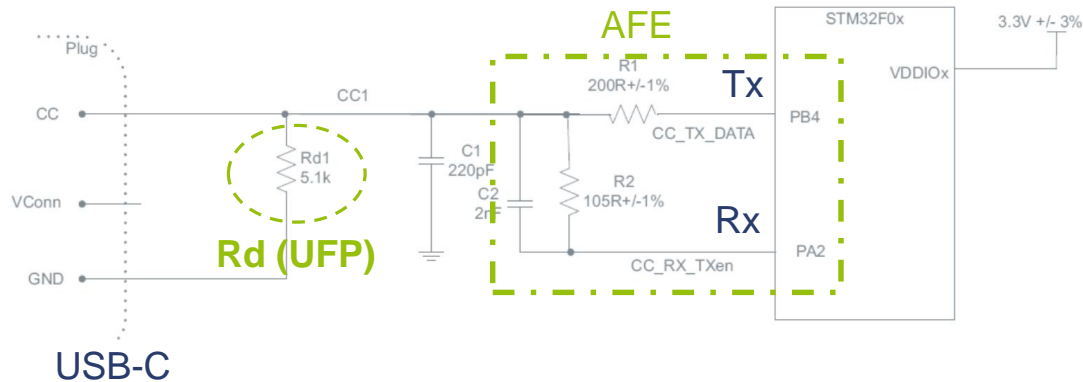
| Memory footprint budget (IAR)	1 port (Provider - DFP) (ex.: AC adapter)	1 DRP (Cons+Prov) (ex.: Notebook)
Flash size	~ 35 Kbytes	~ 38 Kbytes
RAM size	~ 9 Kbytes (with FreeRTOS) ~ 4.4 Kbytes (w/o FreeRTOS, available in July 16)	~ 9 Kbytes (with FreeRTOS)

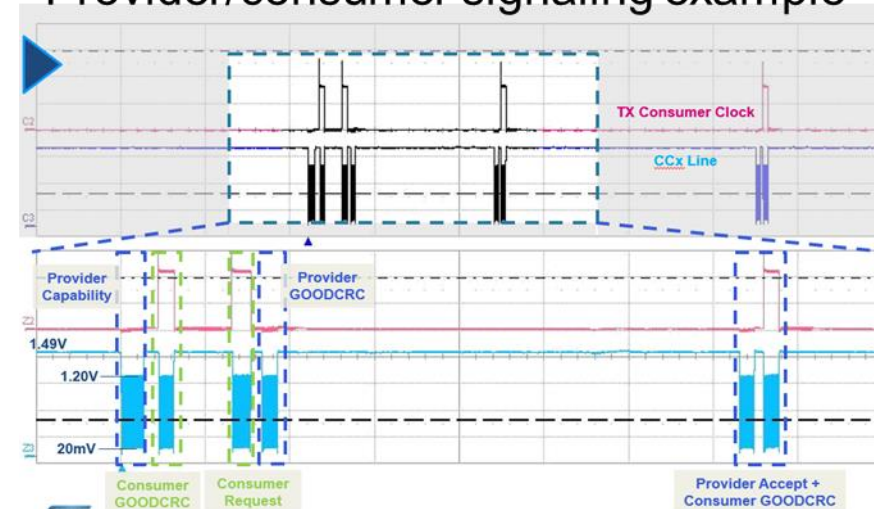## Ex.: 1 consumer port with captive cable using STM32F0

USB-C

- Simple implementation using only 2R +1C (per CC line)
- STM32F0 embedded comparator COMP1 on pin PA2 is used to monitor CC level while receiving BMC data. PB4 mapped as SPI MISO is used to transmit BMC data.
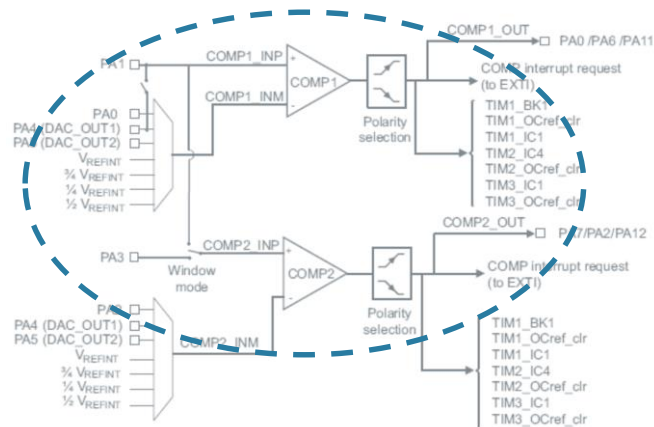
PA2/PA4 I/O structure

Provider/consumer signaling example
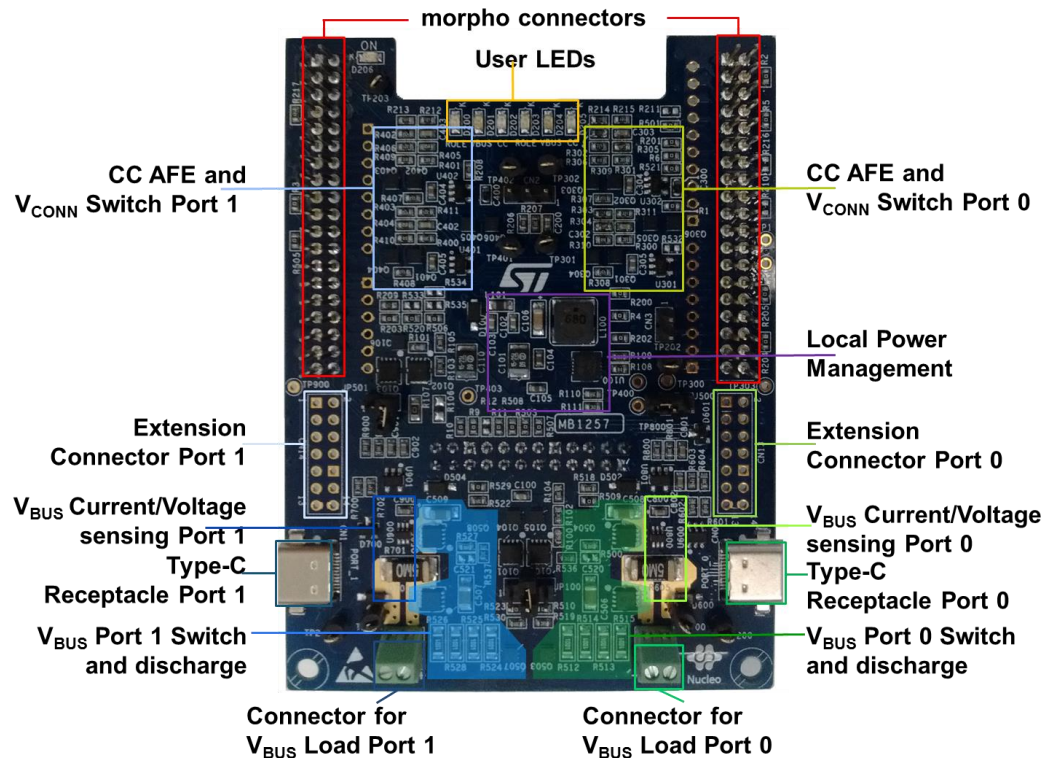
P-NUCLEO-USB001
STM32 Nucleo pack

- **Development kit** to learn and develop USB Type-C™ solutions

- Support two Dual-role ports (DRP)

- Based on Nucleo-F072 with USB-C PD expansion board

- Demonstration firmware example (provider / consumer)

- USB2.0 device peripheral capability on one port

- Ordering code: P-NUCLEO-USB001 @ $49.90 (RRP)

Note: full-featured USB Type-C cable (3A) included

STM32 Nucleo pack overview

USB-C PD expansion board

morpho connectors

User LEDs

CC AFE and V_{CONN} Switch Port 1

CC AFE and V_{CONN} Switch Port 0

Local Power Management

Extension Connector Port 1

Extension Connector Port 0

V_{BUS} Current/Voltage sensing Port 1

V_{BUS} Current/Voltage sensing Port 0

Type-C Receptacle Port 1

Type-C Receptacle Port 0

V_{BUS} Port 1 Switch and discharge

V_{BUS} Port 0 Switch and discharge

Connector for V_{BUS} Load Port 1

Connector for V_{BUS} Load Port 0

NUCLEO-F072RB

Device policy manager

Policy engine

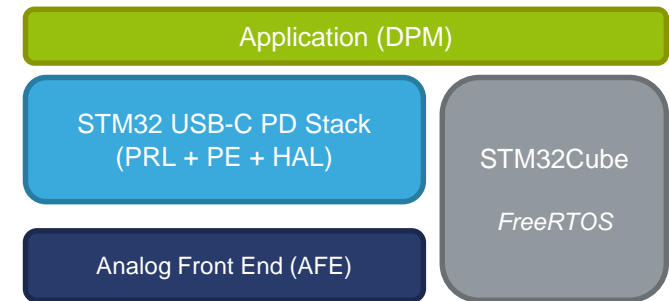Protocol layer

Physical layer (4b5b, CRC, SOP, BMC)

X-CUBE-USB-PD stack

- Full-featured & highly customizable package based on STM32Cube and Analog Front End

- Compliant with USB Type-C™ 1.2 and PD 2.0 specifications

- V_{CONN} swap, dead battery, BIST, and VDM features supported

- Supports up to 2 USB Type-C ports (provider, consumer or dual-role)

Application (DPM)

STM32 USB-C PD Stack
(PRL + PE + HAL)

STM32Cube

FreeRTOS

Analog Front End (AFE)

life.augmented

Summary

Features	Benefits

▪ **2 USB-C supported**
   • Provider/Consumer/DRP
   • Cable detection and orientation
   • Attach/detach, role of port partners
   • Current capability detection
   • PD communication + VDM
▪ **Power management control via standard I/Os**
▪ **Versatile set of peripherals (ADC, DAC, SMBUS, I2C, USB 2.0)**
▪ **Authentication and security features (AES 128, ROP, RNG, etc.)**
▪ **Firmware upgrade**
	High Flexibility to support various topologies and easy implementation of specific application task thanks to STM32Cube library
	
	Adaptability vs USB standard evolution
	
	Authentication ready with STSAFE secure-element
	Ensure business or brand protection with safety use by port partner identification to release full-feature capability

life.augmented

# Software distribution

Type	Binary library distribution, with examples and drivers in source code Runs on STM32 microcontrollers only
License	Binary under MCD-ST Ultimate Liberty V2 Source code under open source BSD or MCD-ST Ultimate Liberty V2
Certification	Fully certified solution (provider)
Location	Available for download on www.st.com/x-cube, once users are logged in

Note: Library sources can be obtained under NDA upon demand to nearest ST sales office:
- Library sources will be provided under MCD-ST Liberty License V2 that prevents source redistribution
- User can modify library sources, but changes would require a re-certification
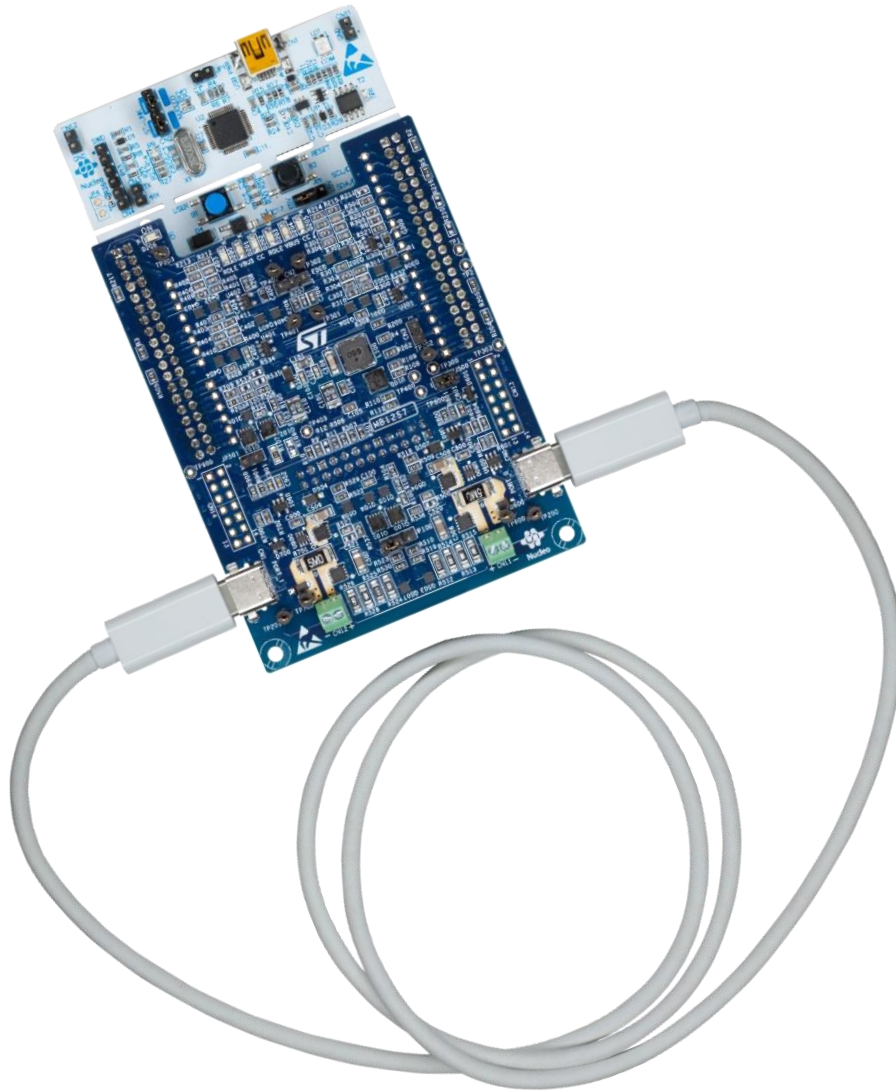
www.st.com/x-nucleo
www.st.com/x-cube