USB Type-C™ PD
USB Power Delivery

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STMicroelectronics
Agenda

- USB Type-C and USB Power Delivery Benefits
- USB Type-C Technical Details
- ST Offer
- Evaluation Tools
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.

- **More flexibility** with a new reversible & thinner connector, more robust
- **More power** with USB Power Delivery (up to 100W)
- **More speed** with USB 3.1 (5/10Gbps), USB 3.2 (20Gbps), USB4 (40Gbps)
- **More protocols** (Display Port, HDMI, Thunderbolt 3, …)

A smart and green technology
Power, Data & Display: All-in-One interface

Power management
100W max

High Speed Data
USB 2.0
USB 3.x

Display Connection
Video + Audio
(DisplayPort™ or HDMI™)
USB Type-C: One port to rule them all

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

USB Type-C and USB Power Delivery

[Diagram of USB Type-C connections including power, display, audio, and data]
STMicroelectronics is a board member of USB-IF and USB 2.0 & USB 3.0 promoter

http://www.usb.org/developers/powerdelivery/
USB Type-C Technical Details
USB Type-C Pinout Functions

Enhance ease of use

**Receptacle**

- A1: GND
- A2: TX1+
- A3: TX1-
- A4: VBUS
- A5: CC1
- A6: D+
- A7: D-
- A8: SBU1
- A9: VBUS
- A10: RX2-
- A11: RX2+
- A12: GND

**Plug**

- A12: GND
- A11: TX2+
- A10: TX2-
- A9: VBUS
- A8: SBU1
- A7: D-
- A6: D+
- A5: CC2
- A4: VBUS
- A3: TX1-
- A2: TX1+
- A1: GND

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.

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 VCONN for powering electronics. Also, only one set of USB 2.0 D+/D- wires are implemented.
USB-C: 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

### Source Power Rp pull-up

<table>
<thead>
<tr>
<th>Power</th>
<th>Rp pull-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legacy</td>
<td>56 kΩ</td>
</tr>
<tr>
<td>1.5A @ 5V</td>
<td>22 kΩ</td>
</tr>
<tr>
<td>3A @ 5V</td>
<td>10 kΩ</td>
</tr>
</tbody>
</table>

### Sink Rd pull-dw

<table>
<thead>
<tr>
<th>Power</th>
<th>Rd pull-dw</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC pin</td>
<td>5.1 kΩ</td>
</tr>
</tbody>
</table>
USB-C principle

- Source-Only meets Sink-Only
Host-to-device Connection

- Logical Model for Data Bus Routing
USB Power Delivery (USB PD)

Key Characteristics

• Voltage and Current values are **negotiated** (via CC pin)
  • Higher voltage and current: power up to 100W (20V / 5A)

• **Swapping** of power direction, data direction and source of VCONN

• Communication with USB Type-C Electronically Marked Cables (EMC)

• Support for **Alternate Modes** of operation (DP, MHL, Thunderbolt)

• Signaling:
  • 1-wire communication, bidirectional
  • Half duplex system
  • Biphase Mark Coding (BMC)
  • Bit rate : 300kbps
  • CRC-32 used to detect data corruption
USB Type-C [vs] USB PD

• **USB-C**
  - **Power:** *15W* max
    - 5V/3A, 5V/1.5A, 5V/LegacyCurrent
    - Legacy USB2.0 power: 5V/500mA (after USB enumeration), 5V/100mA (no enumeration)
  - **Power Role:** Source, Sink, or Dual Role Power (DRP)

• **USB-C Power Delivery**
  - PD communication occurs on CC line
  - **Power:** *100W* max (20V@5A)
    - VBUS min= 5V ; max= 20V
    - Several power profiles possible (PDO). e.g.: [5V, 9V, 15V, 20V]
    - **Power Role:** Source, Sink, or Dual Role Power (DRP)
  - PD mode always starts after USB-C attachment is done (i.e. 5V is available on VBUS at this point)
  - **Additional optional features:**
    - Swap of Power Role, Swap of Data Role
    - Communicate with EMC cables, VDM, authentication, Alternate modes, Firmware update over CC, ...
USB-PD: Power Negotiation Sequence

Source

- Discover Identity (Request, SOP')
- Discover Identity (ACK, SOP')
- Source Capabilities

Cable Plug

- Request
- Accept
- PS_RDY

Sink

- SenderResponseTimer
- PSTransitionTimer
USB-PD 2.0 & 3.0 Power Rules

PDO: Power Data Object (Voltage, Current)

<table>
<thead>
<tr>
<th>PD Power (W)</th>
<th>Current (A) at 5V</th>
<th>Current (A) at 9V</th>
<th>Current (A) at 15V</th>
<th>Current (A) at 20V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 ≤ x ≤ 15</td>
<td>x ÷ 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 &lt; x ≤ 27</td>
<td>3</td>
<td>x ÷ 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27 &lt; x ≤ 45</td>
<td>3</td>
<td>3</td>
<td>x ÷ 15</td>
<td></td>
</tr>
<tr>
<td>45 &lt; x ≤ 60</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>x ÷ 20</td>
</tr>
<tr>
<td>60 &lt; x ≤ 100</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>x ÷ 20 (*)</td>
</tr>
</tbody>
</table>

(*) Requires a 5A cable
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.
ST Offer
ST Product family
USB Type-C & PD Controllers
Covering all use cases from Type-C to full-feature Power Delivery

<table>
<thead>
<tr>
<th>Standalone</th>
<th>PD stack running in SW</th>
</tr>
</thead>
<tbody>
<tr>
<td>STUSB1600</td>
<td>STUSB4500L</td>
</tr>
<tr>
<td>STUSB4500</td>
<td>STUSB47xx</td>
</tr>
<tr>
<td>STUSB1602 + µC</td>
<td>STM32Gx with UCPD interface + TCPP01</td>
</tr>
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<table>
<thead>
<tr>
<th>USB Type-C</th>
<th>≤ 15W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Delivery</td>
<td>15-60W</td>
</tr>
<tr>
<td>15-100W</td>
<td></td>
</tr>
<tr>
<td>Alternate Mode</td>
<td>Up to 100W</td>
</tr>
</tbody>
</table>
USB Type-C & PD Controllers

Certified Solutions

Offer to designers the flexibility to enable the needed optimization of stack partitioning and BOM.

- Highest flexibility and adaptability with GP STM32 MCU for multiports management
- Highest integration with High Voltage USB-C and PD controllers (STUSBXX)
- Embedded Software (X-CUBE-USB-PD) & Low level drivers for USB1602

Digital functions:
- Device Policy Manager
- Policy Engine
- Protocol layer
- 4b5b, CRC, SoP
- BMC encoder
- USB PD RX/TX analog PHY
- Type-C Interface
- High Voltage Analog

Analog functions:
- STUSB1600 DFP/UPP/DRP
- STUSB4500L SINK
- Type-C Controller STUSB1602 DFP/UPP/DRP
- STM32F MCUs
- Full Hardware USB PD Controller Optimized for AC Adapters (Provider)
- Type-C Controller STUSB1602 DFP/UPP/DRP
- Full Hardware USB PD Controller for Device side (Consumer)
- STUSB4500
- High Voltage protection

TCPP01

STM32G0
STM32 G4
STM32 G4
STM32 L5
STM32G0
STM32G4 (UCPD)

STM32G0
STM32G4 (UCPD)

STM32G0
STM32G4 (UCPD)
USB Type-C Protection Devices

ESD & EOS

<table>
<thead>
<tr>
<th>Pin Name</th>
<th>Recommended Protection</th>
<th>Package Size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSTXp1/SSTXn1</td>
<td>HSP053-4M5</td>
<td>1.3(L) 0.8(W) 0.38(D)</td>
</tr>
<tr>
<td>SSRXp1/SSRXn1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VBUS</td>
<td>ESDA25P35-1U1M (for 20V)</td>
<td>1.6(L) 1(W) 0.55 (D)</td>
</tr>
<tr>
<td>CC</td>
<td>ESDZV5-1BF4</td>
<td>0.58(L) 0.28(W) 0.3 (D)</td>
</tr>
<tr>
<td>SBU</td>
<td>ESDA5-1F4</td>
<td></td>
</tr>
<tr>
<td>Dp1/Dn1</td>
<td>USBULC6-2F7</td>
<td>0.73(L) 0.73(W) 0.37(D)</td>
</tr>
</tbody>
</table>
STUSB1600 / STUSB4500L
USB Type-C controller

- **STUSB1600**: Source / Sink / DRP
- **STUSB4500L**: Sink only

### 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)
STUSB4700/4710 - SOURCE

Provider
- all USB PD profiles supported up to 100W
- Suitable for AC/DC and DC/DC

- Auto-run / Plug & Play
- Dead Battery Support
- Up to 5 PDO profiles
- Short to VBUS Protections
- Power sharing capable thru MCU
STUSB4500 - SINK

Standalone USB Power Delivery Controller - SINK

**Consumer**
- all USB PD profiles supported up to 100W
- Fast migration to USB PD

- Auto-run / Plug & Play
- Dead Battery Support
- Up to 3 SINK PDO profiles
- Short to VBUS Protections
- PCB area saving

Certified

To battery charger or system DC/DC
STUSB4500 Footprint
DEMO BOARD – USB Type-C/PD SINK

Power any 100W (or less) device with USB PD!
It’s:
- Tiny,
- Safe,
- Certified,
- Plug-Play
- Customizable
STM32G0 / STM32G4 / STM32L5

- **STM32G0**: World’s 1st USB-C & Power Delivery 3.0 MCU
- **Wider offer** with “UCPD” IP across STM32 portfolio (G0/G4/L5)
- **Companion TCPP** available to make the solution more robust.

**STM32G081 block diagram**

- **UCPD** is a new interface that supports:
  - USB Type-C connector management
  - USB Power Delivery r3.0 communication protocol

**Dual Port - Certified’ Solution**

- Cortex®-M0+ STM32 platform
- Up to 2 built-in USB-C & PD3.0 interfaces
- 128Kbytes of Flash - 36Kbytes of SRAM
- Versatile analog and digital peripherals
- 28,32,48,64-pin packages available
USB Type-C + USB 2.0
HW implementation in DRP mode
STUSB1602 Dual-Role Power (DRP) Implementation example

STUSB1602 controller

POWER path (high Voltage)
- Battery charger
- 5V~20V DC/DC
- 3.3V LDO (optional)
- System & USB PD controller

DATA path
- USB 2.0 controller
- USB 3.1 controller
- ALT mode controller

USB Type-C receptacle
- VBUS
- VBUS_SENSE
- SINK path
- SRC path
- POWER path

I²C interface
- SPI interface
- I²C slave

3.3V LDO (optional)

3.3V LDO

STUSB1602 Dual-Role Power (DRP) Implementation example

STUSB1602 controller

USB 2.0 controller

USB 3.1 controller

ALT mode controller

USB / DP switch

Super Speed MUX & redriver

TX+/TX- RX+/RX-

TX1+/TX1- RX1+/RX1-

TX2+/TX2- RX2+/RX2-

D+/D-

CC1 CC2

STUSB1602 Dual-Role Power (DRP) Implementation example

STUSB1602 controller

USB 2.0 controller

USB 3.1 controller

ALT mode controller

USB / DP switch

Super Speed MUX & redriver

TX+/TX- RX+/RX-

TX1+/TX1- RX1+/RX1-

TX2+/TX2- RX2+/RX2-

D+/D-

CC1 CC2

STUSB1602 Dual-Role Power (DRP) Implementation example
Evaluation Tools
Development Tools
STUSB1600A - DRP

Stand-alone USB Type-C Controller

- Dual Role, provider, consumer
- Fast migration to Type-C <15W
- Configurable start-up profiles
- Dead battery support
- Short to VBUS Protections

Certification:
- Certified according to:
  - USB type-C™ (rev1.2 + ECN)
  - TID: 1000100

Ideal solution for <15W charging (1.5A @5V / 3A@5V) with or without USB DATA
STUSB4500 - SINK

Standalone USB PD Controller - SINK

Consumer
- all USB PD profiles supported up to 100W
- Fast migration to USB PD

- Auto-run / Plug & Play
- Dead Battery Support
- Up to 3 SINK PDO profiles
- Short to VBUS Protections
- PCB area saving

Certification
- Certified according to:
  - USB type-C™ (rev1.2)
  - USB PD (rev2.0)
  - TID: 1000133
- Compliant with USB PD (rev3.0)
STUSB47xx - SOURCE

Stand-alone USB PD Controller - SOURCE

Provider
- all USB PD profiles supported up to 100W
- Suitable for AC/DC and DC/DC

- Auto-run / Plug & Play
- Dead Battery Support
- Up to 5 PDO profiles
- Short to VBUS Protections
- Power sharing capable thru MCU

Certification
- Certified according to:
  - USB type-C™ (rev1.2)
  - USB PD (rev2.0)
  - TID: 1000125 / 1030023
- Compliant with USB PD (rev3.0)
STUSB47 meets STUSB45

Stand-alone controllers for SOURCE and SINK applications

PROVIDER: STUSB47
SOURCE - Autorun

CONSUMER: STUSB45
SINK - Autorun

Typical power: 15V / 1A

shaver

load example
STM32 Smart USB-C ecosystem for short time-to-market

Discover and learn
STM32G071B-DISCO

Develop
NUCLEO-G071RB
STM32G081B-EVAL

Configure & Debug
STM32G0 USB-C Discovery

Promotional kit and tool to learn and discover USB-C port capabilities. It offers 3 operating modes:

1. **“Standalone” mode**: Discover and display power / data / Alternate Mode capability of any USB-C host (source/DRP).

2. **“Sniffer + USB PD meter” mode**: Display current direction, power information ($V_{bus}$ voltage, $I_{bus}$ current) between two USB-C enabled devices.

3. **“Advanced User” mode**: Debug, configure, inject USB PD3.0 packet using “STM32CubeMonUCPD”.

Ordering info:
RPN : STM32G071B-DISCO
POS/RRP : 65$
USB-C STM32 Ecosystem

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

- STM32G071B-DISCO
  - USB-C analyzer (Sink)

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

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

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

- STM32L552E-EVAL
  - 1 Port Sink + USB data

- STM32L552E-EVAL
  - USB data

- STM32CubeMX
  - UCPD configuration

- STM32CubeMonitor-UCPD
  - Debug tool
STM32 USB PD3.0 solutions
C-Authentication ready via USB PD or USB 2.0

1 X-CUBE-USB-PD

STM32 as TCPM + TCPC
(PD3.0 – SNK – SRC – DRP – Multi Port)

- Type-C Port Manager
  - Device Policy Manager
  - Policy Engine
  - Protocol Layer

- Type-C Port Controller
  - GoodCRC / retry
  - Physical Layer
  - Type-C Logic
  - Dead Battery
  - Protection
  - Vbus gate driver

STM32 USB PD3.0 solutions with built-in UCPD

UCPD STM32
- Device Policy Manager
- Policy Engine
- Protocol Layer

- Type-C Port Protection
  - Dead Battery
  - ESD protection
  - 22V CC lines protection
  - Vbus gate Driver

Premium ecosystem for fast time-to-market
STEVAL-USBC2DP:
USB Type-C to DisplayPort adapter

Key Features:

- The USB Type-C to DisplayPort Adapter expands a USB Type-C laptop screen onto a monitor or projector equipped with DisplayPort
- Based on the Alternate Mode Functional Extension of the USB Type-C & Power Delivery to enables the DisplayPort interface

Advantages

- Type-C Alternate Mode demo in a compact PCB design (5.5 x 2.3 mm)
- Full ST BOM for a cost-effective solution based on Discrete AFE approach
- Including the DFU feature

Key Products

- **STM32F072**: the high-performance ARM® Cortex®-M0 32-bit RISC core operating at up to 48 MHz frequency, high-speed embedded memories and with USB 2.0 data interface.
- **LDK220**: 200 mA low quiescent current and low noise LDO.
- **STG3684A**: Low Voltage 0.5 Ohm Max Dual SPDT Switch with Break-Before-Make
- **ESDALC5-1BF4**: Low clamping and low capacitance bidirectional single line ESD protection
- **STPS0520Z**: Power Schottky rectifier
- **X-CUBE-USB-PD**: STM32 USB-PD package consisting of libraries and application examples for STM32F0 devices acting as USB-PD controllers
Summary

• USB Docs:  [www.usb.org/documents](http://www.usb.org/documents)

• 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](http://www.usb.org/documents) using the STUSB1600 or STUSB4500L
  • USB PD & Type-C [Autonomous full HW](http://www.usb.org/documents) controller for Provider Only application using the STUSB4700, or Consumer only with STUSB4500
  • USB PD & Type-C controller for DRP/DFP/UFP application as the perfect companion to Embedded Controller using the STUSB1602+STM32 supporting USB PD rev3.0.
  • New Microcontrollers embedding UCPD 3.0 interface: STM32G0, STM32G4, STM32L5

• Automotive
  • Using STUSB1700Y, STUSB4700Y, STUSB1702Y for [Automotive grade](http://www.usb.org/documents) devices
Thank You

Visit  www.st.com/usb-type-c

Backup
The diagram illustrates the ST offer overview for USB-C and USB-2.0 compatibility with various STM8/STM32 MCU solutions. It categorizes solutions into SINK, SOURCE, and DRP. The options include TCPP02 + STM32, TCPP02 + Any STM32 with USB 2.0 data interface, and TCPP02 + Any STM32 with USB 2.0 data interface + PPS. The power capabilities range from Up to 15W to Up to 100W.
TCPP01-M12
for sink PD3.0 applications, with battery

NO current consumption until powered by MCU (after attach for ex.)

- FLT (FAULT) is an open-drain output pin.
- DB/ is a pull-down TCPP input. Connect to 3.3V if not managed by MCU software.
TCPP01-M12 is a Type-C Protection Port designed by PDG in collaboration with MCD.

Main features
- ESD protection for CC1, CC2 and VBUS
- Compliant with IEC61000-4-2 Level 4
  - ±8kV contact discharge, ±15 kV air discharge
- 24V OVP against CC lines short-to-VBUS overvoltage
- Over Voltage Protection on VBUS line
- Integrated VBUS gate driver of external NMOS
- Thermal protection
- QFN12-pin package 3*3mm (pitch 0.5mm)