TCPP01-M12

USB Type-C™ Port Protection (TCPP)
1. The new USB Type-C™ connector
2. USB Type-C™ protection requirements
3. TCPP01-M12 features & benefits
4. Application
5. Summary and key takeaways

USB Type-C™ and USB-C™ are trademarks of USB Implementers Forum.
1. The New USB Type-C™ Connector
Only One Will Survive

Direction for power or data is defined by...

The connector’s mechanics

USB Type-C™

Electronics behind the connector
Simplified User Experience

One plug, more power & higher data rate

Reversible

Power delivery

USB Type-C™ connector (container)

USB 3.2 Super Speed data rate & Alternate Modes (Display Port, ThunderBolt, …)
Yet a More Complex Application Design

USB legacy connectors

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SINK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type-A</td>
<td>Micro-B</td>
</tr>
<tr>
<td>Micro-A SuperSpeed</td>
<td>Micro-B SuperSpeed</td>
</tr>
</tbody>
</table>

5 V

Legacy: 5 V

Power Delivery: 5 V, 9 V, 15 V, 20 V

Programmable Power Supply (PPS): 3.3 - 21V

USB Type-C™ connector
2. USB Type-C™ Protection Requirements
Top 3 Electrical Hazards

Migrating to USB-C Connector

Mandatory protections for USB-C™ connectors

- ESD
- DEFECTIVE SOURCE
- CC pin Short-to-VBUS
# 1: ESD Discharge

USB Type-C™ Connectors

Protection is required to sustain IEC 61000-4-2 Level 4, (+8 kV contact discharge)

ESD

DEFECTIVE SOURCE

CC pin Short-to-$V_{BUS}$

Melting Flash
### #2: Overvoltage on $V_{BUS}$

A defective adapter/cable can deliver a voltage higher than expected. OVP on $V_{BUS}$ is required.

**ESD**

**SOURCE (DFP)**

$V_{BUS}$ blocked to 20 V due to SW or defective HW

**DEFECTIVE SOURCE**

**CC pin**

Short-to-$V_{BUS}$

**SINK (UFP)**

Requests 5 V max using CC lines

IC damage on $V_{BUS}$
#3: CC-lines Short to \( V_{\text{BUS}} \)

Twisting the plug in the receptacle can create overvoltage on CC lines. OVP on CC1 and CC2 is required.

- \( V_{\text{BUS}} \) contact with to CCx (or SBUx)
  - If the cable if of poor quality or the plug is too hot
- High voltage (9 V, 15 V or 20 V) on 5 V lines
  → Risk of destroying CC

\[ \text{5-20V} \]

\[ \text{5,5V} \]
3. TCPP01-M12 Features & Benefits
TARGET APPLICATIONS
SINK + SOURCE

Automotive
• Mobile device charging
• Tablet & PC charging
• Infotainment

Smart Home & IoT
• Personal computers
• Smartphones & tablets
• Set top box & TVs
• Cameras
• Smart speakers, POS, etc.

Chargers
• Power chargers
• Power HUBs
• Power banks
ST’s Offer for USB Type-C™

**Auto-run solutions**
- **STUSB1600**
- **STUSB1700**
  - + ESDA25P35-1U1M
  - + ESDA25W

**MCU-based solution**
- Any STM8 or STM32 with Type-C Port Protection (TCPP01-M12)
- STM32 “UCPD” MCU with Type-C Port Protection (TCPP01-M12)

**USB-C Only**
- Protection + Attachment
- Protection + Attachment + Alternate Mode (USB 2.0 data)

**USB-C + PD**
Type-C Port Protection (TCPP)

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

1. IEC61000-4-2 Level 4 (+8 kV contact discharge) ESD protection on $V_{BUS}$, CC1 and CC2 lines
2. Overvoltage protection on $V_{BUS}$ line, externally programmable
3. Overvoltage protection for CC pins
TCP01-M12 Features

Compliant with Sink or Source applications using USB Type-C™ connectors

- +8 kV ESD protection on CC pins and $V_{BUS}$
- 6 V overvoltage protection on CC lines
- Integrated “Dead Battery” management logic and Rd
- Overvoltage protection on $V_{BUS}$
- Integrated $V_{BUS}$ load switch gate driver for external N-MOSFET
- Supports Programmable Power Supply (PPS in PD3.0 specification)
TCPP01-M12 Benefits

Safely link USB-C™ connectors to low-voltage controllers

- High robustness against system-level ESD
- No power waste
- Reduced BOM components and cost
- Compliant with USB-PD 3.0 including PPS
- One protection for sink & source
- Housed in small μQFN-12L 3 mm x 3 mm package
4. Application
USB Standards

- **Power Delivery**
  - Standard cable (< 3 A)
  - Electronically marked cable (< 5 A)

### USB Type-C legacy (5 V only)
- 2.5 W, 7.5 W or 15 W

### USB Type-A/B legacy
- USB BC 1.2 (charger only): 5V – 1.5 A: 7.5 W
- USB 3.0: 5V – 0.9 A: 4.5 W
- USB 2.0: 5V – 0.5 A: 2.5 W

Figure 10-2 shows an example of an adapter with a rating at 50W. The adapter is required to support 20V at 2.5A, 15V at 3A, 9V at 3A and 5V at 3A.
Moving from USB-C™ to USB-C PD hardly affects the BOM

Sink Application Example

USB-C « Legacy » 5V

- $V_{BUS} = 5$ V, up 15 W

- BOM:
  - General Purpose STM32/STM8 MCUs
  - TCPP01-M12
  - 2 resistors on CC lines

USB-C PD

- $V_{BUS}$ up to 20 V, up to 100 W

- BOM:
  - STM32 with UCPD (STM32G0, STM32G4, STM32L5)
  - TCPP01-M12
  - 2 capacitors on CC lines
USB-C™ PD SINK 20 V Negotiation

Example

1. TCPP01-M12 presents dead battery clamps on CC lines
2. When SOURCE is plugged in the voltage change appears on one CC line
3. SOURCE applies 5 V on $V_{BUS}$
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 20 V contact negotiation
10. SOURCE applies 20 V on $V_{BUS}$
11. STM32 UCPD voltage acknowledge
USB-C™ PD SINK 20 V Negotiation Example

VCBUS

CC

TCPP01-M12 DB/
LDO output

0 V

3.3 V

5 V

35 V

30 V

25 V

20 V

15 V

10 V

5 V

10 V

5 V

20 V

350 ms

250 ms

150 ms

50 ms

0 ms

-50 ms

-100 ms

-200 ms

-300 ms

P1.max(C1)
P2.max(C2)
P3.max(C3)
P4.max(C2)
P5.width(C1)
P6.width(C2)
P7...
P8...

Measure

value

status

5.00 V/div

-15.00 V/div

1.00 V/div

1.00 V/div

1.00 V/div

1.00 V/div

-1.00 V/div

0.0 mV/div

0.0 mV/div

0.0 mV/div

0.0 mV/div

0.0 mV/div

0.0 mV/div

12 Bins

-200 ms/div

100 ms/div

Normal

2.0 V/div

2.5 MSa/s

2.5 MSa/s

Edge

Positive
TCPP01-M12- USB Type-C™ Use Cases

**SOURCE, without USB-PD**

- Up to 15 W

**SINK, without USB-PD**

- Up to 15 W

**SOURCE, with USB-PD**

- Up to 100 W

**SINK, with USB-PD**

- Up to 100 W
X-NUCLEO-USBPDM1
Optimal Solution for SINK USB-PD Applications

• Very few BOM components
  • No function overlap between TCPP01-M12 and MCU
  • Integrated ESD protection on TCPP01-M12 CC lines
  • TCPP01-M12 drives N-MOSFET $V_{BUS}$ load switch

• Highest level of system protection
  • ESD / EOS
  • Overvoltage Protection

• Low-power mode
  • Zero consumption of TCPP01-M12 in SINK applications when no cable is attached

• TCPP01-M12 supports all USB-C™ up to 15 W and up to 100 W using PD profiles on SINK

• Easy USB-C™ PD migration with the STM32G0 or the STM32G4
5. Summary and Key Takeaways
TCPP01-M12 enables safe, efficient and low-cost migration to USB Type-C™ connector

<table>
<thead>
<tr>
<th>Safe migration to USB Type-C™ connector</th>
<th>Power-efficient port protection</th>
<th>Reduces USB Type-C™ BOM cost</th>
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<tbody>
<tr>
<td>Overvoltage protection against defective power adapter thanks to external N-channel MOSFET</td>
<td>Power consumption equals 0 nA when no cable is connected in consumer application (sink)</td>
<td>Up to 80% PCB space reduction compared to equivalent discrete solutions, thanks to QFN12 3.0 mm x 3.0 mm package</td>
</tr>
<tr>
<td>Short-to-(V_{BUS}) protection for Configuration Lines (CC1 and CC2) thanks to integrated FET</td>
<td>Supports Programmable Power Supply to increase charging efficiency</td>
<td>No need for external USB-C Power Delivery controller when used with STM32G0/G4/L5 MCUs</td>
</tr>
<tr>
<td>System-level ESD protection as per IEC61000-4-2 Level 4 (+ 8 kV contact discharge) on CC1, CC2 and (V_{BUS})</td>
<td>Integrated gate driver for N-channel MOSFET</td>
<td>Use external N-channel MOSFET</td>
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</tbody>
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Type-C Port Protection

Key Takeaways

TCPP01-M12 can be used in all applications with USB Type-C™ connectors ... even without Power Delivery!

100% 

1. Complete protection: system-level ESD, OVP $V_{BUS}$ with external N-MOSFET, CC-line short to $V_{BUS}$

2. Zero power consumption when no cable is connected... cannot be less!

3. Cost-effective and STM32-based
Visit our dedicated webpage
Thank you!