Connect to USB Type-C™ with STM32 MCUs
ST offers two solutions to help developers find the best solution for their applications:

- STM32 UCPD controllers and development ecosystem
- X-CUBE-USB-PD expansion software pack for any STM32
### Why use USB-C™ and Power Delivery technology?

**USB Type-C™ connectors enhance the user experience**
- It’s a 24-pin miniature and reversible connector. USB-C plug is the same on both sides.
- Some pins can be repurposed to support proprietary protocols (Alternate Modes).
- Able to transmit 15W of power natively without USB PD protocol.

**To exchange more data faster with various protocols**
- 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.

**To get more power with a comprehensive and robust protocol**
- **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.

**To protect your application and extend its functionalities**
- 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.
USB Type-C™ pinout functions

**Type-C connector interface:**
- Attach/detach and role management (SNK, SRC, and DRP) between two devices
- Discover and configure VBUS and VCONN
- Resolve twist and cable orientation to establish USB data bus routing

**Power Delivery protocol management:**
- Discover power capabilities of distant ports
- Negotiate power contracts up to 100 W
- Swap power direction
- Swap USB data role
- Handle Alternate Modes (AM)
- Authenticate a device or a charger

Purpose of CC1/CC2 wires (Configuration & Communication channels)
USB Power Delivery is a protocol!

To enhance user experience safely through innovation

To get more power in a robust and safe way!
- Enables advanced and higher voltage and current negotiation (up to 100 W)
- Source and Sink establish power contracts that match their power capabilities and needs (ex: technology of battery used, power budget allocation, number of ports, etc.)
- Supply voltage ($V_{bus}$) is fixed (5V, 9V, 15V, or 20V) or configurable (Programming Power Supply)
- Dual Role Power devices can swap power direction (ex: using a tablet to charge a notebook!)

<table>
<thead>
<tr>
<th>Mode of operation</th>
<th>Nominal voltage</th>
<th>Maximum current</th>
<th>Maximum power</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB PD</td>
<td>Configurable</td>
<td>5 A</td>
<td>100 W</td>
</tr>
<tr>
<td>USB Type-C Current @ 3.0 A</td>
<td>5 V</td>
<td>3.0 A</td>
<td>15 W</td>
</tr>
<tr>
<td>USB Type-C Current @ 1.5 A</td>
<td>5 V</td>
<td>1.5 A</td>
<td>7.5 W</td>
</tr>
<tr>
<td>USB BC 1.2</td>
<td>5 V</td>
<td>Up to 1.5 A</td>
<td>7.5 W</td>
</tr>
<tr>
<td>Default USB Power</td>
<td>USB 3.2</td>
<td>900 mA (x1)</td>
<td>4.5 W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,500 mA (x2)</td>
<td>7.5 W</td>
</tr>
<tr>
<td></td>
<td>USB 2.0</td>
<td>500 mA</td>
<td>2.5 W</td>
</tr>
</tbody>
</table>

To extend devices functionalities and create an unique differentiation!
- Use of USB PD Structured Vendor Defined Messages (VDMs) to extend functionalities (video output, authentication, etc.)
Many combinations

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

Alternate Mode capabilities enabled via USB PD
Authentication
Fast charging using PPS
Two solutions using STM32

Flexible solutions for existing or new designs

By using the UCPD(*) interface available in **STM32G0, STM32G4** and **STM32L5** Microcontrollers.

(*) UCPD = USB-Type-C and Power Delivery interface
A Companion Type-C Port Protection device (TCPPP01-M12) is available to protect the USB-C connector.

By using any **STM32** as Type-C Port Manager (TCPM) running our **X-CUBE-USB-PD** software pack to control 3rd party Type-C Port Controller (TCPC) or STUSB1602.
Solution
STM32 with built-in USB PD interface (UCPD)

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

STM32L5
STM32G0
STM32G4

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)

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

TCP
- USB Type-C

TP
- USB Type-C

STM32G0
STM32G4
STM32L5

USB Type-C

TCPP
- Dead Battery
- ESD protection
- 22V CC lines protection
- \(V_{bus}\) gate Driver
STM32 with built-in USB PD interface (UCPD)
This new UCPD interface manages Type-C™ connector Configuration & Communication channels (the CC lines) for:

1. Type-C™ Control
2. USB PD communication
UCPD built-in features

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

USB PD communication
- PD transceiver PHY
- Digital BMC
- CRC encoding/decoding

- Enabling
  - 15W max (5V/3A)
- Enabling
  - 100W max
- Alternate Mode

- ✔️ 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
- ✔️ 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
Optimized SW/HW architecture
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

More on: www.st.com/STM32G0
STM32G4 MCUs
Mixed-signal

More on: www.st.com/STM32G4

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

STM32G431 block diagram
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

More on: www.st.com/STM32L5
• 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.
Type-c port protection IC TCPP01-M12

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

- $\pm 8kV$ 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)

STM32G0
STM32G4
STM32L5

X-NUCLEO-USBPDM1 shield (availability Q4'2020)
Typical sink application example
Typical sink application example

1. TCPP01-M12 presents dead battery clamps on CC lines
2. When SOURCE is plugged voltage change appears on one CC line
3. SOURCE applies 5V 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
   TCPP01-M12 dead battery clamps removal
9. USB PD 20V contact negotiation
10. SOURCE applies 20V on Vbus
11. STM32 UCPD voltage acknowledge
Typical sink application example

20V negotiation example screenshot
Complete USB-C ecosystem for short time-to-market

STM32G0
- STM32G081B-EVAL
  - 1 Port DRP (45W)
  - 1 port Sink (AM)

STM32G4
- STM32G474E-EVAL
  - 1 Port DRP (15W) + USB data

STM32L5
- STM32L552E-EVAL
  - 1 Port Sink + USB data

STM32CubeMonitor
- UCPD configuration

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.
Easy configuration

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

USB-PD middleware parameters settings

Visit STM32Cube Ecosystem webpage

Code generation
Easy debug with stm32cubemonucpd

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

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)
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

- 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
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, \( V_{\text{conn}} \), dead battery and protection.
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

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

<table>
<thead>
<tr>
<th>Typical TCPM Memory Footprint (no VDM, no Vconn)</th>
<th>Source or Sink only</th>
<th>Dual Role Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 port (w/o RTOS)</td>
<td>32 Kbytes in Flash</td>
<td>40 Kbytes in Flash</td>
</tr>
<tr>
<td></td>
<td>3.6 Kbytes in RAM</td>
<td>3.6 Kbytes in RAM</td>
</tr>
<tr>
<td>2 port (w/RTOS)</td>
<td>32 Kbytes in Flash</td>
<td>43 Kbytes in Flash</td>
</tr>
<tr>
<td></td>
<td>7.8 Kbytes in RAM</td>
<td>8.1 Kbytes in RAM</td>
</tr>
</tbody>
</table>
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)
• 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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