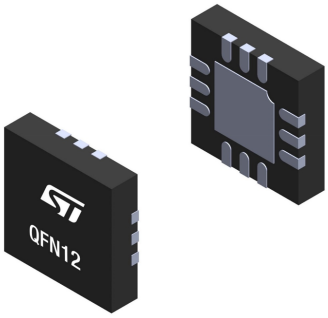
TCPP01-M12

Datasheet

USB type-C port protection



Product labels

SUSTAINABLE TECHNOLOGY

LONGEVITY 10 YEARS COMMITMENT

Product status link

TCPP01-M12

Product summary	
Order code	TCPP01-M12
Package	QFN12
Packing	Tape and reel
Description	PPS compliant USB type-C port protection

Companion chip	
USB Type-C	STM32 or STM8
USB Type-C with power delivery	STM32 with UCPD support, example STM32L5, STM32G0, STM32G4

Features

- Overvoltage protection on VBUS, adjustable up to 22 V, with external N-channel MOSFET
- 6.0 V overvoltage protection (OVP) on CC lines against short-to-VBUS
- System-level ESD protection for USB type-C connector pins (CC1, CC2), compliant with IEC 61000-4-2 level 4 (±8 kV contact discharge, ±15 kV air discharge)
- Integrated charge pump to control the gate of an external N-channel MOSFET (which features a lower R_{DSON} than a P-channel MOSFET)
- Null quiescent current when no USB charging cable is attached for battery-operated "consumer/sink" applications
- Integrated “dead battery” (R_D resistors)
- Over temperature protection (OTP)
- Operating junction temperature from -40°C to 85°C
- Complies with the latest USB type-C and USB power delivery standards
- Compliant with programmable power supply (PPS) as defined in latest USB PD specification
- Open-drain fault reporting
- ECOPACK2 compliant

Applications

- USB type-C used in sink configuration (consumer)
- USB type-C used in source configuration (provider)
- USB type-C for UFP (upstream facing port) or DFP (downstream facing port) configuration
- USB type-C power delivery, PPS compliant

Description

The TCPP01-M12 (type-C port protection) is a single chip solution for USB type-C port protection that facilitates the migration from USB legacy connectors type-A or type-B to USB type-C connectors. The TCPP01-M12 features 22 V tolerant ESD protection as per IEC61000-4-2 level 4 on USB type-C connector configuration channel (CC) pins. For a safe and reliable USB type-C implementation, the TCPP01-M12 provides overvoltage protection on CC1 and CC2 pins when these pins are subjected to short circuit with the VBUS pin that may happen when removing the USB type-C cable from its receptacle. For sink applications, TCPP01-M12 triggers an external N-MOSFET on VBUS line when a defective power source applies a voltage higher than selected OVP threshold. Also, the TCPP01-M12 integrates a “dead battery” management logic that is compliant with the latest USB power delivery specification. The power supply of the TCPP01-M12 for sink applications operated with a battery can be provided by an MCU 3.3 V GPIO in order to drop the power consumption in “cable not attached” condition down to 0 nA. This low power mode will extend the battery operating life when no source equipment is attached.

The TCPP01-M12 can also be used to protect source (provider) applications, and it can support programmable power supply feature from the USB-C power delivery specification.

1 Pinout and functions

Figure 1. **QFN12 pinout (top view)**

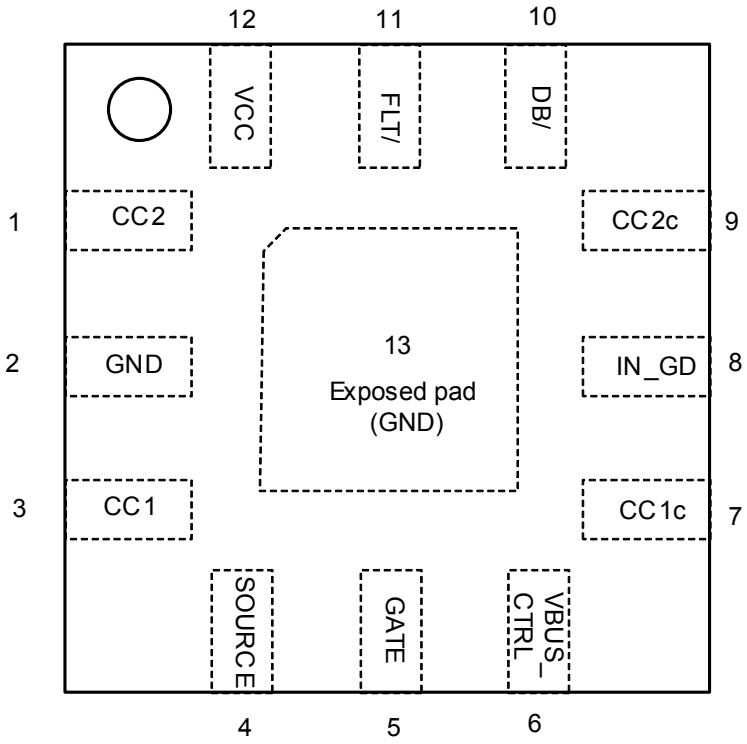


Table 1. **Pinout and functions**

Name	Pin #	Type	Description
CC2	1	Input / Output	USB-PD controller side for the CC2 pin
GND	2	Ground	Ground
CC1	3	Input / Output	USB-PD controller side for the CC1 pin
SOURCE	4	Power	VBUS N-channel MOSFET's SOURCE
GATE	5	Output	VBUS N-channel MOSFET's GATE
VBUS_CTRL	6	Input	Input voltage setting the VBUS OVP threshold by external resistor bridge
CC1c	7	Input / Output	Connector side for CC1 OVP internal FET
IN_GD	8	Power	VBUS N-channel MOSFET's DRAIN, input of the N-channel MOSFET gate driver
CC2c	9	Input / Output	Connector side for CC2 OVP internal FET
DB/	10	Input	Dead battery resistors management
FLT/	11	Output	Fault reporting flag (open-drain), triggered by either OVP (overvoltage protection), OTP (overtemperature protection), or UVLO (undervoltage lockout) event.
V_{CC}	12	Input	3.3 V power supply
Exposed pad	13	Ground	Ground

2 TCPP01-M12 simplified internal block diagram

Figure 2. **Block diagram**

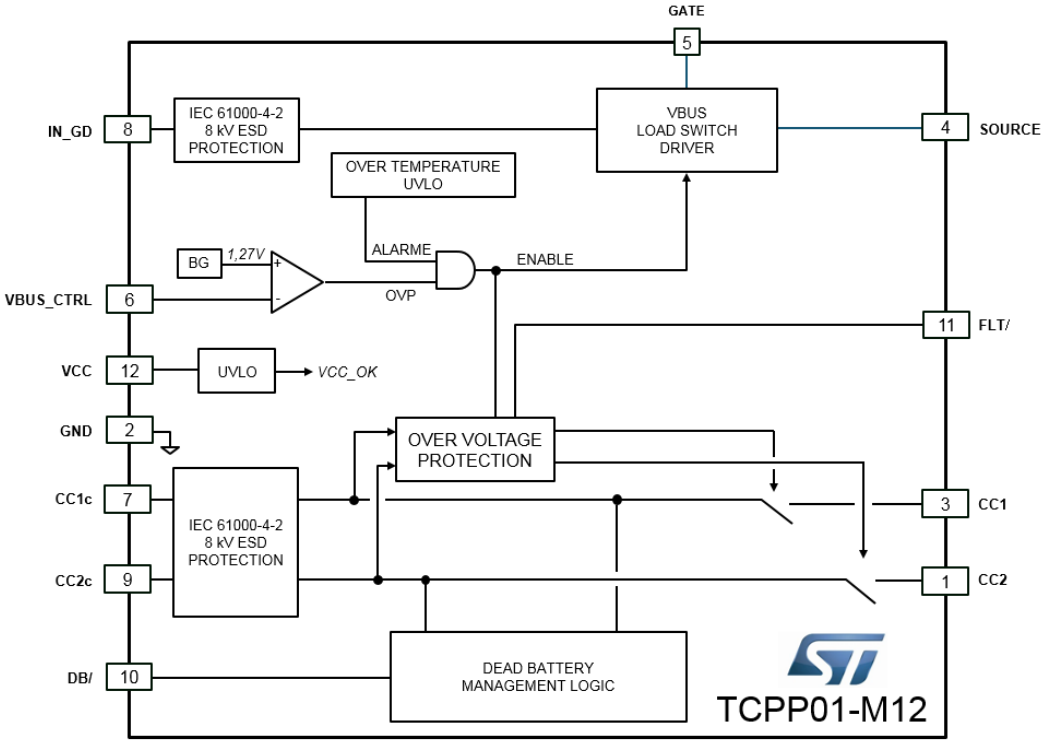
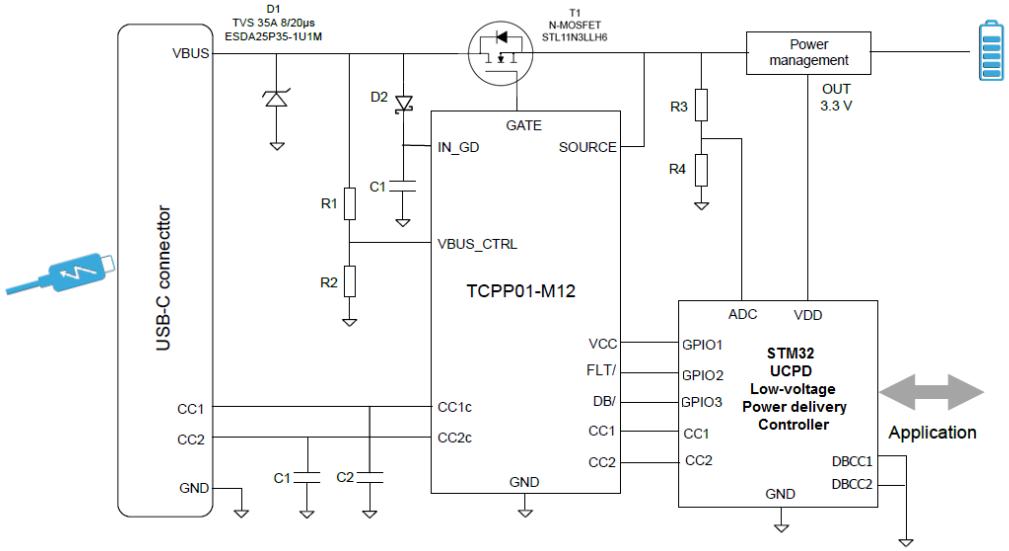


Figure 3. **Typical schematic for battery-operated sink (UFP) power delivery**



3 Characteristics

Table 2. Absolute maximum ratings (T_{amb} = 25°C)

Symbol	Parameter	Pin name	Value		Unit
			Min.	Max.	
V_{POWER}	Voltage for Power pins	VCC	-0.3	4	V_{DC}
		IN_GD	-0.3	22	V_{DC}
V_{IN}	Voltage for Input pins	VBUS_CTRL, DB/, CC1, CC2	-0.3	4	V_{DC}
V_{OUT}	Voltage for Output pins	FLT/, SOURCE	-0.3	5.5	V_{DC}
		GATE	-0.3	27	V_{DC}
$V_{I/O}$	Voltage for CC1c, CC2c pins	CC1c, CC2c	-0.6	22	V_{DC}
R_{thj-a}	Junction-to-ambient thermal resistance			150	°C/W
T_J	Junction temperature		-40	+85	°C
T_{STG}	Storage temperature range		-55	+150	°C

Table 3. ESD ratings (T_{amb} = 25°C)

Symbol	Description	Pins	Value	Unit
V_{ESD_c}	System level ESD robustness on USB type-C connector side IEC61000-4-2 Level 4, air discharge IEC61000-4-2 Level 4, contact discharge	SOURCE, CC1c, CC2c, VBUS_CTRL(1)	 15 8	kV
V_{HBM}	V_{ESD} ratings Human body model (JESD22-A114D, level 2)		2	kV

1. *VBUS_CTRL ESD capability is guaranteed by the external resistor R1min = 3.8 kΩ (see Figure 16. Sink applications, without battery, PPS compliant).*

Note: for more information on IEC61000-4-2 standard testing, please refer to AN3353.

Table 4. Electrical characteristics – Power supply and leakage current, T_{amb} = -40 °C to +85 °C

Symbol	Parameter	Test condition	Value			Unit
			Min.	Typ.	Max.	
V_{CC}	Allowable voltage input range	-	3.0	3.3	3.6	V
I_{VCC}	V_{cc} supply current	V_{CC} = 3.0 - 3.6 V			120	µA
VBUS	Allowable voltage range		3.3		22	V
I_{L_VBUS}	VBUS Supply current at VBUS = 22 V				2	mA

Table 5. Electrical characteristics – VBUS OVP control, T_{OP} = -40 °C to +85 °C

Symbol	Parameter	Test condition	Value			Unit
			Min.	Typ.	Max.	
V_{GS}	GATE to SOURCE voltage	V_{CC} = 3.0 - 3.6 V, VBUSc(1) = 4.0 V	5.0	5.5	6.0	V
		V_{CC} = 3.0 - 3.6 V, VBUSc(1) = 3.3 V	4.0		5.0	
t_{ON_VBUS}	Turn-on time on VBUS pin	V_{CC} = 3.0 - 3.6 V		1		ms
V_{ovp_th}	OVP VBUS threshold voltage	V_{CC} = 3.0 - 3.6 V	1.20	1.25	1.34	V
V_{hyst}	OVP VBUS voltage hysteresis	V_{CC} = 3.0 - 3.6 V		0.13		V
t_{ovp_VBUS}	OVP VBUS response time	Gate capacitance = 470 pF, V_{CC} = 3.0 - 3.6 V			100	ns

1. *VBUSc is the VBUS voltage as seen from USB-C connector between VBUS and GND.*

Table 6. Electrical characteristics – DB/ pin and CC lines OVP, T_{OP} = -40 °C to +85 °C

Symbol	Parameter	Test condition	Value			Unit
			Min.	Typ.	Max.	
R_{ON}	ON resistance of CC OVP FET	V_{CC} = 3.0 - 3.6 V			1.2	Ω
R_{ON_FLAT}	ON resistance flatness	0 - 1.2 V		5.0		mΩ
C_{ON_CC}	Equivalent ON capacitance	0 - 1.2 V, f = 400 kHz	40		100	pF
V_{CL_DB}	Dead battery clamp voltage	I = 200 µA			1.5	V
V_{TH_CC}	CC OVP threshold voltage	V_{CC} = 3.0 - 3.6 V	5.6	6.0	6.4	V
$V_{OVP\_CC\_H}$	CC OVP hysteresis	V_{CC} = 3.0 - 3.6 V		10		mV
t_ovp_cc	OVP response time on the CC pins (internal FET)	V_{CC} = 3.0 - 3.6 V			70	ns
BW_CCx	Bandwidth on CCx pins at -3dB	0 - 1.2 V	10			MHz
R_{DB_off}	Equivalent resistor when dead battery is OFF	V_{CC} = 3.0 - 3.6 V	170	300	460	kΩ

Table 7. Electrical characteristics – Fault reporting, T_{OP} = -40 °C to +85 °C

Symbol	Parameter	Test condition	Value			Unit
			Min.	Typ.	Max.	
t_{pd}	Propagation time from OVP, OTP or UVLO to FLT/	V_{CC} = 3.0 - 3.6 V	-	5	-	µs
R_{ON}	FLT/ pin resistance when active		-	250	-	Ω
R_{OFF}	FLT/ pin resistance when inactive		-	1	-	MΩ

4 Typical electrical characteristics curves

Note: T_{op} = 30 °C, V_{CC} = 3.3 V, SOURCE = 5 V, unless otherwise stated

Figure 4. CC line bandwidth: V_{cm} = 0 V

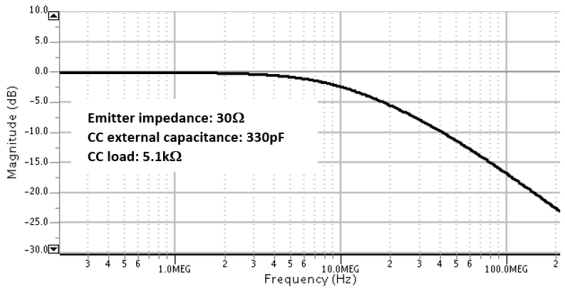


Figure 5. CC line bandwidth: V_{cm} = 1.2 V

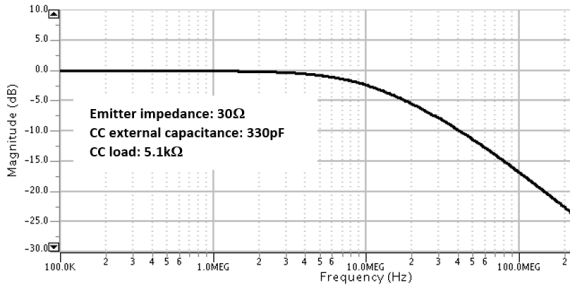


Figure 6. CCx digital communication (eye diagram performed on X-NUCLEO-USBPDM1 and NUCLEO-G071RB)

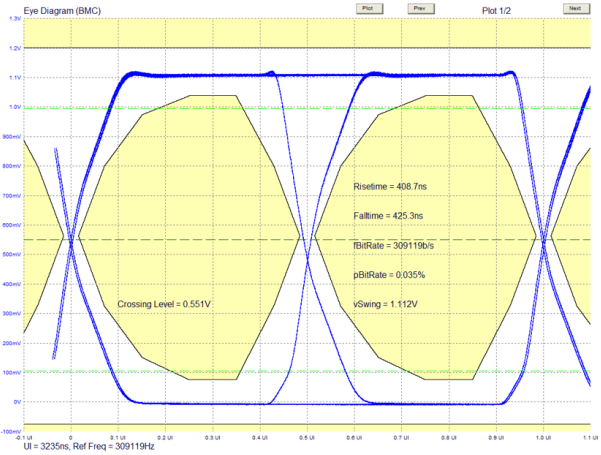


Figure 7. CC1c line short to VBUS (22 V) hot-plug via 1m of USB-C cable, sink configuration

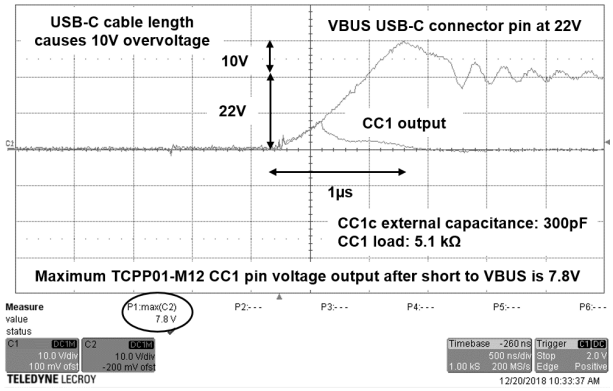


Figure 8. CC line leakage current vs ambient temperature at 5.5 V

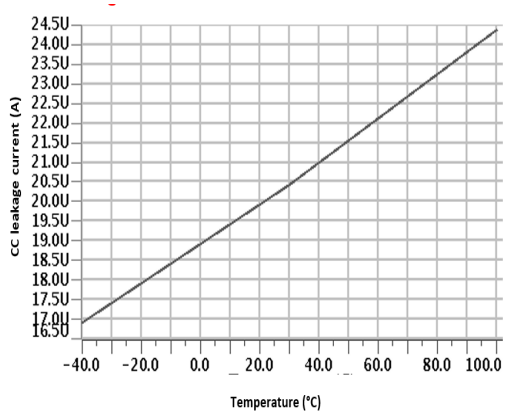


Figure 9. CC line attachment test setup

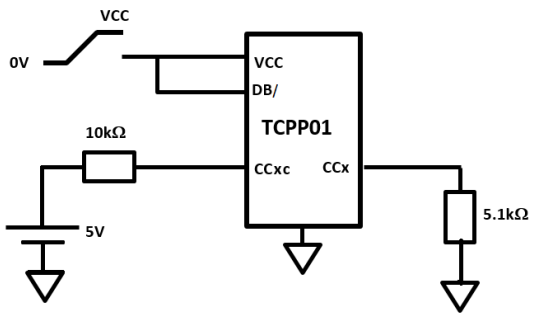


Figure 10. CC line attachment (source advertisement: 3 A at 5 V)

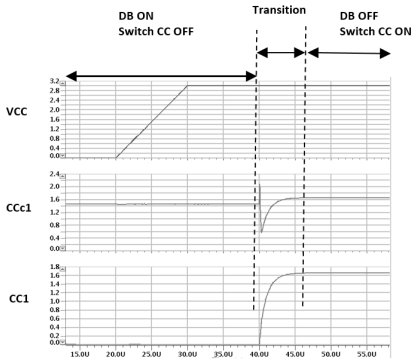


Figure 11. IEC61000-4-2 +8kV ESD applied on CC1c, response on CC1 pin

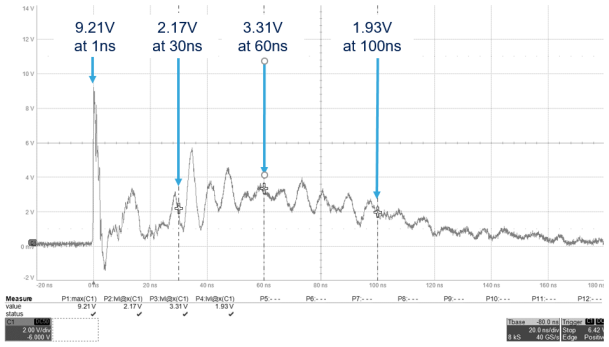


Figure 12. CCx line TLP curve (unpowered)

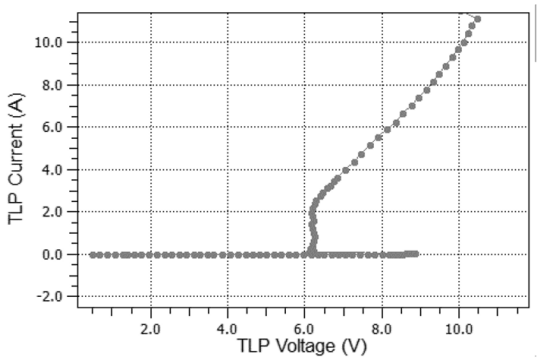


Figure 13. VBUS power-on at 5 V for a Sink device

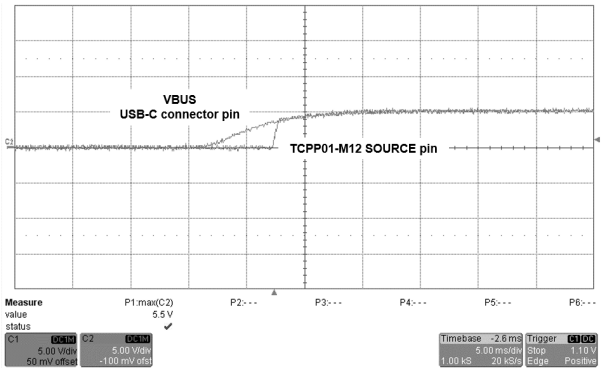


Figure 14. VBUS turn-off test setup

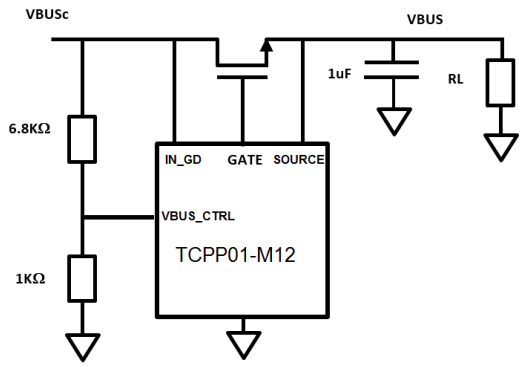
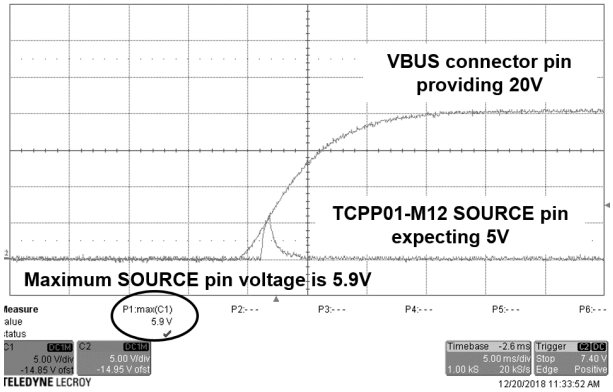


Figure 15. VBUS 5 V overvoltage protection (Sink configuration, 20 V applied on VBUS)



5 Application

5.1 General information

The sections below are not part of the ST product specification. They are intended to give a generic application overview to be used by the customer as a starting point for further implementations and customizations.

ST does not warrant compliance with customer specifications. Full system implementation and validation are under the customer's responsibility.

5.2 Electrical hazards related to USB Type-C

Applications using an USB Type-C connector must be protected against three kinds of hazards:

5.2.1 CC lines short to VBUS

This happens when VBUS high voltage short circuit to the CC lines when hot unplug is done with a poor mechanical quality connector. Over voltage protection is needed on the CC lines because VBUS typical voltage can be as high as 20 V when CC pins are usually 5 V tolerant I/Os on low voltage USB-PHY controllers.

5.2.2 Defective charger

VBUS line is compromised if a defective charger is stuck at a high voltage.

Overvoltage protection is always required on the VBUS line to prevent a voltage higher than negociated is applied on the VBUS.

This use case can occur even when power delivery is not used i.e when VBUS voltage is 5 V

5.2.3 Electrostatic discharge (ESD)

Electrostatic discharges can be conducted by the USB Type-C connector and damage the electronic circuitry of the application.

The ESD surge waveform is modelized by the international electrotechnical commission in the specification IEC61000-4-2.

For more information on IEC61000-4-2 standard testing, please refer to STMicroelectronics application note AN3353.

5.3 USB Type-C protection

Any application using an USB Type-C connector must use a Type-C port protection against above listed electrical hazards.

STMicroelectronics TCPP01-M12 (Type-C port protection housed in QFN12) is a single-chip cost effective solution to protect any application using a USB Type-C connector.

It is especially adapted to SINK (consumer) or SOURCE (provider) applications.

The TCPP01-M12 provides 20 V short-to-VBUS over-voltage and system-level ESD protection on CC lines, as well as adjustable over-voltage protection for the VBUS line: an external N-channel MOSFET gate driver is integrated inside TCPP01-M12.

Also, TCPP01-M12 integrates dead battery management logic.

For consumer (sink) configurations, TCPP01-M12 features a null quiescent current thanks to TCPP01-M12 VCC pin being directly controlled by a MCU GPIO in this configuration.

TCPP01-M12 is the companion chip for:

- any general purpose MCUs (example: STM32, STM8) used for USB-C charging applications exposed to defective charger and electrostatic discharge.
- any low voltage USB power delivery controller (for example: STM32-UCPD like STM32G0 and STM32G4), exposed to short to VBUS, defective charger and electrostatic discharge.

5.4 USB charging system scalability

Thanks to its simple implementation and system compliancy with both legacy USB charging and latest USB power delivery specification, USB-C applications using TCPP01-M12 can simply migrate from legacy USB charging (see Figure 19) to USB power delivery charging (see Figure 20) by simply swapping their STM32 from general purpose (for example: STM32L0) to general purpose + UCPD (example: STM23G0) and remove C1/C2 and add R5/R6 in the PCB to take benefit of the USB-C power delivery. Empty PCB footprints can be planned earlier in the design to allow this system scalability.

5.5 How to handle dead battery (DB) condition with the TCPP01-M12

Dead battery use case happens when a battery-operated sink (consumer or UFP) application has its battery fully depleted. In this case TCPP01-M12 enters into dead battery operation.

Dead battery behavior is basically a pull down (Rd) or a voltage clamp when a USB type-C source voltage is applied to CC. It is interpreted as a request by the sink to receive VBUS. It thus facilitates the charging of equipment with a fully depleted battery:

- It must be present in most cases
- It must not be present in the case of a (pure) type-C Source, for example a wall charger

The DB/ or 'dead battery resistor management' pin is a pulled-down active-low TCPP01-M12 input. The DB/ pin can be used in two ways:

- The DB/ pin is connected to VCC or
- The DB/ pin is driven by an MCU GPIO

As long as the DB/ pin is low or high-impedance (an internal 5 kΩ pull-down sets the level to ‘0’), the dead-battery resistors are connected and CC switches are open (OFF state).

When the DB/ pin is tied to VCC, the DB/ resistors are disconnected and CC OVP switches are closed (ON state).

DB/ usage in SINK (SNK) applications:

- After system power-up, the DB/ pin must be kept at 0. In this case Rd is enabled at TCPP01-M12 level.
- Once Rd is enabled in the UCPD (USB-C power delivery controller), the DB/ pin must be set to the logic level '1'

For DB/ usage in SRC or Source mode, the DB/ pin must be tied to V_{CC}.

Table 8. Dead battery logic states

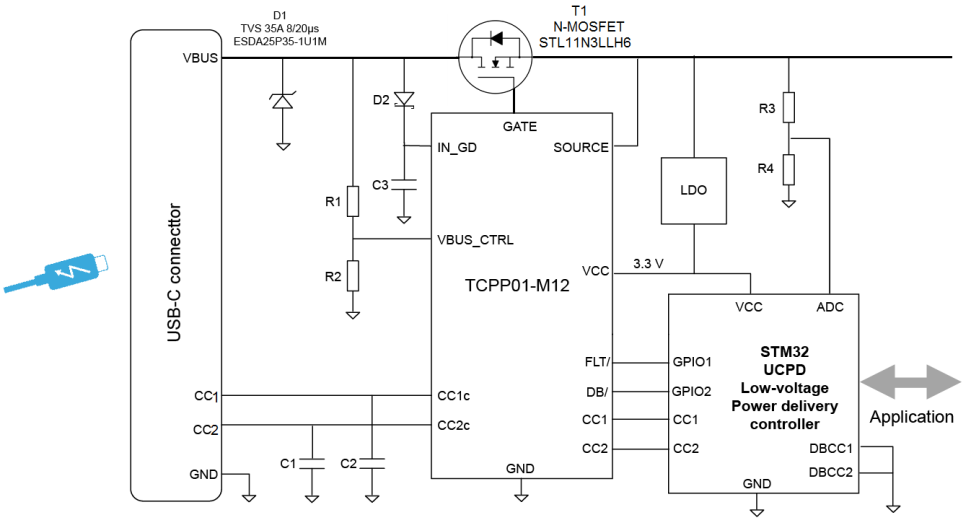
TCPP01-M12 VCC	TCPP01-M12 DB/	TCPP01-M12 DB clamp present	TCPP01-M12 CC1/CC2 OVP FET state	TCPP01-M12 DB function state
0	0	Yes	Open	Activated
0	1	Yes	Open	Activated
1	0	Yes	Open	Activated
1	1	No	Closed	Inactivated

Note: When STM32-UCPD boots, Rd seen on CC lines are coming from TCPP01-M12. When STM32-UCPD has wake-up, Rd from TCPP01-M12 are disconnected and STM32-UCPD set Rd on CC lines from UCPD IP

5.6 Application example for USB type-C power delivery for sink (consumer), PPS compliant, without battery

In this application case, the system is solely powered via the USB-C connector.

Figure 16. Sink applications, without battery, PPS compliant



5.6.1 ESD capacitor (C3)

The system-level ESD capability of the TCPP01-M12 depends on this capacitor. The two constraints about it is a minimum of 35 V DC rated voltage and an ESL (equivalent serial inductance) as low as possible.

A 50 V X7R 100 nF capacitor is strongly recommended to improve the derating performance (X7R capacitance decreases as it voltage increases). ST recommends to choose a capacitor size equal or lower than 0603.

Table 9. Capacitance specification

Capacitor size	Part number
0603	CC0402KRX7R9BB104
0402	GRM188R71H104KA93D

5.6.2 CC line capacitance (C1, C2)

USB PD has a specification for the total amount of capacitance for proper operation on CC lines. This specification is given here after.

Table 10. USB type-C power delivery specification

Description	Min.	Max.
CC receiver capacitance	200 pF	600 pF

Therefore, the capacitance added by the TCPP01-M12 and by the MCU or low voltage controller must fall within these limits. The next table shows the analysis involved in choosing the correct external capacitor for the system.

Table 11. CC line capacitance budget analysis

CC capacitance	Min.	Max.	Comment
CC line target capacitor	200 pF	600 pF	From USB PD Specification Section 5.8.6
TCPP01-M12 CC1c, CC2c capacitance	40 pF	100 pF	
MCU capacitance	60 pF	90 pF	Typical value. To be adapted following the exact reference used
Proposed capacitance C1, C2	120 pF	390 pF	25 V DC min. of rated voltage 0402 or smaller recommended

5.6.3 Sense resistor (R1, R2)

VBUS OVP triggers when VBUS_CTRL pin rises above 1.25 V typical. Choose R1 from any value between 5 kΩ and 10 kΩ and calculate R2 as follows:

$$R2 = \frac{R1}{\frac{VBUScMAX}{VBUS\_CTRL} - 1}$$

With:

- R1 = arbitrary resistor between 5-10 kΩ
- VBUScMAX = desired VBUS OVP threshold level
- VBUS_CTRL = 1.25 V (typical)

5.6.4 N-channel MOSFET (T1)

The TCPP01-M12 ensures a V_{GS} voltage between 5 V and 6 V when the N-channel MOSFET is ON: choose a N-channel MOSFET fully specified (for example: STL11N3LLH6) with 5 V of V_{GS}. Maximum current in USB-PD applications can raises up to 5 A.

5.6.5 Complementary products for USB dataline protection for pins DP, DM, SSRX, SSTX

For applications requiring USB dataline protection, STMicroelectronics recommends the implementation shown in picture below:

Figure 17. **USB dataline protection for pins DP, DM, SSRX, SSTX**

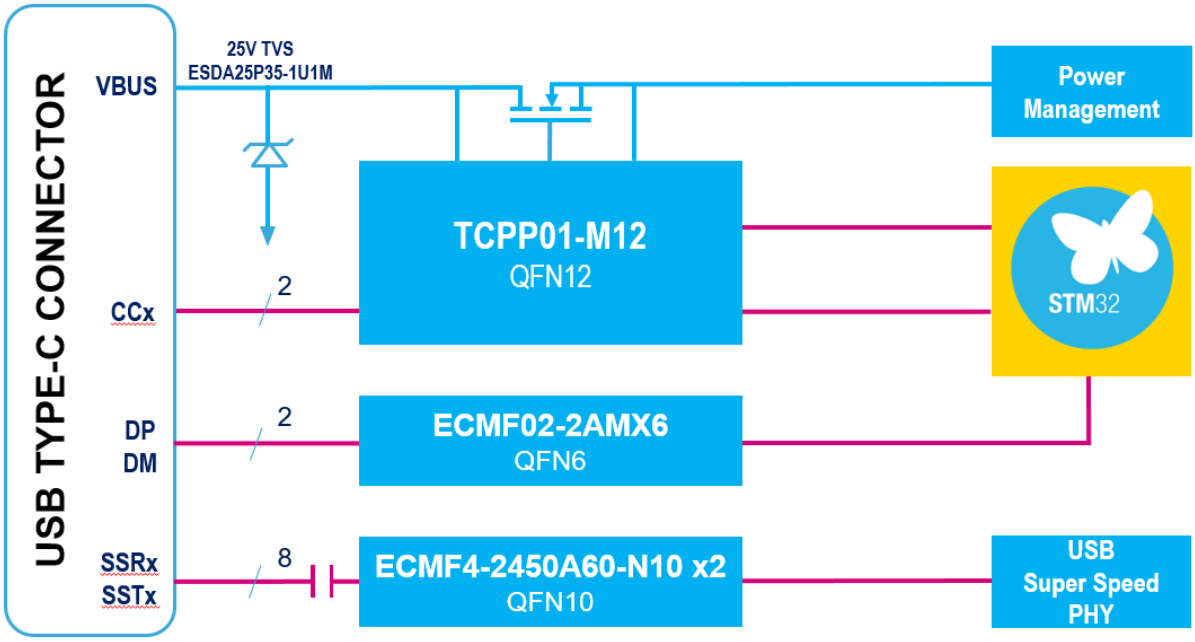


Table 12. **Product recommendations**

Part Number	Description	USB-C connector pin	Protection features
TCPP01-M12	Type-C Port Protection	VBUS, CC1, CC2	ESD protection as per IEC61000-4-2 Level 4 Overvoltage on VBUS CC lines short to VBUS
ESDA25P35-1U1M	Power line transient voltage suppressor	VBUS	ESD protection as per IEC61000-4-2 Level 4 IEC61000-4-5 (8/20µs surge waveform)
ECMF02-2AMX6	Common Mode Filter with integrated ESD protection	D+, D-	ESD protection as per IEC61000-4-2 Level 4 RF antenna desense due to high speed differential link EMI radiation
ECMF4-2450A60N10 (x2)	Common mode filter with integrated ESD protection	TX1+, TX1-, RX1+, RX1- TX2+, TX2-, RX2+, RX2-	ESD protection as per IEC61000-4-2 Level 4 RF antenna desense due to high speed differential link EMI radiation

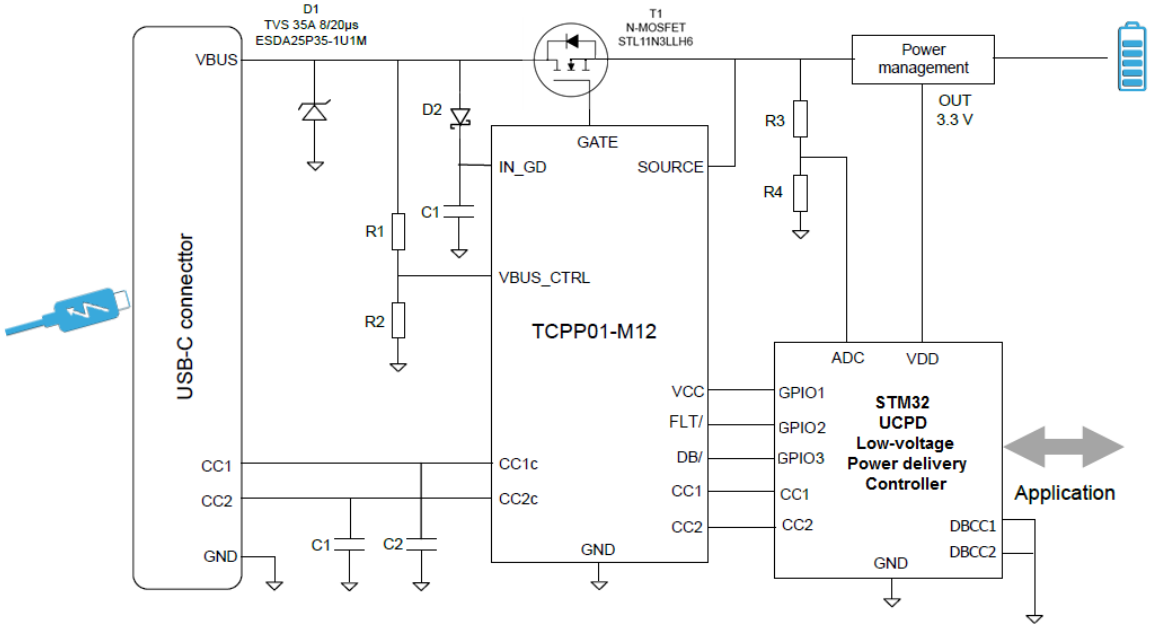
For more information on USB Type-C protection for datalines, please refer to AN4871, USB Type-C protection and filtering.

For more information on RF antenna desense due to high speed differential link EMI radiation, please refer to AN4356, Antenna desense on handheld equipment.

5.7 Typical USB-C battery powered application

In this application use case, the system is typically powered by embedded batteries and the USB connector is used to recharge them.

Figure 18. Sink PD3.0 applications, with battery



Compared to the previous case, the TCPP01-M12 is now powered via GPIO1: This is possible thanks to the very low TCPP01-M12 biasing current (120 µA worst case). In this configuration, the TCPP01-M12 consumes power only during USB attachment. An attachment condition is detected via resistors R3 and R4.

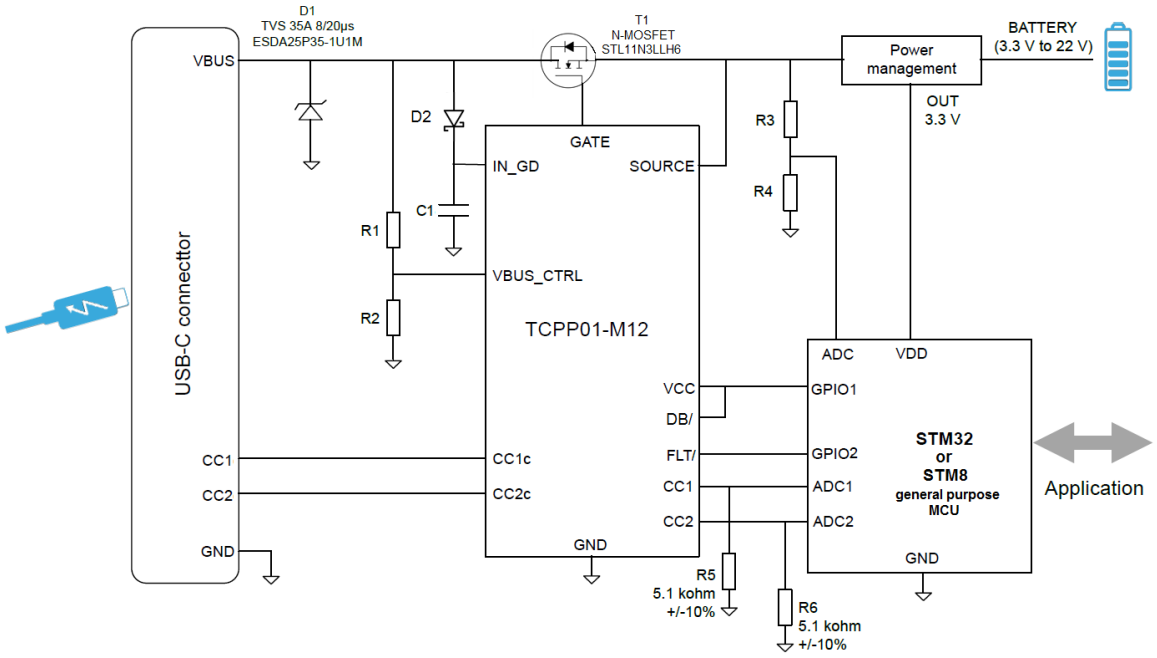
Once a source has detected a SINK attachment, it releases automatically 5 V / 0.5 A on the VBUS. This voltage is detected by the TCPP01-M12 and it turn-on the N-channel MOSFET T1 (needed power is drawn from IN_GD pin). As the VBUS voltage increases, the attachment is detected through ADC.

In the Figure 18, the D1 diode ESDA25P35-1U1M is used to comply with the International electrotechnical commission specification IEC61000-4 on the VBUS power line when it is subjected to switching and lightning transients. For more information, please refer to AN4275: IEC61000-4-5 standard overview.

Please refer to AN5225 for more informations related to USB Type-CTM power delivery using STM32xx Series MCUs and STM32xxx Series MPUs.

For more information on EMI filtering and ESD protection of USB datalines, please refer to AN4871: USB Type-C protection and filtering.

Figure 19. 15 W sink applications, with battery and general purpose MCU (for example: STM32 or STM8)



When the power delivery protocol is not used, the TCPP01-M12 is used for protection against defective charger, ESD protection and dead battery management. The MCU can be an STM8 or any STM32 featuring at least 3 ADCs. The power profile is defined by the pull-down resistors on CC lines on the Sink side and pull-up resistors on the Source side. Cf p:47/56 of AN5225 “USB Type-C™ Power Delivery using STM32xx Series MCUs and STM32xxx Series MPUs”.(AN5225).

Note: In dead battery condition the sequence below applies:

- *TCPP01-M12 dead battery present clamp (1.1 V) on CC1 and CC2 lines*
- *The source detects the clamp presence and applies 5 V on VBUS*
- *The N-channel MOSFET (T1: STL11N3LLH6) switches to ON state and supplies the application's power management with 5 V*
- *The MCU wakes-up and applies 3.3 V on GPIO1: this wakes up the TCPP01-M12*
- *The TCPP01-M12 removes its clamp on the CC lines so that ADC1 or ADC2 can sense the SOURCE power capability with the voltage across R5 or R6 (both resistors are needed)*

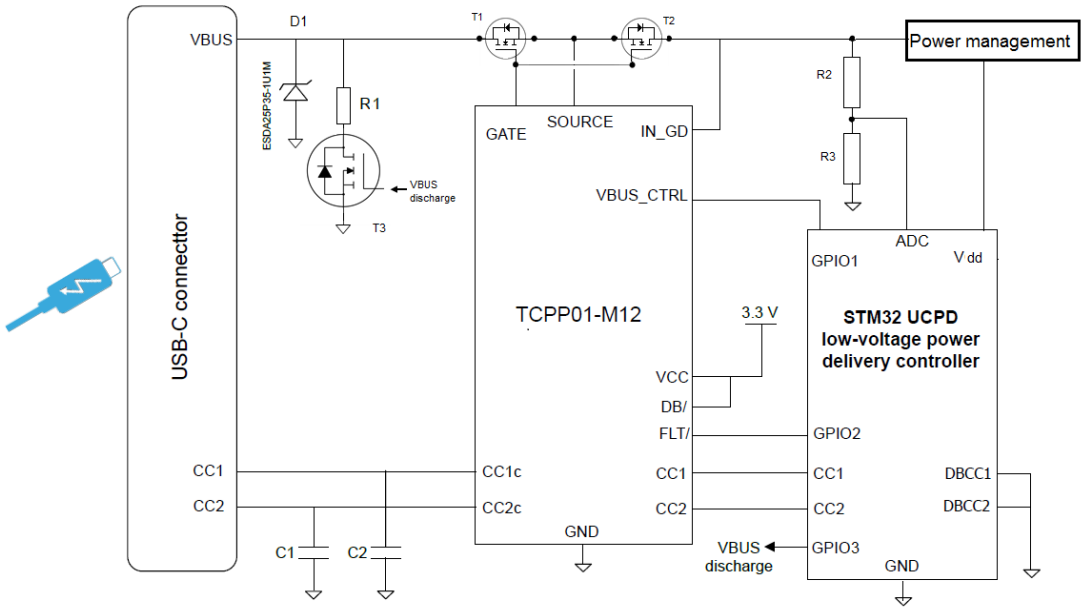
5.8 Typical USB-C source application

SOURCE applications differ from SINK by the following ways:

- TCPP01-M12 dead battery function is no more needed, it must be disabled. It is done by connecting the TCPP01-M12 DB/ signal to V_{CC}.
- Now, it is the MCU which detects an attachment condition and controls the VBUS turn ON / turn OFF.
- Finally, an over-current protection is mandatory on VBUS

Note that the proposed design does not provide V_{CONN} switches. As a consequence, it can handle low speed, full speed, high speed, super speed USB data rate and SOURCE current is limited to 3 A (no active cable support).

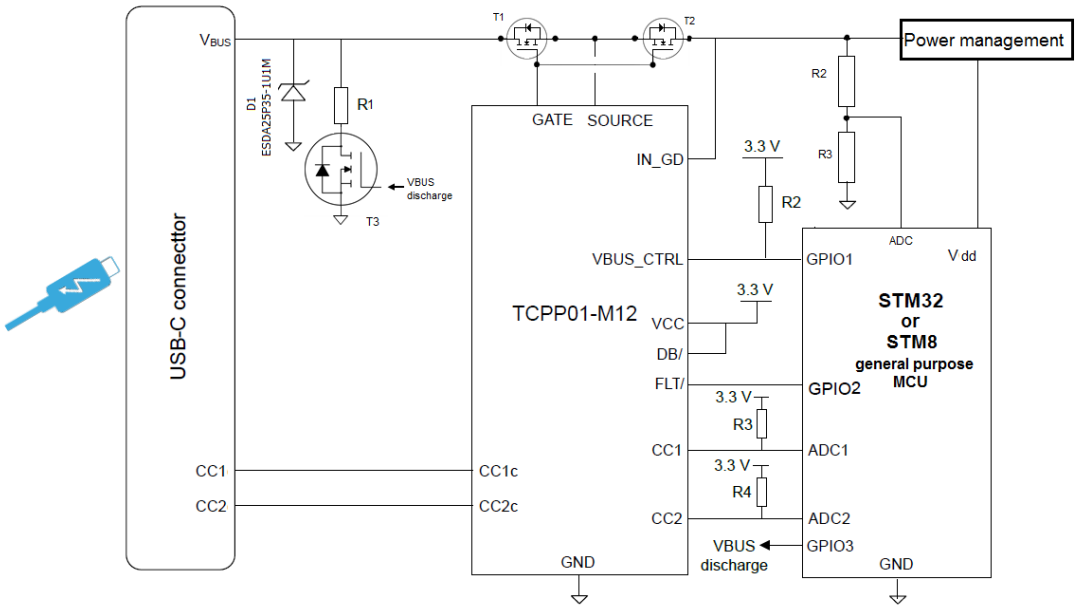
Figure 20. Source application with programmable power supply (PD3.0 specification)



- FLT/ (FAULT) is an open-drain output pin.
- DB/ is a pull-down TCPP input. Connect to 3.3 V if not managed by MCU software.

When the VBUS_CTRL pin is tied to VCC, VBUS N-channel MOSFETs (T1 and T2) are open.
Else, when the VBUS_CTRL pin is tied to GND, N-channel MOSFETs (T1 and T2) are closed.

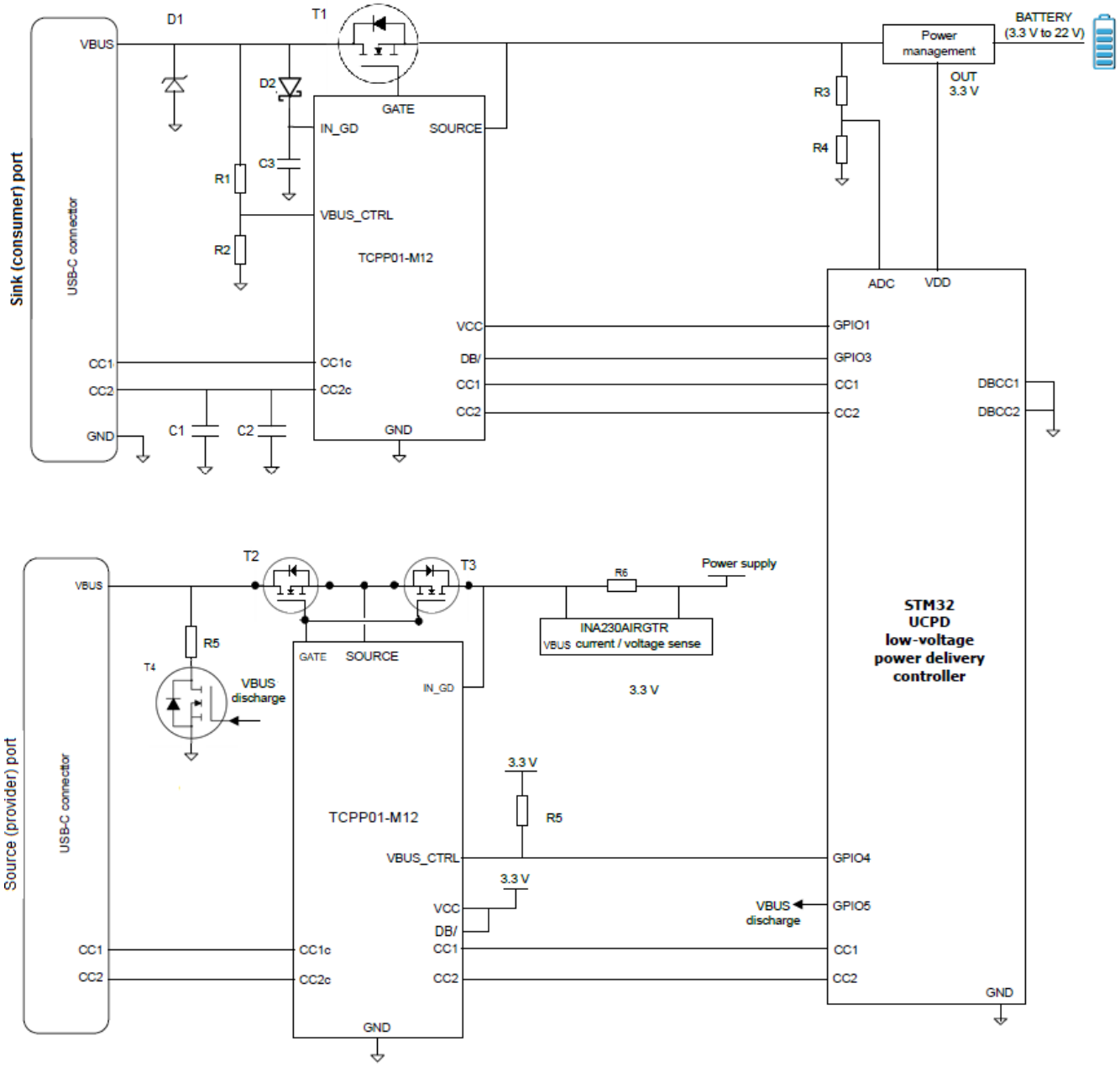
Figure 21. 15 W source applications with STM8/32 general purpose MCU (for example: STM8 or STM32)



- VBUS_CTRL turns the VBUS N-channel MOSFETs to ON-state when needed (the N-channel MOSFETs are normally-off due to the pull-up resistor R2)
- Dead battery resistors are not presented by TCPP01-M12

5.9 Sink-source application example based on STM32G0 (with two UCPD ports)

Figure 22. **Sink-source solution**



6 PCB design recommendations

When routing the TCPP01-M12, please respect the following recommendations:

- Place the circuit as close as possible of the USB connector
- Place the ESD capacitor as close as possible of the TCPP01-M12

An example of routing with two layer board is shown here after.

For more informations on ESD protection layout and placement, please refer to AN576: PCB layout optimization.

Figure 23. layer board for sink mode

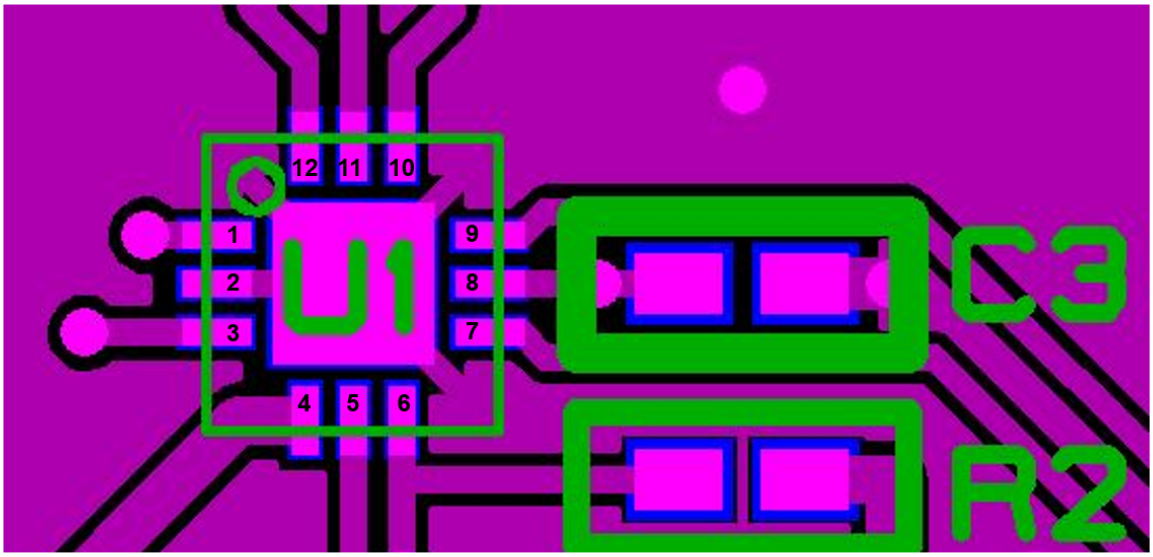
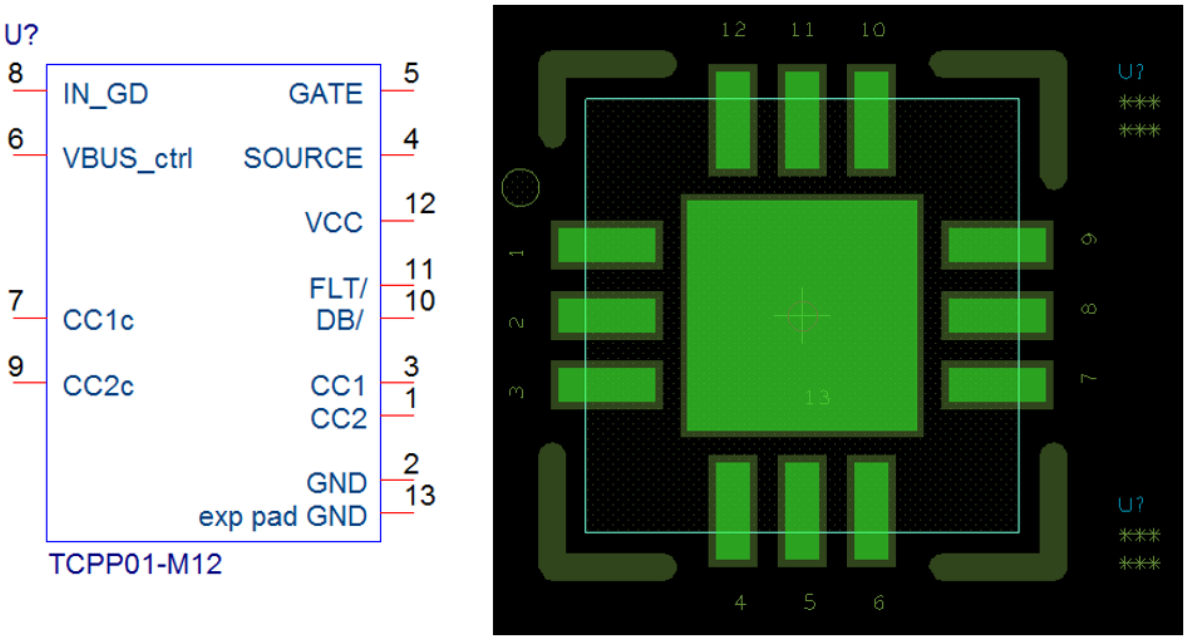


Figure 24. TCPP01-M12 symbol and footprint



7 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

7.1 QFN12 package information

Figure 25. QFN12 package outline

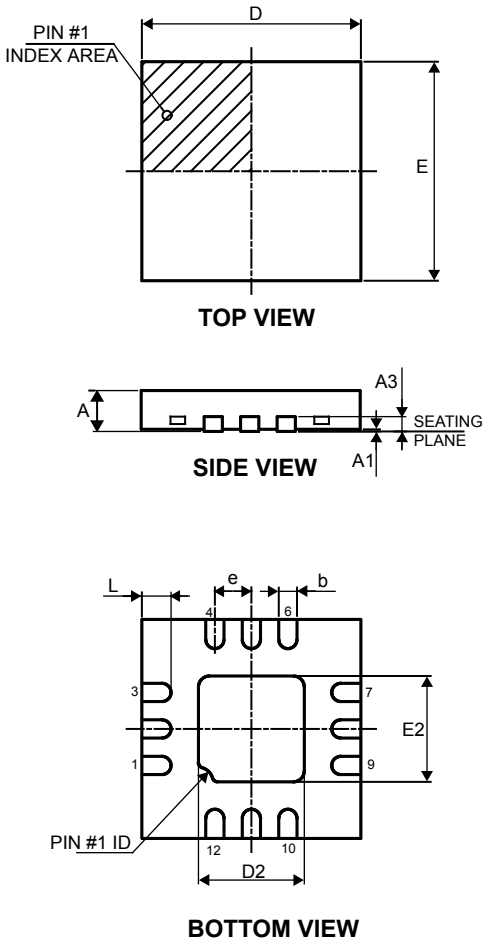


Table 13. **QFN12 package mechanical data**

Ref.	Dimensions		
	Millimeters		
	Min.	Typ.	Max.
A	0.80	0.90	1.00
A1	0.00	0.02	0.05
A3		0.20	
b	0.18	0.25	0.30
D	2.95	3.00	3.05
E	2.95	3.00	3.05
D2	1.30	1.45	1.55
E2	1.30	1.45	1.55
e		0.50	
K	0.20		
L	0.30	0.40	0.50

Figure 26. **QFN12 recommended footprint**

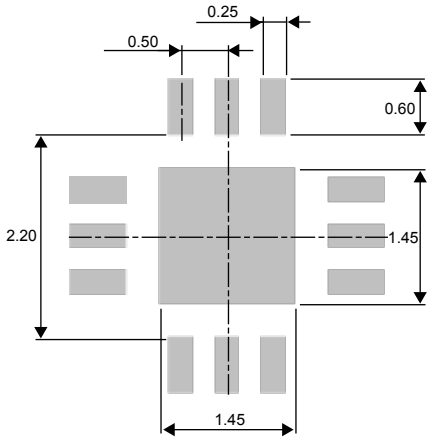
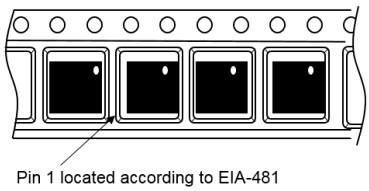


Figure 27. **Package orientation in reel**



Note: Pocket dimensions are not on scale
Pocket shape may vary depending on package

Figure 28. **Tape and reel orientation**

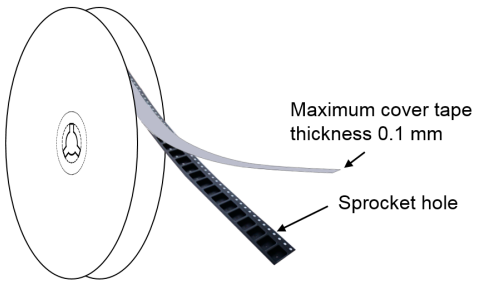


Figure 29. **Reel dimensions (mm)**

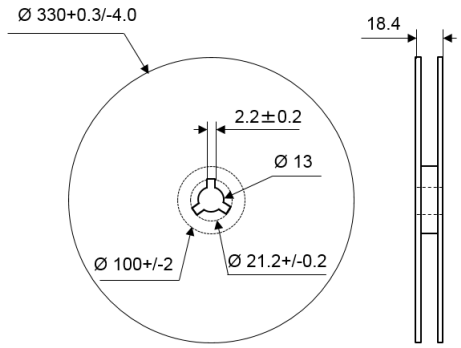


Figure 30. **Inner box dimensions (mm)**

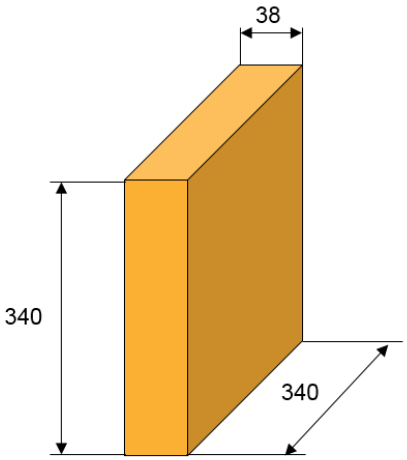
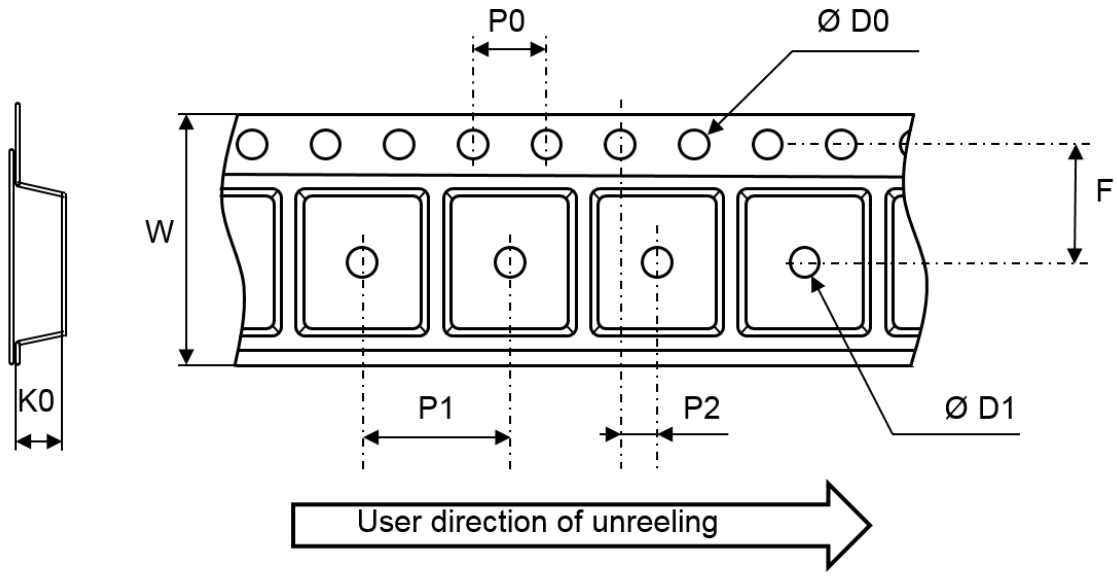


Figure 31. **Tape and reel outline**



Note: Pocket dimensions are not on scale
Pocket shape may vary depending on package

Table 14. **Tape and reel mechanical data**

Ref.	Dimensions		
	Millimeters		
	Min.	Typ.	Max.
D0	1.50	1.55	1.60
D1	1.50		
F	5.45	5.50	5.55
K0	1.00	1.10	1.20
P0	3.90	4.0	4.10
P1	7.90	8.00	8.10
P2	1.95	2.00	2.05
W	11.70	12.00	12.30

8 Ordering information

Table 15. **Ordering information**

Order code	Marking	Package	Weight	Base qty.	Delivery mode
TCPP01-M12	TCPP	QFN12	23 mg	3000	Tape and reel

Revision history

Table 16. **Document revision history**

Date	Revision	Changes
06-Sep-2019	1	Initial release.