Getting started with the X-NUCLEO-SNK1M1 USB Type-C® Power Delivery Sink expansion board based on TCPP01-M12 for STM32 Nucleo

Introduction

The X-NUCLEO-SNK1M1 expansion board allows evaluating the features of TCPP01-M12 and the USB Type-C® overvoltage protection for V_{BUS} and CC lines suitable for Sink applications.

The expansion board is designed to be stacked on top of any STM32 Nucleo-64 development board exploiting the characteristics of the USB Type-C® and Power Delivery (UCPD) peripheral embedded in their microcontrollers.

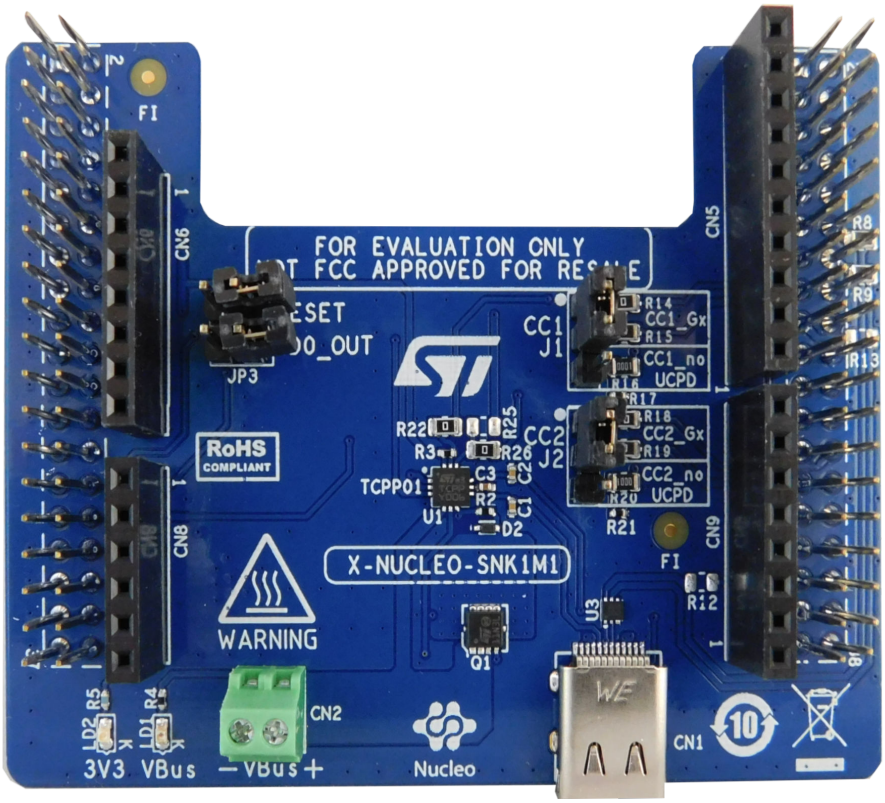
It can also be stacked on other STM32 Nucleo development boards not supporting the UCPD peripheral to demonstrate the USB Type-C® basic operations (attach, detach and power supply current capability recognition).

The X-NUCLEO-SNK1M1 provides an effective demonstration of the dead battery operation, thanks to the integrated ST715PU33R LDO linear regulator that supplies the connected STM32 Nucleo development board when a Source is attached via a USB Type-C® connector.

The X-NUCLEO-SNK1M1 is compliant with the latest USB Type-C® and Power Delivery specifications and is also USB-IF certified as a 100 W solution supporting Programmable Power Supply (PPS) function.

The companion software package (X-CUBE-TCPP) contains the application examples for development boards embedding UCPD-based microcontrollers (NUCLEO-G071RB, NUCLEO-G474RE and NUCLEO-G0B1RE) and for non-UCPD ones (NUCLEO-L412RB-P).

Figure 1. X-NUCLEO-SNK1M1 expansion board



Note: *Before running any demo, set CC1 J1, CC2 J2, JP3 and JP4 jumpers according to the configuration described in Section 1.3: Demo application setup.*

Notice: *For dedicated assistance, please submit a request through our online support portal at* ***www.st.com/support.***

1 Getting started

1.1 Overview

The X-NUCLEO-SNK1M1 expansion board features:

- On-board TCPP01-M12 protection for USB Type-C® and PD Sink applications
- Compliant with the latest USB Type-C® and Power Delivery specification, including the Programmable Power Supply (PPS) feature
- USB-IF certified (Test ID certification: 5205)
- 100 W-rated solution
- 6 V overvoltage protection (OVP) on CC lines against short-to-V_{BUS} when the connector is unplugged
- Up to 22 V adjustable overvoltage protection (OVP) on V_{BUS} line against charger failure
- Surge protection (8/20 µs) and system-level ESD protection on V_{BUS}
- Common mode filter and ESD protection on USB 2.0 High Speed data lines
- System level ESD protection on CC lines as per IEC61000-4-2 level 4 (±8 kV contact discharge)
- Low power mode for battery operation allowing zero current consumption when no cable is attached
- Integrated dead battery management when the device battery is fully depleted
- Overtemperature protection (OTP)
- RoHS compliant

1.2 Hardware architecture

The X-NUCLEO-SNK1M1 expansion board is designed to be used with any STM32 Nucleo-64 development board embedding the UCPD peripheral (mainly NUCLEO-G071RB, NUCLEO-G474RE and NUCLEO-G0B1RE) and also with the ones not supporting the UCPD peripheral.

Note: The compliance with the USB Type-C® and Power Delivery specification is guaranteed only for the STM32 Nucleo development boards embedding the microcontrollers (STM32G071RB and STM32G474RE) with a UCPD peripheral.

When stacked with a non-UCPD STM32 Nucleo development board, the X-NUCLEO-SNK1M1 can still demonstrate some USB Type-C® basic operations like ATTACH/DETACH recognition and identification of source current capability.

Moreover, two couples of resistances, used as solder bridge selectors, allow exploiting the USB2.0 peripheral.

The expansion board must be plugged on the matching pins of the development board CN7 and CN10 ST morpho connectors.

When plugged onto an STM32 Nucleo development board, the expansion board can be supplied in two different ways:

- by the STM32 Nucleo ST-LINK supply using the development board internal LDO
- by the V_{BUS} provided when a Source is plugged into the CN1 USB Type-C® connector and thanks to the integrated ST715PU33R LDO linear regulator (U2) that supplies the entire system, which supports Dead Battery operation mode.

Figure 2. X-NUCLEO-SNK1M1 main functional blocks (top view)

1. Morpho connector (CN7)
2. Arduino connector (CN6, CN8)
3. Reset jumper (JP4)
4. LDO OUT jumper (JP3)
5. 3V3 LED (LD2)
6. V_{BUS} LED (LD1)
7. Power connector (CN2)
8. TCPP01-M12 USB-C overvoltage protection for VBUS and CC lines (U1)
9. BAT54K Schottky diode (D2)
10. CC1 line configuration jumper (J1)
11. CC2 line configuration jumper (J2)
12. USB data setting resistor (R12)
13. ECMF02-2AMX6 common-mode filter and ESD protection for USB 2.0 and MIPI/MDDI interfaces (U3)
14. USB Type-C® connector (CN1)
15. STL11N3LLH6 N-channel 30 V, 6 mOhm typ., 11 A STripFET H6 Power MOSFET (Q1)
16. Arduino connector (CN5, CN9)
17. Morpho connector (CN10)
18. USB data setting resistor (R8, R9)
19. USB data setting resistor (R13)

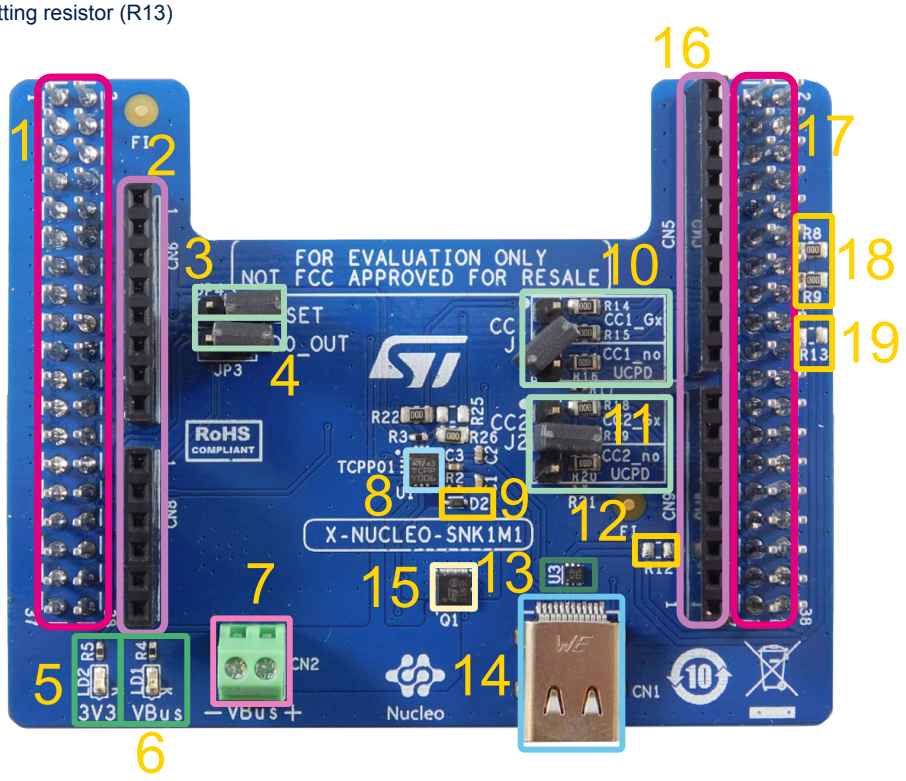
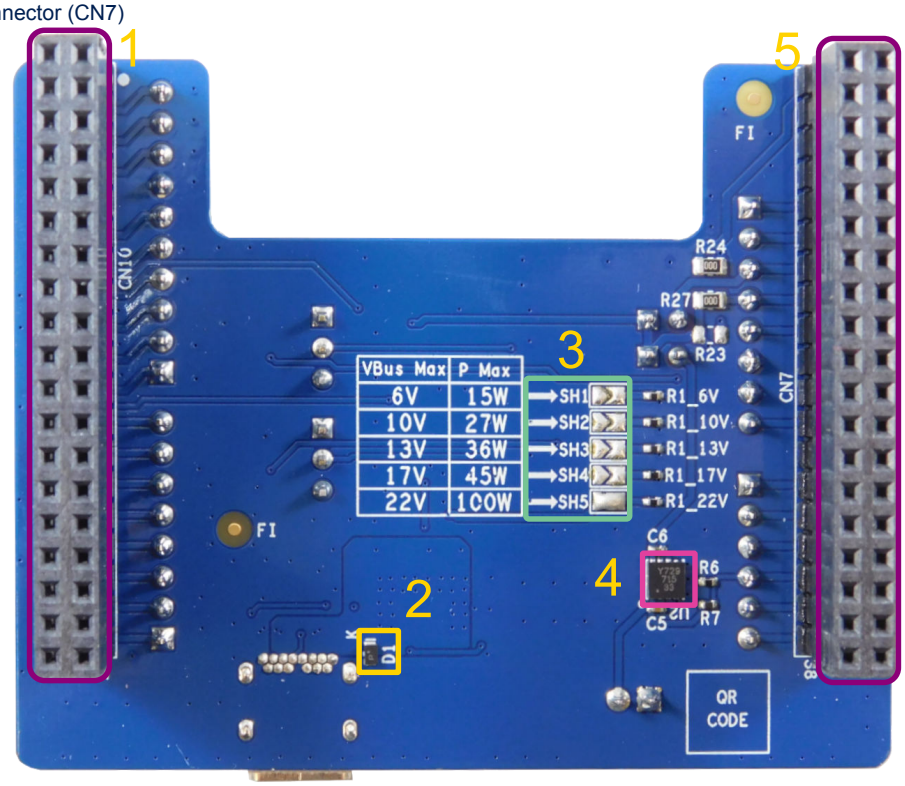


Figure 3. X-NUCLEO-SNK1M1 main functional blocks (bottom view)

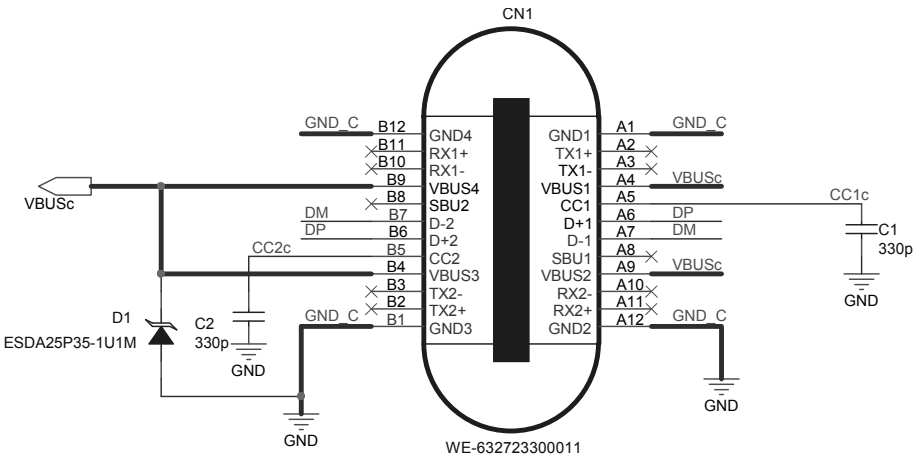
1. Morpho connector (CN10)
2. ESDA25P35-1U1M TVS diode (D1)
3. OVP threshold solder bridges (SH1, SH2, SH3, SH4, SH5)
4. ST715PU33R high input voltage LDO linear regulator (U2)
5. Morpho connector (CN7)



1.2.1 USB Type-C® connector

The USB Type-C® receptacle (CN1) gathers the V_{BUS} path and the main connections, such as CC lines and USB2.0 data lines (DP, DM), before dispatching data to the major functional blocks.

Figure 4. Type-C receptacle (CN1) and ESDA25P35-1U1M TVS diode (D1)



Note: V_{BUS} path capacitive value should be included between 1 µF and 10 µF for a USBPD SINK port design.

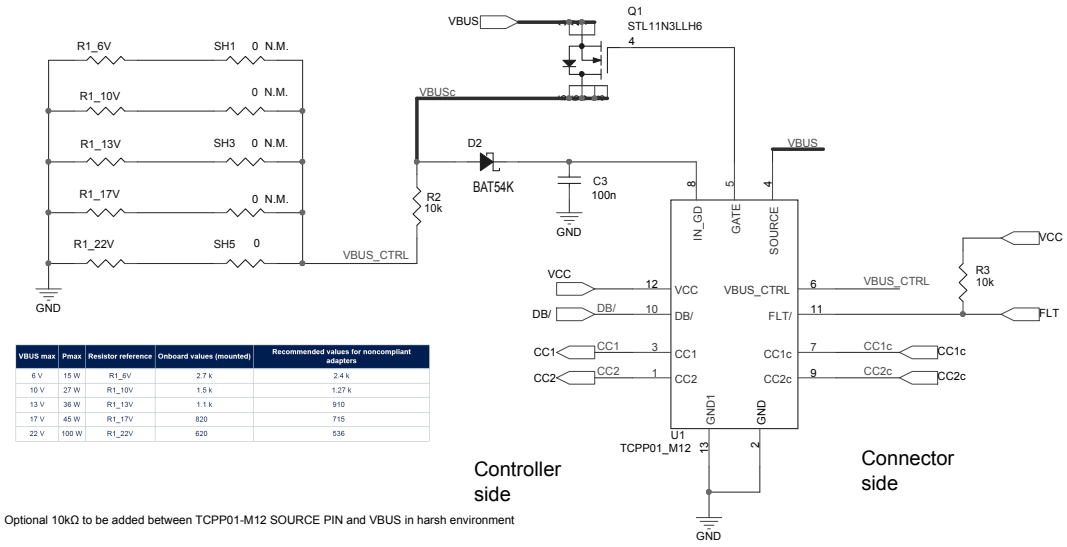
An ESDA25P35-1U1M TVS diode has been integrated to protect the V_{BUS} power line and, consequently, the entire system against EOS and ESD transients when a Source is connected through the USB Type-C® cable.

1.2.2 TCPP01-M12 USB Type-C® protection and V_{BUS} overvoltage protection setup

TCPP01-M12 (U1) protects the CC1 and CC2 pins of the USB Type-C® and PD controller sink against overvoltage in case a short-circuit event with the V_{BUS} occurs during the attach or detach operation with a defective tool.

The protection is implemented by removing the USB Type-C® cable from its receptacle.

Figure 5. TCPP01-M12 protection (U1) driving the STL11N3LLH6 MOS (Q1)



TCPP01-M12 overvoltage protection (OVP) threshold setup mechanism is based on a resistive network composed of five resistors (R1_6V, R1_10V, R1_13V, R1_17V and R1_22V) and five solder bridges (SH1, SH2, SH3, SH4, and the SH5). Connected to the device through the BAT54K signal Schottky diode (D2), this section is shown in the figure above (left side) and is placed at the board bottom.

On the X-NUCLEO-SNK1M1 expansion board, the 22 V OVP threshold is set by default via SH5. To change the threshold to another value (6, 10, 13 or 17 V), remove SH5 and add a different solder bridge on the selected OVP voltage.

When a defective power source plugged onto the Type-C connector produces a voltage higher than the selected OVP threshold, the TCPP01-M12 OVP mechanism controls the external MOSFET Q1 and interrupts the V_{BUS} line.

The current X-NUCLEO-SNK1M1 setup is compliant with the USB Type-C® and Power Delivery specifications. It is certified by USB-IF, with TID certification no. 5205.

However, some USB Type-C® adapters and equipment, which are not compliant with the specification, might latch the solution to overvoltage when connected to it. This is due to the generation of an initial spike that is very close to the OVP upper limit.

In such occurrences, we suggest replacing the resistance values according to the values reported in the table below, in the “Recommended resistor” column.

Table 1. Resistor values

VBUS max	Pmax	Resistor reference	Onboard values (mounted)	Recommended values for noncompliant adapters
6 V	15 W	R1_6V	2.7 k	2.4 k
10 V	27 W	R1_10V	1.5 k	1.27 k
13 V	36 W	R1_13V	1.1 k	910
17 V	45 W	R1_17V	820	715
22 V	100 W	R1_22V	620	536

This new set of resistors still filters against voltage spike at startup, but do not latch the OVP.

You can use several Q1 MOSFET references with various tradeoffs on the key parameters: the size for the PCB surface, $R_{DS(on)}$ for the static drain-source on-resistance insertion losses and V_{DS} for the maximum drain-source voltage when the surge is clamped by the TVS diode (D1).

The dual Q1 MOSFET (back-to-back configuration) is required if the voltage is maintained on the consumer path when there is no V_{BUS} voltage.

Table 2. N-MOSFET performance tradeoff

Order code	N-MOSFET	Package		$R_{DS(on)}$ typ.	V_{DS} max.
STL6N3LLH6	Single	PowerFLAT 2x2	Single island	32 mΩ	30 V
STL11N3LLH6	Single	PowerFLAT 3.3x3.3	Single island	8.4 mΩ	30 V
STL260N4LF7	Single	PowerFLAT 5x6	Single island	1.2 mΩ	40 V
STL40DN3LLH5	Dual	PowerFLAT 5x6	Dual island	20 mΩ	30 V
STL105DN4LF7AG	Dual	PowerFLAT 5x6	Dual island	5.3 mΩ	40 V

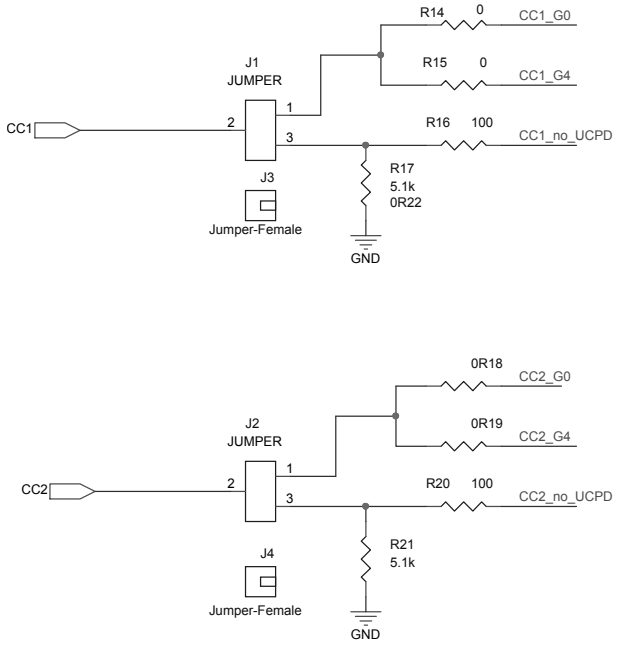
In harsh environment, a 10kΩ resistor may be needed between the TCPP01-M12 SOURCE PIN and VBUS to prevent damage to the TCPP01-M12. This additional resistor does not affect the normal operation of the TCPP01-M12.

1.2.3 CC lines and configuration jumpers

Two headers for jumpers (J1 and J2) have been integrated to change the CC lines paths from the TCPP01-M12 protection to the ST morpho connectors (CN7 and CN10) on the STM32 Nucleo development board, setting them differently according to the peripheral mapping of the STM32 microcontroller.

This integration guarantees the solution flexibility support for the demo across the STM32 Nucleo-64 development board range.

Figure 6. CC line configuration jumpers



The table below shows the jumper settings to configure the X-NUCLEO-SNK1M1 to work with the STM32 Nucleo development boards embedding the UCPD peripherals (NUCLEO-G071RB, NUCLEO-G474RE and NUCLEO-G0B1RE) as well as with other STM32 Nucleo-64 boards (NUCLEO-L412RB-P) implementing the USB Type-C® attach-detach recognition mechanism.

Table 3. **J1 and J2 CC lines configuration setting jumpers**

Compatible STM32 Nucleo boards	Jumpers	
	CC1 - J1	CC2 -J2
Any STM32 Nucleo-64 development board with UCPD (NUCLEO-G071RB, NUCLEO-G474RE and NUCLEO-G0B1RE)		
Any STM32 Nucleo-64 development board without UCPD (NUCLEO-L412RB-P)		

When both configuration jumpers (J1 and J2) are set to positions 1-2, the board is compatible with NUCLEO-G071RB, NUCLEO-G474RE and NUCLEO-G0B1RE offering the UCPD peripheral.

This association permits to fully demonstrate the main characteristics of the USB Type-C® and Power Delivery standards implemented by the demo application example.

When J1 and J2 are both set to positions 2-3, the X-NUCLEO-SNK1M1 can match any STM32 Nucleo-64 development board, demonstrating the basic mechanism of the Type-C specification, thanks to two pull-down resistors (R17 and R21) connected to the pins working as CC lines, allowing the Sink USB Type-C® operations to run with any attached Source.

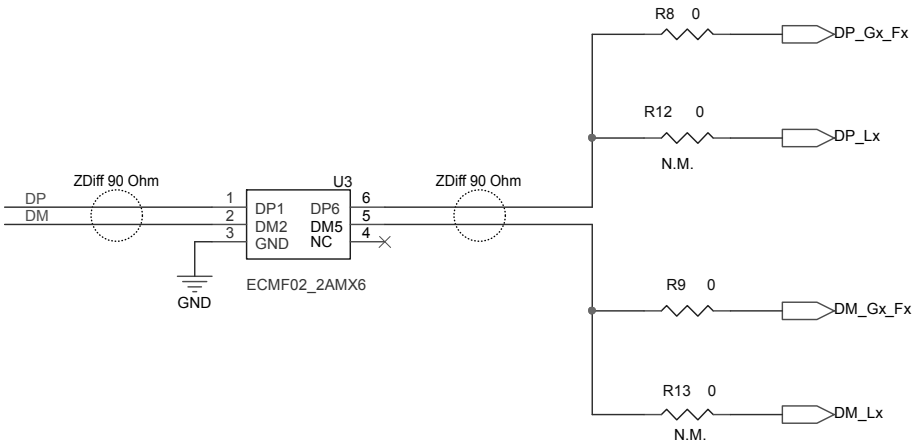
1.2.4 USB 2.0 data path and configuration setting

The X-NUCLEO-SNK1M1 expansion board allows STM32 Nucleo development boards that feature a USB2.0 peripheral to expose the D+/D- lines on the USB Type-C® receptacle (CN1).

Most STM32 Nucleo-64 development boards feature this functionality on the ST morpho connector CN10-12 and CN10-14 pins, whereas NUCLEO-L412RB-P, NUCLEO-L433RC-P, NUCLEO-L452RE-P and NUCLEO-L476RG boards map USB2.0 data pins on CN10-33 and CN10-17 pins.

Two couples of resistances has been implemented and connected to the ECMF02-2AMX6 (U3) USB2.0 data lines protection to extend the use of this peripheral to all the STM32 Nucleo-64 development boards.

Figure 7. **USB2.0 data lines protection ECMF02-2AMX6 (U3) and resistor setup**

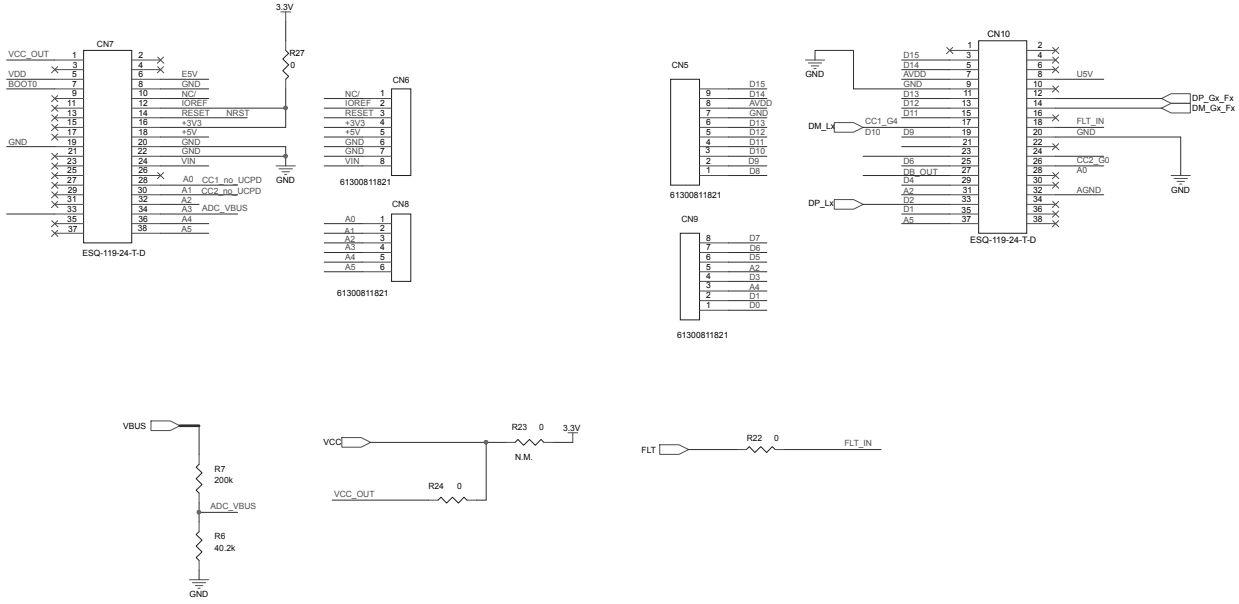


By default, the X-NUCLEO-SNK1M1 board mounts R8 and R9 resistors fitted to guarantee USB2.0 compatibility to all the main microcontroller families, but, for the L4 family (NUCLEO-L412RB-P, NUCLEO-L433RC-P, NUCLEO-L452RE-P and NUCLEO-L476RG) only, they have to be removed and replaced by R12 and R13 solder bridges.

1.2.5 ST morpho and Arduino UNO V3 connectors

The figure below shows the X-NUCLEO-SNK1M1 expansion board ST morpho and Arduino UNO V3 connectors, detailing the main connections, functions and configuration settings.

Figure 8. ST morpho and Arduino UNO V3 connectors



In addition to the main functions related to the USB Type-C® and Power Delivery specification:

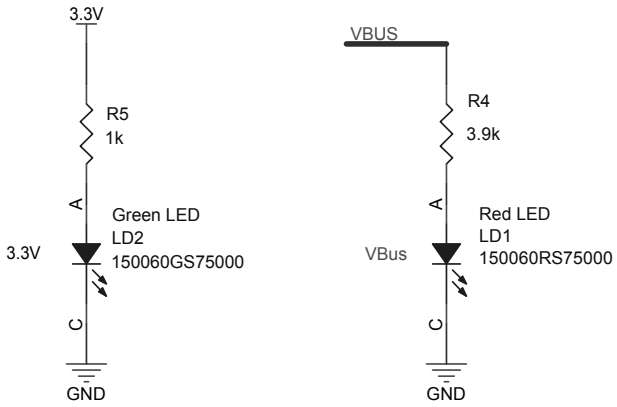
- an ADC channel can be used to monitor the V_{BUS} voltage (ADC_VBUS)
- a supply option path allows supplying the TCPP01-M12 either via the 3.3 V provided by the STM32 Nucleo development board or via a GPIO on the ST morpho connector (CN7-1). You can select the path through R23 and R24 resistances. This option, combined with the TCPP01-M12 low consumption, is useful for battery-powered devices as the TCPP01-M12 can be powered only when an attachment is detected (low-power mode)
- the TCPP01-M12 fault report pin (open drain) is connected to the ST morpho connector pin (CN10 – 18) to be monitored by the STM32 microcontroller (FLT – FLT_IN path)

1.2.6 Indication LEDs

Two LEDs mounted on the X-NUCLEO-SNK1M1 top side indicate the supply status of the expansion board and the stacked STM32 Nucleo development board:

- the red LED (LD1) turns ON when a source application board is plugged to the X-NUCLEO-SNK1M1 CN1 connector and the USB Type-C® V_{BUS} voltage is present;
- the green LED (LD2) indicates that the 3.3 V is present and is supplying the STM32 Nucleo microcontroller development board.

Figure 9. **Indication LEDs**



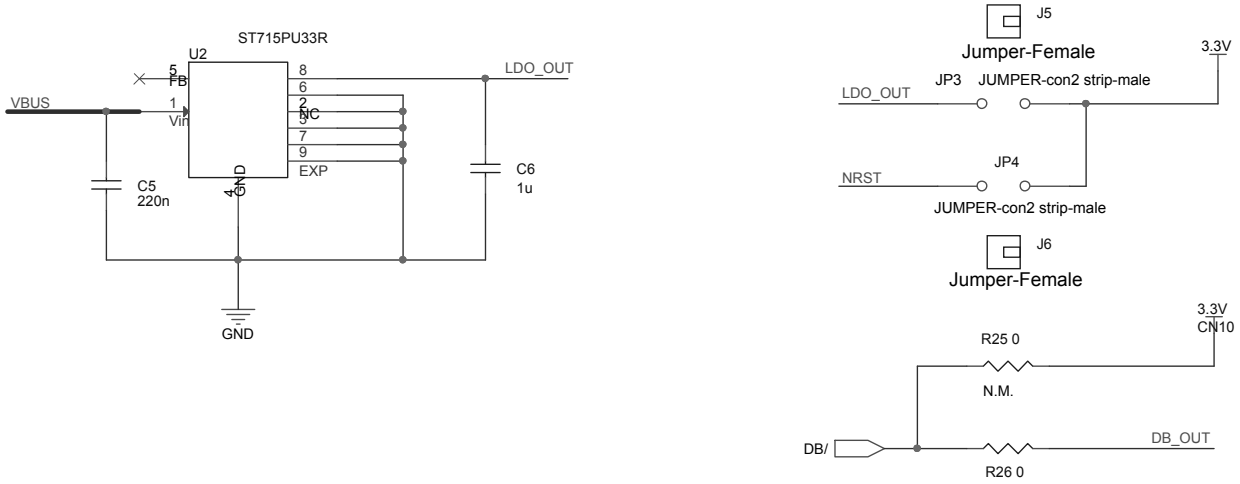
1.2.7 Dead battery mode configuration jumpers and internal LDO

Thanks to the dead battery feature, described by the USB Power Delivery specification and implemented by the X-NUCLEO-SNK1M1, it is possible to directly power the system through the V_{BUS} provided by a Source, as an alternative mode to the standard supply through the STM32 Nucleo ST-LINK.

Note: Before configuring the X-NUCLEO-SNK1M1 to operate in dead battery mode, check whether the supply selection jumpers on the STM32 Nucleo board have been removed:

- *on the NUCLEO-G071RB and the NUCLEO-G0B1RE, remove the jumper from JP2 header*
- *on the NUCLEO-G474RE, remove the jumper from JP5 header 5V_SEL*
- *on the NUCLEO-L412RB-P, remove the jumper from JP5 header*

Figure 10. **Dead battery mode circuitry**



To select the dead battery operation mode on the X-NUCLEO-SNK1M1, JP3 and JP4 jumpers must be fit.

Table 4. **JP3 and JP4 power mode selection jumpers**

Power mode	Jumpers	
	JP3 (LDO_OUT)	JP4 (RESET)
ST-LINK powered mode	 (open)	 (open)

Power mode	Jumpers	
	JP3 (LDO_OUT)	JP4 (RESET)
Dead battery mode	 (fit)	 (fit)

JP3 jumper connects the V_{BUS} path from the Type-C connector to the LDO (U2) which is connected to the STM32 Nucleo development board 3.3 V path and can power the entire solution.

When fitted, JP5 jumper forces the STM32 I/O negative reset to level 1. It must be connected when the STM32 is powered by the X-NUCLEO-SNK1M1.

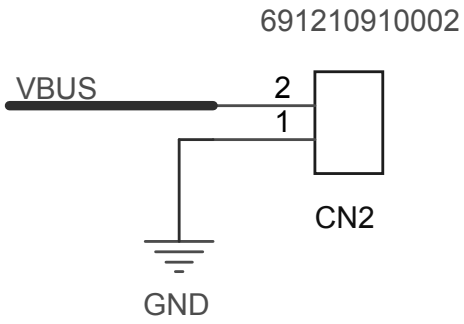
By default, the TCPP01-M12 dead battery option has been set to be driven by an STM32 microcontroller pin through R26 solder bridge, thus removing the TCPP01-M12 dead battery clamp when GPIO is connected on ST morpho connector (CN10-24). The alternative operating mode is to fit the TCPP01-M12 dead battery option to 3V3 through the R25 mounting solder bridge (consequently, R26 must be not fitted).

In the application firmware package, this option has been included in the firmware examples where a GPIO (ST morpho CN10-24) properly drives the dead battery option.

1.2.8 Power connector

CN2 power connector can be used to connect a load and monitor the V_{BUS} voltage level negotiated by the system with a Source attached to CN1 USB Type-C® connector.

Figure 11. CN2 power connector



Note: To monitor the output voltage, an appropriate resistance has to be connected to the X-NUCLEO-SNK1M1 CN2.

1.3 Demo application setup

The X-NUCLEO-SNK1M1 expansion board flexibility permits to demonstrate the TCPP01-M12 protection features and capabilities with a wide range of STM32 Nucleo development boards.

The X-CUBE-TCPP companion software package contains specific application examples for the STM32 Nucleo embedding the USB Type-C® and Power Delivery management (NUCLEO-G071RB, NUCLEO-G474RE and NUCLEO-G0B1RE) and, for the ones without the UCPD peripheral, the package demonstrates how to comply with basic USB Type-C® operations (NUCLEO-L412RB-P).

1.3.1 Programming and debugging

Once the X-NUCLEO-SNK1M1 expansion board has been connected to a NUCLEO-G071RB, NUCLEO-G474RE, NUCLEO-G0B1RE or NUCLEO-L412RB-P, to program and debug, the STM32 Nucleo development board has to be connected to a laptop by the embedded USB ST-LINK connector (CN2) to supply the solution and program the firmware example in the application microcontroller.

Note: Set the jumpers as follows:

- *On the STM32 Nucleo development board, ensure the 5 V selection jumper fits with the 5 V ST-LINK header (JP5 on NUCLEO-G474RE and NUCLEO-L412RB-P, JP2 on NUCLEO-G071RB and NUCLEO-G0B1RE)*
- *On the X-NUCLEO-SNK1M1 expansion board:*
  - *remove LDO OUT jumper (JP3)*
  - *remove NRST jumper (JP4)*

Note: The X-CUBE-TCPP MCU firmware applications are designed to select the highest and closest power profile exposed by the Source, after the explicit contract negotiation.

1.3.1.1 *Running the demo application with NUCLEO-G071RB or NUCLEO-G0B1RE development board*

The NUCLEO-G071RB development board embeds the STM32G071RB microcontroller with the UCPD peripheral. To run the application demo with the NUCLEO-G071RB, powering the system via ST-LINK micro-USB connector, follow the procedure below.

Step 1. Check the jumper is closed on the development board JP2 header, STLK 1-2 pins.

Step 2. On the X-NUCLEO-SNK1M1 expansion board, fit CC1 JP1 and CC2 JP2 jumpers on position 1-2.

Step 3. Plug the expansion board on top of the STM32 Nucleo and leave JP3 and JP4 headers open.

Step 4. Connect the NUCLEO-G071RB or NUCLEO-G0B1RE micro-USB connector (CN1) to the PC/laptop.
The board appears as a virtual disk (NODE_G071RB).

Step 5. Program the STM32G071RB by dragging and dropping the binary file corresponding to the board (G0_SNK1M1_Consumer.bin) to the virtual disk.
STM32 Nucleo LD1 LED blinks red and green for few seconds. When the LED stops blinking, the programming operation is complete and the demo is ready.

Step 6. Plug a Source application board on the X-NUCLEO-SNK1M1 expansion board CN1 connector through a USB Type-C® cable and refer to the following LED operation description to identify the application results:

- NUCLEO-G071RB/NUCLEO-G0B1RE LD3 LED is ON when the board is supplied by the ST-LINK micro-USB connector (CN1)
- X-NUCLEO-SNK1M1 LD2 LED is ON when the 3V3 voltage is provided to the expansion board by the STM32 Nucleo
- X-NUCLEO-SNK1M1 LD1 LED is ON when a Source is connected to the USB Type-C® CN1 connector and the V_{BUS} is provided
- NUCLEO-G071RB/NUCLEO-G0B1RE LD4 LED:
  - blinks once every 2 seconds when USB default (up to 500 mA) is identified
  - blinks twice every 2 seconds when a Source USB Type-C® 1.5 A current capability is identified;
  - blinks 3 times every 2 seconds when a Source USB Type-C® 3 A current capability is identified;
  - is ON when the explicit negotiation between the two contractors is reached.

1.3.1.1.1 Dead battery operation mode

Step 1. Repeat steps 1- 4 described in Section 1.3.1.1

Step 2. Disconnect the micro-USB cable from NUCLEO-G071RB/NUCLEO-G0B1RE CN1.

Step 3. Remove the power selection jumper from the JP2 header on NUCLEO-G071RB/NUCLEO-G0B1RE development board (previously set on STLK 1-2 pins) and leave it fully open.

Step 4. On the X-NUCLEO-SNK1M1, set LDO OUT jumper (JP3) and NRST jumper (JP4).

Step 5. Plug a Source board to X-NUCLEO-SNK1M1 CN1 connector through a USB Type-C® cable.
The provided V_{BUS} supplies the Sink solution while the LEDs define the status as previously described.

1.3.1.2 *Running the demo application with NUCLEO-G474RE development board*

The NUCLEO-G474RE development board embeds the STM32G474RE microcontroller with the UCPD and USB2.0 data peripherals. To run the application demo with the NUCLEO-G474RE, powering the system via ST-LINK micro-USB connector, follow the procedure below.

Step 1. Check the jumper is closed on the development board JP5 header, 5V_STLK 1-2 pins.

Step 2. On the X-NUCLEO-SNK1M1 expansion board, fit CC1 JP1 and CC2 JP2 jumpers on position 1-2.

Step 3. Plug the expansion board on top of the STM32 Nucleo and leave JP3 and JP4 headers open.

Step 4. Connect the NUCLEO-G474RE micro-USB connector (CN1) to the PC/laptop.
The board appears as a virtual disk (NODE_G474RE).

Step 5. Program the STM32G474RE by dragging and dropping the binary file corresponding to the board (G4_SNK1M1_Consumer.bin) to the virtual disk.
STM32 Nucleo LD1 LED blinks red and green for few seconds. When the LED stops blinking, the programming operation is complete and the demo is ready.

Step 6. Plug a Source application board on the X-NUCLEO-SNK1M1 expansion board CN1 connector through a USB Type-C® cable and refer to the following LED operation description to identify the application results:

- NUCLEO-G474RE LD3 LED is ON when the board is supplied by the ST-LINK micro-USB connector (CN1)
- X-NUCLEO-SNK1M1 LD2 LED is ON when the 3V3 voltage is provided to the expansion board by the STM32 Nucleo
- X-NUCLEO-SNK1M1 LD1 LED is ON when a Source is connected to the USB Type-C® CN1 connector and the VBUS is provided
- NUCLEO-G474RE LD2 LED:
  - blinks once every 2 seconds when USB default (up to 500 mA) is identified
  - blinks twice every 2 seconds when a Source USB Type-C® 1.5 A current capability is identified;
  - blinks 3 times every 2 seconds when a Source USB Type-C® 3 A current capability is identified;
  - blinks 4 times every 2 seconds when the explicit negotiation between the two contractors is reached;
  - turns ON when the explicit negotiation between the two contractors is reached and the USB2.0 data connection is established.

1.3.1.2.1 Dead battery operation mode

Step 1. Repeat steps 1- 4 described in Section 1.3.1.2

Step 2. Disconnect the micro-USB cable from NUCLEO-G474RE CN1.

Step 3. Remove the power selection jumper from the JP2 header on NUCLEO-G474RE development board (previously set on STLK 1-2 pins) and leave it fully open.

Step 4. Set JP8 jumper on 2-3 pins.

Step 5. On the X-NUCLEO-SNK1M1, set LDO OUT jumper (JP3) and NRST jumper (JP4).

Step 6. Plug a Source board to X-NUCLEO-SNK1M1 CN1 connector through a USB Type-C® cable.
The provided V_{BUS} supplies the Sink solution while the LEDs define the status as previously described.

1.3.1.3 *Running the demo application with NUCLEO-L412RB-P development board*

The NUCLEO-L412RB-P development board embeds the STM32L412RB microcontroller which includes the USB2.0 data peripheral only. The application example demonstrates that the TCPP01-M12 protection can be matched with microcontrollers which does not include the UCPD peripheral to implement a USB Type-C® Sink port only, thus exploiting the microcontroller ADC peripherals to monitor the current capabilities of the Source. To run the application demo with the NUCLEO-L412RB-P, powering the system via ST-LINK micro-USB connector, follow the procedure below.

Step 1. Check the jumper is closed on the development board JP5 header, 5V_STLK 1-2 pins.

Step 2. On the X-NUCLEO-SNK1M1 expansion board, fit CC1 JP1 and CC2 JP2 jumpers on position 1-2.

Step 3. Plug the expansion board on top of the STM32 Nucleo and leave JP3 and JP4 headers open.

Step 4. Connect the NUCLEO-L412RB-P micro-USB connector (CN1) to the PC/laptop.
The board appears as a virtual disk (NODE_L412RB).

Step 5. Program the STM32L412RB by dragging and dropping the binary file corresponding to the board (SNK1M1_Consumer_TypeC_Only.bin) to the virtual disk.
STM32 Nucleo LD1 LED blinks red and green for few seconds. When the LED stops blinking, the programming operation is complete and the demo is ready.

Step 6. Plug a Source application board on the X-NUCLEO-SNK1M1 expansion board CN1 connector through a USB Type-C® cable and refer to the following LED operation description to identify the application results:

- NUCLEO-L412RB-P LD3 LED is ON when the board is supplied by the ST-LINK micro-USB connector (CN1)
- X-NUCLEO-SNK1M1 LD2 LED is ON when the 3V3 voltage is provided to the expansion board by the STM32 Nucleo
- X-NUCLEO-SNK1M1 LD1 LED is ON when a Source is connected to the USB Type-C® CN1 connector and the V_{BUS} is provided
- NUCLEO-L412RB-P LD2 LED:
  - blinks once every 2 seconds when USB default is identified
  - blinks twice every 2 seconds when a Source USB Type-C® 1.5 A current capability is identified;
  - blinks 3 times every 2 seconds when a Source USB Type-C® 3 A current capability is identified.

1.3.1.3.1 Dead battery operation mode

Step 1. Repeat steps 1- 4 described in Section 1.3.1.3

Step 2. Disconnect the micro-USB cable from NUCLEO-L412RB-P CN1.

Step 3. Remove the power selection jumper from the JP2 header on NUCLEO-L412RB-P development board (previously set on STLK 1-2 pins) and leave it fully open.

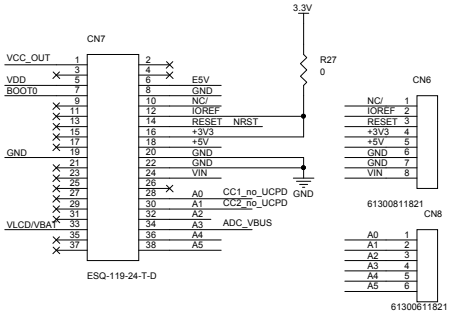
Step 4. On the X-NUCLEO-SNK1M1, set LDO OUT jumper (JP3) and NRST jumper (JP4).

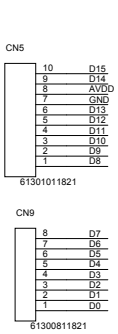
Step 5. Plug a Source board to X-NUCLEO-SNK1M1 CN1 connector through a USB Type-C® cable.
The provided V_{BUS} supplies the Sink solution while the LEDs define the status as previously described.

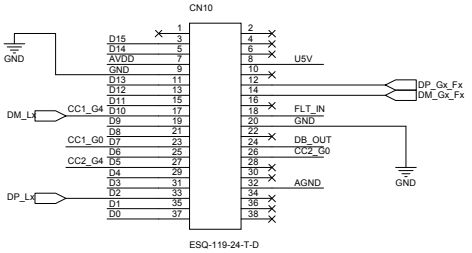
Note: The firmware application example designed for the NUCLEO-L412RB-P embeds the USB2.0 driver which can start the USB enumeration when the board is connected to a laptop or a PC. To test this functionality, R8 and R9 solder bridges have to be mounted while R12 and R13 have to be mounted.

2 Schematic diagrams

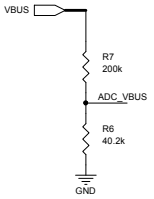
Figure 12. X-NUCLEO-SNK1M1 circuit schematic (1 of 2)

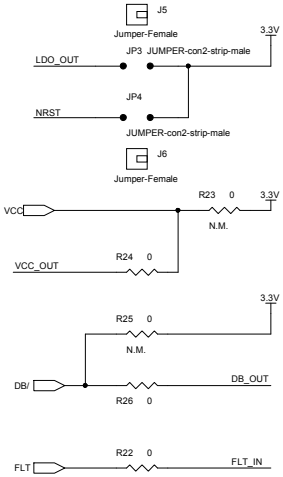


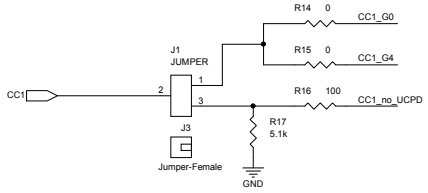


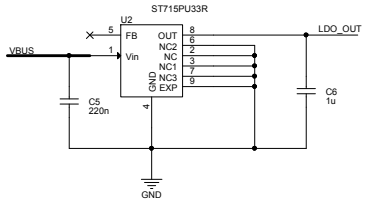


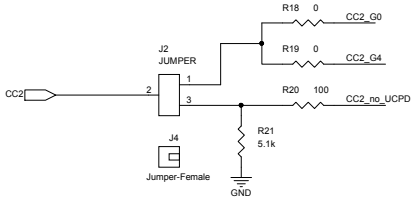
For the STM32 Nucleo families embedding L412, L433, L452 and L476, the USB DM pin coexists with STMG4 CC1 pin.
To exploit the USB functionality with these L4 families, the solder bridges R12, R13 must be fit and removed the R8 and R9.





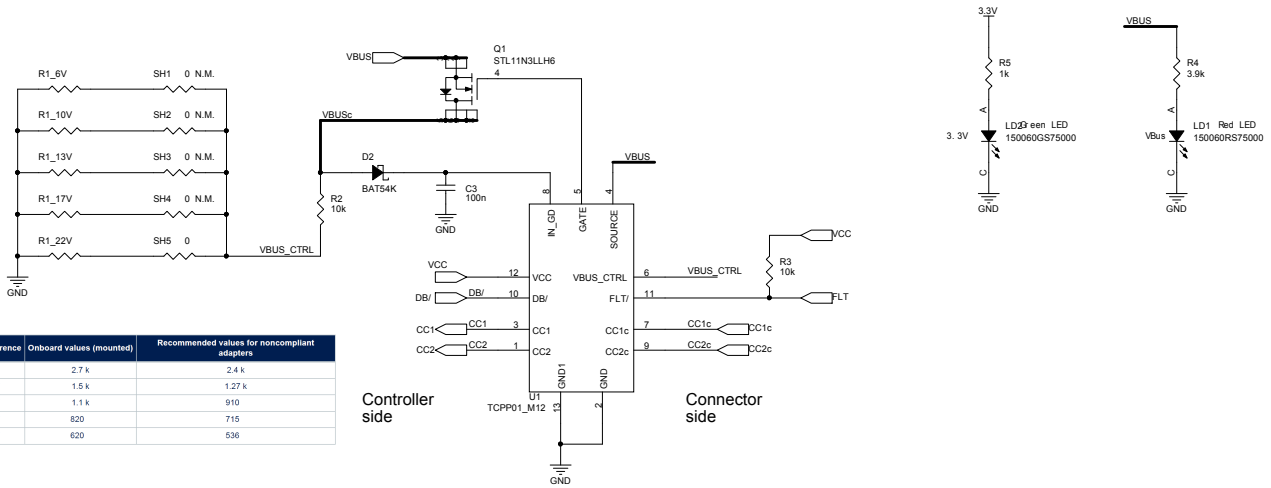






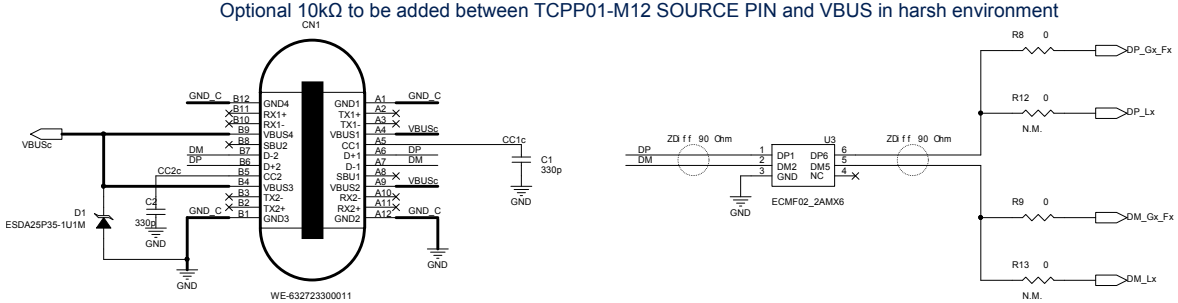
Interface Configuration

Figure 13. X-NUCLEO-SNK1M1 circuit schematic (2 of 2)

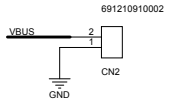


VBUS max	Pmax	Resistor reference	Onboard values (mounted)	Recommended values for noncompliant adapters
6 V	15 W	R1_6V	2.7 k	2.4 k
10 V	27 W	R1_10V	1.5 k	1.27 k
13 V	36 W	R1_13V	1.1 k	910
17 V	45 W	R1_17V	820	715
22 V	100 W	R1_22V	620	536

Optional 10kΩ to be added between TCPP01-M12 SOURCE PIN and VBUS in harsh environment



USB TYPE-C® RECEPTACLE



3 Bill of materials

Table 5. **X-NUCLEO-SNK1M1 bill of materials**

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	2	C1, C2	330 p, 0402 (1005 Metric), 50 Vdc V, ±10 %, SMD 0402 X7R	Ceramic capacitors	Wurth Electronics Inc.	885012205058
2	1	C3	100 n, 0402 (1005 Metric), 50Vdc V, ±10 %, SMD 0402 X7R	Ceramic capacitor	TDK	C1005X7R1H104K050BB
3	1	C5	220n, 0402 (1005 Metric), 35Vdc V, ±10 %, SMD 0402 X7R	Ceramic capacitor	Murata Electronics	GRM155C8YA224ME01D
4	1	C6	1 µF, 0402 (1005 Metric), 6Vdc V, ±10 %, SMD 0402 X5R	Ceramic capacitor	Kemet	C0402C105K8PAC7411
5	1	CN1	WE-632723300011, THT/SM	USB 3.1 Type-C receptacle	Wurth Electronics Inc.	632723300011
6	1	CN2	691210910002, 2.54 mm	Terminal block	Wurth Electronics Inc.	691210910002
7	1	CN5	61301011821, 10 pos., 0.1, gold PCB	Connector receptacle	Wurth Electronics Inc.	61301011821
8	2	CN6, CN9	61300811821, 8 pos., 0.1, gold PCB	Connector receptacles	Wurth Electronics Inc.	61300811821
9	2	CN7, CN10	ESQ-119-24-T-D, 38 pos., 0.1, gold PCB	Connector receptacles	Samtec Inc.	ESQ-119-24-T-D
10	1	CN8	61300611821, 6 pos., 0.1, gold PCB	Connector receptacle	Wurth Electronics Inc.	61300611821
11	1	D1	ESDA25P35-1U1M, 2-UDFN, 1400 W (1.4 kW)	High power transient voltage suppressor	ST	ESDA25P35-1U1M
12	1	D2	BAT54K, SC-79, SOD-523, 900 mV @ 100 mA V, 300mA (DC) A	General purpose Schottky diode	ST	BAT54KFILM
13	2	J1, J2	Jumper, 3 pos.	Connector header	AMTEK	PH1S25-1x03GB6/3-L
14	1	J3 FIT ON PIN 1-2 OF J1	Jumper,female	Connector jumper	AMTEK	MJ1B-AGB-L
15	1	J4, FIT ON PIN 1-2 OF J2	Jumper,female	Connector jumper	AMTEK	MJ1B-AGB-L
16	2	J5, J6 PROVIDE BUT NOT ASSEMBLY	Jumper,female	Connector jumpers	AMTEK	MJ1B-AGB-L

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
17	2	JP3, JP4	Jumpers, con2-strip-male	Connector jumpers	AMTEK	PH1S25-1x02GB6/3-L
18	1	LD1	150060RS75000, 0603 (1608 Metric), 20 m A	Red LED	Wurth Electronics Inc.	150060RS75000
19	1	LD2	150060GS75000, 0603 (1608 Metric), 20 m A	Green LED	Wurth Electronics Inc.	150060GS75000
20	1	Q1	STL11N3LLH6, 8-PowerVDFN	STripFET H6 Power MOSFET in a PowerFLAT 3.3 x 3.3 package	ST	STL11N3LLH6
21	2	R2, R3	10 k, 0402 (1005 Metric), 0.063W, 1/16 W, ±1 %	Chip resistors	Yageo	RC0402FR-0710KL
22	1	R4	3.9 k, 0402 (1005 Metric), 0.063W, 1/16 W, ± 0.1 %	Chip resistor	Vishay	CRCW04023K90FKED
23	1	R5	1k, 0402 (1005 Metric), 0.063W, 1/16 W, ±1 %	Chip resistor	Vishay	CRCW04021K00FKED
24	1	R6	40.2 k, 0402 (1005 Metric), 0.063 W, 1/16 W, ±1 %	Chip resistor	Vishay	CRCW040240K2FKED
25	1	R7	200 k, 0402 (1005 Metric), 0.063W, 1/16 W, ±1 %	Resistor	Vishay	CRCW0402200KFKEDC
27	10	R8, R9, R14, R15, R18, R19, R22, R24, R26, R27	0, 0805 (2012 Metric), 1/8 W	Resistors	Yageo	RC0805JR-070RL
28	4	R12,R13, R23, R25	0805 (2012 Metric), 0.125 W, 1/8 W	Resistors (not mounted)	Yageo	RC0805JR-070RL
29	2	R17, R21	5.1 k, 0402 (1005 Metric), 1/16 W, ±1 %	Chip resistors	Vishay	CRCW04025K10FKED
30	1	R1_10V	1.5 k, 0402 (1005 Metric), 1/4 W, ±1 %	Chip resistor	Yageo	RC0402FR-071K5L
31	1	R1_13V	1.1 k, 0402 (1005 Metric), 1/4 W, ±1 %	Chip resistor	Multicomp	MCWR04X1101FTL
32	1	R1_17V	820, 0402 (1005 Metric), 1/4 W, ±1 %	Chip resistor	Vishay	CRCW0402820RFKED
33	1	R1_22V	620, 0402 (1005 Metric), 1/16 W, ±1 %	Chip resistor	Yageo	RC0402FR-07620RL
34	1	R1_6V	2.7 k, 0402 (1005 Metric), 1/4 W, ±1 %	Chip resistor	Yageo	RC0402FR-072K7L

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
35	4	SH1, SH2, SH3, SH4	0, 0805-Solder Bridge	Jumpers (not mounted)	Any	Any
36	1	SH5	0, 0805-Solder Bridge	Jumper	Any	Any
37	1	U1	TCPP01-M12, 3X3X1 mm,	Overvoltage protection for USB-C or Power Delivery	ST	TCPP01-M12
38	1	U2	ST715PU33R, 8-VDFN Exposed Pad	High input voltage - 85 mA LDO linear regulator	ST	ST715PU33R
39	1	U3	ECMF02_2AMX6, 6-UFQFN, 200 mA	Common-mode filter and ESD protection for USB 2.0 and MIPI/MDDI interfaces	ST	ECMF02-2AMX6
40	1		PCB, 72.6x58.6 mm	FR4 Standard 72.6x58.6x1.55 mm	Massive PCB Technologies LTD	PROT-X-NUCLEO-SNK1M1-ver.2 (0EC0C1)

Revision history

Table 6. **Document revision history**

Date	Version	Changes
15-Mar-2021	1	Initial release.
15-Apr-2021	2	Added NUCLEO-G0B1RE development board compatibility information.
10-May-2021	3	Updated Section 1.2.1 Type-C connector and Section 1.3.1.2.1 Dead battery operation mode.
02-Feb-2022	4	Updated Section 1.2.2 TCPP01-M12 USB Type-C™ protection and VBUS overvoltage protection setup.
01-Mar-2022	5	Updated Section 1.2 Hardware architecture, Section 1.2.7 Dead battery mode configuration jumpers and internal LDO, Section 1.3.1.1 Running the demo application with NUCLEO-G071RB or NUCLEO-G0B1RE development board, Section 1.3.1.2 Running the demo application with NUCLEO-G474RE development board, Section 1.3.1.3 Running the demo application with NUCLEO-L412RB-P development board, and Section 2 Schematic diagrams.
02-Aug-2022	6	Updated Section 1.2.2 TCPP01-M12 USB Type-C® protection and VBUS overvoltage protection setup and Section 2 Schematic diagrams.
20-Sep-2022	7	Updated Section 1.2.2: TCPP01-M12 USB Type-C® protection and VBUS overvoltage protection setup and Section 2: Schematic diagrams.
16-Jul-2024	8	Updated Section 2: Schematic diagrams and Section 1.2.2: TCPP01-M12 USB Type-C® protection and V_{BUS} overvoltage protection setup.

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